

Havant Thicket Reservoir Project

Environmental Statement Volume 4 - Appendices
Appendix A10 Ground Conditions
A10.5 Havant Thicket Winter Storage Reservoir,
Ground Investigation Report

Portsmouth Water Ltd.

20/04/20

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Executive Summary

Atkins Limited (Atkins) has been commissioned by Portsmouth Water to plan, specify, act as Investigation Supervisor, and report on a ground investigation for the proposed Havant Thicket Winter Storage Reservoir Project (HTWSR) works, Havant, Hampshire. This report is the Ground Investigation Report (GIR) for the investigation.

In accordance with Eurocode 7, this GIR presents an evaluation of the geotechnical information, it is not a Geotechnical Design Report or Baseline Report. The user of the interpreted parameter values will need to apply appropriate engineering judgement to the selection of values for specific analyses.

This report uses the background information obtained during a review of publicly available historical data together with historical and recent ground investigation reports to provide a geotechnical interpretation of the ground conditions at the Study Area in relation to the proposed development.

The site (referred to here as the 'Study Area') lies within a shallow valley located between Havant, Leigh Park and Rowlands Castle, Hampshire; and has an approximate OS grid reference of SU 715 097.

The proposed scheme is expected to comprise the construction of a large reservoir (160 Hectares) in Havant, Hampshire, UK. This will be retained, partly by an embankment up to 20m high with a crest length of 3km, and partly by the topographical setting at the site. To generate the bulk of the general earthworks materials a borrow pit will be established within the reservoir footprint.

A total of four ground investigations have been undertaken within the Project Area between 1962 and 2020, in order to provide information for an earth dam as part of the HTWSR project. The most recent ground investigation (GI) was designed and supervised by Atkins and was undertaken between November 2019 and January 2020; this shall be the main focus of this report.

In total there are 58 boreholes and 75 trial pit logs with associated geotechnical laboratory testing available.

The superficial strata present across the Study Area comprises Topsoil and the underlying Head which is present over most of the study area. It is likely that very localised bands of alluvial material follow the routes of the natural drainage lines across the site. These superficial deposits in turn overlie bedrock of the Bognor Sand Member (part of the London Clay Formation), London Clay Formation (including a weathered zone), Harwich Formation and Reading Formation.

The geological cross-sections created for the project, show that the bedrock geology is dipping to the south-west following the topography and creating a geological feather-edge. The feather-edge is causing the deeper bedrock strata to reach ground surface (daylight) progressively to the north-east. Thus the Reading Formation and Harwich Formation outcrop in the north-east and the London Clay Formation and Bognor Sand Member to the south-west. This daylighting is further exacerbated by fluvial processes leading to topographic lows with clear v-shaped river channels or small valleys.

In terms of geomorphology across the Study Area, natural drainage channels, both active and infilled are present as well recorded soil creep. Shear surfaces have also been recorded within the Head deposits and the underlying strata in historical ground investigations.

The Geotechnical Risk Register has been undertaken which comprises an initial assessment of the geotechnical hazards expected within the Study Area prior to the application of mitigation measures. The Risk Register also shows how the risk of the hazards can be reduced by the application of mitigation measures.

Prior to implementation of the proposed mitigation measures, the risks considered to be Medium to High are:

- Buried services;
- Dissolution features;
- High /perched groundwater;
- Variable / deep weathering zone causing changes in soil strength
- Weak bearing / compressible materials;
- Aggressive ground to concrete such as the Thames Group and Lambeth Group. This may cause weakening and degradation of the concrete.

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- Aggressive ground;
- Reactivation of shear surfaces within the Head;
- Compaction induced shear surfaces within the embankment;
- Under-compaction during embankment construction;
- Excavation instability / collapse;
- Unforeseen ground conditions;
- Changes or variations in soil / rock strength;
- Previously unencountered contaminated land;
- Flotation of structures;
- Unexploded ordnance; and
- Shrink-swell potential.

The mitigation measures considered are those that may be applied during design or construction, as appropriate, to mitigate the hazard identified and, in most cases, to render the risk insignificant. Mitigation measures considered appropriate for the Substantial risks listed above include:

- Consideration of geotechnical issues during preliminary and detailed design;
- Continuous monitoring during construction; and
- Removal of the Head.

1. Introduction

1.1. Project Background

Atkins Limited (Atkins) has been commissioned by Portsmouth Water to plan, specify, act as Investigation Supervisor and report on a ground investigation for the proposed Havant Thicket Winter Storage Reservoir Project (HTWSR) works, Havant, Hampshire. This is the Ground Investigation Report (GIR).

This report uses the background information obtained during a review of publicly available historical data together with historical and recent ground investigation reports to provide a geotechnical and geo-environmental interpretation of the ground conditions at the Study Area in relation to the proposed development.

1.2. Proposed Works

The proposed scheme is expected to comprise the construction of a large reservoir (160 Hectares) in Havant, Hampshire, UK. The reservoir is to be capable of storing approximately 11.2 Mm³ of water. This will be retained, partly by an embankment up to 20m high with a crest length of 3km, and partly by the topographical setting at the site. The proposed embankment has a crest level of +40.5m OD with a maximum water level of +39.5m OD and a minimum water level of +27.5m OD. A pipe connecting the reservoir to Portsmouth Water's Bedhampton pumping station site is also expected. The reservoir footprint and the location of the proposed embankment are presented in Appendix A of this report.

To generate the bulk of the general earthworks materials a borrow pit will be established within the reservoir footprint. It is expected that this will be focused on the London Clay Formation, and will be used to produce general fill for the main embankment, as well as the material for the clay core. The borrow pit is not planned to be filled after the completion of the earthworks, other than any treatment of the sides and base that maybe needed to ensure an impermeable base to the reservoir is achieved. Thus, the excavated volume of the borrow pit will contribute to the reservoir's capacity, and its side slopes will need to be designed to ensure their long-term stability. Currently, there is no specified location of the borrow pit.

The reservoir, when constructed, will be filled with surplus water drawn from the Havant and Bedhampton Springs when flows are at their highest in winter. This will be accomplished via a new combined inlet/outline pipeline, which will provide water supplies to Portsmouth Water customers in the Summer months as required. The increase in water supplies available to Portsmouth Water on completion of the scheme will meet a deficit in water supplies to Southern Water created by Southern Water's imminent reduction of its abstraction licences on the River Itchen.

The proposed inlet/outline pipeline will also be used as an emergency draw down pipeline if the reservoir needs to be drained down in emergency conditions in accordance with the Environment Agency's (EA) safety guidance (Environment Agency, 2017).

More than 29,500 people live within reasonable walking distance of the Study Area (1.5km) and 120,000 people live within reasonable cycling distance of the Study Area (4.5km). Complementary to its infrastructure resilience function, the reservoir will also provide a new recreational facility/resource adjacent to one of the more deprived areas in south east Hampshire, in an area which the community can access on foot, by bike, or through existing bus routes. It offers further opportunities to improve the wider footpath, cycleway and bridleway networks in the area.

The development will provide a new wetland habitat and associated area for nature conservation; this will be located to the north of the reservoir. The proximity of the reservoir to the internationally important Langstone Harbour means that it can be used as a safe retreat for roosting birds when there is disturbance in the Harbour.

It should be noted that this report relates only to the reservoir site.

1.3. Aim and Scope of this Report

This report evaluates the available geotechnical and geo-environmental information covering the proposed scheme. The purpose of this report is to:

- Summarise the freely available historical data for the Study Area initially recorded in the Desk Study (Atkins Ltd., 2020a);
- Provide a commentary on the ground investigation work specifically undertaken for this project (SOCOTEC, 2020);
- Present Atkins' evaluation of the geological units at the Study Area using information provided from the Desk Study phase and from the ground investigations;
- Provide a site-specific conceptual ground model, in the form of geological cross-sections, to assist the design of the proposed works;
- Make an assessment of geotechnical parameters values;
- Assess the potential for reuse of excavated material within the proposed scheme as embankment fill and determine preliminary waste classification;
- Assess the potential geo-environmental contamination risk and provide suitable recommendations; and
- Identify potential geohazards and produce a geotechnical risk register for the Study Area.

1.4. Assumptions and Limitations

The conclusions and recommendations of this report are based on the data obtained and design details currently available at the time of writing (March 2020).

This GIR considers the ground conditions only within footprint of the proposed Havant Thicket Winter Storage Reservoir site, as shown in Figure 2-1 and Appendix A.

The findings and opinions conveyed in this report are based on information obtained from a variety of sources, including previous undertaken ground investigations and reports. Atkins cannot and does not guarantee the authenticity or reliability of the third-party information.

Exploratory holes sample or test a fraction of the ground being investigated and variation can occur between sampling points. Therefore, this report cannot guarantee against unexpected ground conditions occurring between the sampling points.

In accordance with Eurocode 7, this GIR presents an evaluation of the geotechnical information, it is not a Geotechnical Design Report or Baseline Report. The user of the interpreted parameter values will need to apply appropriate engineering judgement to the selection of values for specific analyses.

2. Site Description

2.1. Topography

The 'Study Area' gently dips to the south from around 40m OD along the north boundary, to 20m OD south of the proposed embankment toe. Further information on the topography and geomorphology is provided in Section 6.6 of this report and within the Desk Study (Atkins Ltd., 2020a). A plan presenting the topographic contours at the Study Area is provided in Appendix A of this report.

2.2. Site Location and Land Use

The proposed HTWSR site (i.e., the Study Area) is presented in Figure 2-1 below. The Study Area lies within a shallow valley located between Havant, Leigh Park and Rowlands Castle, Hampshire; and has an approximate OS grid reference of SU 715 097.

The Study Area has an area of approximately 160 Hectares and comprises predominantly open grassland with some woodland, hedgerows and ditches. The Study Area is largely utilised for animal grazing with public access retained via a bridleway across the middle of the Study Area and permissive paths around most of the perimeter and along 'The Avenue'.

Figure 2-1 - Proposed reservoir site layout



Key

- Reservoir Footprint
- Proposed Embankment

0 0.5 1 Kilometres

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2.3. Past Land Use Summary

A review of the historical development of the Study Area and surrounding area (within 500m of the site) was undertaken as part of the Desk Study (Atkins Ltd., 2020a) phase of this project; and has been summarised as part of this report.

The earliest available map for the Study Area is from 1870, when the area largely comprised woodland named as Havant Thicket. This was private land owned by Leigh Park Estate. Very little changed in regard to the land use over the next 150 years, except for periods of devegetation and plantation.

Planning permission for the construction of a reservoir was first granted in 1964. The land was acquired by Portsmouth Water in two blocks in 1965 and 1966 for the purpose of constructing a new reservoir to help meet the rising demand for water.

3. Published Geology, Hydrogeology and Hydrology

3.1. Introduction

This section provides a brief summary of the information provided within the Desk Study (Atkins Ltd., 2020a) to present an overview of the Study Area's geological, hydrogeological and hydrological setting.

3.2. Regional Geology

The Study Area, which is located in part of the Hampshire Basin, sits within the Bere Forest/Chichester syncline, with the Portsdown Anticline immediately to the south (which forms the Chalk hills and cliffs immediately to the north of Portsmouth) (British Geological Survey, 1982; British Geological Survey, 1998). The Study Area is on the northern limb of the syncline, approximately 4km from the axis.

The underlying bedrock of the syncline is Cretaceous White Chalk Sub-Group that outcrop to the north and south of the Study Area, within 1km and 3km respectively. The White Chalk outcrop forms a regional high (i.e., the South Downs) approximately 10km to the north of the Study Area in the form of a large escarpment. From there, the topography decreases gently in a southerly direction, towards the Bere Forest/Chichester syncline axis.

Overlying the Cretaceous White Chalk basement rocks are Palaeogene deposits of the Lambeth and Thames Groups, that typically outcrop sequentially from north to south, towards the syncline axis.

Quaternary deposits and surface features associated with periglacial and fluvial activity are present in variable amounts across the region.

Further information on the regional geology is provided in the Desk Study (Atkins Ltd., 2020a).

3.3. Local Geology

The information within the Desk Study (Atkins Ltd., 2020a), and confirmed by the geological map for the region (British Geological Survey, 1998), states that the Study Area is directly underlain by bedrock of the London Clay Formation (of the Thames Group) including the Bognor Sand Member, and the Lambeth Group. White Chalk Sub-Group is expected at depth. The geological strata underlying the White Chalk Sub-Group have not been considered in this report as they are unlikely to have any further impact to the proposed design of the reservoir and supporting infrastructures.

Due to the southerly dip of the topography and strata associated with the Bere Forest/Chichester syncline, the bedrock strata are located on a rough 'feather-edge' meaning that the geological strata daylight in depositional order towards the south.

Superficial deposits of 'Head' overlie the bedrock in this area; these have likely been accumulated by solifluction, hillwash and hillcreep, associated with periglacial conditions during the Quaternary.

Appendix A of this report includes a plan of the Study Area overlain on to the published geological map of the area.

Further information on the local geology following a review of the ground investigation information, is provided in Section 6 of this Report.

3.4. Hydrogeology

The White Chalk Sub-Group present beneath the Study Area is a Principal Bedrock Aquifer meaning it has a high potential for groundwater and is used throughout the South-East of England as potable water source. Within the Study Area, the White Chalk is overlain by largely cohesive Paleogene Deposits causing the aquifer to be confined; this may lead to sub-artesian groundwater pressures.

The nearest monitoring wells to the Study Area are Idsworth Well and Pyle Farm approximately located 1.5km and 2km north (respectively). Idsworth Well is on the chalk outcrop at an approximate ground level of +63m OD with water levels in the monitoring well ranging from between +12.7m OD

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and +36.7m OD with an average of 20.0m OD between the years of 1932 and 2008 (Portsmouth Water, 2008). Pyle Farm, at an approximate ground level of +60m OD, is located directly on chalk outcrop and water levels in the monitoring well range from between +21m OD and +43m OD (Ove Arup & Partners Ltd., 2009).

While the Thames Group and Lambeth Group are predominantly aquitards due to the high amount of cohesive material, they may contain perched or confined water bearing granular strata.

Further information on the hydrogeology of the Study Area is presented in the Desk Study (Atkins Ltd., 2020a) and in Section 6.7.3 of this Report.

3.5. Hydrology

There are a number of hydrological features present within the Study Area. Three unnamed watercourses flow from north to south entering the Study Area along the northern boundary. They converge into one stream to the west of 'The Avenue' in 'Deerslaughter Plain' (see Figure 2-1). The alignment of the channels has been altered over time by anthropogenic activity, which is reported to have been to improve the land for agricultural use.

The western most watercourse originates in Havant Thicket approximately 400m north of the Study Area before flowing south through Middle Clearing and joining the main stream in Deerslaughter Plain. The central watercourse flows south from beyond Havant Thicket, approximately 1.2km north of the Study Area into the Upper Lake, which is located to the north of the Study Area (Atkins Ltd., 2020a).

The Upper Lake covers an area of approximately 6,400 m² and was recorded to have been dammed and therefore constructed in 1869. A weir is located on the southern edge of the lake.

A drain exits the lake flowing south along The Avenue for approximately 200m to a confluence. At this point the third watercourse, which flows from the northern boundary of the Study Area, also joins the central watercourse. There is a drain present towards the east of the Study Area that connects to a series of drains that flow east from Gipsies Plain, west of The Durrants that also joins at this point. An additional drain flows from east to west across The Avenue approximately 290m north of the southern boundary of the Study Area towards the main confluence in Deerslaughter Plain. The combined watercourses and drains continue to flow south across the southwestern boundary of the Study Area, flowing parallel to the residential development west of Thicket Lawn to a culvert below Middle Park Way Road approximately 500m south of the Study Area.

Further information on the hydrology at the Study Area is presented in the Desk Study (Atkins Ltd., 2020a).

3.6. Unexploded Ordnance

As part of the Desk Study (Atkins Ltd., 2020a), a Detailed Unexploded Ordnance (UXO) Risk Assessment (1st Line Defence, 2019) was undertaken. From this risk assessment, it was identified that the Study Area was possibly the location of World War II military camps and therefore has a low to medium risk of encountering UXO.

4. Ground Investigations

4.1. Introduction

This section outlines all ground investigations undertaken within the Study Area.

A total of four ground investigations have been undertaken within the Project Area between 1962 and 2020, in order to provide information for an earth dam as part of the HTWSR project. The most recent ground investigation (GI) was designed and supervised by Atkins and was undertaken between November 2019 and January 2020.

This report takes in to account the information from all four of the ground investigation. In total there are 58 boreholes and 75 trial pit logs with associated geotechnical laboratory testing available.

Appendix B of this report includes the factual reports of the historical and most recent ground investigations undertaken within the Study Area.

4.2. Edgar Morton & Partner with Embankment Design by Professor Rowe – 1962 to 1963

4.2.1. Report Details

The Portsmouth Water Company commissioned Edgar Morton and Partner in 1962 to undertake a feasibility study on site 18 (Havant Thicket). Pre-Piling Surveys Limited, on behalf of Edgar Morton and Partner carried out a ground investigation comprising 20 boreholes, nine of which were located along the then proposed embankment and 11 were located within the reservoir basin (Edgar Morton & Partner, 8 December 1962). Geotechnical laboratory testing was also undertaken.

The proposed embankment footprint has since changed and therefore the boreholes do not align to the existing design.

4.2.2. Boreholes

A total of 20 cable percussive boreholes were undertaken as part of this ground investigation. The boreholes ranged between 7.0 and 15.5m bgl.

No in situ testing was undertaken.

No standpipes or piezometers were installed.

4.2.3. Geotechnical Laboratory Testing

Geotechnical laboratory testing on soil samples were undertaken in two phases; initially testing was undertaken as part of the Pre-Piling Surveys in 1962 (Edgar Morton & Partner, 8 December 1962).

In 1963, additional laboratory soils testing was undertaken by the University of Manchester under the supervision of Professor Peter Rowe (Edgar Morton & Partner / Professor PW Rowe, 30 March 1963).

The total number of geotechnical testing has been summarised in Table 4-1 below:

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Table 4-1 - Summary of geotechnical laboratory testing from Edgar & Morton (1962) and Professor PW Rowe (1963)

Test Type	Test Standard	Number of Tests
Water Content Determination	Unknown*	8
Atterberg Limit Determination	Unknown*	8
Particle Size Distribution Analysis	Unknown*	5
Proctor Compaction Test	Unknown*	8
Unconsolidated Undrained Triaxial Test	Unknown*	17
Consolidated Undrained Triaxial Compression test	Unknown*	17
One Dimensional Consolidation Test	Unknown*	16

Note: *Test Standard is not recorded in the factual reports (Edgar Morton & Partner, 8 December 1962; Edgar Morton & Partner / Professor PW Rowe, 30 March 1963).

4.3. Hampshire Reservoirs Site 18, Mander, Raikes & Marshall (MRM) – 1977-79

4.3.1. Report Details

In 1977, Mander, Raikes & Marshall (MRM) was commissioned by the Southern Water Authority to produce a technical feasibility report on two groups of potential reservoir sites and resource allocation strategies; this included the Havant Thicket Study Area.

The aim of the Study Area investigation was to examine the feasibility of reservoir development, with attention paid to the potential water tightness of the proposed storage areas and the capability of the in-situ soils to support the future embankments or to be used as embankment construction material.

MRM undertook two phases of ground investigation which comprised cable percussion boreholes and machine excavated trial pits with associated geotechnical laboratory testing.

4.3.2. Boreholes

The initial supplementary ground investigation was undertaken in 1977 and comprised four cable percussive boreholes (MRM 18/1, 18/2, 18/3 and 18/4) that were sunk by Foundation Engineering Limited. These were between 7.95 and 34.20m deep.

A supplementary investigation was completed in 1978/79 that comprised a further six cable percussive boreholes (undertaken by Foundation Engineering Ltd) to between 15.00 and 34.40m deep. These are named MRM 18/B1 to 18/B6.

4.3.3. Trial Pits

In 1978, close to the Study Area, a major highway embankment had slipped which was thought to be associated with shear surfaces in the London Clay. MRM believed that such shear surfaces may also be present underlying the proposed reservoir site. As a result, 42 trial pits (A1-A13, E1-E2 & D1-D27) were dug between 3m and 5m b a Hymac back actor under the direct supervision of MRM. The A and E series trial pits were dug along the line of the proposed embankment to investigate any shear planes within the foundation series, whilst the D series trial pits were positioned to investigate the permeable basal beds of the London Clay Formation *sic* (Harwich Formation).

4.3.4. Groundwater Monitoring

Two standpipe piezometers were installed in the boreholes from the 1977 investigation (18/3 and 18/4); these were at depths of 12.2 and 24m bgl within the Harwich Formation.

Eight standpipe piezometers were installed in boreholes from the 1978/78 investigation (18/B1 to 18/B6). These installations comprised four single, and two dual installations and were at depths of 12.2, 9.6, 17.5, 13.75, 13.0 and 11.75m respectively. These installations targeted the London Clay Formation, Harwich Formation and Reading Formation.

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4.3.5. Geotechnical Laboratory Testing

Geotechnical testing from MRM included the following tests:

Table 4-2 - Summary of geotechnical laboratory testing from Mander, Raikes & Marshall (1977-79)

Test Type	Test Standard	Number of Tests
Water Content Determination	Unknown*	48
Atterberg Limit Determination	Unknown*	48
Particle Size Distribution Analysis	Unknown*	50
Compaction Test using 2.5kg Rammer	Unknown*	8
Moisture Condition Value	Unknown*	2
Consolidated Undrained Triaxial Compression test with Measurement of Pore Water Pressure	Unknown*	14
Residual Drained Shear Box Tests	Unknown*	2
Permeability Tests in A Triaxial Cell	Unknown*	5

Note: *Test Standard is not recorded in the factual reports (Mander, Raikes and Marshall, 1977 - 78, 1979?; Mander, Raikes and Marshall, 1980).

4.4. Entec UK Ltd with Soil Mechanics Ltd GI – 2006 / 2007

4.4.1. Report Details

Entec was commissioned on the behalf of Portsmouth Water Ltd to undertake a 'Phase 2' report that considered the engineering and environmental issues associated with the development of the HTWSR scheme (Entec UK Limited, 2006). Within a separate document (Entec UK Limited, 2007), an assessment was made of the available volumes and material properties of the near surface formations within the basin of the proposed HTWSR and the assessment of these in the context of the likely requirements for the embankment construction.

In 2006, Soil Mechanics Ltd were commissioned by Entec to undertake a ground investigation comprising four cable percussion boreholes and four trial pits, with associated laboratory testing.

4.4.2. Boreholes

The four boreholes (SM BH101 to 104) undertaken as part of this investigation were between 13.45 to 14.55m deep. These were located specifically to investigate potential suitability of the London Clay and Reading Beds (Reading Formation) as embankment construction material.

No groundwater monitoring installations were installed.

4.4.3. Trial Pits

The four trial pits (SM TP101 to TP104) were dug between 2.5 and 3.5m below the ground level and were located to the east of the Study Area onto the Reading Beds (Reading Formation). Additional trial pits were planned to be dug where London Clay outcrops to the west of the Study Area, however these were not excavated due to wet ground conditions.

4.4.4. Geotechnical Laboratory Testing

Geotechnical laboratory testing on soil samples recovered from the boreholes comprised:

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Table 4-3 - Summary of geotechnical laboratory testing from Entec UK Ltd with Soil Mechanics Ltd (2007)

Test Type	Test Standard	Number of Tests
Water Content Determination	BS 1377-2	23
Atterberg Limit Determination	BS 1377-2	23
Particle Size Distribution Analysis	BS 1377-2	13
Particle Density	BS 1377-2	7
Compaction Test using 4.5kg Rammer	BS 1377-4	7
Dry Density/Moisture Content Relationship Determination Test	BS 1377-4	3
Unconsolidated Undrained Triaxial Test	BS 1377-7	4
Shear Box Tests	BS 1377-7	3
pH and Sulphate Content of Soil	Unknown*	4

Note: *Test Standard is not recorded in the factual reports (Entec UK Limited, 2007).

4.5. Atkins with SOCOTEC – 2019/2020

Atkins was commissioned by Portsmouth Water in 2019 to develop the HTWSR project, part of this was to scope a new ground investigation for the proposed reservoir footprint and earthworks. The aim of this GI was to obtain enough geotechnical information to develop the design of the proposed reservoir and support the planning application process.

The scope of the GI comprised cable percussion and rotary boreholes, trial pits, observation pits, in situ testing, monitoring, laboratory testing and reporting. Further information on the scope and rationale of works is provided in the Ground Investigation Rationale (Atkins Ltd., 2019a).

The investigation was performed in accordance with the Ground Investigation Specification (Atkins Ltd., 2020c), and the general requirements of BS 5930 (2015), BS EN 1997-2 (2007), BS EN ISO 22475-1 (2006) and other relevant related standards identified within the factual report (SOCOTEC, 2020).

The original scope of works included a geophysical survey of the Study Area with the aim to identify subsurface structures; following discussion with the Client (Portsmouth Water), it was decided to postpone this to a later stage of the project.

The fieldwork took place between 4 November 2019 and 30 January 2020. Atkins were present full time during the GI as Investigation Supervisor.

4.5.1. Boreholes

Twenty cable percussion boreholes were undertaken to between 2.50 and 34.45m bgl using either a Dando 2000 or 2500 rig.

Four rotary boreholes were undertaken to between 38.50 and 72.20m bgl using a variety of multipurpose (dynamic sampling and rotary coring) drill rigs.

The logging of soil and rock materials was completed on site by a SOCOTEC engineering geologist, in accordance with BS EN ISO 14688-1+A1 (2013) for soils and BS EN ISO 14689-1 (2003) for rocks, as specified by BS 5930+A2 (2010).

Small disturbed, bulk and undisturbed UT100 samples were taken within the boreholes at depths specified in the approved Ground Investigation Specification and by the Investigation Supervisor on site.

Groundwater installations were installed as per the specification and at the instruction of the Investigation Supervisor. The installations are summarised in Section 4.5.4 of this report.

4.5.2. Trial Pits

Fourteen machine excavated trial pits were completed to between 1.50 and 4.50m bgl.

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The trial pits with the names 'TPM' were specified to be 'observation pits' for man entry. However, due to difficult ground conditions, adverse weather and health and safety concerns associated with the method of excavation, the man entry pits (ATK-TPM-01 to 07) were removed from this phase of works. A number of these boreholes (ATK-TPM-02 to -05) were instead carried out as standard machine excavated trial pits. After excavation, trial pit ATK-TPM-05 was allowed to stand open overnight to assess the short-term stability.

Twelve shallow hand-dug trial pits were undertaken adjacent to selected boreholes for the recovery of topsoil samples. The trial pits have been designated the same ID as the corresponding boreholes, plus the suffix '-TSS', e.g. ATK-CP-09-TSS. Logs have not been included for these trial pits as they were not extended below the topsoil, therefore these have not been used to create the ground model for the Study Area.

4.5.3. In Situ Testing

Standard Penetration Tests

Standard penetration tests (SPT) were carried out in all of the boreholes, in accordance with BS EN ISO 22476-3+A1 (2011).

Variable Head Permeability Tests

Variable head permeability testing, including both rising and falling head tests, were carried out in general accordance with BS EN ISO 22282-2 (2012); these were undertaken during construction of the hole and during post-fieldwork monitoring of installations. Table 4-4 below outlines the number and location of tests undertaken, as well as the depths and stratum the tests were undertaken in.

Table 4-4 - Summary of variable head testing

Borehole	Tests During Fieldwork		Tests Post-Fieldwork (in Installations)	
	Depth (m bgl)	Stratum	Depth (m bgl)	Stratum
ATK-CP-01	3.00	Bognor Sand Member	3.90	Bognor Sand Member
ATK-CP-02	1.90	Bognor Sand Member	-	-
	7.00	London Clay Fm.	34.00	Harwich Fm.
ATK-CP-03	5.50	London Clay Fm.	-	-
ATK-CP-04	5.00	London Clay Fm.	-	-
	11.50	Harwich Fm.	11.80	Harwich Fm.
ATK-CP-05	7.50	London Clay Fm.	-	-
	13.00	Harwich Fm.	10.70	Harwich Fm.
ATK-CP-06	2.00	Harwich Fm.	2.00	Head / Harwich Fm.
ATK-CP-10	11.00	Harwich Fm.	-	-
ATK-CP-12	-	-	4.50	Harwich Fm.
ATK-CP-13A	-	-	4.00	Harwich Fm.
ATK-CP-15	16.00	Harwich Fm.	18.00	Harwich Fm.
ATK-CP-16	-	-	1.30 – 2.50	Harwich Fm.
ATK-RC-01	-	-	36.00	White Chalk
ATK-RC-02	-	-	71.00	White Chalk
ATK-RC-02A	-	-	39.00	London Clay Formation / Harwich

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Borehole	Tests During Fieldwork		Tests Post-Fieldwork (in Installations)	
	Depth (m bgl)	Stratum	Depth (m bgl)	Stratum
				Formation / Reading Formation
ATK-RC-03	-	-	45.00	White Chalk

Soakaway Tests

Two soakaway tests were scheduled to be undertaken in shallow hand excavated trial pits adjacent to trial pits ATK-TP-05 and ATK-TP-07; the pits were excavated and designated ATK-TP-05i and ATK-TP-07i. Temporary standpipes, nominally 50mm diameter, were installed in the trials pits and the annulus filled with a gravel filter, as detailed on the trial pits logs.

Due to the saturated nature of the shallow strata, the groundwater in the pits was recorded rising before commencement of the tests; therefore, the tests were cancelled.

4.5.4. Groundwater Monitoring

Groundwater monitoring instrumentation was installed in the boreholes outlined in Table 4-5 below during the fieldwork as directed by the Investigation Supervisor. Groundwater monitoring comprised taking a limited number of water depth readings in the standpipe and standpipe piezometers during the fieldwork period. No readings from the vibrating wire piezometers were taken during the fieldwork. Two weeks after fieldwork completion (week commencing 06/01/2020) Socotec took a set of groundwater readings and then purged all the standpipes and standpipe piezometers. Subsequent to this, Socotec has undertaken three rounds of groundwater monitoring as follows:

Round 1 (week commencing 13/01/2020) – water depths in the standpipe and standpipe piezometers, water samples from ATK-CP-01, ATK-CP-05, ATK-CP-06 and ATK-CP-12.

Round 2 (week commencing 27/01/2020) – water depths and rising/falling head permeability tests in the standpipe and standpipe piezometers, water samples from ATK-CP-01, ATK-CP-05, ATK-CP-06 and ATK-CP-12. Installing diver data-loggers in the standpipe and standpipe piezometers. Manual readings from all the vibrating wire piezometer instruments and connecting ATK-CP-11 to a vibrating wire data-logger.

Round 3 (week commencing 10/02/2020) – water depths in the standpipe and standpipe piezometers and water samples from ATK-CP-01, ATK-CP-05, ATK-CP-06 and ATK-CP-12. Downloading approximately two weeks of data from the diver data-loggers in the standpipe and standpipe piezometers and from the vibrating wire piezometer data-logger of ATK-CP-11. Manual readings from the four vibrating wire piezometer instruments in ATK-BH-01 and ATK-BH-02 and connecting them to vibrating wire data-loggers.

The data-loggers for the three boreholes installed with vibrating wire piezometers, and the diver data-loggers in each of the standpipes and standpipe piezometers were set to read hourly on the hour. An additional diver has been installed in ATK-CP-06 to take hourly readings of barometric pressure for use in converting the diver data to water head.

At the time of writing this report no further data downloading from the data-loggers has been possible due to UK government restrictions put in place to deal with the Coronavirus (COVID-19) outbreak.

Table 4-5 - Groundwater installations

Borehole ID	Response Zone Depth (m bgl)	Response Zone Elevation (m OD)	Installation Type	Stratum
ATK-BH-01	7.00	18.73	Vibrating wire piezometer	London Clay Formation
	11.00	14.73	Vibrating wire piezometer	London Clay Formation
ATK-BH-02	4.50	16.95	Vibrating wire piezometer	London Clay Formation

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Borehole ID	Response Zone Depth (m bgl)	Response Zone Elevation (m OD)	Installation Type	Stratum
	8.50	12.95	Vibrating wire piezometer	London Clay Formation
ATK-CP-01	3.40 – 4.00	34.05 – 33.45	Piezometer	Bognor Sand Member
ATK-CP-02	33.50 – 34.00	-3.47 – -8.47	Piezometer	London Clay Formation (base)
ATK-CP-04	11.00 – 12.20	13.90 – 12.70	Piezometer	Harwich Formation
ATK-CP-05	10.00 – 11.00	17.91 – 16.91	Piezometer	Harwich Formation
ATK-CP-06	0.50 – 3.50	34.23 – 31.23	Standpipe	Head/Harwich Formation
ATK-CP-11	11.20	15.15	Vibrating wire piezometer	Harwich Formation
ATK-CP-12	4.00 – 5.00	22.90 – 21.90	Piezometer	Harwich Formation
ATK-CP-13A	3.50 – 4.50	26.25 – 25.25	Piezometer	Harwich Formation
ATK-CP-15	17.50 – 18.50	15.95 – 14.95	Piezometer	Harwich Formation
ATK-CP-16	1.50 – 2.50	36.20 – 35.20	Standpipe	Harwich Formation
ATK-RC-01	35.50 – 36.50	5.03 – 4.03	Piezometer	White Chalk
ATK-RC-02	68.90 – 71.90	-29.03 – -26.03	Piezometer	White Chalk
ATK-RC-02A	36.00 – 39.00	3.85 – 0.85	Piezometer	London Clay Formation / Harwich Formation / Reading Formation
ATK-RC-03	43.00 – 48.00	-11.48 – -16.48	Piezometer	White Chalk

4.5.5. Geotechnical Laboratory Testing

Laboratory tests were scheduled on some of the samples obtained from the exploratory holes for general geotechnical classification and to determine the strength, compressibility and compaction properties, and the chemical aggressivity of the strata, see Table 4-6 below.

Table 4-6 - Summary of geotechnical laboratory testing from SOCOTEC (2020)

Test Type	Test Standard	Number of Tests
Water Content Determination	BS EN ISO 17892-1	167
Atterberg Limit Determination	BS EN ISO 17892-12	154
Particle Size Distribution Analysis	BS EN ISO 17892-4	71
Particle Density	BS EN ISO 17892-3	2
Linear Density	BS EN ISO 17892-3	1
Determination of Shrinkage Characteristics	BS 1377-2	16
Light Compaction (2.5kg Rammer)	BS 1377-4	52
Heavy Compaction (4.5kg Rammer)	BS 1377-4	8
Moisture Condition Value Test	BS 1377-4	41
Moisture Condition Value / Moisture Content	BS 1377-4	30

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Test Type	Test Standard	Number of Tests
Unconsolidated Undrained Triaxial Compression Test	BS EN ISO 17892-8	38
Shear strength by Pilcon Hand Method	BS EN ISO 17892-8	294
Consolidated Undrained Triaxial Compression test with Measurement of Pore Water Pressure	BS EN ISO 17892-9	11
One Dimensional Consolidation Test	BS EN ISO 17892-5	15
Determination of Permeability in a Triaxial Cell	BS EN ISO 17892-11	9
Small Shear Box	BS EN ISO 17892-10	10
Determination of residual shear strength using ring shear apparatus	BS EN ISO 17892-10	4
Determination of Dispersibility - Pinhole Method	BS1377-5	24
BRE Suite (Concrete in aggressive ground)	BRE SD1	12

4.5.1. Geo-environmental Laboratory Testing

4.5.1.1. Analytical Suites

A total of twenty soil samples collected from the site were selected by Atkins for contamination laboratory analysis at Socotec Analytical laboratories, a UKAS accredited laboratory. The selected soil samples were subject to analysis for the following suite determinands which was developed based on the findings of the desk study:

- pH;
- Total and free cyanide;
- Ammonium;
- Phenol;
- Total moisture;
- Sulphate and sulphide;
- Soil Organic Matter (SOM) and Total Organic Carbon (TOC);
- Metals and metalloids – arsenic, boron, cadmium, total chromium, chromium (VI), copper, iron, lead, manganese, mercury, nickel, selenium, vanadium, and zinc;
- Gasoline Range Organics (GRO) (C5 – C8);
- Benzene, toluene, ethylbenzene and xylenes (BTEX);
- Speciated Polycyclic Aromatic Hydrocarbons (PAH): US EPA 16; and,
- Speciated Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG) >C8 – C44.

A total of six soil samples were selected for asbestos screening, with quantification to be completed if asbestos positively identified.

A total of twelve groundwater samples, collected over three monitoring rounds, were obtained from four installed cable percussive borehole locations (ATK-CP-01, ATK-CP-05, ATK-CP-06, ATK-CP-12). Groundwater samples were collected from monitoring wells installed within the London Clay Formation, Head and Harwich Formation and analysed for the following:

- pH;
- Total and free cyanide;
- Total sulphur as SO₄ and sulphide;
- Nitrate;

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- Ammoniacal nitrogen as NH₃, ammoniacal nitrogen as N, and free ammonia as N;
- Chloride;
- Cresols, methylphenols, dimethylphenols, phenol and trimethylphenols;
- TOC;
- Metals and metalloids – aluminium, antimony, arsenic, boron, cadmium, total chromium, chromium (VI), copper, iron, lead, mercury, nickel, selenium, phosphorus, vanadium, zinc;
- GRO (C5 – C10);
- BTEX;
- PAH (US EPA 16); and
- TPH CWG (C8 – C44).

4.5.1.2. Laboratory QA/QC

On receipt of the soil laboratory testing reports from the Socotec site investigation it was noted that the majority of the soil samples analysed were reported to be deviating. 18 of 20 soil samples exceeded holding times for certain analysis. Therefore, where feasible, additional samples were obtained to mitigate the uncertainty associated with the deviating samples.

Fifteen deviating soil samples collected from a shallow depth (<1 m depth) were re-sampled and analysed. Following laboratory analysis, no deviating soil samples were reported.

Re-sampling of three deviating samples (ATK-CP-P6: 2.5 m, 4 m and ATK-CP-16: 3.5 m) collected from sample depths greater than 1 m was not possible. The two deviating samples located at ATK-CP-06 can be mitigated as groundwater samples have been collected from this location, which will provide the relevant information associated with potential risks at this location. The deviating sample from ATK-CP-16 targeted the Reading Formation geology for the purposes of materials management and the organic/anthropogenic contaminants with shorter holding times are considered highly unlikely to be present so the implications of the deviating sample at this location are diminished.

4.5.2. Evidence of Contamination

No visual signs of non-aqueous phase liquids (NAPL) were detected in the exploratory holes. No olfactory signs of contamination were recorded in the exploratory holes.

4.6. Other Historical Ground Investigations

Several Ground Investigation and Desk Study reports for proposed developments within the vicinity of the Study Area were made available by Portsmouth Water for review as part of the investigation covered by this report. The available exploratory hole logs have not been used as part of this report; however, the overall findings of these reports have been considered.

A brief summary of these investigations are provided below:

- **Proposed Landfill at Hazleton Farm, Horndean (0.7 km north of site):** Aspinwall & Company Ltd was commissioned by Hughes Waste Management Ltd to undertake a geophysical and intrusive investigation to assess the suitability of the Hazleton Farm site for a Landfill. Top of chalk and Lambeth Group contour plots are presented in the documents (Hughes Waste Management Ltd, 1997).
- **Horndean (Borrow Land), Portsmouth (1.5 km north of site):** Desk Study, multidisciplinary ground investigation and ground condition assessment undertaken by PBA (the Engineer), TerraDat (the Geophysical Survey Contractor) and CC Ground Investigations (the Ground Investigation Contractor) on behalf of Bloor Homes (TerraDat, 2017; Peter Brett Associates, 2018). The field investigation comprised trial pits, windowless sample boreholes and rotary cored boreholes to a maximum investigation depth of 37.76mOD.
- **Land off Redhill Road, Rowlands Castle (1 km east of site):** Structa LLP was instructed by Explore Living plc to undertake an additional ground investigation at Land off Redhill Road, Rowlands Castle. The supplementary investigation followed two previous phases of investigation completed by Structa LLP (Structa LLP, 2010).
- **Padnall Grange, Padnall Road, Cowplain (1.3 km northwest of site):** Soils Limited was commissioned by Bellway Homes (Wessex) to undertake a Phase 2 ground investigation.

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The investigation included 4 No. windowless sampler boreholes 5 No. trial pits to a maximum depth of 6m below the ground level. The levels above ordinance datum were not recorded. The Study Area investigation does not provide pertinent information to the proposed reservoir site and corresponds to the underlying geological sequence that is indicated on the 1:50,000 BGS geological map (British Geological Survey, 1998) (Soils Ltd, 1997).

- **Southleigh Landfill Site, Havant (1.5 km southeast of site):** The information provided includes sections of a working draft for a ground investigation report undertaken by MJ Carter Associates on behalf of Onyx UK Limited for a proposed extension of the Southleigh Landfill site in Havant. No exploratory hole records have been provided.

5. Geotechnical Parameter Rationale

5.1. Introduction

The following sections summarise the derivation of the geotechnical parameters using results provided from the four historical and recent ground investigations. The geotechnical parameter values for each geological unit are provided in Section 8 of this report.

5.2. Characteristic Values of Geotechnical Parameters

Values of geotechnical parameters are expressed in terms of Characteristic Values, which are defined in BSI BS EN 1997-1 (Eurocodes, 2010) as:

“(1)P The selection of characteristic values for geotechnical parameters shall be based on results and derived values from laboratory and field tests, complemented by well-established experience.

“(2)P The characteristic value of a geotechnical parameter shall be selected as a cautious estimate of the value affecting the occurrence of the limit state.”

Note: “P” denotes that the clause is a Principal of BSI BS EN 1997-1 (Eurocodes, 2010) which means that no alternative method may be used.

The approach to selection of characteristic values provided in this report are generally in accordance with Eurocode 7 (BS EN 1997-1:2004+A1 (2013)). The values are intended to be applied to analyses where the performance of the ground encompasses significant volumes of ground, of the order of many cubic metres.

Eurocode 7 states that characteristic values should be selected as a cautious estimate of the value affecting the limit state (clause 2.4.5.2 (2)). Eurocode 7 further recommends that where the zone of ground governing the limit state is large, the governing parameter is the mean, and hence the characteristic value should be a cautious estimate of the mean (clause 2.4.5.2 (7)). For statistical implementation, it recommends the cautious estimate should be a mean value with a confidence level of 95% (clause 2.4.5.2 (11)).

The results are plotted against depth below ground level for each geological unit. If a change with elevation is noted, more than one characteristic value may be provided for each geological unit.

5.3. Classification and index properties

Classification and index tests do not provide engineering parameters directly but are used to classify soils, identifying trends, strata changes and applying empirical correlations to obtain estimates of other parameters. The classification tests undertaken during the ground investigations comprise Atterberg Limit determinations, moisture content tests and particle size distribution (PSD) gradings. These tests were carried out on disturbed and undisturbed samples.

5.3.1. Natural Moisture Content and Atterberg Limits

The Atterberg Limits is the range of water content over which the soil exhibits plastic behaviour, defined as the liquid limit (w_L) and the plastic limit (w_P), respectively. The water content range itself is defined as the plasticity index (I_P), i.e.:

$$I_P = w_L - w_P$$

The Atterberg limits from the historical ground investigations are notably higher than those from the recent GI; this is likely due to the methodology used to calculate the results. The historical GIs used the Casagrande method, while the recent GI used the drop-cone method as per BS EN ISO 17892-12. Research notes that the drop-cone method provides more reliable results (Wires, 1984), therefore the results from the recent GI have been used as the main basis for deriving geotechnical parameter results.

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5.3.2. Particle Size Distribution

Wet sieving particle size distribution tests were carried out to determine the grading of coarse sized materials. In order to establish the proportion of the fine sized materials (<0.063mm particles), hydrometer tests were carried out on tested samples with >15% clay and silt. The results are plotted as a grading curve with a characteristic grading envelope.

5.3.3. Bulk and Dry Density

Values of bulk and dry density have been determined from laboratory tests on undisturbed UT100 driven samples.

5.3.4. Particle Density

Values of particle density have been determined from laboratory tests on undisturbed UT100 driven samples. Note, these have been taken from the historical GIs only.

5.3.5. Linear Shrinkage

Values of linear shrinkage have been determined from laboratory tests on undisturbed UT100 driven samples.

5.3.6. Dispersibility

The dispersibility of the cohesive soil has been determined by the pinhole method. The classification of the soil has been provided as per Table 2 in BSI BS 1377-5:1990. To summarise, ND1 and ND2 represent a non-dispersive category, ND3 and ND4 are moderately to slightly dispersive, and D1 and D2 as dispersive.

5.4. Strength

5.4.1. Standard Penetration Tests

The N-values derived from SPT results can be correlated with engineering soil parameters by means of established empirical relationships and site-specific correlations where these can be established. Table 5-1 below summarises the properties that can be derived from SPT results (CIRIA, 1995).

Table 5-1 Determination of Parameters from SPT Results (after CIRIA Report C143)

Parameter	Material Type		
	Granular Soil	Cohesive Soil	Chalk
Angle of Friction (ϕ')	✓		
Undrained Shear Strength (c_u)		✓	
Stiffness (E')	✓	✓	✓
Consolidation (m_v)		✓	

Where SPTs met refusal (>50 blows for less than 300mm penetration), the results have been extrapolated to give an N value for the full test drive of 300mm using the equation (CIRIA, 1995):

$$N = \frac{\text{blows during test drive (100)}}{\text{penetration during test drive (mm)}} \times 300$$

The N-values derived from SPT results from the recent GI have been corrected to N_{60} using the energy ratio (E_r) of the SPT hammer as reported in the recent GI factual report (SOCOTEC, 2020) as shown below:

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$$N_{60} = \frac{N \times Er_r}{60}$$

Note: The N-values for the historical ground investigations have not been corrected to N_{60} as no energy certificates are available.

5.4.2. Undrained Shear Strength

The undrained shear strength (c_u) has been assessed using the following tests:

- SPTs; and
- Unconsolidated, undrained triaxial tests.

In cohesive soils it is possible to correlate SPT 'N' values to undrained shear strength using the following relationship proposed by Stroud and Butler (1975) (CIRIA, 1995):

$$c_u = f_1 N$$

The value of f_1 is determined by the characteristic plasticity index and obtained from the Stroud and Butler (1975) figure of f_1 plotted against plasticity index (CIRIA, 1995). The f_1 values used for each stratum is given below:

Bognor Sand Member – 5

Weathered London Clay Formation – 4.4

London Clay Formation – 4.4

Harwich Formation – 4.8

Reading Formation – 4.6

Laboratory undrained unconsolidated triaxial tests directly provide a peak undrained shear strength value.

5.4.3. Remoulded Shear Strength

The remoulded shear strength of the cohesive soil has been determined by hand shear vane tests on recompacted samples used in the compaction and Moisture condition Value (MCV) testing.

5.4.4. Effective Shear Strength (c' and ϕ')

Effective peak angle of shearing resistance has been obtained from s'-t' plots derived from effective stress triaxial tests. Peak and residual angles of shearing resistance have been obtained from small shear box tests and residual angle of shearing resistance from ring shear tests. Note that the characteristic value for effective cohesion (c') is a best estimate of the data set rather than a design value. Therefore, it may not be appropriate to use this value as a design parameter in all situations. This is particularly important in earthwork slopes.

Effective angle of friction (ϕ') for granular material can be obtained indirectly from SPT 'N' values using Figure 36a in CIRIA Report C143 (taken from Peck et al. 1974) (CIRIA, 1995).

Where effective stress tests have not been undertaken on cohesive soil, a correlation based on plasticity index has been used to determine ϕ' , applying Figure 19.7 in Terzaghi et al (1996). The following plasticity index's per stratum have been used:

Head – 37%

Residual friction angle (ϕ_r), where not provided by ring shear tests, has been determined using Skempton et al (1989). The following plasticity index's per stratum have been used:

Head – 37%

Bognor Sand Member – 24%

5.4.5. Stiffness (E')

SPT 'N' values can be correlated to provide stiffness (E') for cohesive soils, using the following relationship provided by the CIRIA Report 143 (CIRIA, 1995):

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$$E' = 0.9 \times N$$

5.5. Consolidation (m_v)

Oedometer consolidation tests were undertaken on undisturbed UT100 samples of cohesive material. The oedometer testing results have been used to derive the coefficient of compressibility (m_v) of cohesive soil.

5.6. Compaction and MCV Testing

Compaction results, including optimum moisture content and dry density have been determined from laboratory tests on disturbed bulk samples. These have been undertaken using a light compaction 2.5kg rammer and heavy 4.5kg rammer. MCV testing has been undertaken as single point tests on disturbed samples at natural water content and calibration test to determine MCV change with water content change.

5.7. Volume Change Potential (VCP)

Volume change potential (VCP) of a soil is the relative change in volume to be expected with changes in soil moisture content and is reflected by shrinking and swelling of the ground. The most widely used parameter for determining the shrinkage and swelling potential of a soil is the Plasticity Index (I_p). Such plasticity parameters, being based on remoulded samples, cannot precisely predict the shrink-swell behaviour of an in-situ soil. Therefore, a Modified Plasticity Index (I_p') is used, which includes particle size data to get a more accurate result. This is done by using the following formula:

$$I_p' = I_p \times \frac{\% < 425\mu m}{100}$$

This result is then used to determine the VCP of a clay using Table 5-2 below, after Building Research Establishment (1993) (Jones & Terrington, 2011).

Table 5-2. Classification of Volume Change Potential (after Building Research Establishment, 1993)

Classification	I_p' (%)	VCP
A	< 10	Non-Plastic
B	10 – 20	Low
C	20 – 40	Medium
D	40 – 60	High
E	> 60	Very High

5.8. Consistency Index (CI)

The consistency index (CI) is used to help determine the reusability of soil for embankment fill. The CI is calculated using the following equation given in Nowak and Gilbert (2015):

$$CI = \frac{LL - \omega}{PI}$$

5.9. Concrete Classification

Chemical tests on potentially aggressive ground/water have been conducted to determine the type of concrete which will be needed for buried structure design. The results of these tests have been correlated with the tables in the BRE Special Digest 1:2005 (BRE, 2005) to determine the Design Sulphate Class (DS) of each unit. Mobile groundwater has been assumed.

6. Ground Model

6.1. General

This section summarises the geology and geomorphology of the Study Area and immediate surrounding area using a ground model that has been developed by Atkins as part of this scope of works. The ground model was created using the borehole data from the historical and recent ground investigations, Desk Study (Atkins Ltd., 2020a), an aerial photographic interpretation and geomorphological mapping of the Study Area, as well as engineering judgement based on Atkins' understanding of the ground conditions within the Study Area and surrounding area.

Geological cross-sections have been created across the Study Area, which summarise the ground conditions present. These are presented in Appendix C of this report.

6.2. Geology

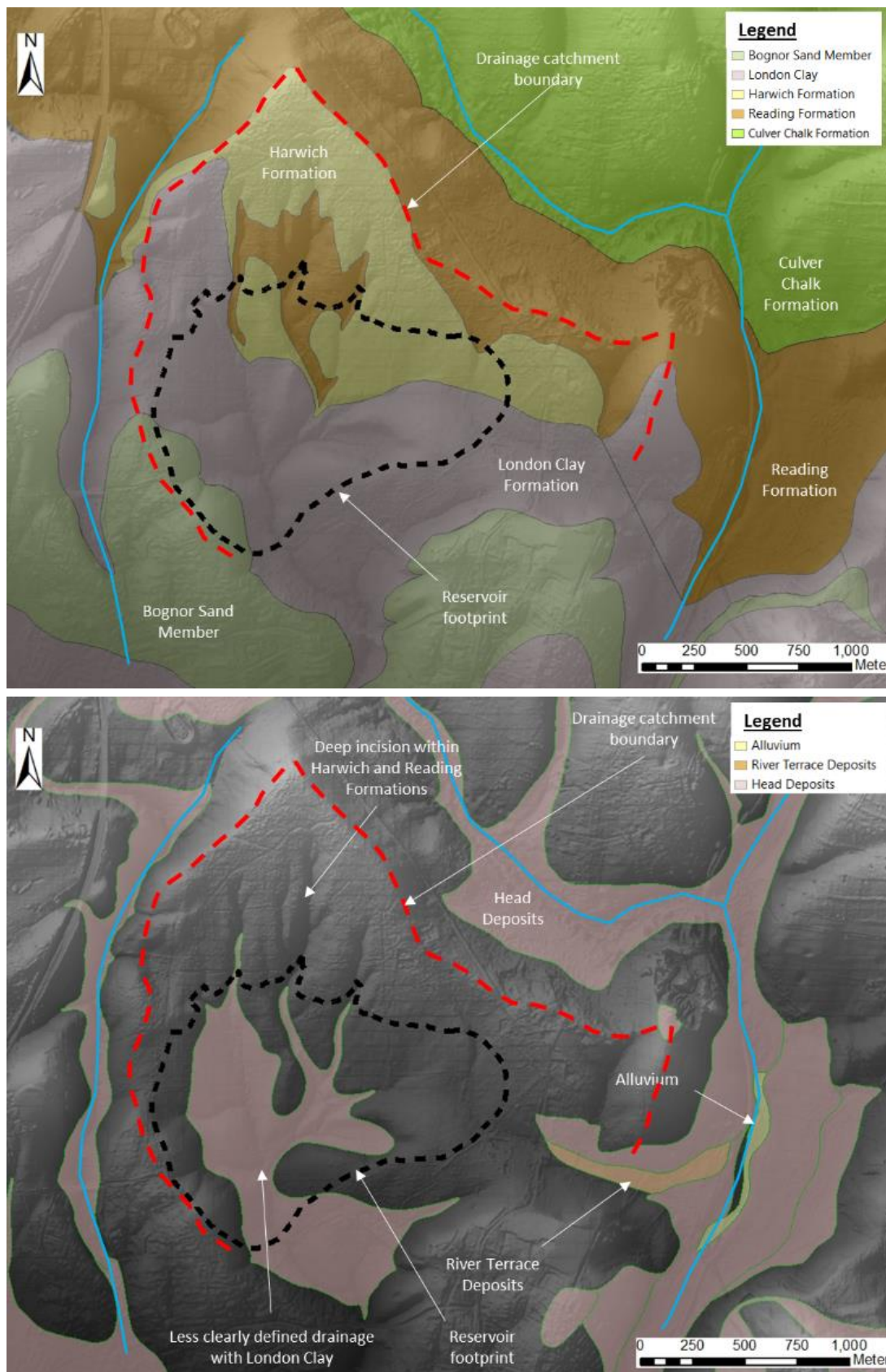
The superficial strata present at the Study Area comprises Topsoil overlying Head which is shown within the shallow depressions and along the drainage lines within the Reservoir Footprint. These superficial deposits in turn overlie bedrock of the Bognor Sand Member (part of the London Clay Formation), London Clay Formation (including a weathered zone), Harwich Formation and Reading Formation.

Figure 6-1 below presents the published BGS 1:50,000 Regional Bedrock Geology (top) and Superficial Deposits (bottom) mapping overlain on a hillshade digital terrain model (DTM) model; this is available through the BGS Geoindex (British Geological Survey, 2020).

The descriptions and distribution of the strata identified during the ground investigations agree with that presented on the published geological map (British Geological Survey, 1998; British Geological Survey, 2020). Appendix A of this report includes a plan of the Study Area footprint overlying the published geological map.

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Figure 6-1 - Geological maps overlaying a DTM for the Study Area and surrounding site



Note: The geological mapping and DTM have been taken from the BGS Geoindex (British Geological Survey, 2020). The images have been edited by Atkins (2020).

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6.3. Cross-Sections

Six geological cross-sections have been created using the available exploratory hole data from the historical and recent ground investigations. These are presented in Appendix C of this report.

The geological cross-sections show that the bedrock geology is dipping to the south-west following the topography and creating a geological feather-edge. The feather-edge is causing the deeper bedrock strata to daylight, i.e. the Reading Formation and Harwich Formation in the north-east and the London Clay Formation and Bognor Sand Member to the south-west. This daylighting is further exacerbated by fluvial processes leading to topographic lows with clear v-shaped river channels or small valleys.

The following can be noted from the cross sections, regarding the bedrock:

- The succession of strata appears regular and uniform across the Study Area;
- The thickness of the Harwich Formation (the only stratum to be routinely penetrated by a significant number of boreholes appears relatively uniform and consistent across the Study Area, showing no signs of disturbance; and
- The surface of the Chalk is at a depth within the range expected from the Desk Study.

Head deposits are present across the Study Area with thicker units located towards the middle and base of slopes; this is consistent with what would be expected from the slope-derived material.

Further information on the thickness and distribution of the strata is given in Section 6.4 of this report.

6.4. Thickness and Distribution

6.4.1. Topsoil

Topsoil was encountered in the majority of boreholes, excluding ATK-CP-12, ATK-TP-03, M03, M05 to M07, M10, M12 to M20, MRM18/1, MRM18/2 and MRM18/4. There does not appear to be any pattern in the distribution of this stratum leading to the conclusion that Topsoil is not necessarily absent from the aforementioned boreholes but is more likely to have been undifferentiated from the underlying strata. Based on this, it is therefore reasonable to assume that Topsoil is present across the whole of the Study Area. This also fits with the current and historical land use within the Study Area.

This unit was encountered at surface in all of the boreholes (0m bgl; 22.15 to 40.43m OD). The thickness of the Topsoil ranges from 0.05 to 1.0m with a typical thickness of 0.3m.

6.4.2. Head

Head was encountered in half of the boreholes completed in the Study Area. There does not appear to be a pattern in the distribution of Head across the Study Area, nor does the distribution correlate with the geological map for the Study Area (British Geological Survey, 1998). The description of Head from the ground investigations (see Section 6.5.2) is very similar to that of the Bognor Sand Member, Weathered London Clay Formation, Harwich Formation and Reading Formation. It is therefore possible, that Head has simply not been differentiated from the bedrock strata. Based on this, it is therefore reasonable to assume that Head is present with possible minor local exceptions across the whole of the Study Area.

This unit was encountered either at surface or underlying Topsoil in all of the boreholes (0.0 to 0.5m bgl; 19.6 to 40.13m OD). The thickness of the Head varies from 0.1 to 2.85m with a typical thickness of 1.0m.

6.4.3. London Clay Formation

The Bognor Sand Member

The Bognor Sand Member was encountered in eight of the exploratory holes (A1, A2, A3, M10, MRM 18/B1, ATK-CP-01, ATK-CP-02 and ATK-RC-02) in the south-western section of the Study Area. This is consistent with the geological map for the region (British Geological Survey, 1998).

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The unit was encountered between ground level and 0.75m bgl (34.46 to 39.06m OD). The thickness of this unit varies between 1.75 and 5.5m; there appears to be no correlation between the location of the boreholes and the thickness of the unit logged in these exploratory holes.

Weathered London Clay Formation

Weathered London Clay Formation was encountered in 46 exploratory holes undertaken within the Study Area. Eighteen further exploratory holes identified London Clay Formation, however there was no obvious weathered zone; for some of these exploratory holes, possibly due to the Bognor Formation overlying the unit; for the remaining exploratory holes, it is possible that the weathered zone was not picked up during logging.

Weathered London Clay Formation is present across the whole of the Study Area which is consistent with the geological map for the region (British Geological Survey, 1998).

The encountered top of this unit varies between ground level and 2.7m bgl (17.9 to 35.14m OD). The thickness of the unit varies between 0.4 and 10.9m with a typical thickness of 1.1m. There appears to be no correlation between the location of the exploratory holes and the thickness of the unit logged in the exploratory hole.

It should be noted that the top depth of the Weathered London Clay Formation may be lower than recorded on the logs as Head deposits may be present instead but not identified.

Unweathered London Clay Formation

London Clay Formation was encountered in 64 exploratory holes undertaken within the Study Area. The presence of unweathered London Clay Formation being encountered within the Study Area, is consistent with the geological map for the region (British Geological Survey, 1998).

The encountered top depth of this unit varied between 1.0 and 14.0m bgl (28.2 to 33.55m OD). The thickness of this unit varies between 0.2 and 30.6m; thickening to the south-west.

6.4.4. Harwich Formation

Harwich Formation was encountered in 79 exploratory holes undertaken within the Study Area; and is present across the whole of the Study Area; except where the Reading Formation is present at surface. Due to the geological feather-edge that the Study Area is located on, this unit outcrops (beneath the Head deposits) towards the north of the site, generally following the topographical fluvial valleys in this area.

The depth this unit was encountered at varies between 0.1 and 36.6m bgl (5.46 to 39.8m OD). The thickness of this unit varies between 0.3 and 5.6m; with a typical thickness of approximately 2.0m which generally thickens to the edges of the site.

6.4.5. Reading Formation

Reading Formation was encountered in 67 of the exploratory holes undertaken within the Study Area; and is present across the whole of the Study Area. Roughly due to the geological feather-edge that the Study Area is located on, this unit outcrops (beneath the Head deposits) towards the north of the Study Area in an area of lower elevation likely associated with relict fluvial channels. This is also evidenced by the topographic valleys of which the outcropping of this unit follows.

The top depth where this unit was encountered varies between ground level and 36.6m bgl (5.3 to 38.03m OD). The base of this unit was only encountered in three boreholes (ATK-RC-01, ATK-RC-02 and ATK-RC-03). The thickness of this unit varies between 29.51 and 32.5m; with an average thickness of 30.7m.

6.4.6. White Chalk Sub-Group

The White Chalk Sub-Group was only encountered in three of the boreholes in the Study Area (ATK-RC-01, ATK-RC-02 and ATK-RC-03) as the other boreholes did not penetrate deep enough. The top depth this unit was encountered varies between 35.0 and 68.7m bgl (-16.48 to 2.03m OD). The thickness of this unit exceeds the 12m proved in the recent GI, and is likely to be around 300 metres thick (British Geological Survey, 1998).

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6.4.7. Summary

Table 6-1 below summarises the thickness and distribution of the strata present in the Study Area. Note, the values have been rounded up to one decimal point.

Table 6-1 - Summary of Strata Thickness and Distribution

Stratum	Depth Top (m bgl)	Elevation Top (m OD)	Thickness Encountered Range (m)	Typical Thickness (m)	Distribution
Topsoil	0.0	22.2 – 40.5	0.1 – 1.0	0.3	Whole of Study Area
Head	0.0 – 0.5	19.6 – 40.1	0.1 – 2.9	1.0	Whole of Study Area
Bognor Sand Member	0.0 – 0.8	34.5 – 39.1	1.8 – 5.5	-	South-western section of Study Area
Weathered London Clay Formation	0.0 – 2.7	17.9 – 35.1	0.4 – 10.9	1.1	Whole of Study Area except where Harwich or Reading Fm. are at surface
London Clay Formation	1.0 – 14.0	28.2 – 33.6	0.2 – 30.6	-	Whole of Study Area except where Harwich or Reading Fm. is at surface
Harwich Formation	0.1 – 36.6	5.46 – 39.8	0.3 – 5.6	2.0	Whole of Study Area except where Reading Fm. are at surface
Reading Formation	0.0 – 39.6	5.3 – 38.0	29.5 – 32.5	30.7	Whole of Study Area
White Chalk Sub-Group	35.0 – 68.7	-4.5 – 5.5	>12	>12	Whole of Study Area

6.5. Stratum Descriptions

6.5.1. Topsoil

The Topsoil is fairly homogenous and is described in the exploratory hole logs as soft to hard light to dark brown clayey/silty slightly sandy and/or gravelly TOPSOIL with abundant rootlets. The stiffness of the soil is likely due to the changes in weather and surface water.

6.5.2. Head

The Head is typically described as soft to very stiff greyish to orangish to yellowish brown silty CLAY, which is locally highly fissured and friable, slightly gravelly (flint, quartzite, sandstone and mudstone) and slightly sandy. Roots and rootlets are often noted.

Six of the exploratory hole logs describe this unit as firm to very stiff orangish brown to grey fine sandy and/or clayey SILT.

Five of the exploratory hole logs describe this unit as medium dense clayey sandy flint GRAVEL.

These descriptions are consistent with the Bognor Sand Member, Weathered London Clay Formation, Harwich Formation and Reading Formation which may be the source of the Head material prior to periglacial solifluction.

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Shear surfaces have been identified in the eight of the historical trial pits; these are discussed in more detail in Section 6.7 of this report.

6.5.3. London Clay Formation

Bognor Sand Member

The Bognor Sand Member is typically described as medium dense light orangish brown slightly silty fine SAND (this bed is between 2.45 and 4.1m thick) overlying soft to stiff brownish grey mottled orangish brown sandy clayey SILT to fine to medium sandy CLAY (between 1.5 and 2.5m thick). In ATK-CP-02 and M10, the whole unit is predominantly clay (3.95m and 2.82m thick respectively).

Weathered London Clay Formation

The Weathered London Clay Formation is described in the exploratory hole logs as soft to very stiff orangish brown mottled grey silty to sandy CLAY, pyritic with frequent small pockets of gypsum / selenite crystals. This unit is locally poorly laminated, highly fissured or gravelly (siltstone). The fissures are randomly orientated, closely to extremely closely spaced, planar, smooth. Occasional organic matter (wood fragments, rootlets) and partings of fine sand are noted throughout.

A band of hard claystone nodules (0.2m thick) is noted in A4 at 1.7m bgl.

Two historical trial pits (A4 and A6) note the presence of near-surface shear surfaces at approximately 2.8m and 1.1m bgl respectively. These are discussed further in Section 6.7 of this report.

Unweathered London Clay Formation

The unweathered London Clay Formation is described in the logs as stiff becoming very stiff locally fissured locally indistinctly laminated, dark brown to dark grey slightly sandy silty CLAY with occasional pockets/lenses (up to 10x5mm) of grey fine sand and silt. Occasional zones of CLAYSTONE are noted throughout; these are typically between 0.05 and 0.5m thick.

6.5.4. Harwich Formation

Based on the available borehole logs, the Harwich Formation can be considered a very heterogenous unit comprising alternating and interleaved beds of:

- Soft to stiff brown to orange brown to dark grey sandy silty CLAY, locally gravelly (flint). Pyritic. Occasional shell fragments, occasional to frequent pockets (<5mm) of orangish fine sand, rare pockets of poorly cemented sand and rare nodules/thin beds of hard brown claystone and mudstone.
- Soft to very stiff brown to dark grey clayey to sandy SILT, locally gravelly (flint) and locally contains worm tubules (trace fossils). Weakly cemented purplish red SILTSTONE is noted in one borehole (D25).
- Medium dense to dense brown (locally orangish or yellowish brown) fine to medium SAND to silty SAND. Locally abundant white worm tubules (trace fossils) are noted. Occasional beds of very weak SANDSTONE 'conglomerate' with very high proportion of bivalve shells and flint gravel.
- Brown and grey clayey sandy medium to coarse GRAVEL and locally cobbles. The gravel and cobbles are flint and limestone.
- Weak to strong thinly bedded to massive dark grey and grey fine to medium grained fossiliferous LIMESTONE.

6.5.5. Reading Formation

The Reading Formation is described in the available exploratory hole logs as predominantly stiff to very stiff mottled reddish brown, light red, pink, light bluish grey mottled and yellowish brown slightly sandy or silty CLAY. Locally this unit is slightly gravelly (sandstone, mudstone, ironstone). In ATK-CP-06 and ATK-RC-01, beds of brown mottled light grey clayey fine to medium SAND are noted (0.06 to 1.73m thick). In ATK-RC-02, D26 and MRM18/B2, 0.1m thick rare beds of weak sandstone is noted.

6.5.6. White Chalk Sub-Group

The White Chalk Sub-Group is described in the available logs as weak to strong high-density light grey to white with some orange and yellowish orange staining CHALK with rare to occasional black flint cobbles. Fractures are 0°, medium to widely spaced, undulating to planar, rough with faint black speckling on surfaces and locally orangish brown staining or clay smearing.

CIRIA grades (CIRIA, 2002) have not been provided as part of the description by the GI Contractor, however Atkins have determined that chalk in the Study Area is primarily A2 grade.

In borehole ATK-RC-02, the top 0.5m of this unit is described as Brown, dark grey and black angular to subangular fine to coarse GRAVEL of flint with medium cobble content overlying very stiff greenish grey, mottled yellowish brown, sandy gravelly CLAY with medium cobble content. This change in consistency of the Chalk could be due to the drilling method used, or due to localised weathering. This has been determined by Atkins to be CIRIA grade Dm (CIRIA, 2002).

6.6. Geomorphology

6.6.1. Introduction

As part of the Desk Study (Atkins Ltd., 2020a; Atkins Ltd., 2020b), Atkins undertook a review and interpretation of available aerial photographs to identify the geomorphological features and potential geohazards that might be present at and adjacent to the Study Area. The study was to review and build upon a Draft Aerial Photographic Interpretation (API) undertaken by Arup in 2009 (Ove Arup & Partners Ltd, 2009).

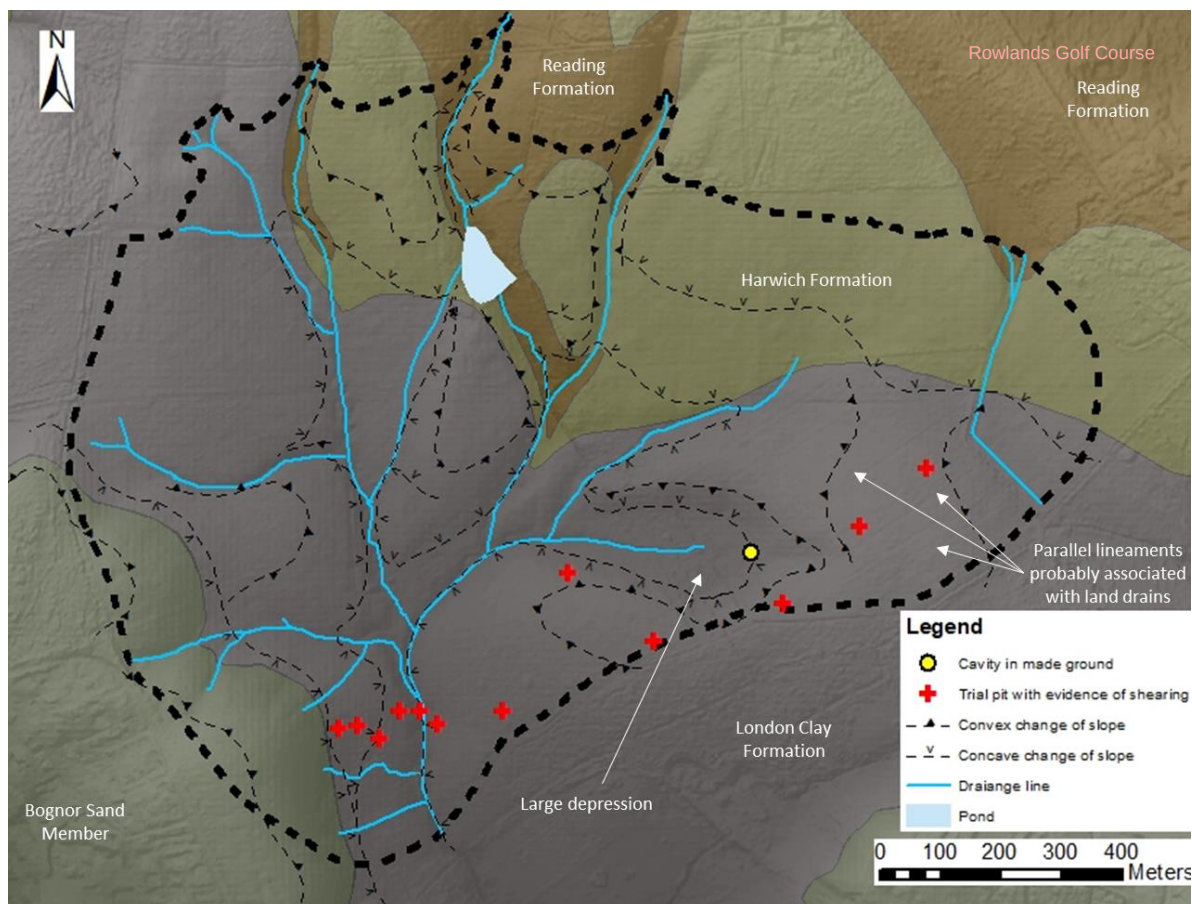
The photographs which were made available included oblique photographs from commissioned flyovers of the Study Area in 2006 (far field), 2007 (near field) and low to medium-resolution digital prints from the historical aerial photograph archive search undertaken by Arup and covering the period 1946 to 1996. Where stereo pairs were available the prints were examined in 3D using a mirror stereoscope to amplify detail and depth of terrain features.

