JBA consulting

Groundwater Level Trends in the City of Portsmouth 2019-2024

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This report describes work commissioned by Portsmouth City Council by an instruction dated 2nd February 2024. The Client's representative for the contract was Harvey Cable of Portsmouth City Council. Euan Riddle and Parvaneh Aghajani of JBA Consulting carried out this work.

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Executive Summary

Portsmouth City Council have developed a good understanding of groundwater levels throughout the City of Portsmouth through installation of a monitoring network in 2015. Groundwater monitoring data collected between 2015 and 2019 was reported on by JBA in 2020 and established that the main response types within shallow groundwater at Portsmouth are generally tidal near the coast and rainfall (recharge) inland and identified several low-lying locations where potential groundwater may emerge at the surface.

This report presents the analysis of groundwater monitoring data collected between 2019 to 2023. The following key conclusions can be drawn from analysis of the aggregated monitoring data:

1 Groundwater levels are generally within 5m of the ground surface in many areas and are located within the permeable superficial deposits. Groundwater responses observed are typical of superficial aquifers as opposed to bedrock aquifers such as the underlying Chalk.

2 Monitoring shows that groundwater levels respond to rainfall, drainage and tides to varying degrees.

3 Groundwater levels following topography and in low-lying areas may be close to or at the surface at times of high groundwater levels.

4 The absence of observed groundwater flooding is likely to be because of sub-surface drainage which intercepts groundwater above certain levels. There may also be some interaction between sewers and groundwater with discharge of groundwater to sewers where these have not been lined.

6 Groundwater levels are likely to rise with sea levels over the next century. This will result in higher groundwater levels and an increased need for pumped drainage in low-lying areas. Brackish or saline water has been identified during more recent monitoring is generally confined to the coastal areas around Portsmouth. Following climate change and sea level rises this may result in an inland migration of the groundwater saline interface, with potential to impact vegetation and invertebrate ecology.

Based upon the findings of this review it is recommended that continued monitoring of groundwater is undertaken at key locations utilising the existing network of boreholes, particularly within areas that may be susceptible to groundwater emergence (shown in Figure 5-4 and Figure 6-3 of this report). Also, drainage infrastructure within the areas susceptible to groundwater emergence should be routinely maintained and repaired (if necessary). In areas which may be susceptible to groundwater emergence and flooding, any developments involving low permeability sub-surface structures (e.g. basements, tunnels or underground services) should ideally be avoided, or include mitigation measures to avoid increased groundwater levels. Conversely, developments that may create permeable groundwater flow paths should be assessed with appropriate risk assessment to determine how groundwater flow paths and levels may be altered, and where groundwater may discharge.

1 Introduction

This Report was commissioned by Portsmouth City Council following a previous report entitled "Groundwater Level Trends in the City of Portsmouth 2015-2019" prepared by JBA in 2020.

This current report has been prepared in accordance with our submission to Portsmouth City Council dated 2nd February 2024.

1.1 Background

Portsea Island is a densely populated island city with low topography, with the largest settlement being Portsmouth City, situated on Portsmouth Island. Portsmouth is a low-lying island surrounded by the sea and estuaries. The combination of proximity to the sea and flat topography gives a vulnerability to high groundwater levels and the potential for groundwater flooding.

A Preliminary Groundwater Flood Risk Management Study (Halcrow, 2013) was undertaken as part of the Local Flood Risk Management Strategy workstream as a statutory duty of the Flood and Water Management Act. The report highlighted areas of the city where further investigation into should be considered.

Following this, Portsmouth City Council installed a monitoring network throughout Portsmouth to obtain groundwater level and salinity data. Further boreholes installed by others were adopted into the programme, with a total of 55 eventually monitored between early 2015 and 2019.

The resulting groundwater datasets collected between 2015 and 2019 were consolidated into the previous JBA report referenced above in 2020. The information has been used to inform and support planning applications, coastal defence works, highway works, testing groundwater for salinity, etc, along the course of the programme. The previous report outlines much of rationale for the analysis and should be read in conjunction with this report which is included within Appendix A for reference.

1.2 Scope of current report

In this updated report groundwater monitoring data collected by Portsmouth City Council between 2019 and 2024 has been used to provide an update on the earlier data which was reported on in 2020. A total of 47 boreholes have been monitored (totalling 67 datasets). Groundwater levels were recorded every 15 minutes using automated logging equipment. The duration of each set of vary, with several of the dataloggers being installed during winter. Multiple sets are available for several of the boreholes.

This report provides a summary of; the baseline geology and hydrogeology; a summary of the recent monitoring data to provide an updated overview of the conceptual hydrogeological model of the area including comment on trends and changes in groundwater conditions; and, our overall conclusions and recommendations in relation to groundwater flood risk based upon the data collected since 2019.

2 Baseline and Portsmouth Conceptualisation

2.1 Baseline

A full discussion of the geological and hydrogeological baseline is presented in the 2020 report. However, a summary of the key elements of the groundwater system underlying Portsmouth is presented below. Figure 2-1 below shows the cross section of Portsmouth with underlying superficial and bedrock geology depths, with groundwater flow and water table heights displayed.

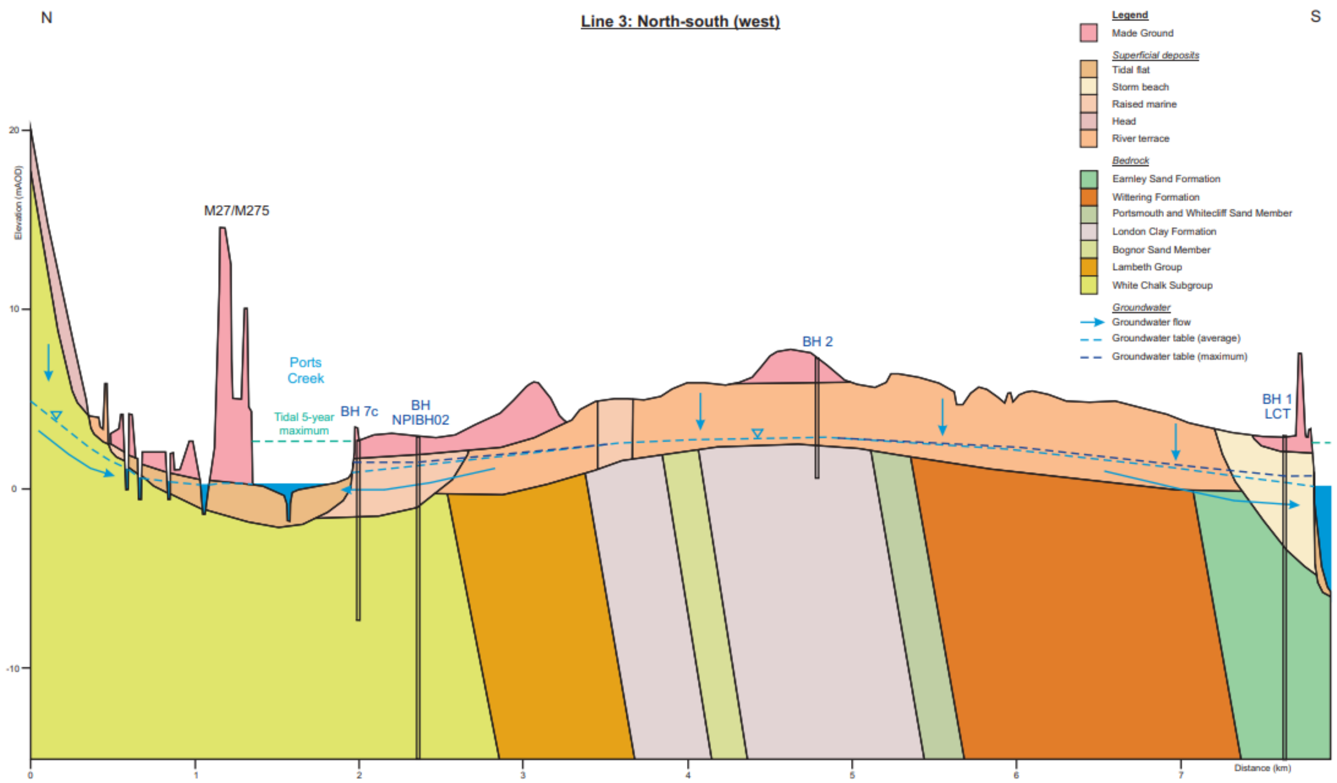


Figure 2-1: Conceptualisation of Portsmouth from north-south (taken from JBA 2019 report)

2.1.1 Bedrock geology

The northern half of Portsmouth is underlain by the permeable Upper (White) Chalk Formation. This is overlain in the central part of Portsea Island by the clays and sands of the Reading Formation (Lambeth Group) and London Clay Formation; and, further to the south, by the silts and sands of the Marsh Farm, Earnley Sand and Wittering Formations (Bracklesham Group).

2.1.2 Superficial geology

With the exception of the Chalk outcrop forming Portsdown Hill, the bedrock is overlain by a range of permeable marine and alluvial deposits comprising river and terrace sands and gravels; alluvial sands, silts; clays and peat; marine silts and clays and storm beach gravels. A small zone of peat is present in the low-lying Great Morass area of Southsea. Selected BGS borehole log scans indicate the thickness of superficial deposits to be in the order of 1 to 5m on Portsea Island and 1 to 12m on the mainland (Halcrow, 2013).

2.1.3 Made Ground

Made Ground deposits are generally contained to the periphery of Portsmouth and comprise approximately one third of Portsea Island. The Made Ground deposits primarily derive from harbour dredgings.

2.1.4 Hydrogeology

A summary of the geological strata and their hydrogeological properties across Portsmouth is provided below:-

Superficial Deposits

- Head (poorly sorted and poorly stratified angular rock debris), up to 6m thick, Secondary (undifferentiated) aquifer;
- Peat (partially decomposed vegetation), up to 7m thick, unproductive aquifer;
- Beach and Tidal Flat Deposits (unconsolidated sediment, mud, sands, gravels and silty clays), up to 10m thick, Secondary (undifferentiated) aquifer;
- River Terrace Deposits (2nd terrace, sands and gravels), up to 8m thick, Secondary A aquifer;
- River Terrace Deposits (undifferentiated, sands and gravels with lenses of silt, clay or peat), up to 8m thick, Secondary (undifferentiated) aquifer;
- Raised Marine Deposits (raised marine and coastal zone deposits of shingle, sand silt and clay), up to 6m thick, Secondary (undifferentiated) aquifer;
- Storm Beach Deposits (gravels, cobbles or boulders), up to 6m thick, Secondary A aquifer.

Bedrock Geology

- Earnley Sand Formation (glauconitic silty sands), between 16 to 25m thick, Secondary A aquifer;
- Witterring Formation (greyish brown laminated clay), 65m thick, Secondary A aquifer;
- London Clay (blue-grey or grey-brown silty to very silty clay, also includes Portsmouth, Whitecliff and Bognor Sand Members), between 100 to 110m thick, Unproductive aquifer (London Clay) and Secondary A (sand members);
- Lambeth Group (silty sandy clay with some gravels), between 30 to 45m thick, Secondary A aquifer;
- Chalk (including the White Chalk Subgroup, Newhaven Chalk Formation, Tarrant Chalk Member, Spetisbury Chalk Member and Portsdown Chalk Formation) comprising white chalks up to 330m thick, all Principal aquifers.

The geology on Portsmouth Island is underlain by a number of variably permeable aquifer strata. The presence of the sea, low-lying topography along with the presence of the superficial deposits means that generally the water table lies within the superficial deposits.

Overall, the flow of groundwater through aquifer systems such as those described above is approximately horizontal on a regional scale. However, in areas where groundwater recharge is occurring the vertical flow direction is often downwards. However, nearer the shoreline the vertical groundwater flow component can be upwards, with subsequent development of springs and seepage areas, particularly in lower lying areas close to the shoreline.

3 Groundwater Level Data Analysis

3.1 Introduction

Portsmouth City Council has continued to monitor groundwater levels throughout Portsmouth since 2019 by installing pressure transducers or dataloggers throughout a series of boreholes. Boreholes were principally monitored for groundwater levels, throughout all seasons (JBA previously recommended that targeting winter would be more beneficial to understanding the maximum groundwater levels). Groundwater levels were also recorded manually using a dip meter (in meters below ground level (bgl)) to convert groundwater levels to m above Ordnance Datum (m AOD).

A series of dataloggers also recorded groundwater salinity (measured in the form of µS/cm and practical salinity units (PSU)). Salinity monitoring was undertaken at locations previously recommended by JBA to assess the potential influence of groundwater with the sea.

The certificates provided by Portsmouth City Council relating to the use of dataloggers and water sampling are provided in Appendix B.

3.2 Changes to monitoring network and data set review

3.2.1 Changes to monitoring network

Since the previous JBA report, approximately 20 monitoring locations have been utilised for monitoring throughout the study area. Also, a series of boreholes (CPTRH01, RCRH02 and BHRH01 to BHRH18) were installed throughout Portsmouth in 2019 that have been used for groundwater level and salinity monitoring. Other newly monitored boreholes include BH16, BH18, BH19, BH21 and BH34a.

FM1 to FM6 are a series of boreholes installed across Farlington Marshes, by a third party. These locations were only manually dipped by Portsmouth City Council and no dataloggers were used. These were not available during the previous assessment.

A number of monitoring locations during the previous report have also not been considered for the present study based off JBA recommendations.

The locations of the monitoring boreholes used in this report are shown in Figure 3-1 below, with a broad coverage across the Portsmouth area.

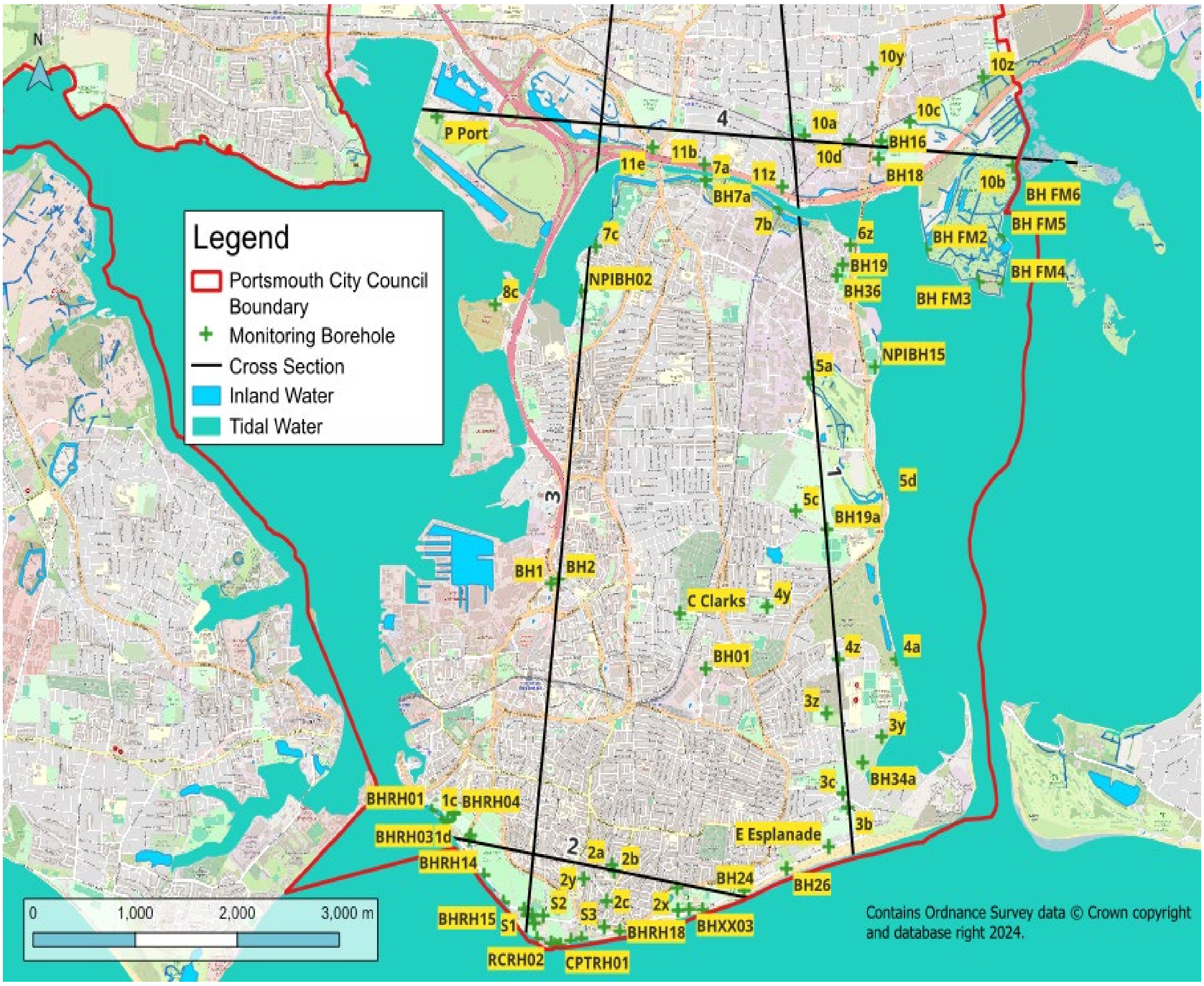


Figure 3-1: Summary of borehole monitoring locations and cross sections

3.2.2 Summary of outstanding issues

Following review of supplied data JBA established that an issue arose with several datasets provided during the period between October 2022 and March 2023. From review of the available data, it appears the Barologger used to correct for barometric pressure was malfunctioning and therefore caused erroneous groundwater level/pressure data.

JBA was able to correct these issues using local freely available barometric pressure data from a local weather station and with the manual dips provided during the installation and collection of the logger.

Details of the locations are provided in Appendix C.

3.2.3 Data quality assessment - QA

A quality assessment was carried out by JBA on the data provided by Portsmouth City Council as part of the project. These include:

- All borehole records were checked for continuity of units used, such as time (BST/GMT) and datum (m AOD and Chart Datum) units.
- Correlation to dips - an assessment of manual groundwater level duos against calibrated logger levels was completed to assess the validity of the logger data. The majority of the datasets had manual dips provided and inaccuracies are depicted as text on the hydrographs present in Appendix E.

3.3 Groundwater level monitoring

Groundwater levels have been monitored at 47 boreholes from late 2019 until September 2023, totalling 67 datasets. Boreholes ranged from approximately 4.4m to 30m deep, with response zones installed within superficial deposits/bedrock geologies. Pressure transducers have been used to record groundwater levels. The transducers have been moved between boreholes to obtain data from all the available boreholes over a range of time periods.

Details of the monitoring borehole location and boreholes used are provided in Appendix C and D. Records of groundwater levels are provided in Appendix E.

3.4 General water conditions

Since the issue of the previous report, available precipitation, groundwater level and river flows data have been reviewed. For both rainfall and river flows within Portsmouth, it is apparent that the winter of 2023 and 2024 has had the wettest conditions than the previous five years. Consequently, groundwater level conditions are likely to give a reasonable 'worst-case scenario' condition.

3.4.1 Rainfall

Recharge (from precipitation) and tidal influence are likely to have a significant influence on the groundwater level and behaviour throughout the study area. Rainfall data has been collated from an Environment Agency (EA) gauging station in Eastney (located 467354, 99333)[1]. The data covers the full study period (2019 to 2024) and is recorded at 15-minutes intervals. Daily rainfall for this period is shown in Figure 3-2, the monthly average for the study period is shown in Figure 3-3 and the yearly total rainfall during the monitoring period is provided in Figure 3-4. In Figure 3-4, a blue line has been plotted which indicates the average annual rainfall in Portsmouth (723.48mm)[2]. The graphs show that the most intense rainfall event occurred on 27th July 2021 (with 21.6mm of rainfall) and the wettest month over the five-year monitoring period on average has been October.

1 Eastney Hydrology Data Explorer, 2024. Department for Environment Food & Rural Affairs.
2 Solent MRSC, UK climate averages, 2024. Met Office.

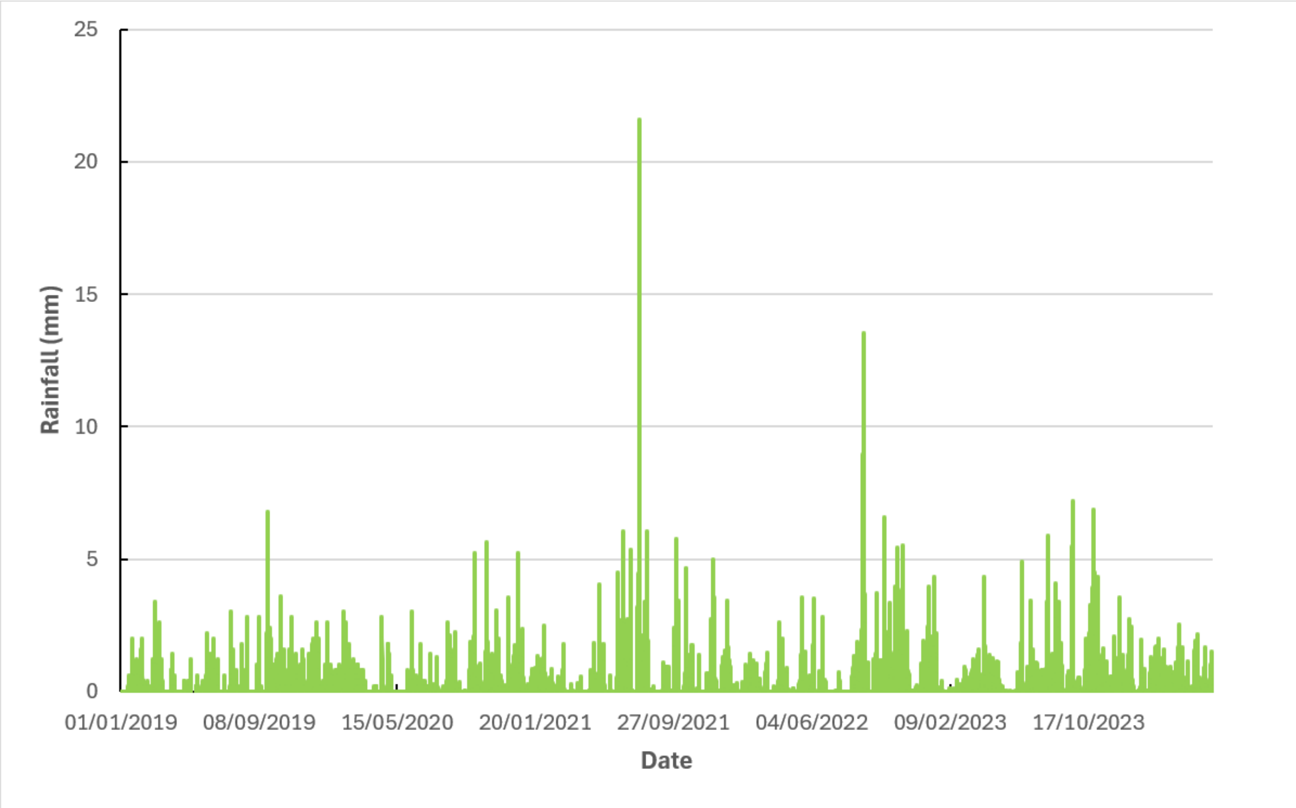


Figure 3-2: Daily rainfall during monitoring period (January 2019 - May 2024)

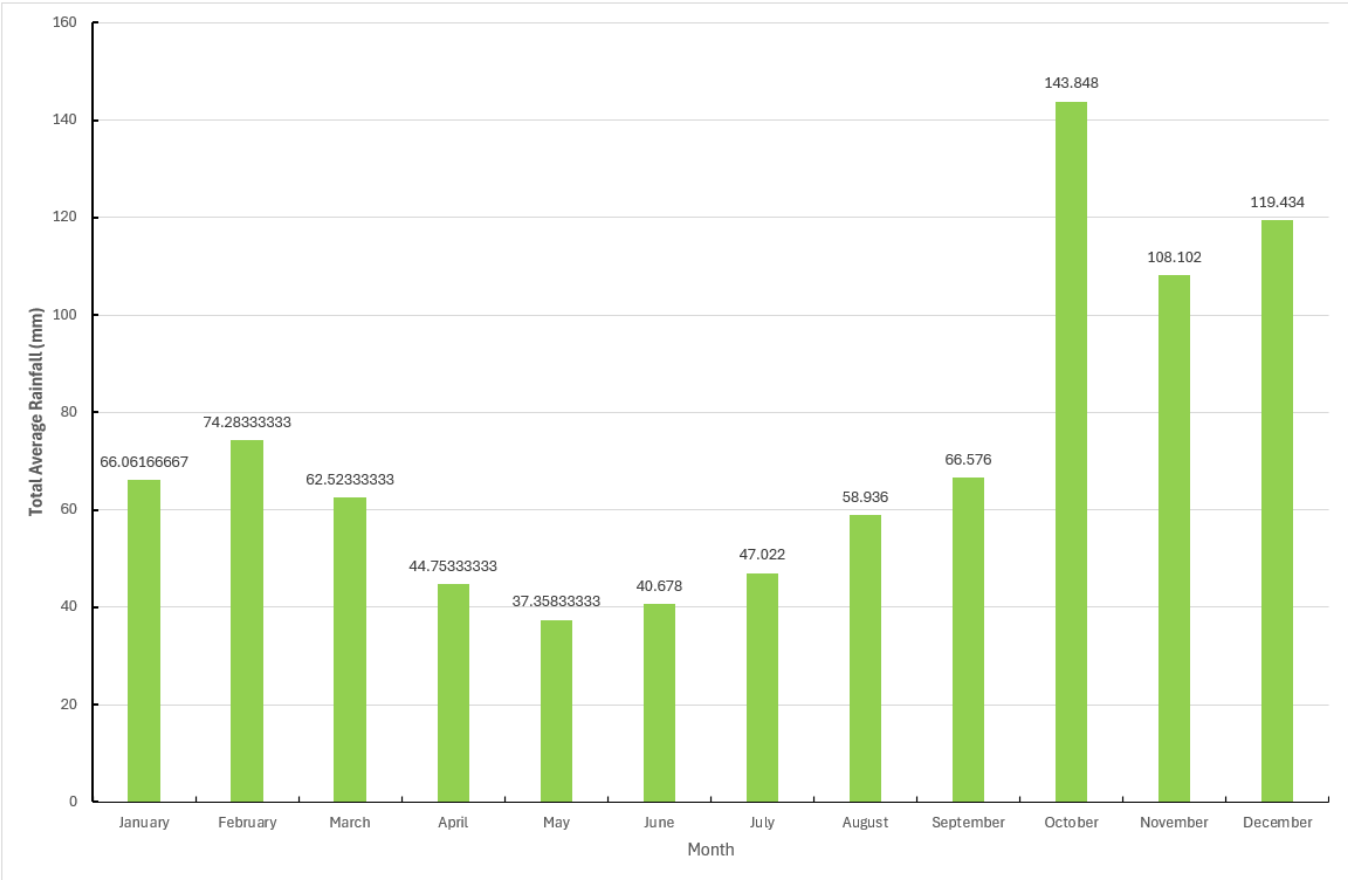


Figure 3-3: Average monthly rainfall data

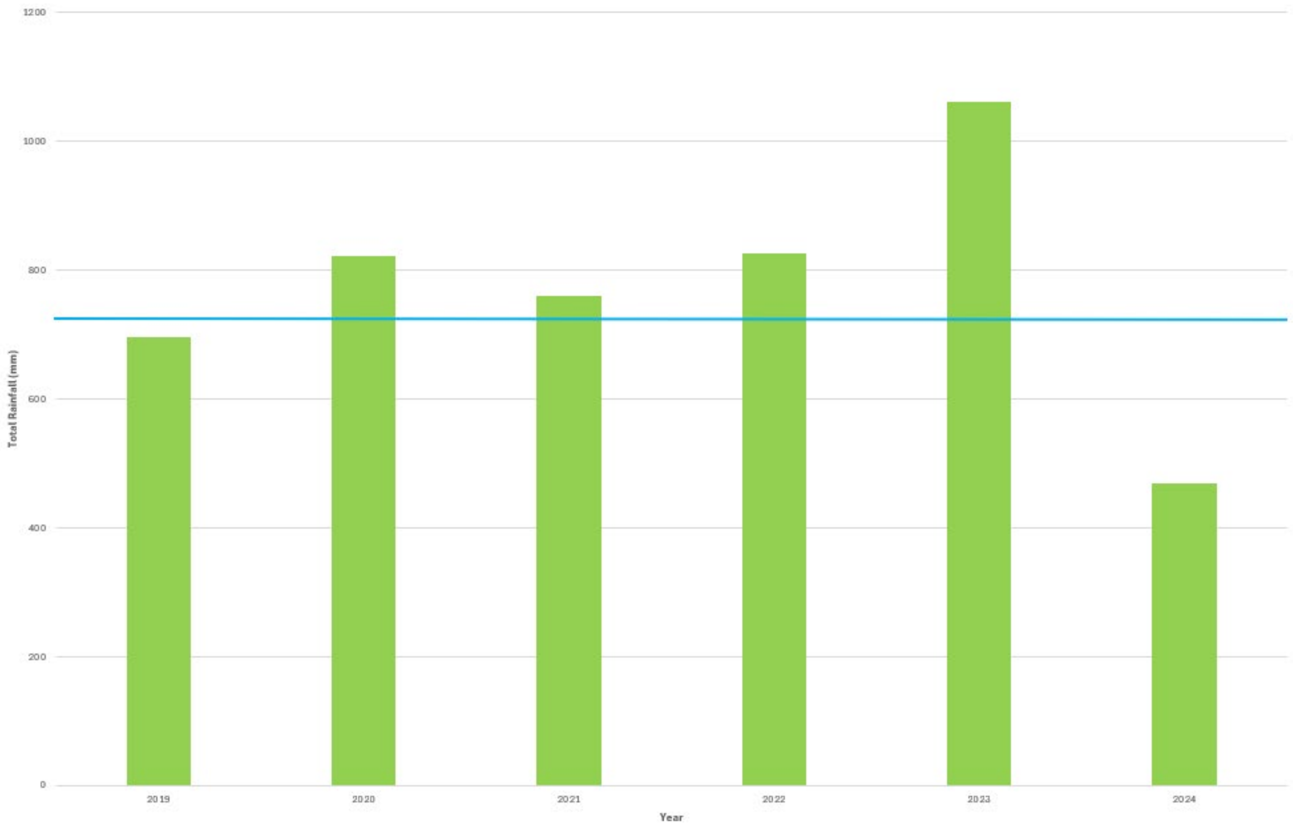


Figure 3-4: Total rainfall per year during the monitoring period, blue line indicates average annual rainfall for Portsmouth

3.4.2 Groundwater levels

An EA groundwater monitoring station located at Rookwood Farm (approximately 8.6km north of the M27) located within the chalk catchment (Tarrant Chalk Member) has recorded the sub-daily groundwater levels in m AOD. The highest recorded groundwater level depth was 54.40m AOD during March 2024 (albeit this is unchecked data at the time of publishing).

Along with Figure 3-4 indicating that 2023 was the wettest year, the hydrograph from the chalk aquifer in Figure 3-5 below demonstrates that in 2023 regional groundwater levels in the chalk aquifer reached their highest levels across the period of this study from 2015.

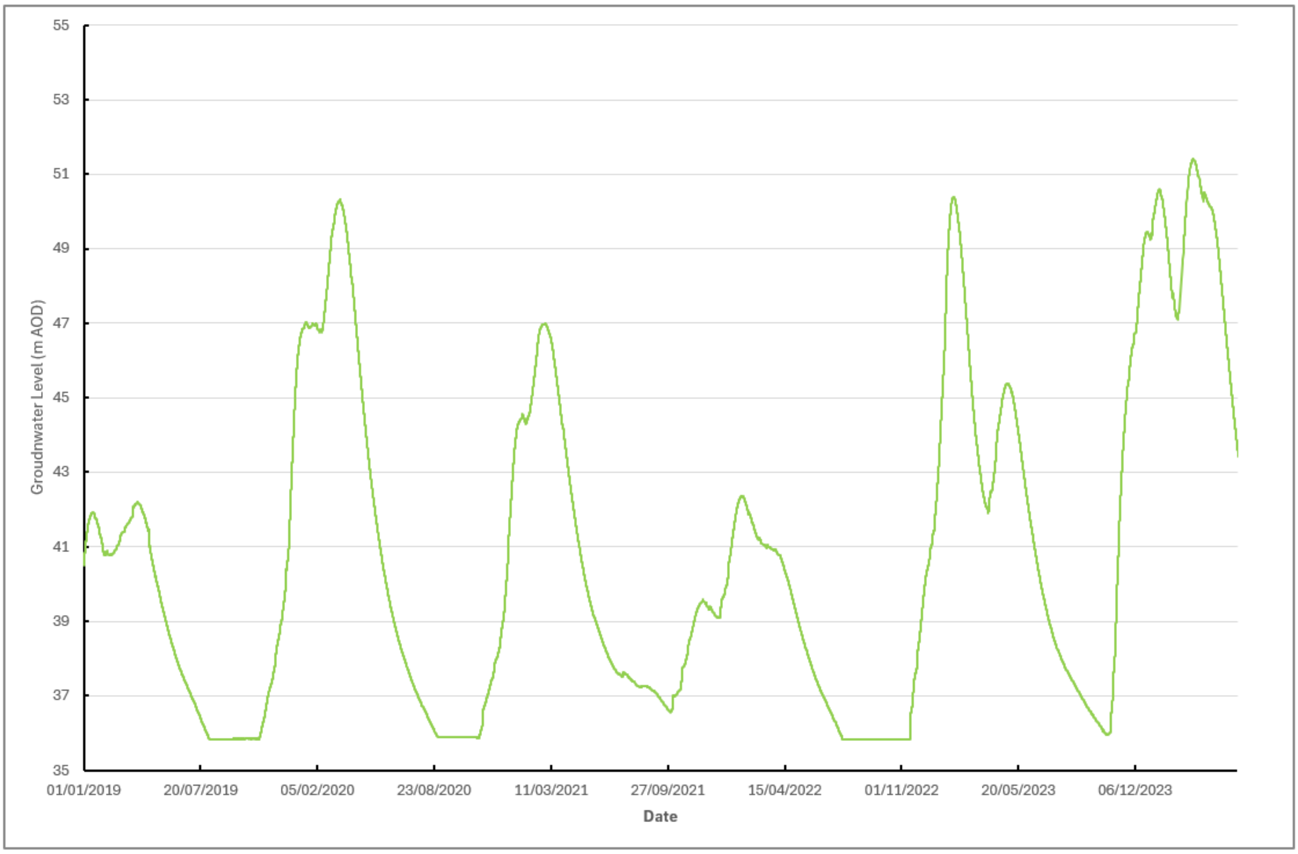


Figure 3-5: Groundwater levels recorded (in m AOD) from Rockwood Farm

3.4.3 River flow and level

As there are a lack of surface watercourses around Portsmouth and river flow is unlikely to have a significant impact on the groundwater levels. Therefore, river flow data has been excluded from the following assessment.

3.4.4 Sea level and tidal influence

It was outlined in the previous study that groundwater levels in Portsmouth are dominated by rainfall recharge and sea level/tidal influence.

The majority of low-lying ground in Portsmouth is situated in the eastern side of the study area. To confirm that this assessment is appropriate for these areas, the current mean sea level for Langstone Harbour has been used as a baseline. Furthermore, to align with this study with the various coastal strategies that have been produced, a projection date of 2115 has been selected as per the previous report.

Previously it was demonstrated that the current mean sea level of Langstone Harbour was 0.19m AOD (Halcrow, 2013). Coupled with the project sea level rise to 2115 (1.11m), this gives the 2115 mean sea level at Langston Harbour as 1.30m AOD.

A graph showing the tide level throughout the study area over the period between 2019 and 2023 is provided in Figure 3-6 below, indicating its usual range is between 3m AOD and -3m AOD.

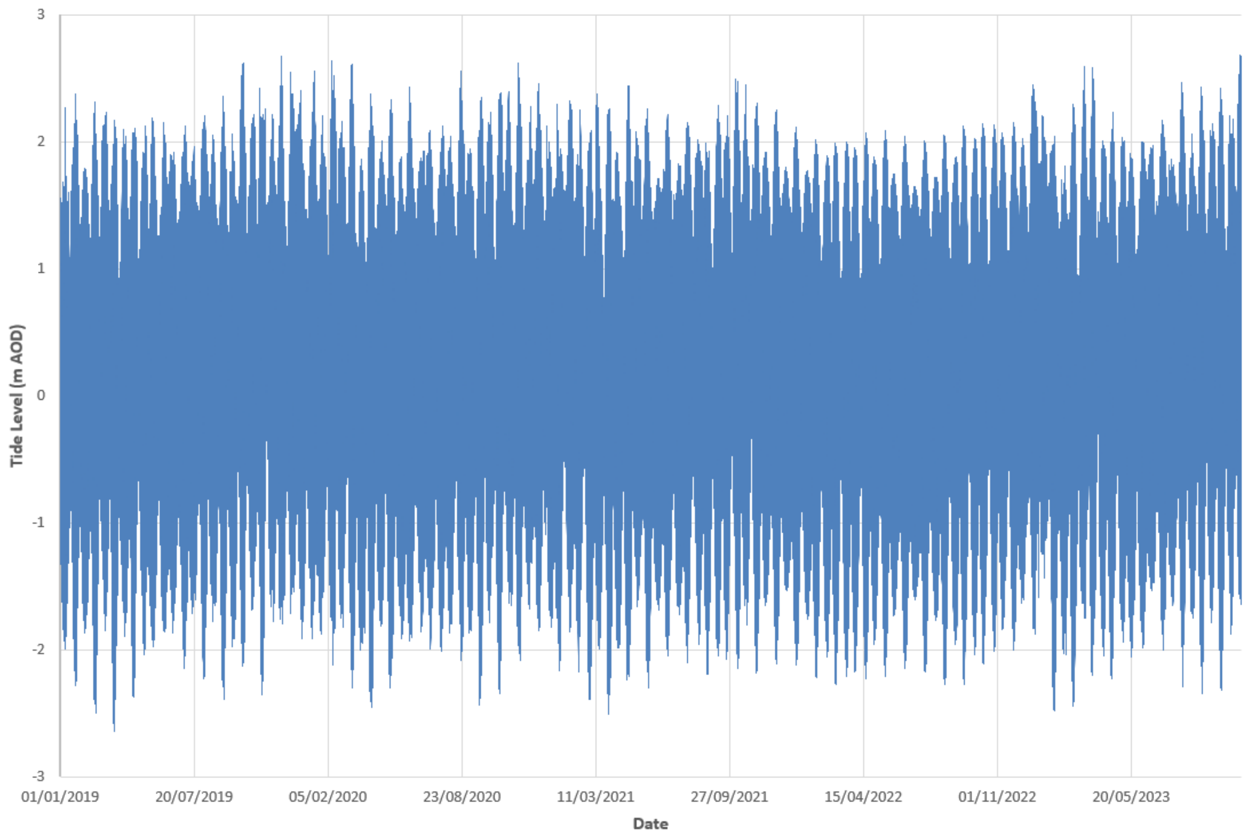


Figure 3-6: Tide level over a five-year period (2019 to October 2023)

A more detailed summary of groundwater and tidal influence is provided in the previous report (see Section 2.5.5 in Appendix A).

4 Overall Trends, Statistics and Response Types

4.1 Introduction

Using the same approach that was adopted for the previous study (contained within Appendix A) the groundwater level monitoring data has been categorised into three main response types dependent upon the dominant control on levels: tidal, rainfall (recharge) and drainage influenced. Two further categories of mixed and no clear dominant response have also been applied based on analysis of available groundwater level data against tide and rainfall data for the same periods.

4.2 Groundwater response type

4.2.1 Overall responses

In Portsmouth, monitoring demonstrates that groundwater levels generally lie within the superficial deposits and are typically within 5m of the ground surface. To the north of Portsmouth, groundwater levels may reflect the water table within the deeper Chalk aquifer. The superficial deposits typically have a moderate permeability combined with a relatively high intergranular storage between sediment grains. Consequently, superficial aquifers often have a limited seasonal groundwater level variation up to a few meters or less. Overall, the groundwater responses in Portsmouth appear to be more typical of superficial deposits rather than bedrock aquifer (which are characterised by relatively rapid and more variable changes in levels). This was demonstrated within the previous report and with the more recent data which has been reviewed.

The findings of the interpreted groundwater response are provided in Figure 4-1 below. Most monitoring locations within proximity to the coast are dominated by tidal influence, with some locations to the south of Portsmouth showing no clear tidal response. The locations that exhibit a tidal response show groundwater levels that fluctuate in response to the daily tide or spring/neap tides. There are several locations that show no distinct response to tides or groundwater. Most locations either side of Ports Creek (the tidal water body separating Portsea Island from the mainland) are tidal dominated, indicating that Ports Creek has a significant impact on groundwater levels in this area.

A few select boreholes located close to the coast show a mixed response, generally dominated by tides with spikes in levels during heavy rainfall.

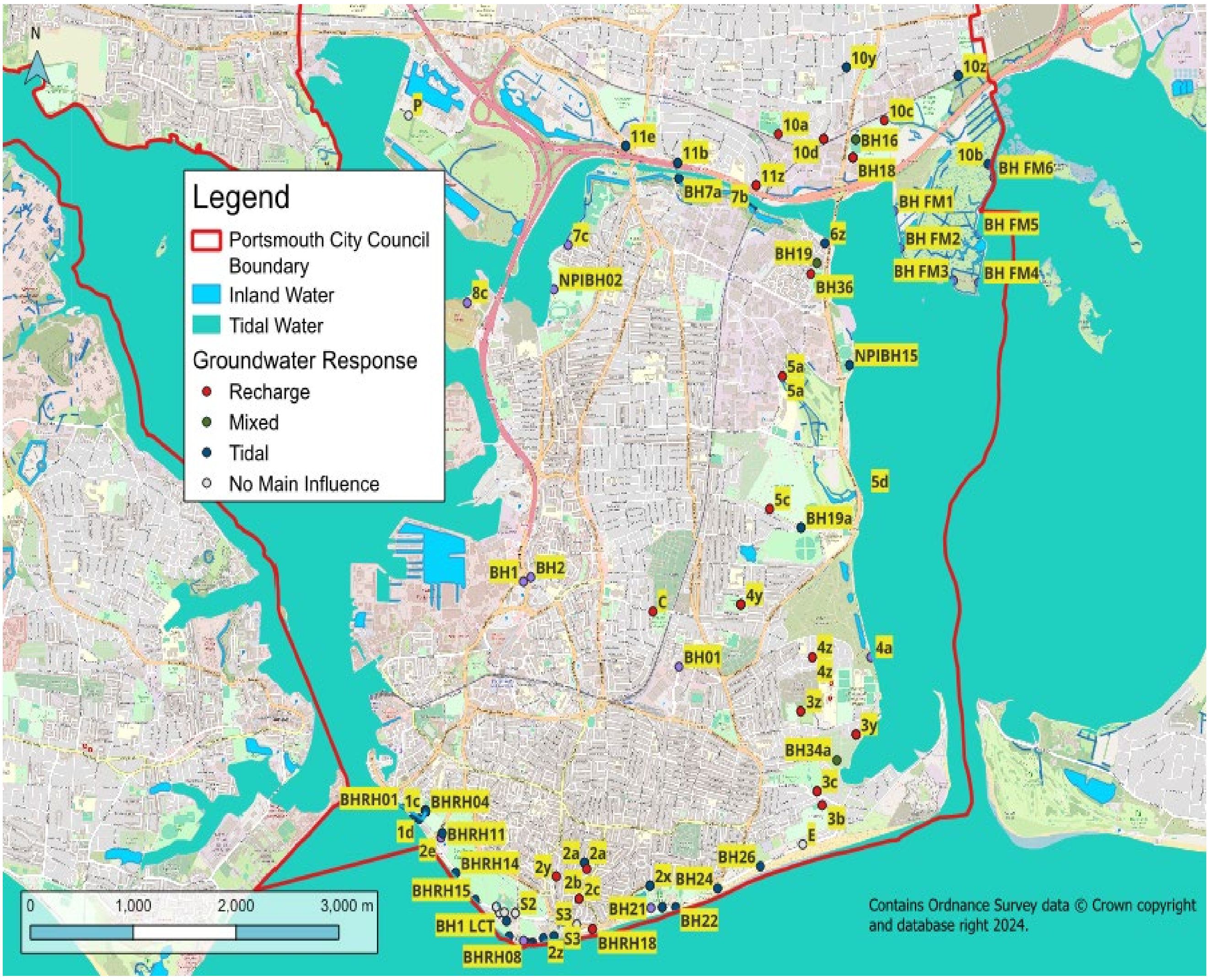


Figure 4-1 - Main groundwater response types

4.2.2 Trends with rainfall

Several borehole locations across Portsmouth have distinct groundwater responses dominated by rainfall recharge. Locations where rainfall is the principal influence on groundwater levels show a distinct spike in groundwater levels during rainfall events with a gradual recession.

An example of recharge is displayed from 10d (Station Road) in Figure 4-2 below.

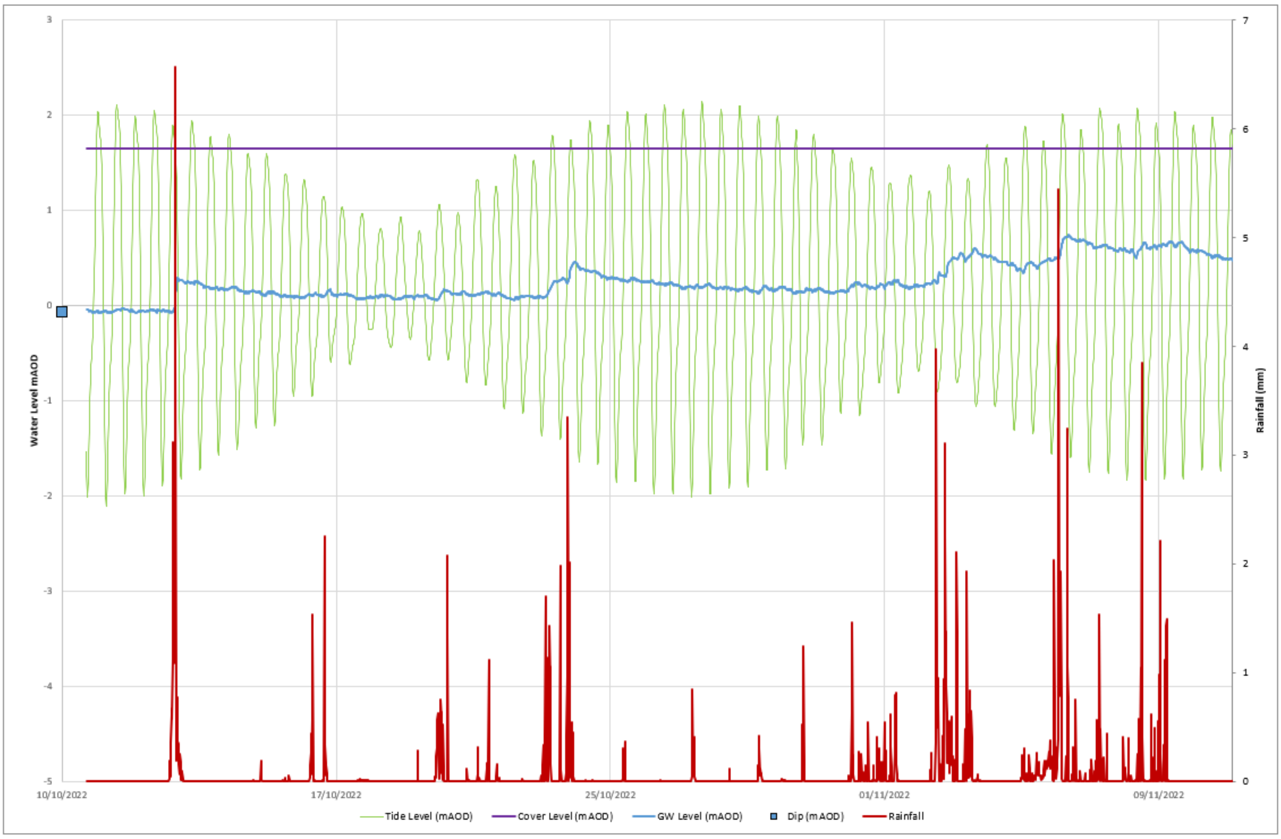


Figure 4-2 - Typical recharge response hydrograph (taken from 10d)

10d (and much of the north of Portsmouth) is underlain by granular superficial deposits and the Chalk aquifer. These relatively high permeability deposits can transmit rainfall recharge following precipitation events.

4.2.3 Trends with sea level

Groundwater that shows a tidal response have a good connectivity with sea levels and respond to the daily tide levels and/or neap and spring tides. An example of groundwater influenced by tidal responses is provided in Figure 4-3 at BHRH03 below.

BHRH03 (and much of the south of Portsmouth) is underlain by superficial deposits of Storm Beach Deposits (gravels) and Wittering Formation. The groundwater levels are located within a sandy gravel layer within the Storm Beach Deposits. The groundwater level response depicts a good indication of a coastal location in good connectivity with sea levels.

This location does not seem to be influenced by rainfall, although some wells have distinct increases during rainfall. This location was also monitored for salinity and shows clear saline water levels throughout the monitoring period.

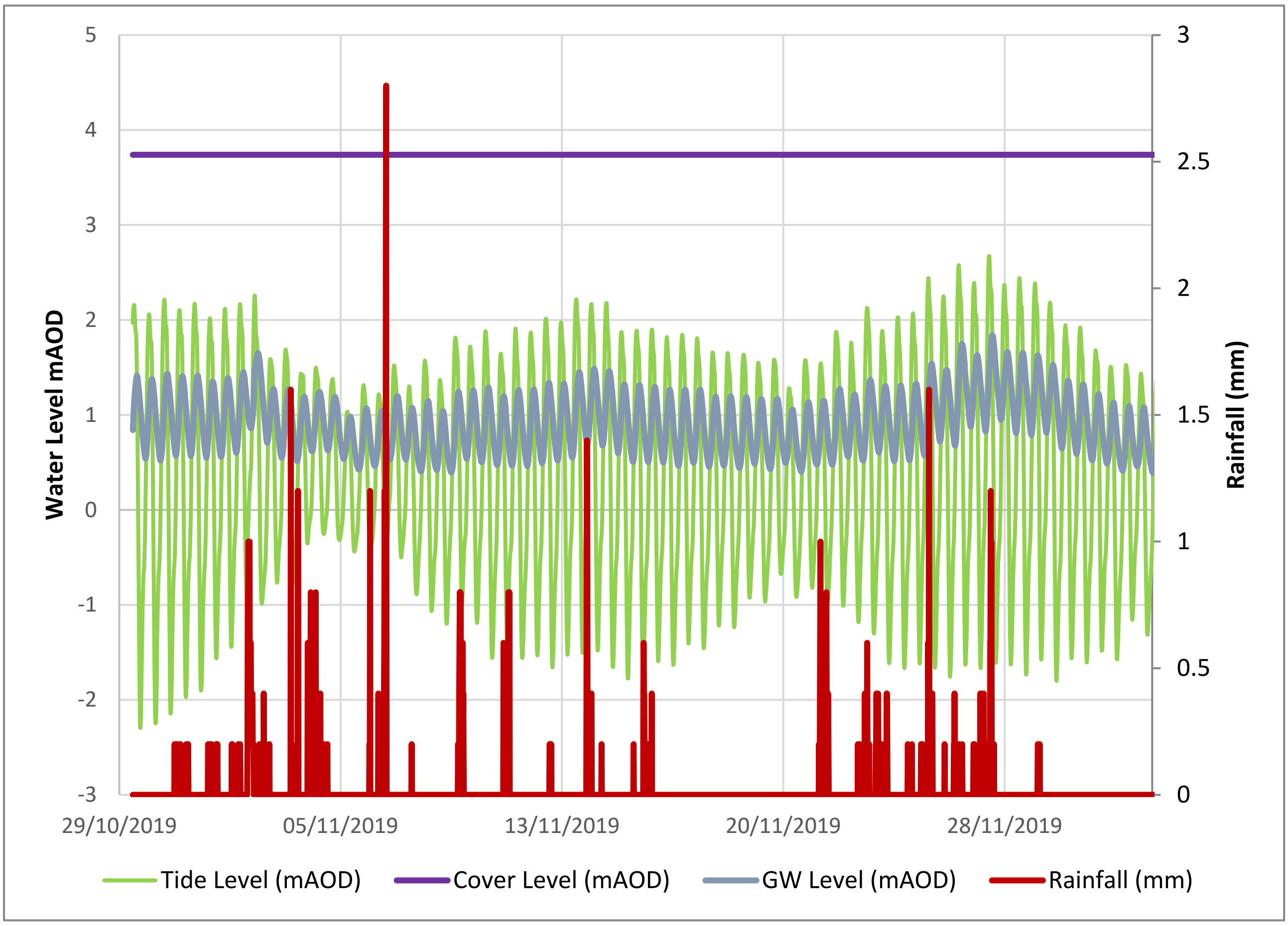


Figure 4-3 - Typical tidal dominated response (taken from BHRH03)

4.2.4 Trends with drainage

There are various monitoring locations throughout Portsmouth that show a groundwater level trend indicative of drainage influence. The drainage influence can be in the form of a subsurface drainage ditch, or structure (including culverts and leaky sewers that gain groundwater). Where groundwater intersects these drains, they will act as a local groundwater sink and control the maximum groundwater level nearby as groundwater flows into the drain and is diverted.

It was previous established that there are several deep (>10m bgl) sewers present throughout Portsea Island that were constructed at the end of the 19th century. Many of these sewers may be in poor condition and have potential to act as a groundwater drain if they are situated below the groundwater table. Sealing of such sewers is likely to cause a rise in the groundwater table and it should be noted that sewer pipes and below ground services are often laid on sand or shingle that can preferentially act as a pathway for groundwater flow.

An example of a drainage response is groundwater levels shown at 3y Milton Allotments located within Portsmouth Sand Member and Whitecliff Sand Member. Groundwater levels at these locations show no response to tidal levels, with increases during rainfall events.

The duration of the monitoring period at borehole 3y is three weeks (shown in Figure 4-4) is three weeks and groundwater levels quickly reduce back to near original levels prior to the rainfall.

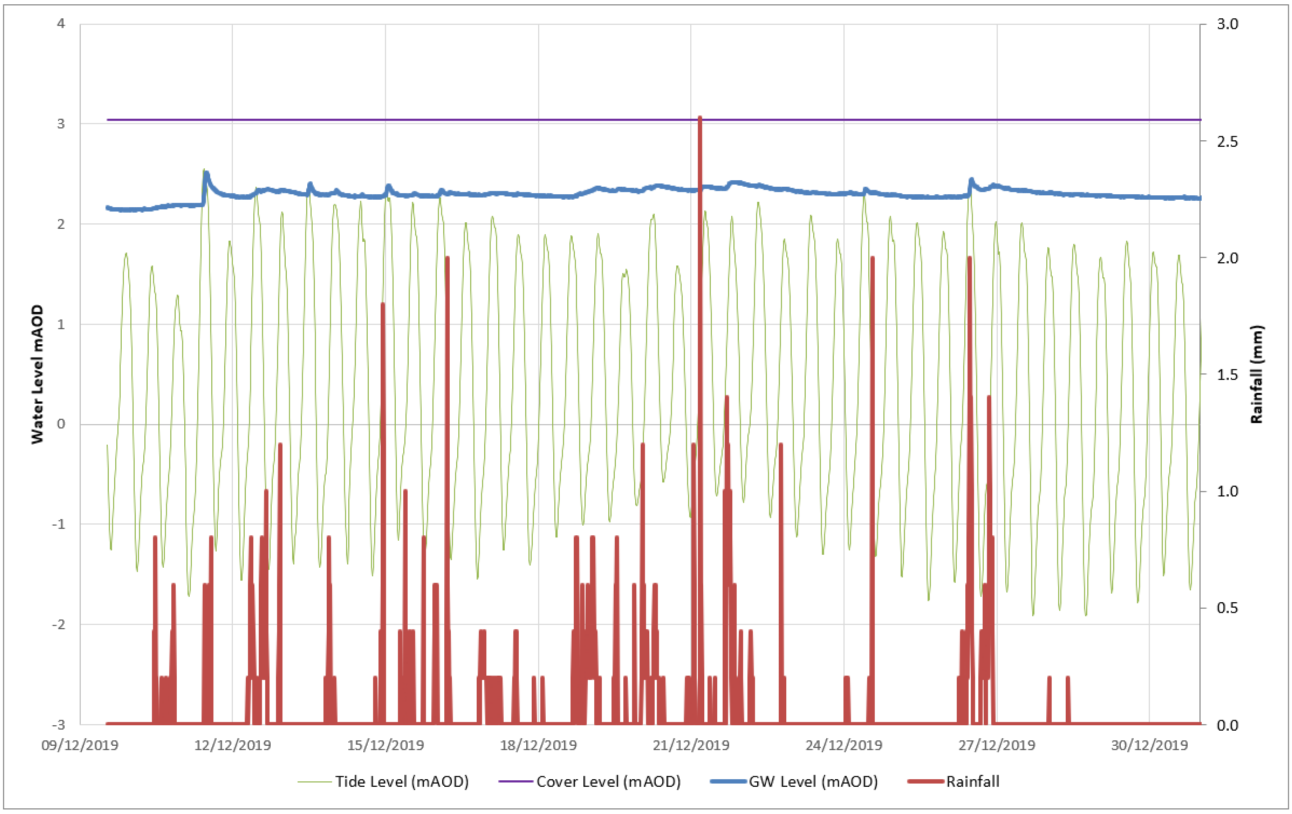


Figure 4-4 - Influence of drainage on groundwater levels (taken from 3y)

The full hydrograph over the monitoring period with groundwater levels along with environmental data such as tide data and rainfall data are provided in Appendix E.

