The Sizewell C Project

9.64 Fen Meadow Plan Draft 1

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CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

1.1 Context

1.1.1 The Sizewell C (SZC) proposals would lead to the permanent loss of approximately 0.46ha of 'fen meadow' habitat from the Sizewell Marshes SSSI [Section 2.9D of AS-209]. This permanent loss arises from the size and location of the SZC main platform to the north of the existing Sizewell B station. The loss of this area of fen meadow is therefore unavoidable.

1.1.2 Sizewell Marshes SSSI is designated in part for its fen meadow habitats and the loss of the fen meadow habitat from the SSSI leads to a need to provide compensatory habitat for this loss.

1.1.3 The original compensatory habitat proposals included two sites but a third site (Pakenham) was added to the proposals in January 2021. This was to address a comment from Natural England at Stage 4 pre-application consultation (Ref. 1) which was:

"We advise that the extent of compensatory habitat required is 9x that which would be destroyed by the development; this is considered a suitable multiplier given the complexity of habitat type to be lost, the risk and uncertainty involved in the habitat restoration being successful and the time to fully functioning habitat…"

1.1.4 SZC Co. is therefore proposing to deliver between 4.14 and 4.5 ha of compensatory fen meadow habitat. The lower figure arises by way of applying the 9x multiplier to the permanent landtake of fen meadow habitat from the SSSI of 0.46ha which was confirmed in January 2021. The higher figure of 4.5ha arose by application of the 9x multiplier to a previous estimate of 0.50ha which was included in the May 2020 application. Natural England now considers the quantum proposed, based on the multiplier, to be sufficient as detailed in issue 49 of their written representation [REP2-153].

1.1.5 The application for development consent includes within the draft order limits, the three sites identified as follows:

- Fen Meadow compensation site at Benhall;
- Fen Meadow compensation site at Halesworth;
- Fen Meadow compensation site at Pakenham.

1.1.6 Requirement 14A in the **draft DCO** (Doc Ref. 3.1(E)) prevents clearance within the SSSI until the Fen Meadow Plan has been submitted to and approved by East Suffolk Council and Suffolk County Council, in consultation with West Suffolk Council, and the relevant Statutory Conservation Body. The Plan must be developed in general accordance with the **Fen Meadow Strategy** [Section 2.9D of AS-209] which has been prepared to define SZC Co's commitment to provide appropriate compensation measures for the loss of fen meadow habitat. This will be achieved through the creation of at between 4.16ha and 4.5 ha of compensatory fen meadow habitats, and the provision of a contingency fund.

1.1.7 The **Fen Meadow Strategy** [Section 2.9D of AS-209] defined a series of three reports, which will lead to the establishment of the Fen Meadow Plan, that will further define the approaches to maximise the extent of fen meadow habitats at the three sites. Three reports are proposed:

- **Fen Meadow Plan Report 1**. This was submitted at Deadline 3 [REP3-051 and REP3-052] and provides the baseline reports for the sites and water data available to May 2021;
- Fen Meadow Plan Draft 1, **this report**, is being submitted at Deadline 6, and provides further interim data and defines, in draft, the management interventions required to create fen meadow habitats. The measures will seek to maximise the extent of the establishment of fen meadow at each site and the report describes interventions that may be required to ensure the successfully delivery of the habitats at each site.
- The Fen Meadow Plan Draft 2 will provide the full scope of the plan after 12 months of water data collection at each site and be provided for review by the Environment Review Group. Upon finalisation it will become the Fen Meadow Plan referred to in DCO Requirement 14A [Section 2.9D of AS-209].

1.1.8 SZC Co. will then implement the establishment of the fen meadow in accordance with the approach and implementation timetable set out in the Fen Meadow Plan.

1.2 Status of the Fen Meadow Plan Draft 1

1.2.1 This report is considered to provide sufficient detail to inform the Examining Authority, the Secretary of State and the other stakeholders as to the proposals at each site.

1.2.2 The proposals presented herein have been informed by all data collected up to and including early July 2021. In relation to hydrology this means that a substantive portion of the data for summer period has informed the proposals. This is important as both groundwater and surface water levels are typically lowest in summer and these levels and related seasonal trends are likely to be amongst the most important variables in determining the potential for establishing new fen meadow on the three sites.

1.3 Environmental Statement and Shadow Habitat Regulations Assessment

1.3.1 The proposals described for each of the three locations will create some small scale and local changes to hydrology within the sites and there will be a need to undertake some shallow excavations. Some protected species are present and other receptors are present nearby, including, in some cases, designated sites or features.

1.3.2 The impacts at the three sites related to the creation of fen meadow habitats were considered in **Volume 2**, **Chapter 14** the **ES** [AS-033] and **Chapter 2** of the **ES addendum** [AS-181]. However, given the greater definition now available for the proposals, further consideration will be given to the potential for impacts and this will be reported at Deadline 7. However, no change to the significance of effects is predicted.

1.3.3 The fen meadow proposals described in this plan will have no adverse effects on integrity for any European Site and there are no consequences in the context of the Habitats Regulations. A note on the potential hydrological consequences on the Abbey Meadows compensation site at Snape of proposals at Benhall was submitted at Deadline 5 in response to the Written Representation by the RSPB (**Appendix L** of [REP5-120]). This concluded that there would be no adverse effect on integrity given the extent of the catchment, the effect on availability of water to the Abbey Farm compensation site.

1.4 Recreation of Fen Meadow Habitats

1.4.1 Whilst the term fen meadow covers more than one botanical community in the National Vegetation Classification (NVC) (Wheeler, Shaw and Tanner, 2009, Ref. 2) the target community in the context of the loss at Sizewell Marshes is M22 *Juncus subnodulosus –Cirsium palustre* fen meadow.

1.4.2 To manipulate site conditions such that conditions are suitable for M22 development it is necessary to recognise the characteristics of the community including appropriate eco-hydrological conditions. The characteristics of M22 have been described by Wheeler et al. (Chapter 18

in Ref. 2), including floristic composition, landscape situation and topography, substratum types, water supply and level requirt M22 can be summarised as:

- Overall, M22 is a community that is botanically variable and can occur in a wide range of eco-hydrological situations. Nonetheless, the key conditions required to support M22 can be summarised as base-rich conditions, but relatively low fertility with limited nutrient concentrations (e.g. phosphate, nitrate); and

- management, by mowing or grazing, which are crucial to the maintenance of M22.

1.4.3 There is an extensive literature on fen meadow restoration in Europe - notably from the Netherlands, Poland and Germany. Van Diggelen & Marrs (2003, Ref. 3) in particular have categorized four essential steps for conservation and restoration of fen meadow:

- establishing or re-establishing the necessary abiotic conditions;

- supplying (sufficient) propagules of constituent species of the target communities;

- creating and maintaining suitable conditions for the (re-) establishment of target species; and

- appropriate management to keep the conditions suitable.

1.4.4 The **Fen Meadow Strategy** [Section 2.9D of AS-209] outlines the types of measure likely to be necessary to facilitate development of the compensatory habitat, as represented by the M22 *Juncus subnodulosus – Cirsium palustre* fen meadow community at appropriate sites. A review of the conditions required for recreating fen meadow was presented in response to Examination Question 'Biodiversity 1.86'. The development of the abiotic and biotic conditions for fen meadow referable to the M22 *Juncus subnodulosus – Cirsium palustre* fen meadow community are considered to have the highest chances of success if the following techniques are employed at the three fen meadow sites:

- **Topsoil removal.** Complete or partial topsoil removal should be undertaken within the context of sediment disposition, surface topography and valley flooding regimes, in order to reduce nutrient levels and increase the influence of groundwater on target species.

- **Creation of microtopography.** The ground surface should be sculpted within hydrologically significant tolerances to assist in the successful colonisation and regeneration of target groundwater-dependent species, particularly those with high light requirements, low competitive abilities and low tolerance of drought or flooding.

- **Rewetting from appropriate water sources**. Rewetting should be undertaken using groundwater-dominated sources to facilitate an appropriate hydrological regime for the target vegetation. Sufficient control is likely to be required to minimise the impact of extreme events leading to flooding by nutrient-rich waters and/or periods of drought, within acceptable limits.

- **Use of hay transfers.** The transfer of hay from suitable sites – or of turves from the FMS donor site – should be undertaken following established best practices. The conditions and timing of collection, transfer and introduction of plant propagules – and their initial establishment – should be carefully monitored to meet restoration requirements.

- **Habitat management.** An agreed annual programme of water and vegetation management should be established and undertaken at appropriate times. These operations – and their impact on the developing fen meadows – should be set with a framework of acceptable limits. Appropriate monitoring should be maintained to enable effective and timely management of the habitat management programme to meet target conditions for the restored fen meadow vegetation.

1.4.5 These techniques are deployed as relevant in the detailed proposals for each of the three sites set out in this report.

1.4.6 Additionally, in accordance with the **Wet Woodland Strategy** [REP1-020], areas at Benhall and Pakenham have been identified for the delivery of wet woodland. The required measures will be detailed in a separate plan but given that they are to be co-located with fen meadow habitats they are defined spatially in this plan.

1.4.7 The **Wet Woodland Strategy** [REP1-020] was submitted into Examination at Deadline 1. This requires the delivery of a total of 2.36ha of wet woodland across the two fen meadow sites at Benhall and Pakenham. The principle of co-location of compensatory wet woodland and fen meadow habitats is supported by Natural England, given that this replicates the situation at the Sizewell Marshes SSSI.

1.5 Fen Meadow Establishment and Management Measures

1.5.1 The detailed proposals provided in Sections 2 to 4 of this draft Fen Meadow Plan are focussed on the establishment phase which would be undertaken in 'Year 1' of the works as outlined in the **Fen Meadow Strategy** [Section 2.9D of AS-209]. These primarily comprise physical measures to be implemented to create the ground conditions to support fen meadow species and the approach to introducing those species.

1.5.2 In subsequent periods (years 2-5 and 6-10), measures outlined focus on continued introduction of species (as detailed in **Fen Meadow Strategy** [Section 2.9D of AS-209]) and on-going management approaches. These will need to remain flexible and be adjusted, annually if necessary, based on monitoring of habitat development. Progress will be reviewed annually and any adjustments to the habitat management approaches approved by the Ecology Working Group. Any substantive changes of approach, which could ultimately impact the ability to deliver the quantum of the target habitat by Year 10, would need to be agreed by the Environment Review Group.

1.6 Report structure

1.6.1 There is a separate plan for the creation and establishment of fen meadow habitat at each site. The report is structured as follows:

- Section 2 - Benhall;
- Section 3 – Halesworth;
- Section 4 – Pakenham;
- Section 5 – Summary.

2 BENHALL

2.1 Site Baseline

a) Summary of investigations

2.1.2 The investigations being undertaken at Benhall were summarised in the **Fen Meadow Plan Report 1**, with the study reports provided as appendices [REP3-051 and REP3-052]. The studies have mostly been completed, as detailed in Table 2.1 below.

Table 2.1: Status of studies as at July 2021

Site	Study	Status
Benhall	Ecology desk study	Completed in 2020
	Ecology field surveys	Phase 1 habitat survey NVC survey Water vole and otter survey Aquatic invertebrate survey of ditches All completed in 2020
	Hydrogeological desk study	Completed in 2021
	Installation of piezometers, dipwell, gaugeboards	Installed October 2020
	Topgraphic survey of site and installations	Completed 2020
	Water flow, level and quality monitoring	Commenced November 2020 for 1 year.

2.2 Environmental Setting

2.2.1 The Fen Meadow Plan Report 1 Baseline Report [REP3-051 and REP3-052] summarised the findings of a series of baseline reports, provided as Appendices, that described the environmental setting of the Benhall site. The majority of the baseline information is not repeated in detail in this Fen Meadow Plan Draft 1 although a summary of the ecological setting is provided below and further hydrological monitoring data are now available so the Water Monitoring Summary – Benhall Site 10 & 11, November 2020 to April 2021, has been updated to July 2021 (**Appendix A**). The updated data have also been further interpreted to update the site conceptual model (**Section 2.3**).

2.2.2 Note that in 2019, two sites were identified, referred to as Site 10 (to the north) and Site 11 (to the south) and there was a gap between them. Subsequently, the site boundaries were revised to combine these sites and include the small parcel of land in between and the combined site was included in the application for development consent. Reference is now made to the northern, central and southern compartments (see **Figure 2.1**).

a) Summary of Ecological Setting from Benhall Ecology Baseline report [REP3-051]

2.2.3 There are no statutory designated sites of nature conservation value within the Benhall site boundary. However, a compartment of Manor Farm County Wildlife Site (CWS) is located within the red line, and a further compartment is located adjacent to the western Site boundary. This latter compartment supports fen meadow habitat.

2.2.4 Coastal and floodplain grazing marsh, deciduous woodland and lowland meadows priority habitats are mapped in MAGIC as occurring on Site.

2.2.5 The site comprises poor semi-improved grassland, inundation vegetation, broadleaved wet woodland, scattered trees, flowing water, with fields divided either by hedges or ditches.

2.2.6 The habitats present on site were broadly categorised, during the NVC survey, as Floodplain and toe slope grasslands (of which three communities, including two rush pasture communities, supported suites of groundwater influenced and typical floodplain species), dry valley side grassland and wet woodland.

2.2.7 Giant hogweed and Himalayan balsam were present along the banks of the River Fromus. A small patch of giant hogweed was also noted within the Site.

2.2.8 No sign of otter presence was recorded on site, although the river and some of the wet ditches provide suitable habitat, and there is an otter record nearby.

2.2.9 Four of the 18 transects surveyed provided optimal aquatic habitat for water voles, with a further two meeting most of the noted habitat requirements but holding less water, and eleven containing relatively shallow water. Water vole presence was confirmed on four transects (two ditches and two river transects).

2.2.10 The aquatic invertebrate fauna of the Benhall site comprises predominantly common and local species.

2.3 Site Conceptual Model

2.3.1 The initial site conceptual model is presented in the hydrogeological report (Appendix D of the Fen Meadow Plan Report 1 Baseline Report [REP3-051 and REP3-052]). This section builds on the assessment provided in the conclusions of that report and all monitoring data collected and made available at the time of writing (July 2021). This section presents the findings on the relationship between ground level, groundwater levels, surface water levels and logged geological strata.

2.3.2 The Benhall site covers an area of 12.9 ha. The surface elevation across much of the northern compartment is relatively flat, generally between 3.8 and 4.0 mAOD (see LIDAR plots in **Appendix A**). At the margins of the site the land surface rises to 6.7 mAOD in the northwest near Aldecar Lane and to 5.2 mAOD in the southwest. The central and southern compartments have a more well-defined slope from west to east towards the River Fromus and contain a cut-off meander channel with a bed level of approximately 3.5 mAOD.

2.3.3 The River Fromus forms the eastern boundary of the Site and flows from north to south.

2.3.4 The bedrock geology at the site is Crag sands (c.10-20m thick) overlying London Clay of the Thames Group. The combined thickness of the Thames Group and Lambeth Group in this locality is thought be c. 25-30 metres in this locality. The Lambeth Group lies over the Chalk Group.

2.3.5 Alluvial deposits of clay, silt, sand and gravel directly overlie the Crag at the Benhall site and borehole logs indicate that they increase in thickness from around 7.7m in the south to >10m in the north of the Site. Head deposits of clay, silt, sand and gravel are mapped at the western edge of the Alluvium close to the boundary of the Site.

2.3.6 The Site is split in two at the boundary of the northern and central compartments by an ordinary watercourse named 'The Canal' which originates to the west of the A12 road. The Canal passes at right angle past two sides of the Benhall Sewage Treatment works before turning east again and discharging to the River Fromus. The Canal is the receiving watercourse for the Benhall Sewage Treatment Works (STW) discharge. The licensed discharge volume is 1.5 Ml/d.

2.3.7 On-site observations suggest that the Canal diverges to the north-east of the STW (downstream of the discharge point) and some water flows into the ditch network which flows northwards towards GB04.

2.3.8 The Benhall site contains a network of land drainage ditches which discharge to the River Fromus at three locations.

2.3.9 There is a licenced surface water abstraction from the River Fromus on the Site boundary (AN/035/0004/017), although this is toward the downstream end of the site away from the potential Fen Meadow areas.

2.3.10 Topographic surveys initially indicated that water levels coming on to the site from the west via the Canal are around 3.9 mAOD and on-site drainage ditches generally between 3.5 and 3.8 mAOD (November 2020). Ditch water levels are slightly lower in the southern half (Ditch W12 and W13) which do not appear to be well connected to other ditches or to the River Fromus.

2.3.11 The ditches in the northern compartment are monitored by GB03, 04 and 05 (Figure 1.1 in Appendix A). The STW discharge is upstream of GB03. A plot of the water levels at the three gaugeboards and the groundwater level in the superficial deposits (BHALL_1001_s) shows that the water level at GB03 (which is located on the higher ground to the north-west) appears to be sustained (Figure C3 in Appendix A), likely by discharges from the STW. A similar water level response is seen in the downstream gaugeboard at GB04 at the northern boundary of the Site showing the influence of the STW here. GB05 to the centre of the northern compartment, and the groundwater level monitoring well at BHALL_1001_s both show a similar seasonal response with reductions in water levels in mid-April and June and do not appear to be maintained by the discharge. On-site observations have confirmed that this central ditch in Site 10 is significantly drier with very little flow.

2.3.12 At the boundary of the southern and central compartments, the surface water levels are recorded by GB02. The water levels here show no decline in spring despite a drop in the nearby superficial deposits recorded in April and June (BHALL_1002_s and BHALL_1003_s). Again, this is likely to be the influence of the STW discharge to the Canal.

2.3.1 The monitored data available at GB01 suggests that water levels in this ditch are lower than the other watercourses on site. The levels are also lower than the surrounding groundwater levels (shown in the 1102 piezometer and 1104 dipwell), further reiterating earlier assumptions that this watercourse is not well connected to the other ditches on site. This ditch is linked to the River Fromus.

2.3.2 Development of peat has occurred in the northern and central compartments and peat is encountered between 0.4 and 2.5 m below ground surface. The borehole logs indicate a peat thickness of up to 4 m

thick in places (Piezometer BHALL_1001_d) with a thickness of 1.1m at borehole HAL_2803_d. Soil cores show that a silty clay layer is often present above the Peat which may hold a higher water level than that of the underlying sands and gravels. The basal part of the peat was more degraded than the upper part in some areas (Zone C Site 11) which may indicate that the groundwater level is fluctuating through the lower part, though it may rise through the peat during periods of heavier rainfall.

2.3.3 The soil core surveys carried out in April 2019 indicated that the initial water table was generally between 0.5m and 1m below ground level, rising to 0.4 and 0.1m below ground level at two locations after rest. The rising groundwater levels indicates that water in the peat and sands and gravels beneath the silty clay layer near the surface has a positive hydrostatic pressure in some locations. The October 2020 drilling programme recorded similar rest ground water levels (0.48 to 0.84m). General groundwater flow is thought to be towards the River Fromus (west to east) but collected data from the surveys suggest a relatively flat water table at the Benhall site.

2.3.4 The soil core surveys, drilling logs and topographic survey indicate that groundwater levels are in continuity with surface water levels in the on-site ditches. The River Fromus has a bed level of 2.8 mAOD and a water level of 3.51 mAOD at the northern end of the Benhall site and this gently decreases downstream to a bed level of 2.3 mAOD and a water level of 2.9 mAOD at the southern end of the Benhall site, indicating the potential for groundwater discharge to the river.

2.3.5 There is a groundwater abstraction at Ham Farm (7/35/04/*G/0095) which is relatively close to (0.2km), and upgradient of, the Site and has the potential to impact groundwater levels on the Site. The impact is likely to be minimal due to the relatively low abstraction quantities.

2.3.6 The groundwater level plots shown in the monitoring note in Appendix A show that the groundwater levels to the north (1001_s, 1002_s, 1003_s) and in the centre (1101_s and 1103_s) of the site in the superficial deposits present a similar pattern with a seasonal response to the dry April causing groundwater levels to decrease.

2.3.7 To the very south of the Site, there is less response to the dry April period in the superficial deposits (1102_s and 1104_s) with a flatter groundwater level hydrograph for these two locations (**Figure A3** in **Appendix A**).

2.3.8 Some of the superficial deposit groundwater levels are showing groundwater levels above the ground level. Notably:

- At 1002_s and 1003_s groundwater levels are above surface in winter (January and early February) but the groundwater level decreases

into spring, dropping below ground level (Figures B3 and B4 in Appendix A). This results in a depth to water table at these two sites of up to 0.6 m below ground level in spring. Levels in these superficial deposits recovered into early summer.

- At 1104_s the groundwater level is above ground level periodically between November and February and declines to approximately 0.4 m below ground level into spring (**Figure B10** in **Appendix A**).

2.3.9 There is an artesian groundwater level response in two of the Crag boreholes. The groundwater levels at 1101_d is above ground level for most of the monitored data series and at 1102_d the groundwater level goes above ground level periodically (**Figure A4** in **Appendix A**).

2.3.10 The piezometer at 1001 (BHALL_1001_s for superficial deposits, BHALL_1001_d for Crag deposits) shows that the Crag groundwater levels increased slowly over the winter and have now remained static (~3.65 to 3.75 mAOD) since February **Figure A2** in **Appendix A**). Conversely, the superficial deposits are showing more of a seasonal response. It is likely that the Crag here is partly confined. Water levels in the superficial deposits will be supported by the head in the Crag but there may be limited upward flow. It is suspected that the increase of Crag groundwater levels from October to January results from a rebound effect after the cessation of nearby pumping.

2.3.11 It is evident in the 1102 piezometer in the shallow and deep wells (1102_s and 1102_d respectively) that the timing and amplitude of the groundwater fluctuations align very well between the two geological strata (**Figure A4** and **A5** in **Appendix A**). The Crag groundwater level is above that in the superficial deposits, so it is plausible that there is a degree of hydraulic continuity with the Crag in this location which is supporting the water level in the superficial deposits at this location.

2.3.12 Slightly further north at 1101_s and 1101_d the results for the shallow (superficial) and deep (Crag) boreholes respectively show that the magnitude and timing of the fluctuations align well (**Figure A4** and **A5** in **Appendix A**), with the levels marginally higher in the Crag than the superficial deposits, again supporting the theory that there may be some upward flow from the Crag here.

2.3.13 The lowest groundwater level and therefore maximum depth to water in the superficial deposits is listed in **Table 2.2**.

Table 2.2: Groundwater levels and depth to water table

Borehole ID	Ground level (mAOD)	Lowest observed groundwater level (mAOD)	Maximum depth to water table (m)	Highest observed groundwater level (mAOD)	Minimum depth to water table (m)*
BHALL_1001_d	3.91	2.28	1.63	3.98	-0.08
BHALL_1001_s	4.35	3.49	0.85	4.20	0.14
BHALL_1002_s	3.93	3.31	0.62	4.31	-0.38
BHALL_1003_s	3.88	3.29	0.59	4.14	-0.27
BHALL_1101_d	3.91	3.92	-0.01*	4.34	-0.44
BHALL_1101_s	3.91	3.83	0.08	4.24	-0.34
BHALL_1102_d	3.92	3.74	0.18	4.15	-0.23
BHALL_1102_s	3.92	3.50	0.42	4.01	-0.09
BHALL_1103_s	3.95	3.43	0.52	4.17	-0.21
BHALL_1104_s	3.92	3.60	0.32	4.19	-0.28

* negative depth to water table shows where groundwater levels are above ground level.

2.3.14 The groundwater and surface water data shows that the northern compartment of the Site demonstrate two slightly different hydrologic responses:

- In the northern compartment the superficial deposits fluctuate in response to seasonal climatic conditions. Surface water levels in The Canal, central east-west ditch and northern drainage outlet are maintained by the STW discharges. The same is not seen in the central Site 10 ditch which shows a decline in water levels due to its hydraulic continuity with the underlying deposits. The groundwater levels in the data available show that groundwater levels have been above ground level at times, but also extend to around 50-80cm below ground level during the spring and early summer. Further monitoring will be required to assess what happens over the rest of summer 2021 and into autumn. There appears to be limited connectivity with the River Fromus and the underlying Crag here. Groundwater levels in the superficial deposits have peaked at around 4.3 mAOD and have also dropped to around 3.3 mAOD.

- In central and southern compartments, there is a less pronounced impact to seasonal variations in the superficial deposits and it is likely that there is some upward flow from the Crag in the here. This is likely more pronounced at the southern end of the southern compartment.

2.3.15 There is some water quality data available for the Site, with more sampling planned over 2021. The data so far show the following:

- Nitrate concentrations are highest in the ditches to the south of the Site (GB1 and GB2 which measured 48.2 and 71.5 mg/l as NO3 respectively). The concentrations are either below the limit of detection or low in the superficial deposits and underlying Crag.

- The Site generally has very low phosphate concentrations as would be expected, with most samples not showing anything above the level of detection. GB1, GB2 and SP5 locations shows phosphate concentrations at 0.057 mg/l, 11.4 mg/l and 4.77 mg/l respectively whilst the only detected level in groundwater was at 1102_s at 0.053 mg/l.

2.4 Suitability of the site for fen meadow creation

2.4.1 The Benhall site is discussed as three compartments - north, central and south.

a) Northern Compartment

2.4.2 This compartment was identified in Wood, 2019 (Ref. 4 [APP-258]) as containing a primary locus for fen meadow in the south-western third (1.5ha) in which it was considered that there was good potential for water management to provide the necessary water to support the habitat. This primary locus area was bordered by a potential additional area for fen meadow (0.7ha), within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies.

2.4.3 In 2021 the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits in the northern compartment are indicated to be maintained below ground level at the location of installation BHALL_1001_s. However, this is in an

elevated location on a bund alongside the western ditch. Relative to the majority of the compartment, water levels are at about ground level over winter falling to, at most, 30cm below a typical ground level of 3.8m AOD (June 2021).

- The presence of relict ditches suggests that the compartment was historically wetter, presumably prior to drainage and at which time fen meadow habitats, or at least groundwater dependent fen meadow species, may have been present.

- Water levels in the central ditch (indicated by GB05) are below, but appear to reflect, those of the shallow groundwater, indicating a hydrological link between the two – with the central ditch potentially limiting the groundwater level in this compartment.

- The compartment is bordered to the west and south by the Canal. The main discharge from the Canal is to the Fromus however there appears currently to be a minor link between the Canal and the ditches within the compartment. Whilst water levels in the Canal, and River Fromus would not be controlled as part of this work due to potential effects off site, it is considered that water levels in the ditch network that drains this compartment can be controlled without adversely affecting areas or receptors off site.

- Groundwater nitrate concentrations are either below the limit of detection or low in the superficial deposits and underlying Crag, and the same applies to the presence of phosphate.

- During high flow events the River Fromus floods the compartment and also backs up the Canal, which is noted as having elevated nitrate and phosphate levels which are likely the result of discharge from the Benhall STW. Whilst river water quality, and that in the Canal, is not considered optimal for fen meadow habitats, during high flow events, nitrate and phosphate concentrations will be diluted and, as indicated in Section 1.5, Wheeler, Shaw and Tanner (2009, Ref. 2) note that the community can accommodate considerable eutrophication without change to its basic composition provided that active management continues.

- Soil data indicates the presence of peat at each of the cored locations, albeit at 50cm+ depth (Wood, 2019, Ref. 4 [APP-258]).

- A network of land drains is visible on LIDAR (see **Appendix A**). These will be reducing the groundwater levels and drying the fields. However, these can be blocked.

2.4.4 Based on the groundwater and surface water level data, and substrate type, it is concluded that it will be possible, by implementing measures detailed in Section 2.5, to provide groundwater influenced conditions in this northern area, potentially with a peaty or gley substrate, that have the potential to support fen meadow habitat.

2.4.5 Water levels in the Canal, and River Fromus to the east, would not be controlled to support these proposals. This is not required under the proposals and could lead to off-site impacts.

a) Central Area of the Site

2.4.6 The southern two thirds of this compartment were identified in Wood, 2019 (Ref. 4 [APP-258]) as containing a primary locus for fen meadow (0.5ha) as the area adjacent to the western ditch already contained some fen meadow species. This primary locus area was bordered by a potential additional area for fen meadow (0.5ha), focussed on an area showing groundwater influence, within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies.

2.4.7 Note that the northern third of the compartment was not assessed in Wood, 2019 (Ref 4. [APP-258]) and was included subsequently when the boundary was re-drafted.

2.4.8 In 2021 the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits at the northern boundary of this compartment (indicated by BHALL1003_s) are above surface in winter (January and early February) but decrease into spring by up to 0.6 m below ground level.

- Groundwater levels in the shallow deposits in the western central area of the site are indicated to be maintained at about ground level (BHALL_1101_s) over the monitoring period to late June 2021. An upward gradient from the deeper deposits is also maintained over the monitoring period. These installations are in a location that was marked by the presence of plant species indicating groundwater influence (phreatophytes), and was identified in Wood, 2019 (Ref 4. [APP-258]) as a primary locus.

- East of installation BHALL_1101_s is BHALL_1103_s groundwater levels in the shallow deposits in the eastern central area of the site

are indicated to be maintained at about ground level over the winter but fall from March onwards (to 50cm below ground level at the lowest point to date), and show a much more marked fluctuation than BHALL_1101_s. The vegetation at this location was also not suggestive of a groundwater influence at the surface.

- Groundwater levels in the shallow deposits are typically at, or above, the adjacent ditch levels suggesting there is potential for groundwater discharge to the adjacent ditches.
- The presence of relict ditches suggests that the compartment was historically wetter, presumably prior to drainage and at which time fen meadow habitats, or at least more groundwater dependent fen meadow species, may have been present.
- Groundwater nitrate concentrations are either below the limit of detection or low in the superficial deposits and underlying Crag, and the same applies to the presence of phosphate.
- Water quality data in the western boundary ditch, and the river, indicate elevated nitrate and phosphate levels, likely the result of discharge from the Benhall Sewage Treatment Works, and, possibly (not confirmed at present), septic tank discharge.
- Although a relict ditch remains, there are no active ditches crossing this central area of the site linking to the surface watercourses. The only interaction this area would have with surface water is therefore via periodic overtopping during high flow events in the River Fromus. Whilst river water quality is not optimal for fen meadow habitats, during high flow events, nitrate and phosphate concentrations will be diluted and, as indicated in **Section 1.5**, Wheeler, Shaw and Tanner (2009, Ref. 2) note that the community can accommodate considerable eutrophication without change to its basic composition provided that active management continues.
- Soil data indicates the presence of peat below surface at the northern end of this compartment [APP-258].

2.4.9 Based on the groundwater and surface water level data, and substrate type, it is concluded that it will be possible, by implementing measures detailed in Section 2.5, to provide groundwater influenced conditions in this central area, potentially with a peaty or gley substrate, that have the potential to support fen meadow habitat.

2.4.10 Water levels in the western boundary ditch, and River Fromus to the east, would not be controlled to support these proposals. This is not required under the proposals and could lead to off-site impacts.

c) Southern Compartment

2.4.11 This compartment was identified in Wood, 2019 (Ref. 4 [APP-258]) as containing a potential additional area for fen meadow (0.7ha). The location of this area served to focus the detailed hydrological studies now on-going.

2.4.12 In 2021 the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits in this compartment are indicated (BHALL_1104_s) to be maintained at about ground level over the winter but fall below surface from March onwards (to 25cm below ground level at the lowest point to date).
- Whilst the vegetation present is a form of rush pasture, it lacks the key groundwater indicator species present to the north.
- Groundwater levels in the shallow deposits are typically at, or above, the ditch level (indicated by GB01) suggesting there is potential for groundwater discharge to the adjacent ditch.
- Groundwater nitrate concentrations are either below the limit of detection or low in the superficial deposits and underlying Crag, and the same applies to the presence of phosphate.
- Water quality data in the ditch at the northern end of this compartment, indicate elevated nitrate and phosphate levels, likely the result of discharge from the Benhall Sewage Works and, possibly (not confirmed at present), septic tank discharge.
- A small area of peat was identified at depth in this area during the site investigation. However other core samples taken in this compartment indicate an absence of peat.
- Water levels in the ditch that flows through the compartment, and River Fromus to the east, however would not be controlled as part of this work due to potential for effects off site. Additionally, this area is topographically lower than the central and northern compartments and as a result is likely to flood more frequently than these areas.

2.4.13 Based on review of the data available, it is concluded that the potential area that could be made suitable for fen meadow would be too restricted to be viable and fen meadow is not proposed in this compartment. It is, therefore, excluded from the fen meadow habitat creation proposals, although access through this area is still required for establishment and subsequent management of the fen meadow habitat in the northern and central compartments, as the only access to the Benhall site is from the A1094 at the southern end of the site.

2.5 Proposed layout and features

a) Proposed layout – Northern Compartment

2.5.2 For the northern compartment the key aim of the proposals is to exert control over the drainage ditch network, reducing drainage from the compartment and sculpt the ground to increase the groundwater influence at the surface.

2.5.3 Exerting control over the drainage ditch network will support groundwater levels in the shallow deposits such that they are maintained at, or just above, ground level (target approximately 3.85m AOD).

2.5.4 The ground surface either side of the central (north-south oriented) drain will be sculpted to create a matrix of terrestrial, wetland and shallow open water habitat niches to maximise the potential for target species to colonise. It is anticipated that 20-30cm of the surface material would need to be removed to deliver the proposed matrix of habitats, subject to the results of focussed soil coring during the implementation stage.

2.5.5 Natural colonisation, from the nearby fen meadow habitat on the Manor Farm Meadows County Wildlife Site (CWS), will form a component of the habitat development. However, green hay transfer, from Sizewell Marshes SSSI, or another nearby fen meadow source, to the sculpted areas in mid-summer will assist with species introduction. Application to areas of bare earth is beneficial in respect of establishment of species with high light requirements and low competitive abilities, whilst creation of a matrix will maximise the potential for species that have low tolerance of drought or flooding, to find an appropriate niche. Application of green hay may be undertaken on more than one occasion.

2.5.6 M22 species introduction will also occur through translocation of turves from the area of M22 being lost at Sizewell Marshes to within the areas identified for creation of a habitat matrix. This approach has the added benefit of providing the appropriate substrate for the species introduced. Use of this

approach is subject to programme considerations and would only be undertaken once.

2.5.7 An area for wet woodland creation (0.6ha) has also been identified at Benhall. The approach to creation of this habitat is set out in the **Wet Woodland Strategy** [REP1-020].

2.5.8 Site proposals are indicated on **Figure 2.1**.

i. Physical measures in northern compartment

2.5.9 Physical measures proposed to be implemented in the northern compartment are:

- Controlling water levels by installing a finely adjustable water control structure on the ditch linking to the watercourse that forms the northern compartment boundary. The water control structure will support levels in summer but will also enable any river flood waters getting onto the compartment in winter to escape. The water control structure will be set to around 3.85-3.90 m AOD initially. This could be adjusted up or down, if required, based on effectiveness indicated through monitoring;
- If confirmed that a culvert exists at the southern end of the central ditch, this will be blocked, as will a potential culvert, indicated on **Figure 2.1** on the south-eastern corner of the existing wet woodland;
- Sculpting of the land east of the central ditch, removing up to 20-30cm of soil;
- Blocking or breaking up land drains, where encountered, to reduce drainage from the compartment;
- Removal of a 3-4m wide bund of arisings from ditch clearance from both banks of the central ditch;
- Installation of stock proof fence to control stock access to areas of created habitat;
- Application of green hay to areas of bare earth; and
- Translocation of turves from the area of M22 being lost at Sizewell Marshes to the areas identified for creation of the habitat matrix in the northern compartment.

b) Proposed layout – Central Compartment

2.5.10 The key aim of the proposals is to sculpt the ground surface to increase the groundwater influence at the surface and create a matrix of terrestrial, wetland and shallow open water habitat niches to maximise the potential for target species to colonise. It is anticipated that 30-40cm of the surface material would need to be removed to deliver the proposed matrix of habitats, subject to the results of focussed soil coring at the time.

2.5.11 Natural colonisation, from the nearby fen meadow habitat on the Manor Farm Meadows CWS, will form a component of the habitat development. However, green hay transfer, from Sizewell Marshes SSSI, or another nearby fen meadow source, to the sculpted areas in mid-summer will assist with species introduction. Application to areas of bare earth is beneficial in respect of establishment of species with high light requirements and low competitive abilities, whilst creation of a matrix will maximise the potential for species that have low tolerance of drought or flooding, to find an appropriate niche. Application of green hay may be undertaken on more than one occasion.

2.5.12 M22 species introduction will also occur through translocation of turves from the area of M22 being lost at Sizewell Marshes to within the areas identified for creation of a habitat matrix. This approach has the added benefit of providing the appropriate substrate for the species introduced. Use of this approach is subject to programme considerations and would only be undertaken once.

2.5.13 Site proposals are indicated on **Figure 2.1**.

i. Physical measures in central compartment

2.5.14 Physical measures proposed to be implemented in the central compartment are:

- Sculpting of the land to the south, and immediately north of the relict drain, removing up to 30-40cm of soil;
- Blocking or breaking up land drains, where encountered, to reduce drainage from the compartment;
- Provision of a boardwalk along the footpath in the central compartment to provide walkers a dry route;
- Installation of stock proof fence to control stock access to areas of created habitat;

- Application of green hay to areas of bare earth; and
- Translocation of turves from the area of M22 being lost at Sizewell Marshes to the areas identified for creation of the habitat matrix in the central compartment.

a) Habitat creation works

2.5.15 A temporary site compound will be established and access routes marked for the habitat creation works. Indicative locations for site compound and access routes, and notes on accessibility, are provided in **Figure 2.2**. Of particular note is that a new bridge will be needed to cross the Canal to enable equipment to access the northern compartment. The site compound and access route across the southern compartment could be agreed with the landowner to minimise impacts and only indicative locations and routes are shown on **Figure 2.2**.

2.5.16 Arisings will be removed from the floodplain, off-site.

2.5.17 The establishment works described above would be undertaken in late spring/summer, avoiding periods with the highest risk of surface inundation and the highest water tables that result in soft ground.

2.5.18 Working areas will be subject to ecological walkovers to confirm and update ecological constraints. Works to ditch banks will be micro-sited to avoid effects on water voles. A Protected Species Licence would be sought in the event that one is required, although, based on the reported ecological baseline [REP3-051 and REP3-052] it is considered that effects requiring licensing can be avoided.

2.5.19 Activities will be controlled via measures in the the **Code of Construction Practice** [REP5-078].

2.6 Conservation management

2.6.1 Management measures during the establishment period (Year 1) and in Years 2-5 and 6-10 are summarised below.

a) Management units

2.6.2 Stock proof fence will be used to control stock access to areas of created habitat in both the Northern and Central compartments, particularly during the sensitive establishment phase in Year 1, and potentially beyond, during years 2-5, depending upon ground conditions. Proposed fence lines are indicated on Figure 2.1.

2.6.3 Management of areas outside the fen meadow creation areas/fence lines will comprise taking a hay crop, followed by aftermath grazing.

b) Fen Meadow Establishment period (Year 1)

2.6.4 Hay transfer would be achieved within a few hours of harvesting, with green hay spread thinly and evenly in the receptor areas on bare ground. Seed-drop from the strewn hay would be completed within 1-3 weeks. Seed should be pressed into the ground using stock (ideally cattle), if ground conditions allow, or a roller.

2.6.5 Where germination is sub-optimal, subsequent hay-transfer during August-September would be undertaken.

2.6.6 Following hay-transfer, colonization of the receptor areas by perennial weeds and/or slug populations would be monitored and, if required, treated appropriately to protect the new seedlings.

2.6.7 In the period after hay-transfer (July-November and again in the early part of the following growing season) germination would be favoured by maintaining a short sward.

2.6.8 During and following the first growing season, further introductions of green hay – or of collected propagules of target species – would be undertaken as appropriate.

2.6.9 Subject to programme considerations, translocation of turves from the area of M22 being lost at Sizewell Marshes to the Benhall site will take place within a few hours to minimise the potential for drying prior to placement. The turves will be re-laid as a sward to retain the integrity of the turves and maximise the potential for survival of the translocated species.

2.6.10 The water control structure in the northern compartment will require adjustment as appropriate, based on monitoring, to deliver the target water level conditions for fen meadow habitat.

c) Fen Meadow Management – Years 2-5 and 6-10

2.6.11 In the first spring after initial hay transfer cutting, or grazing where ground conditions allow, may be required to avoid seedlings being shaded out.

2.6.12 Any perennial weeds that colonise would be controlled by spot treatment with herbicide and, as in Year 1, slug populations controlled as required.

2.6.13 From Year 3 onwards, the receptor areas will be managed as hay meadows and therefore should be cut late (for example, after mid July), with swath

turning or tedding undertaken to assist seed shedding. The cutting date would be matched to that of the donor meadow, if possible. The use of livestock, particularly for aftermath grazing, is important, where ground conditions allow, because they create gaps in the sward and trample in the seed, which helps the introduced species to spread.

2.6.14 There will be no use of inorganic fertilisers or widespread application of herbicides.

2.6.15 The water control structure in the northern compartment will require adjustment as appropriate, based on monitoring, to deliver the target water level conditions for fen meadow habitat.

2.7 Monitoring

2.7.1 The effects on ground and surface water levels, and surface wetness, would be monitored for effectiveness using existing installations and observation.

2.7.2 An annual botanical assessment of the establishment of species in the area will be undertaken, including assessment of the presence of phreatophyte species characteristic of M22. Note that some of the introduced species may take several years to appear and so the success of the hay transfer should not be judged immediately but kept under review.

2.7.3 Management of the water levels and habitats developing on site will be amended as required based on the monitoring results.

2.8 Area of Potential Fen Meadow

2.8.1 The initial primary loci and potential additional areas for fen meadow provided in Wood, 2019 (Ref. 4 [APP-258] were used to focus the detailed hydrological studies. Based on the data now available it is considered that implementing the proposed measures in the northern and central compartments will result in elevated water levels and/or creation of a habitat matrix, creating the conditions for establishment of fen meadow habitat across 2.4 ha of the site. This figure supersedes the primary loci and potential additional areas for fen meadow provided in Wood, 2019 (Ref. 4 [APP-258]).

2.8.2 An additional area of 0.6ha has also been identified for inclusion of wet woodland in the northern compartment.

3 HALESWORTH

3.1 Site Baseline

a) Summary of investigations

3.1.2 The investigations being undertaken at Halesworth were summarised in the **Fen Meadow Plan Report 1**, with the study reports provided as appendices [REP3-051 and REP3-052]. The studies have mostly been completed, as detailed in Table 3.1 below.

Table 3.1: Status of studies as at July 2021

Site	Study	Status
Halesworth	Ecology desk study	Completed in 2020
	Ecology field surveys	Phase 1 habitat survey NVC survey Water vole and otter survey Aquatic invertebrate survey of ditches All completed in 2020
	Hydrogeological desk study	Completed in 2021
	Installation of piezometers, dipwell, gaugeboards	Installed October 2020
	Topgraphic survey of site and installations	Completed 2020
	Water flow, level and quality monitoring	Commenced November 2020 for 1 year.

3.2 Environmental Setting

3.2.1 The **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052] summarised the findings of a series of baseline reports, provided as Appendices, that described the environmental setting of the Halesworth site. The majority of the baseline information is not repeated in detail in this Fen Meadow Plan Draft 1 although a summary of the ecological setting is provided below and further hydrological monitoring data are now available so the Water Monitoring Summary – Halesworth Site 28, November 2020 to April 2021, has been updated to July 2021 (**Appendix B**). The updated data have also been further interpreted to update the site conceptual model (**Section 3.3**).

a) Summary of Ecological Setting from Halesworth Ecology Baseline report [REP3-051]

3.2.2 There are no statutory, or non-statutory, designated sites of nature conservation value within the Site or immediately adjacent to it.

3.2.3 Coastal and floodplain grazing marsh priority habitats are mapped in MAGIC as occurring on Site. There are no areas of existing fen meadow habitat nearby.

3.2.4 The site comprises a mix of semi-improved neutral grassland (most of it marshy), with scrub, scattered broadleaved trees, a defunct species-poor hedge, flowing and standing water.

3.2.5 Four distinct grassland-types were recorded during the NVC survey. An area of rush pasture flanking the catch-dyke contained species indicating groundwater influence.

3.2.6 No sign of otter presence was recorded on site.

3.2.7 A number of ditches provided optimal water vole habitat and water vole presence was located on seven of the surveyed transects (3 different ditches) in the summer, although no presence was recorded in the autumn hen water levels were high.

3.2.8 The aquatic invertebrate fauna of the Halesworth site comprises predominantly common and local species.

3.3 Site Conceptual Model

3.3.1 The initial site conceptual model is presented in the hydrogeological report (Appendix F of the **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052]). This section builds on the assessment provided in the conclusions of that report and all monitoring data collected and made available at the time of writing (July 2021). This section outlines the findings on the relationship between ground level, groundwater levels, surface water levels and logged geological strata.

3.3.2 The surface elevation slopes gently from northwest to southeast towards the Walpole River, which is a main river that flows north-easterly. Ground elevations are highest in the northwest at 7.5-8.25 mAOD, flattening out to between 6.6-7 mAOD across much of the Site (see LIDAR plots in Appendix B). The Walpole River cuts a channel past the south-eastern boundary of the Site and has relatively steep banks, particularly to the south.

3.3.3 The site contains a network of land drainage ditches, most of which feed into a main catch-dyke.

3.3.4 Surface drainage from Blyth Road industrial estate is culverted beneath the catch-dyke but discharges to an open ditch and is conveyed along the lower part of the site before discharge to the Walpole River via a second culvert.

3.3.5 Topographic surveys initially indicate that water levels in the catch-dyke and attached drainage ditches are between 6.4 and 6.5 mAOD (November 2020). The Blyth Road drainage channel (W6) recorded a water level of 5.69 mAOD during the survey visit and Walpole River levels were 5.6 mAOD.

3.3.6 The bedrock geology at the site is Crag sands (c.21-26m thick) overlying London Clay. Although the Site is near the feather edge of the London Clay it is recorded to have a >10m thickness at the deeper on site borehole. The London Clay overlies the Chalk. Superficial deposits of Lowestoft Sands and Gravels overlie the Crag sands which are in turn overlaid by a combination of Alluvium (clay, silt, sand and gravel) and Head deposits.

3.3.7 Development of peat has occurred on the southern side of the catch-dyke and is encountered between 0.4 and 0.7 m bgl with a thickness of 1.1m at borehole HAL_2803_d. Soil cores show that a silty clay layer is often present above the Peat and is likely to impede movement of groundwater, rainwater and also flood water.

3.3.8 The soil core survey (Wood, 2019, Ref 3. [APP-258]) indicated that groundwater levels were within the Peat (often below its upper surface) between 0.45 and 0.9 m bgl. The October 2020 drilling programme, which occurred during a relatively wet few weeks, showed a slightly higher rest groundwater level between 0.07 and 0.2 m, which indicates that the upper part of the peat may experience seasonal wetting and drying as the water table changes. Groundwater flow is generally toward the Walpole river in the southeast.

3.3.9 Groundwater in the deeper Crag sands is under positive hydrostatic pressure, resulting in slightly artesian conditions at piezometer HAL_2803_d (**Figure A1** in **Appendix B**). This indicates the presence of semi-confining clay layers within the Crag.

3.3.10 Groundwater levels at HAL-2802_s and HAL-2802_d show that the Crag and superficial deposits demonstrate the same magnitude and timing of fluctuations therefore in hydraulic continuity here (**Figure A2** in **Appendix B**). The peaks generally correlate with peaks to the surface water level GB03 (**Figure A2** in **Appendix B**) indicating a response to recharge from rainfall. There may be some upward flow from the Crag.

3.3.11 To the north-east, the superficial deposit groundwater levels exhibit a similar response in HAL-2802_s to those at the centre of the site (**Figure A2** in **Appendix B**). Whilst the surface water levels at GB01 on site decrease during the dry April, the same decrease in water level is not seen in GB02 which receives a discharge from the Blyth Road Industrial Estate which may provide additional support during this dry period.

3.3.12 Groundwater levels recorded in the monitoring installations in the superficial deposits drop to between 6 and 6.2 mAOD (**Figure A2** in **Appendix B**).

3.3.13 The soil core surveys, drilling logs and topographic survey indicate that groundwater levels are in continuity with surface water levels in the on-site ditches. The catch-dyke intercepts groundwater flow from the northwest. Beyond the catch-dyke to the southeast the water table flattens out and is higher than the Walpole River water level, indicating the potential for groundwater discharge to the river.

3.3.14 There are two significant groundwater abstractions licences for public water supply from six boreholes within 1.2km of the Halesworth site. These abstractions are sourced from the Chalk aquifer and their potential impact on near surface groundwater levels below the Site is likely to be small due to the presence of London Clay and semi-confining clay layers within the Crag. Nevertheless, the Site falls within Zone 3 of the groundwater protection zones for those sources.

3.3.15 The Halesworth STW discharges to the Walpole River approximately 50m downstream of the Site. The licensed discharge volume is 3.553 Ml/d. Flow is not gauged in the Walpole River. The closest permanent flow gauging station is located on the River Blyth approx. 2km downstream (east) of the Site at Holton (Ref No. 35013) which has an average flow of 0.46 m3/s (39.7 Ml/d).

3.3.16 The spot flow data for the site shows very limited surface water flows within the onsite drainage channels (**Table 4.1** in **Appendix B**).

3.3.17 There is some water quality data available for the site, with more sampling planned over 2021 and 2022. The data available to date shows the following:

- Nitrate concentrations are very low across the site. Where nitrate is present above the limit of detection it is in the deeper Crag deposits and Walpole River.
- Phosphate concentrations are below the level of detection across the site.

3.4 Suitability of the site for fen meadow creation

3.4.1 The site was identified in Wood, 2019 (Ref. 4 [APP-258]) as containing a primary locus for fen meadow (1.2ha) spanning the catch-dyke (the west-east aligned ditch that is the main drainage pathway for the site) where the vegetation indicates groundwater influence near to the surface. This primary locus area was bordered by a potential additional area for fen meadow (1.3ha), within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies now on-going.

3.4.2 In 2021 the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits north of the catch-dyke are variable and show a general downward gradient to the deeper deposits. Winter levels in HALL_2803_s and HALL_2804_s fluctuate 15-30cm below ground level, but recess in the spring and early summer to 50-70cm below ground level.

- However, the groundwater levels in the shallow deposits north of the catch-dyke are, in general, above those of the catch-dyke, which has a typical level of between 6.3m AOD and 6.4m AOD (**Figure A1** in **Appendix B**). It is noted also that recorded levels in the catch-dyke at GB01 peaked over winter at about 6.98m AOD, with lesser peaks reaching 6.8m AOD (**Figure A1** in **Appendix B**). At these elevations, significant areas of the site south of the catch-dyke will have been under water, albeit the peaks are very short-lived. These peaks were likely the result of backing up of the catch-dyke as a result of high river levels downstream.

- South of the catch-dyke installations HALL 2802_s and _d show a similar pattern of fluctuation as those to the north but maintain an upward hydraulic gradient. In this area however, the adjacent ditch, that conveys the surface drainage from the nearby industrial estate, to the river is likely acting to drain the nearby surface deposits.

- Whilst not clearly apparent from the spring groundwater level data, the vegetation lying either side of the catch-dyke, represented in the National Vegetation Classification (NVC) survey reported in Appendix B of **Fen Meadow Plan Report 1** [REP3-051 and REP3-052], as MG10b *Holco-Juncetum effusi, Juncus inflexus* sub-community

(referred to as stand C2), contained species indicative of flushing with mildly calcareous groundwater.

- Soil data for the area north of the catch-dyke indicates an absence of peat; silty clay and sands forming the full depth of cores taken. To the south of the catch-dyke silty clay overlies peat encountered at around 40cm below ground (Wood, 2019, Ref. 4 [APP-258]).
- Nitrate concentrations are very low across the site and phosphate concentrations are below the level of detection.
- Water quality data for the catch-dyke indicate a very low concentration of nitrate, and phosphate below detection limits, indicating that the Halesworth STW, is not influencing the ditch water quality.
- A network of land drains is visible on LIDAR (see **Appendix B**). These will be reducing the groundwater levels and drying the fields. However, these can be blocked.

3.4.3 Based on the groundwater and surface water level data, substrate type, and vegetation indicators it is concluded that it will be possible, by implementing measures detailed in Section 3.5, to provide groundwater influenced conditions in the area of the catch-dyke, potentially with a peaty substrate to the south of the dyke, that have the potential to support fen meadow habitats.

3.4.4 Water levels in the River Walpole would not be controlled to support these proposals. This is not required under the proposals and could lead to off-site impacts.

3.5 Proposed layout and features

3.5.1 The key aim of the proposals is to exert control over the drainage ditch network, with the effect of raising the base surface water level and supporting the groundwater levels in the shallow deposits, reducing drainage from the site and sculpting the ground to increase the groundwater influence at the surface.

3.5.2 The target catch dyke water level would be 6.6-6.7m AOD.

3.5.3 To the north of the catch dyke ground levels rise towards the northern site boundary (the northern bank level varying from 6.8-7.1m AOD and rising northwards). Therefore, whilst groundwater at the surface will be unlikely to occur, additional surface water level control will reduce leakage and support flushed situations in the immediate vicinity of the dyke.

3.5.4 Removal of a bund of recently placed arisings from the northern bank of the catch-dyke, will also facilitate a reduction in the ground level by a few centimetres to increase the potential for fen meadow species in this mildly flushed area.

3.5.5 Ground levels to the south of the dyke are lower (the southern bank level varying from 6.6 (at the extreme eastern end) - 6.8m AOD. Raising the dyke water level is expected to support shallow groundwater levels such that groundwater may occur at the surface in the vicinity of the dyke.

3.5.6 The ground surface to the south of the dyke, between the existing ditches, will be sculpted to create a matrix of terrestrial, wetland and shallow open water habitat niches to maximise the potential for target species to colonise. It is anticipated that 30-40cm of the surface material would need to be removed to deliver the proposed matrix of habitats, subject to the results of focussed soil coring during the implementation stage.

3.5.7 The three westernmost ditches on site are blind ended and hence retain water. However, the ditch that conveys the industrial estate drainage, and which is likely also draining the near surface deposits, would be infilled and the drainage discharge piped down the river. This would reduce the drainage from the shallow deposits in this area. No works are proposed to the ditch on the eastern site boundary as this will be downstream of the proposed water control structure.

3.5.8 There is no adjacent seed source for natural colonisation. Therefore, green hay transfer, from Sizewell Marshes SSSI, or another nearby fen meadow source, to the sculpted areas in mid-summer will assist with species introduction. Application to areas of bare earth is beneficial in respect of establishment of species with high light requirements and low competitive abilities, whilst creation of a matrix will maximise the potential for species, that have low tolerance of drought or flooding, to find an appropriate niche. Application of green hay may be undertaken on more than one occasion.

3.5.9 M22 species introduction will also occur through translocation of turves from the area of M22 being lost at Sizewell Marshes to within the areas identified for creation of a habitat matrix. This approach has the added benefit of providing the appropriate substrate for the species introduced. Use of this approach is subject to programme considerations and would only be undertaken once.

3.5.10 Site proposals are indicated on **Figure 3.1**. No wet woodland is proposed at this site.

a) Physical measures

3.5.11 Physical measures proposed to be implemented on site are:

- Controlling water levels by installing a finely adjustable water control structure on the catch-dyke. The water control structure will support levels in summer but will also enable any river flood waters getting onto the site in winter to escape. As indicated above the target level would be 6.6-6.7m AOD, which dictates that it be located adjacent to the bridge crossing the catch-dyke. Much further east the land levels will be too low, and the dyke water could overtop the south bank;
- Setting the water control structure to around 6.7m AOD initially. This could be adjusted up or down, if required, based on effectiveness indicated through monitoring;
- Piping the industrial estate drainage to the river and infilling the ditch that currently carries the drainage in an open channel;
- Preventing groundwater from following the path of the former ditch by including clay stanks at approximately 25m intervals;
- Sculpting land to the south of the catch-dyke, removing up to 30-40cm of soil. The sculpting works will extend approximately 60m from the catch-dyke towards the river, working within existing topographic features (e.g. avoiding works to elevated ground alongside the river);
- Removal of a 3-4m wide bund of recently placed arisings from the northern bank of the catch-dyke. This will also facilitate a reduction in the ground level by a few centimetres to increase the potential for fen meadow species in this mildly flushed area;
- Blocking or breaking up land drains, where encountered, to reduce drainage from the site;
- Installation of stock proof fence to control stock access to areas of created habitat;
- Application of green hay to areas of bare earth; and
- Translocation of turves from the area of M22 being lost at Sizewell Marshes to the areas identified for creation of the habitat matrix.

b) Habitat creation works

3.5.12 A temporary site compound will be established and access routes marked for the habitat creation works. Indicative locations for site compound and access routes, and notes on accessibility, are provided in **Figure 3.2**.

3.5.13 Arisings will be used to infill the ditch and/or removed from the floodplain, off-site.

3.5.14 The establishment works described above would be undertaken in late spring/summer, avoiding periods with the highest risk of surface inundation and the highest water tables that result in soft ground.

3.5.15 Working areas will be subject to ecological walkovers to confirm and update ecological constraints. Works to ditch banks will be micro-sited to avoid effects on water voles. A Protected Species Licence would be sought in the event that one is required, although, based on the reported ecological baseline [REP3-051 and REP3-052] it is considered that effects requiring licensing can be avoided.

3.5.16 Activities will be controlled via implementation of measures in the **Code of Construction Practice** [REP5-078].

3.6 Conservation management

3.6.1 Management measures during the establishment period (Year 1) and in Years 2-5 and 6-10 are summarised below.

a) Management units

3.6.2 Stock proof fence will be used to control stock access to areas of created habitat, particularly during the sensitive establishment phase in Year 1, and potentially beyond, during years 2-5, depending upon ground conditions. Proposed fence lines are indicated on **Figure 3.1**.

3.6.3 Management of areas outside the fen meadow creation areas/fence lines will comprise taking a hay crop, followed by aftermath grazing.

b) Fen Meadow Establishment period (Year 1)

3.6.4 As described for Benhall.

c) Fen Meadow Management – Years 2-5 and 6-10

3.6.5 As described for Benhall.

3.7 Monitoring

3.7.1 The effects on ground and surface water levels, and surface wetness, would be monitored for effectiveness using existing installations and observation.

3.7.2 An annual botanical assessment of the establishment of species in the area will be undertaken, including assessment of the presence of phreatophyte species characteristic of M22. Note however that some of the introduced species may take several years to appear and so the success of the hay transfer should not be judged immediately but kept under review.

3.7.3 Management of the water levels and habitats developing on site will be amended as required based on the monitoring results.

3.8 Area of Potential Fen Meadow

3.8.1 The initial primary loci and potential additional areas for fen meadow provided in Wood, 2019 (Ref. 4 [APP-258] were used to focus the detailed hydrological studies. Based on the data now available it is considered that implementing the proposed measures on site will result in elevated water levels and/or creation of a habitat matrix, creating the conditions for establishment of fen meadow habitat across 1.0 ha of the site. This figure supersedes the primary loci and potential additional areas for fen meadow provided in Wood, 2019 (Ref. 4 [APP-258]).

4 PAKENHAM

4.1 Site Baseline

a) Summary of investigations

4.1.2 The investigations being undertaken at Pakenham were summarised in **Fen Meadow Plan Report 1**, with the study reports available at the time provided as appendices [REP3-051 and REP3-052]. Since the **Fen Meadow Plan Report 1** [REP3-051 and REP3-052] was produced, the NVC survey and spring water vole and otter survey have been completed and therefore studies are now mainly complete, as detailed in Table 4.1.

Table 4.1: Status of studies as at July 2021

Site	Study	Status
Pakenham	Ecology desk study	Completed in 2021
	Ecology field surveys	Phase 1 habitat survey completed May 2021 NVC survey completed June 2021 Spring water vole and otter survey completed May 2021 Aquatic invertebrate survey undertaken late June 2021
	Hydrogeological desk study	Completed in 2021
	Installation of piezometers, dipwell, gaugeboards	Completed March 2021
	Topgraphic survey of site and installations	Undertaken March 2021
	Water flow, level and quality monitoring	Commenced April 2021 for 1 year

4.2 Environmental Setting

4.2.1 The **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052] summarised the findings of a series of baseline reports, provided as Appendices, that described the environmental setting of the Pakenham site. The majority of the baseline information is not repeated in detail in this Fen Meadow Plan Draft 1 although a summary of the ecological setting is

provided below, accompanied by a summary of the results of the NVC and water vole/otter surveys, which are also are provided in:

- Pakenham Site 54 Ecology Baseline (NVC and water vole/otter survey) in **Appendix C**;

4.2.2 Further hydrological monitoring data are also now available and the Water Monitoring Summary – Pakenham Site 54, April 2021, has been updated with data to July 2021 (**Appendix D**). The updated data have also been further interpreted to update the site conceptual model (**Section 4.3**).

a) Summary of Ecological Setting from Pakenham Ecology Baseline report [REP3-051]

4.2.3 There are no statutory, or non-statutory, designated sites of nature conservation value within the Site. However, Pakenham Meadows SSSI is located adjacent to the Site, to the east of Pakenham Stream, and Pakenham Fen Meadows County Wildlife Site is also located to the east of Pakenham Stream. Both of these designated sites contain fen meadow habitat.

4.2.4 Coastal and floodplain grazing marsh and deciduous woodland priority habitats are mapped in MAGIC as occurring on Site.

4.2.5 The site comprises a mix of grassland (some of it marshy), semi-improved and improved grassland, broadleaved wet woodland, swamp, standing water and running water, with fields divided either by hedges or ditches.

b) Pakenham Site 54 Ecology Baseline (NVC and water vole/otter survey) (Appendix C)

i. National Vegetation Classification (NVC) survey

4.2.6 The NVC survey identified vegetation-types from six phytosociological groups within and on the margin of the floodplain. These vegetation types are assigned to the following NVC communities:

Fen meadow

- M22b *Juncus subnodulosus-Cirsium palustre* fen meadow, *Briza media-Trifolium* spp. sub-community; and

- M22a *Juncus subnodulosus-Cirsium palustre* fen meadow, Typical sub-community.

Rush pasture

- MG10b *Holcus lanatus-Juncus effusus* rush pasture, *Juncus inflexus* sub-community; and
- MG10b/S22c *Holcus lanatus-Juncus effusus* rush pasture, *Juncus inflexus* sub-community, grading to *Glyceria fluitans* water-margin vegetation, *Alopecurus geniculatus* sub-community.

Inundation grassland

- MG13 *Agrostis stolonifera-Alopecurus geniculatus* grassland.

Floodplain grassland

- MG7b/MG10b *Lolium perenne-Poa trivialis* ley grading to *Holcus lanatus-Juncus effusus* rush pasture, *Juncus inflexus* sub-community;
- MG7b *Lolium perenne-Poa trivialis* leys ; and
- MG7c *Lolium perenne-Alopecurus pratensis-Festuca pratensis* grassland.

Valley footslope grasslands

- MG7d *Lolium perenne-Alopecurus pratensis* grassland;
- MG7a *Lolium perenne-Trifolium repens* leys;
- MG1e *Arrhenatherum elatius* grassland, *Centaurea nigra* sub-community; and
- MG1a *Arrhenatherum elatius* grassland, *Festuca rubra* sub-community.

Fertile reed-fen

- S25a *Phragmites australis-Eupatorium cannabinum* tall-herb fen, *Phragmites australis* sub-community.

Poplar woodland

- W6b *Alnus glutinosa-Urtica dioica* woodland, *Salix fragilis* sub-community.

4.2.7 The grassland habitats present qualify as coastal and floodplain grazing marsh, whilst the woodland qualifies as deciduous woodland, both of which

are habitats of principal importance listed under Section 41 (S41) of the Natural Environment and Rural Communities (NERC) Act 2006.

ii. Otter and water vole survey

4.2.8 The Site contains suitable habitat and conditions to support both water vole and otter.

4.2.9 During the presence/absence survey, two water vole latrines were located (one on each of two ditches), as were two feeding stations (both on the same ditch) and small mammal runs on four ditches. No water vole burrows were identified however it is noted that due to unseasonably wet conditions encountered in spring 2021, some of the potential field signs identified during the survey may have been diluted or hidden by rising water levels etc. and hence water vole may make more use of the site than was recorded in May.

4.2.10 A number of otter spraints were recorded, all from the Pakenham Stream. No signs of otter presence were recorded from ditches on site.

4.3 Site Conceptual Model

4.3.1 The initial site conceptual model is presented in the hydrogeological report (Appendix H of the **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052]). This section builds on the assessment provided in the conclusions of that report and all monitoring data collected and made available at the time of writing (July 2021). This section presents the findings on the relationship between ground level, groundwater levels, surface water levels and logged geological strata.

4.3.2 The Pakenham Site covers the valley floor of the Pakenham Stream. The bedrock geology underlying the Site is Chalk. The chalk is overlain by superficial deposits of varying thicknesses; the most dominant is Peat, but there are also river terrace sands and gravels and Head deposits which thin towards the western margin. The boundary to the west is the upland toeslope. The margin of this upland is composed of sands and gravels. The upland also has a pronounced sandy terrace toe-slope occupying much of the northern part of this site. To the east, the site is bounded by the Pakenham Stream. There is a buried valley running roughly south of the course of the River Sapiston (Black Bourn) and another which dissects the site which is filled with Glacial Till/ Boulder Clay.

4.3.3 Development of peat has occurred at the site and is encountered between 0.1 and 0.6 m bgl with a thickness of up to 2.9 m at borehole PAK-HA-2. Soil cores show that where present the peat is between 30 and 110 cm thick. Most cores exhibited the deposition of peat over sand, with chalky

boulder clay or 'putty' chalk proved in cores in the centre of the survey or the south west corner, respectively

4.3.4 The highest ground is to the west of the Site with elevations to over 32.5 mAOD. The catchment topography generally slopes towards the Pakenham Stream to the east, however, LiDAR data for the site shows that the central ditch which bisects the site is the low point at around 30 mAOD (see Appendix D). The Pakenham Stream to the east of the site is the main drainage channel for the wider catchment and there is a bund on the left bank which is at about 31.5 mAOD, although a low point is indicated by the LIDAR data (see **Appendix D**) immediately to the north of the footpath, where cattle gather to drink and have eroded the bank. Although not recorded in the available data, during initial visits this area of the site was noted to be under water, arising from flooding from the Stream. Generally, over the main central Pakenham Site the ground levels are between 30.5 and 31 mAOD.

4.3.5 The Pakenham site contains a network of land drainage ditches. The main ditch across the site runs from south to north parallel with the Pakenham Stream. This central ditch is bisected by a second west-east primary ditch; both ditches appear to be carriers for near-surface groundwater. There are several small boundary drains which appear to drain along the upland margin and run to the main central drain.