In total, 258 photographs were analysed within the footprint and near-field of the Study Area and ranged in dates between 1946 and 2007. A complete list of the aerial photographs reviewed as part of the study is provided within the Desk Study (Atkins Ltd., 2020a).

Following the Desk Study and aerial photographic interpretation, geomorphological field mapping of the Study Area was undertaken by Atkins on the 13 December 2019 as part of the API Technical Note (Atkins Ltd., 2020b) produced as a supplement to the Desk Study. In addition, during the ground investigation, the geomorphology was reviewed to identify any changes. The results of the geomorphological mapping confirmed the findings of the aerial photographic interpretation; these findings are summarised in Figure 6-2 and Sections 6.6.2 to 6.6.5 below.

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Figure 6-2 - Site-specific geomorphology and active drainage lines overlain on to the Published BGS 1:50,000 Bedrock Geological mapping and the hillshade DTM model



Note: This image has been taken from the Aerial photography and LiDAR interpretation Technical Note (Atkins Ltd., 2020b).

The geological mapping and DTM have been taken from the BGS Geoindex (British Geological Survey, 2020).

The images have been edited by Atkins (2020).

6.6.2. Study Area Geomorphology – Overview

Historical aerial photographs confirm that the majority of the Study Area was cleared of woodland between 1946 and 1954. Portsmouth Water obtained grants from the Ministry of Agriculture Food and Farming (MAFF) between 1967 and 1973 to improve the land for agriculture by removing scrub and enhancing the land drainage across the Study Area. This is reflected on the photographs during this time with straightening of the stream channels within the Study Area and the clearing of overgrown land. This means that some natural geomorphological features were lost, although others can still be seen within the landscape which are summarised below.

The Study Area comprises gentle slopes and small meandering tributary channels feeding into a slightly larger channel, that flows southwards away from the southern boundary of the Study Area (see Figure 6-2). Some of these tributary channels are fed by seepage lines that occur across some of the slopes. It is likely that these are associated with artesian groundwater and the boundary between the Bognor Sand Member and London Clay Formation. It is also noted that some of the tributary stream channels are meandering channels, which may pick up preferential pathways through the landscape following either geological boundaries, structural discontinuities within the geology or anthropogenic activity within the landscape.

Slope morphology across the Study Area can be seen to relate to the underlying geology, with breaks or changes in slope angle corresponding to a number of the geological boundaries present across the site. This is discussed further in Section 6.6.3 below.

Some of the slopes across the Study Area are affected by soil creep – a very slow mass movement of soil which can be seasonal or continuous depending on the climate of the region (Highland &

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Bobrowsky, 2008); in the Study Area, it is likely to be seasonal and affected by prolonged periods of rainfall. Across the site soil-creep was confirmed during the historical ground investigations by the presence of shear surfaces within the Head deposits. This is discussed further in Section 6.7 of this report.

The API and Desk Study (which covered both the Study Area and an area of approximately 1km surrounding the Study Area) also noted the presence of surface depressions and evidence of possible karstic terrain in some of the areas outside of the Study Area boundary (but not within the Study Area itself). These features are discussed further in Section 6.6.4 below.

The Desk Study also highlighted the potential for the area in which the Study Area is located to be affected by geomorphological features such as solifluction, sinkholes and pingos. However, neither the API nor the geomorphological field mapping identified any of these features within the Study Area boundary. An assessment has also been made of the likelihood of pingos to be present within the Study Area. This is discussed further in Section 6.6.5 below.

6.6.3. Study Area Geomorphology - Detailed Description

The Study Area can be sub-divided into four relatively distinct areas:

Southwest portion of the Study Area

The southwest of the site is defined by a north-south trending valley between the land immediately west of Round Wood and the ridge of high ground across the west boundary of the Study Area. The west valley side is generally steeper than the eastern valley side, with slope angles recorded between 11° to 15° compared to approximately 5° (respectively). Seepage is encountered along the west valley face immediately upstream to the inferred geological boundary (from 1:10,000 geological mapping) between the Bognor Sand Member and London Clay Formation. This geological boundary is reflected in the slope morphology in the area known as Deerslaughter Plain (see Figure 6-2) with the area, which forms the valley floor, being characterised by marshy / boggy conditions and the presence of hydrophilic vegetation. The hillslopes either side of this area are also affected by soil creep.

Within the valley floor, linear depressions relating to either past seasonal drainage and/or existing seasonal drainage patterns, are present. These are largely infilled stream channels likely associated with migrating streams. From aerial photographs, these features are indicated by vegetation patterns and the presence of stream channels which are typically orientated north-south and east-west. These smaller stream channels appear to converge with the larger existing stream channel which flows southwards away from the Study Area (see Figure 6-2).

Southeast portion of the Study Area

Drainage channels intersect this part of the Study Area, following breaks in the grassland as seen in the geomorphological map (Figure 6-2). The topographic high is towards the southern boundary of the Study Area, west of Gipsies Plain and is approximately +34mOD.

A large, shallow bottomed depression is evident at the location of 'Thicket Bottom'; which measures around 200m wide by 300m long by 4m deep, with side flanks typically inclined at less than 5°. A smaller, poorly defined, depression is evident at the head of this large depression feature. The depression feature appears to have been formed within the London Clay Formation. In the late 1800s, 'The Avenue' was constructed obliquely across the depression. However, the changes in slope associated with the depression remain clearly evident along 'The Avenue' alignment.

During the December 2019 site walkover, the ground within the depression was found to be heavily waterlogged (Figure 6-3). Made Ground, comprising slightly sandy clay/silt, was identified in the eastern part of the depression. The Made Ground contained a network of surface cavities up to 0.5m deep and possibly interconnected. A section of clay piping was identified in the base of one cavity and is likely a damaged section of a land drainage network which extends beyond the lateral extents of the depression. It is believed that these cavities represent washout features associated with uncontrolled water movement along this land drain network.

The origin of the large depression itself is potentially a naturally occurring feature in the landscape that has then possibly been modified through human activities. A possible natural origin of the landform could be related to localised, regressive mass movement along shallow angle relict shear surfaces within the uppermost portion of the London Clay. The depression and relict shear surfaces could therefore be associated with past periglacial conditions. However, historical maps for the area show that brickworks and clay pits exist within the local area beyond the Study Area.

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It should be noted that no evidence of recent instability was observed during the onsite geomorphological mapping or the recent ground investigation.

Figure 6-3 – Field photos taken during the December 2019 onsite geomorphological mapping showing the depression feature.



Note: The yellow dotted line indicates the convex edge of the depression feature. (Left) Photo taken facing northwest. (Right) Photo taken facing west.

Northeast portion of the Study Area

This part of the Study Area generally dips to the south-southwest between 1° to 3°. Drainage channels are present to the east and west of the area and form shallow north-south trending stream valleys that flow towards the southwest of the Study Area. No other significant geomorphological features were recorded within the northeast of the Study Area.

Northwest portion of the Study Area

The area to the north of the Upper Lake comprises undulating ground that forms the east valley side of an incised stream valley. The 1:10,000 geological mapping indicates that the underlying geology is the Reading Formation. To the west of Upper Lake, another north-south orientated stream is present. There is also a seasonal stream in the north-western corner of the Study Area and indicates south-southeast flow towards Middle Clearing. Within the seasonal drainage channels, the presence of shallow washout features were seen to incise into the underlying ground forming 500 to 600mm deep soil rills. No other significant geomorphological features were recorded within the northwest of the Study Area.

Within 1km of the Study Area

Surface depressions potentially indicating a karst dominated terrain were noted in Rowlands Golf Course to the east and northeast of the Study Area, between 0.25km and 1km outside of the Study Area boundary. No evidence of similar features were observed within the Study Area.

6.6.4. Karstic Environments

The term 'karst' is associated with chalk and limestone environments and comprise a distinctive succession of landforms and hydrogeology. In hydrogeological terms the importance of karst is that groundwater is concentrated in, and flows rapidly through, a network of fractures, conduits and caves (Maurice, et al., 2006). Geomorphological evidence of karst characteristics is widespread across the south-east of England and is largely characterised by dissolution features.

Several types of karst dissolution features within the White Chalk Sub-Group are recorded in the Study Area's region (British Geological Survey, 2016); these include:

Stream Sinks / swallow holes - typically characterised by a surface water stream sinking rapidly into the ground. While streams are present at the site, they clearly converge with other streams outside of the Study Area; therefore, these have not been evidenced at the site.

Dolines - these may include surface depressions or may not be visible from the surface at all. Typically, in this area, these occur around Paleogene deposits/Cretaceous chalk boundaries and are therefore often infilled with weaker superficial deposits. While the Study Area is not specifically located on a Paleogene deposits/Cretaceous chalk boundary, these or similar features have been observed

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outside of the Study Area (Jeffery, et al., 2020) and therefore should be considered as a reasonable risk to the project.

Solution pipes - solution pipes typically have no surface depression and like dolines, are often infilled with weaker superficial deposits. These features can be up to 10 to 15m deep. As superficial deposits do not overlie the chalk in the Study Area, solution pipes are not expected to be present.

The API, geomorphological mapping and intrusive ground investigation has not identified any evidence for karst within the Study Area boundary.

Karst Zones

Using a method developed in Maurice et al. (2006), chalk regions can be divided into three karst zones based on the distance from the Chalk-Palaeogene boundary:

Karst Zone 1 - characterised by frequent stream sinks and dolines associated with the boundary.

Karst Zone 2 - is an intermediate area where the Clay-With-Flints Formation superficial deposits are present. In this zone, dolines and solution pipes are likely to occur, but few hydrologically active stream sinks are present.

Karst Zone 3 - the area furthest from the geological boundary, where stream sinks are absent and dolines are rare.

Considering the geological ground conditions across the Study Area, the area can be classified as being located in a Karst Zone 3.

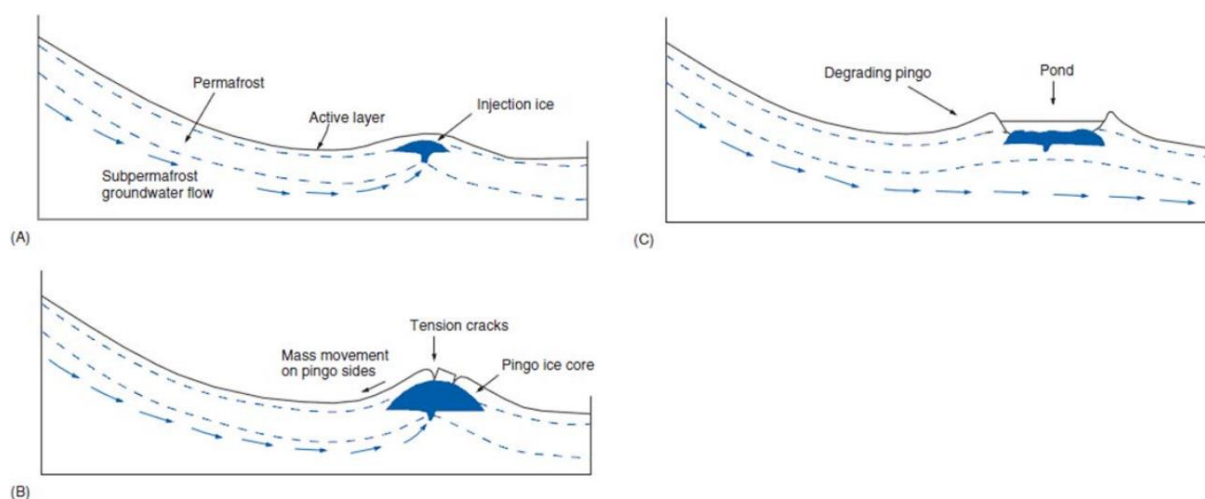
6.6.5. Pingo Scars

During the glacial and periglacial history of the southern UK, pingos of ice, frost-shattered chalk, or frozen water bearing sand may have uplifted and penetrated through the overlying cohesive beds of the London Clay and Harwich Formations (see schematics A and B in Figure 6-4 below). In the south-east of England, these typically occur in areas of artesian groundwater (CIRIA, 2004).

Upon thaw, the pingos collapse creating 'pingo scars'; these are typically characterised at surface by shallow circular depressions often surrounded by raised rampart-like rims (Higginbottom & Fookes, 1970; Flemal, 1976) as shown in schematic C in Figure 6-4 below.

Pingo scars pose a risk to reservoirs as they can allow leakage from the reservoir, as well as lead to settlement and stability complications during excavation of materials and construction of earthworks.

Figure 6-4 - Schematic drawing of the formation of a pingo



Note: Taken from Yoshikawa (2013).

Using the Study Area as an example, a pingo scar might have enabled a hydraulic pathway in the form of a chimney (or throat) to develop through the cohesive beds of the London Clay Formation, connecting surface waters / the permeable stratum of the Harwich Formation with the underlying Reading Formation basal beds / Chalk (CIRIA, 2004).

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Although features similar to pingo scars have been identified close to the site, as referenced in Jeffery et al (2020); based on the findings of the Desk Study, API, geomorphological mapping and the intrusive ground investigation undertaken across the Study Area, Atkins has not found any evidence to suggest the presence of a pingo or pingos being present within the Study Area. For example:

- The depth to the chalk under the Study Area and the lack of evidence of disturbance indicates that the presence of relict pingos underlying the Study Area is unlikely.
- The presence of the Reading Formation at surface in the Study Area has also been investigated as a possible pingo, however the lack of disturbance of this unit and the low elevation, suggests the Reading Formation is daylighting due to the structural geology of the area and fluvial erosion instead.
- Noting that the topography (and therefore the geomorphology) of the Study Area has been subjected to anthropogenic activity, which may have effectively removed this evidence, there is limited morphological evidence (such as shallow circular depressions) to suggest the presence of a pingo within the Study Area.
- The ground investigation did not encounter any evidence of uplifted or disturbed bedrock which could be associated with pingo formation.

6.7. Shear Surfaces

6.7.1. Introduction

Solifluction was the predominant form of periglacial mass movement in Britain during glacial periods. The resultant slope deposits are often referred to as Head or Colluvium. The process occurs due to migration of water to the freezing zone that forms lenses of segregated ice. As a result, the overlying ground is heaved, and its structure dilated. Upon thawing, the lenses of water ensure saturated or near-saturated conditions prevail. Excess porewaters are generated from undrained or near-undrained self-loading from settlement of the loosened overlying soil structure back to its original denser packing (Hutchinson, 1991). Depending on the rate of thaw, material movement is possible on slopes down to inclinations of 1 to 2° (Hutchinson, 1991).

With regards to the Study Area, shear surfaces were recorded in the Head deposits and Weathered London Clay Formation. These are expected to be relict shear surfaces as no obvious sign of recent movement (i.e. tension cracks or disturbed vegetation) was observed during the geomorphological mapping or the recent ground investigation.

6.7.2. Head

Possible shear surfaces have been identified in the Head deposits in eleven of the historical trial pit logs (A4 to A12, E1 and E2) within the Head deposits; these are located to the south of the Study Area beneath the proposed embankment plan.

Shear surfaces were not recorded in any other trial pit log, including those from the recent GI. This however, does not mean that they are not present. It is likely that shear surfaces were not identified in the recent GI trial pits due to current health and safety requirements with regards to entering unsupported excavations and leaving pits open overnight. They are also very difficult to identify in borehole samples and trial pits.

The shear surfaces are typically described as shiny, slightly striated grey shear planes which appear at depths between 0.95 and 3.1m bgl. They are recorded as being traced for up to 400mm and often overlap with one another.

The recorded dip and dip directions of the shear surfaces are provided in Table 6-2 below.

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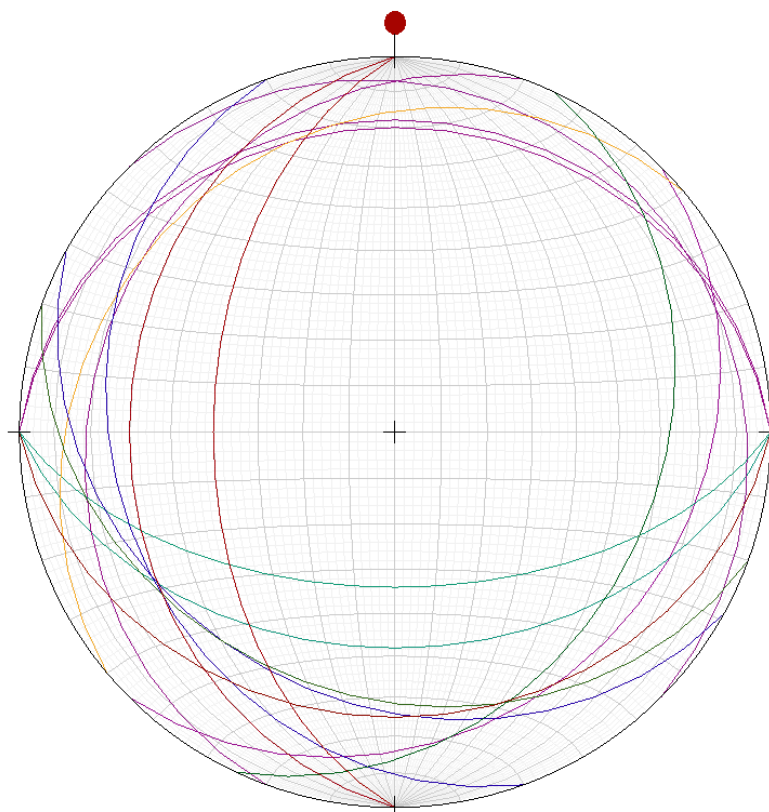
Table 6-2 - Shear surfaces recorded within Quaternary Head deposits / soliflucted London Clay Formation

Trial Pit	Shear Surface Dip / Orientation	Depth (m bgl)	Stratum	Notes
A4	25-30/090	1.5	Head	Stiff-very stiff grey and brown mottled silty CLAY with many interleaved and overlapping shiny surfaced slightly striated shear planes, most prominent around 1.5m and to a slightly lesser extent 2.2m but present to base of pit, can be traced for 400mm but overlap with adjacent planes.
A4	30-40/180	1.5	Head	
A4	50-60/180	2.2	London Clay Formation	
A5	±30/025	0.7 - 1.4	Head	Shiny shear planes with striations parallel to dip trending in approximate downslope directions with undulating surfaces. Most common between 0.7 and 1.4m but can be found at all depths to 4m, also most continuous and extensive 0.7 and 1.4m.
A5	±30/110	0.7 - 1.4	Head	
A6	26/160	1.1	Head	Few shiny striated shear surfaces which can be traced laterally 400mm.
A6	29/119	1.1	London Clay Formation	
A7	Sub-vertical	0.5 - 0.9	Head	Well-developed shear surfaces present approximately 100mm spacing vertically. A well-defined plane which can be traced across the south face at 0.95m seems to mark the lower limit of the shear planes which dip generally northwards.
A8	- / -	0.4 - 1.6	Head	Variously orientated shiny shear surfaces with striations parallel to dip extend to 1.5m. Surfaces mainly grey in colour.
A9	- / -	0.5 - 1.0	Head	Non-pervasive shear surfaces
A10	20-45/230	<1.2	Head	Extensive curving of shear planes exposed on the south face; striations parallel to dip.
A11	- / -	0.4 - 1.4	Head	Shiny striated shear surfaces dipping mainly northeast at approximately 30°.
A12	- / -	1.0	Head	Some shiny striated mainly grey shear planes.
E1	007/090	0.25 - 0.9	Head	Many interleaved and overlapping shear planes strongly developed.
E1	42/090	1.7 - 3.1 (1.7)	Head	Major shear surface starts at 1.7m extends to 3.1m over full width of pit.
E1	56/090	1.7 - 3.1 (3.1)	Head	
E2	27/270	0.25 - 2.1	Head	Variously orientated grey shear surfaces with striations parallel to dip and overlapping.
E2	22/045	0.25 - 2.1	Head	
E2	10/315	0.25 - 2.1	Head	
E2	20/200	0.25 - 2.1	Head	
E2	20/270	0.25 - 2.1	Head	
E2	18/270	0.25 - 2.1	Head	

The dip and dip directions of the shear surfaces have been plotted on to a stereonet and is presented as Figure 6-5 below. From this figure, the shear surfaces can be seen to be orientated primarily to the west and south, which is consistent with the topography in this region. The dip of the shear surfaces are quite variable but can be summarised as typically being between 20 and 30°.

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Figure 6-5 - Stereonet of shear surfaces



Note: Trial pit A4 – red; A5 – green; A6 – blue; A10 – orange; E11 – turquoise; and E2 – purple

6.7.3. London Clay Formation

Shear surfaces are recorded in two historical trial pits (A4 and A6) within the recorded Weathered London Clay Formation. The shear surfaces are recorded at approximately 2.8m and 1.1m bgl respectively and are simply described as being shiny and striated and extending for no more than 400mm. One dip and dip direction was recorded (in A4) as 20/090; this is consistent with the shear surfaces encountered in the Head and with the slope of the topography.

6.7.4. Summary

The presence of relict shear surfaces has been identified from both the current (2019) GI, although relatively infrequently, and, from the MRM GI, (1977). The latter found relict shear surfaces in a significant number of trial pits and undisturbed borehole samples.

Key features regarding the shear surfaces that have been identified are as follows:

- They have been routinely and frequently found in the upper 2 to 3m bgl;
- The shear surfaces found at shallow depth are mainly associated with the Head, however they were also encountered in the weathered London Clay Formation;
- There is a range of dip angles and strike directions found, with no predominance of relatively shallow (say < 15°) surfaces parallel or sub-parallel to the ground surface; and
- No continuous or semi-continuous shear surfaces, such as might be associated with slope processes or instability were identified that extended over more than 400mm. However, this may reflect the limited scale of the investigation methods adopted, such as relatively small trial pits and boreholes.

It is considered that there are likely to have been three major origins for the shear surfaces, all associated with periglacial conditions, (Spink, 1991; Atkins Ltd., 2020a) as follows:

- Slope movement typically identified as solifluction associated with the development of the Head. It is likely that amongst other things one or more basal shear surfaces could have developed at or close to the base of the Head;

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- General freeze-thaw action during periglacial periods causing the near surface deposits to be sheared both horizontally and vertically, with this process not being limited to the Head; and
- General earth movements including the erosion of the upper parts of the London Clay and strata overlying the London Clay.

With regard to the possible presence of 'basal shears' at or close to the base of the Head, and solifluction, it is noted that the generally modest nature of the topography with slopes generally less than 5°, and often less than 3°, is not typically or routinely associated with slope instability. However, the presence of basal and/or extensive shear surfaces in otherwise benign topography would not be unique to this site.

Thus, allowance should be made in terms of parameters and engineering works for the presence of relict shear surfaces. These could tend to weaken the materials generally, and provide surfaces, in the case of a continuous or semi-continuous and extensive basal shear, on which potential failure surfaces associated with earthworks slopes could develop.

7. Groundwater

7.1. Groundwater Strikes

Thirty-eight groundwater strikes were encountered during the recent ground investigation. These were primarily seepages and strikes within the Harwich Formation. Below is a summary of the groundwater strike depths per stratum:

Topsoil: Two results ranging from 0 to 0.1m bgl (32.0 to 32.47m OD).

Head: Six results ranging from 0.4 to 1.6m bgl (21.05 to 39.73m OD); two results rose after 20 minutes by 0.2 to 0.3m.

Bognor Sand Member: One result at 0.9m bgl (36.55m OD).

London Clay Formation: Nine results ranging from 0.5 to 2.5m bgl (19.29 to 32.61m OD).

Harwich Formation: Eighteen results ranging from 1.0 to 34.0m bgl (-3.97 to 36.25m OD); 11 of the strikes rose after 20 minutes by between 0.2 and 18.9m. The most significant rises were within boreholes ATK-CP-02 (18.9m), ATK-CP-04 (10.3m) and ATK-CP-11 (8.6m).

Reading Formation: Two results ranging from 0.4 to 21.2m bgl (12.25 to 32.99m OD); one result rose after 20 minutes by 8.2m.

Forty-two groundwater strikes were also recorded within the historical GIs. These agree with the results of the 2020 ground investigation and were again primarily within the Harwich Formation, with seepages recorded in the London Clay and Reading Formations.

7.2. Groundwater Monitoring Results

As described in Section 4.5.4, there is limited groundwater monitoring available at the time of writing this report. In addition, the groundwater readings from each monitoring round may not be representative of the actual groundwater due to the activities carried out on the installations during previous visits. Therefore only the manual monitoring results from Round 3 are summarised in Table 7-1 and shown on Figure 7-1 below.

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Table 7-1 - Groundwater Monitoring Results: Round 3 (week commencing 10/02/2020)

Hole	Ground Level (m OD)	Installation Type	Response Zone Geology **	Monitoring result (m bgl)	Monitoring result (m OD)	Reading Date
ATK-CP-01	37.45	Standpipe piezometer	Bognor Sand Member	1.31	36.14	11/02/20
ATK-CP-02	30.03	Standpipe piezometer	Harwich Formation	2.56	27.47	12/02/20
ATK-CP-04	24.90	Standpipe piezometer	Harwich Formation	-0.48 (pipe top)	25.38 (pipe top)	11/02/20
ATK-CP-05	27.91	Standpipe piezometer	Harwich Formation	2.18	25.73	11/02/20
ATK-CP-06	34.73	Standpipe	Head/Harwich Formation	0.81	33.92	11/02/20
ATK-CP-11*	26.15	Vibrating wire piezometer	Harwich Formation	-0.16	26.31	28/01/20
ATK-CP-12	26.90	Standpipe piezometer	Harwich Formation	0.19	26.71	11/02/20
ATK-CP-13A	29.75	Standpipe piezometer	Harwich Formation	0.57	29.18	12/02/20
ATK-CP-15	33.45	Standpipe piezometer	Harwich Formation	2.97	30.48	11/02/20
ATK-CP-16	37.70	Standpipe	Harwich Formation	0.46	37.24	11/02/20
ATK-BH-01	25.73	Vibrating wire piezometer	London Clay Formation	1.00	24.73	11/02/20
ATK-BH-01	25.73	Vibrating wire piezometer	London Clay Formation	1.33	24.40	11/02/20
ATK-BH-02	21.45	Vibrating wire piezometer	London Clay Formation	0.09	21.36	11/02/20
ATK-BH-02	21.45	Vibrating wire piezometer	London Clay Formation	-0.53	21.98	11/02/20
ATK-RC-01	40.53	Standpipe piezometer	White Chalk Sub-Group	7.23	33.30	11/02/20
ATK-RC-02	39.87	Standpipe piezometer	White Chalk Sub-Group	22.36	17.51	12/02/20
ATK-RC-02A	39.85	Standpipe piezometer	Harwich Formation	1.36	38.49	12/02/20
ATK-RC-03	31.52	Standpipe piezometer	White Chalk Sub-Group	6.55	24.97	12/02/20

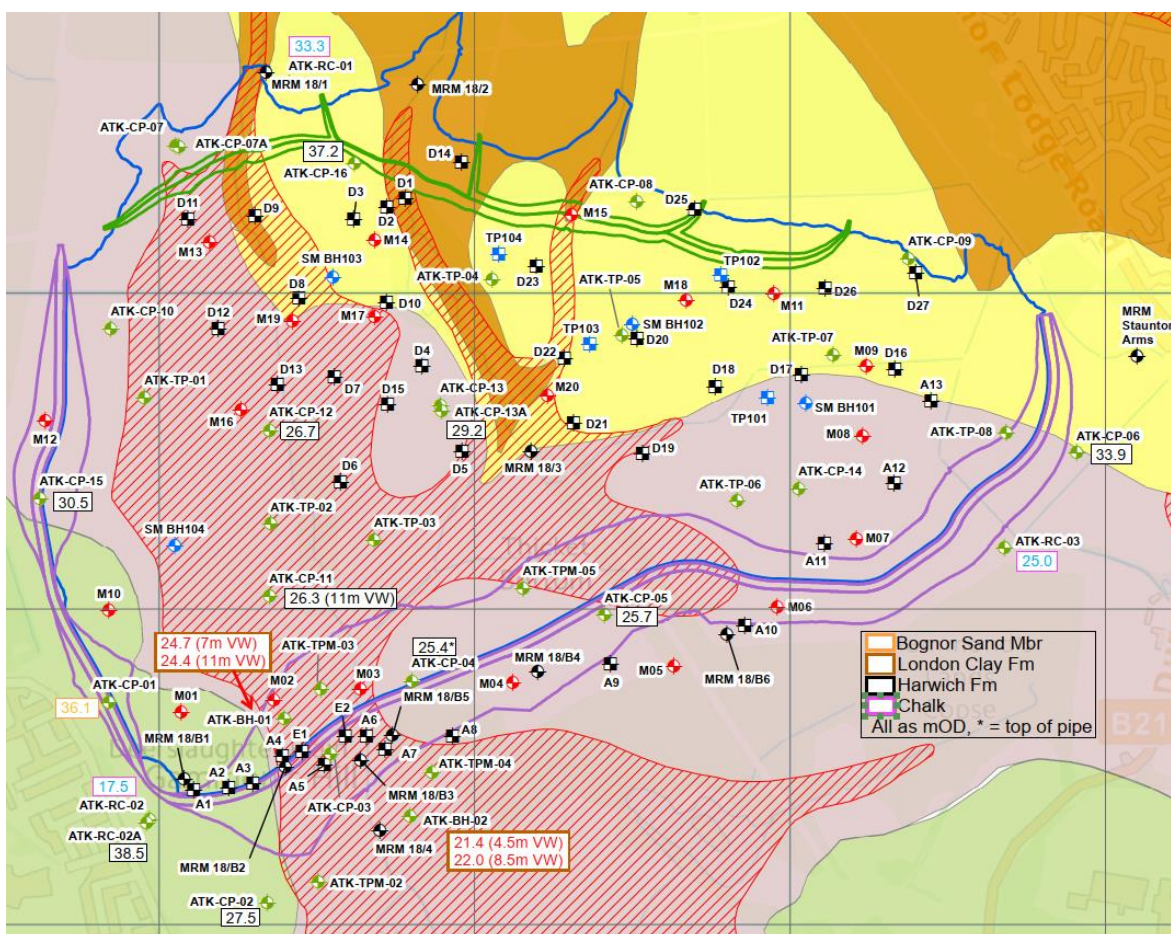
Note: * Manual monitoring is from Round 2 as none taken in Round 3

** More responsive/permeable geology indicated.

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Figure 7-1 - Groundwater Monitoring Results: Round 3 (week commencing 10/02/2020)



8. Geotechnical Parameters

8.1. Introduction

The following geotechnical parameter values have been determined from the correlations given in Section 5 of this report. The corresponding plots for each parameter value is given in Appendix D of this report.

The responsibility for the selection of specific input parameter values for analyses must remain with the Designer. This is because of the effects that the various analytical idealisations, loading scenarios and performance constraints impose on these values.

It must be noted that the parameters that represent some of the soil tests provided herein are based on a limited data set.

8.2. Topsoil

Geotechnical testing was not undertaken on the Topsoil present at the Study Area.

8.3. Head

8.3.1. Geotechnical Parameter Values

The geotechnical parameter values for the Head present at the Study Area is summarised in Table 8-1 below.

Table 8-1 - Geotechnical parameter values for Head

Test	Units	Range (no of results)	Characteristic Value	Plot Number
Moisture Content	%	6 - 43 (16)	27*	1.1
Liquid Limit	%	43 - 86 (13)	63	1.1
Plastic Limit	%	18 - 33 (13)	24	1.1
Plasticity Index	%	23 - 58; one result NP (13)	37*	2.1
A-Line Plot	-	High plasticity CLAY; two results very high; two results intermediate. (13)		3.1
Particle Size Distribution	-	Slightly sandy SILT/CLAY and silty/clayey sandy GRAVEL (5)		4.1
Bulk Density	Mg/m ³	2.02 - 2.06 (2)	2.04*	-
Dry Density	Mg/m ³	1.57 (1)	1.57*	-
Classification by SPT N ₆₀ -Value	-	12 (1)	Firm	-
C _u from N ₆₀	kPa	53 (1)	55*	-

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Test	Units	Range (no of results)	Characteristic Value	Plot Number
c _u from Triaxials	kPa	58 (1)		-
φ' from PI	°	-	27	-
φ _r from PI	°	-	14	-
Optimum Moisture Content (2.5kg rammer)	%	19 - 24 (3)	22	14.1
Moisture Condition Value	-	6.5 – 9.7 (5)	9	15.1 / 16.1
Dispersion by pinhole method	-	ND1 (1)	ND1	
SO ₄	mg/l	299 (1)	DS-1 AC-1 ^d	-
pH	-	7.3 - 8.3 (3)		-

Note: * Due to variable and/or minimal results, mean values have been given as characteristic values.
 NP denotes 'non-plastic'.

8.3.2. Permeability

No permeability tests were undertaken within the Head deposits.

8.4. London Clay Formation – Bognor Sand Member

8.4.1. Geotechnical Parameter Values

The geotechnical parameter values for the Bognor Sand Member present at the Study Area is summarised in Table 8-2 below.

Table 8-2 - Geotechnical parameter values for Bognor Sand Member (of the London Clay Formation)

Test	Units	Range (no of results)	Characteristic Value	Plot Number
Moisture Content	%	20 - 36 (11)	27	1.2
Liquid Limit	%	29 - 72 (10)	49*	1.2
Plastic Limit	%	21 - 28 (10)	24	1.2
Plasticity Index	%	8 - 44; one result NP (12)	24*	2.2
A-Line Plot	-	Low to high plasticity CLAY; one result low plasticity SILT (10)		3.2
Particle Size Distribution	-	Slightly silty slightly gravelly SAND and slightly sandy CLAY/SILT		4.2

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Test	Units	Range (no of results)	Characteristic Value	Plot Number
		(10)		
Bulk Density	Mg/m ³	1.95 (1)	1.95*	-
Dry Density	Mg/m ³	1.51 (1)	1.5*	-
Classification by SPT N ₆₀ -Value	-	7 - 27 (11)	Soft to stiff (cohesive); medium dense (granular)	6.1
c _u from N ₆₀	kPa	35 - 135 (8)	70*	7.1
c _u from Triaxials	kPa	67 (1)		7.1
φ' from N ₆₀ (Granular only)	°	29 - 39 (6)	33	9.1
φ _r from PI	°	-	27	-
E' from N ₆₀ (Cohesive only)	MPa	6 - 19 (11)	12*	13.1
Optimum Moisture Content (2.5kg rammer)	%	18 – 24.5 (5)	21	14.2
SO ₄	mg/l	20 – 60 (4)	DS-1 AC-2z	-
pH	-	4.9 – 7.2 (4)		-

Note: * Due to variable and/or minimal results, mean values have been given as characteristic values.
 NP denotes 'non-plastic'.

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8.4.2. Permeability

Three laboratory permeability tests and two falling head tests in the constructed borehole were undertaken to measure the permeability of the Bognor Sand Member. The results of the tests are presented in Table 8-3.

Table 8-3 - Permeability results for the Bognor Sand Member

Borehole ID	Depth [base of test] (m)	Test Type	Coefficient of Permeability (m/sec)
ATK-CP-02	1.9	Falling head in borehole	6.00E-10
ATK-RC-02	2.0	Laboratory in triaxial cell	3.70E-08
ATK-CP-02	2.5	Laboratory in triaxial cell	9.50E-09
ATK-CP-01	3.0	Falling head in borehole	1.40E-06
ATK-RC-02	4.0	Laboratory in triaxial cell	No result

8.5. Weathered London Clay Formation

8.5.1. Geotechnical Parameter Values

The geotechnical parameter values for the Weathered London Clay Formation present at the Study Area is summarised in Table 8-4 below.

Table 8-4 - Geotechnical parameter values for the Weathered London Clay Formation

Test	Units	Range (no of results)	Characteristic Value	Plot Number
Moisture Content	%	13 - 45 (73)	32	1.3
Liquid Limit	%	53 - 87 (44)	75	1.3
Plastic Limit	%	18 - 33 (44)	25	1.3
Plasticity Index	%	27 - 56 (44)	42*	2.3
A-Line Plot	-	High to very high plasticity CLAY (44)		3.3
Particle Size Distribution	-	Slightly sandy SILT/CLAY (17)		4.3
Bulk Density	Mg/m ³	1.79 - 2.06 (26)	1.90	5a.1 5b.1
Dry Density	Mg/m ³	1.35 - 1.69 (9)	1.47*	5a.1 5b.1
Classification by SPT N ₆₀ -Value	-	3 - 35 (14)	Very soft becoming stiff; typically firm	6.2 / 6.4

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Test	Units	Range (no of results)	Characteristic Value	Plot Number
c _u from N ₆₀	kPa	13 – 153 (14)	15+19z	7.2 / 7.4
c _u from Triaxials	kPa	26 - 198 (6)		7.2 / 7.4
φ' from effective stress tests	°	12 - 18 (5)	22	8.1 / 8.3 / 9.2
c' from effective stress tests	kPa	27 - 49 (4)	3	8.1 / 8.3
φ _r from shear box/ring shear tests	°	6 - 12.5 (4)	12	8.1 / 8.3
c _r from shear box/ring shear tests	kPa	3 - 17 (4)	0	8.1 / 8.3
M _v	MN/m ²	0.027 - 0.29 (3)	-	10.1 / 11.1 / 12.1
E' from N ₆₀ (Cohesive only)	MPa	3 - 23 (14)	8	13.2
Optimum Moisture Content (2.5kg rammer)	%	16 - 37 (27)	25	14.3
Optimum Moisture Content (4.5kg rammer)	%	17 - 28 (4)	24	14.4
Moisture Condition Value	-	4.6 – 15.3 (26)	10	15.2 / 16.2
Dispersion by pinhole method	-	ND1 - ND3 (3)	ND1	
SO ₄	mg/l	18 (1)	DS-1 AC-1 ^d	-
pH	-	8 (1)		-

Note: * Due to variable and/or minimal results, mean values have been given as characteristic values.
 z denotes 'per metre below ground level'.

8.5.2. Permeability

No permeability testing was undertaken in the Weathered London Clay Formation.

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8.6. Unweathered London Clay Formation

8.6.1. Geotechnical Parameter Values

The geotechnical parameter values for the unweathered London Clay Formation present at the Study Area are summarised in Table 8-5 below.

Table 8-5 - Geotechnical parameter values for the unweathered London Clay Formation

Test	Units	Range (no of results)	Characteristic Value	Plot Number
Moisture Content	%	18 - 46.3 (177)	27	1.4
Liquid Limit	%	42 - 98 (84)	70	1.4
Plastic Limit	%	15 - 34 (84)	25	1.4
Plasticity Index	%	23 - 67 (84)	44*	2.4
A-Line Plot	-	Intermediate to high plasticity CLAY (84)		3.4
Particle Size Distribution	-	Slightly sandy SILT/CLAY (6)		4.4
Bulk Density	Mg/m ³	1.83 - 2.10 (110)	2.00	5a.2 5b.2
Dry Density	Mg/m ³	1.43 - 1.73 (58)	1.60	5a.2 5b.2
Particle Density	Mg/m ³	2.64 – 2.79 (2)	2.72*	-
Linear Shrinkage	%	13 – 17 (6)	15	-
Classification by SPT N ₆₀ -Value	-	5 - 67 (45)	Soft becoming very stiff; typically stiff	6.3 / 6.4
c _u from N ₆₀	kPa	23 - 295 (45)	53+6z	7.3 / 7.4
c _u from Triaxials	kPa	63 - 207 (12)		7.3 / 7.4
φ' from effective stress tests	°	12 - 24 (8)	25	8.2 / 8.3 / 9.3
c' from effective stress tests	kPa	16 - 49 (6)	3	8.2 / 8.3
φ _r from shear box/ring shear tests	°	6 - 13 (6)	14	8.2 / 8.3
c _r from shear box/ring shear tests	kPa	0 - 22 (8)	0	8.2 / 8.3

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Test	Units	Range (no of results)	Characteristic Value	Plot Number
Mv from oedometer tests (loading cycle)	MN/m ²	0.0061 - 0.26 (9)	-	10.2 / 11.2 / 12.2
E' from N ₆₀ (Cohesive only)	MPa	4 - 60 (45)	12+1z	13.3
Optimum Moisture Content (2.5kg rammer)	%	13 - 23 (8)	18	14.5
Optimum Moisture Content (4.5kg rammer)	%	22 - 23 (3)	23	14.6
Moisture Condition Value	-	11.3 - 12.3 (4)	12	15.3 / 16.3
Dispersion by pinhole method	-	ND1 - ND3 (11)	ND1	
SO ₄	mg/l	391 - 430 (2)	DS-1 AC-1 ^d	-
pH	-	8.1 - 8.2 (2)		-

Note: * Due to variable and/or minimal results, mean values have been given as characteristic values.
 z denotes 'per metre below ground level'.

8.6.2. Permeability

Three laboratory permeability tests and two falling head tests in the constructed borehole were undertaken to determine the permeability of the London Clay Formation. The results of the tests are as follows presented in Table 8-6.

Table 8-6 - Permeability results for the unweathered London Clay Formation

Borehole ID	Depth [base of test] (m)	Test Type	Coefficient of Permeability (m/sec)
ATK-CP-01	4	Rising head in standpipe	2.80E-09
ATK-CP-04	5	Falling head in borehole	1.50E-06
ATK-CP-03	5.5	Falling head in borehole	No result
ATK-CP-02	7	Falling head in borehole	No result
ATK-CP-05	7.5	Falling head in borehole	No result
ATK-CP-15	15	Falling head in borehole	No result

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8.7. Harwich Formation

8.7.1. Geotechnical Parameter Values

The geotechnical parameter values for the Harwich Formation present at the Study Area is summarised in Table 8-7 below.

Table 8-7 - Geotechnical parameter values for the Harwich Formation

Test	Units	Range (no of results)	Characteristic Value	Plot Number
Moisture Content	%	17 - 44 (23)	27	1.5
Liquid Limit	%	36 - 80 (17)	45	1.5
Plastic Limit	%	17 - 33 (17)	22	1.5
Plasticity Index	%	11 - 51; three results non- plastic (20)	27*	2.5
A-Line Plot	-	Intermediate to very high plasticity CLAY; one result intermediate plasticity SILT (17)		
Particle Size Distribution	-	(13)	Slightly sandy SILT/CLAY and clayey/silty SAND	4.5
Bulk Density	Mg/m ³	2.0 - 2.14 (2)	2.10*	-
Dry Density	Mg/m ³	1.59 - 1.78 (2)	1.70*	-
Particle Density	Mg/m ³	2.67 (1)	2.67*	-
Linear Shrinkage	%	13 (1)	13*	-
Classification by SPT N ₆₀ -Value	-	1 - 104 (25)	Soft to very stiff (cohesive); Very loose to very dense (granular)	6.5
c _u from N ₆₀	kPa	15 - 499 (14)	122*	7.5
c _u from Triaxials	kPa	83 (1)		7.5
φ' from N ₆₀ (Granular only)	°	28 - 43 (7)	33	9.4

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Test	Units	Range (no of results)	Characteristic Value	Plot Number
ϕ' from effective stress tests (cohesive only)	°	35 - 64.2 (2)	35**	9.4
ϕ_r from shear box/ring shear tests (cohesive only)	°	(3)	24***	8.4
c_r from shear box/ring shear tests (cohesive only)	kPa	(3)	1***	8.4
E' from N ₆₀ (Cohesive only)	MN/m ²	3 - 94 (22)	23	13.4
Optimum Moisture Content (2.5kg rammer)	%	15 - 27 (8)	21	14.7
Moisture Condition Value	-	2.6 – 11.3 (4)	7	15.4 / 16.4
Dispersion by pinhole method	-	ND2 (2)	ND2	
SO ₄	mg/l	58 (1)	DS-1 AC-1 ^d	-
pH	-	5.8 (1)		-

Note: * Due to variable and/or minimal results, mean values have been given as characteristic values.

** Minimum used due to variable results.

*** Based on engineering judgement.

z denotes 'per metre below ground level'.

8.7.2. Permeability

Four laboratory permeability tests, four falling head tests in the constructed borehole and seven rising head tests in installed standpipes were undertaken to determine the permeability of the Harwich Formation. The results of the tests are as follows presented in Table 8-8; to the summarise, the Harwich Formation is typically impermeable.

Table 8-8 - Permeability results for the Harwich Formation

Borehole ID	Depth [base of test] (m)	Test Type	Coefficient of Permeability (m/sec)
ATK-CP-08	0.5	Laboratory in triaxial cell	5.60E-10
ATK-TP-08	1.5	Laboratory in triaxial cell	1.30E-08
ATK-TP-07	1.6	Laboratory in triaxial cell	2.90E-08
ATK-CP-09	1.65	Laboratory in triaxial cell	1.40E-08

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Borehole ID	Depth [base of test] (m)	Test Type	Coefficient of Permeability (m/sec)
ATK-CP-06	2	Falling head in borehole	3.20E-07
ATK-CP-16	2.5	Rising head in standpipe	No result
ATK-CP-12	5	Rising head in standpipe	1.20E-06
ATK-CP-05	11	Rising head in standpipe	1.10E-06
ATK-CP-06	3.5	Rising head in standpipe	No result
ATK-CP-10	11	Falling head in borehole	4.80E-07
ATK-CP-04	11.5	Falling head in borehole	No result
ATK-CP-04	12.2	Falling head in borehole	1.10E-06
ATK-CP-13A	4.5	Rising head in standpipe	2.40E-07
ATK-CP-15	18.5	Rising head in standpipe	5.50E-09
ATK-CP-02	34	Rising head in standpipe	1.30E-06
ATK-RC-02A	40	Rising head in standpipe	6.10E-08

8.8. Reading Formation

8.8.1. Geotechnical Parameter Values

The geotechnical parameter values for the Reading Formation present at the Study Area is summarised in Table 8-9 below.

Table 8-9 - Geotechnical parameter values for the Reading Formation

Test	Units	Range (no of results)	Characteristic Value	Plot Number
Moisture Content	%	10 - 35 (91)	18	1.6
Liquid Limit	%	32 - 66 (62)	55	1.6
Plastic Limit	%	12 - 25 (62)	16	1.6
Plasticity Index	%	17 - 43 (62)	30	2.6
A-Line Plot	-	Low to high plasticity CLAY (62)		3.6

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Test	Units	Range (no of results)	Characteristic Value	Plot Number
Particle Size Distribution	-	Slightly sandy SILT/CLAY (13)		4.6
Bulk Density	Mg/m ³	1.95 - 2.35 (38)	2.2	5a.3 5b.3
Dry Density	Mg/m ³	1.54 - 2.13 (29)	1.85	5a.3 5b.3
Particle Density	Mg/m ³	2.68 – 2.79 (8)	2.74	-
Linear Shrinkage	%	10 – 17 (9)	14	-
Classification by SPT N ₆₀ -Value	-	15 - 120 (57)	Firm to very stiff	6.6
c _u from N ₆₀	kPa	69 - 552 (57)	0-2m c _u = 50kPa >2m c _u = 23z	7.6
c _u from Triaxials	kPa	46 - 1025 (19)		7.6
φ' from effective stress tests	°	14 - 24 (5)	22	8.5 / 9.5
c' from effective stress tests	kPa	16 - 23 (3)	5	8.5
φ _r from shear box/ring shear tests	°	6 - 13 (3)	12	8.5
c _r from shear box/ring shear tests	kPa	1 - 16 (3)	0	8.5
M _v	MN/m ²	0.0058 - 0.37 (3)	-	10.3 / 11.3 / 12.3
E' from N ₆₀ (Cohesive only)	MPa	11 - 108 (57)	10+3z	13.5
Optimum Moisture Content (2.5kg rammer)	%	17 - 24 (9)	20	14.8
Optimum Moisture Content (4.5kg rammer)	%	18 - 19 (2)	19	14.9
Moisture Condition Value	-	4.6 – 18.8 (26)	11	15.5 / 16.5
Dispersion by pinhole method	-	ND1 (7)	ND1	
SO ₄	mg/l	16 - 27 (3)	DS-1 AC-1 ^d	-
pH	-	8.1 – 8.6		-

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Test	Units	Range (no of results)	Characteristic Value	Plot Number
		(3)		

Note: z denotes 'per metre below ground level'.

8.8.2. Permeability

Two laboratory permeability tests, one falling head test in the constructed borehole and one rising head test in an installed standpipe were undertaken to determine the permeability of the Reading Formation. The results of the tests are presented in Table 8-8.

Table 8-10 - Permeability results for the Reading Formation

Borehole ID	Depth [base of test] (m)	Test Type	Coefficient of Permeability (m/sec)
ATK-TP-05	0.4	Laboratory in triaxial cell	2.90E-10
ATK-TP-05	0.9	Laboratory in triaxial cell	1.90E-08
ATK-CP05	13	Falling head in borehole	5.20E-08

8.9. White Chalk Sub-Group

8.9.1. Geotechnical Parameter Values

Geotechnical testing was not undertaken on the White Chalk Sub-Group present at the Study Area.

8.9.2. Permeability

Three falling head tests in the constructed boreholes were undertaken to determine the permeability of the White Chalk Sub-Group. The results of the tests are as follows presented in Table 8-11; to the summarise, the White Chalk Sub-Group is typically impermeable.

The test undertaken in ATK-RC-03 at 48.0m bgl was recorded as not having a result as the test deemed to be faulty; the readings showed a fall then rise in water.

Table 8-11 - Permeability results for the White Chalk Sub-Group

Borehole ID	Depth [base of test] (m)	Test Type	Coefficient of Permeability (m/sec)
ATK-RC-01	36.5	Falling head in borehole	4.00E-08
ATK-RC-03	48.0	Falling head in borehole	No result
ATK-RC-02	72.0	Falling head in borehole	No result

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8.10. Summary of Geotechnical Parameters

A summary of the geotechnical parameter values for geological units present at the Study Area is summarised in Table 8-12 below. Where values cannot be given, engineering judgement based on published literature has been provided.

Table 8-12 - Summary of characteristic geotechnical parameter values

Test	Head	Bognor Sand Mbr.	Weathered London Clay Fm.	Un-weathered London Clay Fm.	Harwich Fm.	Reading Fm.
Water Content (%)	27*	27	32	27	27	18
Plasticity Index (%)	37*	24*	42*	44*	27*	30
Bulk Density (Mg/m ³)	2.04*	1.95*	1.90	2.00	2.10*	2.20
Dry Density (Mg/m ³)	1.57*	1.51*	1.47*	1.60	1.70*	1.85
cu (kPa)	55*	70*	15+19z	53+6z	122*	0-2m cu = 50kPa >2m cu = 23z
φ' (°)	27	33	22	25	33	22
φ _r (°)	14	27	12	14	24***	5
c' (kPa)	-	-	3	3	35**	5
c _r (kPa)	-	-	0	0	1***	0
E' (MPa)	-	12*	8	12+1z	23	10+3z
Optimum Moisture Content (%)	22 (2.5kg)	21 (2.5kg)	25 (2.5kg)	23 (4.5kg)	21 (2.5kg)	20 (2.5kg)
Moisture Condition Value	9	-	10	12	7	11
BRE SD1 Classifications	DS-1 AC-1d	DS-1 AC-2z	DS-1 AC-1d	DS-1 AC-1d	DS-1 AC-1d	DS-1 AC-1d

Note: * Due to variable and/or minimal results, mean values have been given as characteristic values.

** Minimum used due to variable results.

*** Based on engineering judgement.

z denotes 'per metre below ground level'.

Mbr denotes 'Member'

Fm. denotes Formation.

In Section 6.7 of this report, the presence of relict shear surfaces has been noted. It is likely that on such surfaces the effective stress shear strength parameters will be at or close to residual strength. Such surfaces will have some effect on the bulk strength of the various layers but will not generally mean that the whole of the layer or zone affected will be at residual strength. However, it is possible

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that potential zones of shearing or potential slip surfaces could to some degree, align along such surfaces, while still being controlled by what is kinematically possible.

The following is proposed to allow for such affects:

- Assume that the base of the Head, or at a depth of up to around 3 metres generally, a continuous or semi-continuous shear surface could be present that would be operating at residual strength of the same value, as the Head identified above.
- More generally for materials in the upper 5 metres below ground level, the shear strength in effective stress terms would be reduced by around 10% of the values given above, and in any case with c' not greater than 1 kPa.

9. Land Contamination Assessment

Land contamination is assessed through development of a conceptual model (CM) that describes the relationship between contaminants which may be present from past and current activities (including any off-site activities from which contaminants may migrate on-site), receptors to those contaminants and any potential connecting pathways.

Sources of contamination and associated contaminants, receptors to that contamination and the pathways between the two are identified and assessed to determine whether all three are present or are likely to be present and if so, described as a potential contaminant linkage (PCL). These PCLs can then be subjected to the risk assessment process.

The approach adopted by Atkins is in accordance with the Contaminated Land Exposure Assessment (CLEA) model produced by Defra and the Environment Agency and as outlined in Contaminated Land Report (CLR11) (DEFRA, 2009) and the Land Contamination: Risk Management guidance (Environment Agency, 2019). CLR11 provides a technical framework for identifying and remediating contamination through the application of a risk management process. The question of whether risk is unacceptable in any particular case involves not only scientific and technical assessments, but also appropriate criteria by which to judge the risk and conclude exactly what level of risk would be unacceptable.

Based on site specific data obtained between November 2019 and February 2020, as part of a ground investigation undertaken by Socotec, a generic quantitative risk assessment has been undertaken to refine the outline CM produced as part of the November 2019 Havant Thicket Winter Storage Reservoir, Geology and Hydrogeology Desk Study (Atkins Ltd., 2020a). An assessment of risk has been undertaken using precautionary Generic Assessment Criteria (GAC), that represent minimal or tolerable risk, relevant to the PCLs. The potential implications of the contaminant concentrations, suitability of material for reuse and the preliminary waste classification have been assessed.

9.1. Outline Conceptual Model

The outline conceptual model was prepared based on desk study information and a risk rating was determined for various PCL. The outline conceptual model is included in full in the following sections for completeness. Ground investigation was designed to provide information about the PCLs which were assessed as being higher risk and to obtain a general indication of soil and groundwater quality across the site.

9.1.1. Potential Sources of Contamination

Based on available information the following sources of contamination have been identified:

On-site

- re-worked site won material used during the construction of the Upper Lake, Upper Lake Weir, Boat House and the George Canning Monument;
- re-worked site material used during the channelization of unnamed watercourses;
- potentially contaminated natural superficial strata from localised spills / leaks during past mechanical de-vegetation; and
- potentially contaminated natural superficial strata from localised spills / leaks from previously observed dumped and burnt out cars or motorbike use.

Off-site

- potentially contaminated ground and groundwater associated with a fuel station located approximately 84m east of the site;
- Made Ground of unknown provenance used for the infilling of surrounding brick, chalk and clay pits located between 100m and 350m to the south east of the site as well as potentially

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contaminated ground associated with the operation of the pits, brickfields and associated brickworks;

- Made Ground and potentially contaminated groundwater associated with an historical landfill located approximately 327m west of the site;
- Made Ground of unknown provenance used in construction of housing estates to the east and south of the site;
- Made Ground and potentially contaminated ground associated with the former Leigh Park Estate battery located approximately 60m south of the site and military base located approximately 350m south of the site;
- Made Ground and potentially contaminated ground associated with the former allotments located approximately 250m southeast of the site; and
- Made Ground and potentially contaminated ground associated with the former smithy located approximately 225m southeast of the site.

9.1.2. Potential Receptors

The following receptors have been identified at the site.

9.1.2.1. Human:

- Current on-site users including members of the public using footpaths and trails;
- Future on-site users including reservoir operatives, maintenance workers and members of the public visiting the reservoir;
- Off-site workers and residents in surrounding commercial and residential areas; and
- Off-site visitors using the surrounding footpaths and parks.

9.1.2.2. Controlled Waters:

- Surface water – on-site: the proposed reservoir, unnamed watercourses, drains and the Upper Lake;
- Surface water – off-site: drains, ponds and the lake within 500 m of the site;
- Groundwater in the Superficial Undifferentiated aquifer, bedrock Secondary A aquifers; and
- Groundwater in the Chalk Principal aquifer.

9.1.2.3. Property:

- Future below ground on-site infrastructure; and
- Off-site residential / commercial properties within the surrounding 500 m.

9.1.3. Potential Pathways

9.1.3.1. Human

The following potential pathways to human receptors have been identified:

- Dermal contact / ingestion / inhalation of contaminants in soil and soil-derived dust;
- Dermal contact / ingestion of contaminants in groundwater within excavations;
- Inhalation of ground gas / vapours which may have migrated onto site from off-site sources;
- Dermal contact with and ingestion of contaminants in soil-derived dusts and water that may have migrated off-site; and
- Inhalation of soil-derived dust and fibres which may have migrated off-site.

9.1.3.2. Controlled Waters

The potential exposure pathways to controlled water receptors include:

- Leaching or dissolution of contaminants in soils and subsequent migration of contaminants;
- Lateral migration of dissolved phase contaminants via preferential pathways such as drains and low permeability strata horizons in the Harwich Formation and Bognor Sands Member
- Lateral migration of dissolved phase contaminants in groundwater to surface water;
- Migration of contaminants entrained in surface water runoff;
- Leaching or dissolution of contaminants in soils and subsequent migration of contaminants in groundwater; and
- Vertical migration of dissolved phase contaminants to the underlying groundwater.

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9.1.3.3. Property

The potential exposure pathways to property / infrastructure include:

- Direct contact of contaminated soils/water with infrastructure, services and structures and subsequent chemical attack;
- Direct contact of migrating contaminated groundwater within infrastructure, services and structures; and
- Migration of contaminated groundwater along strata and preferential pathways such as service routes or differentially permeable strata and subsequent chemical attack.

9.1.3.4. Ecological

The potential exposure pathways to ecological receptors include:

- Uptake of contaminants in soil and soil-derived dust; and
- Leaching / dissolution of contaminants from unsaturated soils followed by migration in groundwater / perched water.

9.2. Generic Quantitative Risk Assessment

A Generic Quantitative Risk Assessment (GQRA) has been carried out using information from the Socotec ground investigation as summarised in this report.

The soil chemical data have been screened against their respective GACs to assess the risks to the previously identified receptors. The outcome of this assessment is presented in the following sections.

9.3. Human Health

9.3.1. Selection of Human Health Generic Assessment Criteria

Detailed guidance on human health risk assessment is provided in Science Report SR2 (Environment Agency, 2009), SR3 (DEFRA, 2013) and the CLEA Model. The GQRA for identified human receptors has compared the recorded soil contaminant concentration data with GAC.

Category 4 Screening Values (C4SLs), derived to be protective of chronic risks to human health have been published by DEFRA (DEFRA, 2013) for six contaminants (benzo(a)pyrene, benzene, lead, arsenic, cadmium and chromium). C4SLs represent low risk levels, they are not representative of significant possibility of significant harm (SPoSH). If the C4SLs are not exceeded, land can be demonstrated as being in Category 4 and cannot be determined as contaminated land.

Atkins has produced soil screening values (SSVs) based on minimal toxicological risk for a variety of standard land uses at 1% soil organic matter (SOM) (sand soil type) and 6% SOM (sandy loam soil type) using CLEA v1.071 in accordance with Environment Agency guidance. Based on the ratio of genotoxic PAHs to benzo(a)pyrene, the surrogate marker approach for genotoxic PAHs as set out in the C4SL Project Methodology has been adopted.

The proposed scheme involves the construction of a large reservoir, retained partly by an embankment, currently located within open grassland with some woodland. The site is used for animal grazing and is accessed by members using the bridleway / footpaths. The use of the site is not covered under standard GAC scenarios. Therefore, to undertake the assessment, soil samples have been screened against SSVs and C4SLs where available (collectively referred to as GAC) for a public open space (parkland) land use. This scenario is considerate of long-term exposure for current users and future site users comprising members of the public using the footpaths / visiting the reservoir.

The presence of SOM is important in determining the fate and behaviour of a number of organic contaminants such as PAHs. The mobility of these contaminants decreases with increasing SOM. Generally, the greater the SOM content the greater the sorptive capacity of the soil. The SOM content across the twenty analysed samples was reported to range between 0.38 % and 3.48 % with a geometric mean of 1.35 %. The SOM across the site varies although the average is below 6%; therefore, Atkins' derived SSVs for a 1% SOM have been used to inform the GAC as a conservative approach.

Potential acute risks resulting from short term exposure of by construction workers to contamination involved with the proposed development cannot be assessed using these GACs because they relate

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to the long-term (chronic) risk. Risks to construction workers should be managed with the use of appropriate Personal Protective Equipment (PPE) and working methods.

It should be noted that the GAC may change as new policy and technical guidance, including toxicological data, are published by the Environment Agency and other authoritative sources, but they are valid at the time of writing.

9.3.2. Comparison of Soil Concentration Data with Human Health Generic Assessment Criteria

A total of twenty soil samples were analysed from across the site, comprising ten from the topsoil, two from Head Deposits, four from the London Clay Formation, one from the Harwich Formation, two from the sandy clay of an unspecified geological unit and one from the Reading Formation. No Made Ground was encountered during the investigation. Samples were collected between the depths of 0.1 m and 4.0 m bgl. The majority of samples were collected from depths less than 0.8 m bgl for assessment of soils most likely to be disturbed or most likely to come into contact with receptors.

The soil results were screened against GAC for an open space (parkland) end use. No exceedances of the GAC were identified in the samples analysed.

Six topsoil samples collected between the depths of 0.1 m and 0.3 m bgl were analysed for asbestos fibres. No asbestos fibres or Asbestos Containing Material (ACM) was identified within any of the samples analysed.

Based on the available data, contaminants in site soils at the concentrations recorded are considered unlikely to present unacceptable risks to identified human receptors. The screened results are available in Appendix E.

9.4. Preliminary Controlled Waters Risk Assessment

9.4.1. Selection of Controlled Waters Generic Assessment Criteria

The preliminary controlled waters risk assessment has been designed to assess the potential risks posed to the identified controlled waters receptors from the migration of contaminants from identified sources. To assess potential risks to the identified receptors, a comparison of recorded contamination concentrations in groundwater against pertinent water quality standards (WQS) has been undertaken.

The screening criteria for controlled waters assessment are dependent on the nature of the key receptor(s).

Superficial deposits underlying the site comprise Head deposits classified by the Environment Agency as a Secondary Undifferentiated aquifer. Bedrock underlying the site comprises the London Clay Formation (classified as Unproductive strata), the Harwich Formation (classified as a Secondary A aquifer), the Reading Formation (Lambeth Group) (classified as a Secondary A aquifer) and the White Chalk (classified as a Principal aquifer).

The site is located within an Inner Zone (Zone 1c) Source Protection Zone (SPZ) with the northeast of the site classified as an Outer Zone (Zone 2) (Landmark Information Group, 2019).

Three unnamed watercourses flow from north to south entering the site along the northern boundary. The unnamed watercourses converge into one stream located to the west of the Avenue in Deerslaughter Plain. Upper Lake is located within the northern area of the site. Several drains are also located on-site. Off-site a lake is located approximately 60 m south of the site and several drains are present (approximately 70 m and 170 m south).

Considering the hydrological and hydrogeological regime as summarised above, both surface water and groundwater are primary receptors to potential contamination. Groundwater monitoring data has been screened against Environmental Quality Standards for inland freshwater (EQS) protective of aquatic life in surface water and Drinking Water Standards (DWS) (HMSO, 2015).

9.4.2. Comparison of Groundwater Data with Controlled Waters Generic Assessment Criteria

Data from twelve groundwater samples collected by Socotec between January and February 2020 were screened against EQS and DWS values.

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9.4.2.1. Comparison of Groundwater Data with EQS Values

Groundwater EQS exceedances were identified for ammoniacal nitrogen, metals (cadmium, copper, lead, mercury, nickel, zinc, chromium VI) and TPHs (aliphatic >C21-C35, >C35-C44 and aromatic >C16-C21, >C21-C35).

All of the groundwater EQS exceedances are either in the same order of magnitude or one order of magnitude of the EQS screening value.

A summary of the EQS groundwater exceedances is presented Table 9-1 below.

Table 9-1 - Groundwater EQS exceedances

Constituent	Standard	Units	EQS (mg/l)	No. of samples	Min concentration	Max concentration	No. of exceedances	Location
Ammoniacal Nitrogen as N	EQS freshwater	mg/l	0.2	12	0.01	0.6	3	ATK-CP-06 (round 1) ATK-CP-12 (round 1) ATK-CP-01 (round 3)
Cadmium	EQS freshwater	mg/l	0.00008	12	<0.00002	0.00022	1	ATK-CP-01 (round 1)
Copper	EQS freshwater	mg/l	0.001	12	0.001	0.006	2	ATK-CP-01 (round 1 & 3)
Lead	EQS freshwater	mg/l	0.0012	12	<0.001	0.02	2	ATK-CP-01 (round 1 & 3)
Mercury	EQS freshwater	mg/l	0.00007	12	<0.00003	0.00009	1	ATK-CP-05 (round 1)
Nickel	EQS freshwater	mg/l	0.004	12	0.002	0.011	5	ATK-CP-01 (round 1 & 3) ATK-CP-06 (round 1 & 3) ATK-CP-12 (round 1)
Zinc	EQS freshwater	mg/l	0.0123	12	0.005	0.412	10	ATK-CP-01 (round 1, 2 & 3) ATK-CP-05 (round 1 & 2) ATK-CP-06 (round 1, 2 & 3) ATK-CP-12 (round 2 & 3)

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Constituent	Standard	Units	EQS (mg/l)	No. of samples	Min concentration	Max concentration	No. of exceedances	Location
Chromium VI	EQS freshwater	mg/l	0.0034	12	<0.003	0.006	1	ATK-CP-06 (round 3)
Aliphatic TPH >C21-C35	EQS freshwater	mg/l	0.01	12	0.01	0.056	5	ATK-CP-01 (round 1, 2) ATK-CP-05 (round 1, 2) ATK-CP-12 (round 2)
Aliphatic TPH >C35-C44	EQS freshwater	mg/l	0.01	12	<0.01	0.059	3	ATK-CP-01 (round 1) ATK-CP-05 (round 1) ATK-CP-06 (round 1)
Aromatic TPH >C16-C21	EQS freshwater	mg/l	0.01	12	<0.01	0.021	2	ATK-CP-01 (round 1) ATK-CP-05 (round 3)
Aromatic TPH >C21-C35	EQS freshwater	mg/l	0.01	12	<0.01	0.029	2	ATK-CP-01 (round 1) ATK-CP-05 (round 3)

9.4.2.2. Comparison of Groundwater Data with DWS Values

Groundwater DWS exceedances were identified for ammoniacal nitrogen and metals (lead, aluminium and iron)

All of the groundwater DWS exceedances are the same order of magnitude of the DWS screening value.

A summary of the DWS groundwater exceedances are summarised in Table 9-2 below.

Table 9-2 - Groundwater DWS exceedances

Constituent	Standard	Units	EQS (mg/l)	No. of samples	Min concentration	Max concentration	No. of exceedances	Location
Ammoniacal Nitrogen as N	DWS	mg/l	0.39	12	0.01	0.6	2	ATK-CP-06 (round 1) ATK-CP-12 (round 1)
Lead	DWS	mg/l	0.01	12	<0.001	0.02	1	ATK-CP-01 (round 1)
Aluminium	DWS	mg/l	0.2	12	0.01	0.77	2	ATK-CP-01 (round 3)

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Constituent	Standard	Units	EQS (mg/l)	No. of samples	Min concentration	Max concentration	No. of exceedances	Location
								ATK-CP-06 (round 3)
Iron	DWS	mg/l	0.2	12	0.01	0.84	3	ATK-CP-01 (round 3) ATK-CP-06 (round 1 & 3)

9.4.2.3. Comparison of Groundwater Data with EQS and DWS Values Discussion

Groundwater EQS exceedances were identified for ammoniacal nitrogen, metals and TPH fractions. Groundwater DWS exceedances were identified for ammoniacal nitrogen and metals. All of the recorded exceedances in groundwater are either the same order of magnitude or within one order of magnitude as the EQS and DWS. Generally, the identified groundwater exceedances are not consistent across the site or across the three groundwater monitoring rounds. Although exceedances of the TPH EQS were identified, no Made Ground or visual and olfactory evidence of contamination was identified within the soils during the site investigation and the TPH EQS exceedances are considered to be marginal. There was no evidence of groundwater impact within the well ATK-CP-06 that could be associated with the nearby off-site petrol station.

It is likely that the DWS and EQS metal and ammoniacal nitrogen exceedances are representative of background concentrations within the natural geology. It is also considered that the presence of the underlying London Clay formation and the Lambeth Group clay will reduce the likelihood of lateral migration of contaminated groundwater to occur.

On the basis of the above the risk to controlled waters is evaluated as low considering a medium consequence and unlikely probability.

9.4.3. Summary of GQRA

9.4.3.1. Human Health Receptors

The results of the GQRA summarised above indicates that there are no exceedances in the samples analysed against the GAC considerate of an open space (parkland) end use in the underlying natural strata. No asbestos fibres were identified within the soil matrix in the samples analysed. Therefore, based on the results obtained and summarised above there are considered to be no unacceptable risks to human receptors.

9.4.3.2. Controlled Waters Receptors

Groundwater DWS and EQS exceedances were identified for ammoniacal nitrogen, metals and TPHs (EQS exceedances only). However, these are considered to be marginal exceedances and based on the available data, potential contaminants in site groundwater samples at the concentrations recorded are considered unlikely to present potentially unacceptable risks to identified controlled water receptors.

9.5. Property Risk Assessment

Sources of landfill and ground gases comprise the off-site former clay pits therefore ground gases may be present on-site. Samples obtained in proximity to the closest of these sources (to the south of the reservoir footprint indicated no evidence of landfill type material, Made Ground or peat-derived ground gas sources. The risk to on-site receptors is considered to be very low due to the presence of impermeable strata in close proximity to the of former clay pits and due to the distance (between 100m and 350m) of the former clay pits from the site.

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There are no proposed occupiable buildings as part of the proposed scheme in proximity to the identified potential sources. Therefore, the risk is evaluated as very low considering a mild consequence and unlikely probability.