4.3 Salinity Analysis

4.3.1 Salinity within Portsmouth

Salinity levels have been monitored at various boreholes around Portsmouth using a data logger that simultaneously measure groundwater levels and conductivity (which is directly proportional to the salinity of the water). Salinity was measured as conductivity, with units of micro-Siemens (µS/cm).

Fresh water is defined as having between 0 - 1,000 total dissolved solids (TDS) in mg/l. Brackish water is defined as having between 1,000 and 10,000mg/l of TDS[3]. Converting brackish water to appropriate units (in µS/cm) indicates that concentrations between 1,560µS/cm and 15,600µS/cm can be considered to be brackish water. Anything above these levels is classified as saline.

3 Jian, J & Post, V (2019). Coastal hydrogeology, 1st Edition. Cambridge University Press.

Salinity levels were found to range between 0 µS/cm (freshwater) to approximately 52,843 µS/cm (sea water). Figure 4-5 shows locations where salinity monitoring has been undertaken and which locations have been classified as saline. 'Yes' indicates a location where monitoring has shown the groundwater to be saline during the monitoring period, while 'No' indicates that the water has remained within the region of freshwater. The salinity concentrations and trends at each monitored location is summarised in Appendix F.

Naturally inland groundwater originating from rainfall shows limited salinity corresponding to natural dissolution of minerals in sub-surface geology. Seawater is naturally highly saline due to its ionic content. Salinity in groundwater can be indicative of the influence of seawater.

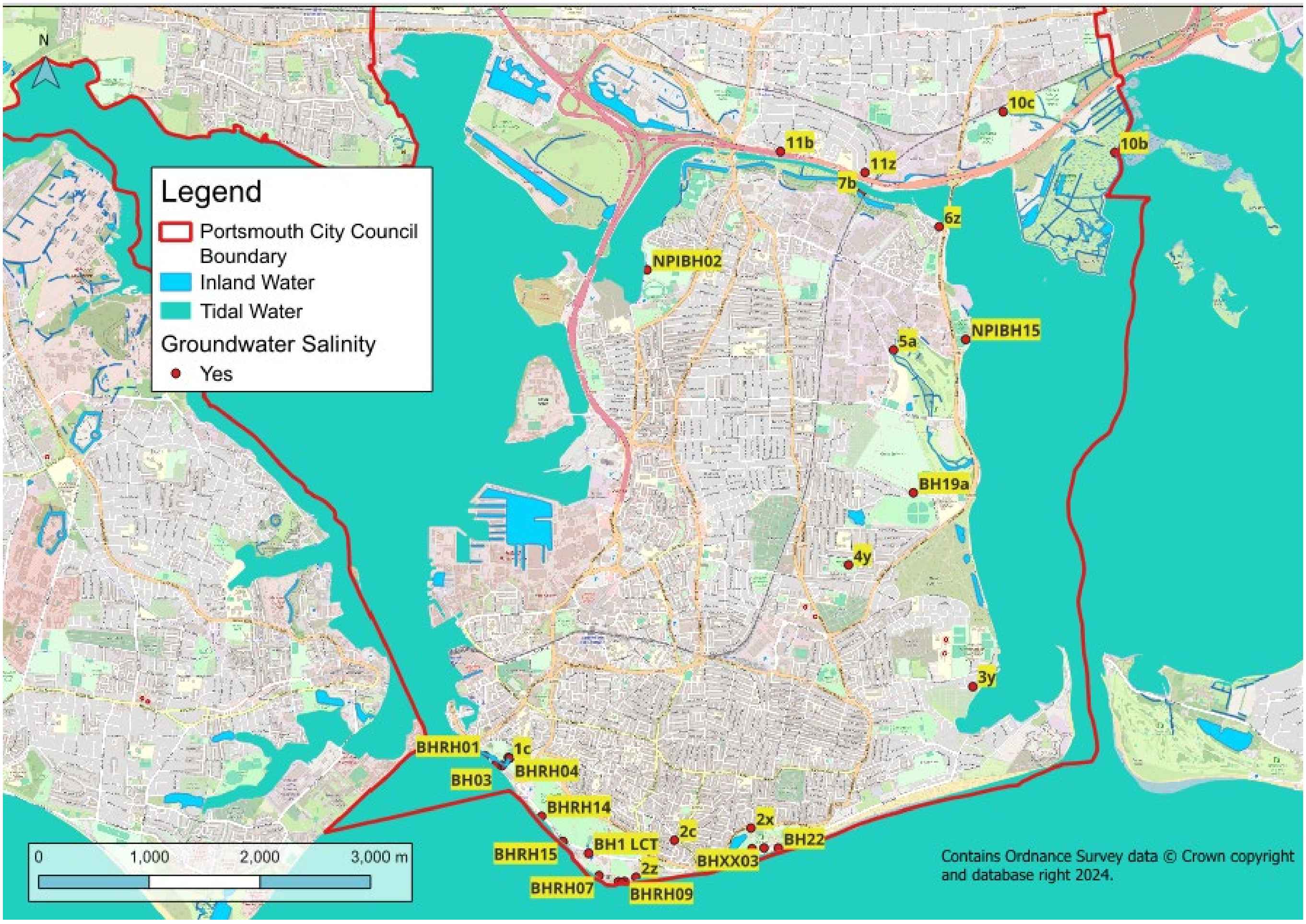


Figure 4-5 - Locations with saline water

Borehole 4y (Tamworth Park) is located inland and had relatively high salinity concentrations, peaking at 17,917µS/cm. This would not be expected from a borehole located this inland (the borehole is located 1.15km inland).

Following climate change there is a potential for sea level rise around Portsmouth. This may result in an inland migration of the groundwater saline interface, particularly in areas where groundwater rises are limited by drainage. There may be impacts resulting from increasing salinity of groundwater, including:

- Impacts on vegetation which may not be saline tolerant. This may particularly impact upon deeper rooted trees; and
- Impacts on invertebrate ecology where there will be a change to more salt tolerant species (where surface waters become more saline).

Increased erosion caused by rising sea levels can also lead to gradual changes in the morphology of the coastline and erosion that may also lead to inland migration of the groundwater saline interface.

5 Groundwater Level Mapping

5.1 Groundwater mapping

The groundwater level records for each monitoring location have been assessed in relation to the maximum groundwater level (by either dip or transducer data), minimum depth to groundwater using LiDAR and comparisons with the 2019 interpolation mapping.

The groundwater level data have been used to produce various groundwater level maps across Portsmouth using interpolation. The interpolation carried out on the point borehole monitoring data was done using the natural neighbour methodology within ArcGIS. This analysis produces a raster grid (1m x 1m) and calculates level values (in m AOD) for each cell, based on the values of the nearest observation values, and the distance of those observations from the cell to be calculated. This is a commonly used method of interpolation for natural features such as water levels and topography.

For limitations of the interpolation mapping along with further information, please see the previous report in Appendix A.

The maximum groundwater level interpolated mapping was used using the highest groundwater levels based off the March 2024 dip round or maximum readings from the loggers in m AOD. Groundwater level maps are provided below, including maximum groundwater levels (Figure 5-1), maximum groundwater levels from loggers only (Figure 5-2) and the relatively difference between the previous and current study groundwater levels (Figure 5-3).

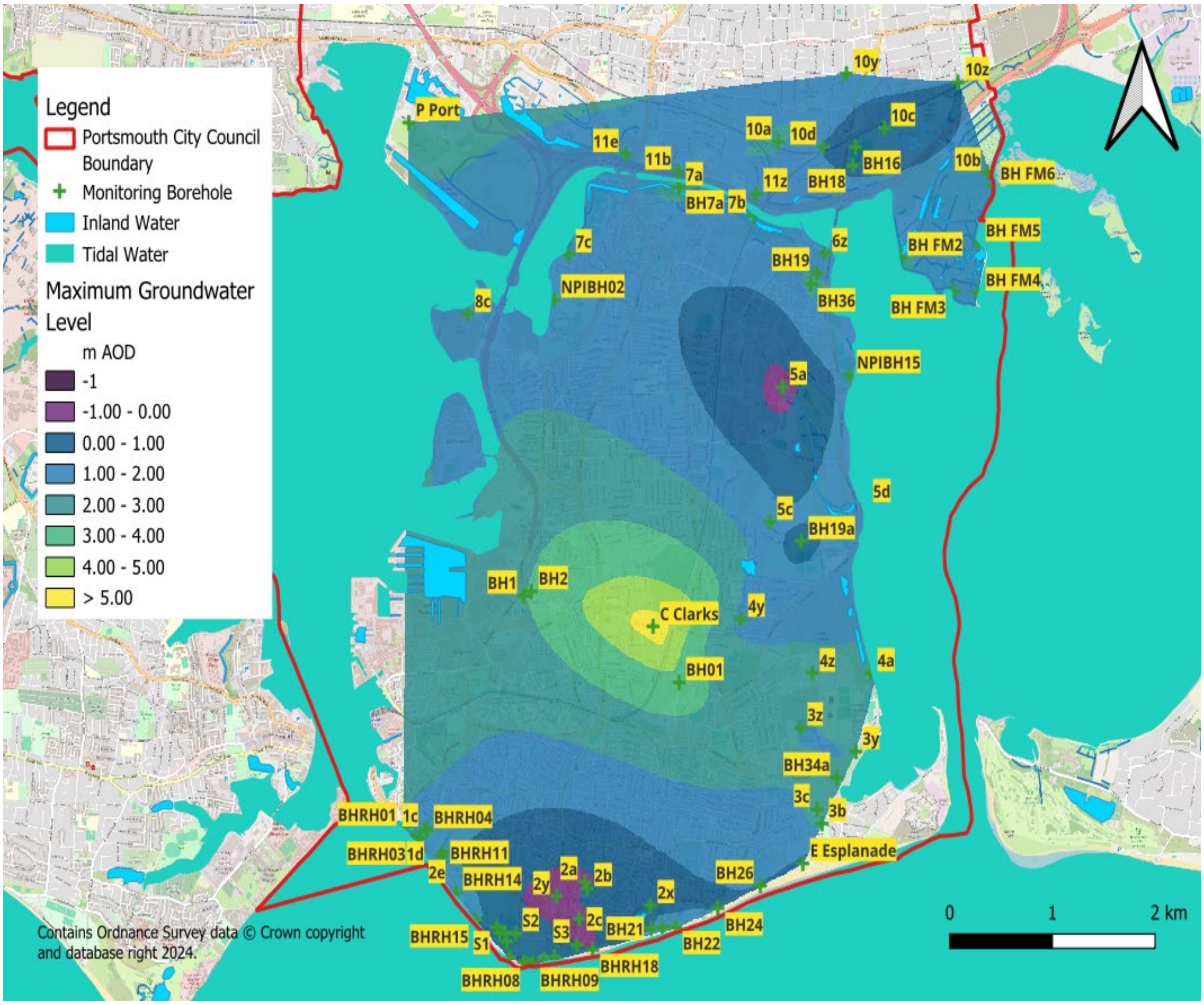


Figure 5-1 Maximum groundwater level (m AOD)

The maximum groundwater level follows a similar trend to topography. The maximum level (in m AOD) is located in central Portsmouth, and areas with the minimum levels generally in coastal areas and the north-east of Portsmouth.

Figure 5-2 depicts the maximum groundwater levels from transducer data only. The figure is similar to the maximum groundwater levels. The major differences relate to Farlington Marshes in the north-east, which is limited to a single manual dip round in March 2024, and some minor changes in groundwater levels near the D-Day Museum.

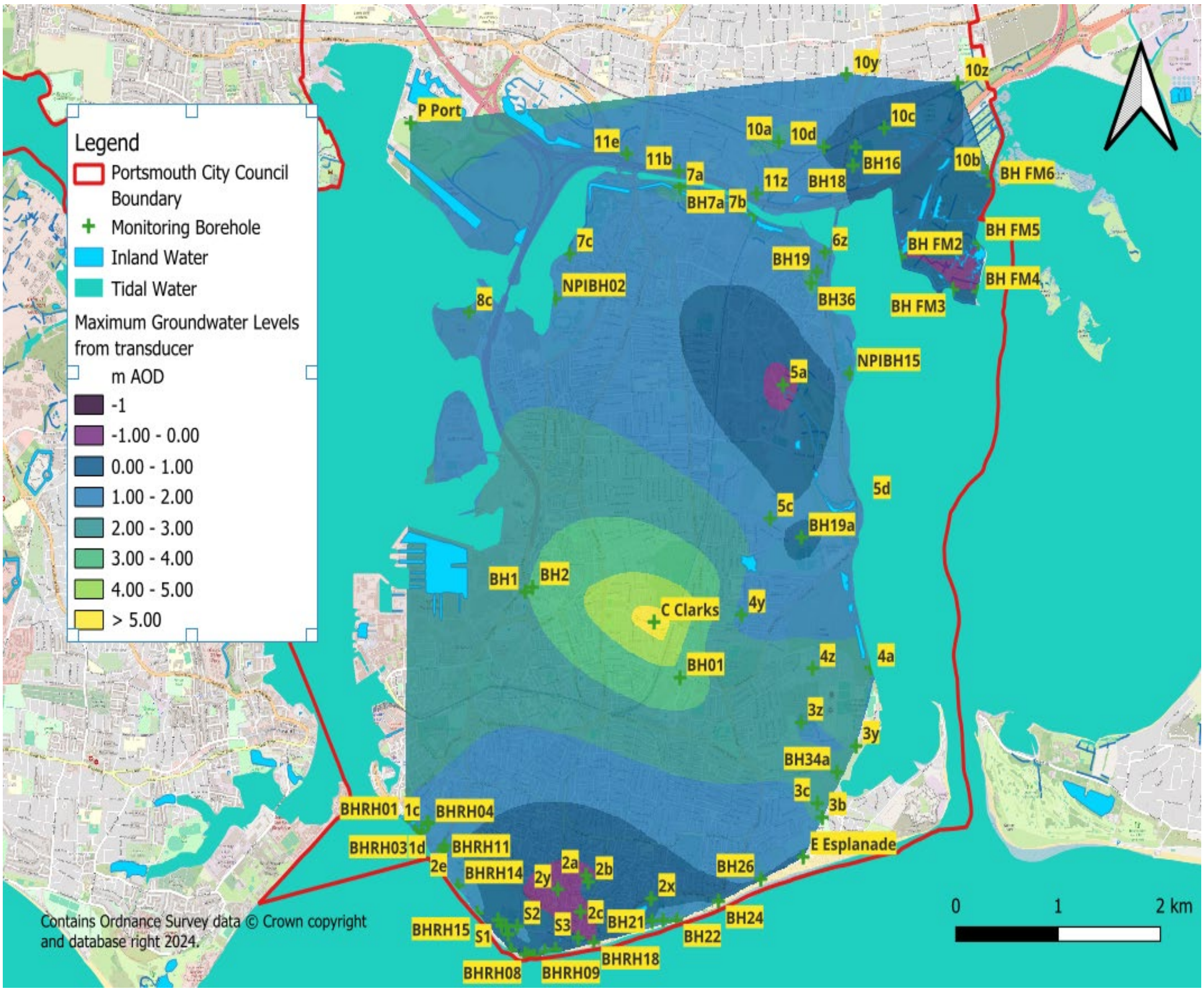


Figure 5-2: Maximum groundwater level (m AOD) from transducers

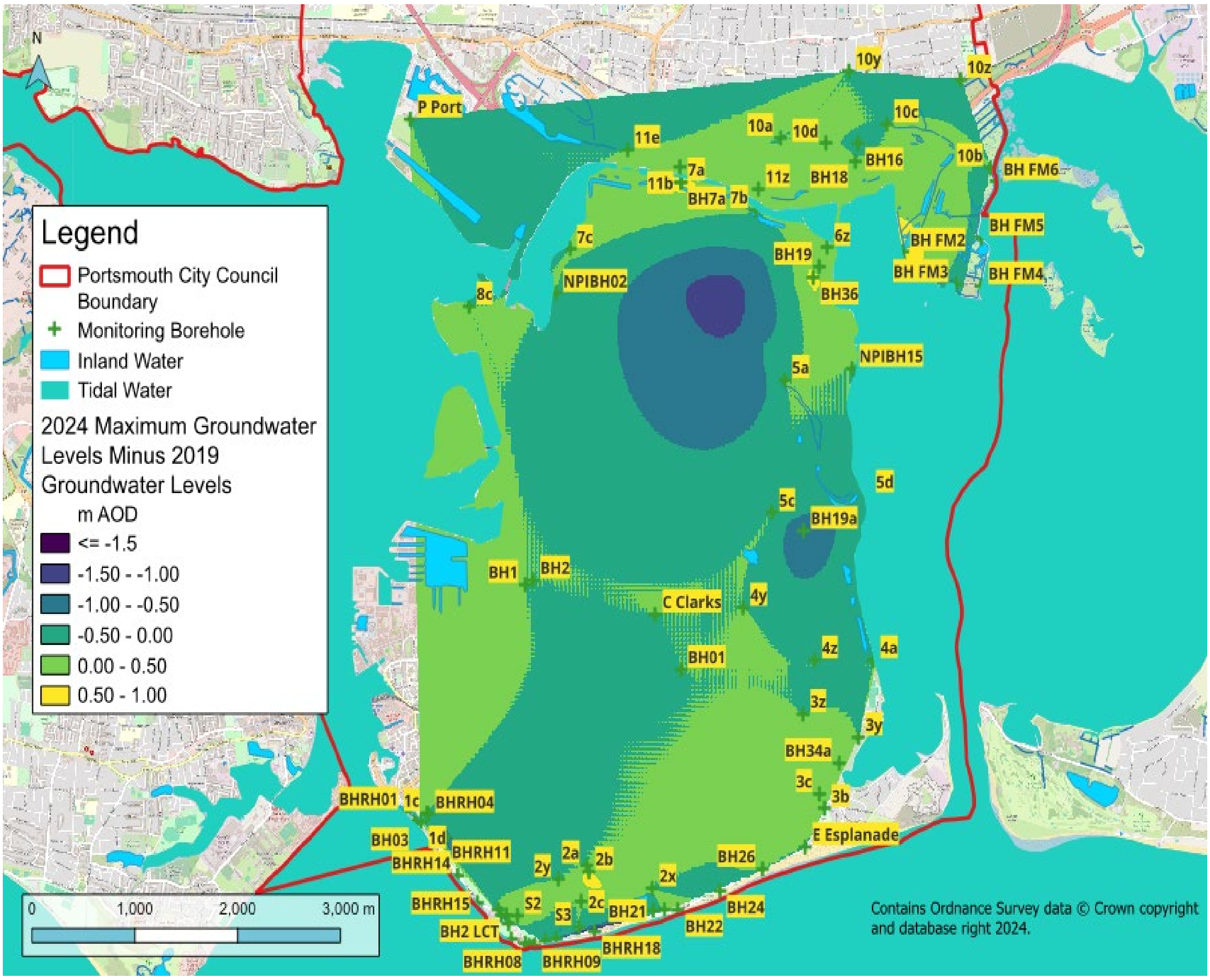


Figure 5-3: 2024 groundwater levels minus the 2019 groundwater levels

Figure 5-3 shows the relative difference between the 2024 groundwater levels (present) minus the 2019 groundwater levels (previous report) to depict the areas where there are changes. The negative values indicate that the groundwater levels have dropped (i.e. lower-lying water table). The interpolation has added new monitoring locations and groundwater levels may not be reflected from differing strata.

The figure indicates that most groundwater levels throughout Portsmouth are within 0.5m of their respective locations from the 2015 - 2019 monitoring period. These ranges are to be expected from monitoring periods allowing for seasonal fluctuations in water table elevations.

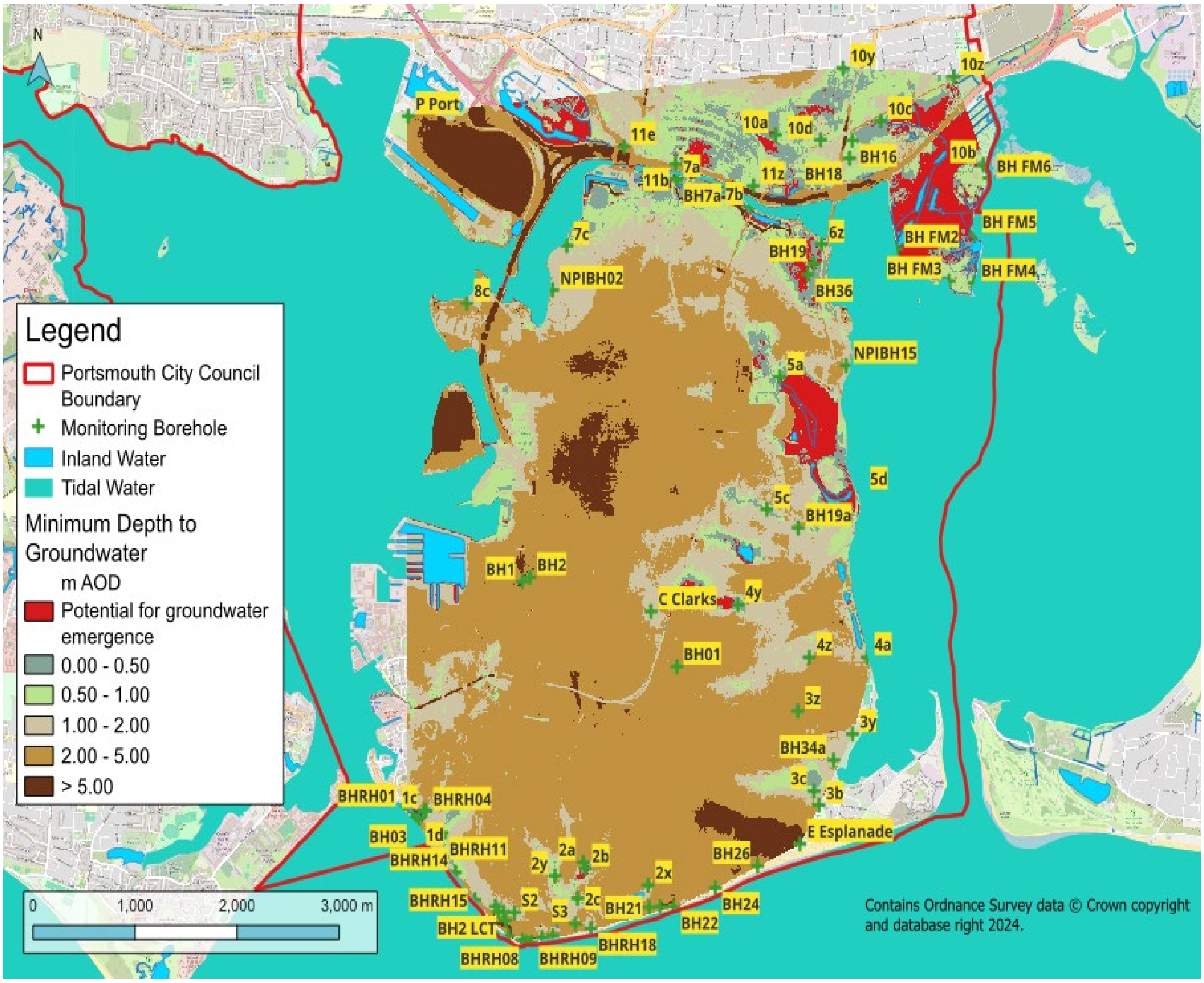


Figure 5-4: Minimum depth to water

The maximum groundwater level interpolation mapping has also been used to produce a minimum depth to groundwater map (Figure 5-4). This was created by subtracting the maximum groundwater levels from the ground elevations at that monitoring location (using the EA's 1m LIDAR DTM). Positive values indicate the likely minimum depth to groundwater (in meters) based on the interpolation of observed maximum groundwater levels across Portsmouth. Negative values indicate that the grid cell is estimated to have groundwater above the ground surface and may therefore be more susceptible to groundwater emergence. The mapped areas are generally situated within low lying areas and that a greater density of borehole coverage in these areas may lead to further refinement.

Based upon the above analysis, the main areas for potential groundwater emergence (highlighted in red) are:

- Area surrounding the Lakeside development (north-west);
- Anchorage Park (north-east);
- Farlington Marshes (north-east);
- Great Salterns (east);
- Tamworth Park; and

- Wimbledon Park.

There does not appear to be any major changes or differences in areas with potential groundwater emergence from the previous study to present-day. The main areas susceptible to potential groundwater emergence are generally low-lying areas. Newly highlighted areas of potential concern relate to Anchorage Park, Tamworth Park and Wimbledon Park. It should also be noted that for the earlier study there was no monitoring data available for Farlington Marshes.

5.2 Interpretation of groundwater levels throughout Portsmouth

The areas that are interpreted to be most susceptible to groundwater flooding are low-lying areas as described below.

5.2.1 Northern Portsmouth

5.2.1.1 Great Salterns

In the east of Portsmouth, this includes the area surrounding Admiral Lord Nelson School and Great Salterns Golf Course as well as Great Salterns Lake just south.

Borehole 5a located north of Great Salterns Golf Course is located at approximately 0.33m AOD. Groundwater monitoring data has indicated that the groundwater level at this location generally fluctuates within one meter of the surface, with the maximum groundwater level being 0.09m AOD. However, this area is currently managed through drainage network of the golf course. Therefore, the absence of observed groundwater flooding is likely to be because of the active drainage system, including pumping, which is currently controlling groundwater levels when they reach the level of the drainage network.

To the south of Great Salterns surrounding 5c (Stanley Avenue), the area shown in Figure 5-5 is susceptible to groundwater flooding. The area is low-lying and comprises residential garages and gardens. Evidence provided by Portsmouth City Council indicates that groundwater flooding occurs has historically occurred in the area. The ground conditions comprise gravelly/clayey Made Ground overlying a clay cap for contaminated land, thus the groundwater is likely perched water.

5.2.1.2 Anchorage Park

BH19 and BH36 are located just north of Anchorage Park in housing developments. Data was analysed from these boreholes between the period of October 2022 to December 2022 (receiving 322mm of rainfall during this period). At BH19, according to the logger groundwater may have intercepted the surface on three separate incidents coinciding with periods of prolonged heavy rainfall (maximum height recorded was 1.79m AOD, compared to ground level of 1.71m AOD). The maximum groundwater level recorded at BH36 was 2.3m AOD, 11cm off ground level.

Both these boreholes are located on fairly low-lying ground and the groundwater levels recorded during this wet period may reflect the dataloggers being flooded and submerged, or surface water ingress into the borehole itself.

The lakeside development has been previously identified as an area with potential for groundwater emergence. Farlington Marshes to the north-east is also potentially susceptible to groundwater emergence. Other minor areas in northern Portsmouth with sporadic potential for groundwater emergence relate to low-lying areas situated around Highbury Campus (City of Portsmouth College) (borehole 11b), the Railway Triangle Industrial Estate (borehole 10a), and the area east of Drayton Park (north of borehole 10d).

The aforementioned areas are provided in Figure 5-5 below.

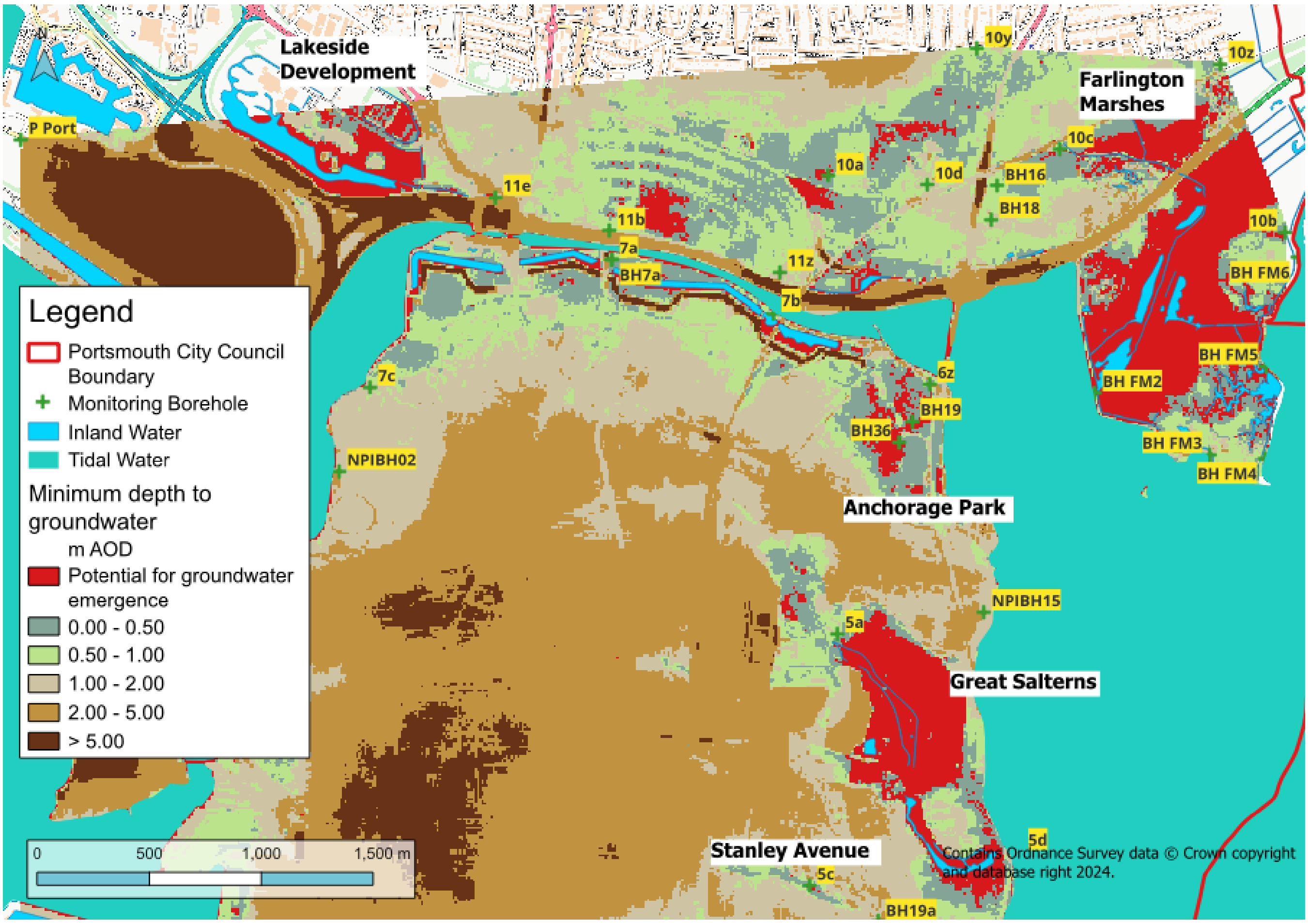


Figure 5-5: Areas in northern Portsmouth with potential for groundwater emergence

5.2.2 South of Portsmouth

5.2.2.1 Wimbledon Park

In the south of Portsmouth, an area of low-lying land is present around Wimbledon Park and the surrounding residential properties. Available borehole data surrounding the area (namely 2a and 2b) indicate that the ground surface is between 0.1m AOD and 1.22m AOD.

The nearest borehole is 2b, which could not be verified to m AOD due to no manual dip being available. However, data from the previous study indicates that the groundwater levels were generally within one meter of the ground surface. The inferred horizon using the borehole log would indicate that the groundwater is present within sandy gravelly silty Made Ground deposits. Borehole 2a (located at 1.22m AOD) has a generally constant groundwater level at -0.36m AOD, which did not show strong signals to neither recharge nor tides. The groundwater level is consistently around 0.9m from the ground surface from the recorded data during September 2022. This would place the water table within a gravelly sand (River Terrace Deposits).

5.2.2.2 Tamworth Park

A smaller area of land susceptible to groundwater flooding is Tamworth Park and the surrounding properties to the west. Borehole 4y is located within the east of the park. 4y is located at an elevation of 2.09m AOD and groundwater levels generally fluctuate between 0.3m AOD to 1.43m AOD (i.e. within 0.65m of the ground level). The groundwater levels are at their highest during winter months and show a rainfall dominated response.

Historically Tamworth Park was a marshland and according to the Portsmouth City Council website, the area becomes 'very wet in winter' and a quarter of the area is set aside to facilitate a wet meadow area and to develop and attract local wildlife[4]. The former marshland area may also explain the high salinity measurements recorded in this area, despite its distance from the tidal areas (maximum concentration recorded was 17,917μS/cm.

Both the areas surrounding Wimbledon Park and Tamworth Park are depicted in Figure 5-6 below.

4 Tamworth Field, Portsmouth City Council, 2024.

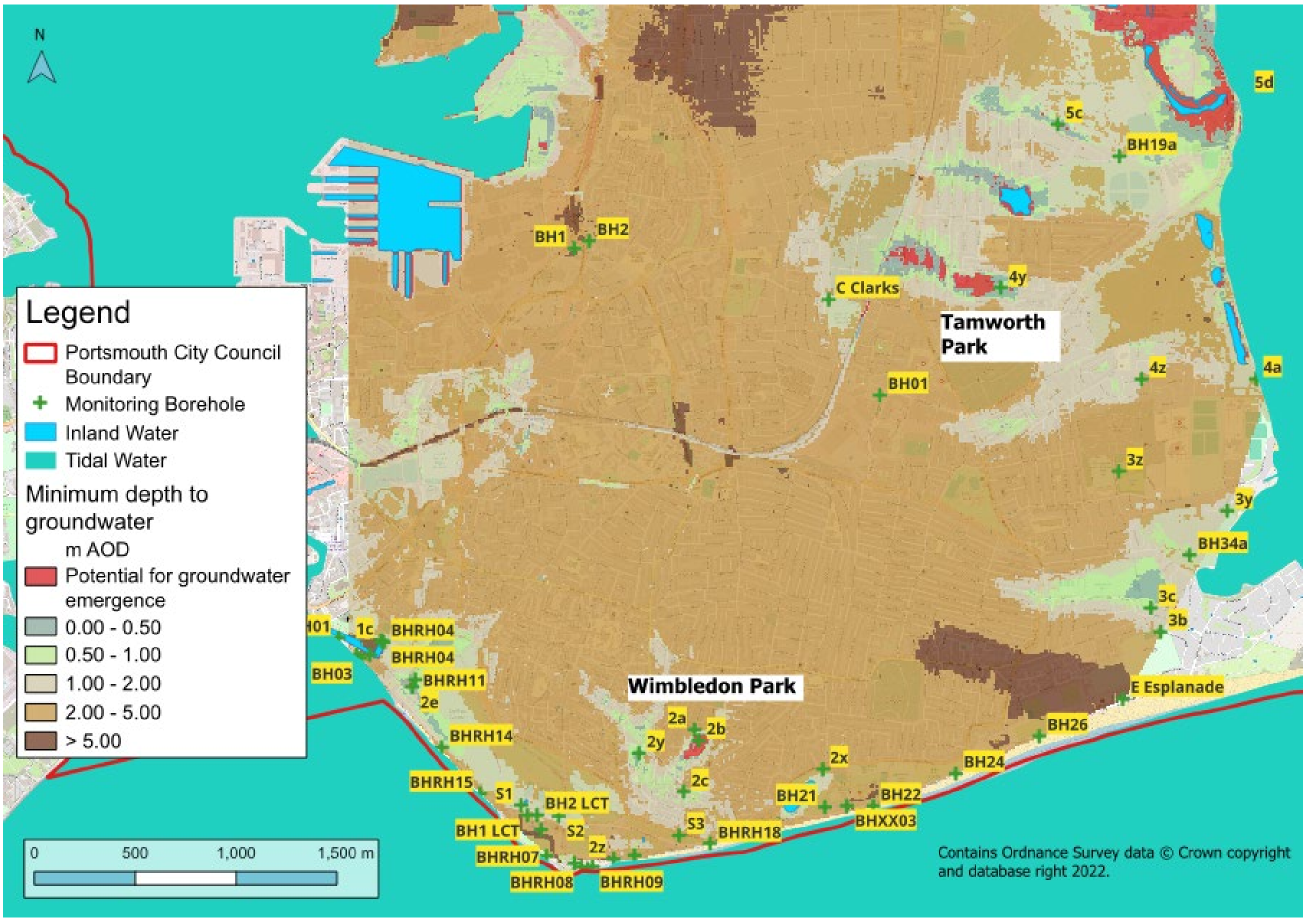


Figure 5-6: Areas in central and southern Portsmouth with potential for groundwater emergence.

6 Groundwater Flood Risk Assessment

6.1 Introduction to groundwater flood risk assessment

Groundwater flooding occurs due to the water table rise within the ground to levels significantly higher than normal and often above the surrounding ground surface. The previous JBA report in Appendix A for a more robust synthesis of the groundwater flood risk assessment.

6.2 Current groundwater flooding situation

Currently (as was the case at the time of issuing of the previous report), groundwater flooding is not widely reported as a problem in Portsmouth. This was previously thought be due to the existing drainage systems in place throughout Portsmouth, which these help to alleviate against rising groundwater levels.

At present, the drainage systems appear to be keeping groundwater levels below the ground surface most of the time. However, as sea levels are predicted to rise, drainage systems will have to rely more on pumped drainage to keep groundwater levels from reaching the ground surface. Future pumped drainage networks will need to make allowance for the increased risk of ingress of groundwater.

Climate change poses a significant risk to the sub-region. The predicted sea level rise over the next century will reduce the level of protection currently provided by most of the sub-regions flood deference and will result in the inundation of larger areas by extreme tidal floods. Additionally, increased storm severity is predicted to result in an increase in river flood flows and increase the risk and likelihood of fluvial flooding. However, in the absence of main rivers throughout Portsmouth, the principal mode of flooding will be coastal.

Groundwater flooding is generally the result of high rainfall and infiltration that consequently can generate high groundwater levels. The critical duration of high rainfall that results in groundwater flooding is generally of the order of a few months (compared to hours/days with pluvial/fluvial flooding). Despite this, the critical duration of high rainfall that is likely to result in exceptional groundwater levels is a function of the size and response characteristics of the aquifer concerned. In the absence of widespread groundwater flooding in Portsmouth, estimating a critical duration/amount of rainfall would be very difficult and highly uncertain. However, the limited extent and thickness of the superficial deposits means that their response to rainfall is likely to be fairly rapid. The high intergranular storage within the permeable superficial deposits combined with the reasonable permeability means that very high levels of recharge will be required to raise the groundwater level significantly where regular groundwater flooding would be anticipated.

6.3 Impact of climate change

The impact of climate change was assessed in the PGWFRMS for the year 2115. The report was updated in 2019. Full details of the report can be found in the previous assessment in Appendix A.

The mean sea level for Langstone Harbour was used as a best representative for Portsmouth (due to most of the low-lying areas being located on the eastern side). The current mean sea level of Langstone Harbour (as of 2013) was 0.19m AOD with an expected increase of 1.11m AOD by 2115, resulting in a mean sea level of 1.3m AOD in 2115.

The extent of land mass that is under this value is depicted in Figure 6-1 and indicates areas that would be underwater following circumventing of any coastal flood defences. The blue areas show inundation due to current mean sea level in Langstone Harbour (0.19m AOD), and the brown areas show the predicted increase to 1.3m AOD in 2115.

Other datasets are available to assess the impact of sea level rise around Portsmouth. NASA Sea Level Projection Tool[5] has scenarios relating to sea level rise at Portsmouth, ranging from SSP1-1.9: Very Low (0.41m rise) to SSP5-8.5 Very High (0.8m rise).

For continuity purposes, JBA has continued to keep the same sea level projection rise outlined in the previous report.

5 Sea Level Projection Tool: IPCC 6th Assessment Report Sea Level Projections NASA, 2024.

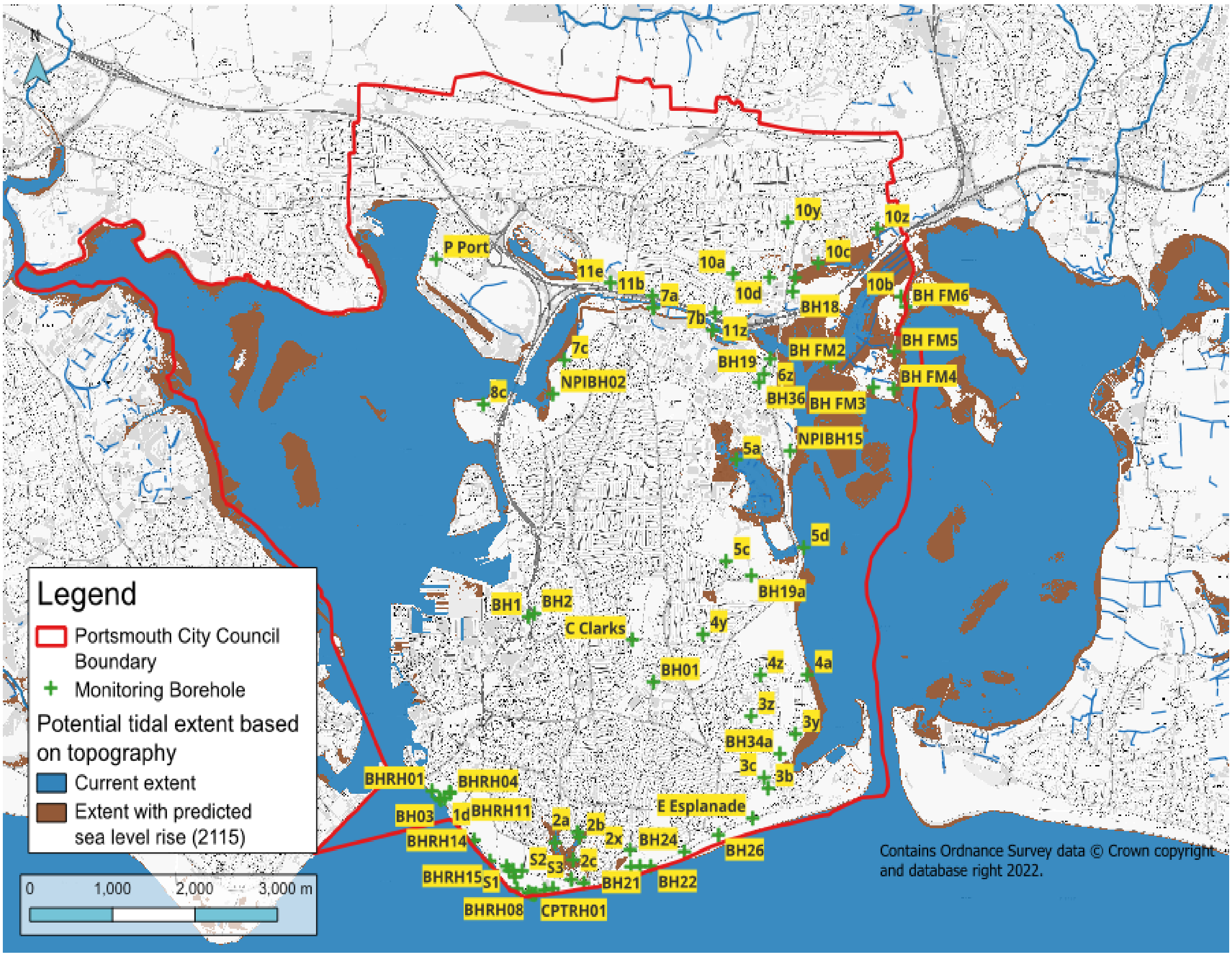


Figure 6-1: Inundation extent due to mean sea level increase 1.3m AOD by 2115.

The estimated maximum groundwater levels across Portsmouth following sea level rise in 2115 is depicted is Figure 6-2. The estimated values are based on a flat increase of 1.11m (projected rise by 2115) to modelled current maximum groundwater levels. The model assumes a potential worst-case scenario, although it is unlikely in reality that groundwater levels would equally increase throughout Portsmouth. The largest increases would be expected to result near the coast within permeable superficial deposits.

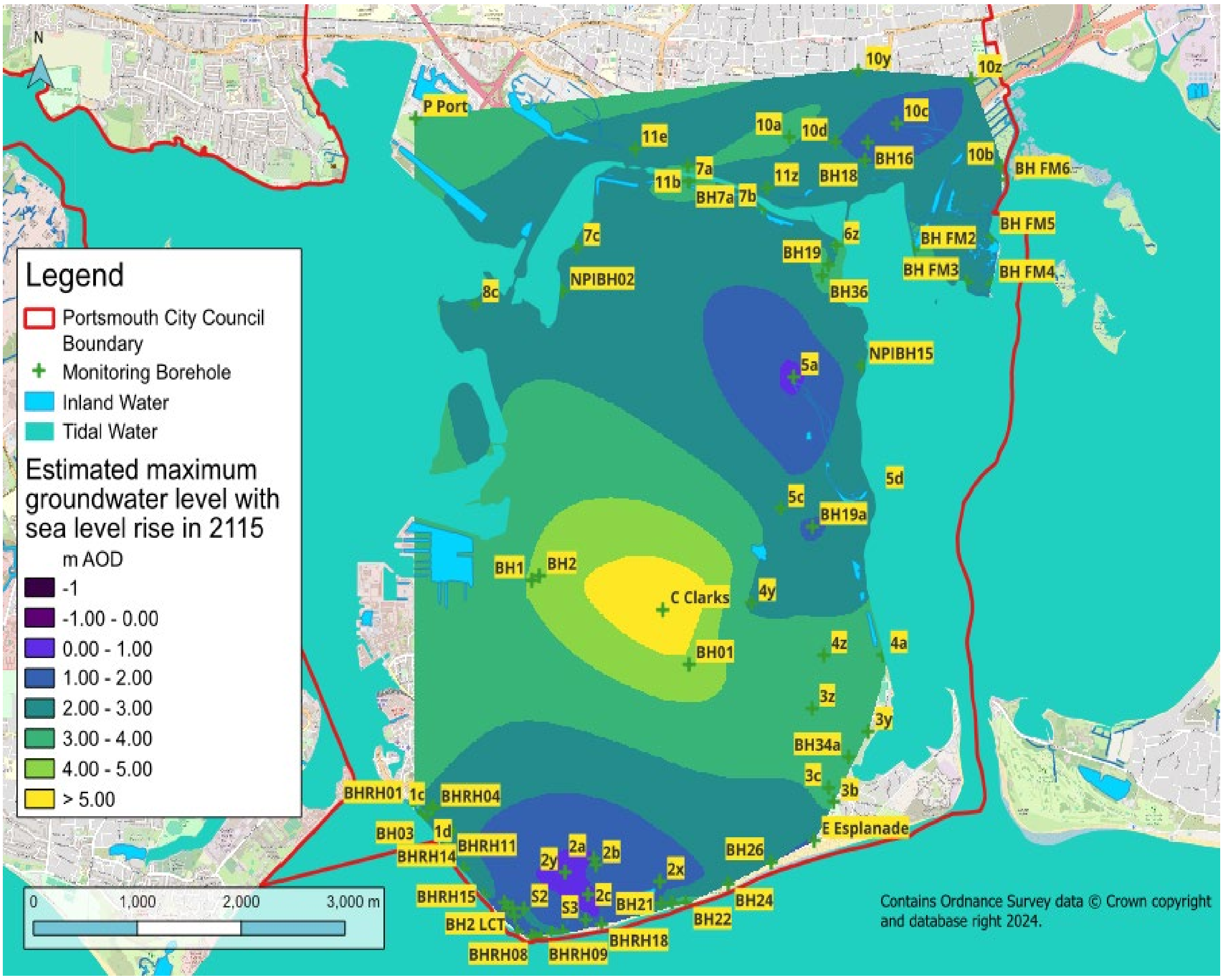


Figure 6-2: Estimated maximum groundwater levels with sea level rise 2115.

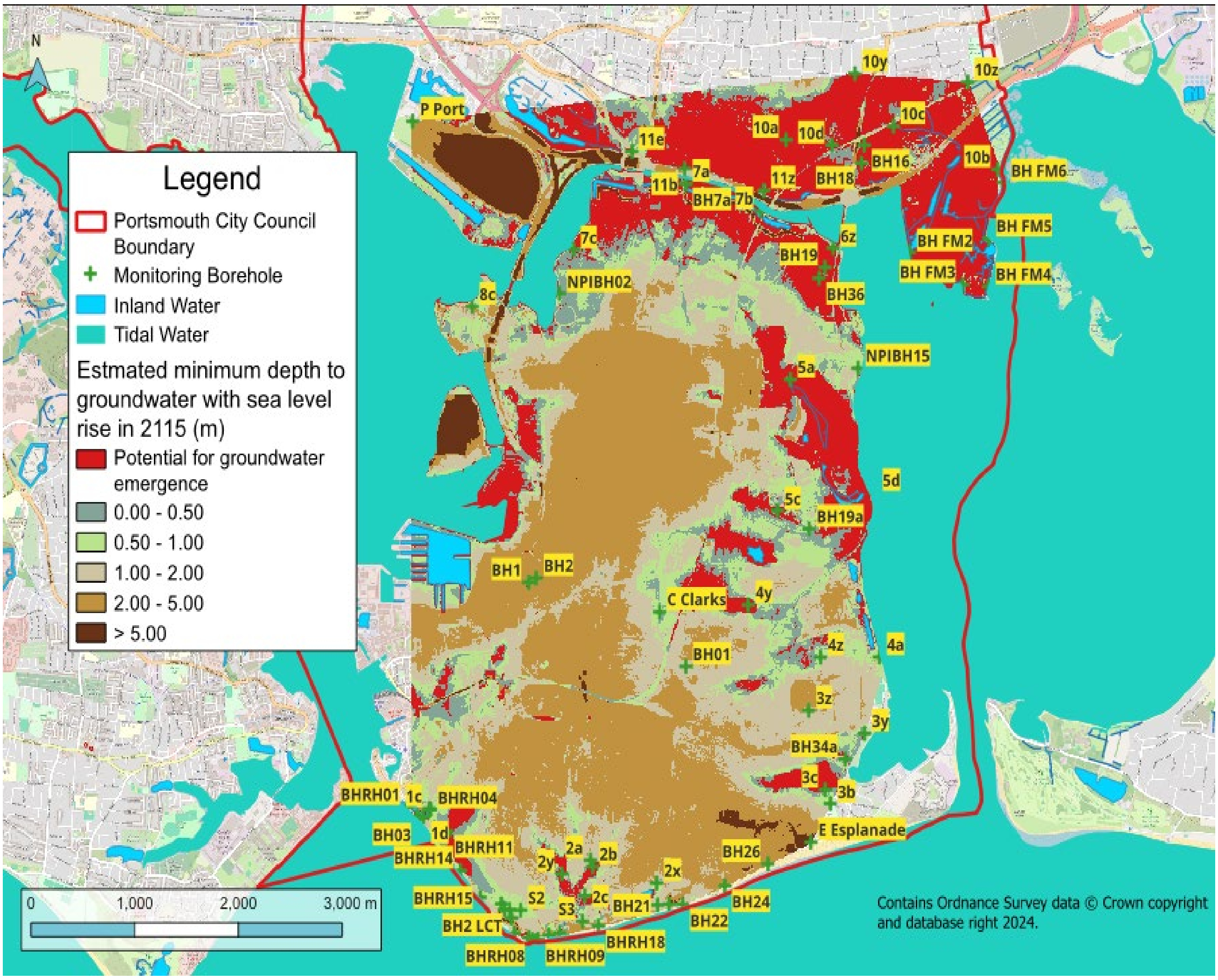


Figure 6-3: Estimated minimum depth to water with sea level rise in 2115.

The estimated groundwater level maximum for 2115 has been set to assess the minimum depth to groundwater following sea level rise and is shown is Figure 6-3. The map indicates areas that have the potential the groundwater table near or above the ground surface. Where water levels are predicted to be above the ground surface (red areas) there is a potential for groundwater emergence. This may be in the form of newly activated springs or seepage faces, increases in baseflow to drains/water bodies or an increase in the groundwater table above the ground surface leading to new areas of standing water.

When compared to the Figure 5-3 in the previous report (see Appendix A), it is apparent that most of the "at risk" areas remain the same with minimal changes. However, the main areas where changes have been identified are the University of Portsmouth North Zone and HMS Temeraire/United Services Rugby Ground in the west of Portsmouth where greater potential for groundwater emergence at the ground surface is estimated, and the area surrounding Hilsea that has less potential for groundwater to intercept the ground surface. The area to the west corresponds with a low-lying area, and the area surrounding Hilsea is also where the negative values indicate areas where groundwater levels may have fallen (shown in Figure 5-3).

It should be noted that the analysis is a fairly generic and simplistic approach to estimate how groundwater behaviour and levels may rise in response to climate change and assumes a simple uniform increase to the entire maximum groundwater table equal to the predicted sea level rise by 2115 at Langstone Harbour. It does not account for the influence of sea level rise to decrease with distance from the sea; nor does it account for potential increases in recharge following climate change. It does not give an accurate groundwater surface. Despite this, it is suitable for highlighting where groundwater levels may become close to or at the surface and enter the drainage system. The map serves to highlight particular areas where near surface groundwater levels should be considered. However, it is also recognised that groundwater levels are close to the surface over much of Portsmouth.

Appendix H highlights the potential for groundwater emergence map based on Figure 6-3 in more detail.

7 Updated Conceptual Model

The following section provides a summary of the conceptual groundwater model based upon review of the data used in this study. Many elements of the model are the same as those reported previously by JBA.

7.1 Updated conceptual model

7.1.1 Hydrogeology and groundwater bodies

The main bedrock groundwater body are the chalk formations that make up the majority of northern Portsmouth.

Groundwater level analysis and conceptualisation has demonstrated that the groundwater levels that are recorded are largely limited to the superficial deposits across Portsmouth with responses in groundwater indicate of recharge of a superficial aquifer. This differs to the very north of the study area where there is limited bedrock cover by superficial deposits. This is observed in the groundwater analysis where long recessions were observed that are typical of chalk aquifers.

No significant changes have been observed from the previous report relating to hydrogeology and groundwater bodies.

7.1.2 Groundwater response

The presence of permeable bedrock combined with permeable superficial deposits over the majority of Portsmouth means that groundwater is generally unconfined. There are no significant low permeability strata at the surface to confine groundwater levels.

Generally, the groundwater table lies within the superficial deposits and groundwater shows superficial aquifer response. Within the superficial deposits some low permeability areas had limited groundwater level variation and did not show a distinct response.

Generally, groundwater responses that were affected by tidal influence were confined to coastal areas. The majority of other locations (including boreholes inland) show a clear recharge response following precipitation. In some cases, no distinct groundwater response was observed, which may indicate perched water is present within Made Ground deposits (such as 5c (Stanley Avenue)).

7.1.3 Hydrogeological conceptual cross-sections

Previously ground investigation and groundwater monitoring data have been used to develop four hydrogeological conceptual model cross-sections across Portsmouth. Cross-sections are shown in Appendix G and include two north-south and two west-east. The locations of the cross sections are depicted in Figure 3-1.

The cross sections have been updated since the issue of the last report, to show updated strata depth, newly installed/monitored boreholes and new groundwater heights (in relation to the maximum and average groundwater levels).

The cross sections are very similar to those presented previously show the following:

- Groundwater levels are typically still within 5m of the ground surface and generally situated within the superficial aquifers. Groundwater patterns are generally similar to those previously analysed;
- Overall, there is limited range in groundwater levels between average and maximum, typical of superficial aquifer as was the case with the earlier monitoring data;
- Near to the coast (including Ports Creek), the range of groundwater levels are greater and more closely linked to tide levels. Salinity monitoring clearly shows the effect of seawater intrusion in these areas;
- JBA understand that as previously areas that would naturally experience groundwater emergence (such as Great Salterns) are currently being managed through drainage networks;
- Large areas of Portsmouth have Made Ground (including reclaimed land such as Port Solent Marina). These may form a confining layer in areas of low permeability material and limit recharge of the superficial deposits; and
- The main controls on groundwater boundaries and thus controls on groundwater flows are the surrounding sea level and drainage levels/pumping.