4.3.6 Data obtained from the topographic surveys initially indicate that water level in the Pakenham Stream is around 31.1 mAOD. The lowest elevation of the channel bed on the short Pakenham Stream reach accessible during the topographic survey (water levels were very high in March 2021) was 29.9 mAOD. The Pakenham Stream is at a higher elevation than the central ditch, although there is still likely continuity between the Pakenham Stream and groundwater levels.

4.3.7 Site visits have identified a breach in the Pakenham Stream bank where the stream crosses over the west-east ditch, which is culverted at this location. The flow, from east to west, in to the site in this ditch, and subsequently in to the central ditch, is being supported by flow from Pakenham Stream via this breach.

4.3.8 The topographic survey indicated initially that water level in the central ditch is around 30.4 mAOD. The lowest channel elevation recorded in the topographic survey was 28.6 mAOD. Groundwater levels across the site recorded at between around 29.5 mAOD and 30.6 mAOD for the same day.

4.3.9 Regionally, groundwater flow in the chalk is towards the Little Ouse but is considered to deflect towards the Pakenham Stream locally and to the

north-east regionally. Chalk groundwater levels are generally considered to be at between 32 mAOD and 36 mAOD in the regional groundwater model produced by the Environment Agency.

4.3.10 The water levels in the chalk borehole monitored on Site (BH-2_d,) shows that the piezometric surface of the Chalk is higher than ground level at between 33.25 mAOD in early spring (29th March 2021) and 32.4 mAOD by summer 2021 (12th July 2021). Ground level at BH2 is 32.22 mAOD. The groundwater level data at BH-2_d demonstrates that there has been a generally declining trend over the spring and early summer of 2021 (**Figure A4** in **Appendix D**). BH-2_s which measures the water level in the superficial deposits at the same location shows a clear declining trend over the same period which aligns with that seen in BH-2_d (**Figure A4** in **Appendix D**) indicating some hydraulic continuity of the near surface deposits with the underlying chalk. Groundwater levels are below ground level at 30.25 mAOD in early spring (29th March 2021) and 29.59 mAOD by summer 2021 (12th July 2021).

4.3.11 In the centre of the site, the central ditch has a water level around 30.4 mAOD (as monitored by GB01 and GB03, Figure A3 in Appendix D). There are no significant fluctuations in the observed data. The land to the east of the central ditch is mostly flat between 30.35 and 30.5 mAOD and very similar to the water levels in the ditch.

4.3.12 The ditch to the north-west of the central ditch has a higher water level (GB02) at 31.4 mAOD, most likely a function of the higher topography to the west of the site. The base of the ditch at GB02 is approximately 1.3 mAOD above the base of the central ditch.

4.3.13 The water levels in the near surface dipwells (PAK-HA-1 to PAK-HA-6) all show a similar hydrogeologic response (**Figure A3** in **Appendix D**).

4.3.14 It is noted that the groundwater levels observed are generally similar between the central ditch (GB01 and GB03) and the surrounding boreholes closest to the ditch (HA-3, HA-4 and HA-6) and that groundwater levels here are close to ground level (**Figure A3** in **Appendix D**).

4.3.15 Groundwater levels in PAK-HA-2 are significantly below ground level (~1-1.5m) (**Figure B14** in **Appendix D**) and this is repeated in the soil core sample (Core 1) which shows no obvious water table to 1.25m bgl. Similar depth to water, and corresponding lower absolute water levels (in mAOD), are seen at PAK-HA-1 and PAK-HA-5, reflecting local variability in behaviour of the superficial deposits.

4.3.16 To the north of the Site, the water levels in PAK-HA-1, PAK-HA-2 and PAK-HA-3 show a similar water level trend (**Figure A3** in **Appendix D**). PAK-HA-3 has a higher absolute level than the other two boreholes.

4.3.17 The surface water levels in the GB02 and GB04 are higher than the main central ditch, which is in part a function of the topography which is higher at these two locations. Water will therefore drain towards the central ditch and ultimately flow northwards.

4.3.18 The groundwater level response in PAK-BH-1 shows less pronounced fluctuations in the groundwater levels. BH-1 measures the groundwater conditions in the buried valley, and close to the surface water abstraction. BH1 is not considered to be in hydraulic continuity with the rest of the superficial deposits at the site.

4.3.19 The lowest groundwater level and therefore maximum depth to water in the superficial deposits is listed in **Table 4.2** below.

Table 4.2: Groundwater levels and depth to water table

Borehole ID	Ground level (mAOD)	Lowest observed groundwater level (mAOD)	Maximum depth to water table (m)	Highest observed groundwater level (mAOD)	Minimum depth to water table (m)*
PAK-BH-1	31.9	30.2	1.7	30.6	1.3
PAK-BH-2_d	32.2	32.4	-0.2*	33.2	-1.0*
PAK-BH-2_s	32.2	29.6	2.6	30.3	2.0
PAK-HA-1	30.7	29.2	1.5	29.8	0.9
PAK-HA-2	30.7	29.1	1.5	29.6	1.0
PAK-HA-3	30.6	30.2	0.4	30.6	0.0
PAK-HA-4	30.7	30.2	0.5	30.7	0.0
PAK-HA-5	30.9	29.5	1.4	30.1	0.8
PAK-HA-6	30.7	30.3	0.5	30.6	0.2

* negative depth to water table shows where groundwater levels are above ground level.

4.3.20 Anecdotal evidence suggests that the ground around HA-1 (current Fen Meadow) is damp underfoot. The groundwater data do not show this, which implies that there is locally perched water table here which is currently not being measured, potentially due to layering in the peat. There is also

potential for this area to be supported by winter flooding from Pakenham Stream and the on-site ditches.

4.3.21 Two surface water abstraction points, from one abstraction licence, are located on the ditches on site. One further abstraction, which abstracts during the winter, is located on the Pakenham Stream adjacent to the site and piped to the west under the site.

4.3.22 The soil cores also showed little in terms of water. It is likely that the historical water table relates to the zones of sapric peat or, in Core 9, where manganiferous streaks were proved. It is also evident that where peat is at the ground surface, it is in poor condition, and recorded as earthy peat. The reduction of the water table from the ground surface is clearly long-standing.

4.3.23 The water quality data available to date shows the following:

- Nitrate concentrations are highest at BH2_S in the superficial deposits at 99.7 mg/l as NO3. Concentrations are lower in the underlying chalk (BH2_D) which monitored nitrate at 33.7 mg/l as NO3. Elsewhere concentrations are high at the nearby surface water monitoring point at GB03 (50.8 mg/l as NO3) but low across the main central Pakenham dipwells (<2 mg/l as NO3). The Pakenham Stream nitrate concentrations are at 36.4 mg/l as NO3.

- The site generally has very low phosphate concentrations as would be expected, with most samples below detection limits. The Pakenham Stream shows phosphate concentrations at 0.958 mg/l, and elsewhere there are low concentrations at HA-2 (0.273 mg/l) and GB02 (0.602 mg/l).

4.4 Suitability of the site for fen meadow creation

4.4.1 The Pakenham site is discussed as two compartments, north and south.

a) Northern Compartment

4.4.2 This compartment was identified in Wood, 2019 (Ref. 4 [APP-258]) as containing two areas of primary locus for fen meadow (totalling 3.2ha), one incorporating the western slope of the site to the west of the central drain, and the other around the north side of an area of existing fen meadow habitat. The western primary locus area was bordered by a potential additional area for fen meadow to the east of the central drain (4ha), within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies.

4.4.3 However, in 2021, the NVC survey identified that the northern primary locus, which sits to the north of existing fen meadow vegetation, is also fen meadow. Therefore no measures to create fen meadow are required in this part of the compartment. Nonetheless, the potential for fen meadow creation in the remainder of this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits in the primary locus area to the west of the central ditch fall significantly below ground level (up to 1.5m in PAK-HA-2), which is also 1m below the ditch water level (around 30.4m AOD). This depth to water reflects the results of a soil core from a similar area reported in Wood, 2019 (Ref. 4 [APP-258]), which did not strike water in a depth of 125cm.

- However, to the east of the central ditch shallow water levels remain within 25cm of the ground surface (PAK-HA-3), a similar elevation as the stream water level. It is noted, although not confirmed, that the groundwater levels may be supported by occasional overtopping from the Stream. A soil core in the same area recorded water at 60cm depth.

- Although not recorded in the available data, during initial visits this area of the site was noted to be under water, arising from flooding from the Stream. The lowest point in the bank appears, from LIDAR data (**Appendix D**), to be located immediately adjacent to the north of the footpath crossing the Stream.

- The rush pasture communities present either side of the central ditch at its northern end (MG10b and MG10b/S22c, see NVC report in **Appendix A**), contain a combination of obligate and non-obligate phreatophytes, suggesting that the near surface deposits are, or have been, influenced by groundwater.

- Substrate both sides of the central ditch was found to be peat over marl, and so substrate is appropriate for fen meadow.

- There are some instances of elevated nitrate concentrations in groundwater, although concentrations in most groundwater monitoring installations are low, with phosphate below the level of detection.

- Elevated nitrate concentrations have been recorded from surface water samples, which likely reflects surrounding, arable, land uses.

Phosphate above the level of detection was also recorded from Pakenham Stream, indicating the presence of a sewage treatment works discharge upstream.

- The drainage system is complex and there are a number of factors to consider in respect of supporting water levels on site:
  - Due to its linkage with Pakenham Meadows SSSI to the east of Pakenham Stream, it is not possible to raise the levels in the system, without potentially also affecting levels in the SSSI.
  - Levels in the system at this end of the site may be being supported by the leak from the Pakenham Stream.
  - There is a spring/summer abstraction from the ditches on the western site margin that will depress the ditch water levels, although currently these are being supported by the leak from the Pakenham Stream bank.
- LIDAR data suggests the presence of land drains running parallel north-south between the central ditch and Pakenham Stream, presumably draining to the cross ditches. It is possible, although they are not visible on LIDAR, that similar drains are present in the western compartment. These will be reducing groundwater levels and drying the field surface. However, these can be blocked.

4.4.4 Based on the data available, the substrate type is appropriate and, with implementation of the measures detailed in Section 4.5, it is considered that it will be possible to deliver groundwater influenced surface conditions in this compartment, particularly to the east of the central ditch, and potentially also to the eastern side of the western area alongside the central ditch.

b) Southern Compartment

4.4.5 This compartment was identified in Wood, 2019 (Ref. 4 [APP-258]) as containing an arrow shaped area of primary locus for fen meadow bordering the wet woodland at the southern end of the site (1.7ha). An area of fen meadow habitat is located immediately adjacent to the south-west of the primary locus to the north of the woodland as indicated (see Wood, 2019 (Ref. 4 [APP-258]). The area of primary locus was flanked by a more extensive potential additional area for fen meadow (4.3ha) within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies now on-going.

4.4.6 In 2021, the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

4.4.7 In respect of the suitability for fen meadow in the area to the north and upslope of the woodland:

- Groundwater levels in the shallow deposits upslope of the primary locus area to the north of the woodland (and its boundary ditch that joins the main central ditch to the north of the woodland/reed fen area) fall significantly below ground level (almost 1.4m in PAK-HA-5), approaching 1m below the ditch water level (around 30.4m AOD). This depth to water reflects the results of Core 14 from a similar elevation reported in Wood, 2019 (Ref 3. [APP-258]), which did not strike water in a depth of 125cm. However, downslope of PAK-HA-5 Core 17 struck water at a depth of 63cm.

- The botanical community present in the field north of the woodland is a floodplain grassland, MG7b, which contains no obligate phreatophytes and only low numbers of non-obligate phreatophytes, suggesting that there is little groundwater influence at the surface.

- Upslope to the north of the woodland, substrate was found to be sand to 60cm in Core 14, and predominantly sands and gravels in the PAK-HA-5, however Core 17 downslope was found to be peat. To the east of the woodland Core 16 was earthy peat over marl and then peat. Substrate appears to be more appropriate for fen meadow on the lower margins of this field.

- There are some instances of elevated nitrate concentrations in groundwater at the northern end of the Pakenham site, although concentrations in most groundwater monitoring installations are low, with phosphate below the level of detection.

- Elevated nitrate concentrations have however been recorded from surface water samples, which likely reflects surrounding arable land uses. Phosphate above the level of detection was also recorded from Pakenham Stream, indicating the presence of a sewage treatment works discharge upstream.

- As indicated for the northern compartment, the drainage system is complex and in general it is not possible to manipulate the levels. However, it is considered that:

  - The ditch separating the fen meadow from the floodplain grassland could be managed without affecting off-site receptors. Although not currently monitored, field observations suggest that it receives run-off, originating as groundwater, from the fen meadow compartment. As such it is expected that water quality would be good.
  - The ditch along the northern edge of the woodland could be controlled without affecting off-site receptors provided that this control occurred before it's confluence with the central ditch. This would reduce drainage from the area, at least from the south-western end of the field.

- No field drains are evident in this field on LIDAR data (**Appendix D**) in this field, although there is a suggestion of presence in the fen meadow field (running north-west to south-east), perhaps evidence of historic efforts to drain the area.

4.4.8 In respect of the suitability for fen meadow in the area to the east of the woodland:

- To the east of the woodland and the central ditch shallow water levels (PAK-HA-6) remain within 45cm of the ground surface, a similar elevation as the stream water level. Core 16 in the area struck water at 80cm below ground level. Core 15 in the same field, but to the north, struck water at 50cm below ground level.
- To the east of the woodland, the floodplain grassland is transitional rush pasture (MG7b/MG10b). This contains a very low number of obligate phreatophytes and a greater number of non-obligate phreatophytes, suggesting a greater current, or historic, groundwater influence at the surface.
- To the east of the woodland Core 16 was earthy peat over marl and then peat, whilst Core 15 was earthy peat over peat. Substrate appears to be appropriate for fen meadow in this field.
- This field is bordered by the central ditch to the west, and Pakenham Stream to the east. No water level control on these watercourses is considered possible without affecting off site receptors.
- There are some instances of elevated nitrate concentrations in groundwater at the northern end of the Pakenham site, although concentrations in most groundwater monitoring installations are low, with phosphate below the level of detection.

- Elevated nitrate concentrations have however been recorded from surface water samples, which likely reflects surrounding, arable, land uses. Phosphate above the level of detection was also recorded from Pakenham Stream, indicating the presence of a sewage treatment works discharge upstream.

- LIDAR data suggests the presence of land drains running parallel north-south between the central ditch and Pakenham Stream (**Appendix D**). It is likely, although they are not visible on LIDAR, that similar drains are present in the western compartment. These will be reducing groundwater levels and drying the field surface. However, these can be blocked.

4.4.9 As for the northern compartment, based on the data available, the substrate type is appropriate and, with implementation of the measures detailed in Section 4.5, it is considered that it will be possible to deliver groundwater influenced surface conditions to the east of the woodland. However, it is concluded that the potential area that could be made suitable for fen meadow to the north of the woodland would be too restricted to be viable. This conclusion is based on the requirement for significant on-going management of water level control structures and any shallow water distribution channels and the very small area in the south-western corner of this field over which conditions for fen meadow habitat could be provided. Fen meadow is therefore not proposed in this area of the southern compartment and it is therefore excluded from the proposals.

4.5 Initial proposed layout and features

a) Proposed layout (Northern compartment)

4.5.2 The key aim is to achieve groundwater influence at the surface by lowering the surface and reducing the contribution from surface water in the area between the central ditch and Pakenham Stream, and also to the west of the central ditch.

4.5.3 There will be no control of surface water levels in the drainage ditch network.

4.5.4 The ground surface between the central ditch and the Pakenham Stream, and also immediately to the west of the central ditch, will be sculpted to create a matrix of terrestrial, wetland and shallow open water habitat niches to maximise the potential for target species to colonise. It is anticipated that 30-40cm of the surface material would need to be removed to deliver the proposed matrix of habitats, subject to the results of focussed soil coring at the time.

4.5.5 There is a nearby seed source from adjacent areas of non-designated fen meadow habitats within the wider site which will support natural colonisation. However, to assist the colonisation process, green hay from on site or, with permission from the owner and Natural England, from Pakenham Meadows SSSI, will be applied to the sculpted areas in mid-summer. Application to areas of bare earth is beneficial in respect of establishment of species with high light requirements and low competitive abilities, whilst creation of a matrix will maximise the potential for species that have low tolerance of drought or flooding to find an appropriate niche. Application of green hay may be undertaken on more than one occasion.

4.5.6 Site proposals are indicated on **Figure 4.1**.

i. Physical measures

4.5.7 Physical measures proposed to be implemented in the northern compartment are:

- Sculpting of the land between the central ditch and the Pakenham Stream, and also immediately to the west of the central ditch, removing up to 30-40cm of soil;
- Blocking or breaking up of land drains, where encountered, to reduce drainage from the compartment;
- Raising the western bank of Pakenham Stream immediately to the north of the footpath crossing to the same level as elsewhere on site (level to be determined by further topographic survey) to reduce the potential for site flooding, without affecting the floodplain function of the area. An Environmental Permit will be required from the EA to enable this work to take place;
- Application of green hay to areas of bare earth; and
- Provision of a boardwalk along the footpath to provide walkers a dry route.

4.5.8 Although not physical measures it is noted that:

- Continued operation of the summer surface water abstraction presents a significant risk to the successful provision of appropriate conditions for fen meadow because it suppresses ditch water levels in the summer, which results in a greater drainage effect on the adjacent land, and hence reduced groundwater levels in the northern compartment. Additionally, as the drain from which the abstraction takes place is a continuation of the drain that is culverted under

Pakenham Stream and forms the northern boundary drain of Pakenham Meadows SSSI, the abstraction also has the potential to reduce water levels in the SSSI. However, the full effects of the abstraction on ditch, and adjacent groundwater, levels are currently buffered by the leak from Pakenham Stream (see below), so the level of effect on the ditch, and groundwater, levels is not apparent in the monitoring data. The level of risk to the creation of conditions for fen meadow is therefore not quantifiable at this stage. To maximise potential for fen meadow habitat in this location, this abstraction should cease; and

- Retention of the leak from Pakenham Stream supports, and is therefore beneficial to, ditch water levels on site, and also those in Pakenham Meadows SSSI, as it is supporting levels in the ditch forming the northern boundary of the SSSI. .

b) Proposed layout (Southern compartment)

4.5.9 The key aim is to achieve groundwater influence at the surface by lowering the surface, sculpting the land to create a habitat matrix. Given the presence of marl in this area to the east in particular it is proposed that the matrix removes a greater depth than proposed elsewhere, up to 45cm, to create areas of calcareous standing water, as well as adjacent wetland habitats, including fen meadow, subject to the results of focussed soil coring at the time during the implementation stage.

4.5.10 The approach to establishing fen meadow species in sculpted areas will be the same in the southern compartment as in the northern compartment.

4.5.11 An area for wet woodland creation (1.76 ha) has also been identified at Pakenham in this compartment. The approach to creation of this habitat is set out in the **Wet Woodland Strategy** [REP1-020].

4.5.12 Site proposals are indicated on **Figure 4.1**.

i. Physical measures

4.5.13 Physical measures proposed to be implemented in the southern compartment are:

- Sculpting the land between the central ditch and the Pakenham Stream to the east of the woodland, removing up to 45cm of soil.
- Blocking or breaking up of land drains, where encountered, to reduce drainage from the compartment to the east of the woodland; and.

- Application of green hay to areas of bare earth.

c) Habitat creation works

4.5.14 A temporary site compound will be established and access routes marked for the habitat creation works. Indicative locations for site compound and access routes, and notes on accessibility, are provided in **Figure 4.2**. The site compound and access route across the southern compartment could be agreed with the landowner to minimise impacts and only indicative locations and routes are shown on **Figure 4.2**.

4.5.15 Arisings will be removed from the floodplain, off-site.

4.5.16 Works would take place in late spring/summer, avoiding periods with the highest risk of surface inundation and the highest water tables that result in soft ground.

4.5.17 Working areas will be subject to ecological walkovers to confirm and update ecological constraints. Works to ditch banks will be micro-sited to avoid effects on water voles and otters. A Protected Species Licence would be sought in the event that one is required, although, based on the reported ecological baseline [REP3-051 and REP3-052] it is considered that effects requiring licensing can be avoided.

4.5.18 Activities will be controlled via implementation of measures in the **Code of Construction Practice** [REP5-078].

4.6 Conservation management

4.6.1 Management measures during the establishment period (Year 1) and in Years 2-5 and 6-10 are summarised below.

a) Management units

4.6.2 Stock proof fence will be used to control stock access to areas of created habitat, particularly during the sensitive establishment phase in Year 1, and potentially beyond, during years 2-5, depending upon ground conditions. Proposed fence lines are indicated on **Figure 4.1**.

4.6.3 Management of areas outside the fen meadow creation areas / fence lines will comprise taking a hay crop, followed by aftermath grazing.

b) Fen Meadow Establishment period (Year 1)

4.6.4 Hay transfer would be achieved within a few hours of harvesting, with green hay spread thinly and evenly in the receptor areas on bare ground. Seed-

drop from the strewn hay would be completed within 1-3 weeks. Seed should be pressed into the ground using stock (ideally cattle), if ground conditions allow, or a roller.

4.6.5 Where germination is sub-optimal, subsequent hay-transfer during August-September would be undertaken.

4.6.6 Following hay-transfer, colonization of the receptor areas by perennial weeds and/or slug populations would be monitored and, if required, treated appropriately to protect the new seedlings.

4.6.7 In the period after hay-transfer (July-November and again in the early part of the following growing season) germination would be favoured by maintaining a short sward.

4.6.8 During and following the first growing season, further introductions of green hay – or of collected propagules of target species – would be undertaken as appropriate.

c) Fen Meadow Management – Years 2-5 and 6-10

4.6.9 In the first spring after initial hay transfer cutting, or grazing where ground conditions allow, may be required to avoid seedlings being shaded out.

4.6.10 Any perennial weeds that colonise would be controlled by spot treatment with herbicide and, as in Year 1, slug populations controlled as required.

4.6.11 From Year 3 onwards, the receptor areas will be managed as hay meadows and therefore should be cut late (for example, after mid July), with swath turning or tedding undertaken to assist seed shedding. The cutting date would be matched to that of the donor meadow, if possible. The use of livestock, particularly for aftermath grazing, is important, where ground conditions allow, because they create gaps in the sward and trample in the seed, which helps the introduced species to spread.

4.6.12 There will be no use of inorganic fertilisers or widespread application of herbicides.

4.7 Monitoring

4.7.1 The effects on ground and surface water levels, and surface wetness, would be monitored for effectiveness using existing installations and observation.

4.7.2 An annual botanical assessment of the establishment of species in the area will be undertaken, including assessment of the presence of phreatophyte

species characteristic of M22. Note however that some of the introduced species may take several years to appear and so the success of the hay transfer should not be judged immediately but kept under review.

4.7.3 Management of the water levels and habitats developing on site will be amended as required based on the monitoring results.

4.8 Area of Potential Fen Meadow

4.8.1 The initial primary loci and potential additional areas for fen meadow provided in Wood, 2019 (Ref. 4 [APP-258] were used to focus the detailed hydrological studies. Based on the data now available it is considered that implementing the proposed measures on site will result in elevated water levels and/or creation of a habitat matrix, creating the conditions for establishment of fen meadow habitat across 4.73 ha of the site. This figure supersedes the primary loci and potential additional areas for fen meadow provided in Wood, 2019 (Ref. 4 [APP-258]).

4.8.2 An additional area of 1.76 ha has also been identified for inclusion of wet woodland in the southern compartment.

5 SUMMARY

5.1.1 Implementation of proposals in this Fen Meadow Plan Draft 1 are expected to deliver conditions that have the potential to support fen meadow species on each of the three sites.

5.1.2 The proposals are intended result in elevated water levels and/or creation of a habitat matrix, creating the conditions for establishment of fen meadow habitat.

5.1.3 The proposals are therefore anticipated to deliver conditions suitable to support fen meadow habitat across the site areas summarised below:

- Benhall – 2.4 ha of fen meadow, 0.6 ha of wet woodland;
- Halesworth – 1.0 ha of fen meadow; and
- Pakenham: 4.73 ha of fen meadow, 1.76 ha of wet woodland.

5.1.4 In total therefore the plan could deliver up to **8.13 ha** of fen meadow and **2.36 ha** of wet woodland.

5.1.5 The 8.13 ha area, across which conditions suitable to support fen meadow habitat are anticipated, exceeds the 4.14 to 4.5 ha stated in the **Fen Meadow Strategy** [Section 2.9D of AS-209] as revised by paragraph 1.1.4.

5.1.6 Within any of the sites, it is not considered possible to set a single ground level that will deliver appropriate conditions for fen meadow year round allowing for a smaller area to be identified for fen meadow delivery, because of the uncertainties in groundwater level fluctuation with a limited ability to control these on these sites, and uncertainties in the precise development of the habitat in any one particular location within the site. Instead, the sculpting approach proposed, results in a variable micro-topography that will support a range of hydrological conditions, varying from shallow open water through to more terrestrial habitat. This maximises the provision of areas with appropriate hydrology, and hence potentially suitable area for fen meadow, whilst allowing for the uncertainties in groundwater level fluctuation and limited ability to control these.

5.1.7 The proposals have been prepared with reference to the data available to the beginning of July 2021 and data collection is on-going at each site. It remains possible therefore that future data may indicate the necessity to make minor adjustments to the proposals. However, the most likely changes that may be necessary will be to depths of sculpting indicated.

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1. Natural England (2020). Stage 4 pre-application consultation. [Online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/908003/Response_to_Sizewell_C_Development_Consent_Order_stage_4_consultation.pdf

2. Wheeler B.D., Shaw S. & Tanner K. (2009). A wetland framework for impact assessment at statutory sites in England and Wales. Science report: SC030232. Environment Agency, Bristol.

3. van Diggelen R. & Marrs R.H. (2003). Restoring plant communities – Introduction. Appl. Veg. Sci. 6: pp. 105-110.

4. Wood (2019). Fen Meadow Compensation Study – Report of Visits to Target Sites 2019. Report to EDF Energy.

FIGURES

NOTES

KEY

Benhall site boundary

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION / COMMENTS	APPROVED

NOT PROTECTIVELY MARKED

PROJECT:
SIZEWELL C

DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
BENHALL SITE LOCATION PLAN

DRAWING NO: FIGURE 1.1

REVISION:

DATE: JULY 2021

DRAWN: J.P.

SCALE : 1:20,000 @A3

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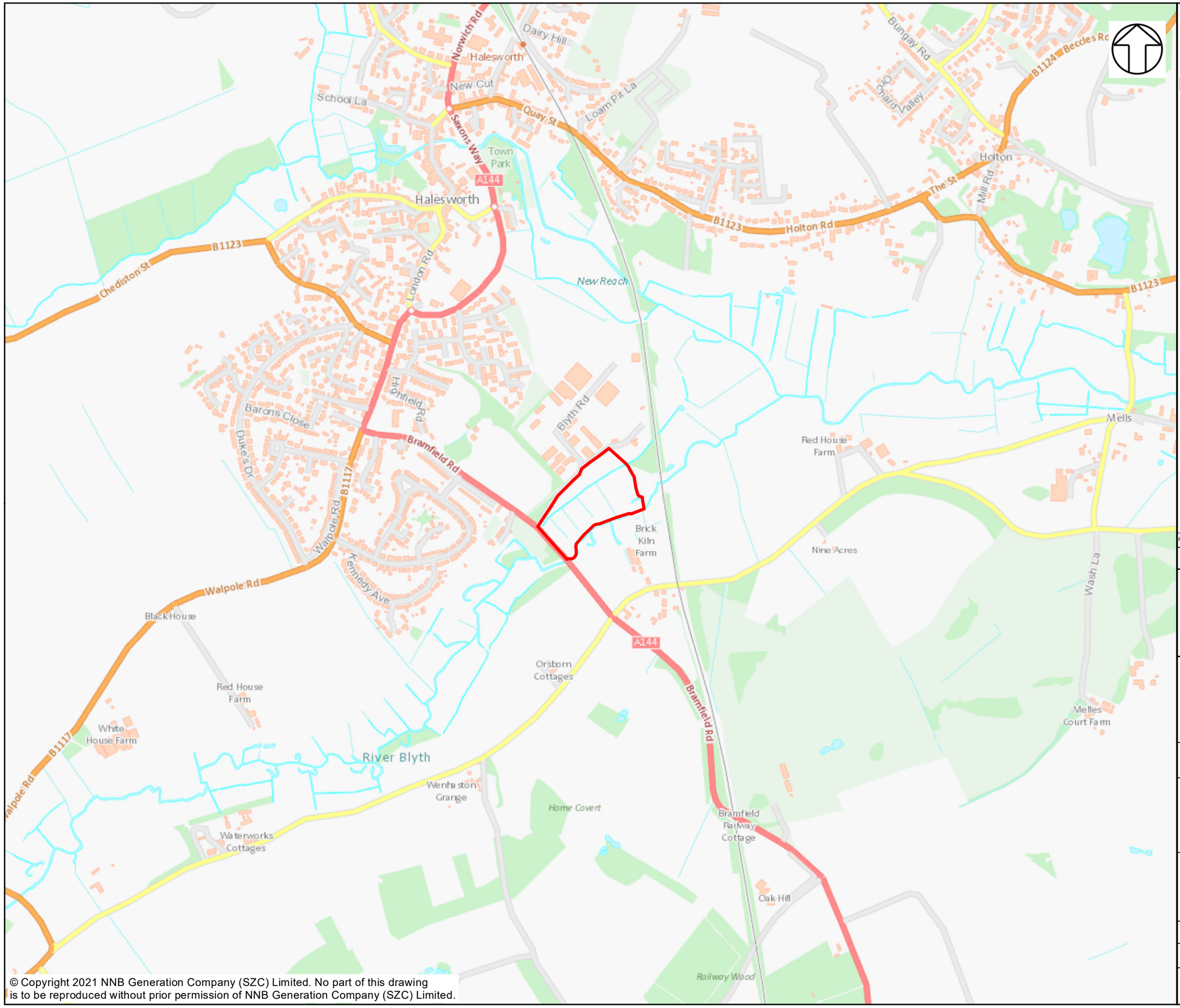

NOTES

KEY

Halesworth site boundary

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION / COMMENTS	APPROVED

NOT PROTECTIVELY MARKED

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PROJECT:
SIZEWELL C

DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
HALESWORTH SITE LOCATION PLAN

DRAWING NO: FIGURE 1.2

REVISION:

DATE: JULY 2021

DRAWN: J.P.

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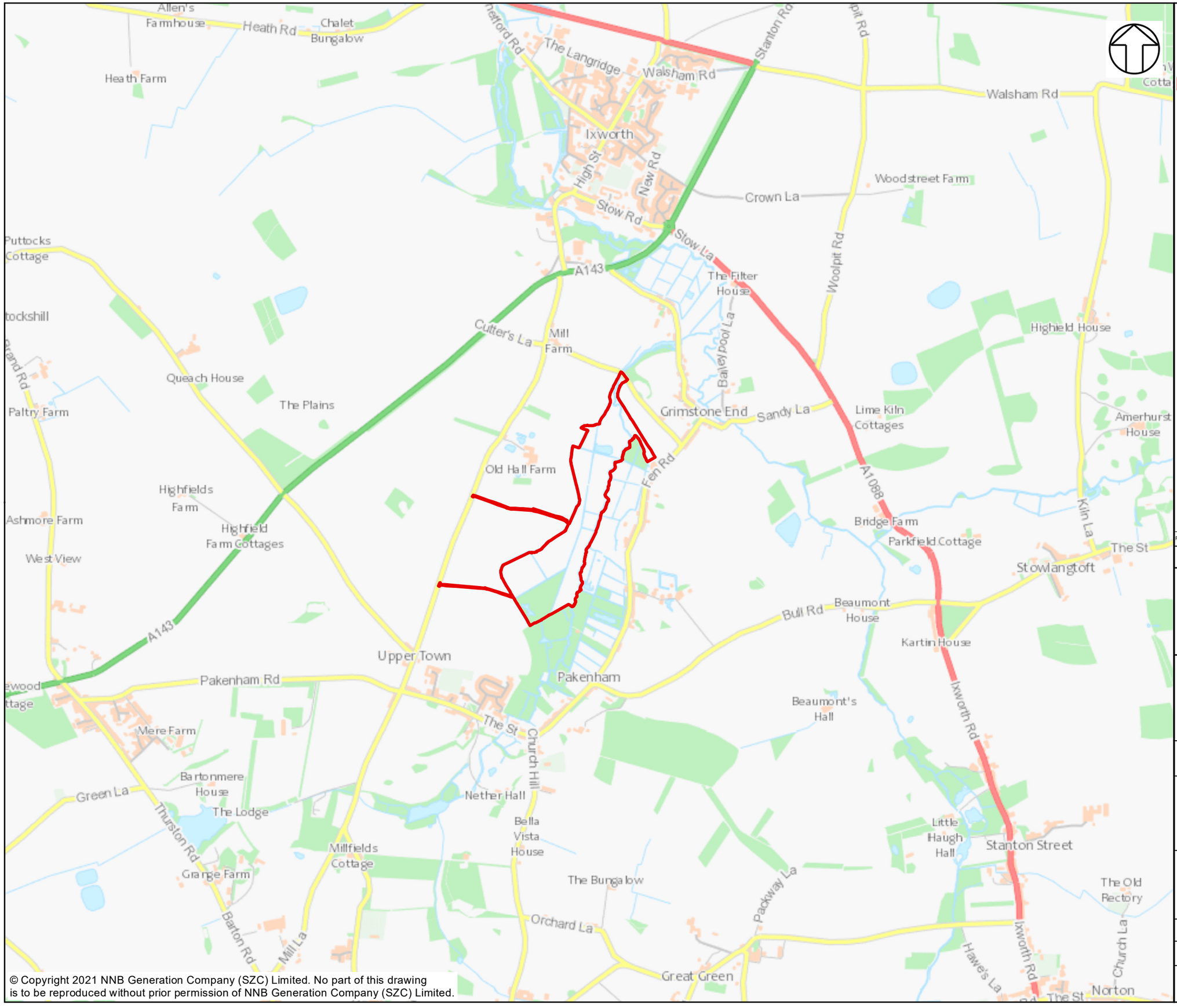

NOTES

KEY

Pakenham site boundary

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NOT PROTECTIVELY MARKED

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PROJECT:
SIZEWELL C

DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
PAKENHAM SITE LOCATION PLAN

DRAWING NO: FIGURE 1.3

REVISION:

DATE: JULY 2021

DRAWN: J.P.

SCALE : 1:20,000 @A3

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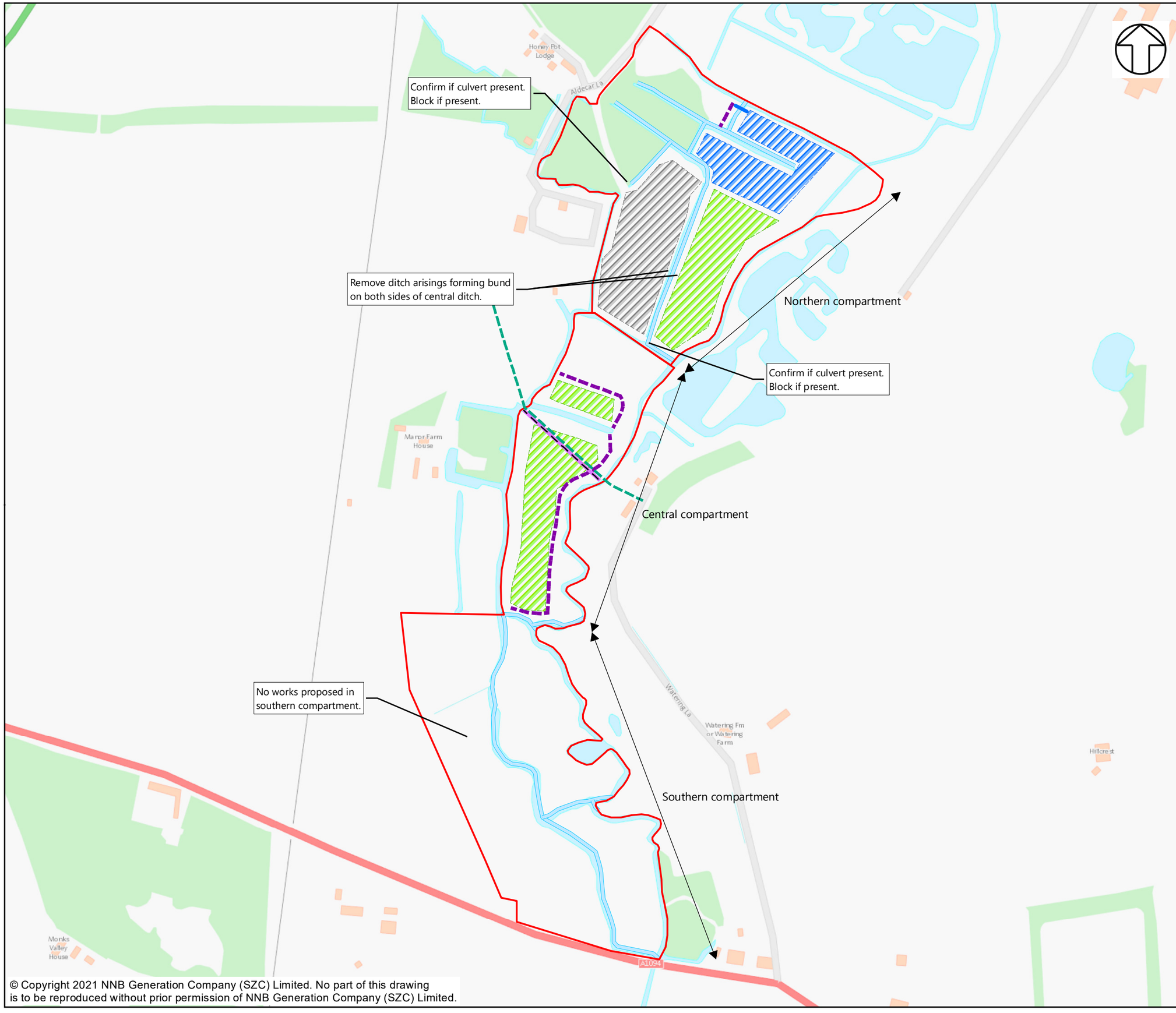

NOTES

KEY

- Benhall site boundary
- River or drainage ditch
- Public footpath
- Footpath boardwalk
- Area for wet woodland
- Area of land sculpting to create habitat matrix
- Elevated groundwater levels only in this area
- Fenceline to manage stock access to new fen meadow areas
- Water control structure

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION / COMMENTS	APPROVED

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PROJECT:
SIZEWELL C

DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
SITE PROPOSALS (BENHALL)

DRAWING NO: FIGURE 2.1

REVISION:

DATE: JULY 2021

DRAWN: J.P.

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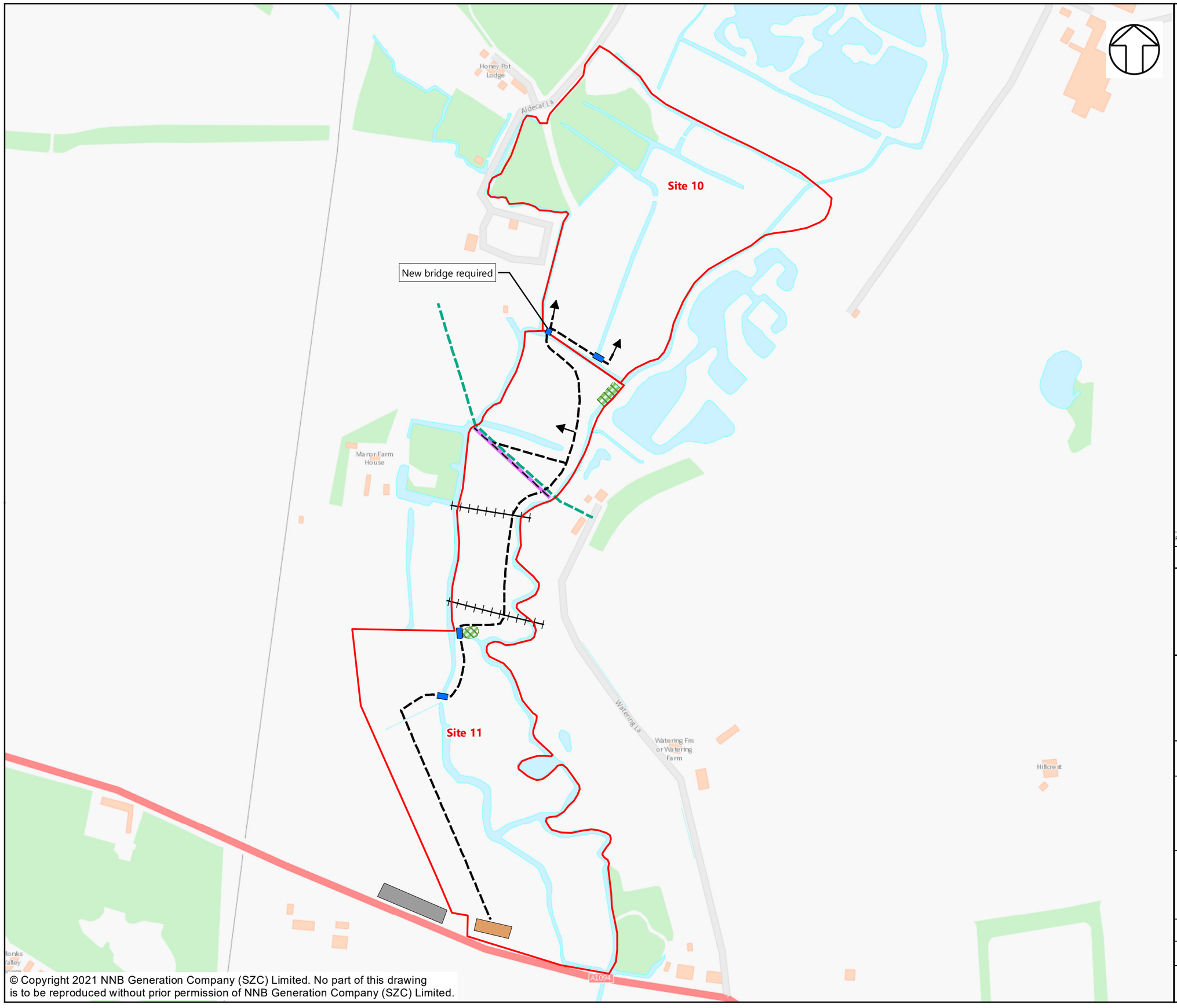

NOTES

KEY

- Benhall site boundary
- River or drainage ditch
- Public footpath
- Bridge
- Indicative access route
- Footpath boardwalk
- Power line
- Site compound
- Turning area
- Hogweed

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION / COMMENTS	APPROVED

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PROJECT:
SIZEWELL C

DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
NOTES ON ACCESSIBILITY AND HAZARDS FOR HABITAT CREATION ACTIVITIES (BENHALL)

DRAWING NO: FIGURE 2.2
REVISION:
DATE: JULY 2021
DRAWN: J.P.
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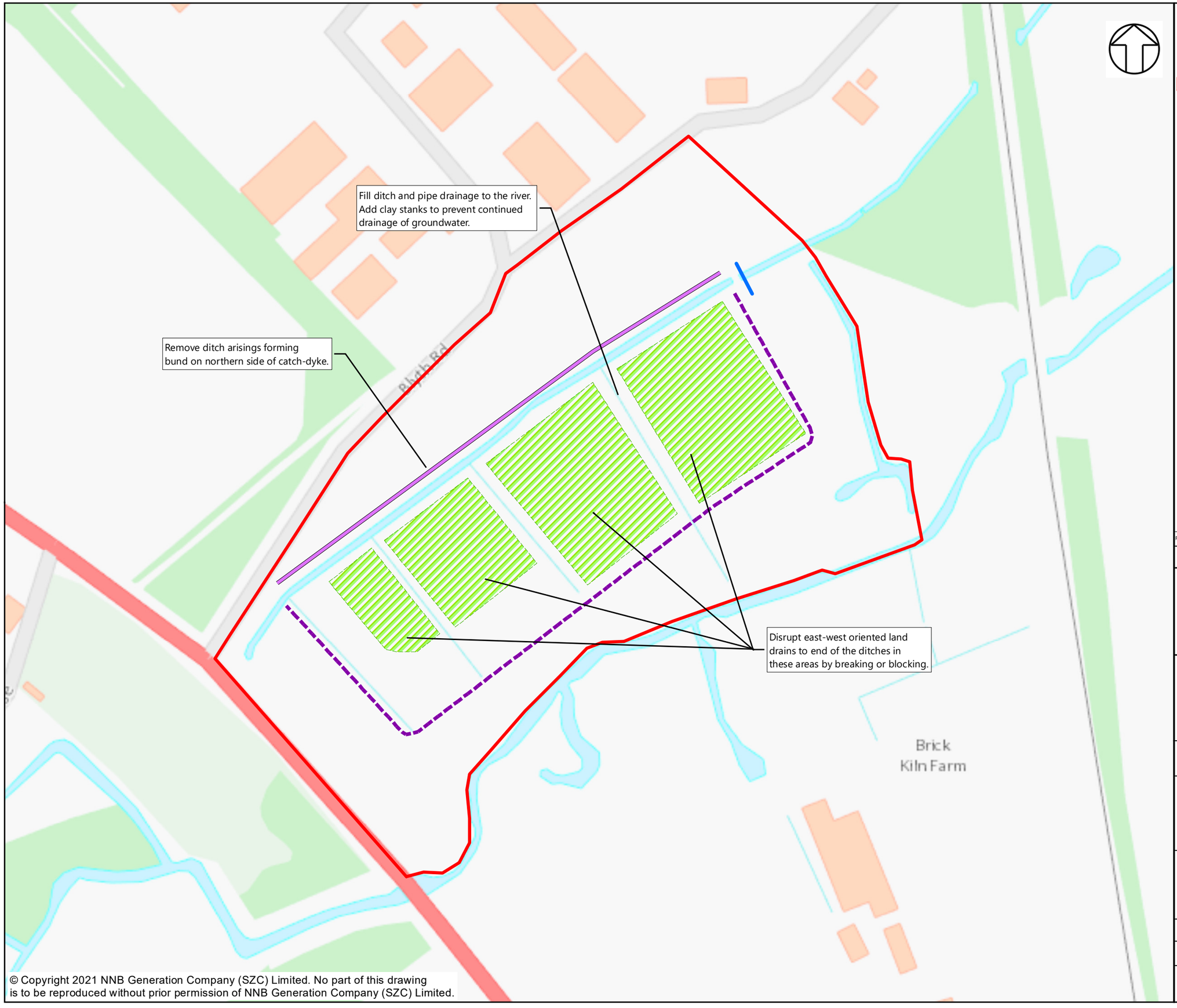

NOTES

KEY

- Halesworth site boundary
- Area of land sculpting to create habitat matrix
- Fenceline to manage stock access to new fen meadow areas
- Water control structure
- Ditch arisings

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION / COMMENTS	APPROVED

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PROJECT:
SIZEWELL C

DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
SITE PROPOSALS (HALESWORTH)

DRAWING NO:	REVISION:
FIGURE 3.1	

DATE:	DRAWN:	SCALE :
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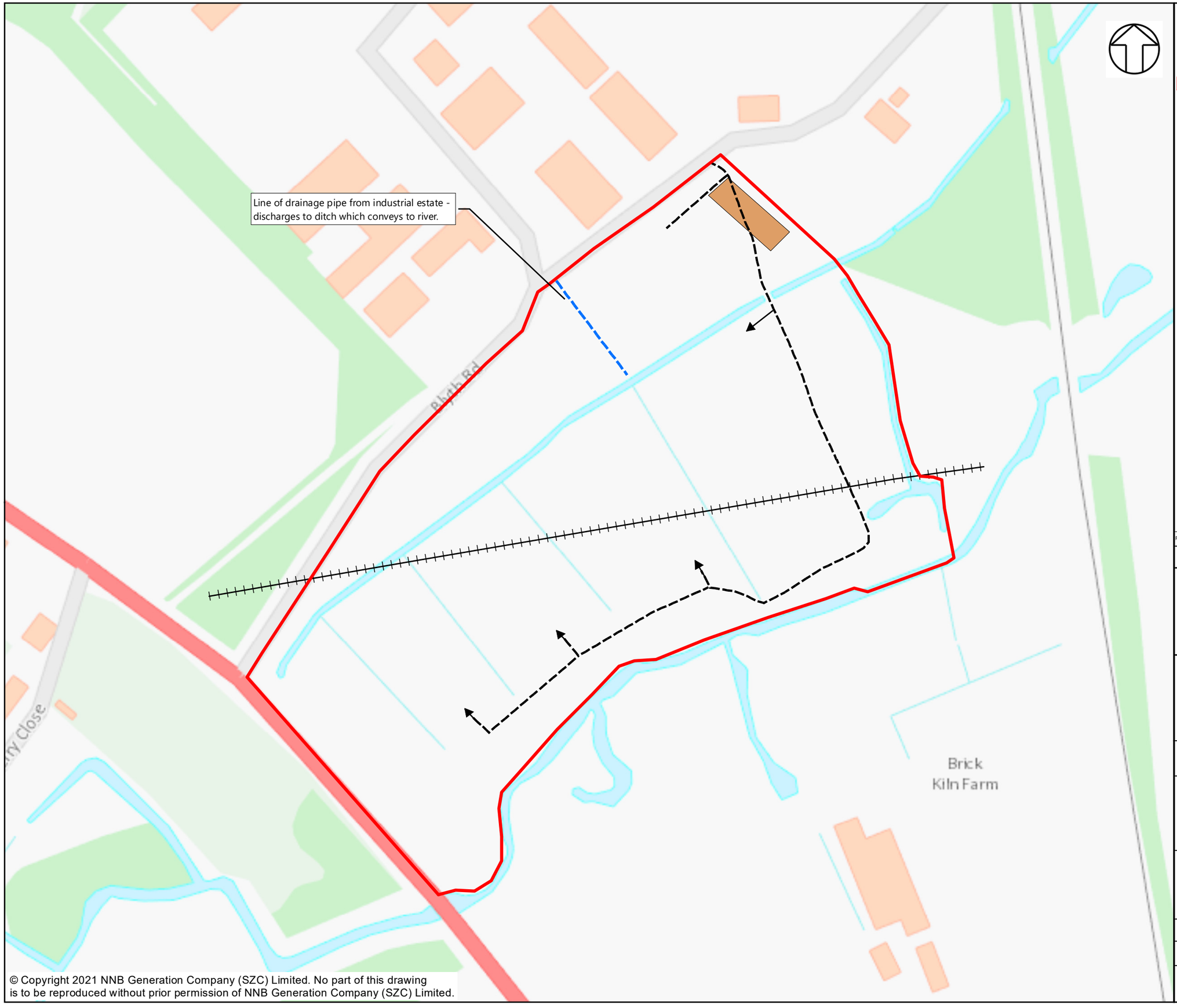

NOTES

KEY

- Halesworth site boundary
- River or drainage ditch
- Indicative access route
- Power line
- Site compound
- Drainage pipe

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION / COMMENTS	APPROVED

NOT PROTECTIVELY MARKED

PROJECT:
SIZEWELL C

DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
NOTES ON ACCESSIBILITY AND HAZARDS FOR HABITAT CREATION ACTIVITIES (HALESWORTH)

DRAWING NO:	REVISION:
FIGURE 3.2	

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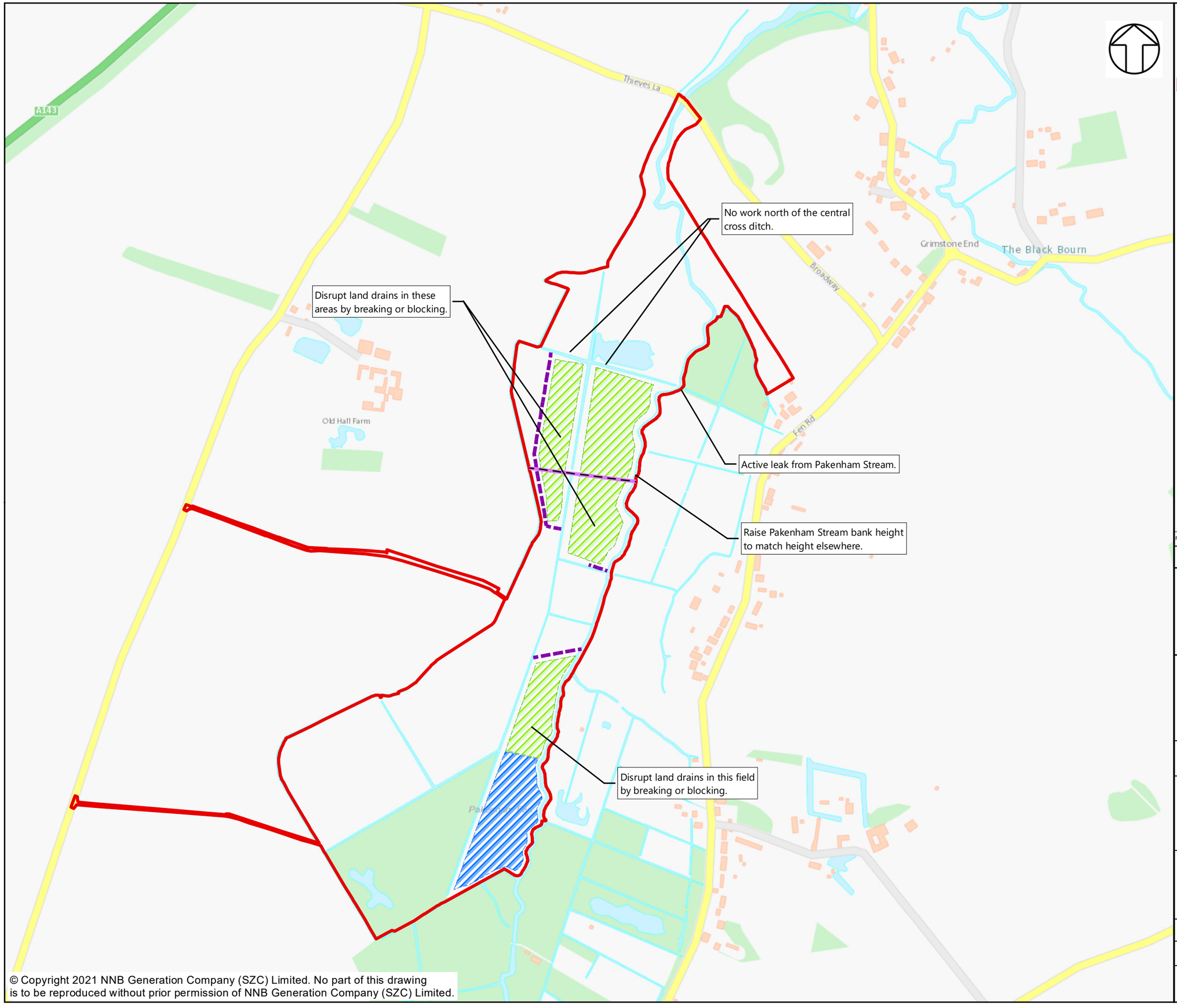

NOTES

KEY

- Pakenham site boundary
- River or drainage ditch
- Area for wet woodland
- Area of land sculpting to create habitat matrix
- Fenceline to manage stock access to new fen meadow areas
- Footpath boardwalk

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION / COMMENTS	APPROVED

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DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
SITE PROPOSALS (PAKENHAM)

DRAWING NO: FIGURE 4.1
REVISION:

DATE: JULY 2021
DRAWN: J.P.
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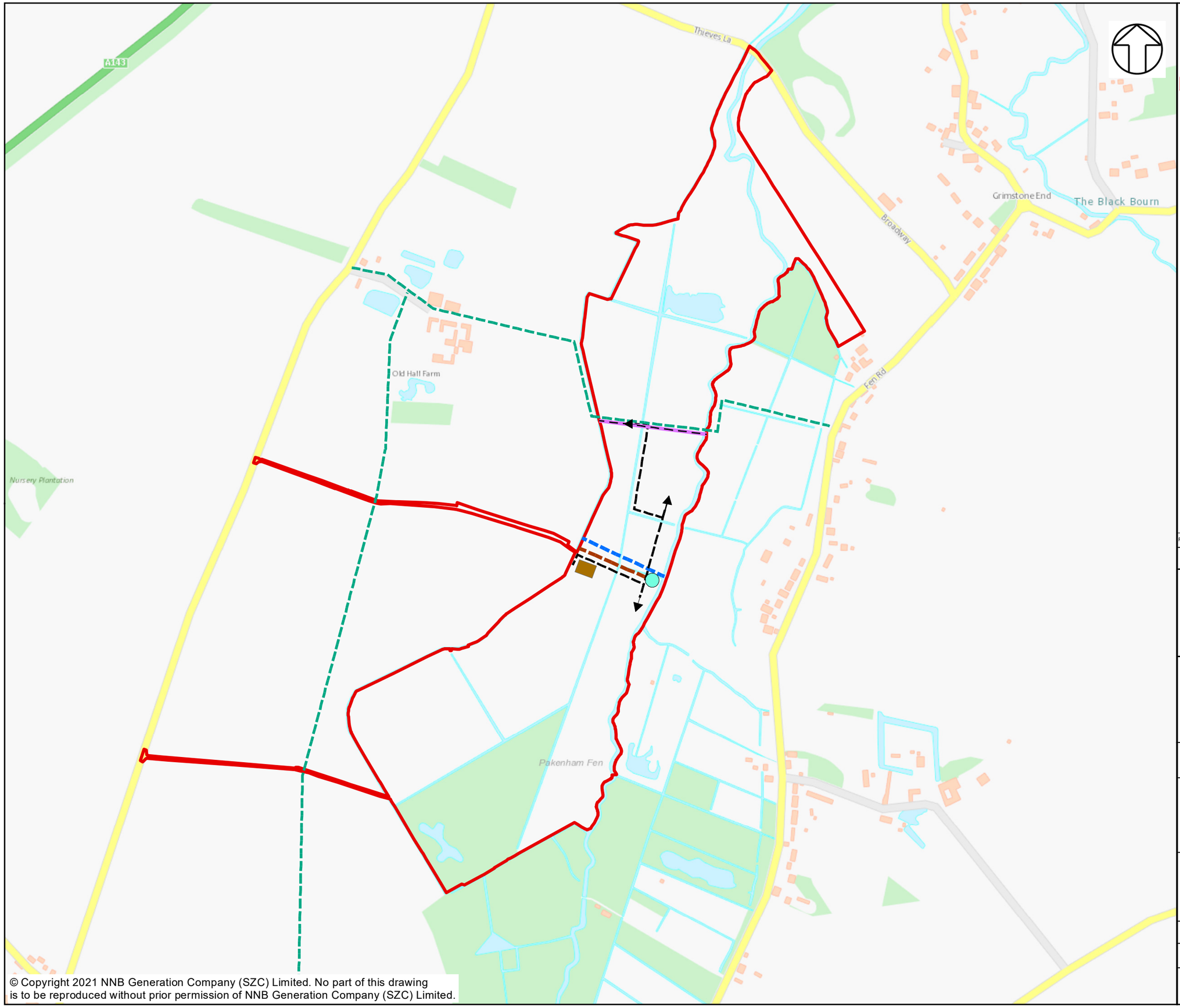

NOTES

KEY

- Pakenham site boundary
- River or drainage ditch
- Public footpath
- Indicative access route
- Approximate line of underground pipe
- Landowner boundary
- Footpath boardwalk
- Site compound
- Biosecurity point

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION / COMMENTS	APPROVED

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PROJECT:
SIZEWELL C

DOCUMENT:
FEN MEADOW PLAN

DRAWING TITLE:
NOTES ON ACCESSIBILITY AND HAZARDS FOR HABITAT CREATION ACTIVITIES (PAKENHAM)

DRAWING NO:	REVISION:
FIGURE 4.2	

DATE:	DRAWN:	SCALE :
JULY 2021	J.P.	1:6,000 @A3

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APPENDIX A: WATER MONITORING SUMMARY – BENHALL SITE 10 & 11, NOVEMBER 2020 TO PRESENT (JULY 2021)

Technical note:
Sizewell C Fen Meadow Compensation Water Monitoring Summary – Benhall Site November 2020 to July 2021

1. Introduction

The technical note summarises water monitoring data collected between November 2020 and July 2021 at the Benhall site (hereafter referred to as 'the Site') which has been identified as a potential fen meadow development area. Benhall was originally identified as two sites (Sites 10 and 11) however, these were subsequently combined into one, with areas now referred to as the northern compartment (former Site 10) and the central and southern compartments (former Site 11). The site referencing is however retained in the naming of the installations.

This technical note is predominantly a factual presentation of the data rather than an interpretive report.

Figure 1.1 shows a map of the Site and the installations referred to in this technical note.

2. Groundwater Level Monitoring

Ten groundwater monitoring points were installed at the Sites between 5th and 23rd October 2020. Seven shallow dipwells were installed to measure groundwater levels in the shallow superficial near surface deposits and three piezometers were installed to measure groundwater levels in the underlying sands and gravels. Two of the sands and gravels piezometers are nested (within the same borehole) with a dipwell. An installation summary is provided in Table 2.1 below.

Table 2.1 Summary of groundwater monitoring installations

Name	Drillers ID	NGR	Datum: Metal Cover (mAOD)	Ground Level (mAOD)	Depth (m bgl*)	Diameter (mm)	Notes
BHALL_1001_d	bh1001	TM3824360485	7.254	6.689	10	50	
BHALL_1001_s	ws1001	TM3823760625	4.177	3.906	3	19	
BHALL_1002_s	ws1002a	TM3828760508	4.671	4.347	3	19	
BHALL_1003_s	ws1003	TM3824060487	4.207	3.931	3	19	
BHALL_1101_d	bh1101	TM3817360414	4.190	3.875	10	50	Nested with BHALL_1101_s
BHALL_1101_s	ws1101	TM3817360414	4.178	3.906	2.4	50	Nested with BHALL_1101_d

Name	Drillers ID	NGR	Datum: Metal Cover (mAOD)	Ground Level (mAOD)	Depth (m bgl*)	Diameter (mm)	Notes
BHALL_1102_d	bh1102	TM3813060268	4.178	3.906	10	50	Nested with BHALL_1102_s
BHALL_1102_s	ws1102	TM3813060268	4.147	3.92	3	50	Nested with BHALL_1102_d
BHALL_1103_s	ws1103	TM3820260405	4.147	3.92	3	50	
BHALL_1104_s	ws1104	TM3810560190	4.252	3.952	3	50	

s = shallow; d = deep
*m bgl = metres below ground level

Each installation is fitted with a water level datalogger which is being downloaded on a quarterly basis. Table 2.2 and 2.3 summarise the data collected manually between November 2020 and present (July 2021) for installations in the northern and central areas of the site respectively. BHALL_ 1002_s was entirely flooded in November 2020. In December 2020 BHALL_ 1003_s was flooded. Hydrographs, presenting both logger and manually collected data) for the installations are provided in Appendix A (Combined Hydrograph Figures A1 to A5) and Appendix B (Individual Groundwater Hydrographs Figures B1-B20). Note that in Appendix B there are a combination of hydrographs providing both absolute water levels and depth to water table.

Table 2.2 Groundwater Levels (m bgl and mAOD) in installations in the northern area of the site

Date	BHALL_ 1001_d	BHALL_ 1001_s	BHALL_ 1002_s	BHALL_ 1003_s
m bgl				
19-20/11/20	0.837	0.423	0.033	0.042
09/12/20	0.569	0.376	-0.016	-0.03
13/01/21	0.79	0.78	0.04	0.33
17/02/21	0.386	0.316	-0.013	-0.024
10/03/21	0.365	0.746	0.416	0.415
27/04/21	0.45	0.96	0.88	0.89
11/05/21	0.406	0.788	0.692	0.594
08/06/21	0.52	1.029	-.94	0.873
13/07/21	0.466	0.836	0.476	0.446
mAOD*				
19-20/11/20	3.069	3.924	3.898	3.833
09/12/20	3.337	3.971	3.947	3.905

13/01/21	3.387	3.891	4.167	3.860
17/02/21	3.791	4.031	3.944	3.899
10/03/21	3.812	3.925	3.791	3.775
27/04/21	3.727	3.711	3.327	3.300
11/05/21	3.771	3.883	3.515	3.596
08/06/21	3.657	3.642	3.267	3.317
13/07/21	3.711	3.835	3.731	3.744

*m AOD = metres above ordnance datum
Note: negative m bgl value indicates positive hydrostatic pressure

Table 2.3 Groundwater Levels (m bgl and mAOD) in installations in the central area of the site

Date	**BHALL_ 1101_d**	**BHALL_ 1101_s**	**BHALL_ 1102_d**	**BHALL_ 1102_s**	**BHALL_ 1103_s**	**BHALL_ 1104_s**
m bgl						
19-20/11/20	-0.052	-0.017	0.233	0.213	0.057	0.115
09/12/20	-0.077	-0.07	-0.106	0.135	-0.08	-0.017
13/01/21	0.1	0.1	0.38	0.41	0.36	0.36
17/02/21	-0.110	0.169	-0.042	-0.007	0.221	-0.125
10/03/21	0.155	0.305	0.386	0.422	0.418	0.330
27/04/21	0.83	1.05	0.81	0.52	0.77	0.36
11/05/21	1.082	1.237	0.42	0.434	0.56	0.414
08/06/21	1.15	1.282	0.528	0.554	0.739	0.52
13/07/21	0.892	1.064	0.324	0.496	0.426	0.532
mAOD*						
19-20/11/20	3.958	3.923	3.687	3.707	3.895	3.801
09/12/20	3.983	3.976	4.026	3.785	4.032	3.933
13/01/21	4.016	4.078	3.767	3.737	3.892	3.919
17/02/21	4.016	3.737	3.962	3.927	3.731	4.041
10/03/21	4.023	3.873	3.761	3.725	3.834	3.949

27/04/21	3.348	3.128	3.337	3.627	3.482	3.919
11/05/21	3.096	2.941	3.727	3.713	3.692	3.865
08/06/21	3.896	4.028	3.619	3.593	3.513	3.759
13/07/21	4.035	4.114	3.823	3.651	3.826	3.474

*m AOD = metres above ordnance datum
Note: negative m bgl value indicates positive hydrostatic pressure

3. Surface Water Level Monitoring

Five gaugeboards were installed between 12th and 16th October 2020 to allow monitoring of surface water levels across the site's watercourses / drains. All gaugeboards included stilling wells and water level data loggers. An installation summary is given in Table 3.1 below.