Given the absence of credible ground gas sources within the development footprint and the absence of specific receptors that may be impacted by nearby off-site sources, no ground gas monitoring was undertaken as part of the recent GI.

9.6. Refined Conceptual Model

Based on the human health and controlled waters GQRAs presented above, the preliminary CSM presented in Section 6.1 has been refined based on the data collected from the site.

The updated risk assessment, resulting from the information discussed above are shown below in Table 9-3 - Refined Conceptual Model.

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Table 9-3 - Refined Conceptual Model

Source	Receptor		Contaminant Exposure / Migration Pathway	Potential Consequence	Probability	Risk Classification	Comments
<u>On-site</u> - Historic re-worked site won material used during the construction of the Upper Lake, Upper Lake Weir, Boat House and the George Canning Monument - Historic re-worked site won material used during the channelization of unnamed watercourses - Potentially contaminated natural superficial strata from localised spills / leaks during past mechanical de-vegetation - Potentially contaminated natural superficial strata from localised spills / leaks from previously observed dumped and burnt out cars or motorbike use.	<u>Human Health:</u> On-site	Current on-site users including members of the public using footpaths and trails and future members of the public visiting the reservoir	Dermal contact / ingestion / inhalation of contaminants in soil and soil-derived dust Dermal contact / ingestion / of contaminants in groundwater within excavations	Mild	Unlikely	Very Low Risk	No soil exceedances of the GAC for an open space (parkland) end use were identified and no asbestos fibres were detected in soils. No Made Ground was encountered during the site investigation and there was no evidence of contamination or peat-derived ground gas sources on site. No Made Ground has been encountered at the site and the potential for ground gas generation from on-site sources is considered to be very low. In addition, the presence of the London Clay formation and the Lambeth Group clay will reduce the likelihood of lateral migration of ground gas / vapours from potential off-site sources (infilled clay, brick and clay pits) to occur. It is assumed that potential risks to ground workers would be managed through robust risk assessments to identify appropriate PPE and working methods.
		Future on-site users including reservoir operatives and maintenance workers	Inhalation of ground gas / vapours which may have migrated onto site	Mild	Low Likelihood ²¹ ₁	Low Risk	
	<u>Human Health:</u> Off-site	Off-site workers and residents in surrounding commercial and residential areas	Dermal contact with and ingestion of contaminants in soil-derived dusts and water that may have migrated off-site	Mild	Unlikely	Very Low Risk	
		Off-site visitors to surrounding footpaths and parks	Inhalation of soil-derived dust and fibres which may have migrated off-site	Mild	Unlikely	Very Low Risk	
	<u>Controlled Waters:</u> Surface water	The proposed reservoir, watercourses, drains and the Upper Lake located on-site.	Leaching or dissolution of contaminants in soils and subsequent migration of contaminants	Medium	Unlikely	Low Risk	

¹ It has been assumed that risks to future site users including reservoir operatives and maintenance workers will be mitigated by the implementation of appropriate PPE.

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Source	Receptor		Contaminant Exposure / Migration Pathway	Potential Consequence	Probability	Risk Classification	Comments
<u>Off-site</u> - Potentially contaminated ground and groundwater associated with the fuel station located approximately 84m east of the site - Made Ground of unknown provenance used for the infilling of surrounding brick, chalk and clay pits located between 100m and 350m to the south east of the site as well as potentially contaminated ground associated with the operation of the pits, brickfields and associated brickworks - Made Ground and potentially contaminated groundwater associated with the historical landfill located approximately 330m west of the site - Made Ground of unknown provenance used in construction of housing estates to the east and south of the site - Made Ground and potentially contaminated ground associated with the former Leigh Park		Off-site watercourses, drains, ponds and The Lake	Lateral migration of dissolved phase contaminants via preferential pathways such as drains and low permeability strata horizons in the Harwich Formation and Bognor Sands. Lateral migration of dissolved phase contaminants in groundwater to surface water. Migration of contaminants entrained in surface water runoff.				potential contaminants in site groundwater samples at the concentrations recorded are considered unlikely to present potentially unacceptable risks to identified surface water receptors. Groundwater DWS exceedances were identified for ammoniacal nitrogen and metals. However, all of the groundwater DWS exceedances are considered to be marginal exceedances and based on the available data, potential contaminants in site groundwater samples at the concentrations recorded are considered unlikely to present potentially unacceptable risks to identified groundwater receptors. The presence of the London Clay formation and the Lambeth Group clay will reduce the likelihood of vertical migration of potentially contaminated groundwater to occur. There was no evidence of impact to groundwater that could be associated with potential off-site sources, including the fuel station located to the east of the site.
	<u>Controlled Waters Groundwater</u>	Superficial Secondary Undifferentiated aquifer and bedrock Secondary A aquifers (on-site and off-site)	Leaching or dissolution of contaminants in soils and subsequent migration of contaminants in groundwater	Medium	Unlikely	Low Risk	
		Chalk Principal aquifer (on-site and off-site)	Vertical migration of dissolved phase contaminants to the underlying groundwater Lateral migration of dissolved phase contaminants via preferential pathways such as drains and low permeability strata horizons in the Harwich Formation and Bognor Sands	Medium	Unlikely	Low Risk	

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Source	Receptor		Contaminant Exposure / Migration Pathway	Potential Consequence	Probability	Risk Classification	Comments
Estate battery located approximately 60m south of the site and military base located approximately 350m south of the site - Made Ground and potentially contaminated ground associated with the former allotments located approximately 250m southeast of the site - Made Ground and potentially contaminated ground associated with the Smithy located approximately 225m southeast of the site	<u>Property</u>	On-site future below ground infrastructure	Direct contact of contaminated soils/water with infrastructure, services and structures and subsequent chemical attack Direct contact of migrating contaminated groundwater within infrastructure, services and structures	Minor	Unlikely	Very Low Risk	It is assumed that appropriate concrete classifications will be adopted for the proposed reservoir structures and infrastructure as part of the design of the works.
		Off-site residential / commercial properties	Migration of contaminated groundwater along strata and preferential pathways such as service routes or differentially permeable strata and subsequent chemical attack.	Minor	Unlikely	Very Low Risk	
	Ecological	Woodland (on-site and off-site) and County Park on-site	Uptake of contaminants in soil and soil-derived dust Leaching / dissolution of contaminants from unsaturated soils followed by migration in groundwater / perched water	Minor	Unlikely	Very Low Risk	The site is predominately grassed / vegetated / wooded, which reduces the risk of direct contact / ingestion of loose soils during normal use as the soil matrix is bound by vegetation roots.

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9.7. Suitability for Reuse

Material can be reused on site if there is a genuine design requirement (and only the volume needed is used), it meets geotechnical criteria and it can be demonstrated that it does not pose an unacceptable risk to human health or the environment. It is intended that the reservoir embankments are constructed of site-won material.

Based on the sampling and laboratory testing undertaken, there are not considered to be potential unacceptable risks to human health from contaminants detected in soils from the site. Samples obtained from topsoil, Head deposits, Harwich Formation, London Clay Formation and Reading Formation all indicate that the material is suitable for reuse from an environmental and human health perspective.

However, it should be noted that appropriate sampling of the actual material excavated will be required with concentrations compared to appropriate reuse criteria to confirm suitability for reuse or otherwise, specific to the required end use.

9.8. Classification of Waste

Material that is surplus to requirements and where there is no clear strategy for reuse on-site is classified as waste and should be disposed of in accordance with the Duty of Care as specified in the Landfill Regulations (DEFRA, 2016)

Waste is classified into three categories comprising inert, non-hazardous and hazardous. A preliminary waste assessment has been undertaken based on analysed concentrations of contaminants in the soil samples obtained during the ground investigation summarised in this report and using Atkins' on-line waste classification tool, CAT-WASTE^{SOIL} (Atkins Ltd., 2019b). The assessment was undertaken with TPH inputted as unknown hydrocarbon / oil with marker compound on the basis that this represents the most conservative approach.

The results of the CAT-WASTE^{SOIL} assessment indicates that none of the soil within the samples analysed would be classified as hazardous waste for the purposes of off-site disposal.

This classification is a preliminary assessment based on a limited number of point samples from locations across the site. The actual material to be removed off-site for disposal, if any, must be appropriately classified and the classification agreed with the chosen landfill operator, including Waste Acceptance Criteria (WAC) testing to determine appropriate disposal measures. WAC testing would be required to determine the final waste classification, for example whether the waste may be classified as inert.

It is the responsibility of the waste producer to classify, treat, manage and dispose of waste appropriately and to ensure the chosen landfill is licensed to accept such material. In addition, note that individual landfill sites may have their own soil and soil leachate limits for waste acceptance as stipulated in their waste permit.

9.9. Conclusions and Recommendations

Based on the investigation and assessment presented herein, the overall contamination risk associated with the site is considered to be very low to low (to both human health and controlled waters).

In relation to the proposed scheme, the following is also likely to be required:

- adoption of appropriate health and safety measures, practices and procedures during construction to mitigate potential risks to construction workers and visitors;
- adoption of appropriate best practice environmental management during construction, e.g. minimisation of dust generation and migration, to mitigate potential risks to controlled waters, visitors and surrounding off-site users; and
- vigilance to be maintained throughout the works for Made Ground or other unexpected contamination during site clearance and earthworks in areas not previously investigated and potential asbestos containing material at surface.

9.10. Limitations

It should be noted that, as with any physical site investigation involving discrete sampling, test results will only be representative of the point sampled and further investigation and analysis may be required should ground conditions differ from those reported. If, during any excavation/construction works, visibly contaminated material is encountered in excavations, advice should be sought from an Environmental Scientist and the requirement for additional testing and assessment of the risks agreed.

10. Geotechnical Considerations

10.1. Geotechnical Parameter Values Considerations

The user of the interpreted parameter values contained herein must apply appropriate engineering judgement to the selection of values for specific analyses and design. Depending on the type of analysis an upper and / or lower characteristic value may be appropriate. In cases where the limit state affects only small volumes of soil or rock the characteristic values may need to be re-assessed. In cases where the analytical models may require substantial simplifications of the ground, full consideration will be required in parameter value selection for design.

10.2. Earthworks Operations

10.2.1. Trafficability

The site operations will be dominated by the high cohesive component of the strata. The earthworks will be overwhelmingly in the Head, London Clay, Harwich Formation, (which has a significant cohesive component), and the Reading Formation. Close to ground surface the undrained strength can be as low as around 40 to 60kPa. In addition, the plastic nature of the materials will render them susceptible to significant reductions in undrained strength in periods of wet weather. The undrained strength of clay materials govern its trafficability and at strengths below approximately 50kPa, significant rutting/deformation under the weight of compaction or construction plant can, and is likely, to occur, (Nowak & Gilbert, 2015). Thus, the Head deposits and bedrock strata have the potential to have low trafficability during earthworks operations, which will be exacerbated in sustained periods of wet weather.

Trafficability may be improved by employing lighter compaction plant where possible, reducing traffic and tyre pressures, drying out of the cohesive fill, and the use of all-weather haul roads (Nowak & Gilbert, 2015). Due to this, construction within winter and wetter months will need to take account of these mitigation measures.

10.2.2. Reusability of Soil

Acceptable fill for earthworks as classified by the Specification for Highways Works Series 601 (Highways England, 2016) is:

'...material excavated from within the site or imported on to the site which meets the requirements of Table 6/1 and contract specific Appendix 6/1 for acceptability for use in the permanent works'.

It is proposed that the Paleogene bedrock strata (Bognor Sand Member, London Clay Formation (including the weathered zone), Harwich Formation and Reading Formation) be used as the source of material for the reservoir embankment and shall be extracted from a borrow pit within the Study Area.

The material properties of the soil extracted from within the Study Area shall be classed as 2A (wet cohesive material) as per the Specification for Highways Works Series 601 Table 6/1 (Highways England, 2016).

Consistency Index

The consistency index (CI) has been determined for each stratum with the purpose of identifying any negative CI values. All of the strata have positive CI values and are not expected to be difficult to handle and compact.

Ground Aggressivity

Based on the guidance given in the Specification for Highways Works Series 601 (Highways England, 2016), the following criteria are met for the bedrock strata to be deemed as acceptable embankment fill:

- Water-soluble sulfate (SO₄) content does not exceed 1500mg/l of sulfate; and
- Total sulfur content does not exceed 1%.

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Shrink-Swell Potential

Shrink-swell of cohesive soil may result in desiccation of the embankment at surface which in turn can cause water pathways and deeper weathering of the fill material. Furthermore, shrink-swell has the potential to cause 'ratcheting' where horizontal swelling in wet periods does not recover in dry periods, leading to progressive settlement of the embankment crest.

The Modified Plasticity Index (I_p) and corresponding Volume Change Potential (VCP) for the Paleogene bedrock strata was determined using the calculation given in Section 5.7 of this report. The VCP provides a guide as to the swelling potential of over-consolidated cohesive soil. The VCP for each stratum is given below:

- Bognor Sand Member – low to medium
- Weathered London Clay Formation – medium to high
- London Clay Formation – medium to high
- Harwich Formation – low to high
- Reading Formation – low to medium

To summarise, each cohesive bedrock stratum has the potential for shrink-swell, in particular the London Clay Formation (including the weathered zone).

Dispersibility

Tests for dispersibility by the pinhole method indicate that for London Clay the results were generally non-dispersive ND1 but included four results classed as ND2 or ND3. These occurred from 50% of the samples taken from within the top 3m of this stratum. For tests in the Reading Formation all were classed as ND1.

10.3. Embankments and Cut Slopes

An earthwork embankment, up to a height of approximately 20m in height, is expected to be constructed around the western, southern and eastern boundary of the Study Area. Side slopes of between 1(v) to 7(h) and 1(v) to 5(h) are being considered.

The stability of any embankment construction will depend on its geometry and on the strength of the underlying foundation material. The presence of relict shear surfaces is likely to have a significant effect of the stability of embankment and cut slopes, in both the undrained (short term) and fully drained (long term) conditions. In earlier sections of this report, it is noted that as well as causing a general reduction of shear strength it is possible that the near surface deposits (Head) may be characterised by the presence of a continuous or semi continuous relict shear surface. Unless further investigation can confirm its absence, any assessment of stability of embankment and cut slopes should assume that they are present.

A number of methods can be considered for dealing with continuous or semi-continuous and extensive shear surfaces and should be considered in this case. These include the following:

- The Head deposits present at formation level be part excavated and replaced with suitable engineered fill, to form shear keys beneath embankment side slopes. The fill could include the excavated Head, subject to its meeting acceptability criteria
- The use of drainage measures in the Head and any other at risk near surface layers to dissipate excess porewater pressures during construction. This should be coupled to controls on the rate of construction; and,
- The use of appropriately low gradient slopes to avoid the need for foundation treatment.

In any case, embankment construction on cohesive soils is likely to elevate pore pressures within the foundation soils. Notwithstanding the effects of relict shear surfaces, this may of itself, reduce the stability of the embankment. Therefore, appropriate controls on construction should be considered to allow for excess pore water pressures in the foundation soils to be controlled.

10.4. Excavations

An excavation for the proposed borrow pit is expected to be undertaken within the Study Area. The excavated material is envisaged to be used as embankment fill. All strata types are likely to be excavated and re-used in the embankment.

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Excavations within both the Head and Harwich Formation is likely to be encounter variable material in both its composition and density. The Harwich Formation also includes bands of variable strength and composition rock and the London Clay has discrete claystone bands. Where London Clay and Reading Formation exist near ground surface the upper weathered layers will be at the bottom end of the strength profile (i.e. soft, firm). Below the weathered horizon strength will increase becoming very stiff with depth.

Groundwater is present within all the strata types to a varying degree (see Section 10.5) and the presence of groundwater will affect both the stability of excavation slopes and the re-usability of the excavated material. Both the Bognor Sand Member and the Harwich Formation include sand and gravel horizons where groundwater emission could cause undermining of excavation slopes.

10.5. Groundwater

The recent ground investigation and the limited groundwater monitoring by Socotec has confirmed the findings of previous ground investigations (Atkins Ltd., 2020a) regarding groundwater.

The groundwater regime on the Study Area can be summarised as comprising:

- An elevated groundwater body within the Bognor Sand Member in the southwest of the Study Area;
- A semi-confined aquifer within the Harwich Formation that is inferred to be confined by the overlying London Clay Formation and underlying Reading Formation; and
- A confined White Chalk Sub-Group aquifer beneath the Reading Formation.

A consideration of the groundwater at the Study Area is provided in Table 10-1 below.

Table 10-1 - Summary of groundwater conditions

Stratum	Groundwater conditions
Head	Seepages have been noted at various depths, some of which were sufficient to cause small rises. On open excavation faces control by gravity drainage to collection sumps.
Bognor Sand Member	Seepages have been noted at various depths and typically towards the base of the stratum. On open excavation faces control by gravity drainage to collection sumps. Heavier inflows may exist in the sandier parts of the stratum.
London Clay Formation	Seepages have been noted associated with sand partings and claystone horizons. On open excavation faces control by gravity drainage to collection sumps.
Harwich Formation	Significant inflows and rises have been recorded in this stratum leading to both artesian and sub-artesian groundwater conditions depending on location within the Study Area. Excavations in the overlying London Clay stratum will need to consider bottom heave issues. On open excavation faces inflows may be too large for gravity drainage to sumps and groundwater lowering or exclusion method may need to be considered.
Reading Formation	Seepages, that rose about 2m, have been noted in a sandier horizon typically 9 to 12m below the top of the stratum. On open excavation faces control by gravity drainage to collection sumps.
White Chalk Sub-Group	Monitored groundwater at three locations indicate a hydraulic gradient of 0.012 in a south-southeast direction and is sub-artesian beneath the Study Area. This is not exposed by excavations.

Analysis of the ongoing automated groundwater monitoring, when obtained, is required to fully understand the various groundwater regimes that exist in the Study Area. This should look at both seasonal variation and determine the likely maximum and minimum levels over the design life of the reservoir.

10.6. Aggressivity to Concrete

The BRE SD1 test results for the aggressivity of the soil to concrete, shows that the strata present at the Study Area has a typical classification of DS-1 AC-1^d with the exception of Head which has DS-1 AC-2z (BRE, 2005). The results for all strata suggested that no pyrite was present with the soil samples; pyrite is particularly aggressive to concrete when oxidised.

The BRE SD1 test results do not agree with the field descriptions of the soil which note the presence of pyrite and gypsum within the Weathered London Clay Formation and the Harwich Formation. The presence of pyrite and gypsum within the Paleogene deposits of the South-East of England is also well known in the literature.

Based on the soil descriptions and the available literature, the following BRE SD1 classification should be used for designing concrete structures within the Study Area:

DS-3

AC-3

11. Geotechnical Risk Register

11.1. General

The Geotechnical Risk Register is presented in Table 11-4 below. It comprises an initial assessment of the geotechnical hazards expected within the Study Area prior to the application of mitigation measures. The Risk Register also shows how the risk of the hazards can be reduced by the application of mitigation measures.

In most cases the mitigation measures will be sufficient to reduce the risk to low. In some cases, the risk may be reduced but a significant residual risk remains which must be managed.

Prior to implementation of the proposed mitigation measures, the risks considered to be Medium to High are:

- Buried services;
- Dissolution features;
- High /perched groundwater;
- Variable / deep weathering zone causing changes in soil strength
- Weak bearing / compressible materials;
- Aggressive ground to concrete such as the Thames Group and Lambeth Group. This may cause weakening and degradation of the concrete.
- Aggressive ground;
- Reactivation of shear surfaces within the Head;
- Compaction induced shear surfaces within the embankment;
- Under-compaction during embankment construction;
- Excavation instability / collapse;
- Unforeseen ground conditions;
- Changes or variations in soil / rock strength;
- Previously unencountered contaminated land;
- Flotation of structures;
- Unexploded ordnance; and
- Shrink-swell potential.

11.2. Definition of Risk

The risks included in this report shall not be considered exhaustive of every aspect of the project; rather they are illustrative of the key geotechnical risks, and corresponding planning, commercial and construction risks.

In line with industry norms, Risk (R) is defined as:

$$R = P \times I$$

Where:

P = Probability (%) of an event (hazard) occurring

I = Impact of the event (hazard), should it occur

It should be noted for the purposes of this report, impact (I) is defined in terms of construction and operation/maintenance. Other definitions of impact (e.g. based on environmental considerations) can also be applied once additional information becomes available.

Definitions of the scale of Probability (P) and Impact (I) values used in this report are presented in Table 11-1 and Table 11-2 below. The rating has been assigned based on experience and engineering judgment.

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Table 11-3 below presents the definitions of the risk levels derived from probability and impact using the risk classification matrix. The overall risk classification shall be considered as qualitative rather than quantitative as the rating is largely based on experience and engineering judgement, therefore the overall risk rating shall not be used for quantitative statistical analyses.

The preliminary risk register shows the calculated risk result for some of the key geotechnical and project hazards along with the calculated risk results, both prior to, and post risk control measures (RCM).

Not all the constraints and hazards identified in this report have been assessed in terms of risk at this stage. However, the risk register represents an initial means of demonstrating how the risks can be reduced once control measures are in place.

Table 11-1 - Qualitative scale of probability (P)

Probability of event (P)

Scale	Likelihood	Probability (%)
5	Very Likely	>70
4	Likely	40 – 70
3	Possible	10 – 40
2	Unlikely	1 – 10
1	Very Unlikely	<1

Table 11-2 - Qualitative scale of Impact (I)

Impact of event (I)

Scale	Class Descriptor	Construction Impact	Operation / Maintenance Impact
5	Very Serious	Construction unsustainable	Scheme operation unsustainable/deaths & serious injury
4	Serious	Significantly increased construction costs & operational difficulty	Increased scheme costs Injury/Illness
3	Moderate	Impact to costs/programme	Effect on scheme costs
2	Slight	Impact to programme	Small effect on scheme costs
1	Negligible	Negligible	Negligible

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Table 11-3 - Risk classification matrix

Risk Matrix (R = P x I)							Risk Classification		
Probability (P)	5	5	10	15	20	25	17 - 25	High Risk	Unacceptable. Consider unfeasible and review concepts
	4	4	8	12	16	20			
	3	3	6	9	12	15	9 - 16	Medium Risk	Identify and implement all practical risk control measures
	2	2	4	6	8	10			
	1	1	2	3	4	5	5 - 8	Low Risk	Identify and implement cost effective risk control measures
		1	2	3	4	5	1 - 4	Very Low Risk	Acceptable. Monitor at key stages
		Impact (I)							

11.3. Mitigation and Residual Risk

11.3.1. Mitigation Measures

The mitigation measures considered are those that may be applied during design or construction, as appropriate, to mitigate the hazard identified and, in most cases, to render the risk insignificant. Mitigation measures considered appropriate for the Substantial risks listed above include:

- Consideration of geotechnical issues during preliminary and detailed design;
- Continuous monitoring during construction; and
- Removal of the Head.

11.3.2. Residual Risk

Following risk identification, assessment and the application of recommended mitigation/avoidance measures most risks have been assessed to be low. However, it should be recognised that some residual risks remain.

11.4. Geotechnical Risk Register

Table 11-4 - Geotechnical Risk Register

Ref No	Hazard/Risk Raised	Risk Raised by	Initial Risk Rating			Proposed Mitigation/Controls	Final Risk Rating		
			P	I	R		P	I	R
1	Damage to buried services and injury or death to personnel if buried services are struck	Atkins	2	5	10	Suitably certified personnel shall undertake CAT and Genny scanning at the location of all breaking of ground. Where required, a GPR survey may also be commissioned.	1	5	5
2	Collapsible ground due to dissolution features within the White Chalk Sub-Group	Atkins	2	5	10	Construction works will need to consider that there may be dissolution features present, however this is expected to be low. Continuous monitoring on site is recommended by an engineering geologist or geotechnical engineer.	1	5	5
3	High /perched groundwater causing flooding of excavations	Atkins	3	4	12	Appropriate systems and monitoring is recommended. Pumping is also recommended when excessive groundwater is encountered.	2	4	8
4	Variable / deep weathering zone causing changes in soil strength	Atkins	4	3	12	Continuous monitoring on site is recommended by an engineering geologist or geotechnical engineer. Sufficient design is recommended to allow for changes in rock / soil strength.	3	3	9
5	Weak bearing / compressible materials, including Head	Atkins	3	3	9	Removal of the weak bearing / compressible material is recommended. If this is not possible, staged or controlled rate of construction of the embankment shall be implemented.	2	3	6
6	Aggressive ground to concrete such as the Thames Group and Lambeth Group. This may cause weakening and degradation of the concrete.	Atkins	4	2	8	Concrete specified in BRE SD1 is recommended using the classification recorded in Section 9.7 of this report.	3	2	6
7	Aggressive ground leading to chemical attack on limestone (within the Harwich Formation) and subsequent voiding.	Atkins	3	2	6	Remove limestone where present from the soil reused as fill material.	2	2	4

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Ref No	Hazard/Risk Raised	Risk Raised by	Initial Risk Rating			Proposed Mitigation/Controls	Final Risk Rating		
			P	I	R		P	I	R
8	Reactivation of shear surfaces within the Head will cause ground instability and possible failure of the proposed earthworks.	Atkins	4	4	16	Removal of the Head within the footprint of the earthworks, prior to construction of the earthworks, is proposed.	3	4	12
9	Compaction induced shear surfaces within the embankment.	Atkins	4	4	16	Adequate design and methodology of the construction of the embankment is to be undertaken; with pore water pressures within the fill material to be considered.	3	4	12
10	Under-compaction during embankment construction.	Atkins	4	4	16	Stiffer soil is to be avoided where possible. Where this is not possible, conditioning of the soil is recommended. Drying out leading to desiccation of the soil is to be avoided.	3	4	12
11	Excavation instability / collapse due to low friction angle of the soil	Atkins	4	4	16	Excavation face stability measures may need to be considered for excavations at the Site. Measures include shoring and reducing the angle of the excavation faces.	3	4	12
12	Unforeseen ground conditions	Atkins	3	3	9	Continual monitoring and logging of excavations during construction, with frequent liaison with an engineering geologist or geotechnical engineer.	2	3	6
13	Risk of contamination existing on site from the historical land use, present land use and future construction of the reservoir. Very low to low risks to human health, property, controlled waters and ecological receptors have been identified for the site. Presence of contamination may also limit materials reuse / waste disposal costs.	Atkins	2	3	6	Laboratory tests on the chemical concentrations within soils have been undertaken as part of geotechnical investigation works. No soil exceedances of the GAC for an open space (parkland) end use were identified and no asbestos fibres were detected in soils. Groundwater DWS and EQS exceedances were identified for inorganics, metals and TPHs (EQS exceedances only). However, all of the groundwater DWS and EQS are considered to be marginal exceedances and based on the available data, potential contaminants in site groundwater samples at the concentrations recorded are considered unlikely to present potentially unacceptable risks to identified controlled water receptors. Construction workers to follow robust risk assessments and method statement and wear PPE appropriate for the task.	1	3	3

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Ref No	Hazard/Risk Raised	Risk Raised by	Initial Risk Rating			Proposed Mitigation/Controls	Final Risk Rating		
			P	I	R		P	I	R
						Adequately classify all soils which are destined for reuse or disposal and process in accordance with relevant legislation.			
14	Changes or variations in soil / rock strength, such as flints and hardgrounds within the White Chalk Subgroup, rock beds and nodules within the Thames Group and Lambeth Group.	Atkins	3	3	9	Where unanticipated hard layers are encountered at shallow depths hindering development, appropriate pneumatic plant or localised blasting may be required for removal. Continuous monitoring on site is recommended during construction by an engineering geologist or geotechnical engineer. Sufficient design is recommended to allow for changes in soil / rock strength.	2	3	6
15	Flotation of structures due to groundwater pressure head.	Atkins	3	3	9	Appropriate systems and monitoring is recommended. Sufficient design is required to reduce the floatation risk to structures.	2	3	6
16	Unexploded ordnance leading to injury or death of personnel	Atkins	3	5	15	A UXO Management Plan shall be undertaken by a suitably qualified company. Undertake site specific UXO awareness briefings at the start of any site works. If necessary, undertake a watching brief during any further ground investigation and construction activities.	2	5	10
17	Presence of ground conditions with shrink-swell potential (e.g. Thames Group, Lambeth Group)	Atkins	4	3	12	Adequate design of foundations to allow for the possibility of shrink-swell in the future; this shall allow for design tolerances for the proposed structure. Ground improvement to be designed and implemented if deemed necessary.	3	3	9

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12. References

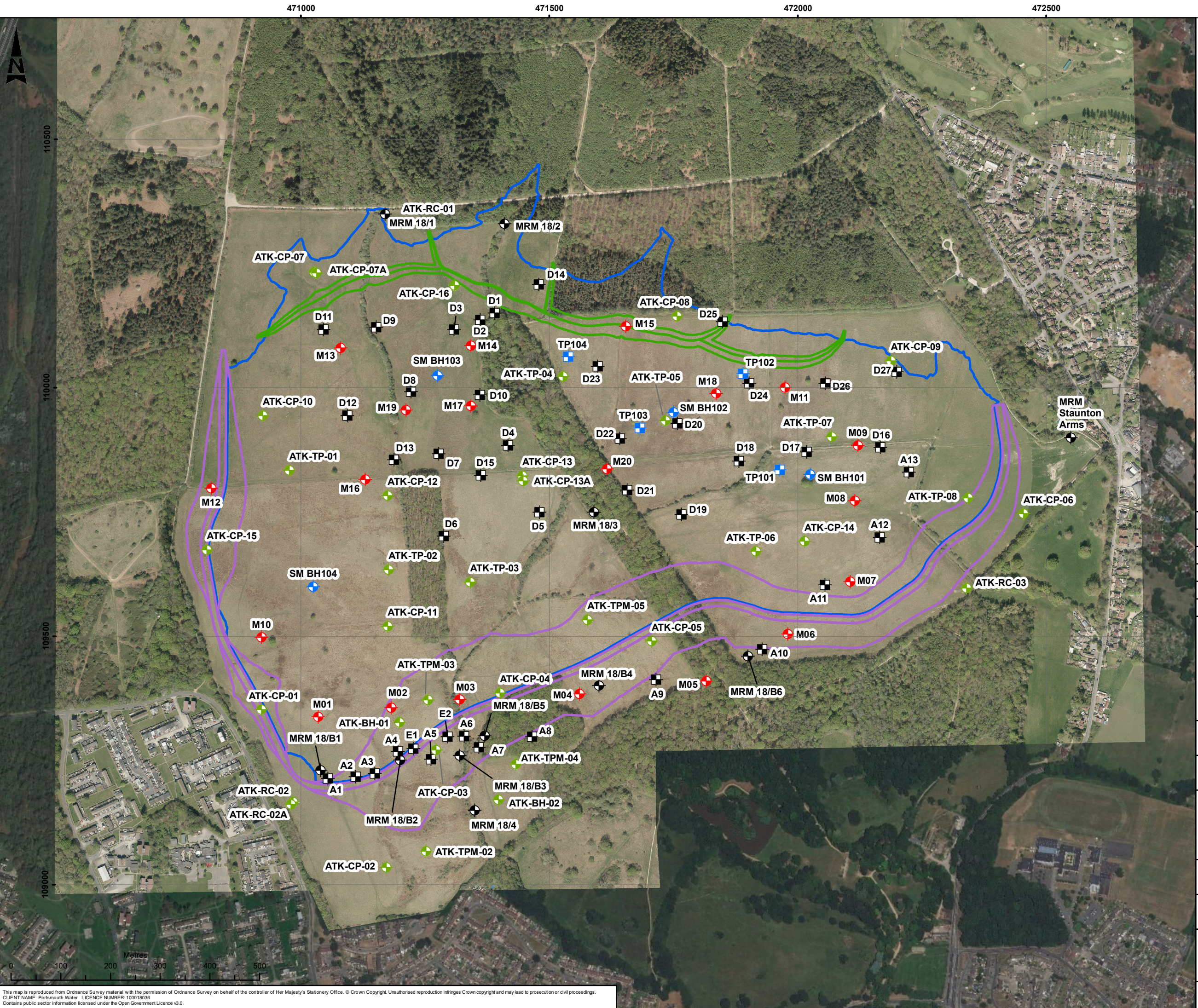
- 1st Line Defence, 2019. *Detailed Unexploded Ordnance (UXO) Risk Assessment: Havant Thicket* (Report no. DA9681a-01), Hoddesdon: 1st Line Defence.
- Atkins Ltd., 2019a. *Havant Thicket Winter Storage Reservoir Ground Investigation Rationale*. Report no. HTWSR-ATK-ZZ-ZZ-RP-C-0003, Epsom: Atkins Ltd..
- Atkins Ltd., 2019b. *CATWasteSoil*. [Online]
Available at: www.catwastesoil.co.uk
- Atkins Ltd., 2020a. *Havant Thicket Winter Storage Reservoir Project Geology and Hydrogeology Desk Study*. Doc No: HTR-ATK-ZZ-ZZ-RP-C-0001, Epsom: Atkins Ltd..
- Atkins Ltd., 2020b. *Aerial photography and LiDAR interpretation Technical Note* (Report no. HTR-ATK-ZZ-ZZ-RP-C-0010), Epsom: Atkins.
- Atkins Ltd., 2020c. *Havant Thicket Winter Storage Reservoir: Ground Investigation (Phase 1) Specification*. Document no. HTWSR-ATK-ZZ-ZZ-CD-C-0003., Epsom: Atkins.
- BRE, 2005. *Special Digest: 1:2005, Concrete in aggressive ground*, s.l.: s.n.
- British Geological Survey, 1982. *The Hampshire Basin and adjoining areas*. Fourth edition ed. London: British Geological Survey.
- British Geological Survey, 1998. *British Geological Survey Sheet 316: Fareham (Solid and Drift Geology); 1:50,000 Solid and Drift*. London: British Geological Survey.
- British Geological Survey, 2016. *Karst hydrogeology of the Bedhampton and Havant springs*. [Online]
Available at: <https://www.bgs.ac.uk/research/groundwater/about/karstAquifers/bedhamptonHavantSprings.html>
[Accessed 19 February 2020].
- British Geological Survey, 2020. *Geoindex (onshore and offshore)*. [Online]
Available at: <http://www.bgs.ac.uk/geoindex/>
[Accessed 07 February 2020].
- British Standard Institute, 2015. *BS 8002:2015 - Code of practice for Earth retaining structures*, s.l.: British Standard Institute.
- CIRIA, 1995. *The Standard Penetration Test (SPT): Methods and Uses*. Report 143, s.l.: s.n.
- CIRIA, 2002. *C574: Engineering in chalk*, London: CIRIA.
- CIRIA, 2004. *C583: Engineering in the Lambeth Group*, London: CIRIA.
- DEFRA, 2009. *Model Procedures for the Management of Land Contamination: Contaminated Land Report CLR11*, London: DEFRA.
- DEFRA, 2013. *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination*, London: DEFRA.
- DEFRA, 2016. *Waste Duty of Care Code of Practice*. London: DEFRA.
- Edgar Morton & Partner / Professor PW Rowe, 30 March 1963. *Proposed Storage Reservoir at Havant Thicket*, s.l.: s.n.
- Edgar Morton & Partner, 8 December 1962. *Geological Report on the proposed storage reservoir at Havant Thicket*.
- Entec UK Limited, 2006. *Havant Thicket Winter Storage Reservoir Engineering Study*, Bristol: Entec UK Limited.
- Entec UK Limited, 2007. *Havant Thicket Winter Storage Reservoir, Embankment Material Investigations*, s.l.: Entec UK Limited.
- Environment Agency, 2009. *Human health toxicological assessment of contaminants in soil: Science Report SC050021/SR2*, Bristol: Environment Agency.
- Environment Agency, 2017. *Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning*, Bristol: Environment Agency.
- Environment Agency, 2019. *Land Contamination: Risk Management*. [Online]
Available at: <https://www.gov.uk/guidance/land-contamination-how-to-manage-the-risks>
- Eurocodes, 2010. *Eurocode 7 - Geotechnical Design Part 2: Ground Investigation and Testing*. Ref: BS EN 1997-2:2007, s.l.: s.n.
- Flemal, R. C., 1976. Pingos and pingo scars: Their characteristics, distribution, and utility in reconstructing former permafrost environments. *Quaternary Research*, 6(1), pp. 37-53.

ATKINS BASELINE - LOW RISK

- Google, 2020. *Google Earth Pro*. [Online]
Available at: [Downloadable Application](#)
[Accessed 06 April 2020].
- Higginbottom, I. E. & Fookes, P. G., 1970. Engineering aspects of periglacial features in Britain. *Quarterly Journal of Engineering Geology and Hydrogeology*, Volume 3, pp. 85-117.
- Highland, L. M. & Bobrowsky, P., 2008. *The Landslide Handbook - A Guide to Understanding Landslides*, Reston, Virginia: USGS.
- Highways England, 2016. *Specification for highways works. Series 600 - Earthworks*. s.l.:s.n.
- HMSO, 2015. *The Water Framework Directive (Standards and Classification) Direction (England and Wales)*, London: HMSO.
- Hughes Waste Management Ltd, 1997. *Proposed Landfill and Waste Recycling Facility, Hazleton Farm, Horndean*, s.l.: s.n.
- Hutchinson, J., 1991. Theme Lecture: Periglacial and Slope Processes. *Quaternary Engineering Geology*, pp. 283-331.
- Jeffery, Z. E., Penn, S., Giles, D. P. & Hastewell, L., 2020. Identification, investigation and classification of surface depressions and chalk dissolution features using integrated LiDAR and geophysical methods. *Quarterly Journal of Engineering Geology and Hydrogeology*, TBC(TBC), p. TBC.
- Jones, L. D. & Terrington, R., 2011. Modelling volume change in the London Clay. *Quarterly Journal of Engineering Geology and Hydrogeology*, 14(1), pp. 109-122.
- Landmark Information Group, 2019. *Envirocheck Report 202069335-1_1*, Reading: Landmark Information Group.
- Mander, Raikes and Marshall, 1977 - 78, 1979?. *Technical Report on Reservoir Investigation, East Hampshire*. s.l.:s.n.
- Mander, Raikes and Marshall, 1980. *Reservoir Investigation - Hampshire, Report on Engineering Studies*. s.l.:s.n.
- Maurice, L. D. et al., 2006. Karstic behaviour of groundwater in the English Chalk. *Journal of Hydrology*, Volume 330, pp. 56-70.
- Nowak, P. & Gilbert, P., 2015. *Earthworks: A guide*. 2nd ed. London: ICE.
- Ove Arup & Partners Ltd., 2009. *Havant Thicket Winter Storage Reservoir - Hydrogeological Desk Study*, Leeds: Arup.
- Ove Arup & Partners Ltd, 2009. *Havant Thicket Winter Storage Reservoir: Havant Reservoir - Aerial Photography Interpretation*, London: s.n.
- Peter Brett Associates, 2018. *Horndean, Portsmouth, Ground Condition Assessment and Ground Investigation Report*, Reading: Peter Brett Associates.
- Portsmouth Water, 2008. *Idworth Well Water Supply Information 1932-2008*, Portsmouth: Portsmouth Water.
- Portsmouth Water, March 2012. *Havant Thicket Winter Storage Reservoir Site - Site History Information*, s.l.: s.n.
- Skempton, A. W., Leadbetter, A. P. & Chandler, R. J., 1989. The Mam Tor landslide, north Derbyshire. *Philosophical Transactions of the Royal Society*, 329(1607), pp. 503-547.
- SOCOTEC, 2020. *Factual Ground Investigation Report: Havant Thicket Winter Storage Reservoir. Report no. A9031-19.*, Doncaster: SOCOTEC.
- Soils Ltd, 1997. *Phase 2 Ground Investigation Report at Padnell Grange, Padnell Road, Cowplain, Hampshire PO8 8ED*, s.l.: Soils Limited.
- Spink, T. W., 1991. Periglacial discontinuities in Eocene clays near Denham, Buckinghamshire. *Quaternary Engineering Geology, Geological Society Engineering Geology Special Publication No 7*, pp. 389-396.
- Structa LLP, 2010. *Land at Redhill Road, Rowlands Castle*, Hemel Hempstead: Structa LLP.
- TerraDat, 2017. *Land at Horndean, East Hampshire, Geophysical Survey Report*, Cardiff: TerraDat.
- Wires, K. C., 1984. The Casagrande method versus the drop-cone penetrometer method for the determination of Liquid Limit. *Canadian Journal of Soil Science*, 64(2), pp. 297-300.
- Yoshikawa, K., 2013. Pingos 8.18. Reference Module in Earth Systems and Environmental Sciences. *Treatise on Geomorphology*, Issue 8, pp. 274-297.

Appendices

Appendix A. Ground Investigation Plans



Top Water Level

Embankment P01

Wetland Bund P01

Current Ground Investigation (Socotec/Atkins 2019)

Historical Trial Pit Locations

MRM 1979

Soil Mechanics 2006

Historic Ground Investigation Exploratory Positions

MRM 1977 - 1979

Morton 1963

Soil Mechanics 2006

P00	EM	GR	XX	XX	WORK IN PROGRESS	09/04/2020
Rev.	Dwn By	Ckd By	Rev By	Auth By	Description	Date

ATKINS

Member of the SNC-Lavalin Group

Aztec West

500 Park Avenue

Almondsbury

Bristol

BS32 4RZ

Tel: +44 (0) 1454 662000

Fax: +44 (0) 1454 663333

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WORK IN PROGRESS					S0

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Project	Originator	Volume	Location	Type	Role	Number
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Fax: Havant (023) 9245 3632

Website: www.portsmouthwater.co.uk

Registered Office: PO Box 8 West Street

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Project Title

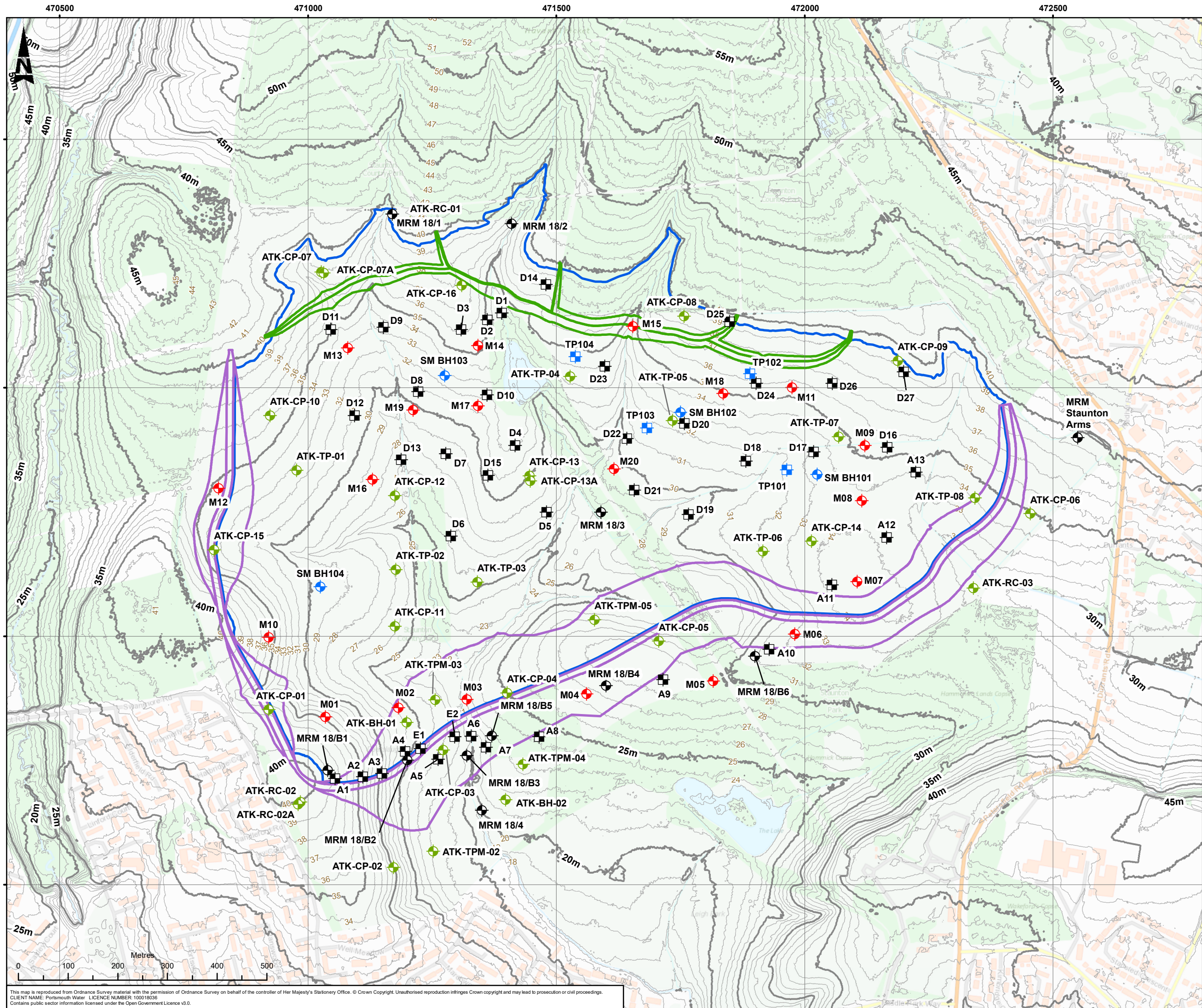
HAVANT THICKET
WINTER STORAGE RESERVOIR

Drawing Title

GROUND INVESTIGATION PLAN
WITH AERIAL IMAGERY

Portsmouth Water Drawing Number	Rev
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- Top Water Level
- Wetland Bund P01
- Embankment P01
- Current Ground Investigation (Socotec/Atkins 2019)
- Historical Trial Pit Locations
 - MRM 1979
 - Soil Mechanics 2006
- Historic Ground Investigation Exploratory Positions
 - MRM 1977 - 1979
 - Morton 1963
 - Soil Mechanics 2006
- 1m Contour
- 5m Contour

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Aztec West
500 Park Avenue
Almondsbury
Bristol
BS32 4RZ

Tel: +44 (0) 1454 6620000
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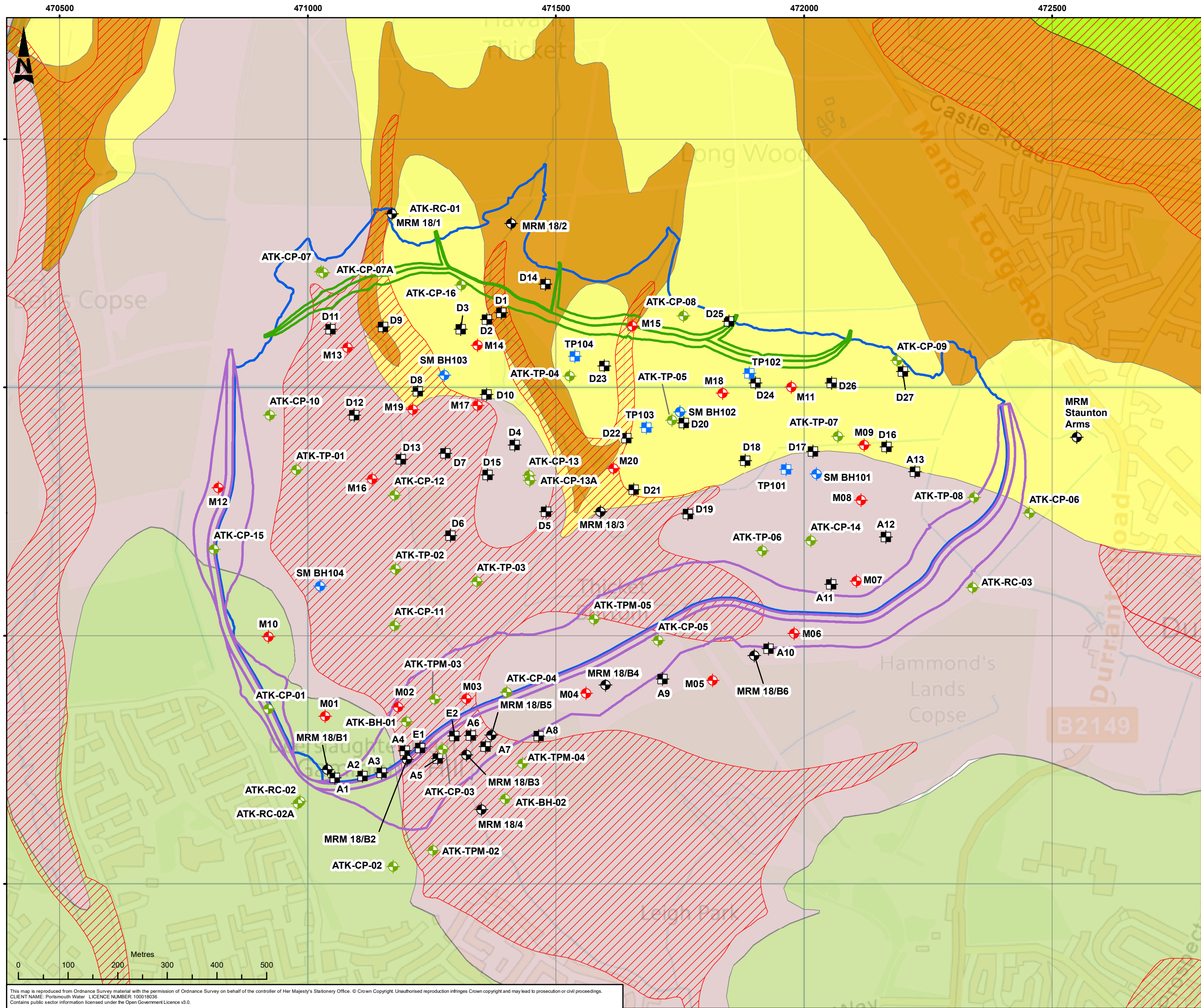
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Drawing Title
GROUND INVESTIGATION PLAN WITH CONTOURS

Portsmouth Water Drawing Number	Rev
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Top Water Level

Embankment P01

Wetland Bund P01

Current Ground Investigation (Socotec/Atkins 2019)

MRM 1979

Soil Mechanics 2006

MRM 1977 - 1979

Morton 1963

Soil Mechanics 2006

Superficial Deposits

London Clay (Bognor Member)

London Clay

London Clay (Harwich Formation)

Reading Formation

Chalk

Historical Trial Pit Locations

MRM 1979

Soil Mechanics 2006

Historic Ground Investigation Exploratory Positions

MRM 1977 - 1979

Morton 1963

Soil Mechanics 2006

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Tel: +44 (0) 1454 662000

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1 of 1

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HAVANT THICKET
WINTER STORAGE RESERVOIR

Drawing Title

GROUND INVESTIGATION PLAN
WITH GEOLOGY

Portsmouth Water Drawing Number

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Appendix B. Ground Investigation Factual Reports

Refer to ES_Volume_4_Appendix_A10.5_Appendix_B1

B.1 – Edgar Morton (1962-63)

Refer to ES_Volume_4_Appendix_A10.5_Appendix_B2

B.2 – MRM (1975-79)

Refer to ES_Volume_4_Appendix_A10.5_Appendix_B3

B.3 – Soil Mechanics (2007)

Refer to ES_Volume_4_Appendix_A10.5_Appendix_B4

B.4 – Socotec (2020)

Appendix C. Geological Cross-Sections



DO NOT SCALE

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE GEOLOGICAL CROSS SECTIONS NS01, NS02, NS03, WE01, WE02 AND WE03 (DRAWINGS HTR-ATK-RZ-RE-DR-C-0002 to -0008) AND WITH REFERENCE TO THE GROUND INVESTIGATION REPORT HTR-ATK-RZ-RE-RP-C-0001.
3. EXPLORATORY HOLE LOCATIONS FROM GROUND INVESTIGATION UNDERTAKEN UPTO JANUARY 2020.
4. THE GEOLOGICAL BOUNDARIES PRESENTED ON THIS PLAN ARE BASED ON THE BGS GEOINDEX, NOT INTERPRETED FROM THE GROUND INVESTIGATIONS.

	BH - Morton (1963)		DS RC - Atkins (2020)
	CP - Atkins (2020)		TP - Atkins (2020)
	CP- Soil Mechanics (2006)		TP- Soil Mechanics (2006)
	CP- MRM (1977-1979)		TP- MRM (1977-1979)

Legend

	Superficial Deposit (HEAD)
	London Clay (Bognor Member)
	London Clay
	London Clay (Harwich Formation)
	Reading Formation
	Chalk

[illegible]

P01	09/04/20	Draft GIR Issue- For Portsmouth Water Review	SBR	RL	JA
Rev.	Date	Description	By	Chk'd	App'd

Drawing Status	Suitability
WORK IN PROGRESS	SO


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ATKINS

Member of the SNC-Lavalin Group

Woodcote Grove
Ashley Road
Epsom
Surrey
KT18 5BW

Tel: +44 (0)1372 726140
Fax: +44 (0)1372 740055
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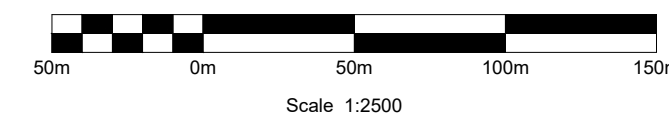
Drawing Title

EXPLORATORY HOLE LOCATION
AND GEOLOGICAL
CROSS SECTION PLAN

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Original Size A1	Date 06/04/20	Date 06/04/20	Date 17/04/20	Date 17/04/20
Drawing Number				Revision

Drawing Number	Revision
HTR-ATK-RZ-RE-DR-C-0001	P01

DO NOT SCALE



- | Legend | |
|---|--------------------|
|  | TOPSOIL |
|  | HEAD |
|  | Bognor Sand Member |
|  | London Clay |
|  | Harwich Formation |
|  | Reading Formation |
|  | Chalk |

SPT N Values
(uncorrected)

[illegible]

P01	09/04/20	Draft GIR Issue- For Portsmouth Water Review	SBR	RL	JA
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ATKINS

Member of the SNC-Lavalin Group

Woodcote Grove
Ashley Road
Epsom
Surrey
KT18 5BW

Tel: +44 (0)1372 726140
Fax: +44 (0)1372 740055
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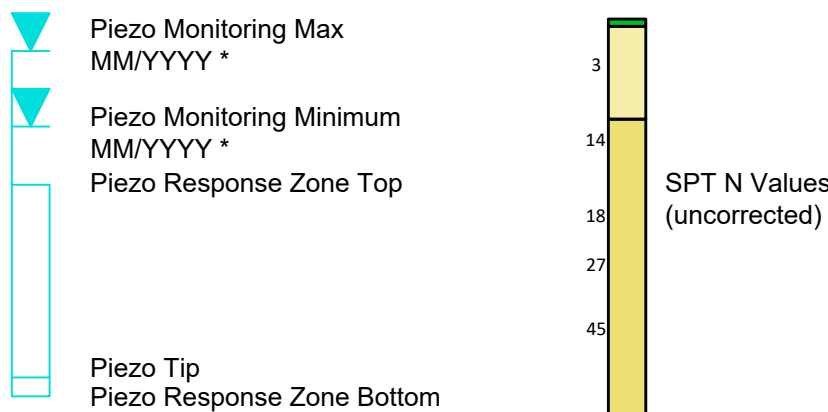
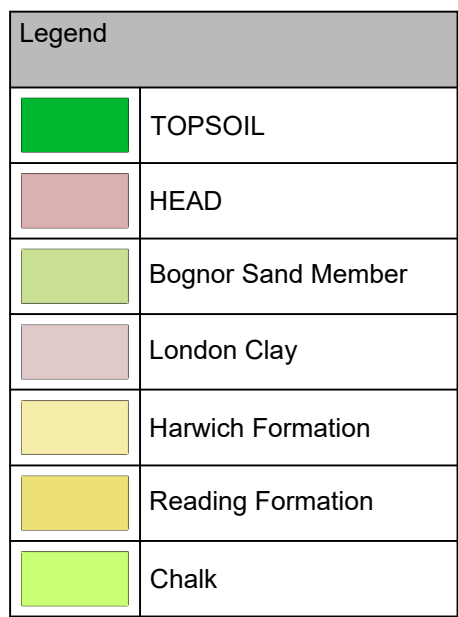
GEOLOGICAL
CROSS SECTION NS01

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Original Size A1	Date 06/04/20	Date 06/04/20	Date 17/04/20	Date 17/04/20

Drawing Number	Revision
HTR-ATK-RZ-RE-DR-C-0006	P01

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2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE EXPLORATORY HOLE LOCATION PLAN
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3. CROSS SECTIONS ARE PREPARED FROM GROUND INVESTIGATION INFORMATION UNDERTAKEN UP TO JANUARY 2020.
4. INTERPRETATIONS HAVE BEEN MADE PRINCIPALLY FROM EXPLORATORY HOLES CLOSEST TO THE SECTION LINE. THE OVERALL GEOLOGICAL SECTION HAS BEEN INTERPRETED FROM ALL AVAILABLE DATA. INTERPRETED STRATA BOUNDARIES THEREFORE MAY NOT MATCH THE STRATA BOUNDARIES OF INDIVIDUAL EXPLORATORY HOLES. THE READING FORMATION/ CHALK BOUNDARY IS SHOWN ONLY FOR THE ZONE ENCLOSED BY THE THREE SOCOTEC HOLES BORED INTO THE CHALK.
5. FOR DETAILED INFORMATION REGARDING STRATIGRAPHY AND MATERIAL TYPE, REFERENCE SHOULD BE MADE TO THE INDIVIDUAL EXPLORATORY HOLE RECORDS.
6. EXPLORATORY HOLES HAVE BEEN REMOVED FROM THE SECTION WHERE EXPLORATORY HOLES OVERLAP. IN THE CASE OF OVERLAPPING EXPLORATORY HOLES, THOSE WITH HIGHER QUALITY AND/OR MORE RELEVANT DATA HAVE BEEN PRESENTED.
7. THE BOREHOLE OFFSET FROM THE CROSS SECTION LINE IS SHOWN IN THE BOREHOLE STRIP HEADER. HOLES THAT SHOW A NEGATIVE OFFSET ARE EAST OF THE SECTION LINE. POSITIVE OFFSETS ARE WEST OF THE SECTION LINE.



*Piezo Monitoring (manual, Socotec, Round 3)

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P01	09/04/20	Draft GIR Issue- For Portsmouth Water Review	SBR	RL	JA
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Woodcote Grove
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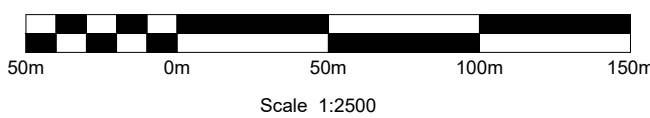
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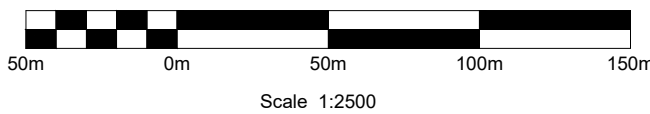


HAVANT THICKET WINTER STORAGE RESERVOIR PROJECT

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Drawing Number								Revision	
HTR-ATK-RZ-RE-DR-C-0007								P01	





NOTES:

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3. CROSS SECTIONS ARE PREPARED FROM GROUND SURVEY INFORMATION UNDERTAKEN UP TO JANUARY 2020.
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5. FOR DETAILED INFORMATION REGARDING STRATIGRAPHY AND MATERIAL TYPE, REFERENCE SHOULD BE MADE TO THE INDIVIDUAL EXPLORATORY HOLE RECORDS.
6. EXPLORATORY HOLES HAVE BEEN REMOVED FROM THE SECTION WHERE EXPLORATORY HOLES OVERLAP. IN THE CASE OF OVERLAPPING EXPLORATORY HOLES, THOSE WITH HIGHER QUALITY AND/OR MORE RELEVANT DATA HAVE BEEN PRESENTED.
7. THE BOREHOLE OFFSET FROM THE CROSS SECTION LINE IS SHOWN IN THE BOREHOLE STRIP HEADER. HOLES THAT SHOW A NEGATIVE OFFSET ARE EAST OF THE SECTION LINE. POSITIVE OFFSETS ARE WEST OF THE SECTION LINE.

Piezo Monitoring Max
MM/YYYY *

Piezo Monitoring Minimum
MM/YYYY *

Piezo Response Zone Top

Piezo Tip

Piezo Response Zone Bottom

*Piezo Monitoring (manual, Socotec, Round 3)
MM/YYYY

SPT N Values
(uncorrected)

3

14

18

27

45

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P01	09/04/20	Draft GIR Issue- For Portsmouth Water Review	SBR	RL	JA
Rev.	Date	Description	By	Chk'd	App't

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ATKINS

Member of the SNC-Lavalin Group

Woodcote Grove
Ashley Road
Epsom
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KT18 5BW

Tel: +44 (0)1372 726 140
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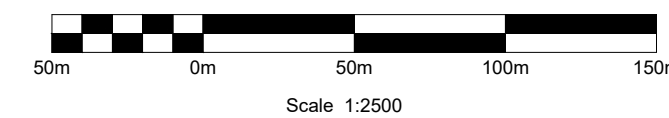
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Drawing Number	Revision
HTR-ATK-RZ-RE-DR-C-0008	P01

DO NOT SCALE



- *Piezo Monitoring (manual, Socotec, Round 3)

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Woodcote Grove
Ashley Road
Epsom
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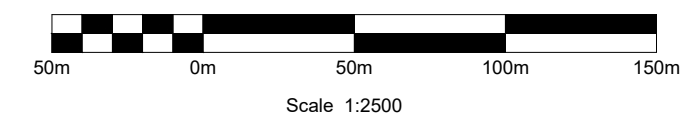
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Drawing Title

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(Sheet 1 of 2)

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Drawing Number				Revision
HTR-ATK-RZ-RE-DR-C-0002				P01

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5. FOR DETAILED INFORMATION REGARDING STRATIGRAPHY AND MATERIAL TYPE, REFERENCE SHOULD BE MADE TO THE INDIVIDUAL EXPLORATORY HOLE RECORDS.
6. EXPLORATORY HOLES HAVE BEEN REMOVED FROM THE SECTION WHERE EXPLORATORY HOLES OVERLAP. IN THE CASE OF OVERLAPPING EXPLORATORY HOLES, THOSE WITH HIGHER QUALITY AND/OR MORE RELEVANT DATA HAVE BEEN PRESENTED.
7. THE BOREHOLE OFFSET FROM THE CROSS SECTION LINE IS SHOWN IN THE BOREHOLE STRIP HEADER. HOLES THAT SHOW A NEGATIVE OFFSET ARE NORTH OF THE SECTION LINE. POSITIVE OFFSETS ARE SOUTH OF THE SECTION LINE.