8 Conclusions and Recommendations

8.1 Conclusions

Portsmouth City Council have established a robust groundwater monitoring network throughout Portsmouth that has been monitored over the last nine years. Consequently, a good understanding of groundwater levels throughout the city of Portsmouth have been established and consolidated.

The main drivers for near surface groundwater levels at Portsmouth are a result of permeable thin superficial deposits and low-lying developed areas. When data from the current study is compared with that from the earlier study the main key conclusions from the overall nine-year study are:

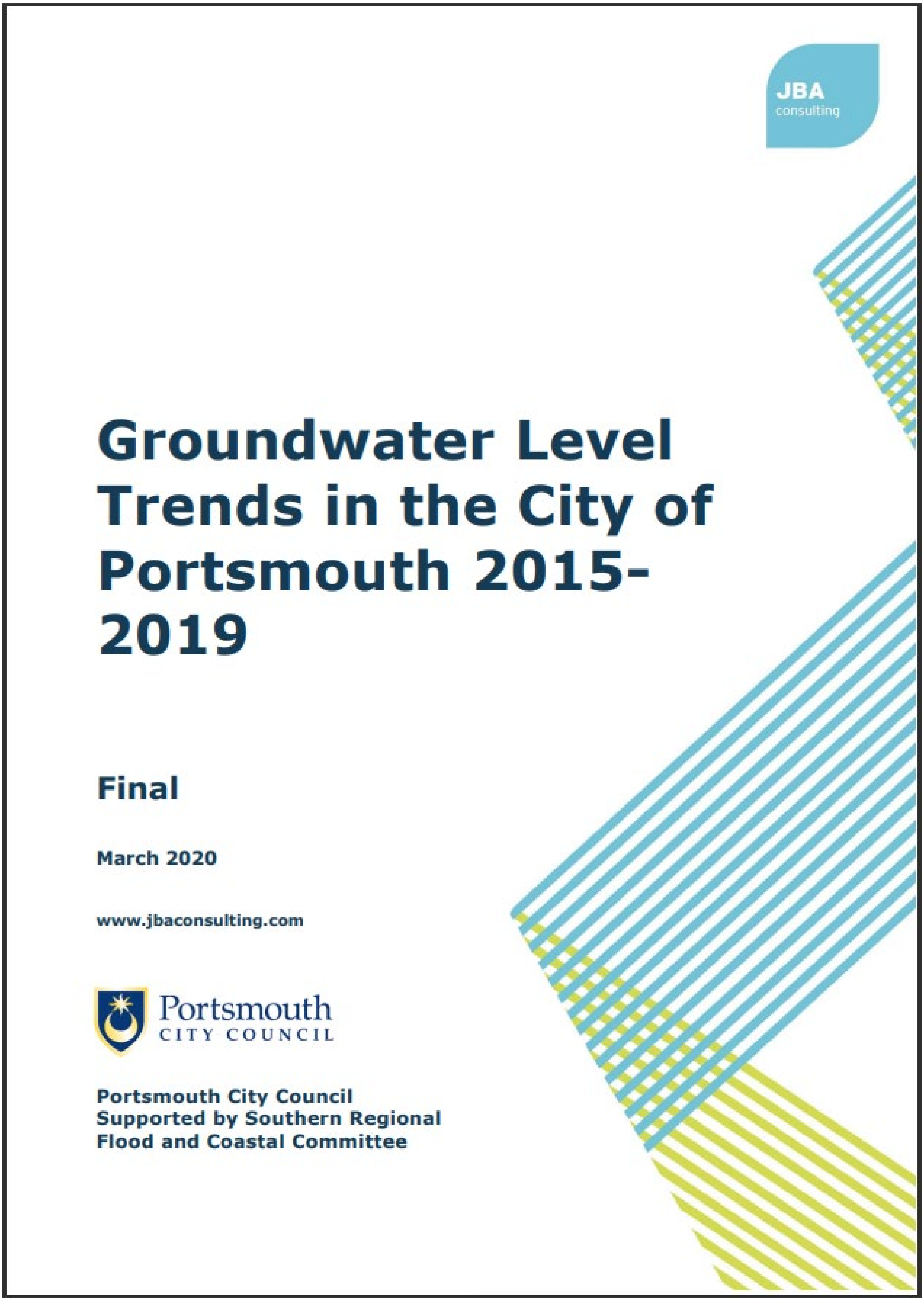
1. Groundwater levels are generally close to the ground level in many areas and are located within the permeable superficial deposits. Groundwater responses observed are typical of superficial aquifers as opposed to bedrock (chalk) aquifers.
2. The monitoring network shows that groundwater levels respond to rainfall, drainage and tides to varying degrees, which is a function of their location. Some locations do not show a distinct response.
3. Groundwater levels generally represent a subdued expression of the topography and in low-lying areas may be close to or at the surface at times of high groundwater levels.
4. The absence of observed groundwater flooding is likely to be because drains intercept the groundwater when they reach the level of the drainage network.
5. There may be some interaction between sewers and groundwater with discharge of groundwater to sewers where these have not been lined.
6. Groundwater levels are likely to rise with sea levels over the next century. This will result in higher groundwater levels and an increased need for pumped drainage in low-lying areas to maintain their status. It should be noted that the method used to estimate future areas of potential groundwater emergence is a fairly generic simplistic approach to estimating how groundwater levels will rise in response to sea level rises. It does not give an accurate groundwater surface (see Figure 6-2 and Figure 6-3).
7. Brackish or saline groundwater that has been observed is generally confined to the coastal areas around Portsmouth. Following climate change and sea level rises this may result in an inland migration of the groundwater saline interface.

8.2 Recommendations

The following recommendations are made:

1) Continued monitoring of groundwater levels at key locations utilising the existing network of boreholes. Recommend continued monitoring within areas susceptible to groundwater emergence, depicted in Figure 5-4 and Figure 6-3 would be useful to monitoring groundwater levels that are located in low-lying areas. Installation of additional wells could be considered in order to provide greater refinement of the areas where the likelihood of emergence is greatest (refer to Appendix H for details of areas with potential for groundwater emergence, based on Figure 6-3). Isolated areas throughout Portsmouth such as Stamshaw, Portsea, Bransbury Park, Eastney Engine House and Cosham could benefit from the addition of further monitoring wells to further refine areas of emergence.
2) It is recommended that drainage infrastructure within the areas susceptible to groundwater emergence be routinely maintained and repaired (if necessary). The upkeep of drainage infrastructure will help alleviate and mitigate against groundwater inundation into sewers and help retain their capacity. Liaising with relevant utilities regarding lining sewers to prevent ingress and maintain capacity could be considered where these are at risk of gaining groundwater.
3) In areas where land is susceptible to groundwater emergence and flooding, any planning applications regarding impermeable sub-surface structures (e.g. basements, tunnels or underground services) should be avoided. Developments involving infiltration SuDS should also ideally be avoided in these areas. Conversely, developments that may create permeable groundwater flow paths should be assessed with appropriate risk assessment to determine how groundwater flow paths and levels may be altered and determine where groundwater may discharge.

A Previous Report



Groundwater Level Trends in the City of Portsmouth 2015-2019

Final

March 2020

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Portsmouth City Council
Supported by Southern Regional Flood and Coastal Committee

B Portsmouth City Council Certificates

C Borehole Geology Summary

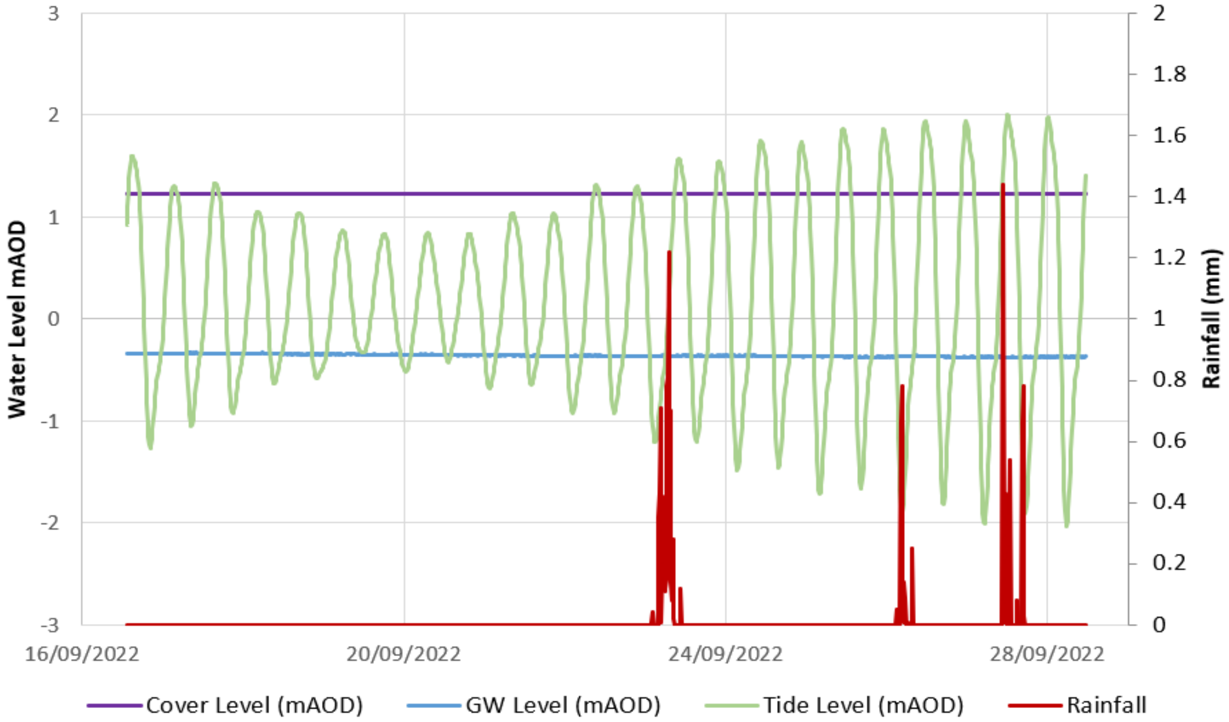
D Monitoring Borehole Summary

THIS APPENDIX WAS NOT USED

E Hydrographs

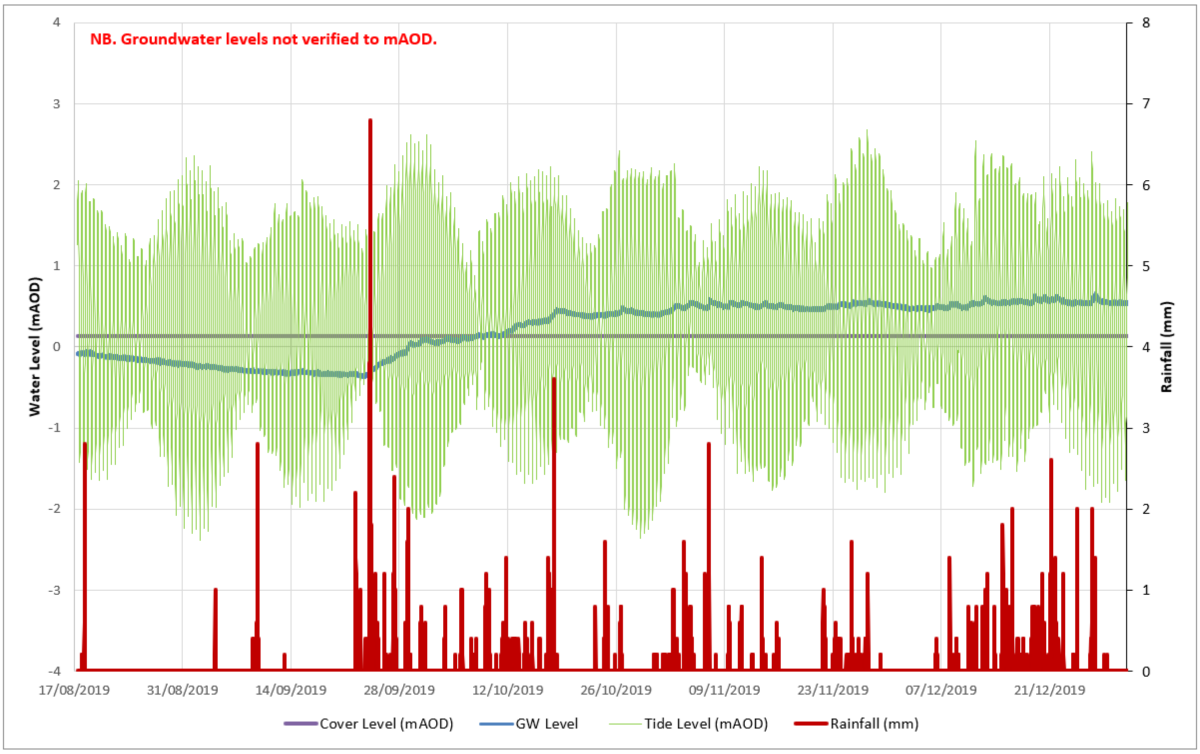
E.1 2a – Wimbledon Park North Hydrograph

Hydrograph for 2a Wimbledon Park North shows a rising and falling tide level between 16/09/2022 to 28/09/2022. The maximum tide level was 2.0m above Ordnance Datum (AOD) and the minimum level was -2.04m AOD. The blue line denotes a steady groundwater level between -0.378m and -0.331m AOD during the monitoring period. Borehole shows slight response to tidal influence but is generally unresponsive to rainfall. The ground surface level for borehole 2a is 1.23m AOD.

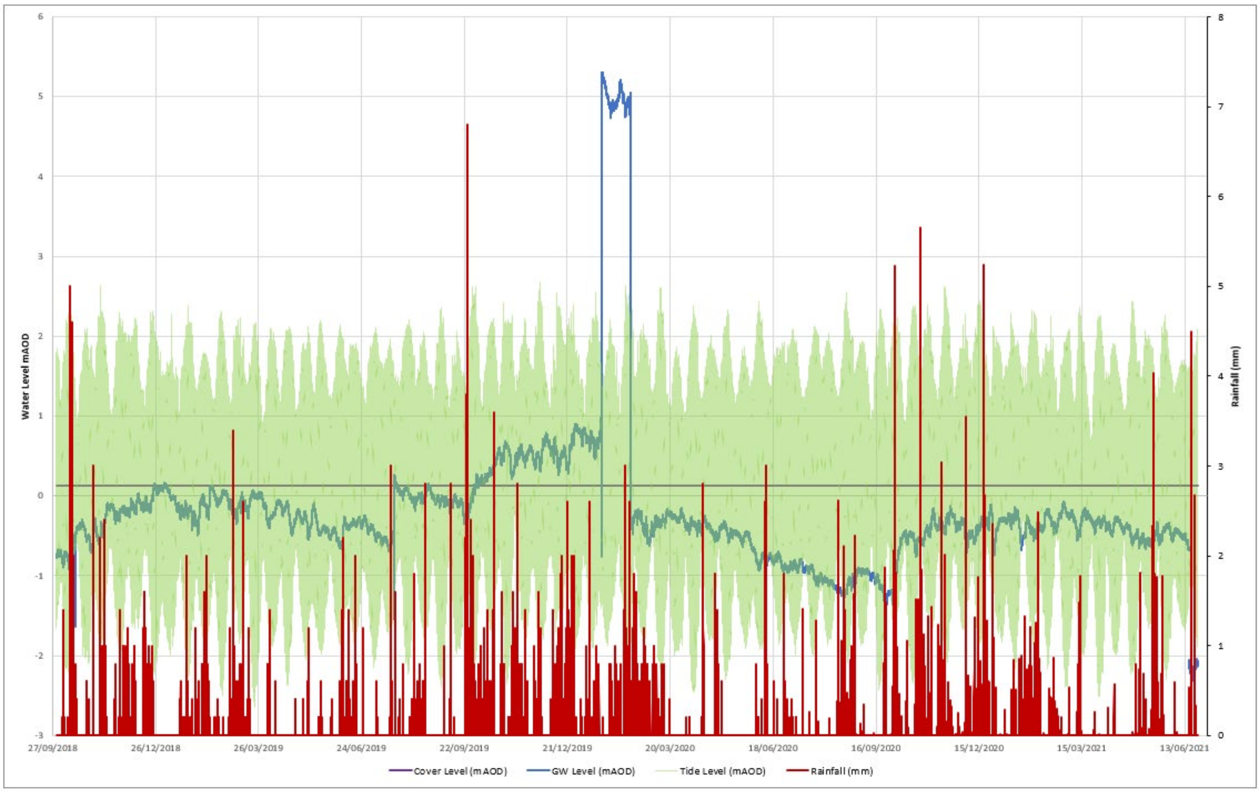


E.2 2b – Wimbledon Park South Hydrographs

Hydrograph for 2b Wimbledon Park South shows a rising and falling tide level between 17/08/2019 to 31/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.39m AOD. The blue line denotes a groundwater level between -0.372m rising gradually to 0.667m AOD during the monitoring period, reflecting wetter winter periods and response to rainfall. The ground surface level for borehole 2b is 0.13m AOD.

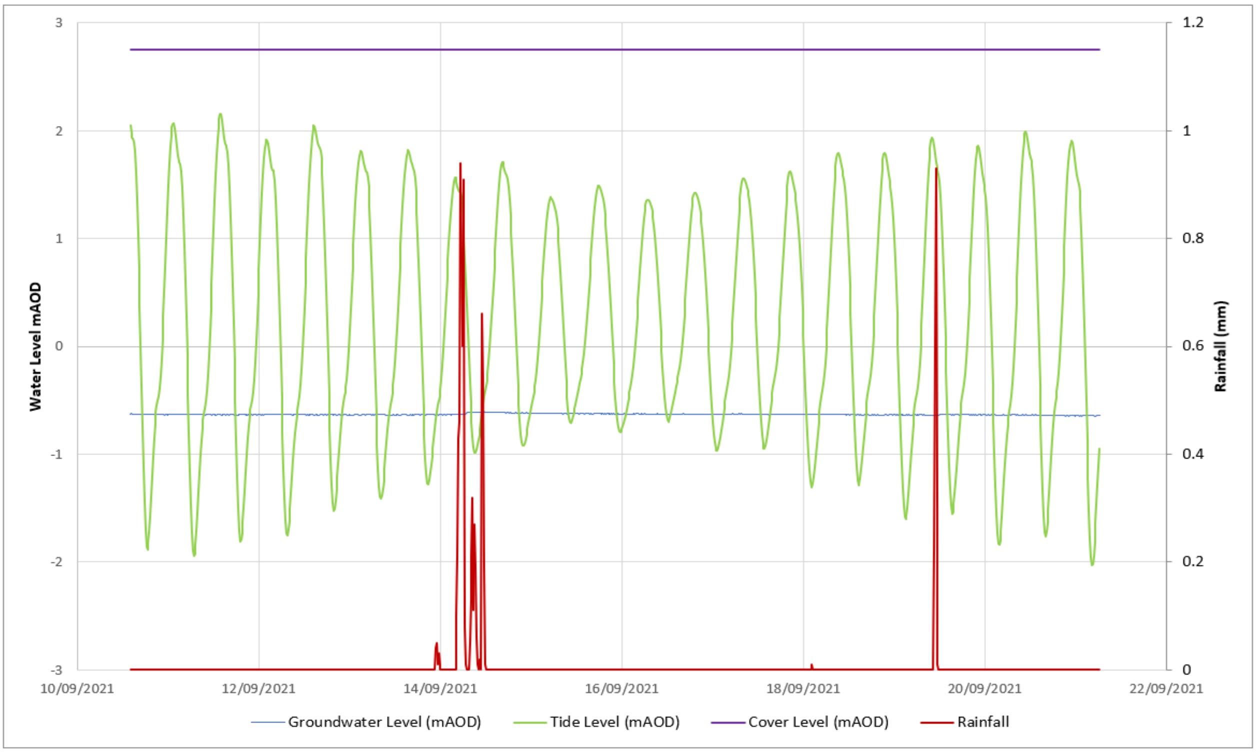


Hydrograph for telemetry monitoring at 2b Wimbledon Park South shows a rising and falling tide level between 27/09/2018 to 24/06/2021. The maximum level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.64m AOD. The blue line denotes a groundwater level between -1.63m during autumn 2020 to a maximum level of 5.30m AOD during late December 2019 to January 2020. This likely reflects periods of groundwater flooding or inundation of the datalogger. The ground surface level for borehole 2b is 0.13m AOD.



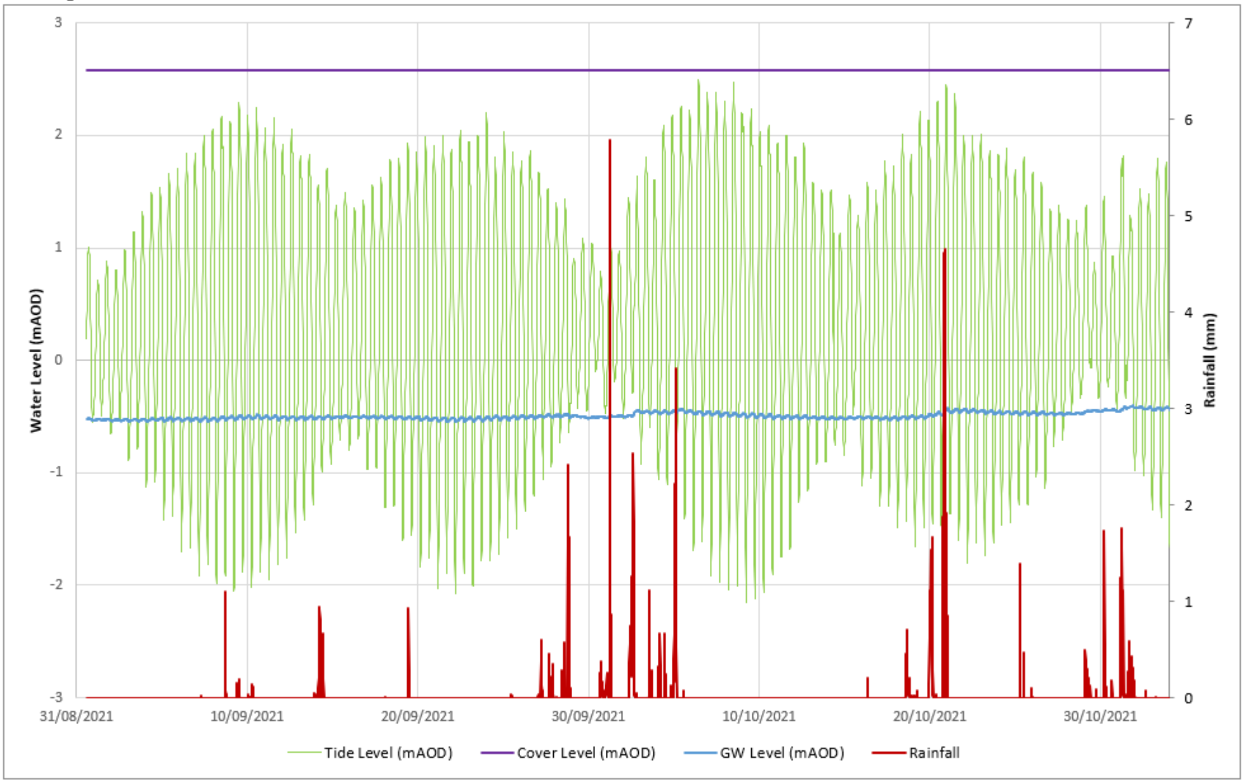
E.3 2c – Strand Hydrograph

Hydrograph for 2c Strand shows a rising and falling tide level between 10/09/2021 to 21/09/2021. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.03m AOD. The blue line denotes a steady groundwater level between -0.645m to -0.60m AOD during the monitoring period, with the borehole being slightly responsive to rainfall. The ground surface level for borehole 2c is 1.15m AOD.



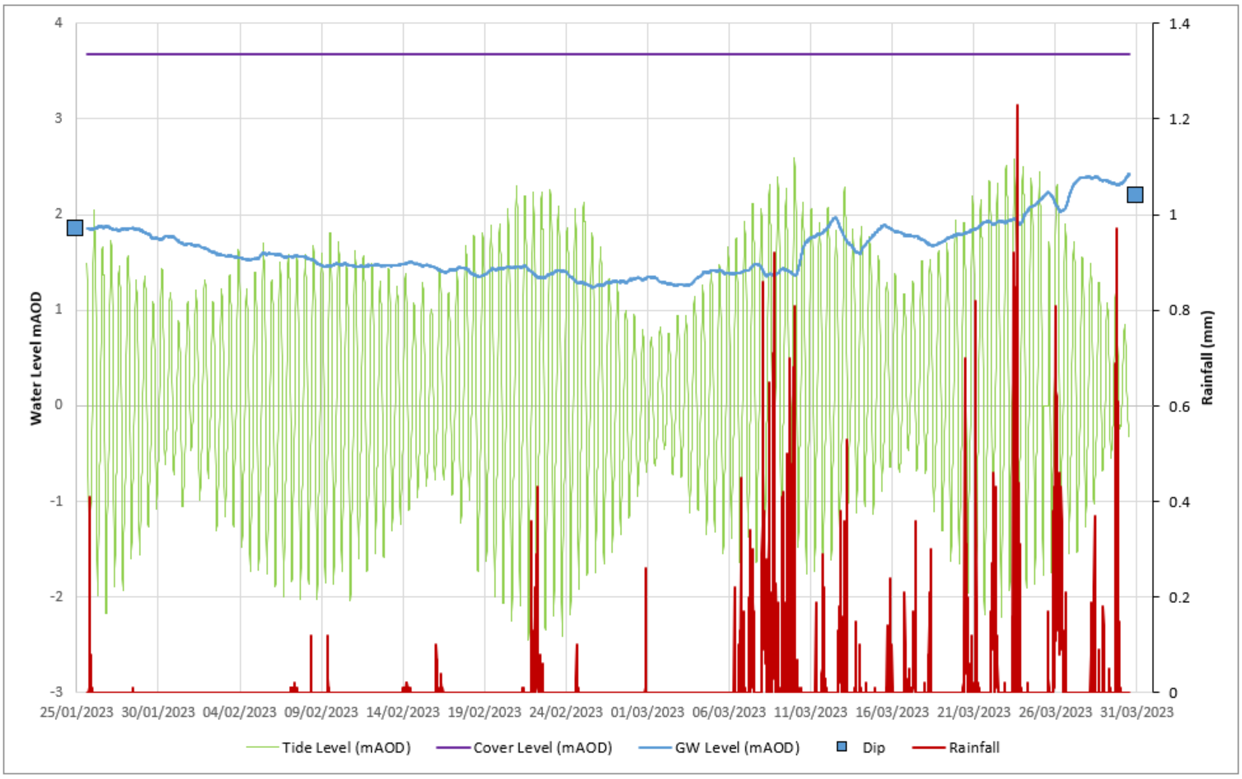
E.4 2x – Canoe Lake Hydrograph

Hydrograph for 2x Canoe Lake shows a rising and falling tide level between 31/08/2021 to 03/11/2021. The maximum tide level was 2.49m above Ordnance Datum (AOD) and the minimum level was -2.15m AOD. The blue line denotes a gradually rising groundwater level between -0.55m to -0.40m AOD during the monitoring period responding to tidal variation. The ground surface level for borehole 2x is 2.58m AOD.



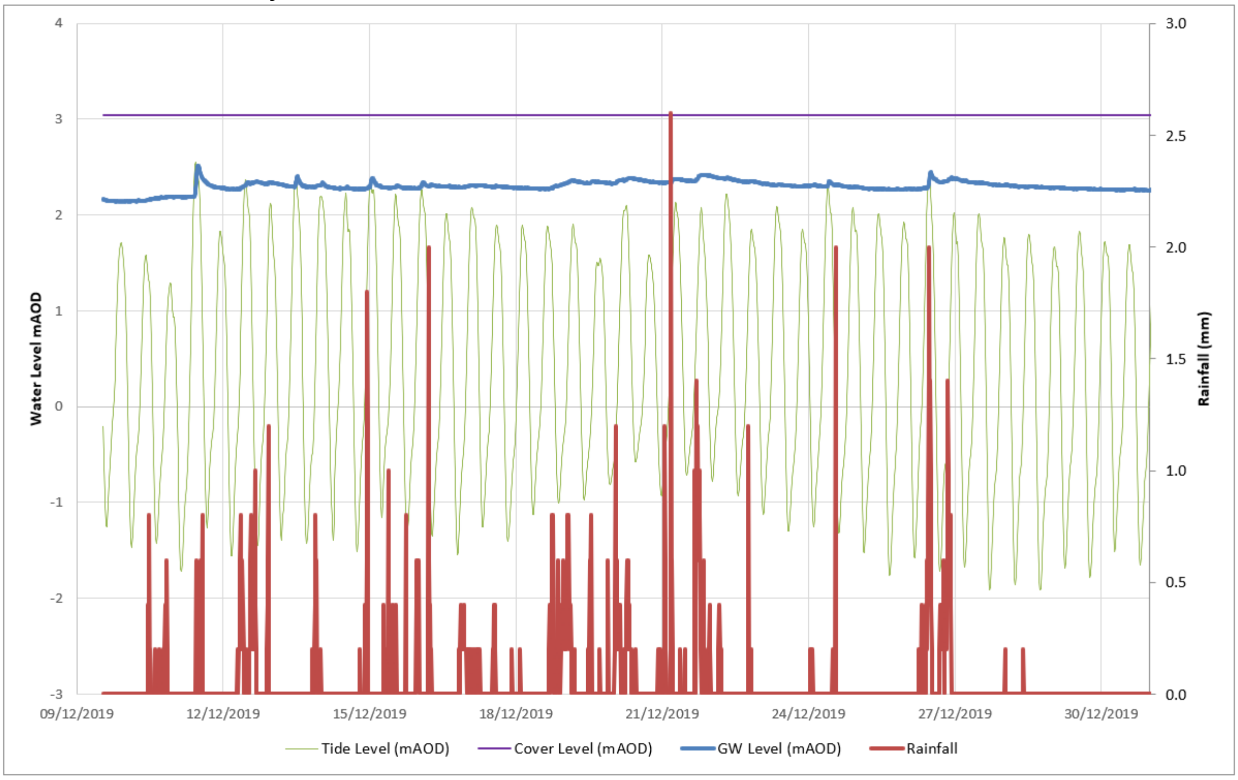
E.5 3c Bransbury Park Hydrograph

Hydrograph for 3c Bransbury Park shows a rising and falling tide level between 25/01/2023 to 30/03/2023. The maximum tide level was 2.60m above Ordnance Datum (AOD) and the minimum level was -2.45m AOD. The blue line denotes a receding then rising groundwater level between 1.236m to 2.432m AOD during the monitoring period responding to rainfall. The ground surface level for borehole 3c is 3.67m AOD.



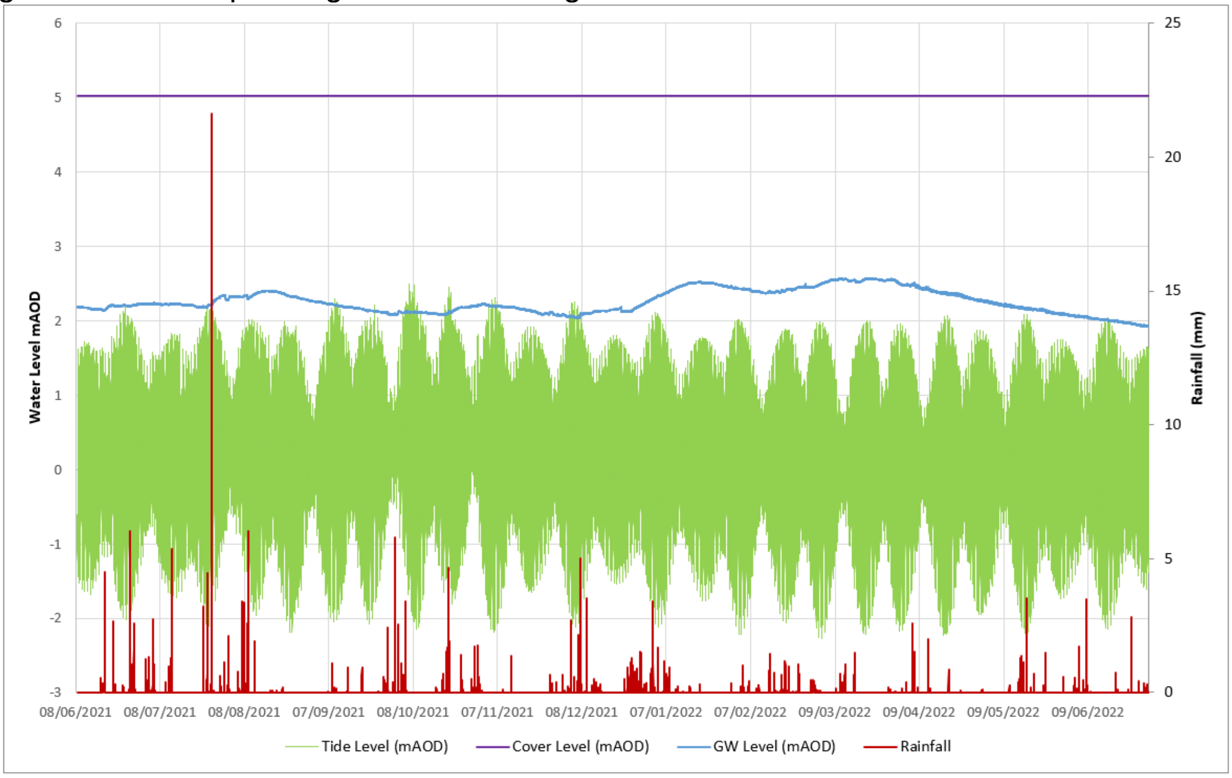
E.6 3y Milton Allotments Hydrograph

Hydrograph for 3y Milton Allotments shows a rising and falling tide level between 09/12/2019 to 31/12/2019. The maximum tide level was 2.55m above Ordnance Datum (AOD) and the minimum level was -1.92m AOD. The blue line denotes the groundwater level between 2.139m to 2.516m AOD during the monitoring period, depicting the groundwater responding to rainfall and potential drainage influences. The ground surface level for borehole 3y is 3.04m AOD.



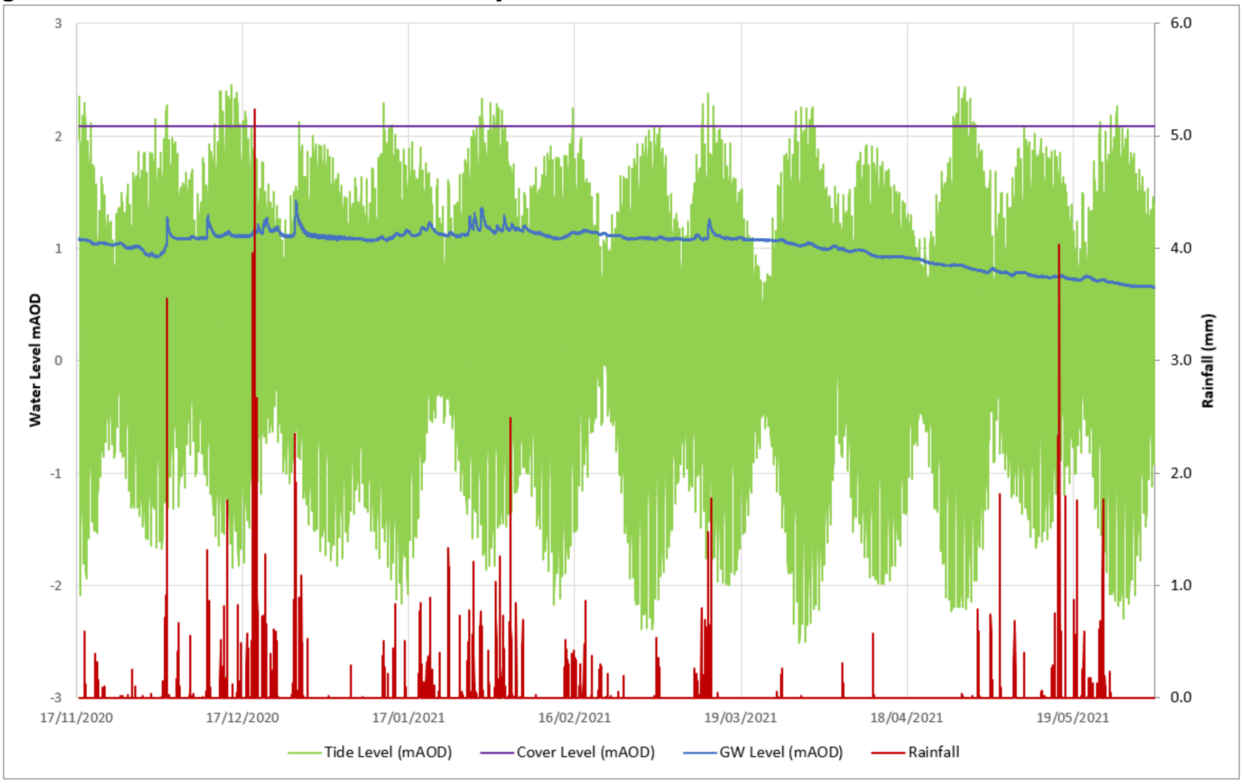
E.7 3z St James Green Hydrograph

Hydrograph for 3z St James Green shows a rising and falling tide level between 08/06/2021 to 01/07/2022. The maximum tide level was 2.49m above Ordnance Datum (AOD) and the minimum level was -2.27m AOD. The blue line denotes the groundwater level between 1.915m to 2.573m AOD during the monitoring period, depicting seasonal variation and groundwater responding to rainfall. The ground surface level for borehole 3z is 5.02m AOD.

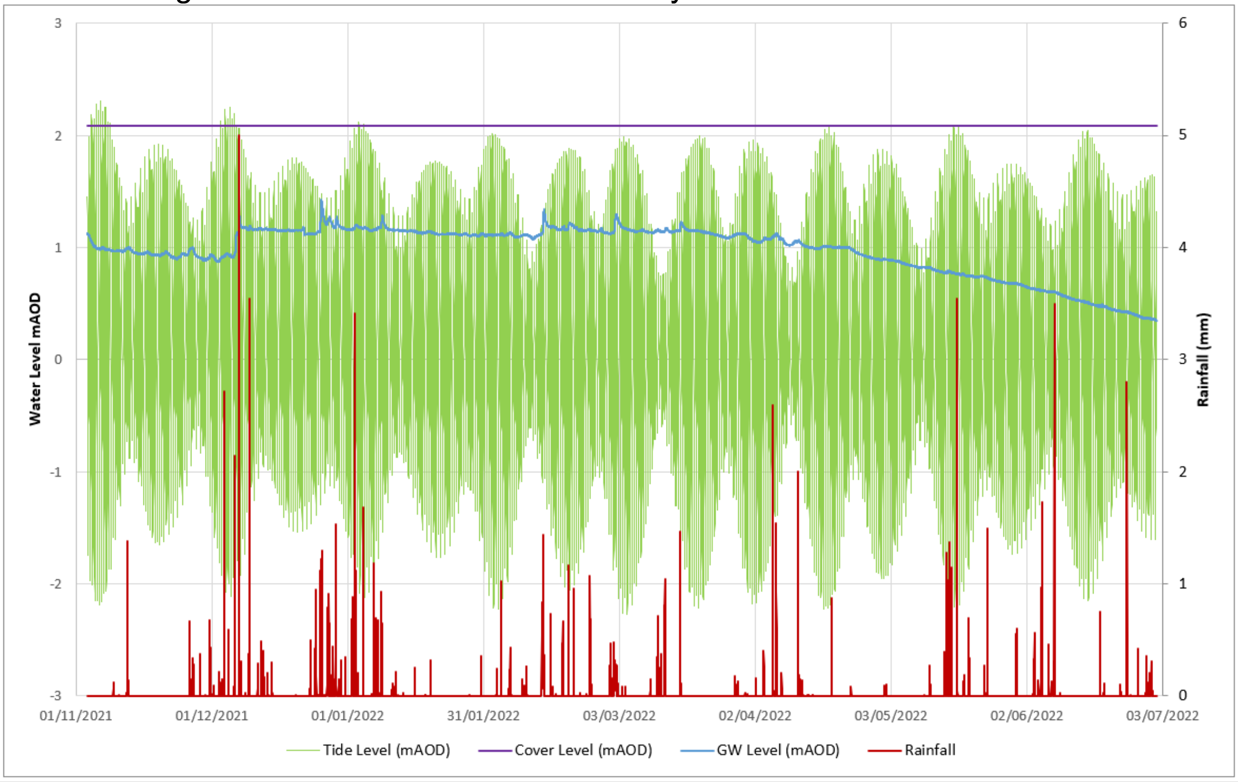


E.8 4y Tamworth Park Hydrographs

Hydrograph for 4y Tamworth Park shows a rising and falling tide level between 17/11/2020 to 03/06/2022. The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.51m AOD. The blue line denotes the groundwater level generally receding from 0.642m 1.431m AOD during the monitoring period responding to rainfall. The ground surface level for borehole 4y is 2.09m AOD.

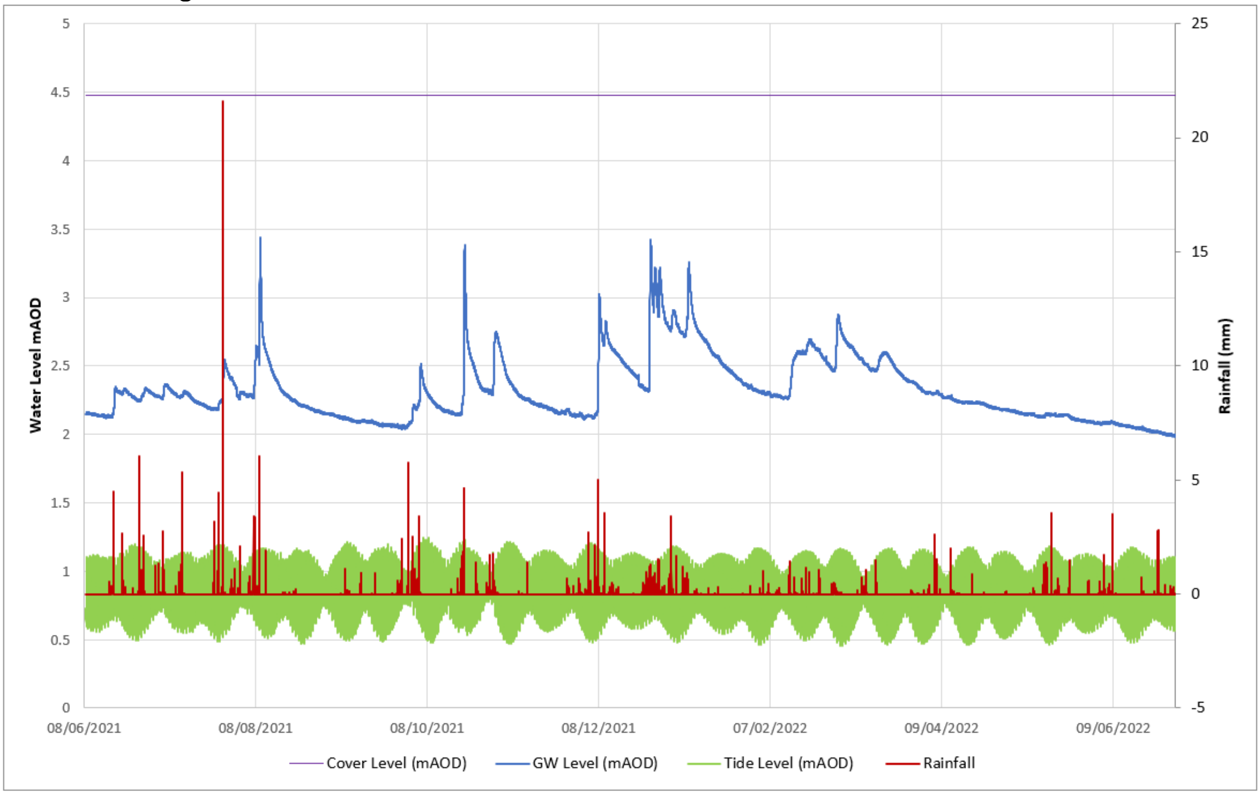


Hydrograph for 4y Tamworth Park shows a rising and falling tide level between 03/11/2021 to 01/07/2022. The maximum tide level was 2.31m above Ordnance Datum (AOD) and the minimum level was -2.27m AOD. The blue line denotes the groundwater level generally receding from 0.345m to 1.43m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 4y is 2.09m AOD.



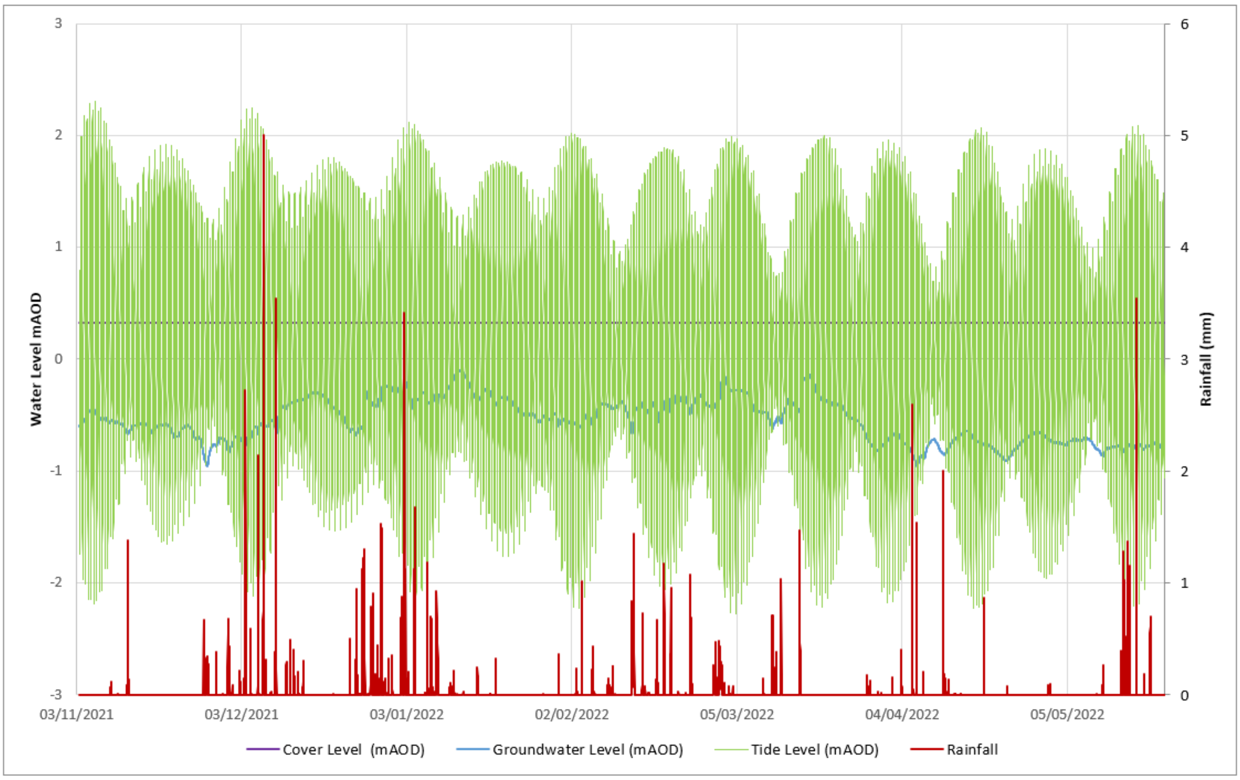
E.9 4z Milebush Gardens Hydrograph

Hydrograph for 4z Milebush Gardens shows a rising and falling tide level between 08/06/2021 to 01/07/2022. The maximum tide level was 2.49m above Ordnance Datum (AOD) and the minimum level was -2.27m AOD. The blue line denotes the groundwater level from 1.981m to 3.439m AOD during the monitoring period and responding strongly to rainfall. The ground surface level for borehole 4z is 4.48m AOD.

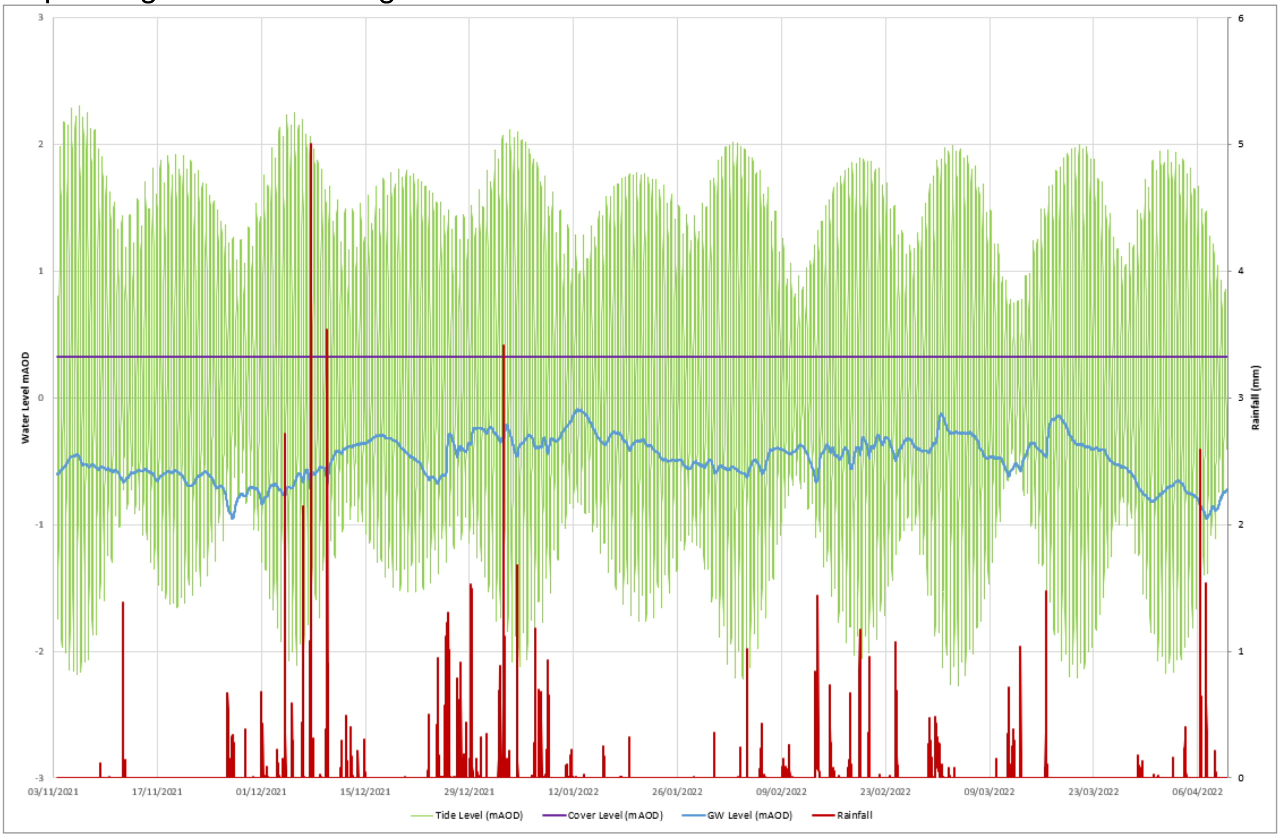


E.10 5a Great Salterns/Quartremaine Road Hydrographs

Hydrograph for 5a Great Salterns/Quartremaine Road shows a rising and falling tide level between 03/11/2021 to 23/05/2022. The maximum tide level was 2.31m above Ordnance Datum (AOD) and the minimum level was -2.27m AOD. The blue line denotes the groundwater level from -0.958m to -0.091m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 5a is 0.33m AOD.

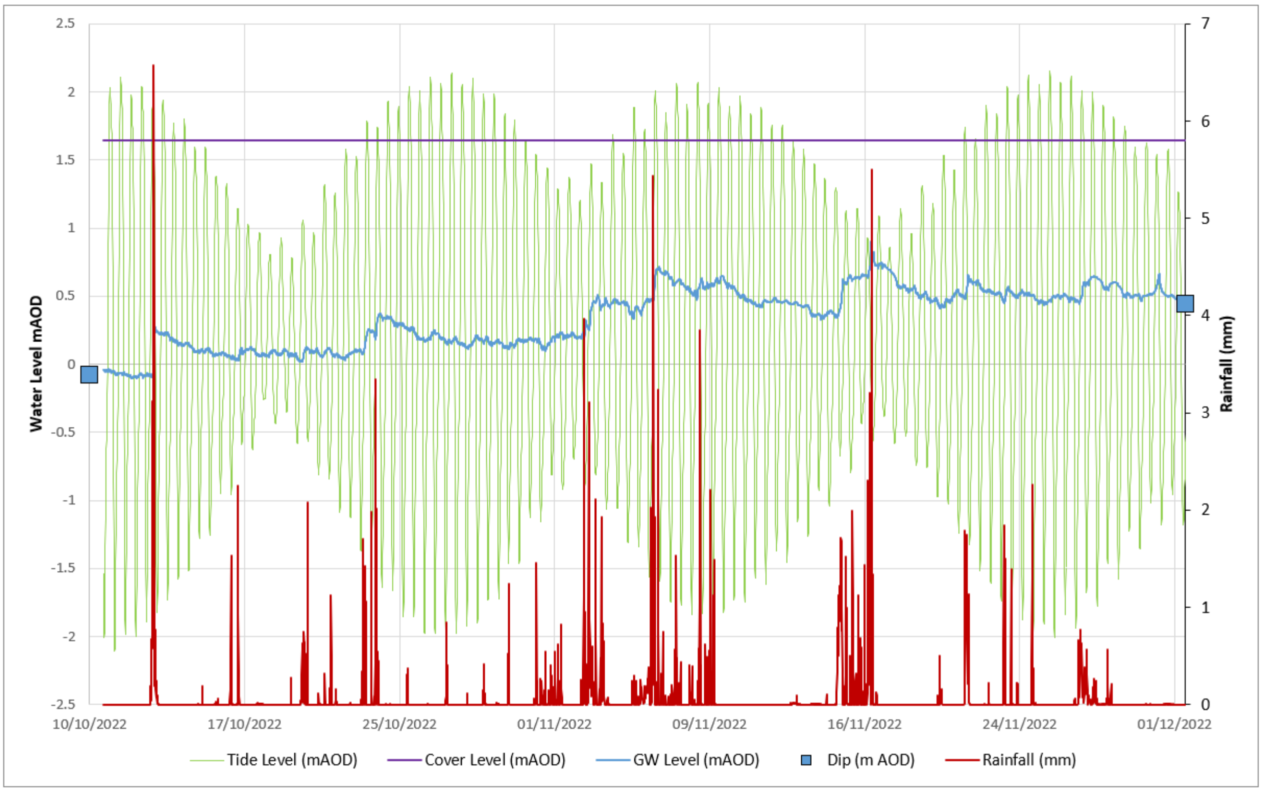


Hydrograph for 5a Great Salterns/Quartremaine Road shows a rising and falling tide level between 03/11/2021 to 10/04/2022. The maximum tide level was 2.31m above Ordnance Datum (AOD) and the minimum level was -2.27m AOD. The blue line denotes the groundwater level from -0.958m to -0.091m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 5a is 0.33m AOD.