Table 3.1 Summary of gaugeboard installations

Ref.	GPS Grid Ref.	Top of Gaugeboard Datum (mAOD*)	Gaugeboard Length (m)	Datalogger	Log Interval (minutes)
SNP-GB01	TM 38130 60235	3.73	1	OTT Orpheus Mini	15
SNP-GB02	TM 38249 60509	4.24	1	OTT Orpheus Mini	15
SNP-GB03	TM 38207 60658	4.8	1	OTT Orpheus Mini	15
SNP-GB04	TM 38350 60725	4.72	2	OTT Orpheus Mini	15
SNP-GB05	TM 38300 60618	4.71	2	OTT Orpheus Mini	15

*mAOD = metres above ordnance datum

Table 3.2 summarises the gaugeboard water level readings taken manually between November 2020 and June 2021. The water level at all gaugeboard locations is continuously monitored and are downloaded on a monthly basis during spot gauging visits. Hydrographs of surface water levels are presented in Appendix C, and in combination with groundwater hydrographs in Appendix A (data are currently available to mid June 2021).

Table 3.2 Surface Water Levels (mAOD)

Date	SNP-GB01	SNP-GB02	SNP-GB03	SNP-GB04	SNP-GB05	SNP-SF05*
19-20/11/20	3.028	3.623	4.096	3.575	3.653	4.605
09/12/20	3.178	4.039	4.255	4.195	4.048	4.489
13/01/21	3.109	3.701	4.137	3.741	3.725	4.44

17/02/21	3.255	3.760	4.181	3.855	3.815	
10/03/21	2.952	3.651	4.104	3.538	3.666	4.709
08/04/21	2.933	3.61	4.09	3.454	3.621	4.668
11/05/21	2.962	3.64	4.085	3.498	3.63	4.635
08/06/21	2.962	3.637	4.072	3.495	3.531	4.702

*Manual reading from dip point (no gaugeboard or datalogger).

4. Spot Flow Gauging

Monthly spot flow gauging of five gaugeboard locations commenced in November 2020. Results to date are shown in Table 4.1 below. Negative flow readings in Table 4.1 indicate static conditions where flow is not sufficiently high to be measurable.

Table 4.1 Spot Flow (m^3/s)

Date	SNP-SF01	SNP-SF02	SNP-SF03	SNP-SF04	SNP-SF05
19-20/11/20	0.0015	0.0128	0.0012	No suitable location to gauge. Channel too deep to wade.	0.0718
09/12/20	0.0098	-0.0651	0.0207	No suitable location to gauge. Channel too deep to wade.	0.1909
13/01/21	0.0036	0.0282	0.0047	No suitable location to gauge. Channel too deep to wade.	0.2646
17/02/21	0.0163	0.0470	0.0162	No suitable location to gauge. Channel too deep to wade.	Too deep to safely wade, severe flooding and significant snow meltwater from previous days.
10/03/21	0.0023	0.0324	0.0024	No suitable location to gauge. Channel too deep to wade.	0.0637
08/04/21	0.0024	0.0226	-0.0002	No suitable location to gauge. Channel too deep to wade.	0.0571
11/05/21	0.0025	0.022	0.0012	No suitable location to gauge. Channel too deep to wade.	0.0576
08/06/21	0.002	0.0327	0.0007	No suitable location to gauge. Channel too deep to wade.	0.0519.

5. Water Quality Monitoring

In-situ water quality readings are collected from all groundwater and surface water installations on a monthly basis. *In-situ* water quality results are presented in Table 5.1 below.

In addition to this, water quality samples have been collected quarterly at selected locations and sent for laboratory analysis. Quarterly sampling was undertaken in January 2021 (for groundwaters only) and April 2021 (both groundwater and surface water), with samples (both groundwater and surface water) collected in July 2021 being analysed. Available results for key water quality parameters indicative of nutrient enrichment, and its source (nitrate, phosphate and chloride), are presented in Table 5.2. In April 2021, SNP_1001_d could not be sampled due to a blockage and insufficient water.

Table 5.1 In-situ Water Quality Results

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
19/11/20	BHALL_1001_d	12	4.2	1398	6.94	3.2	22.2
09/12/20	BHALL_1001_d	9.9	48.6	1362	6.97	-25.4	57
13/01/21	BHALL_1001_d	7.1	26.9	1244	6.91	134.2	19.5
17/02/21	BHALL_1001_d	7.2	42.9	1391	6.64	-115.3	96.7
10/03/21	BHALL_1001_d	7.6	41.9	1421	6.5	-101.3	9.96
27/04/21	BHALL_1001_d	11.6	30.3	1447	6.61	1001	19.3
11/05/21	BHALL_1001_d	12.5	15.8	1452	6.73	-97.8	58.68
24/05/21	BHALL_1001_d	11.6	30.3	1447	6.61	1001	19.3
08/06/21	BHALL_1001_d	13.7	11.9	1438	6.7	-107.8	13.25
13/07/21	BHALL_1001_d	13.4	249	1441	6.62	-102.8	29.6
20/11/20	BHALL_1001_s	cns	cns	cns	cns	cns	cns
09/12/20	BHALL_1001_s	cns	cns	cns	cns	cns	cns
13/01/21	BHALL_1001_s	5.5	19.4	938	7.17	137.6	249
17/02/21	BHALL_1001_s	7.2	58.8	545	7.18	-111.9	78.2
10/03/21	BHALL_1001_s	6.9	59	1040	6.87	-51.1	51.92
11/05/21	BHALL_1001_s	12.7	69.3	1081	7.22	-62.7	23.7

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
08/06/21	BHALL_1001_s	n/a	n/a	n/a	n/a	n/a	n/a
19/11/20	BHALL_1002_s	9.6	35	804	7.68	-20.5	329.1
09/12/20	BHALL_1002_s	8.1	53	370.5	9.1	67.4	176.5
13/01/21	BHALL_1002_s	3.4	28.7	630	8.47	140.8	80.4
17/02/21	BHALL_1002_s	7	73.2	566	7.85	125.1	144.2
10/03/21	BHALL_1002_s	6.2	43	768	7.01	-13	157.77
11/05/21	BHALL_1002_s	12.1	58.1	1027	7.51	-114.9	66.78
08/06/21	BHALL_1002_s	16	43.7	1110	7.03	-98.6	56.23
13/07/21	BHALL_1002_s	14	279	1521	6.55	-99.1	794
19/11/20	BHALL_1003_s	12.1	32.2	1611	6.82	-70.2	137.05
09/12/20	BHALL_1003_s	7.5	63	588	7.46	32.8	192
13/01/21	BHALL_1003_s	7.7	23.4	947	6.72	137.2	>1050
17/02/21	BHALL_1003_s	6.3	58.5	434.3	7.5	110	164.5
10/03/21	BHALL_1003_s	6.1	52.5	668	6.95	-97.3	122.81
27/04/21	BHALL_1003_s	9.4	20.3	1268	6.54	95.8	259
11/05/21	BHALL_1003_s	13.8	37.7	16.13	6.78	-83.3	39.34
24/05/21	BHALL_1003_s	9.4	20.3	1268	6.54	95.8	259
08/06/21	BHALL_1003_s	n/a	n/a	n/a	n/a	n/a	n/a
13/07/21	BHALL_1003_s	13.2	27.3	1705	6.58	-54.3	257
19/11/20	BHALL_1101_d	11.4	3	1000	7.05	-120.9	13.34
09/12/20	BHALL_1101_d	8.4	19.9	1000	6.97	-88.8	94.2
13/01/21	BHALL_1101_d	8.7	17	910	7.07	137.9	40.3
17/02/21	BHALL_1101_d	7.7	31.8	985	6.97	-118.9	2.9
10/03/21	BHALL_1101_d	7.7	11	990	6.74	-72.8	8.7
27/04/21	BHALL_1101_d	10.5	20	956	5.89	85.3	136

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
11/05/21	BHALL_1101_d	15.1	21.2	999	7.06	-42.5	25.65
24/05/21	BHALL_1101_d	10.5	20	956	5.89	85.3	136
08/06/21	BHALL_1101_d	18.5	23.8	999	6.98	-40	58.17
13/07/21	BHALL_1101_d	16.2	176	1008	7	-18.9	113
19/11/20	BHALL_1101_s	10.8	3.4	1024	7.5	-142.3	19
09/12/20	BHALL_1101_s	8	30.9	1006	7.03	-101.6	16
13/01/21	BHALL_1101_s	6.6	34.1	919	7.13	143.7	289
17/02/21	BHALL_1101_s	7.9	35.3	992	6.95	-91.6	861.1
10/03/21	BHALL_1101_s	7.5	21.6	986	6.8	-73.1	124.32
27/04/21	BHALL_1101_s	10.7	32.7	961	5.96	89.9	>1050
11/05/21	BHALL_1101_s	13.6	23.6	997	7.07	-37.1	15.61
24/05/21	BHALL_1101_s	10.7	32.7	961	5.96	89.9	>1050
08/06/21	BHALL_1101_s	17.2	32.5	988	7.2	-62.1	46.78
13/07/21	BHALL_1101_s	15.1	344	1007	7.11	-51.2	>1050
19/11/20	BHALL_1102_d	11.1	31.2	1187	10.05	-31.1	291.4
09/12/20	BHALL_1102_d	7.6	26	1012	8.16	-194.6	37.9
13/01/21	BHALL_1102_d	6.4	17.8	968	7.28	175.2	28.6
17/02/21	BHALL_1102_d	7.2	38.5	877	7.16	-102.6	51
10/03/21	BHALL_1102_d	7.2	39.5	1050	7.06	-52.8	181.53
27/04/21	BHALL_1102_d	11.2	35.2	1080	7.16	84.7	42.6
11/05/21	BHALL_1102_d	13.8	47.1	1096	7.19	-48.4	96.19
24/05/21	BHALL_1102_d	11.2	35.2	1080	7.16	84.7	42.6
08/06/21	BHALL_1102_d	16.7	39.2	1068	7.27	-75.5	38.25
13/07/21	BHALL_1102_d	13.8	400	1131	7.26	-63.4	1332
19/11/20	BHALL_1102_s	10.6	3.7	1318	7.46	-157.2	26.45

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
09/12/20	BHALL_1102_s	7.7	49.6	1252	7.16	87.2	41
13/01/21	BHALL_1102_s	7.1	19.1	1117	6.98	165.3	25.2
17/02/21	BHALL_1102_s	7.7	45.2	1090	7.06	-164.7	191.8
10/03/21	BHALL_1102_s	7.7	20.7	1158	6.78	-104.9	47.15
27/04/21	BHALL_1102_s	12.1	7.9	1056	7.39	72.6	>1050
11/05/21	BHALL_1102_s	11.8	16.4	1083	7.18	5.9	39.28
24/05/21	BHALL_1102_s	12.1	7.9	1056	7.39	72.6	>1050
08/06/21	BHALL_1102_s	15.5	27.3	1065	7.16	-47.8	30
13/07/21	BHALL_1102_s	14.5	114	1122	6.99	-74.3	>1050
19/11/20	BHALL_1103_s	11	3.6	1385	6.88	-146.8	71.24
09/12/20	BHALL_1103_s	7.7	48.9	1373	6.95	-109.9	156.7
13/01/21	BHALL_1103_s	6.3	11.9	1147	6.99	133.2	154
17/02/21	BHALL_1103_s	6.6	63.5	876	7.23	-86.9	38
10/03/21	BHALL_1103_s	6.6	37	1268	6.57	-75.1	65.1
11/05/21	BHALL_1103_s	11.3	17	1231	6.84	-72.5	11.49
08/06/21	BHALL_1103_s	12.9	17.2	1245	6.76	-92.3	11.08
19/11/20	BHALL_1104_s	11.1	6.5	1160	7.06	-134.9	54.4
09/12/20	BHALL_1104_s	7.6	40.3	953	6.89	241.9	50.1
13/01/21	BHALL_1104_s	6.9	22.8	886	6.95	199.1	78.2
17/02/21	BHALL_1104_s	9	42.2	906	7.17	-60.8	211.7
10/03/21	BHALL_1104_s	7.5	21.1	990	6.83	120.2	20.21
11/05/21	BHALL_1104_s	12.8	51.5	981	7.22	257.4	4.73
08/06/21	BHALL_1104_s	15.2	49.7	969	7.33	180.2	8.3
27/04/21	BHALL_FRO	9.8	87.2	964	7.44	113.3	12.5
24/05/21	BHALL_FRO	9.8	87.2	964	7.44	113.3	12.5

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
13/07/21	BHALL_FRO	16.3	703	1032	7.46	62.4	6.7
19/11/20	BHALL_GB1	10	34.2	1022	7.28	41	1.9
09/12/20	BHALL_GB1	5.5	60	1077	7.22	223	7.3
17/02/21	BHALL_GB1	5.3	53.7	835	7.29	135.5	12.3
10/03/21	BHALL_GB1	7.7	62.4	998	7.4	149.1	3.1
27/04/21	BHALL_GB1	11.9	91.1	943	7.22	73.7	9.77
11/05/21	BHALL_GB1	13.2	101	1008	7.23	247.2	4.09
24/05/21	BHALL_GB1	11.9	91.1	943	7.22	73.7	9.77
08/06/21	BHALL_GB1	13.3	70.1	1017	7.18	114.1	-0.63
19/11/20	BHALL_GB2	12.3	56.7	1618	7.46	88.1	4.45
09/12/20	BHALL_GB2	5.2	95.4	836	7.85	81.3	64
17/02/21	BHALL_GB2	8.1	81.5	1141	7.47	91.4	15.2
10/03/21	BHALL_GB2	8.7	50.4	1664	6.93	1.3	262.78
27/04/21	BHALL_GB2	11.7	84.5	1511	7.46	111.5	16
11/05/21	BHALL_GB2	15.9	68	1479	7.27	-85	4.75
24/05/21	BHALL_GB2	11.7	84.5	1511	7.46	111.5	16
08/06/21	BHALL_GB2	18.8	40	1786	7.18	44.7	55.36
13/07/21	BHALL_GB2	19.8	230	1618	7.33	69.5	10.9
20/11/20	BHALL_GB3	5.6	56.9	1067	7.6	5.6	3.49
09/12/20	BHALL_GB3	5	92.1	871	7.74	87.3	70.3
17/02/21	BHALL_GB3	5.1	90.2	629	7.58	80.8	21
10/03/21	BHALL_GB3	6.5	80.5	956	7.25	-77.2	26.41
11/05/21	BHALL_GB3	14.5	68.2	1031	7.38	10	10
08/06/21	BHALL_GB3	18.5	63.4	961	7.51	-8.8	7.43
20/11/20	BHALL_GB4	5	41.7	1227	7.52	-21.4	10.1

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
09/12/20	BHALL_GB4	5.3	88.6	888	7.67	92.2	42.1
17/02/21	BHALL_GB4	7.2	73.9	875	7.49	121.9	36
10/03/21	BHALL_GB4	6.1	62.7	1021	7.15	16.2	11.6
27/04/21	BHALL_GB4	16.5	96	991	7.63	84.2	30.7
11/05/21	BHALL_GB4	14.5	62.5	1032	7.37	-16.1	14.28
24/05/21	BHALL_GB4	16.5	96	991	7.63	84.2	30.7
08/06/21	BHALL_GB4	16.3	46.2	1035	7.26	-73.3	11.19
13/07/21	BHALL_GB4	16.5	664	991	7.5	65	12.1
20/11/20	BHALL_GB5	7.6	5.4	1581	7.09	-176.4	4.3
09/12/20	BHALL_GB5	5.4	57.3	1006	7.49	86.3	4
17/02/21	BHALL_GB5	7	67.3	857	7.47	127.1	22.4
10/03/21	BHALL_GB5	5.8	30.7	1096	6.84	-9	55.26
27/04/21	BHALL_GB5	8.5	29.6	1350	6.92	134.1	>1050
11/05/21	BHALL_GB5	16.8	100.6	947	7.29	-66.1	46.33
24/05/21	BHALL_GB5	8.5	29.6	1350	6.92	134.1	>1050
08/06/21	BHALL_GB5	17	5	995	6.86	-82.9	203.5
13/07/21	BHALL_GB5	17.1	415	946	7.15	-70.3	16.1
19/11/20	BHALL_SP5	9.5	65.2	1037	7.52	178.7	3.82
09/12/20	BHALL_SP5	4.9	82	1108	7.43	26.5	115
17/02/21	BHALL_SP5	4.5	87	675	7.68	214.5	22.1
10/03/21	BHALL_SP5	7.7	74.1	1084	7.26	203.7	7.43
27/04/21	BHALL_SP5	12.5	113.2	1208	7.62	71.4	16.3
11/05/21	BHALL_SP5	12.2	70.2	922	7.19	324	27.22
24/05/21	BHALL_SP5	12.5	113.2	1208	7.62	71.4	16.3
08/06/21	BHALL_SP5	14.3	47.3	1120	7.19	191	1.89

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
13/07/21	BHALL_SP5	16.2	52.6	1062	7.08	-5.6	13.8

cns = could not sample. Insufficient water / blockage

Table 5.2 Results for key water quality parameters

Location ID	Date	Chloride (mg/l)	Nitrate as NO3)mg/l)	Phosphate (Ortho as PO4 mg/l)
BHALL - 1001_D	13/01/2021	132	<0.3	<0.05
BHALL - 1001_D	27/04/2021	67.5	<0.3	<0.05
BHALL - 1003_S	13/01/2021	37.2	27.6	<0.05
BHALL - 1003_S	27/04/2021	118	5.72	<0.05
BHALL - 1003_D	27/04/2021	113	<0.3	<0.05
BHALL - 1101_D	13/01/2021	64.9	<0.3	<0.05
BHALL - 1101_D	27/04/2021	63.6	9.22	<0.05
BHALL - 1101_S	13/01/2021	90.8	<0.3	<0.05
BHALL - 1101_S	27/04/2021	63.2	<0.3	<0.05
BHALL - FRO	27/04/2021	79.5	13.4	<0.05
BHALL - GB1	27/04/2021	69.4	48.2	0.057
BHALL - GB2	27/04/2021	267	71.5	11.4
BHALL - GB5	27/04/2021	89.8	<0.3	<0.05
BHALL - SP5	27/04/2021	145	38.7	4.77
BHALL-1102-D	13/01/2021	79.4	<0.3	<0.05
BHALL-1102-D	27/04/2021	78.2	<0.3	<0.05
BHALL-1102-S	13/01/2021	63.7	<0.3	<0.05
BHALL-1102-S	27/04/2021	88	<0.3	0.053
BHALL-GB4	27/04/2021	89.4	7.55	<0.05

6. LIDAR Data

To aid interpretation of the data, two LIDAR plots have been added in Appendix D. The first (D1) illustrates available data on a graded scale and the second (D2) provides the data sub-divided into elevation bands. The graded scale enables fine topographic features to be discerned, whilst the figure with data sub-divided into height bands enables identification of areas at broadly similar elevations.

Issued by	Approved by
.....	.....
Jon Mainhagu	**Ellie Creer**

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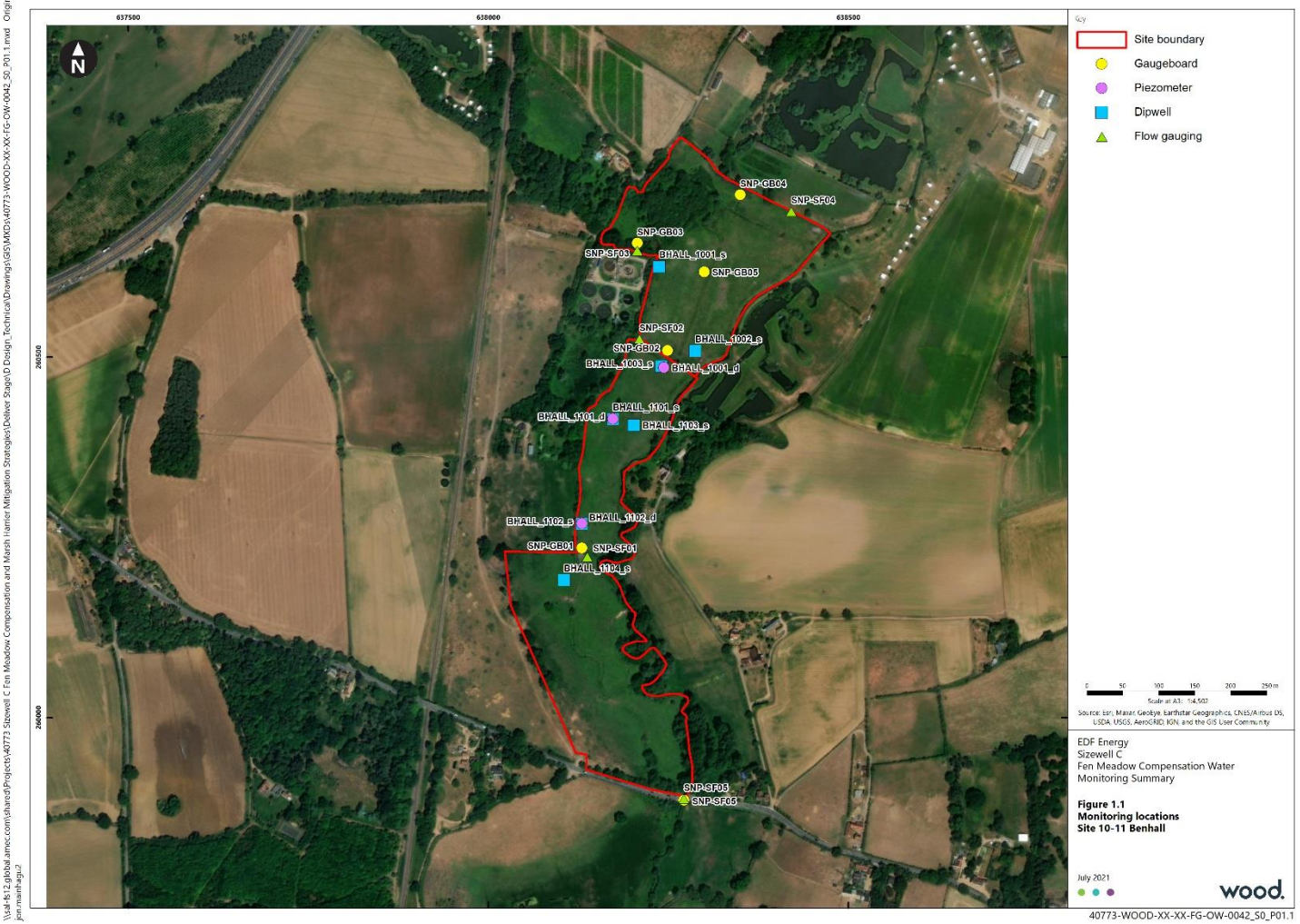
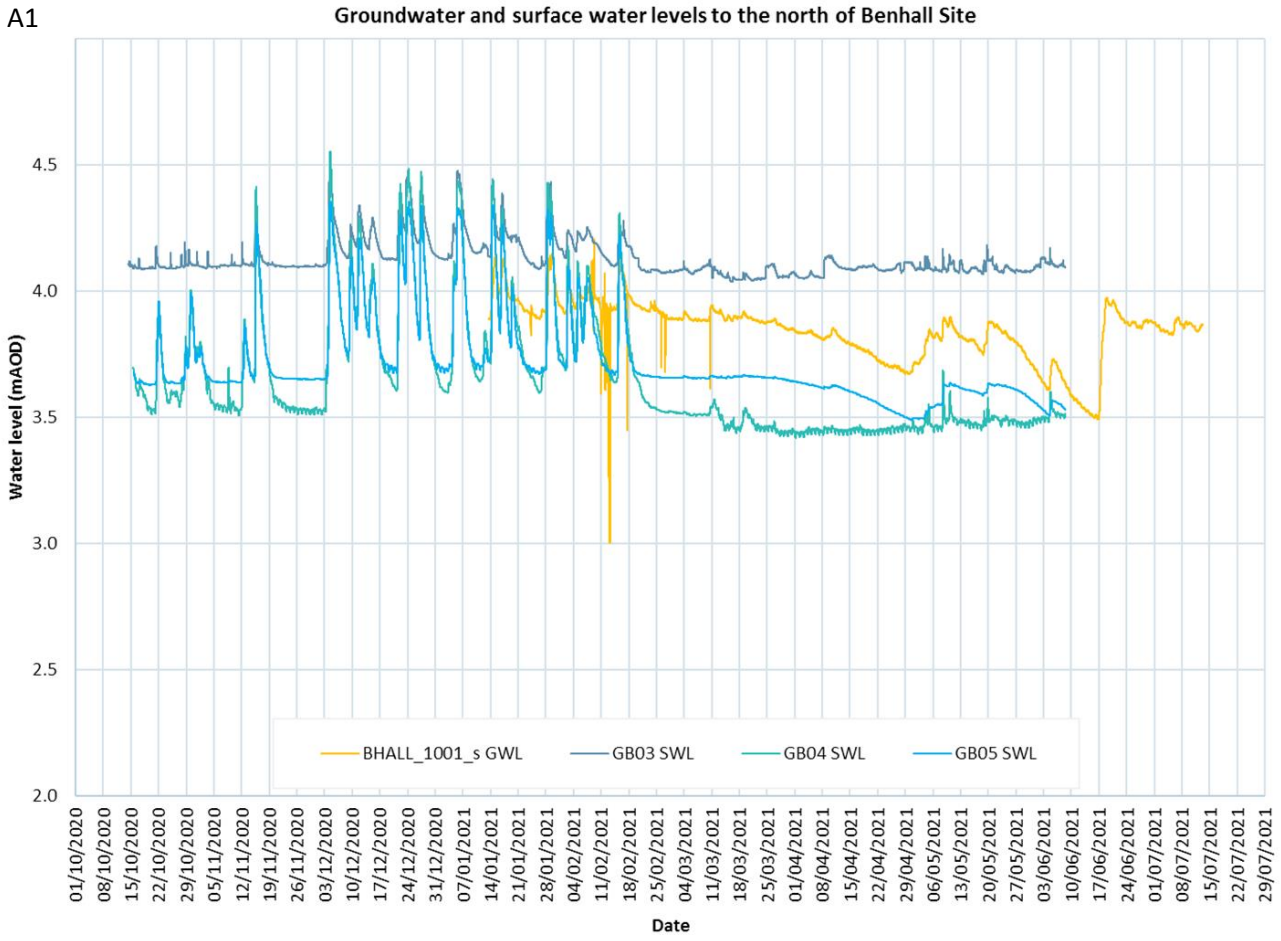
Figure



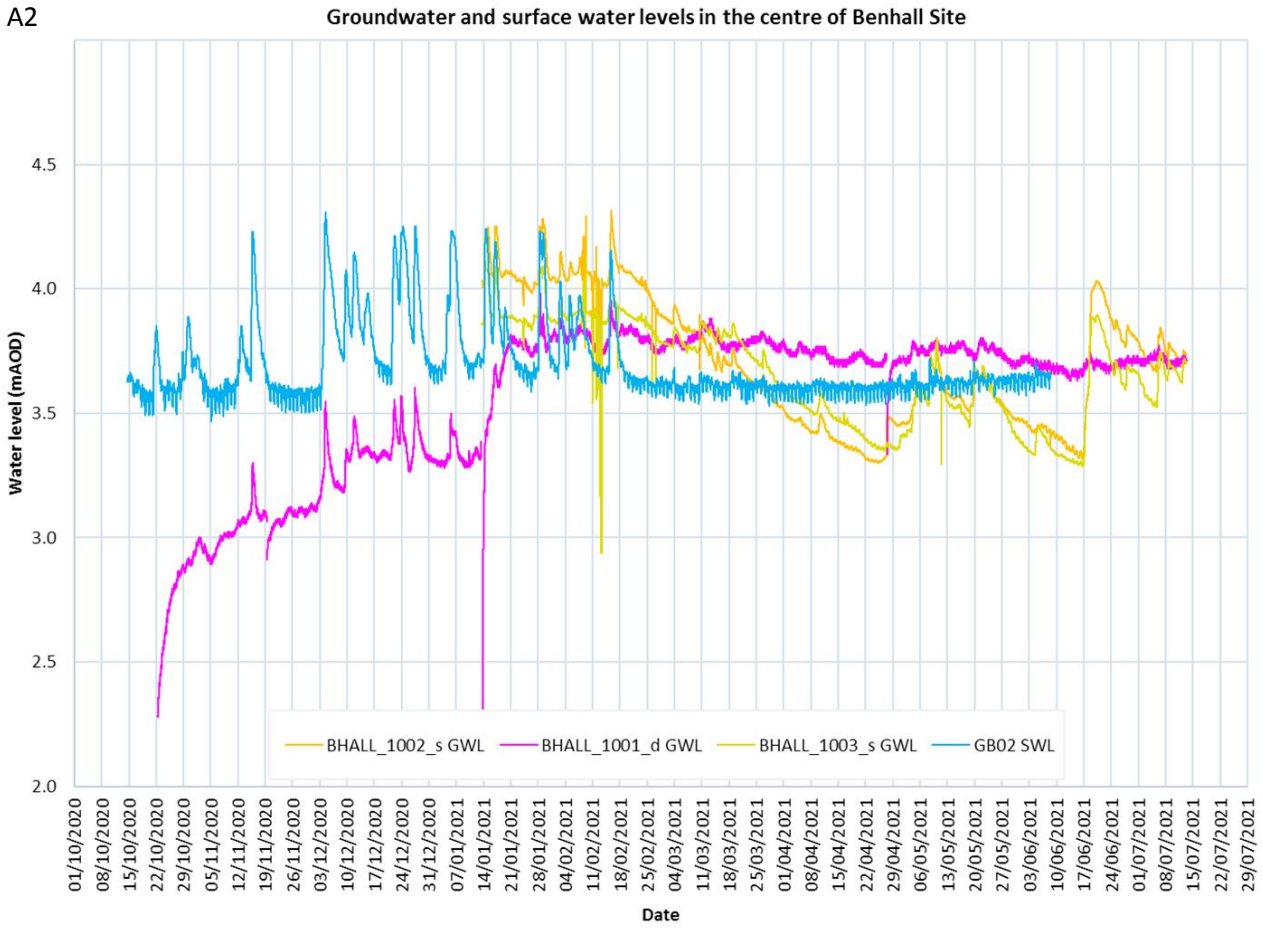
Appendix A
Combined Hydrographs

A1



BHaLL1001_s and GB05 showing similar response – decrease in superficial water levels in spring months?
GB03 has higher levels – is this where the WRCSTW discharge is? No access to the area to double check for a potential discharge.
River flows from outside the site via GB03 location

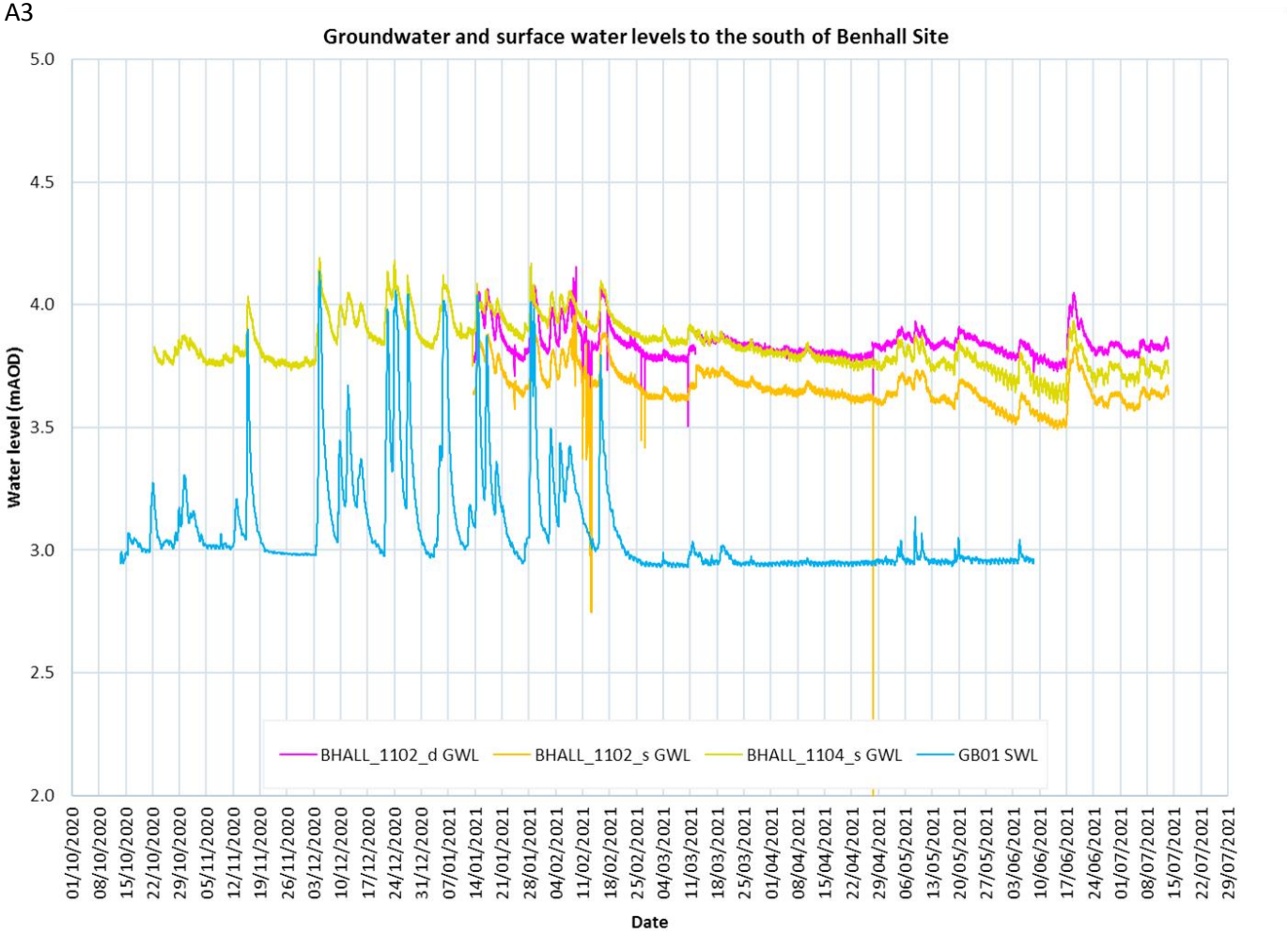
A2

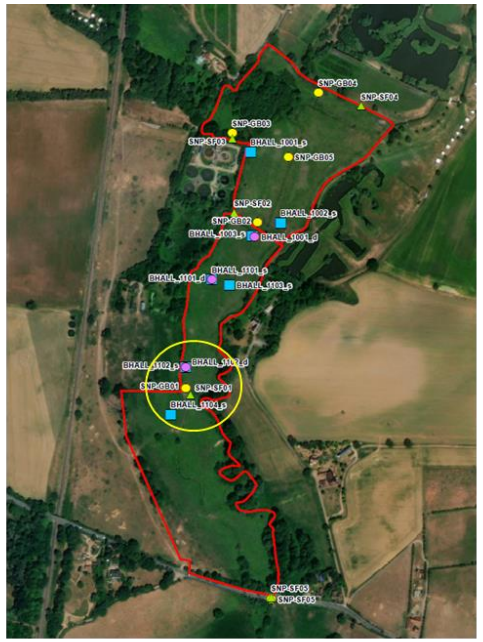


The superficial deposits 1002_s and 1003_s are showing decreases over the spring period, the same is not seen in the Crag borehole 1001_d.

Water levels in GB02 are being maintained despite drop in water levels in the superficial – No other visible input upflow

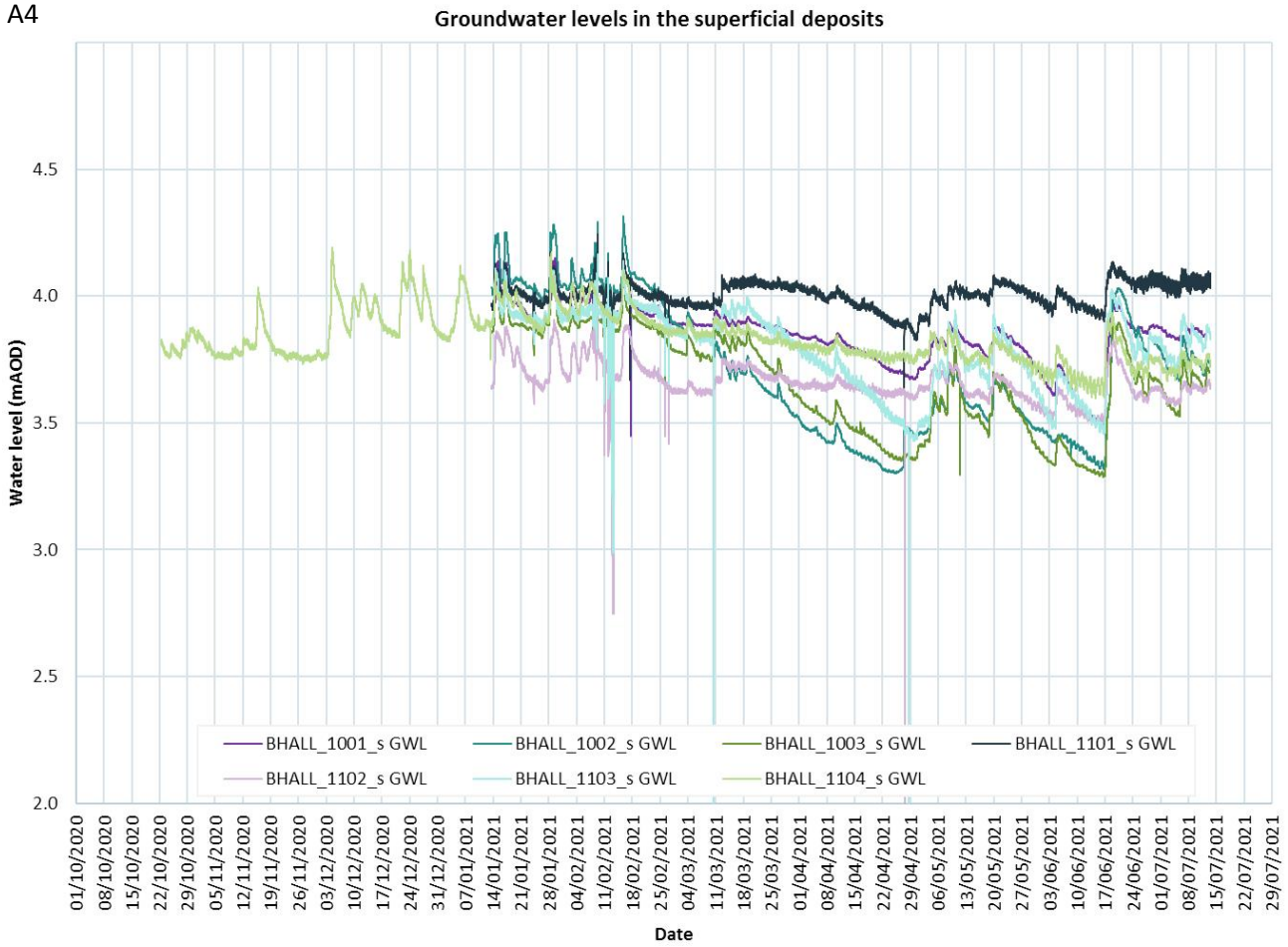
A3





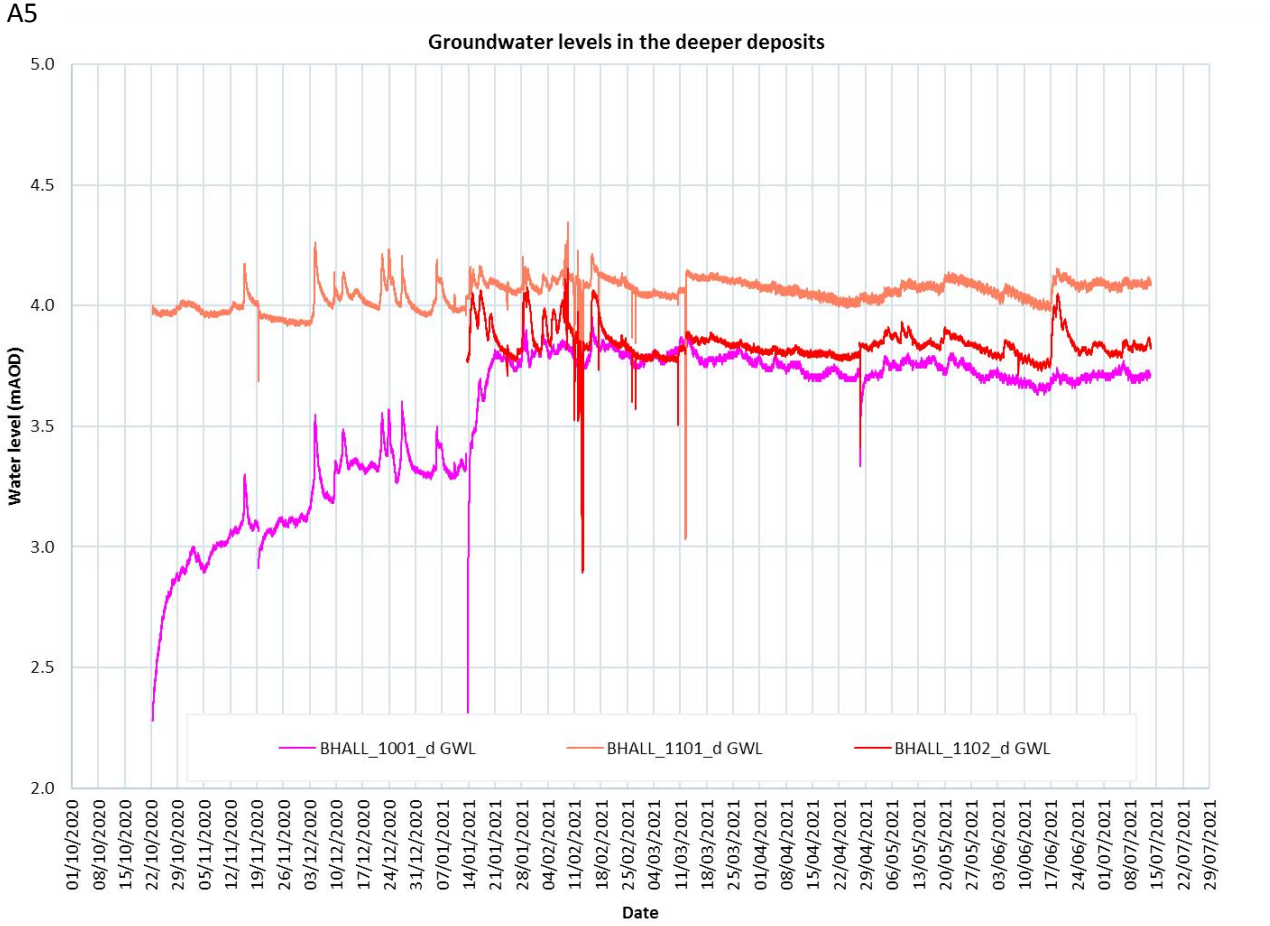
1102_d and 1102_s showing similar levels of fluctuation although deeper borehole water level is slightly above that of superficals – some upward flow?
Timing in fluctuations in SW GB01 same as in piezometer and dipwell.

A4



All showing similar decline over spring period. Fluctuation muted in 1102_s (upward flow from Crag to support levels?)

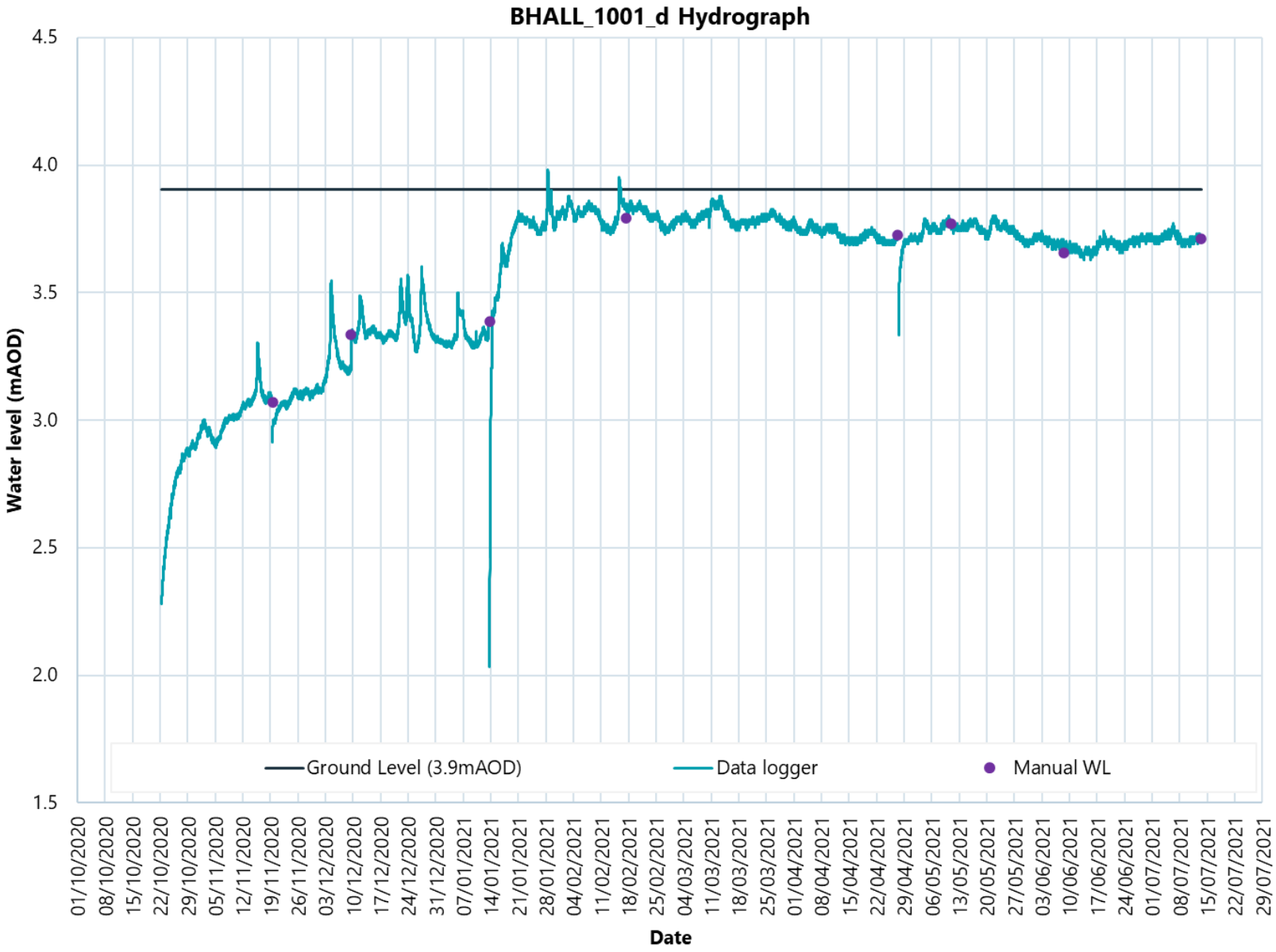
A5



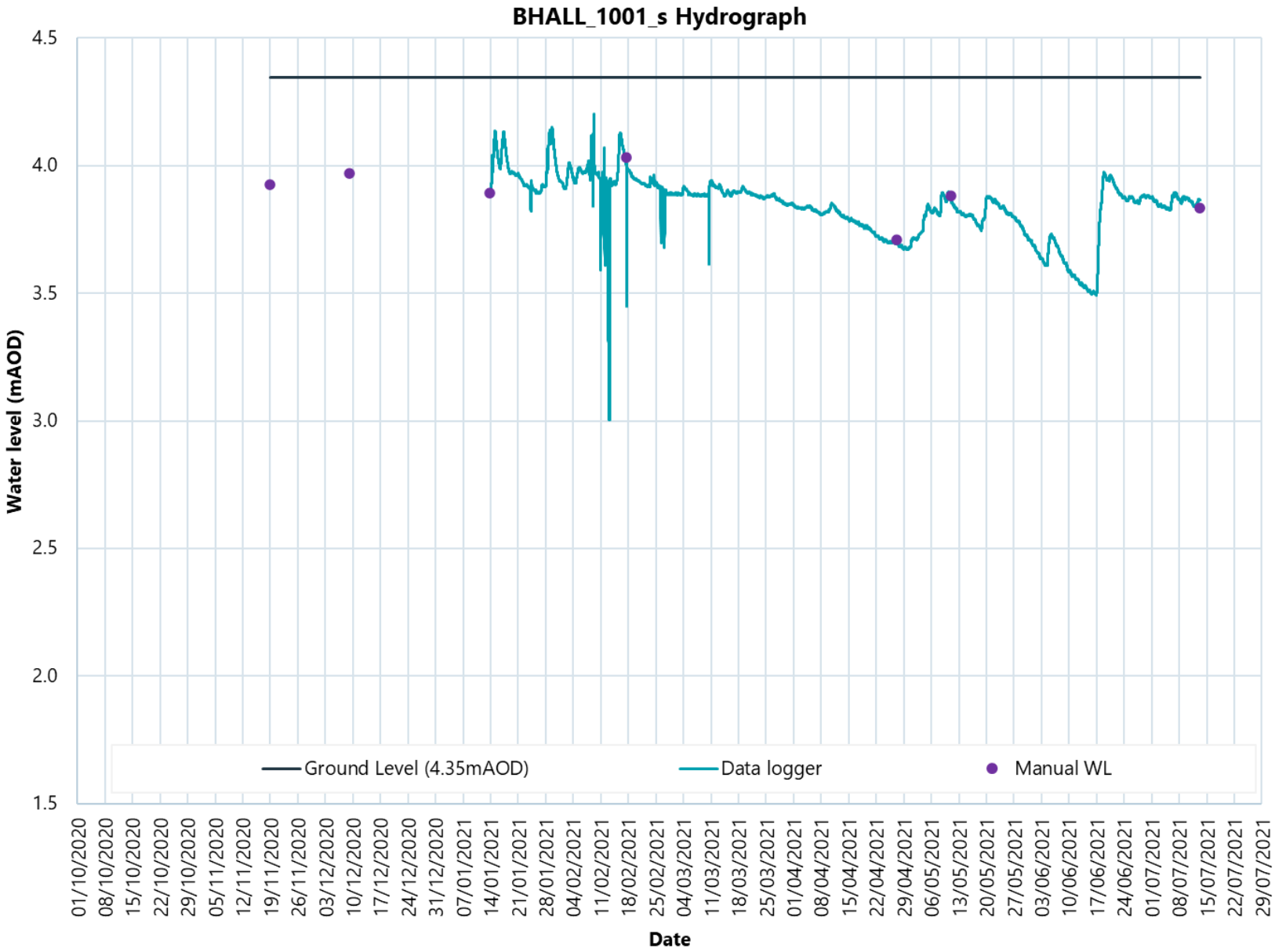
Pattern shows a much small decrease in the drier spring months as compared to the superficial deposits

Appendix B
Individual Groundwater Hydrographs

B1



B2



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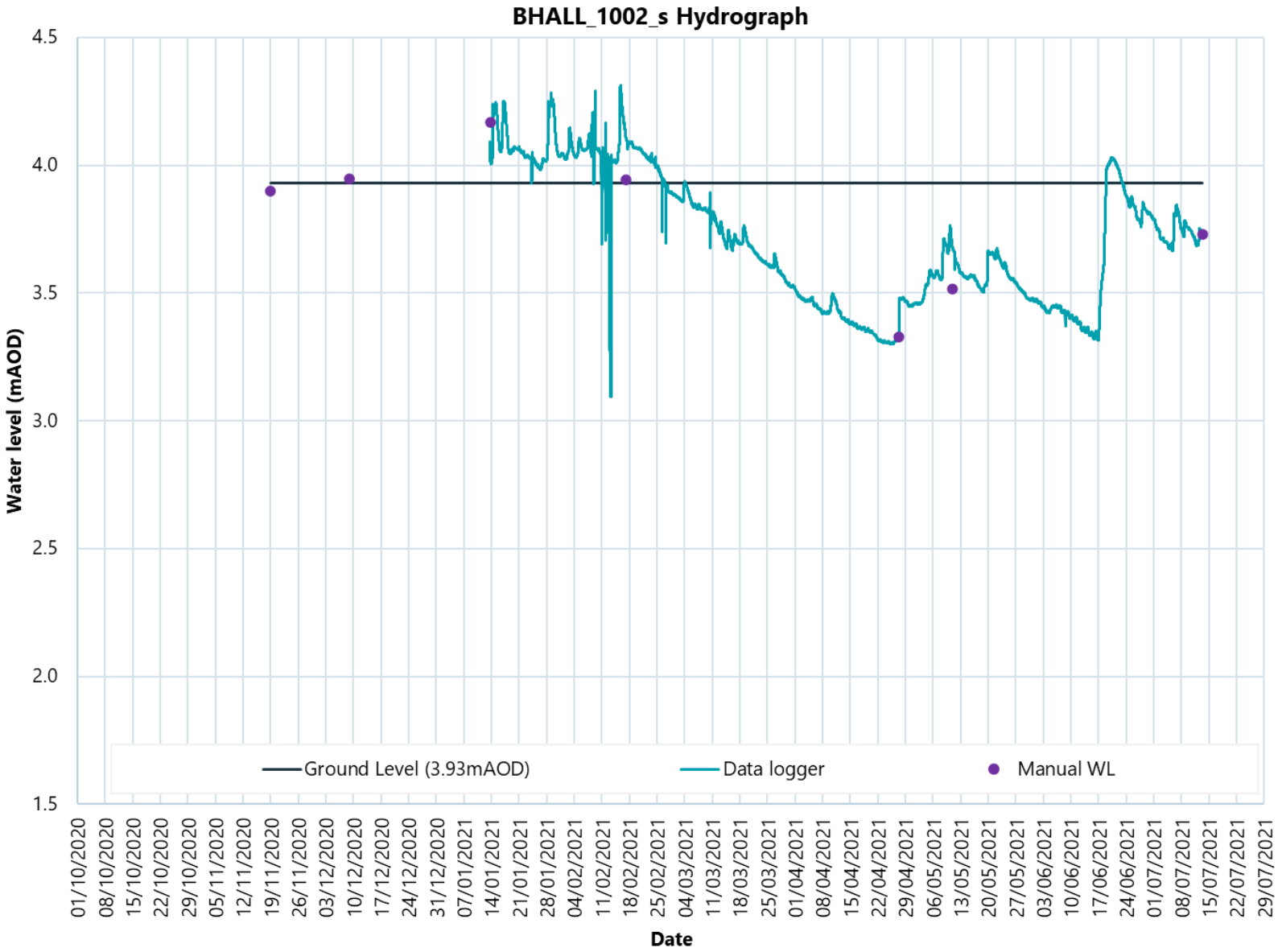

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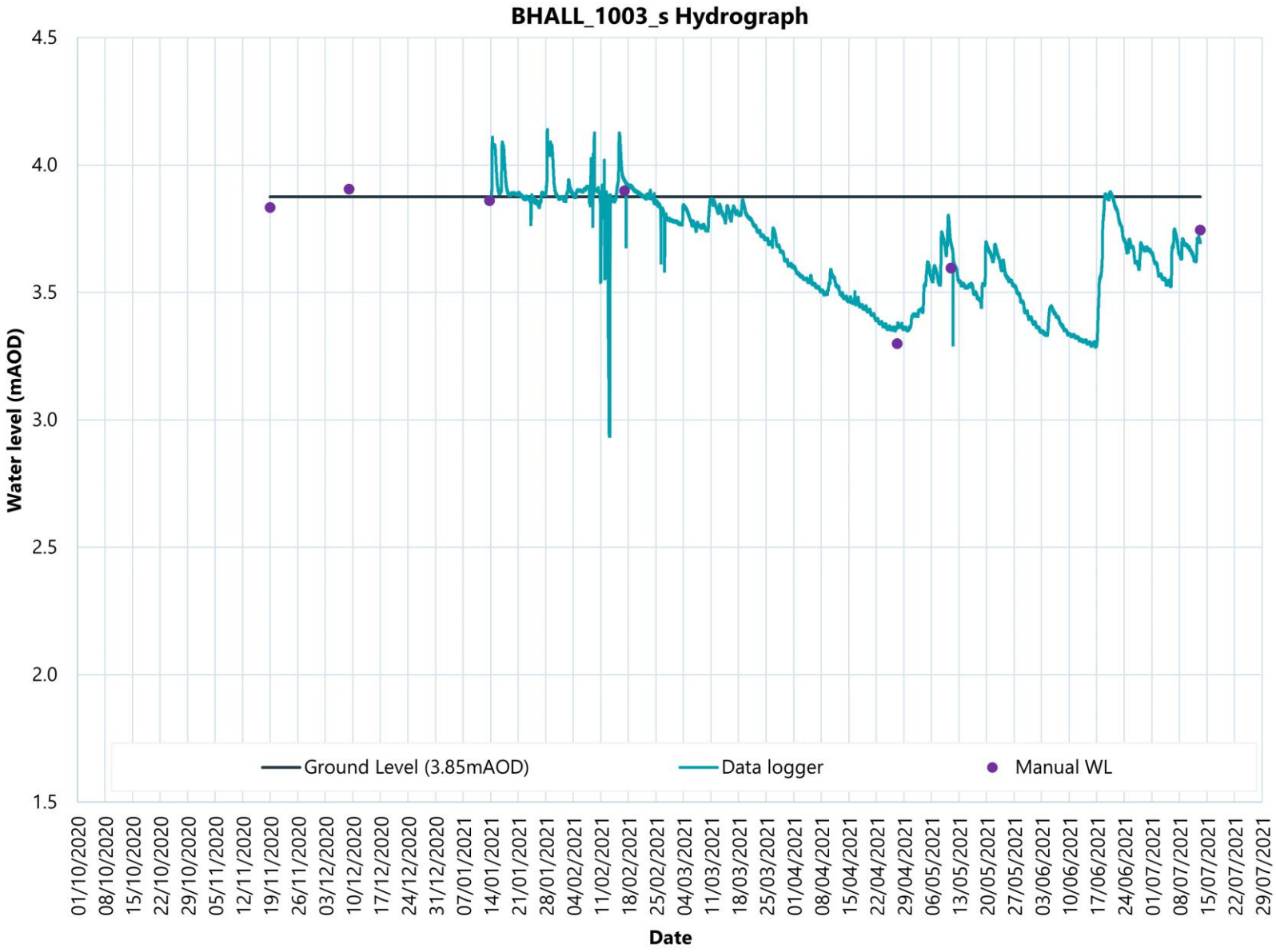

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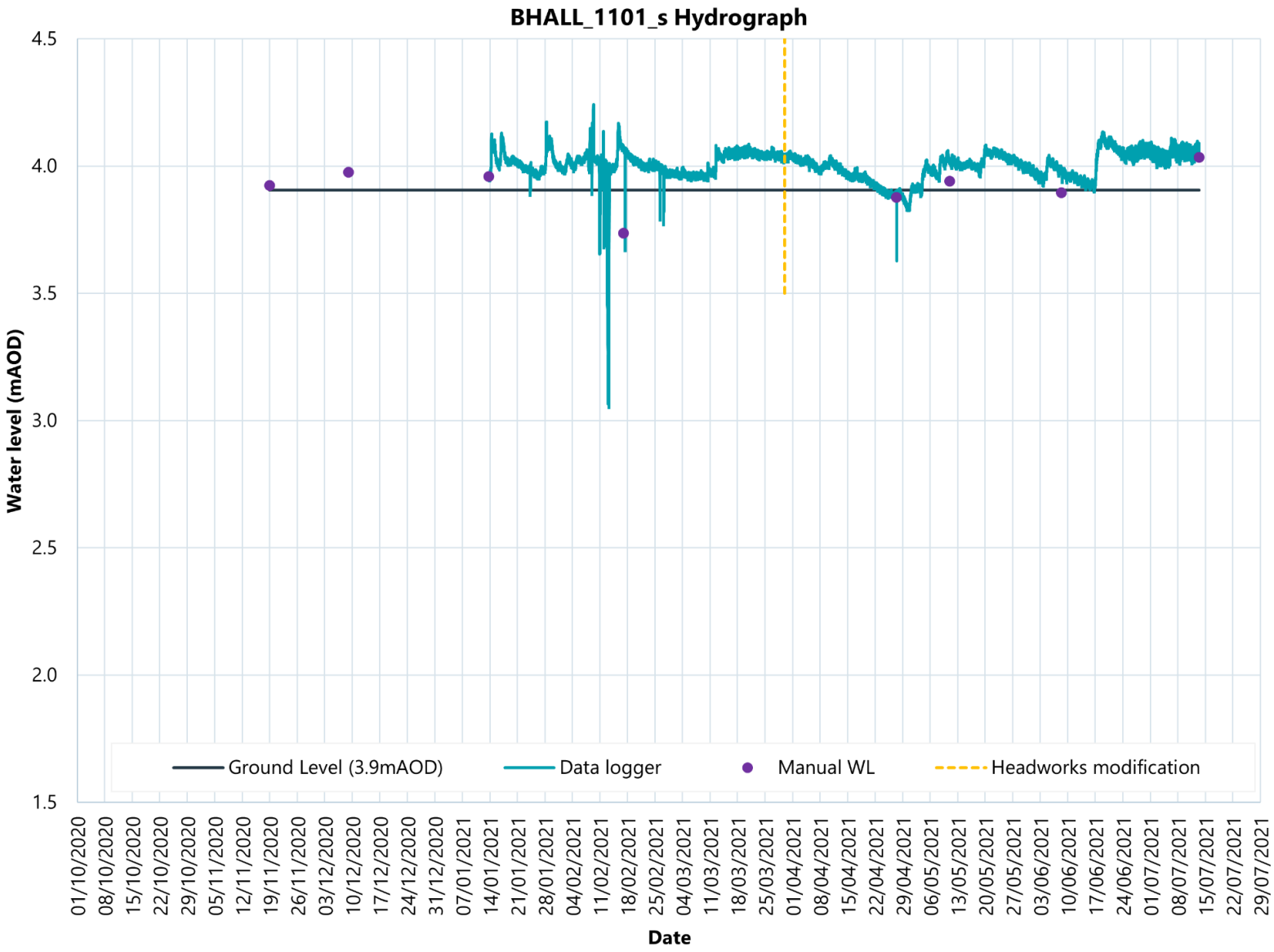
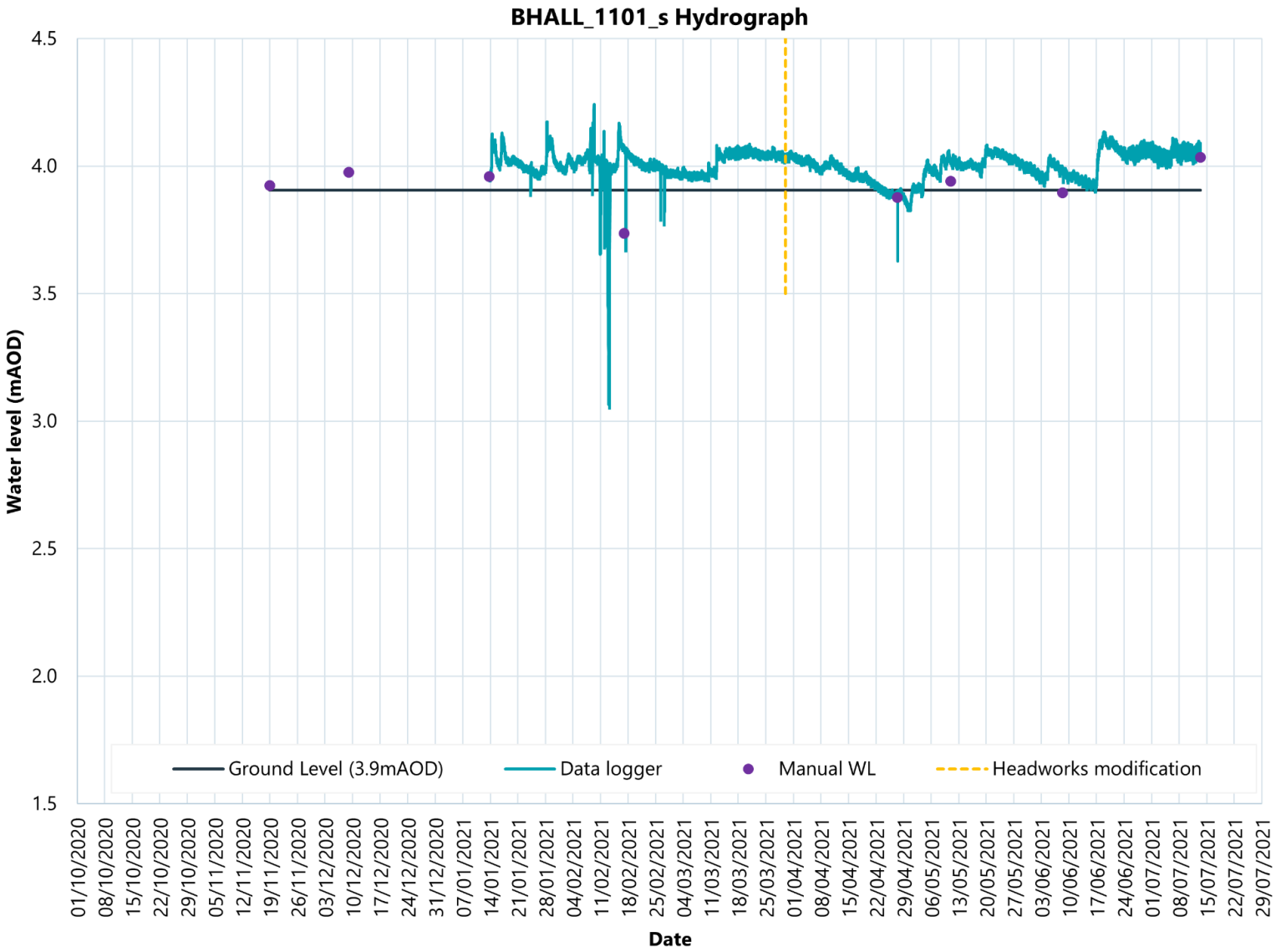