Piezo Monitoring Max
 MM/YYYY *
 Piezo Monitoring Minimum
 MM/YYYY *
 Piezo Response Zone Top
 Piezo Tip
 Piezo Response Zone Bottom
 Piezo Monitoring (manual, Socotec, Round 3)
 M/YYYY

[illegible]

P01	09/04/20	Draft GIR Issue- For Portsmouth Water Review	SBR	RL	JA
Rev.	Date	Description	By	Chk'd	App'd

Drawing Status	Suitability
WORK IN PROGRESS	SO


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**Portsmouth
Water**

Project Title	HAVANT THICKET WINTER STORAGE RESERVOIR PROJECT
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Drawing Title

GEOLOGICAL
CROSS SECTION WE01
(Sheet 2 of 2)

Scale	Designed	Drawn	Checked	Authorised
1:2,500	GR	SBR	RL	JA
Original Size	Date	Date	Date	Date
A1	06/04/20	06/04/20	17/04/20	17/04/20
Drawing Number				Revision
HTR-ATK-RZ-RE-DR-C-0003				P01

DO NOT SCALE

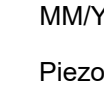
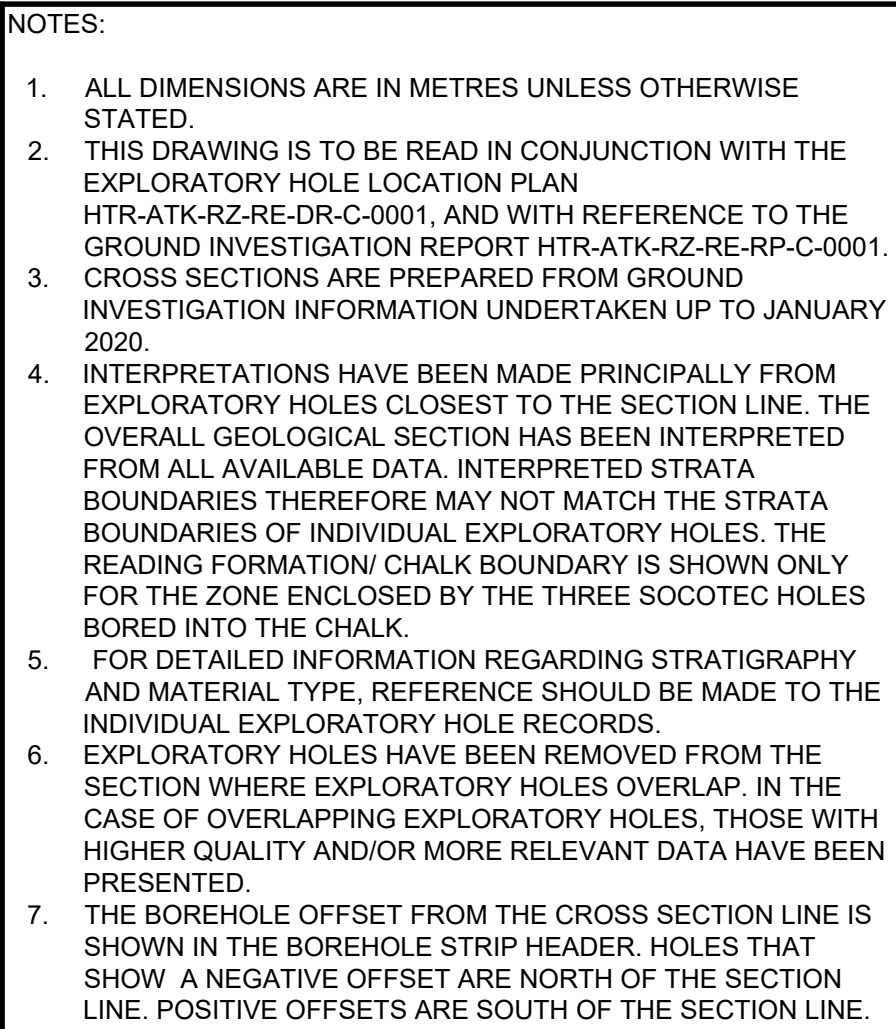


Diagram illustrating the components of the Piezo Monitoring system:

- Piezo Monitoring Max MM/YYYY *
- Piezo Monitoring Minimum MM/YYYY *
- Piezo Response Zone Top
- Piezo Tip
- Piezo Response Zone Bottom
- Piezo Monitoring (manual, Socotec, Round 3)

*Piezo Monitoring (manual, Socotec, Round 3)

[illegible]

P01	09/04/20	Draft GIR Issue- For Portsmouth Water Review	SBR	RL	JA
Rev.	Date	Description	By	Chk'd	App'd

Drawing Status	Suitability
WORK IN PROGRESS	SO


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KT18 5BW

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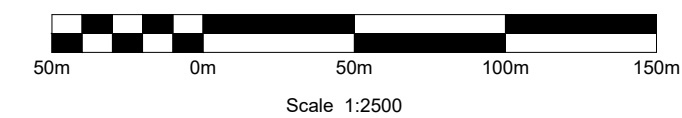
Project Title	HAVANT THICKET WINTER STORAGE RESERVOIR PROJECT
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Drawing Title

GEOLOGICAL
CROSS SECTION WE02

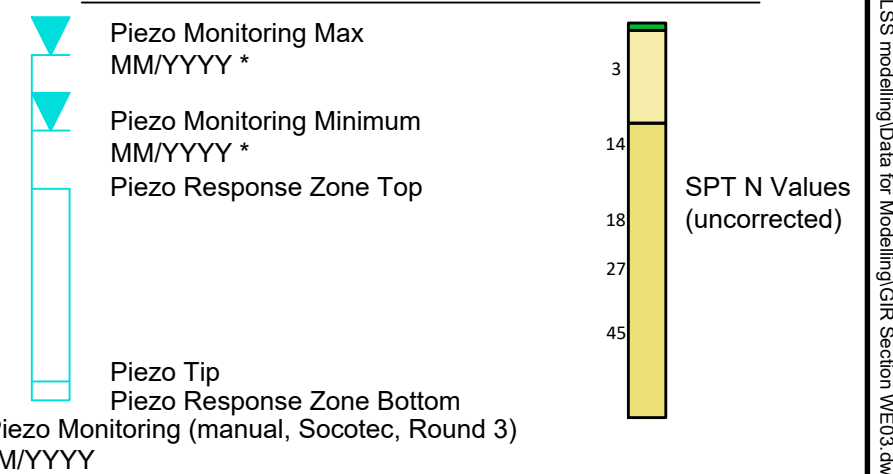
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Original Size A1	Date 06/04/20	Date 06/04/20	Date 17/04/20	Date 17/04/20

Drawing Number HTR-ATK-RZ-RE-DR-C-0004	Revision P01
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[illegible]

NOTES:

- | Legend | |
|---|--------------------|
|  | TOPSOIL |
|  | HEAD |
|  | Bognor Sand Member |
|  | London Clay |
|  | Harwich Formation |
|  | Reading Formation |
|  | Chalk |



P01	09/04/20	Draft GIR Issue- For Portsmouth Water Review	SBR	RL	JA
Rev.	Date	Description	By	Chk'd	App'd

Drawing Status	Suitability
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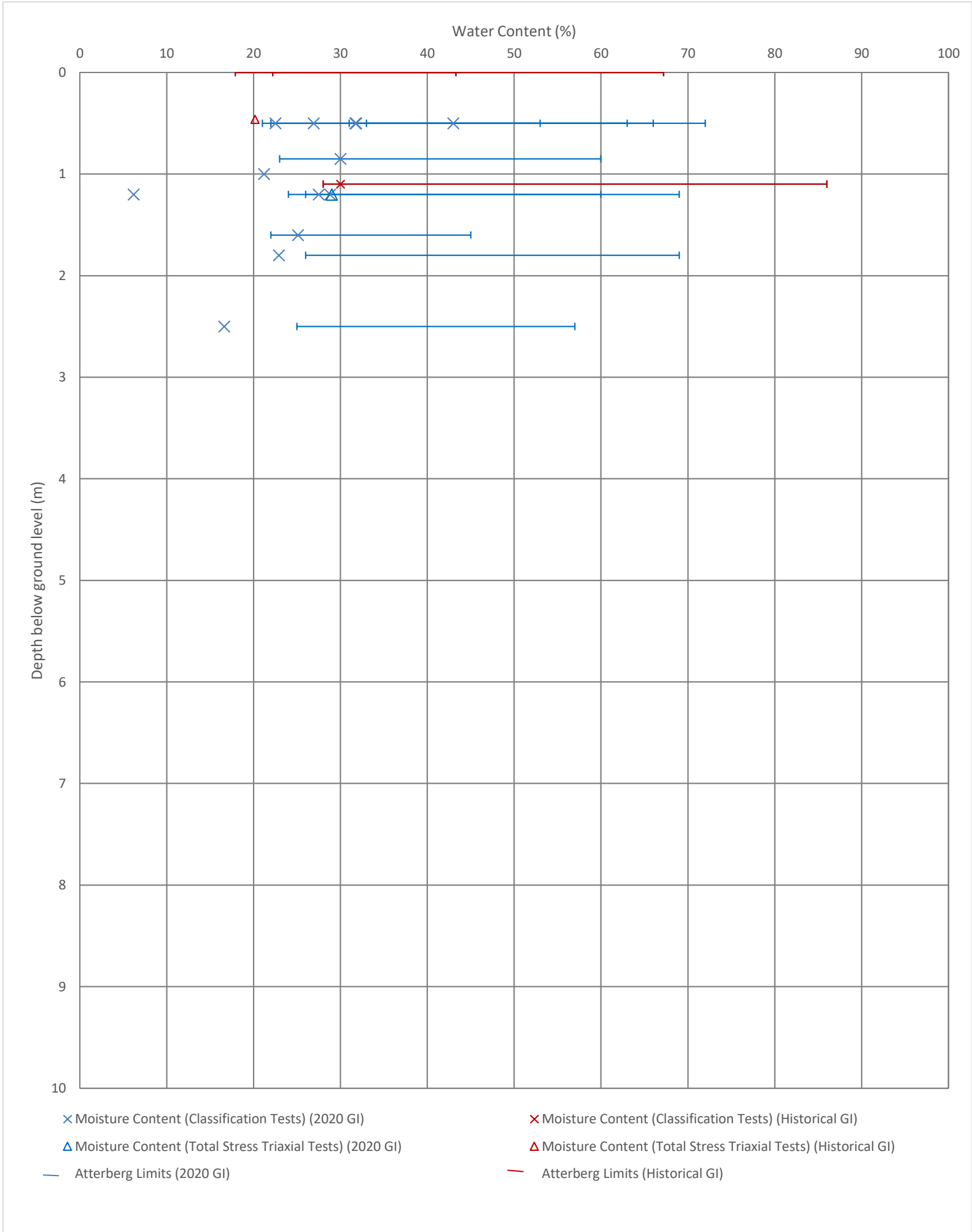
Project Title	HAVANT THICKET WINTER STORAGE RESERVOIR PROJECT
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Drawing Title

GEOLOGICAL
CROSS SECTION WE03

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Original Size	Date	Date	Date	Date
A1	06/04/20	06/04/20	17/04/20	17/04/20
Drawing Number				Revision
HTR-ATK-RZ-RE-DR-C-0005				P01

Appendix D. Geotechnical Parameter Plots



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Title

Water Content vs Depth - Head

Project

Havant Thicket Winter Storage Reservoir

Sheet size

A4

Status

FINAL

Drawn: H.Fisher

Date: 10/03/20

Checked: R.Lindsay

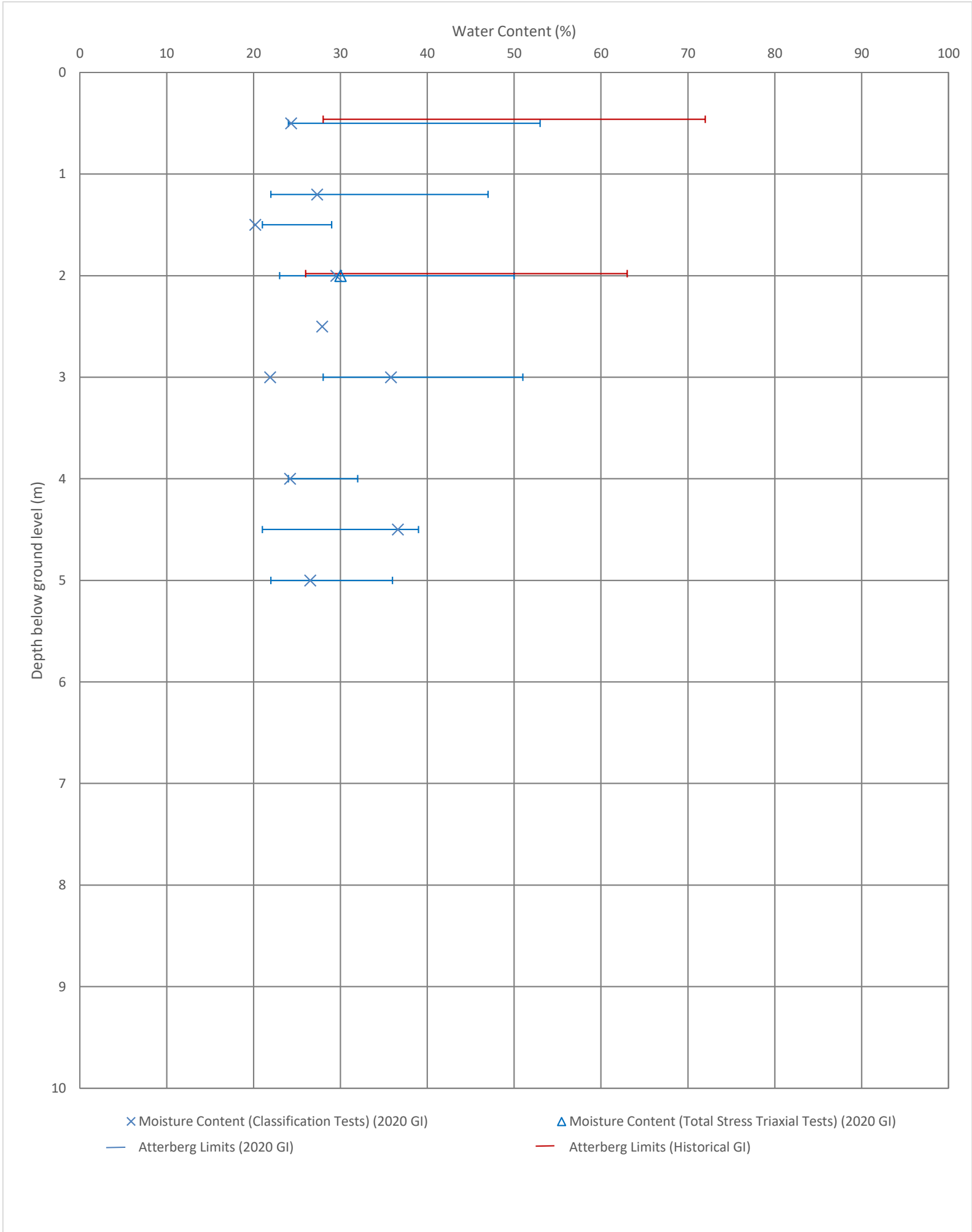
Date: 24/03/20

Reviewed: J.Apted

Date: 03/04/2020

Rev

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Title

**Water Content vs Depth - Bognor Sand Member
(London Clay Formation)**

Sheet size

A4

Status

FINAL

Drawn: H.Fisher

Date: 10/03/20

Checked: R.Lindsay

Date: 24/03/20

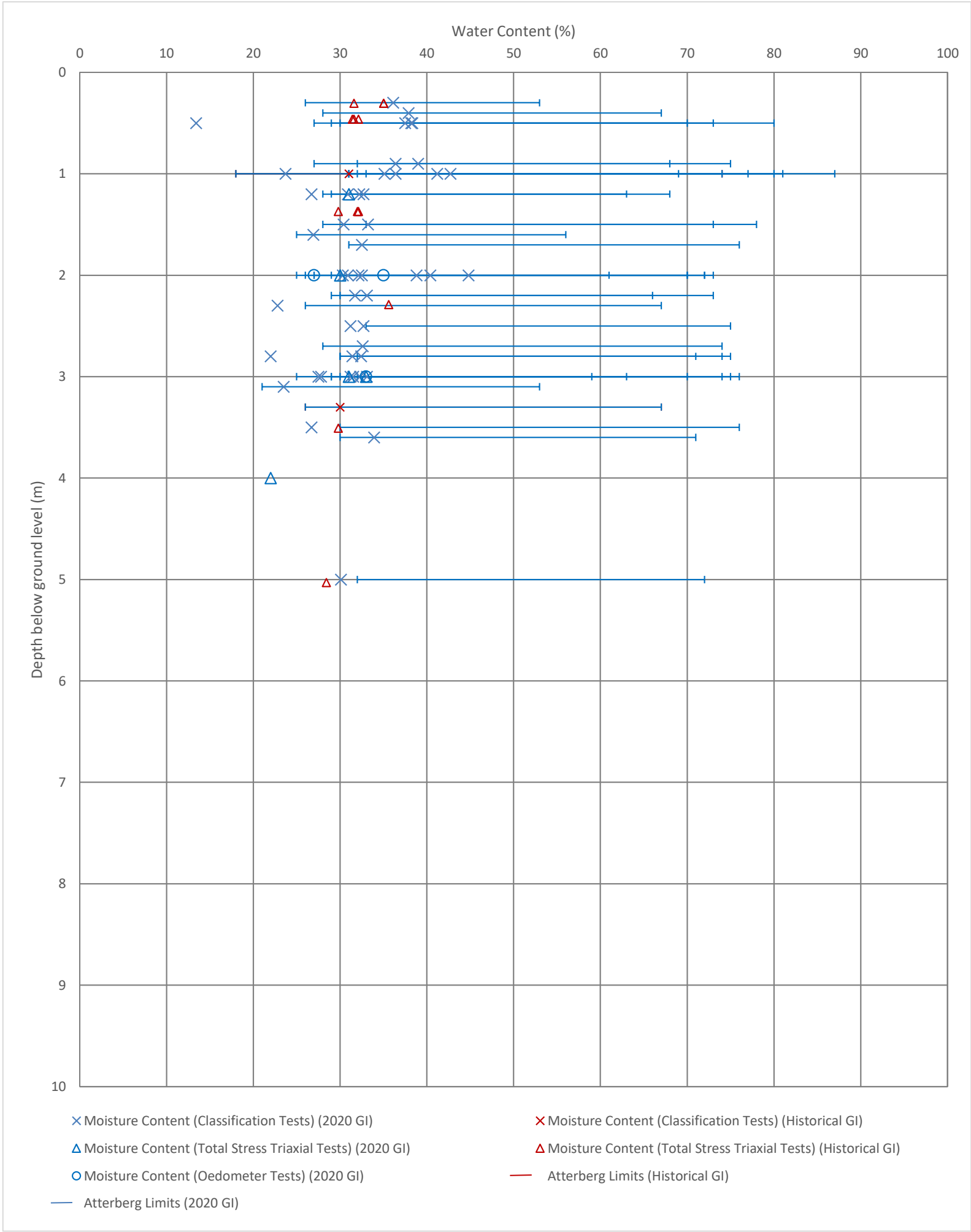
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Date: 03/04/2020

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1.2



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Project

Havant Thicket Winter Storage Reservoir

Title

Water Content vs Depth - Weathered London Clay Formation

Sheet size

A4

Status

FINAL

Drawn: H.Fisher

Date: 10/03/20

Plot Number

1.3

Checked: R.Lindsay

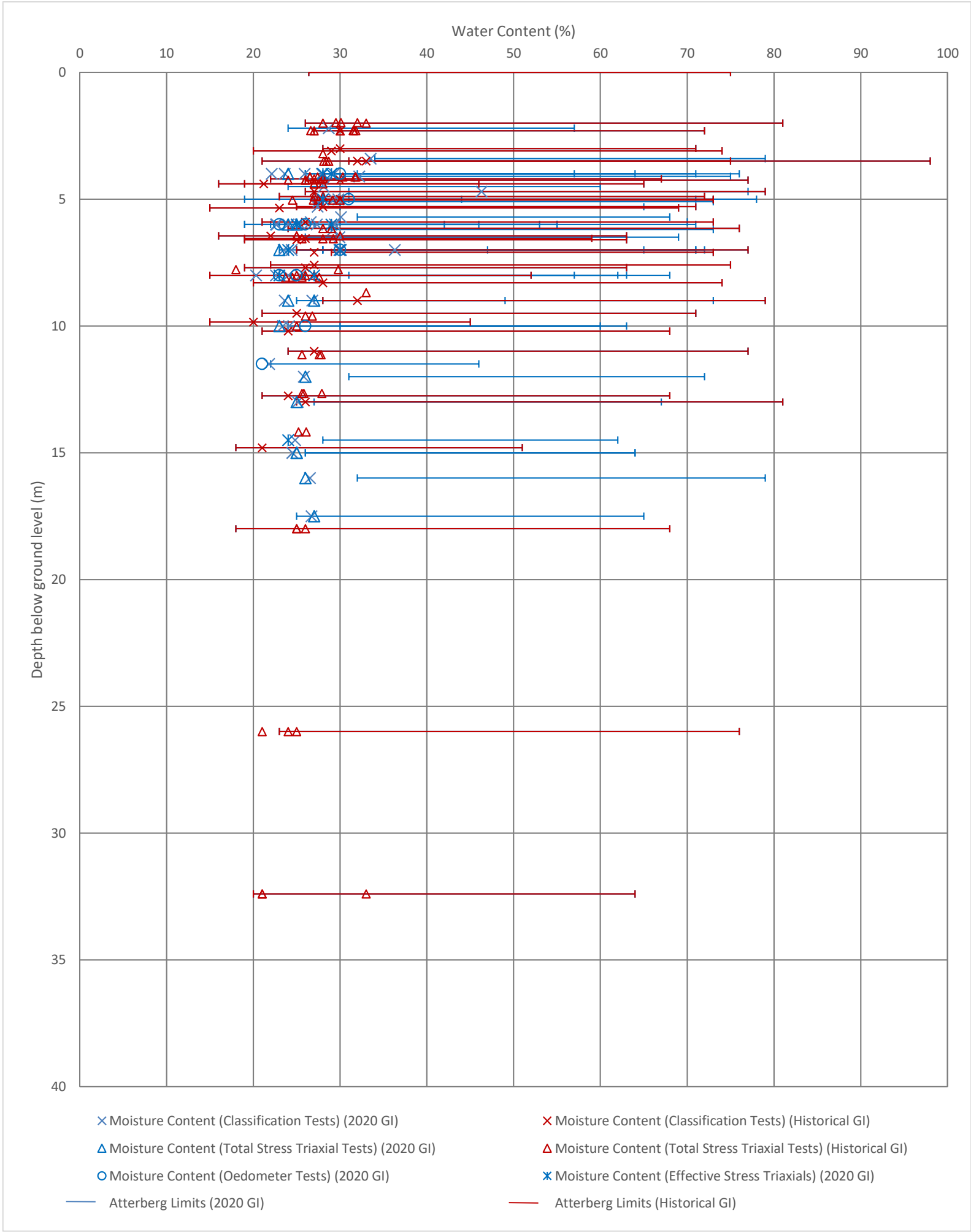
Date: 24/03/20

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Date: 03/04/2020

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Havant Thicket Winter Storage Reservoir

Title

**Water Content vs Depth - Unweathered London
Clay Formation**

Sheet size

A4

Status

FINAL

Drawn: H.Fisher

Date: 10/03/20

Plot Number

1.4

Checked: R.Lindsa

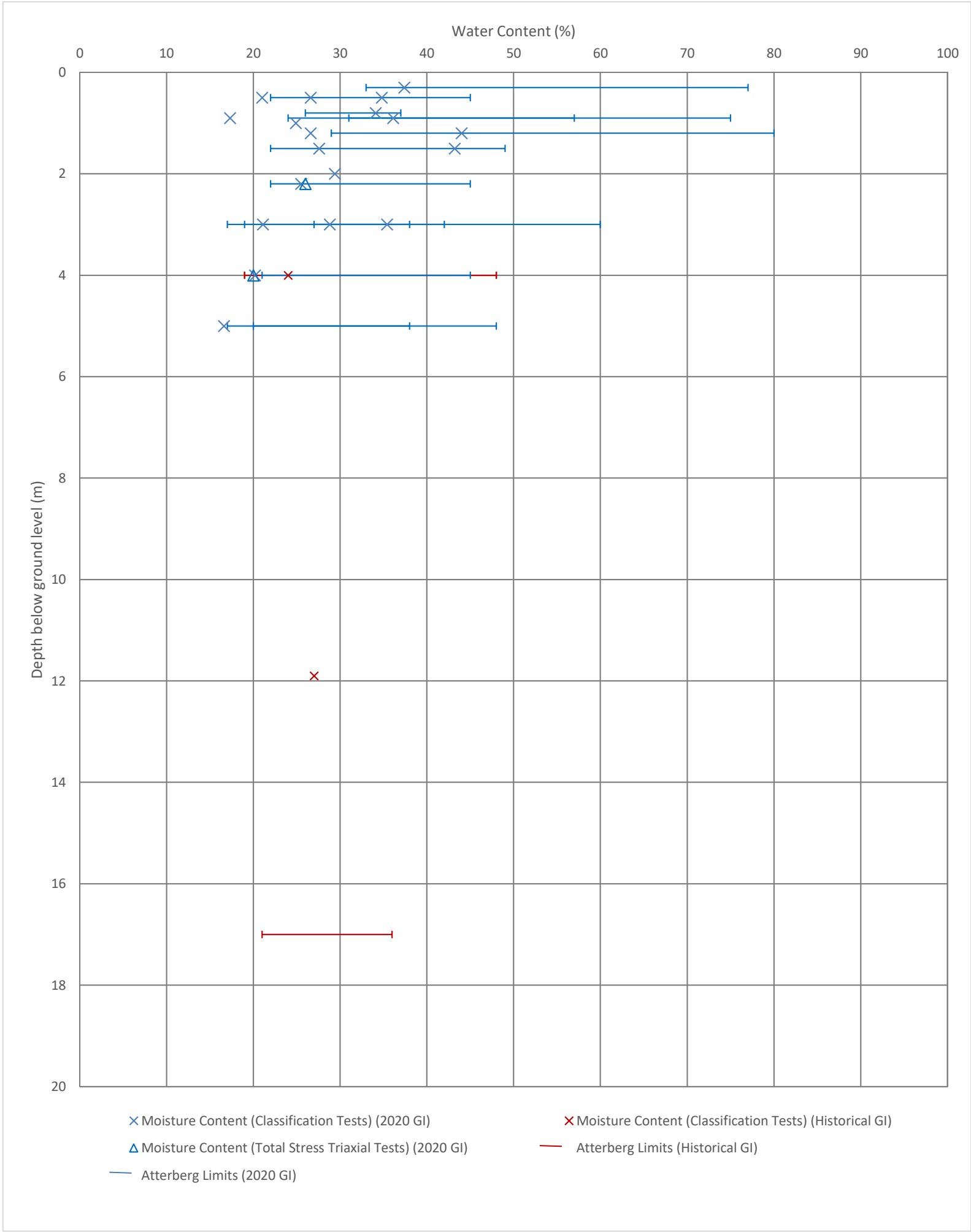
Date: 24/03/20

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Date: 03/04/2020

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Title

Water Content vs Depth - Harwich Formation

Sheet size

A4

Status

FINAL

Drawn: H.Fisher

Date: 10/03/20

Checked: R.Lindsay

Date: 24/03/20

Reviewed: J.Apted

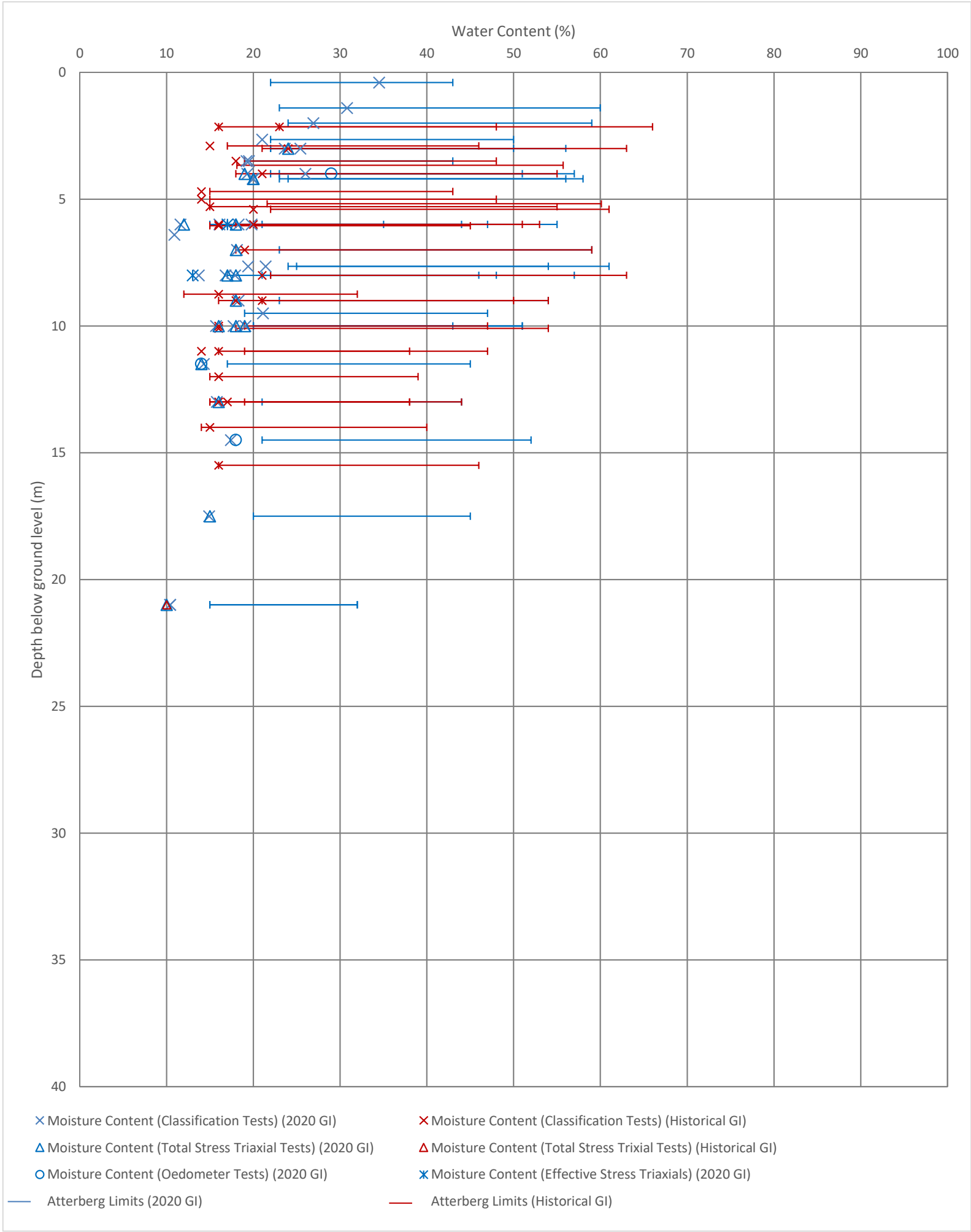
Date: 03/04/2020

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Project

Havant Thicket Winter Storage Reservoir

Title

Water Content vs Depth - Reading Formation

Sheet size

A4

Status

FINAL

Drawn: H.Fisher

Date: 10/03/20

Plot Number

Checked: R.Lindsay

Date: 24/03/20

Rev

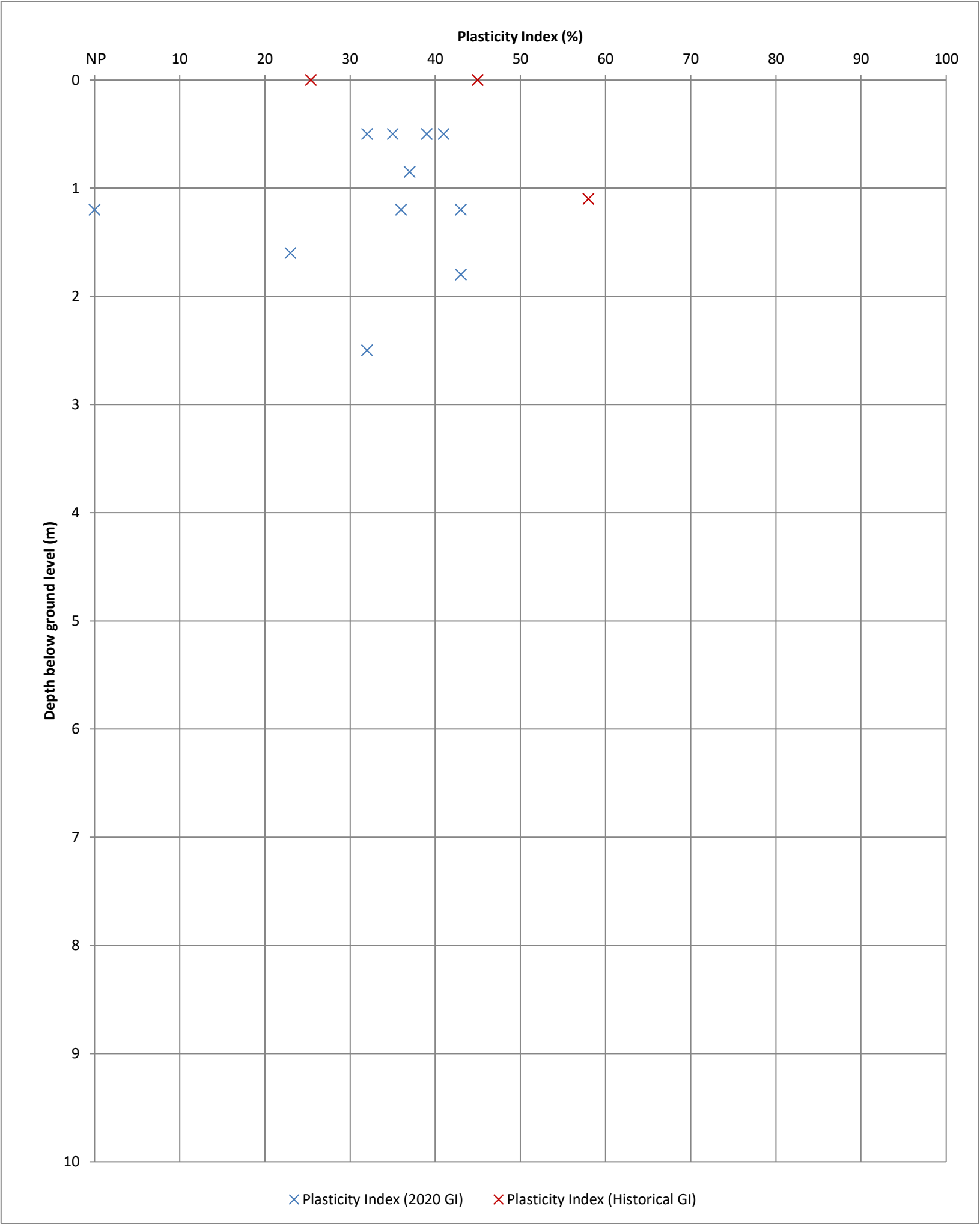
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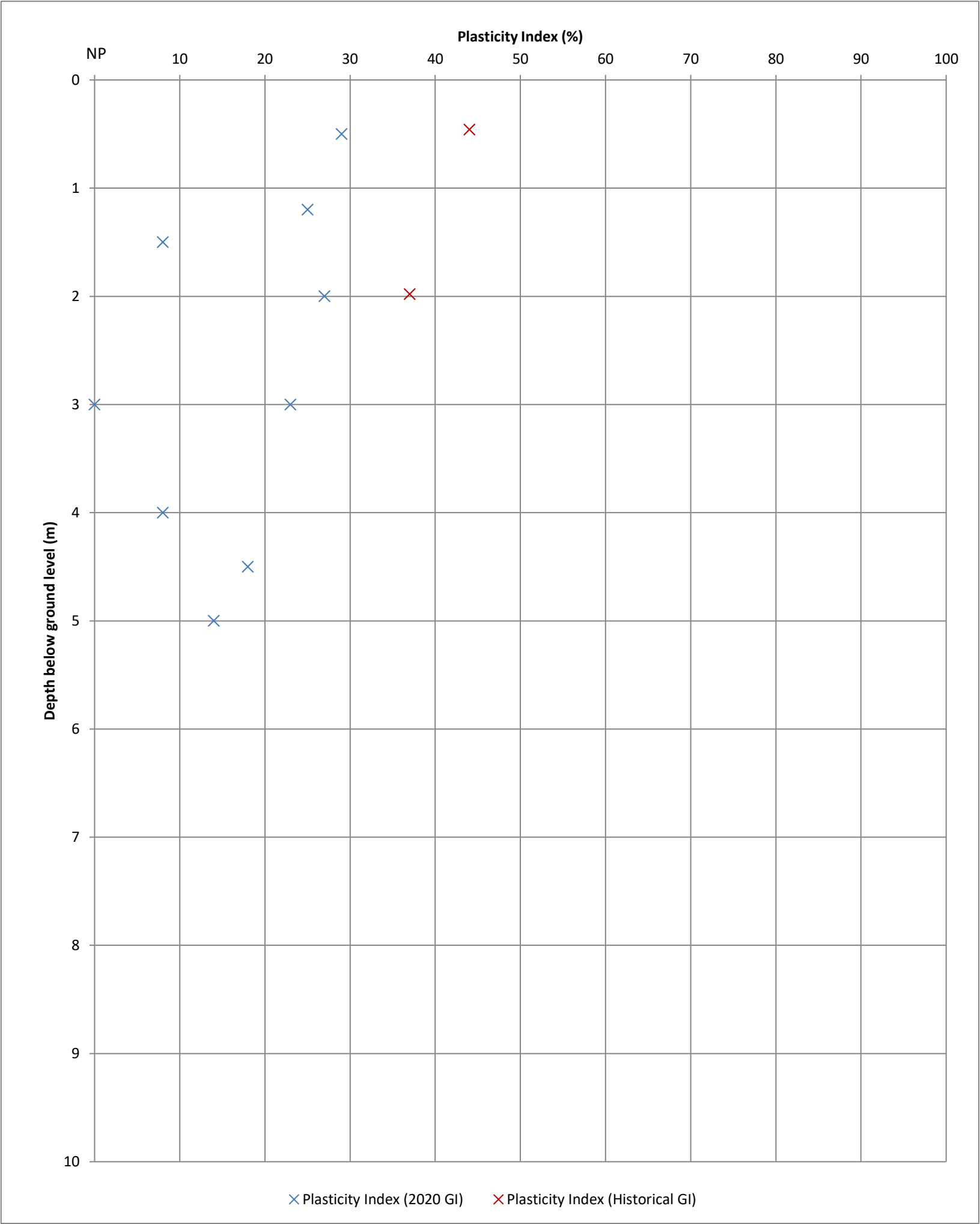
Date: 03/04/2020

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	Portsmouth Water	Plasticity Index vs Depth - Head			
	Project	Sheet size A4	Drawn: H.Fisher Date: 10/03/20	Checked: R.Lindsa Date: 24/03/20	Reviewed: J.Apted Date: 03/04/2020
	Havant Thicket Winter Storage Reservoir	Status FINAL	Plot Number 2.1		Rev P01



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Portsmouth Water

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**Plasticity Index vs Depth - Bognor Sand Member
(London Clay Formation)**

Project

Havant Thicket Winter Storage Reservoir

Sheet size

A4

Drawn: H.Fisher

Date: 10/03/20

Checked: R.Lindsay

Date: 24/03/20

Reviewed: J.Apted

Date: 03/04/2020

Status

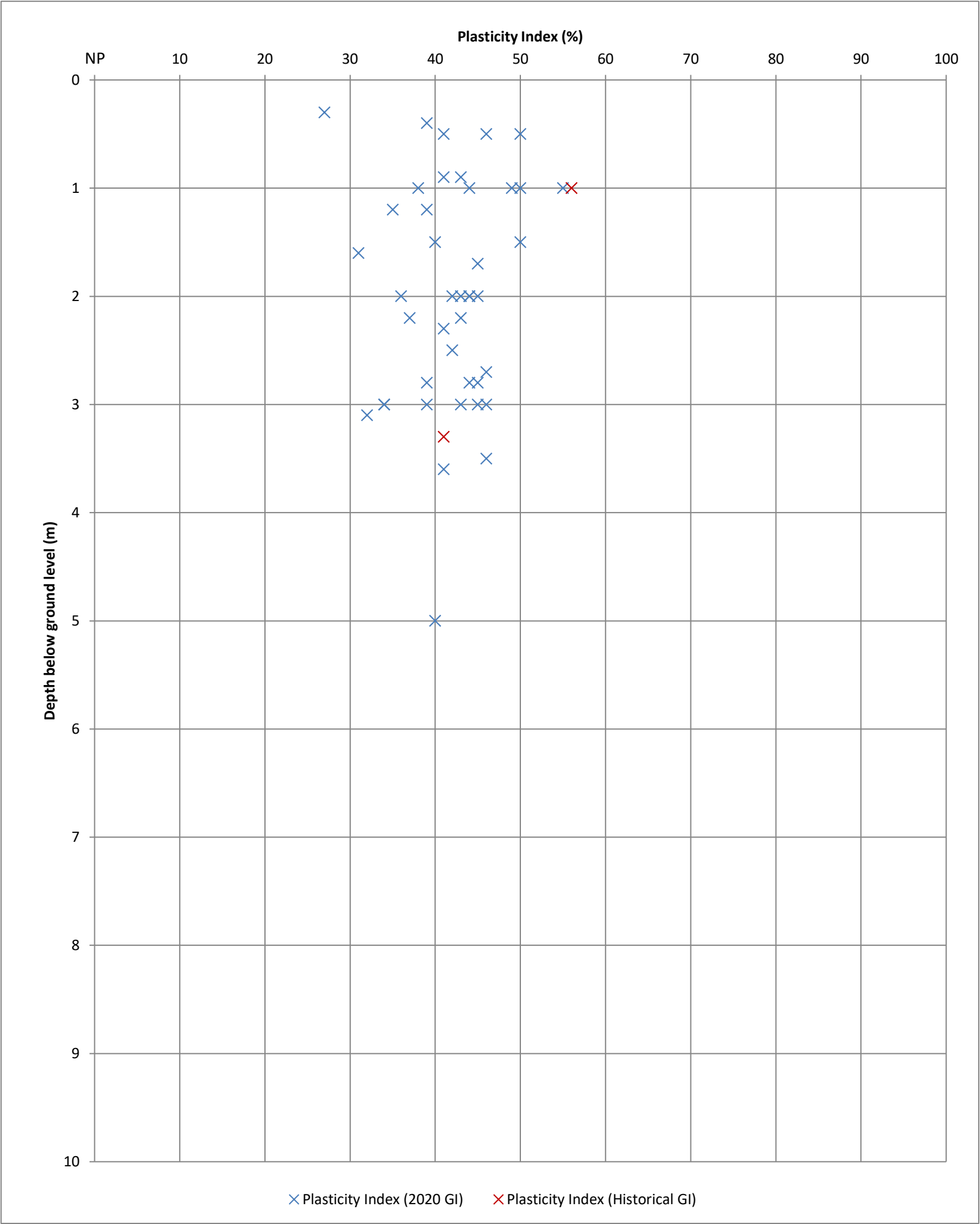
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Plot Number

2.2

Rev

P01

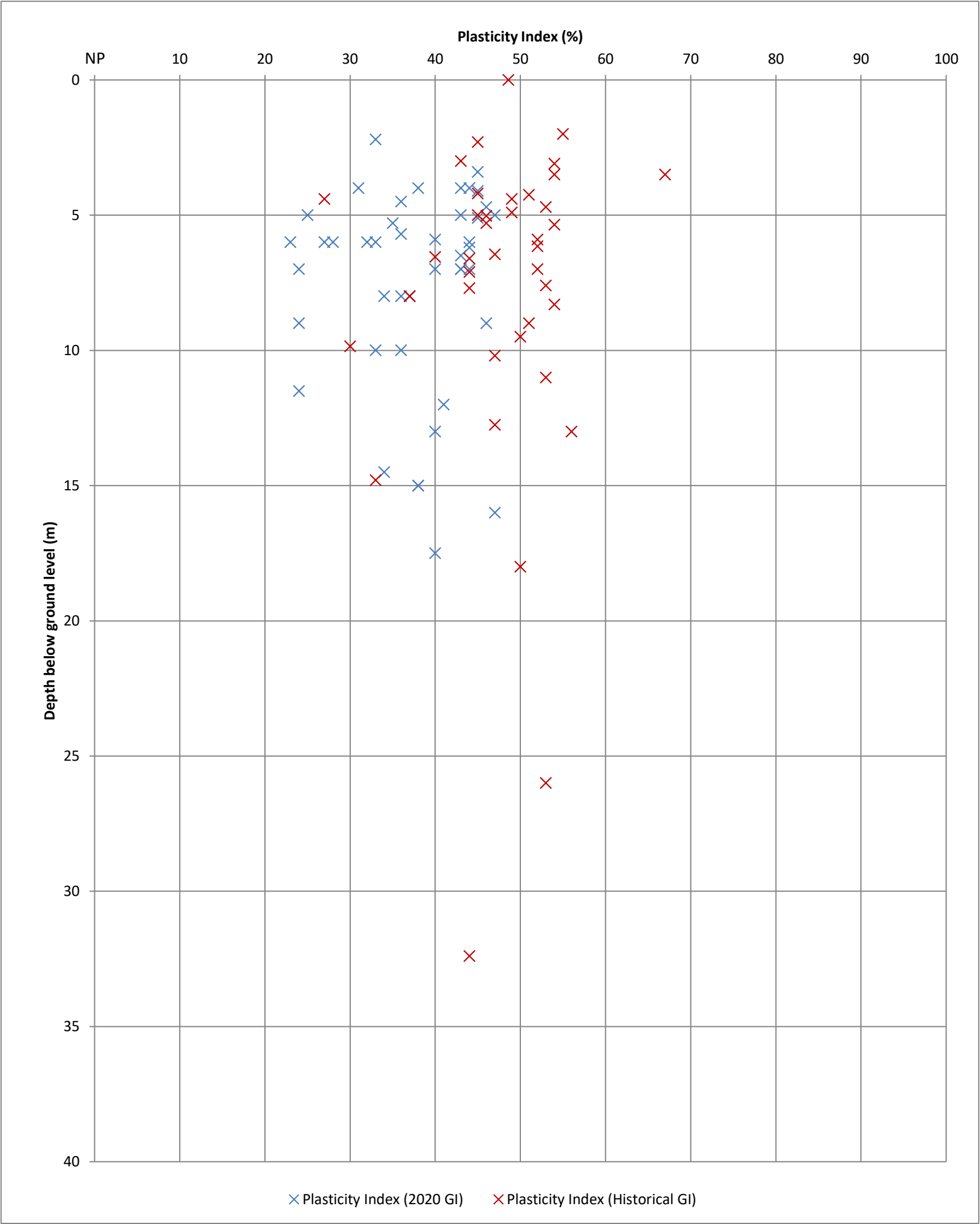


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Client		Title			
Portsmouth Water		Plasticity Index vs Depth - Weathered London Clay Formation			
Project		Sheet size	Drawn: H.Fisher	Checked: R.Lindsa	Reviewed: J.Apted
Havant Thicket Winter Storage Reservoir		A4	Date: 10/03/20	Date: 24/03/20	Date: 03/04/2020
		Status	Plot Number		Rev
		FINAL	2.3		P01



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Portsmouth Water

Title

**Plasticity Index vs Depth - Unweathered London
Clay Formation**

Project

Havant Thicket Winter Storage Reservoir

Sheet size

A4

Drawn: H.Fisher

Date: 10/03/20

Checked: R.Lindsa

Date: 24/03/20

Reviewed: J.Apted

Date: 03/04/2020

Status

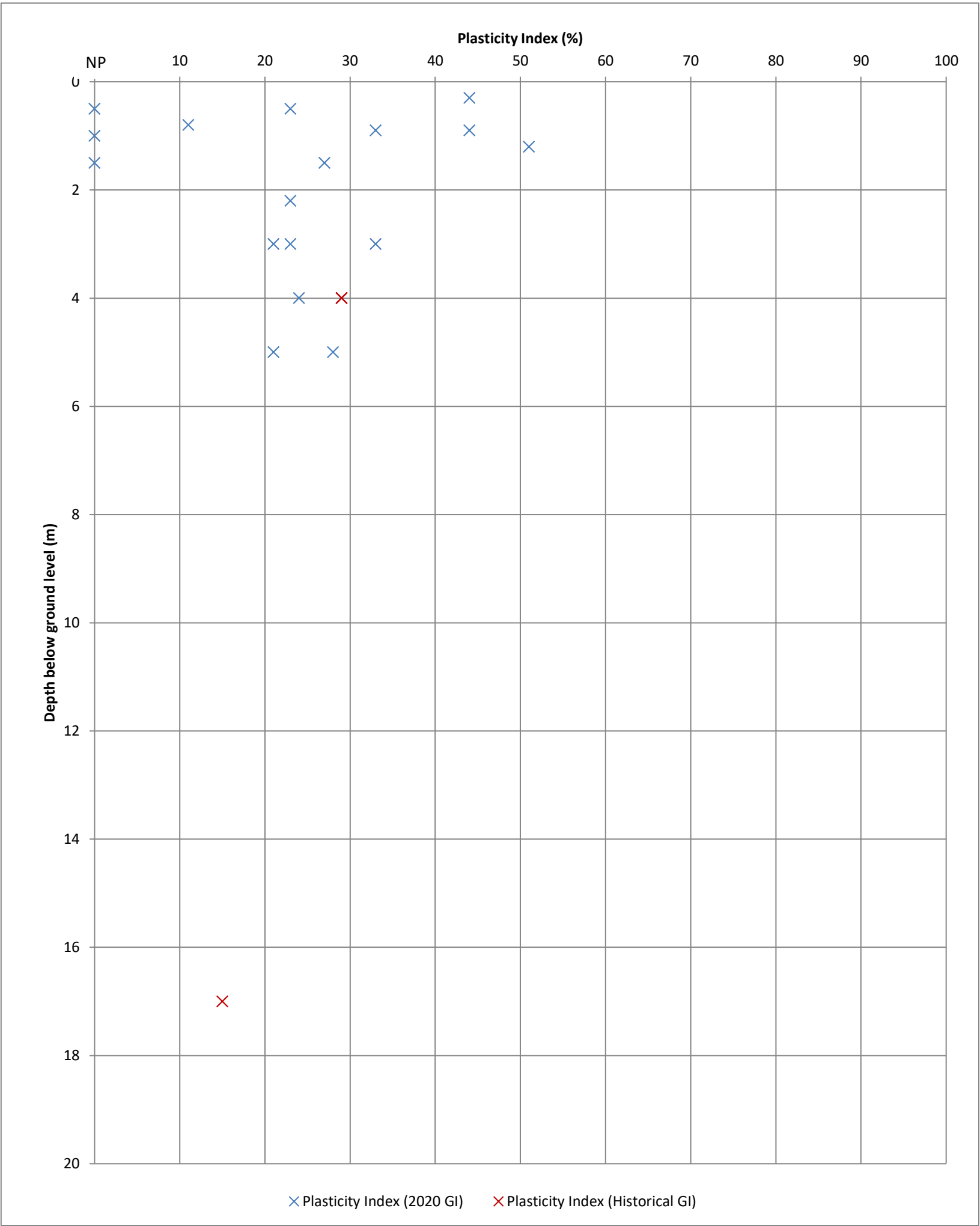
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Portsmouth Water

Title

Plasticity Index vs Depth - Harwich Formation

Project

Havant Thicket Winter Storage Reservoir

Sheet size

A4

Drawn: H.Fisher

Date: 10/03/20

Checked: R.Lindsa

Date: 24/03/20

Reviewed: J.Apted

Date: 03/04/2020

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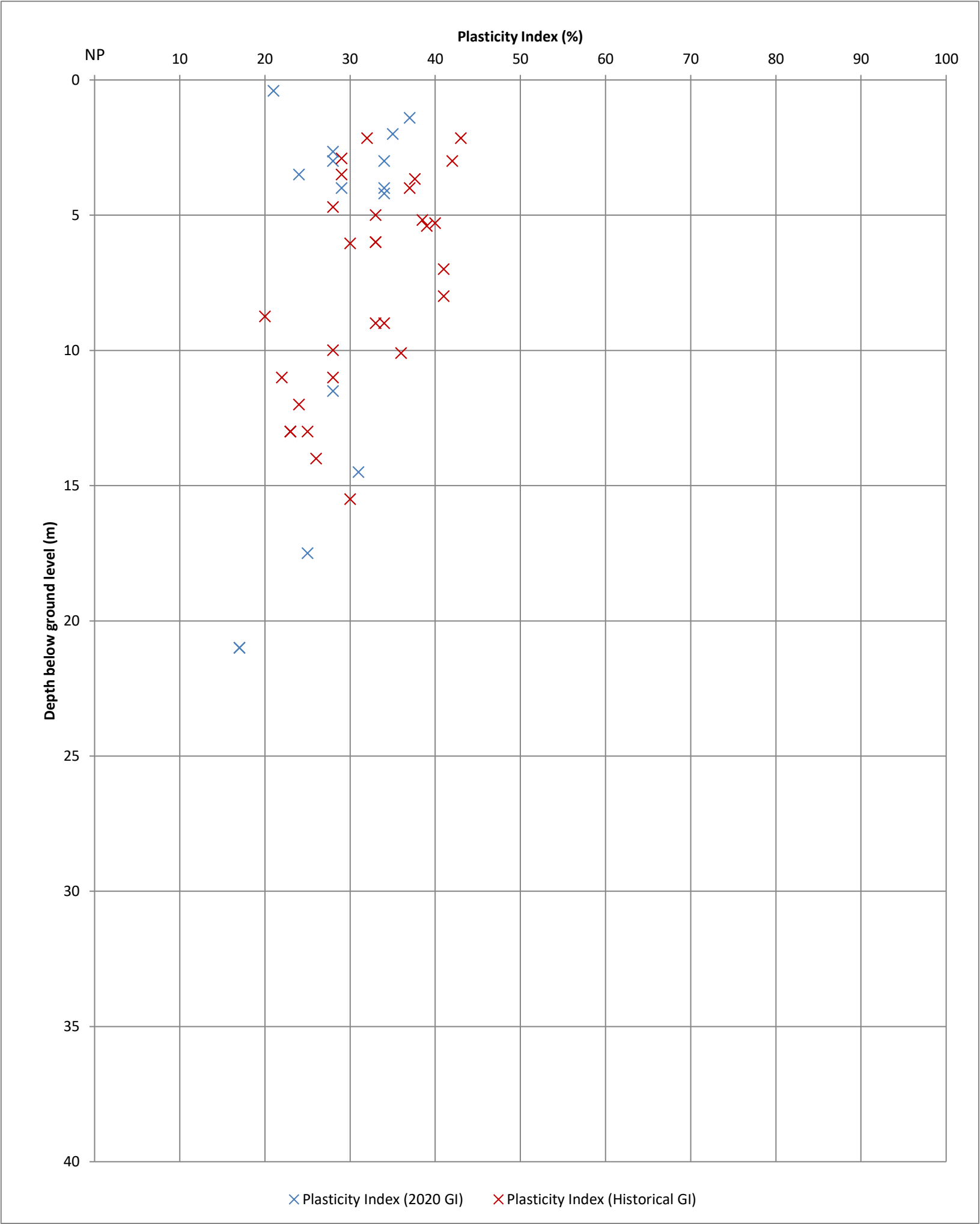
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Portsmouth Water

Title

Plasticity Index vs Depth - Reading Formation

Project

Havant Thicket Winter Storage Reservoir

Sheet size

A4

Drawn: H.Fisher

Date: 10/03/20

Checked: R.Lindsay

Date: 24/03/20

Reviewed: J.Apted

Date: 03/04/2020

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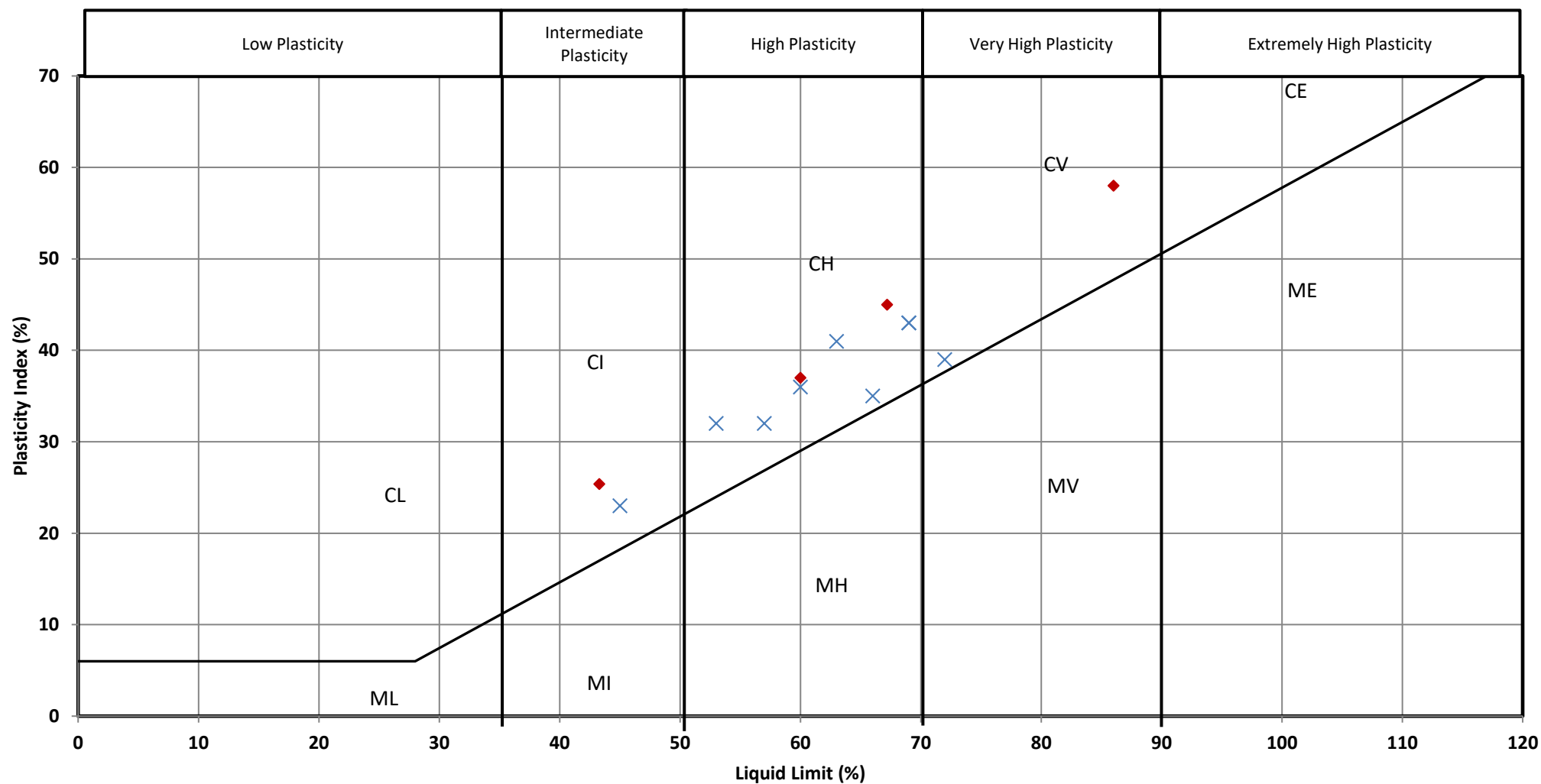
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— A Line × 2020 GI ♦ Historical GI

C = Clay; M = Silt

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Havant Thicket Winter Storage Reservoir

Title

A-line for Head

Sheet size

A4

Drawn

Date

H.Fisher

10/03/2020

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Date

R.Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

Status

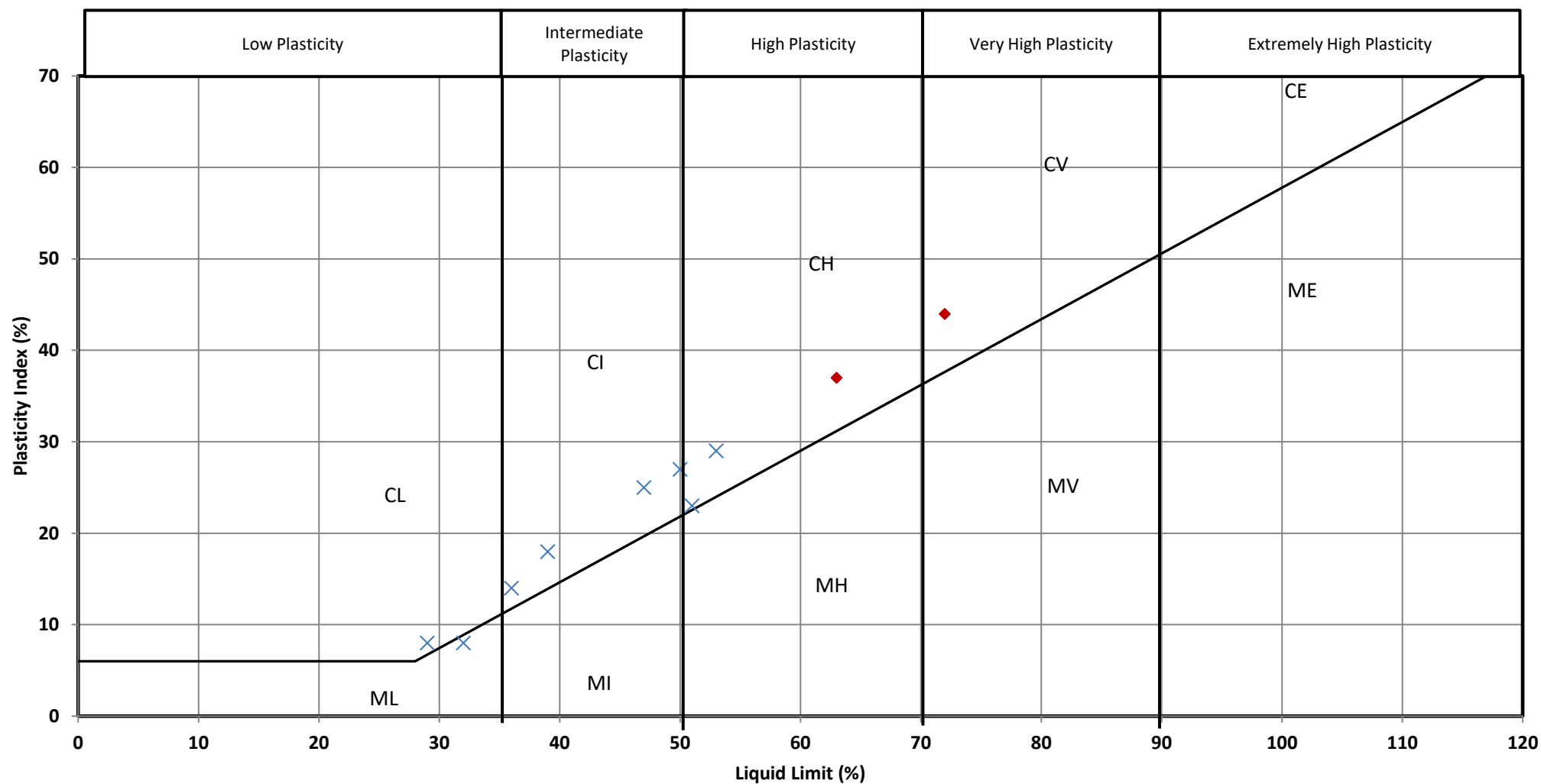
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Title

A-line for Bognor Sand Member (London Clay Formation)

Sheet size

A4

Drawn

H.Fisher

Date

10/03/2020

Checked

R.Lindsay

Date

26/03/2020

Authorised

J. Apted

Date

03/04/2020

Status

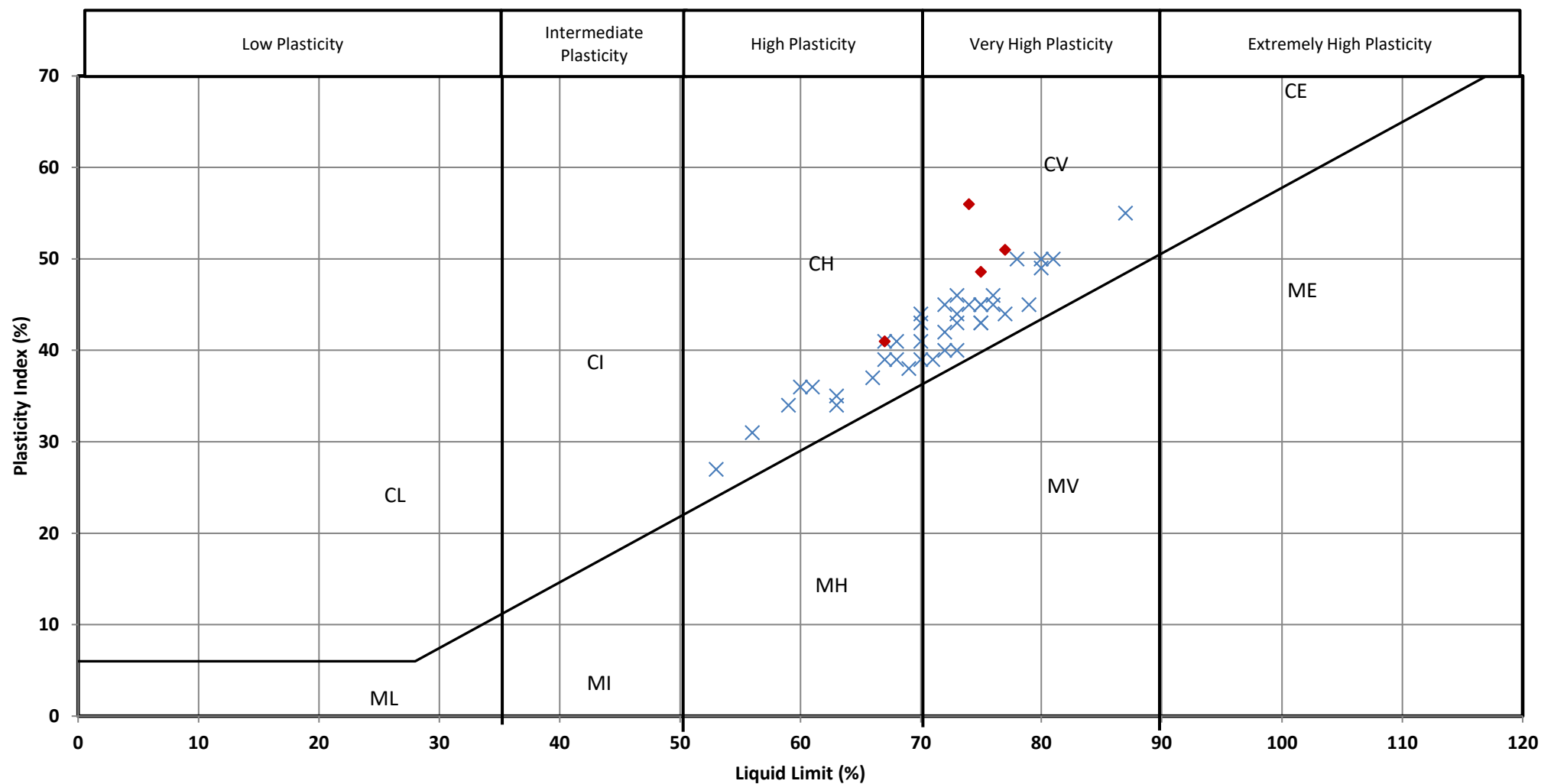
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Havant Thicket Winter Storage Reservoir

Title

A-line for Weathered London Clay Formation

Sheet size

A4

Drawn

Date

H.Fisher

10/03/2020

Checked

Date

R.Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

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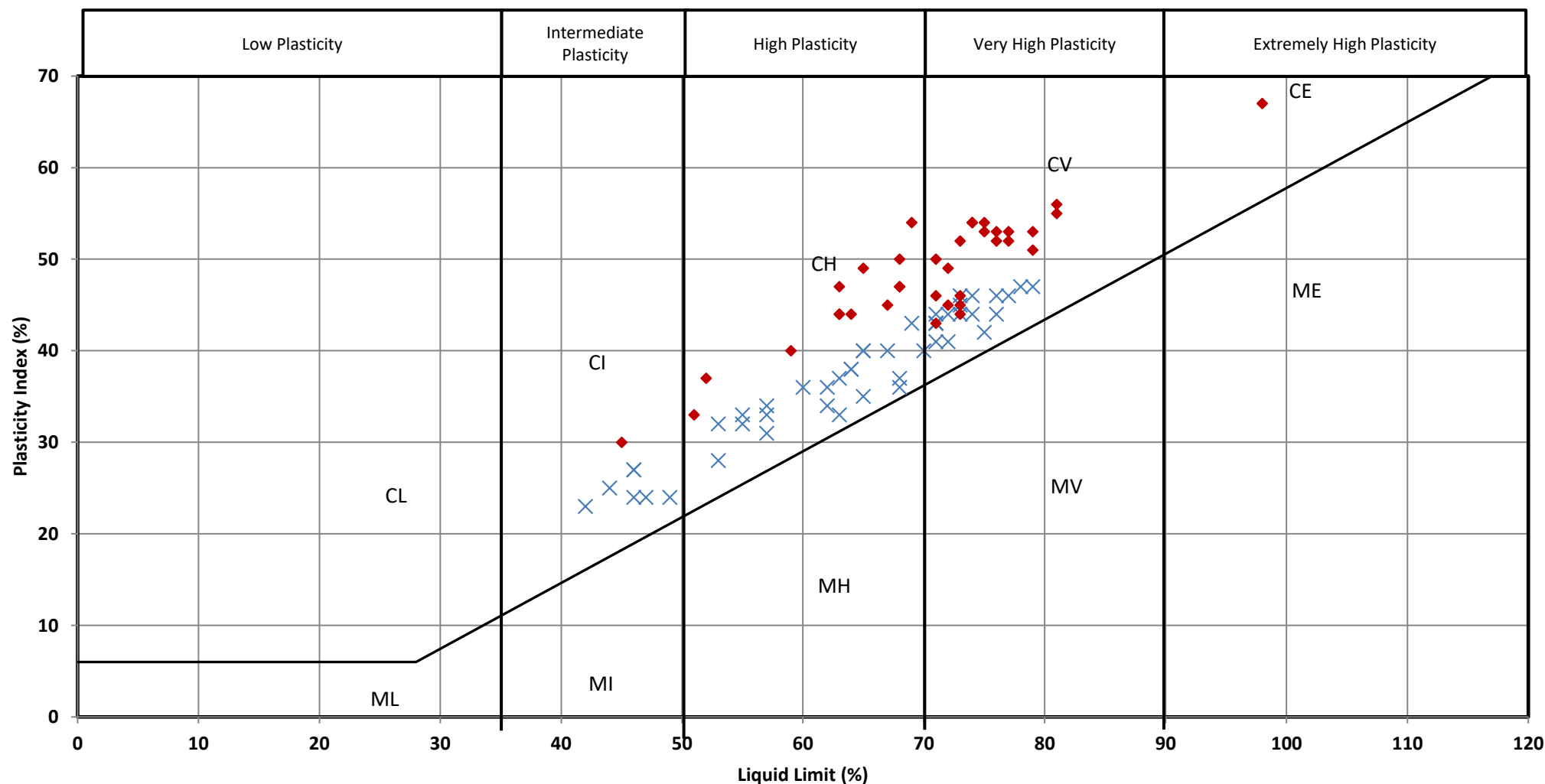
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Plot Number

3.3

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Havant Thicket Winter Storage Reservoir

Title

A-line for Unweathered London Clay Formation

Sheet size

A4

Drawn

Date

H.Fisher

10/03/2020

Checked

Date

R.Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

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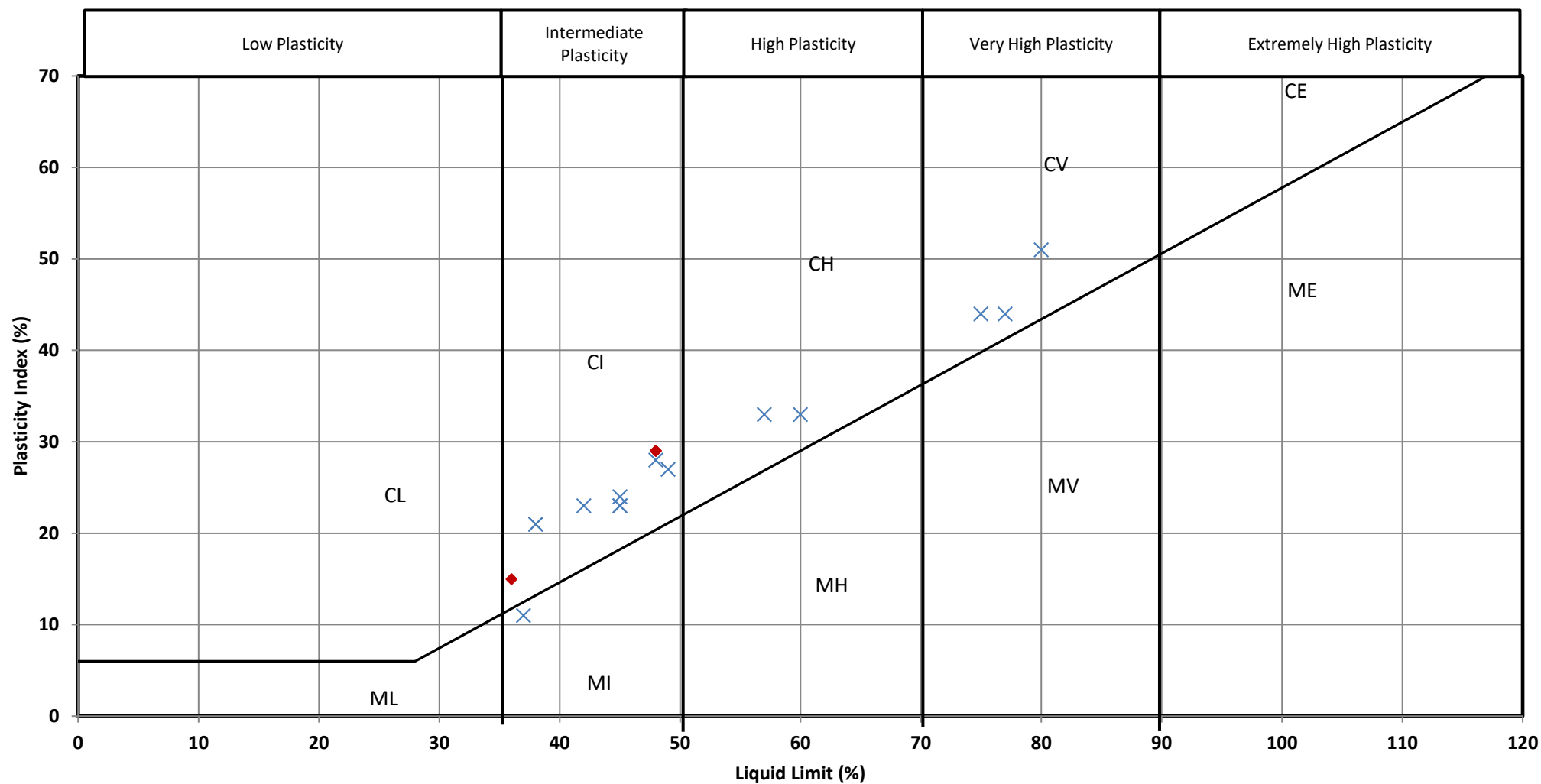
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3.4

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Havant Thicket Winter Storage Reservoir

Title

A-line for Harwich Formation

Sheet size

A4

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Date

H.Fisher

10/03/2020

Checked

Date

R.Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

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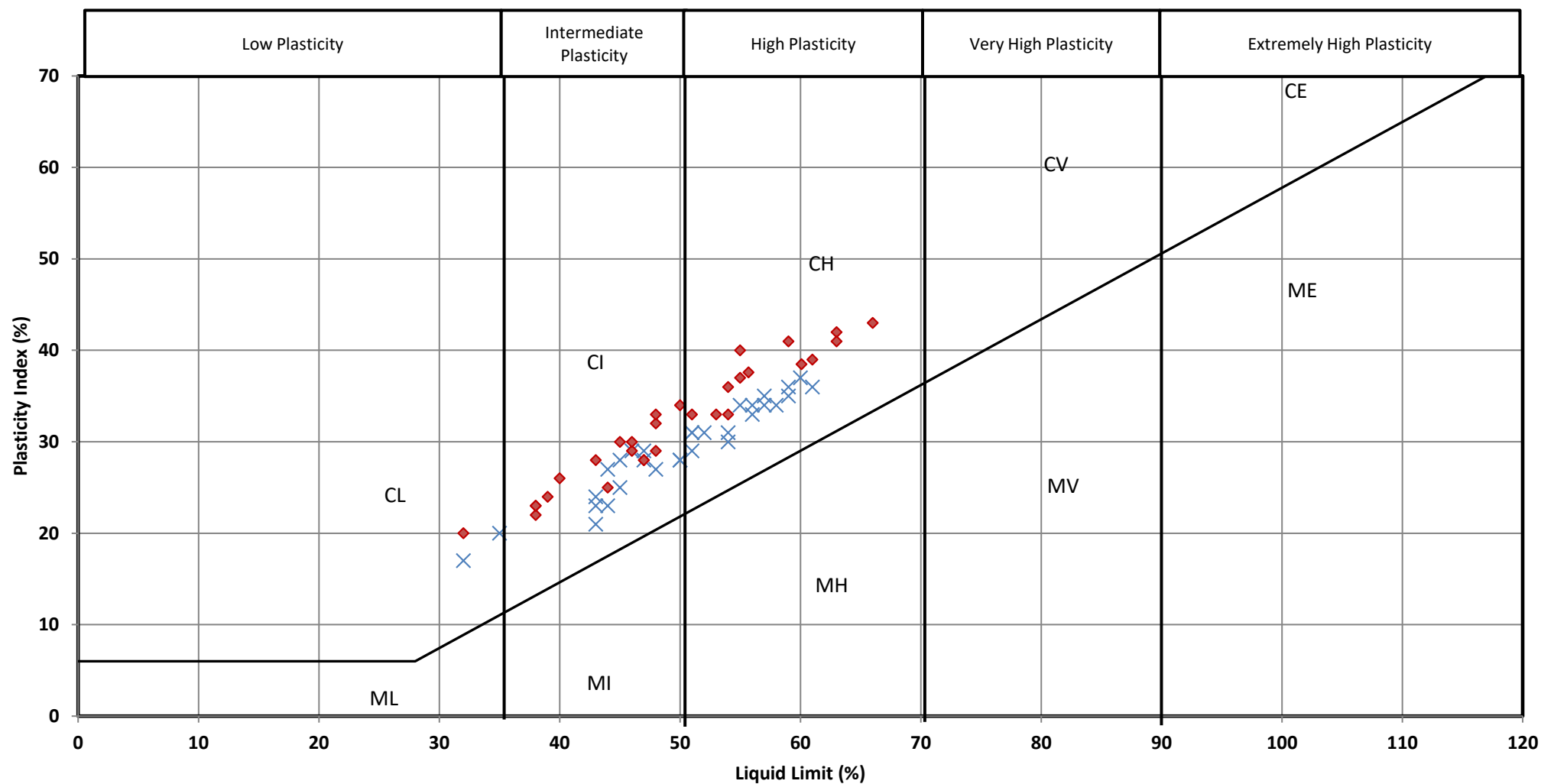
FINAL