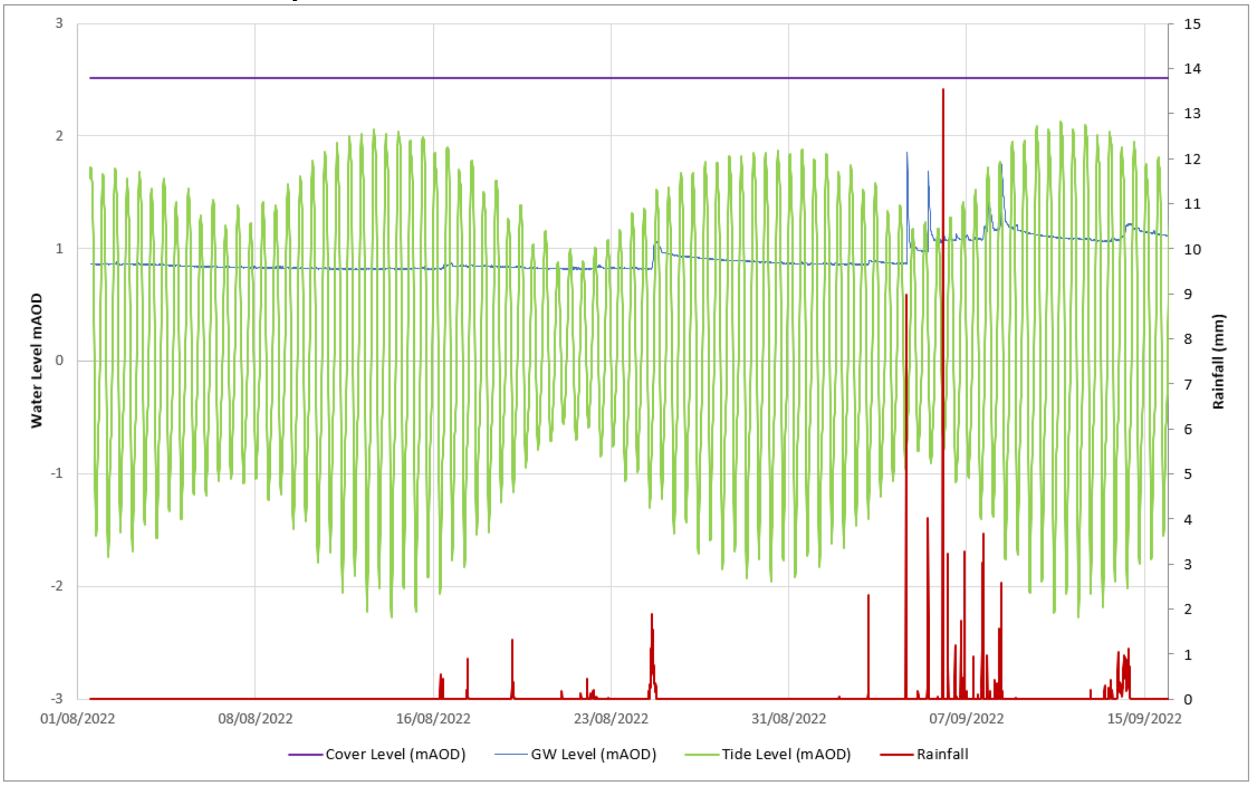
E.11 10d Station Road Hydrograph

Hydrograph for 10d Station Road shows a rising and falling tide level between 10/10/2022 to 02/12/2022. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.11m AOD. The blue line denotes the groundwater level from -0.106m to 0.90m AOD during the monitoring period and responding strongly to rainfall. The ground surface level for borehole 10d is 1.65m AOD.



E.12 10y Central Road Hydrograph

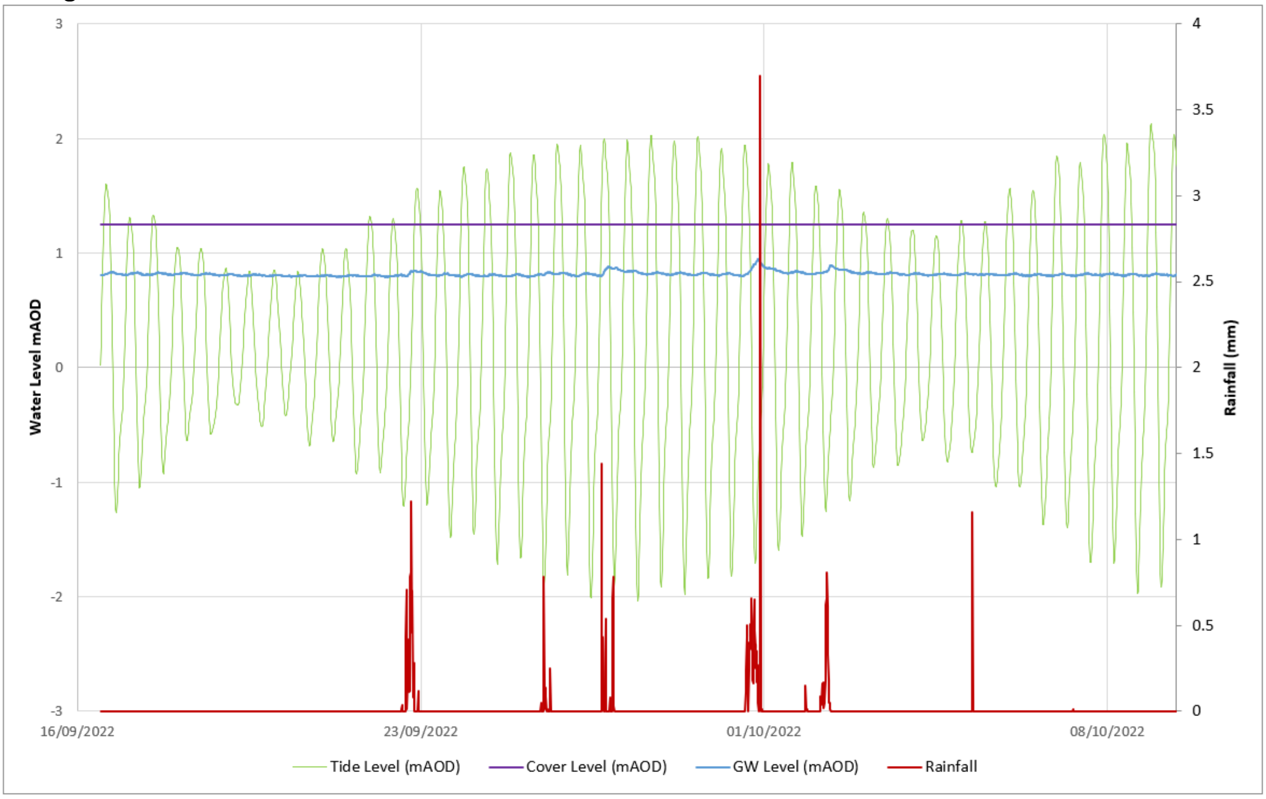
Hydrograph for 10d Station Road shows a rising and falling tide level between 01/08/2022 to 16/09/2022. The maximum tide level was 2.13m above Ordnance Datum (AOD) and the minimum level was -2.28m AOD. The blue line denotes the groundwater level from 0.81m to 1.85m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 10y is 2.51m AOD.



E.13 10z Cygnet Road Hydrographs

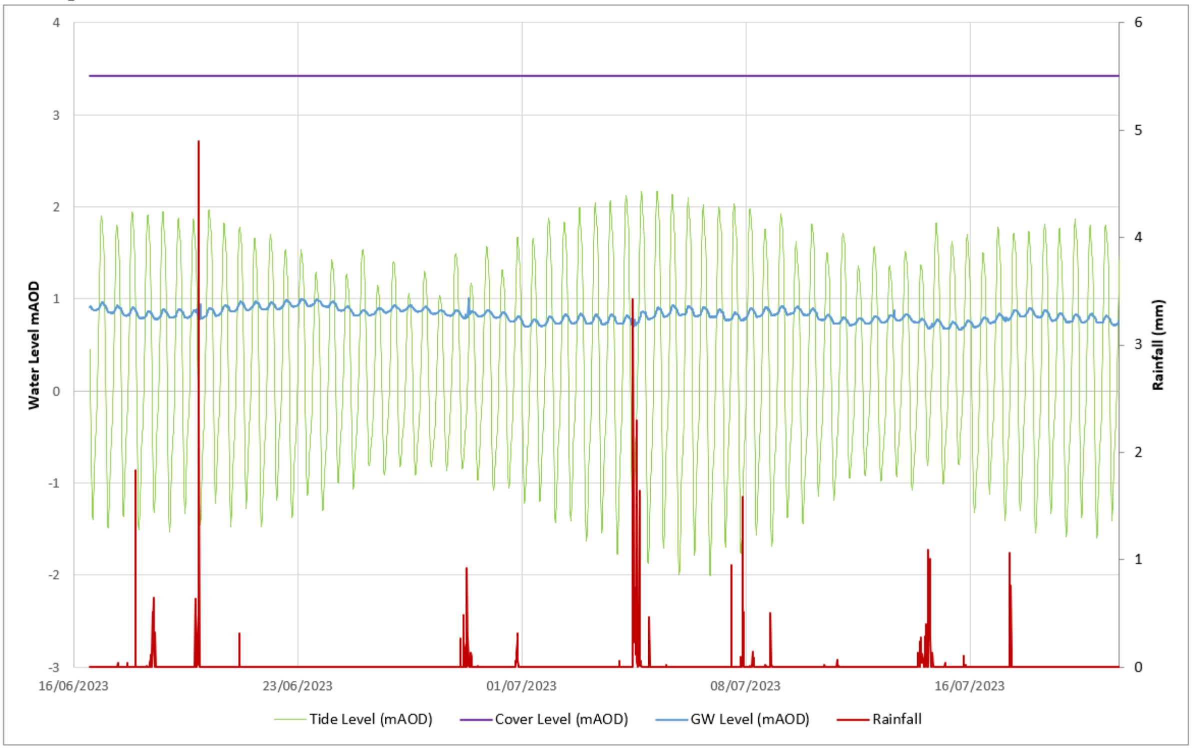
Hydrograph for 10z Cygnet Road shows a rising and falling tide level between 04/07/2022 to 16/09/2022. The maximum tide level was 2.13m above Ordnance Datum (AOD) and the minimum level was -2.28m AOD. The blue line denotes the groundwater level from 0.761m to 1.022m AOD during the monitoring period and to tidal variation and rainfall. The ground surface level for borehole 10z is 1.253m AOD.

Hydrograph for 10z Cygnet Road shows a rising and falling tide level between 16/09/2022 to 10/10/2022. The maximum tide level was 2.14m above Ordnance Datum (AOD) and the minimum level was -2.11m AOD. The blue line denotes the groundwater level from 0.79m to 0.944m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole 10z is 1.253m AOD.



E.14 11b Tudor Crescent Hydrographs

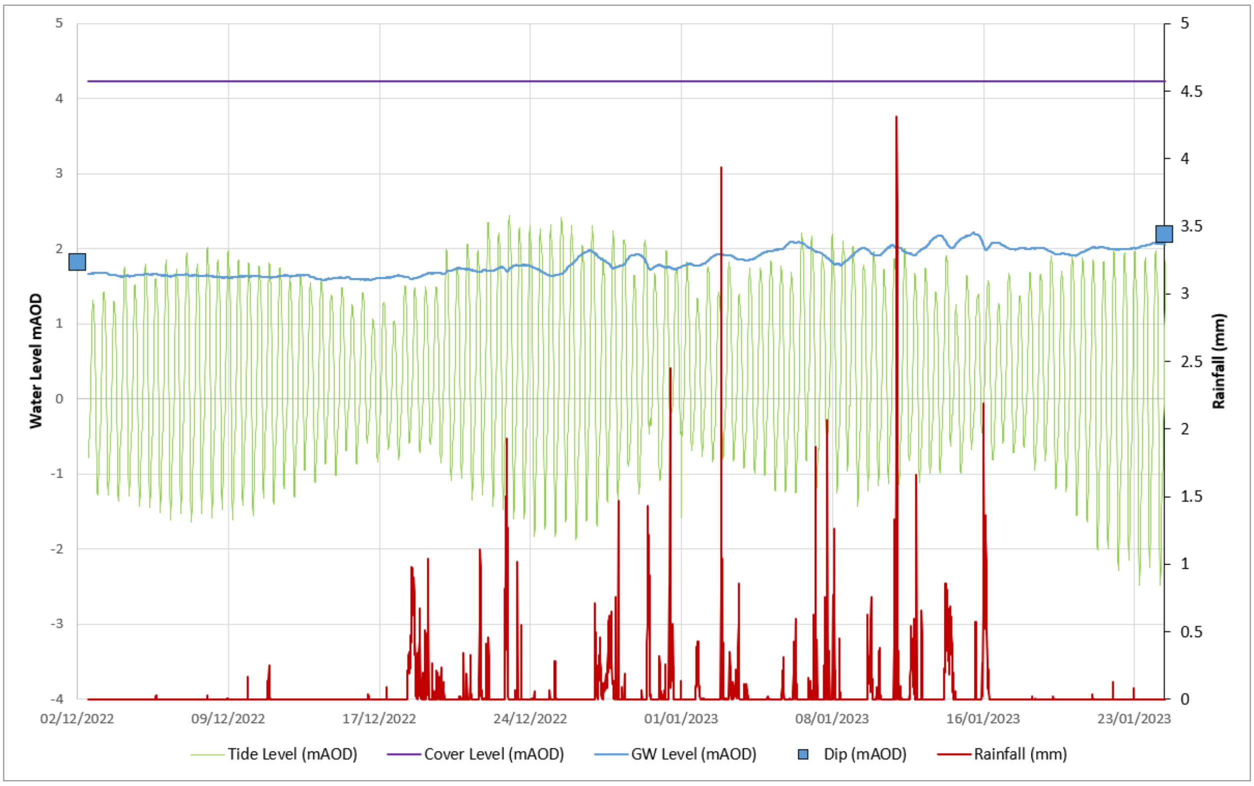
Hydrograph for 11b Tudor Crescent shows a rising and falling tide level between 16/06/2023 to 21/07/2023. The maximum tide level was 2.17m above Ordnance Datum (AOD) and the minimum level was -2.0m AOD. The blue line denotes the groundwater level from 0.667m to 1.014m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole 11b is 3.421m AOD.



Hydrograph for 11b Tudor Crescent shows a rising and falling tide level between 21/07/2023 to 14/08/2023. The maximum tide level was 2.47m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from 0.199m to 1.715m AOD during the monitoring period and responding to tidal variation and some response to rainfall. The ground surface level for borehole 11b is 3.421m AOD.

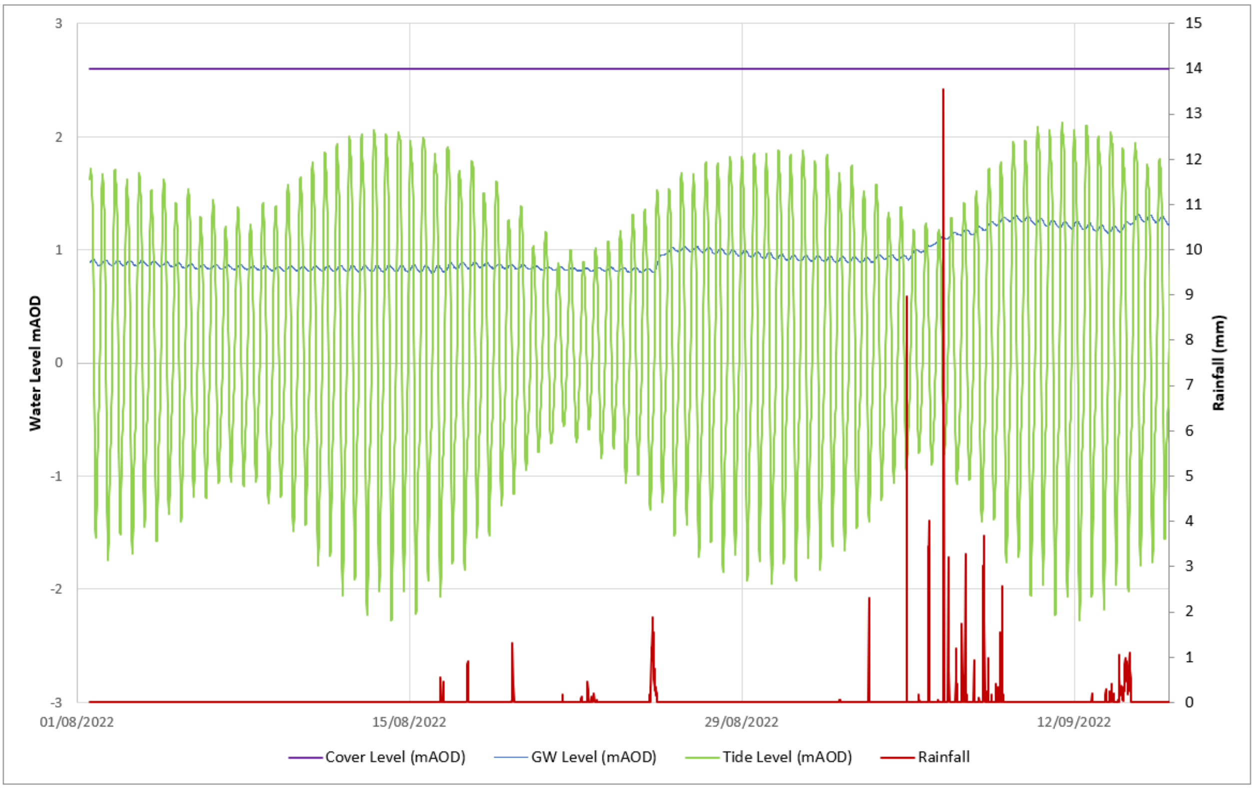
E.15 11e Lynx House Hydrograph

Hydrograph for 11e Lynx House shows a rising and falling tide level between 02/12/2022 to 25/01/2023. The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.48m AOD. The blue line denotes the groundwater level from 1.746m to 2.378m AOD during the monitoring period and responding to rainfall and tidal variation. The ground surface level for borehole 11e is 4.228m AOD.



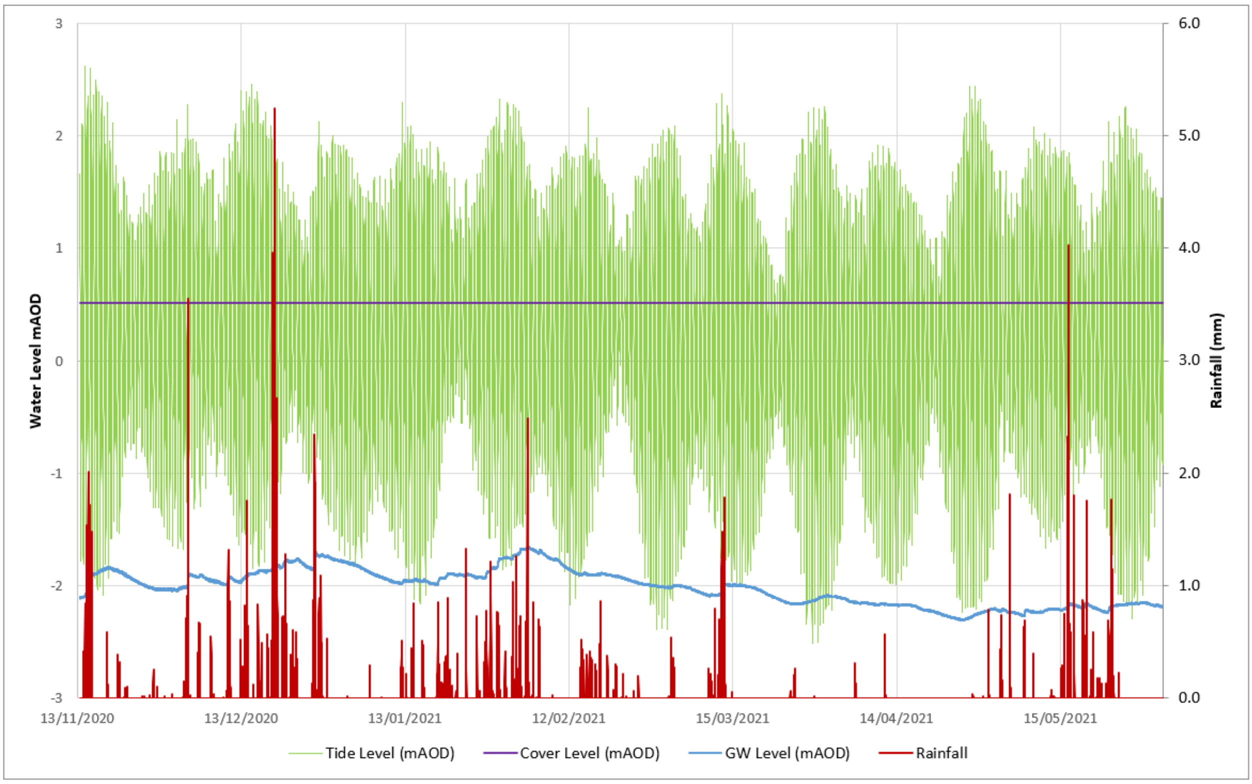
E.16 11z Highbury Grove Hydrograph

Hydrograph for 11z Highbury Grove shows a rising and falling tide level between 01/08/2022 to 16/09/2022. The maximum tide level was 2.13m above Ordnance Datum (AOD) and the minimum level was -2.28m AOD. The blue line denotes the groundwater level from 0.797m to 1.313m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole 11z is 2.595m AOD.



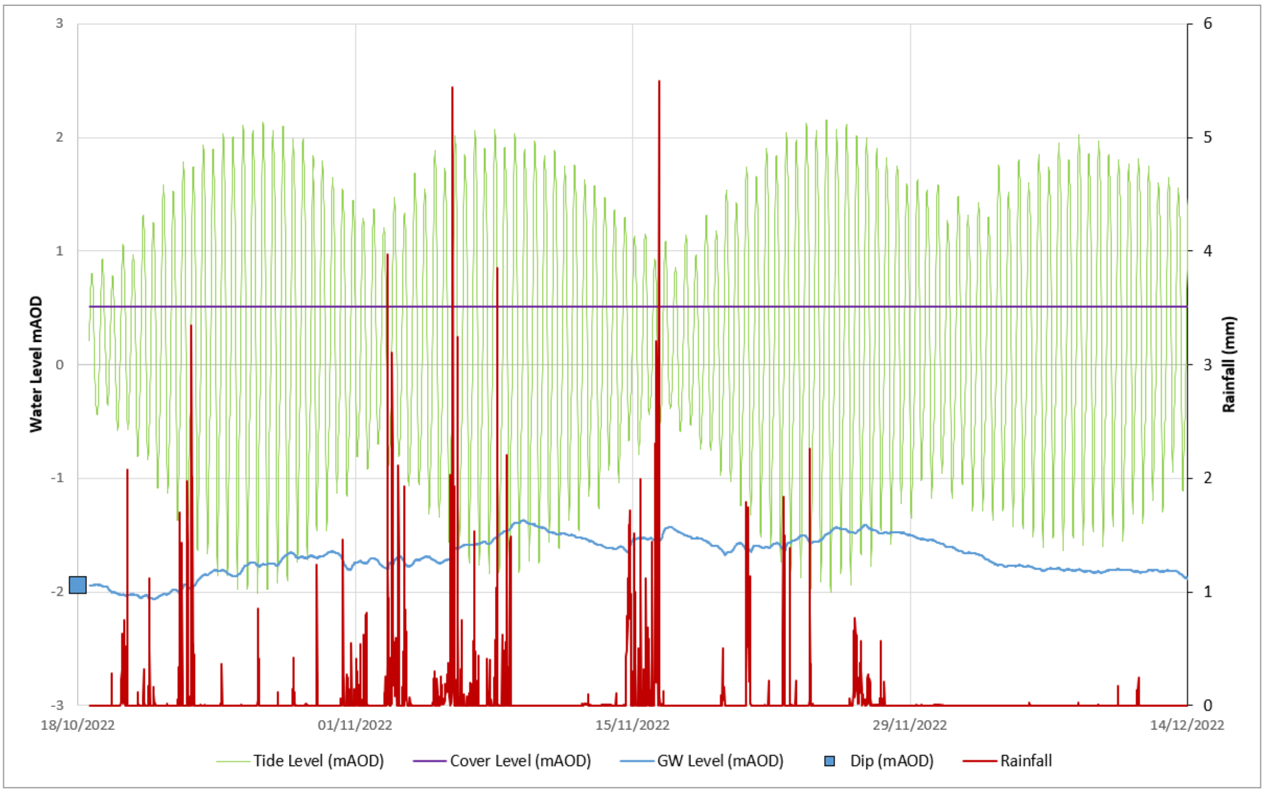
E.17 BH1 LCT Car Park Hydrographs

Hydrograph for BH1 LCT Car Park shows a rising and falling tide level between 13/11/2020 to 03/06/2021. The maximum tide level was 2.62m above Ordnance Datum (AOD) and the minimum level was -2.51m AOD. The blue line denotes the groundwater level from -2.309m to -1.655m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BH1 is 0.51m AOD.



Hydrograph for BH1 LCT Car Park shows a rising and falling tide level between 13/11/2020 to 10/10/2022. The maximum tide level was 2.14m above Ordnance Datum (AOD) and the minimum level was -2.73m AOD. The blue line denotes the groundwater level from -1.146m to -0.66m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BH1 is 0.51m AOD.

Hydrograph for BH1 LCT Car Park shows a rising and falling tide level between 18/10/2022 to 14/12/2022. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.01m AOD. The blue line denotes the groundwater level from -2.063m to -1.369m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BH1 is 0.51m AOD.



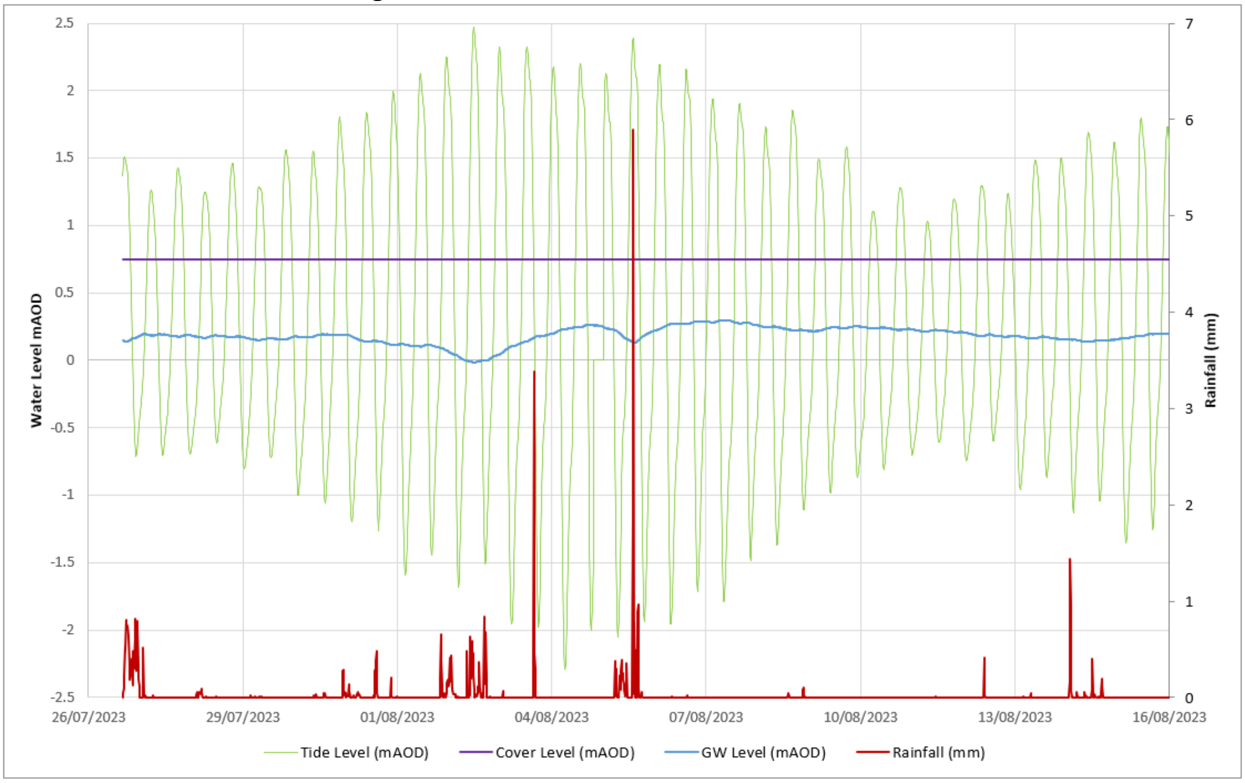
E.18 BH7a Rugby Camp Hydrograph

Hydrograph for BH7a Rugby Camp shows a rising and falling tide level between 26/07/2023 to 06/09/2023. The maximum tide level was 2.47m above Ordnance Datum (AOD) and the minimum level was -2.35m AOD. The blue line denotes the groundwater level from 0.311m to 0.769m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BH7a is 2.61m AOD.

E.19 BH16 Farlington Playing Fields Hydrographs

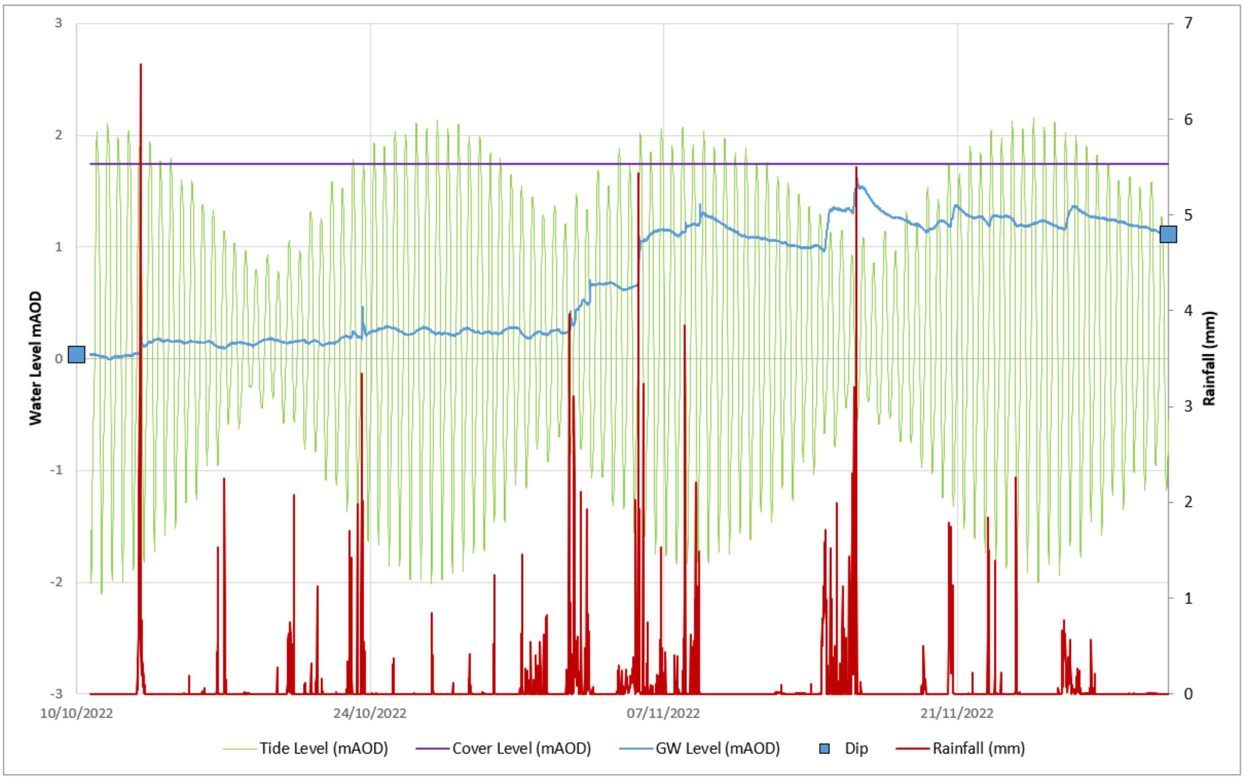
Hydrograph for BH16 Farlington Playing Fields shows a rising and falling tide level between 16/06/2023 to 21/07/2023. The maximum tide level was 2.17m above Ordnance Datum (AOD) and the minimum level was -2.0m AOD. The blue line denotes the groundwater level from 0.005m to 0.61m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BH16 is 0.75m AOD.

Hydrograph for BH16 Farlington Playing Fields shows a rising and falling tide level between 26/07/2023 to 16/08/2023. The maximum tide level was 2.47m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from -0.016m to 0.298m AOD during the monitoring period responding to tidal variation and rainfall. The ground surface level for borehole BH16 is 0.75m AOD.

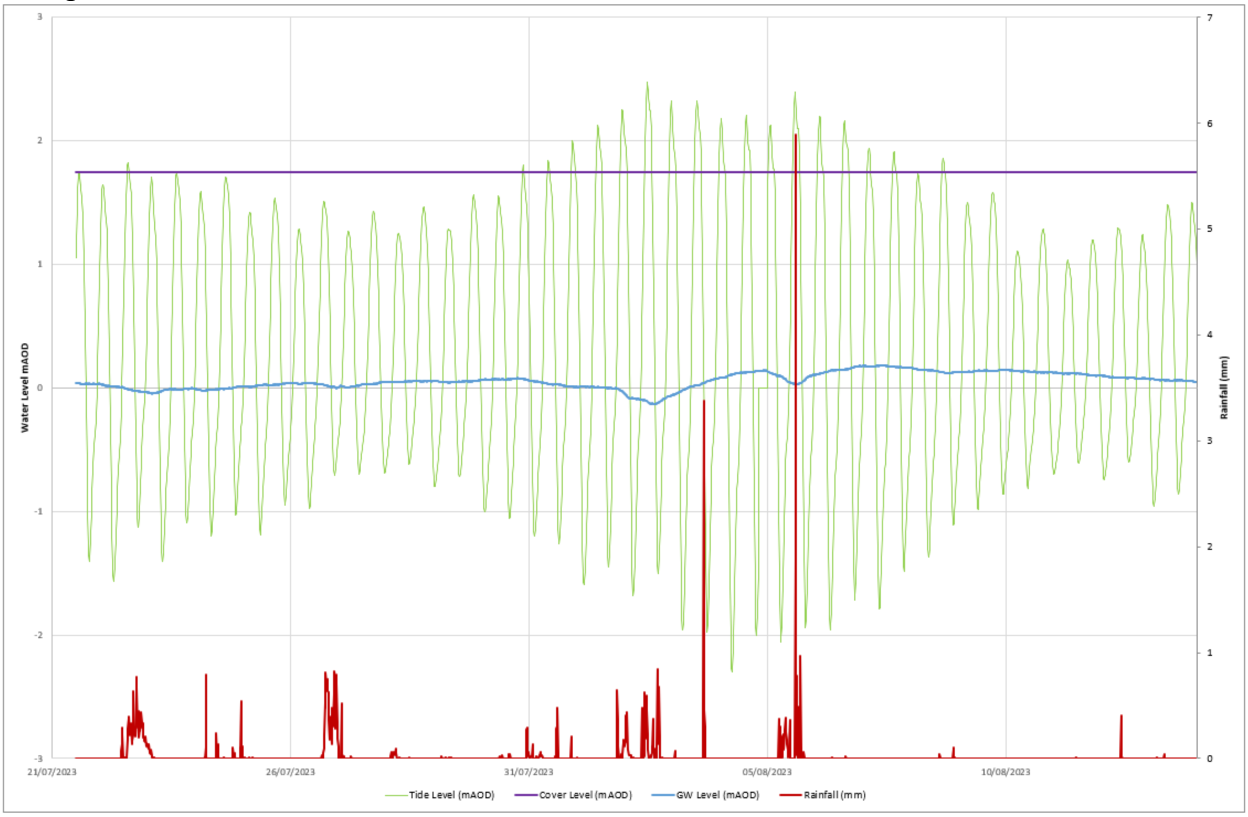


E.20 BH18 Farlington Playing Fields Hydrographs

Hydrograph for BH18 Farlington Playing Fields shows a rising and falling tide level between 10/10/2022 to 02/12/2022. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.11m AOD. The blue line denotes the groundwater level from -0.006m to 1.616m AOD during the monitoring period and responding to rainfall and seasonal variation. The ground surface level for borehole BH18 is 1.74m AOD.



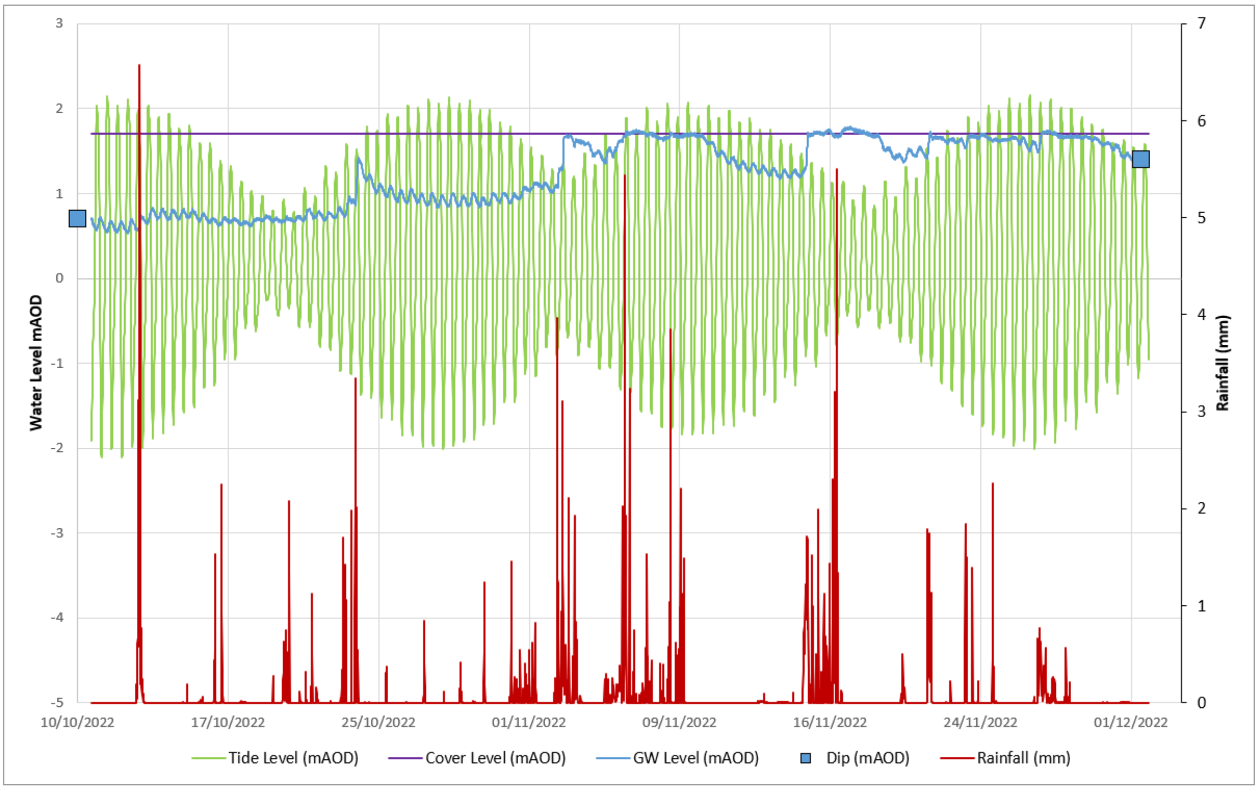
Hydrograph for BH18 Farlington Playing Fields shows a rising and falling tide level between 21/07/2023 to 14/08/2023. The maximum tide level was 2.47m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from -0.136m to 0.182m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BH18 is 1.74m AOD.



Hydrograph for BH18 Farlington Playing Fields shows a rising and falling tide level between 14/08/2023 to 10/10/2023. The maximum tide level was 2.43m above Ordnance Datum (AOD) and the minimum level was -2.35m AOD. The blue line denotes the groundwater level from -0.19m to 0.82m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BH18 is 1.74m AOD.

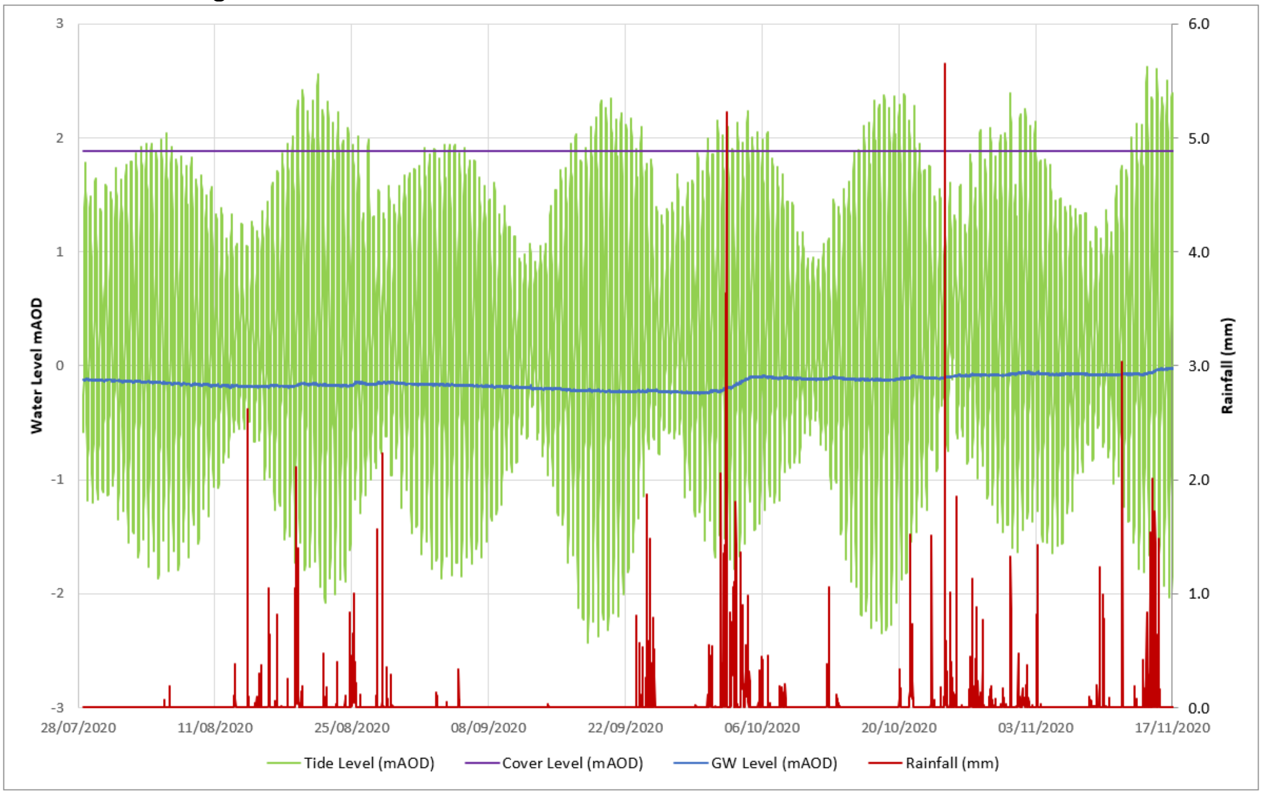
E.21 BH19 Anchorage Park Hydrograph

Hydrograph for BH19 Anchorage Park shows a rising and falling tide level between 10/10/2022 to 02/12/2022. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.11m AOD. The blue line denotes the groundwater level from 0.532m to 1.785m AOD during the monitoring period and responding to tidal variation and strong rainfall events. The ground surface level for borehole BH19 is 1.71m AOD.

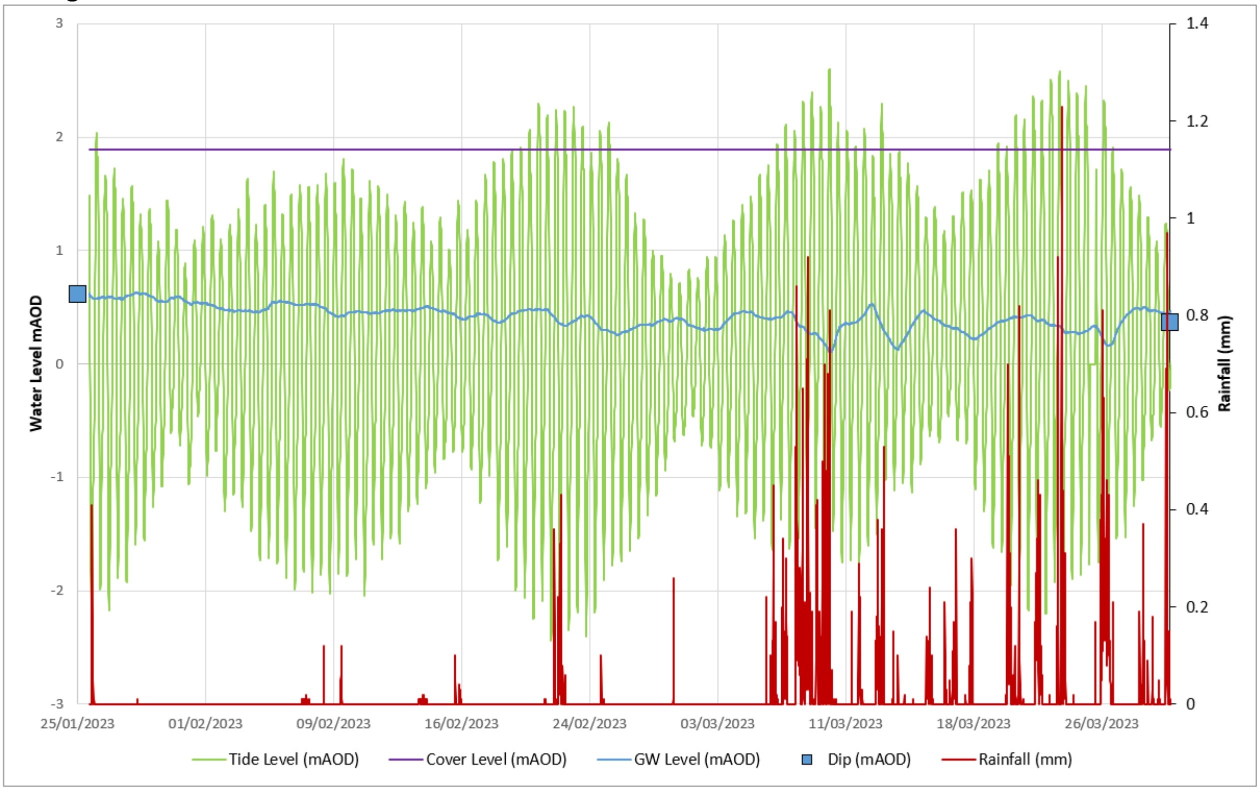


E.22 BH19a Tangier Road Hydrographs

Hydrograph for BH19a Tangier Road shows a rising and falling tide level between 28/07/2020 to 17/11/2020. The maximum tide level was 2.62m above Ordnance Datum (AOD) and the minimum level was -2.43m AOD. The blue line denotes the groundwater level from -0.247m to -0.018m AOD during the monitoring period and with a slight response to rainfall. The ground surface level for borehole BH19a is 1.89m AOD.

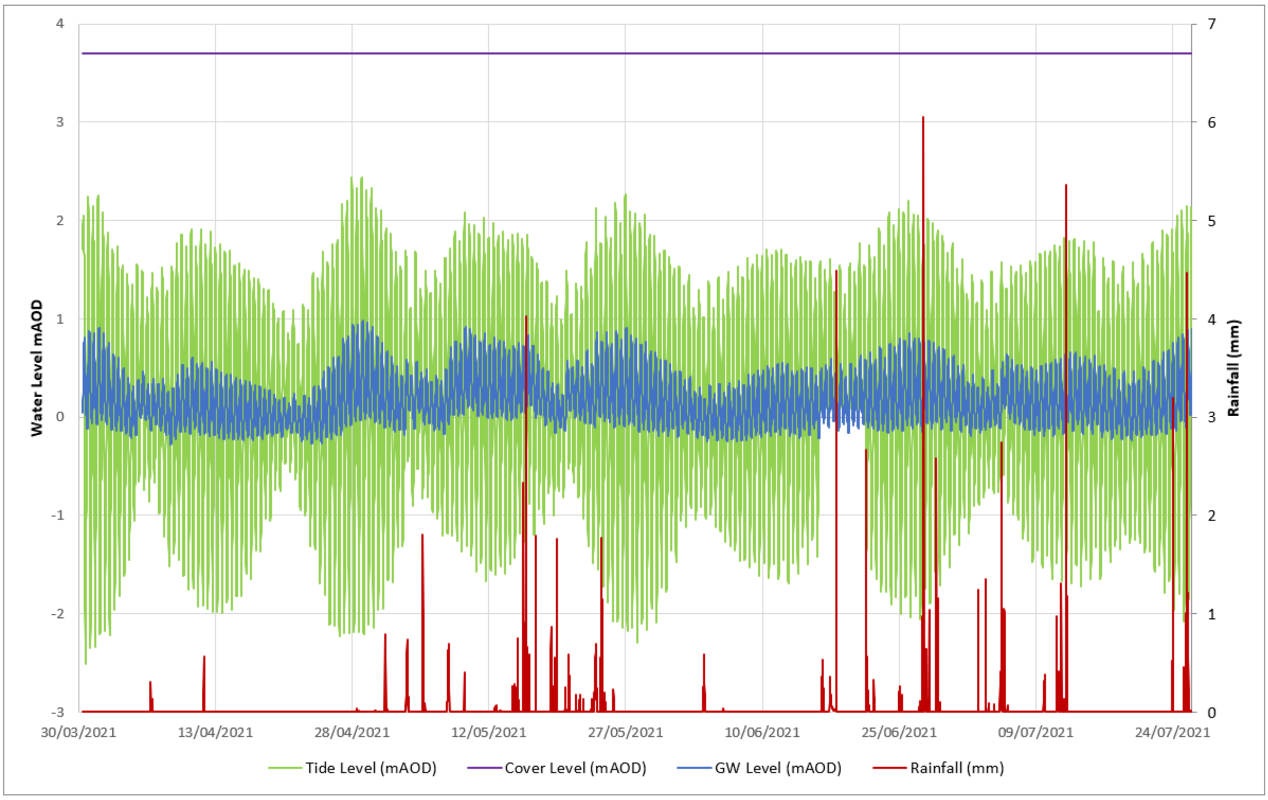


Hydrograph for BH19a Tangier Road shows a rising and falling tide level between 25/01/2023 to 30/03/2023. The maximum tide level was 2.60m above Ordnance Datum (AOD) and the minimum level was -2.45m AOD. The blue line denotes the groundwater level from 0.107m to 0.634m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BH19a is 1.89m AOD.



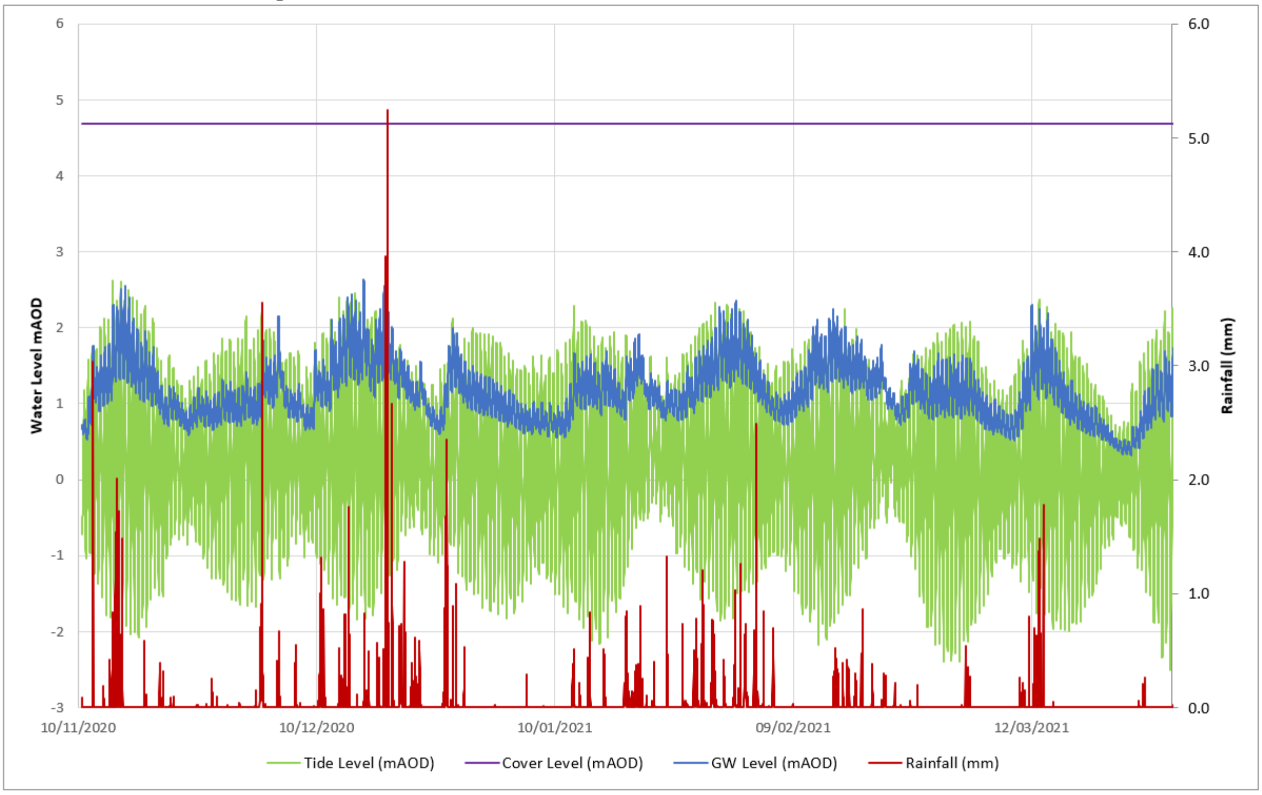
E.23 BH21 Canoe Lake Car Park West Hydrograph

Hydrograph for BH21 Canoe Lake Car Park West shows a rising and falling tide level between 30/03/2021 to 26/07/2021. The maximum tide level was 2.44m above Ordnance Datum (AOD) and the minimum level was -2.51m AOD. The blue line denotes the groundwater level from -0.276m to 0.98m AOD during the monitoring period and responding strongly to tidal variation. The ground surface level for borehole BH21 is 3.70m AOD.



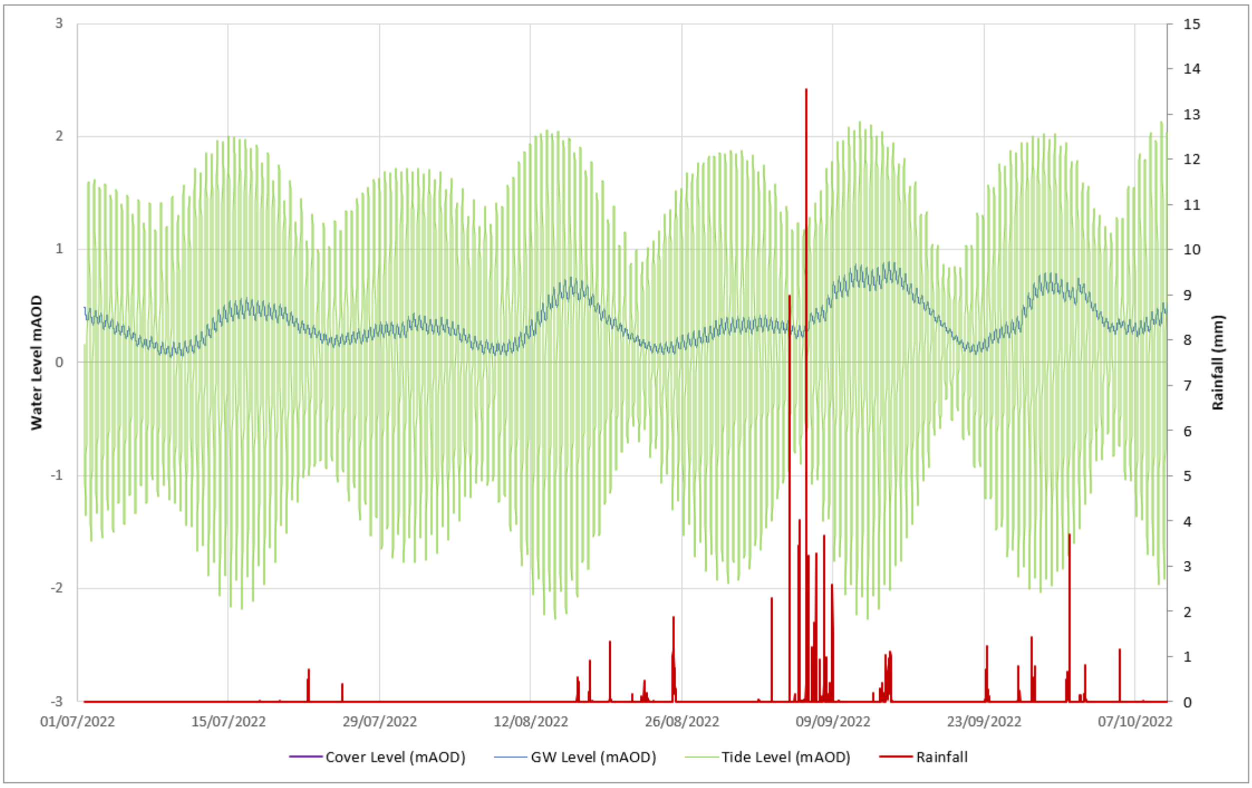
E.24 BH22 Splash Wall West End Hydrograph

Hydrograph for BH22 Splash Wall West End shows a rising and falling tide level between 10/11/2020 to 30/03/2021. The maximum tide level was 2.62m above Ordnance Datum (AOD) and the minimum level was -2.51m AOD. The blue line denotes the groundwater level from 0.323m to 2.629m AOD during the monitoring period and responding strongly to tidal variation. The ground surface level for borehole BH22 is 4.68m AOD.