B6



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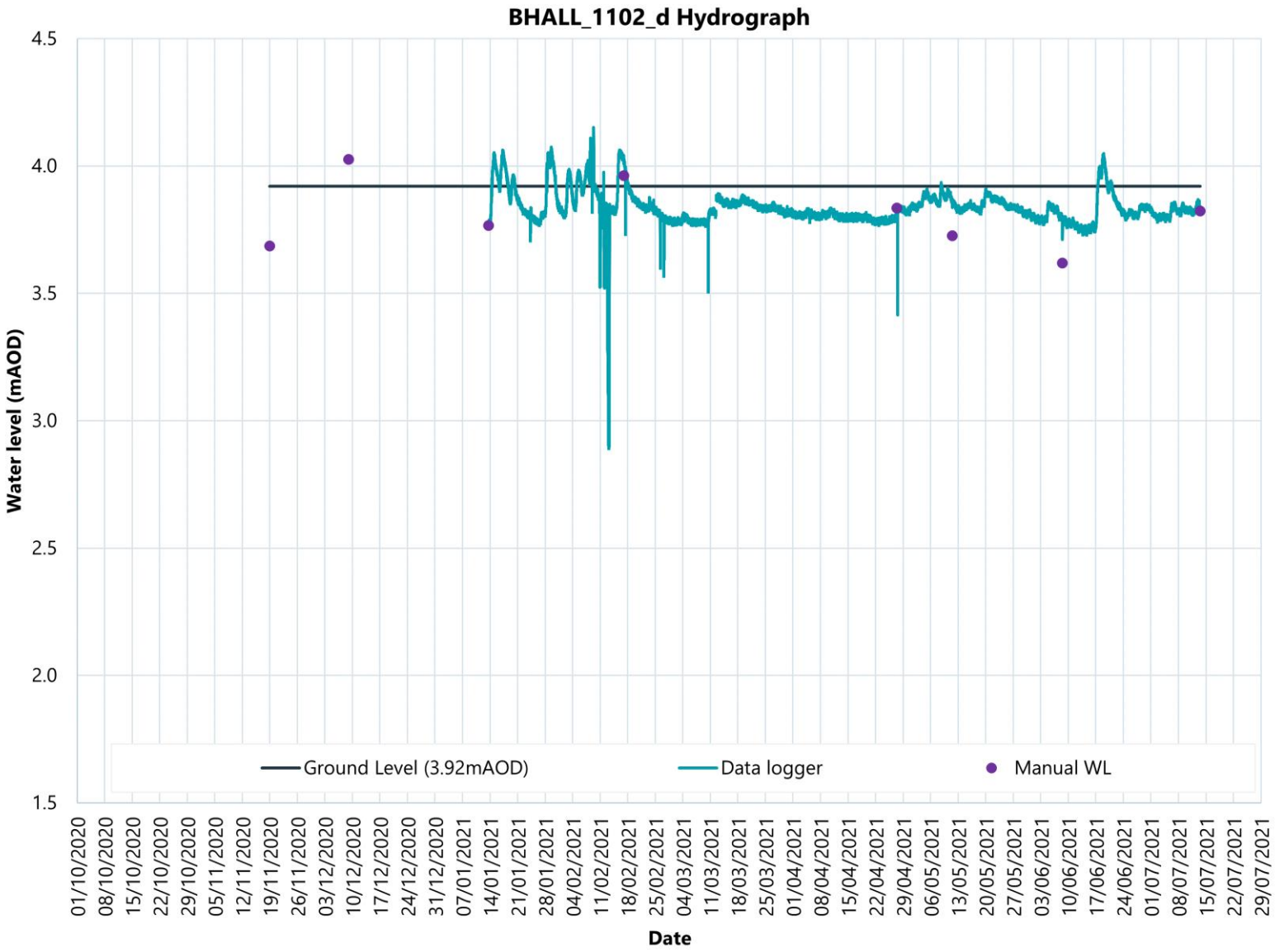
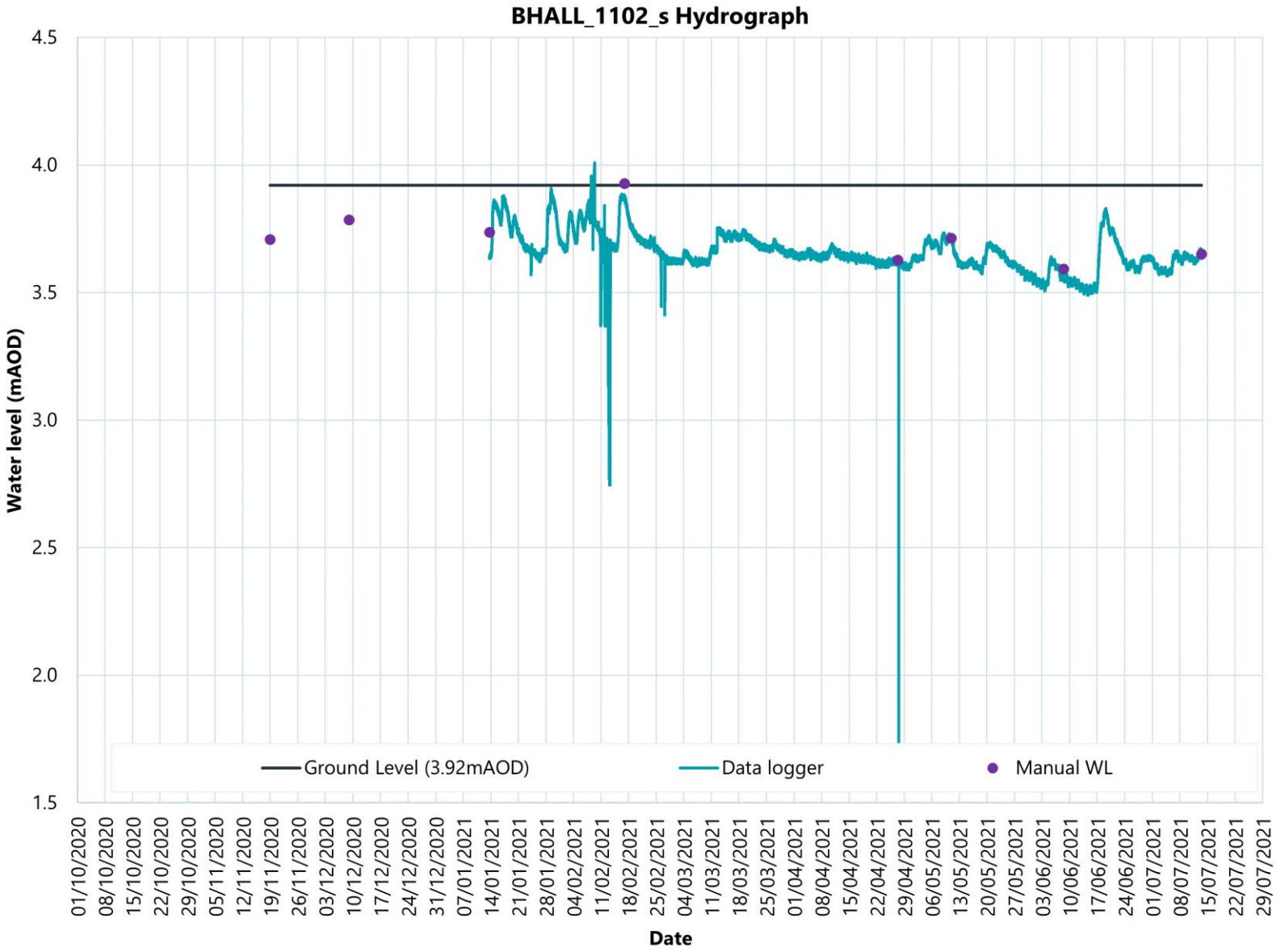
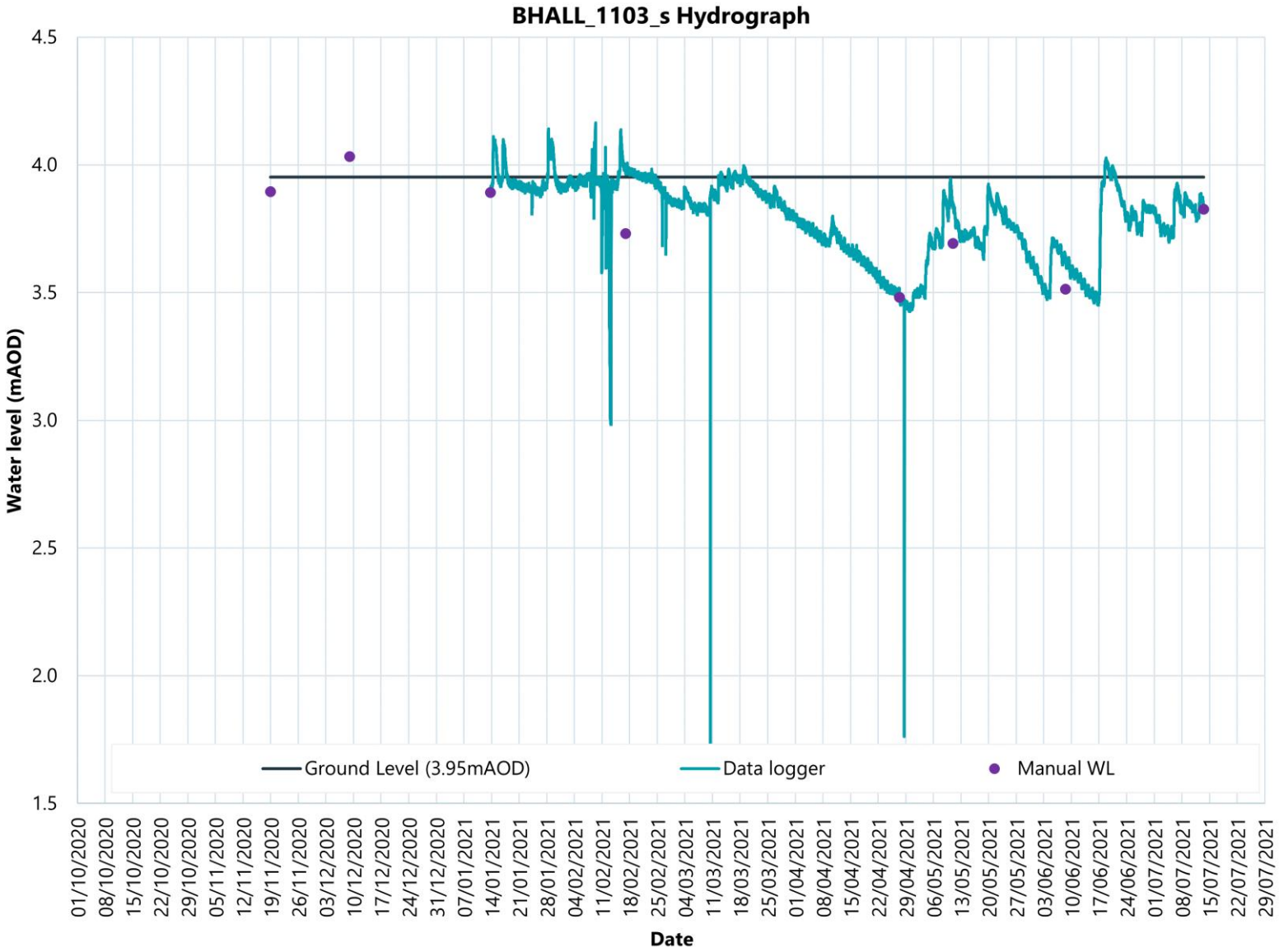


B8



B9



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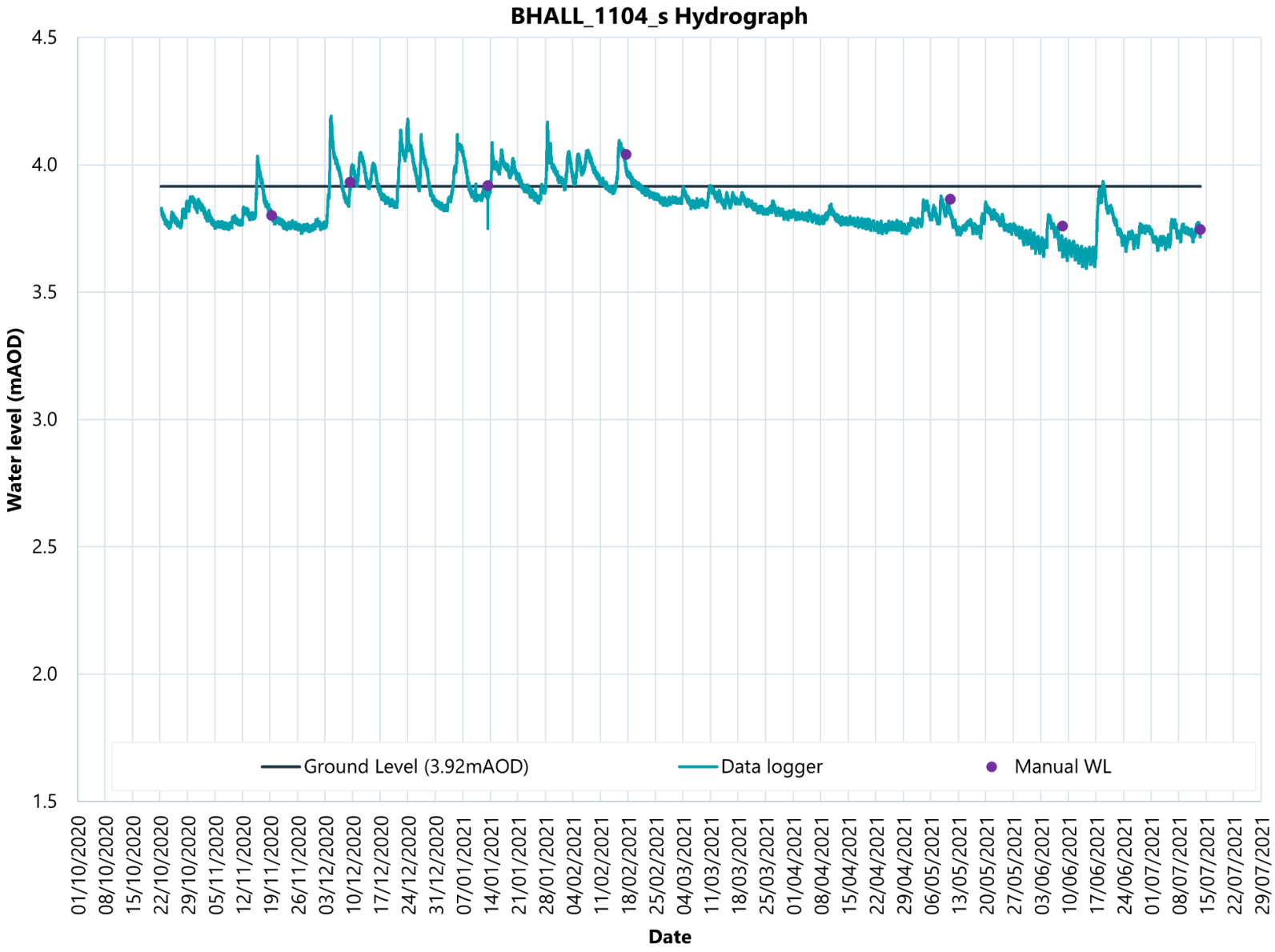

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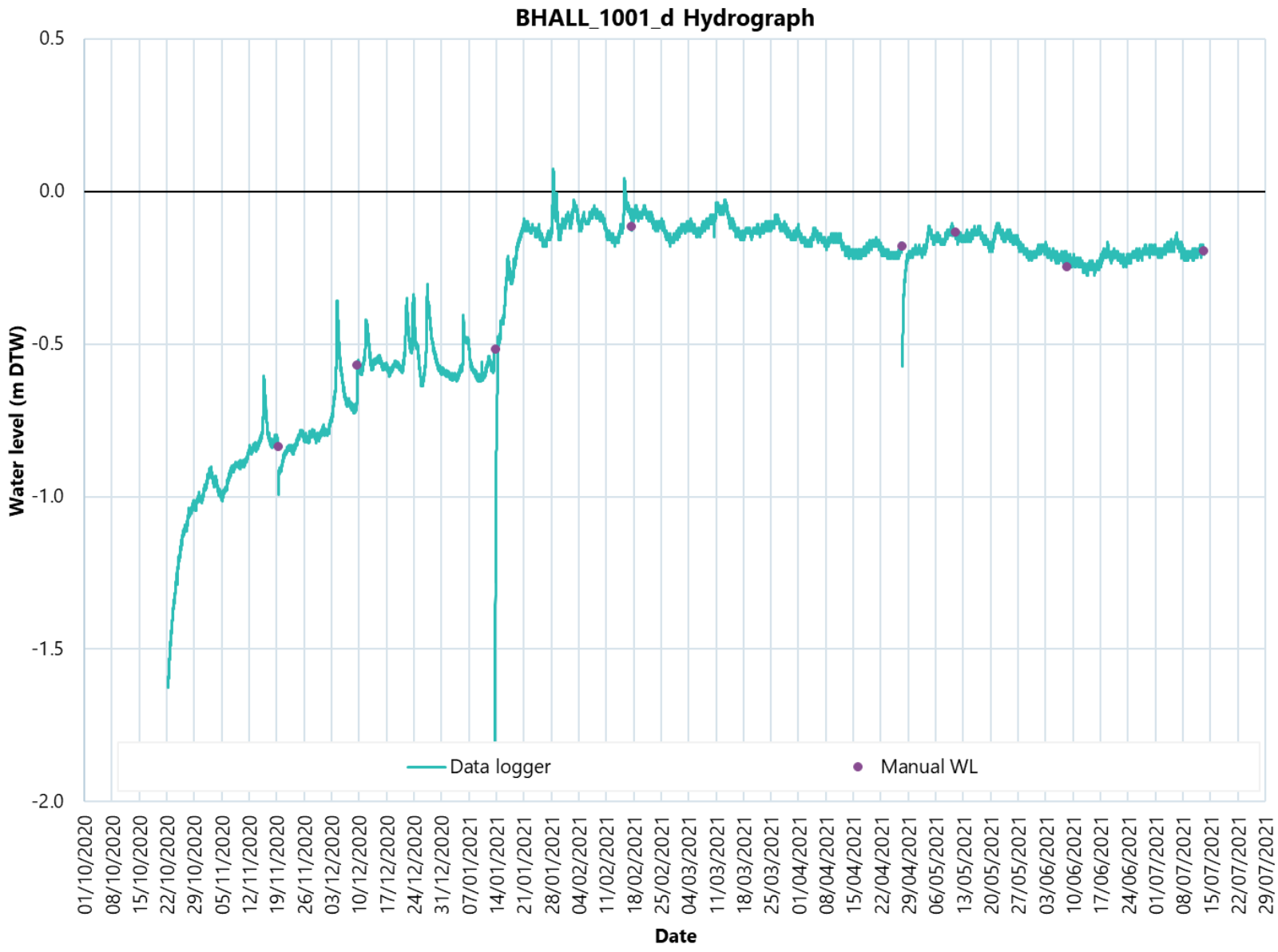

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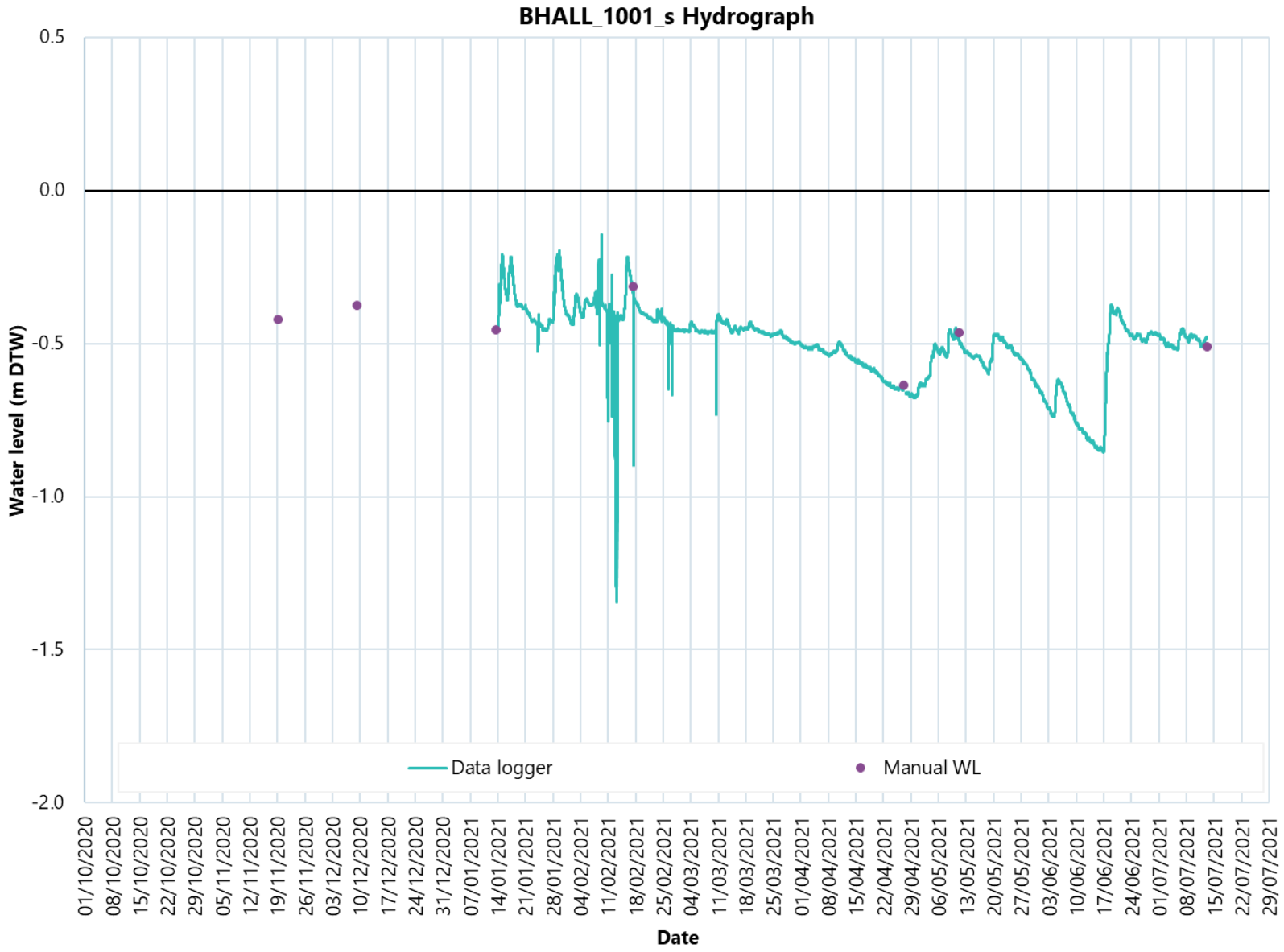
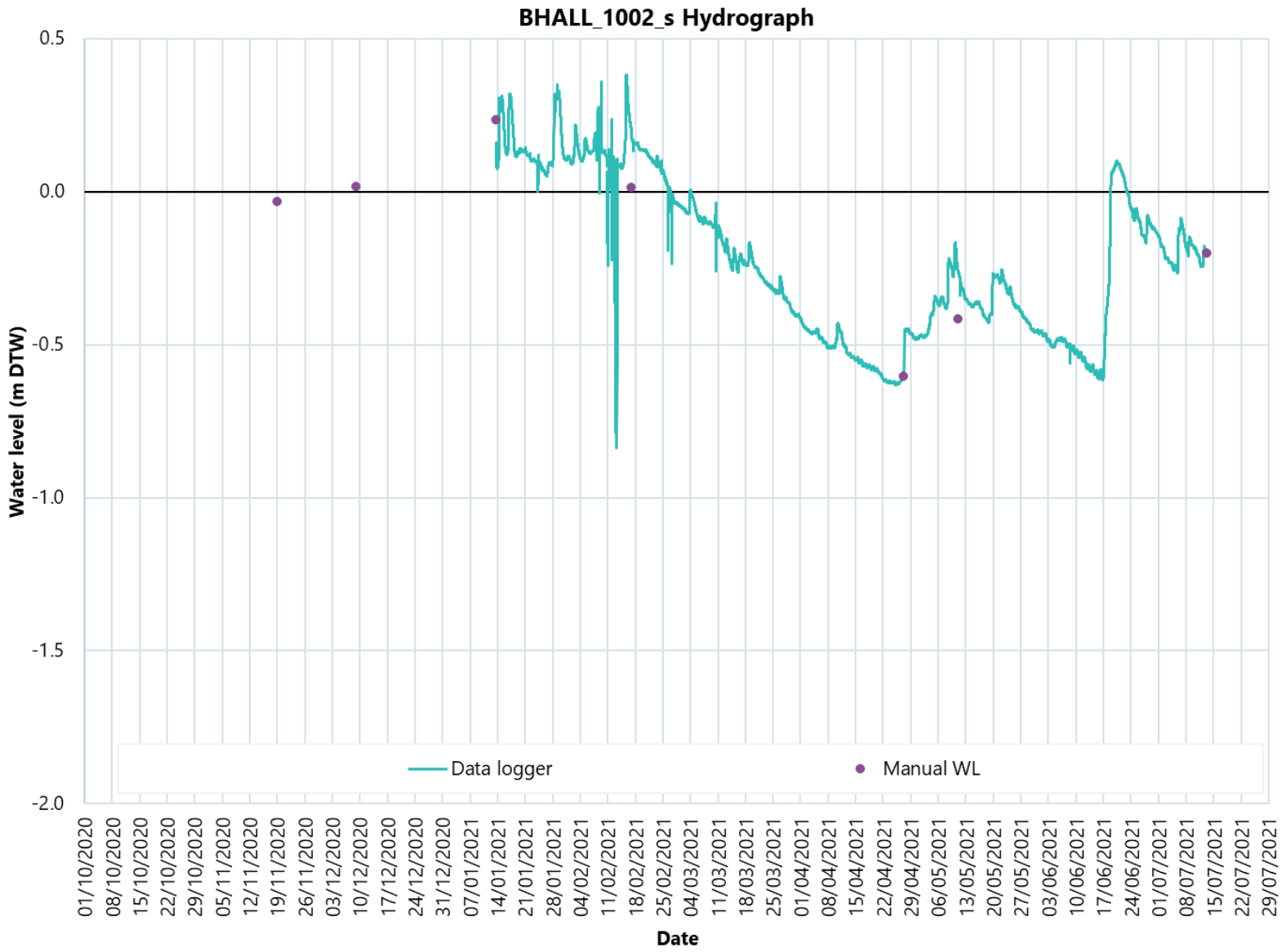
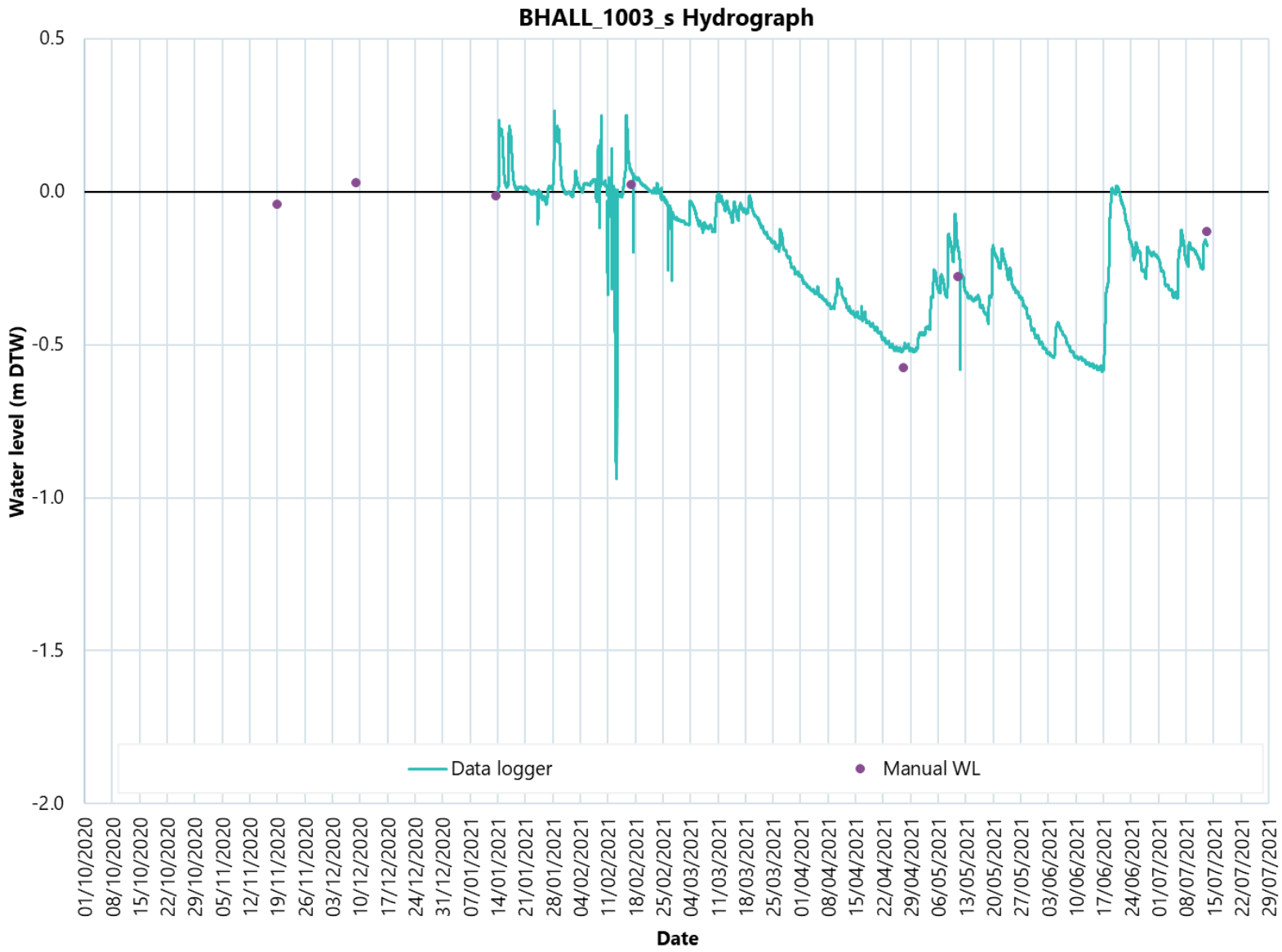


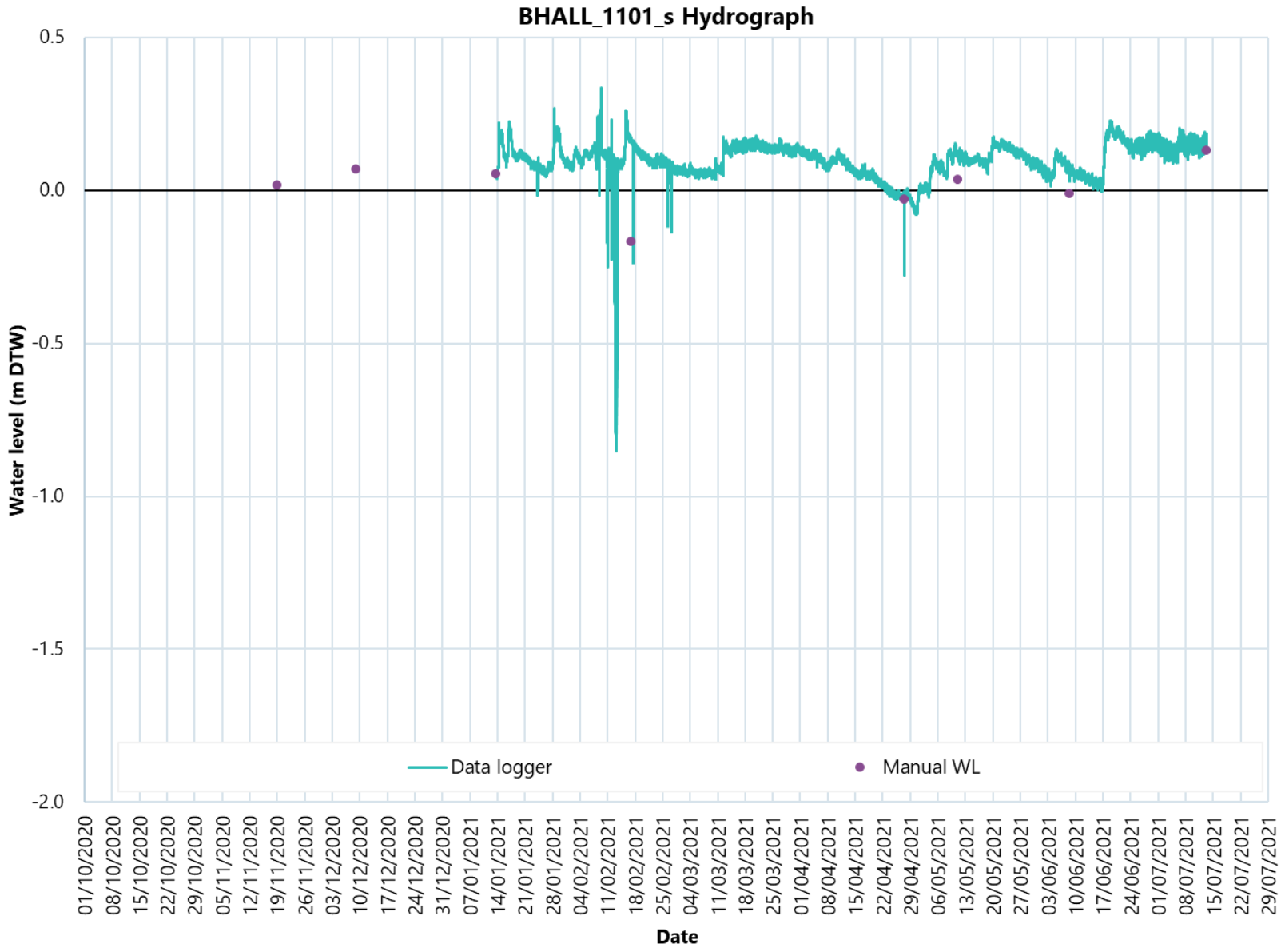
B13



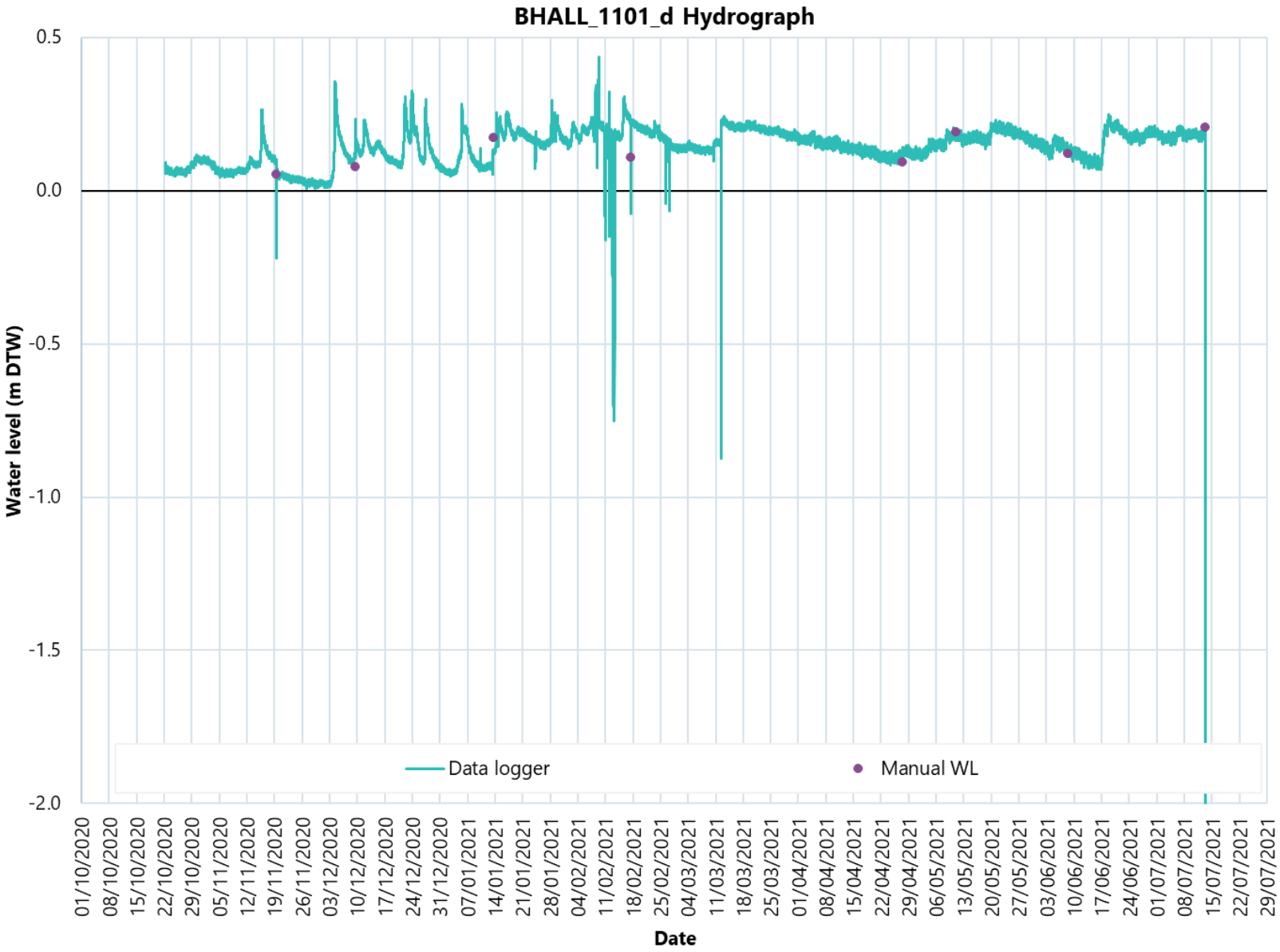
B14



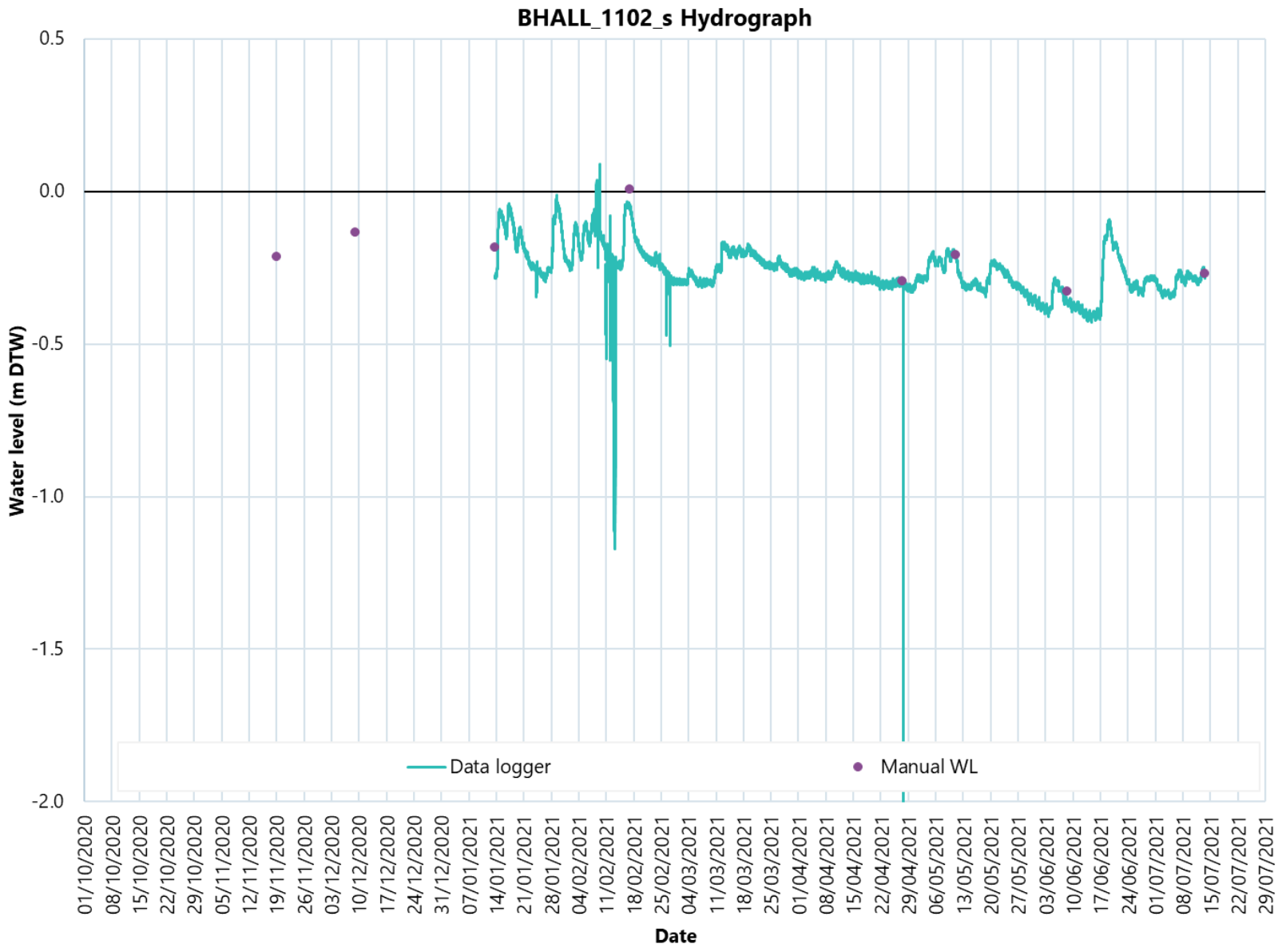
B15



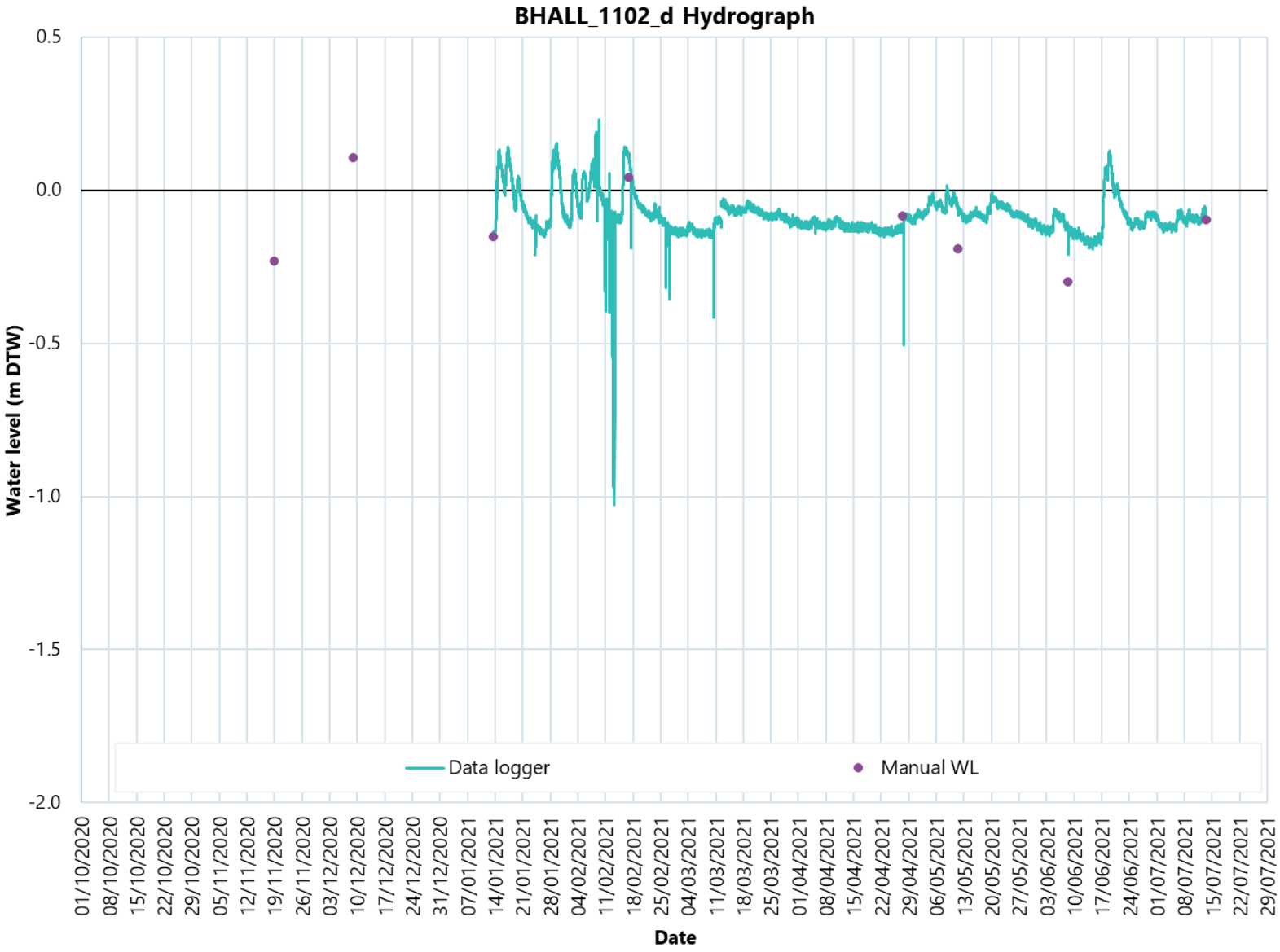
B16



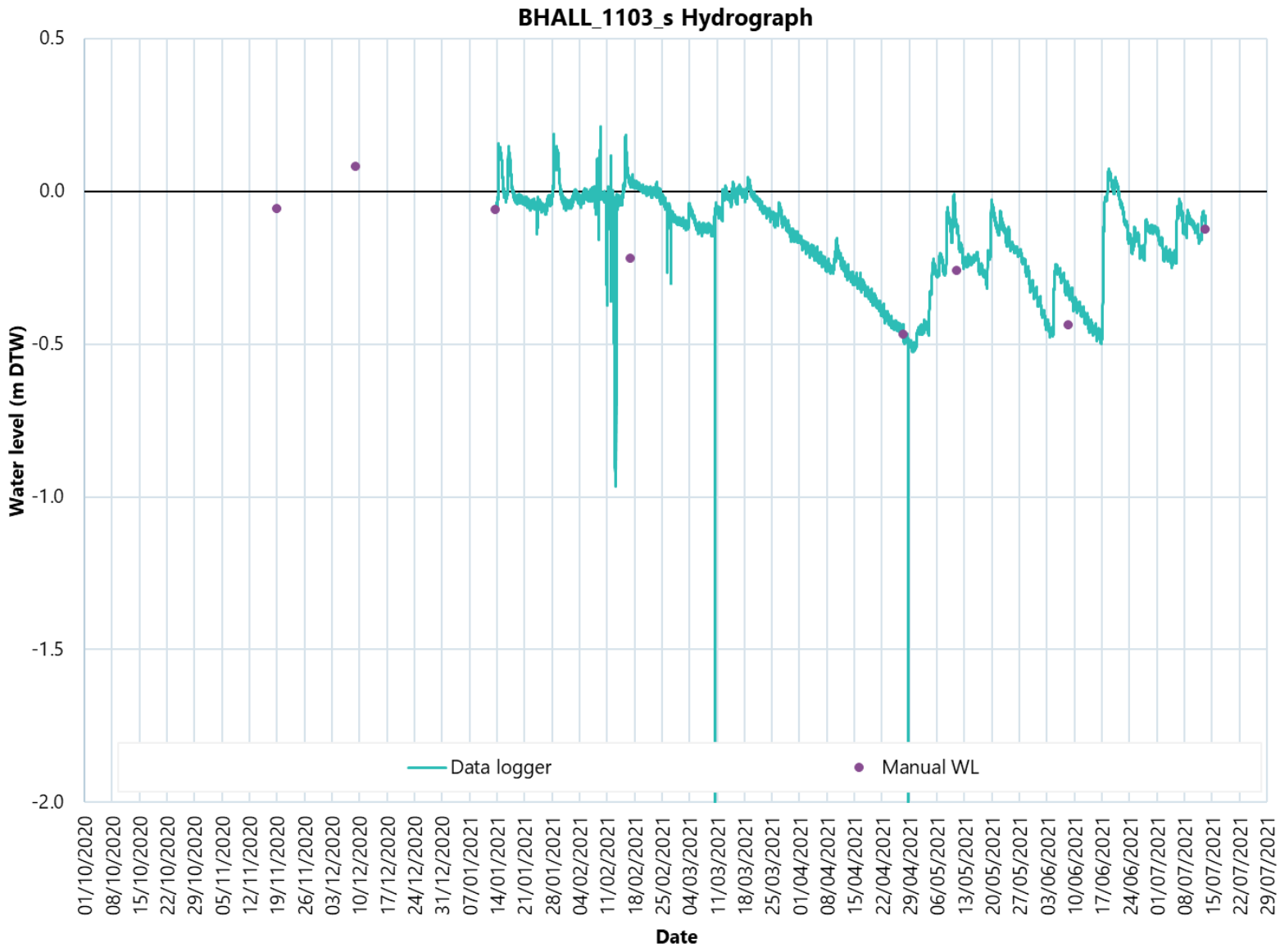
B17



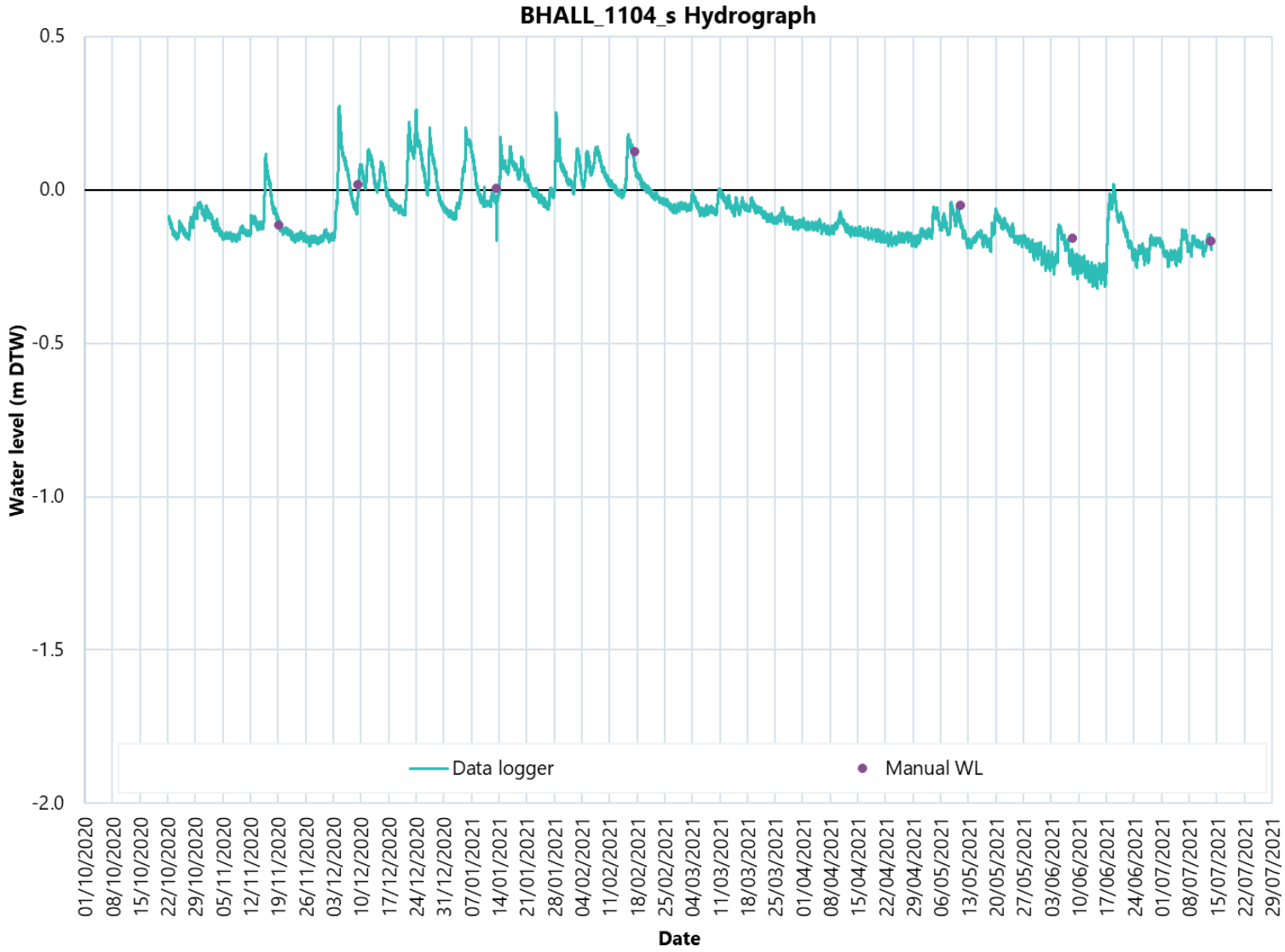
B18



B19

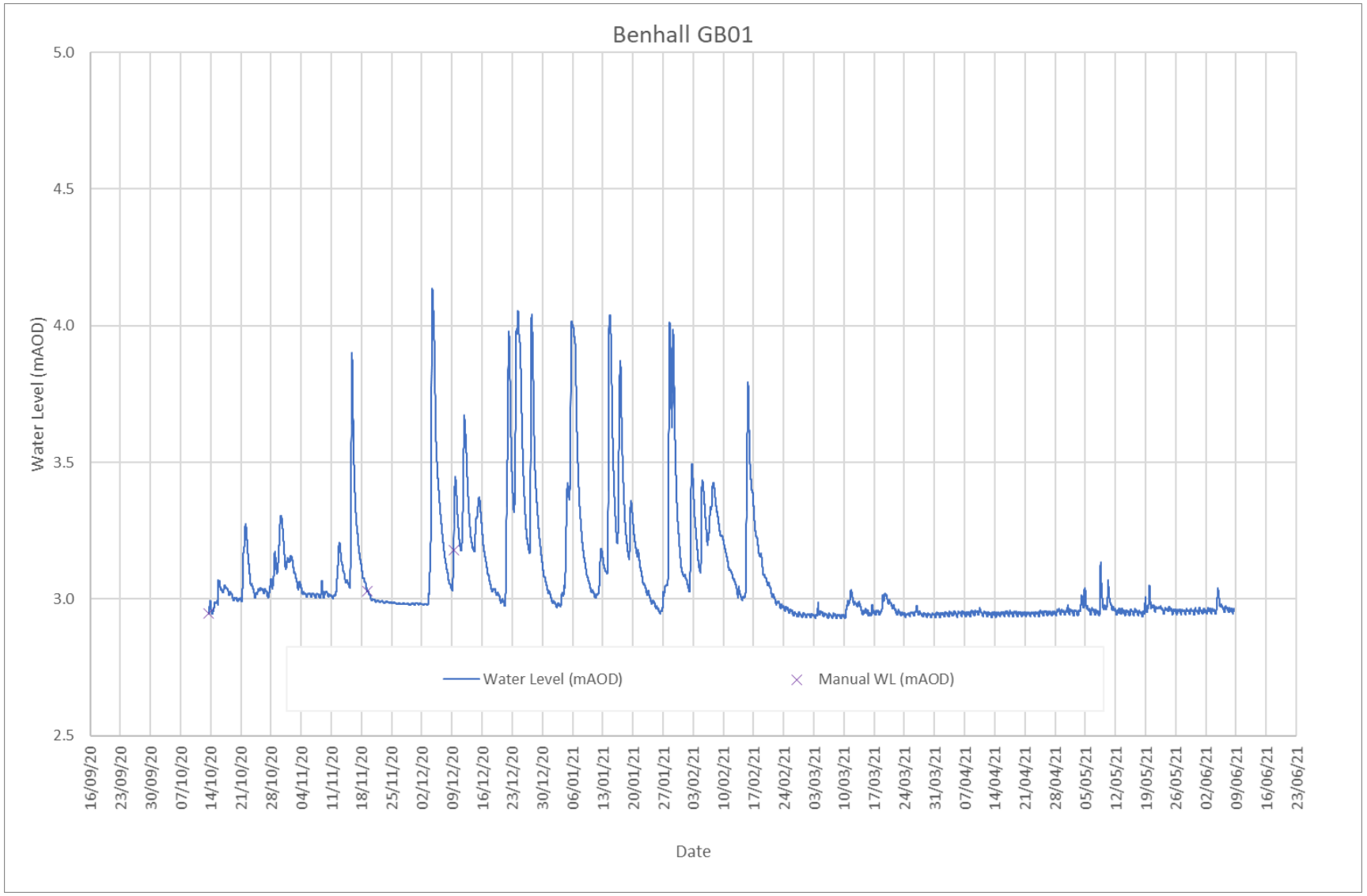


B20



Appendix C
Individual Surface Water Hydrographs

C1



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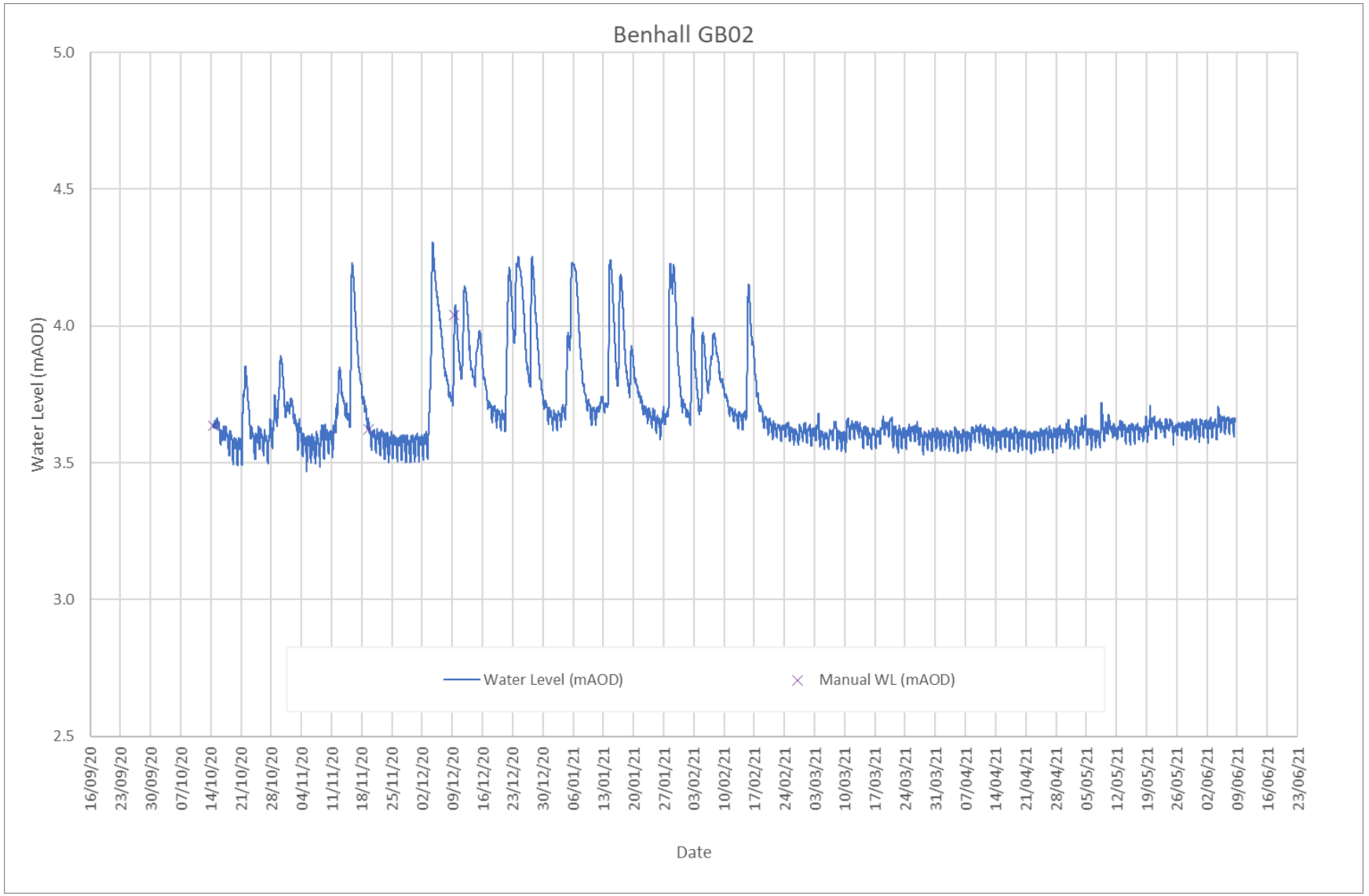

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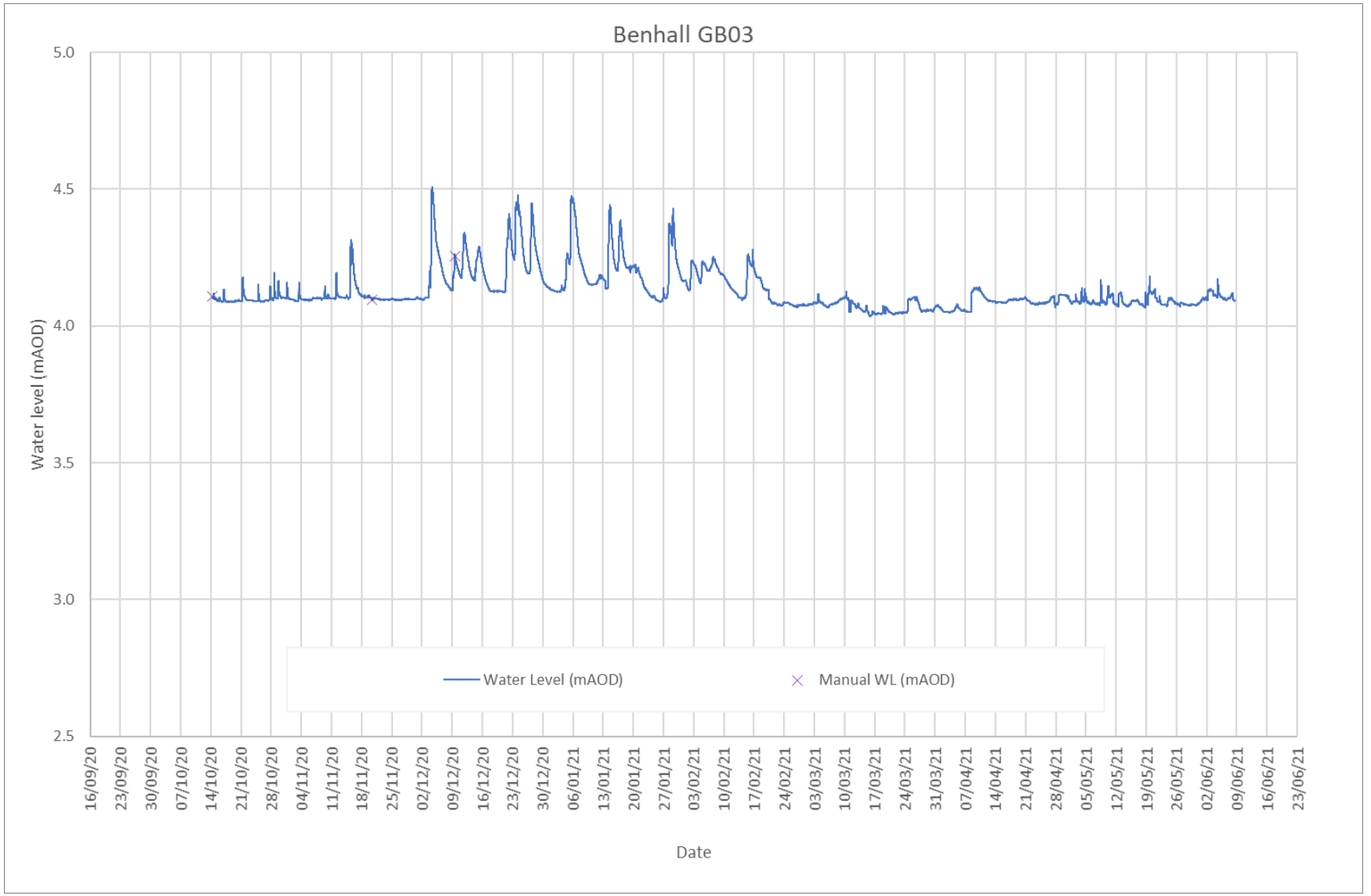