Plot Number

3.5

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— A Line × 2020 GI ♦ Historical GI

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Havant Thicket Winter Storage Reservoir

Title

A-line for Reading Formation

Sheet size

A4

Drawn

H.Fisher

Date

10/03/2020

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R.Lindsay

Date

26/03/2020

Authorised

J. Apted

Date

03/04/2020

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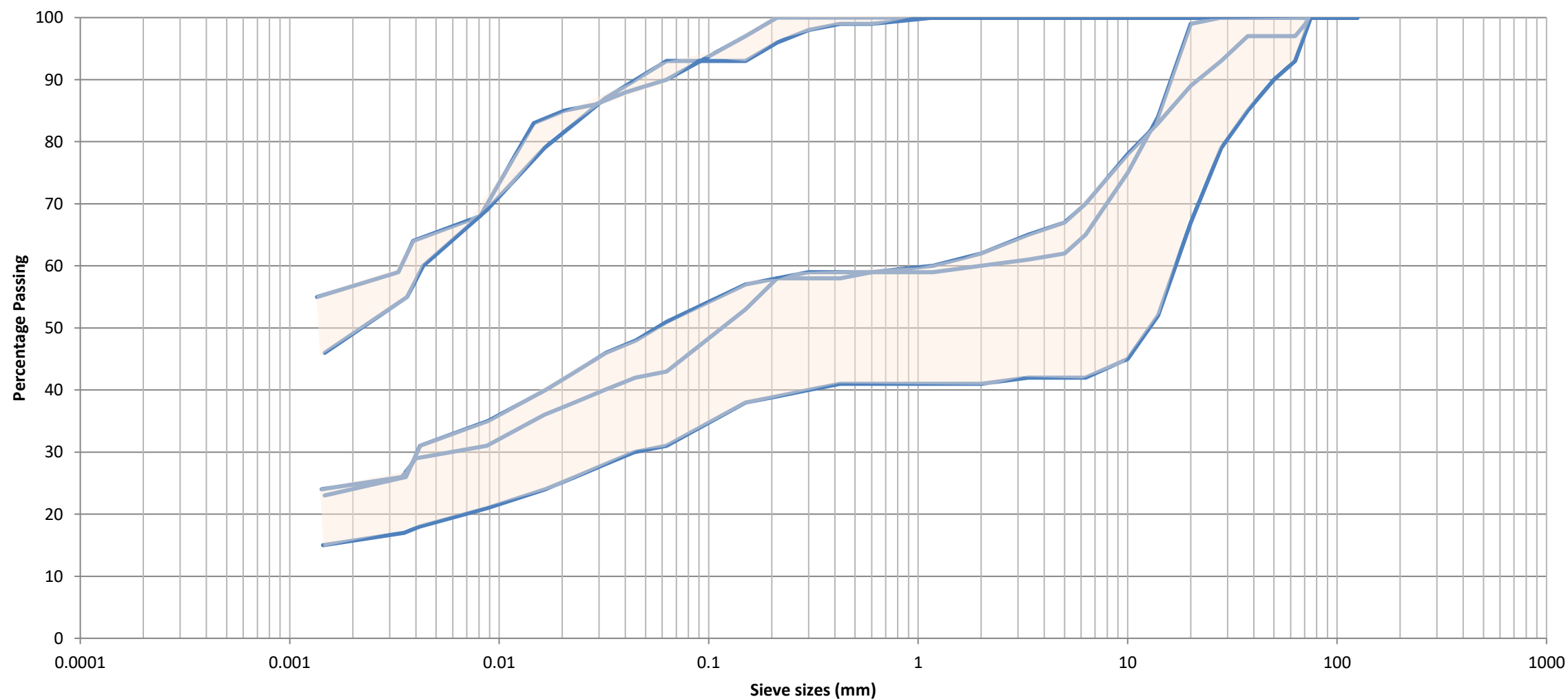
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CLAY	SILT	SAND	GRAVEL	COBBLES
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Havant Thicket Winter Storage Reservoir

Title

Particle Size Distribution for Head

Sheet size

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Drawn

Date

H. Fisher

19/03/2020

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Date

R. Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

Status

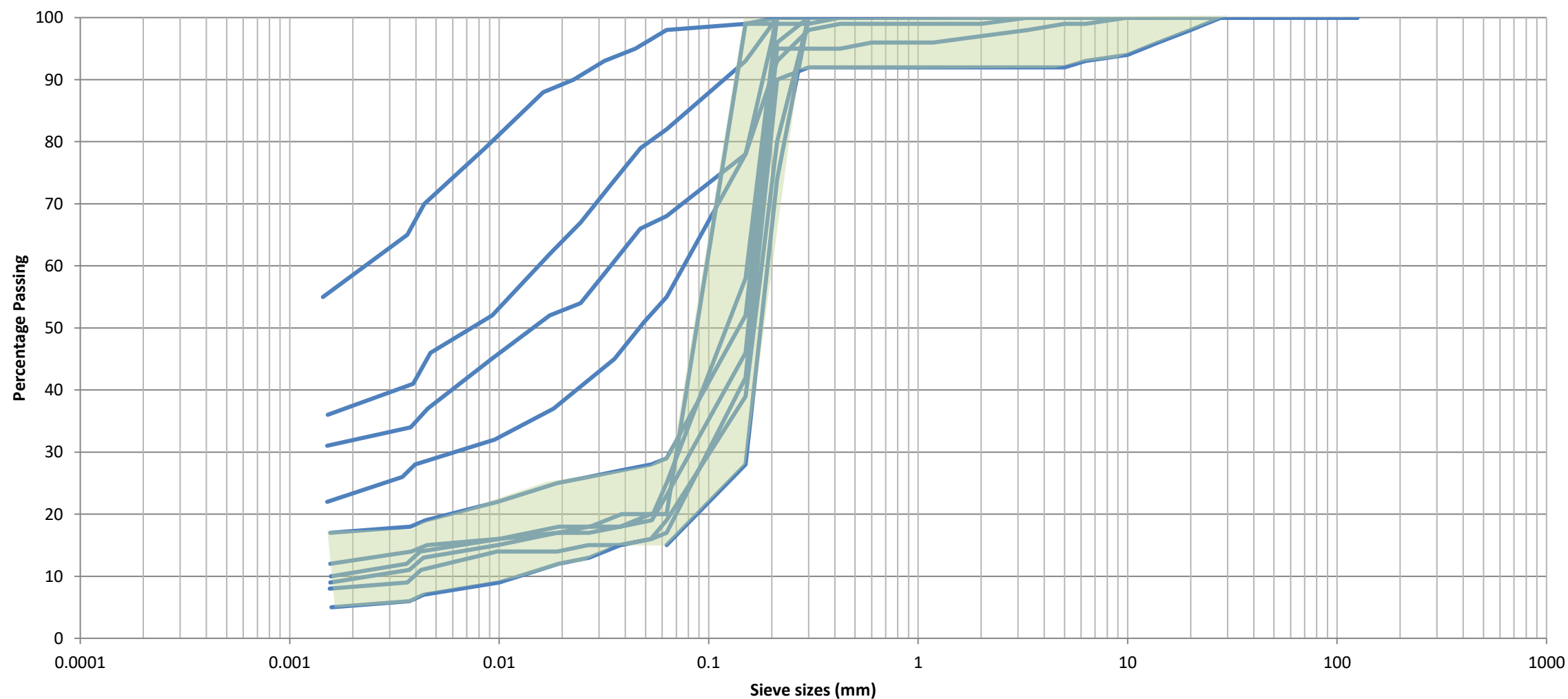
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CLAY	SILT	SAND	GRAVEL	COBBLES
------	------	------	--------	---------

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Particle Size Distribution for Bognor Sand Member (London Clay Formation)

Sheet size

A4

Drawn

Date

H. Fisher

19/03/2020

Checked

Date

R. Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

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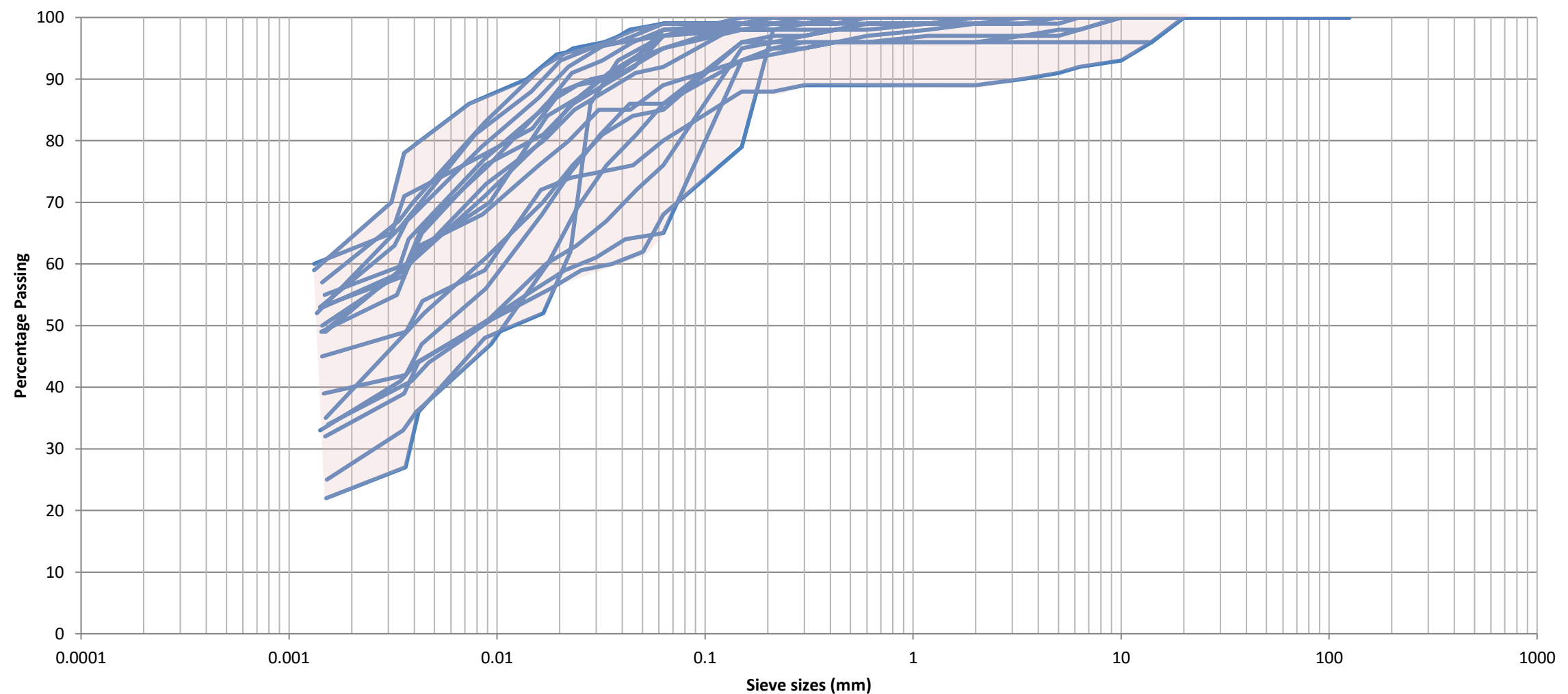
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CLAY	SILT	SAND	GRAVEL	COBBLES
------	------	------	--------	---------

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Title

Particle Size Distribution for Weathered London Clay Formation

Sheet size

A4

Drawn

Date

H. Fisher

19/03/2020

Checked

Date

R. Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

Status

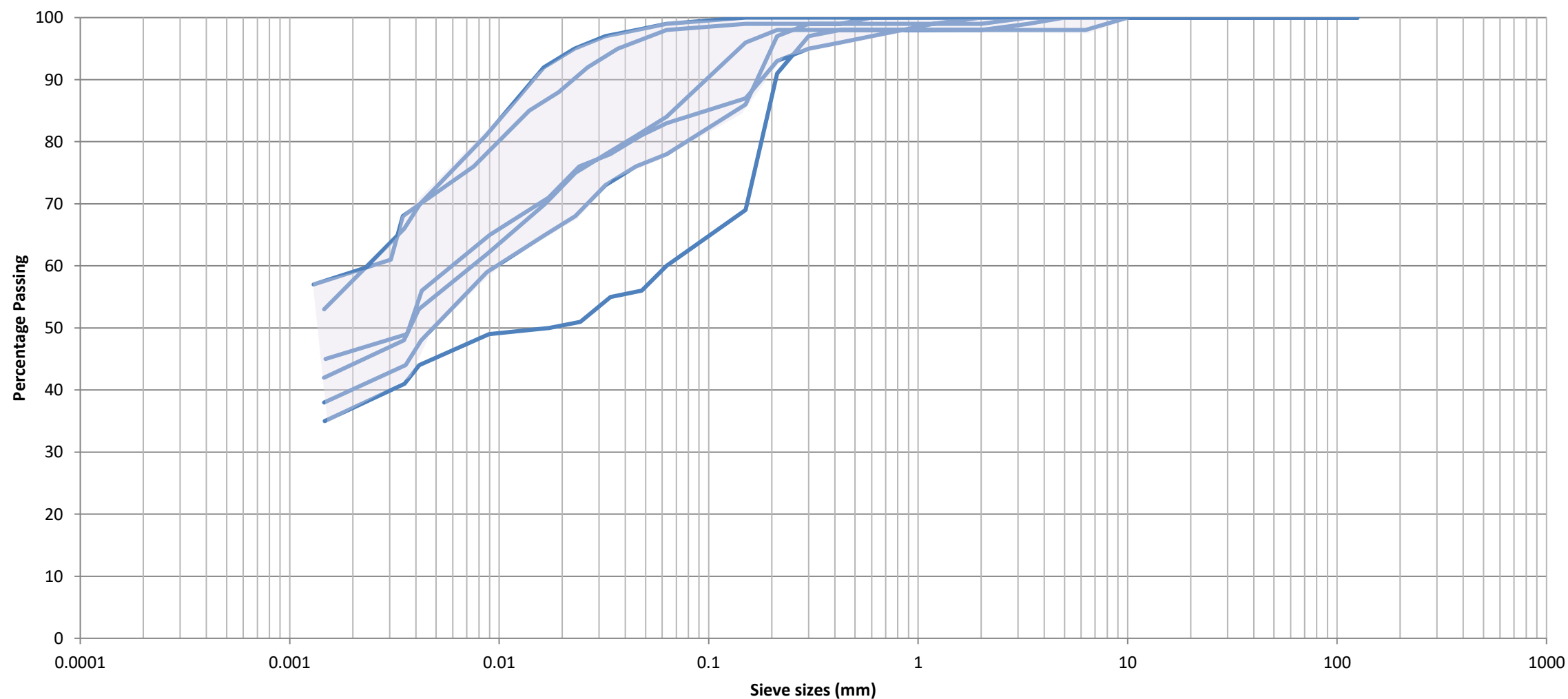
FINAL

Plot Number

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Rev

P01



CLAY	SILT	SAND	GRAVEL	COBBLES
------	------	------	--------	---------

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Havant Thicket Winter Storage Reservoir

Title

Particle Size Distribution for Unweathered London Clay Formation

Sheet size

A4

Drawn

Date

H. Fisher

19/03/2020

Checked

Date

R. Lindsay

26/03/2020

Authorised

Date

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03/04/2020

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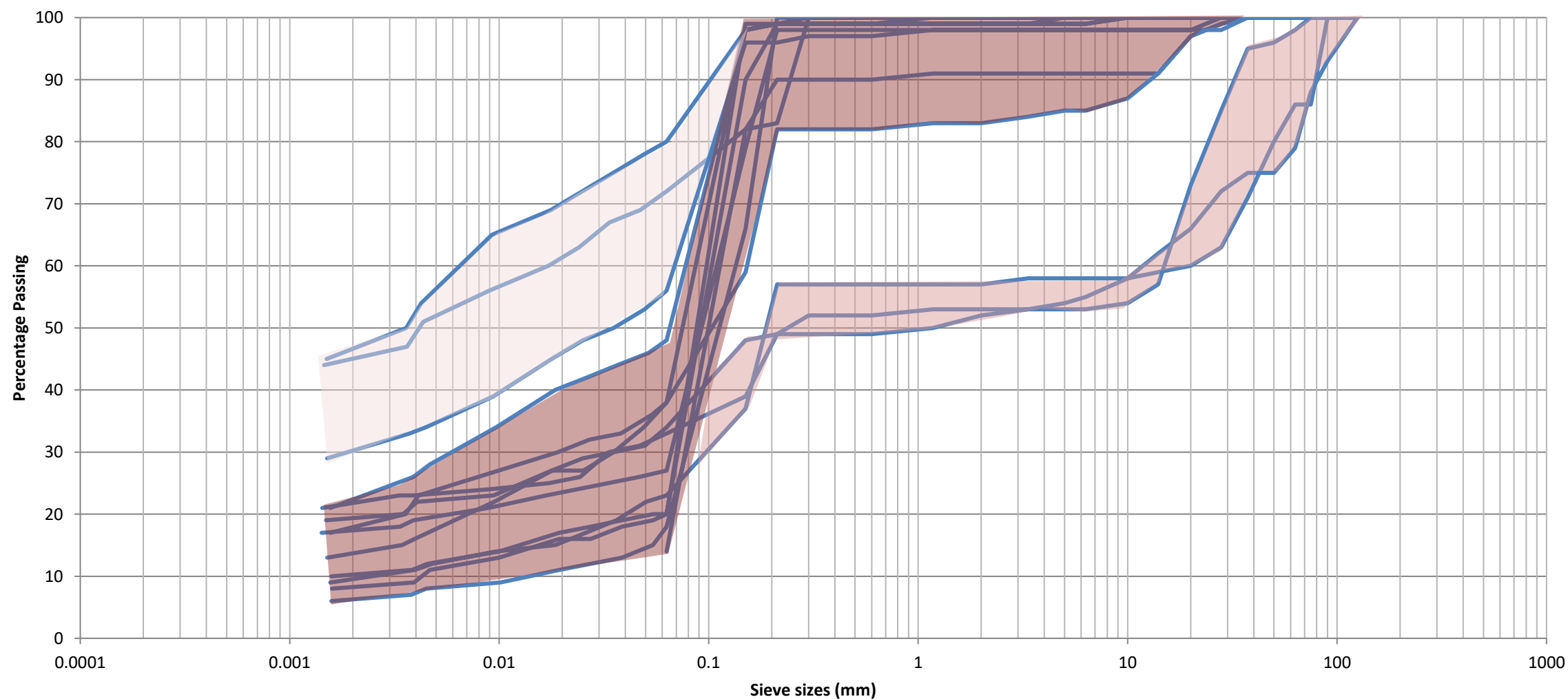
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Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

Particle Size Distribution for Harwich Formation

Sheet size

A4

Drawn

Date

H. Fisher

19/03/2020

Checked

Date

R. Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

Status

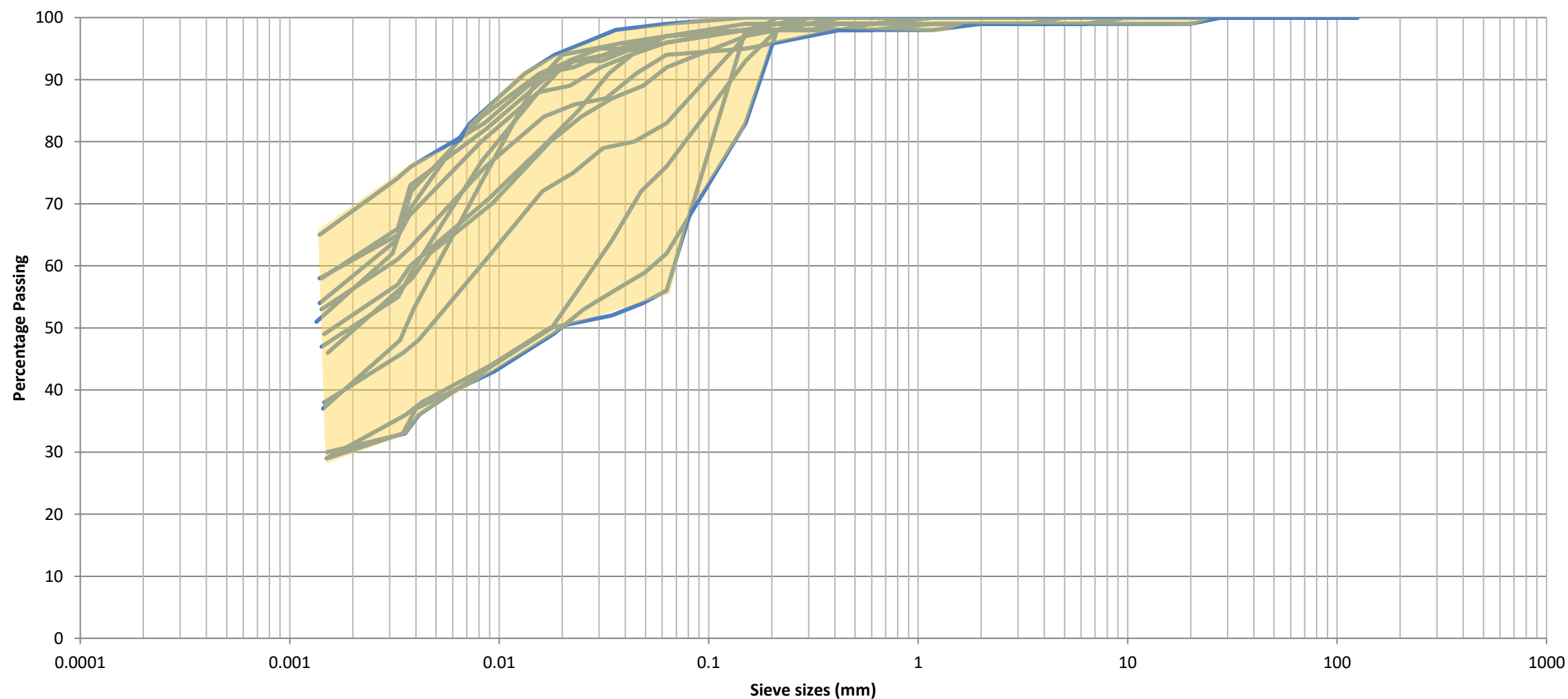
FINAL

Plot Number

4.5

Rev

P01



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Woodcote Grove

Ashley Road

Epsom

KT18 5BW

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Fax: (01372) 740055

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Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

Particle Size Distribution for Reading Formation

Sheet size

A4

Drawn

Date

H. Fisher

19/03/2020

Checked

Date

R. Lindsay

26/03/2020

Authorised

Date

J. Apted

03/04/2020

Status

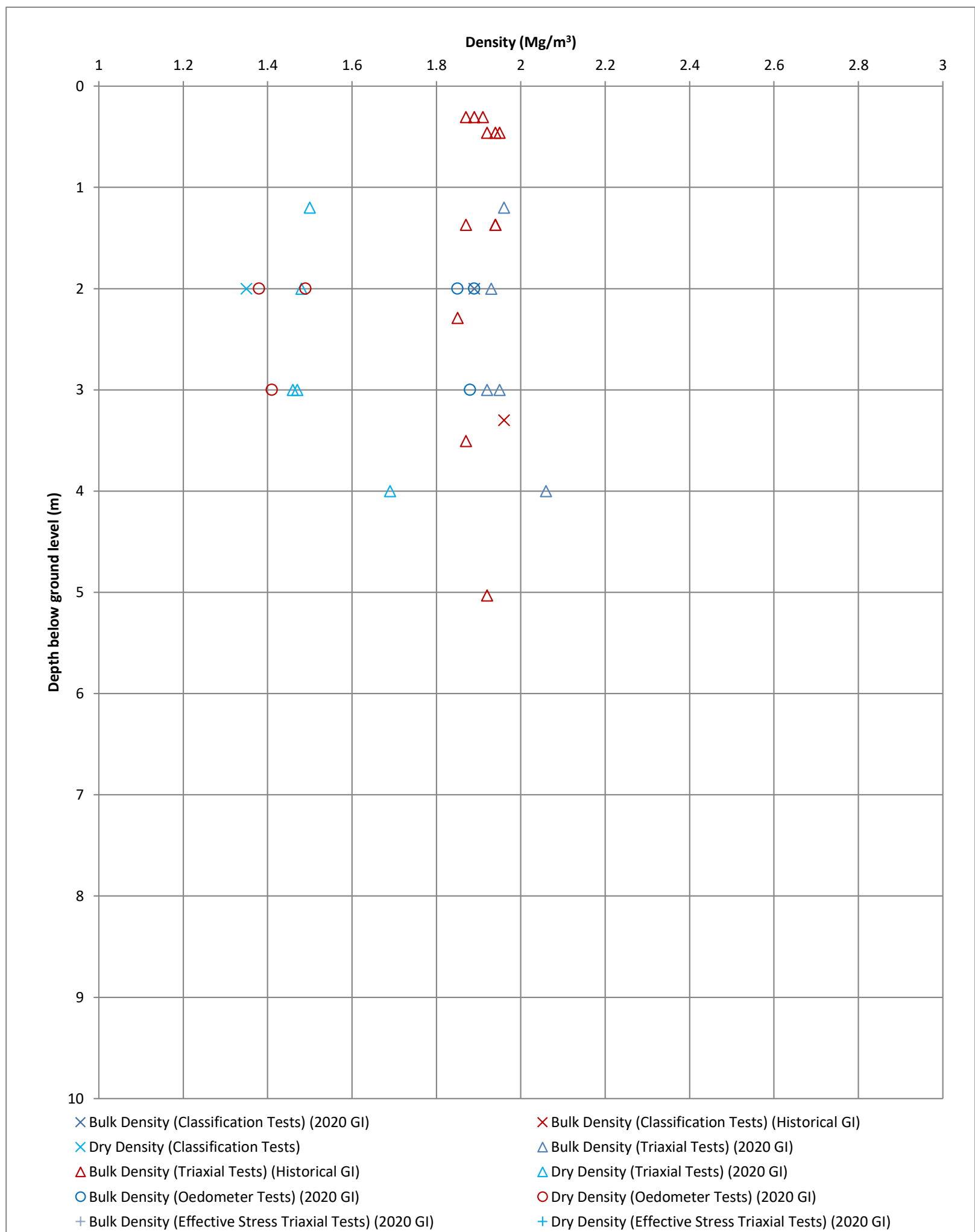
FINAL

Plot Number

4.6

Rev

P01



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Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

Density vs Depth - Weathered London Clay Formation

Sheet size
A4

Drawn: H.Fisher
Date: 10/03/20

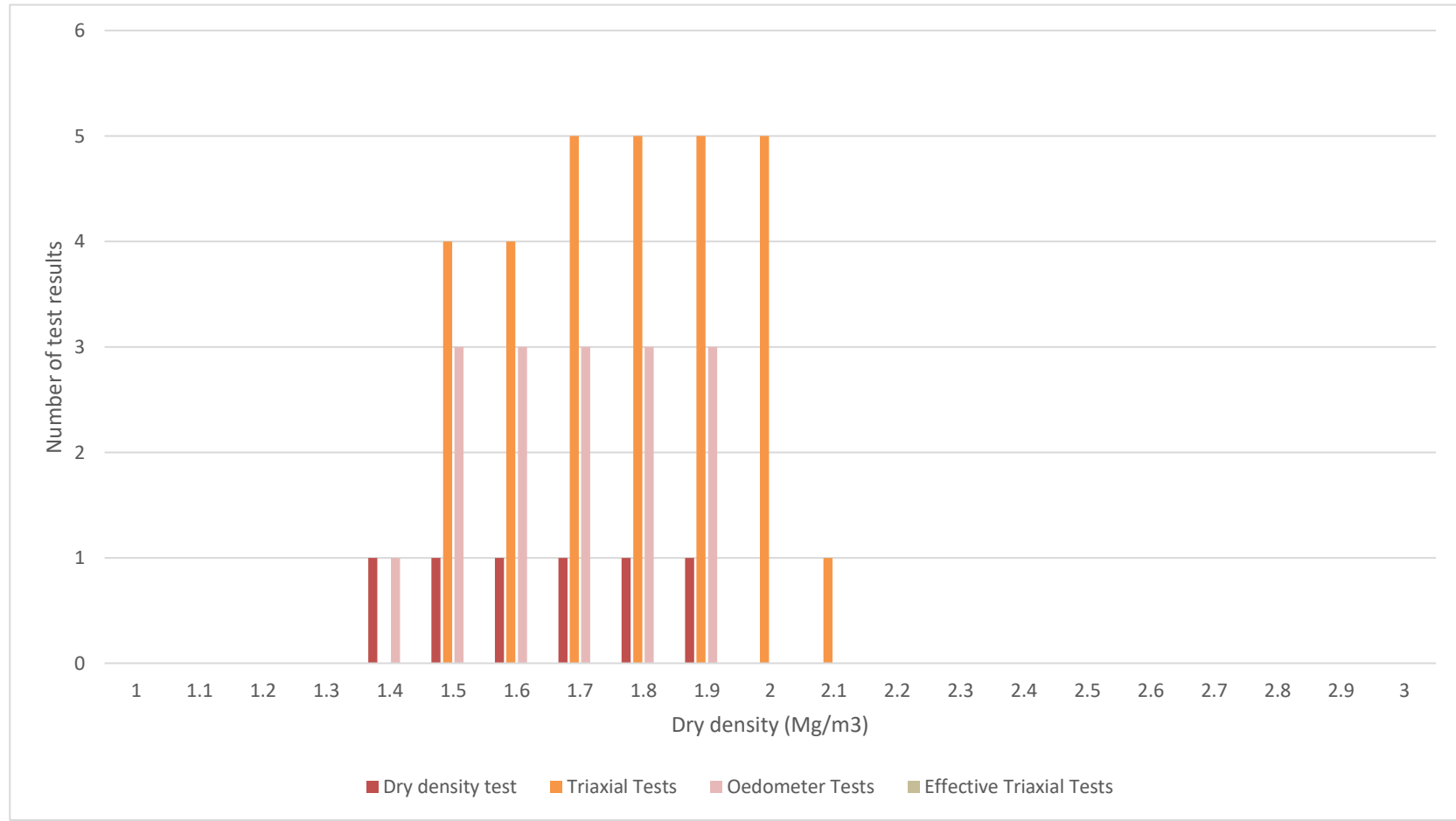
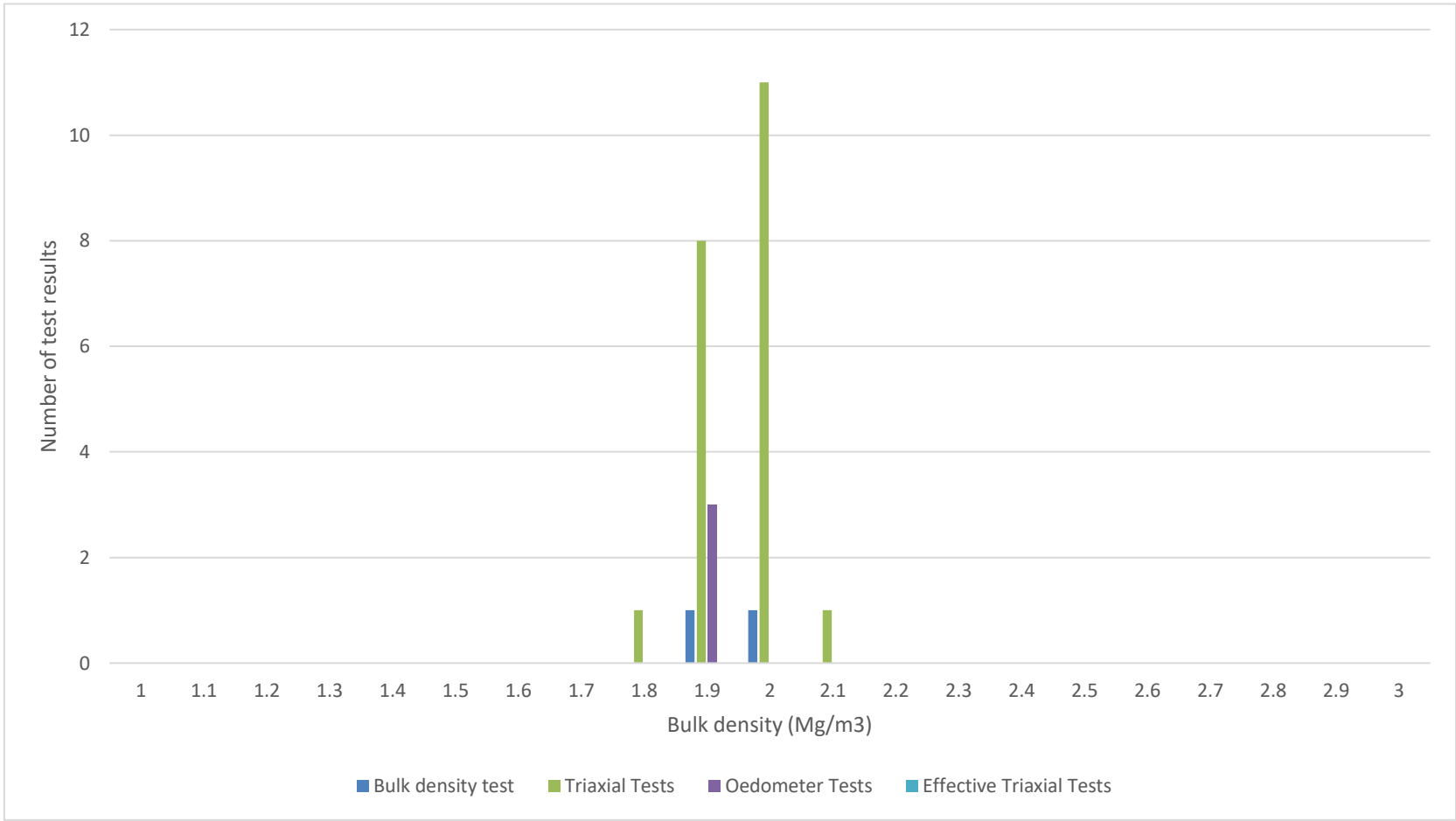
Checked: R.Lindsa
Date: 24/03/20

Reviewed: J.Apted
Date: 03/04/2020

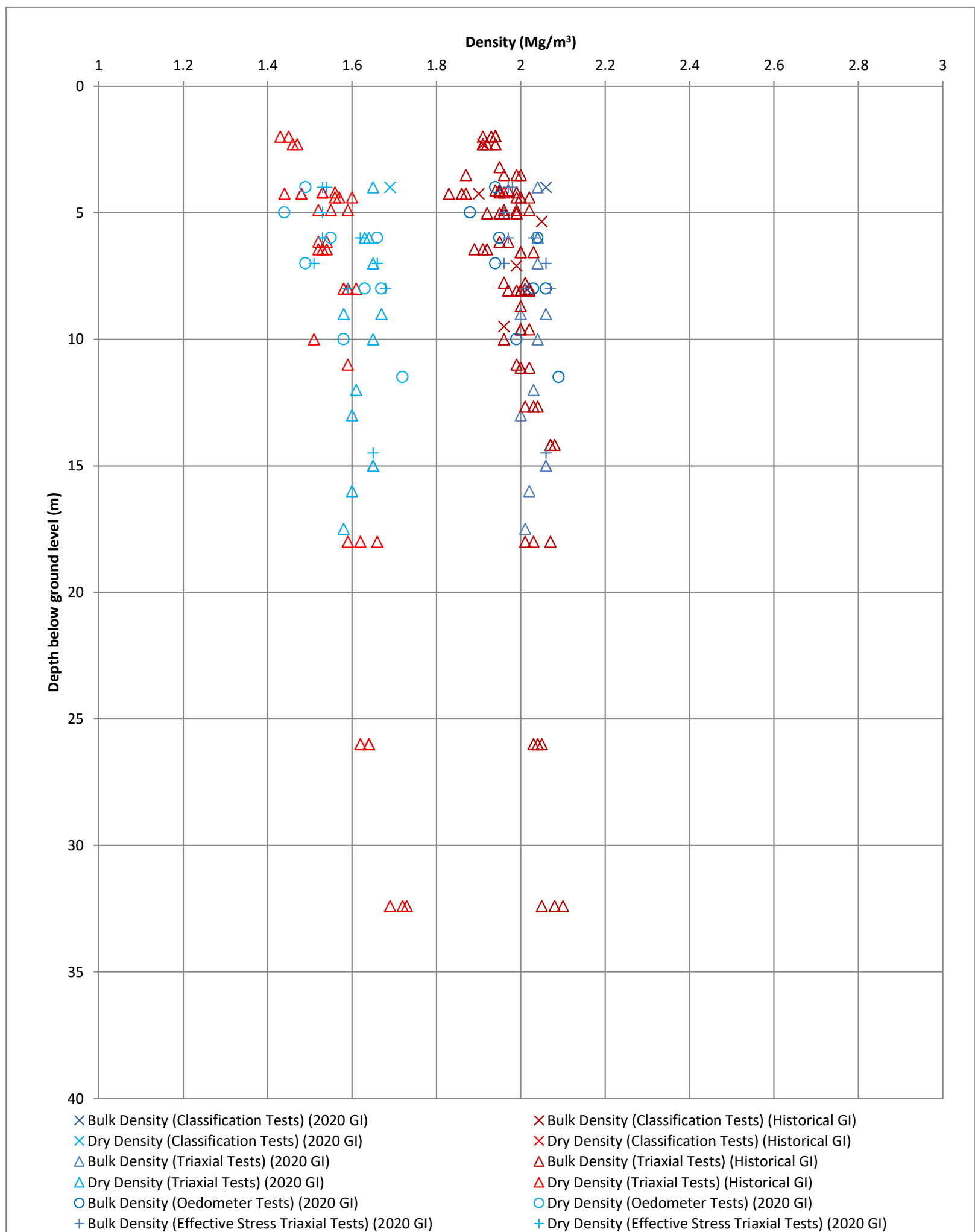
Status
FINAL

Plot Number
5a.1

Rev
P01



ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Histograms for Bulk Density and Dry Density - Weathered London Clay Formation			
	Project	Sheet size	Drawn: H.Fisher	Checked: R.Lindsa	Reviewed: J.Apted
Havant Thicket Winter Storage Reservoir		A4	Date: 10/03/20	Date: 24/03/20	Date: 03/04/2020
		Status	Plot Number		Rev
		FINAL	5b.1		P01



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KT18 5BW

Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

**Density vs Depth - Unweathered London
Clay Formation**

Sheet size
A4

Drawn: H.Fisher
Date: 10/03/20

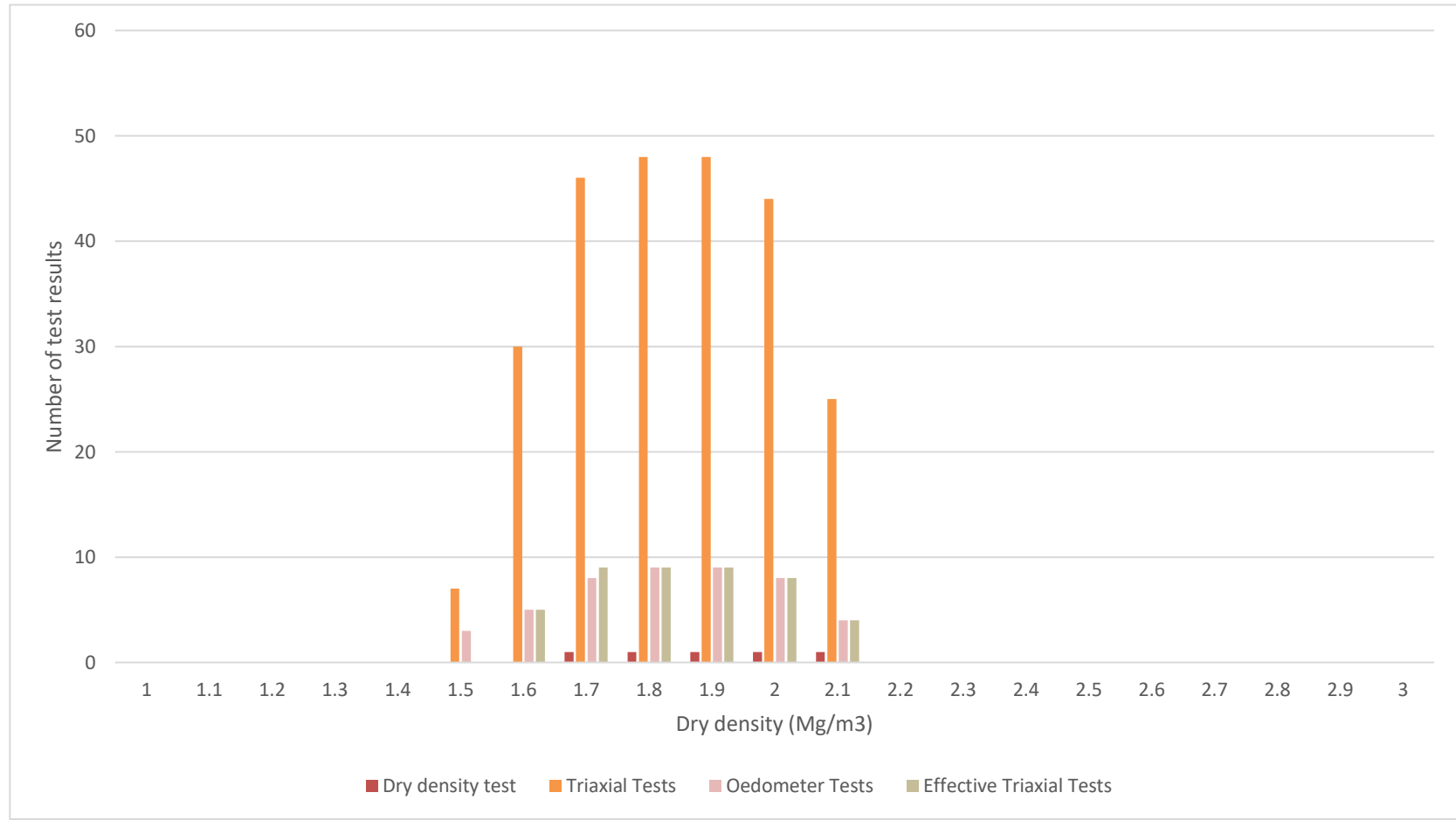
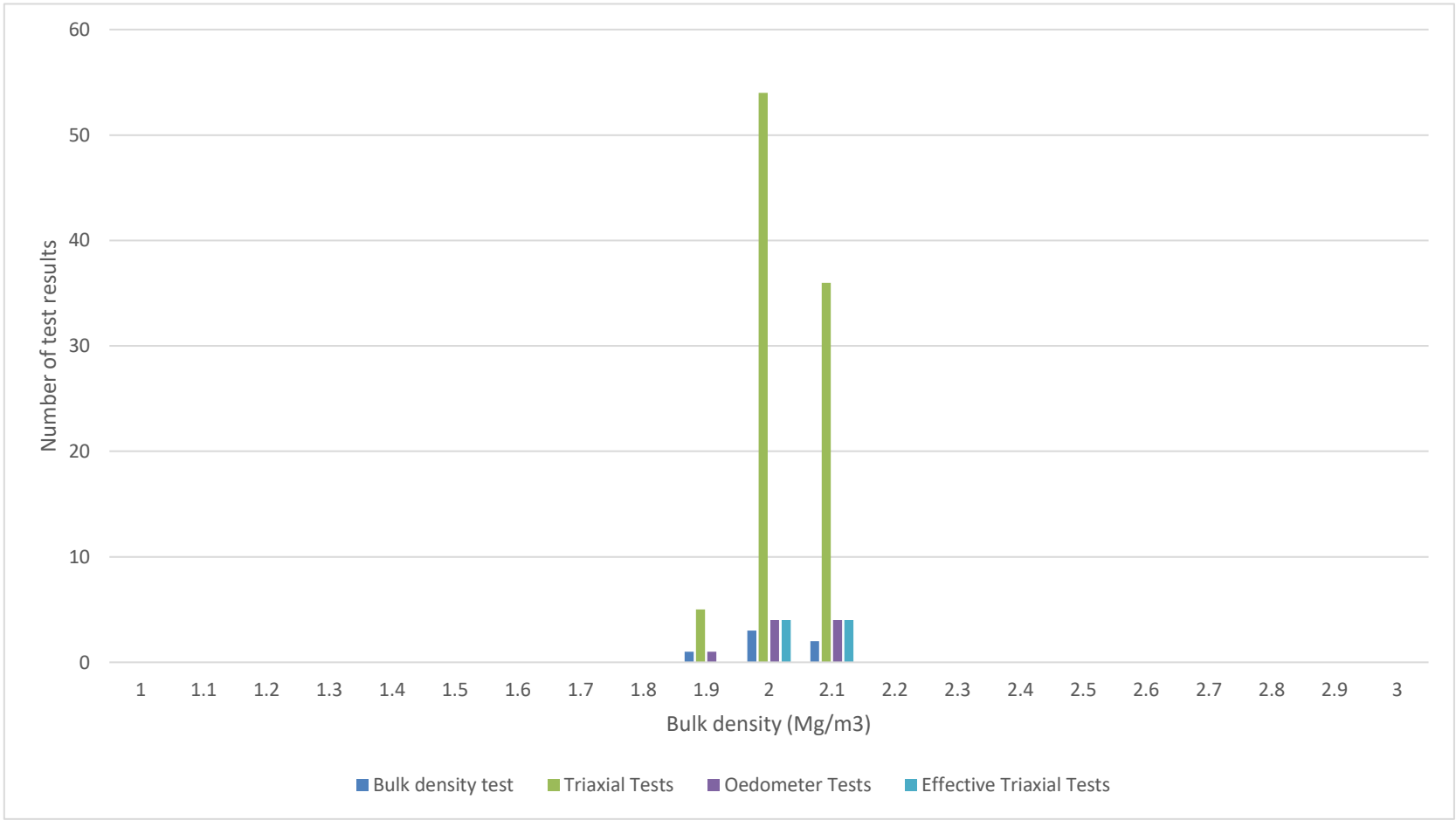
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Date: 24/03/20

Reviewed: J.Apted
Date: 03/04/2020

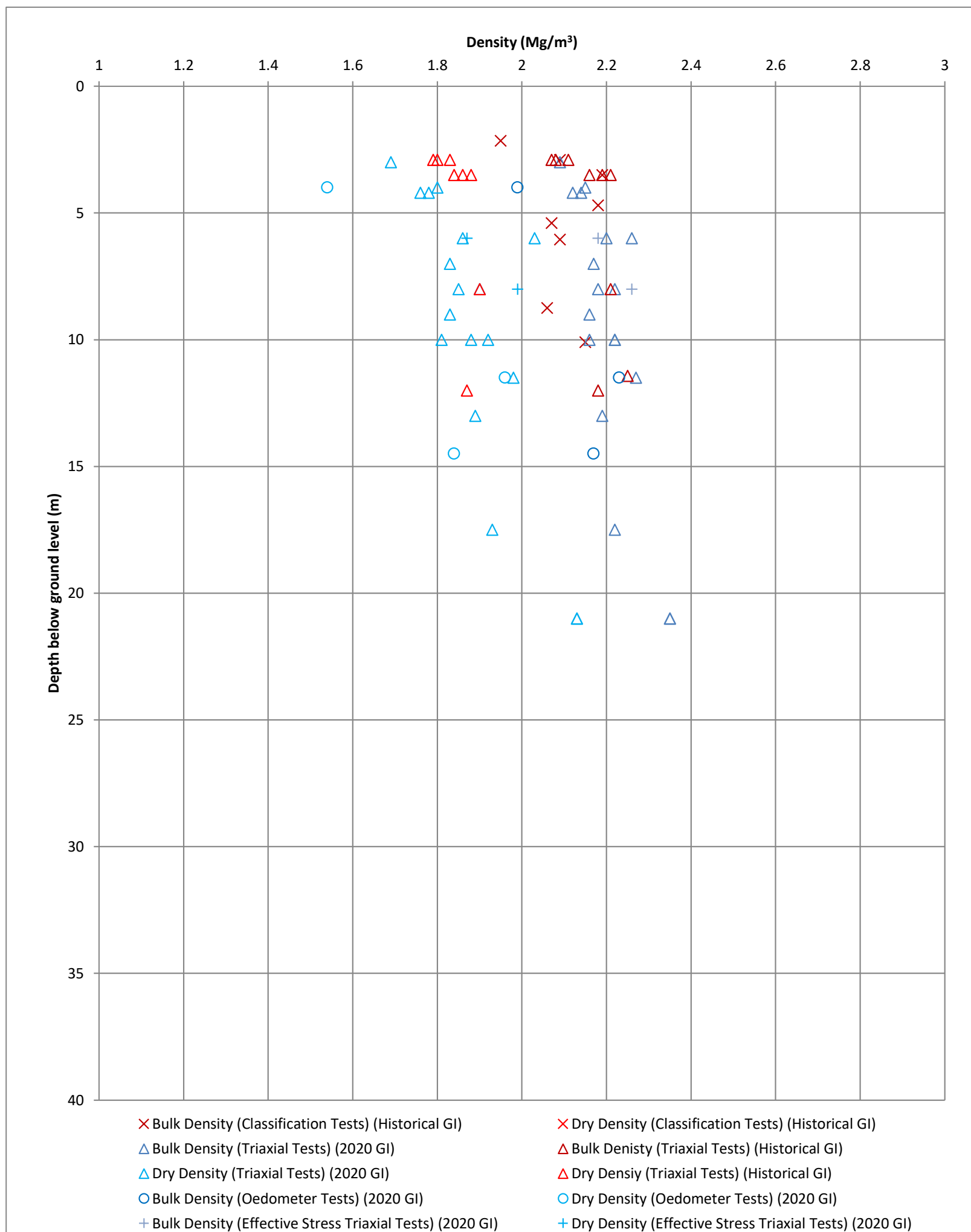
Status
FINAL

Plot Number
5a.2

Rev
P01



ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Histograms for Bulk Density and Dry Density - Unweathered London Clay Formation			
	Project	Sheet size	Drawn: H.Fisher	Checked: R.Linds	Reviewed: J.Apted
Havant Thicket Winter Storage Reservoir		A4	Date: 10/03/20	Date: 24/03/20	Date: 03/04/2020
		Status	Plot Number		Rev
		FINAL	5b.2		P01



Atkins

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Road, Epsom, Surrey,
KT18 5BW

Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

Density vs Depth - Reading Formation

Sheet size
A4

Drawn: H.Fisher
Date: 10/03/20

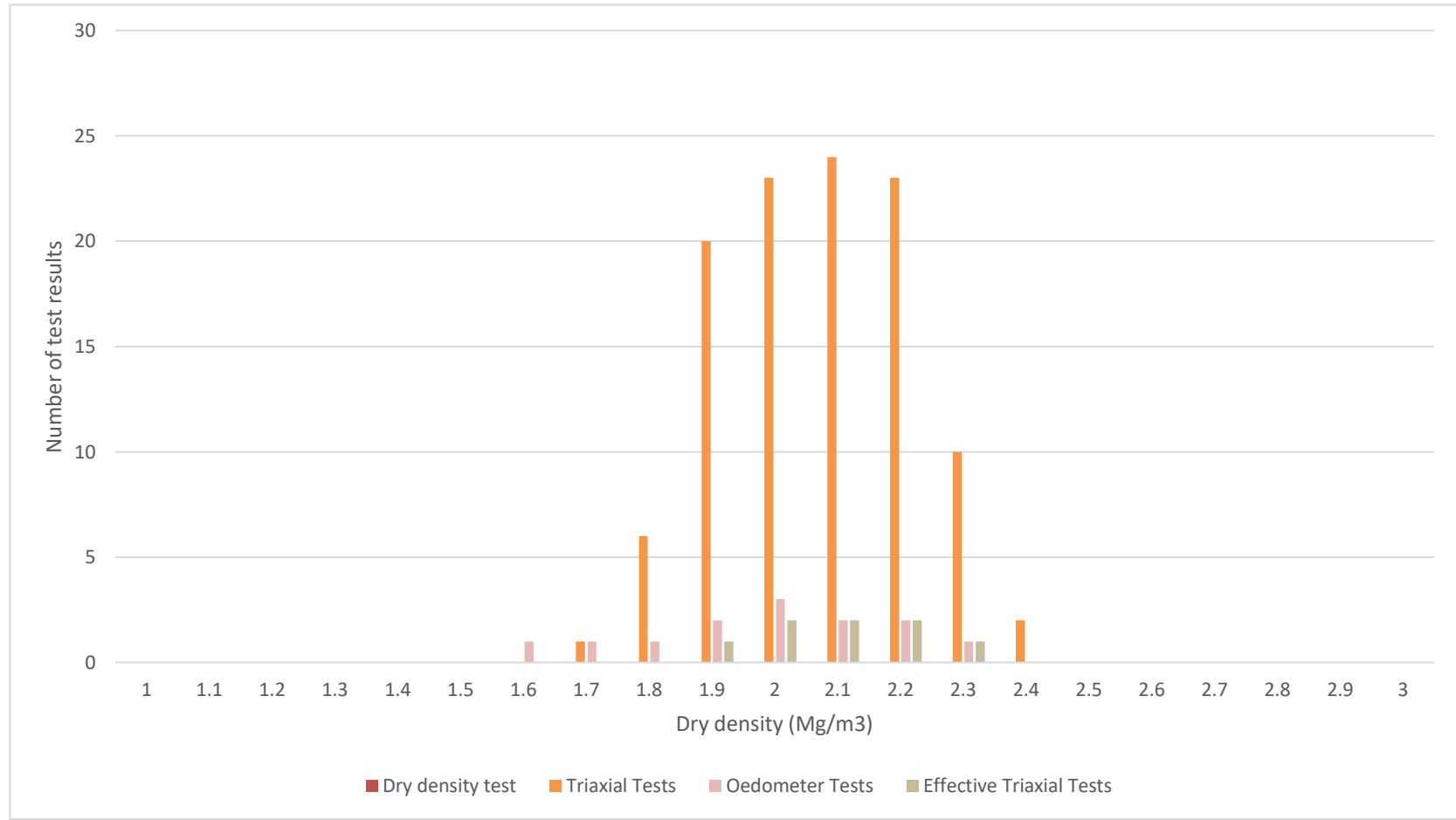
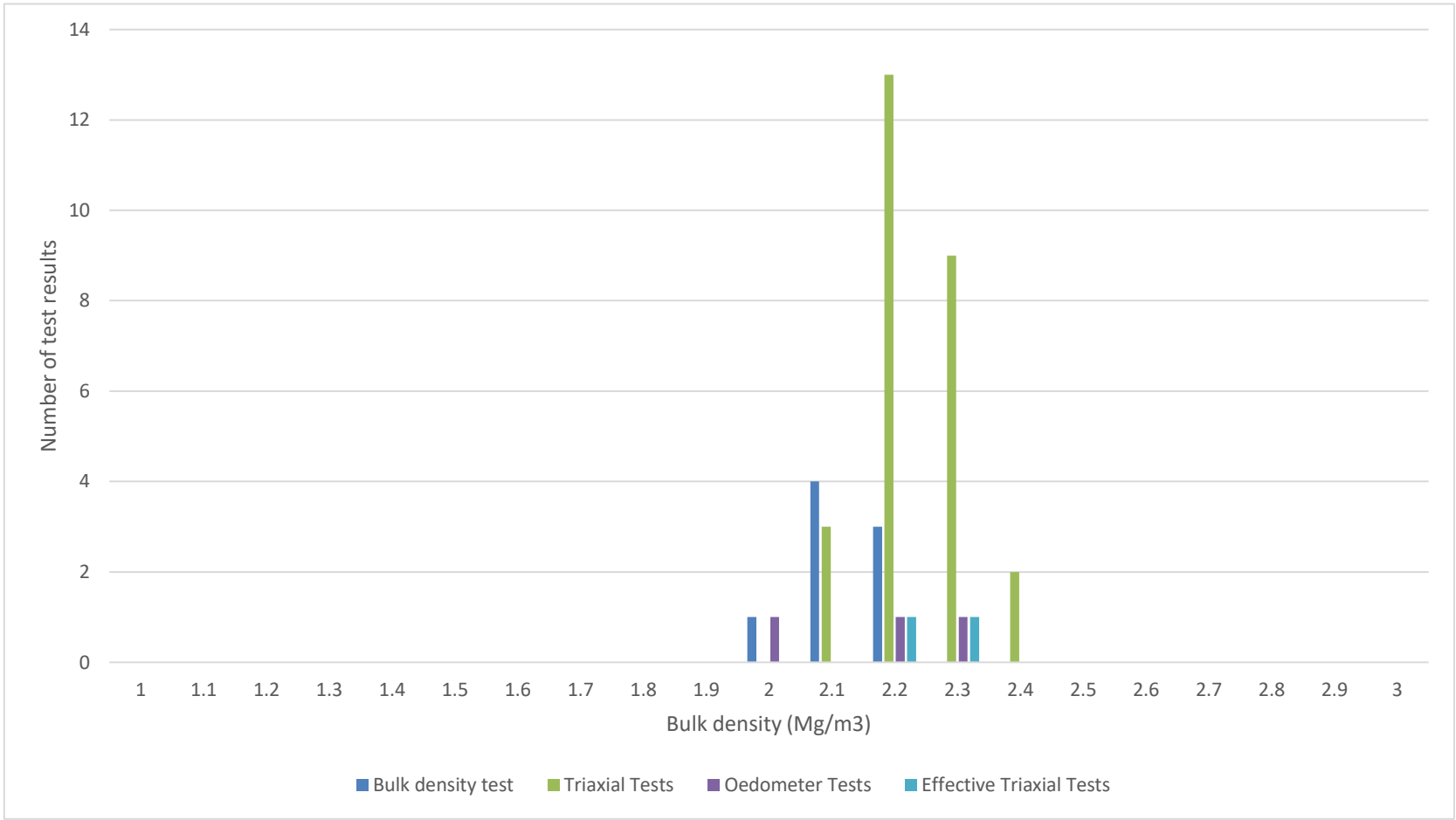
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Date: 24/03/20

Reviewed: J.Apted
Date: 03/04/2020

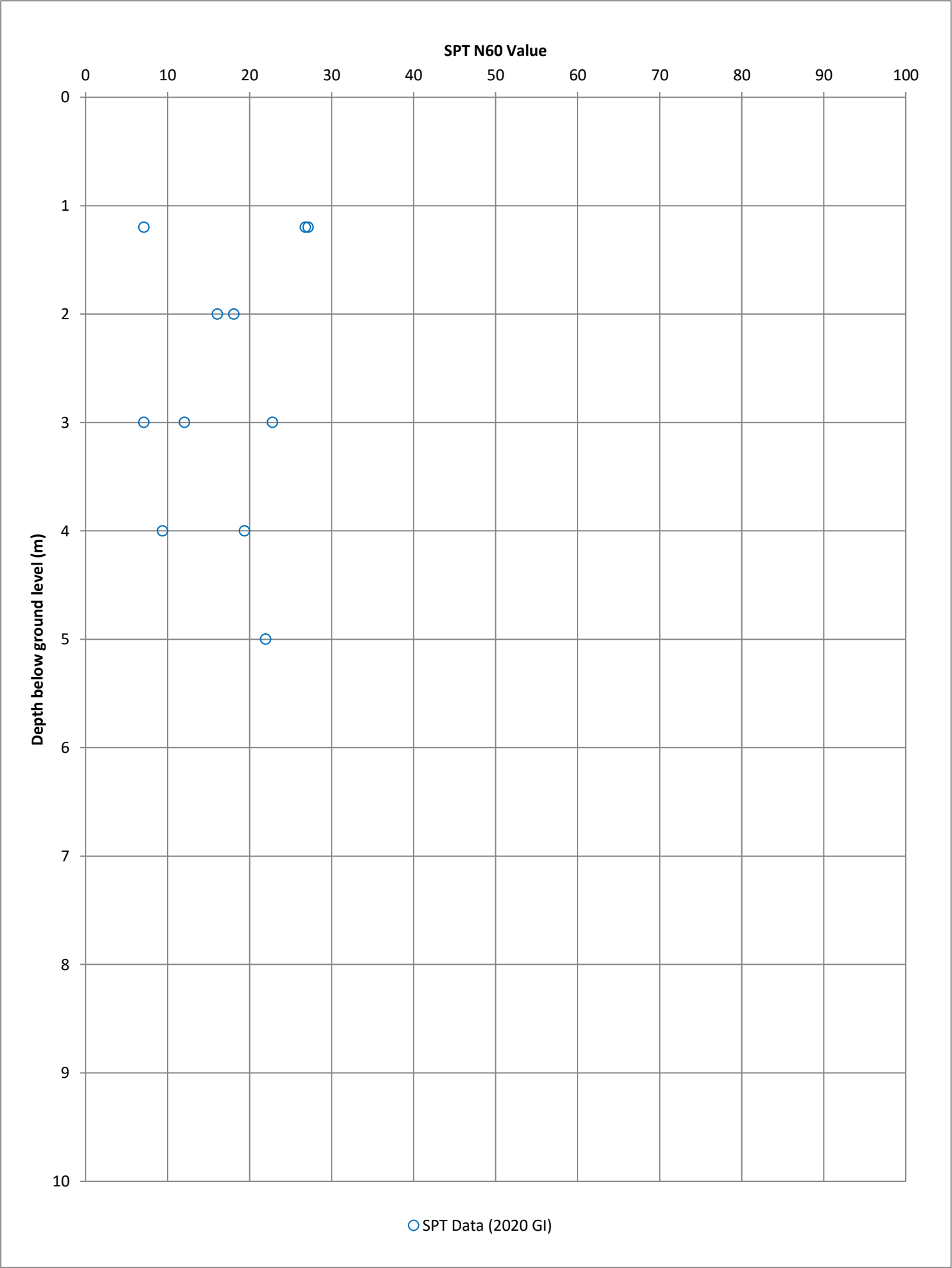
Status
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Plot Number
5a.3

Rev
P01

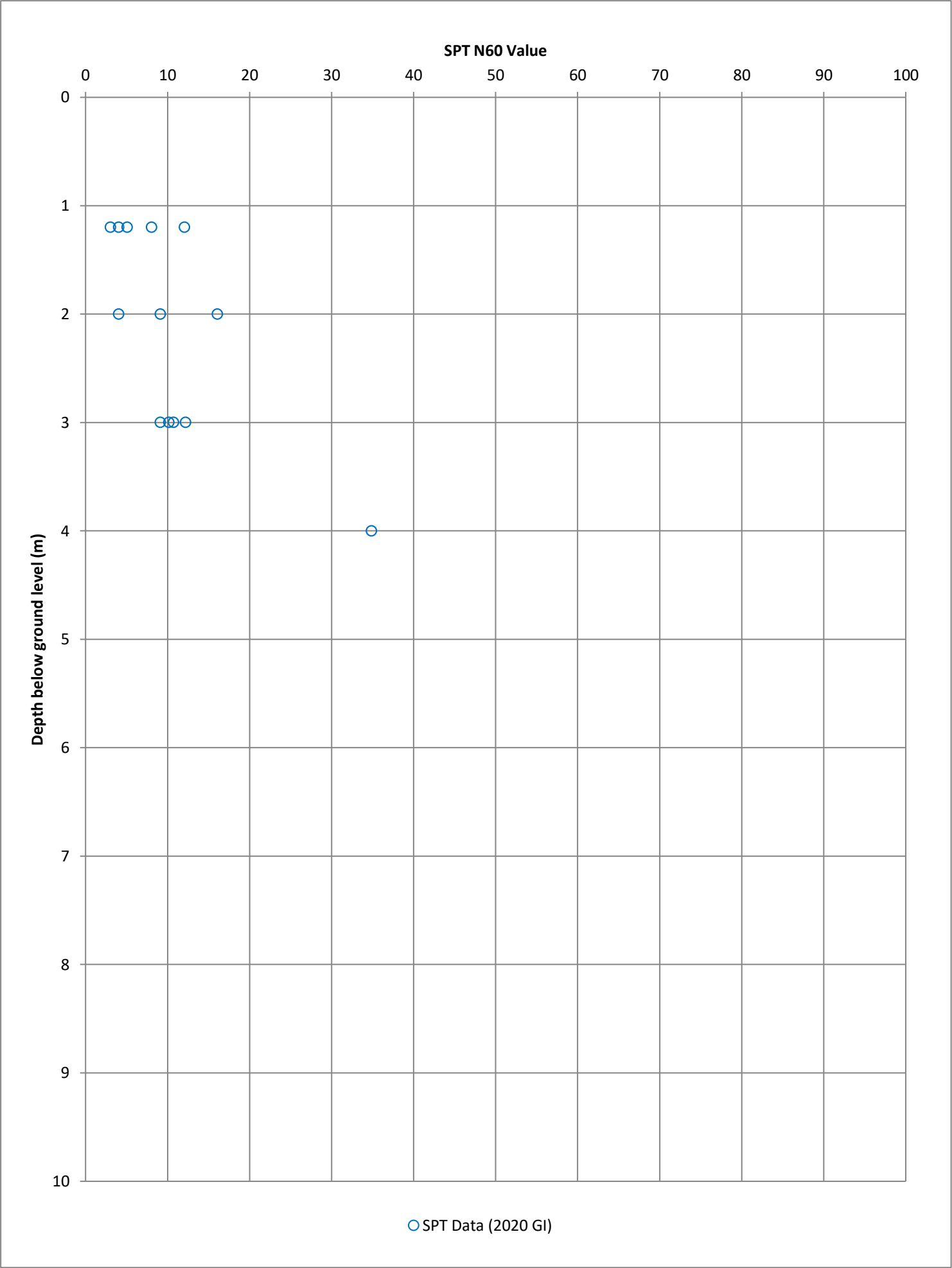


ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Histograms for Bulk Density and Dry Density - Reading Formation			
	Project	Sheet size A4	Drawn: H.Fisher Date: 10/03/20	Checked: R.Linds Date: 24/03/20	Reviewed: J.Apted Date: 03/04/2020
Havant Thicket Winter Storage Reservoir		Status FINAL	Plot Number 5b.3		Rev P01



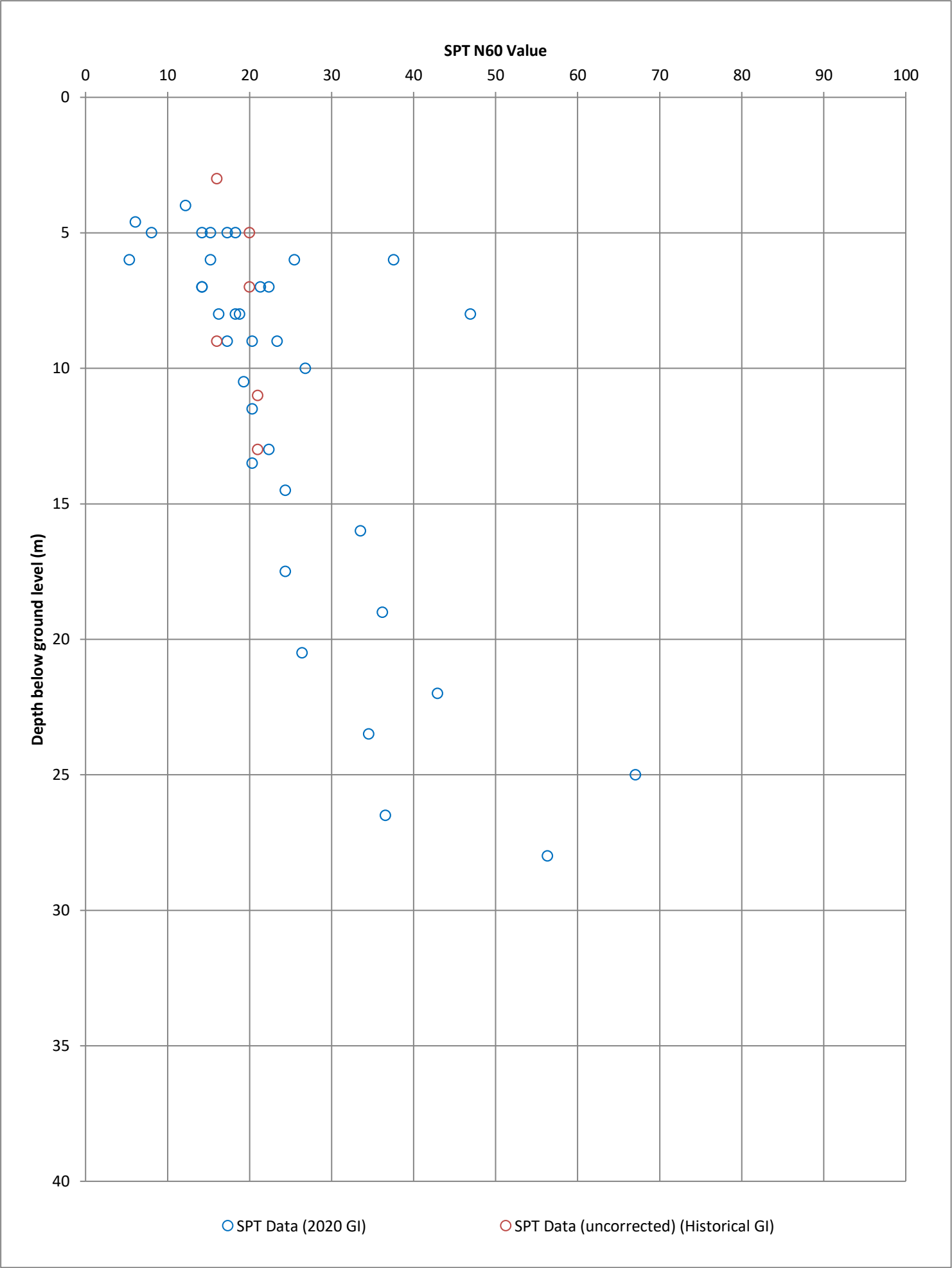
Maximum Extrapolated N60 Value	200
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ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055	Client	Title			
	Portsmouth Water	SPT N60 Value vs Depth for Bognor Sand Member (London Clay Formation)			
	Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
	Havant Thicket Winter Storage Reservoir	A4	Date: 10/3/20	Date: 27/3/20	Date: 03/04/20
		Status	Plot Number	Rev	
		FINAL	6.1	P01	