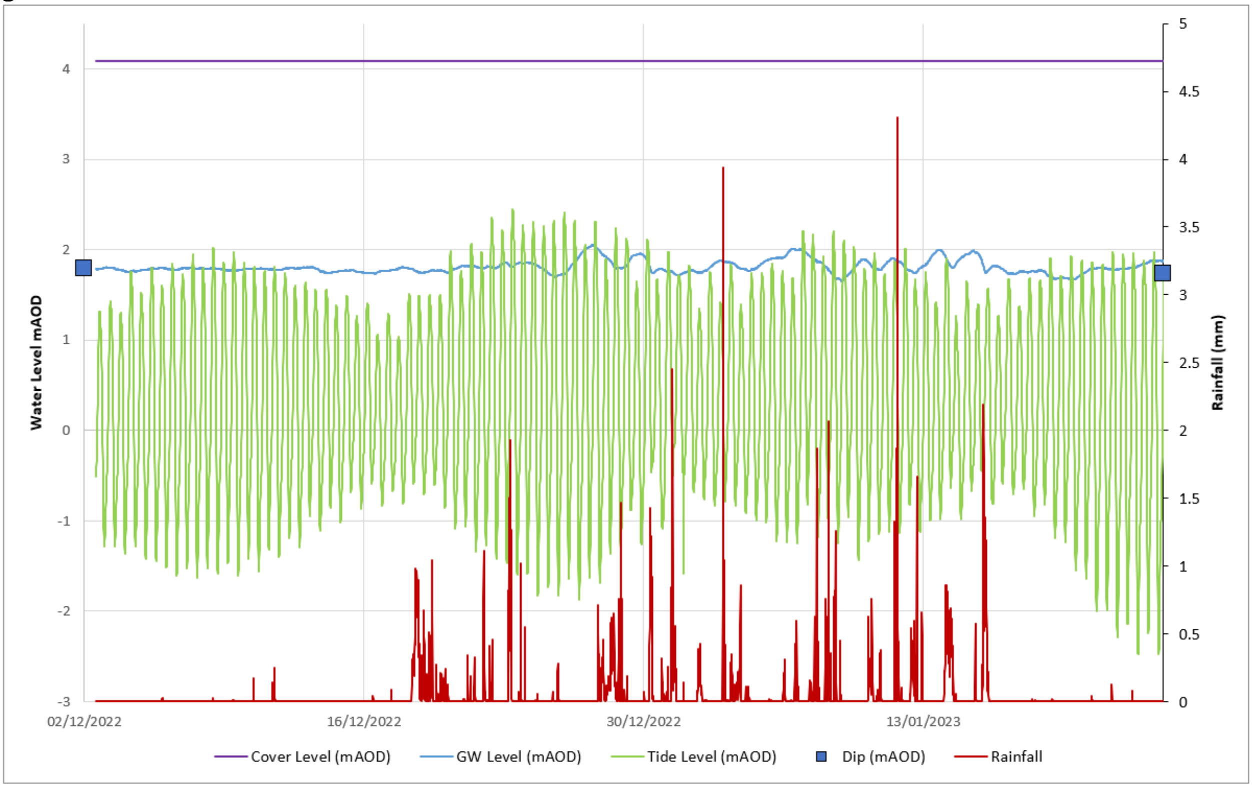
E.25 BH24 Splash Wall East End Hydrograph

Hydrograph for BH24 Splash Wall East End shows a rising and falling tide level between 01/07/2022 to 10/10/2022. The maximum tide level was 2.14m above Ordnance Datum (AOD) and the minimum level was -2.28m AOD. The blue line denotes the groundwater level from 0.043m to 0.895m AOD during the monitoring period and responding strongly to tidal variation. The ground surface level for borehole BH24 is 4.64m AOD.



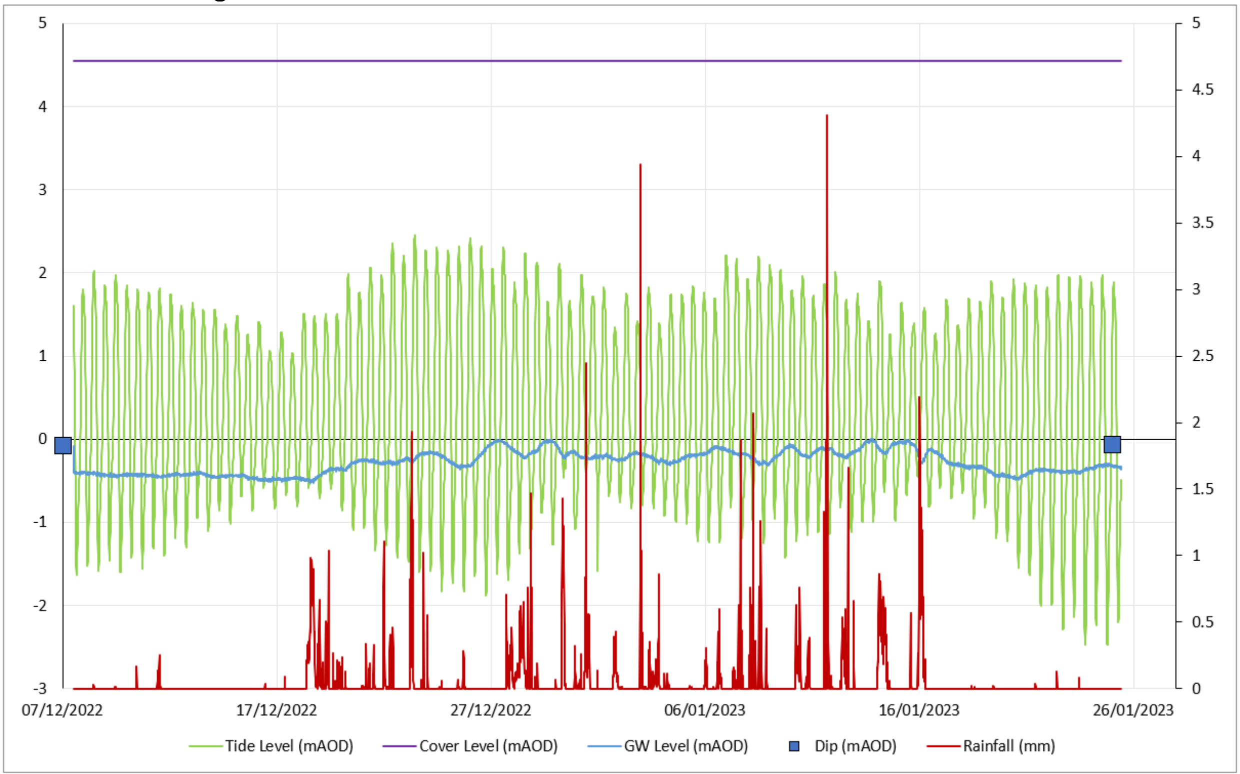
E.26 BH34a Kingsley Road Hydrograph

Hydrograph for BH34a Kingsley Road shows a rising and falling tide level between 02/12/2022 to 25/01/2023. The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.48m AOD. The blue line denotes the groundwater level from 1.65m to 2.05m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BH34a is 4.09m AOD.



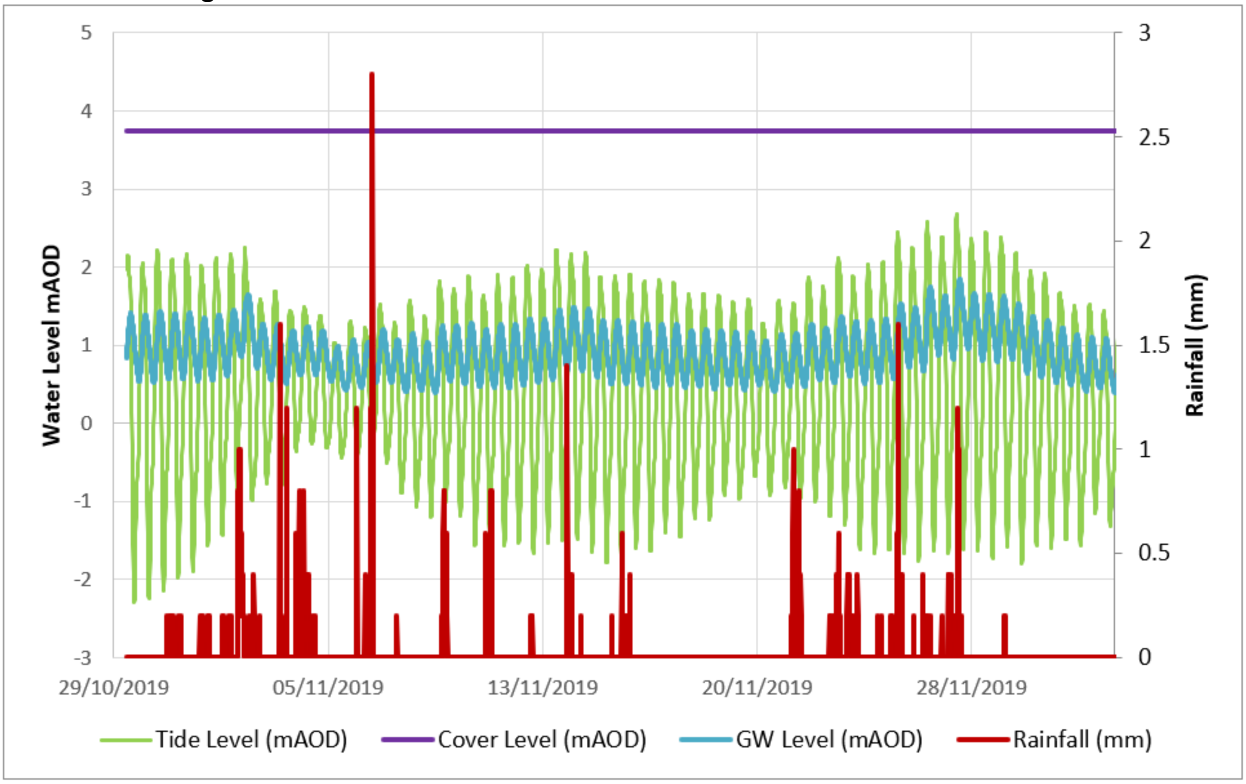
E.27 BH36 Anchorage Park Playing Field Hydrograph

Hydrograph for BH36 Anchorage Park Playing Field shows a rising and falling tide level between 10/10/2022 to 02/12/2022. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.11m AOD. The blue line denotes the groundwater level from 0.633m to 2.30m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BH36 is 2.41m AOD.



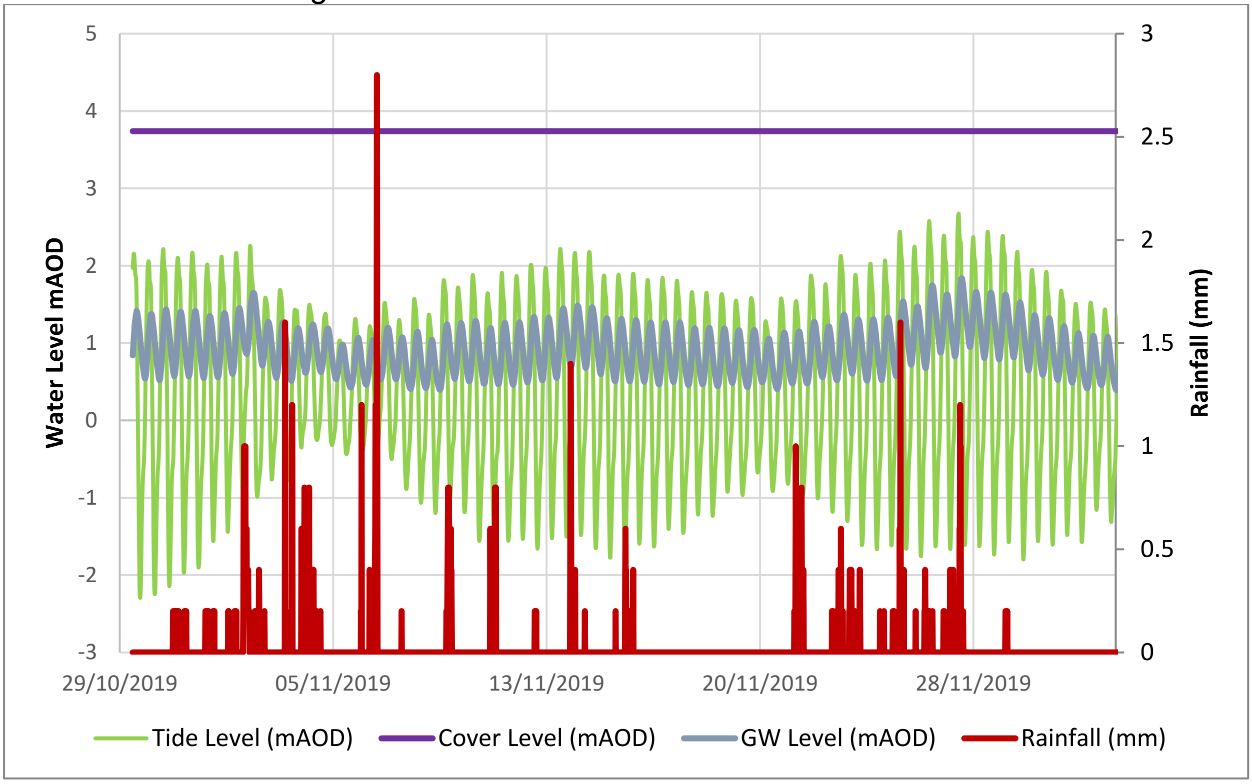
E.28 BHRH01 LCM Revetment Hydrograph

Hydrograph for BHRH01 LCM Revetment shows a rising and falling tide level between 29/10/2019 to 03/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from -0.29m to 2.01m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHRH01 is 4.2m AOD.



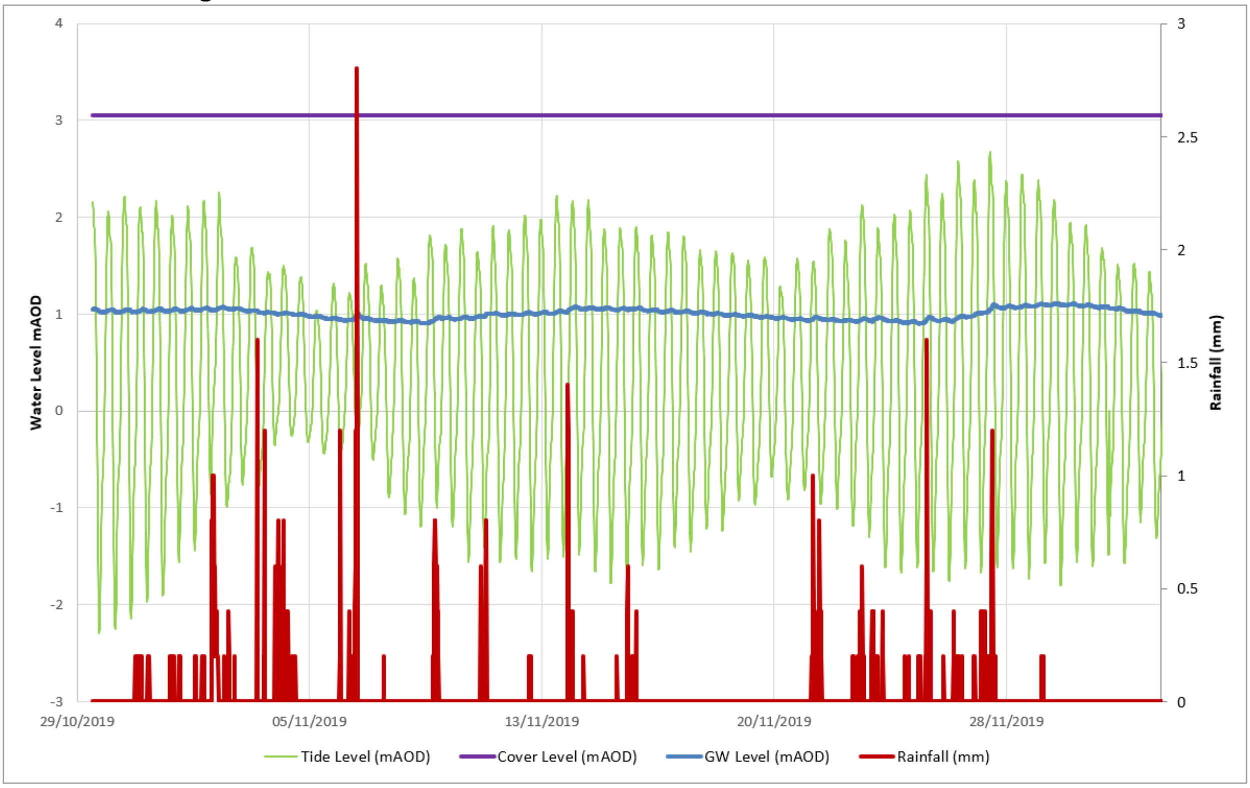
E.29 BHRH03 Clarence Pier Promenade Hydrograph

Hydrograph for BHRH03 Clarence Pier Promenade shows a rising and falling tide level between 29/10/2019 to 03/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from 0.39m to 1.839m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHRH03 is 3.74m AOD.

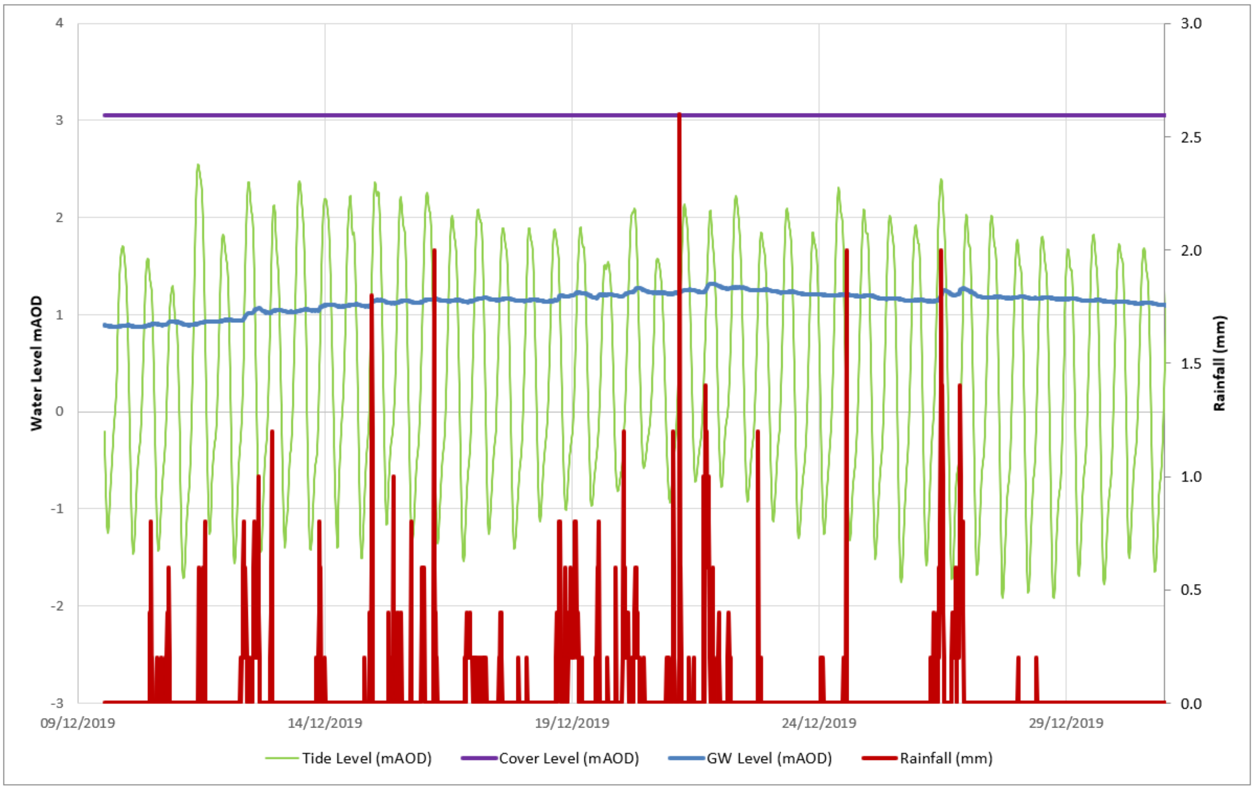


E.30 BHRH04 LCM Deep Hydrographs

Hydrograph for BHRH04 LCM Deep shows a rising and falling tide level between 29/10/2019 to 03/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from 0.902m to 1.115m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHRH04 is 3.05m AOD.

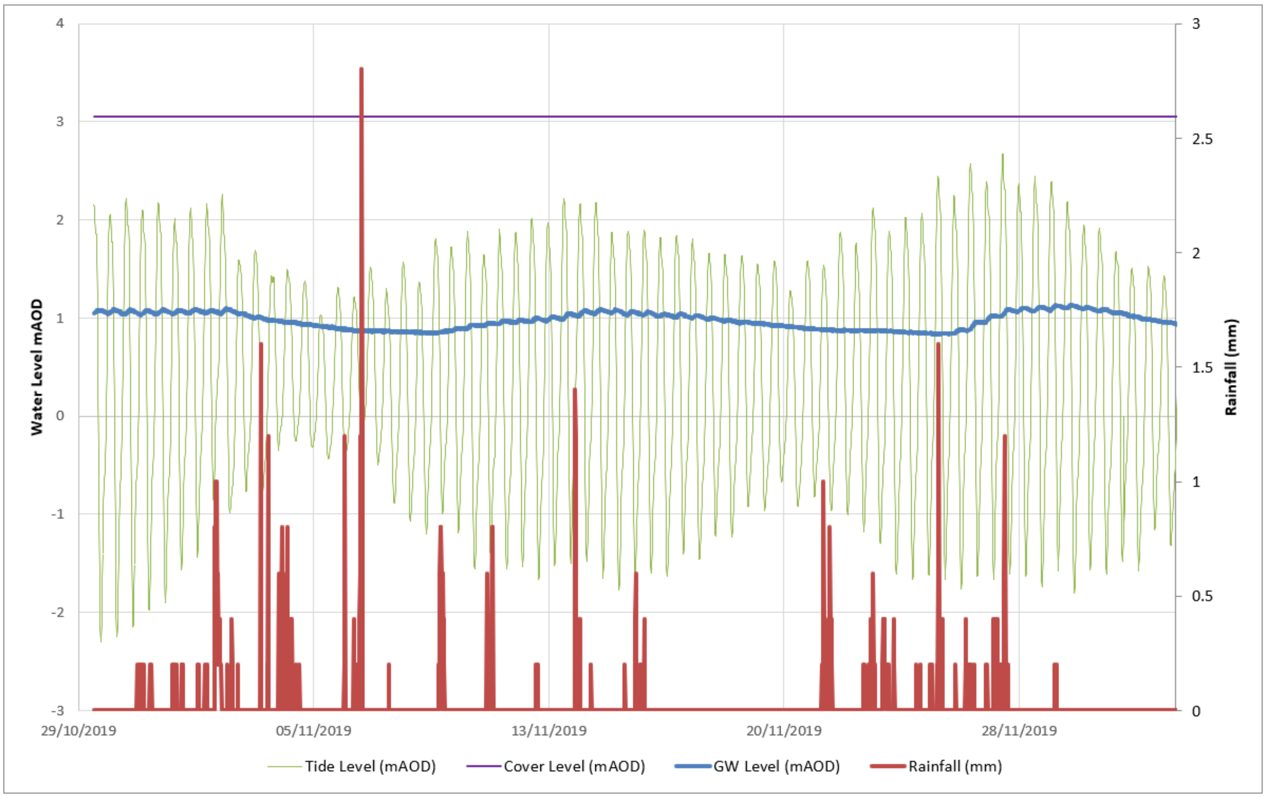


Hydrograph for BHRH04 LCM Deep shows a rising and falling tide level between 09/12/2019 to 31/12/2019. The maximum tide level was 2.55m above Ordnance Datum (AOD) and the minimum level was -1.92m AOD. The blue line denotes the groundwater level from 0.872m to 1.322m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BHRH04 is 3.05m AOD.

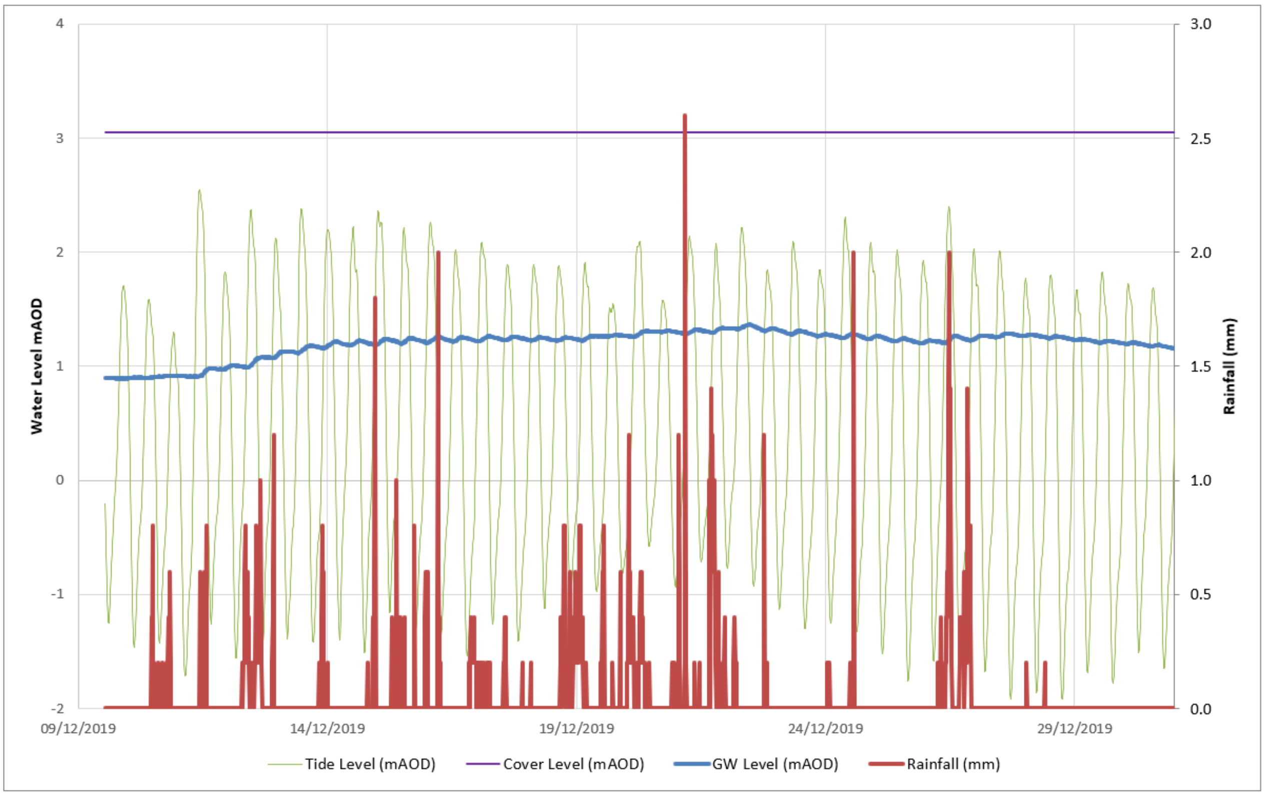


E.31 BHRH04 Shallow Grassed Area By 1c Hydrographs

Hydrograph for BHRH04 Shallow Grassed Area By 1c shows a rising and falling tide level between 29/10/2019 to 03/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from 0.831m to 1.137m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BHRH04 is 3.05m AOD.

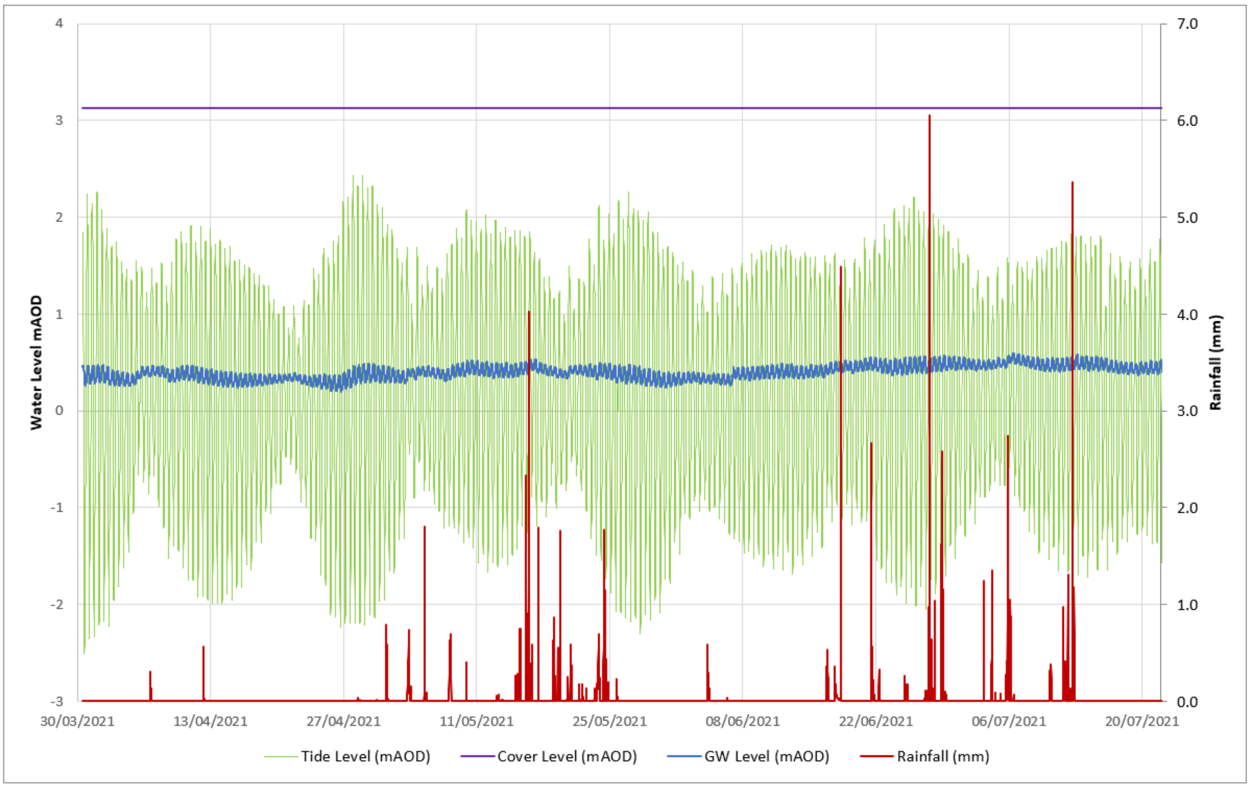


Hydrograph for BHRH04 Shallow Grassed Area By 1c shows a rising and falling tide level between 09/12/2019 to 31/12/2019. The maximum tide level was 2.55m above Ordnance Datum (AOD) and the minimum level was -1.92m AOD. The blue line denotes the groundwater level from 0.889m to 1.366m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BHRH04 is 3.05m AOD.



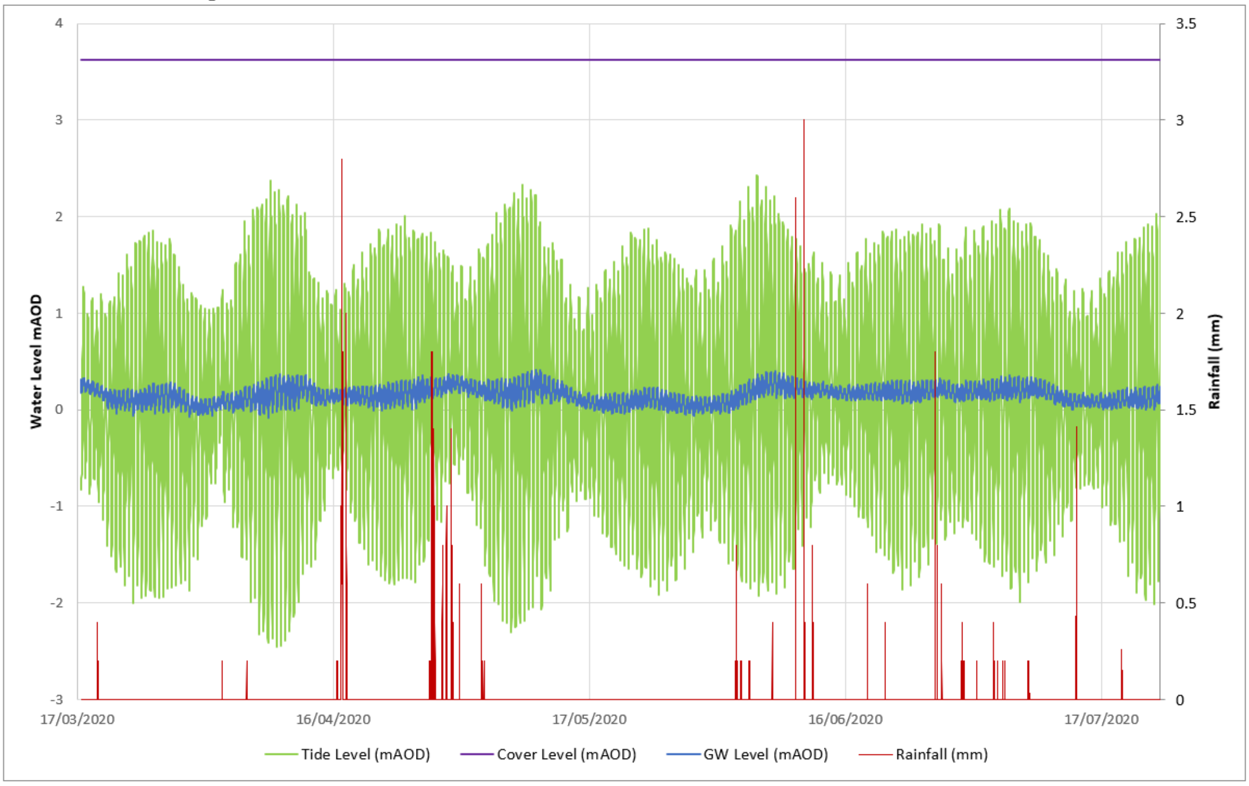
E.32 BHRH06 D Day Museum Car Park Hydrograph

Hydrograph for BHRH06 D Day Museum Car Park shows a rising and falling tide level between 30/03/2021 to 22/07/2021. The maximum tide level was 2.44m above Ordnance Datum (AOD) and the minimum level was -2.51m AOD. The blue line denotes the groundwater level from 0.197m to 0.599m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHRH06 is 3.13m AOD.



E.33 BHRH07 Bandstand Hydrograph

Hydrograph for BHRH07 Bandstand shows a rising and falling tide level between 17/03/2020 to 24/07/2020. The maximum tide level was 2.43m above Ordnance Datum (AOD) and the minimum level was -2.45m AOD. The blue line denotes the groundwater level from -0.08m to 0.413m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHRH07 is 3.62m AOD.

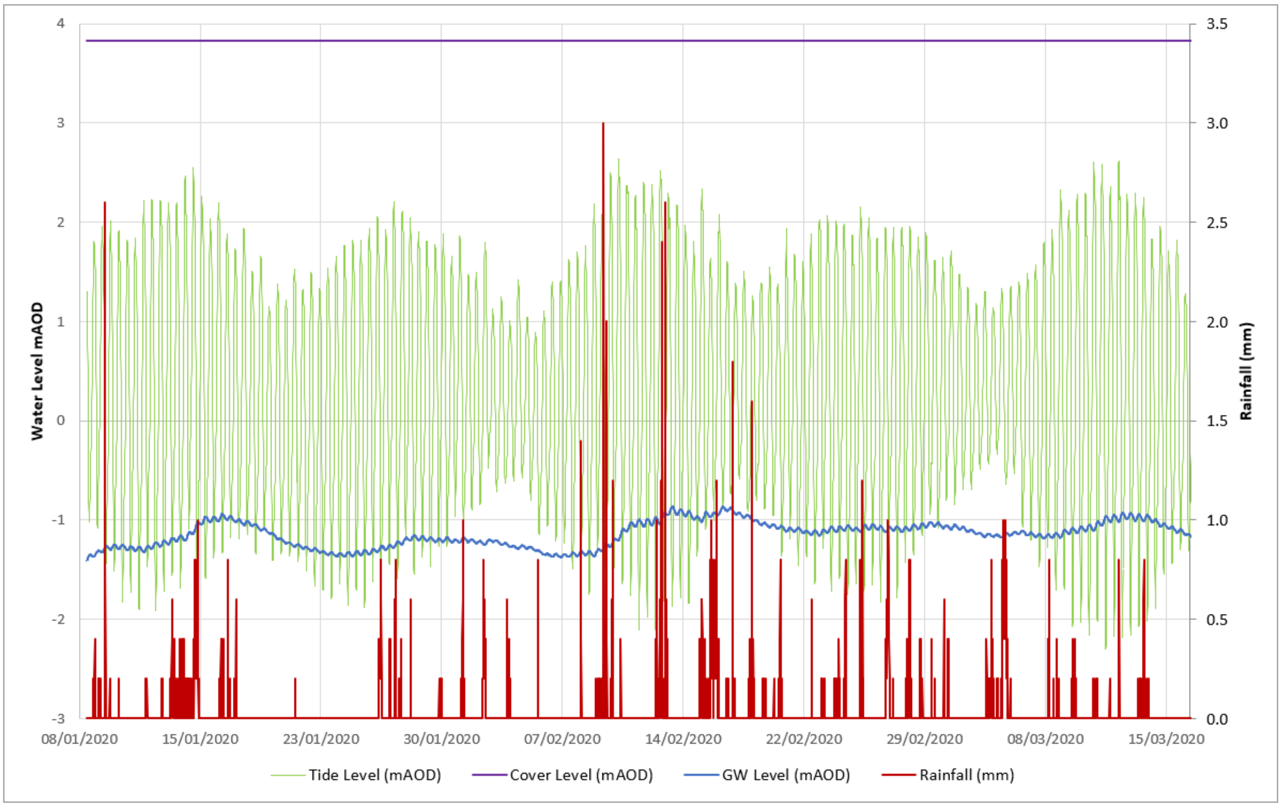


E.34 BHRH08 Southsea Castle Promenade Hydrograph

Hydrograph for BHRH08 Southsea Castle Promenade shows a rising and falling tide level between 17/03/2020 to 24/07/2020. The maximum tide level was 2.43m above Ordnance Datum (AOD) and the minimum level was -2.45m AOD. The blue line denotes the groundwater level from 0.143m to 0.754m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHRH08 is 4.53m AOD.

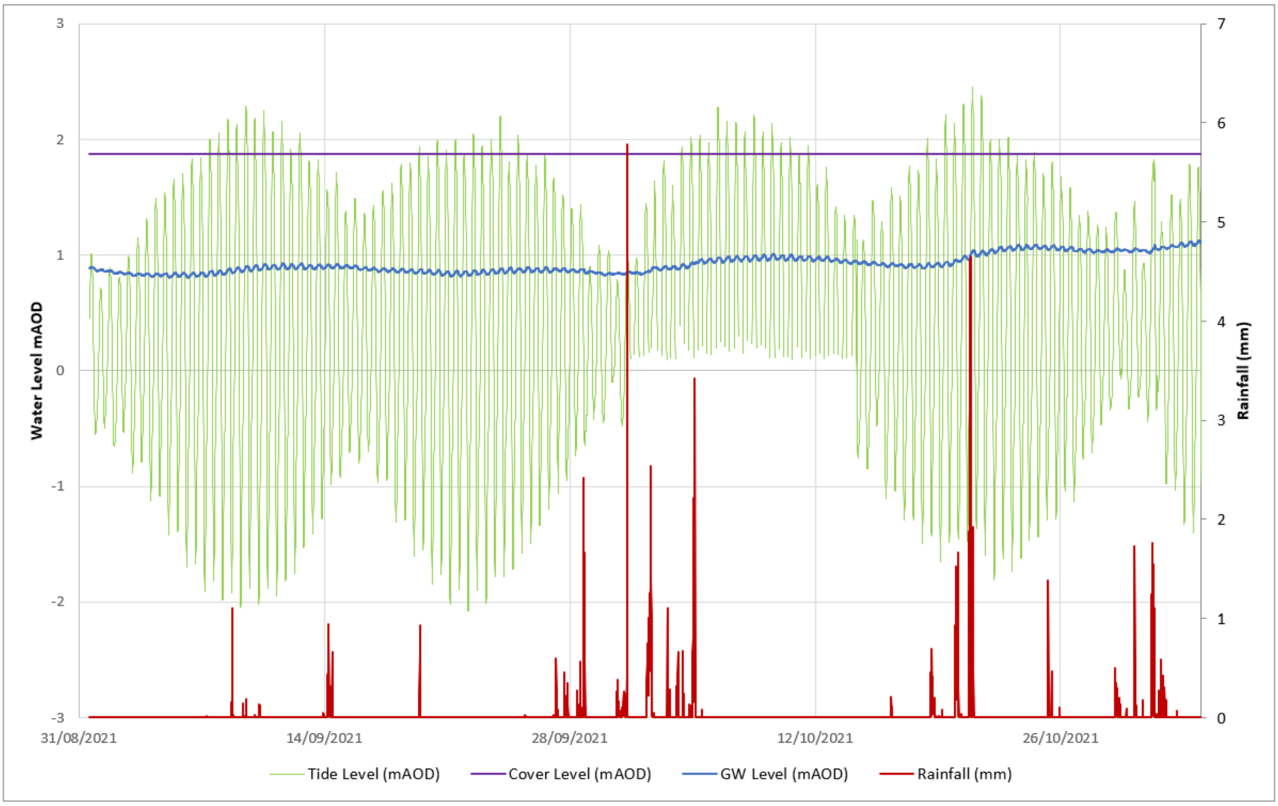
E.35 BHRH09 Southsea Castle Hydrograph.

Hydrograph for BHRH08 Southsea Castle Promenade shows a rising and falling tide level between 08/01/2020 to 17/03/2020. The maximum tide level was 2.64m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from -1.406m to -0.864m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BHRH09 is 3.83m AOD.

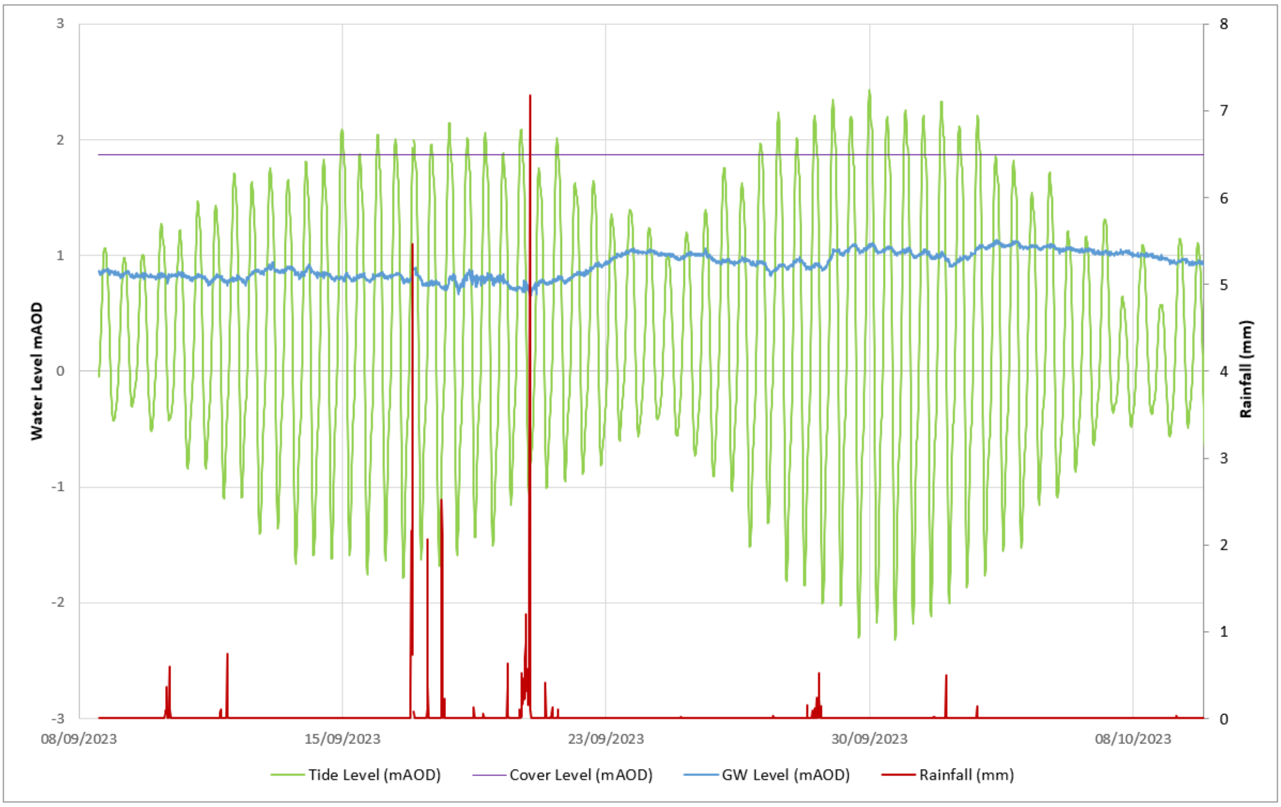


E.36 BHRH11 Little Morass Hydrographs

Hydrograph for BHRH11 Little Morass shows a rising and falling tide level between 31/08/2021 to 03/11/2021. The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.08m AOD. The blue line denotes the groundwater level from 0.803m to 1.123m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHRH11 is 1.87m AOD.

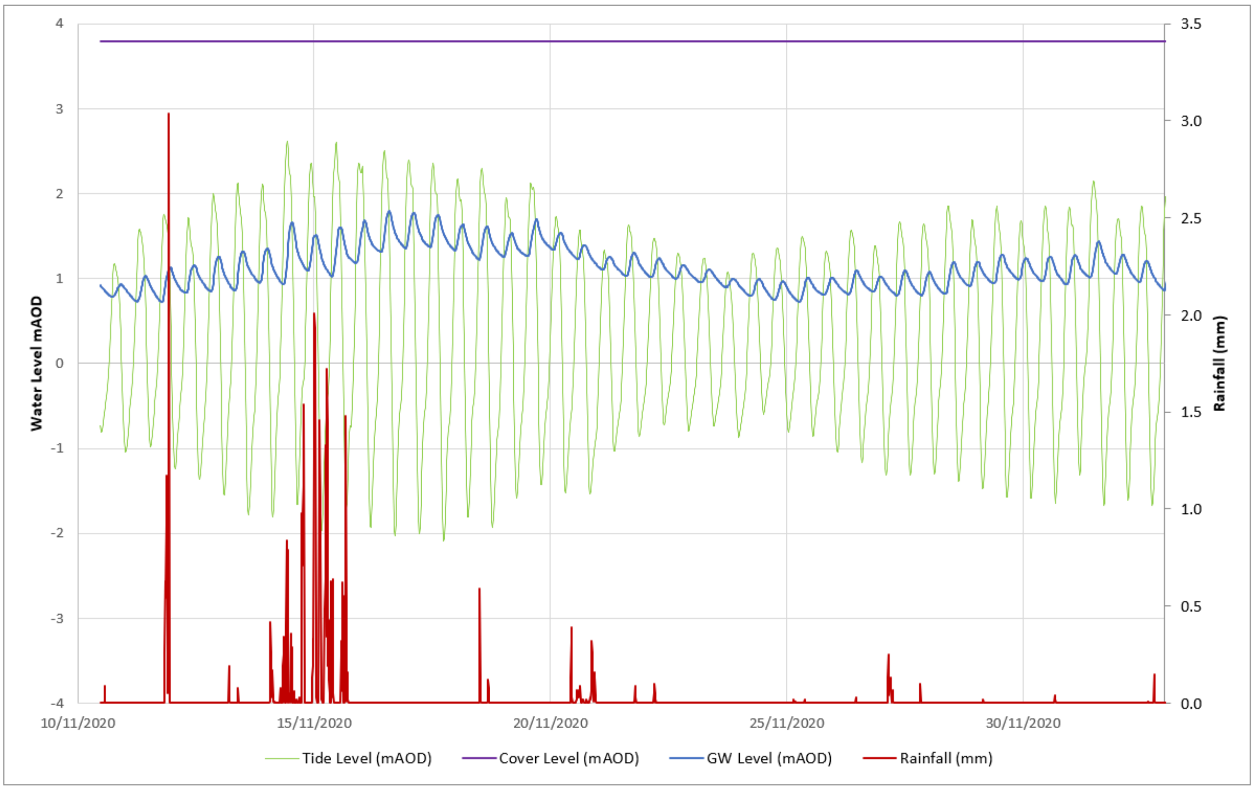


Hydrograph for BHRH11 Little Morass shows a rising and falling tide level between 08/09/2023 to 10/10/2023. The maximum tide level was 2.43m above Ordnance Datum (AOD) and the minimum level was -2.32m AOD. The blue line denotes the groundwater level from 0.641m to 1.132m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHRH11 is 1.87m AOD.



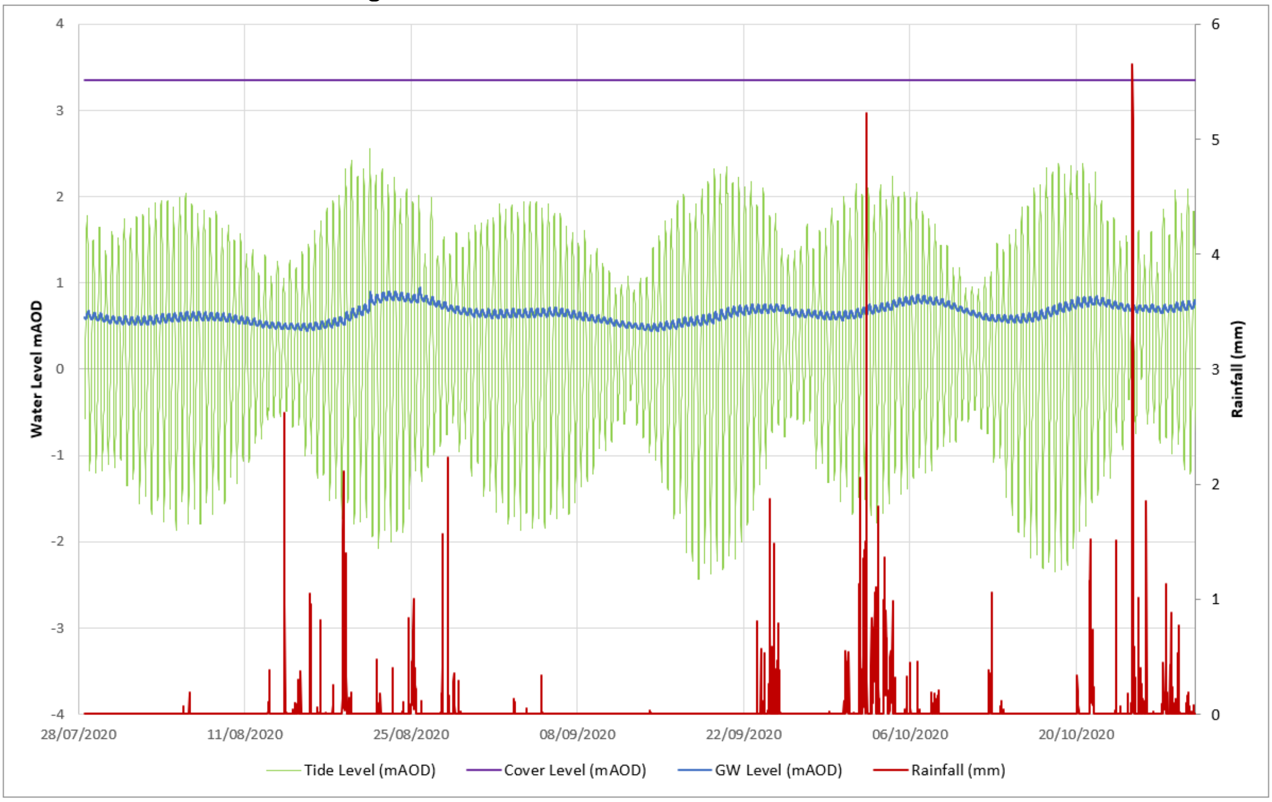
E.37 BHRH14 Mozz Joe Hydrograph

Hydrograph for BHRH14 Mozz Joe shows a rising and falling tide level between 10/11/2020 to 03/12/2020. The maximum tide level was 2.62m above Ordnance Datum (AOD) and the minimum level was -2.09m AOD. The blue line denotes the groundwater level from 0.704m to 1.792m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BHRH14 is 3.79m AOD.



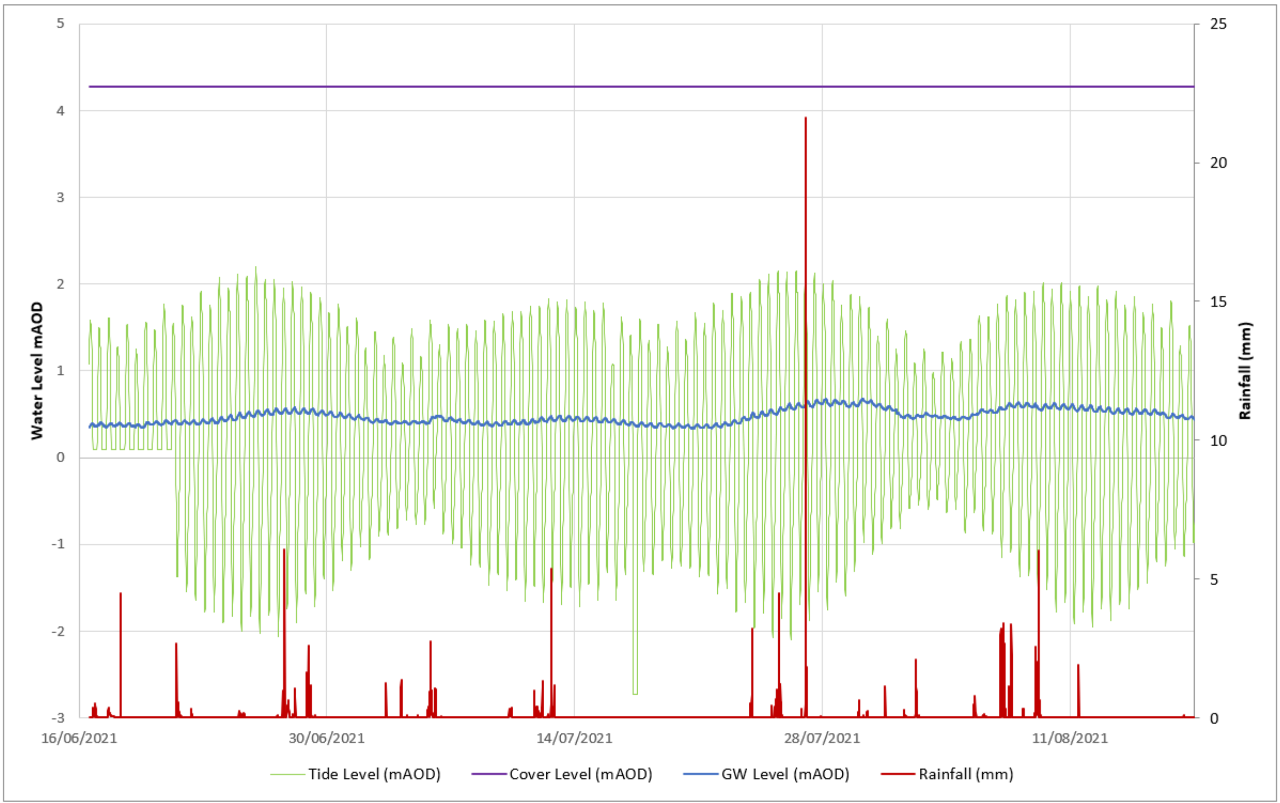
E.38 BHRH15 Esplanade Hydrograph

Hydrograph for BHRH15 Esplanade shows a rising and falling tide level between 28/07/2020 to 30/10/2020. The maximum tide level was 2.56m above Ordnance Datum (AOD) and the minimum level was -2.43m AOD. The blue line denotes the groundwater level from 0.439m to 0.943m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BHRH15 is 3.35m AOD.