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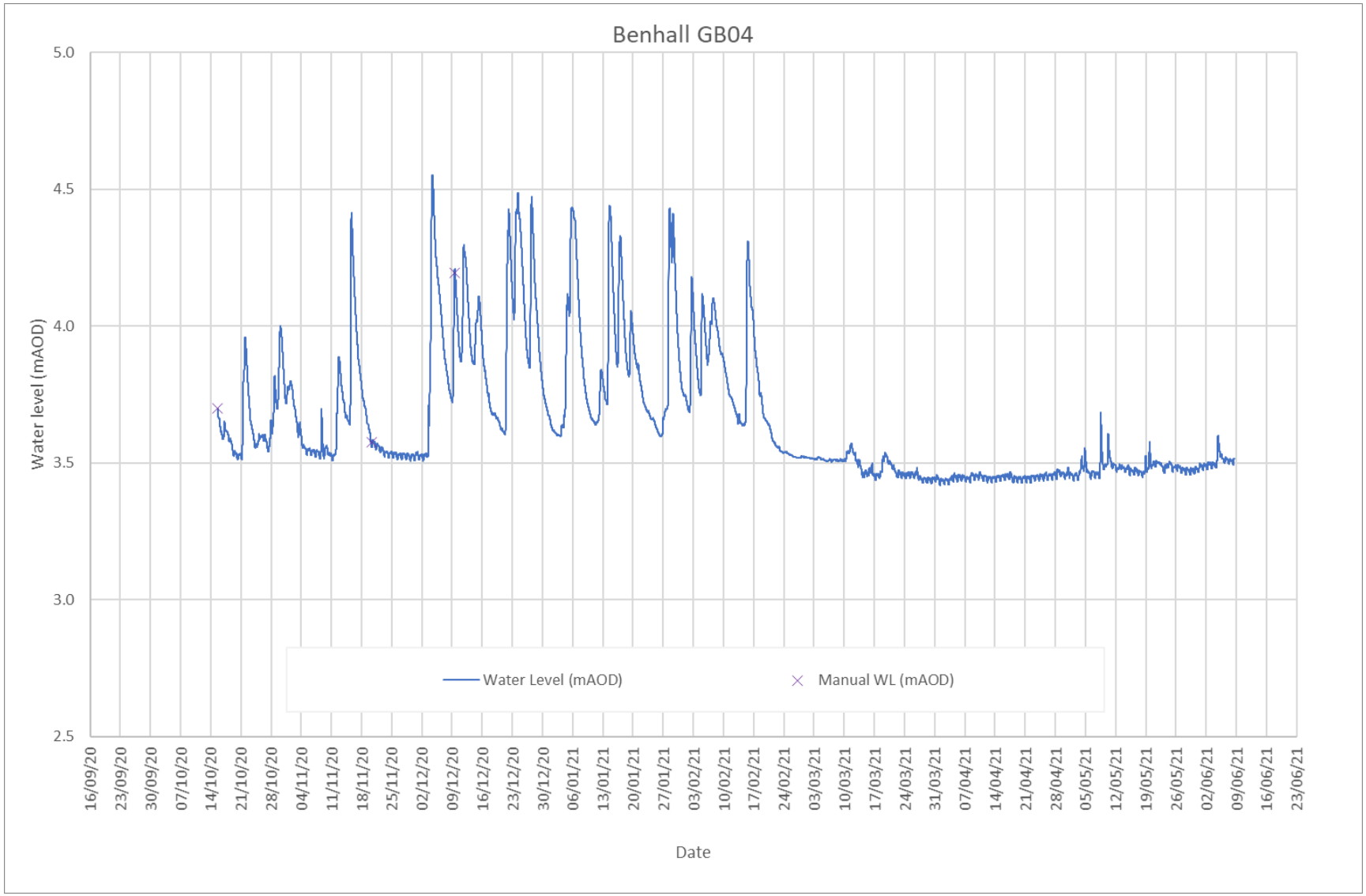
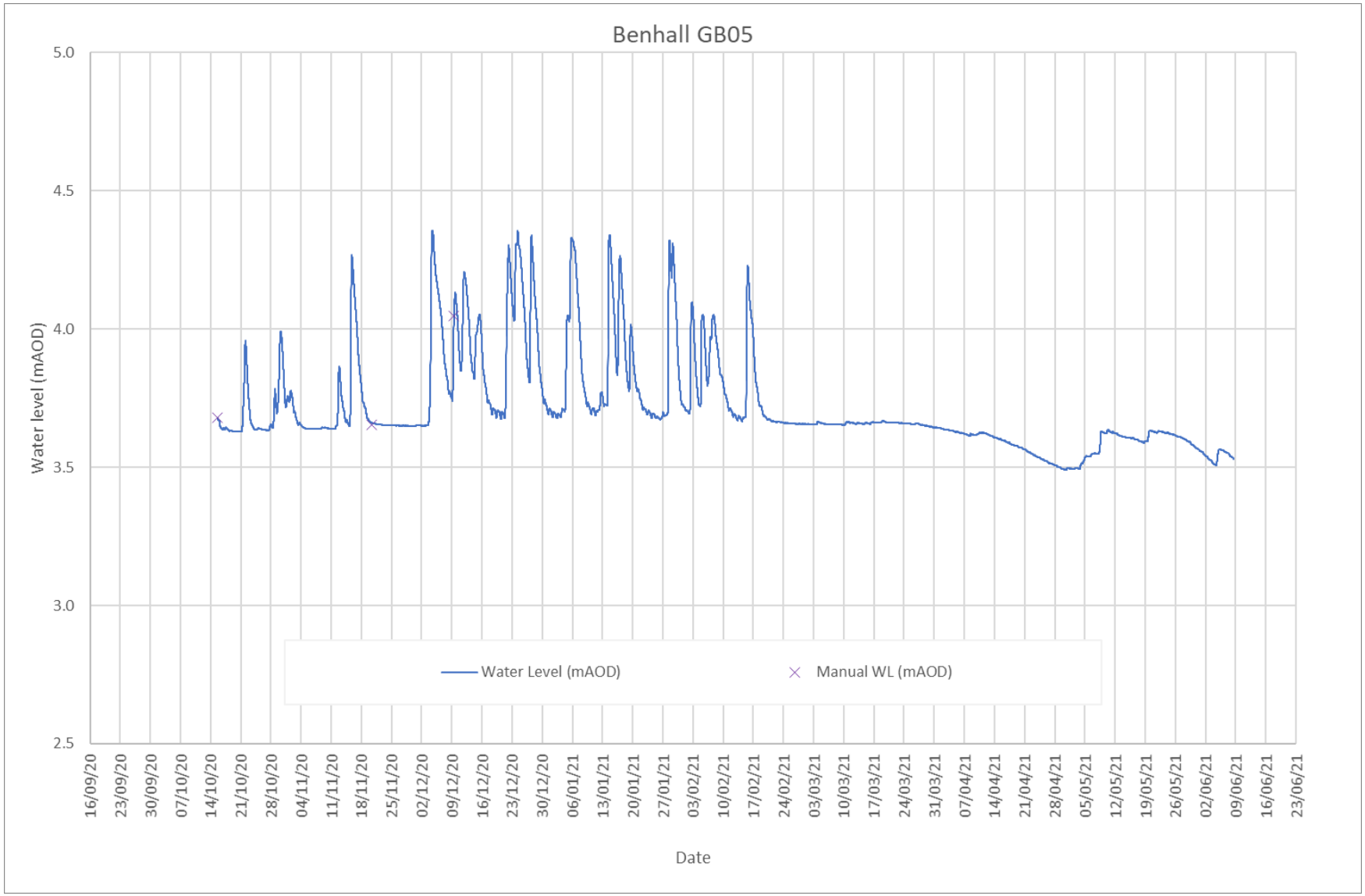
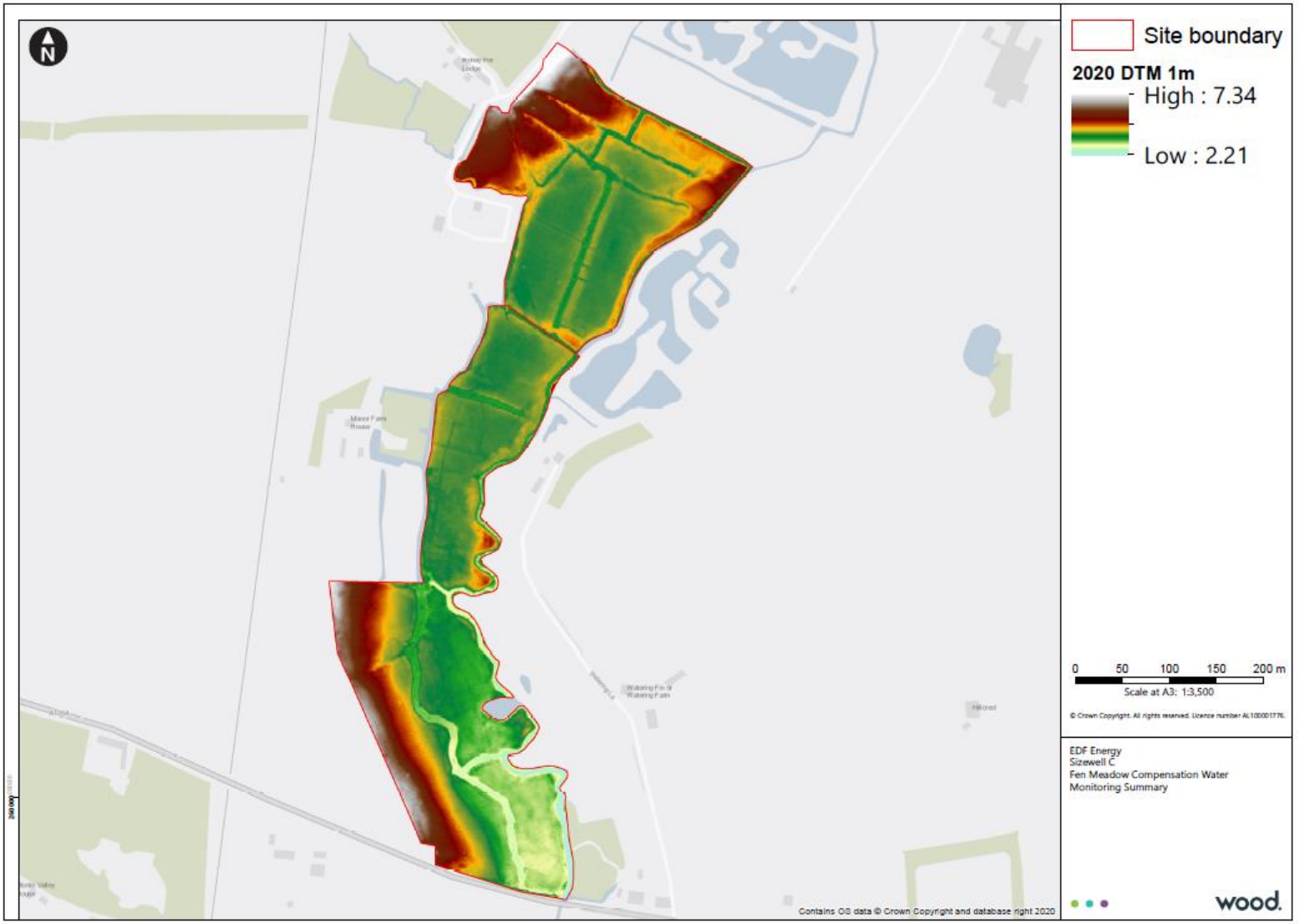


C5

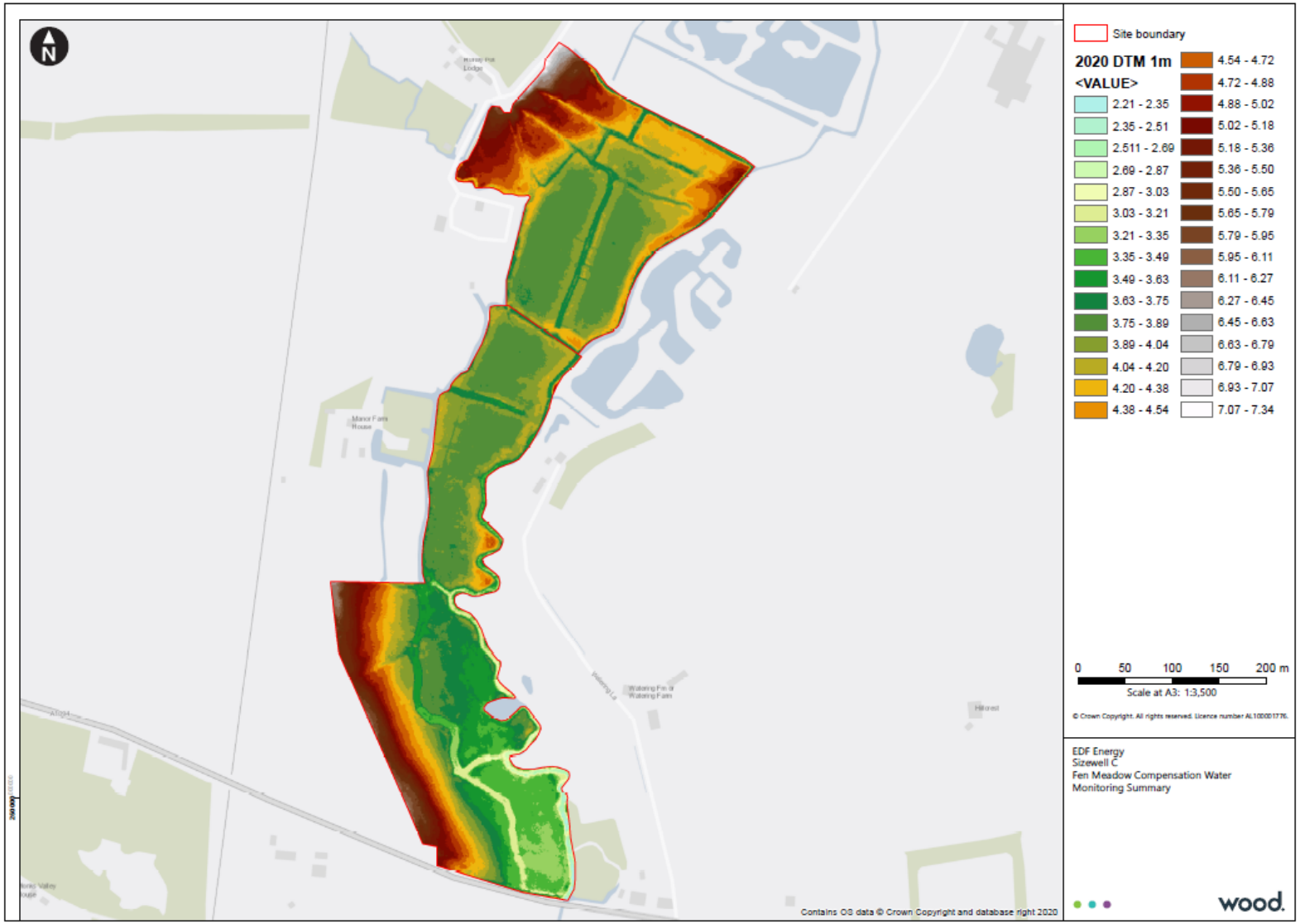


Appendix D
LIDAR Plots for the Site

D1



D2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2020 DTM 1m
<VALUE>
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2.35 - 2.51
2.511 - 2.69
2.69 - 2.87
2.87 - 3.03
3.03 - 3.21
3.21 - 3.35
3.35 - 3.49
3.49 - 3.63
3.63 - 3.75
3.75 - 3.89
3.89 - 4.04
4.04 - 4.20
4.20 - 4.38
4.38 - 4.54
4.54 - 4.72
4.72 - 4.88
4.88 - 5.02
5.02 - 5.18
5.18 - 5.36
5.36 - 5.50
5.50 - 5.65
5.65 - 5.79
5.79 - 5.95
5.95 - 6.11
6.11 - 6.27
6.27 - 6.45
6.45 - 6.63
6.63 - 6.79
6.79 - 6.93
6.93 - 7.07
7.07 - 7.34
0 50 100 150 200 m
Scale at A3: 1:3,500
EDF Energy
Sizewell C
Fen Meadow Compensation Water
Monitoring Summary
Contains OS data © Crown Copyright and database right 2020

APPENDIX B: WATER MONITORING SUMMARY – HALESWORTH SITE 28, NOVEMBER 2020 TO PRESENT (JULY 2021)

Technical note:
Sizewell C Fen Meadow Compensation
Water Monitoring Summary – Halesworth Site 28 November 2020 to July 2021

1. Introduction

The technical note summarises water monitoring data collected between November 2020 and July 2021 at the Halesworth site (hereafter referred to as 'the Site') which has been identified as a potential fen meadow development area. This technical note is predominantly a factual presentation of the data rather than an interpretive report.

Figure 1.1 shows a map of the Site and the installations referred to in this technical note.

2. Groundwater Level Monitoring

Seven groundwater monitoring points were installed at the Site between 5th and 23rd October 2020. Four shallow dipwells were installed to measure groundwater levels in the shallow superficial near surface deposits. Three piezometers were installed to measure groundwater levels in the Crag, one of which was originally planned to penetrate the underlying chalk but complications during drilling (collapse) resulted in completion of this installation near the base of the Crag deposits. Two of the Crag piezometers are nested (within the same borehole) with a dipwell. An installation summary is provided in Table 2.1 below.

Table 2.1 Summary of groundwater monitoring installations

Name	Drillers ID	NGR	Datum: Metal Cover (mAOD)	Ground Level (mAOD)	Depth (m bgl*)	Diameter (mm)	Notes
HAL_2801_d	bh2801	TM 38990 76600	7.254	6.689	10	50	Nested with HAL_2801_s
HAL_2801_s	WS2801	TM 38990 76600	7.254	6.869	40	50	Nested with HAL_2801_d
HAL_2802_d	bh2802	TM 39098 76604	6.886	6.653	10	50	Nested with HAL_2802_s
HAL_2802_s	WS2802	TM 39098 76604	6.886	6.653	10	50	Nested with HAL_2802_d
HAL_2803_d	bh2803	TM 38985 76600	7.142	6.881	40	50	
HAL_2803_s	ws2803	TM 39051 76659	7.312	7.05	3	50	

Name	Drillers ID	NGR	Datum: Metal Cover (mAOD)	Ground Level (mAOD)	Depth (m bgl*)	Diameter (mm)	Notes
HAL_2804_s	ws2804	TM 39143 76703	7.114	6.869	2	50	

s = shallow; d = deep
*m bgl = metres below ground level

Each installation is fitted with a water level datalogger which is being downloaded on a quarterly basis. Table 2.2 summarises the data collected manually between November 2020 to present (July 20201). Hydrographs, presenting both logger and manually collected data for the installations are provided in Appendix A (Combined Hydrograph Figures A1 to A3) and Appendix B (Individual Groundwater Hydrographs Figures B1-B10). Note that in Appendix B there are a combination of hydrographs providing both absolute water levels and depth to water table. Data from 2801 are not presented due to anomalous behaviour currently being investigated.

Table 2.2 Groundwater Levels (m bgl and mAOD)

Date	HAL_2801_d	HAL_2801_s	HAL_2802_d	HAL_2802_s	HAL_2803_d	HAL_2803_s	HAL_2804_s
m bgl							
20/11/20	-0.265	-0.063	0.202	0.319	0.226	0.421	0.381
10/12/20	-0.274	-0.094	0.096	0.169	0.12	0.468	0.233
14/01/21	0.28	-0.2	0.2	0.26	-0.2	0.42	0.66
18/02/21	-0.333	-0.214	0.012	0.117	-0.01	0.144	0.176
11/03/21	0.223	0.190	0.303	0.426	0.315	0.569	0.544
28/04/21	0.70	1.27	1.35	1.51	0.39	0.41	ND
12/05/21	0.66	1.22	1.41	1.564	0.458	0.748	0.655
09/06/21	0.452	0.889	1.533	1.675	0.642	1.044	0.837
14/07/21	0.71	1.345	1.3	1.6	0.38	0.73	0.8
mAOD							
20/11/20	6.954	6.932	6.451	6.334	6.655	6.448	6.669
10/12/20	6.963	6.963	6.557	6.484	6.761	6.401	6.817
14/01/21	6.974	7.454	6.686	6.626	7.342	6.694	6.652
18/02/21	7.022	7.083	6.641	6.536	6.891	6.725	6.874

Date	HAL_2801_d	HAL_2801_s	HAL_2802_d	HAL_2802_s	HAL_2803_d	HAL_2803_s	HAL_2804_s
11/03/21	7.031	7.064	6.583	6.460	6.827	6.743	6.570
28/04/21	6.554	6.684	6.456	6.176	6.752	6.704	ND
14/05/21	6.594	6.034	5.476	5.322	7.52	6.564	6.459
09/06/21	6.802	6.365	6.273	6.131	7.336	6.268	6.277
14/07/21	6.373	6.497	6.363	6.081	7.463	6.387	6.217

*m AOD = metres above ordnance datum

3. Surface Water Level Monitoring

Four gaugeboards were installed between 12th and 16th October 2020 to allow monitoring of surface water levels in site watercourses / drains. Three of the gaugeboards included stilling wells and water level data loggers. An installation summary is given in Table 3.1 below.

Table 3.1 Summary of gaugeboard installations

Ref.	GPS Grid Ref.	Bottom of Gaugeboard Datum (mAOD*)	Gaugeboard Length (m)	Datalogger	Log Interval (minutes)
HAL-GB01	TM 39161 76703	5.81	1	OTT Orpheus Mini	15
HAL-GB02	TM 39185 76674	5.43	1	OTT Orpheus Mini	15
HAL-GB03	TM 39132 76581	5.37	2	OTT Orpheus Mini	15
HAL-GB04	TM 39080 76655	6.00	1	n/a	n/a

*mAOD = metres above ordnance datum

Table 3.1 summarises the gaugeboard water level readings taken between November 2020 and present. The water level at the three gaugeboard locations are continuously monitored and are downloaded on a monthly basis during spot gauging visit. Hydrographs of surface water levels are presented in Appendix C, and in combination with groundwater hydrographs in Appendix A (data are currently available to mid June 2021).

Table 3.2 Surface Water Levels (mAOD)

Date	HAL-GB01	HAL-GB02	HAL-GB03	HAL-GB04*
20/11/20	6.412	5.972	5.672	6.416
10/12/20	6.446	6.011	5.842	6.445
14/01/21	6.471	6.059	6.160	6.480

Date	HAL-GB01	HAL-GB02	HAL-GB03	HAL-GB04*
18/02/21	6.451	6.019	5.831	6.450
11/03/21	6.442	6.01	5.768	6.441
09/04/21	6.34	5.995	5.645	6.335
12/05/21	6.336	5.985	5.632	6.325
09/06/21	6.255	5.97	5.632	6.25

*Manual reading only (no datalogger).

4. Spot Flow Gauging

Monthly spot flow gauging of three gaugeboard locations (HAL-SF01, 02 & 03) commenced in November 2020. Results to date are shown in Table 4.1 below. Negative flow readings in Table 4.1 indicate static conditions where flow is not sufficiently high to be measurable.

Table 4.1 Spot Flow (m^3/s)

Date	HAL-SF01	HAL-SF02*	HAL-SF03
20/11/20	-0.0008	Channel too deep to wade with very soft bed. Water appeared Static.	0.0006
10/12/20	-0.0001	Channel too deep to wade with very soft bed. Water appeared Static.	-0.0016
14/01/21	0.0015	No suitable gauging location. Channel too deep to wade with very soft bed along entire length. Water appeared static with no obvious inflow/outflow.	Too deep to gauge after prolonged period of rain and severe local flooding.
18/02/21	0.0008	0.63463	0.0013
11/03/21	0.0002	0.0008	0.0013
09/04/21	-0.0006	0.0001	0.0002
12/05/21	0.0008	0.0001	0.0009
9/06/21	-0.0004	0.0	0.0005

5. Water Quality Monitoring

In-situ water quality readings are collected from all groundwater and surface water installations on a monthly basis. In-situ water quality results are presented in Table 5.1 below.

In addition to this, water quality samples have been collected quarterly at selected locations and sent for laboratory analysis. Quarterly sampling was undertaken in January 2021 (for groundwaters only) and April 2021 (both groundwater and surface water), with samples (both groundwater and surface water) collected in July 2021 being analysed. Available results for key water quality parameters indicative of nutrient enrichment, and its source (nitrate, phosphate and chloride), are presented in Table 5.2.

Table 5.1 In-situ Water Quality Results

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
20/11/20	HAL_2801_d	11.0	2.5	5969	12.63	-201.1	11.06
10/12/20	HAL_2801_d	8.5	38.7	387	12.22	-117.8	46.8
14/01/21	HAL_2801_d	6.7	22.5	1058	7.09	158.8	79.5
17/02/21	HAL_2801_d	7.6	21.7	1496	11.91	-160.5	25.2
11/03/21	HAL_2801_d	7.8	12	1169	11.59	172.3	16.98
28/04/21	HAL_2801_d	10.2	20.7	1258	11.13	-58.9	>1050
12/05/21	HAL_2801_d	20.0	31.1	597	11.08	-81.3	3.41
14/07/21	HAL_2801_d	14.9	199	465.3	10.88	-36.8	10.8
20/11/20	HAL_2801_s	10.5	4.9	16804	12.61	-169.5	5.6
10/12/20	HAL_2801_s	9.0	24.4	15101	12.32	-138.5	3.5
14/01/21	HAL_2801_s	6.3	21.8	1046	8.54	146.7	102.5
17/02/21	HAL_2801_s	7.5	36.9	1439	11.88	-119.9	6
11/03/21	HAL_2801_s	7.5	20.2	1437	11.59	172.7	1.8
28/04/21	HAL_2801_s	10.9	24.7	653	10.96	-37.5	26.1
12/05/21	HAL_2801_s	12.7	27.9	802	10.34	-58.4	4.52
14/07/21	HAL_2801_s	14.4	200.4	1183	9.29	-36.8	>1050
20/11/20	HAL_2802_d	10.7	10.8	1022	7.04	54.7	30.1
10/12/20	HAL_2802_d	9.0	22.5	1024	6.98	20.6	31.9
14/01/21	HAL_2802_d	6.2	12.6	1078	8.11	141.3	81.2
17/02/21	HAL_2802_d	8.0	36	1057	7.01	-1.5	3
11/03/21	HAL_2802_d	8.7	27.5	1061	7.09	30	60.28

Date	Ref.	Temp (ºC)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
28/04/21	HAL_2802_d	10.1	62	901	7.08	-23.3	95.8
12/05/21	HAL_2802_d	n/a	n/a	n/a	n/a	n/a	n/a
14/07/21	HAL_2802_d	12.6	234	1012	6.82	-18.6	26.7
14/07/21	HAL_2802_s	12.6	234	1012	6.82	-18.6	26.7
20/11/20	HAL_2802_s	10.6	11	1097	7.16	21.7	19.53
10/12/20	HAL_2802_s	8.4	36.2	979	6.91	9.3	27.2
14/01/21	HAL_2802_s	6.1	11.7	1025	7.05	139.3	>1050
17/02/21	HAL_2802_s	7.8	20.9	1128	6.92	-58.8	445
11/03/21	HAL_2802_s	8.1	19	988	6.79	29.4	108.5
28/04/21	HAL_2802_s	9.7	28.3	997	6.81	-33.3	365
12/05/21	HAL_2802_s	10.4	21.3	1043	7.14	-19	16.04
14/07/21	HAL_2802_s	12.0	147	957	6.44	-16.9	>1050
20/11/20	HAL_2803_d	10.8	5.6	1165	7.65	2.5	4.2
10/12/20	HAL_2803_d	8.2	30.1	1117	6.98	34.9	17.5
14/01/21	HAL_2803_d	6.1	35.1	2153	12.2	131.1	65.4
17/02/21	HAL_2803_d	7.4	47.5	1142	7.03	12.6	10.4
11/03/21	HAL_2803_d	8.0	11.9	1142	7.07	22.4	0.92
28/04/21	HAL_2803_d	10.7	27.5	103.9	7.3	-54.3	30.6
12/05/21	HAL_2803_d	11.5	39	1144	7.91	-0.5	0.92
14/07/21	HAL_2803_d	13.9	63.2	1127	6.76	-37	7.42
20/11/20	HAL_2803_s	10.9	14.4	2094	6.45	101.7	91.5
10/12/20	HAL_2803_s	8.4	33.4	2239	8.29	-22.6	75
14/01/21	HAL_2803_s	6.2	33.2	688	6.7	165.4	130
17/02/21	HAL_2803_s	6.0	33.8	1144	8.04	5.7	18.2
11/03/21	HAL_2803_s	7.1	54.3	1038	8.23	-24.8	7.08

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
12/05/21	HAL_2803_s	10.4	48.6	1014	7.05	23.4	2.64
20/11/20	HAL_2804_s	10.7	4	822	6.67	-77.3	78.5
10/12/20	HAL_2804_s	7.4	255.7	811	6.68	-4.5	446.9
14/01/21	HAL_2804_s	6.2	15.4	1417	6.14	159	305
17/02/21	HAL_2804_s	6.5	47.8	749	7.13	-79.2	48.1
11/03/21	HAL_2804_s	7.3	25.6	763	7.24	162	100.83
12/05/21	HAL_2804_s	10.1	16.1	853	6.86	-128.6	6.73
20/11/20	HAL-GB01	5.9	28.6	1187	7.28	-0.09	14.2
10/12/20	HAL-GB01	4.9	38.8	1155	6.99	123.3	10.4
17/02/21	HAL-GB01	7.0	78.5	1459	7.2	-38	74.6
11/03/21	HAL-GB01	7.3	75.5	13.1	7.28	41.8	136.88
12/05/21	HAL-GB01	14.8	68.6	1265	7.29	-90.6	10.2
20/11/20	HAL-GB02	6.0	9.3	1478	6.94	-71.4	24.32
10/12/20	HAL-GB02	6.4	22.9	1319	6.67	-45.3	15.5
17/02/21	HAL-GB02	7.8	46.9	1255	6.95	-45.4	14.4
11/03/21	HAL-GB02	7.3	48.2	11.25	7	-14.5	175.88
28/04/21	HAL-GB02	10.5	83	726	7.06	-28.1	13.6
12/05/21	HAL-GB02	11.8	53.9	1402	7.07	66.6	14.36
14/07/21	HAL-GB02	15.5	39.6	1405	6.82	-15.1	35.4
20/11/20	HAL-GB03	8.6	46	1067	7.08	19.6	1.96
10/12/20	HAL-GB03	7.3	33.9	1510	6.78	10.9	44.9
17/02/21	HAL-GB03	8.9	58.2	2120	6.82	-1.6	101.8
11/03/21	HAL-GB03	7.9	61.1	2162	7.06	-14.6	45.6
12/05/21	HAL-GB03	12.1	12.5	1037	7.08	-67.5	321.95
20/11/20	HAL-GB04	7.3	3.2	1420	7.02	-136.2	55.2

Date	Ref.	Temp (ºC)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
10/12/20	HAL-GB04	5.6	36.6	1190	6.94	-14.1	60.5
17/02/21	HAL-GB04	7.2	69.1	1639	6.99	-13.4	14.1
11/03/21	HAL-GB04	7.8	52	1324	7.1	103.6	441.55
28/04/21	HAL-GB04	13.8	92.4	207.4	7.91	-51.4	12.8
12/05/21	HAL-GB04	15.5	92.6	1316	7.4	14.4	19.87
14/07/21	HAL-GB04	18.2	126	1105	7.6	34.6	5.75
28/04/21	HAL-WAL	11.7	96.9	892	7.57	-33	30.4
14/07/21	HAL-WAL	15.8	364	885	7.39	-5.3	292

Table 5.2 Results for key water quality parameters

Location ID	Date	Chloride (mg/l)	Nitrate as NO3)mg/l)	Phosphate (Ortho as PO4 mg/l)
HAL-2801-D	14/01/2021	159	6.49	<0.05
HAL-2801-D	28/04/2021	168	0.698	<0.05
HAL-2801-S	14/01/2021	1180	<0.3	<0.05
HAL-2801-S	28/04/2021	32.9	<0.3	<0.05
HAL-2802-D	14/01/2021	105	<0.3	<0.05
HAL-2802-D	28/04/2021	81.5	<0.3	<0.05
HAL-2802-S	14/01/2021	71.6	<0.3	<0.05
HAL-2802-S	28/04/2021	116	<0.3	<0.05
HAL-2803-D	14/01/2021	51	0.384	<0.05
HAL-2803-D	28/04/2021	149	12.1	<0.05
HAL-GB2	28/04/2021	224	<0.3	<0.05
HAL-GB4	28/04/2021	191	0.975	<0.05
HAL-WAL	28/04/2021	63.3	2.54	<0.05

6. LIDAR Data

To aid interpretation of the data, two LIDAR plots have been added in Appendix D. The first (D1) illustrates available data on a graded scale and the second (D2) provides the data sub-divided into elevation bands. The graded scale enables fine topographic features to be discerned, whilst the figure with data sub-divided into height bands enables identification of areas at broadly similar elevations.

Issued by	Approved by
.....	.....
Jon Mainhagu	**Ellie Creer**

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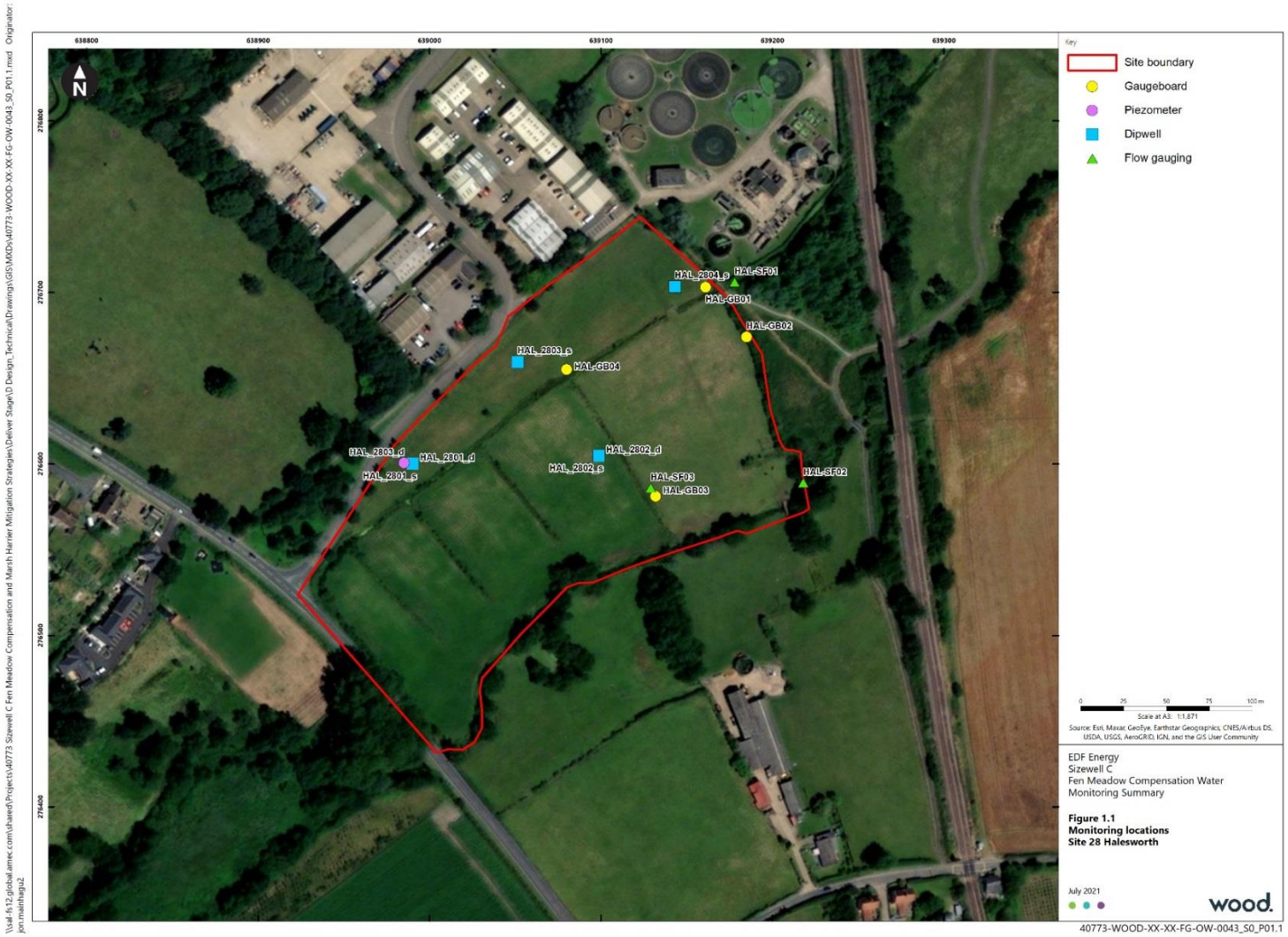
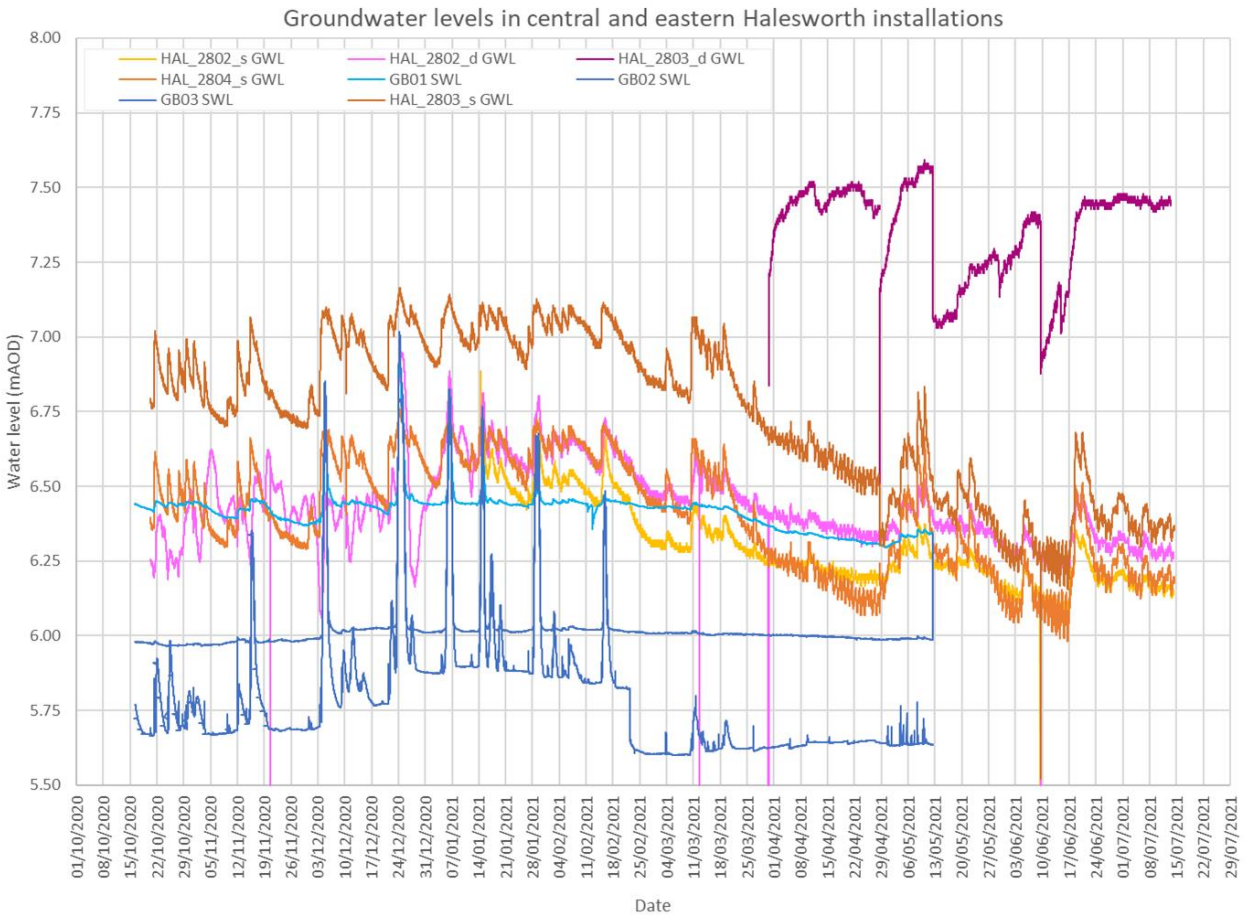
Figure.



Appendix A
Combined Hydrographs

A1



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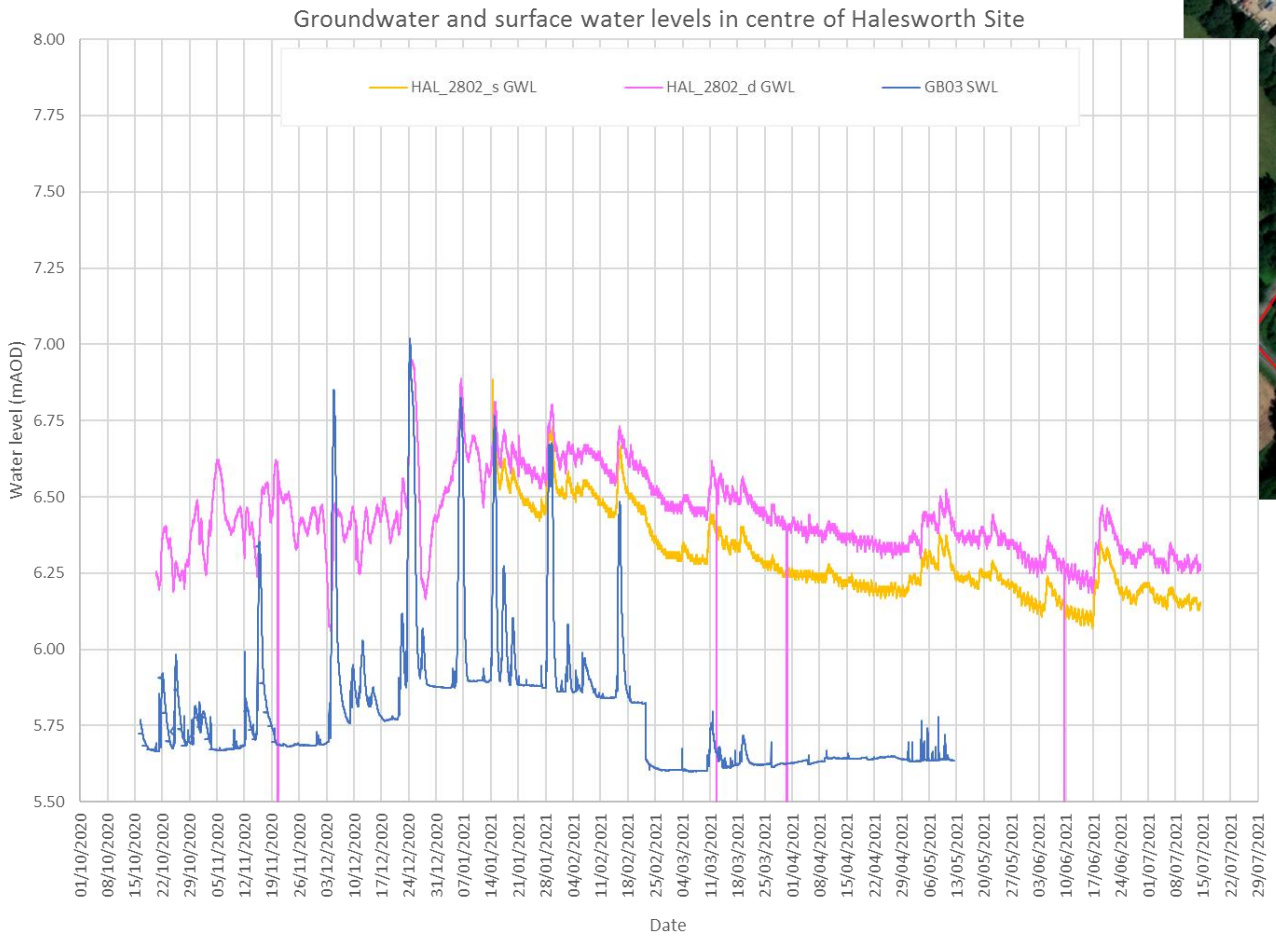
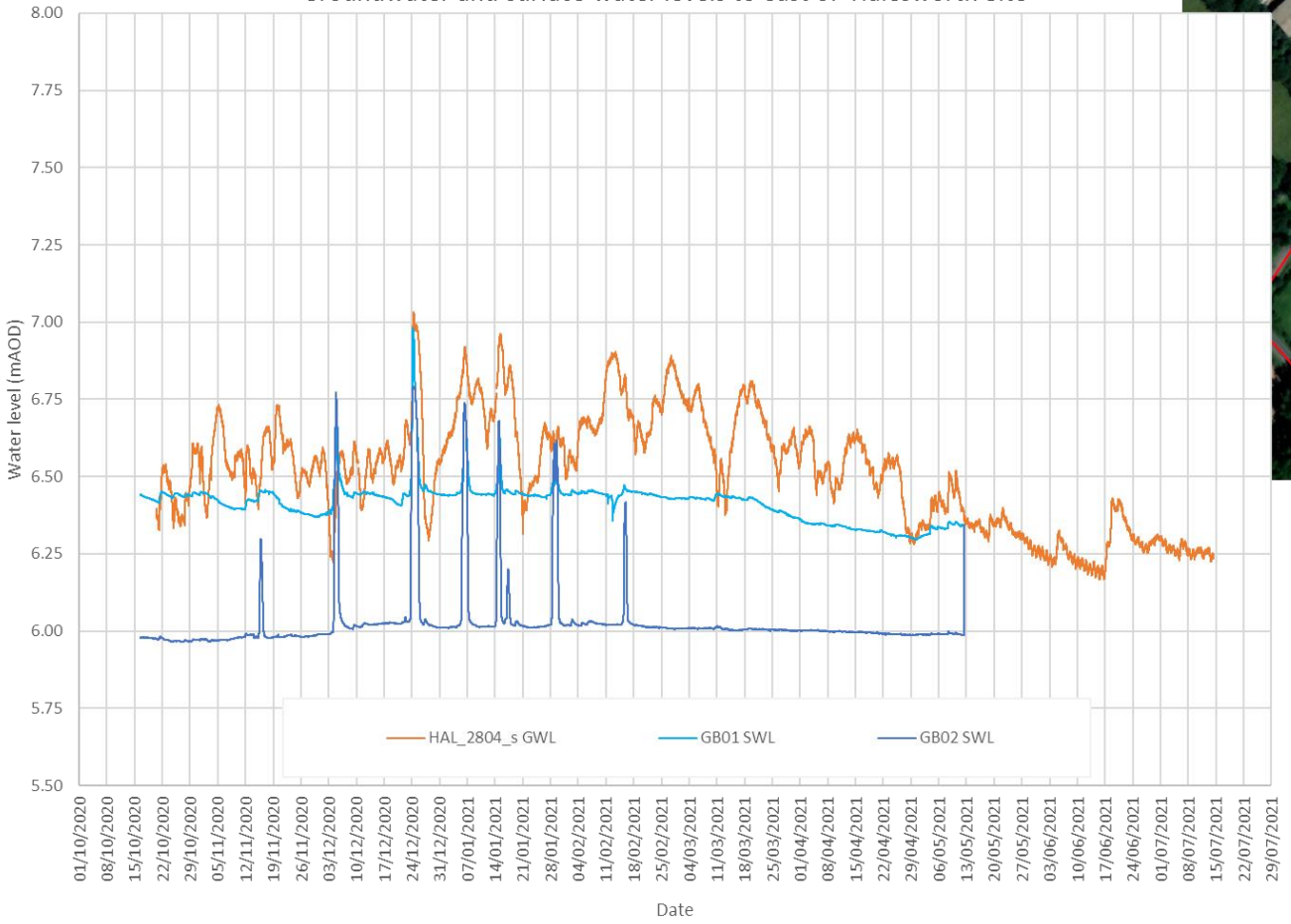
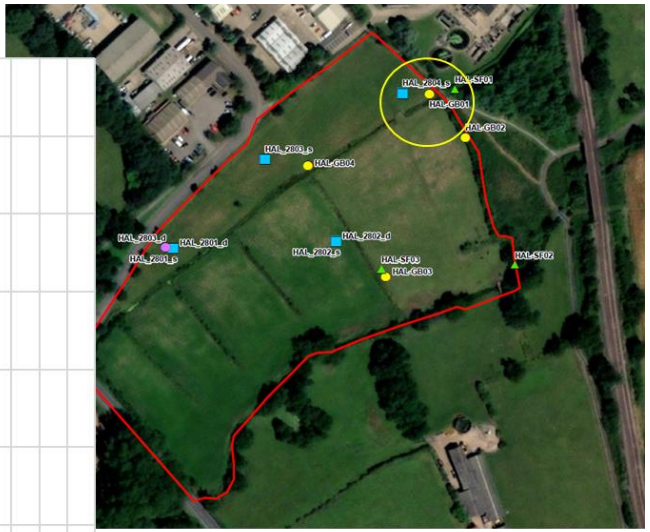


Groundwater levels to the north above those observed in the drainage ditch. Peaks in SW levels also seen in GWL.

Generally declining trend over the spring months matched with low SW levels.

A3



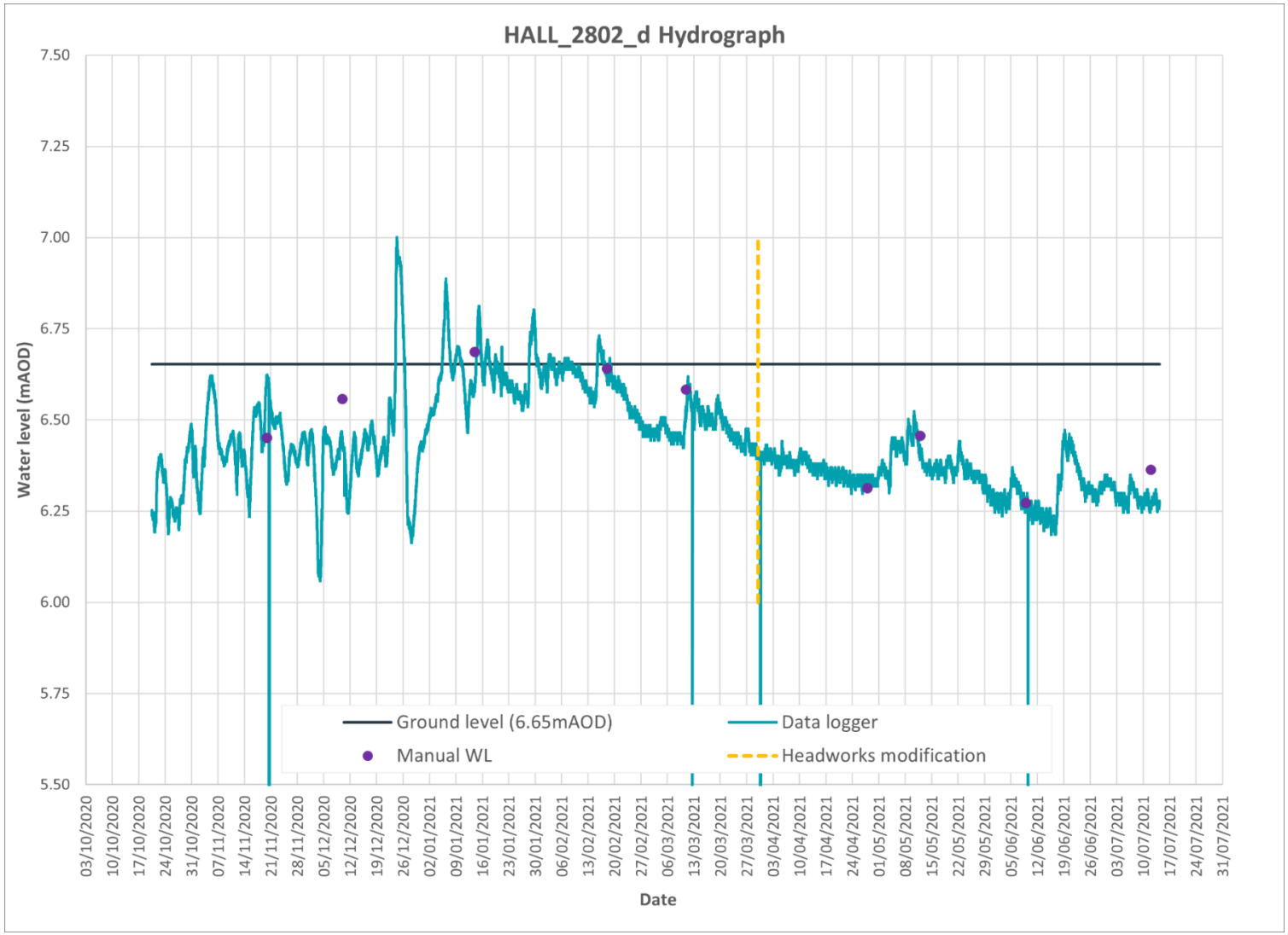


Groundwater levels showing much larger fluctuations that the adjacent drainage ditches.

Clear spikes in SWL matched in GWL flow spikes

Appendix B Groundwater Hydrographs

B1



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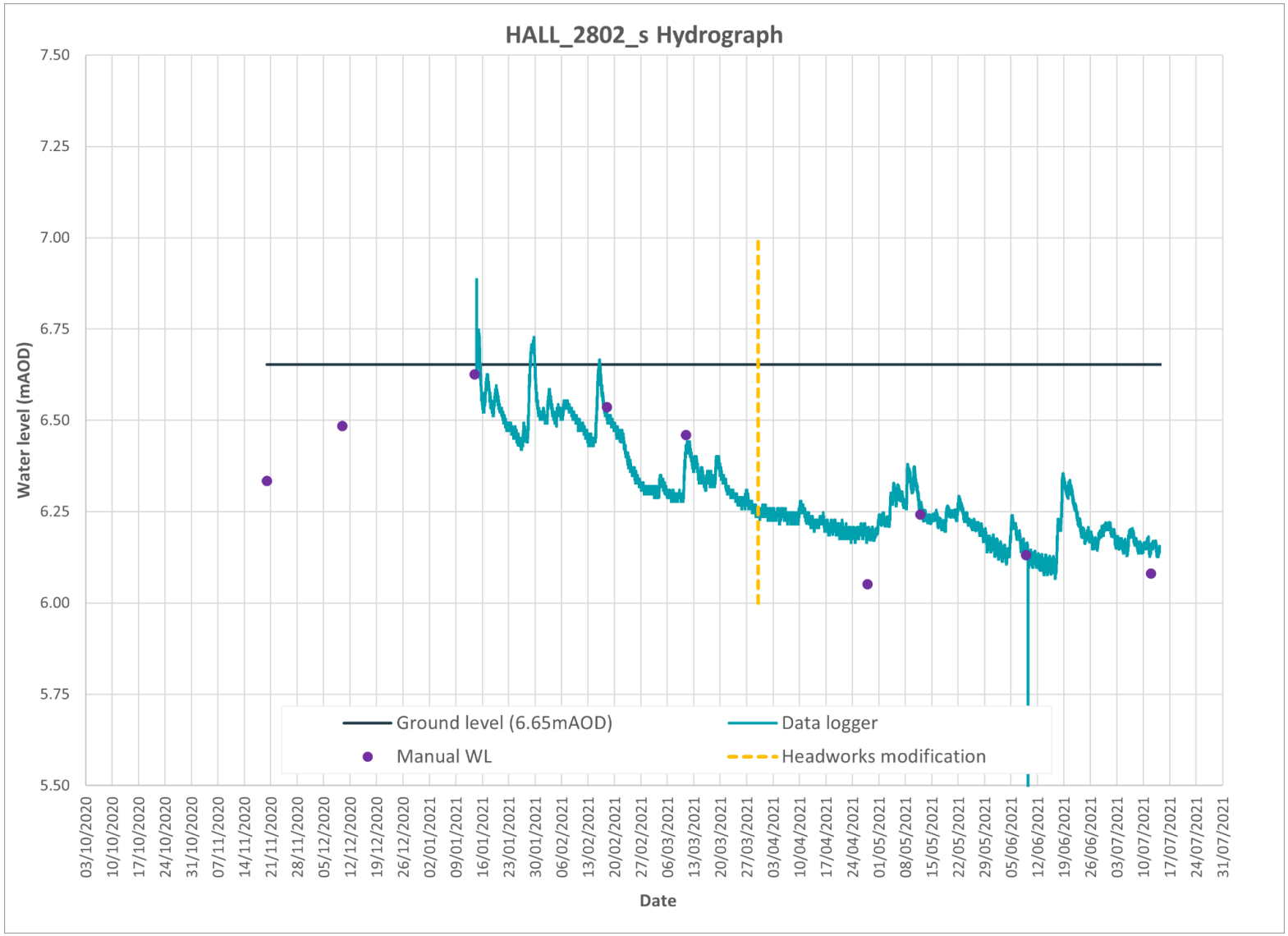

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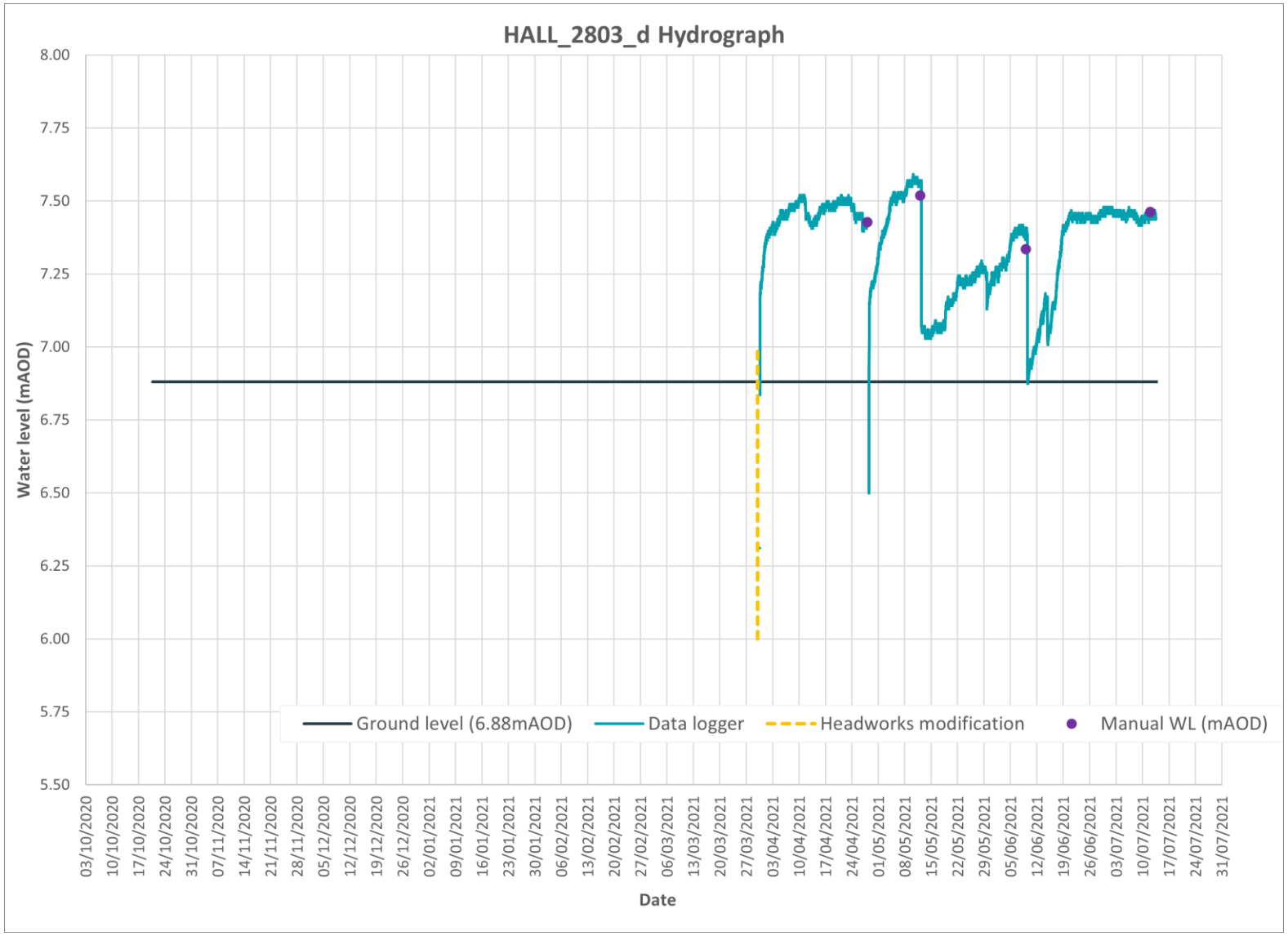

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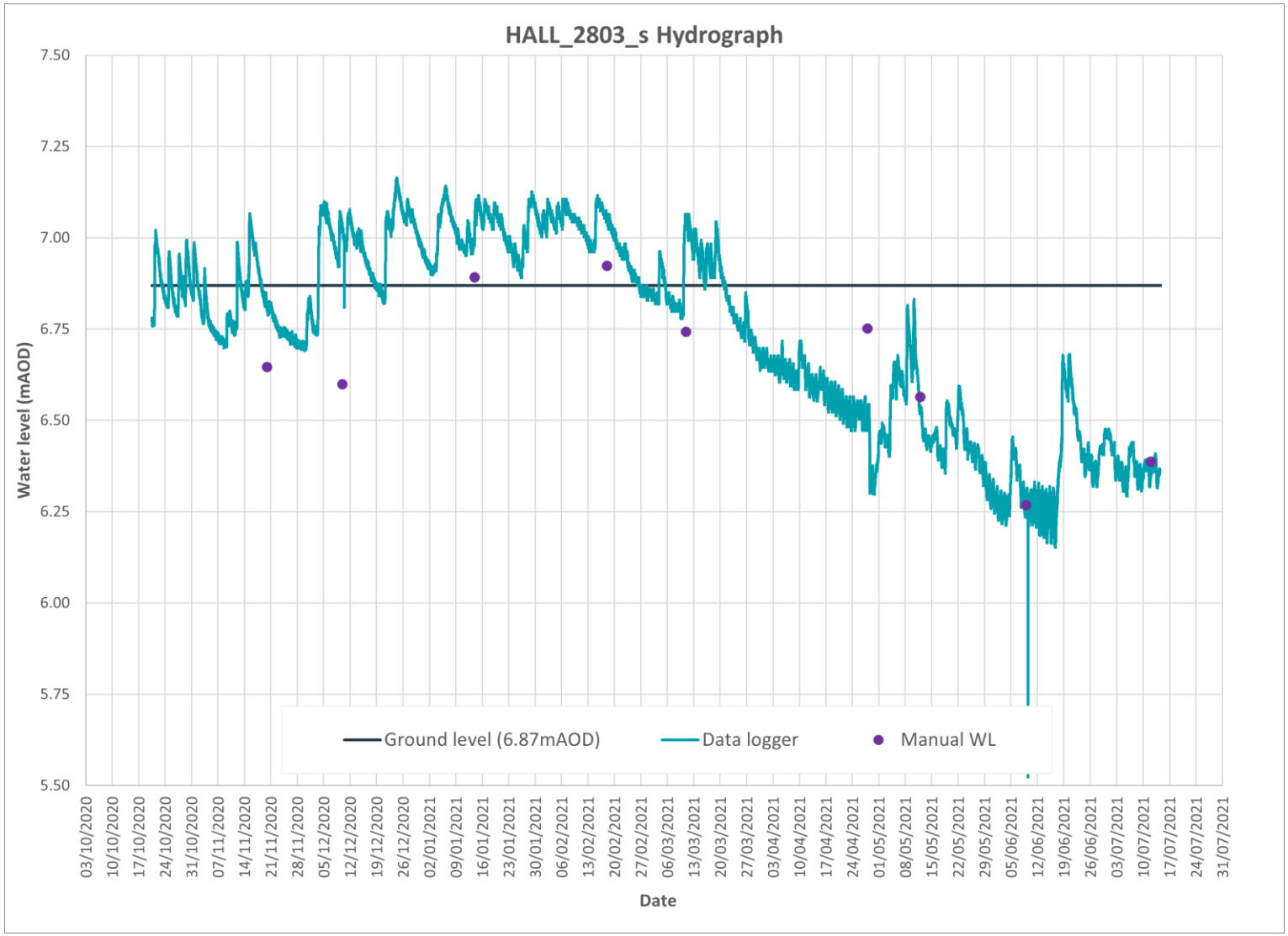

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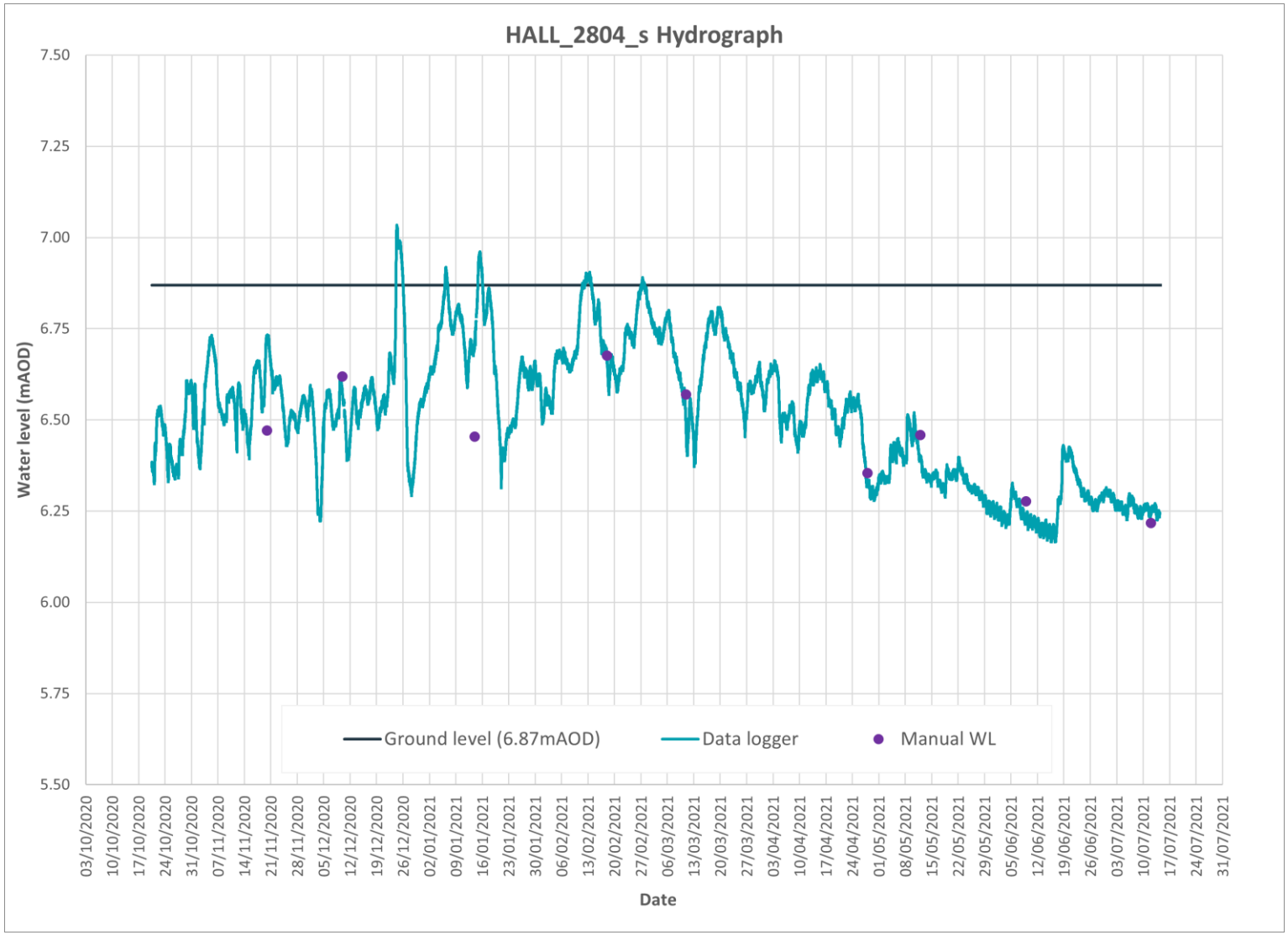

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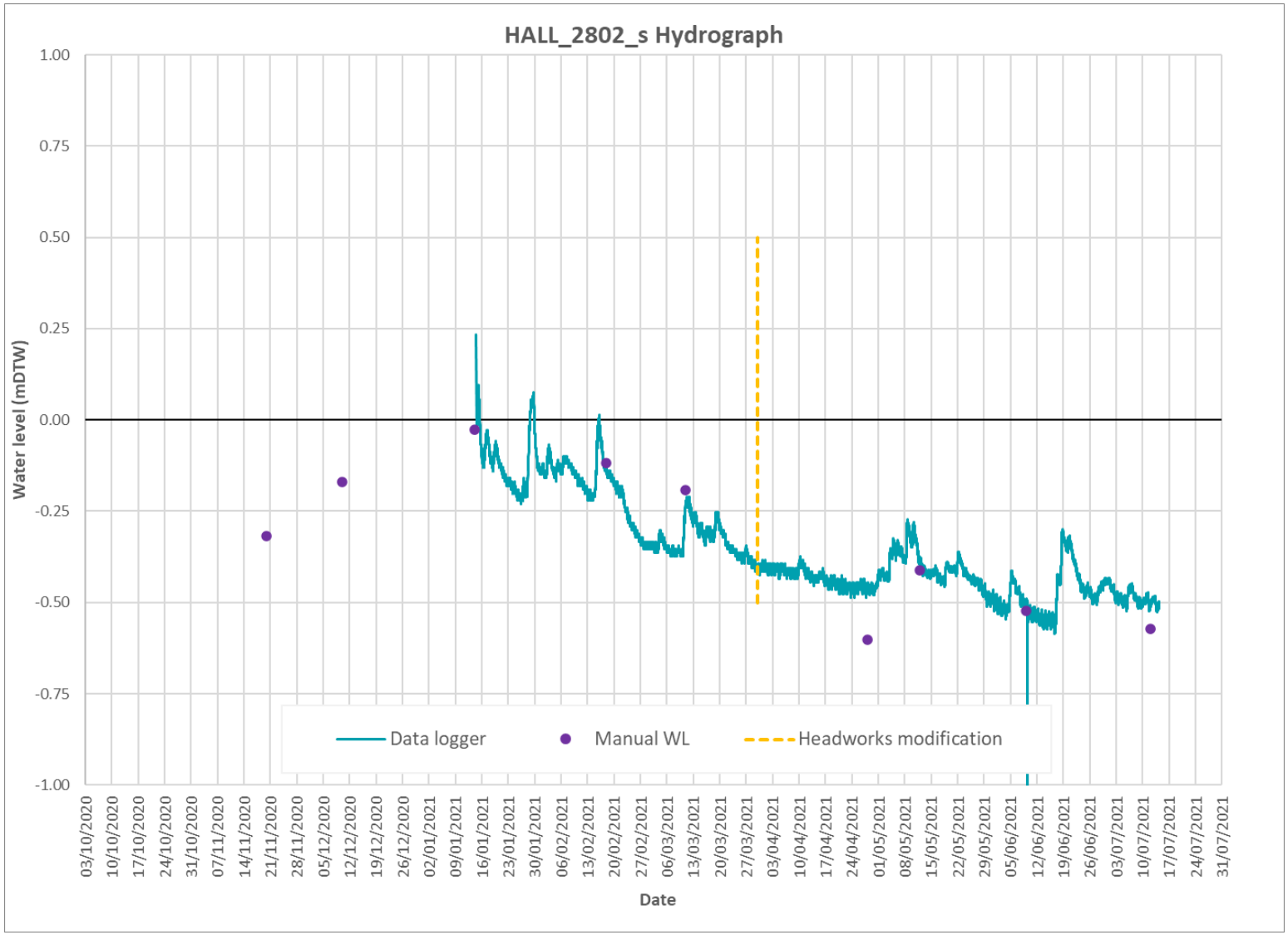