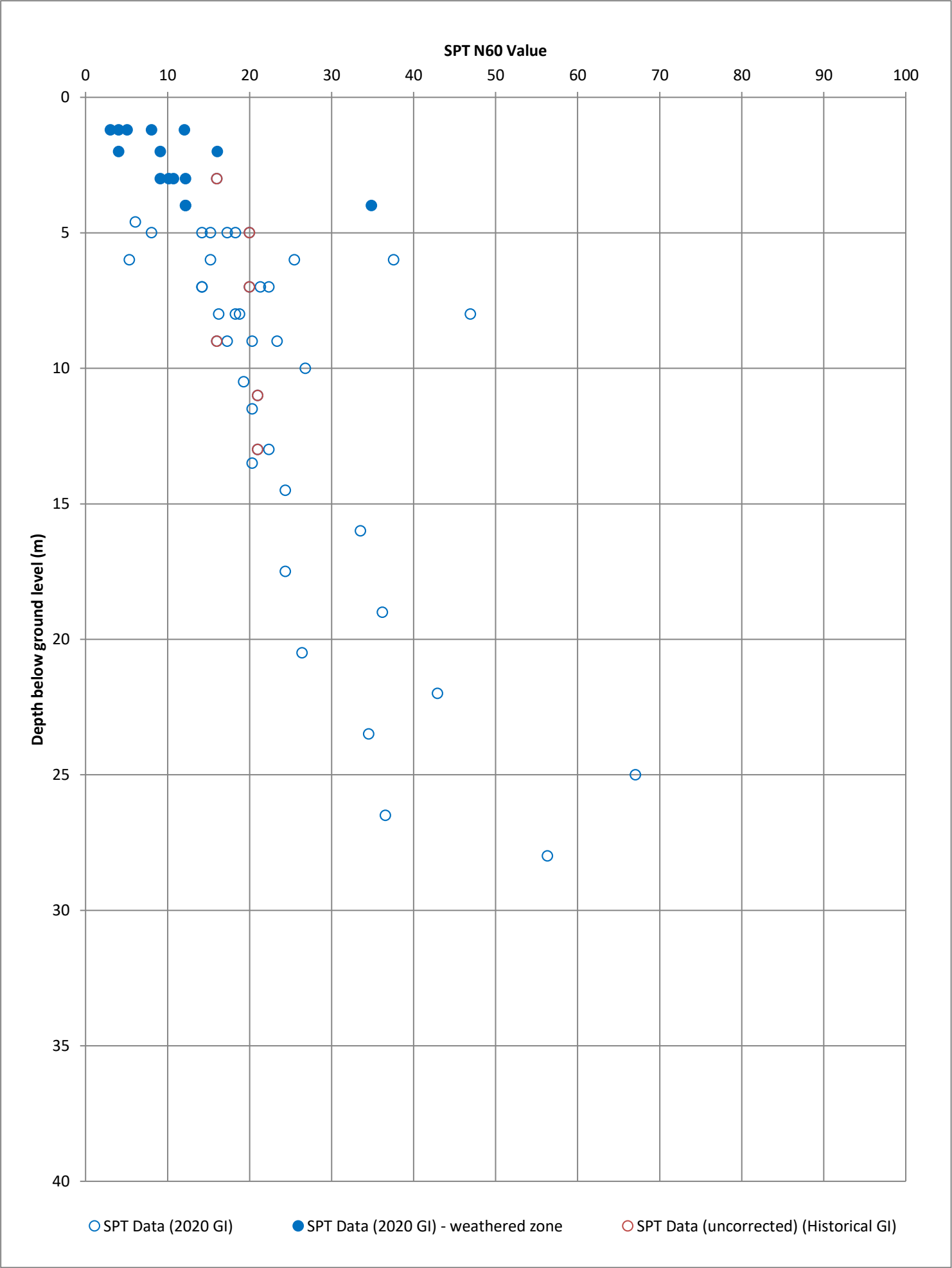
Maximum Extrapolated N60 Value	200
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ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055 <td colspan="2">Client</td> <td colspan="4">Title</td>	Client		Title			
	Portsmouth Water		SPT N60 Value vs Depth for Weathered London Clay Formation			
	Project		Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
	Havant Thicket Winter Storage Reservoir		A4	Date: 10/3/20	Date:27/3/20	Date: 03/04/20
		Status	Plot Number		Rev	
		FINAL	6.2		P01	



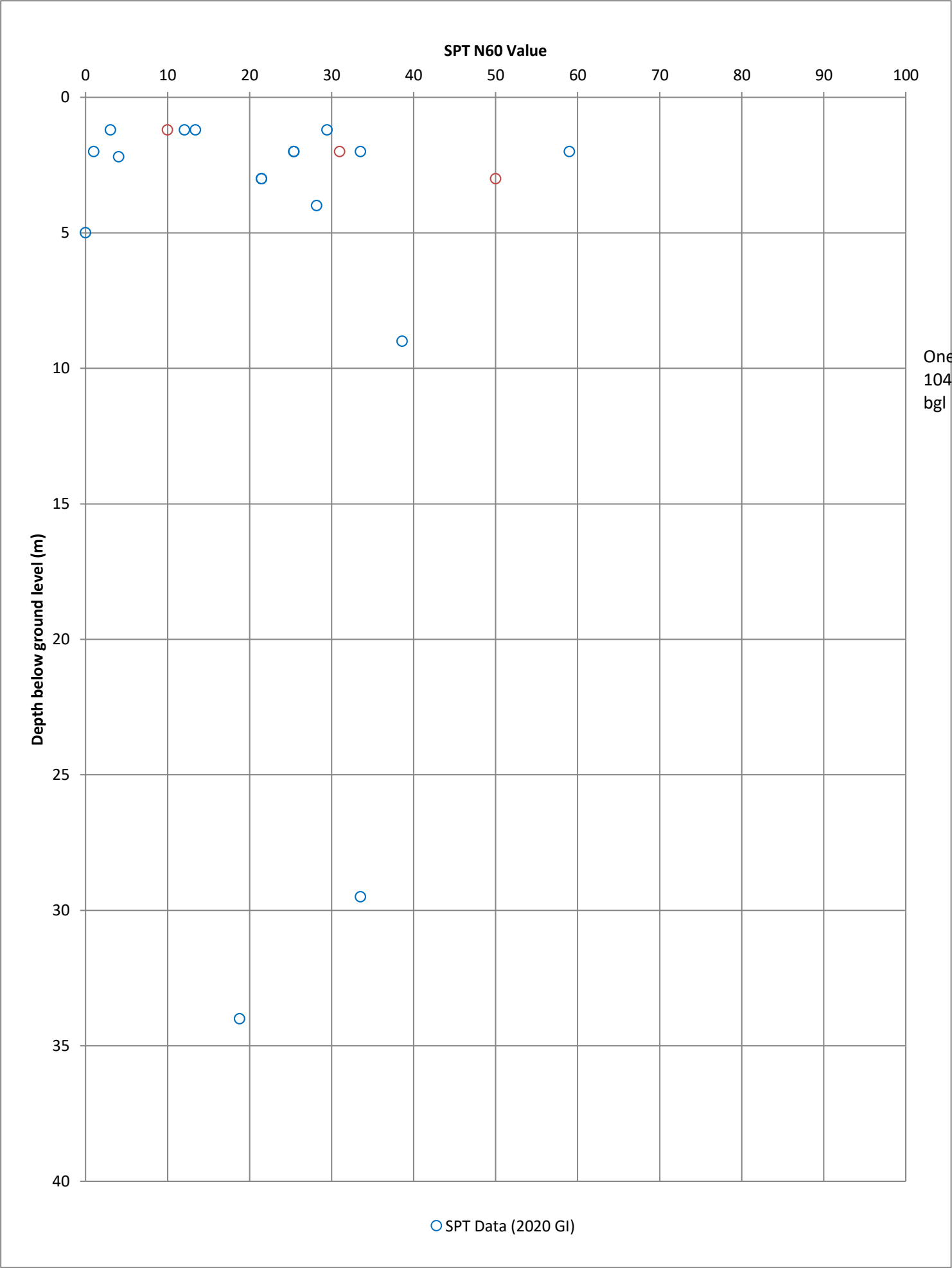
Maximum Extrapolated N60 Value	200
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ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055	Client	Title			
	Portsmouth Water	SPT N60 Value vs Depth for Unweathered London Clay Formation			
	Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
	Havant Thicket Winter Storage Reservoir	A4	Date: 10/3/20	Date: 27/3/20	Date: 03/04/20
		Status	Plot Number	Rev	
		FINAL	6.3	P01	



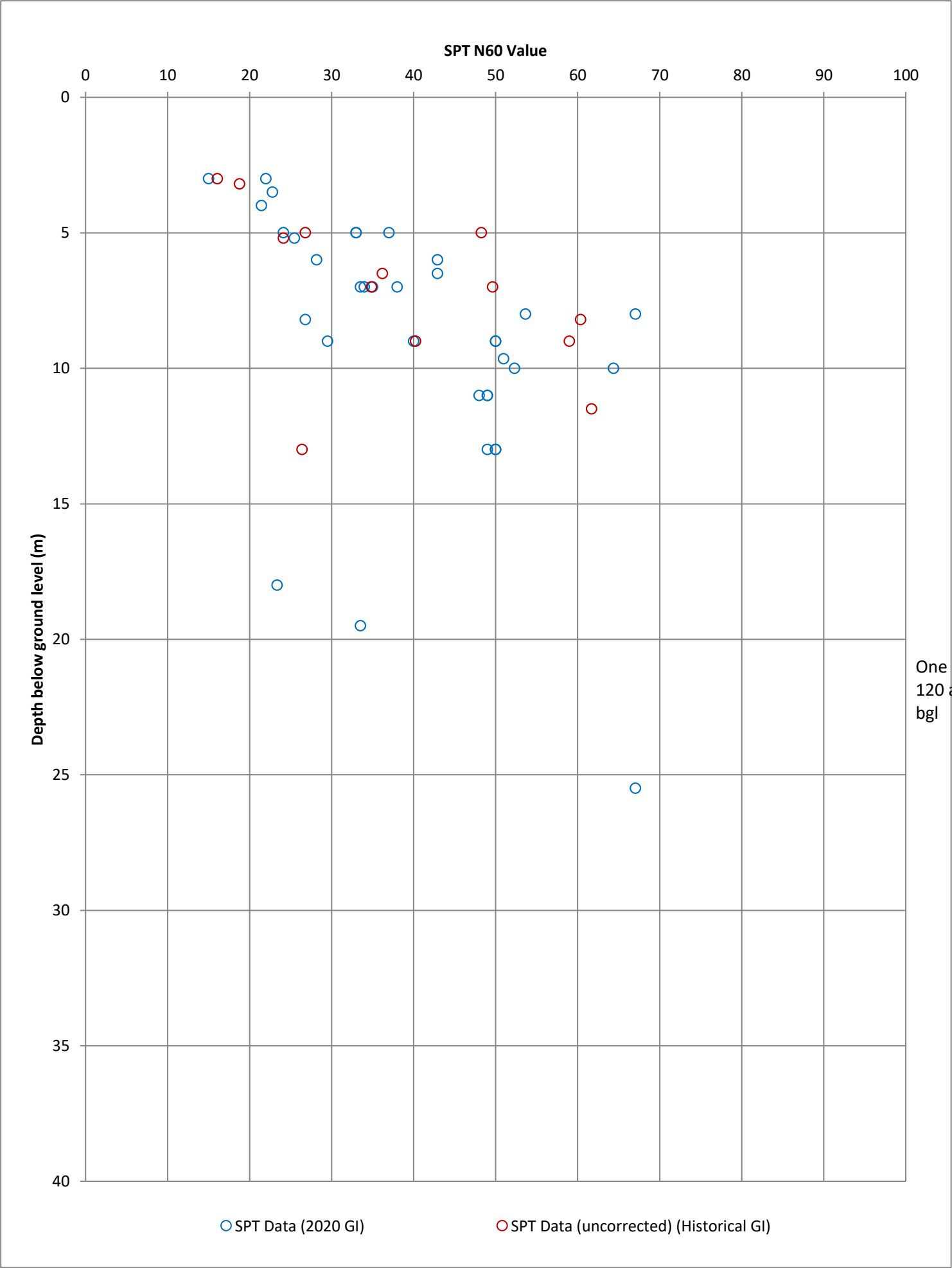
Maximum Extrapolated N60 Value	200
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ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055	Client	Portsmouth Water				Title			
	Project	Havant Thicket Winter Storage Reservoir				Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
						A4	Date: 10/3/20	Date: 27/3/20	Date: 03/04/20
						Status	Plot Number	Rev	
						FINAL	6.4	P01	



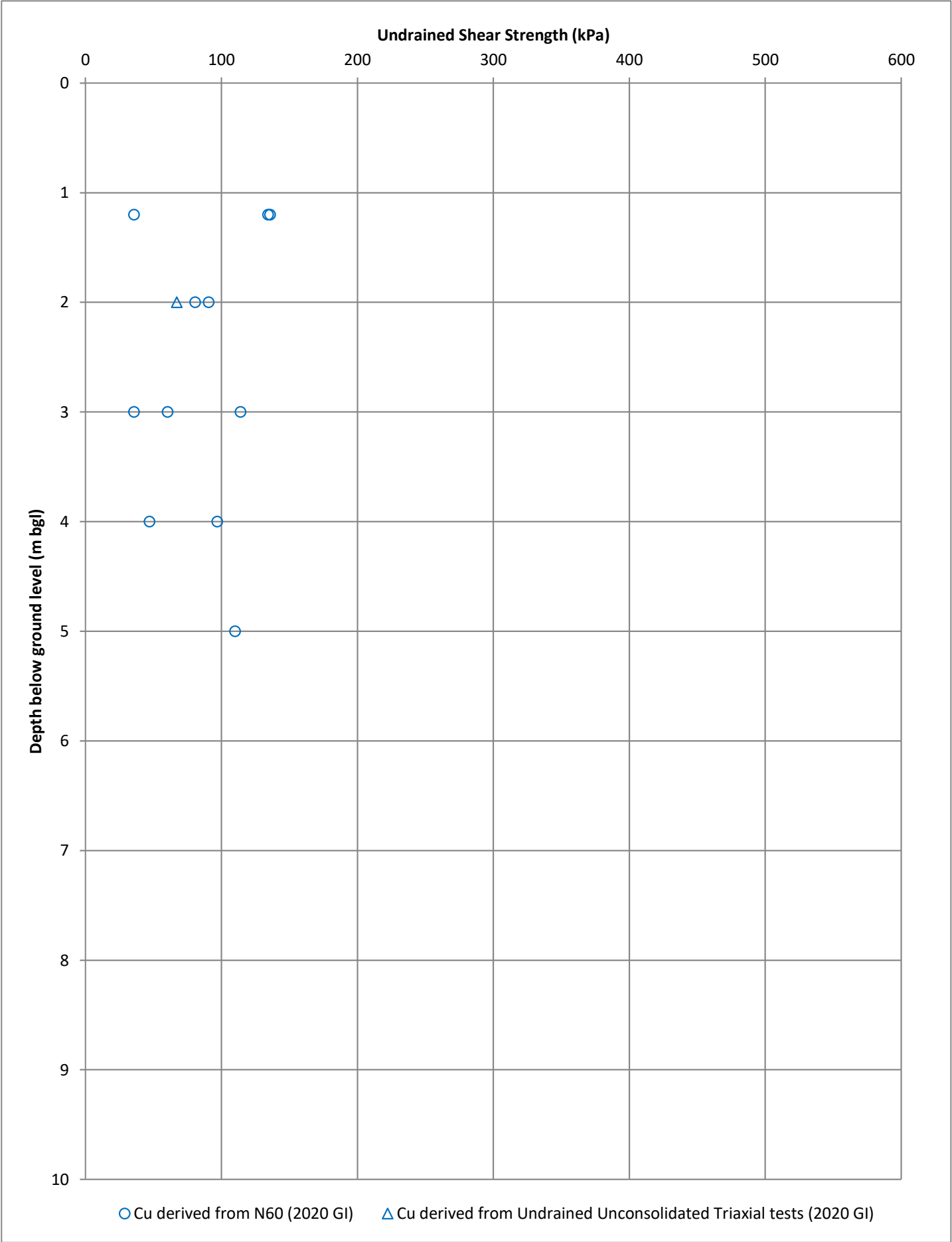
Maximum Extrapolated N60 Value	200
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ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055 <td colspan="2">Client</td> <td colspan="4">Title</td>	Client		Title			
	Portsmouth Water		SPT N60 Value vs Depth for Harwich Formation			
	Project		Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
	Havant Thicket Winter Storage Reservoir		A4	Date: 10/3/20	Date:27/3/20	Date: 03/04/20
		Status	Plot Number		Rev	
		FINAL	6.5		P01	



Maximum Extrapolated N60 Value	200
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ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055	Client	Portsmouth Water				Title SPT N60 Value vs Depth for Reading Formation			
	Project	Havant Thicket Winter Storage Reservoir				Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
						A4	Date: 10/3/20	Date:27/3/20	Date: 03/04/20
						Status	Plot Number		Rev
						FINAL	6.6		P01



Maximum Extrapolated N60 Value	200
f, value (Cu = f ₁ N60)	5

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Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

Undrained Shear Strength vs Depth for Bognor Sand Member (London Clay Formation)

Sheet size

A4

Drawn: HEF

Date: 10/3/20

Checked: RL

Date:27/3/20

Reviewed: JA

Date: 03/04/20

Status

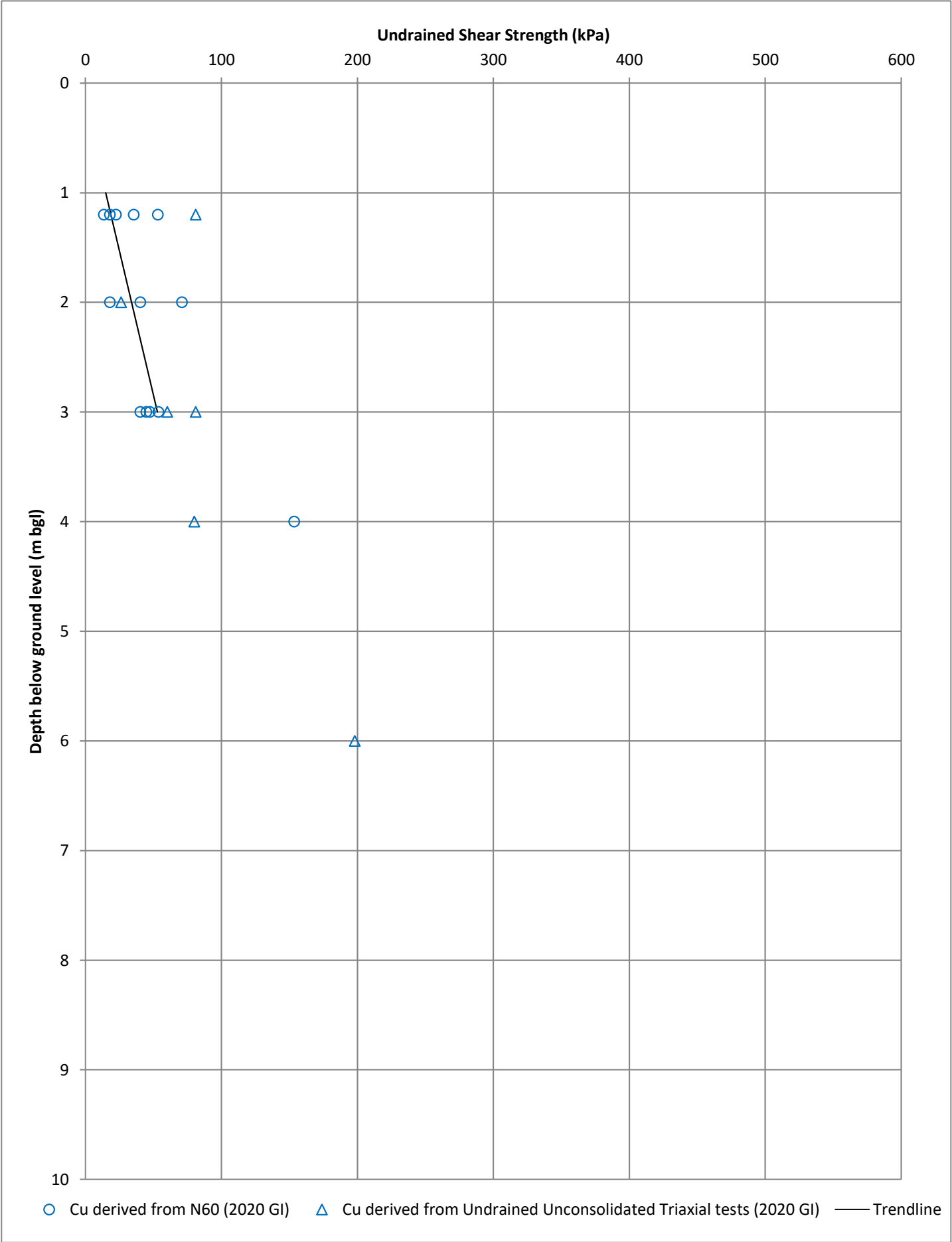
FINAL

Plot Number

7.1

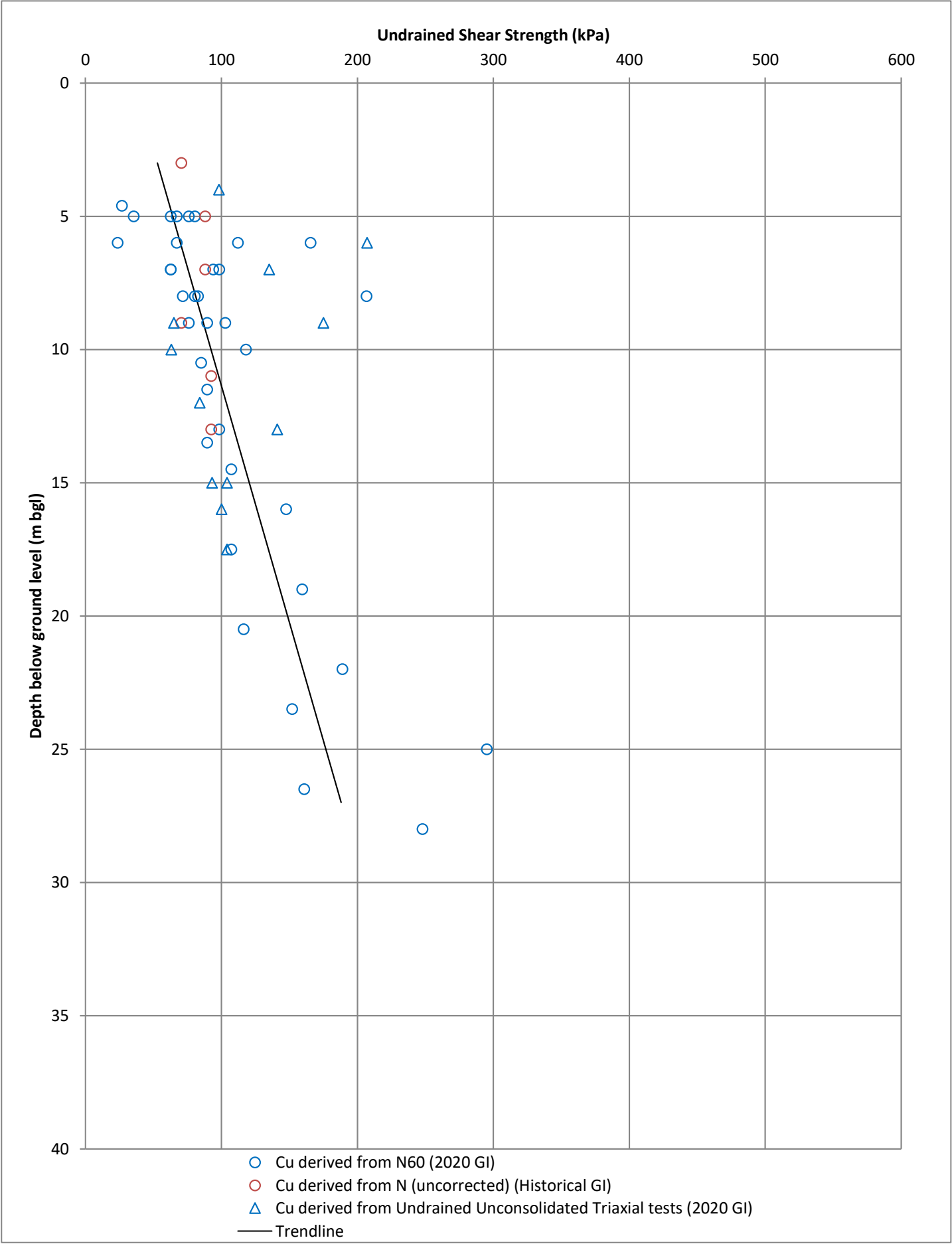
Rev

P01



Maximum Extrapolated N60 Value	200
f, value (Cu = f ₁ N60)	4.4

ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055	Client	Title			
	Portsmouth Water	Undrained Shear Strength vs Depth for Weathered London Clay Formation			
	Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir		A4	Date: 10/3/20	Date: 27/3/20	Date: 03/04/20
		Status	Plot Number	Rev	
		FINAL	7.2	P01	



Maximum Extrapolated N60 Value	200
f, value (Cu = f ₁ N60)	4.4



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Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

**Undrained Shear Strength vs Depth for
Unweathered London Clay Formation**

Sheet size
A4

Drawn: HEF
Date: 10/3/20

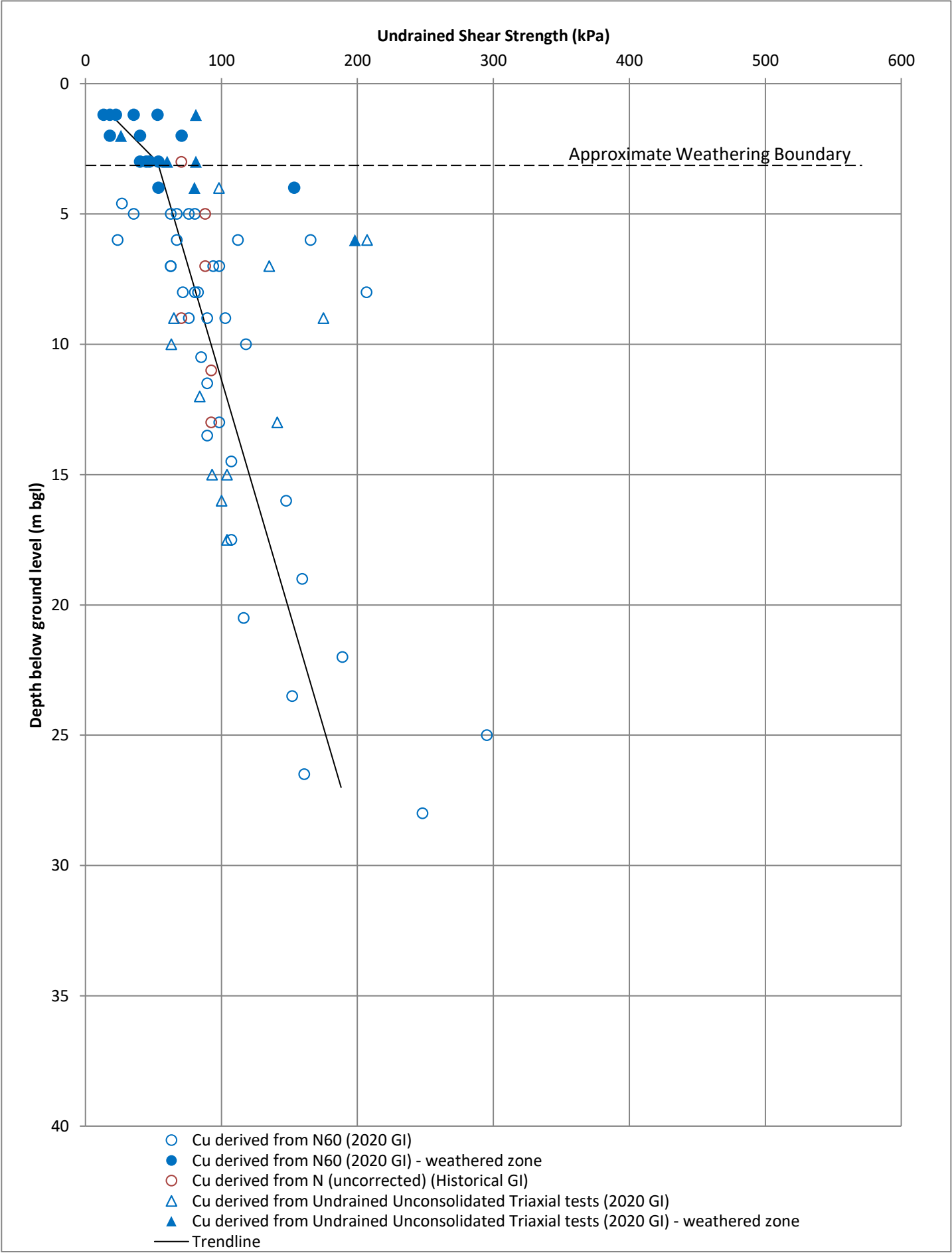
Checked: RL
Date: 27/3/20

Reviewed: JA
Date: 03/04/20

Status
FINAL

Plot Number
7.3

Rev
P01



Maximum Extrapolated N60 Value	200
f, value (Cu = f ₁ N60)	4.4



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Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

Undrained Shear Strength vs Depth for London Clay Formation (including Weathered Section)

Sheet size
A4

Drawn: HEF
Date: 10/3/20

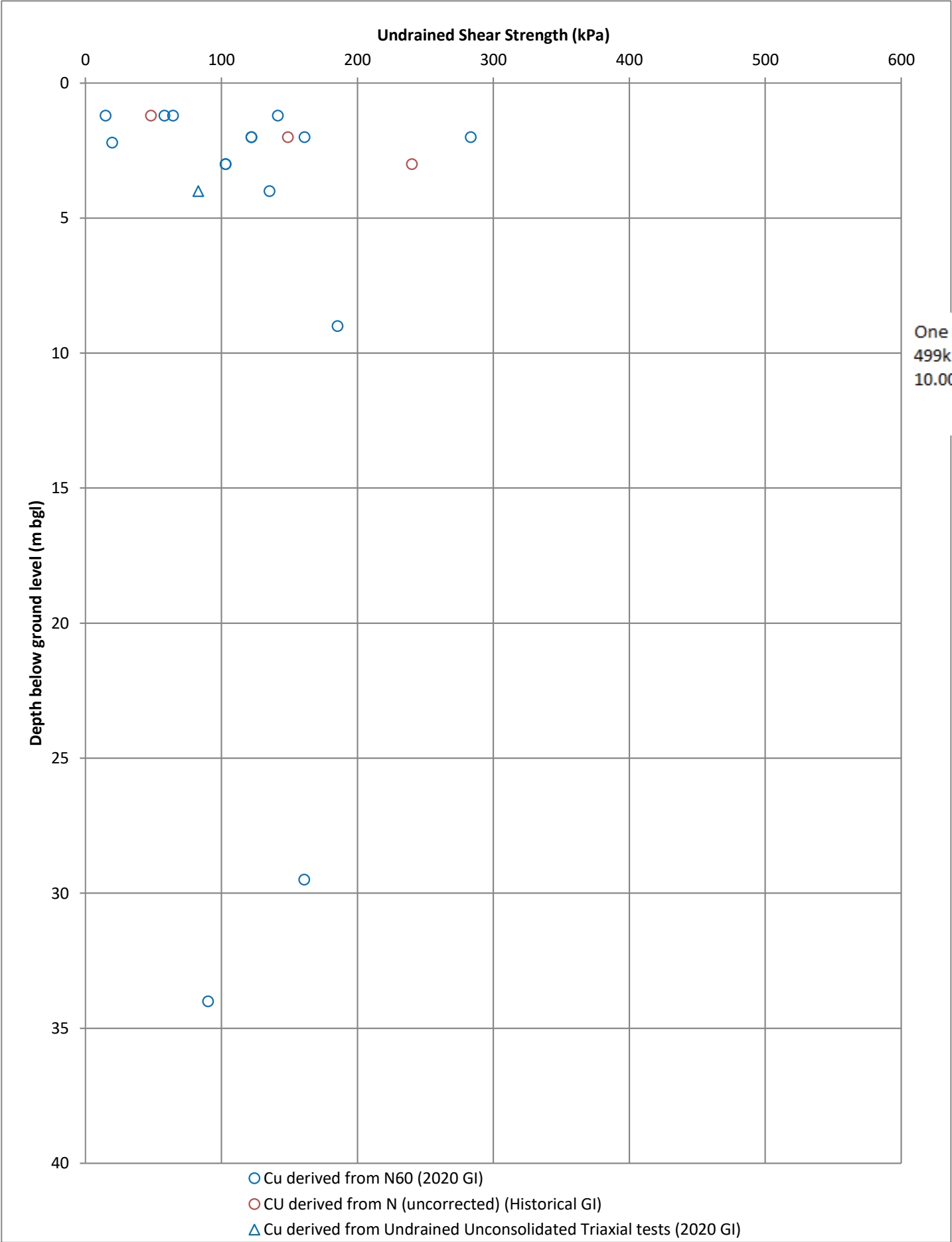
Checked: RL
Date: 27/3/20

Reviewed: JA
Date: 03/04/20

Status
FINAL

Plot Number
7.4

Rev
P01



Maximum Extrapolated N60 Value	200
f, value (Cu = f ₁ N60)	4.8



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Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

Undrained Shear Strength vs Depth for Harwich Formation

Sheet size
A4

Drawn: HEF
Date: 10/3/20

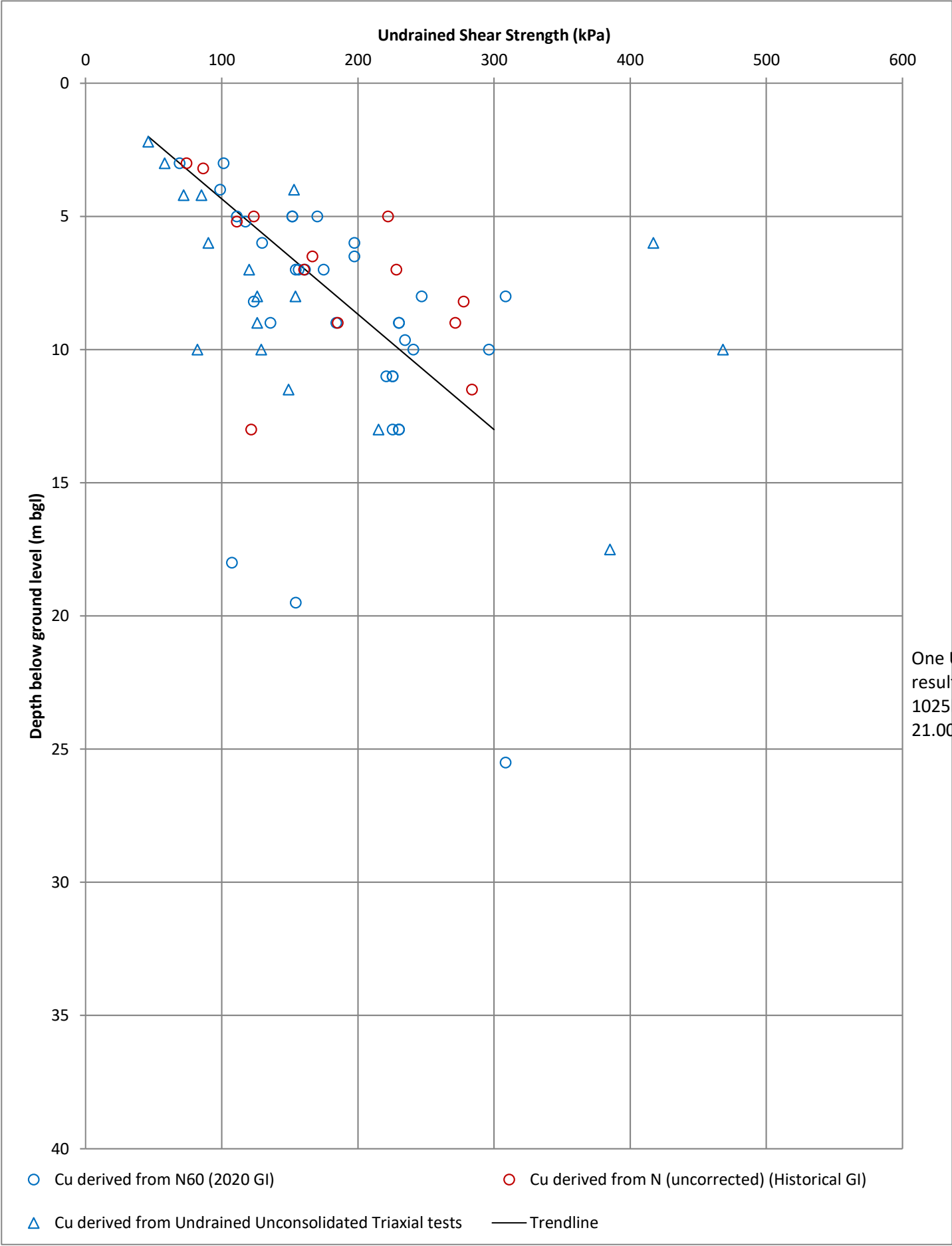
Checked: RL
Date:27/3/20

Reviewed: JA
Date: 03/04/20

Status
FINAL

Plot Number
7.5

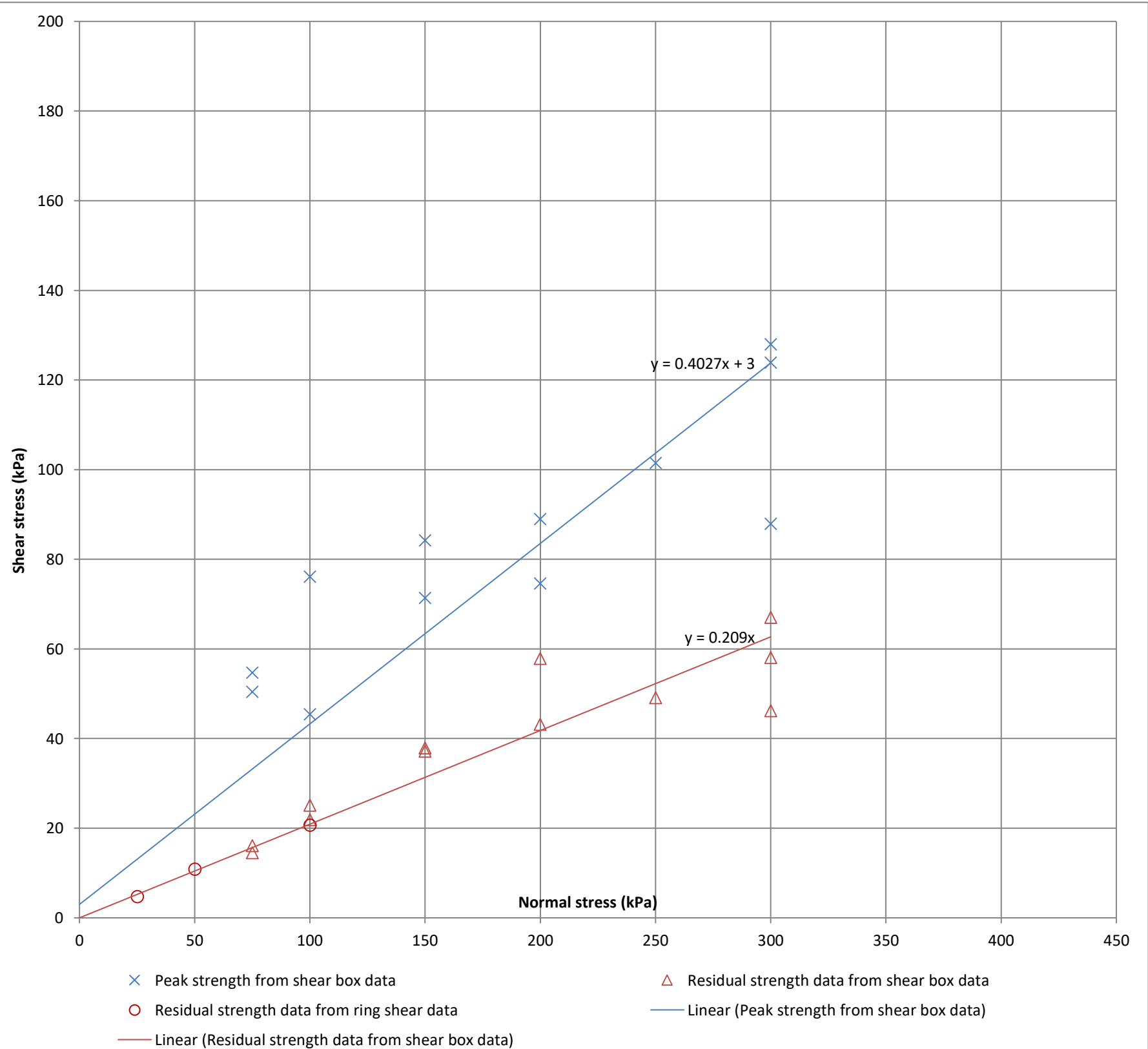
Rev
P01



One UU Triaxial
result of
1025kPa at
21.00m bgl

Maximum Extrapolated N60 Value	200
f, value (Cu = f ₁ N60)	4.6

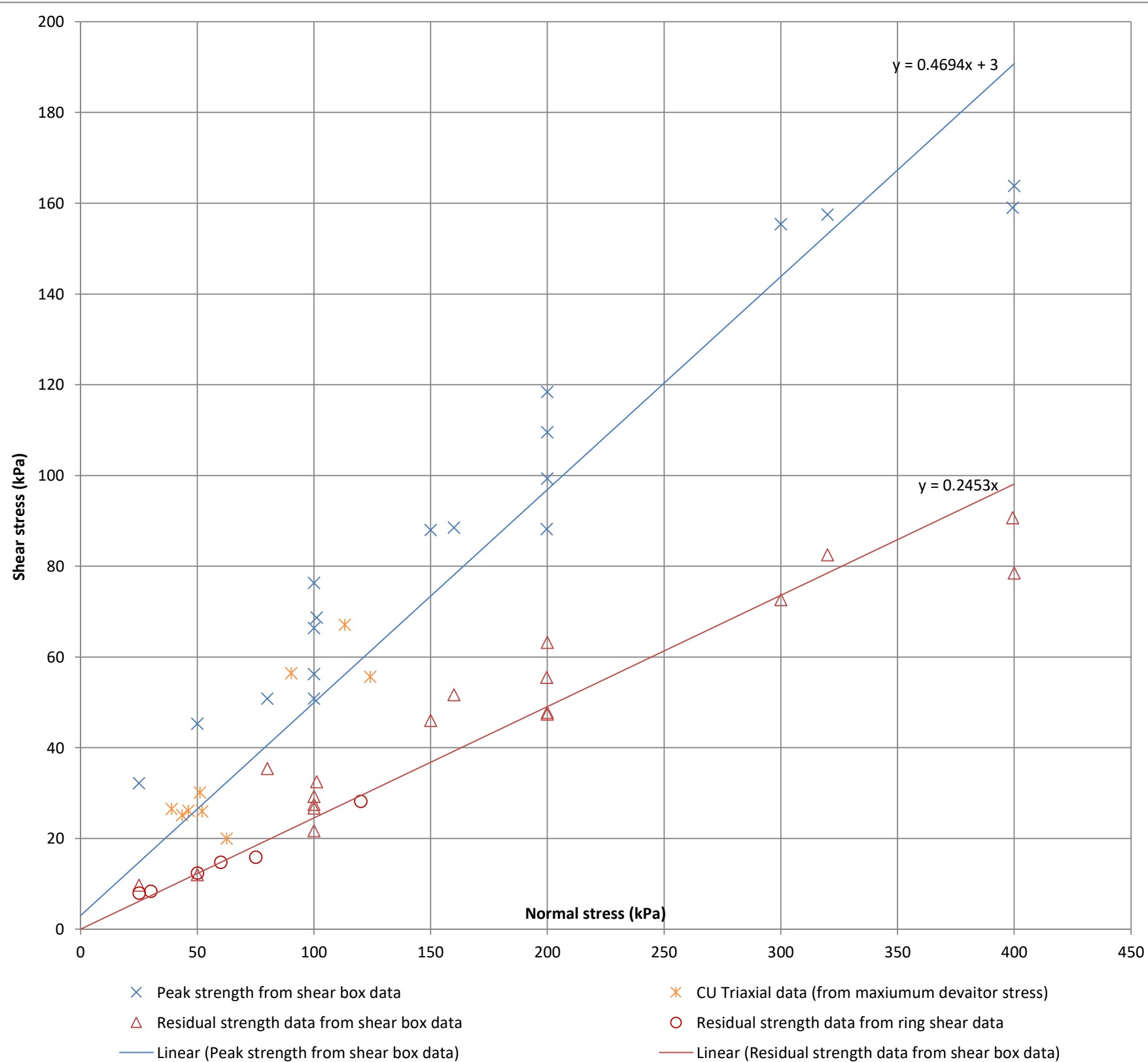
ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055 <td> Client Portsmouth Water </td> <td colspan="4"> Title Undrained Shear Strength vs Depth for Reading Formation </td>	Client Portsmouth Water	Title Undrained Shear Strength vs Depth for Reading Formation			
	Project Havant Thicket Winter Storage Reservoir	Sheet size A4	Drawn: HEF Date: 10/3/20	Checked: RL Date: 27/3/20	Reviewed: JA Date: 03/04/20
		Status FINAL	Plot Number 7.6		Rev P01



c'p =	3.0
φ'p =	21.9

c'r =	0
φ'r =	11.8

ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Tel: (01372) 726140 Epsom Fax: (01372) 740055 KT18 5BW	Client	Title			
	Project	Effective Strength for Weathered London Clay Formation			
	Havant Thicket Winter Storage Reservoir	Sheet size A4	Drawn: HEF Date: 10/03/20	Checked: RL Date: 24/03/20	Authorised: JA Date: 06/04/20
		Status FINAL	Plot Number 8.1	Rev P01	



c'p =	3.0
φ'p =	25.1

c'r =	0
φ'r =	13.8

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Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

Effective Strength for Unweathered London Clay Formation

Sheet size

A4

Drawn: HEF

Date: 10/03/20

Checked: RL

Date: 24/03/20

Authorised: JA

Date: 06/04/20

Status

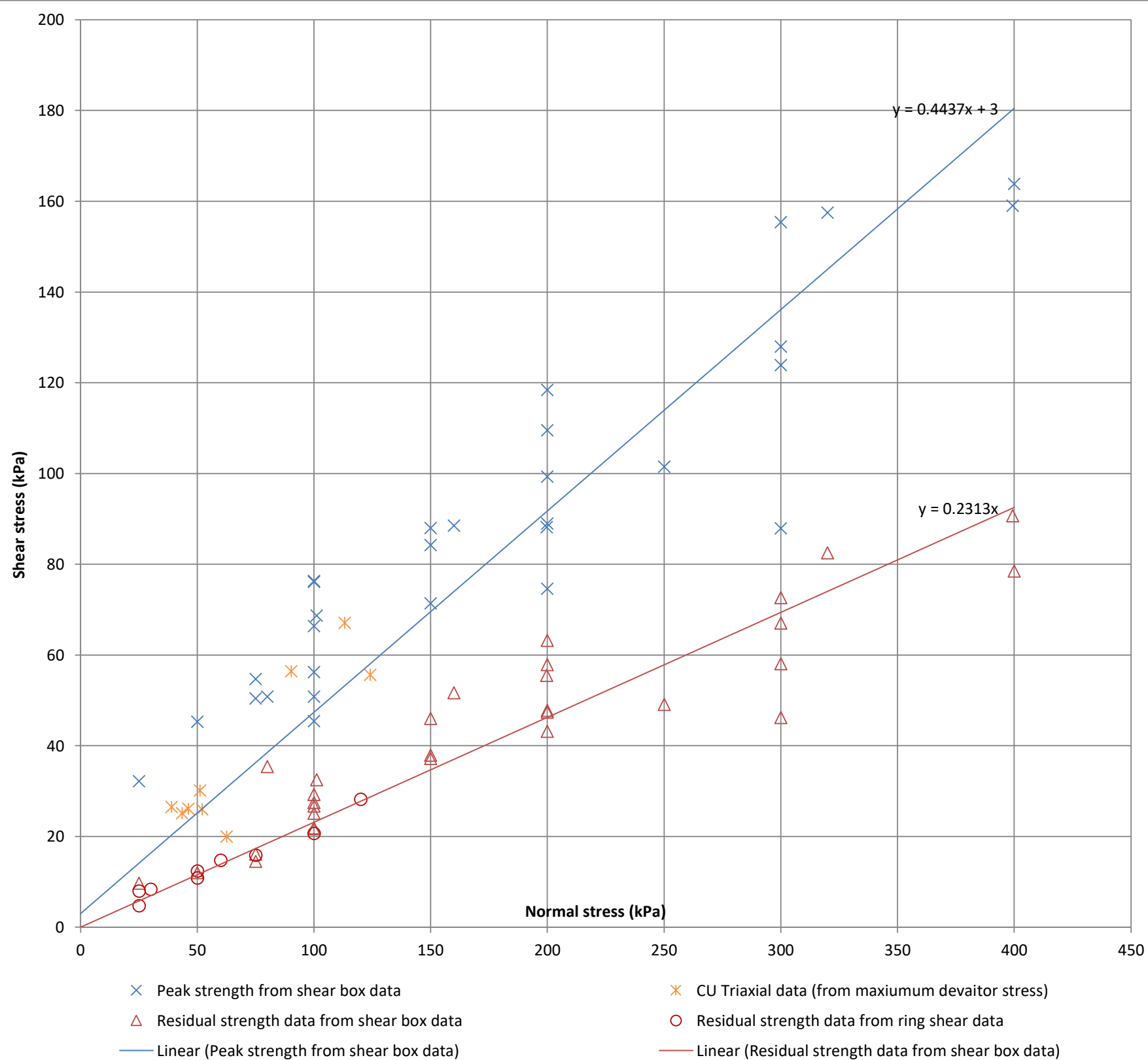
FINAL

Plot Number

8.2

Rev

P01



$c'_p = 3.0$
$\phi'_p = 23.9$

$c'_r = 0$
$\phi'_r = 13.0$

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Client

Portsmouth Water

Project

Havant Thicket Winter Storage Reservoir

Title

**Effective Strength for London Clay Formation
(including weathered section)**

Sheet size

A4

Drawn: HEF

Date: 10/03/20

Checked: RL

Date: 24/03/20

Authorised: JA

Date: 06/04/20

Status

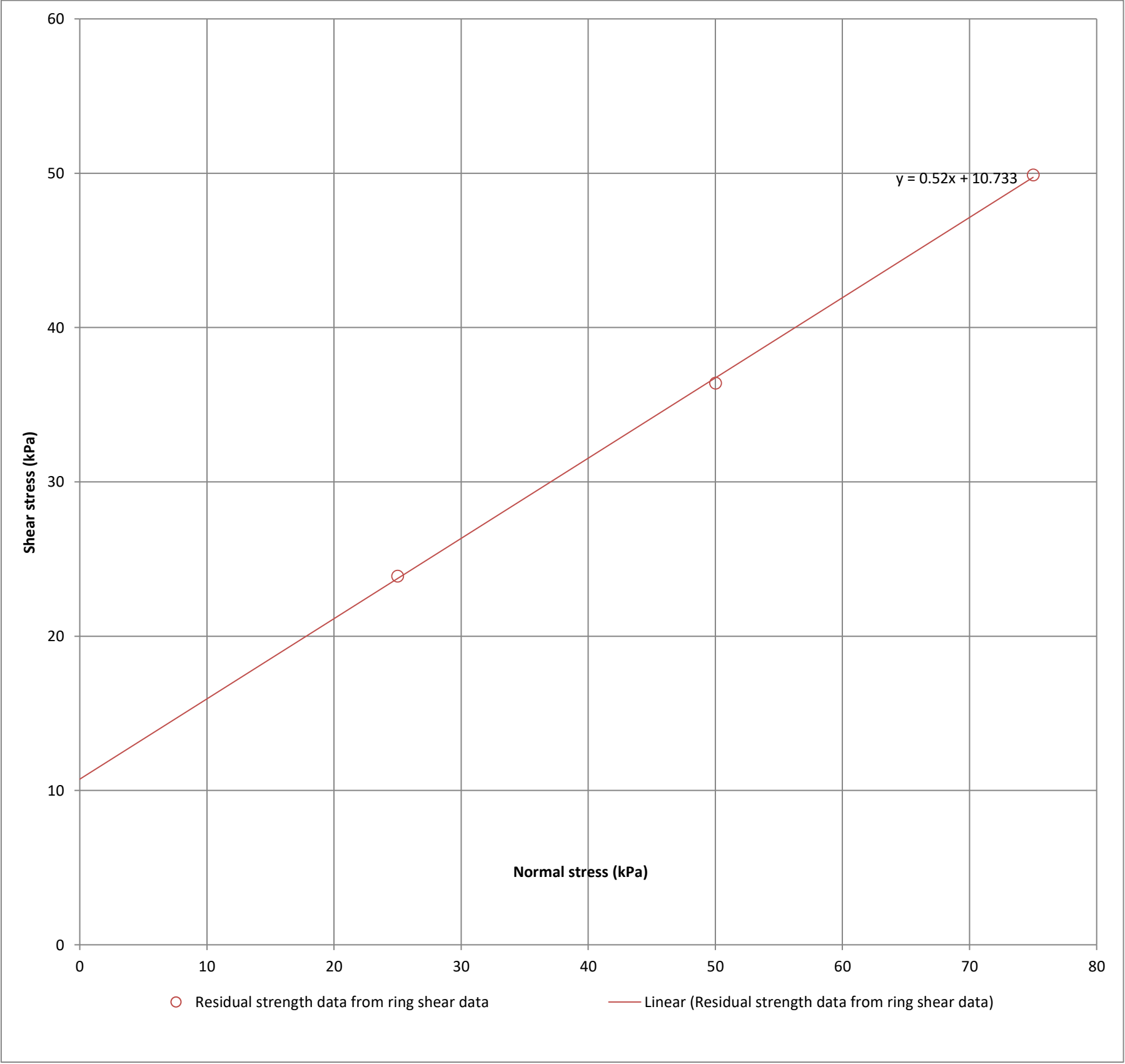
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Plot Number

8.3

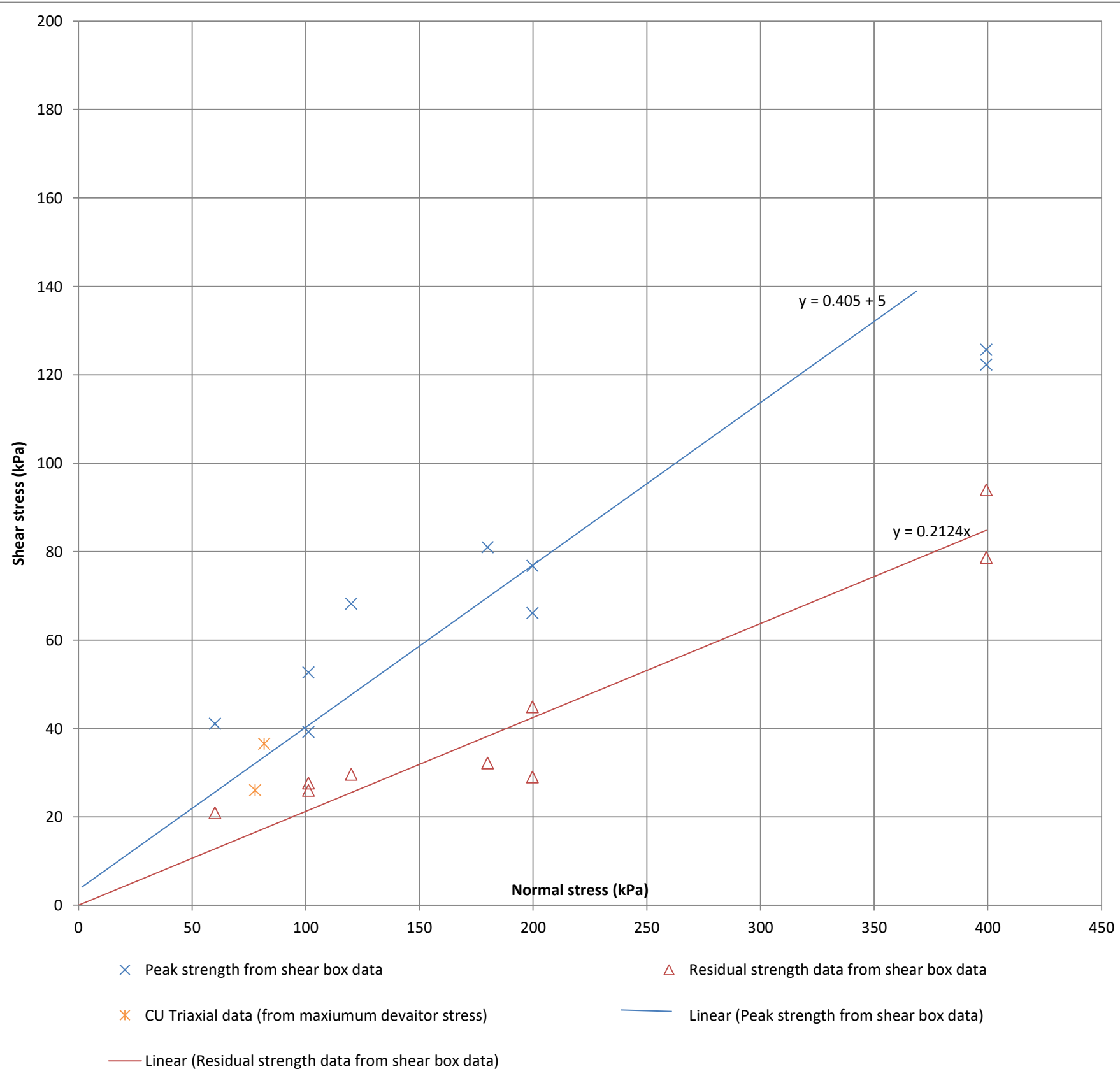
Rev

P01



c'r =	11
φ'r =	27.5

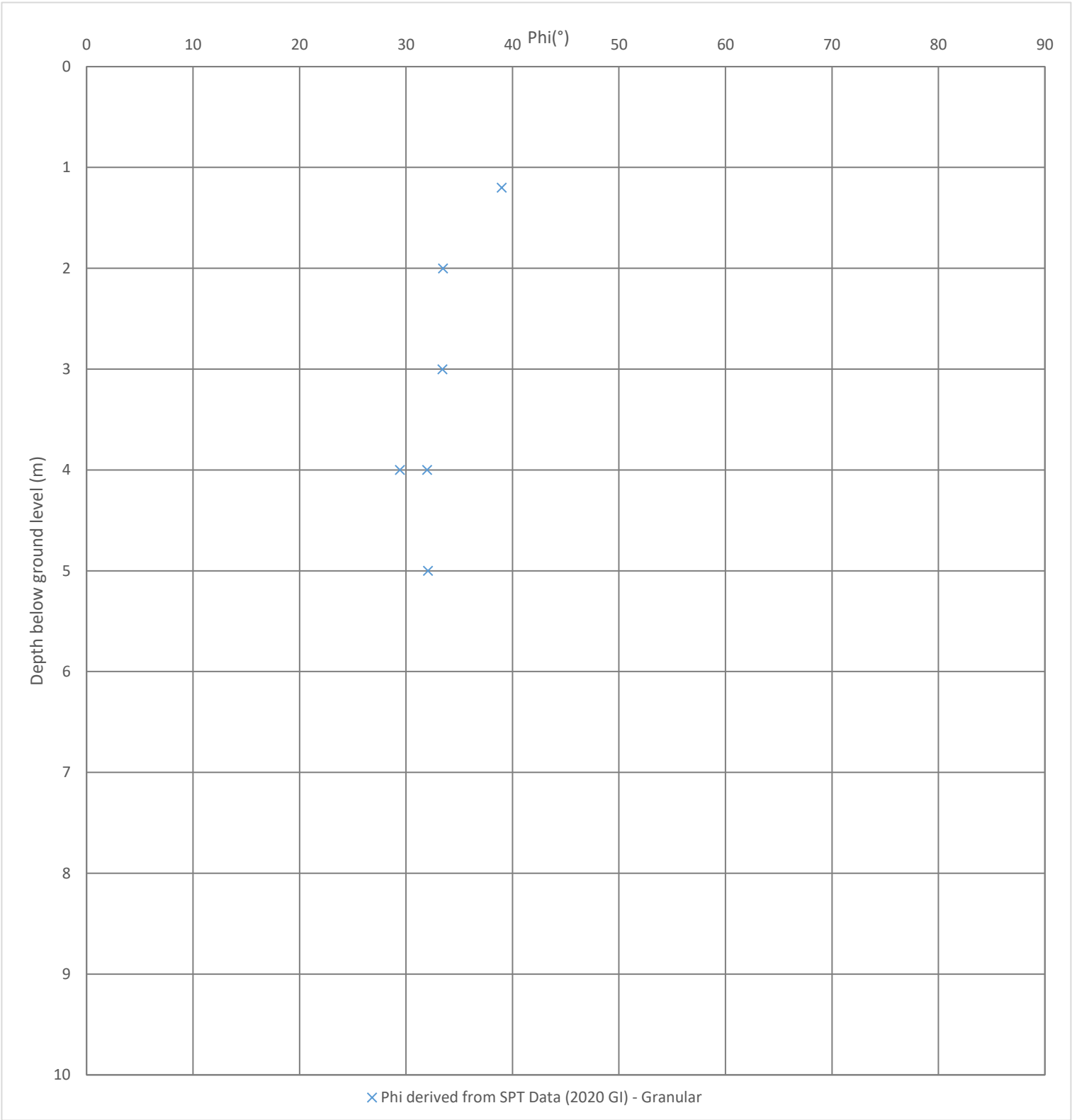
ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Tel: (01372) 726140 Epsom Fax: (01372) 740055 KT18 5BW	Client	Title			
		Portsmouth Water			
	Project	Sheet size	Drawn: HEF	Checked: RL	Authorised: JA
Havant Thicket Winter Storage Reservoir		A4	Date:10/03/20	Date: 24/03/20	Date: 06/04/20
		Status	Plot Number		Rev
		FINAL	8.4		P01



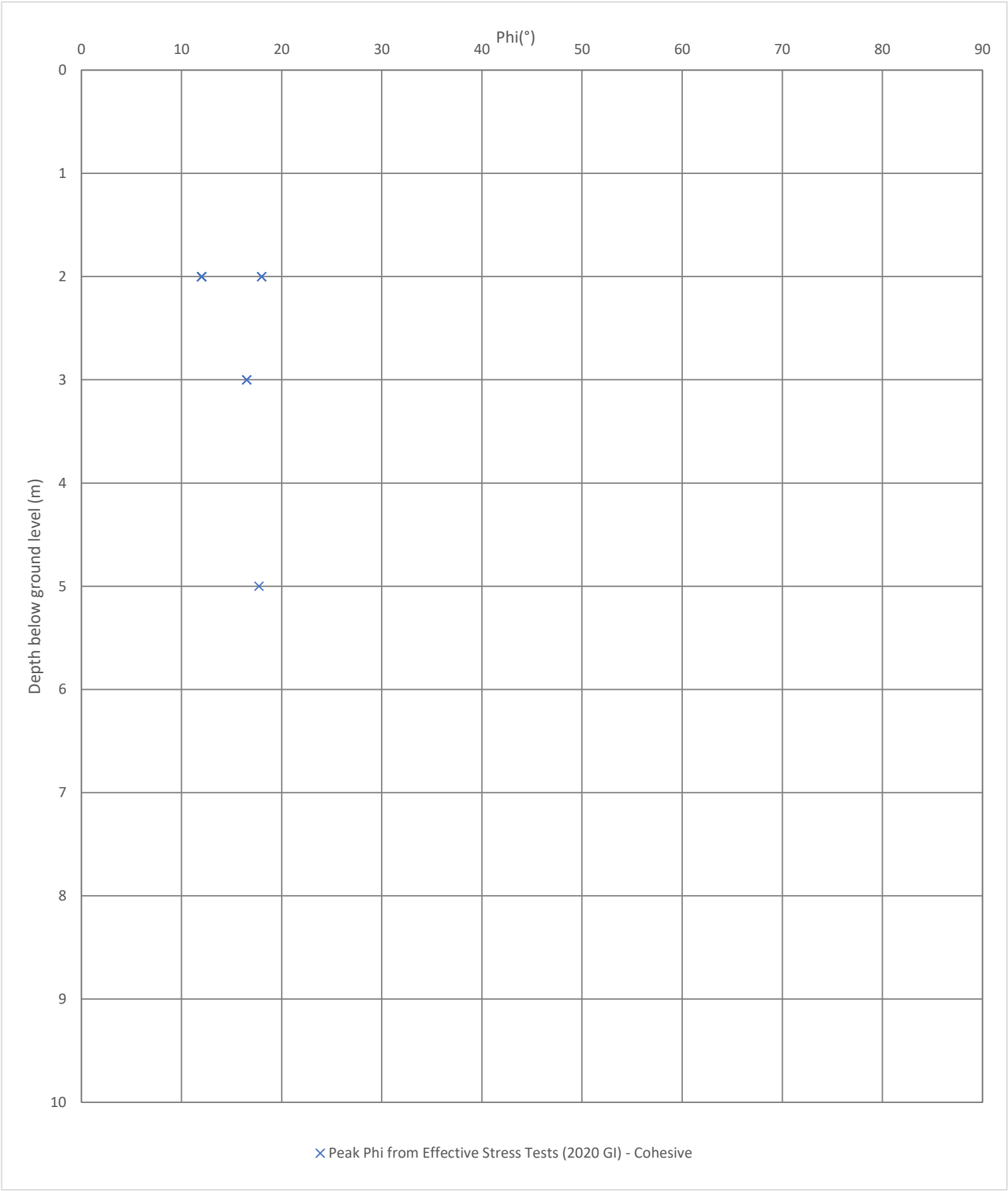
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φ'p =	22.0

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φ'r =	12.0

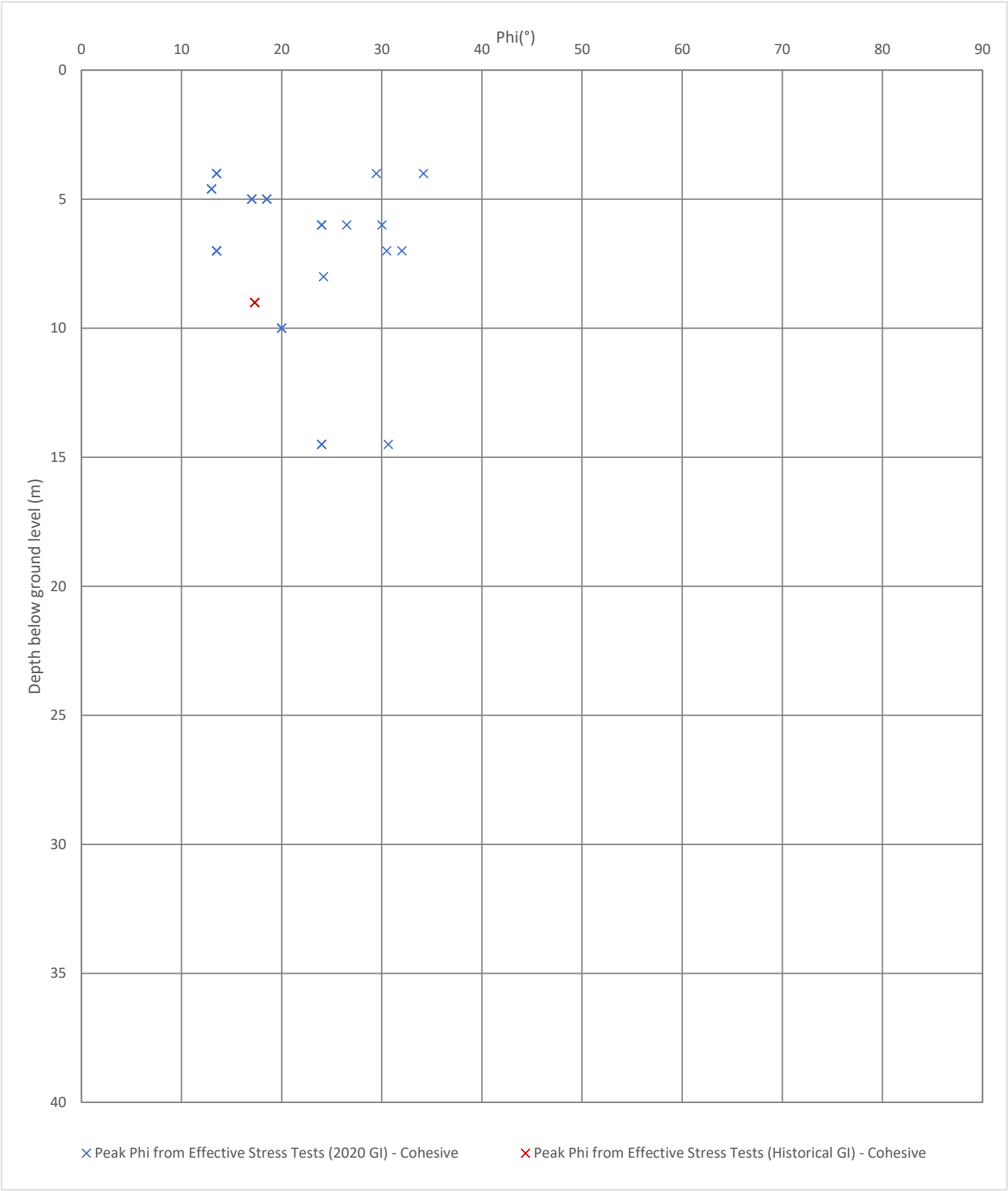
ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Tel: (01372) 726140 Epsom Fax: (01372) 740055 KT18 5BW	Client	Portsmouth Water			Title		
	Project	Havant Thicket Winter Storage Reservoir			Sheet size	Drawn: HEF	Checked: RL
					A4	Date: 10/03/20	Date: 24/03/20
					Status	Plot Number	Authorised: JA
					FINAL	8.5	Date: 06/04/20
							Rev
							P01