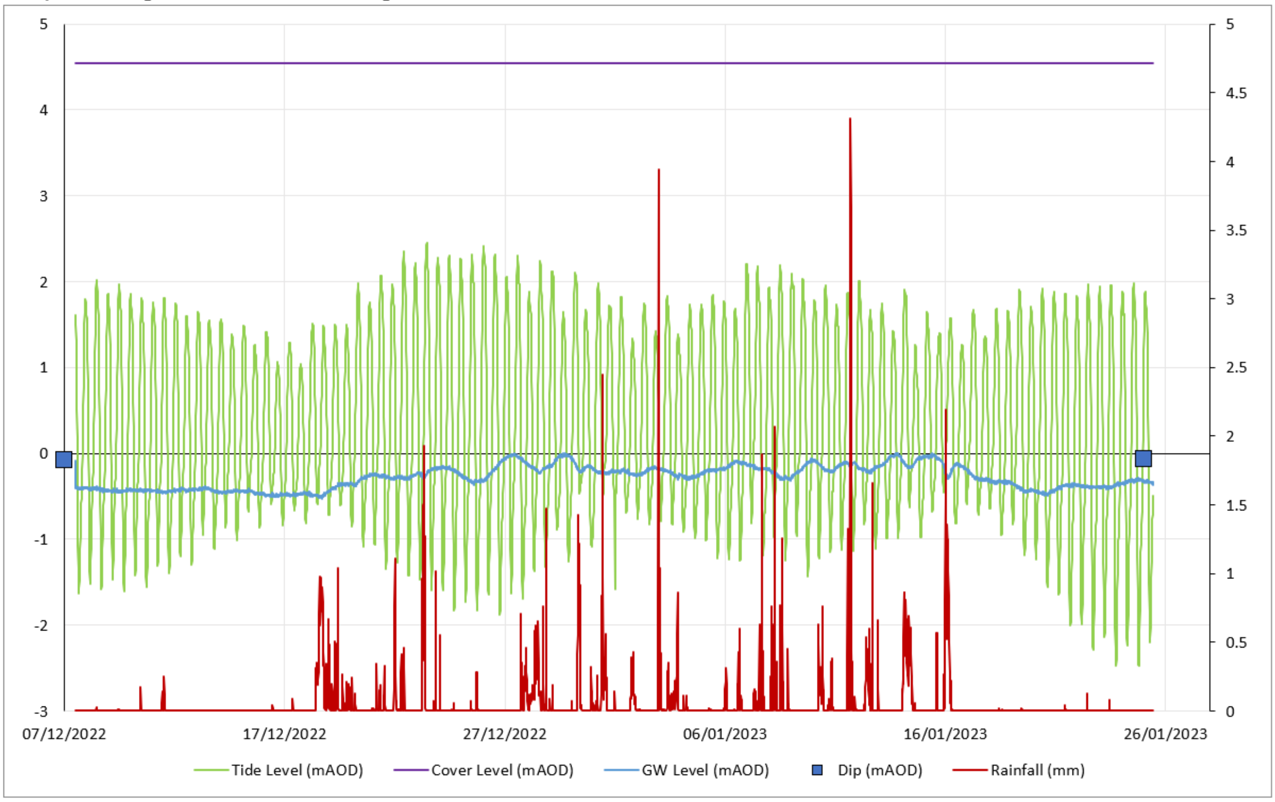
E.39 BHRH16a Pyramids Hydrograph

Hydrograph for BHRH16a Pyramids shows a rising and falling tide level between 06/06/2021 to 18/08/2021. The maximum tide level was 2.20m above Ordnance Datum (AOD) and the minimum level was -2.73m AOD. The blue line denotes the groundwater level from 0.334m to 0.677m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole BHRH16a is 4.28m AOD.



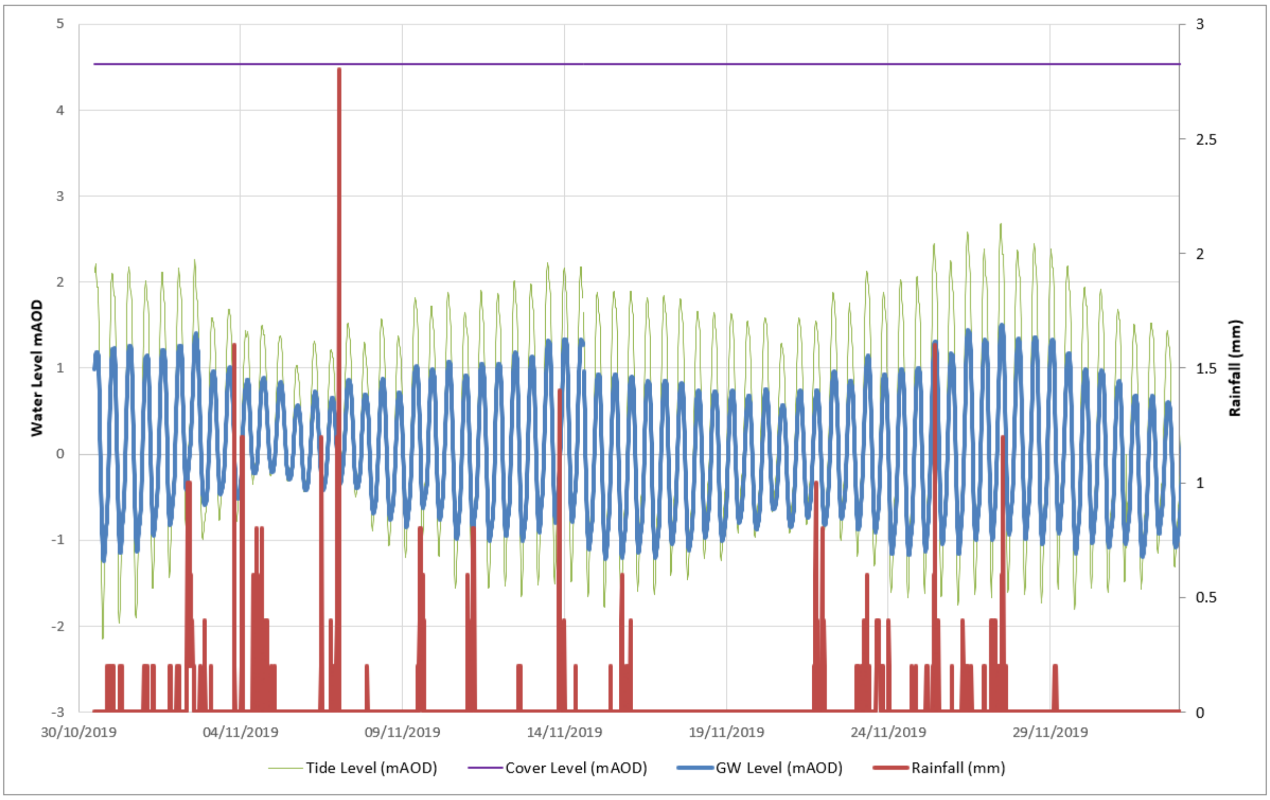
E.40 BHRH18 Promenade SPP East Hydrograph

Hydrograph for BHRH18 Promenade SPP East shows a rising and falling tide level between 07/12/2022 to 25/01/2023. The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.48m AOD. The blue line denotes the groundwater level from -0.528m to 0.006m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole BHRH18 is 4.55m AOD.



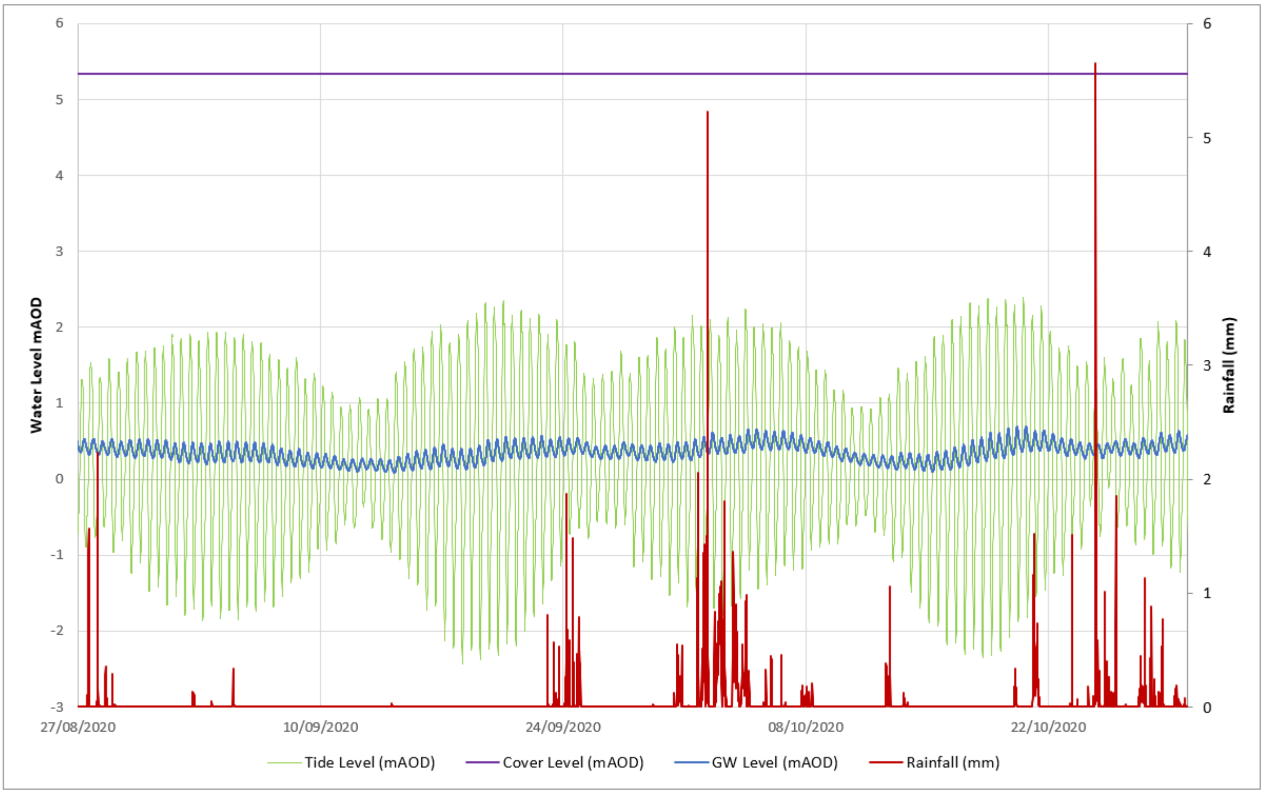
E.41 BHXX03 Canoe Lake Hydrograph

Hydrograph for BHXX03 Canoe Lake shows a rising and falling tide level between 30/10/2019 to 03/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.14m AOD. The blue line denotes the groundwater level from -1.243m to 1.505m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole BHXX03 is 4.53m AOD.



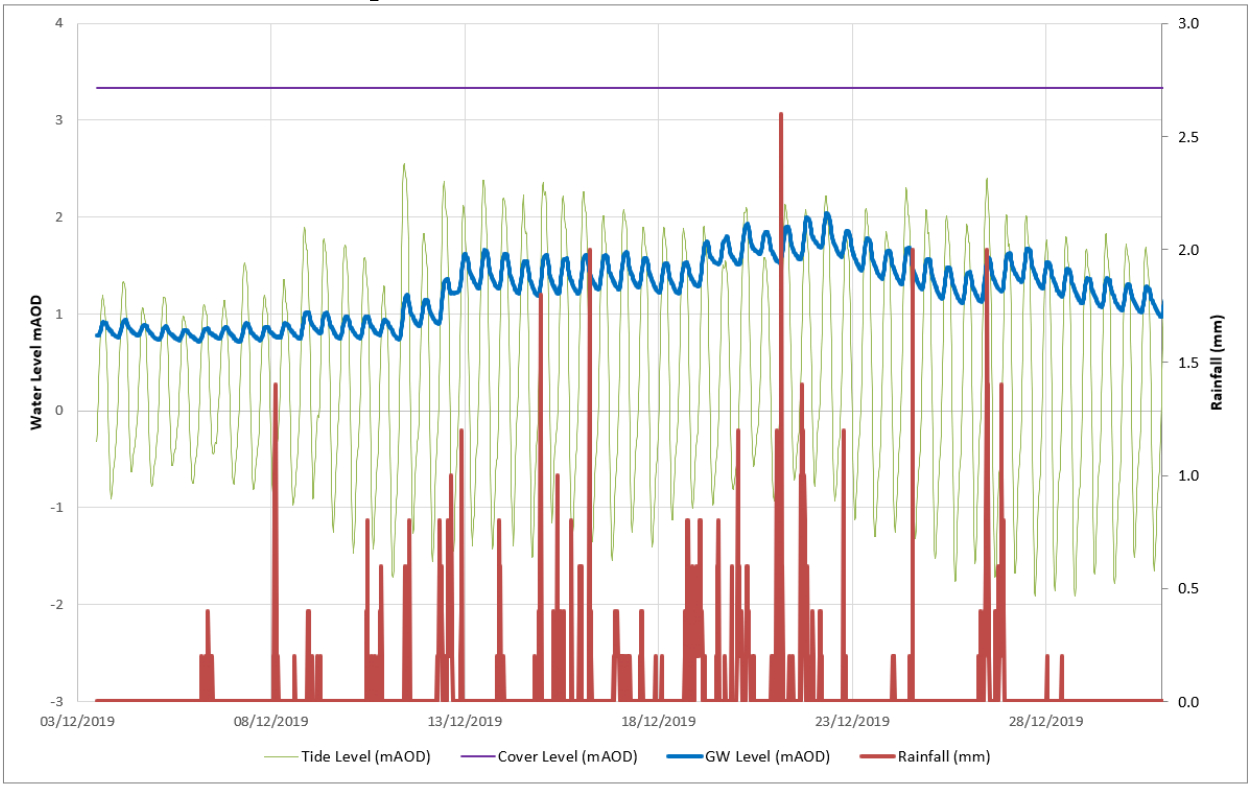
E.42 CPTRH01 Castle Promenade Hydrograph

Hydrograph for CPTRH01 Castle Promenade shows a rising and falling tide level between 30/10/2019 to 03/12/2019. The maximum tide level was 2.56m above Ordnance Datum (AOD) and the minimum level was -2.434m AOD. The blue line denotes the groundwater level from 0.077m to 1.029m AOD during the monitoring period and responding to tidal variation. The ground surface level for borehole CPTRH01 is 5.34m AOD.



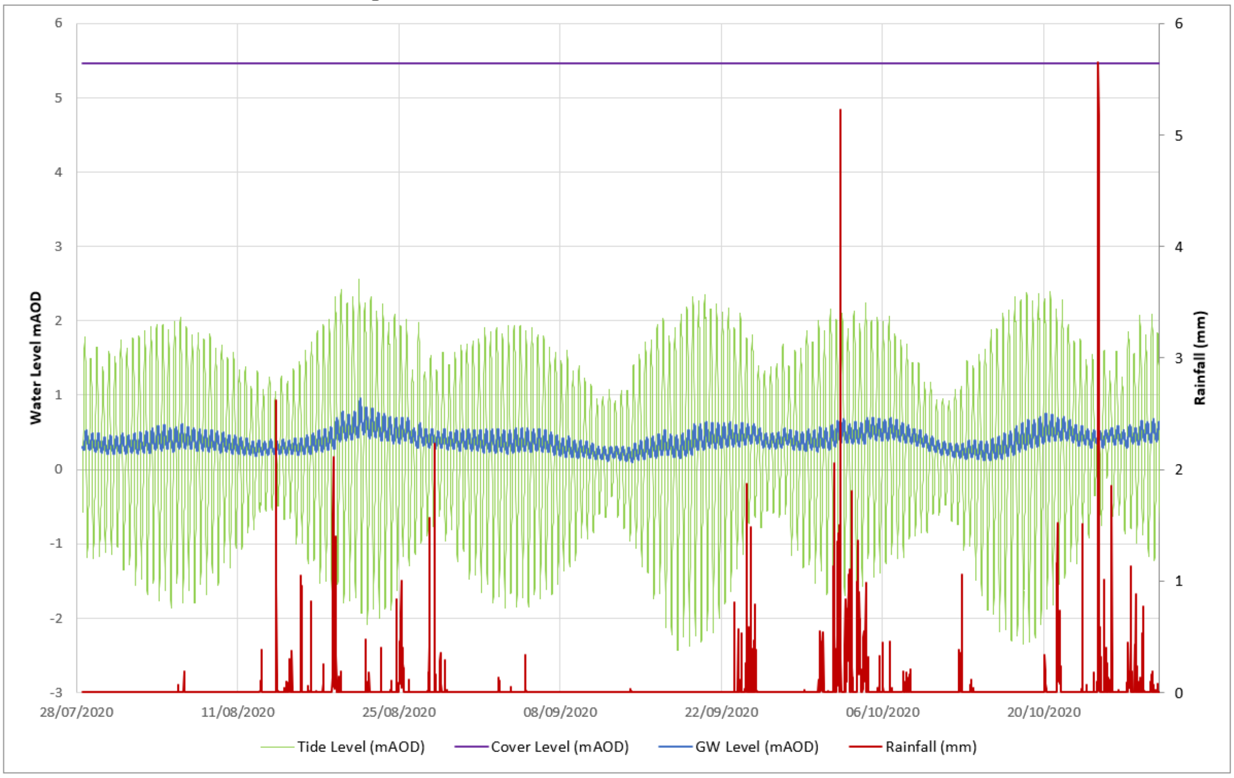
E.43 NPIBH15 Tudor Sailing Club Hydrograph

Hydrograph for NPIBH15 Tudor Sailing Club shows a rising and falling tide level between 03/12/2019 to 31/12/2019. The maximum tide level was 2.55m above Ordnance Datum (AOD) and the minimum level was -1.916m AOD. The blue line denotes the groundwater level from 0.711m to 2.039m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole CPTRH01 is 3.33m AOD.



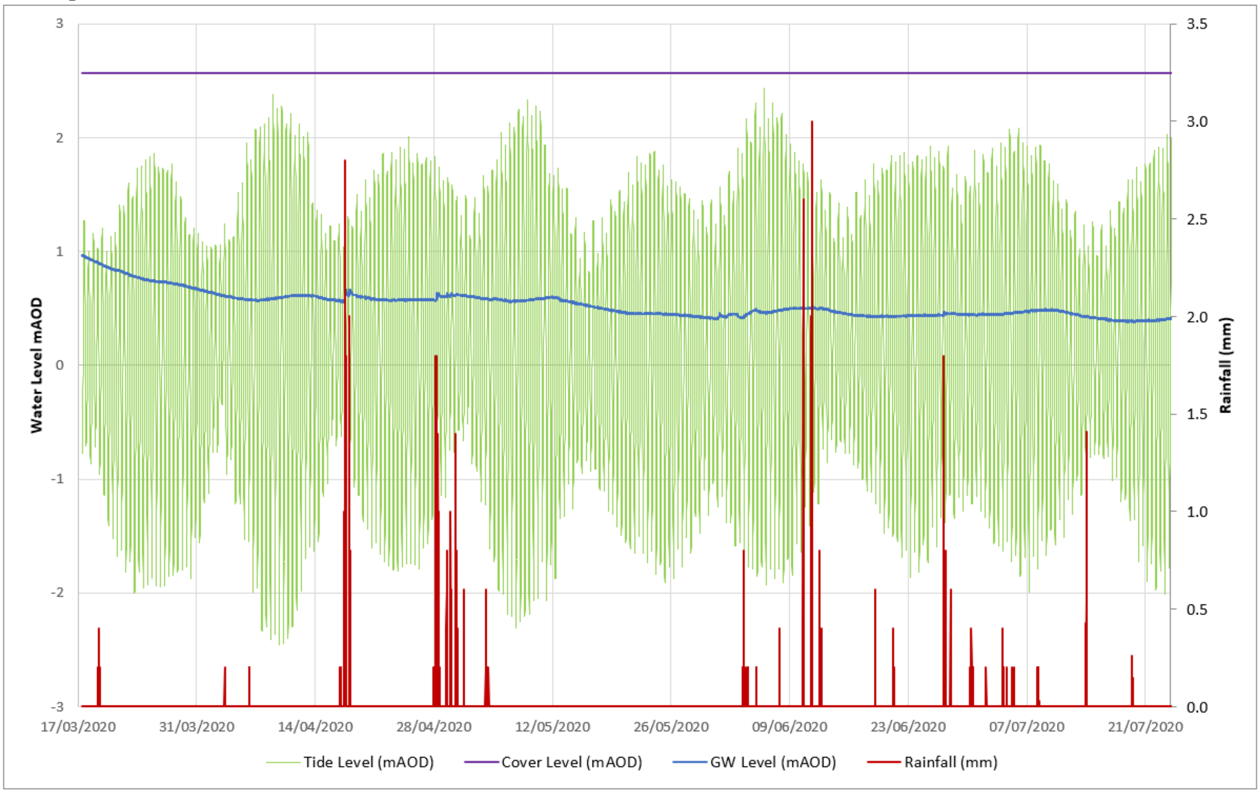
E.44 RCRH02 Castle Revetment Hydrograph

Hydrograph for RCRH02 Castle Revetment shows a rising and falling tide level between 28/07/2020 to 30/10/2020. The maximum tide level was 2.56m above Ordnance Datum (AOD) and the minimum level was -2.434m AOD. The blue line denotes the groundwater level from 0.098m to 0.953m AOD during the monitoring period and responding to tidal variation and rainfall. The ground surface level for borehole RCRH02 is 5.46m AOD.



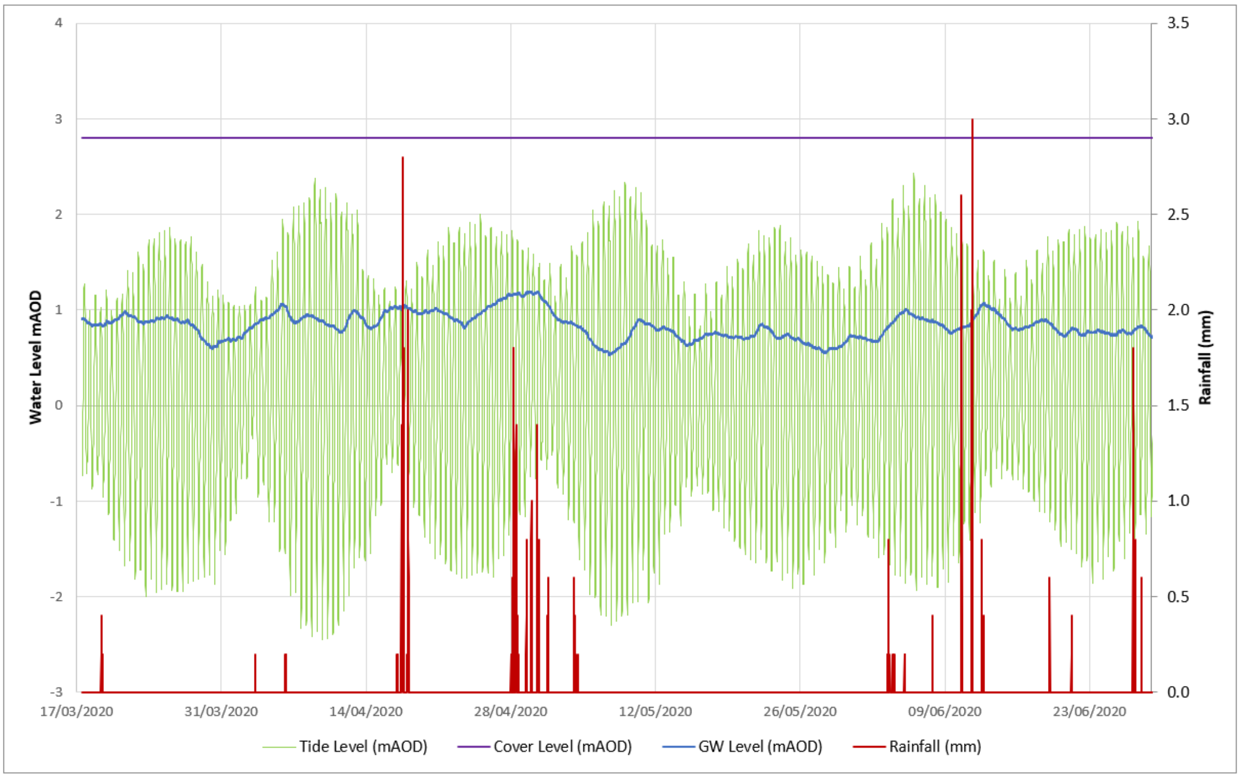
E.45 S1 Esplanade Blue Reef Hydrograph

Hydrograph for S1 Esplanade Blue Reef shows a rising and falling tide level between 17/03/2020 to 24/07/2020. The maximum tide level was 2.43m above Ordnance Datum (AOD) and the minimum level was -2.45m AOD. The blue line denotes the groundwater level from 0.379m to 0.97m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole S1 is 2.57m AOD.

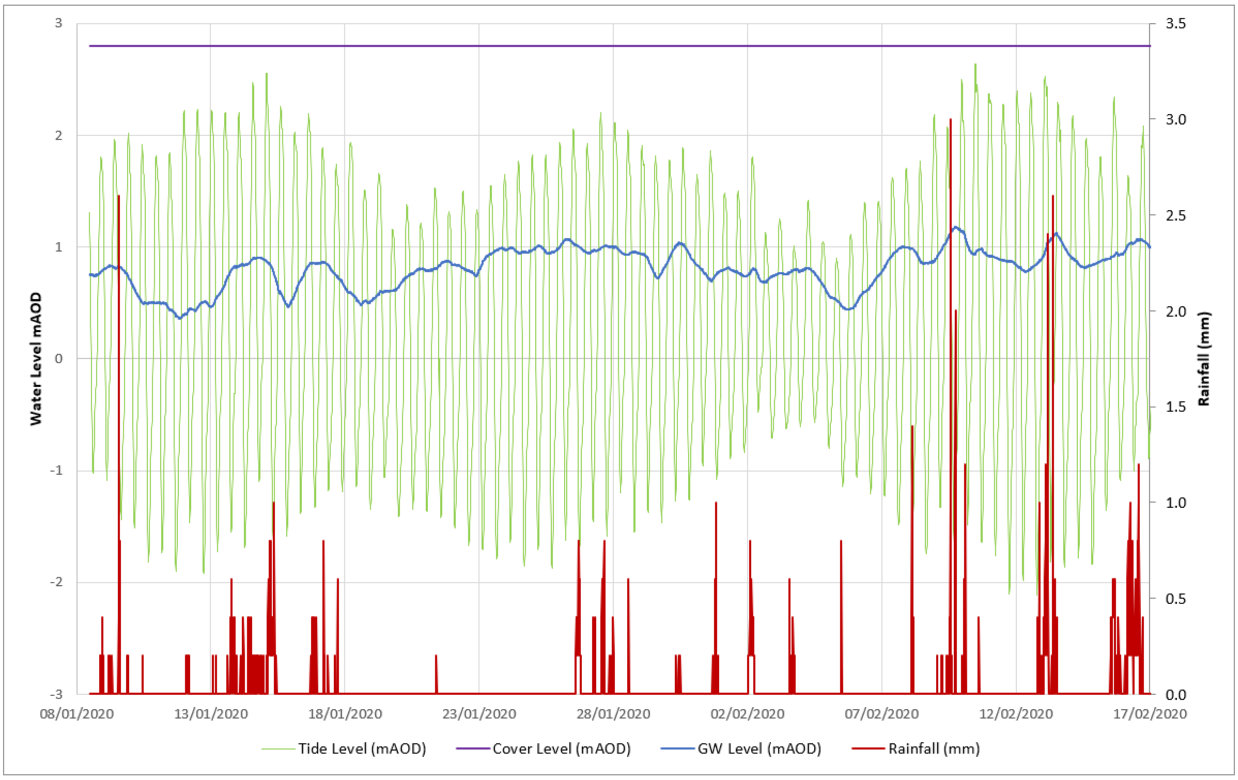


E.46 S2 D Day Museum Hydrographs

Hydrograph for S2 D Day Museum shows a rising and falling tide level between 17/03/2020 to 29/06/2020. The maximum tide level was 2.43m above Ordnance Datum (AOD) and the minimum level was -2.45m AOD. The blue line denotes the groundwater level from 0.529m to 1.194m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole S2 is 2.80m AOD.



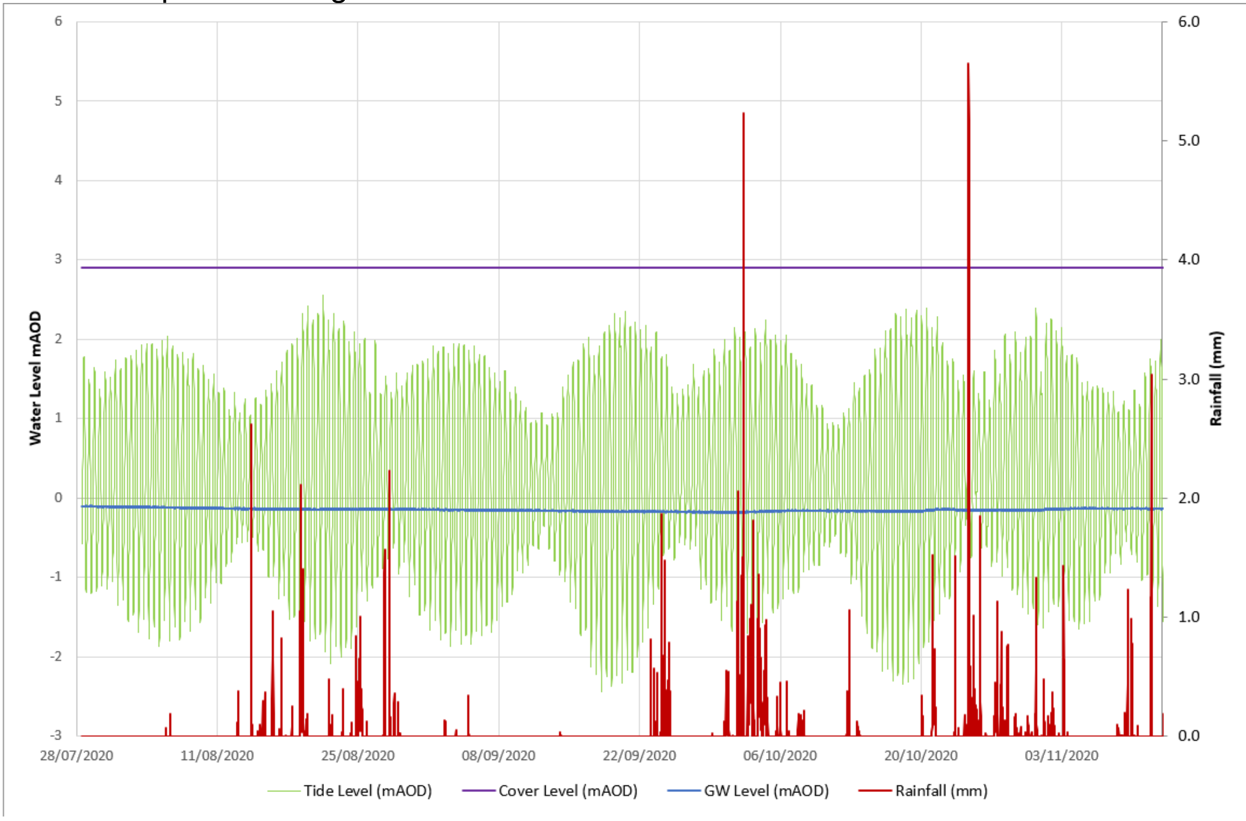
Hydrograph for S2 D Day Museum shows a rising and falling tide level between 08/01/2020 to 17/02/2020. The maximum tide level was 2.64m above Ordnance Datum (AOD) and the minimum level was -2.12m AOD. The blue line denotes the groundwater level from 0.355m to 1.179m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole S2 is 2.80m AOD.



Hydrograph for S2 D Day Museum shows a rising and falling tide level between 14/12/2022 to 25/01/2023 The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.48m AOD. The blue line denotes the groundwater level from 0.783m to 1.423m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole S2 is 2.80m AOD.

E.47 S3 Burgoyne Road Hydrograph

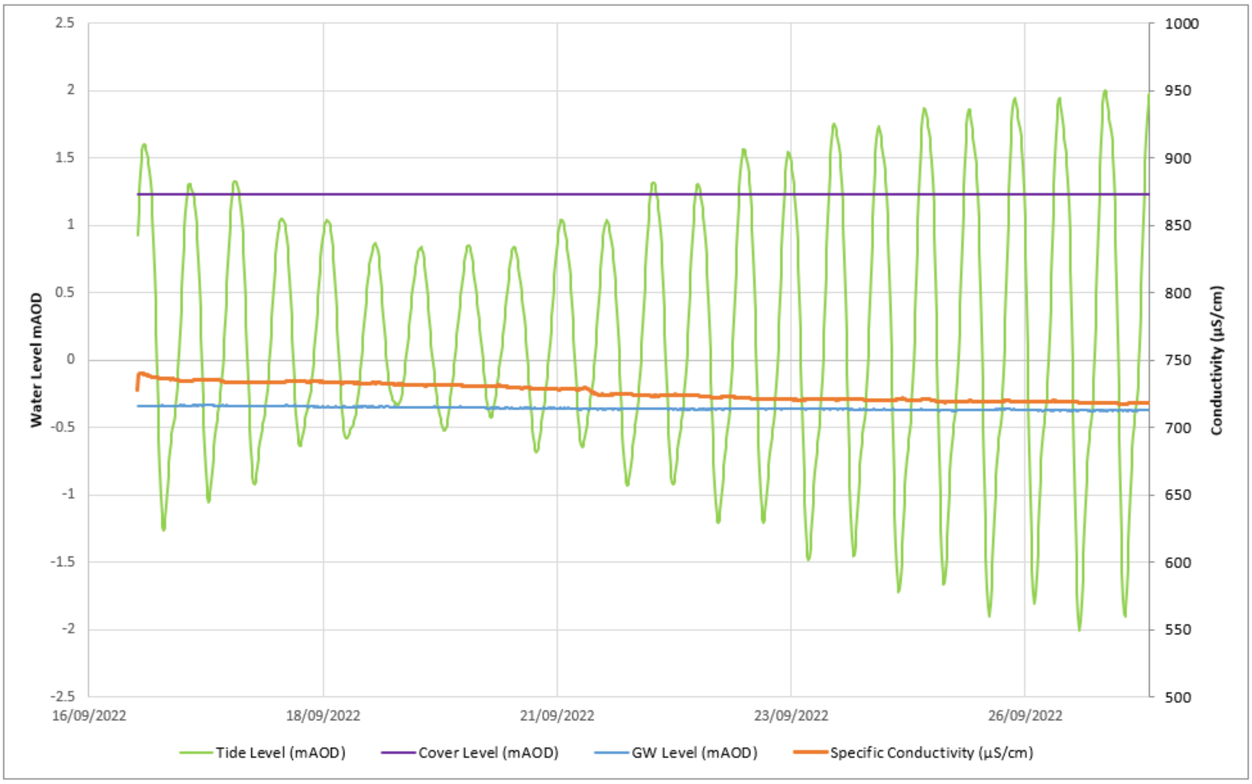
Hydrograph for S3 Burgoyne Road S2 D Day Museum shows a rising and falling tide level between 28/07/2020 to 13/11/2020. The maximum tide level was 2.56m above Ordnance Datum (AOD) and the minimum level was -2.43m AOD. The blue line denotes the groundwater level from -0.194m to -0.097m AOD during the monitoring period and no obvious response. The ground surface level for borehole S3 is 2.90m AOD.



F Salinity Graphs

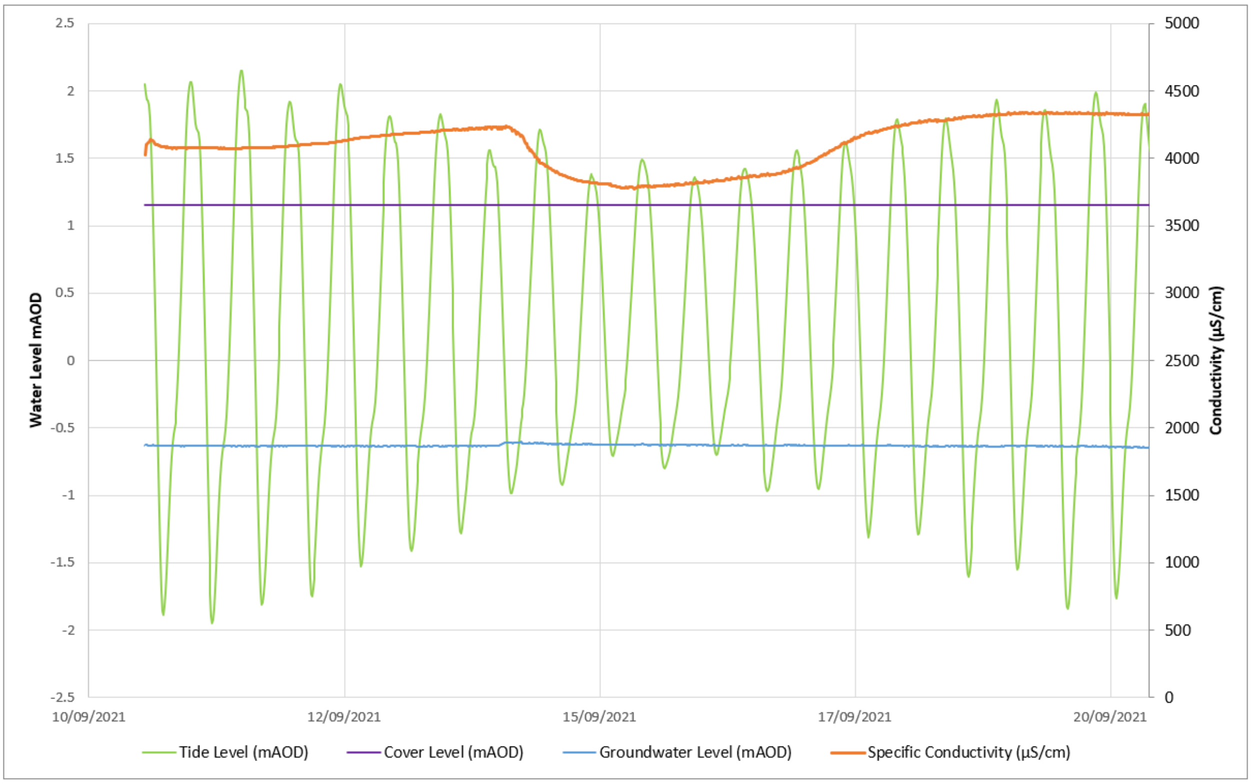
F.1 2a Wimbledon Park North

Salinity graph for 2a Wimbledon Park North shows a rising and falling tide level between 16/09/2022 to 28/09/2022. The maximum tide level was 2.0m above Ordnance Datum (AOD) and the minimum level was -2.04m AOD. The blue line denotes a steady groundwater level between -0.378m and -0.331m AOD during the monitoring period. The ground surface level for borehole 2a is 1.23m AOD. The maximum electrical conductivity (µS/cm) concentration was 740µS/cm and the minimum concentration was 715µS/cm, which is beneath brackish concentrations.



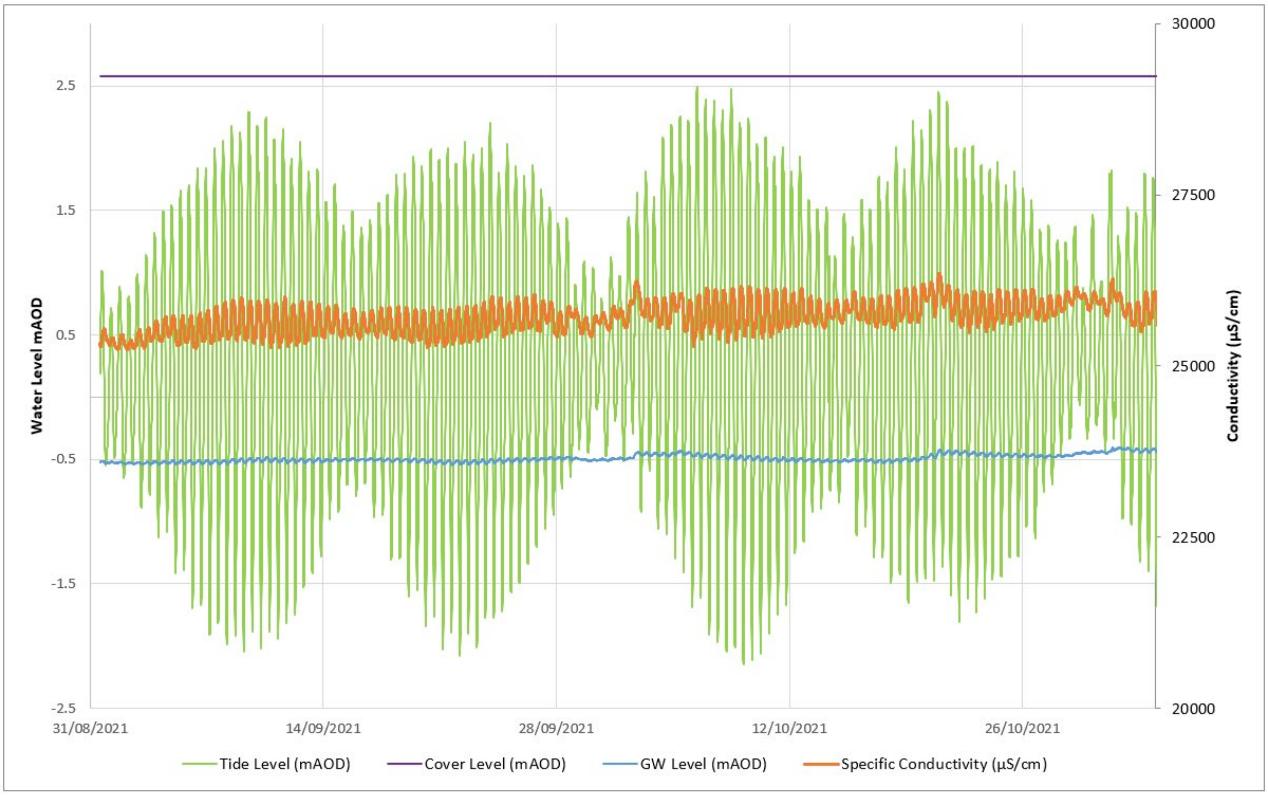
F.2 2c Strand

Salinity graph for 2c Strand shows a rising and falling tide level between 10/09/2021 to 21/09/2021. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.03m AOD. The blue line denotes a steady groundwater level between -0.645m to -0.60m AOD during the monitoring period. The ground surface level for borehole 2c is 1.15m AOD. The maximum electrical conductivity (µS/cm) concentration was 4,342µS/cm and the minimum concentration was 3,775µS/cm, exhibiting slightly brackish water.



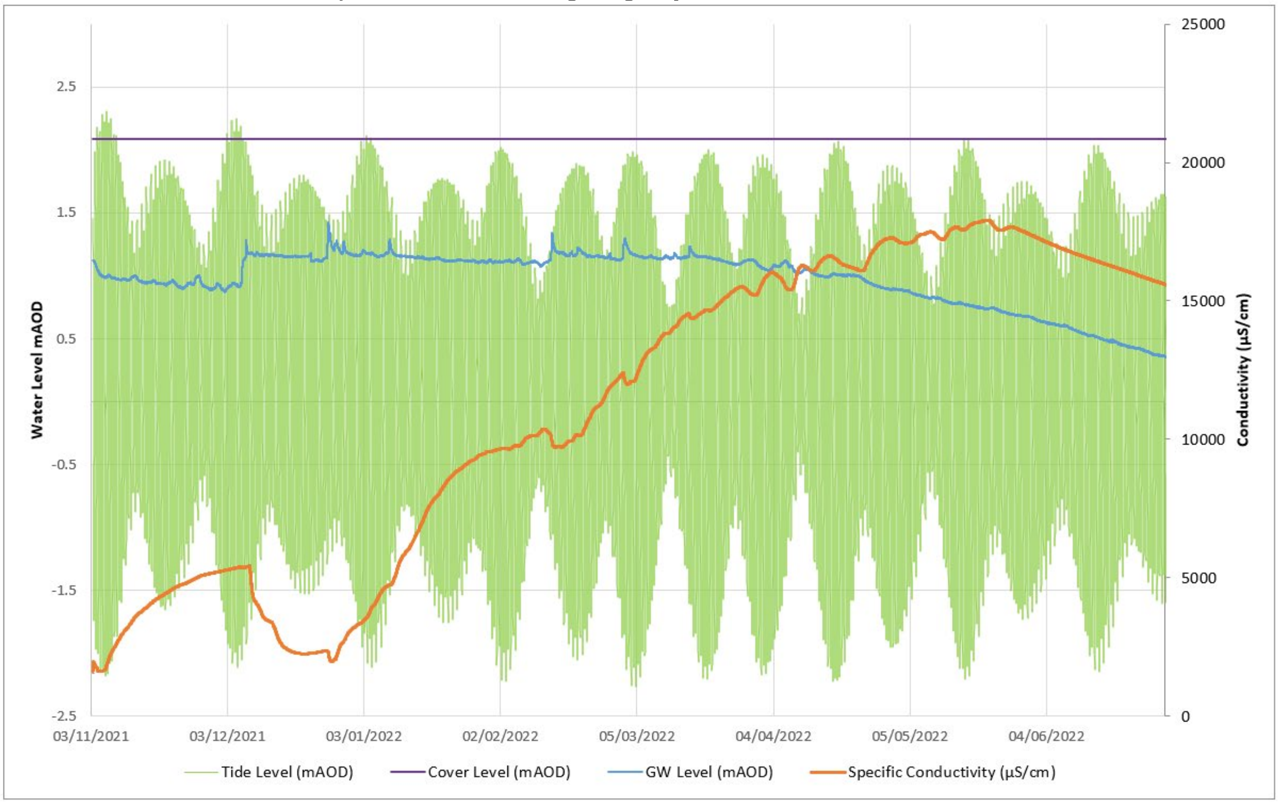
F.3 2x Canoe Lake

Salinity graph for 2x Canoe Lake shows a rising and falling tide level between 31/08/2021 to 03/11/2021. The maximum tide level was 2.49m above Ordnance Datum (AOD) and the minimum level was -2.15m AOD. The blue line denotes a gradually rising groundwater level between -0.55m to -0.40m AOD during the monitoring period. The ground surface level for borehole 2x is 2.58m AOD. The maximum electrical conductivity (µS/cm) concentration was 4,342µS/cm and the minimum concentration was 3,775µS/cm, exhibiting brackish water.



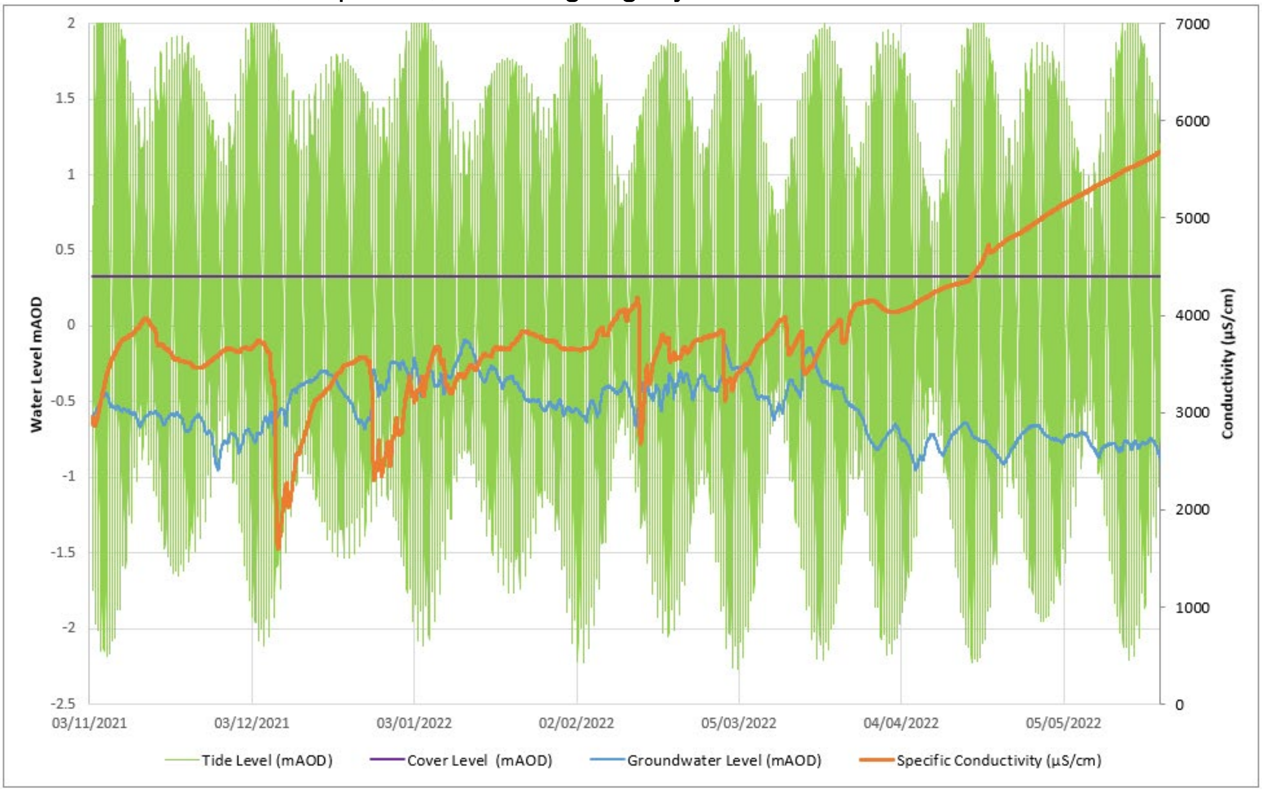
F.4 4y Tamworth Park

Salinity graph for 4y Tamworth Park shows a rising and falling tide level between 03/11/2021 to 01/07/2022. The maximum tide level was 2.31m above Ordnance Datum (AOD) and the minimum level was -2.27m AOD. The blue line denotes the groundwater level generally receding from 0.345m to 1.43m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 4y is 2.09m AOD. The maximum electrical conductivity (µS/cm) concentration was 17,917µS/cm and the minimum concentration was 1,588µS/cm, indicating slightly brackish to brackish water.

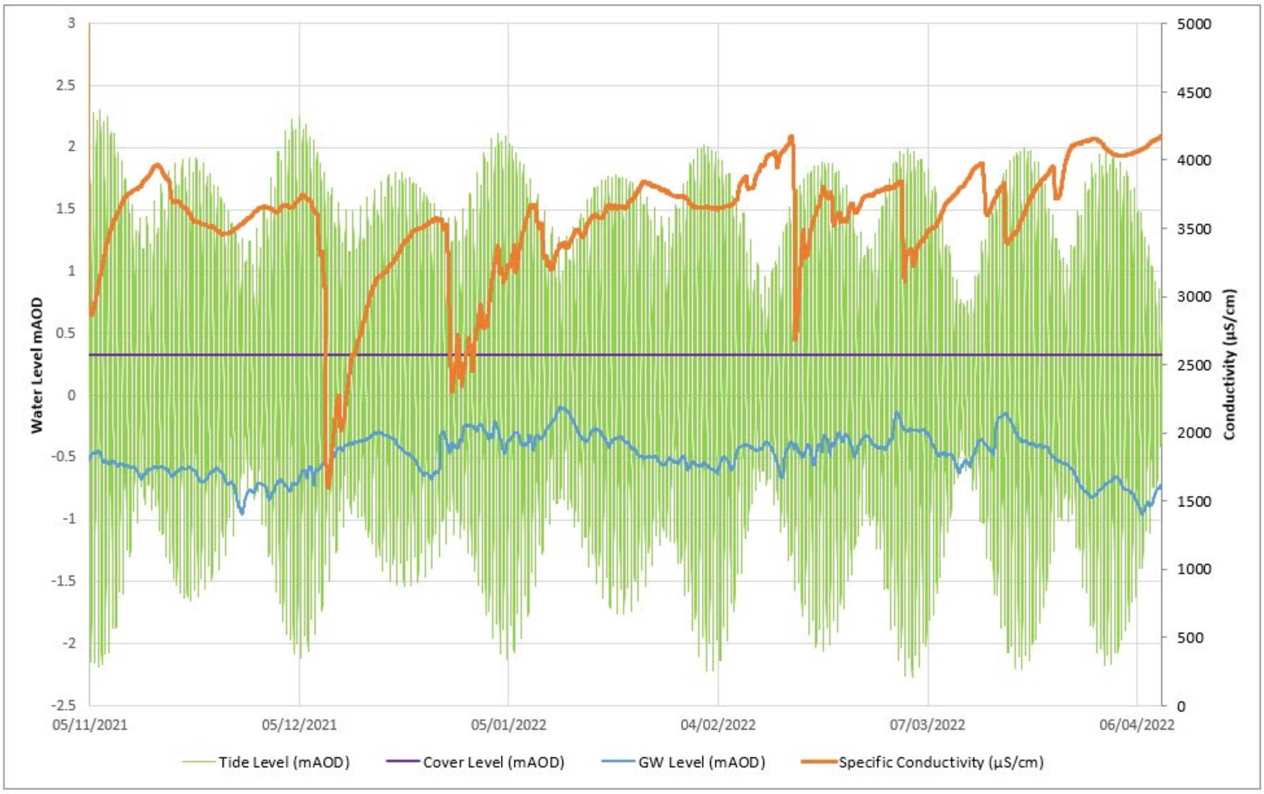


F.5 5a Great Salterns/Quartremaine Road

Salinity graph for 5a Great Salterns/Quartremaine Road shows a rising and falling tide level between 03/11/2021 to 23/05/2022. The maximum tide level was 2.31m above Ordnance Datum (AOD) and the minimum level was -2.27m AOD. The blue line denotes the groundwater level from -0.958m to -0.091m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 5a is 0.33m AOD. The maximum electrical conductivity (µS/cm) concentration was 5,701µS/cm and the minimum concentration was 1,601µS/cm, indicating slightly brackish water.

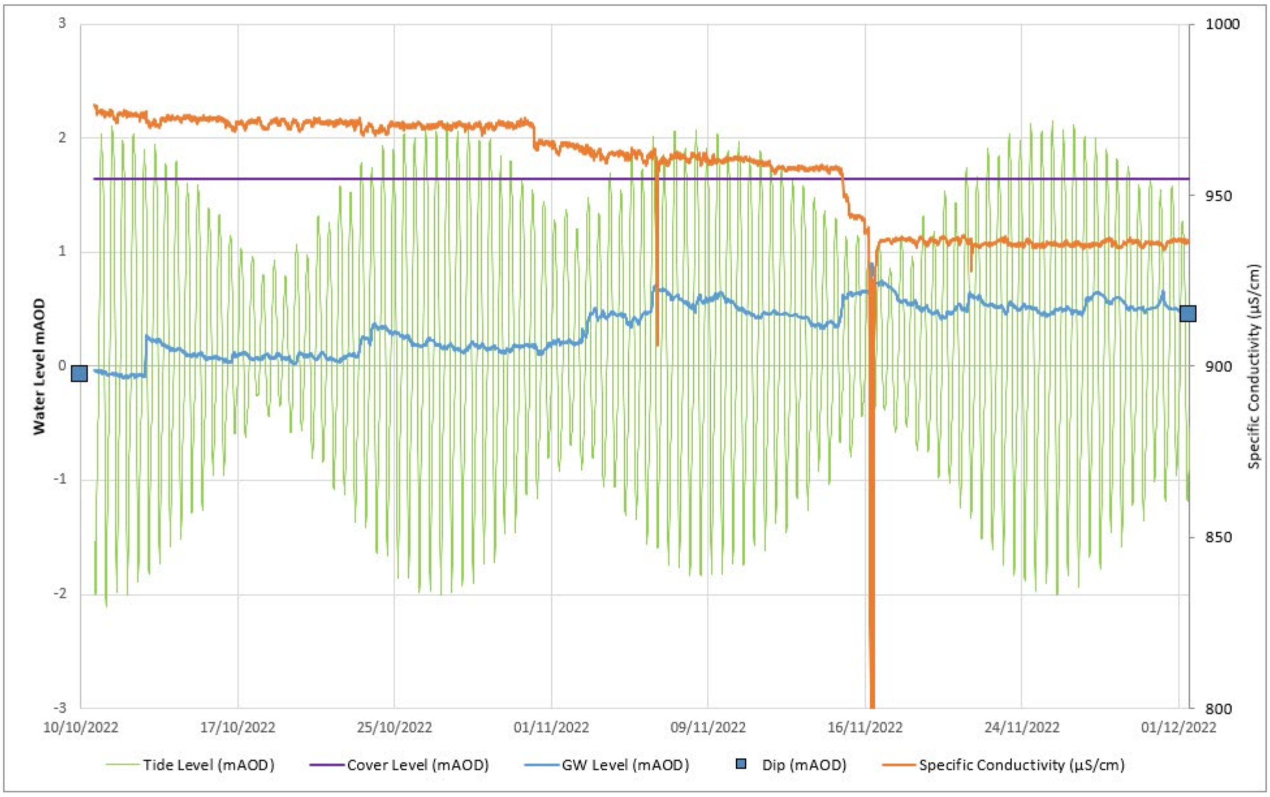


Salinity graph for 5a Great Salterns/Quartremaine Road shows a rising and falling tide level between 03/11/2021 to 10/04/2022. The maximum tide level was 2.31m above Ordnance Datum (AOD) and the minimum level was -2.27m AOD. The blue line denotes the groundwater level from -0.958m to -0.091m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 5a is 0.33m AOD. The maximum electrical conductivity (µS/cm) concentration was 4,238µS/cm and the minimum concentration was 1,601µS/cm, indicating slightly brackish water.