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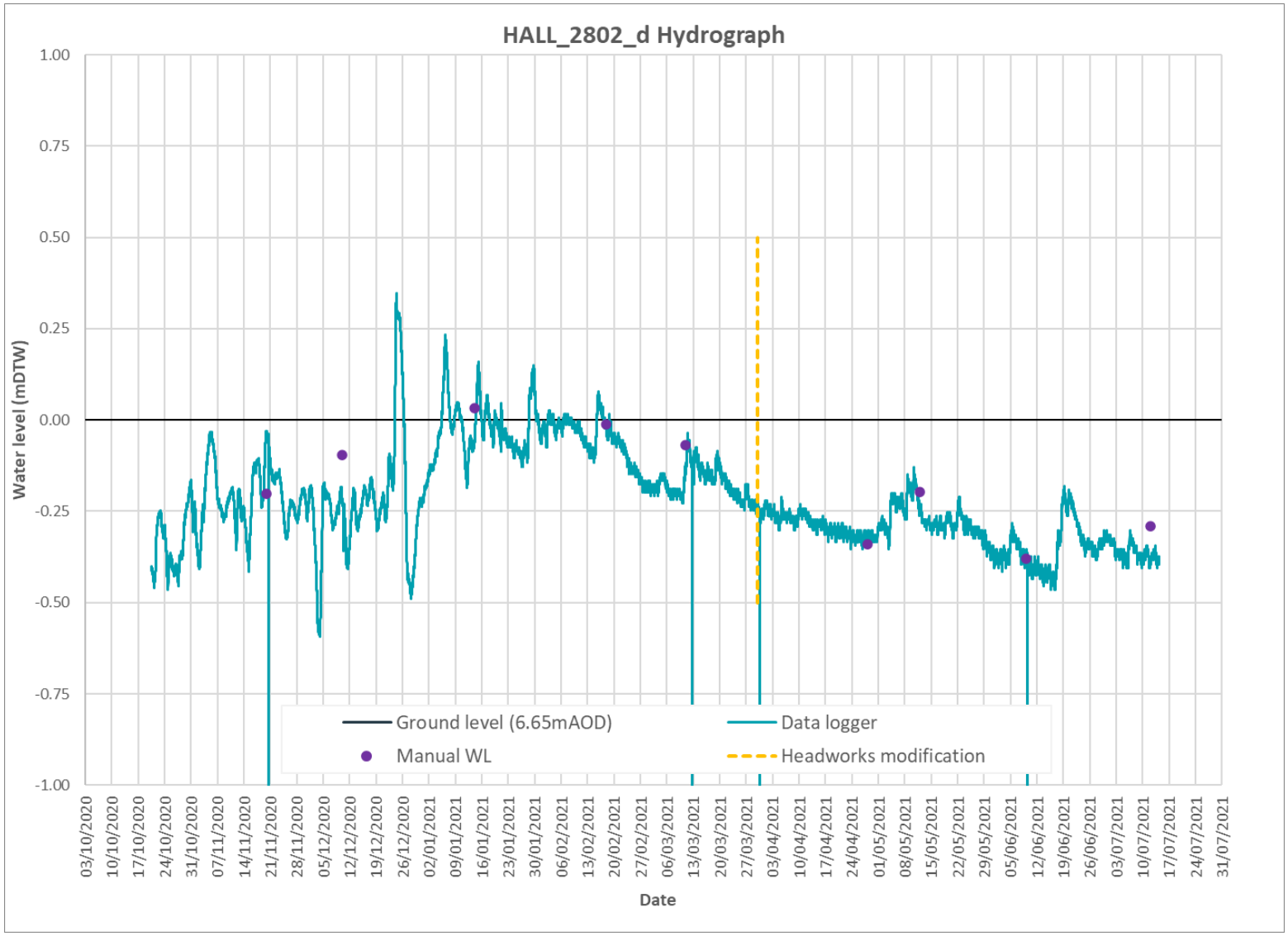

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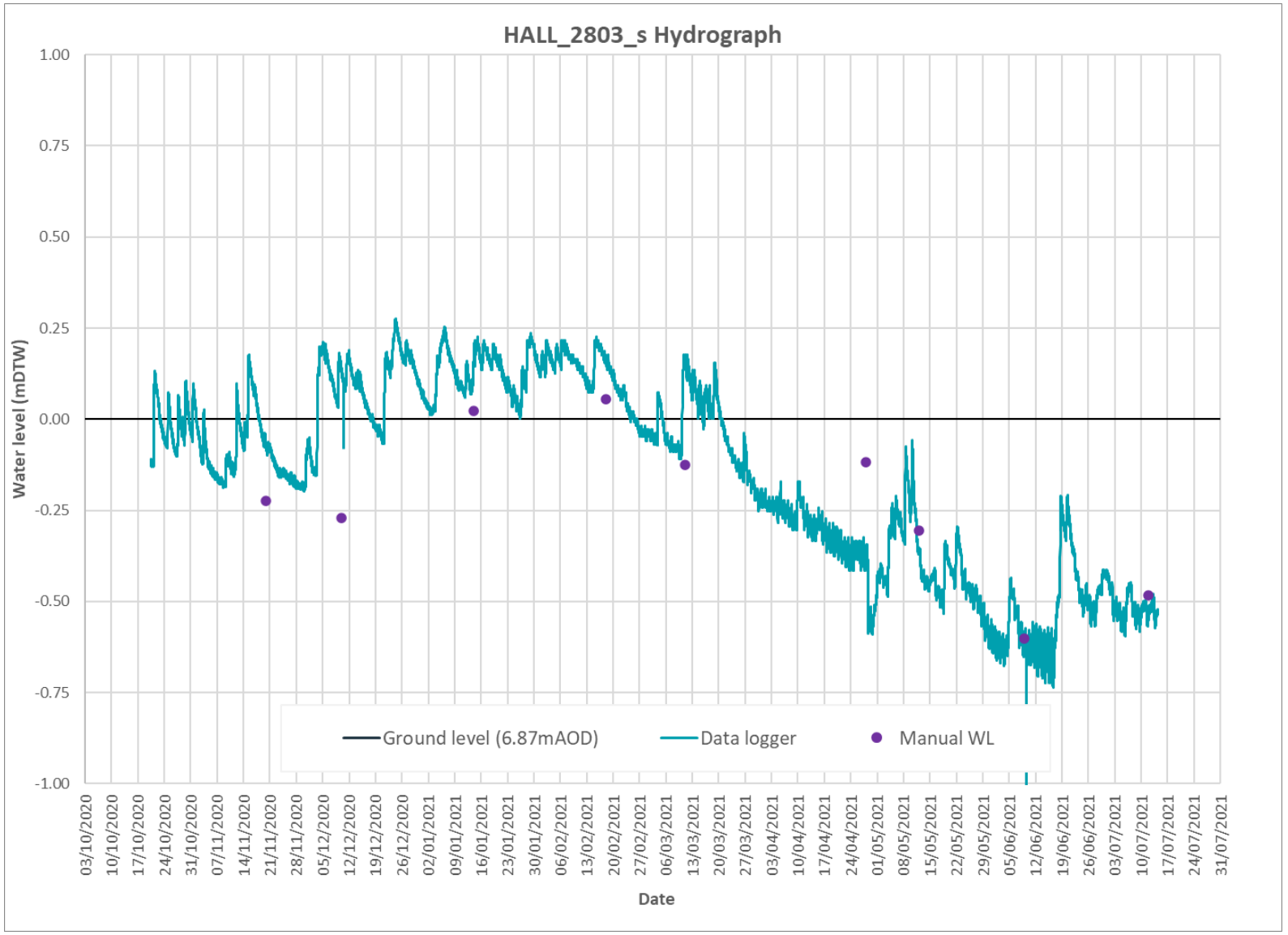

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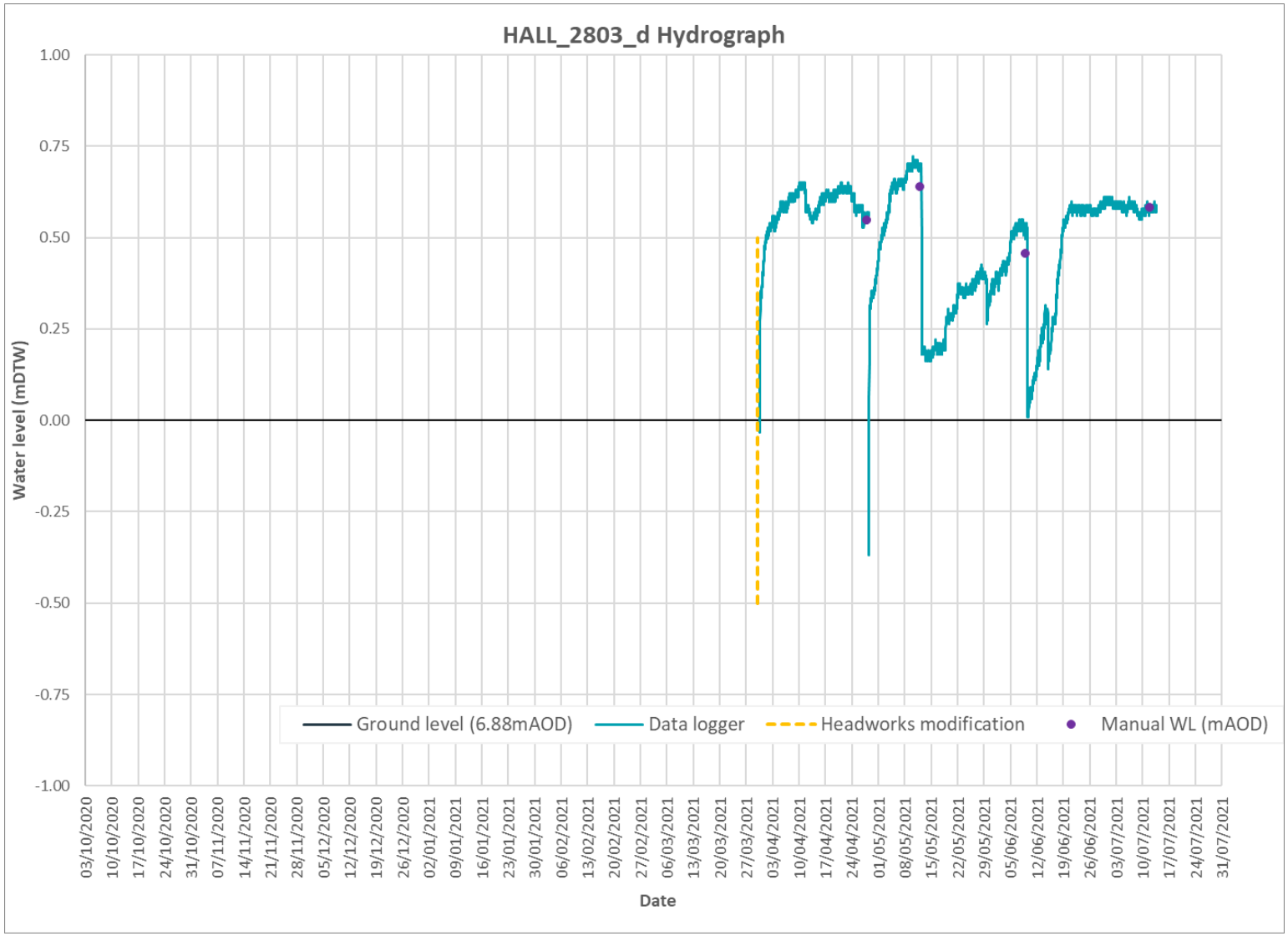
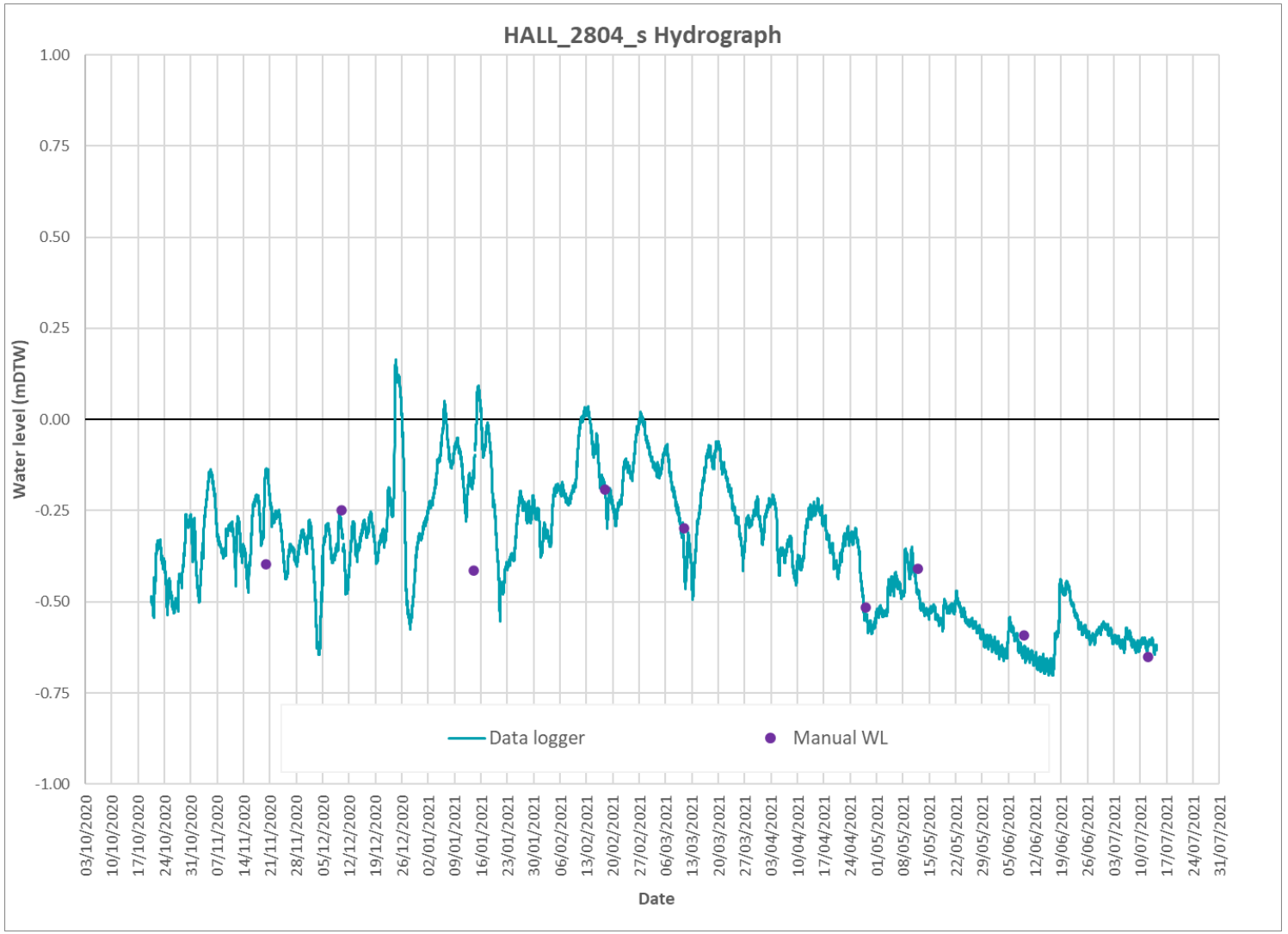
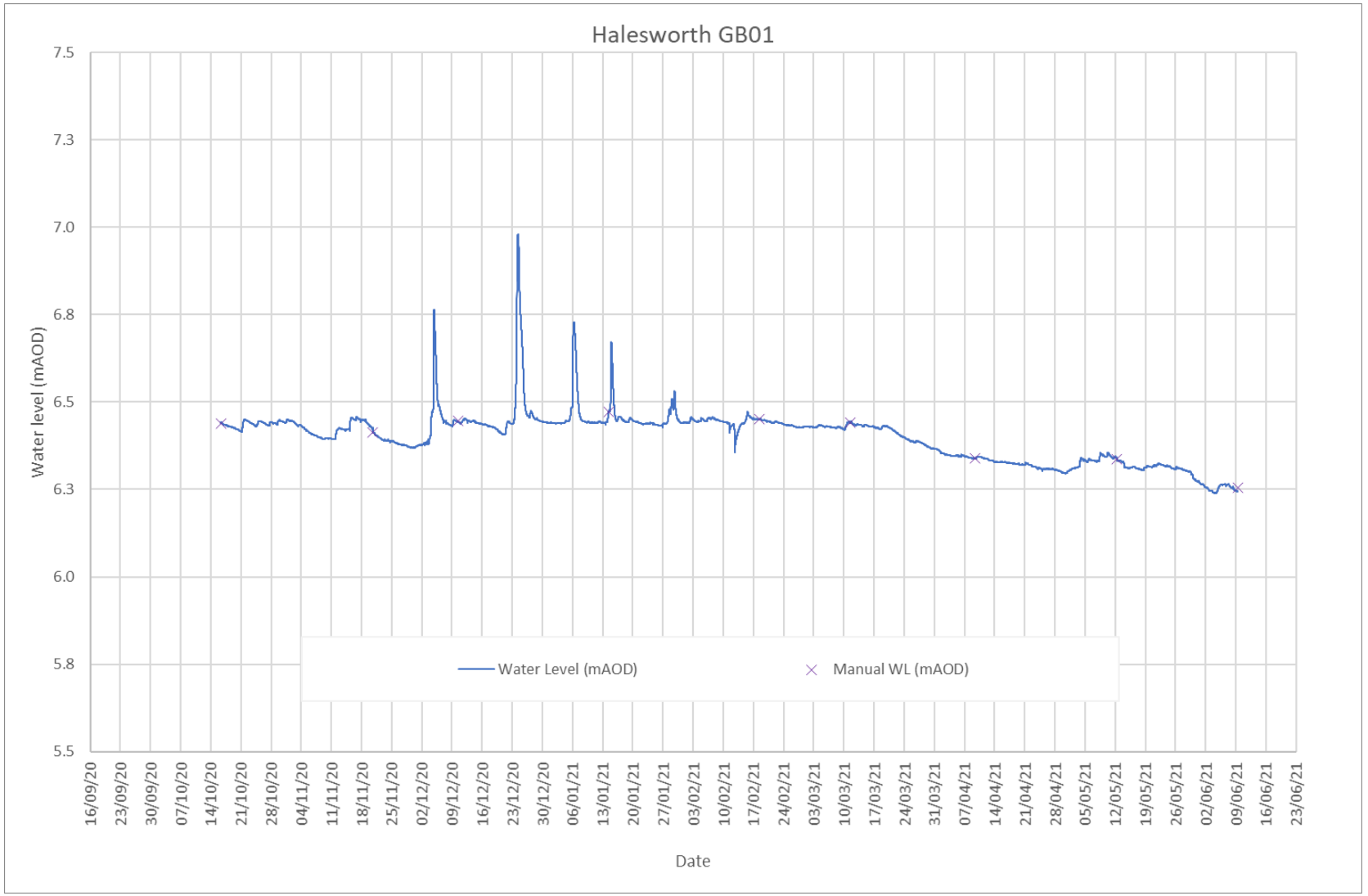


B10



Appendix C Surface water Hydrographs

C1



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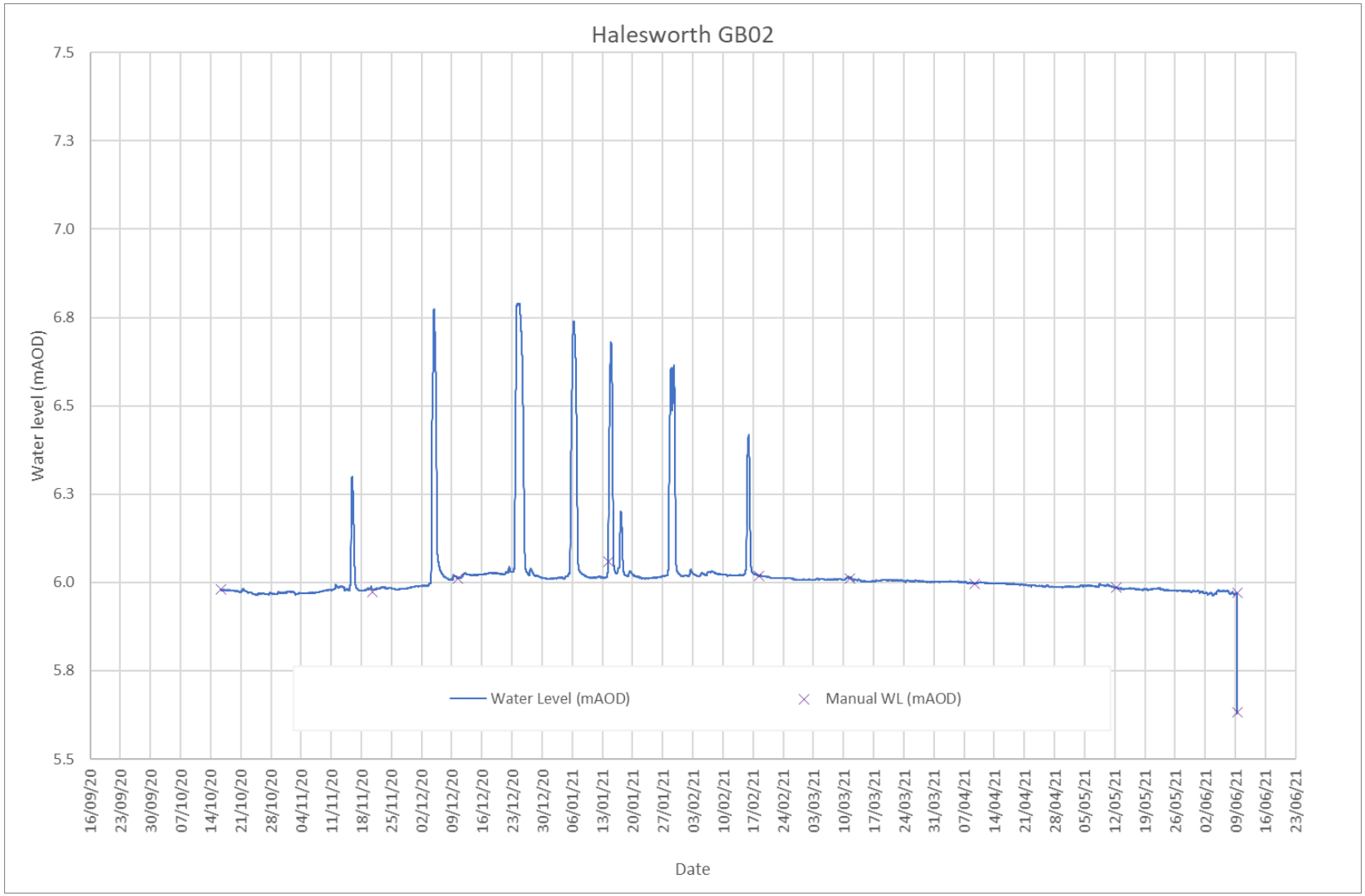
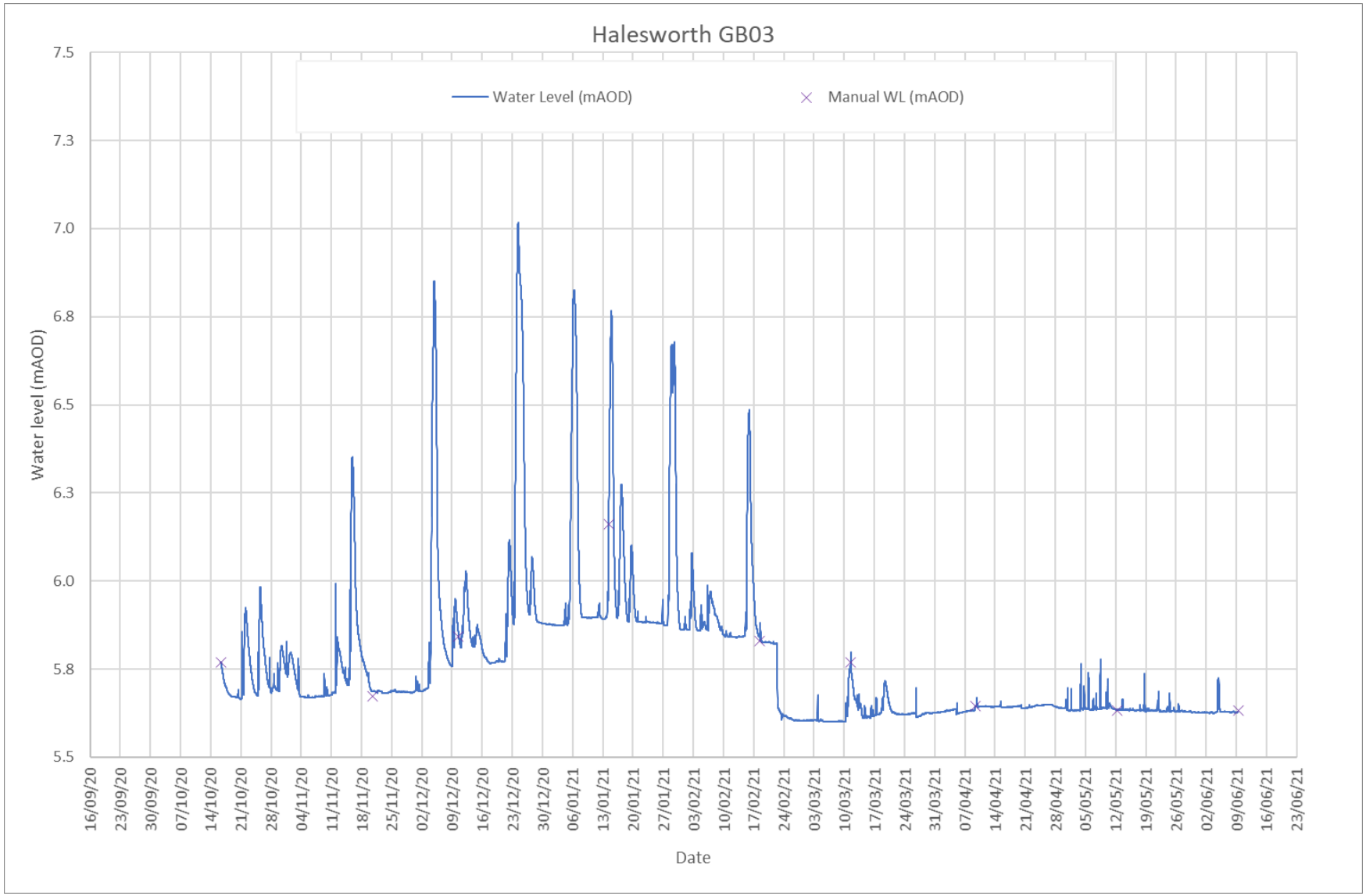


C3

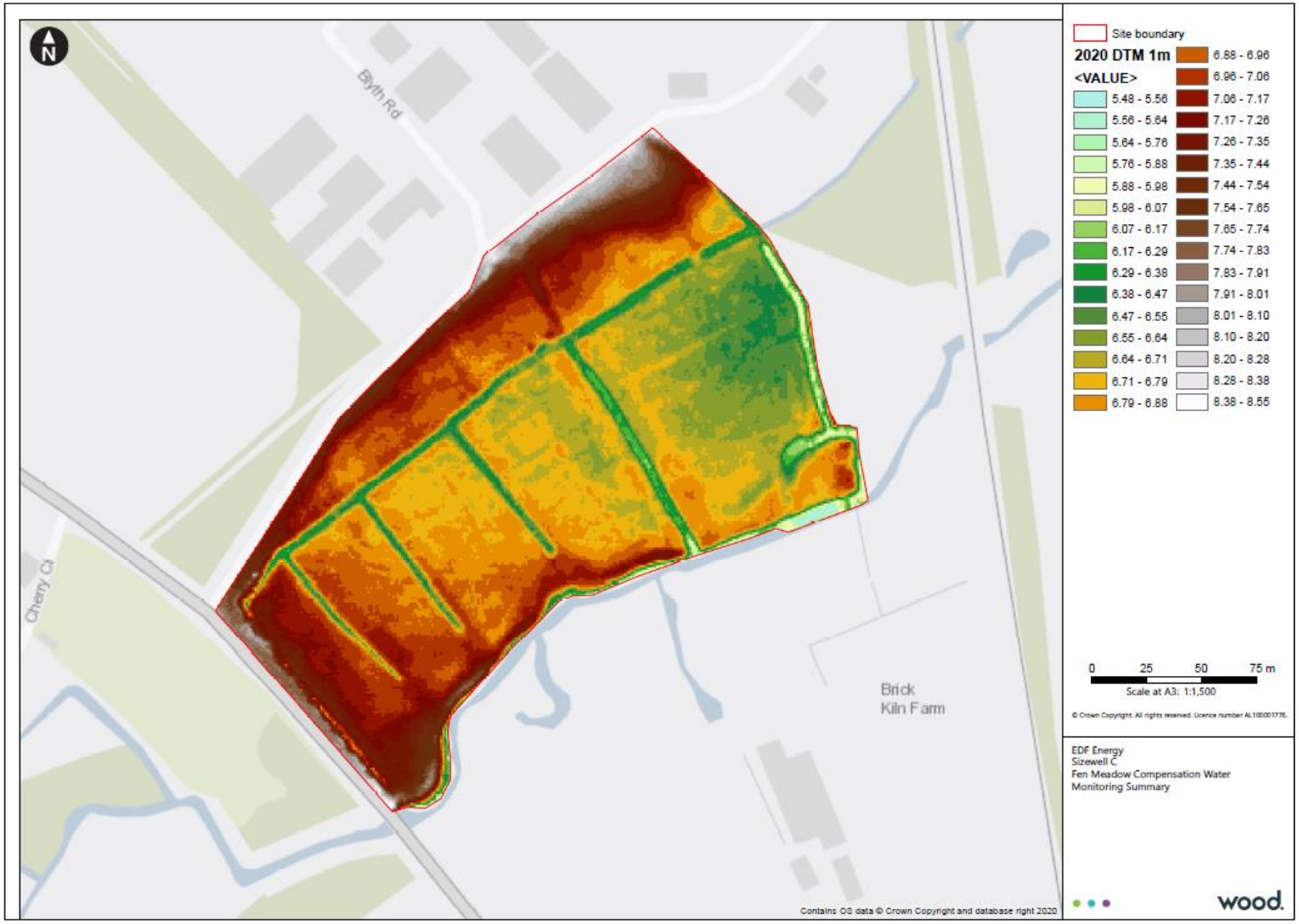


Appendix D
LIDAR Plots for the Site

D1


N
Blyth Rd
Chery Ct
Brick
Kiln Farm
Contains OS data © Crown Copyright and database right 2020
Site boundary
2020 DTM 1m
High : 8.55
Low : 5.49
0 25 50 75 m
Scale at A3: 1:1,500
© Crown Copyright. All rights reserved. Licence number AL100001776.
EDF Energy
Sizewell C
Fen Meadow Compensation Water
Monitoring Summary
wood.

D2


Site boundary
2020 DTM 1m
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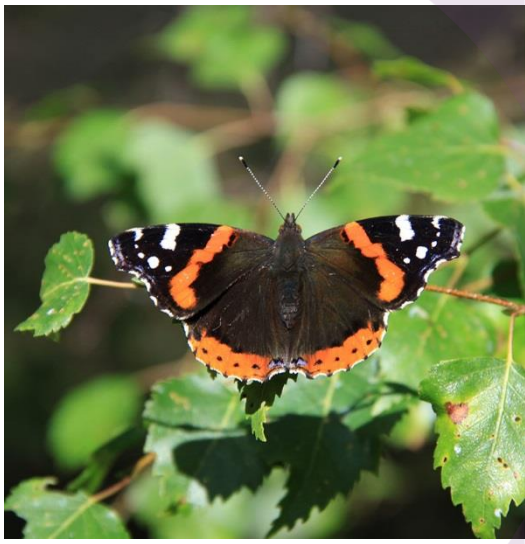
5.48 - 5.56
5.56 - 5.64
5.64 - 5.76
5.76 - 5.88
5.88 - 5.98
5.98 - 6.07
6.07 - 6.17
6.17 - 6.29
6.29 - 6.38
6.38 - 6.47
6.47 - 6.55
6.55 - 6.64
6.64 - 6.71
6.71 - 6.79
6.79 - 6.88
6.88 - 6.96
6.96 - 7.06
7.06 - 7.17
7.17 - 7.26
7.26 - 7.35
7.35 - 7.44
7.44 - 7.54
7.54 - 7.65
7.65 - 7.74
7.74 - 7.83
7.83 - 7.91
7.91 - 8.01
8.01 - 8.10
8.10 - 8.20
8.20 - 8.28
8.28 - 8.38
8.38 - 8.55
0 25 50 75 m
Scale at A3: 1:1,500
EDF Energy
Sizewell C
Fen Meadow Compensation Water
Monitoring Summary
Blyth Rd
Chery Ct
Brick
Kiln Farm
Contains OS data © Crown Copyright and database right 2020

APPENDIX C: PAKENHAM SITE 54 ECOLOGY BASELINE REPORT (ADDENDUM)

EDF Energy

Sizewell C

Fen Meadow Compensation Sites: Pakenham Site 54 Baseline Ecology Report



Wood Group UK Limited – June 2021

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Doc Ref. 40773-WOOD-XX-XX-RP-OE-0001-S0-P01.1

40773-WOOD-XX-XX-RP-OE-0001-S0-P01.1

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Document revisions

No.	Details	Date
1	Report of Work undertaken to date	10/06/21

Contents

1. Introduction

1.1 Background

The proposed development platform for Sizewell C will extend a short distance into the eastern margins of Sizewell Marshes Site of Special Scientific Interest. The toe of the batter of the proposed platform will define the extent of permanent land-take but, additional to that, ditch re-alignment is required which will take a limited amount of further land.

Based on National Vegetation Classification (NVC) survey data the main affected habitats are M22 *Juncus subnodulosus – Cirsium palustre* fen meadow, S26 *Phragmites australis - Urtica dioica* tall-herb fen, S4 *Phragmites australis* reedbed and some W5 *Alnus glutinosa – Carex paniculata* wet woodland.

Studies focussed on the provision of compensatory fen meadow habitat, particularly M22 *Juncus subnodulosus – Cirsium palustre* fen meadow, were reported in Wood (2018). Five sites were identified for further investigation, whilst 17 sites were put on hold subject to further assessment of the initial five sites. The five sites identified for further investigation (Wood (2018)) were:

- Site No. 10 – Aldecar Lane, Benhall;
- Site No. 11 – Watering Lane, Benhall;
- Site No. 28 – Halesworth;
- Site No. 33 – Stratford St Andrew; and
- Site No. 54 – Pakenham Fen.

Subsequently, one day site visits to Sites 10, 11, 28 and 54 were undertaken in April and May 2019. Site 33 was not visited as access had not been agreed at the time (Wood, 2019), however, following further consideration of the site characteristics and suitability for fen meadow creation, it was also concluded that the sites that were taken forward all provide greater potential for fen meadow creation than Site 33.

The one day site visits to Sites 10, 11, 28 and 54 comprised:

- A walkabout survey to identify areas where (1) the peat is currently influenced by groundwater or near-surface seepage; and (2) fen meadow species are present within or close to the site margins;
- A reconnaissance hand augering survey to identify general peat quality (substrate condition), sub-surface geological materials, presence of water table and areas of upwelling groundwater; and
- Consideration of broad options for water management and potential for changes to land management.

Findings were reported in Wood (2019). Sites 10, 28 and 54 were all identified as having potential for the development of fen meadow as follows:

- Site 10: primary locus 1.5ha, further area 0.7ha (Site 11 has relatively limited potential (primary locus of 0.5ha although part already supports fen meadow species, and further area of 1.2ha) but is close to Site 10, so warrants further consideration in that context);
- Site 28: primary locus 1.2ha, further area 1.3ha;
- Site 54 north: primary locus 3.2ha, further area 6.2ha; and

- Site 54 south: primary locus 1.7ha, further area: 4.3ha.

Subsequently EDF has progressed with detailed site conceptualisation and feasibility assessment work at Sites 10/11, 28 and 54.

The scope of the conceptualisation and feasibility assessment work can be summarised as follows:

- Ecological studies:
  - Desk based review of ecological data for the sites and surrounding area; and
  - Targeted ecological surveys.
- Hydrological studies:
  - Desk based review of available groundwater level data (including output from the Environment Agency model for high, low and average groundwater level conditions) and the seasonal variation in groundwater levels. Also, effects of groundwater abstraction on groundwater levels below the site;
  - Collection of topographic data;
  - Collection of surface water level and groundwater level data to determine the relationship between groundwater and surface water levels on site. Also detailed study of the existing and wider ditch network to determine potential for water management without risk to upstream receptors; and
  - Collection of hydrochemical data.

1.2 This report

The scope of the studies undertaken were defined following consideration of:

- The habitat types present on site defined from the one-day visit undertaken in the previous project phase;
- The types of ecological receptor that would be expected to occur in such habitats in Suffolk, based on professional judgement; and
- The potential activities and related impacts of creating fen meadow habitat, principally through raising water levels, on such sites.

The studies proposed comprise:

- A desk study;
- An extended Phase 1 habitat survey;
- A National Vegetation Classification (NVC) survey;
- A survey for signs of otter and water vole; and
- A survey of aquatic invertebrates of the ditches.

The desk study and extended Phase 1 habitat survey have been completed to date and are reported in this ecological baseline for Site 54 Pakenham (hereafter the 'Pakenham site' or 'the Site') (Figure 1.1). The results of the other studies will be reported when complete.

In this report, where possible, common species names are used in the text, though scientific names may also be used for clarity, particularly in naming the published community-types and in instances when the given

common names are not widely used. Common and scientific names of species referred to in this report are presented in Appendix A.

The structure of this report is as follows:

- Section 2 presents the methods and results of a desk study;
- Section 3 presents the methods and results of an extended Phase 1 habitat survey;

P:\Projects\40773 Sizewell C Fen Meadow Compensation and Marsh Harrier Mitigation Strategies\Deliver Stage\D Design_Technical\Drawings\GIS\MXDs\40773-WOOD-XX-XX-FG-OE-0031_S0_P01.1.mxd
jon.squire

591000 592000 593000 594000 595000 596000

271000 270000 269000 268000 267000 266000

N

Farmhouse
Chalet Bungalow
Heath Farm
Ixworth
A143
Woodstreet Farm
The Black Bourn
Stow Lane
Kiln Farm
Mill Farm
Queach House
The Plains
Grimstone End
Lime Kiln Cottages
Old Hall Farm
A1088
Highfields Farm
Highfield Farm Cottages
Bridge Farm
Parkfield Cottage
Stowlangtoft
Beaumont House
Kartin House
Upper Town
Pakenham
Beaumont's Hall
Ixworth Road
Mere Farm
Bartonmere House
The Lodge
Nether Hall
Bella Vista House
Millfields Cottage
Grange Farm
The Bungalow
Little Haugh Hall
Stanton Street
The Old Rectory
Pakenham Stream
Pakenham
Great Green

Key

Site 54 boundary

River

0 250 500 750 1,000 m

Scale at A3: 1:20,000

Fen Meadow Compensation Sites
Pakenham Site 54
Baseline Ecology report

Figure 1.1
Site location plan

June 2021

wood.

2. Desk study

2.1 Method

A data-gathering exercise was undertaken in April 2021 to obtain information relating to statutory and non-statutory biodiversity sites (excluding sites designated for geological features of interest); species or habitats of principal importance for the conservation of biodiversity; legally protected and controlled species; and other conservation-notable habitats or species (see Boxes 2.1 and 2.2).

Box 2.1 – Designated Biodiversity Sites, and Priority Habitats and Species

Statutory Biodiversity Sites

- European sites: Important biodiversity sites designated under international law or treaties. European sites are any Special Area of Conservation (SAC) from the point at which the European Commission and the UK Government agree the site as a 'Site of Community Importance' (SCI); any classified Special Protection Area (SPA); any candidate SAC (cSAC); and (exceptionally) any other site or area that the Commission believes should be considered as an SAC but which has not been identified by the Government. This term is also commonly used when referring to potential SPAs (pSPAs), to which the provisions of Article 4(4) of Directive 2009/147/EC (the 'new wild birds directive') apply; and to possible SACs (pSACs) and listed Ramsar sites, to which the provisions of *The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019* (the Habitats Regulations) are applied as a matter of Government policy (NPPF para 118) when considering development proposals that may affect them;
- Sites of Special Scientific Interest (SSSIs): Nationally important sites notified under the *Wildlife and Countryside Act 1981* (as amended) that provide the best examples of the UK's flora, fauna, or geological or physiographical features (note, this assessment focuses on those sites notified for their biodiversity interest);
- National Nature Reserves (NNRs): Nationally important sites notified under the *National Parks and Access to the Countryside Act 1949* and the *Wildlife and Countryside Act 1981*; in practice most NNRs are SSSIs also; and
- Local Nature Reserves (LNRs): statutory sites that are designated under the *National Parks and Access to the Countryside Act 1949* with the objective of encouraging their use for the study, research or enjoyment of nature. If an LNR has no other statutory or non-statutory designation it is treated as being of borough/district-level importance for biodiversity (although it may be of greater socio-economic value).

Non-statutory Biodiversity Sites

Non-statutory biodiversity sites in Suffolk are known as County Wildlife Sites (CWS) or Potential CWS (pCWS) or Candidate Local Wildlife Sites (cLWS).

Other important habitats or species

Species or habitats of "*principal importance for the conservation of biodiversity*" are those listed by Natural England (NE) pursuant to Section 41 of the *Natural Environment and Rural Communities Act 2006* (as amended). These include those UK Biodiversity Action Plan (UK BAP) priority habitats and species that occur in England. They are commonly referred to as 'Section 41' or 'S.41' habitats or species.

Other conservation-notable habitats and species would include:

- Species listed as being of conservation concern in the relevant UK Red Data Book (RDB) or the Birds of Conservation Concern 4 Red List (Eaton *et al.* 2015);
- Ancient woodland (i.e. areas that have been under continuous woodland cover since at least 1600) on the Ancient Woodland Inventory (AWI);
- Nationally Rare and Nationally Scarce species in the UK, which are species recorded from, respectively, 1-15 and 16-100 hectads (10x10km squares of the UK national grid);
- Populations of birds comprising at least 1% of the relevant British breeding/wintering population (where data are available).
- Priority habitats and species listed in the Suffolk Biodiversity Action Plan (LBAP);
- Other species or assemblages such as large populations of animals considered uncommon or threatened in a wider context; and
- Important hedgerows as defined using the habitat criteria in *The Hedgerows Regulations 1997*.

Box 2.2 – Legally Protected and Controlled Species

Legal Protection

Many species of animal and plant receive some degree of legal protection. For the purposes of this report, legal protection refers to:

- Species included on Schedules 5 and 8 of the *Wildlife and Countryside Act 1981* (as amended), excluding species that are only protected in relation to their sale (see section 9[5] and 13[2]);
- Species included on Schedules 2 and 5 of *The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019*; and
- Badgers, which are protected under the *Protection of Badgers Act 1992*.

Further detail on the legislative protection afforded to species and sites is provided in Appendix B.

Legal Control

Schedule 9 of the *Wildlife and Countryside Act 1981* (as amended) lists species of animal that it is an offence to release or allow to escape into the wild (for example grey squirrel) and species of plant that it is an offence to plant or otherwise cause to grow in the wild (for example, Japanese knotweed).

Data were obtained for:

- Statutory designated sites within 2km of the Site boundary;
- Other statutory and non-statutory sites designated for their nature conservation interest within 1km;
- Habitats of principal importance for the conservation of biodiversity, or other conservation-notable habitats recorded within 1km; and
- Protected species, species of principal importance for the conservation of biodiversity, or other conservation-notable species recorded within 1km.

The geographical context of the Site was examined using the relevant Ordnance Survey 1:10,000 scale maps and freely-available aerial photographs, to identify key landscape features that may be important for protected or conservation-notable species, such as potential migration or dispersal routes, or any potential receptors of site-derived pollutants in the wider landscape.

The sources of desk study information were:

- MAGIC (the government environmental information partnership project) www.magic.gov.uk;
- Natural England (https://designatedsites.naturalengland.org.uk/);
- Joint Nature Conservation Committee (JNCC, http://jncc.defra.gov.uk/page-4); and
- Suffolk Biodiversity Information Service (https://www.suffolkbis.org.uk/biodiversity/speciesandhabitats).

2.2 Results

Designated Sites

There are no statutory designated sites present on Site but there is one statutory site within 2km. This is Pakenham Meadows SSSI which is located immediately to the east of the site, across the Pakenham Stream.

There are no non-statutory designated sites on-site but there are four non-statutory designated County Wildlife Sites within 1km.

The interest features of these sites are summarised in **Error! Reference source not found.** and the site l ocations are shown in Figures 2.1 and 2.2.

Table 2.1 Designated Sites and proximity to Pakenham Site 54

Designation	Distance from Site Boundary	Description
Statutory Designated Sites within 2km		
Pakenham Meadows SSSI	Immediately to the east.	The SSSI citation indicates that the meadow is unusually species rich, unimproved and poorly drained, and forms one of the best examples of its kind in the county. The small-scale complex mosaic of vegetation types present reflects the variation in soils from loam to peat. The meadow is also herb rich and contains a number of uncommon species, and the dykes provide a valuable additional habitat for invertebrates.
Non-Statutory Designated Sites within 1km		
Micklemere CWS	0.40 km north of the Site.	The CWS site consists of 10 riverside meadows, that lie underwater for much of the year. A sluice in the north west corner of the site is the only outlet but the river itself backs up into the ditches and floods the meadows. This constant flooding has created a large area of bare ground which when wet attracts large numbers of wetland birds. The remainder of the land, which does not flood, is rank grassland, which has been ungrazed for several years. The site supports good numbers of wetland birds throughout the year. Plant species at Micklemere are unexceptional.
Pakenham Fen Meadows CWS	0.10km south east of the Site.	The Site is divided into small fields, some of which have not been agriculturally improved and retain a diverse fen meadow flora, which is a Priority habitat. These areas support a good range of wetland plants and a number of uncommon Suffolk plants. The site also provides habitat opportunities for other wildlife, such as invertebrates.
Pakenham Wood CWS	0.60km south east of the Site.	The Site was at one time a Site of Special Scientific Interest (SSSI). However, in recent years much of the wood has been clear-felled and replanted with Corsican pine and larch affecting the wildlife value of the wood. Remnants of the rich woodland flora are confined to the wide woodland rides, which cross the wood.
Roadside Nature Reserve 133	0.65km north west of the Site.	Seeded in 1986 with meadow flowers and grasses.

Note: The site forms part of Nitrate Vulnerable Zones 2017 designations and SSSI Impact Risk Zones.

Priority Habitats

MAGIC indicates that four priority habitats are located within 1km of the Site, with three priority habitats identified as being present on-site (the nearest distance provided for each priority habitat):

- Coastal and floodplain grazing marsh (on Site);
- Deciduous woodland (on Site);
- Lowland meadows (immediately to the east); and
- Woodpasture and parkland (0.5km south).

Species Records

A summary of the key species records within 1km of the Site are presented in Table 2.2.

Table 2.2 Protected and conservation notable species within 1km[1] of Pakenham Site 54

Common Name	Distance of Record from Site (nearest)	Protection		Other Conservation Criteria (as identified on SBIS records)
		HR	WCA	
Mammals				
Brown Hare	0.2km north-west			✓ (S41)
Bat – brown long-eared	0.5km north-east	✓	✓	✓ (S41)
Bat – Pipistrelle	0.5km north-east	✓	✓	
Harvest Mouse	0.2km east			✓ (RL and S41)
Hedgehog	0.1km west			✓ (RL and S41)
Otter	0.4km east	✓	✓	✓ (RL and S41)
Water Vole	0.1km north-east		✓	✓ (RL and S41)
Birds				
Avocet +	0.4km north-east		✓*	✓ (RL)
Barn Owl	0.3km east		✓*	
Bewick's Swan +	0.4km north-east		✓*	
Black-tailed godwit	0.2km east			✓ (RL)
Black Tern +	0.4km north-east		✓*	
Black-winged Stilt	0.4km north-east		✓*	
Brambling +	0.1km south-east		✓*	
Bullfinch	0.1km south-east			✓ (S41)
Cuckoo	0.1km south-east			✓ (RL and S41)
Curlew	0.1km south-east			✓ (RL and S41)
Fieldfare +	0.5km south-west		✓*	✓ (RL)
Grasshopper Warbler	0.4km north-east			✓ (RL, S41)
Green Sandpiper +	0.4km north-east		✓*	
Greenshank +	0.4km north-east		✓*	
Grey Partridge	0.4km north-east			✓ (RL, S41)
Grey Wagtail	0.4km north-east			✓ (RL)
Hobby	0.1km south-east		✓*	

[1] Due to the differing levels of accuracy of location data provided (e.g. 2, 4, 6 and 10 figure grid references) and differences in location indicated by national grid reference relative to latitude and longitude, where necessary some interpretation of the likely location has been applied by additional reference to site name used.

Common Name	Distance of Record from Site (nearest)	Protection		Other Conservation Criteria (as identified on SBIS records)
		HR	WCA	
House Sparrow	On site (albeit only 4 figure grid reference provided)			✓ (RL, S41)
Kingfisher	0.3km east		✓*	
Lapwing	0.4km north-east			✓ (RL, S41)
Lesser Redpoll	0.4km north-east			✓ (RL, S41)
Linnet	0.4km north-east			✓ (RL S41)
Little Gull +	0.4km north-east		✓*	
Little Ringed Plover	0.4km north-east		✓*	
Marsh Harrier	0.1km south-east		✓*	
Marsh Tit	0.1km south-east			✓ (RL, S41)
Mediterranean Gull	0.4km north-east		✓*	
Merlin +	0.4km north-east		✓*	✓ (RL)
Mistle Thrush	0.4km north-east			✓ (RL)
Nightingale	0.4km north-east			✓ (RL)
Osprey +	0.4km north-east		✓*	
Peregrine	0.4km north-east		✓*	
Pintail	0.4km north-east		✓*	
Pochard	0.4km north-east			✓ (RL)
Red Kite	0.4km north-east		✓*	
Red-necked Phalarope +	0.4km north-east		✓*	✓ (RL)
Reed bunting	0.1km south-east			✓ (S41)
Redwing +	0.4km north-east		✓*	✓ (RL)
Ringed Plover	0.5km north-west			✓ (RL)
Ruff	0.4km north-east		✓*	✓ (RL)
Scaup +	0.4km north-east		✓*	✓ (RL, S41)
Skylark	0.1km south-east			✓ (RL and S41)
Song Thrush	0.5km south-west			✓ (RL)
Spotted Flycatcher	0.4km north-east			✓ (RL, S41)
Starling	0.4km north-east			✓ (RL S41)

Common Name	Distance of Record from Site (nearest)	Protection		Other Conservation Criteria (as identified on SBIS records)
		HR	WCA	
Temminck's Stint +	0.4km north-east		✓*	
Tree sparrow	0.3km south-west			✓ (RL, S41)
Turtle Dove	0.5km south-west			✓ (RL, S41)
Whimbrel	0.4km north-east		✓*	✓ (RL)
Whinchat	0.4km north-east			✓ (RL)
White-fronted Goose	0.4km north-east			✓ (RL)
White-tailed Eagle +	0.4km north-east		✓*	✓ (RL)
Woodcock	1km east			✓ (RL)
Woodlark	0.4km north-east		✓*	✓ (S41)
Wood Sandpiper +	0.4km north-east		✓*	
Yellow Wagtail	0.1km south-east			✓ (RL, S41)
Yellowhammer	0.1km south-east			✓ (RL, S41)
Herpetofauna				
Common Toad	0.3km north-east			✓(S41)
Great Crested Newt	0.3km west	✓	✓	✓ (S41)
Invertebrates				
Anaglyptus mysticus	0.6km south-west			✓ (NS)
Adonis ladybird	0.4km south-west			✓ (NS)
Cinnabar	0.5km north-west			✓ (S41)
Ptinus sexpunctatus	0.4km south-west			✓ (NS)
Red-tailed Mason Bee	0.5km north-west			✓ (NS)
Small heath	0.9km south			✓ (S41)
White admiral	0.7km south-east			✓ (RL, S41)
White-letter Hairstreak	0.1km north-east			✓ (RL, S41)
Vascular plants				
Dwarf spurge	0.8km south-east			✓ (RL)
Cornflower	1km north-east			✓ (S41)

* Schedule 1 (*Wildlife and Countryside Act 1981*)
+ Schedule 1 of the Wildlife and Countryside Act 1981 (as amended) affords additional protection to species during the breeding period in particular providing protection at nest sites. The species highlighted with a + are species which occur as wintering and passage

migrants but have not been identified as a breeding species within the search area and are considered unlikely to occur as a breeding species.
The other principle protective legislation and conservation designations for individuals of a species in England are:
WCA – *Wildlife and Countryside Act 1981* (as amended)
HR – *The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019*
ER – *The Eels (England and Wales) Regulations 2009*
S41 – Section 41 species; see Box 2.1
RL – Red list species; see Box 2.1
NR – Nationally Rare; See Box 2.1
NS – Nationally Scarce; See Box 2.1

There is also a record of ash, classed as Ancient Veteran Trees, north-west of the Site at NGR TL93116868.

Non-native Species / Notifiable Weeds

There were no records for species listed in Schedule 9 of the *Wildlife and Countryside Act 1981* (as amended) found on-site. However, the following Schedule 9 species were found within 1km (with the nearest record to Site):

- American mink 0.1km east;
- Bar-headed goose 0.6km north-east;
- Barnacle goose 0.3km south-west (nearest);
- Canada goose 0.3km south-west (nearest);
- Canadian waterweed 1km north-east;
- Chinese muntjac 0.7km north-east;
- Egyptian goose 0.3km south-west (nearest);
- Grey squirrel 0.7km south (nearest);
- Nuttall's waterweed 0.3km north-east;
- Ruddy duck 0.7km north-east (nearest);
- Ruddy shelduck 0.6km north-east (nearest)
- Snow goose 0.3km north-east (nearest); and
- White-tailed eagle 0.1km west (although record suggests Micklemere which is 0.4km north-east at its nearest). .

Water bodies

Twenty seven water bodies have been identified from ordnance survey mapping within 500m of the Site boundary, including a single waterbody on site in woodland at the southern end. These are shown on Figure 2.3 and listed in Table 2.3. The Site also contains a network of drains that are not specifically listed in the table.

Pakenham Stream forms the eastern site boundary, with a network of drains present on-site and within the wider area. Great crested newts are not typically found in rivers, and the wettest drains on site are likely to support fish, which would make them sub-optimal for great crested newts.

However, the on site pond, and those located to the west of the Site are not separated by a barrier to great crested newt migration.

Table 2.3 Water bodies within 500m of Pakenham Site 54

Water body	NGR	Distance and direction from Site	Description
W1	TL 9338 6956	279m north	Large waterbody, may contain fish.
W2	TL 9373 6959	479m north	Waterbody likely to be connected to drainage network and may contain fish.
W3	TL 9369 8315	425m north-east	Pond
W4	TL 9369 7414	350m north-east	Pond.
W5	TL 9369 6714	290m north-east	Pond
W6	TL 9369 6107	195m north-east	Large waterbody may contain fish.
W7	TL 9369 6904	268m north-east	Large waterbody may contain fish.
W8	TL 9368 4675	52m east	Waterbody likely to be connected to drainage network and may contain fish.
W9	TL 9368 5553	8m east	Pond
W10	TL 9368 6423	283m east	Pond
W11	TL 9368 6112	299m east	Large waterbody may contain fish.
W12	TL 9368 7707	478m east	Pond
W13	TL 9367 6797	379m east	Large waterbody may contain fish.
W14	TL 9367 2789	121m south-east	Large waterbody may contain fish.
W15	TL 9367 3879	291m south-east	Detached waterbody.
W16	TL 9367 1779	153m south-east	Waterbody likely to be connected to drainage network and may contain fish.
W17	TL 9267 9752	375m south	Waterbody likely to be connected to drainage network and may contain fish.
W18	TL 9267 8992	155m south-west	Large waterbody may contain fish.
W19	TL 9268 8932	63m west	Pond
W20	TL 9268 8370	283m west	Large waterbody may contain fish.
W21	TL 9327 6821	79 m east	Pond
W22	TL 9268 7783	314m west	Large waterbody may contain fish.
W23	TL 9268 8587	260m west	Large waterbody may contain fish.
W24	TL 9268 8991	203m west	Pond
W25	TL 9268 8391	255m west	Pond
W26	TL 9369 0242	372m north-west	Pond
W27	TL 9322 6805	49m east	Pond

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590000 590500 591000 591500 592000 592500 593000 593500 594000 594500 595000 595500 596000

271500 271000 270500 270000 269500 269000 268500 268000 267500 267000 266500 266000

N

Abbey Farm
Allen's Farmhouse
Chalet Bungalow
Heath Farm
Heath Cottages
Puttocks Cottage
White Clouds
Puttockshill
Queach House
The Plains
Paltry Farm
Highfields Farm
Ashmore Farm
Highfield Farm Cottages
West View
Edgewood Cottage
Mere Farm
Bartonmere House
The Lodge
Green Lane Farm
Grange Farm
Millfields Cottage
Nether Hall
Bella Vista House
The Bungalow
Manor Farm
Great Green
Moat Farm
Norton
Upper Town
Pakenham
Old Hall Farm
Mill Farm
Grimstone End
Ixworth
Woodstreet Farm
Kiln Farm
Lime Kiln Cottages
Bridge Farm
Parkfield Cottage
Stowlangtoft
Beaumont House
Kartin House
Beaumont's Hall
Ixworth Road
Little Haugh Hall
Stanton Street
The Old Rectory
Amerhur House
Wyken Cot

A1088
A143
Stow Lane

Pakenham Meadows

Key

- Site 54 boundary
- 2km search area
- Site of Special Scientific Interest (SSSI)

0 250 500 750 1,000 1,250 m

Scale at A3: 1:22,000

Fen Meadow Compensation Sites:
Pakenham Site 54
Baseline Ecology Report

Figure 2.1
Statutory designated sites within 2km of the Site

May 2021

wood.

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591000 591500 592000 592500 593000 593500 594000 594500 595000

270500 270000 269500 269000 268500 268000 267500 267000

N

Micklemere

RNR 133

Pakenham Fen Meadow

Pakenham Fen Meadow

Pakenham Fen Meadow

Pakenham Wood

Key

Site 54 boundary

1km search area

County Wildlife Site (CWS)

0 250 500 750 m

Scale at A3: 1:15,000

Fen Meadow Compensation Sites:
Pakenham Site 54
Baseline Ecology Report

Figure 2.2
Non-statutory designated Sites within 1km of the site

May 2021

wood.

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591500 592000 592500 593000 593500 594000 594500

269500 269000 268500 268000 267500

N

A143 A1088

Great Queach
Cutter's La
Thieves La
The Plains
Nursery Plantation
Stow La
Baileypool La
Broadway
Grimstone End
The Black Bourn
Sandy La
Fen Rd
Broom Covert
Pakenham Fen
Bull R
Upper Town
Pakenham Rd
The Owell
Pakenham
The Meadows
The St
Beaumont Hall

W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19 W20 W21 W22 W23 W24 W25 W26 W27

Key

- Site 54 boundary
- Site 54 boundary 500m buffer
- W1 Waterbody

0 100 200 300 400 500 600 m

Scale at A3: 1:10,000

Fen Meadow Compensation Sites:
Pakenham Site 54
Baseline Ecology Report

Figure 2.3
Waterbodies located with 500m of the site

May 2021

wood.

3. Extended Phase 1 Habitat Survey

3.1 Method

Habitats

A Phase 1 habitat survey of the Site and, where possible, a 30m buffer, was completed by a Wood Ecologist on 6th May 2021. During the survey, distinct habitats were identified, and any features of interest recorded and included on a Phase 1 habitat map as a target note (TN), in accordance with JNCC (2010).

Protected and Notable Species

As the standard Phase 1 habitat survey methodology is mainly concerned with vegetation communities, the survey was extended, in general accordance with IEA (1995), to allow for the provision of information on other ecological features, including identification of the presence, or potential presence, of legally protected or conservation notable species.

The methodologies used to establish the presence or potential presence of species and / or species groups are summarised below. Species or biological taxa included in the surveys were targeted due to the desk study and / or habitat types indicating potential for presence on the Site.

Great crested newt

Great crested newt is legally protected and is also a Species of Principal Importance.

The Site was assessed for its potential to support a population of this species. This assessment considered the presence of suitable aquatic and terrestrial habitats on site (the latter including foraging habitat, hibernacula and refugia). All accessible waterbodies were subject to Habitat Suitability Index HSI assessment (Oldham *et al*., 2000), recording the context and features of them to generate a score relative to the likelihood of great crested newts using them

Reptiles

All species of British reptile are legally protected and are also Species of Principal Importance.

The Site was assessed for its potential to support populations of reptile species. This involved looking for potential foraging habitat, hibernacula, refugia and areas for basking (as described in Froglife, 1999).

Birds

All nesting birds are legally protected, some are afforded a higher level of protection when breeding, and many are also Species of Principal Importance.

The habitats on site were assessed for their potential to support important populations of breeding and wintering birds.

Badger

Badgers and their setts are legally protected.

The Site was searched for evidence of badger activity. This involved looking for setts, badger trails, snuffle holes, latrines and badger hairs. Furthermore, information was gathered about the suitability of habitats for

foraging badger on-Site and of suitable sett-digging habitat likely to be present within 30m of the Site (as described in Natural England, 2015).

Bats (all species)

All species of British bats and their roosts are legally protected and many are also Species of Principal Importance.

A general assessment was made for the potential of onsite trees to contain potential roost features for bats (e.g. rot and woodpecker holes, splits, cracks, and dense woody ivy on trees). Additionally, a general assessment was made as to whether habitats within and adjacent to the Site are likely to provide an important foraging resource and/or commuting route for bats (as described in Collins *et al*., 2016).

Dormouse

Dormouse is legally protected and is also a Species of Principal Importance.

The extent and quality of the habitats within and adjacent to the Site were assessed for their potential to support dormouse; in particular whether or not key food plants occurred and whether any of the habitats present are connected to large areas of suitable woodland (as described in Bright *et al*, 2006).

Otter

Otter is legally protected and is also a Species of Principal Importance.

The Site was assessed for its potential to provide habitat that could support otter. This involved considering the size and connectivity of any watercourse present on site (or within the vicinity) with regard to providing suitable foraging resources, as well as the presence of areas of woodland and other dense vegetation suitable for creation of holts, natal dens and/or laying-up areas (as described in Chanin, 2003).

Water vole

Water vole is legally protected and is also a Species of Principal Importance.

The Site was assessed for its potential to provide habitat that could support a population of water vole. This involved considering the size and connectivity of any watercourse present on site (or within the vicinity), as well as the potential presence of suitable foraging resources and burrowing substrate along the banks (as described in Strachan *et al*, 2011).

Invertebrates

A number of invertebrate species are legally protected and some are also Species of Principal Importance.

An assessment was made of the potential for habitats on site to support an assemblage of priority invertebrate species, by considering the provision of a mosaic of varied habitat and substrate types and nectar-rich flowering species.

Other priority faunal species

Drawing upon information that was collected during the desk study, an assessment was made of the potential for the Site to support any other legally protected and/or Species of Principal Importance.

Limitations

While every effort has been made to provide a comprehensive description of the Site, this survey does not constitute a full botanical survey. Nevertheless, it is considered that the survey is sufficient quality to capture the overall character of the Site and all of the major vegetation communities.

To determine presence or likely absence of protected species usually requires multiple visits at suitable times of the year. As a result, this survey focuses on assessing the potential of the Site to support habitats and species of note, which are considered to be of principal importance for the conservation of biodiversity with reference to those given protection under UK or European wildlife legislation. This survey therefore cannot be considered a comprehensive assessment of the ecological interest of the Site. However, it does provide an assessment of the ecological interest present on the day the Site was visited and highlights areas where further survey work may be required.

Due to the ground being waterlogged in places it was not possible to safely access all areas for survey. The greatest limitation was in the broadleaved woodland in the south-east (including WB18) and the grassland immediately to the north. Although this prevented a detailed species list being collected it did not prevent a general assessment of the habitat type, nor has it prevented an accurate assessment of further work required.

The data from this survey is generally considered valid for a maximum of two years. Therefore, if more than two years elapse prior to commencement of the works, a repeat survey might be required to ensure up-to-date information is available to inform decisions.

3.2 Results

Habitats

The habitats present on site comprise:

- Semi-natural broadleaved woodland;
- Parkland and scattered trees – broadleaved;
- Parkland and scattered trees – mixed;
- Semi-improved neutral grassland;
- Marsh/marshy grassland;
- Improved grassland;
- Swamp;
- Standing water;
- Running water;
- Intact hedge native species poor;
- Defunct hedge native species poor; and
- Bare ground.

Further details are provided below. Habitat distribution is illustrated on Figure 3.1, and target notes are presented in Appendix C.

Semi-natural broadleaved woodland

Wet broadleaved woodland, comprising a mixture of ages of tree, was well established in the south-east corner of the site. The soil was waterlogged (limiting the extent of the survey to the northern half where it could be safely accessed). Within the visible northern areas there was a limited understorey with a sparse ground flora, that included tufted hairgrass. To the south, although not accessible, the ground flora has a thin pond-sedge and tussock-sedge flora, with a thin reed cover. Tree species present in both areas were dominated by mature poplars, with occasional willow and alder, over patches of grey willow and with occasional hawthorn trees. A large pond was found in this area (see Standing water).