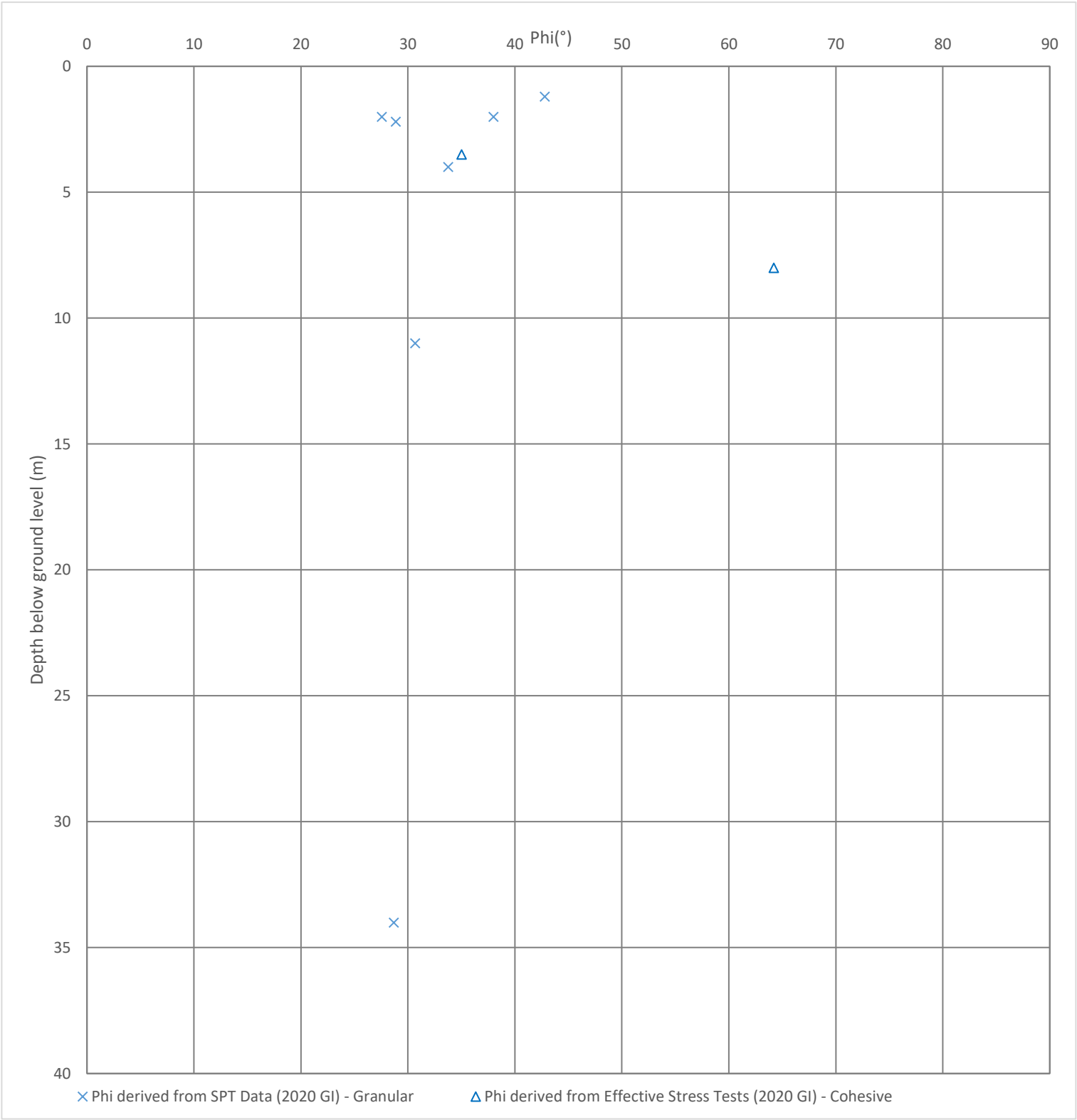
ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Phi vs Depth for Bognor Sand Member (London Clay Formation)			
	Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed:JA
	Havant Thicket Winter Storage Reservoir	A4	Date:10/3/20	Date: 24/3/20	Date:06/4/20
		Status	Plot Number	Rev	
		FINAL	9.1	P01	



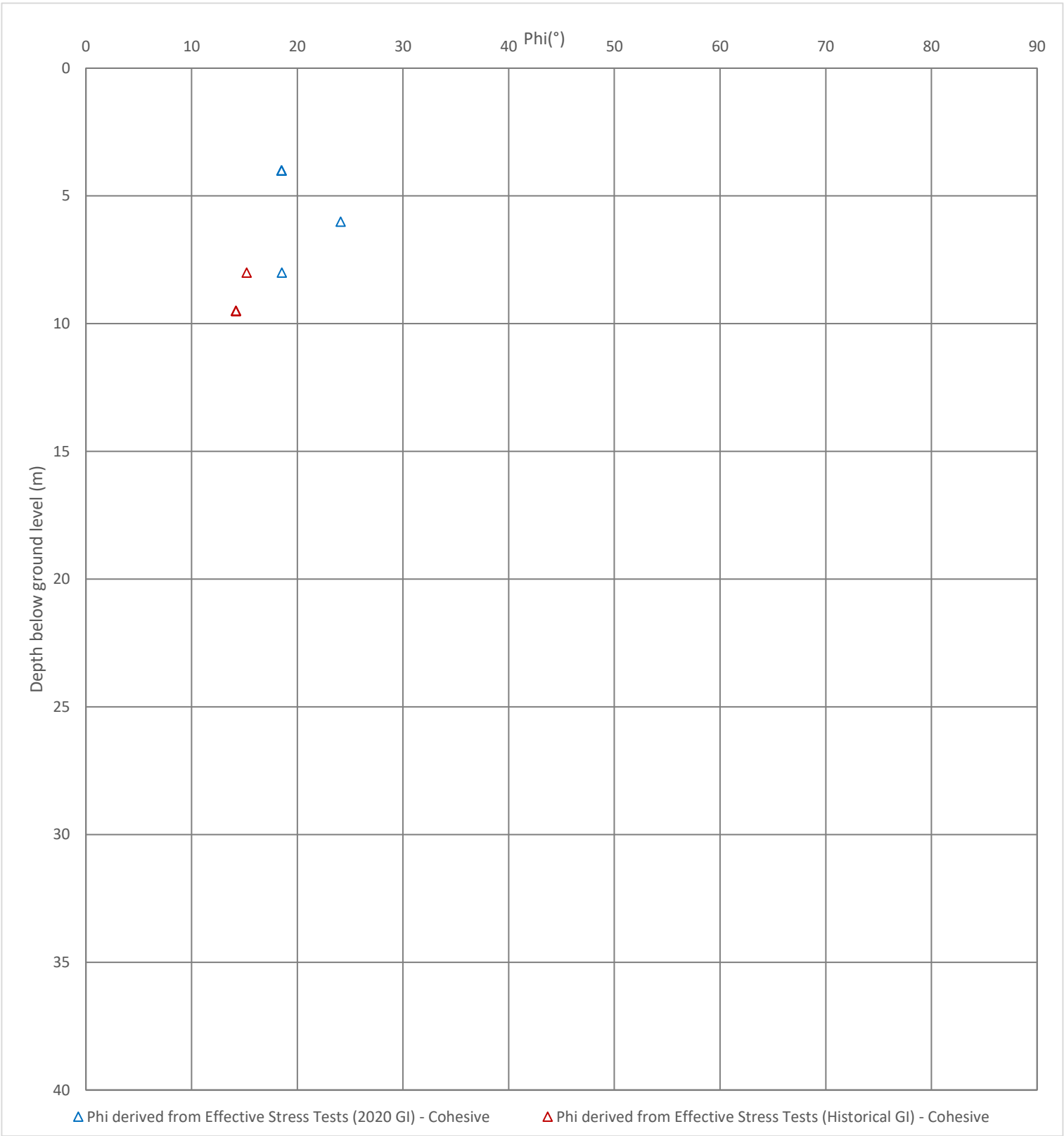
ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Phi vs Depth for Weathered London Clay Formation			
	Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed:JA
Havant Thicket Winter Storage Reservoir		A4	Date:10/3/20	Date: 24/3/20	Date:06/4/20
		Status	Plot Number		Rev
		FINAL	9.2		P01



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	Portsmouth Water	Phi vs Depth for Unweathered London Clay Formation			
	Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed:JA
Havant Thicket Winter Storage Reservoir		A4	Date:10/3/20	Date: 24/3/20	Date:06/4/20
		Status	Plot Number		Rev
		FINAL	9.3		P01



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	Portsmouth Water		Phi vs Depth for Harwich Formation			
	Project		Sheet size	Drawn: HEF	Checked: RL	Reviewed:JA
	Havant Thicket Winter Storage Reservoir		A4	Date:10/3/20	Date: 24/3/20	Date:06/4/20
			Status	Plot Number		Rev
			FINAL	9.4		P01



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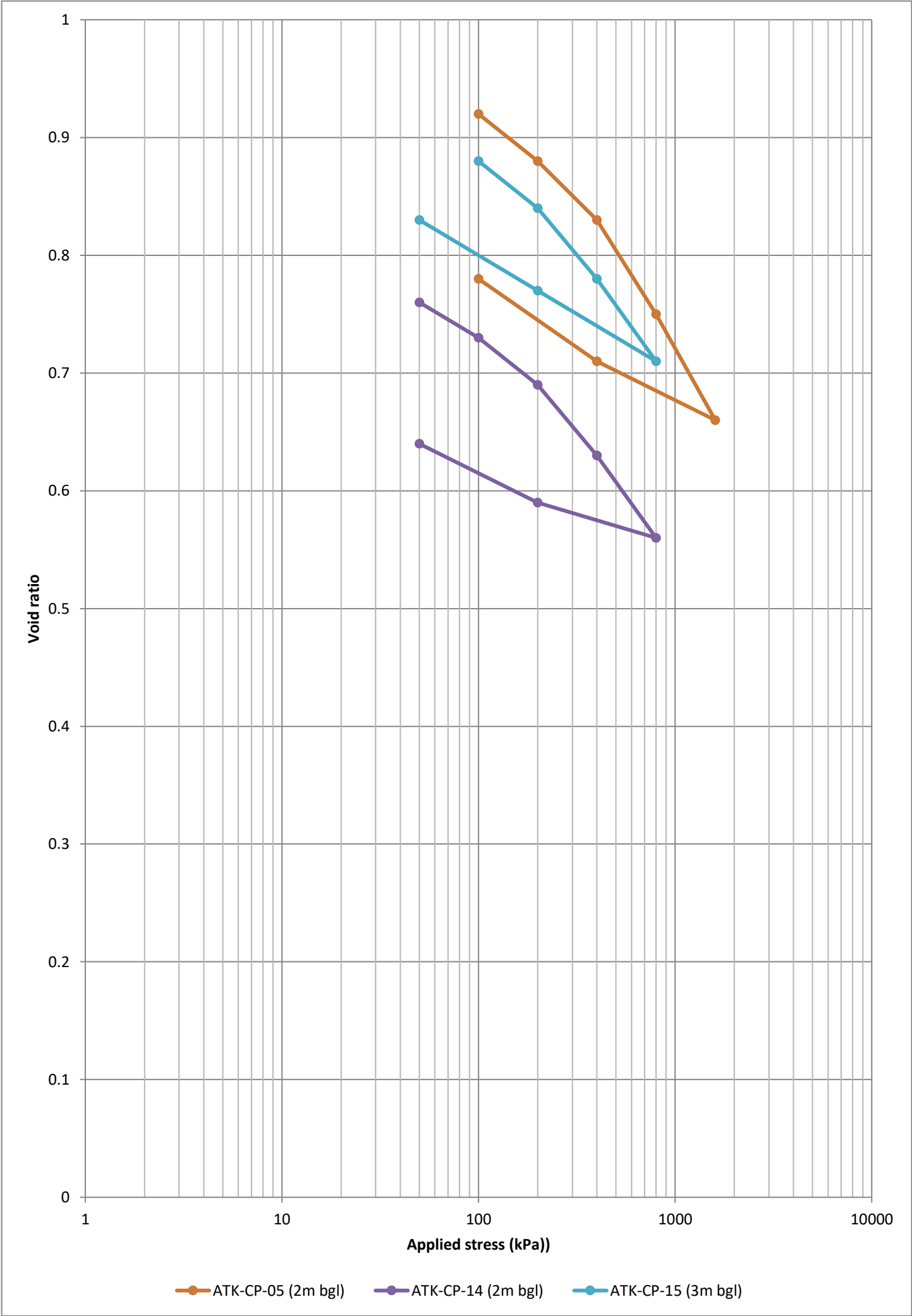
Epsom (All Offices)

Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW

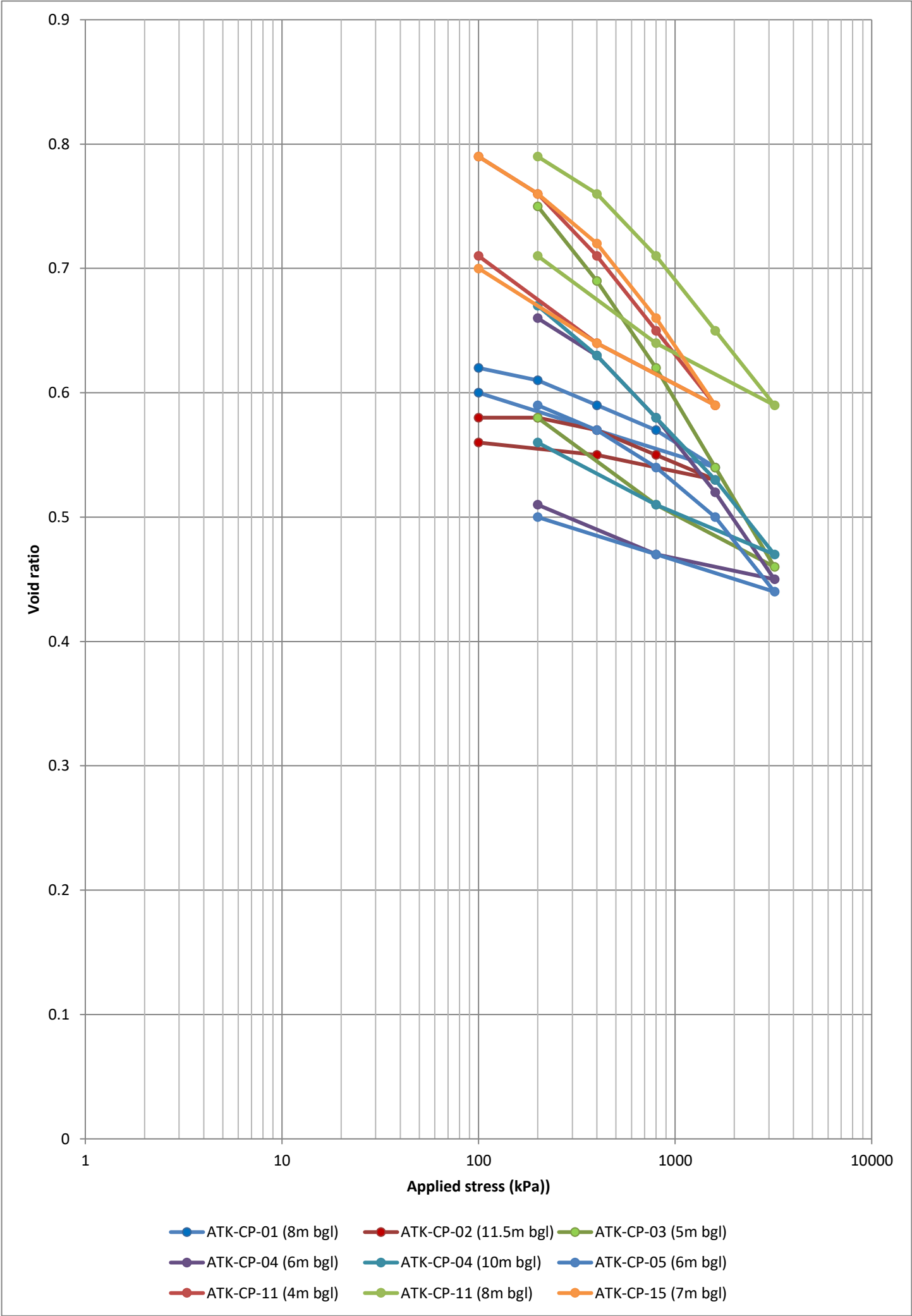
Telephone:

+44 1372 726140

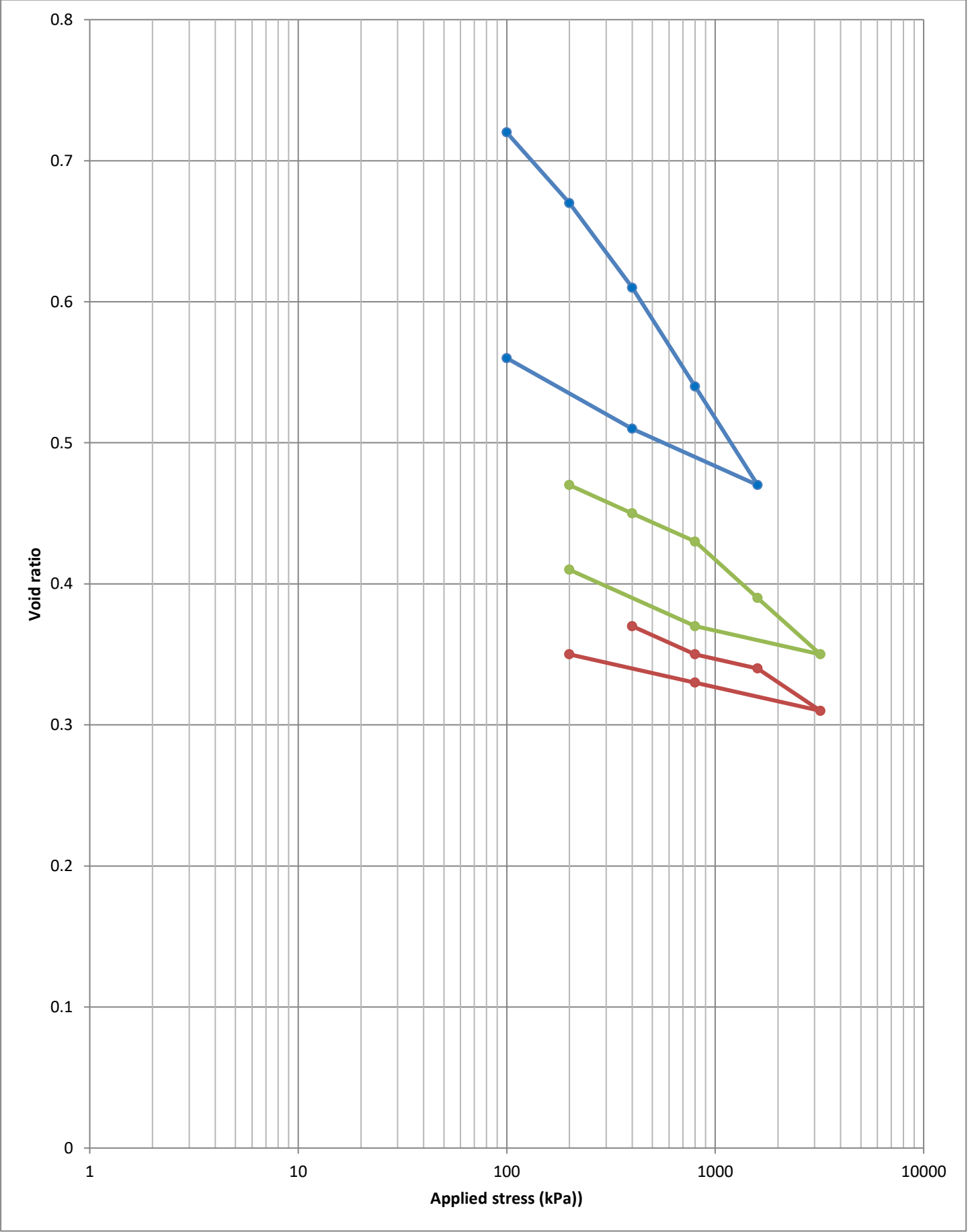
Client	Title			
Portsmouth Water	Phi vs Depth for Reading Formation			
Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed:JA
Havant Thicket Winter Storage Reservoir	A4	Date:10/3/20	Date: 24/3/20	Date:06/4/20
	Status	Plot Number		Rev
	FINAL	9.5		P01



ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Applied Stress vs Void Ratio for Weathered London Clay Formation			
	Project	Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir		A4	Date:10/3/20	Date: 25/3/20	Date: 03/4/20
		Status	Plot No	Rev	
		FINAL	10.1	P01	



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	Portsmouth Water	Applied Stress vs Void Ratio for Unweathered London Clay Formation			
	Project	Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir		A4	Date:10/3/20	Date: 25/3/20	Date: 03/4/20
		Status	Plot No	Rev	
		FINAL	10.2	P01	



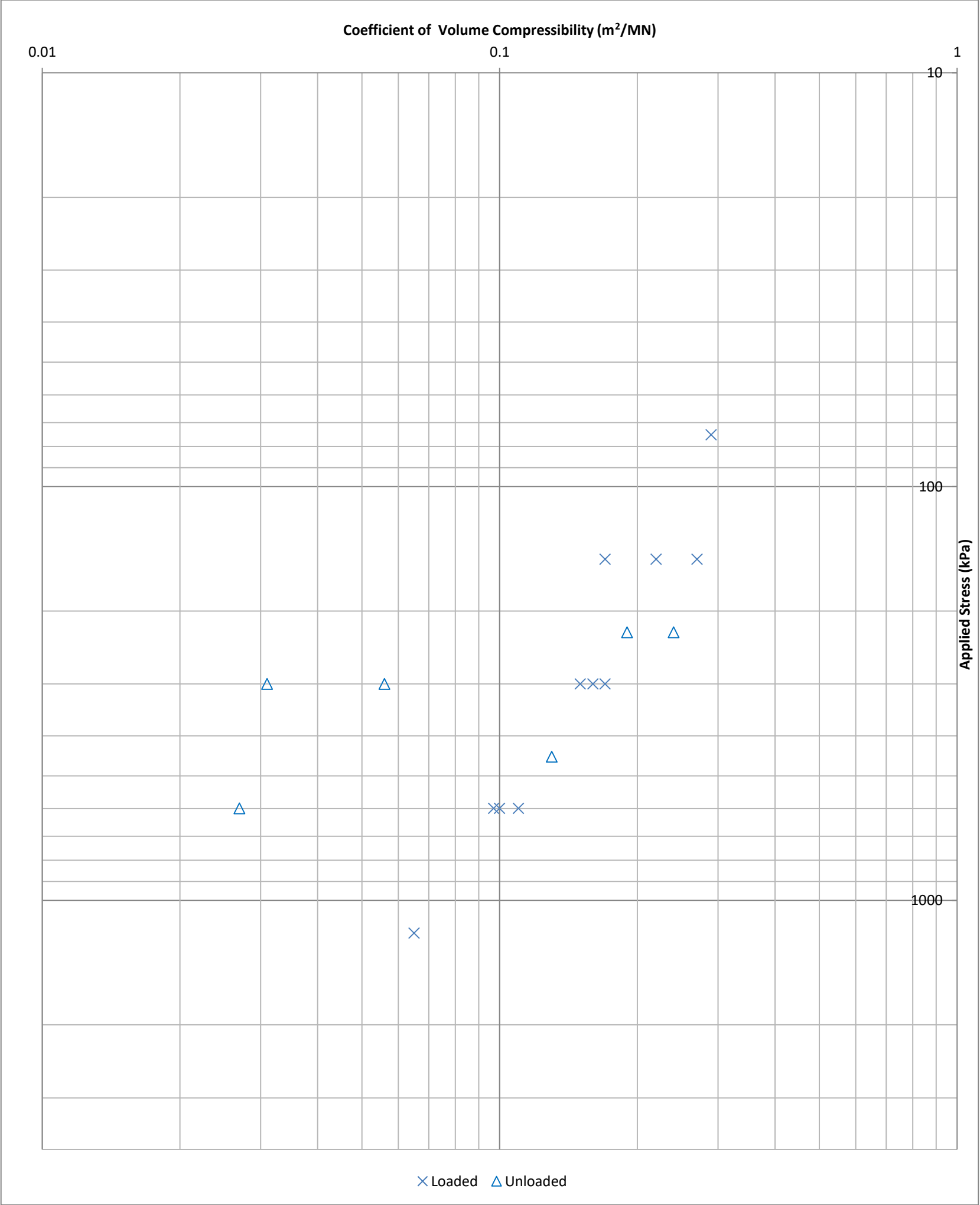
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KT18 5BW

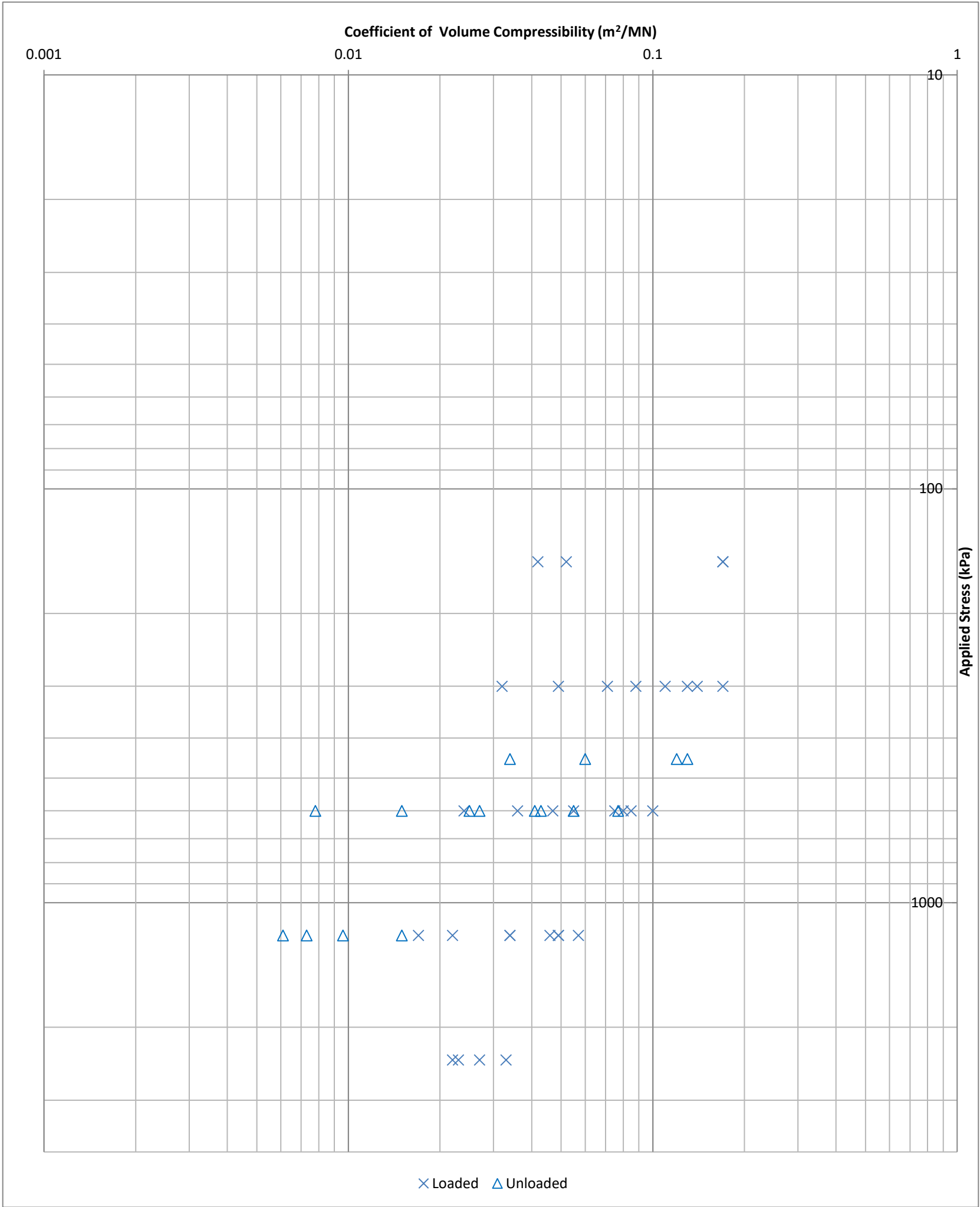
Telephone:
+44 1372 726140

Client
Portsmouth Water
Project
Havant Thicket Winter Storage Reservoir

Title			
Applied Stress vs Void Ratio for Reading Formation			
Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
A4	Date:10/3/20	Date: 25/3/20	Date: 03/4/20
Status	Plot No	Rev	
FINAL	10.3	P01	



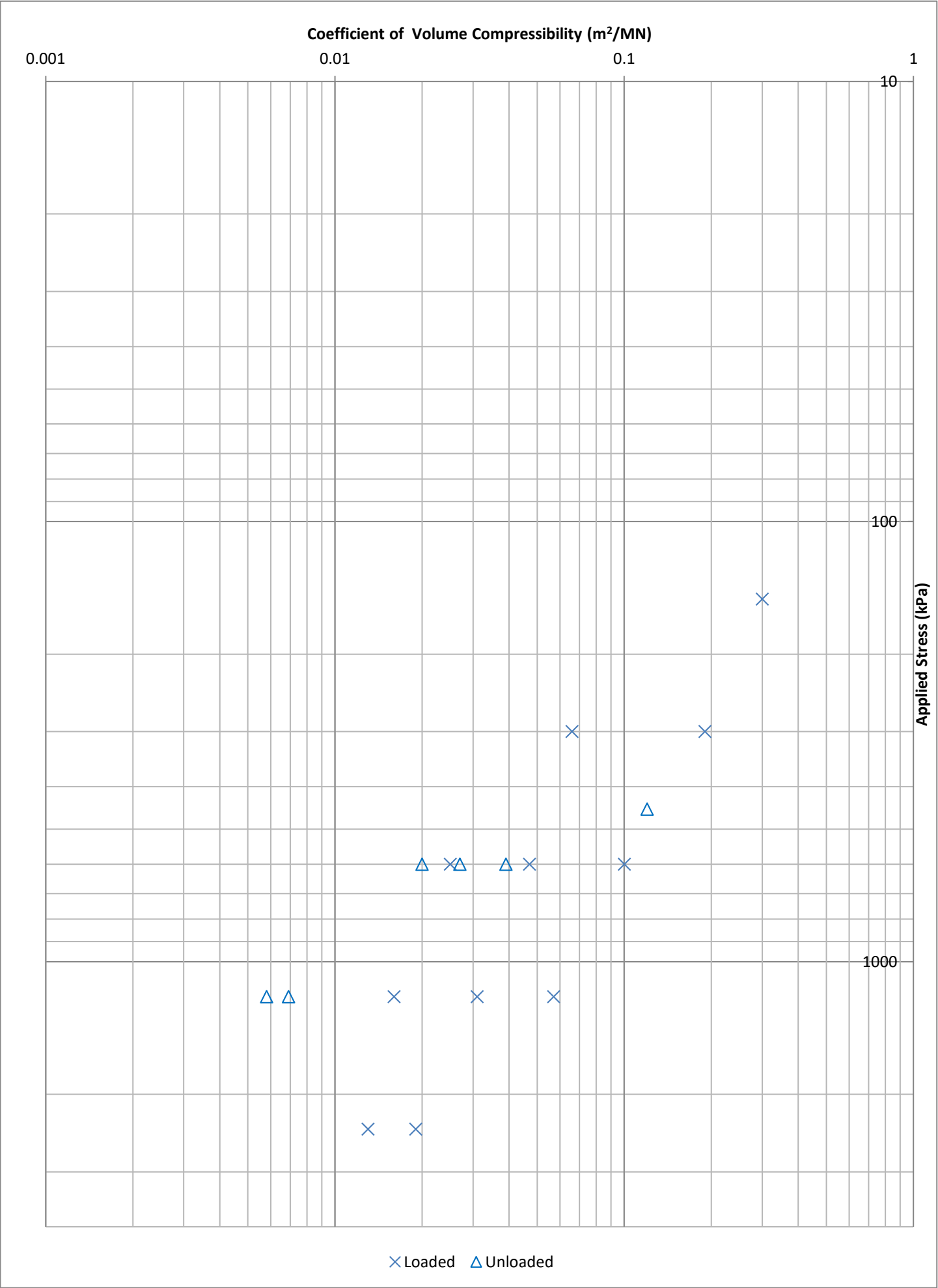
ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client		Title			
	Portsmouth Water		Coefficient of Volume Compressibility vs Applied Stress for Weathered London Clay Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir			A4	Date:10/3/20	Date: 25/3/20	Date: 03/4/20
			Status	Plot No		Rev
			FINAL	11.1		P01



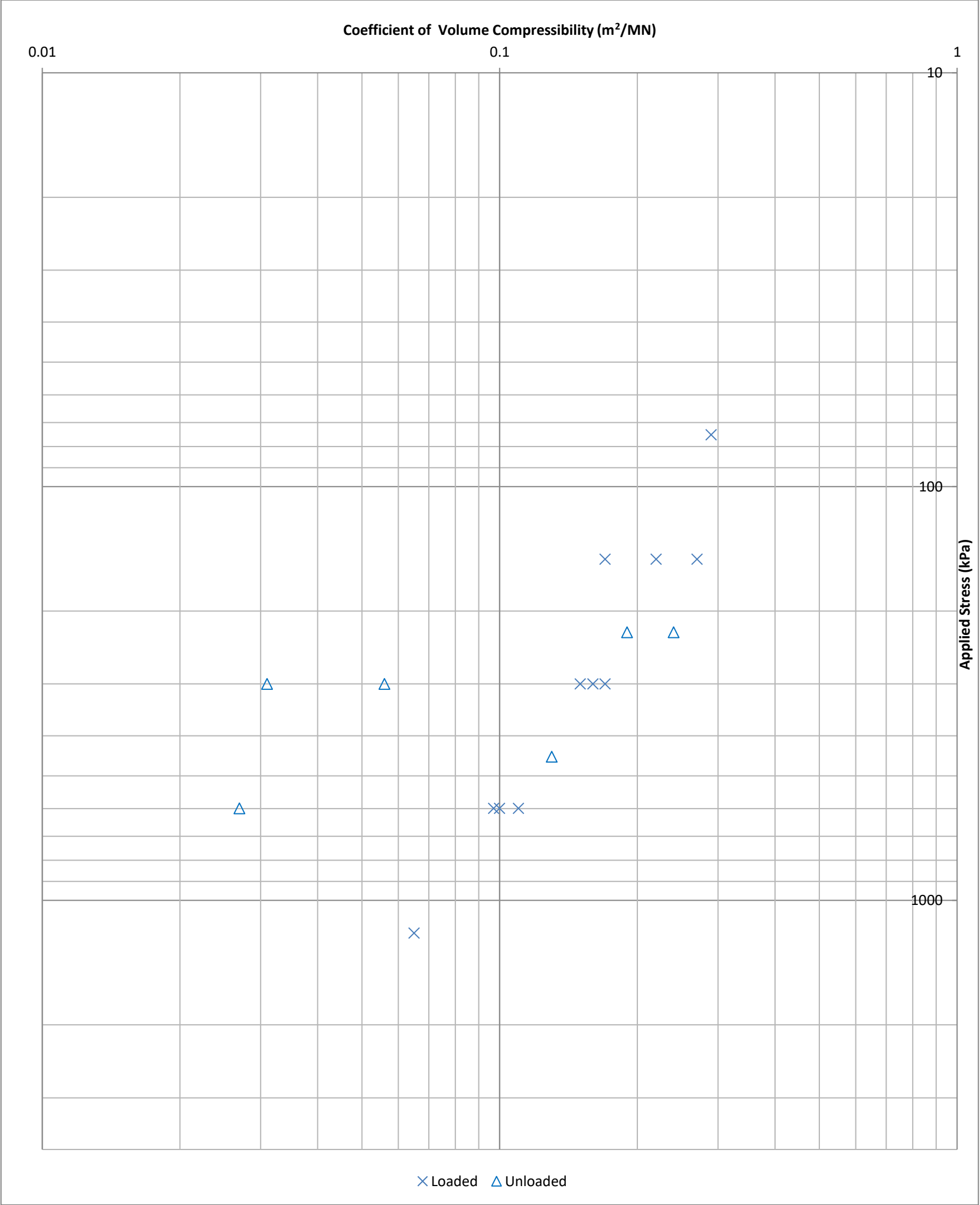
Atkins
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Road, Epsom, Surrey,
KT18 5BW

Client	Portsmouth Water		
Project	Havant Thicket Winter Storage Reservoir		

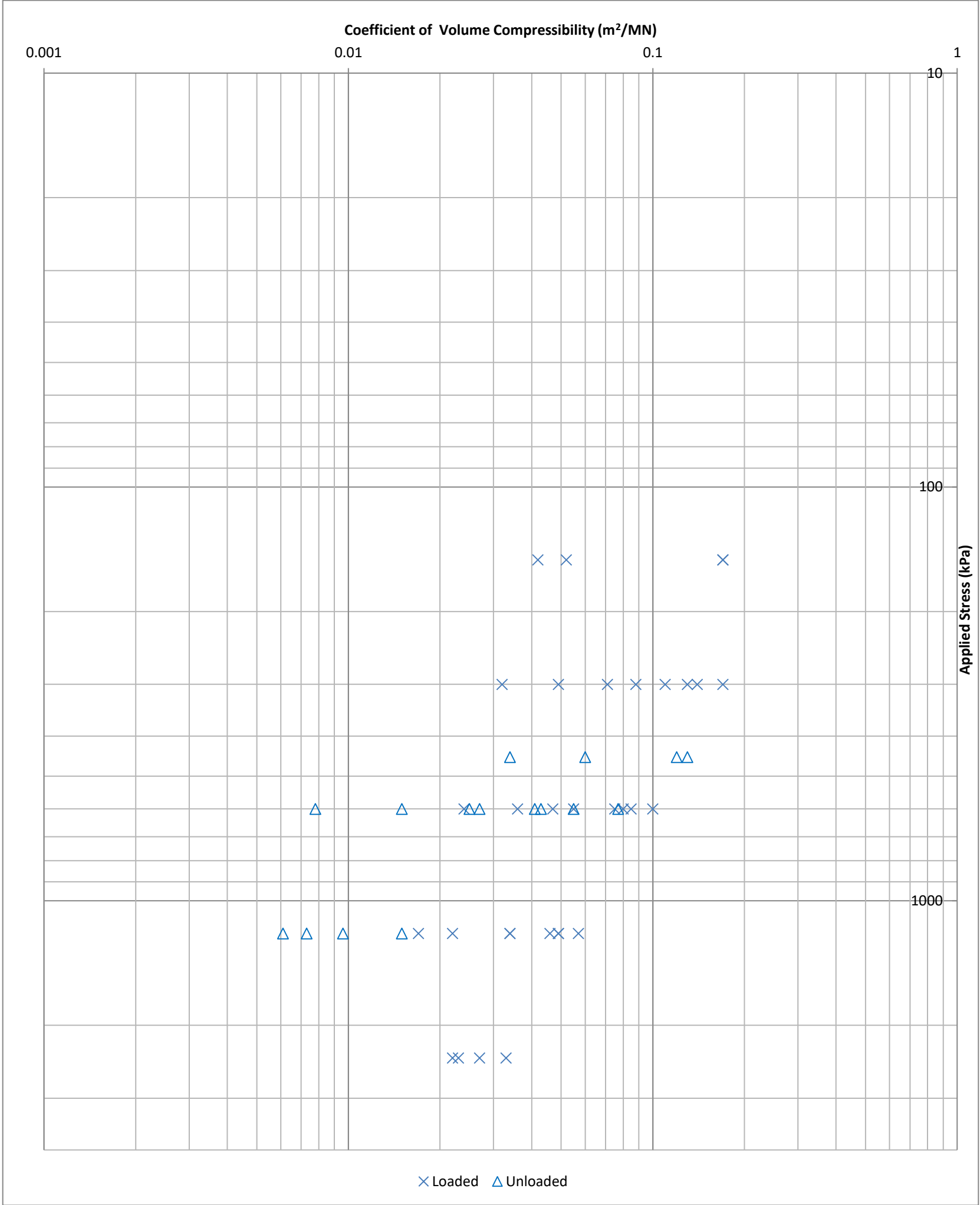
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Coefficient of Volume Compressibility vs Applied Stress for London Clay Formation			
Sheet Size	A4	Drawn: HEF Date:10/3/20	Checked: RL Date: 25/3/20
Status	FINAL	Plot No 11.2	Reviewed: JA Date: 03/4/20 Rev P01



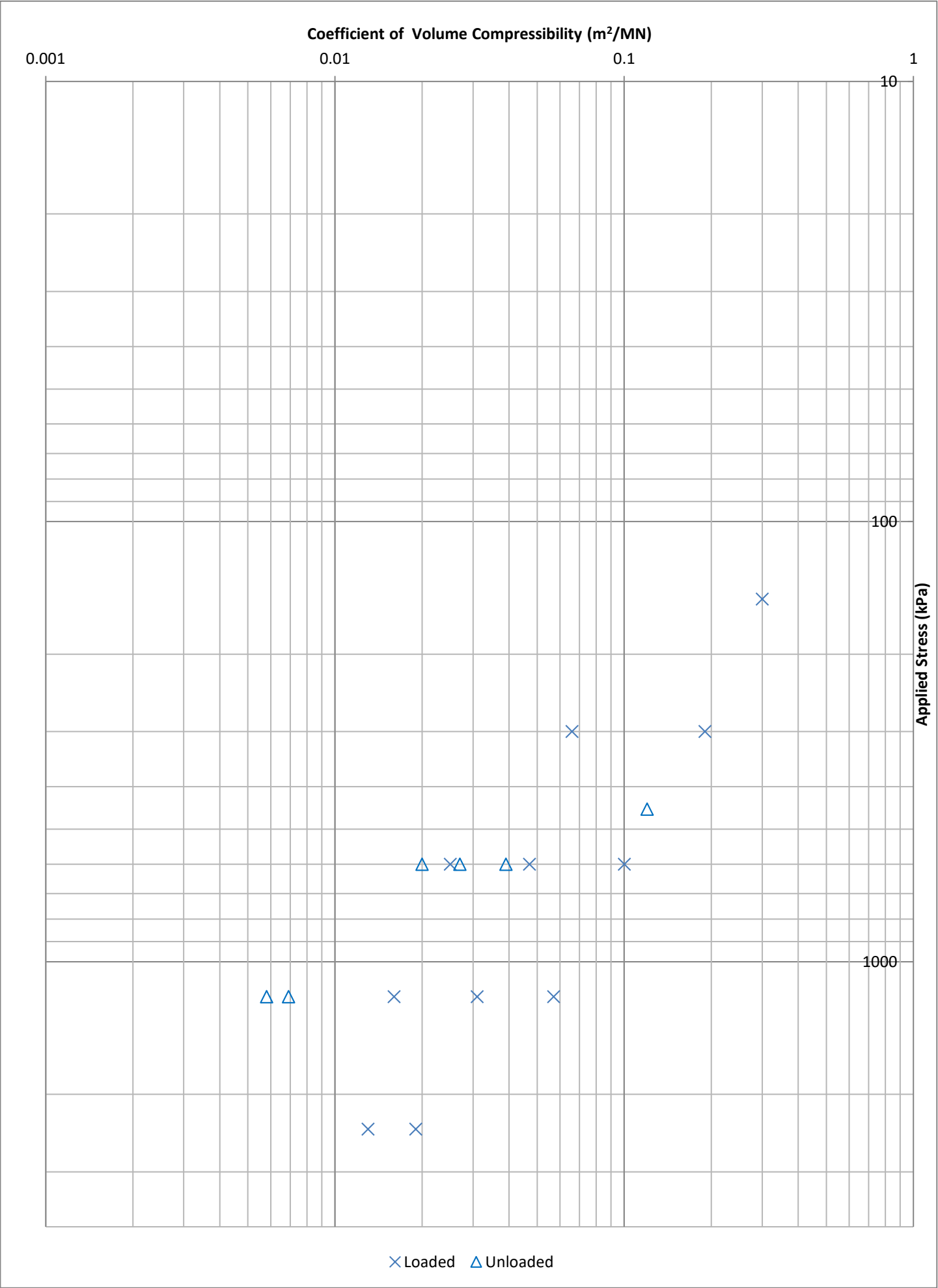
ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client		Title			
	Portsmouth Water		Coefficient of Volume Compressibility vs Applied Stress for Reading Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir		Status	A4	Date:10/3/20	Date: 25/3/20	Date: 03/4/20
			FINAL	Plot No	11.3	Rev P01



ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client		Title			
	Portsmouth Water		Coefficient of Volume Compressibility vs Applied Stress for Weathered London Clay Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir			A4	Date:10/3/20	Date: 25/3/20	Date: 03/4/20
			Status	Plot No		Rev
			FINAL	11.1		P01

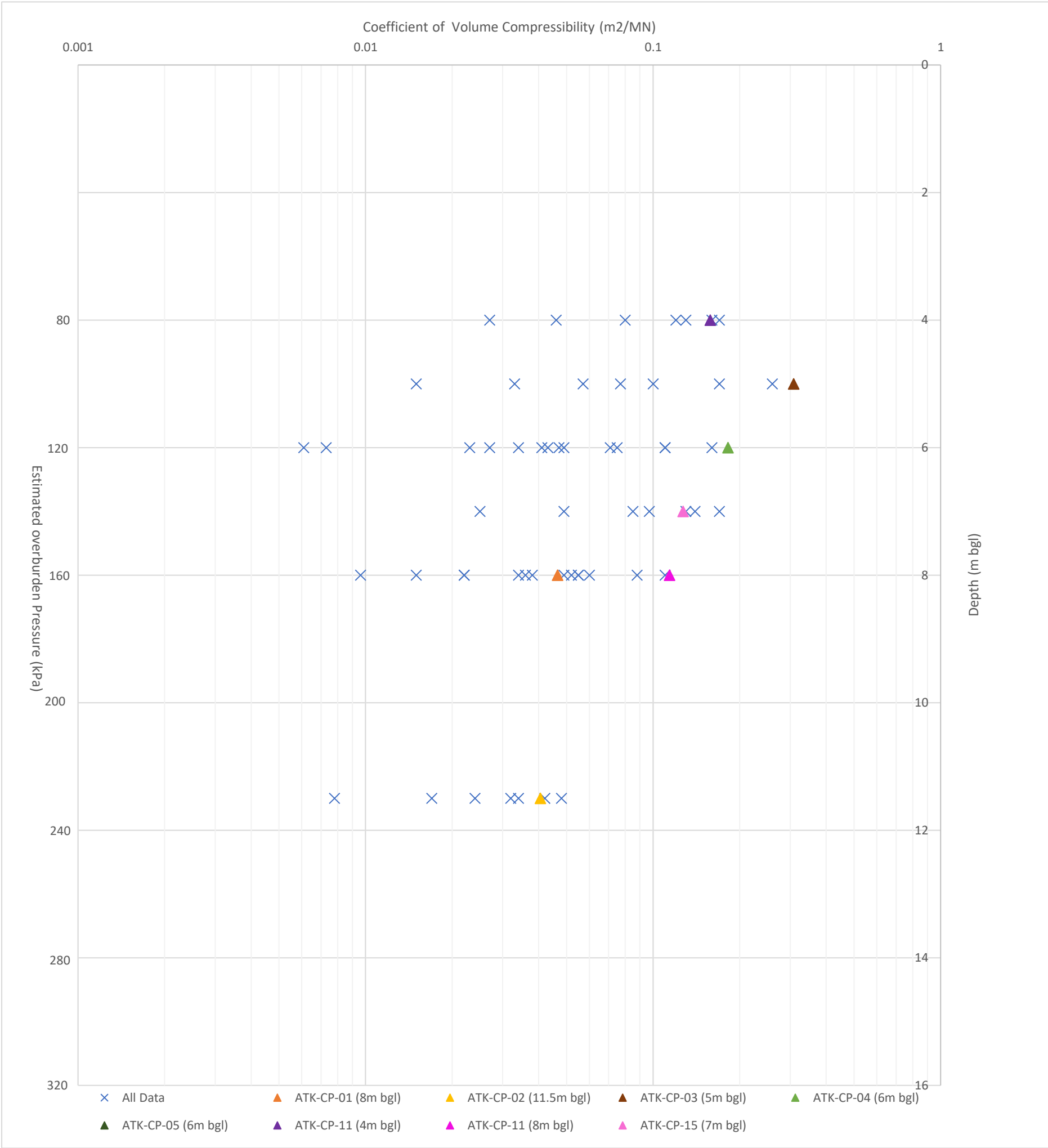


ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client		Title			
	Portsmouth Water		Coefficient of Volume Compressibility vs Applied Stress for Unweathered London Clay Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir			A4	Date:10/3/20	Date: 25/3/20	Date: 03/4/20
		Status	Plot No			Rev
		FINAL	11.2			P01



ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Coefficient of Volume Compressibility vs Applied Stress for Reading Formation			
	Project	Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
	Havant Thicket Winter Storage Reservoir	A4	Date:10/3/20	Date: 25/3/20	Date: 03/4/20
	Status	Plot No		Rev	
	FINAL	11.3		P01	

 Atkins Member of the SNC-Lavalin Group Epsom (All Offices) Telephone: Woodcote Grove, Ashley +44 1372 726140 Road, Epsom, Surrey, KT18 5BW	Client	Title			
	Project	Portsmouth Water Coefficient of Volume Compressibility vs Depth for Weathered London Clay Formation			
	Havant Thicket Winter Storage Reservoir	Sheet Size A4	Drawn: HEF Date:10/3/20	Checked: RL Date: 25/3/20	Reviewed: JA Date: 03/4/20
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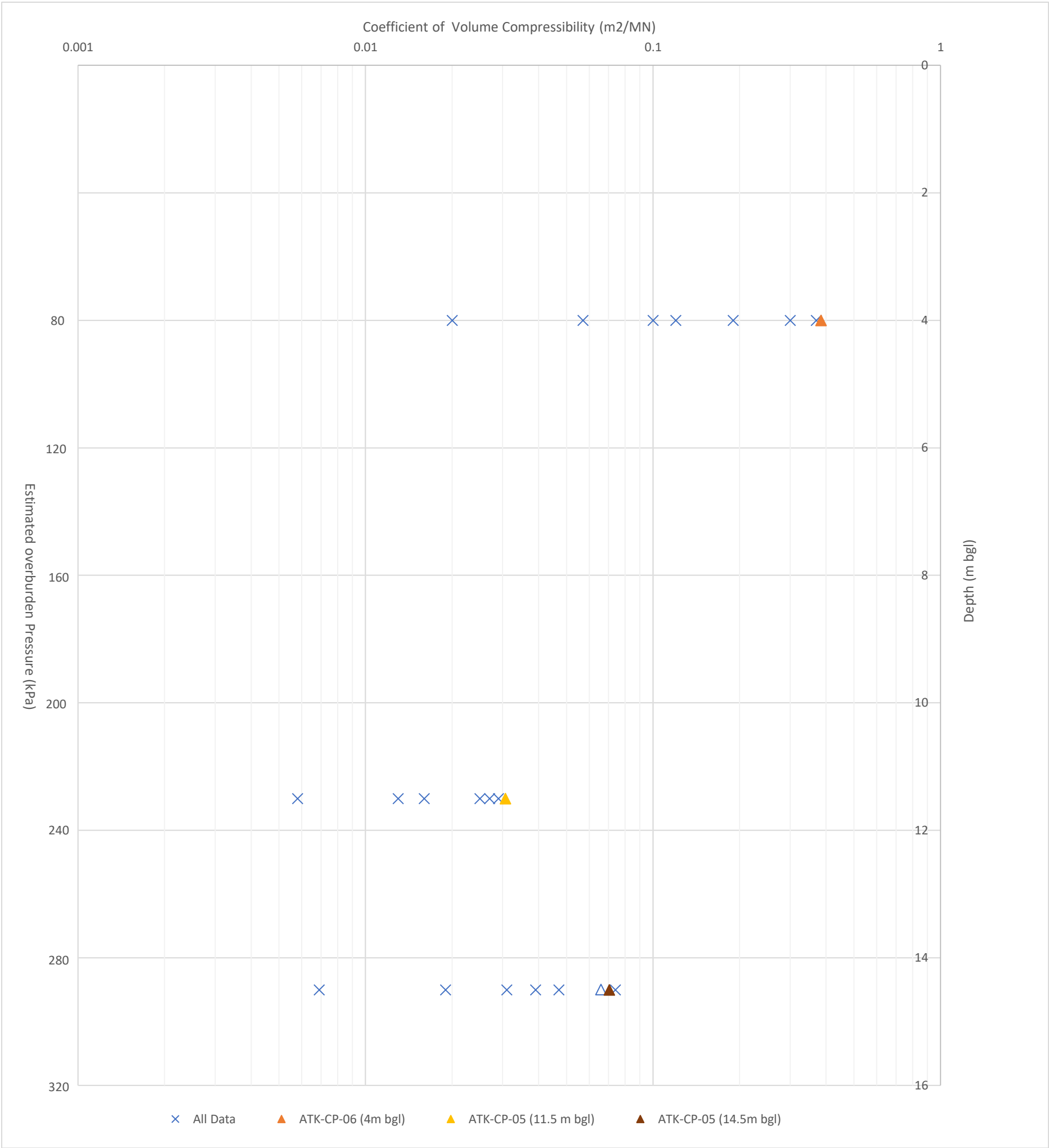
Atkins
Epsom (All Offices)
Woodcote Grove, Ashley
Road, Epsom, Surrey,
KT18 5BW

Telephone:
+44 1372 726140

Client
Portsmouth Water

Project
Havant Thicket Winter Storage Reservoir

Title			
Coefficient of Volume Compressibility vs Depth for Unweathered London Clay Formation			
Sheet Size	Drawn: HEF Date:10/3/20	Checked: RL Date: 25/3/20	Reviewed: JA Date: 03/4/20
A4	Plot No 12.2		Rev P01
Status	FINAL		



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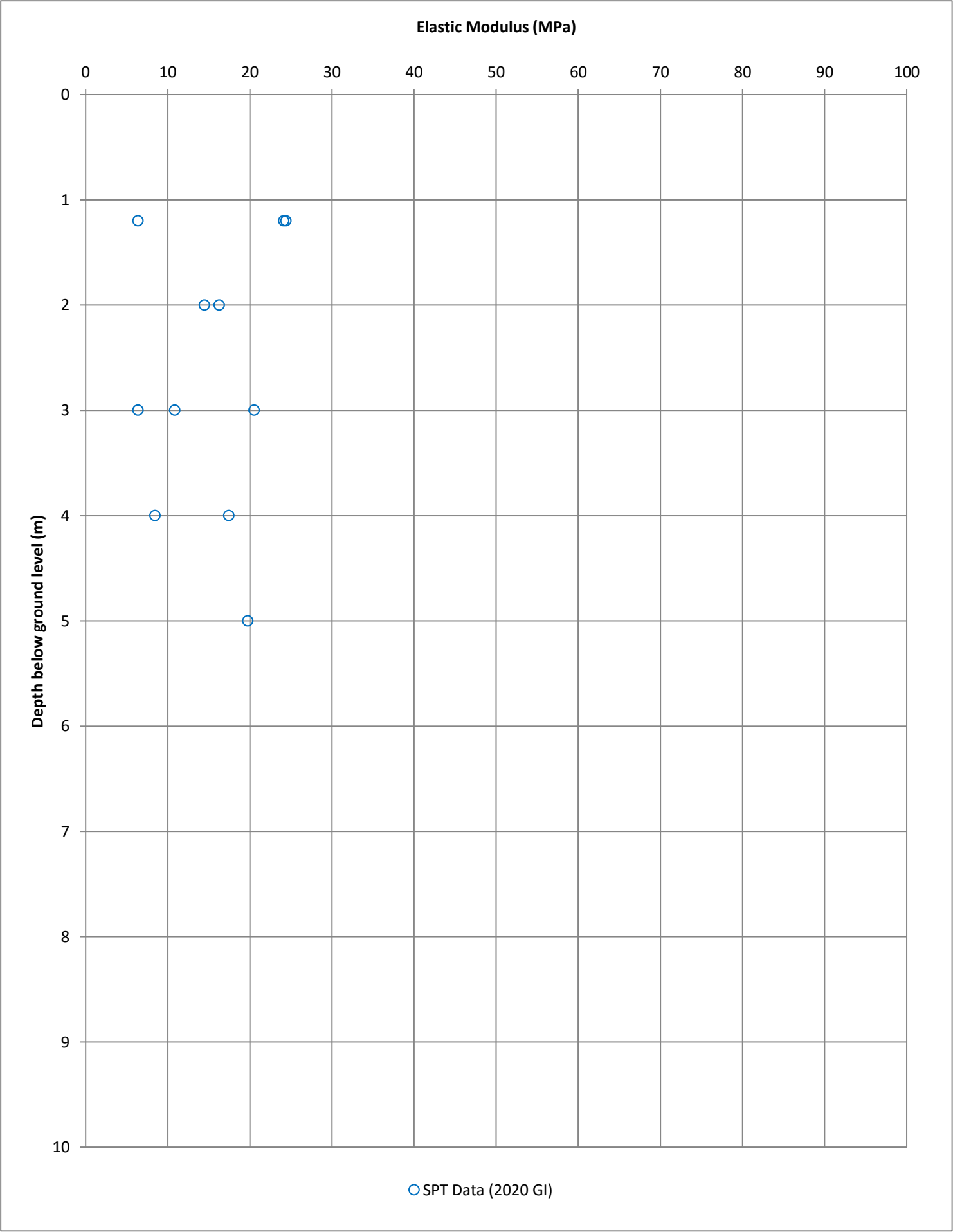
Atkins
Epsom (All Offices) Telephone:
Woodcote Grove, Ashley +44 1372 726140
Road, Epsom, Surrey,
KT18 5BW

Client
Portsmouth Water

Project
Havant Thicket Winter Storage Reservoir

Title
Coefficient of Volume Compressibility vs Depth for Reading Formation

Sheet Size A4	Drawn: HEF Date: 10/3/20	Checked: RL Date: 25/3/20	Reviewed: JA Date: 03/4/20
Status FINAL	Plot No 12.3		Rev P01



Correlation Factor as per CIRIA C143	0.9
Maximum Extrapolated N60 Value	200

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Atkins Limited

Woodcote Grove

Ashley Road

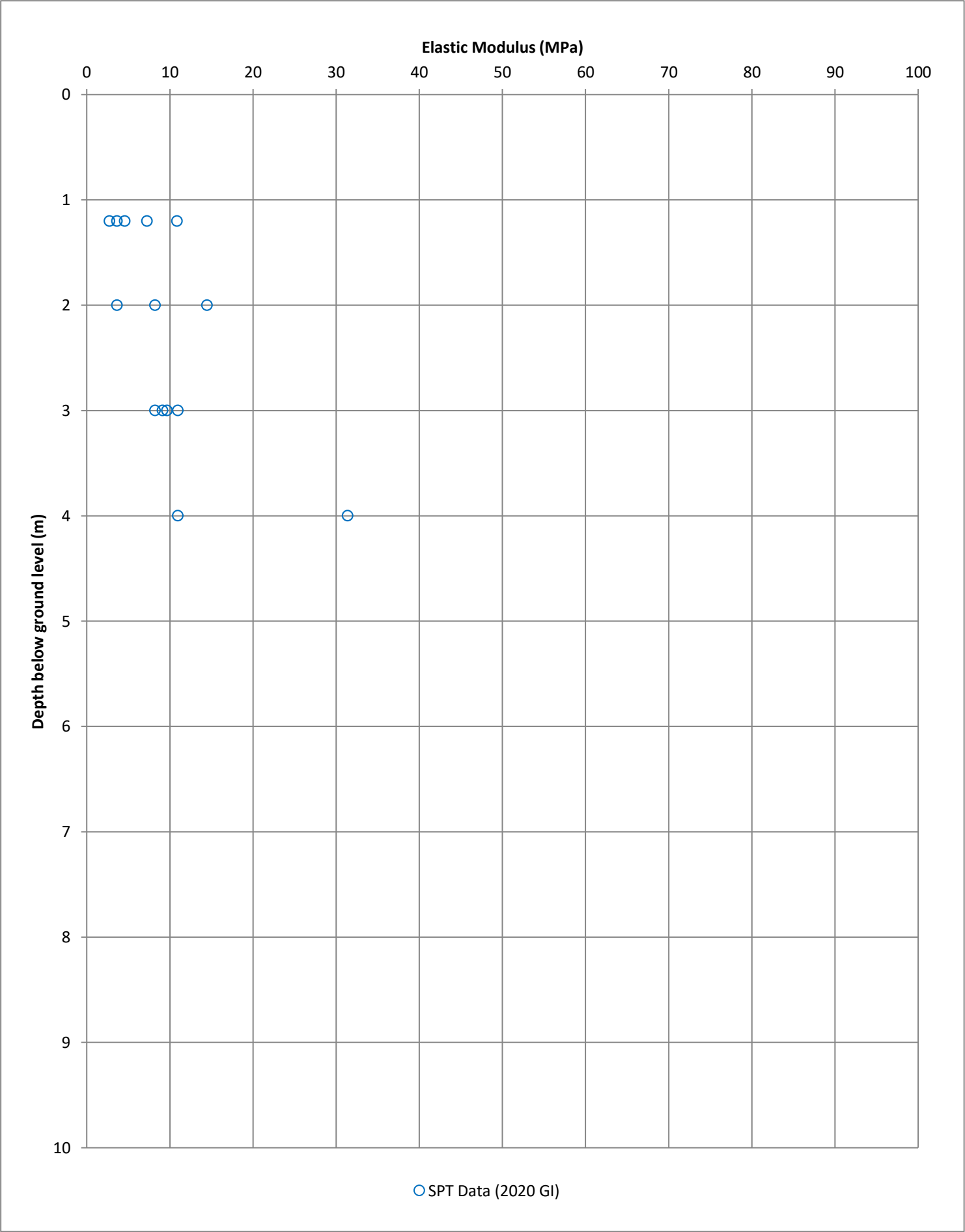
Epsom

KT18 5BW

Tel: (01372) 726140

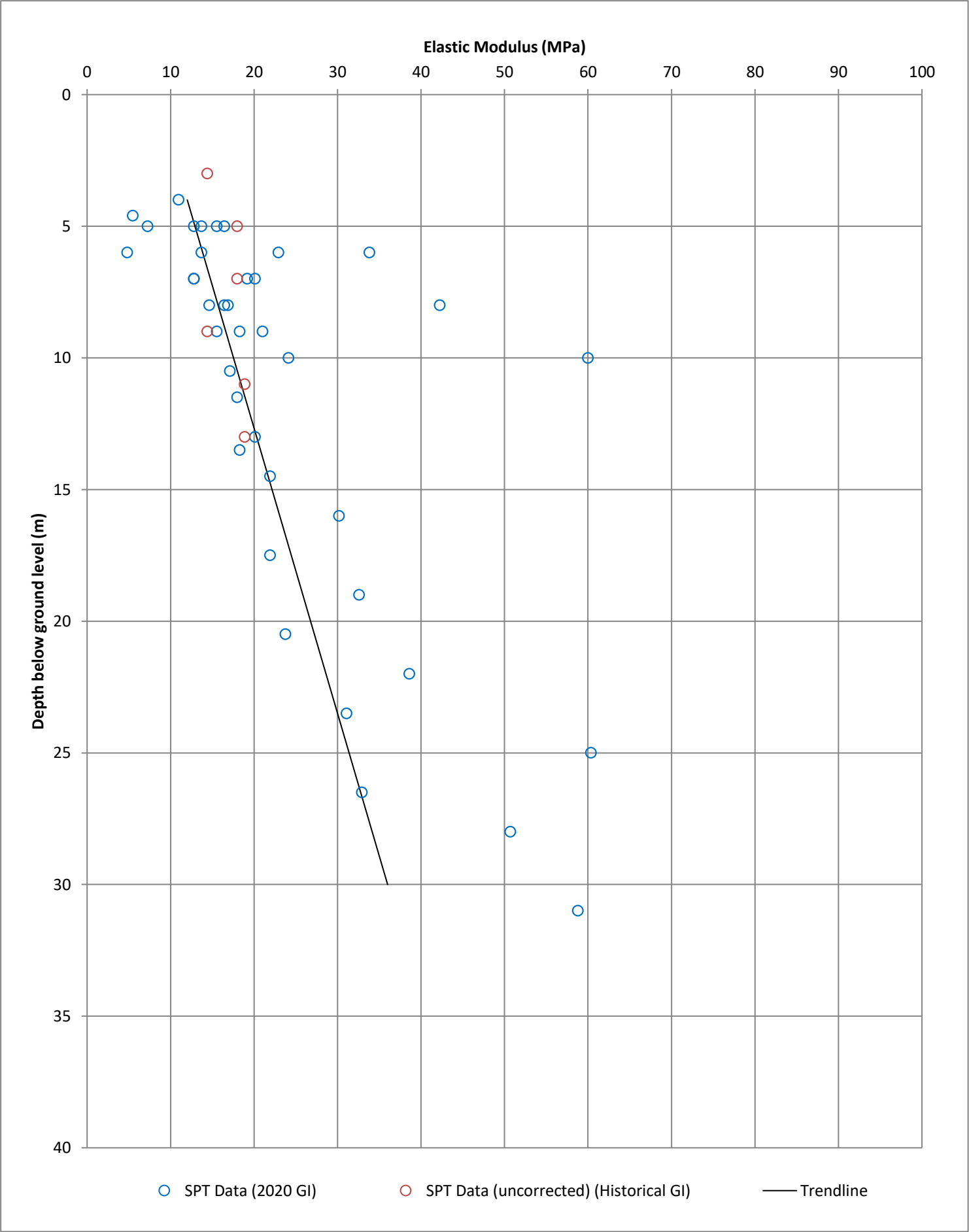
Fax: (01372) 740055

Client	Portsmouth Water			Title		
				Elastic Modulus from SPT N60 Value vs Depth for Bognor Sand Member (London Clay Formation)		
Project	Havant Thicket Winter Storage Reservoir			Sheet size	Drawn: HEF	Checked: RL
				A4	Date: 10/03/20	Date: 26/3/20
				Status	Plot Number	Reviewed: JA
				FINAL	13.1	Date: 03/04/20
						Rev
						P01



Correlation Factor as per CIRIA C143	0.9
Maximum Extrapolated N60 Value	200

ATKINS Member of the SNC-Lavalin Group Atkins Limitea Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055	Client	Title			
	Portsmouth Water	Elastic Modulus from SPT N60 Value vs Depth for Weathered London Clay Formation			
	Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
	Havant Thicket Winter Storage Reservoir	A4	Date: 10/03/20	Date: 26/3/20	Date: 03/04/20
		Status	Plot Number	Rev	
		FINAL	13.2	P01	



Correlation Factor as per CIRIA C143	0.9
Maximum Extrapolated N60 Value	200



Atkins Limited
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Ashley Road
Epsom
KT18 5BW

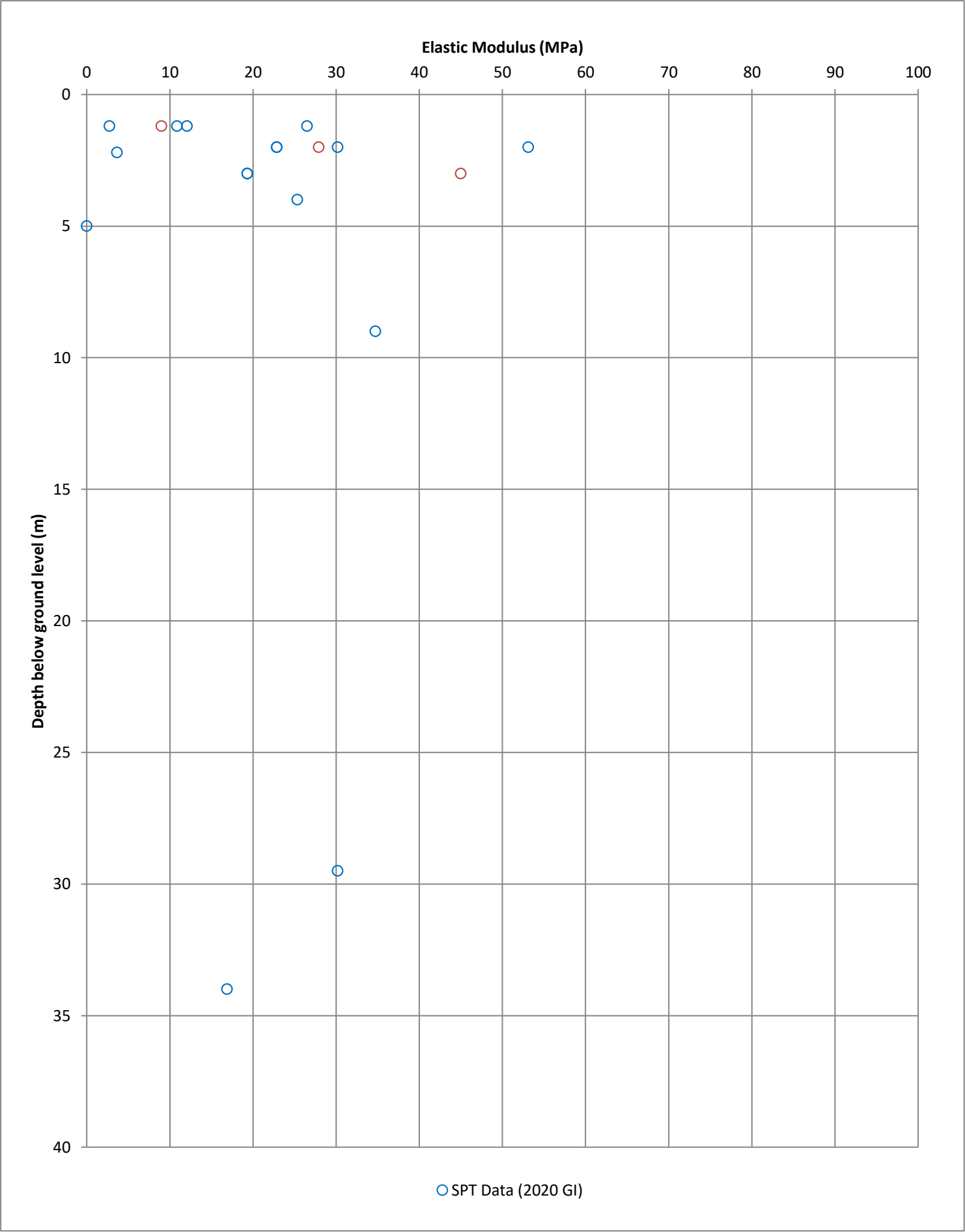
Tel: (01372) 726140
Fax: (01372) 740055

Client
Portsmouth Water

Project
Havant Thicket Winter Storage Reservoir

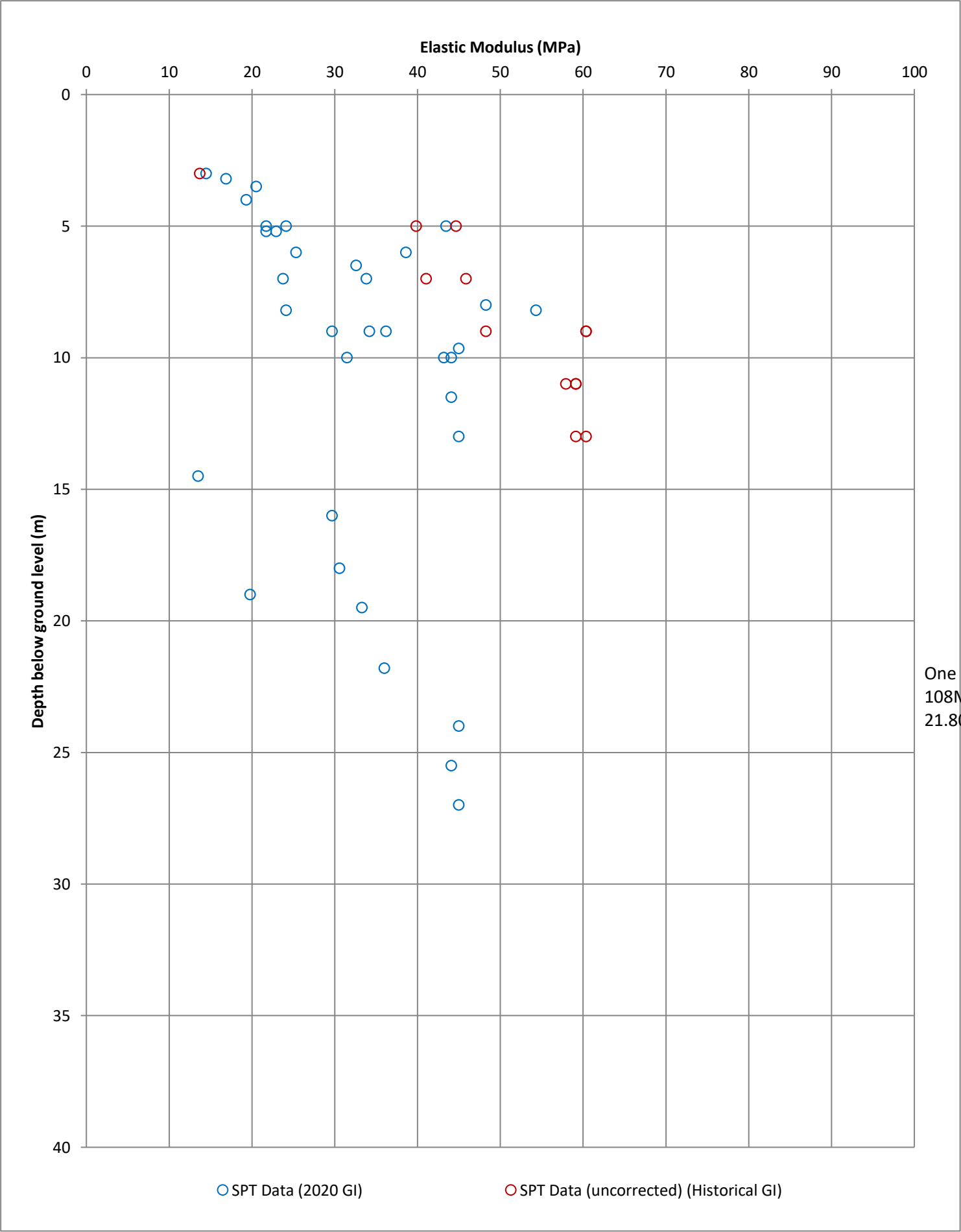
Title
Elastic Modulus from SPT N60 Value vs Depth for Unweathered London Clay Formation