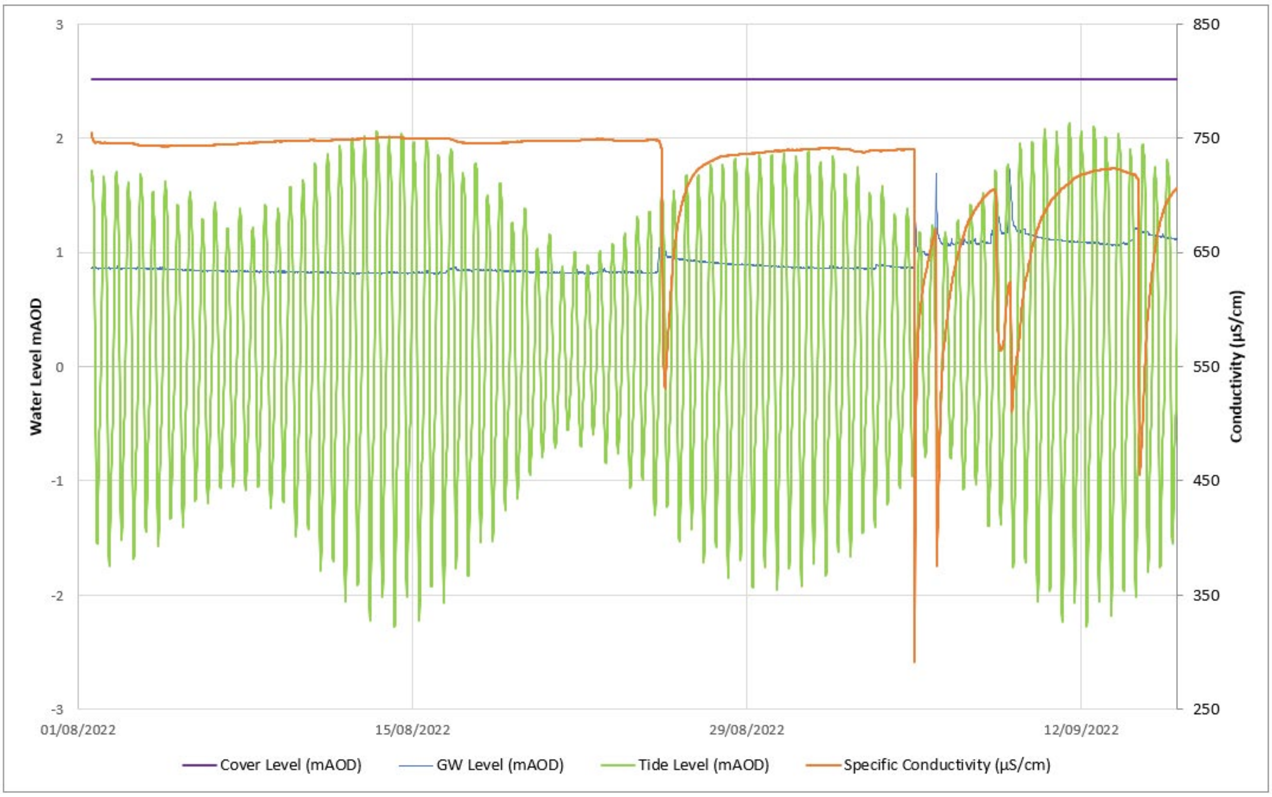
F.6 10d Station Road

Salinity graph for 10d Station Road shows a rising and falling tide level between 10/10/2022 to 02/12/2022. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.11m AOD. The blue line denotes the groundwater level from -0.106m to 0.90m AOD during the monitoring period and responding strongly to rainfall. The ground surface level for borehole 10d is 1.65m AOD. The maximum electrical conductivity (µS/cm) concentration was 976µS/cm and the minimum concentration was 454µS/cm, which is below brackish concentrations.



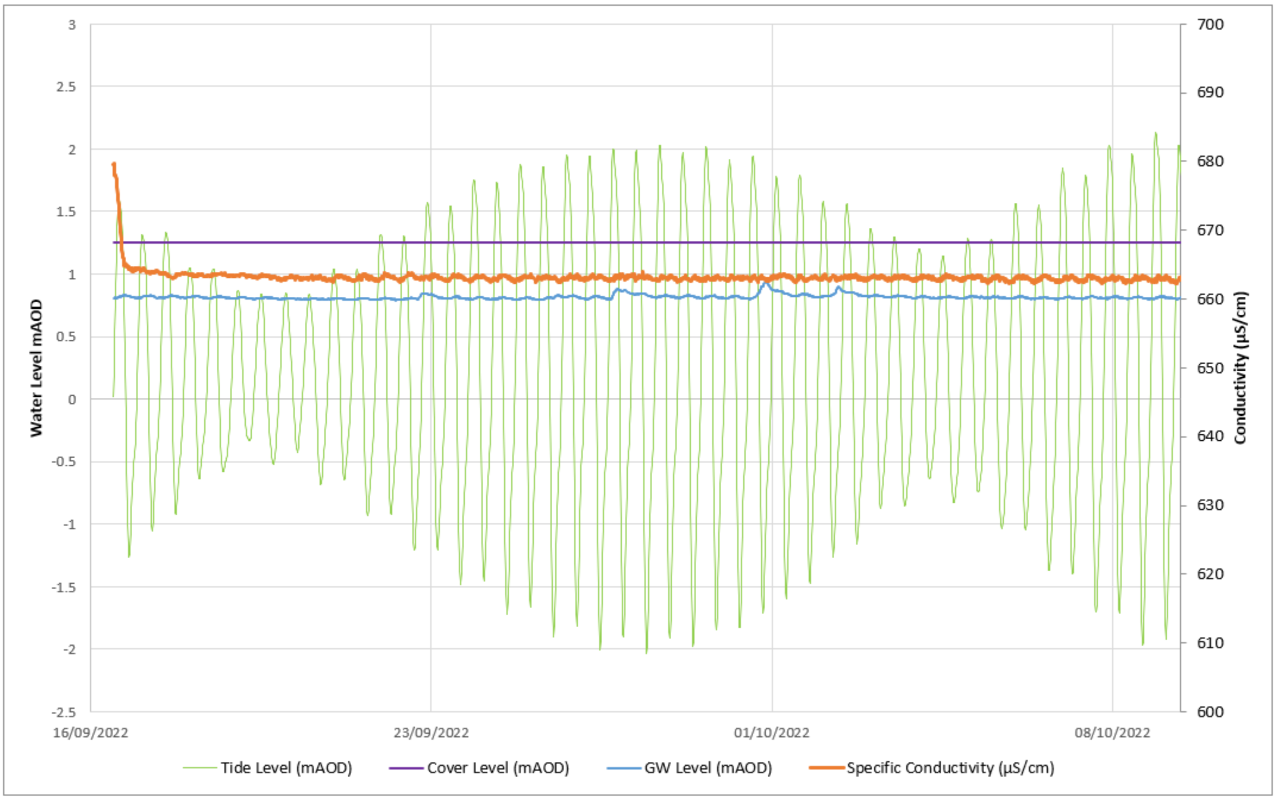
F.7 10y Central Road

Salinity graph for 10d Station Road shows a rising and falling tide level between 01/08/2022 to 16/09/2022. The maximum tide level was 2.13m above Ordnance Datum (AOD) and the minimum level was -2.28m AOD. The blue line denotes the groundwater level from 0.81m to 1.85m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 10y is 2.51m AOD. The maximum electrical conductivity (µS/cm) concentration was 754µS/cm and the minimum concentration was 291µS/cm, which is below brackish concentrations. There appears to be a dilution of salinity concentrations during rainfall events.



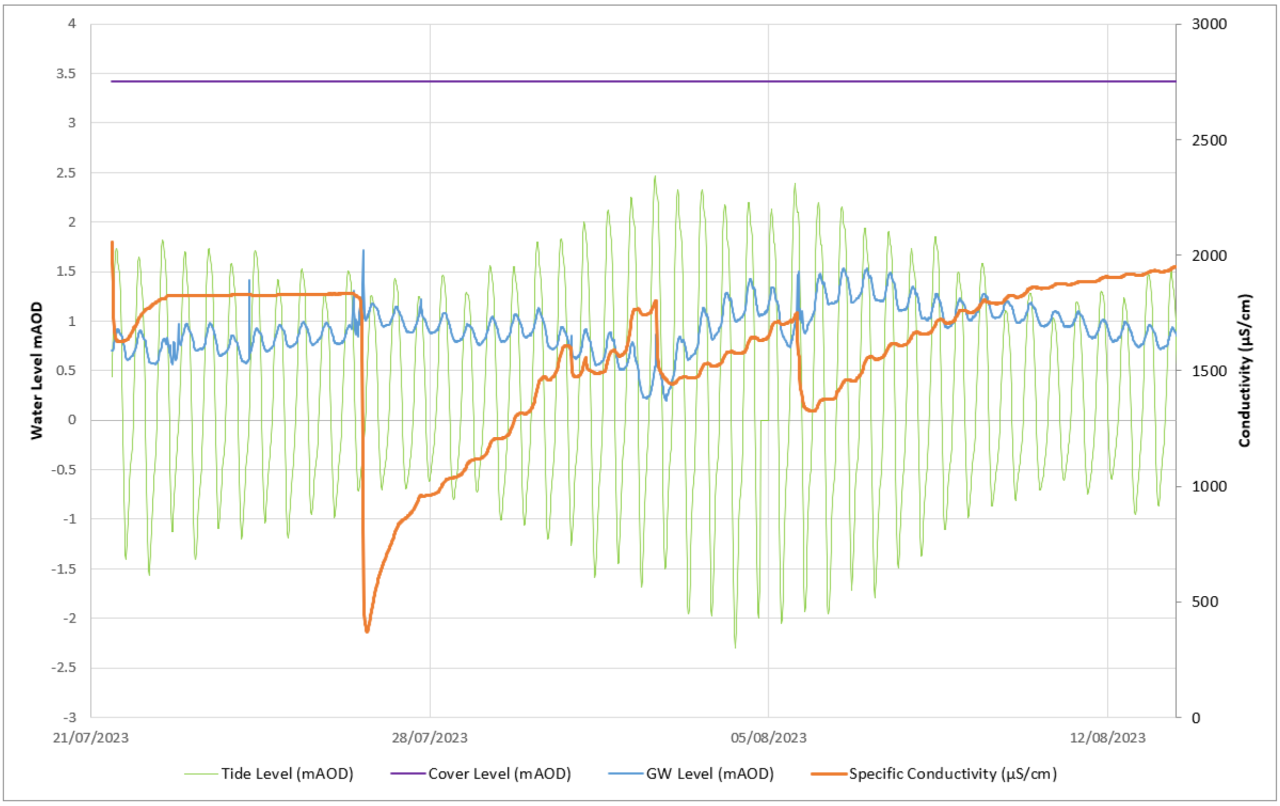
F.8 10z Cygnet Road

Salinity graph for 10z Cygnet Road shows a rising and falling tide level between 16/09/2022 to 10/10/2022. The maximum tide level was 2.14m above Ordnance Datum (AOD) and the minimum level was -2.11m AOD. The blue line denotes the groundwater level from 0.79m to 0.944m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 10z is 1.253m AOD. The maximum electrical conductivity (µS/cm) concentration was 679µS/cm and the minimum concentration was 661µS/cm, which is below brackish concentrations.



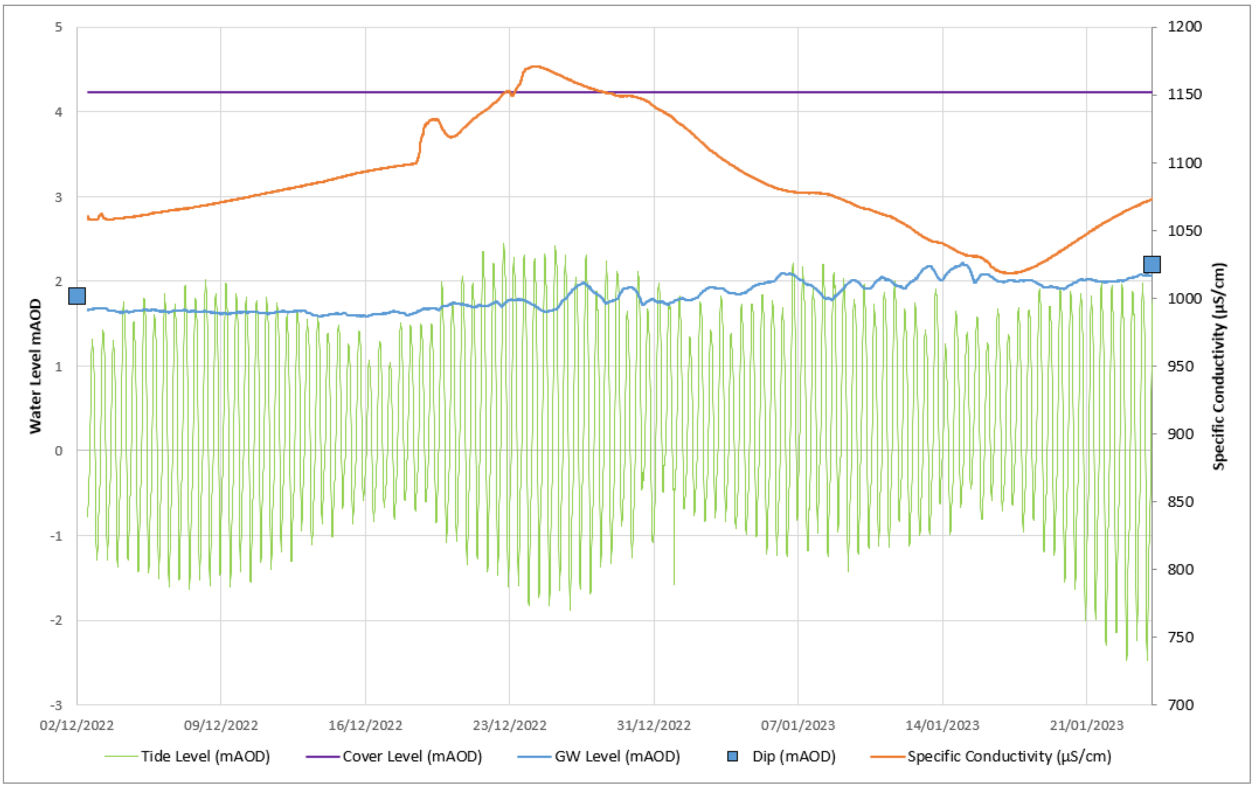
F.9 11b Tudor Crescent

Salinity graph for 11b Tudor Crescent shows a rising and falling tide level between 16/06/2023 to 21/07/2023. The maximum tide level was 2.17m above Ordnance Datum (AOD) and the minimum level was -2.0m AOD. The blue line denotes the groundwater level from 0.667m to 1.014m AOD during the monitoring period and responding to tidal variance. The ground surface level for borehole 11b is 3.421m AOD. The maximum electrical conductivity (µS/cm) concentration was 2,055µS/cm and the minimum concentration was 369µS/cm, which indicates slightly brackish concentrations. Salinity appears to be influenced by tides.



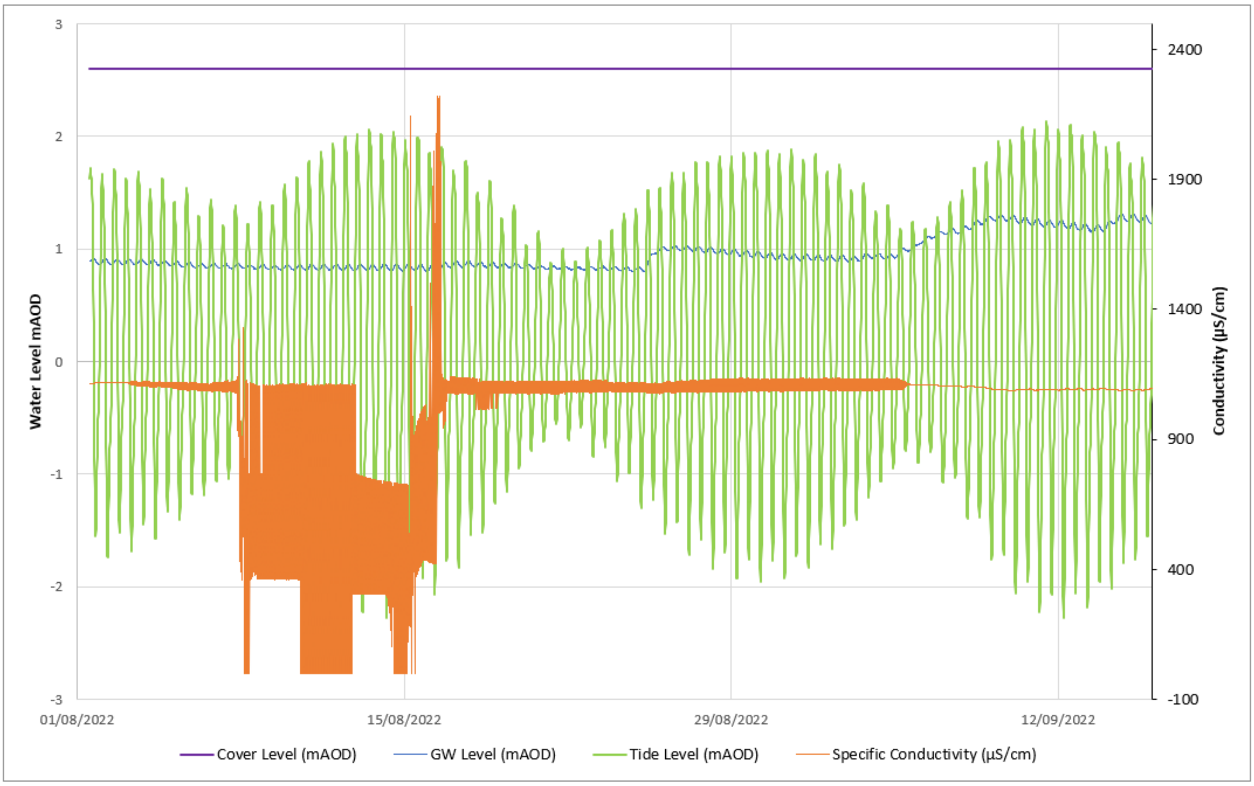
F.10 11e Lynx House

Salinity graph for 11e Lynx House shows a rising and falling tide level between 02/12/2022 to 25/01/2023. The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.48m AOD. The blue line denotes the groundwater level from 1.746m to 2.378m AOD during the monitoring period and responding to rainfall. The ground surface level for borehole 11e is 4.228m AOD. The maximum electrical conductivity (µS/cm) concentration was 1,171µS/cm and the minimum concentration was 1,018µS/cm, which is below brackish concentrations.



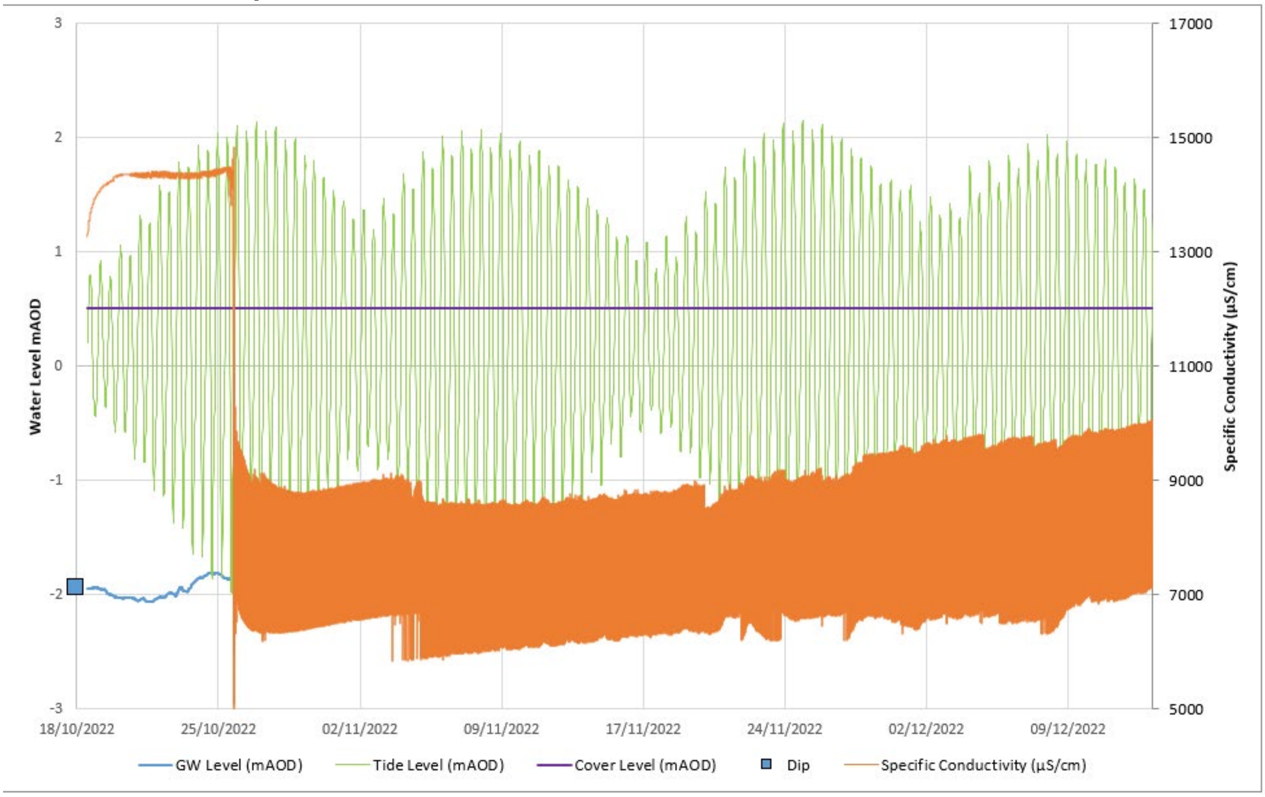
F.11 11z Highbury Grove

Salinity graph for 11z Highbury Grove shows a rising and falling tide level between 01/08/2022 to 16/09/2022. The maximum tide level was 2.13m above Ordnance Datum (AOD) and the minimum level was -2.28m AOD. The blue line denotes the groundwater level from 0.797m to 1.313m AOD during the monitoring period. The ground surface level for borehole 11z is 2.595m AOD. The maximum electrical conductivity (µS/cm) concentration was 2,221µS/cm and the minimum concentration was 0µS/cm. Data appears erroneous.



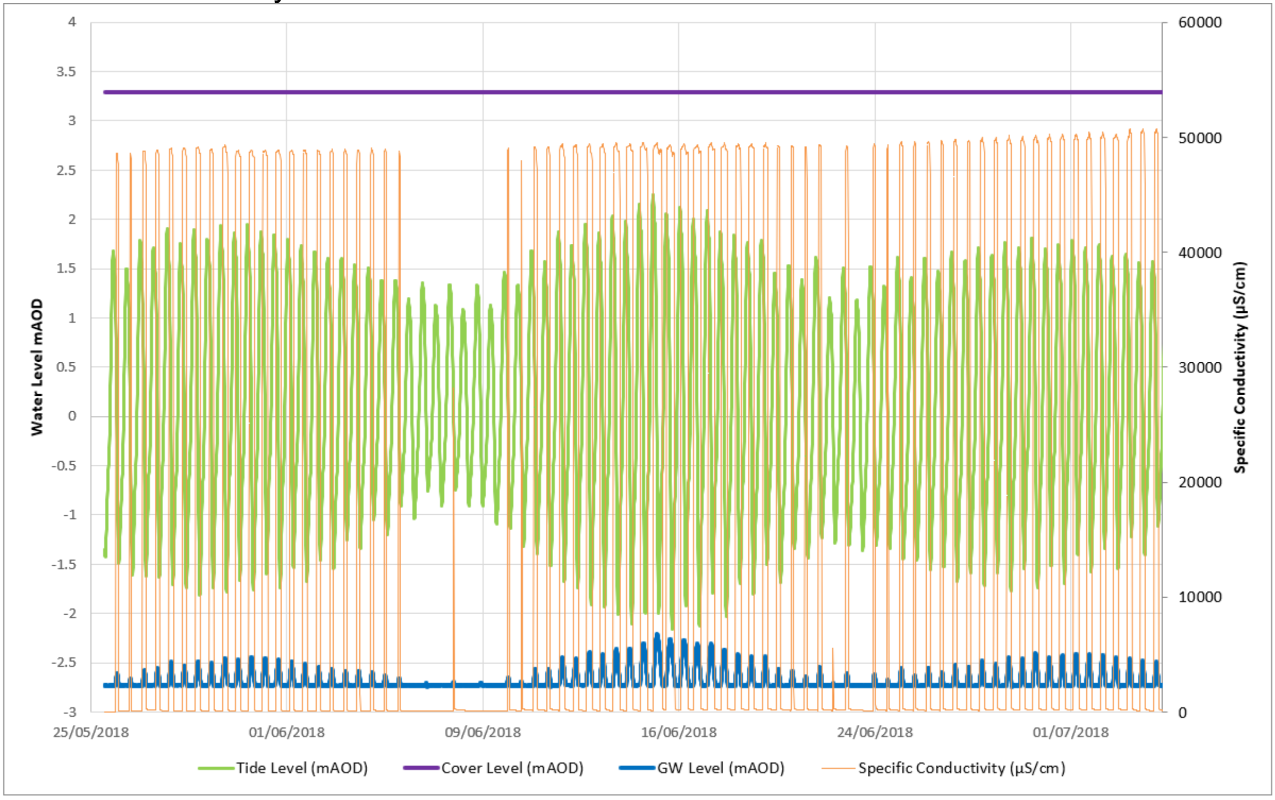
F.12 BH1 LCT Car Park

Salinity graph for BH1 LCT Car Park shows a rising and falling tide level between 18/10/2022 to 14/12/2022. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.01m AOD. The blue line denotes the groundwater level from -2.063m to -1.369m AOD during the monitoring period. The ground surface level for borehole BH1 is 0.51m AOD. The maximum electrical conductivity (μS/cm) concentration was 14,847μS/cm and the minimum concentration was 4,044μS/cm, which is brackish. Data may be erroneous.



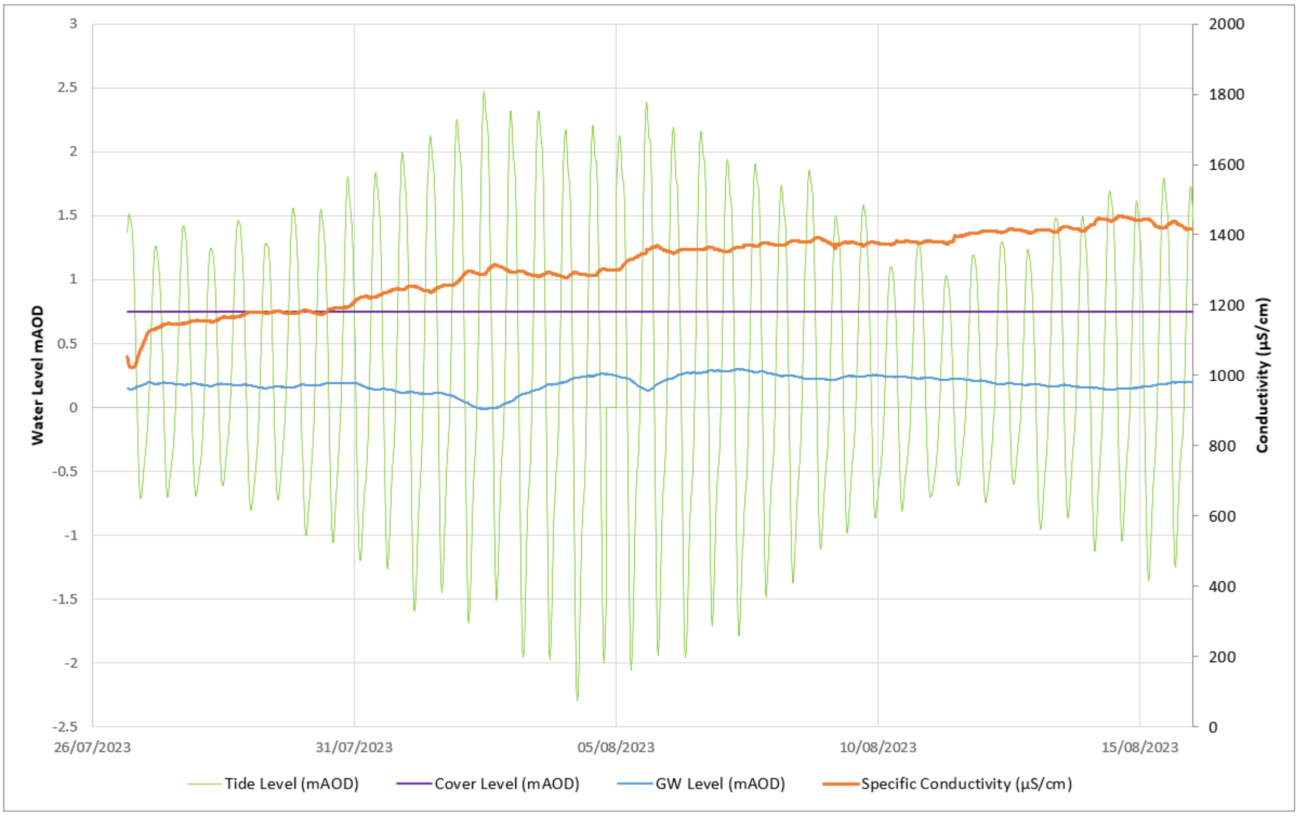
F.13 BH03 Clarence Pier Esplanade

Salinity graph for BH03 Clarence Pier Esplanade. The maximum electrical conductivity (µS/cm) concentration was 50,775µS/cm and the minimum concentration was 0µS/cm, indicating influxes of saline water High variable salinity between sea water and none (likely related to the borehole going dry/groundwater below the logger). Salinity trend shows a correlation with daily tides.



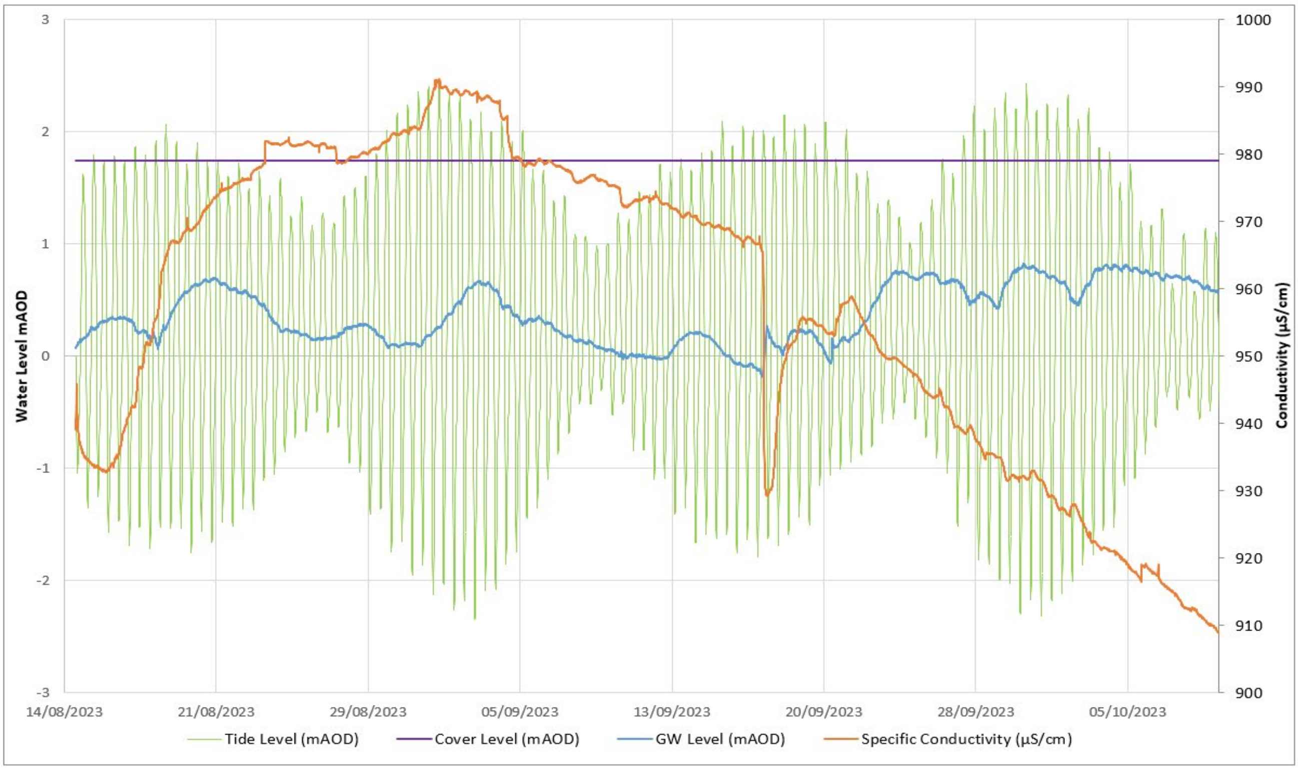
F.14 BH16 Farlington Playing Fields

Salinity graph for BH16 Farlington Playing Fields shows a rising and falling tide level between 16/06/2023 to 21/07/2023. The maximum tide level was 2.17m above Ordnance Datum (AOD) and the minimum level was -2.0m AOD. The blue line denotes the groundwater level from 0.005m to 0.61m AOD during the monitoring period. The ground surface level for borehole BH16 is 0.75m AOD. The maximum electrical conductivity (µS/cm) concentration was 1,454µS/cm and the minimum concentration was 1,021µS/cm, which is below brackish concentrations.



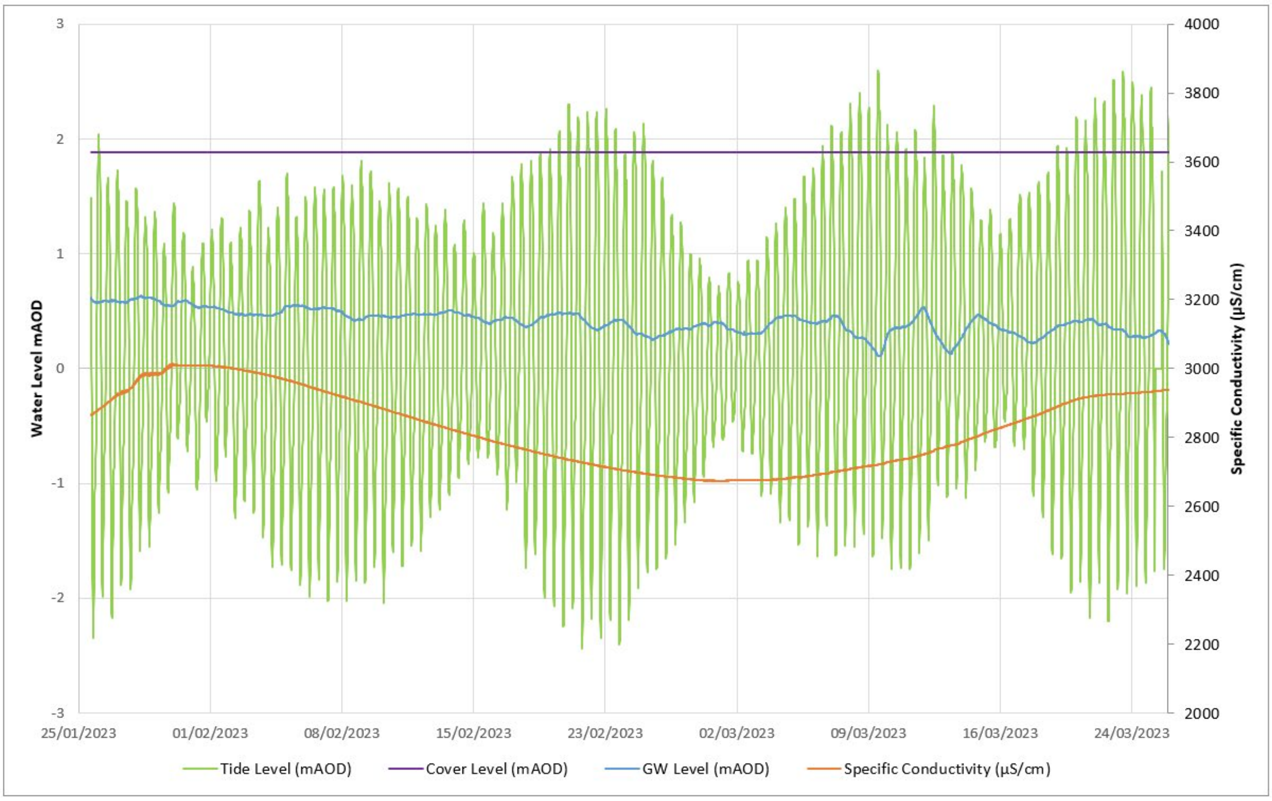
F.15 BH18 Farlington Playing Fields

Salinity graph for BH18 Farlington Playing Fields shows a rising and falling tide level between 10/10/2022 to 02/12/2022. The maximum tide level was 2.15m above Ordnance Datum (AOD) and the minimum level was -2.11m AOD. The blue line denotes the groundwater level from -0.006m to 1.616m AOD during the monitoring period. The ground surface level for borehole BH18 is 1.74m AOD. The maximum electrical conductivity (µS/cm) concentration was 991µS/cm and the minimum concentration was 908µS/cm, which is below brackish concentrations.



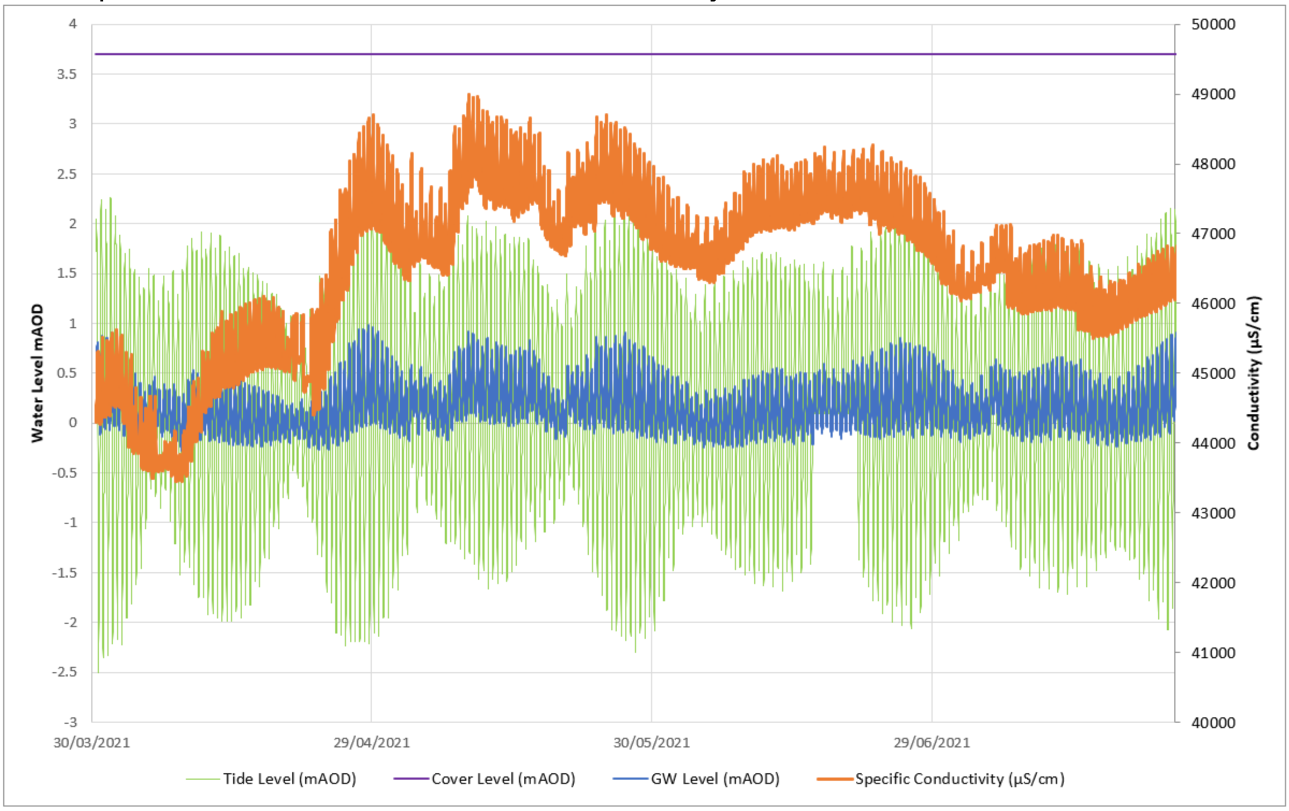
F.16 BH19a Tangier Road

Salinity graph for BH19a Tangier Road shows a rising and falling tide level between 28/07/2020 to 17/11/2020. The maximum tide level was 2.62m above Ordnance Datum (AOD) and the minimum level was -2.43m AOD. The blue line denotes the groundwater level from -0.247m to -0.018m AOD during the monitoring period. The ground surface level for borehole BH19a is 1.89m AOD. The maximum electrical conductivity (µS/cm) concentration was 3,013µS/cm and the minimum concentration was 2,673µS/cm, which indicates brackish water.



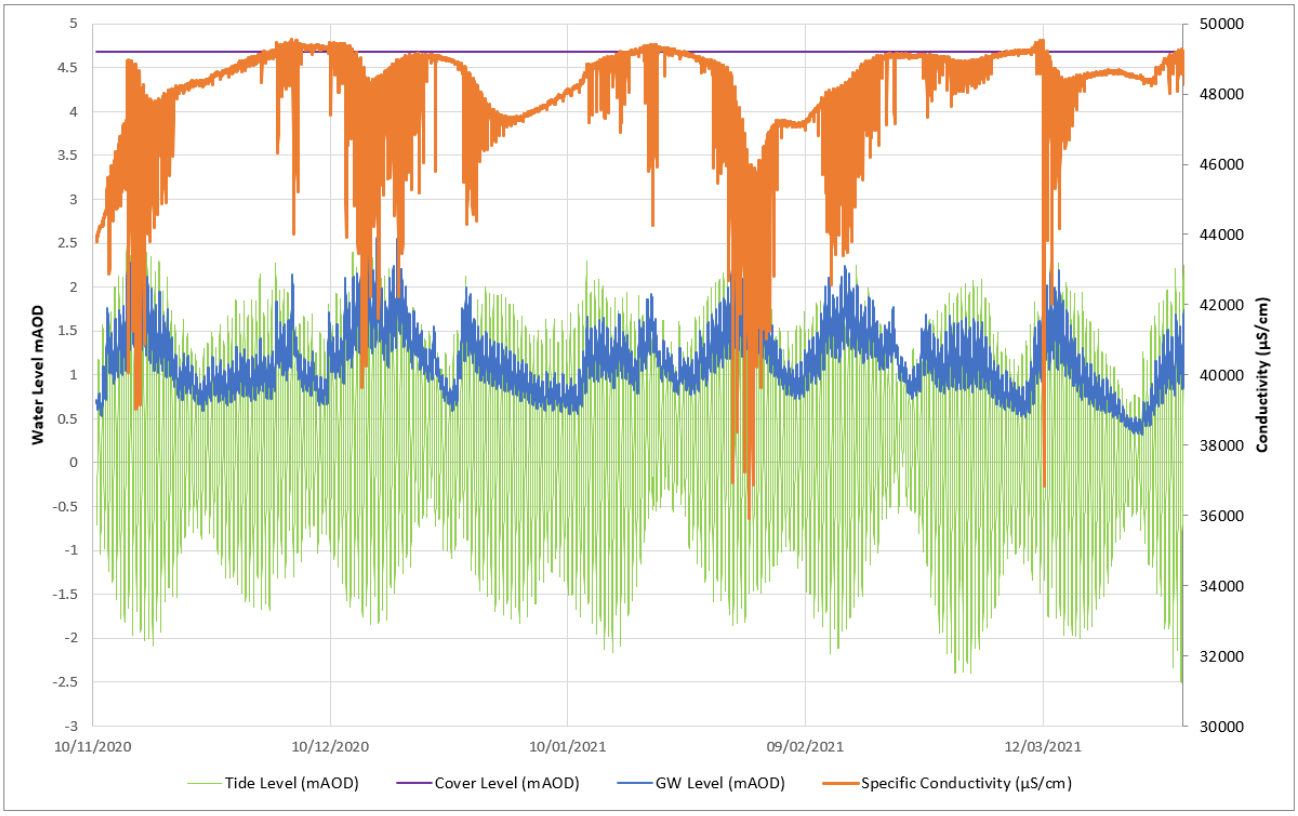
F.17 BH21 Canoe Lake Car Park

Salinity graph for BH21 Canoe Lake Car Park West shows a rising and falling tide level between 30/03/2021 to 26/07/2021. The maximum tide level was 2.44m above Ordnance Datum (AOD) and the minimum level was -2.51m AOD. The blue line denotes the groundwater level from -0.276m to 0.98m AOD during the monitoring period. The ground surface level for borehole BH21 is 3.70m AOD. The maximum electrical conductivity (µS/cm) concentration was 48,988µS/cm and the minimum concentration was 43,450µS/cm, which indicates saline water. Salinity shows a tidal influence.



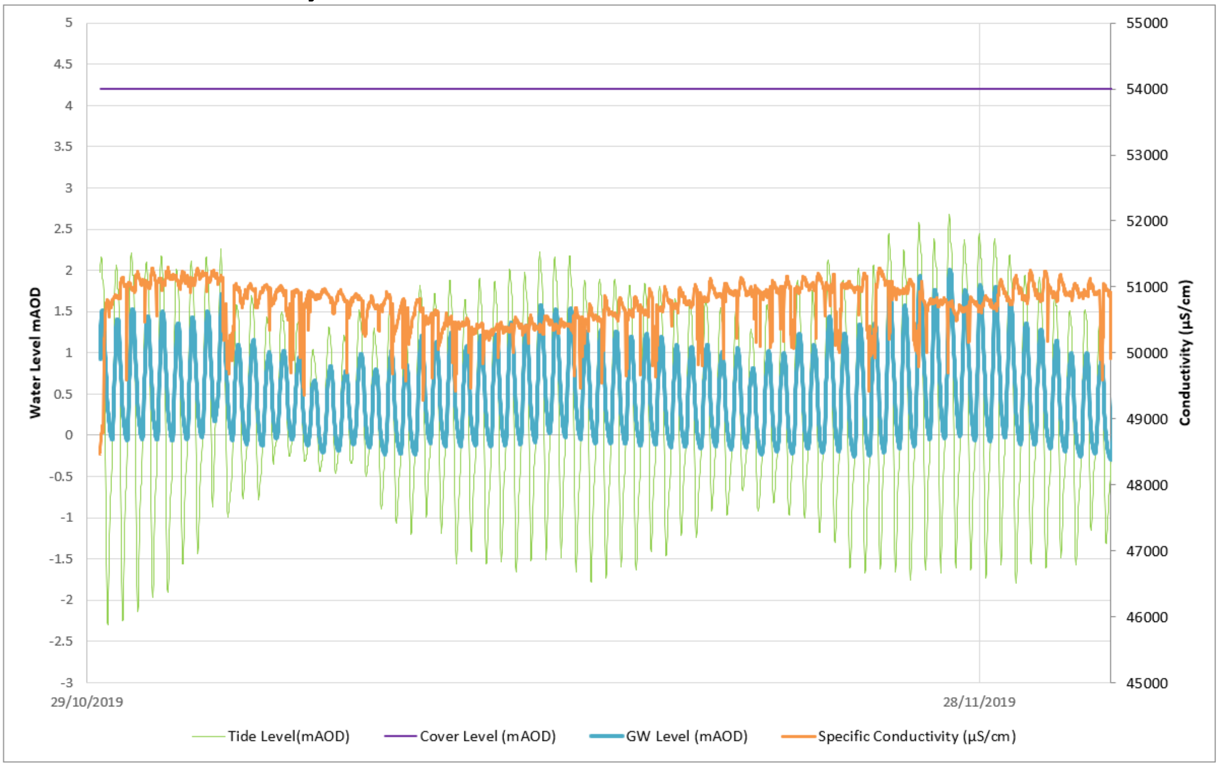
F.18 BH22 Splash Wall West End

Salinity graph for BH22 Splash Wall West End shows a rising and falling tide level between 10/11/2020 to 30/03/2021. The maximum tide level was 2.62m above Ordnance Datum (AOD) and the minimum level was -2.51m AOD. The blue line denotes the groundwater level from 0.323m to 2.629m AOD during the monitoring period. The ground surface level for borehole BH22 is 4.68m AOD. The maximum electrical conductivity (µS/cm) concentration was 49,456µS/cm and the minimum concentration was 35,914µS/cm, which indicates saline water. Salinity shows a tidal influence.



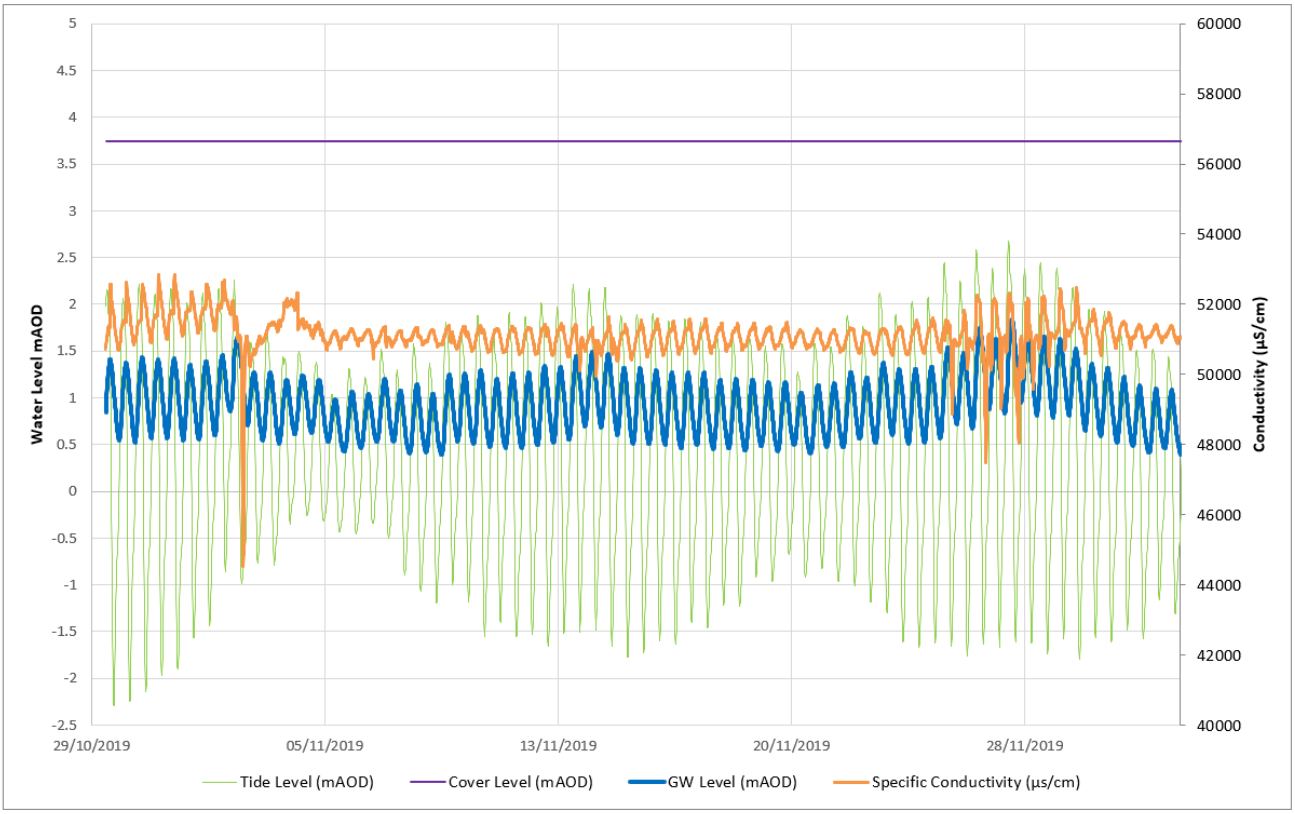
F.19 BHRH01 LCM Revetment

Salinity graph for BHRH01 LCM Revetment shows a rising and falling tide level between 29/10/2019 to 03/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from -0.29m to 2.01m AOD during the monitoring period. The ground surface level for borehole BHRH01 is 4.2m AOD. The maximum electrical conductivity (µS/cm) concentration was 29,081µS/cm and the minimum concentration was 15,629µS/cm, which is saline water. Salinity shows a tidal influence.



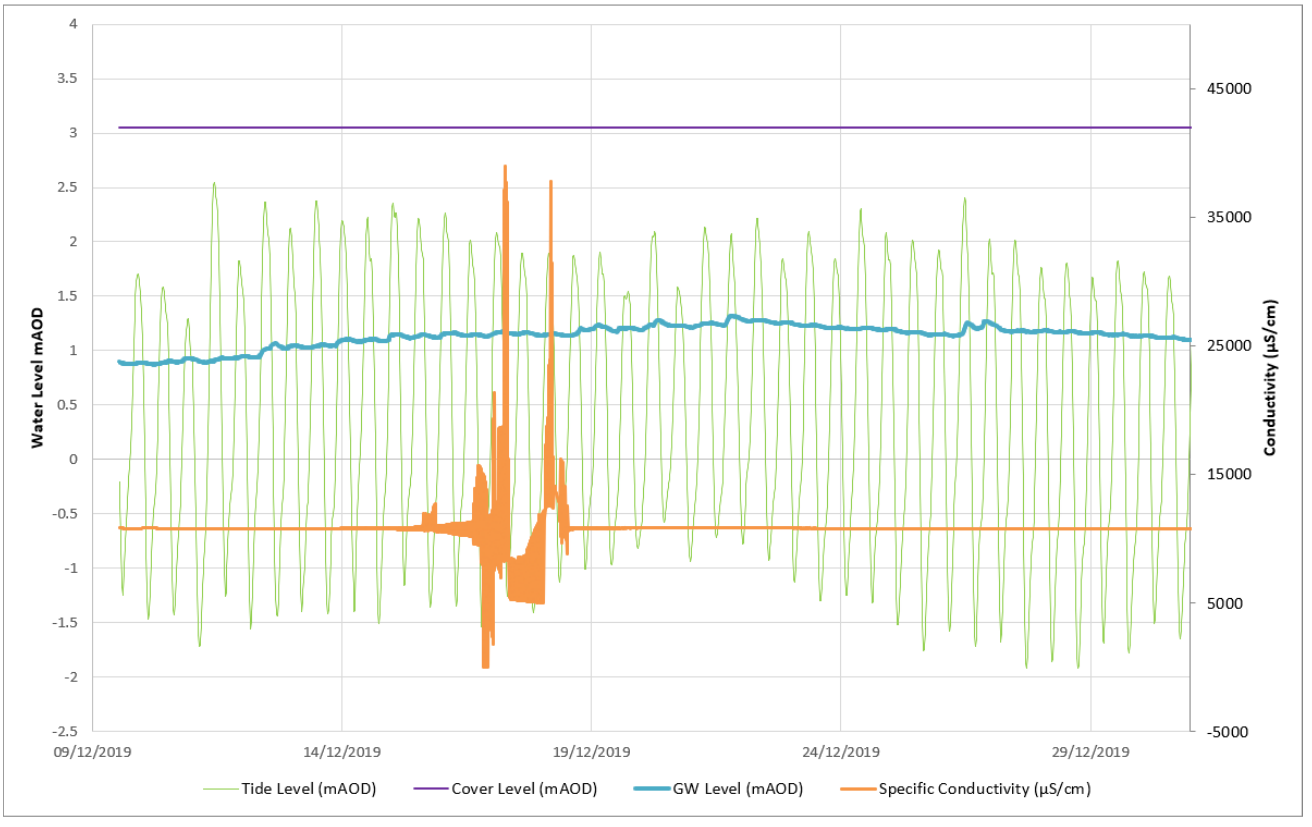
F.20 BHRH03 Clarence Pier Promenade

Salinity graph for BHRH03 Clarence Pier Promenade shows a rising and falling tide level between 29/10/2019 to 03/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from 0.39m to 1.839m AOD during the monitoring period. The ground surface level for borehole BHRH03 is 3.74m AOD. The maximum electrical conductivity (µS/cm) concentration was 52,843µS/cm and the minimum concentration was 44,530µS/cm, which is saline water. Salinity shows a tidal influence.