In the north of the woodland a fenced off area was used for a pheasant pen (Target Note 1, Figure 3.1). This area was cleared, and grasses had grown up in the space fenced off by Heras fencing.

Parkland and scattered trees broadleaved

Lines of semi-mature willow up to 4 m tall were present along some of the ditches. There were also several mature pedunculate oak trees in fields. These are estimated to be well over 100 years old, and had grown to around 15 m.

Parkland and scattered trees mixed

A short line (approximately 60 m) of mixed coniferous and broadleaved trees was present at the northern end of the site. This included Scots pine, willow species and Lombardy poplar.

Semi-improved neutral grassland

This habitat was found within the central portion of the site. It was dominated by hard rush and cock's-foot, which was quite tussocky in places. The fields are likely grazed but this does not appear to be limiting the rush growth, which had a sward height of up to 500 mm. Other species frequently found were dandelion, black thistle, meadow buttercup and more occasionally black sedge.

Marsh/marshy grassland

Marshy grassland was present on inundated soil in two locations: one towards the northern end and one in the south-west corner of the site. The habitat was dominated by sedges and rushes, including great wood-rush, black sedge, pendulous sedge, and hard rush. Grass species included sweet vernal grass and Yorkshire fog. Other species included water mint, marsh-marigold, meadowsweet, curled dock, sphagnum moss and cuckooflower. This grassland appeared relatively unmanaged at the time of the survey, in most areas, had grown to around 500 mm in height.

The northern patch graded into improved grassland with more dandelion, red dead-nettle, silverweed and fleabane present. There were patches of very boggy ground (Target Note 2, Figure 3.1), with other areas markedly drier (Target Note 3, Figure 3.1).

Improved grassland

This habitat covered much of the south-central area of the site, and it was also present at the very northern end. It was markedly drier than the marshy grassland and much of it appeared managed by grazing, and was no more than 100-250 mm tall. It was mostly dominated by annual meadow grass and cock's-foot with sections of abundant hard rush where the ground was damper and it graded into marsh/marshy grassland (e.g. Target Note 5, Figure 3.1) with meadow foxtail. In these areas the vegetation was up to 500 mm in height. Other species frequently found were spear thistle, dandelion, broad-leaved dock, purple dead-nettle, common mouse ear, daisy and meadow buttercup.

Swamp

To the north-east of the woodland was an area of sedge swamp (Target Note 4, Figure 3.1). Due to the ground conditions this could not be accessed at the time of the survey but during previous visits (January 2021) it consisted mainly of pond sedges with common reed colonising, and encroachment by grey willow.

Standing water

A network of ditches ran throughout the site. Some of these were completely open whilst others were partially covered by water mint. Water in most of the ditches was shallow, up to 250 mm deep. At the margins were water-loving herbs and trees including willow and black sedge. There was a culvert over one of the southern ditches to enable access to that end of the site (Target Note 6, Figure 3.1). At the southern end of the site, within the southern deciduous woodland block, was a large pond. This was largely open water, with some fringing common reed at the margins, and shading from overhanging trees.

Running water

The Pakenham Stream forms the eastern boundary of the site. It is maximum of 4-5 m wide and appears to be up to 1m deep.

Intact hedge, native species-poor

Functioning hedgerows were found along the boundary of the access tracks. These were dominated by hawthorn, itself supporting ivy, with occasional hornbeam and spindle. The hedges were more managed than those found on the main part of the site and have been maintained at around 2 m height.

Defunct hedge native species-poor

The majority of the hedgerows on the site appear unmanaged and the species within them (e.g. oak) have grown to their full height, creating gaps between the trees and shrubs. Each hedgerow had a fence running through or adjacent, to provide the boundary function that the hedge once would have. The hedgerows were hawthorn dominated with frequent bramble, hornbeam and oak. The hedges were generally around 3-4 m tall, though the mature trees had grown up to 15 m.

Bare ground

Bare ground was present on site, represented by the compacted earth tracks on the access routes and a cleared area in one of the fields (Target Note 7, Figure 3.1). Much of this was devoid of vegetation but the areas outside the wheel tracks (i.e. the centre and verges) was improved grassland with annual meadow grass, cock's-foot, common nettle and cow parsley.

Protected and notable species

Badger

No evidence of badgers was found during the survey, although they are likely to be present in the vicinity of the site, given its rural location, and they may use the site in future.

Bats (all species)

There were many mature oak and hornbeam trees in the hedgerows, woodland and individually in the fields, which were of sufficient age and size to support roosting bats. The habitats around these trees (hedgerows and linear water features) link them well to foraging areas increasing the likelihood bats roost in some of the trees.

The mixture of vegetation types and waterbodies is likely to support a large diversity and volume of invertebrates whether they roost on the site or offsite for example in nearby farm buildings. Hedgerows, ditches, lines of scattered trees and the stream adjacent to the site create good navigational aides for bats to commute along. Overall these features make up continuous high-quality habitats for bats to use and therefore the site is high suitability for foraging and commuting bats following the Bat Conservation Trust Guidance (Collins, 2016).

Nesting birds

There is general nesting bird potential in the woodland, the hedgerows and parkland and scattered trees, as well as the grassland that occur across the site. Cuckoo were heard calling throughout the site, and lapwing were seen in the grasslands at the northern end.

Great crested newt

The ditch network and single pond on site, and ponds off site, could potentially support breeding great crested newts. Great crested newts could use tree and hedgerow roots to hibernate. Potential refugia were present including two wood piles were found, one located in the pheasant pen (See Target Note 1, Figure 3.1) and one in the middle of the field (Target Note 8, Figure 3.1).

Reptiles

The habitats present on-site (grassland, hedgerows and water) provide foraging habitat, whilst the roots of trees and hedgerow along with the wood piles found at Target Notes 1 and 8 (Figure 3.1) provides suitable hibernation areas. Grass snake is often found in aquatic environments and the ditches provide a suitable foraging ground.

Hazel dormouse

There are no records of dormouse within 1 km of the site. The habitats on the site (woodland, some scattered trees and hedgerows) provide suitable foraging habitat albeit a limited diet given the lack of floral diversity noted.

Otter

The water bodies on and around the site provide habitats for otter to feed, and opportunities for them to build holts nearby. There is an otter record from near to the site indicating otter are likely in the area.

Water vole

The stream and ditches on and around the site provide a network of waterbodies where water voles could feed under cover and/or escape into the water as needed. Most of the banks had a steep profile such that water voles could access them without their burrows being regularly submerged. There is a water vole record from near to the site indicating they are likely in the area.

Other species – Terrestrial Invertebrates

The mix of habitats on-site including marshy grassland through to woodland provides a variety of niches for terrestrial invertebrates. A diverse community including notable species is possible.

Other species – Aquatic Invertebrates

The waterbodies on site would be expected to support a range of aquatic invertebrate species, potentially including some notable species.

Other priority faunal species

During the survey several brown hares (priority species) were seen in the fields.

Controlled species

During the survey no controlled species were noted. However, the presence of legally controlled species cannot be ruled out on the basis of this survey alone.

592500 593000 593500 594000

269000 268500 268000

N

A143

Old Hall Farm

Grimstone End

The Black Bourn

Broadway

Fen Rd

Pakenham Fen

1 2 3 4 5 6 7 8

Key

- Site 54 boundary
- Broadleaved woodland - semi-natural
- Neutral grassland - semi-improved
- Improved grassland
- Marsh/marshy grassland
- Swamp
- Standing water
- Bare ground
- Parkland and scattered trees - broad-leaved
- Parkland and scattered trees - mixed
- Running water
- Intact hedge native species poor
- Defunct hedge native species poor
- Parkland and scattered trees- broad-leaved
- Target note

0 100 200 300 m

Scale at A3: 1:6,000

Fen Meadow Compensation Sites:
Pakenham Site 54

Figure 3.1
Phase 1 habitat Plan

June 2021

wood.

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Appendix A
Species Scientific Name

Table A1 Species Names

Common name	Scientific name
Plants	
Annual meadow grass	*Poa annua*
Broad leaved dock	*Rumex obtusifolius*
Canadian waterweed	*Elodea canadensis*
Cock's-foot	*Dactylis glomerata*
Common mouse ear	*Cerastium fontanum*
Common nettle	*Urtica dioica*
Common water-starwort	*Callitriche stagnalis*
Cornflower	*Centaurea cyanus*
Cow parsley	*Anthriscus sylvestris*
Cuckooflower	*Cardamine pratensis*
Curled dock	*Rumex crispus*
Daisy	*Bellis perennis*
Dandelion	*Taraxacum agg.*
Dwarf spurge	*Euphorbia exigua*
Fleabane	*Pulicaria sp.*
Great wood-rush	*Luzula sylvatica*
Hard rush	*Juncus erectus*
Hawthorn	*Crataegus monogyna*
Hornbeam	*Carpinus betulus*
Lombardy poplar	*Populus nigra italica*
Marsh-marigold	*Caltha palustris*
Meadow buttercup	*Trifolium dubium*
Meadow foxtail	*Alopecurus pratensis*
Meadowsweet	*Filipendula ulmaria*

Common name	Scientific name
Nuttall's waterweed	*Elodea nuttalli*
Pedunculate oak	*Quercus robur*
Pendulous sedge	*Carex pendula*
Red dead-nettle	*Lamium purpureum*
Scots pine	*Pinus sylvestris*
Silverweed	*Argentina anserina*
Soft brome	*Bromus hordeaceus*
Spear thistle	*Cirsium vulgare*
Sphagnum moss	*Sphagnum sp*
Spindle	*Euonymus europaeus*
Sweet vernal grass	*Anthoxanthum odoratum*
Water mint	*Mentha aquatica*
Willow	*Salix sp*
Yorkshire fog	*Holcus lanatus*
Mammals	
American mink	*Mustela vison*
Badger	*Meles meles*
Brown Hare	*Lepus europaeus*
Bat – brown long-eared	*Plecotus auritus*
Bat – Pipistrelle	*Pipistrellus pipistrellus*
Chinese muntjac	*Muntiacus reevesi*
Dormouse	*Muscardinus avellanarius*
Grey squirrel	*Sciurus carolinensis*
Harvest Mouse	*Micromys minutus*
Hedgehog	*Erinaceus europaeus*
Otter	*Lutra lutra*
Water Vole	*Arvicola amphibius*
Birds	
Avocet +	*Recurvirostra avosetta*

Common name	Scientific name
Bar-headed goose	*Anser indicus*
Barn Owl	*Tyto alba*
Barnacle goose	*Branta leucopsis*
Bewick's Swan +	*Cygnus columbianus*
Black Tern +	*Chlidonias niger*
Black-tailed godwit	*Limosa limosa*
Black-winged Stilt	*Himantopus himantopus*
Brambling +	*Fringilla montifringilla*
Bullfinch	*Pyrrhula pyrrhula*
Canada goose	*Branta canadensis*
Cuckoo	*Cuculus canorus*
Curlew	*Numenius arquata*
Egyptian goose	*Alopochen aegyptiaca*
Fieldfare +	*Turdus pilaris*
Grasshopper Warbler	*Locustella naevia*
Green Sandpiper +	*Tringa ochropus*
Greenshank +	*Tringa nebularia*
Grey Partridge	*Perdix perdix*
Grey Wagtail	*Motacilla cinereal*
Hobby	*Falco Subbuteo*
House Sparrow	*Passer domesticus*
Kingfisher	*Alcedo atthis*
Lapwing	*Vanellus vanellus*
Lesser Redpoll	*Acanthis cabaret*
Linnet	*Linaria cannabina*
Little Gull +	*Hydrocoloeus minutus*
Little Ringed Plover	*Charadrius dubius*
Marsh Harrier	*Circus aeruginosus*
Marsh Tit	*Poecile palustris*

Common name	Scientific name
Mediterranean Gull	*Ichthyaetus melanocephalus*
Merlin +	*Falco columbarius*
Mistle Thrush	*Turdus viscivorus*
Nightingale	*Luscinia megarhynchos*
Osprey +	*Pandion haliaetus*
Peregrine	*Falco peregrinus*
Pheasant	*Phasianus colchicus*
Pintail	*Anas acuta*
Pochard	*Aythya farina*
Red Kite	*Milvus milvus*
Red-necked Phalarope +	*Phalaropus lobatus*
Redwing +	*Turdus iliacus*
Reed bunting	*Emberiza schoeniclus*
Ringed Plover	*Charadrius hiaticula*
Ruddy duck	*Oxyura jamaicensis*
Ruddy shelduck	*Tadorna ferruginea*
Ruff	*Calidris pugnax*
Scaup +	*Aythya marila*
Skylark	*Alauda arvensis*
Snow goose	*Chen caerulescens*
Song Thrush	*Turdus philomelos*
Spotted Flycatcher	*Muscicapa striata*
Starling	*Sturnus vulgaris*
Temminck's Stint +	*Calidris temminckii*
Tree sparrow	*Passer montanus*
Turtle Dove	*Streptopelia turtur*
Whimbrel	*Numenius phaeopus*
Whinchat	*Saxicola rubetra*
White-fronted Goose	*Anser albifrons*

Common name	Scientific name
White-tailed Eagle +	*Haliaeetus albicilla*
Wood Sandpiper +	*Tringa glareola*
Woodcock	*Scolopax rusticola*
Woodlark	*Lullula arborea*
Yellow Wagtail	*Motacilla flava*
Yellowhammer	*Emberiza citrinella*
Herpetofauna	
Common Toad	*Bufo bufo*
Great Crested Newt	*Triturus cristatus*
Invertebrates	
Anaglyptus mysticus	*Anaglyptus mysticus*
Adonis ladybird	*Hippodamia variegata*
Cinnabar	*Tyria jacobaeae*
Ptinus sexpunctatus	*Ptinus sexpunctatus*
Red-tailed Mason Bee	*Osmia bicolor*
Small heath	*Coenonympha pamphilus*
White admiral	*Limenitis Camilla*
White-letter Hairstreak	*Satyrium w-album*

Appendix B
Species Protection or Control Legislation

Great crested newts, bats, otter, dormouse

These species / species groups are listed in Schedule 5 of the *Wildlife and Countryside Act 1981* (as amended) and Schedule 2 of *The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019*. They are afforded full protection under Section 9(4) of the Act and Regulation 43 of the Regulations. These make it an offence, *inter alia*, to:

- Deliberately capture, injure or kill any such animal; and
- Deliberately disturb any such animal, including in particular any disturbance which is likely;
  - to impair its ability to survive, breed, or rear or nurture their young;
  - to impair its ability to hibernate or migrate; and
  - to affect significantly the local distribution or abundance of that species.
- Damage or destroy a breeding site or resting place of any such animal;
- Intentionally or recklessly disturb any of these animals while it is occupying a structure or place that it uses for shelter or protection (for bats this is taken to mean all bat roosts whether bats are present or not); or
- Intentionally or recklessly obstruct access to any place that any of these animals uses for shelter or protection.

In addition, five British bat species are listed on Annex II of the Habitats Directive. These are:

- Greater horseshoe bat (*Rhinolophus ferrumequinum*);
- Lesser horseshoe bat (*Rhinolophus hipposideros*);
- Bechstein's bat (*Myotis bechsteinii*);
- Barbastelle (*Barbastella barbastellus*); and
- Greater mouse-eared bat (*Myotis myotis*).

In certain circumstances where these species are found the Directive requires the designation of Special Areas of Conservation (SACs) by EC member states to ensure that their populations are maintained at a favourable conservation status. Outside SACs, the level of legal protection that these species receive is the same as for other bat species.

Badger

The *Protection of Badgers Act 1992* consolidates previous legislation (including the *Badgers Acts 1973* and the *Badgers (Further Protection) Act 1991*). It makes it an offence to:

- Kill, injure or take a badger;
- Attempt to kill, injure or take a badger; and
- To damage or interfere with a sett.

The 1992 Act defines a badger sett as "any structure or place which displays signs indicating current use by a badger".

Nesting Birds

With certain exceptions, all wild birds, their nests and eggs are protected by Section 1 of the *Wildlife and Countryside Act 1981* (as amended). Therefore, it is an offence, inter alia, to:

- Intentionally kill, injure or take any wild bird;
- Intentionally take, damage or destroy the nest of any wild bird while it is in use or being built; and
- Intentionally take or destroy the egg of any wild bird.

Bird species listed on Schedule 1 of the Act receive further protection, thus for these species it is also an offence to:

- Intentionally or recklessly disturb any bird while it is nest building, or is at a nest containing eggs or young; and
- Intentionally or recklessly disturb the dependent young of any such bird.

Reptiles

The four widespread species of reptile that are native to Britain, namely common or viviparous lizard (*Zootoca vivipara*), slow worm (*Anguis fragilis*), adder (*Vipera berus*) and grass snake (*Natrix natrix*), are listed in Schedule 5 of the *Wildlife and Countryside Act 1981* (as amended) and are afforded limited protection under Section 9 of this Act. This makes it an offence, inter alia, to:

- Intentionally kill or injure any of these species.

In addition sand lizard and smooth snake are listed in Schedule 5 of the *Wildlife and Countryside Act 1981* (as amended) and Schedule 2 of *The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019*: They are afforded full protection under Section 9(4) of the Act and Regulation 43 of the Regulations.

These make it an offence, inter alia, to:

- Deliberately capture, injure or kill any such animal;
- Deliberately disturb any such animal, in particular in such a way as to be likely to:
- Impair their ability to survive, breed or reproduce, or rear or nurture their young;
- Impair their ability to hibernate or migrate which could affect significantly the local distribution or abundance of that species;
- Damage or destroy a breeding site or resting place of any such animal;
- Intentionally or recklessly disturb any of these animals while it is occupying a structure or place that it uses for shelter or protection; or
- Intentionally or recklessly obstruct access to any place that any of these animals uses for shelter or protection.

The legislation applies to all life stages of these species.

Notifiable / Controlled Species

Schedule 9 of the *Wildlife and Countryside Act 1981* (as amended) lists species of animal that it is an offence to release or allow to escape into the wild (for example grey squirrel) and species of plant that it is an offence to plant or otherwise cause to grow in the wild (for example, Japanese knotweed).

Appendix C
Phase 1 Target Notes

Table C.1 Extended Phase 1 Survey Target Notes

Target Note no.	Ordnance Survey Grid Reference	Description
1	TL9301268057	Pheasant pen adjacent to woodland, ground flora is dominated by grasses and there is a pile of dead wood inside suitable for invertebrates, amphibians and reptiles.
2	TL9293768175	Patch of very boggy grassland which includes water mint and common water-starwort.
3	TL9289968238	Patch of drier grassland dominated by soft brome
4	TL9305468116	Area not accessed during this visit due to H&S concerns. However when accessed in January 2021, it was reported to consist of pond sedges with frequent common reed and occasional grey willow.
5	TL9315968194	Damp area of improved grassland grading into marsh/marshy grassland dominated by hard rush
6	TL9279168012	Concrete culvert over ditch
7	TL9311368395	Cleared area of bare ground at the end of an access track
8	TL9317868541	Pile of logs which has been burned but still offers a refugia for amphibians or reptiles.

APPENDIX D: WATER MONITORING SUMMARY – PAKENHAM SITE 54, APRIL 2021 – PRESENT (JULY 2021)

Technical note:
Sizewell C Fen Meadow Compensation
Water Monitoring Summary – Pakenham Site 54
April 2021 to July 2021

1. Introduction

The technical note summarises water monitoring data collected between April 2021 and July 2021 at the Pakenham Site (hereafter referred to as 'the Site') which has been identified as a potential fen meadow development area. This technical note is predominantly a factual presentation of the data rather than an interpretive report.

Figure 1.1 shows a map of the Site and the installations referred to in this technical note.

2. Groundwater Level Monitoring

Nine groundwater monitoring points were installed at the Site between 22nd and 26th March 2021. Seven shallow dipwells were installed to measure groundwater levels in the shallow superficial near surface deposits and three piezometers were installed to measure groundwater levels in the underlying sands and gravels. Two of the sands and gravels piezometers are nested (within the same borehole) with a dipwell. An installation summary is provided in Table 2.1 below.

Table 2.1 Summary of groundwater monitoring installations

Name	NGR	Datum: Metal Cover (mAOD)	Ground Level (mAOD)	Depth (m bgl*)	Diameter (mm)	Notes
PAK-BH-1	TL 93282 68982	32.986	31.871	5	19	
PAK-BH-2D	TL 93102 68394	33.652	32.222	33	19	Nested with BH-2S
PAK-BH-2S	TL 93102 68394	33.652	32.222	4	19	Nested with BH-2D
PAK-HA-1	TL 93319 68927	31.753	30.694	3	19	
PAK-HA-2	TL 93161 68834	31.656	30.654	3	19	
PAK-HA-3	TL 93262 68661	31.727	30.583	3	19	
PAK-HA-4A	TL 93168 68445	32.021	30.934	2	19	

Name	NGR	Datum: Metal Cover (mAOD)	Ground Level (mAOD)	Depth (m bgl*)	Diameter (mm)	Notes
PAK-HA-5	TL 92935 68197	31.859	30.905	2	19	
PAK-HA-6	TL 93075 68079	31.685	30.747	3	19	

*m bgl = metres below ground level

Each installation is fitted with a water level datalogger which will be downloaded on a quarterly basis. Table 2.2 and 2.3 summarises the data collected in April 2021. Hydrographs of groundwater levels are presented in Appendix A. Hydrographs, presenting both logger and manually collected data) for the installations are provided in Appendix A (Combined Hydrograph Figures A1 to A4), Appendix B (Individual Groundwater Hydrographs Figures B1-B18) and Appendix C (Individual Surface Water Hydrographs Figure C1 to C5). Note that in Appendix B there are a combination of hydrographs providing both absolute water levels and depth to water table.

Table 2.2 Site 54 Groundwater Levels (m bgl and mAOD)

Date	PAK-BH-1	PAK-BH-2D	PAK-BH-2S	PAK-HA-1	PAK-HA-2	PAK-HA-3	PAK-HA-4	PAK-HA-5	PAK-HA-6
m bgl									
28/04/21	2.24	0.61	3.23	2.14	2.1	1.05	1.58	2.14	1.1
14/05/21	2.605	0.8	2.553	1.115	1.12	1.114	1.58	1.405	1.134
11/06/21	2.72	1.03	0.735	1.432	1.359	1.262	1.802	1.543	1.258
12/07/21	2.335	1.22	3.67	2.2	2.21	1.22	1.745	2.17	1.095
mAOD*									
28/04/21	30.389	32.959	30.131	29.522	29.427	30.482	30.386	29.677	30.424
14/05/21	30.381	32.852	31.099	30.638	30.536	30.573	30.441	30.516	30.551
11/06/21	30.381	32.622	32.917	30.321	30.297	30.425	30.219	30.378	30.427
12/07/21	30.294	32.349	29.691	29.462	29.317	30.312	30.221	29.647	30.429

*m AOD = metres above ordnance datum
Note: negative m bgl value indicates positive hydrostatic pressure

3. Surface Water Level Monitoring

Five gaugeboards were installed between 22nd and 26th March 2021 to allow monitoring of surface water levels in site watercourses / drains. All gaugeboards included stilling wells and water level data loggers. An installation summary is given in Table 3.1 below.

Table 3.1 Summary of gaugeboard installations

Ref.	GPS Grid Ref.	Bottom of Gaugeboard Datum (mAOD*)	Gaugeboard Length (m)	Datalogger	Log Interval (minutes)
PAK-GB01	TL93239 68817	29.027	2	Yes (install in May 2021)	15
PAK-GB02	TL93064 68381	31.2	2	Yes (install in May 2021)	15
PAK-GB03	TL93175 68400	29.917	2	Yes (install in May 2021)	15
PAK-GB04	TL92873 67891	31.084	2	Yes (install in May 2021)	15

*mAOD = metres above ordnance datum

Table 3.2 summarises the gaugeboard water level readings taken between April 2021 and June 2021. The water level at all gaugeboard locations is continuously monitored and are downloaded on a monthly basis during spot gauging visit. Hydrographs of surface water levels are presented in Appendix C, and in combination with groundwater hydrographs in Appendix A (data are currently available to mid June 2021).

Table 3.2 Surface Water Levels (mAOD)

Date	PAK-GB01	PAK-GB02	PAK-GB03	PAK-GB04
14/04/21	30.372	31.475	29.917	31.084
14/05/21	27.695	31.452	30.382	31.955
11/06/21	27.783	31.4	30.32	31.908

*Manual reading from dip point (no gaugeboard or datalogger).

4. Spot Flow Gauging

Monthly spot flow gauging of six locations commenced in April 2021. Results to date are shown in Table 4.1 below.

Table 4.1 Spot Flow (m^3/s)

Date	PAK-SF01	PAK-SF02	PAK-SF03	PAK-SF04	PAK-SF05	PAK-SF06
14/04/21	0.0502	0.0003	0.0201	0.1602	0.0701	0.1102
14/05/21	-0.0286	0.0002	0.0164	0.1538	0.0540	0.1106
11/06/21	0.0376	0.0	0.0064	0.1208	0.0440	0.1008

5. Water Quality Monitoring

In-situ water quality readings are collected from all groundwater and surface water installations on a monthly basis. *In-situ* water quality results are presented in Table 5.1 below.

In addition to this, water quality samples have been collected quarterly at selected locations and sent for laboratory analysis. Quarterly sampling was undertaken in April 2021, with the next samples collected in July 2021 being analysed. Available results for key water quality parameters indicative of nutrient enrichment, and its source (nitrate, phosphate and chloride), are presented in Table 5.2.

Table 5.1 In-situ Water Quality Results

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
14/05/21	PAK_BH1	8.90	8.60	718.00	7.20	-85.20	12.00
11/06/21	PAK_BH1	11.40	19.40	705.00	7.14	-140.60	12.40
12/07/21	PAK_BH1	13.90	300.00	707.00	6.86	121.10	>1050
28/04/21	PAK_BH2_d	10.30	41.30	694.20	7.23	111.90	268.00
14/05/21	PAK_BH2_d	14.90	25.00	703.00	7.39	-84.00	5.43
11/06/21	PAK_BH2_d	19.30	44.30	675.00	7.45	-56.80	1.23
12/07/21	PAK_BH2_d	17.00	608.00	691.00	7.40	54.40	41.30
28/04/21	PAK_BH2_s	9.20	27.00	1154.00	6.98	92.50	>1050
14/05/21	PAK_BH2_s	9.80	13.90	1368.00	6.94	-44.00	51.61
11/06/21	PAK_BH2_s	19.80	88.10	4.30	7.51	-65.00	0.95
12/07/21	PAK_BH2_s	16.50	321.00	1440.00	6.83	86.90	>1050
28/04/21	PAK_HA1	10.60	13.70	682.00	7.12	59.40	>1050
14/05/21	PAK_HA1	12.30	49.80	678.00	7.37	-83.10	56.18
11/06/21	PAK_HA1	n/a	n/a	n/a	n/a	n/a	n/a
12/07/21	PAK_HA1	14.00	500.00	678.00	7.00	-59.80	>1050
28/04/21	PAK_HA2	10.60	19.80	766.00	6.74	-35.20	790.00
14/05/21	PAK_HA2	11.80	50.10	794.00	7.08	-114.20	128.70
11/06/21	PAK_HA2	15.50	40.80	797.00	6.90	-116.50	325.21

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
12/07/21	PAK_HA2	15.40	259.00	750.00	6.66	-122.60	>1050
14/05/21	PAK_HA3	12.50	42.40	568.00	7.48	-113.60	50.60
11/06/21	PAK_HA3	18.20	42.70	572.00	7.46	-105.10	95.14
12/07/21	PAK_HA3	15.10	274.00	573.30	7.31	-125.70	255.00
28/04/21	PAK_HA4	10.10	22.20	573.70	6.99	34.60	6.82
11/06/21	PAK_HA4	17.30	53.30	1537.00	7.15	-21.30	1778.23
12/07/21	PAK_HA4	14.90	424.00	1410.00	7.15	-96.40	>1050
28/04/21	PAK_HA5	9.20	36.10	778.00	7.21	68.60	>1050
14/05/21	PAK_HA5	12.80	58.00	845.00	7.32	99.30	80.13
11/06/21	PAK_HA5	16.80	60.10	925.00	7.17	-92.00	122.03
12/07/21	PAK_HA5	15.90	147.00	974.00	6.85	-90.90	>1050
14/05/21	PAK_HA6	12.80	53.00	661.00	7.60	-81.00	30.00
11/06/21	PAK_HA6	16.40	43.10	654.00	7.18	-104.00	55.49
28/04/21	PAK_STR	12.40	97.00	814.00	7.43	80.40	2.40
12/07/21	PAK_STR	16.60	83.80	872.00	7.40	-69.10	25.50
14/05/21	PAK-GB01	11.80	56.10	807.00	7.31	-136.70	0.59
11/06/21	PAK-GB01	16.20	27.60	756.00	7.29	3.10	-0.84
28/04/21	PAK-GB02	10.80	64.10	761.00	7.27	80.60	>1050
14/05/21	PAK-GB02	14.30	59.60	731.00	7.41	-35.80	223.00
12/07/21	PAK-GB02	Dry	Dry	Dry	Dry	Dry	Dry
28/04/21	PAK-GB03	11.50	106.70	689.00	7.43	81.00	12.20
14/05/21	PAK-GB03	11.10	65.10	754.00	7.38	56.60	1.32
11/06/21	PAK-GB03	14.20	31.00	705.00	7.22	-73.00	6.00
12/07/21	PAK-GB03	15.70	402.00	732.00	7.25	35.70	8.69

Date	Ref.	Temp (°C)	Diss. Oxygen (%)	Conductivity (SPC)	pH	Redox (ORP)	Turbidity (NTU)
14/05/21	PAK-GB04	13.30	87.40	565.00	7.67	-66.00	54.80
11/06/21	PAK-GB04	18.00	16.60	596.00	7.19	24.90	0.15

cns = could not sample. Insufficient water / blockage

Table 5.2 Results for key water quality parameters

Location ID	Date	Chloride (mg/l)	Nitrate as NO3)mg/l)	Phosphate (Ortho as PO4 mg/l)
PAK-BH2D	26/04/2021	26.4	33.7	<0.05
PAK-BH2S	26/04/2021	97.7	99.7	<0.05
PAK-HA-5	26/04/2021	22.7	0.334	<0.05
PAK-HA-1	26/04/2021	27.5	<0.3	<0.05
PAK-HA-2	26/04/2021	18.4	1.63	0.273
PAK-HA-4	26/04/2021	34	0.427	<0.05
PAK-GB-2	26/04/2021	31.4	<0.3	0.602
PAK - GB_3	26/04/2021	35.6	50.4	<0.05
PAK - STR	26/04/2021	63.1	36.4	0.958
PAK - GB_3_D	26/04/2021	35.5	50.8	<0.05

6. LIDAR Data

To aid interpretation of the data, two LIDAR plots have been added in Appendix D. The first (D1) illustrates available data on a graded scale and the second (D2) provides the data sub-divided into elevation bands. The graded scale enables fine topographic features to be discerned, whilst the figure with data sub-divided into height bands enables identification of areas at broadly similar elevations.

Issued by	Approved by
Jon Mainhagu	**Ellie Creer**

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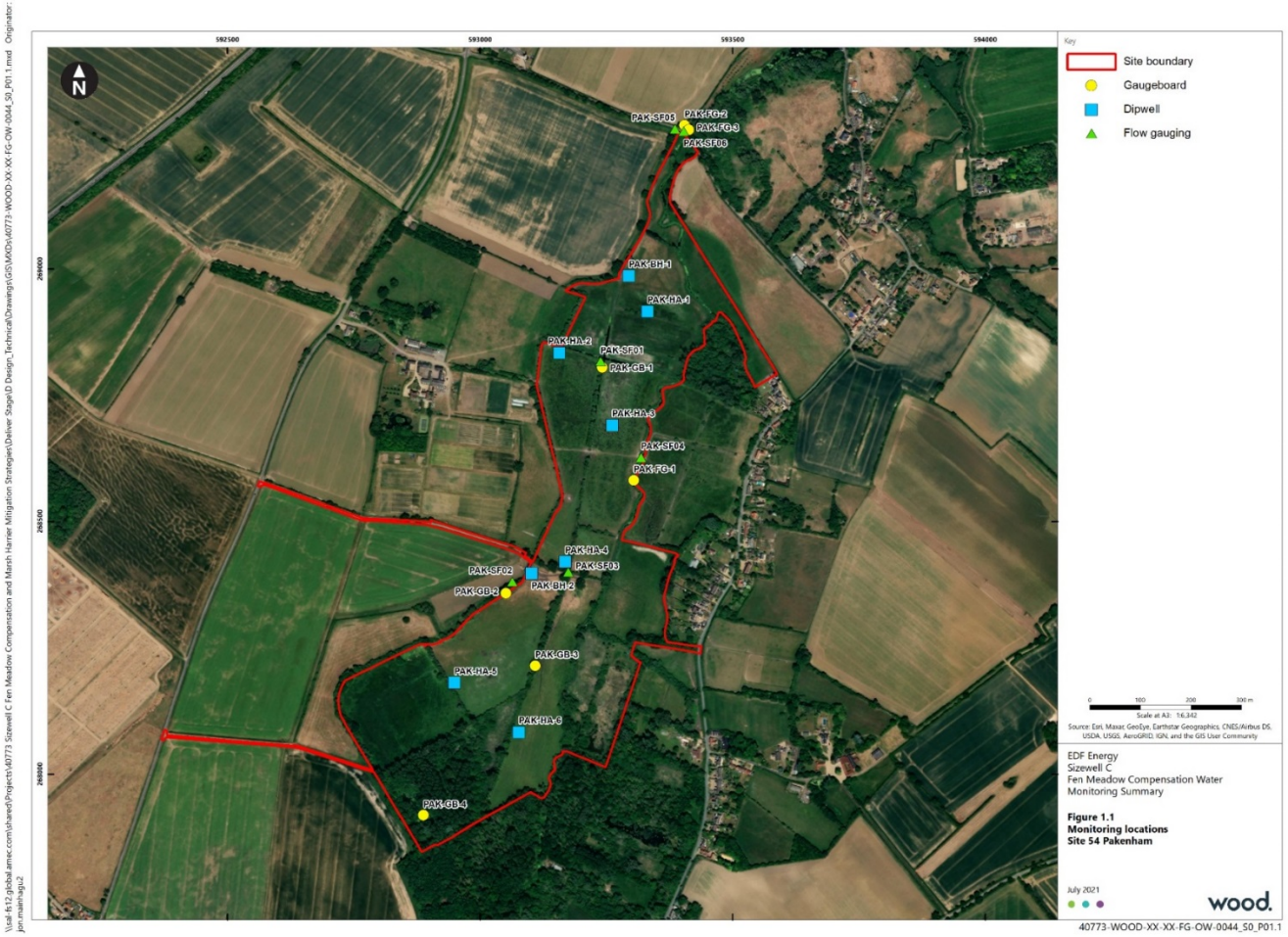
Management systems

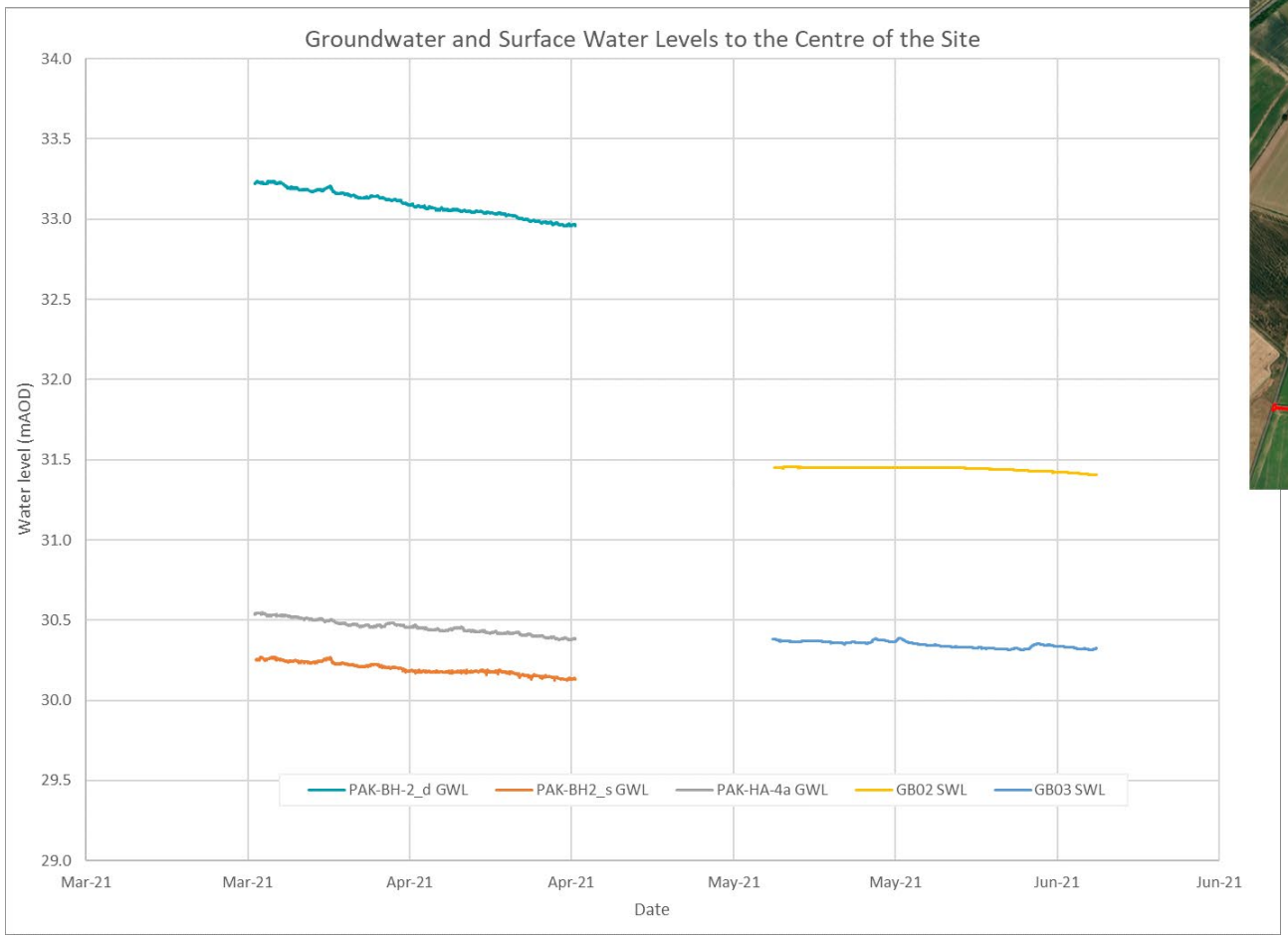
This document has been produced by Wood Group UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and ISO 45001 by Lloyd's Register.

Figure



Appendix A
Combined Hydrographs

A1



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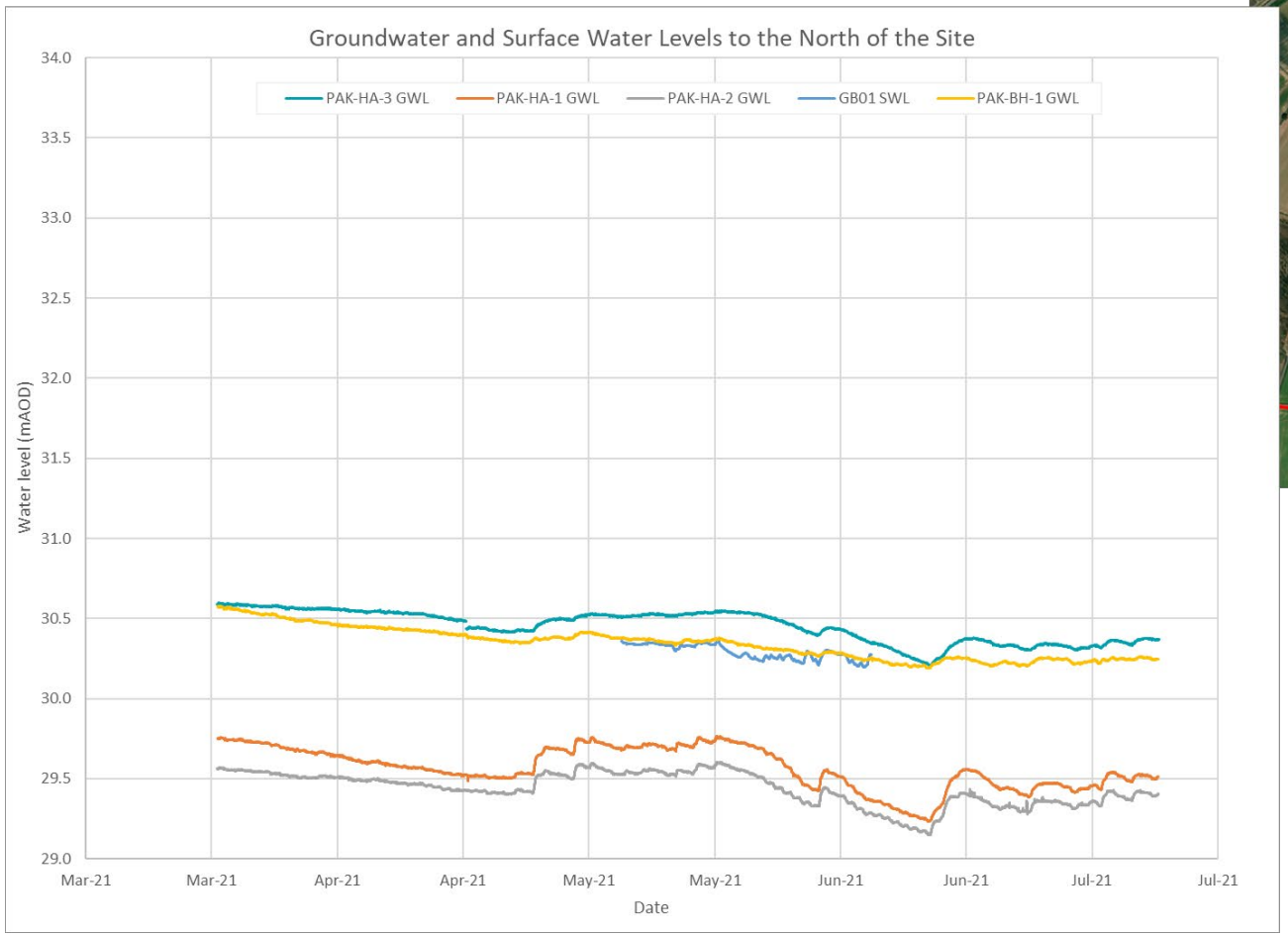
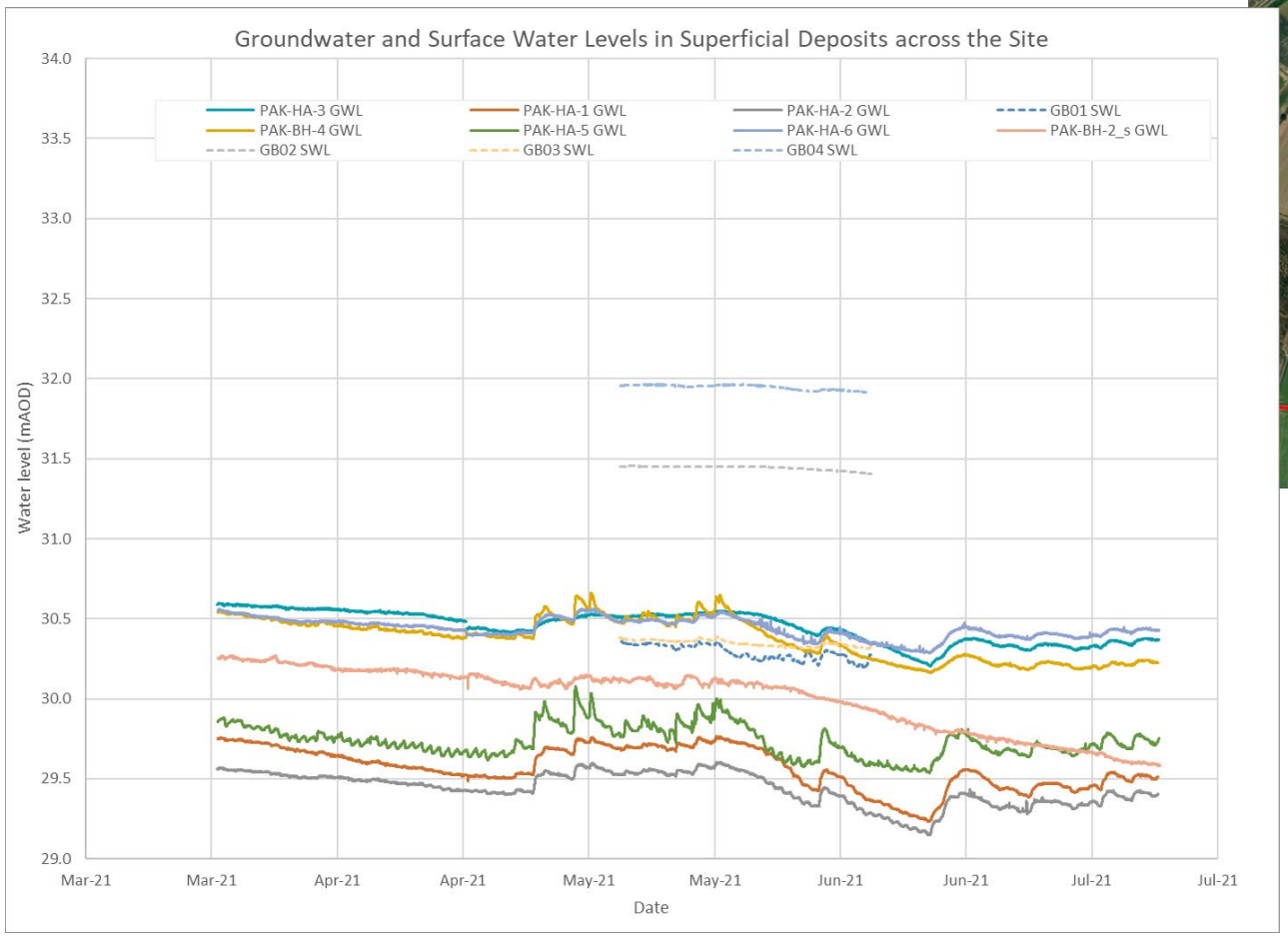


Portion of the site between HA3 and GB-1 was still saturated in water during April site visit, although overall weather was dry and hot

A3



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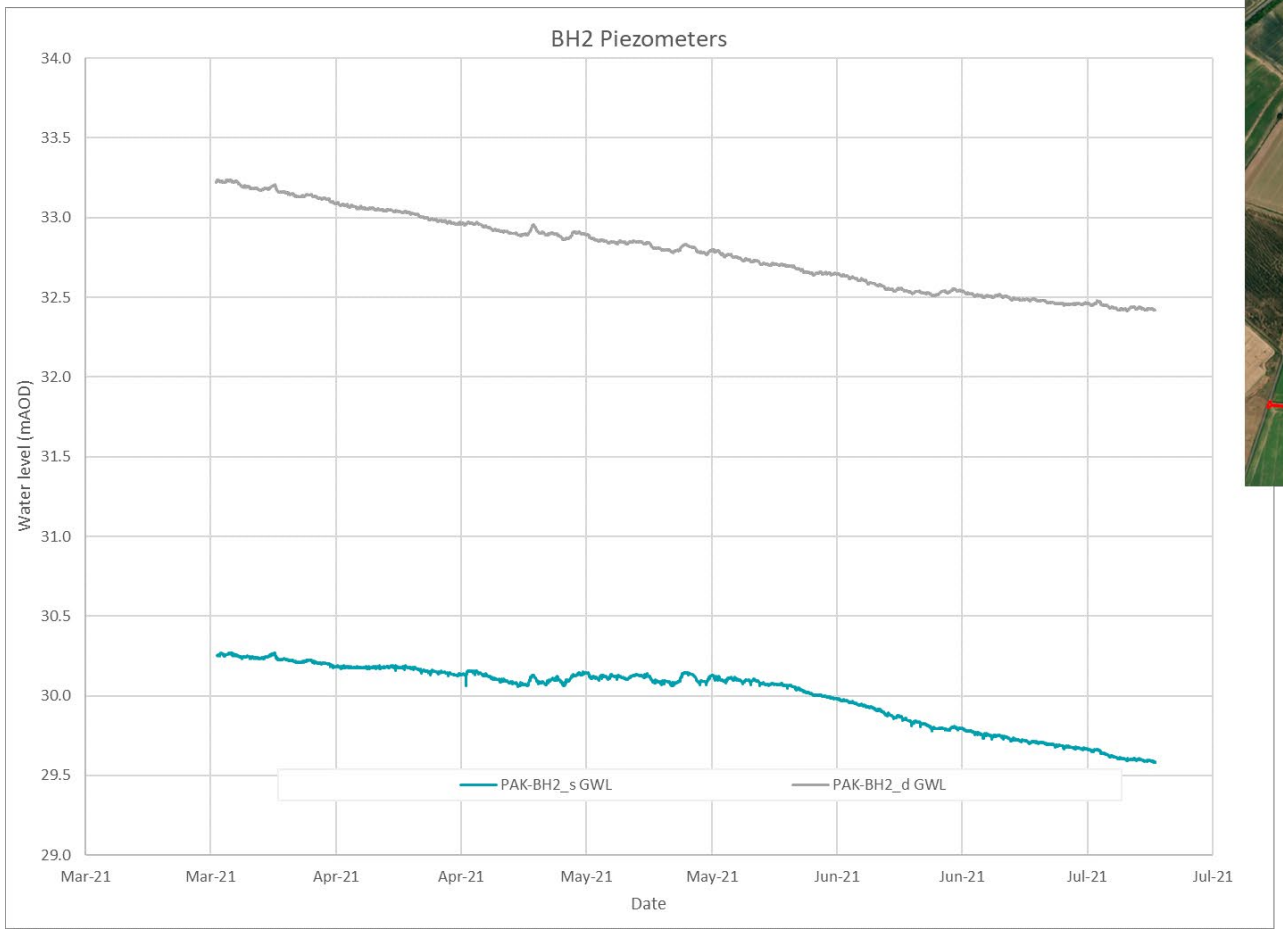
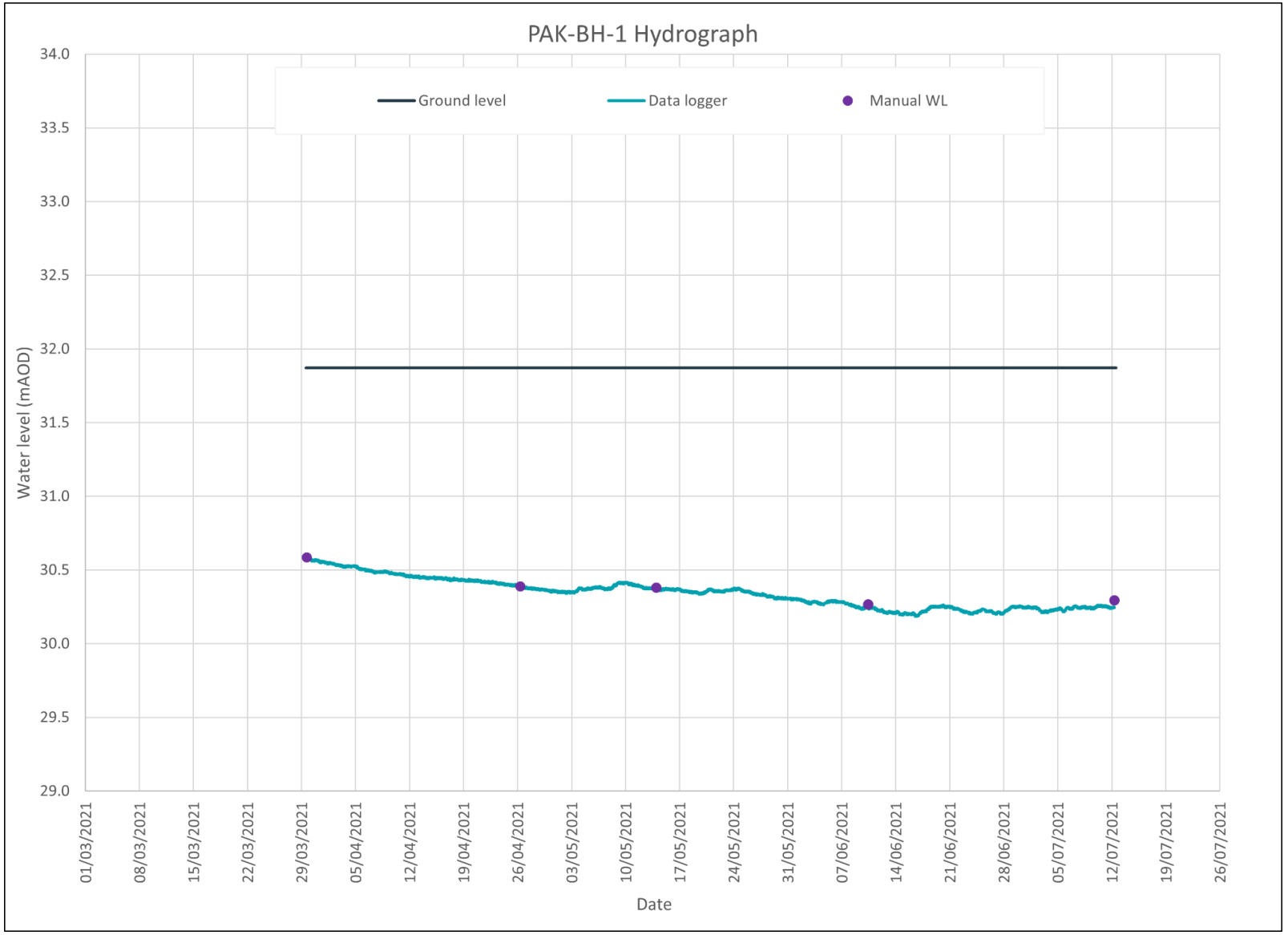


Appendix B
Groundwater Hydrographs

B1



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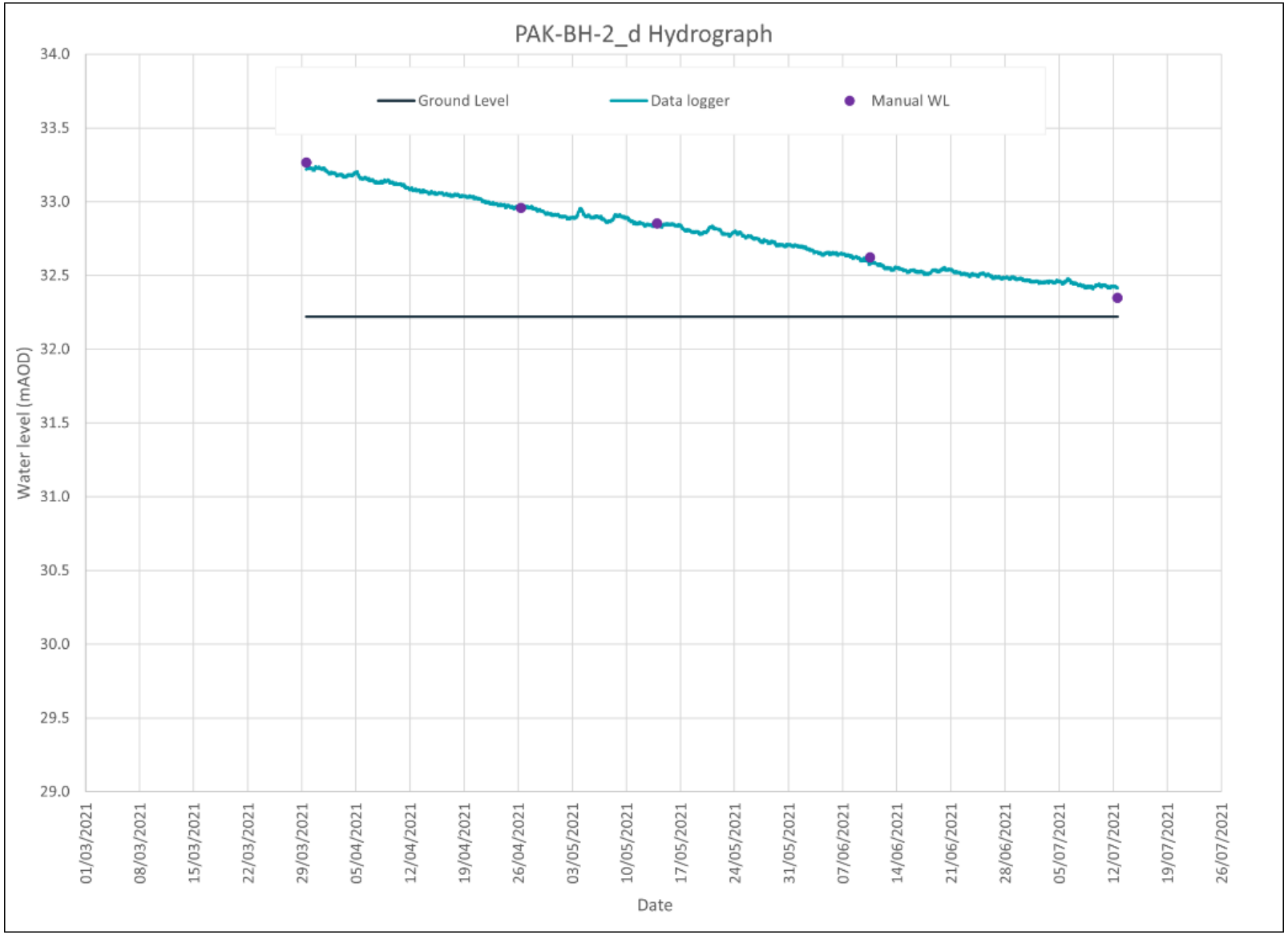

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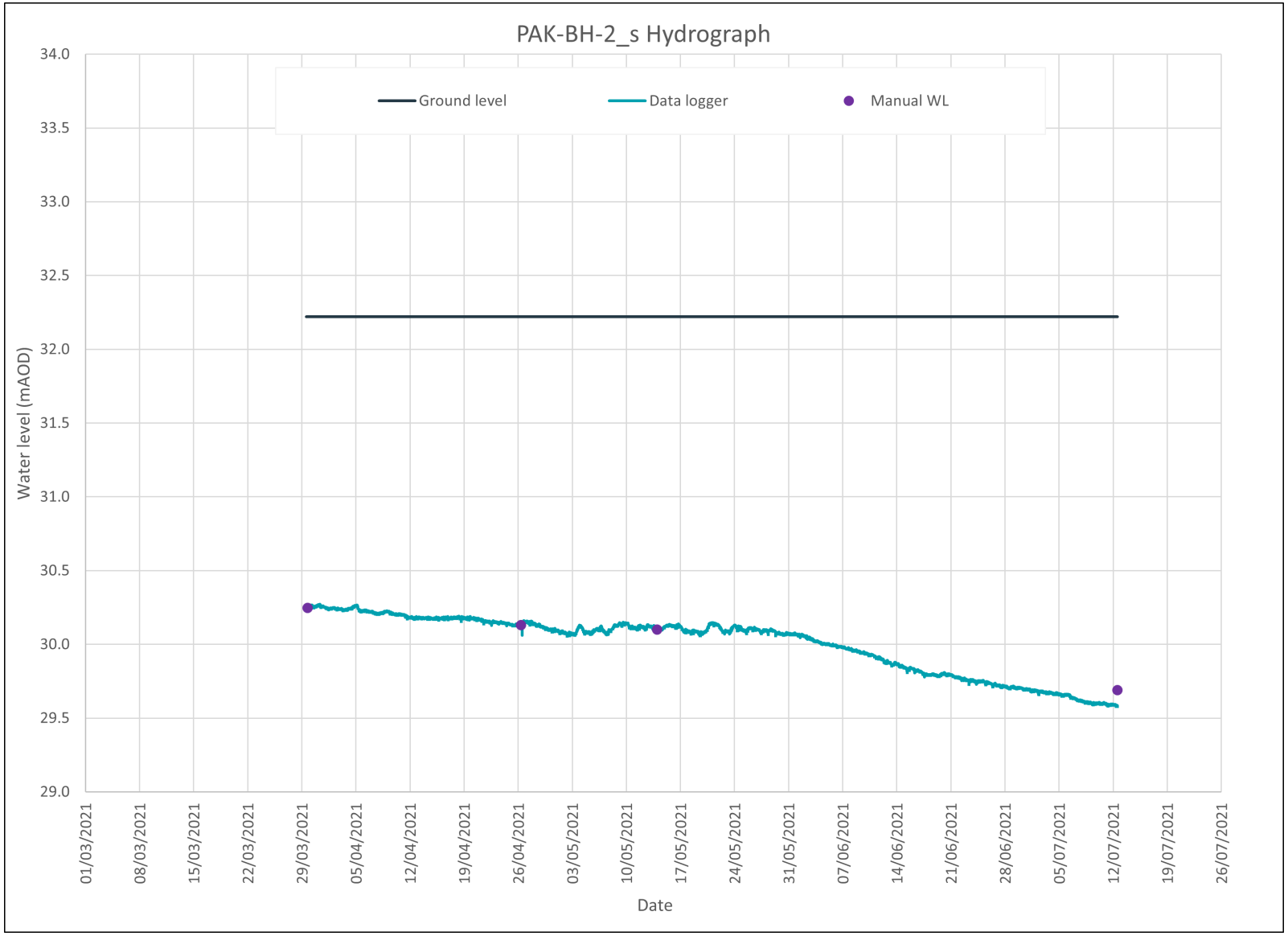

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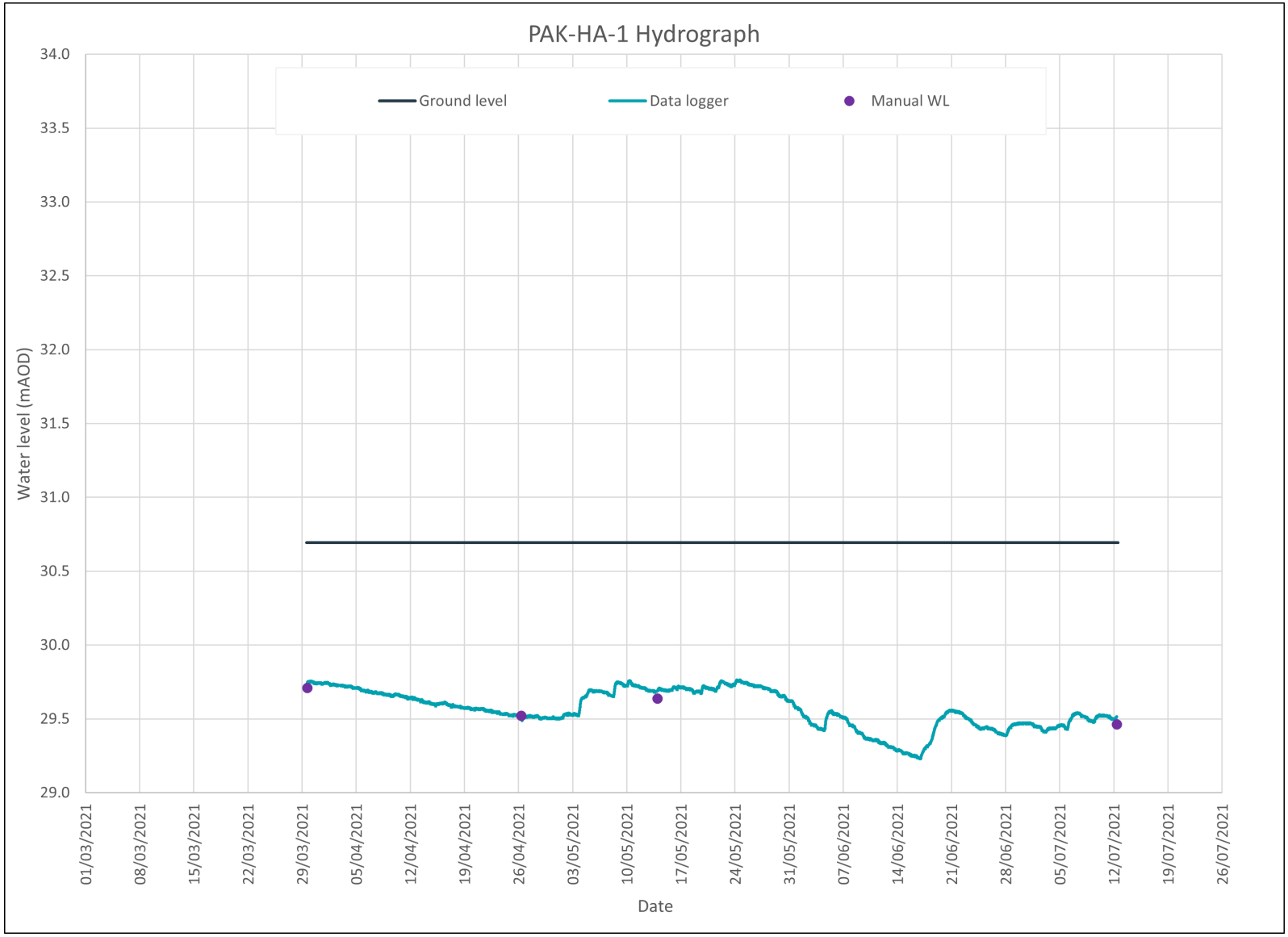