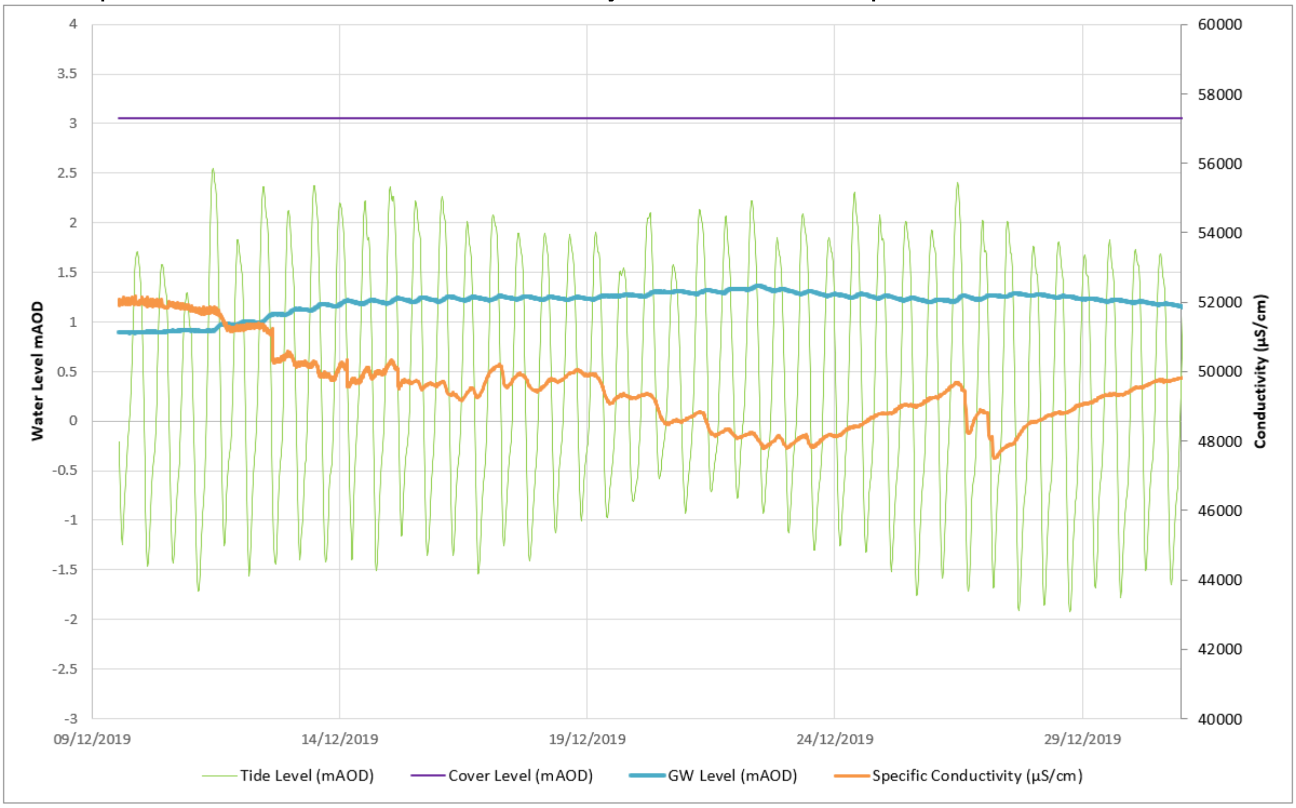
F.21 BHRH04 LCM Deep

Salinity graph for BHRH04 LCM Deep shows a rising and falling tide level between 29/10/2019 to 03/12/2019. The maximum tide level was 2.67m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from 0.902m to 1.115m AOD during the monitoring period. The ground surface level for borehole BHRH04 is 3.05m AOD. The maximum electrical conductivity (µS/cm) concentration was 38,953µS/cm and the minimum concentration was 1,761µS/cm., which is brackish to saline water.



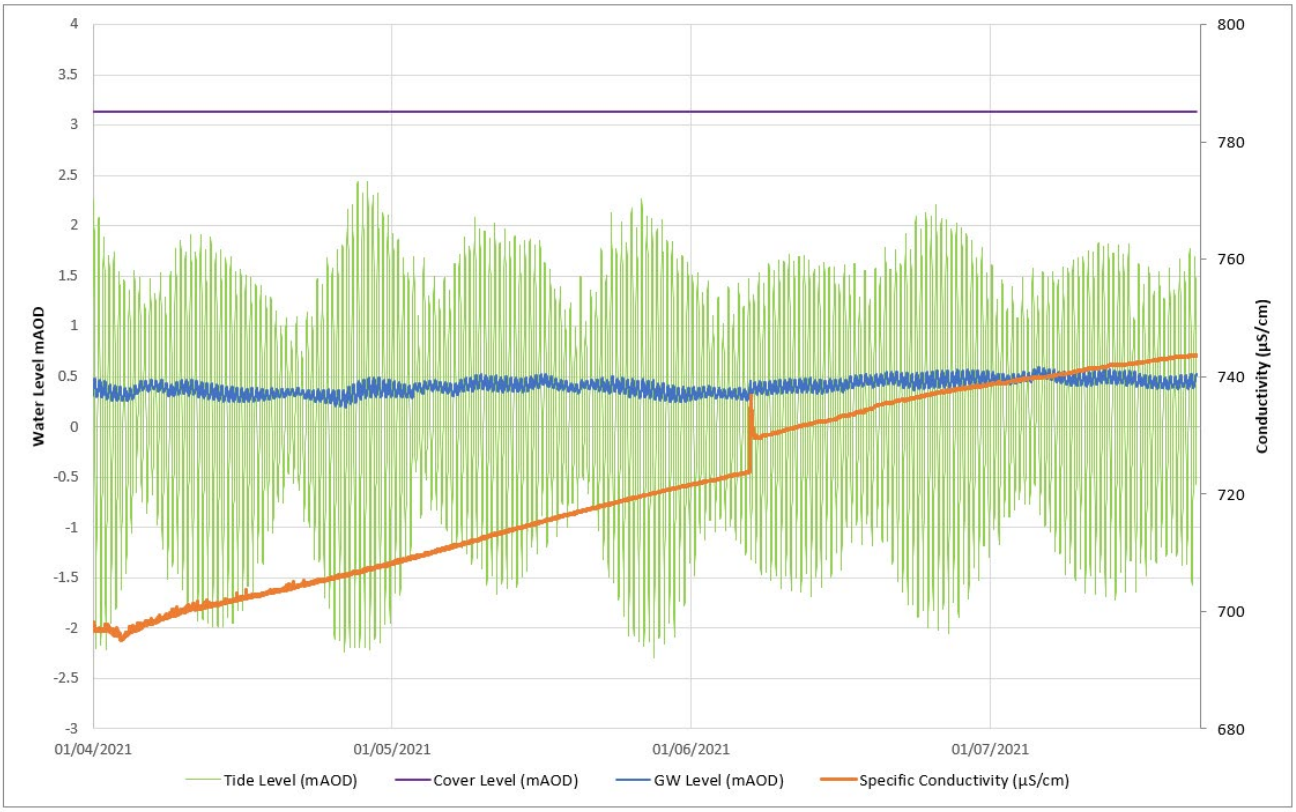
F.22 BHRH04 LCM Shallow

Salinity graph for BHRH04 Shallow Grassed Area By 1c shows a rising and falling tide level between 09/12/2019 to 31/12/2019. The maximum tide level was 2.55m above Ordnance Datum (AOD) and the minimum level was -1.92m AOD. The blue line denotes the groundwater level from 0.889m to 1.366m AOD during the monitoring period. The ground surface level for borehole BHRH04 is 3.05m AOD. The maximum electrical conductivity (µS/cm) concentration was 52,169µS/cm and the minimum concentration was 47,501µS/cm, which is saline water. Salinity shows a tidal response and rainfall dilution.



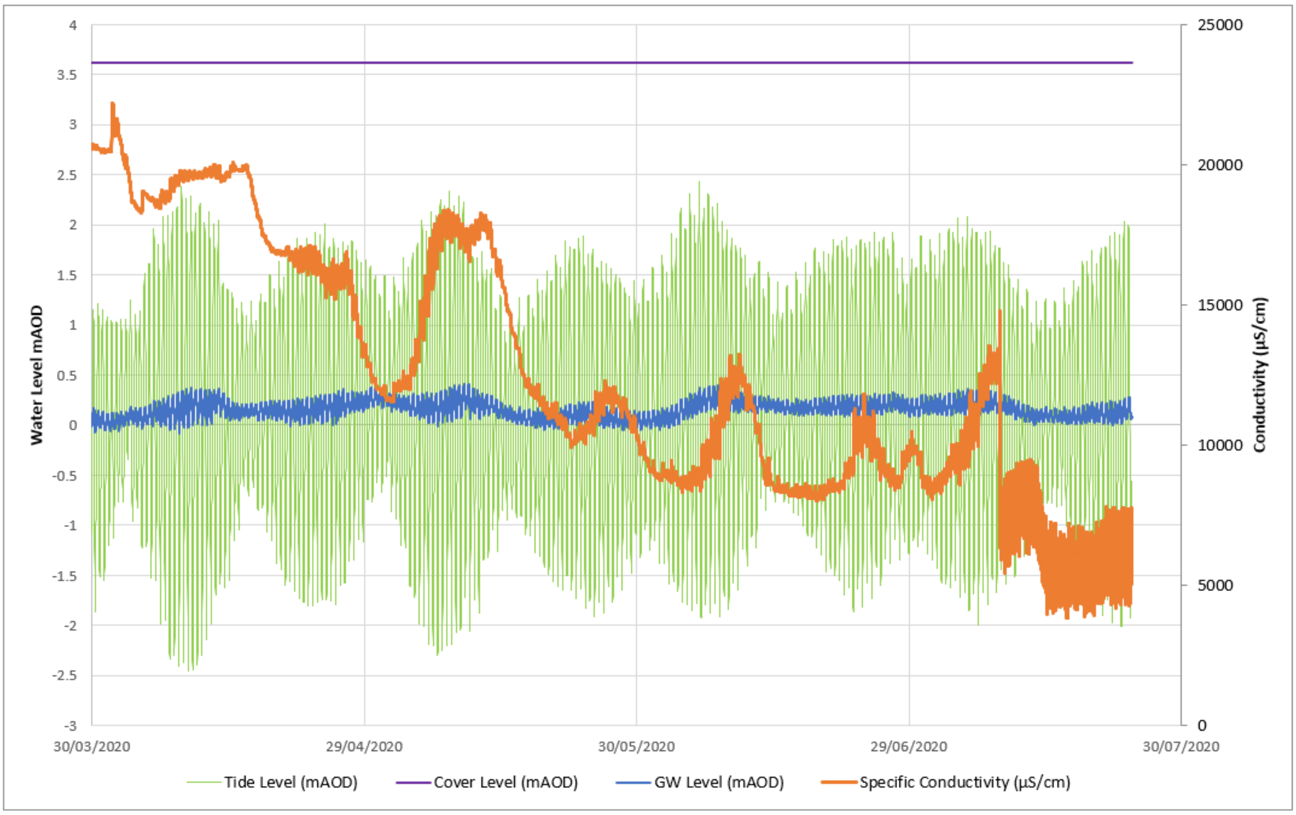
F.23 BHRH06 D Day Museum Car Park

Salinity graph for BHRH06 D Day Museum Car Park shows a rising and falling tide level between 30/03/2021 to 22/07/2021. The maximum tide level was 2.44m above Ordnance Datum (AOD) and the minimum level was -2.51m AOD. The blue line denotes the groundwater level from 0.197m to 0.599m AOD during the monitoring period. The ground surface level for borehole BHRH06 is 3.13m AOD. The maximum electrical conductivity (µS/cm) concentration was 743µS/cm and the minimum concentration was 694µS/cm, which is below brackish concentrations.



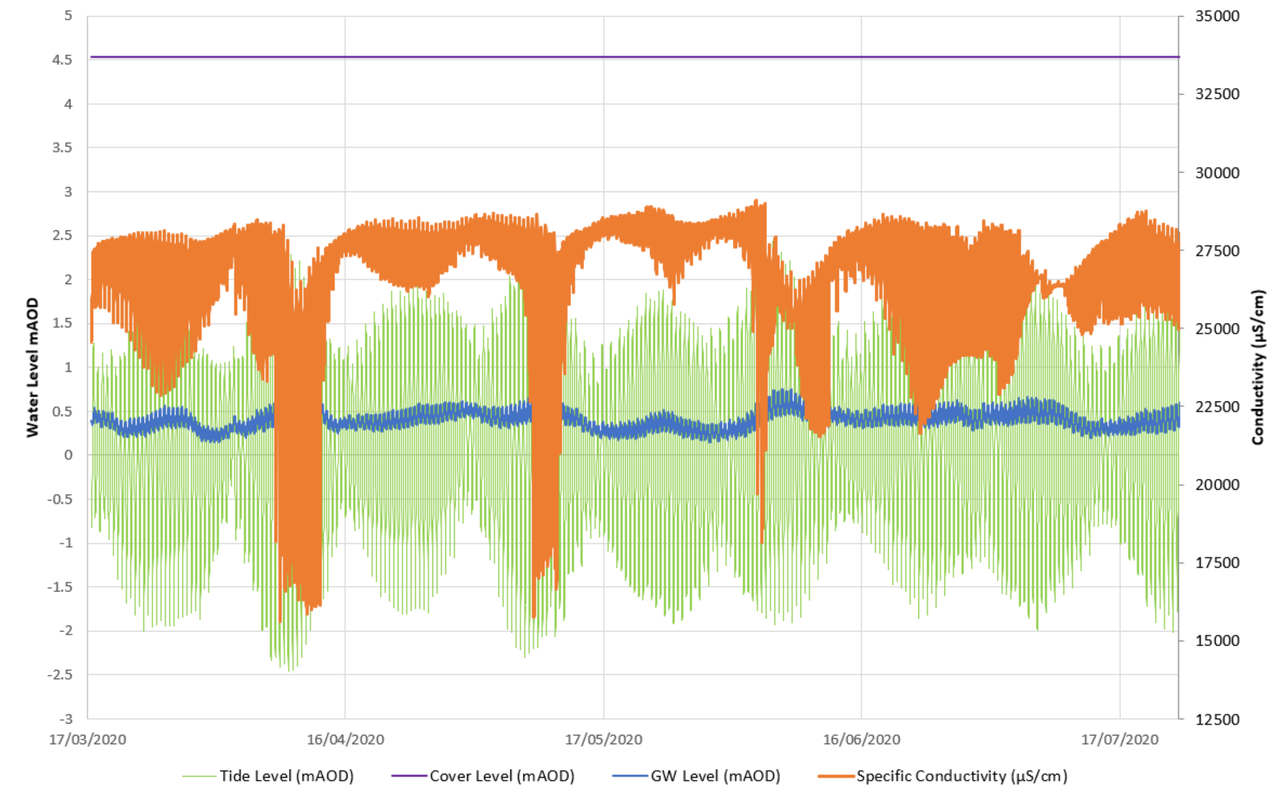
F.24 BHRH07 Bandstand

Salinity graph for BHRH07 Bandstand shows a rising and falling tide level between 17/03/2020 to 24/07/2020. The maximum tide level was 2.43m above Ordnance Datum (AOD) and the minimum level was -2.45m AOD. The blue line denotes the groundwater level from -0.08m to 0.413m AOD during the monitoring period. The ground surface level for borehole BHRH07 is 3.62m AOD. The maximum electrical conductivity (µS/cm) concentration was 22,487µS/cm and the minimum concentration was 3,826µS/cm, which ranges from saline to slightly brackish water. Salinity appears to be tidally influenced.



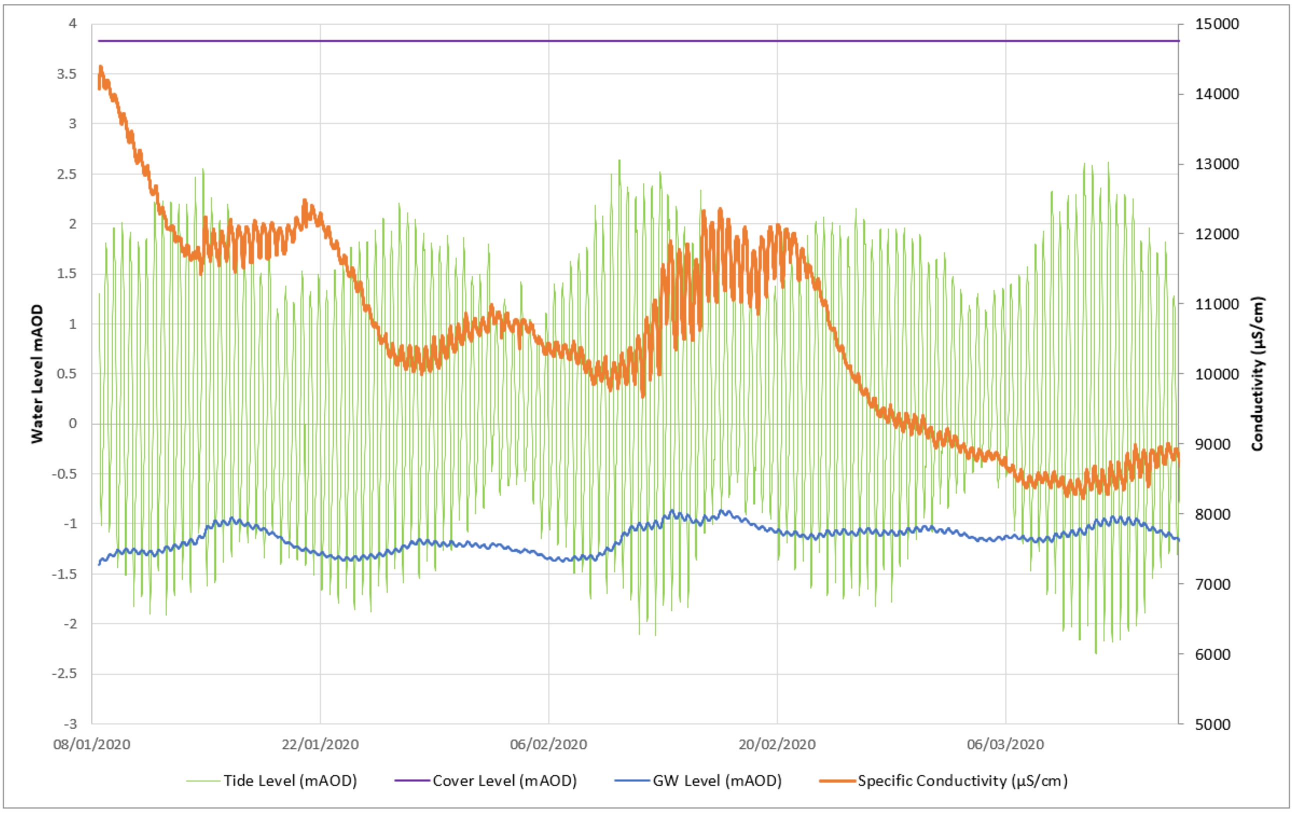
F.25 BHRH08 Southsea Castle Promenade

Salinity graph for BHRH08 Southsea Castle Promenade shows a rising and falling tide level between 17/03/2020 to 24/07/2020. The maximum tide level was 2.43m above Ordnance Datum (AOD) and the minimum level was -2.45m AOD. The blue line denotes the groundwater level from 0.143m to 0.754m AOD during the monitoring period. The ground surface level for borehole BHRH08 is 4.53m AOD. The maximum electrical conductivity (µS/cm) concentration was 29,081µS/cm and the minimum concentration was 15,629µS/cm, which is saline water. Salinity appears to be tidally influenced.



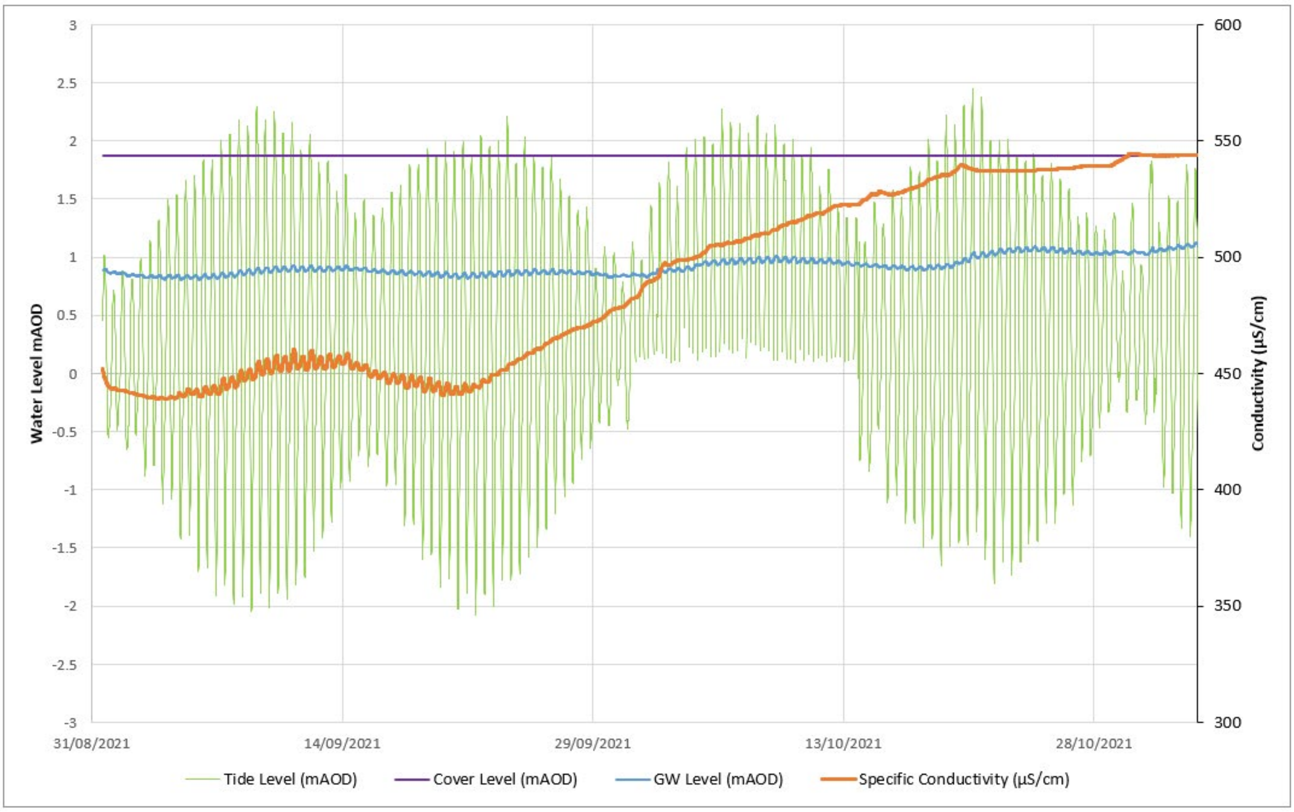
F.26 BHRH09 Southsea Castle

Salinity graph for BHRH08 Southsea Castle Promenade shows a rising and falling tide level between 08/01/2020 to 17/03/2020. The maximum tide level was 2.64m above Ordnance Datum (AOD) and the minimum level was -2.30m AOD. The blue line denotes the groundwater level from -1.406m to -0.864m AOD during the monitoring period. The ground surface level for borehole BHRH09 is 3.83m AOD. The maximum electrical conductivity (µS/cm) concentration was 14,390µS/cm and the minimum concentration was 8,226µS/cm. Salinity appears to be tidally influenced.



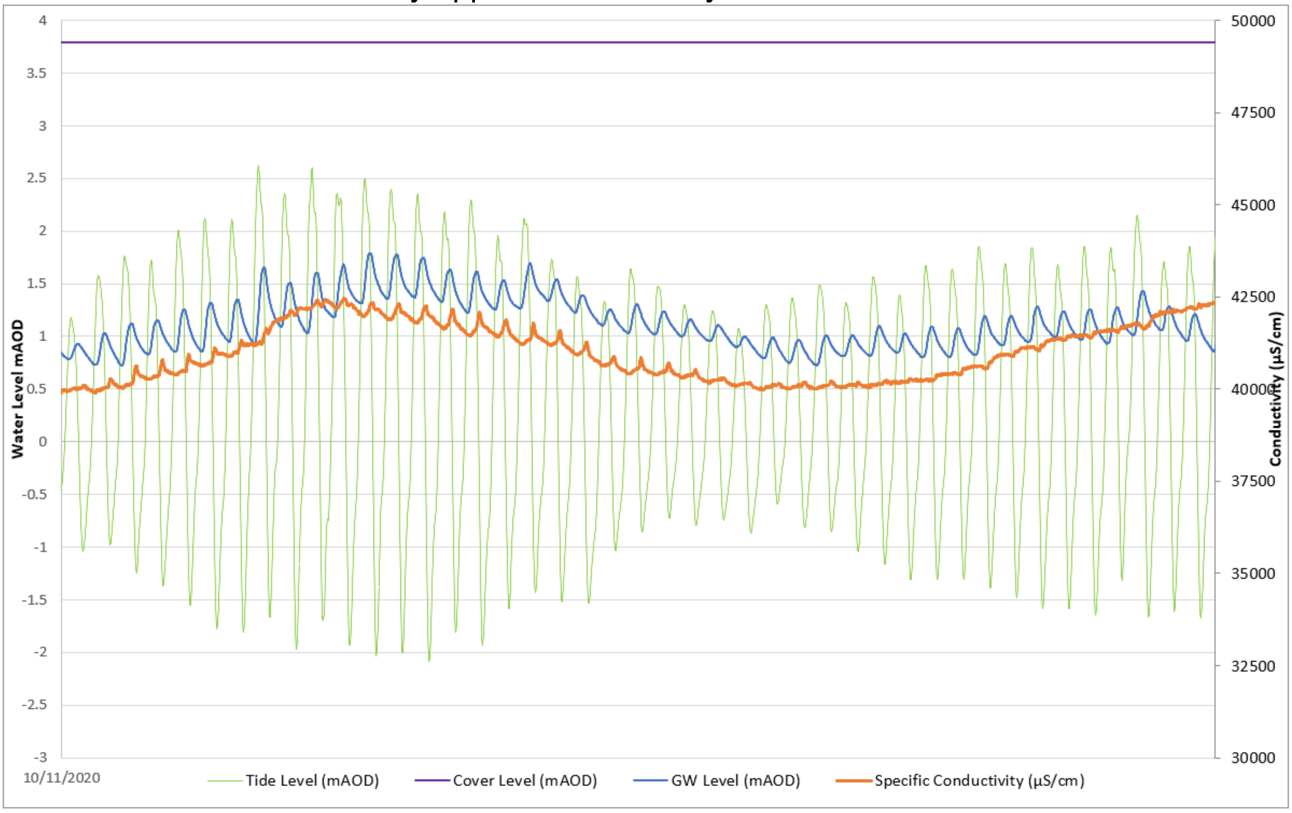
F.27 BHRH11 Little Morass

Salinity graph for BHRH11 Little Morass shows a rising and falling tide level between 31/08/2021 to 03/11/2021. The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.08m AOD. The blue line denotes the groundwater level from 0.803m to 1.123m AOD during the monitoring period. The ground surface level for borehole BHRH11 is 1.87m AOD. The maximum electrical conductivity (µS/cm) concentration was 544µS/cm and the minimum concentration was 438µS/cm, which is below brackish concentrations. Salinity appears to be tidally influenced.



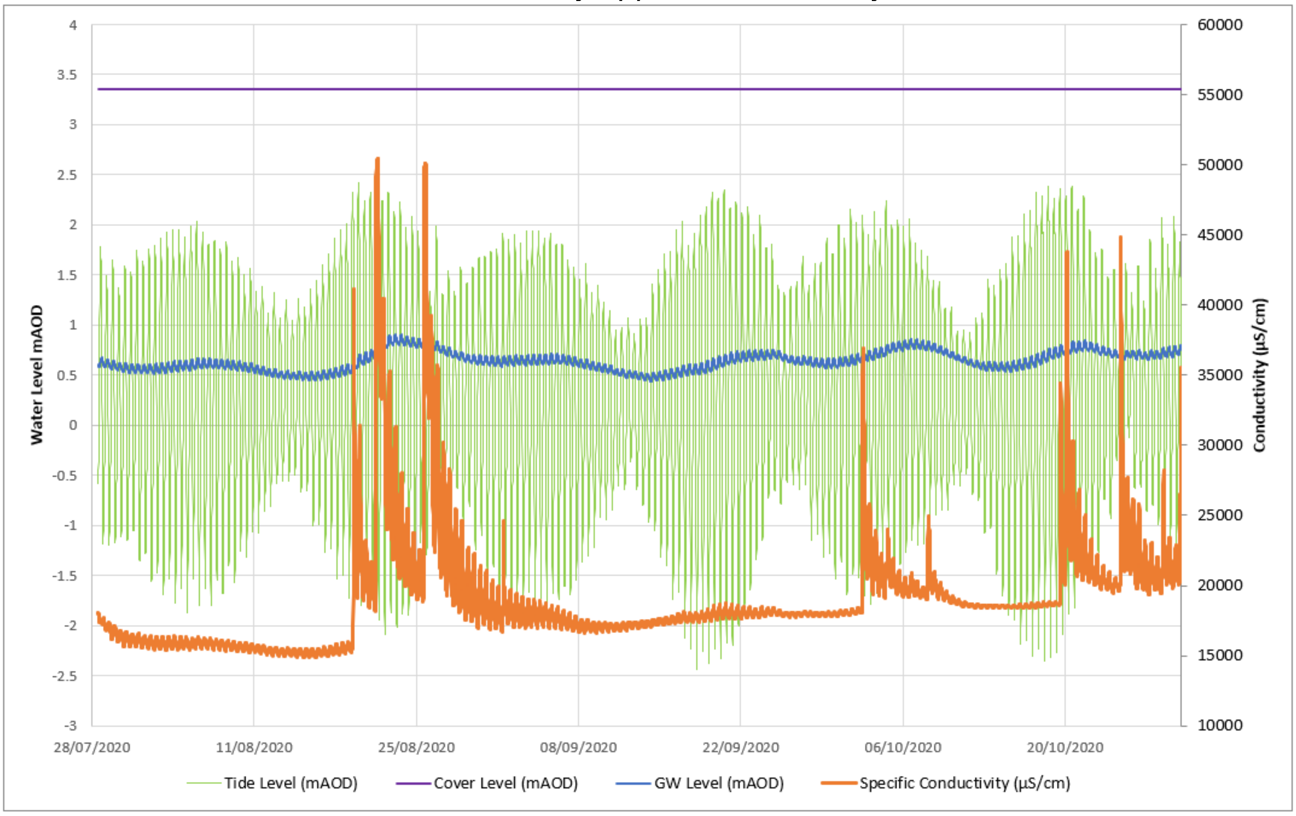
F.28 BHRH14 Mozz Joe

Salinity graph for BHRH14 Mozz Joe shows a rising and falling tide level between 10/11/2020 to 03/12/2020. The maximum tide level was 2.62m above Ordnance Datum (AOD) and the minimum level was -2.09m AOD. The blue line denotes the groundwater level from 0.704m to 1.792m AOD during the monitoring period. The ground surface level for borehole BHRH14 is 3.79m AOD. The maximum electrical conductivity (µS/cm) concentration was 42,569µS/cm and the minimum concentration was 39,569µS/cm, which indicates saline water. Salinity appears to be tidally influenced.



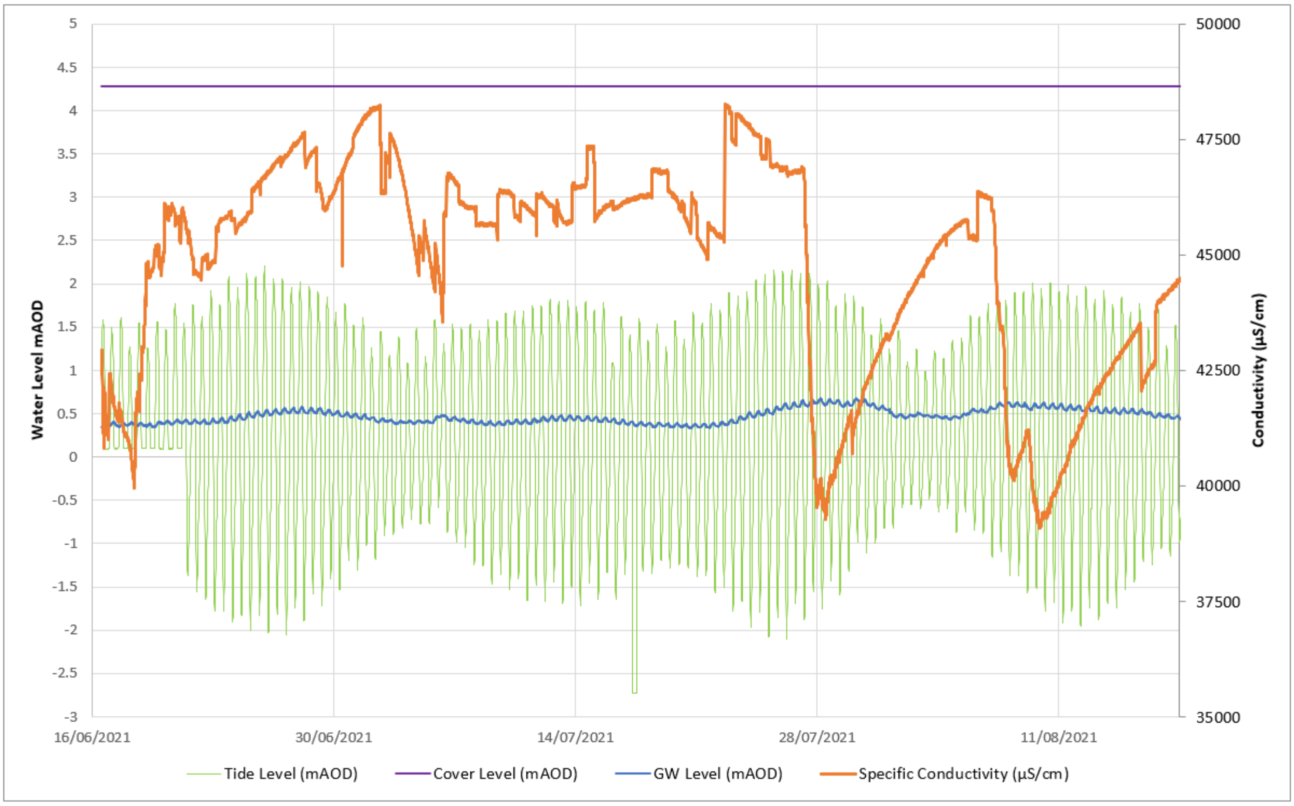
F.29 BHRH15 Esplanade

Salinity graph for BHRH15 Esplanade shows a rising and falling tide level between 28/07/2020 to 30/10/2020. The maximum tide level was 2.56m above Ordnance Datum (AOD) and the minimum level was -2.43m AOD. The blue line denotes the groundwater level from 0.439m to 0.943m AOD during the monitoring period. The ground surface level for borehole BHRH15 is 3.35m AOD. The maximum electrical conductivity (µS/cm) concentration was 50,465µS/cm and the minimum concentration was 14,852µS/cm, which indicates saline to brackish water. Salinity appears to be tidally influenced.



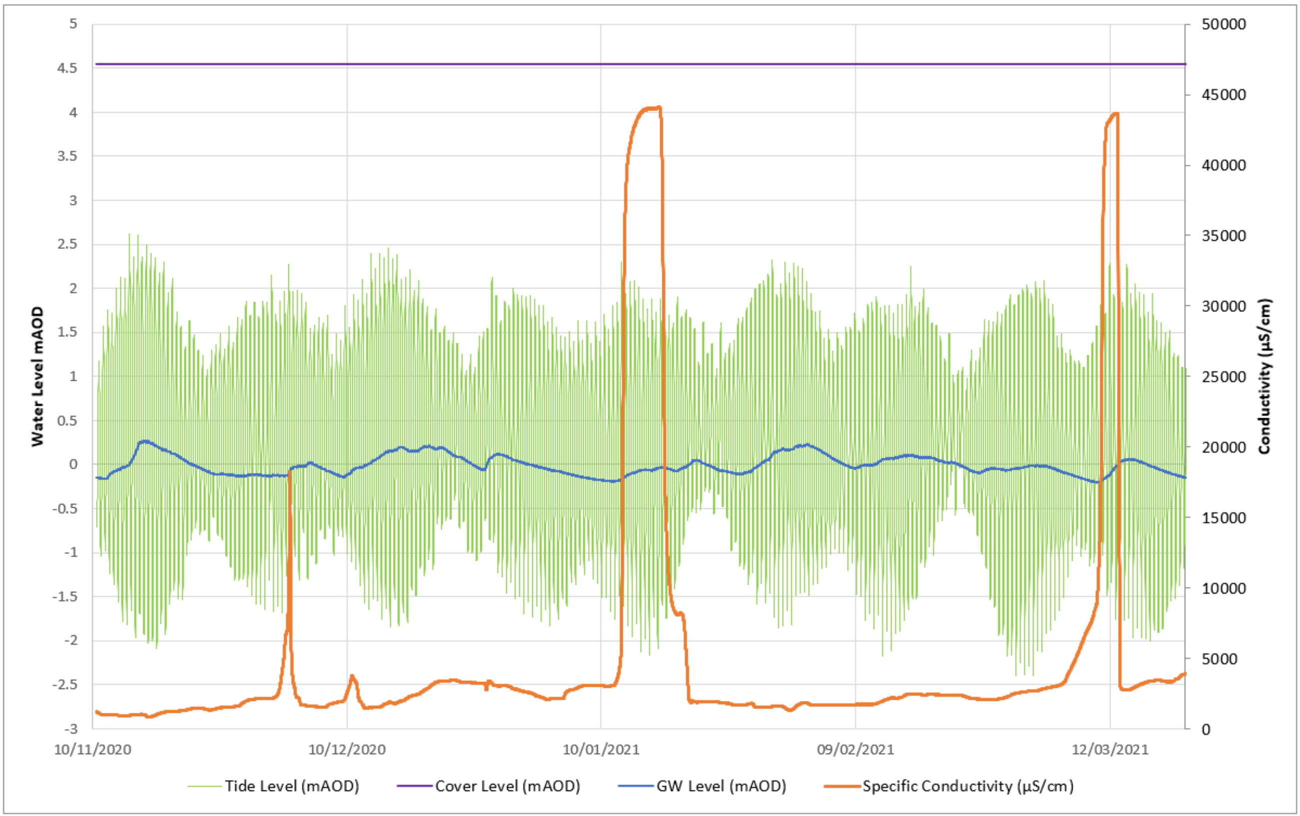
F.30 BHRH16a Pyramids

Salinity graph for BHRH16a Pyramids shows a rising and falling tide level between 06/06/2021 to 18/08/2021. The maximum tide level was 2.20m above Ordnance Datum (AOD) and the minimum level was -2.73m AOD. The blue line denotes the groundwater level from 0.334m to 0.677m AOD during the monitoring period. The ground surface level for borehole BHRH16a is 4.28m AOD. The maximum electrical conductivity (µS/cm) concentration was 48,254µS/cm and the minimum concentration was 39,083µS/cm, which indicates saline water. Salinity has large dilution during rainfall.



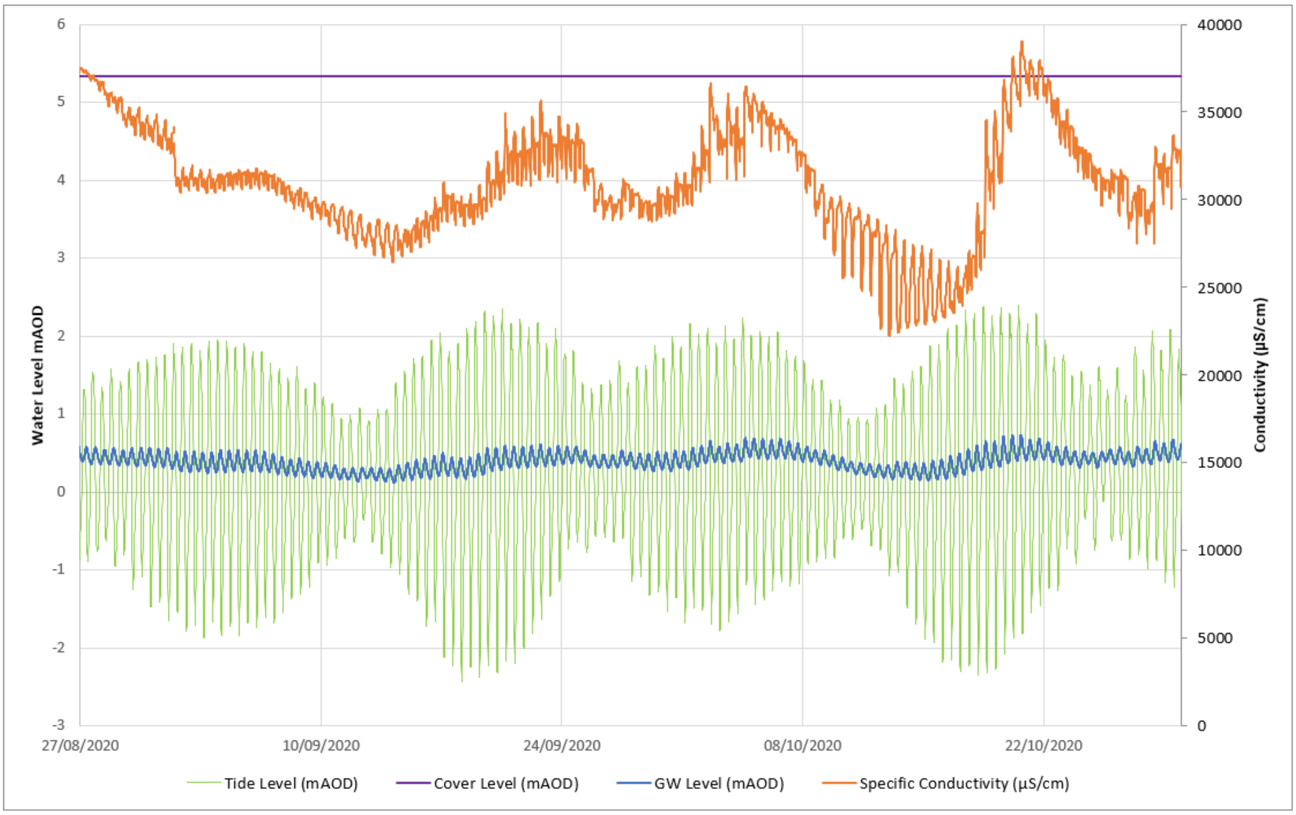
F.31 BHRH18 Promenade East

Salinity graph for BHRH18 Promenade SPP East shows a rising and falling tide level between 07/12/2022 to 25/01/2023. The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.48m AOD. The blue line denotes the groundwater level from -0.528m to 0.006m AOD during the monitoring period. The ground surface level for borehole BHRH18 is 4.55m AOD. The maximum electrical conductivity (µS/cm) concentration was 44,096µS/cm and the minimum concentration was 835µS/cm, which indicates saline to below brackish water. Large peaks appear to match spring tides.



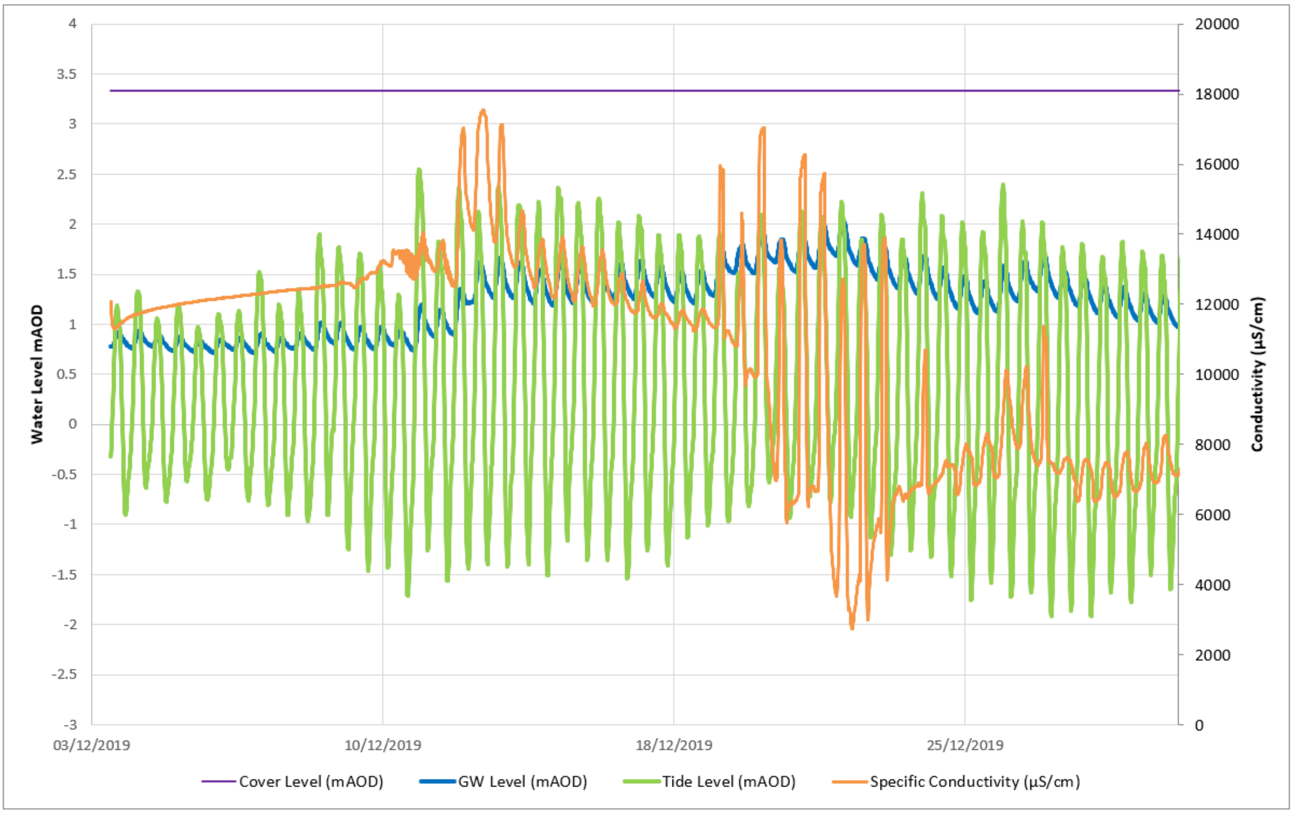
F.32 CPTRH01 Castle Promenade

Salinity graph for CPTRH01 Castle Promenade shows a rising and falling tide level between 30/10/2019 to 03/12/2019. The maximum tide level was 2.56m above Ordnance Datum (AOD) and the minimum level was -2.434m AOD. The blue line denotes the groundwater level from 0.077m to 1.029m AOD during the monitoring period. The ground surface level for borehole CPTRH01 is 5.34m AOD. The maximum electrical conductivity (µS/cm) concentration was 43,685µS/cm and the minimum concentration was 21,391µS/cm, which indicates saline water. Salinity appears to be tidally influenced.



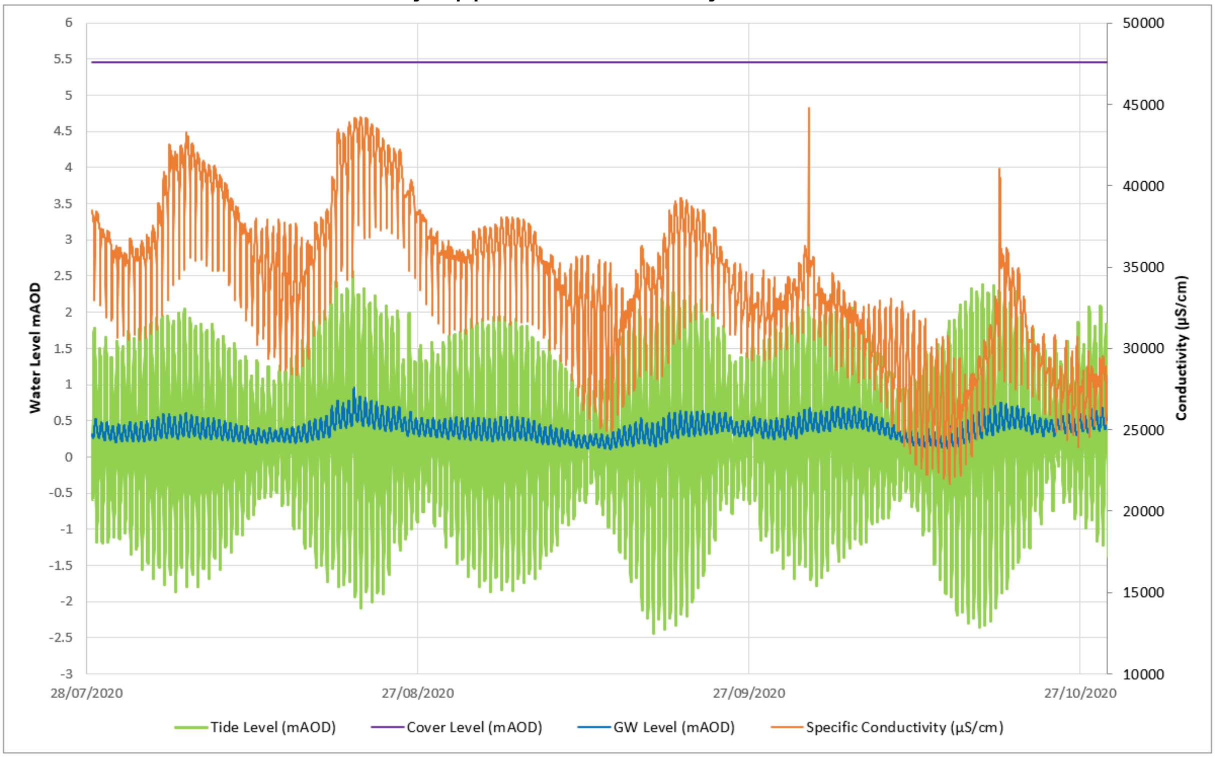
F.33 NPIBH15 Tudor Sailing Club

Salinity graph for NPIBH15 Tudor Sailing Club shows a rising and falling tide level between 03/12/2019 to 31/12/2019. The maximum tide level was 2.55m above Ordnance Datum (AOD) and the minimum level was -1.916m AOD. The blue line denotes the groundwater level from 0.711m to 2.039m AOD during the monitoring period. The ground surface level for borehole CPTRH01 is 3.33m AOD. The maximum electrical conductivity (µS/cm) concentration was 17,546µS/cm and the minimum concentration was 2,729µS/cm, which indicates saline to slightly brackish water. Salinity appears to be tidally influenced.



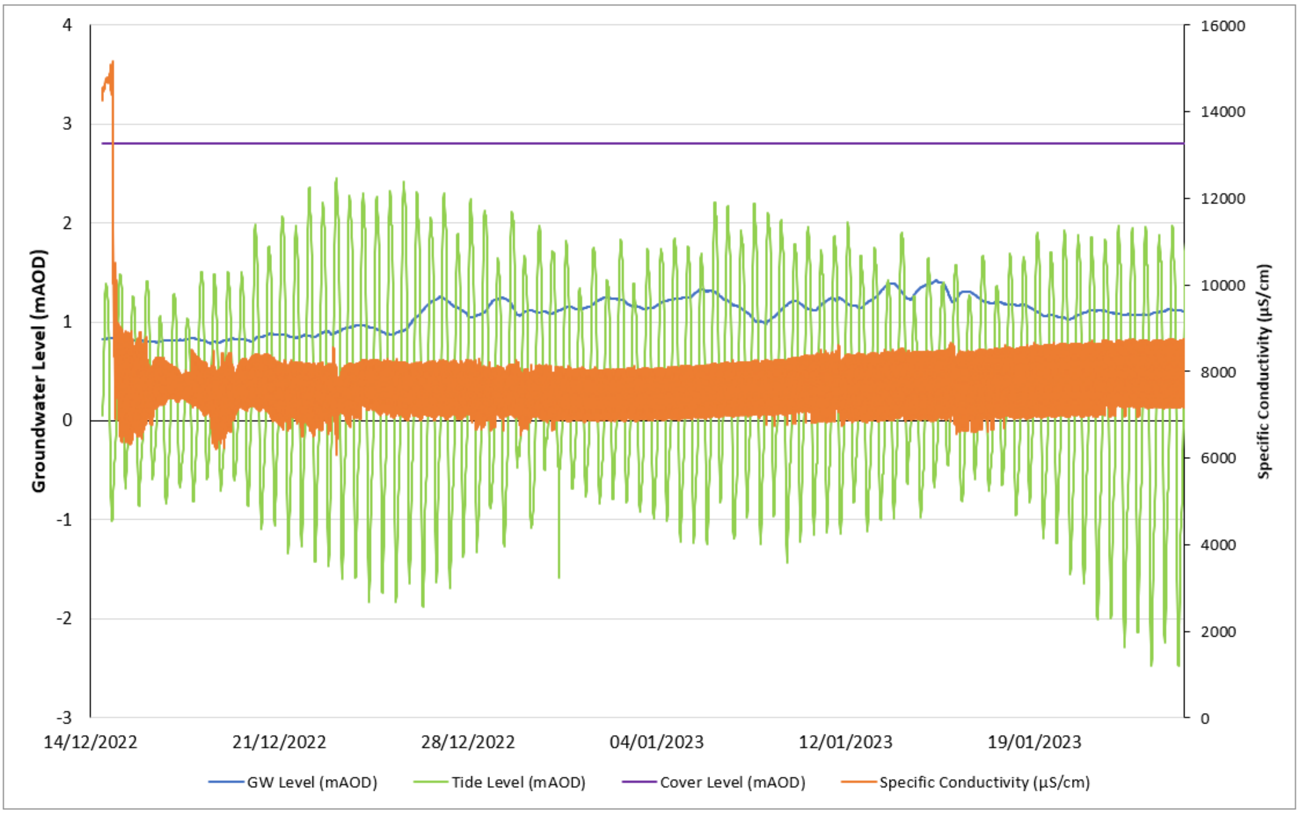
F.34 RCRH02 Castle Revetment

Salinity graph for RCRH02 Castle Revetment shows a rising and falling tide level between 28/07/2020 to 30/10/2020. The maximum tide level was 2.56m above Ordnance Datum (AOD) and the minimum level was -2.434m AOD. The blue line denotes the groundwater level from 0.098m to 0.953m AOD during the monitoring period. The ground surface level for borehole RCRH02 is 5.46m AOD. The maximum electrical conductivity (µS/cm) concentration was 44,770µS/cm and the minimum concentration was 21,697µS/cm, which indicates saline water. Salinity appears to be tidally influenced.



F.35 S2 D Day Museum

Salinity graph for S2 D Day Museum shows a rising and falling tide level between 14/12/2022 to 25/01/2023 The maximum tide level was 2.45m above Ordnance Datum (AOD) and the minimum level was -2.48m AOD. The blue line denotes the groundwater level from 0.783m to 1.423m AOD during the monitoring period. The ground surface level for borehole S2 is 2.80m AOD. The maximum electrical conductivity (µS/cm) concentration was 15,180µS/cm and the minimum concentration was 6,066µS/cm, which indicates brackish water. Salinity appears to be tidally influenced.



G Cross Sections

H Potential for Groundwater Emergence

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