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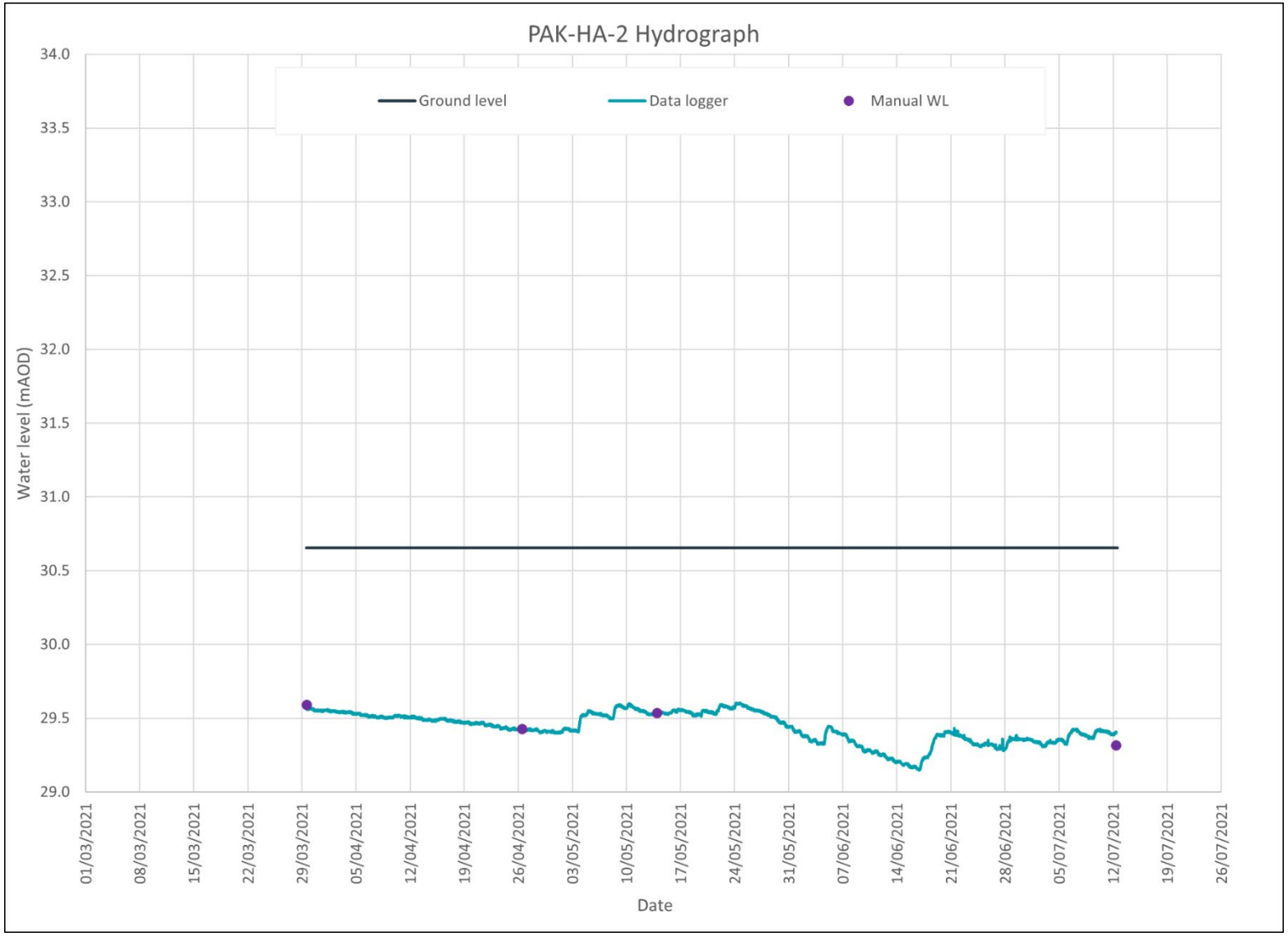

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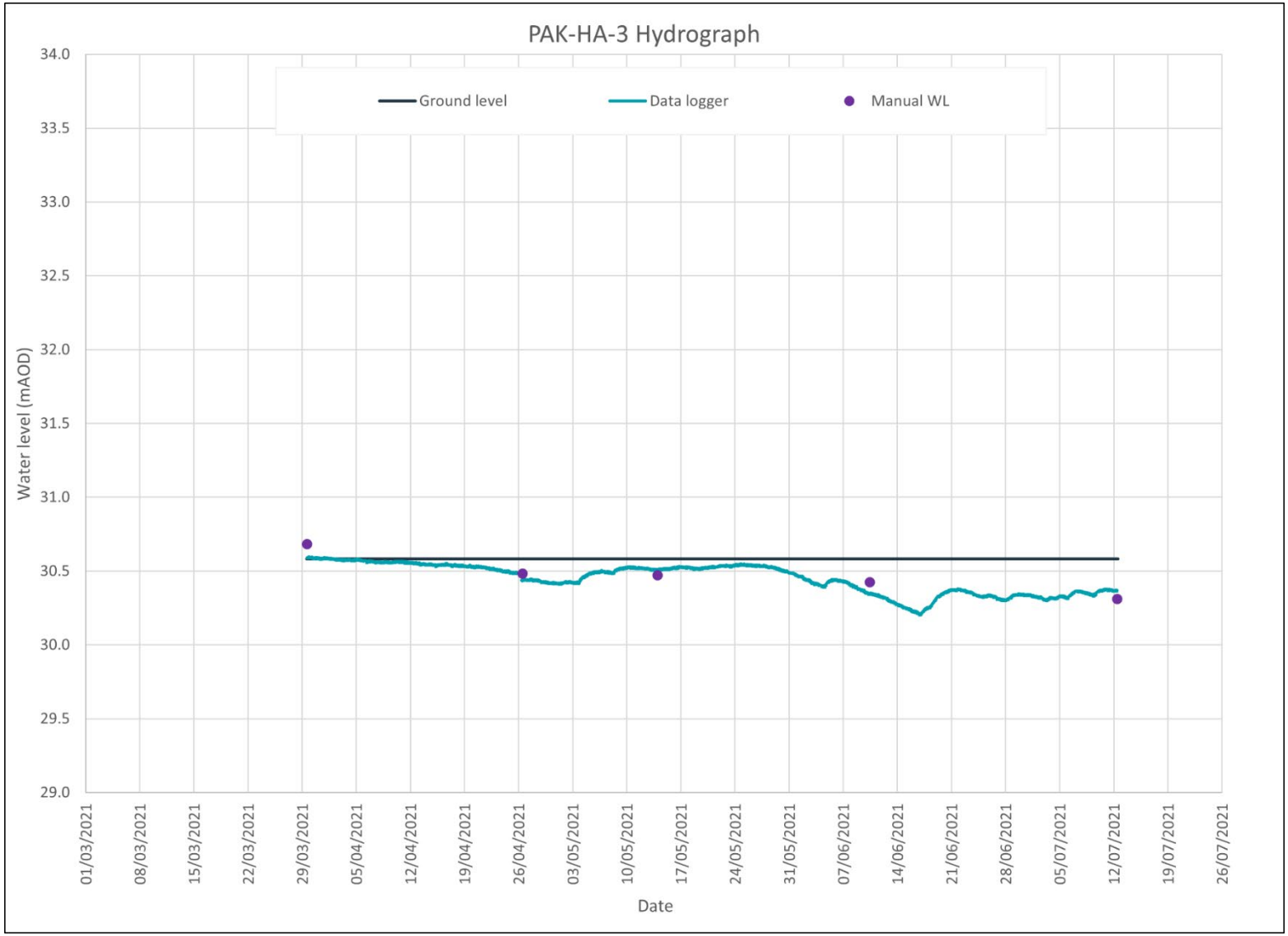

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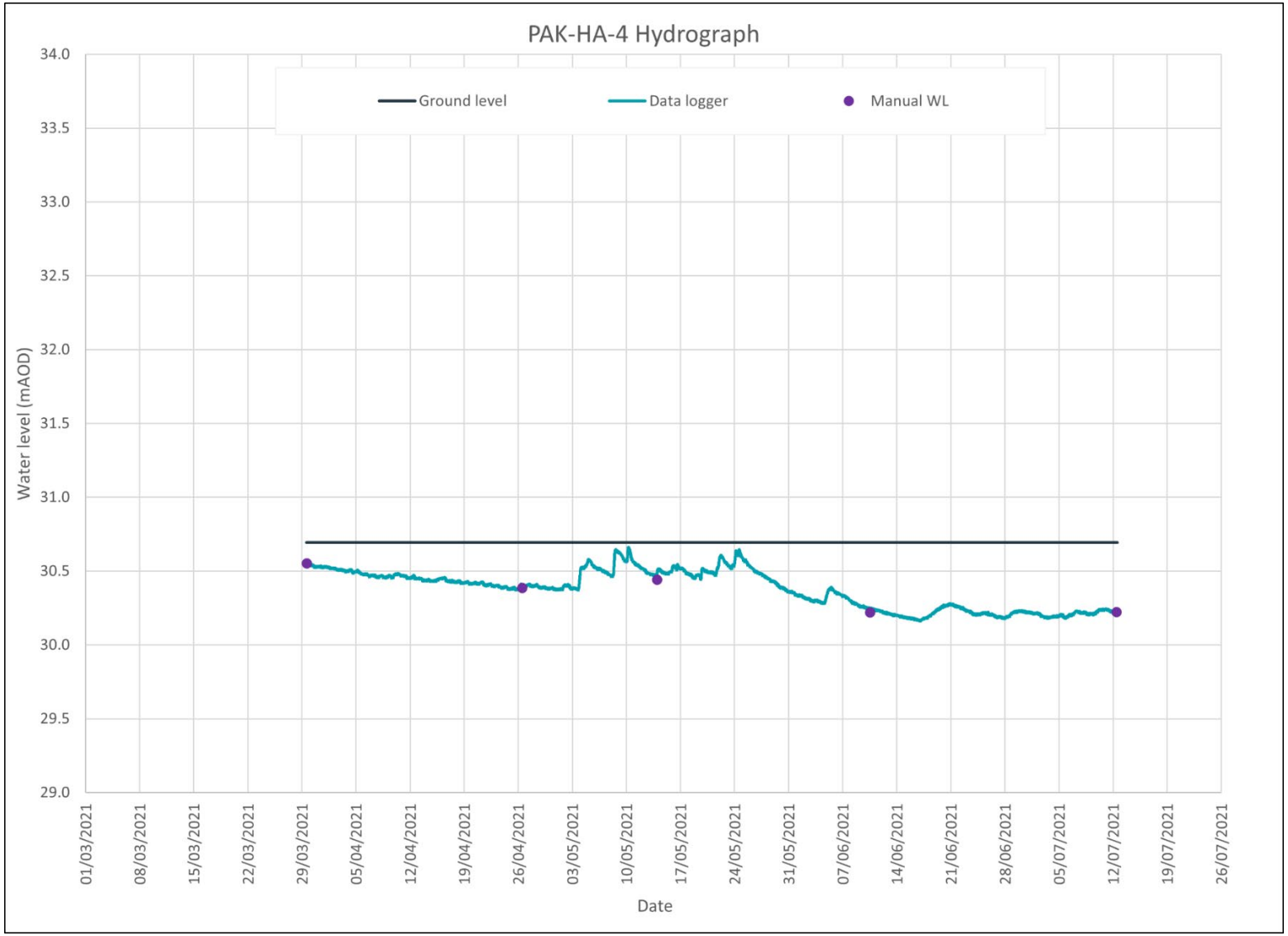

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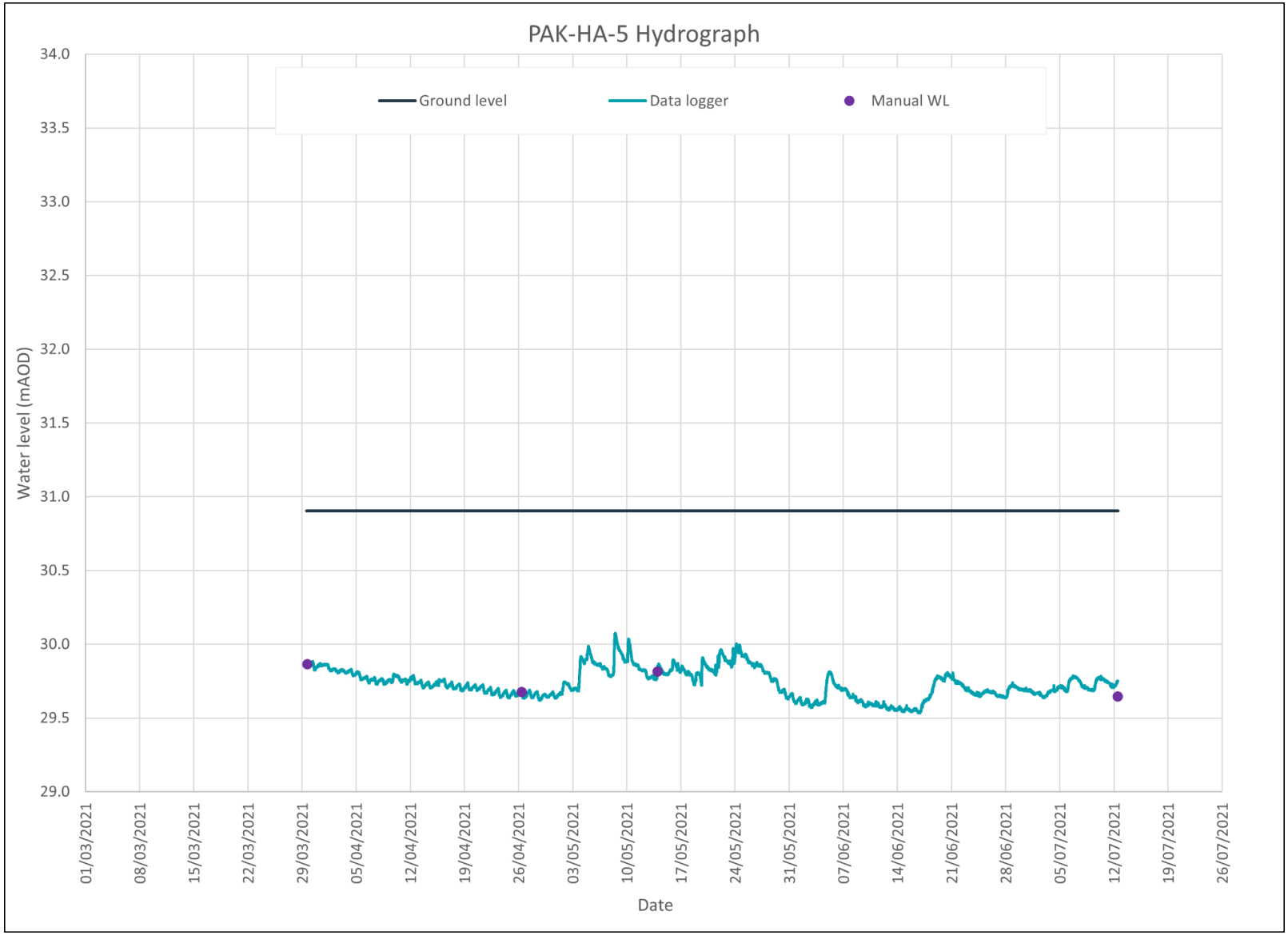

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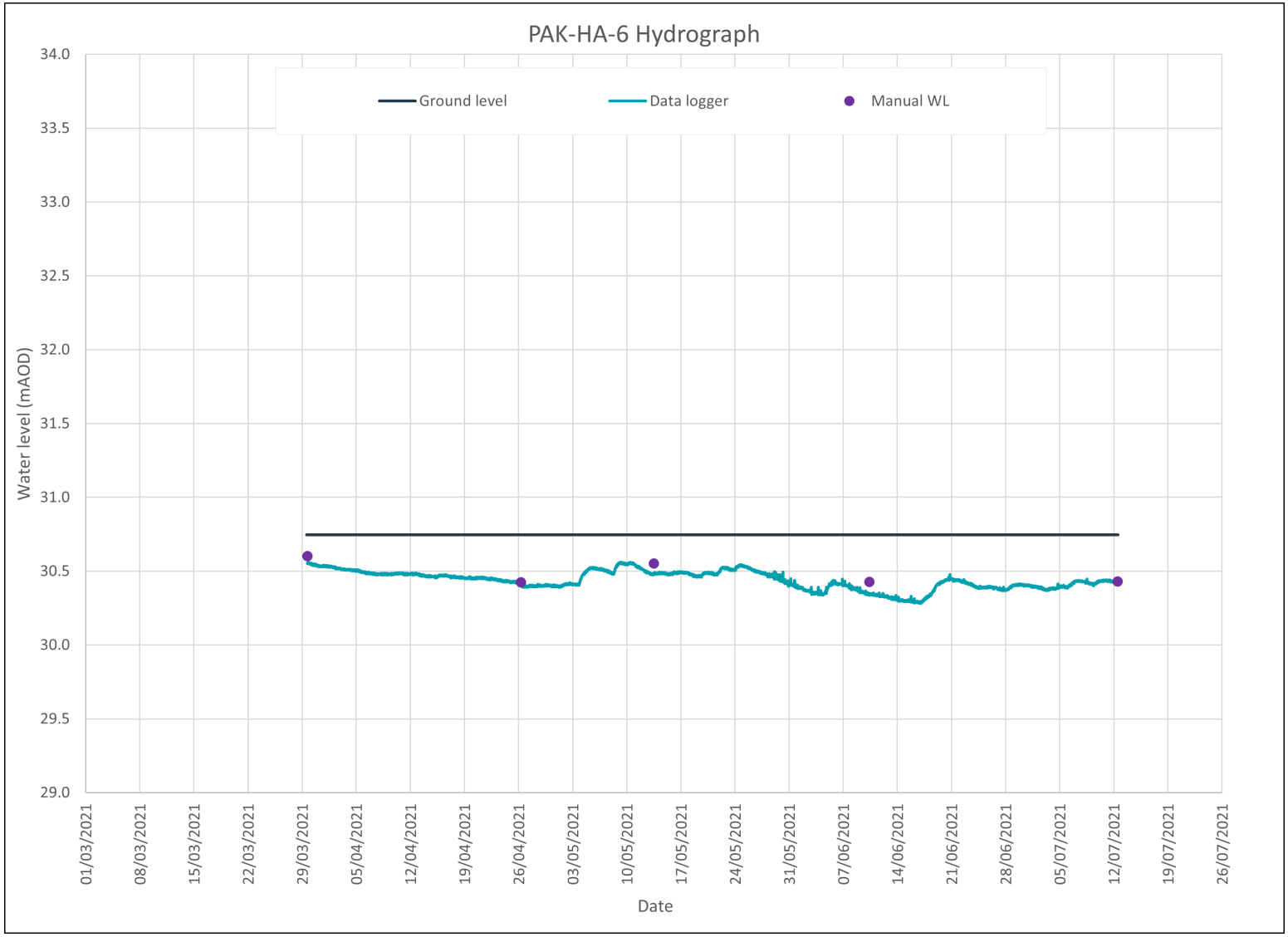

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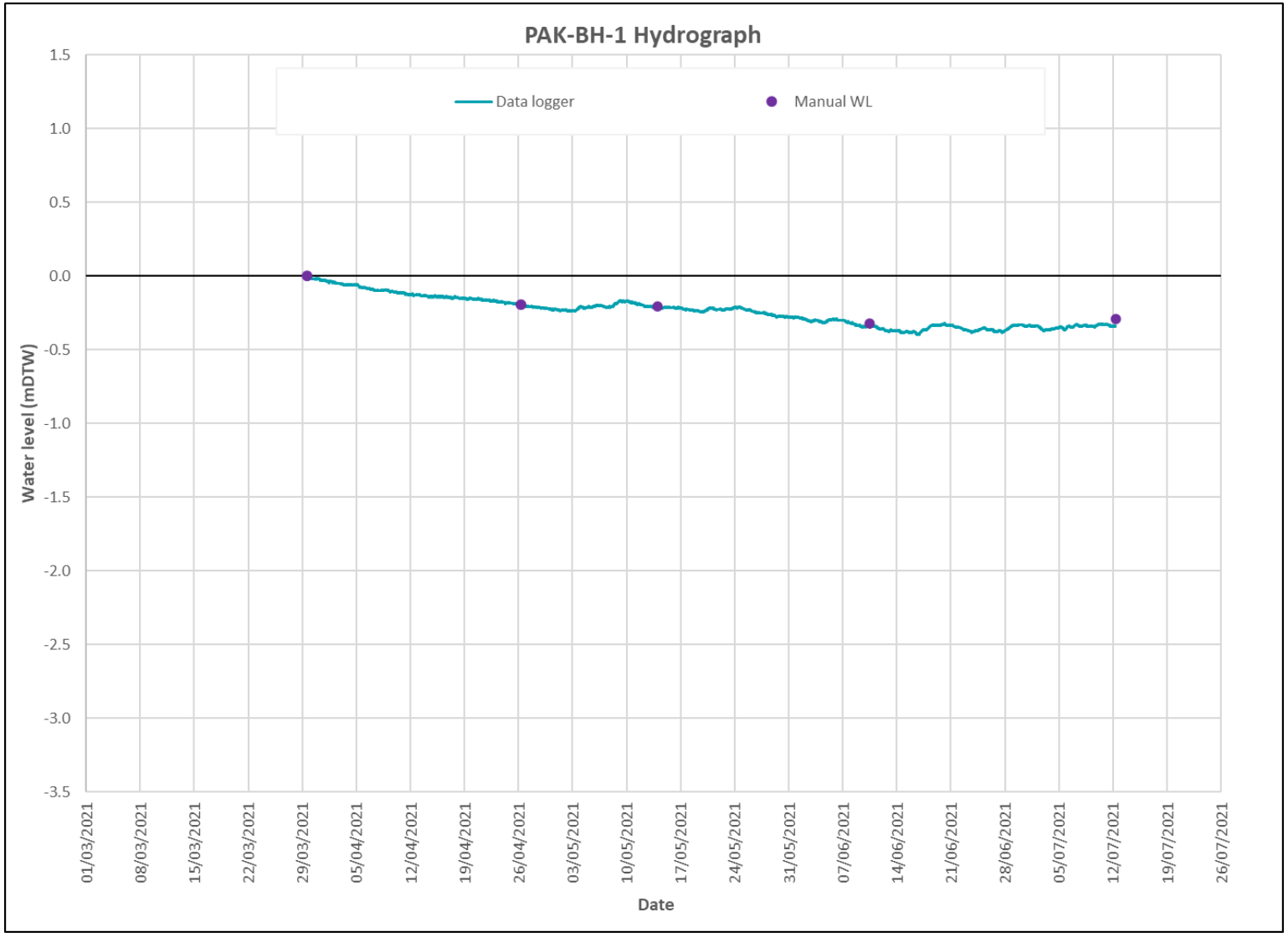

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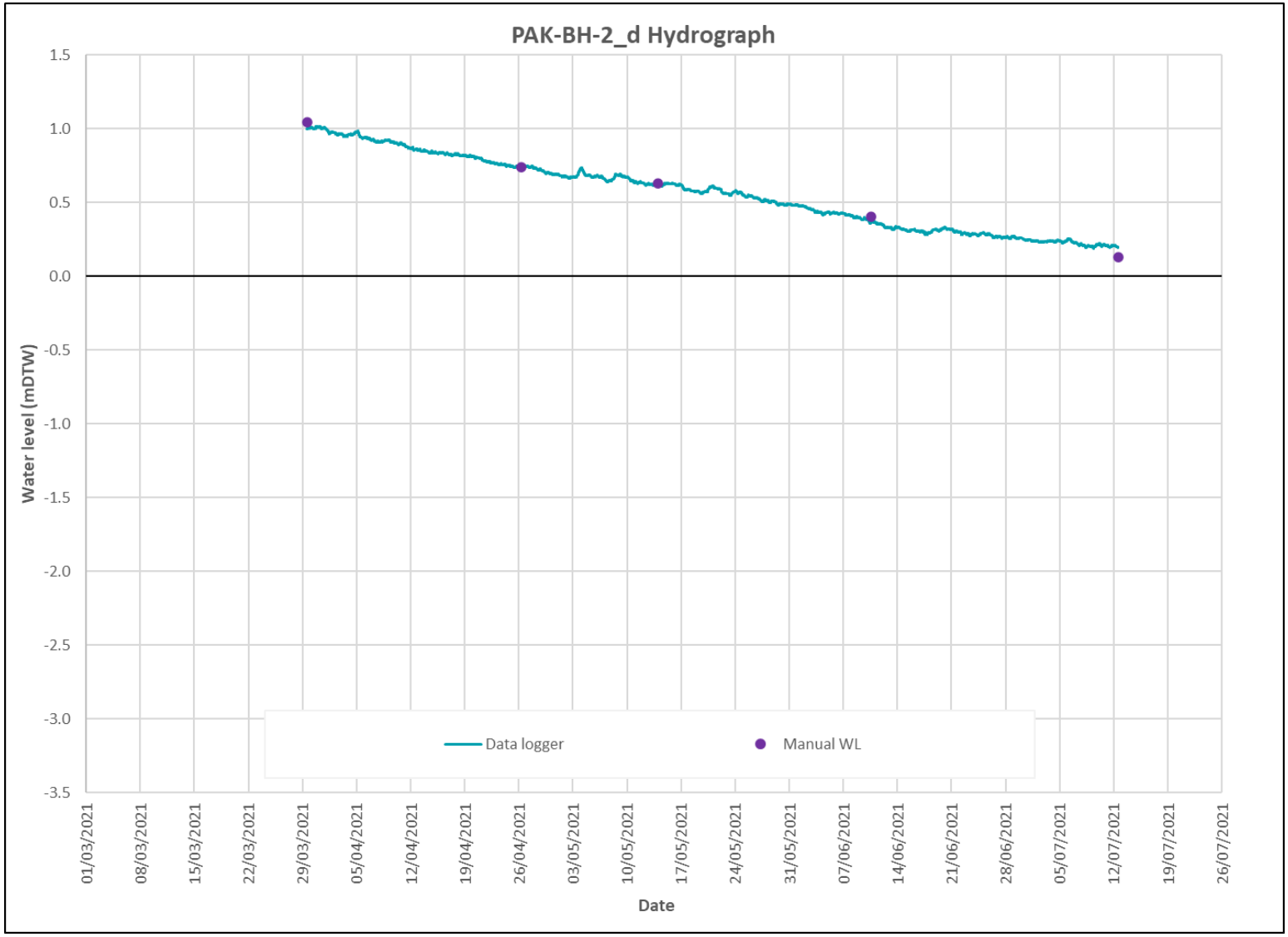

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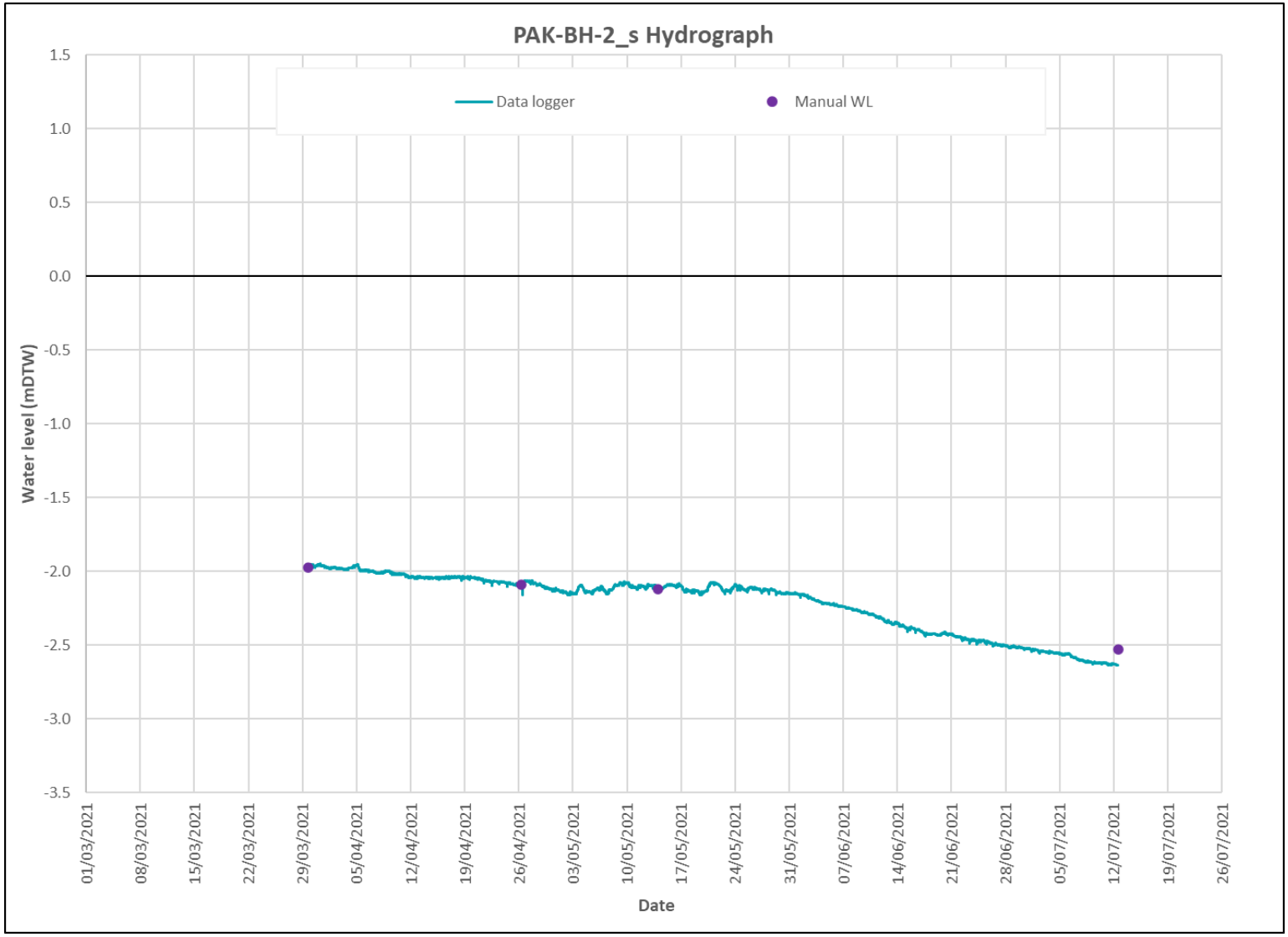

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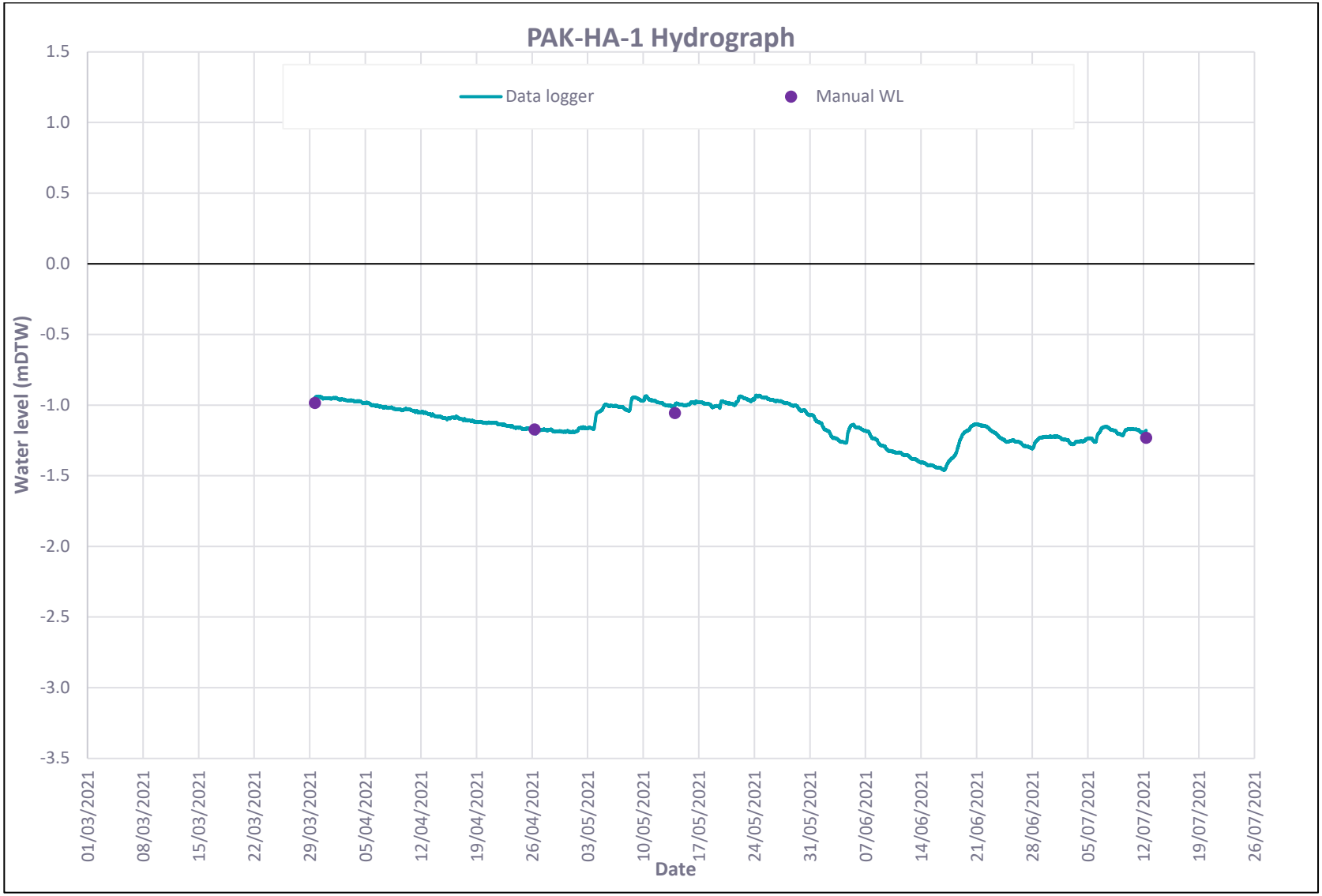

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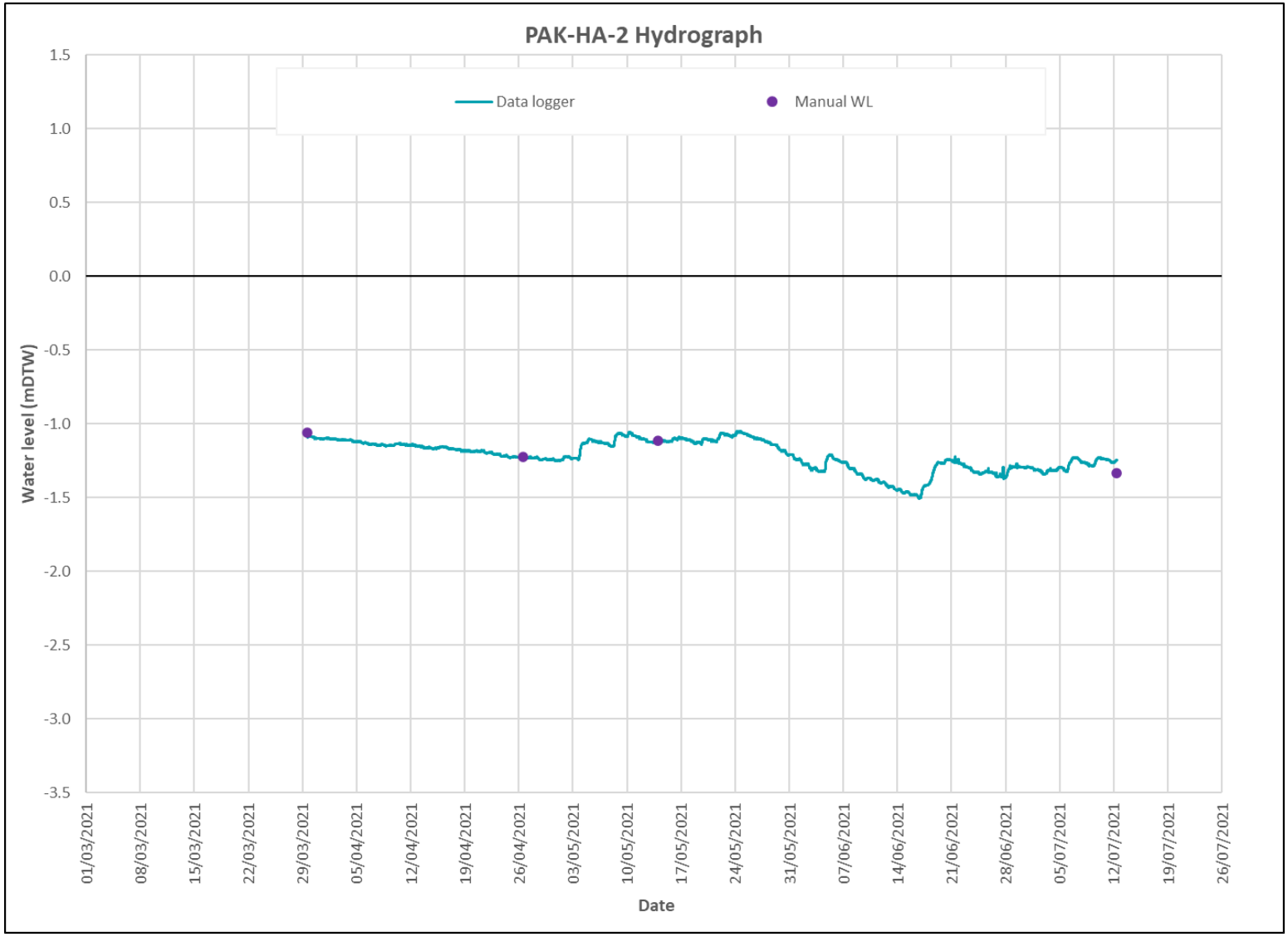

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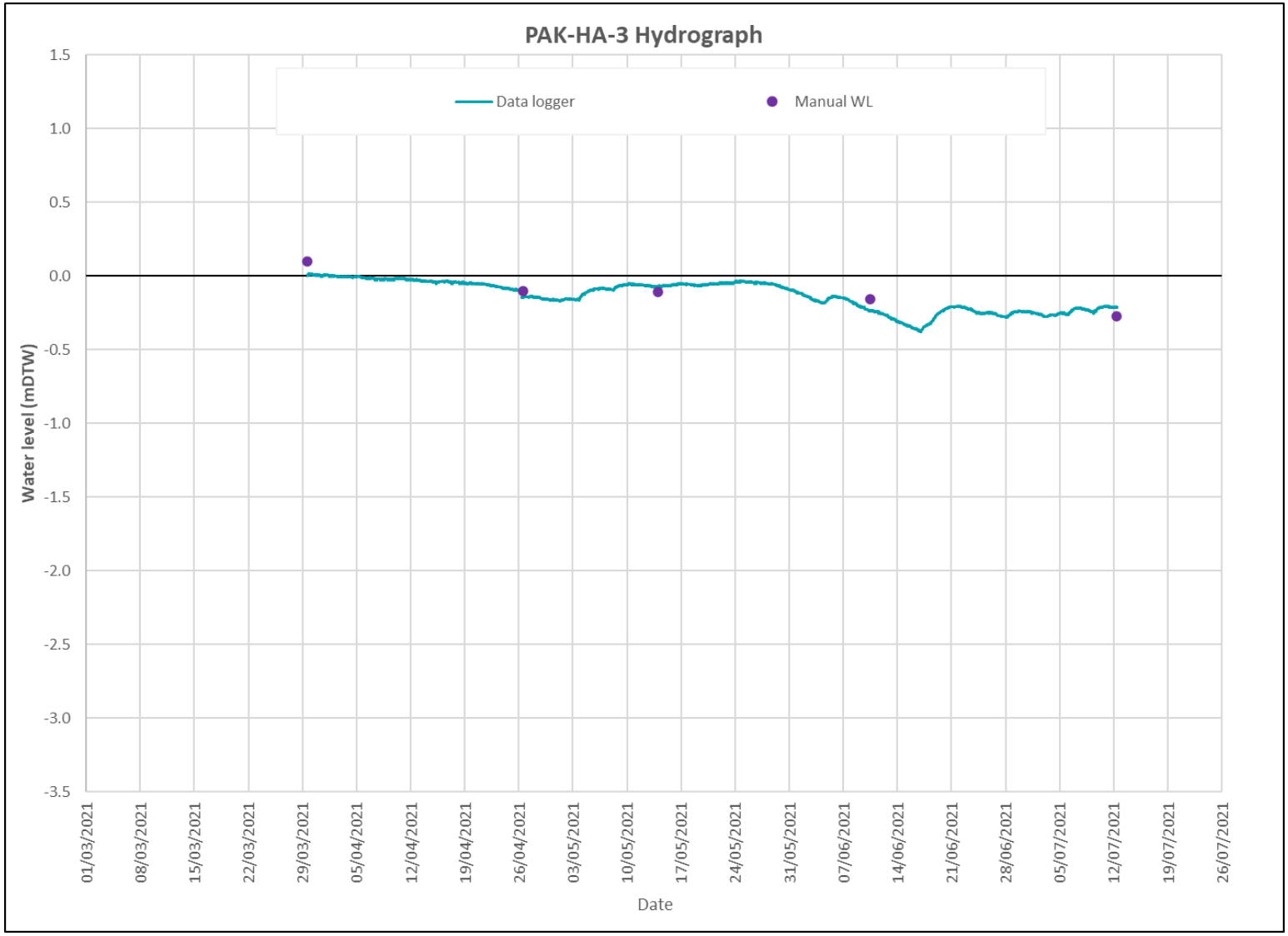

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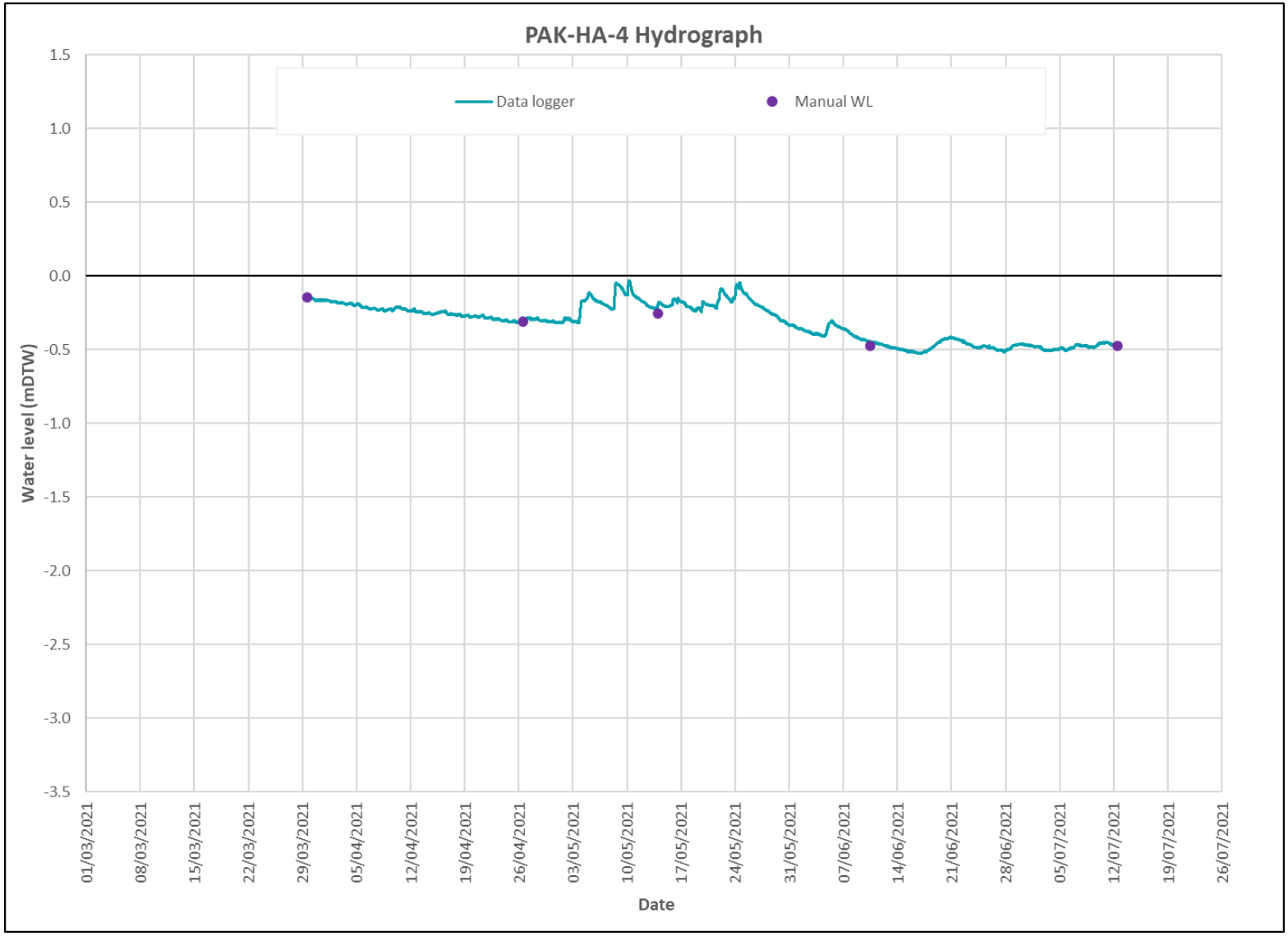

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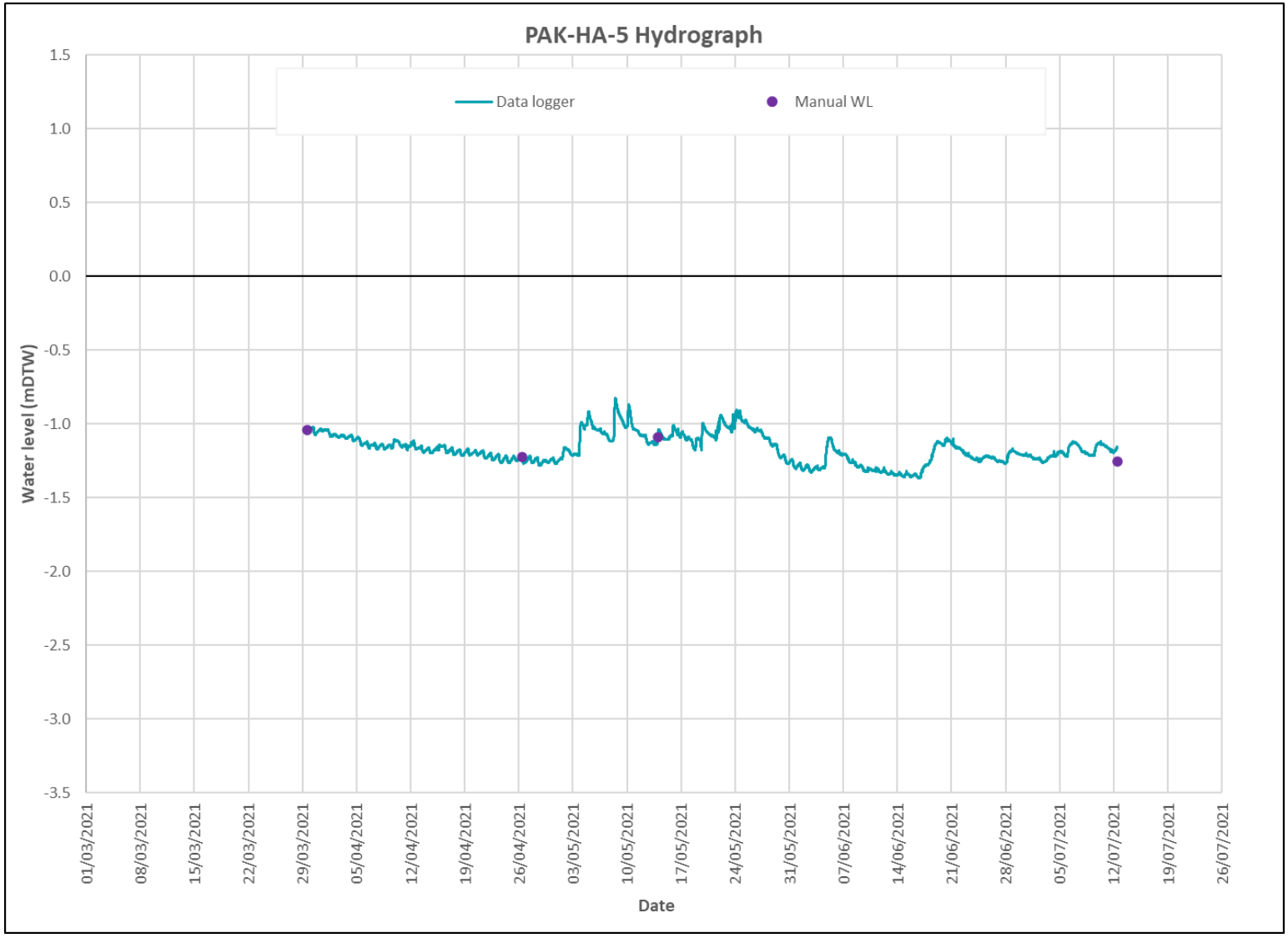

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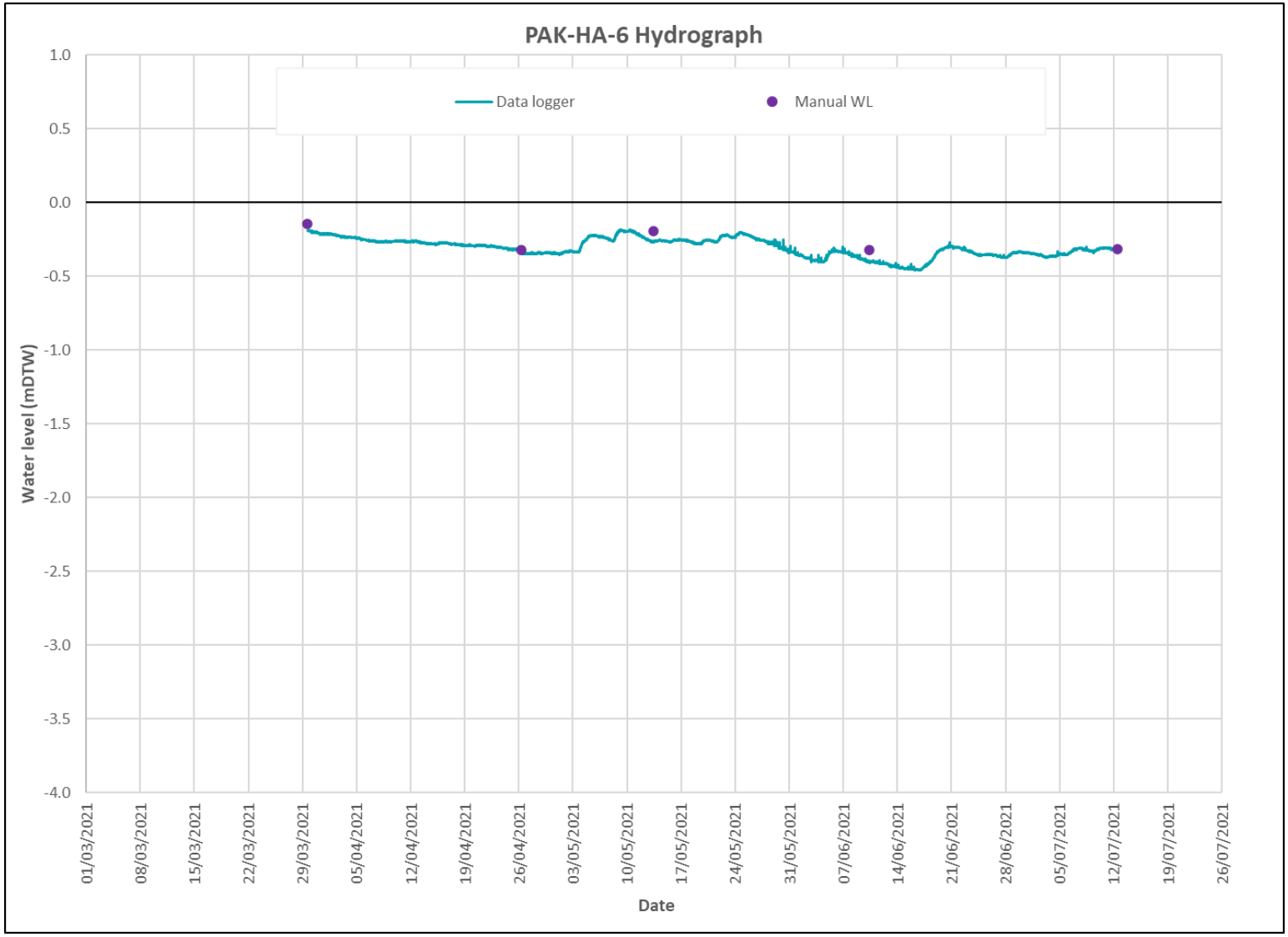
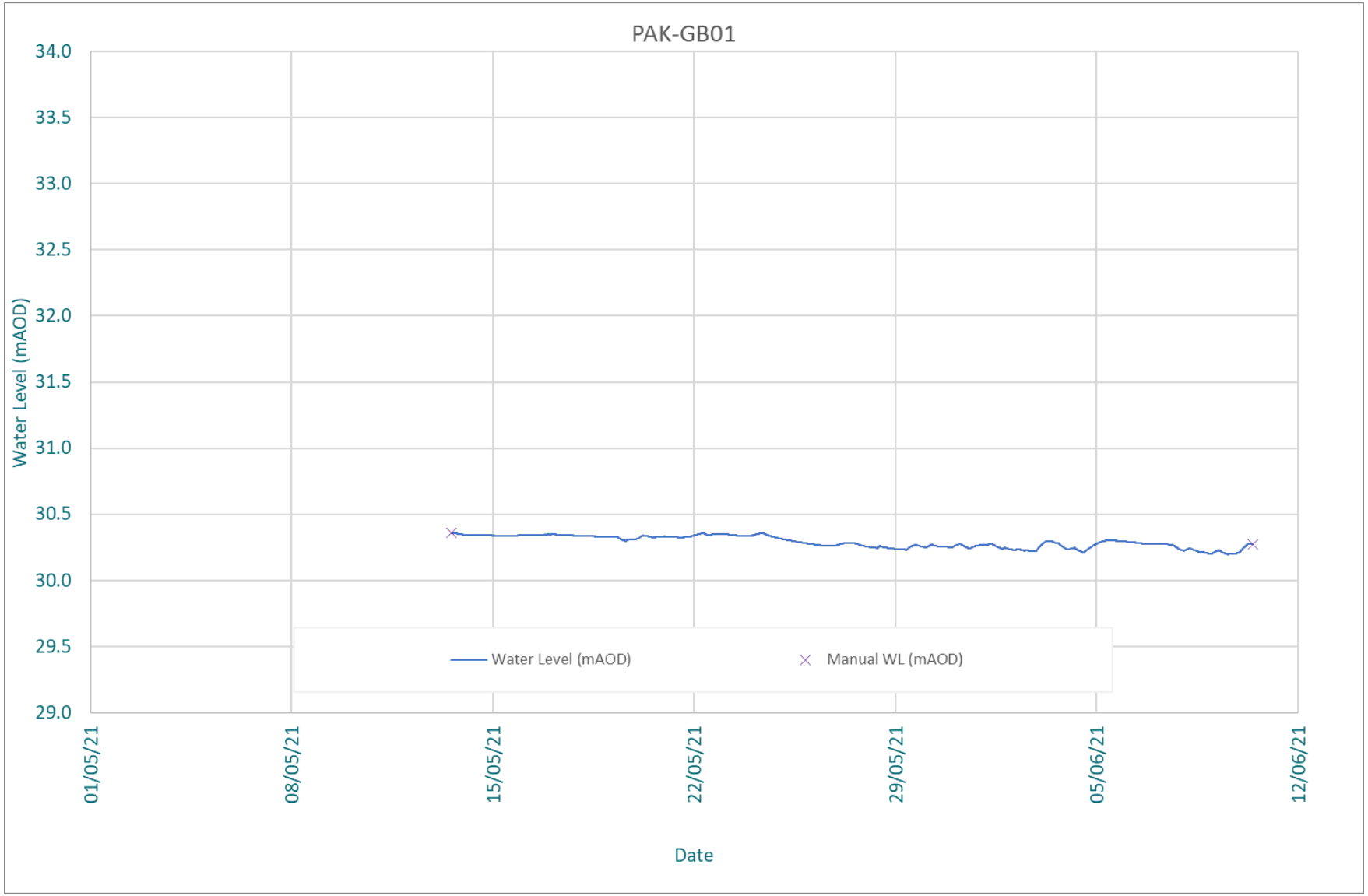


Appendix C
Surface water Hydrographs

C1



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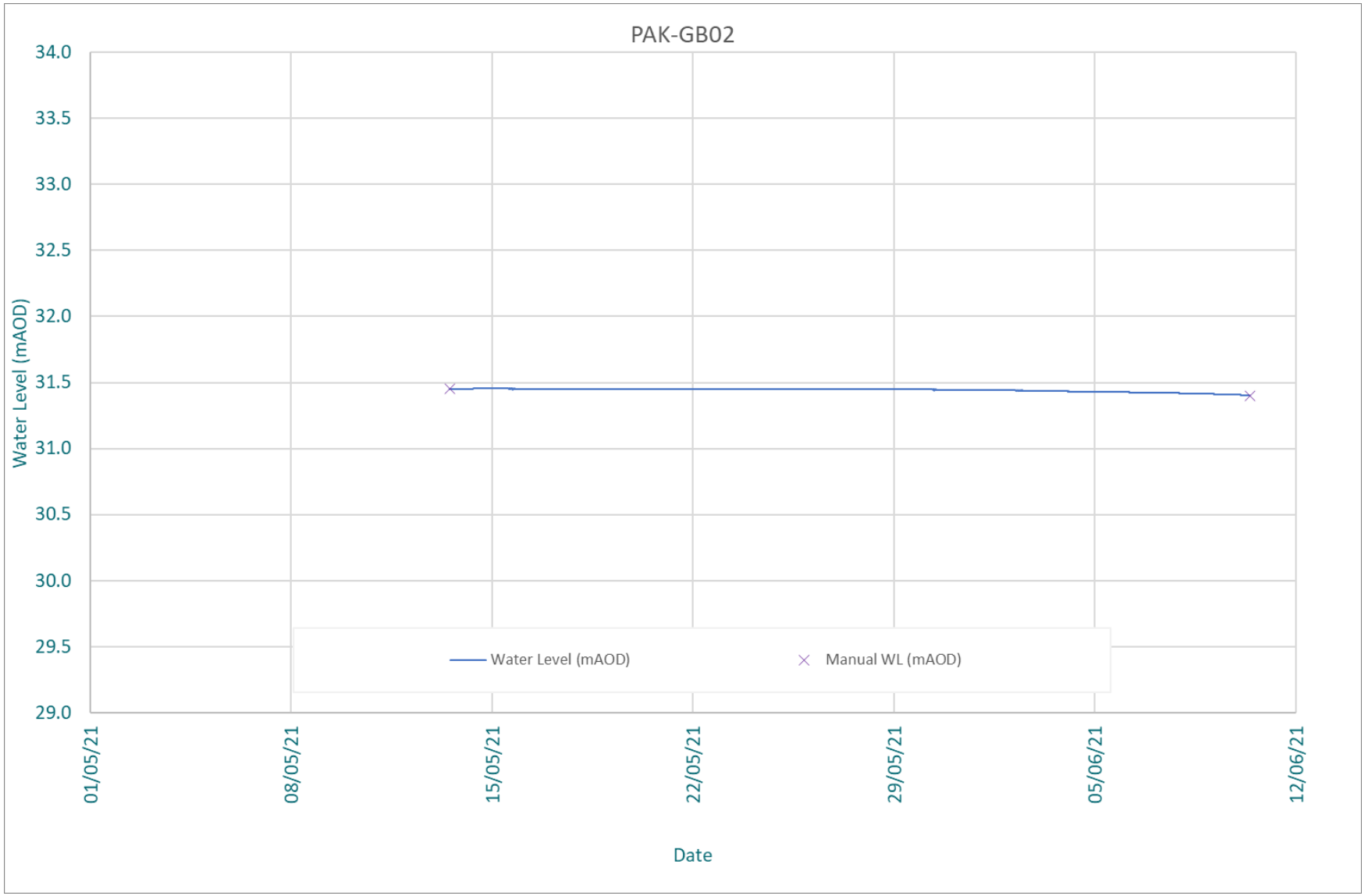

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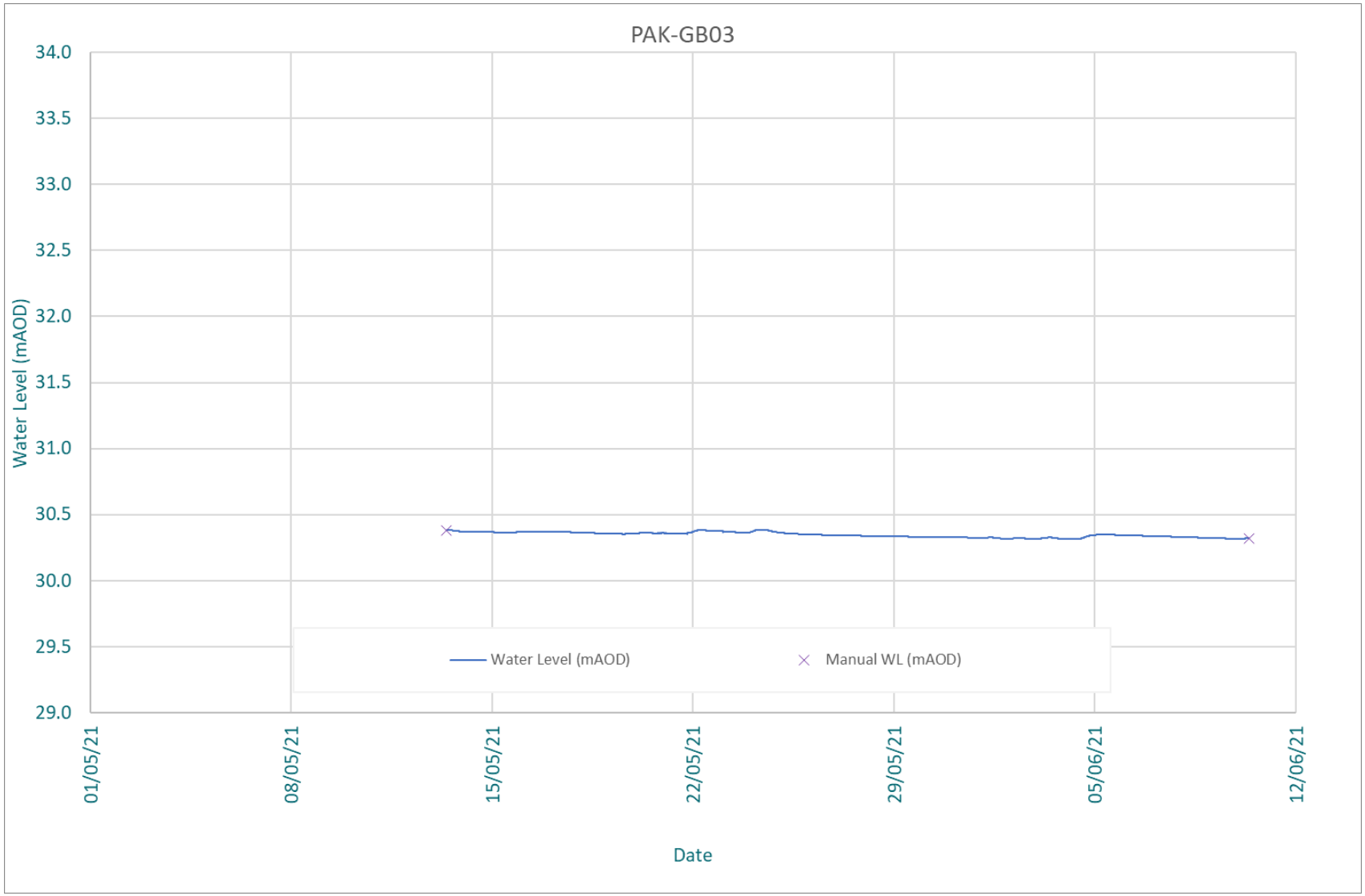

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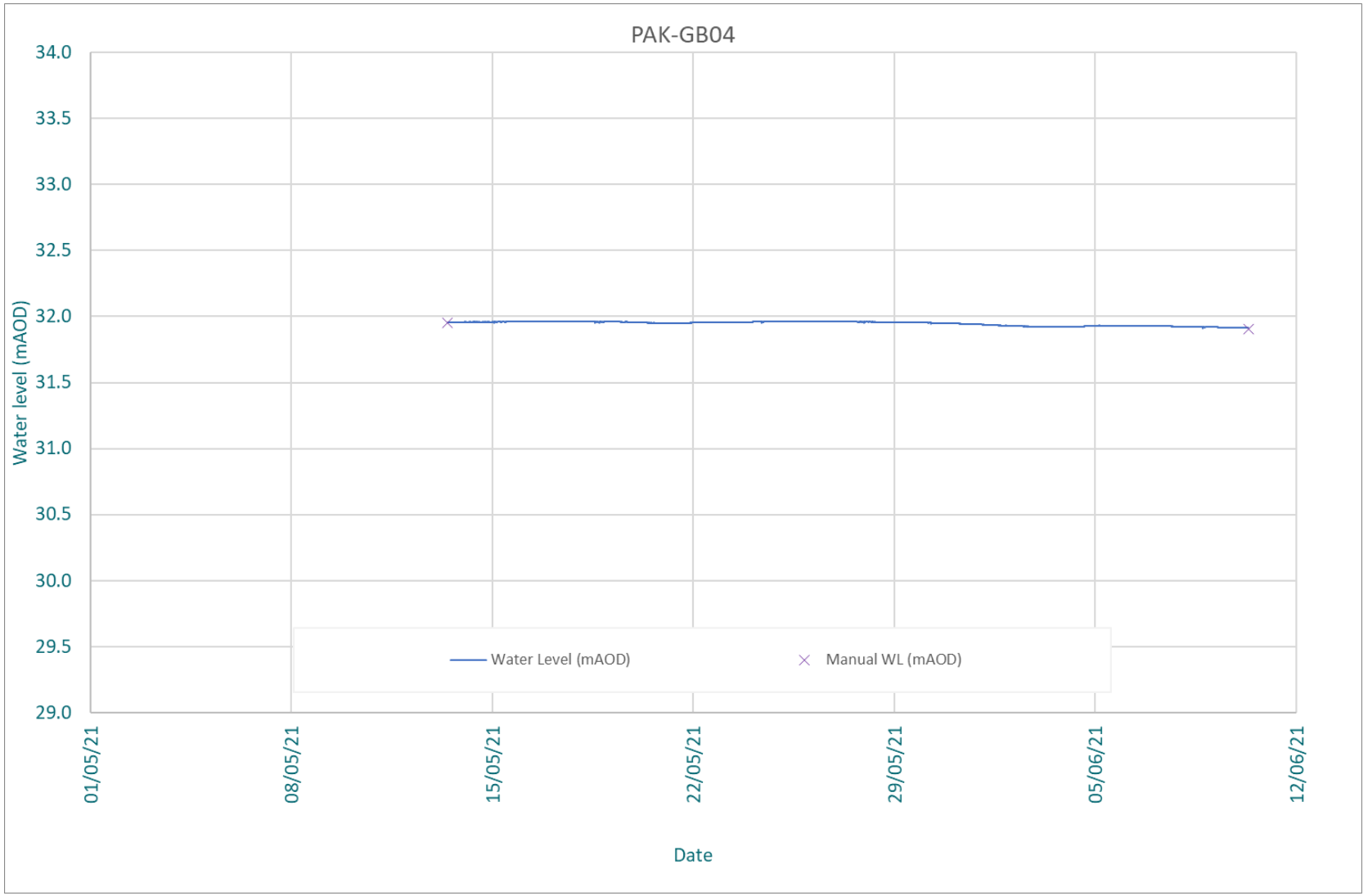

Appendix D
LIDAR Plots for the Site

D1

D2