Sheet size A4	Drawn: HEF Date: 10/03/20	Checked: RL Date: 26/3/20	Reviewed: JA Date: 03/04/20
Status FINAL	Plot Number 13.3	Rev P01	



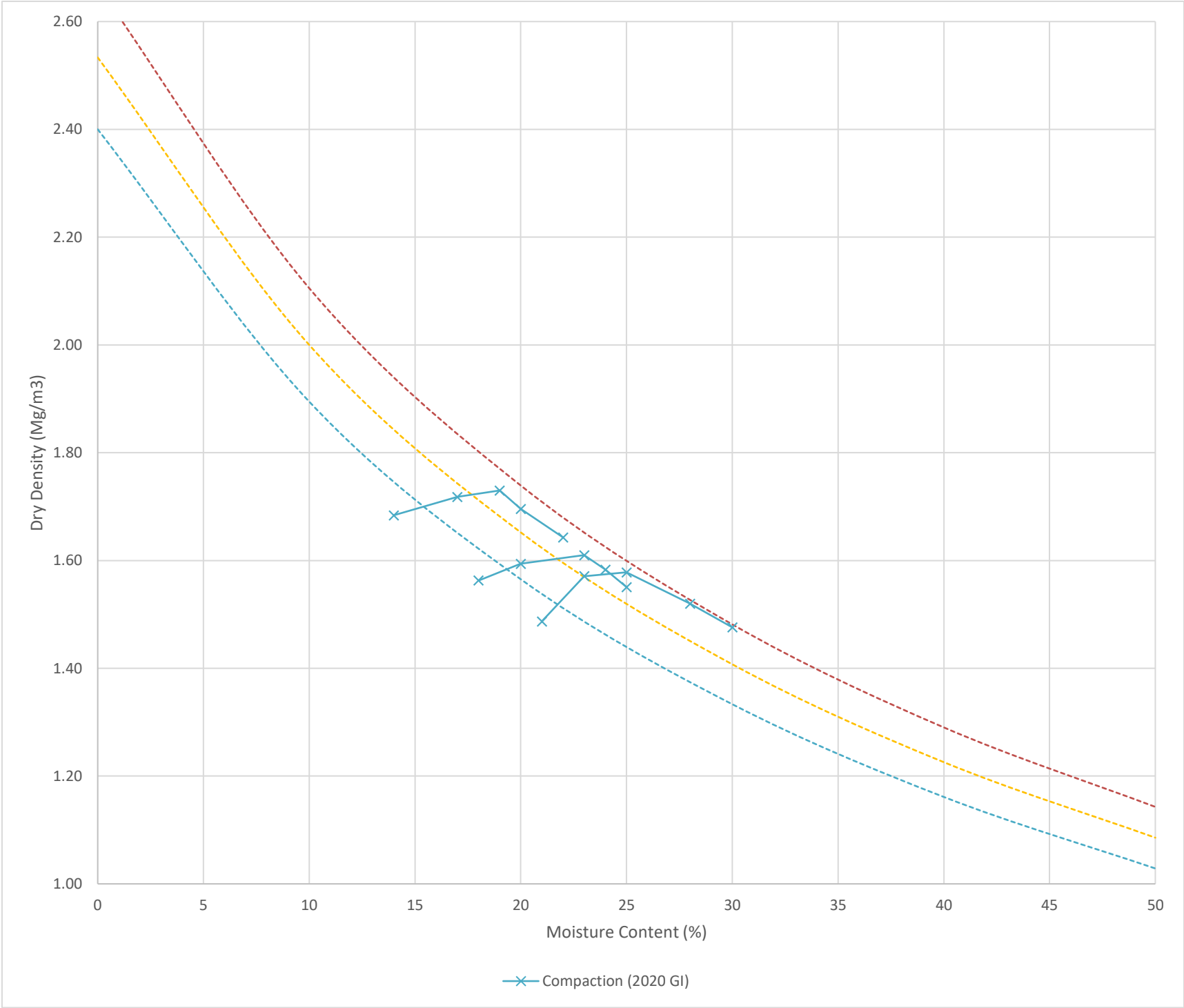
Correlation Factor as per CIRIA C143	0.9
Maximum Extrapolated N60 Value	200

ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055	Client	Title			
	Portsmouth Water	Elastic Modulus from SPT N60 Value vs Depth for Harwich Formation			
	Project	Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir		A4	Date: 10/03/20	Date: 26/3/20	Date: 03/04/20
		Status	Plot Number		Rev
		FINAL	13.4		P01



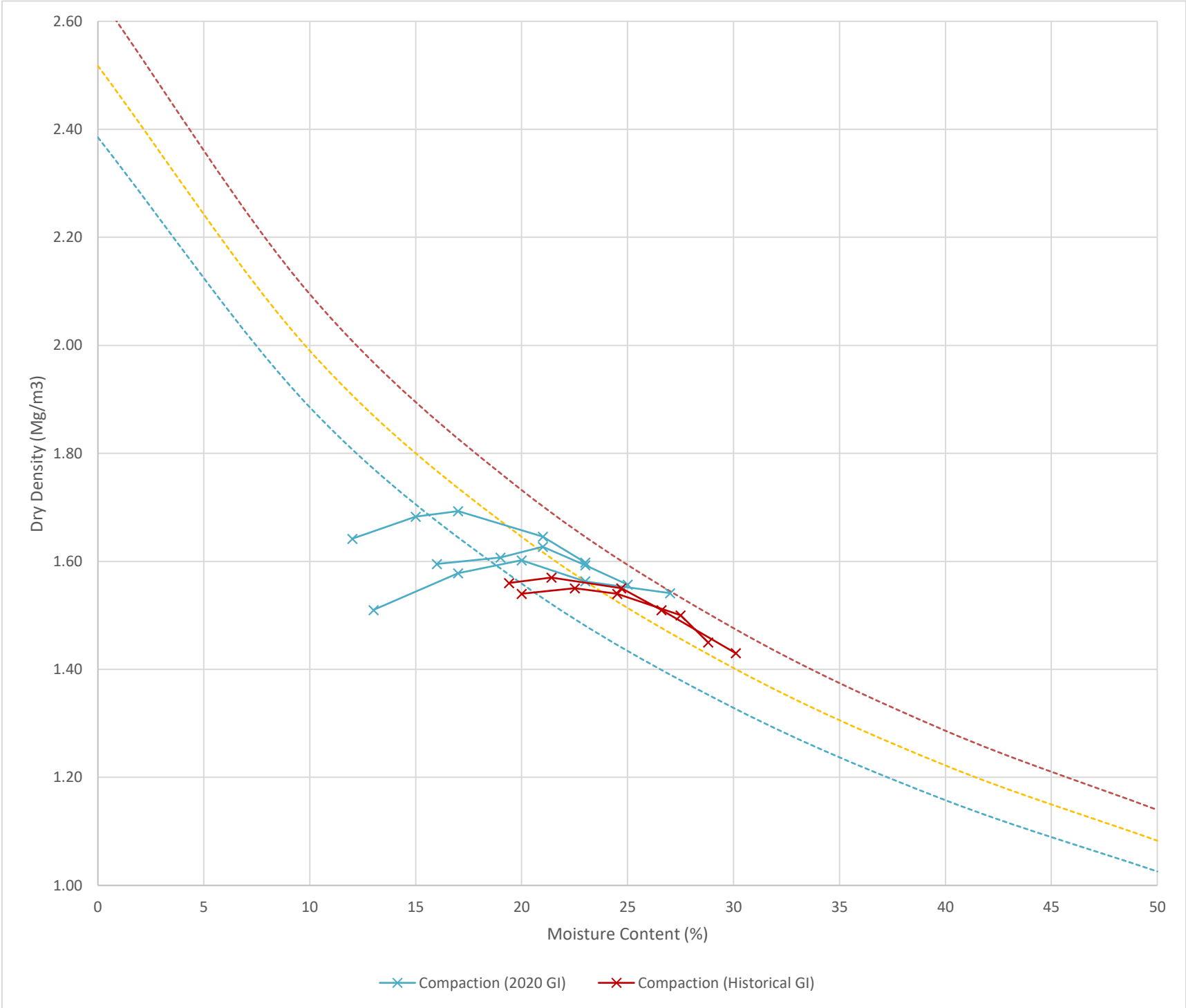
Correlation Factor as per CIRIA C143	0.9
Maximum Extrapolated N60 Value	200

ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 Fax: (01372) 740055	Client		Title			
	Portsmouth Water		Elastic Modulus from SPT N60 Value vs Depth for Reading Formation			
	Project		Sheet size	Drawn: HEF	Checked: RL	Reviewed: JA
	Havant Thicket Winter Storage Reservoir		A4	Date: 10/03/20	Date: 26/3/20	Date: 03/04/20
		Status	Plot Number		Rev	
		FINAL	13.5		P01	



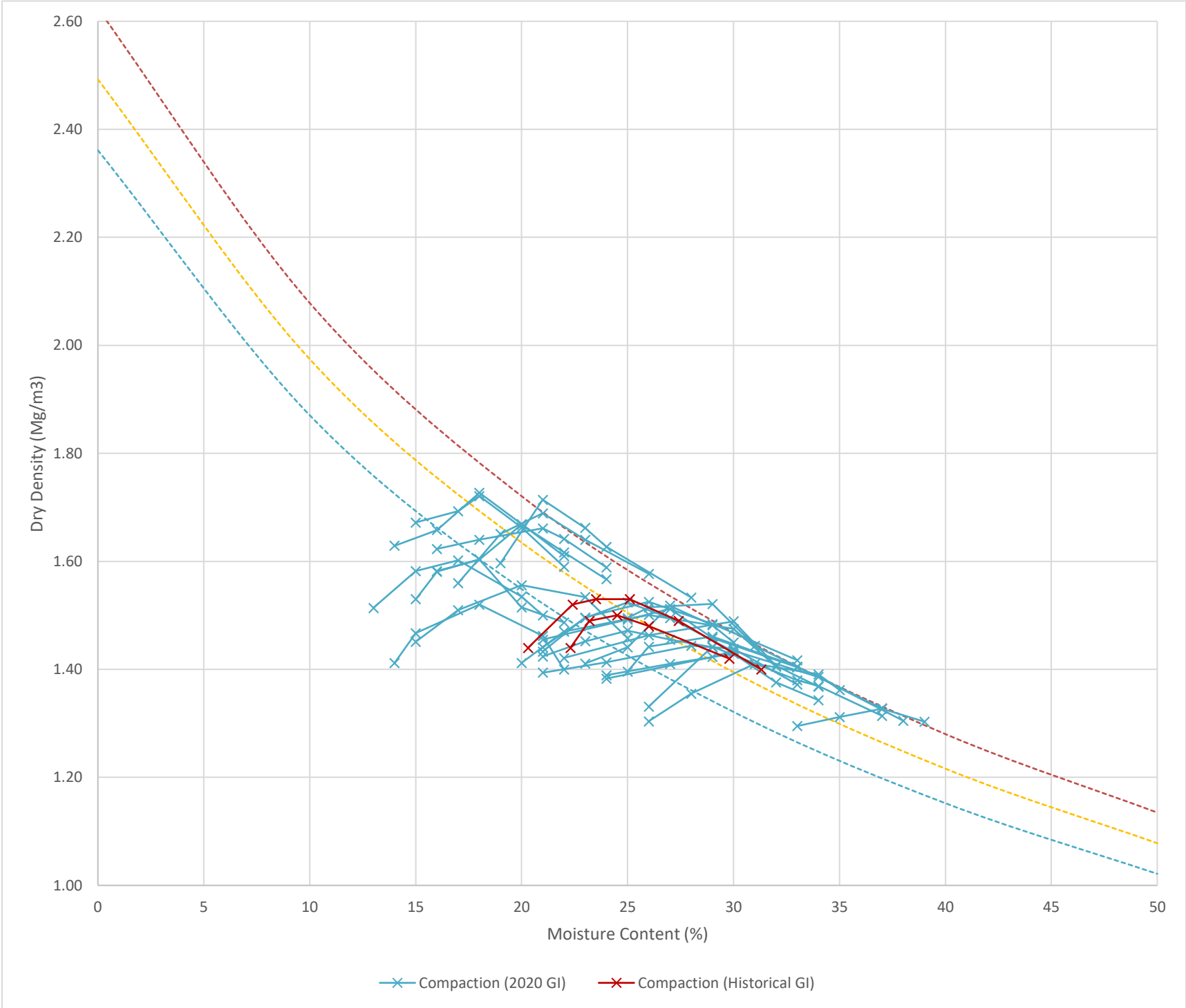
Test methods	2.5kg			Notes:
Mean proportion retained on 20mm sieve (%)	4.00	Mean maximum dry density (Mg/m ³)	1.64	
Mean proportion retained on 37.5mm sieve (%)	7.33	Mean optimum moisture content (%)	22.00	
Mean particle density (assumed)	2.67			
remarks:				
- - - - represents 0% air voids curve				
- - - - represents 5% air voids curve				
- - - - represents 10% air voids curve				

ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Dry Density Moisture Content Relationship for Head (2.5kg)			
	Project	Sheet size	Drawn: H.Fisher	Checked:R. Lindsay	Reviewed: JA
Havant Thicket Winter Storage Reservoir		A4	Date: 16/03/2020	Date: 26/03/20	Date: 06/04/20
		Status	Plot Number	Rev	
		FINAL	14.1	P01	



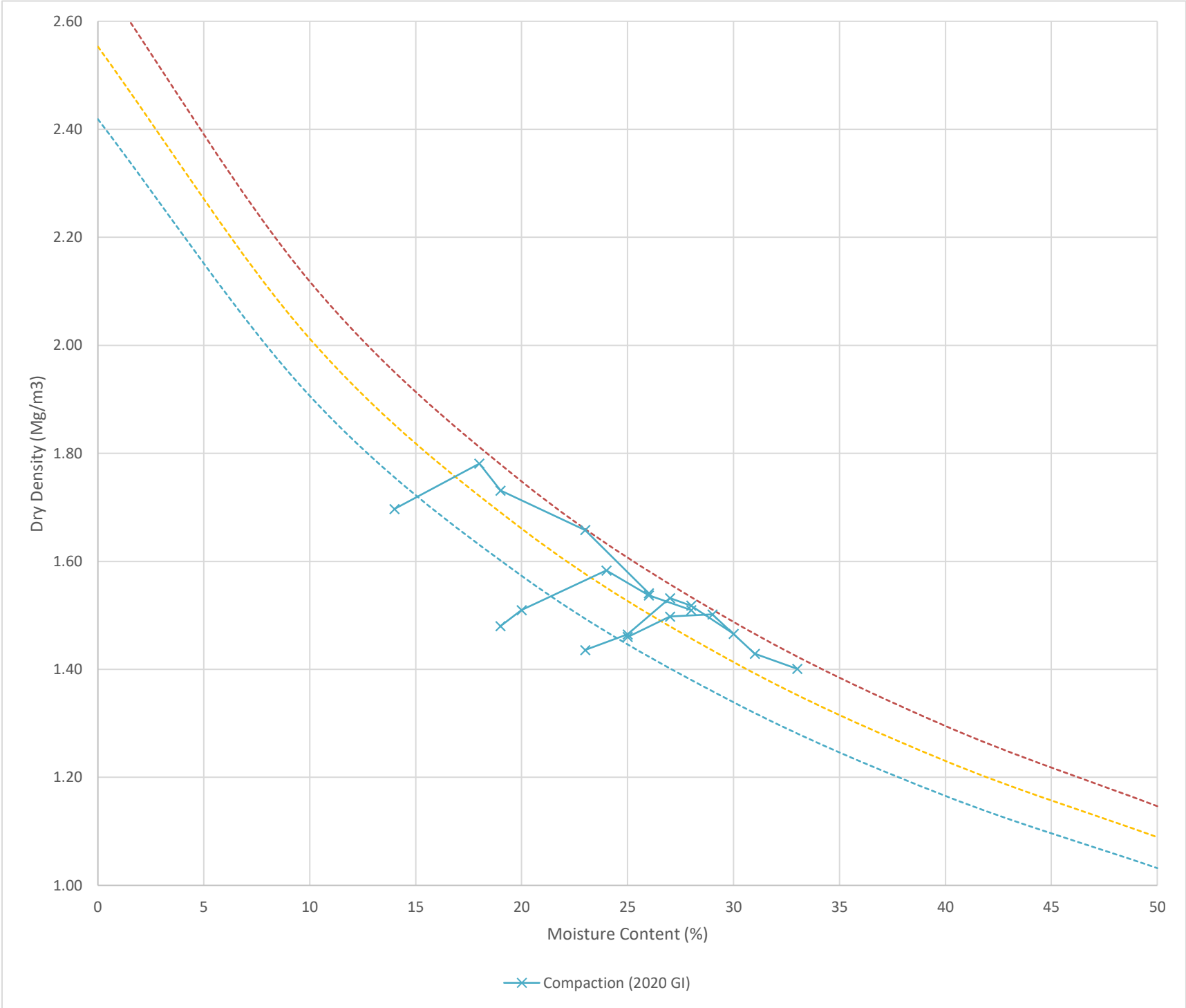
Test methods	2.5kg, Proctor			Notes:
Mean proportion retained on 20mm sieve (%)	0.00	Mean maximum dry density (Mg/m ³)	1.61	
Mean proportion retained on 37.5mm sieve (%)	0.00	Mean optimum moisture content (%)	20.98	
Mean particle density (assumed)	2.65			
remarks:				
- - - represents 0% air voids curve - - - represents 5% air voids curve - - - represents 10% air voids curve				

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	Portsmouth Water	Dry Density Moisture Content Relationship for Bognor Sand Member (London Clay Formation) (2.5kg)		
	Project	Sheet size	Drawn: H.Fisher	Checked:R. Lindsay
Havant Thicket Winter Storage Reservoir		A4	Date: 16/03/2020	Reviewed: JA
		Status	Plot Number	Rev
		FINAL	14.2	P01



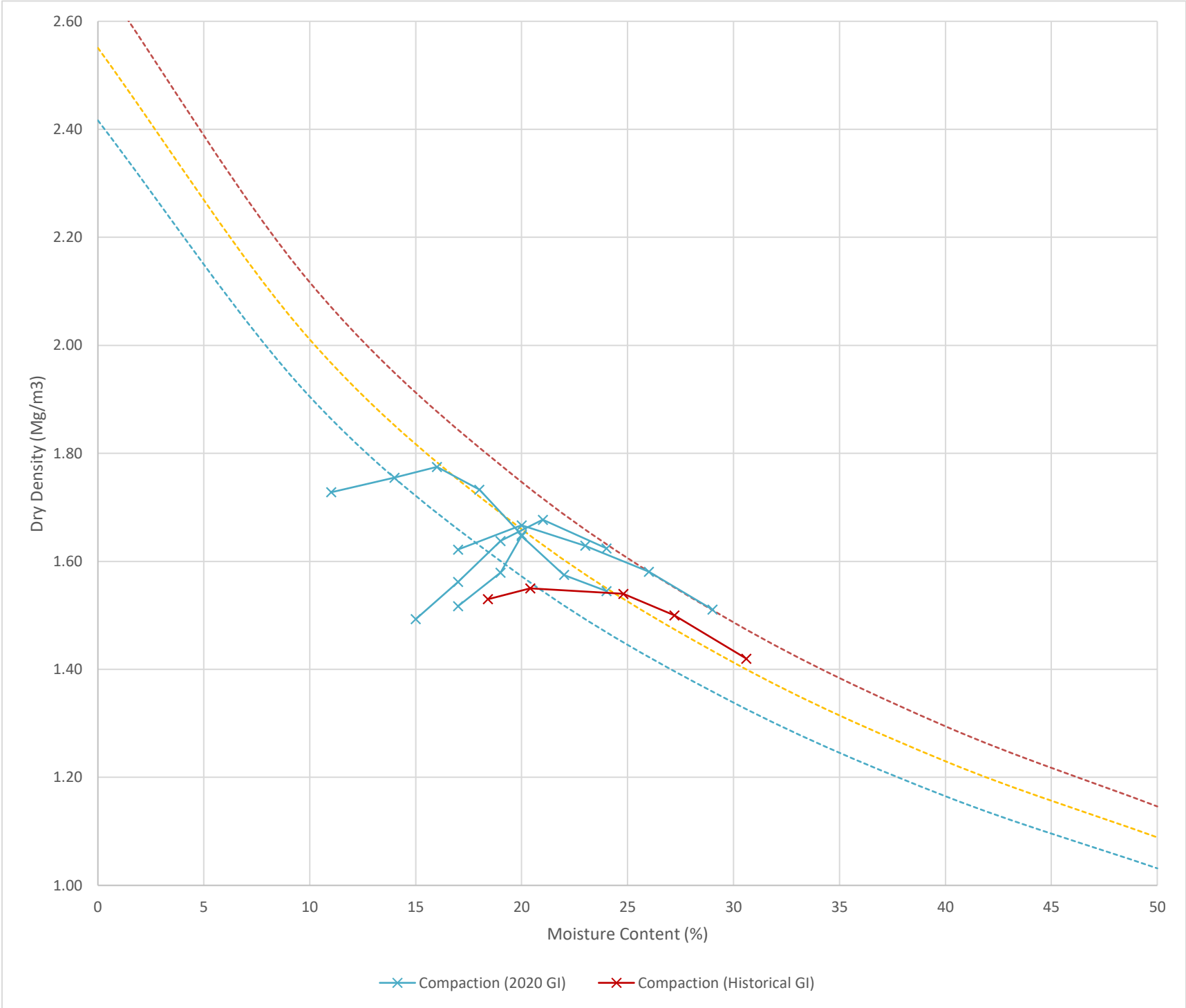
Test methods	2.5kg, Proctor			Notes:
Mean proportion retained on 20mm sieve (%)	0.00	Mean maximum dry density (Mg/m ³)	1.54	
Mean proportion retained on 37.5mm sieve (%)	0.00	Mean optimum moisture content (%)	24.90	
Mean particle density (assumed)	2.62			
remarks:				
- - - - - represents 0% air voids curve				
- - - - - represents 5% air voids curve				
- - - - - represents 10% air voids curve				

ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Portsmouth Water			Title			
	Project	Havant Thicket Winter Storage Reservoir			Sheet size	Drawn: H.Fisher	Checked:R. Lindsay	Reviewed: JA
					A4	Date: 16/03/2020	Date: 26/03/20	Date: 06/04/20
					Status	Plot Number		Rev
					FINAL	14.3		P01



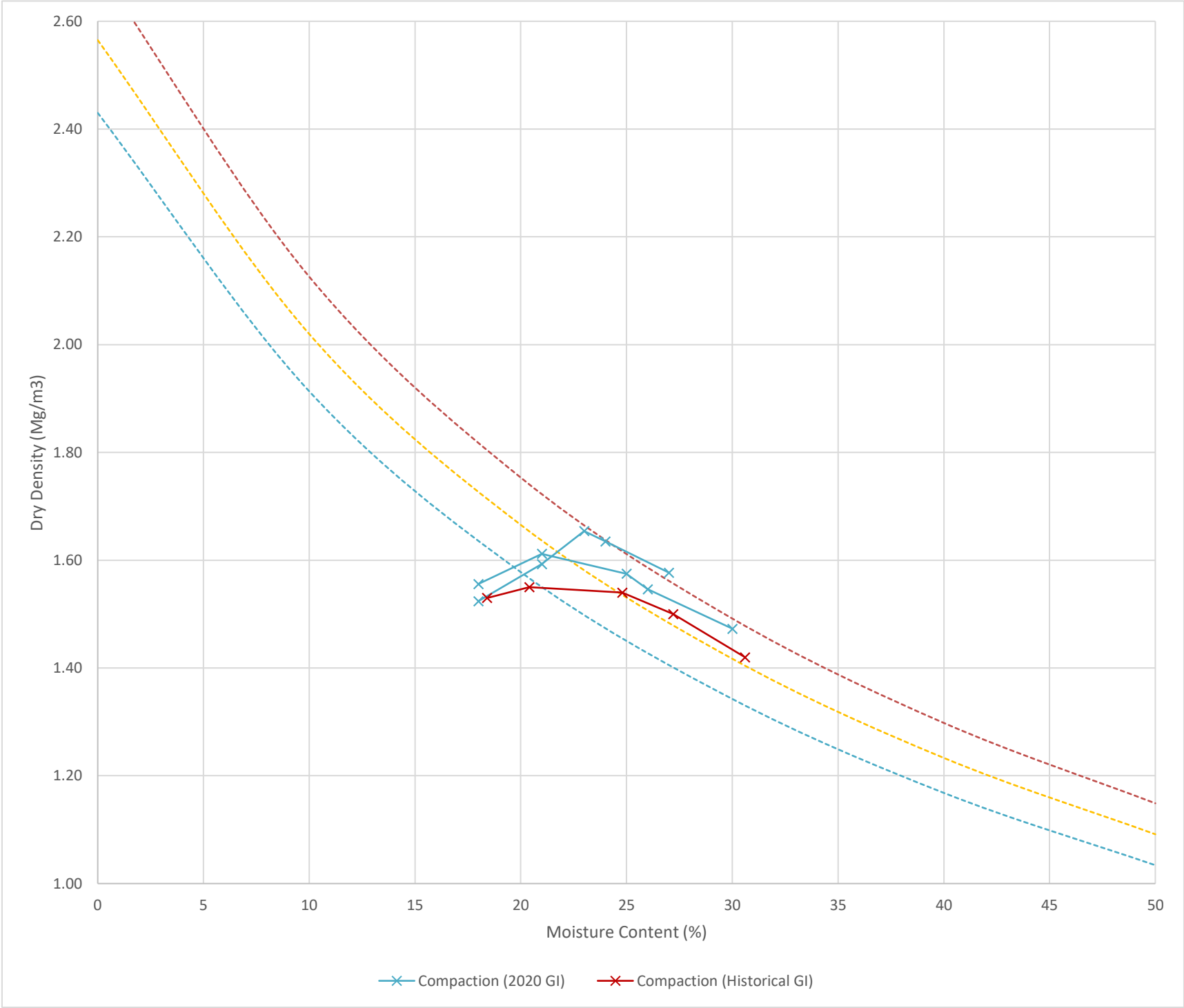
Test methods	4.5kg, Proctor			Notes:
Mean proportion retained on 20mm sieve (%)	0.00	Mean maximum dry density (Mg/m ³)	1.60	
Mean proportion retained on 37.5mm sieve (%)	0.00	Mean optimum moisture content (%)	23.50	
Mean particle density (assumed)	2.69			
remarks: - - - - represents 0% air voids curve - - - - represents 5% air voids curve - - - - represents 10% air voids curve				

ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title		
	Portsmouth Water	Dry Density Moisture Content Relationship for Weathered London Clay Formation (4.5kg)		
	Project	Sheet size A4	Drawn: H.Fisher Date: 16/03/2020	Checked:R. Lindsay Date: 26/03/20
Havant Thicket Winter Storage Reservoir		Status FINAL	Plot Number 14.4	Reviewed: JA Date: 06/04/20
				Rev P01



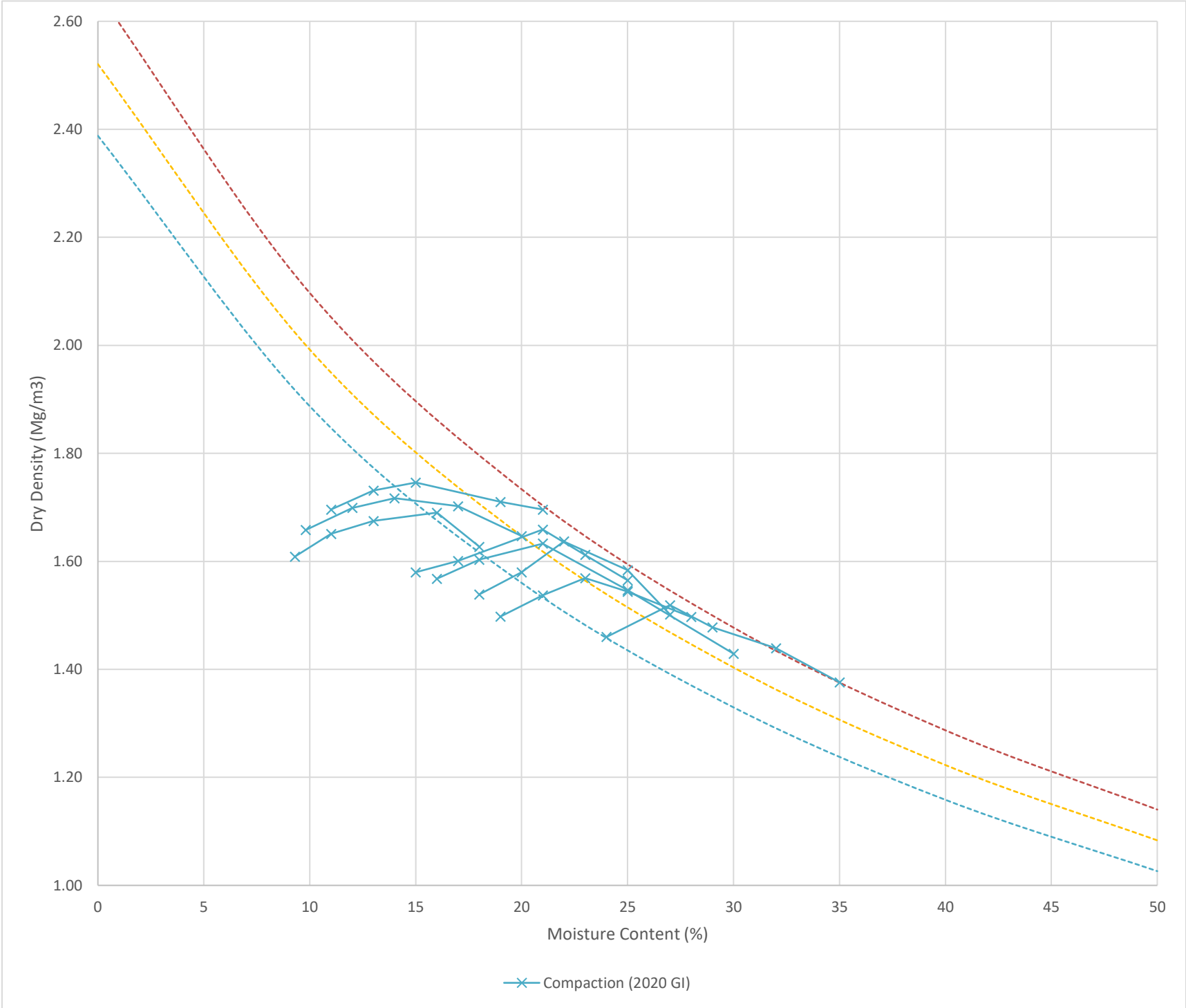
Test methods	2.5kg, Proctor			Notes:
Mean proportion retained on 20mm sieve (%)	0.00	Mean maximum dry density (Mg/m ³)	1.68	
Mean proportion retained on 37.5mm sieve (%)	0.00	Mean optimum moisture content (%)	18.17	
Mean particle density (assumed)	2.69			
remarks: - - - - represents 0% air voids curve - - - - represents 5% air voids curve - - - - represents 10% air voids curve				

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	Project			Havant Thicket Winter Storage Reservoir			
	Status			FINAL			
Sheet size		Drawn: H.Fisher		Checked:R. Lindsay		Reviewed: JA	
A4		Date: 16/03/2020		Date: 26/03/20		Date: 06/04/20	
Plot Number		14.5		Rev		P01	



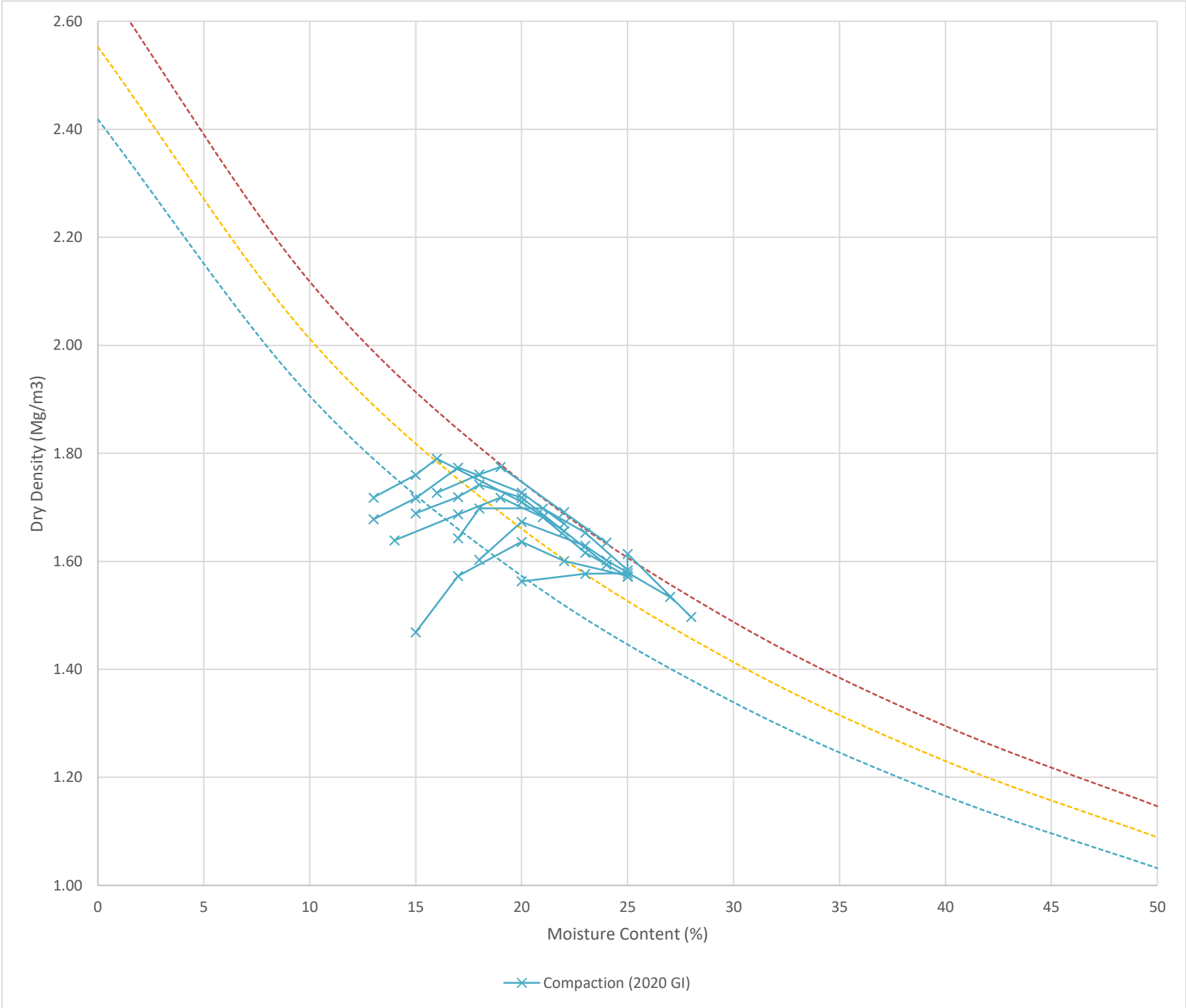
Test methods	4.5kg			Notes:
Mean proportion retained on 20mm sieve (%)	0.00	Mean maximum dry density (Mg/m ³)	1.61	
Mean proportion retained on 37.5mm sieve (%)	0.00	Mean optimum moisture content (%)	22.50	
Mean particle density (assumed)	2.70			
remarks: - - - represents 0% air voids curve - - - represents 5% air voids curve - - - represents 10% air voids curve				

ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Telephone: Woodcote Grove, Ashley +44 1372 726140 Road, Epsom, Surrey, KT18 5BW	Client	Title			
	Portsmouth Water	Dry Density Moisture Content Relationship for Unweathered London Clay (4.5kg)			
	Project	Sheet size	Drawn: H.Fisher	Checked:R. Lindsay	Reviewed: JA
	Havant Thicket Winter Storage Reservoir	A4	Date: 16/03/2020	Date: 26/03/20	Date: 06/04/20
Status		Plot Number		Rev	
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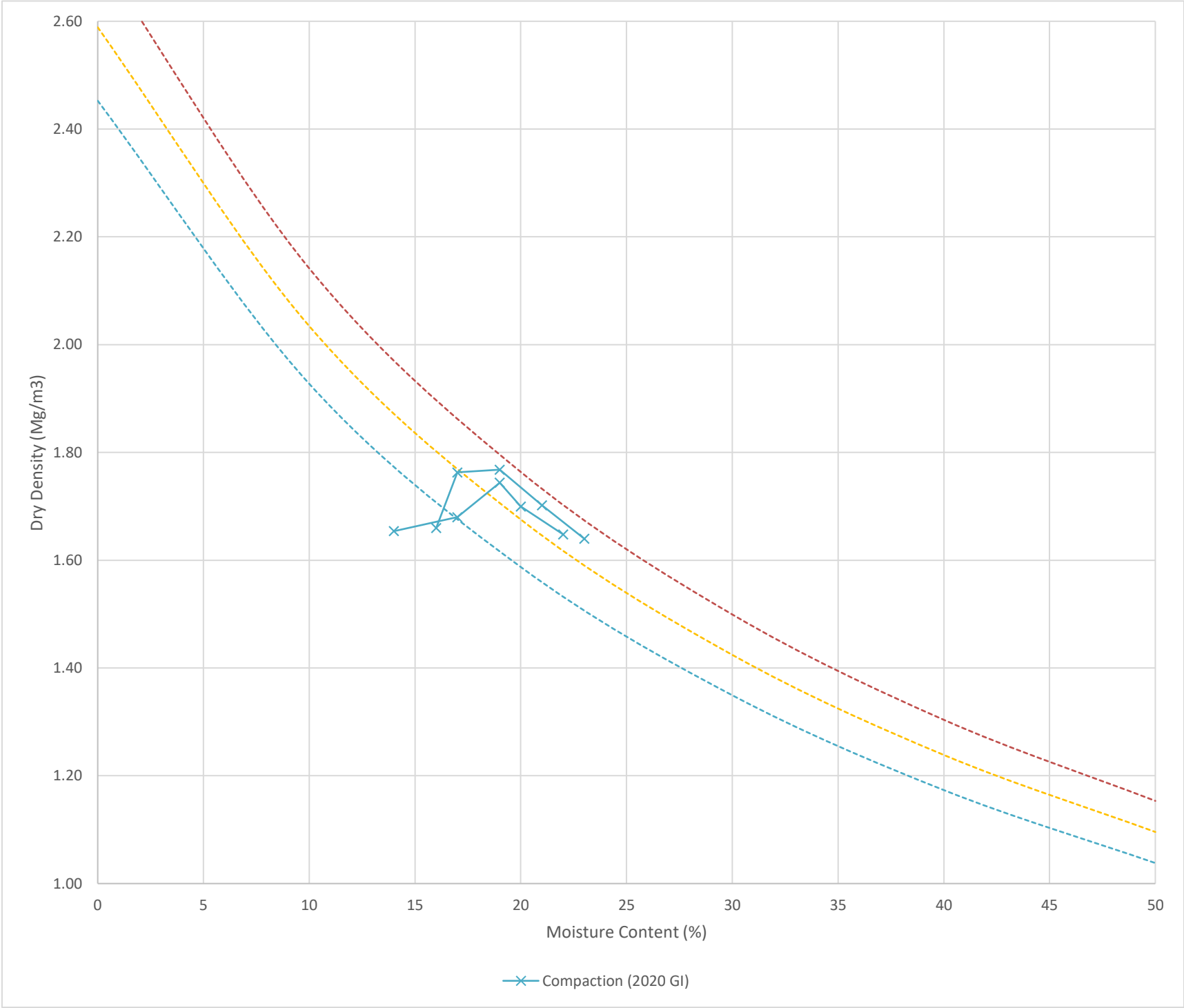
Test methods	2.5kg			Notes:
Mean proportion retained on 20mm sieve (%)	0.83	Mean maximum dry density (Mg/m ³)	1.64	
Mean proportion retained on 37.5mm sieve (%)	4.08	Mean optimum moisture content (%)	20.92	
Mean particle density (assumed)	2.65			
remarks:				
- - - - represents 0% air voids curve				
- - - - represents 5% air voids curve				
- - - - represents 10% air voids curve				

ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title		
	Portsmouth Water	Dry Density Moisture Content Relationship for Harwich Formation (2.5kg)		
	Project	Sheet size	Drawn: H.Fisher	Checked:R. Lindsay
Havant Thicket Winter Storage Reservoir		A4	Date: 16/03/2020	Reviewed: JA
		Status	Plot Number	Rev
		FINAL	14.7	P01



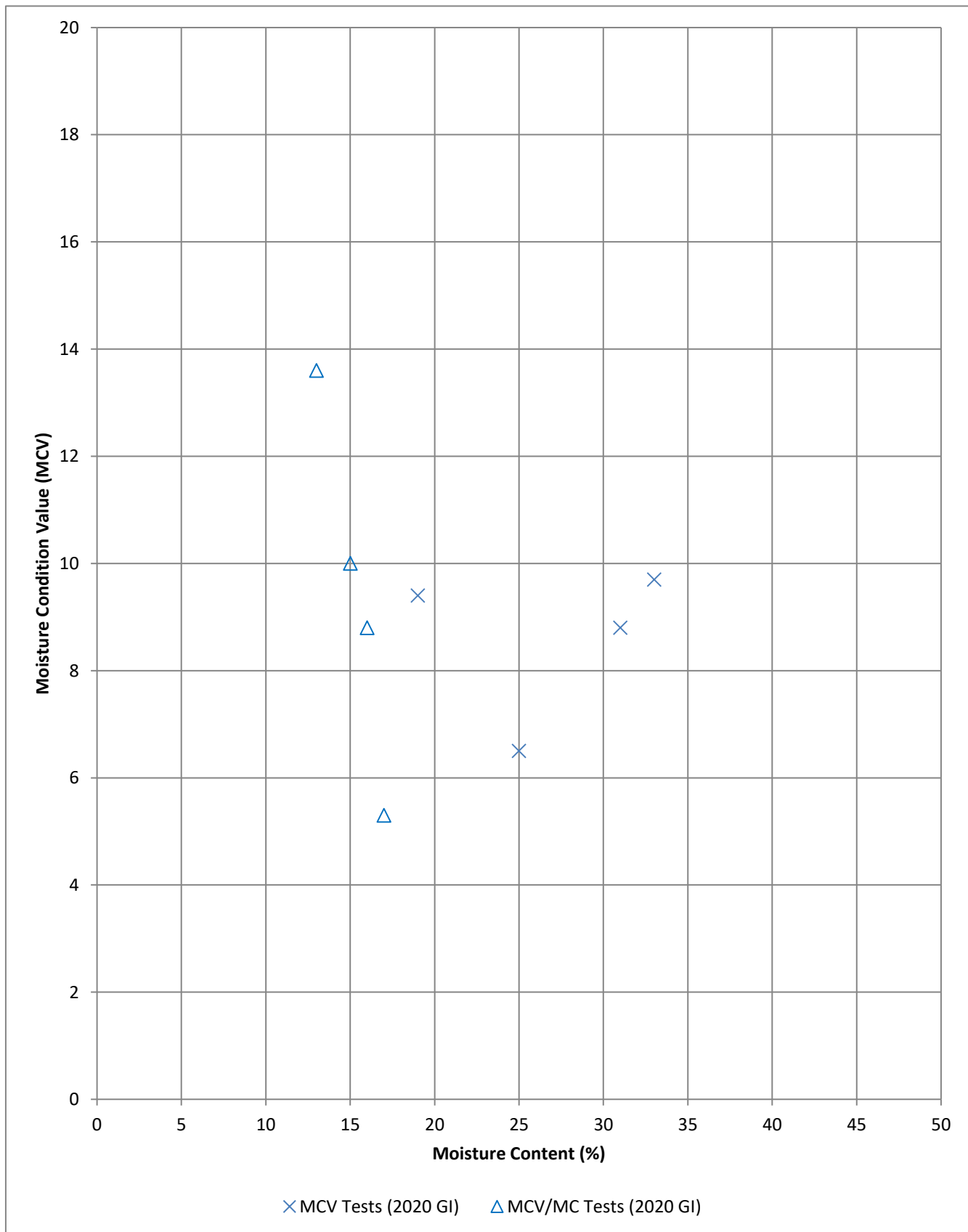
Test methods	2.5kg			Notes:
Mean proportion retained on 20mm sieve (%)	0.00	Mean maximum dry density (Mg/m ³)	1.72	
Mean proportion retained on 37.5mm sieve (%)	0.26	Mean optimum moisture content (%)	19.51	
Mean particle density (assumed)	2.69			
remarks: - - - represents 0% air voids curve - - - represents 5% air voids curve - - - represents 10% air voids curve				

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	Portsmouth Water	Dry Density Moisture Content Relationship for Reading Formation (2.5kg)			
	Project	Sheet size	Drawn: H.Fisher	Checked:R. Lindsay	Reviewed: JA
Havant Thicket Winter Storage Reservoir		A4	Date: 16/03/2020	Date: 26/03/20	Date: 06/04/20
		Status	Plot Number		Rev
		FINAL	14.8		P01

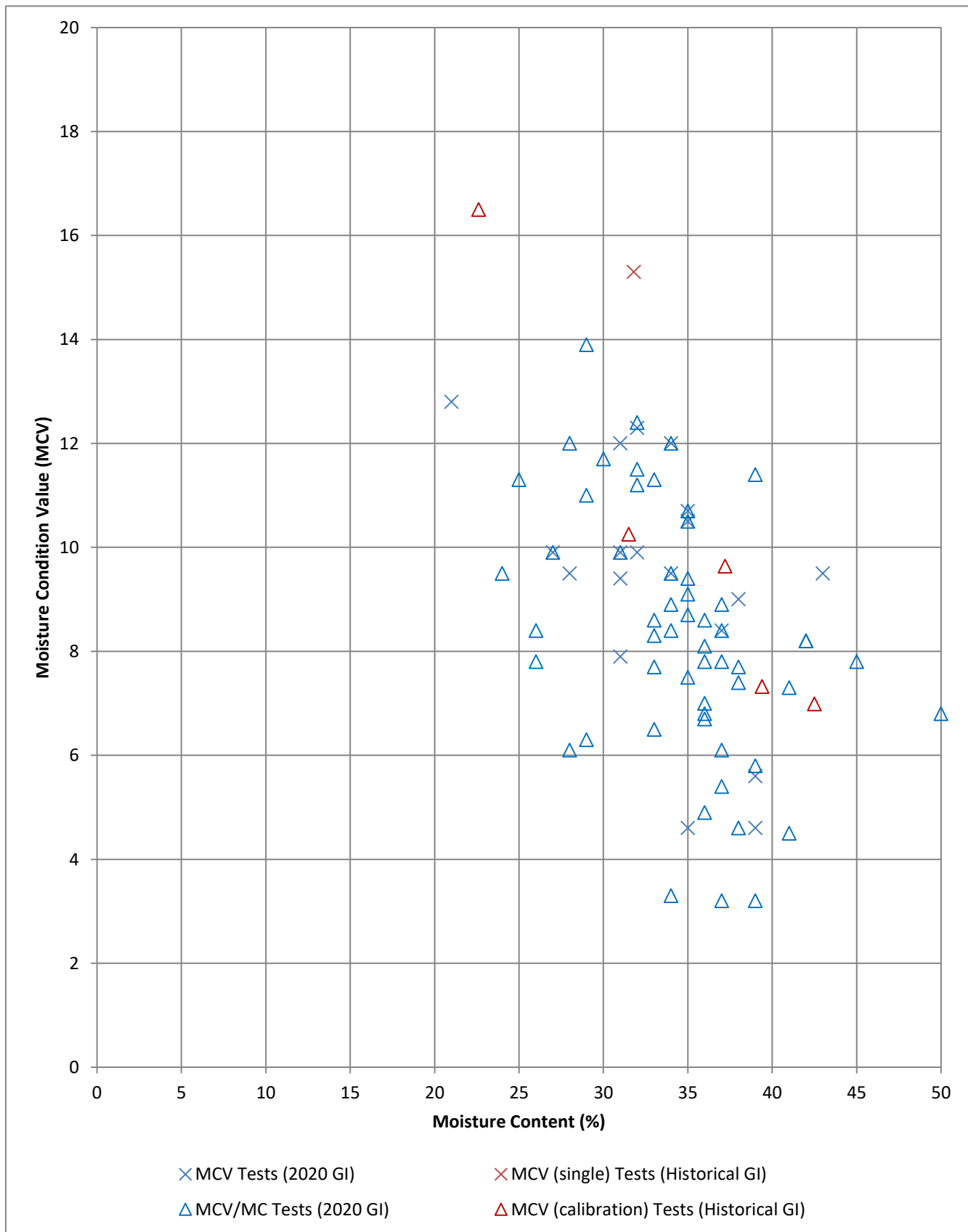


Test methods	4.5kg			Notes:
Mean proportion retained on 20mm sieve (%)	0.00	Mean maximum dry density (Mg/m ³)	1.76	
Mean proportion retained on 37.5mm sieve (%)	0.00	Mean optimum moisture content (%)	18.50	
Mean particle density (assumed)	2.73			
remarks: - - - - - represents 0% air voids curve - - - - - represents 5% air voids curve - - - - - represents 10% air voids curve				

ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Telephone: +44 1372 726140	Client	Title			
	Portsmouth Water	Dry Density Moisture Content Relationship for Reading Formation (4.5kg)			
	Project	Sheet size	Drawn: H.Fisher	Checked:R. Lindsay	Reviewed: JA
Havant Thicket Winter Storage Reservoir		A4	Date: 16/03/2020	Date: 26/03/20	Date: 06/04/20
		Status	Plot Number		Rev
		FINAL	14.9		P01



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	Portsmouth Water		Moisture Condition Value vs Moisture Content for Head			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir		Status	A4	Date: 18/03/20	Date: 25/3/20	Date: 06/4/20
			FINAL	Plot No	Rev	
				15.1	P01	



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Project

**Havant Thicket Winter Storage
Reservoir**

Title

**Moisture Condition Value vs Moisture
Content for Weathered London Clay
Formation**

Sheet Size

A4

Drawn: HEF

Date: 18/03/20

Checked: RL

Date: 25/3/20

Reviewed: JA

Date: 06/4/20

Status

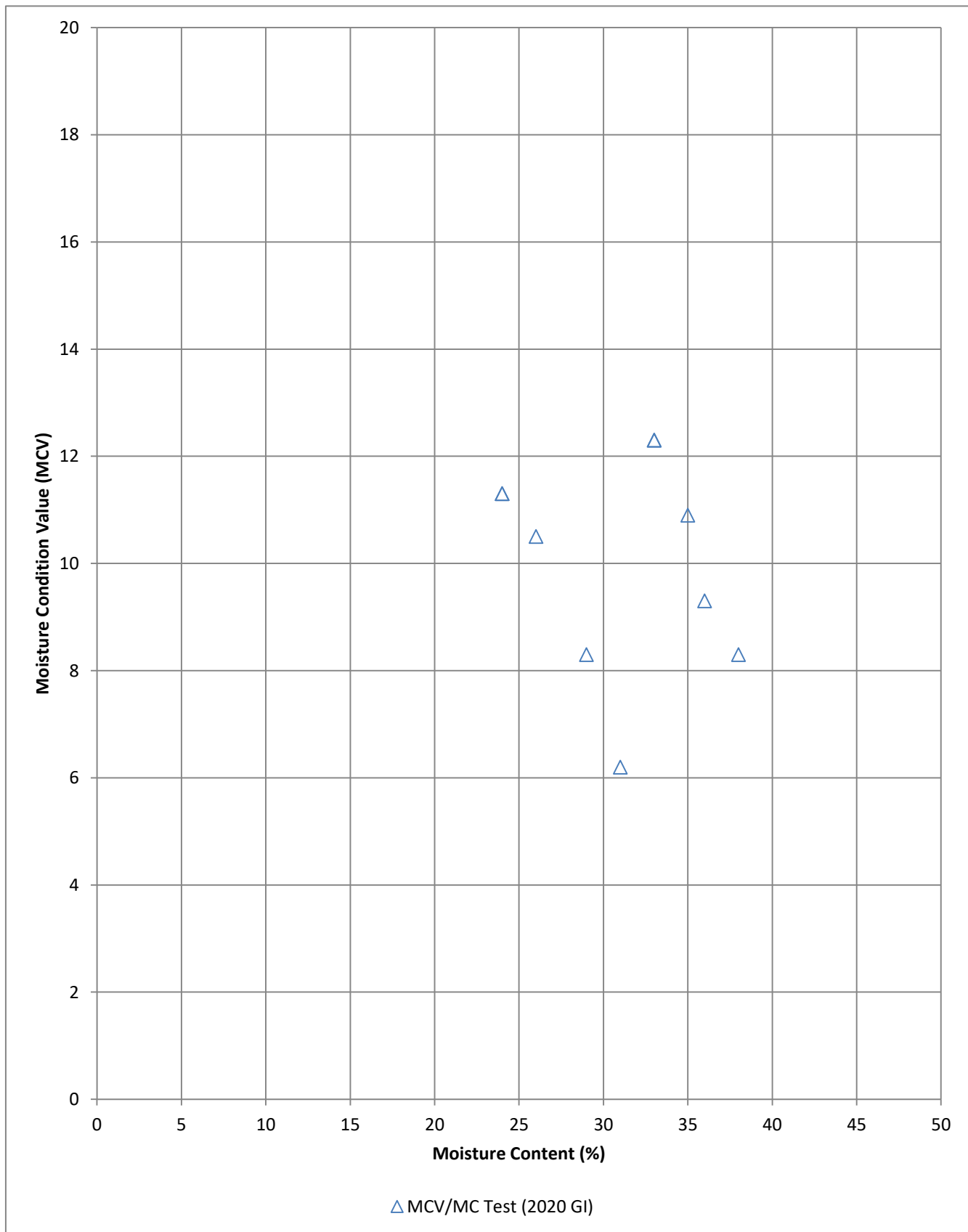
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Plot No

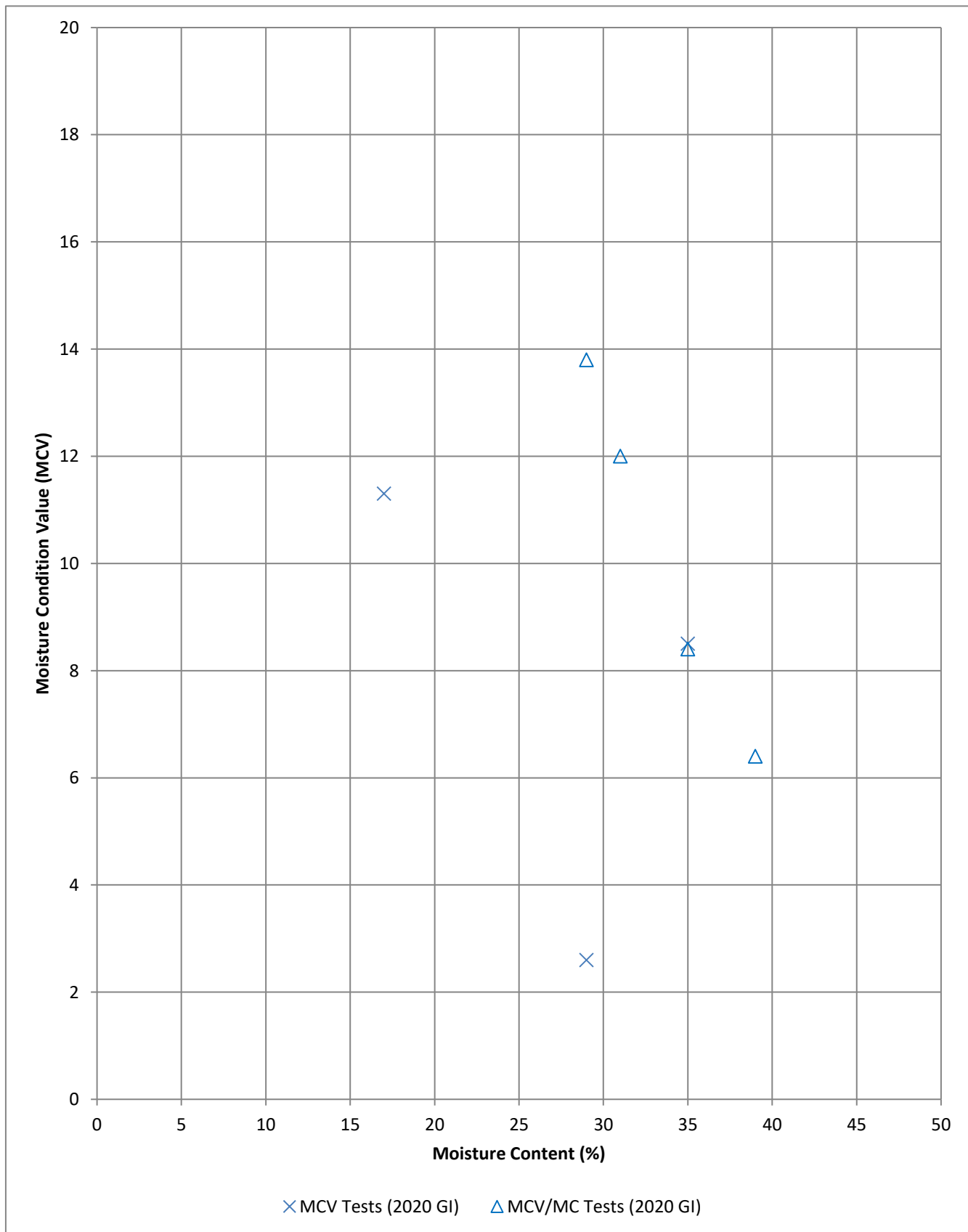
15.2

Rev

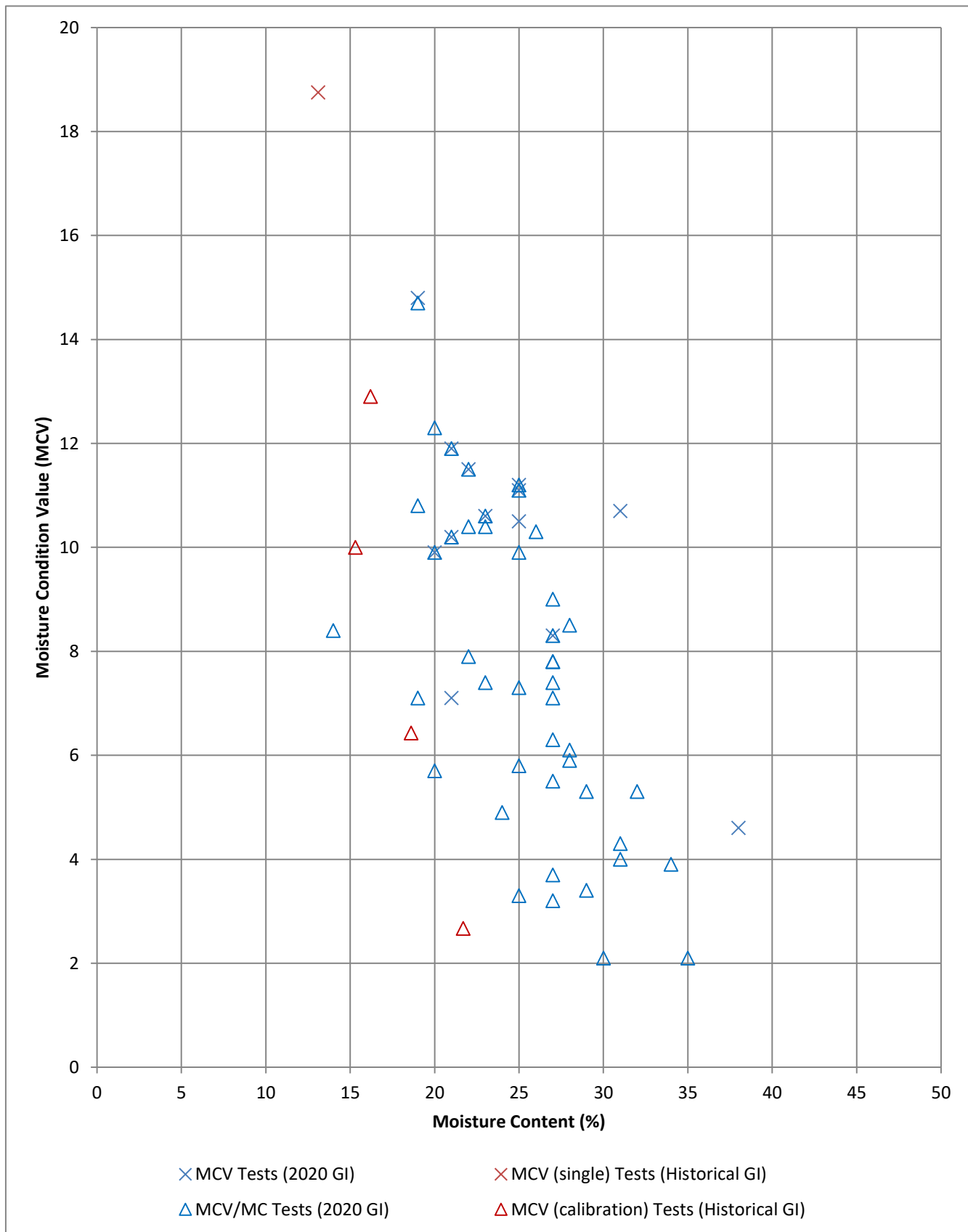
P01



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	Portsmouth Water		Moisture Condition Value vs Moisture Content for Unweathered London Clay Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir			A4	Date: 18/03/20	Date: 25/3/20	Date: 06/4/20
		Status	Plot No	Rev		
		FINAL	15.3	P01		



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	Portsmouth Water		Moisture Condition Value vs Moisture Content for Harwich Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir		Status	A4	Date: 18/03/20	Date: 25/3/20	Date: 06/4/20
			FINAL	Plot No	Rev	
				15.4	P01	



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Project

**Havant Thicket Winter Storage
Reservoir**

Title

**Moisture Condition Value vs Moisture
Content for Reading Formation**

Sheet Size

A4

Drawn: HEF

Date: 18/03/20

Checked: RL

Date: 25/3/20

Reviewed: JA

Date: 06/4/20

Status

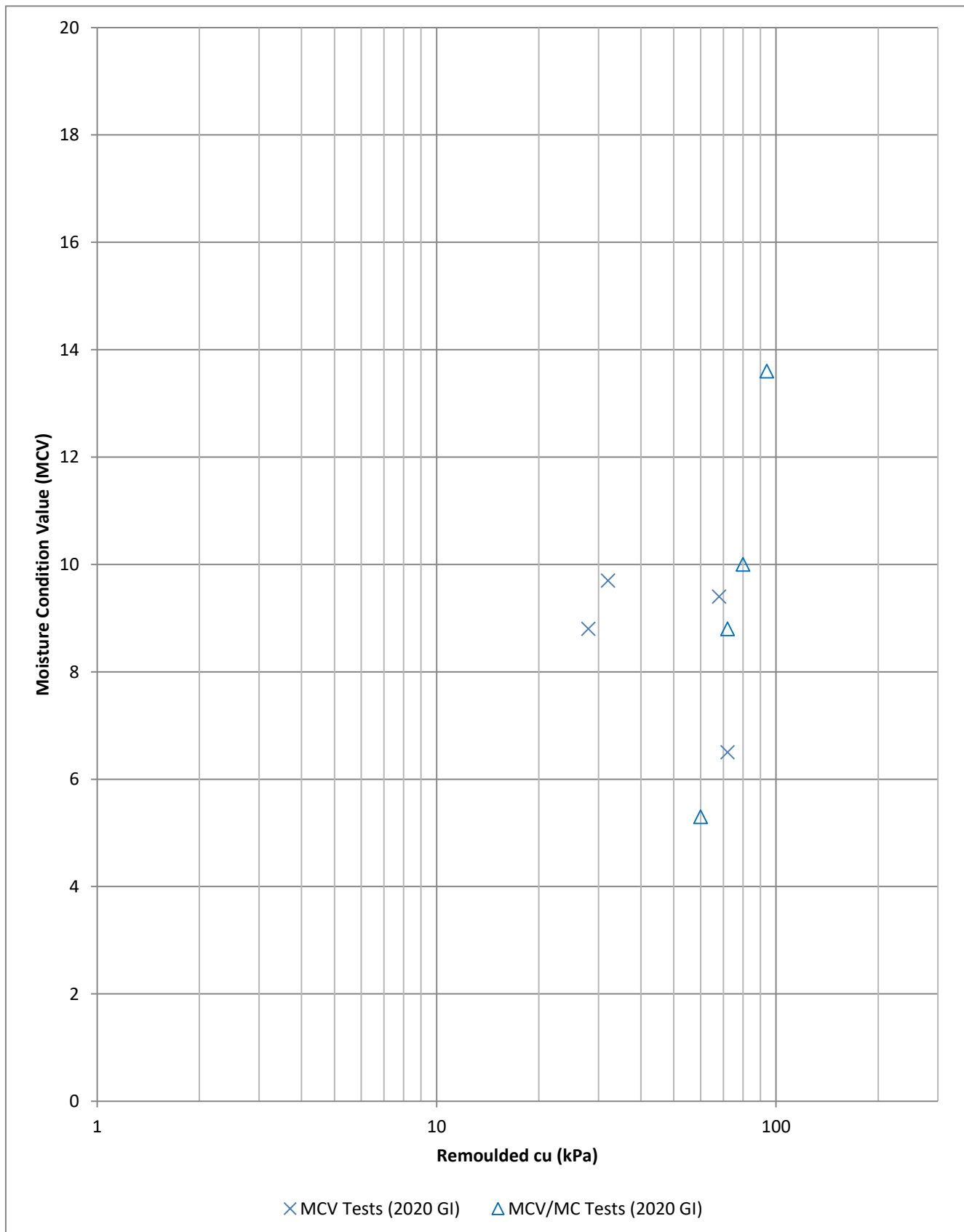
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Plot No

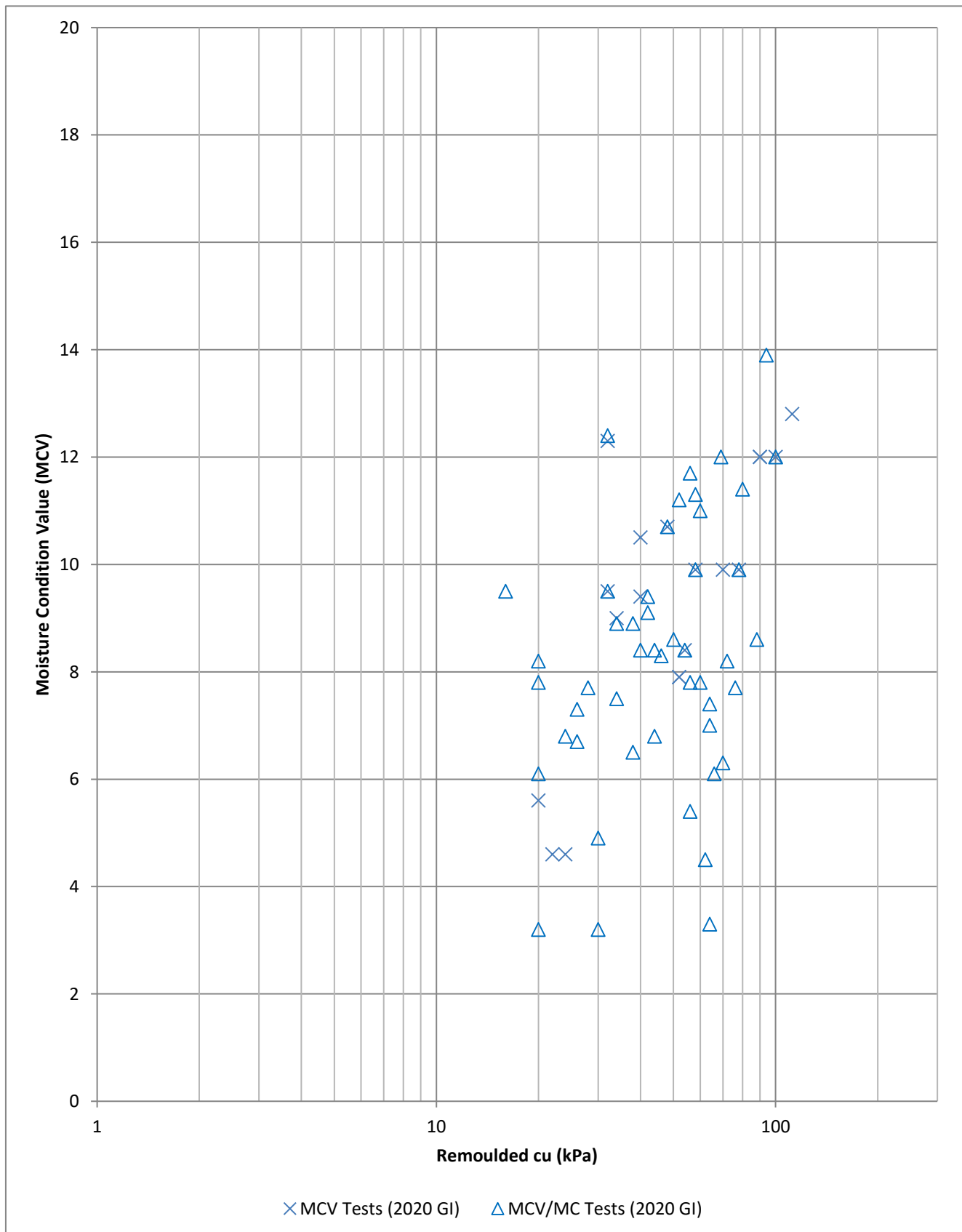
15.5

Rev

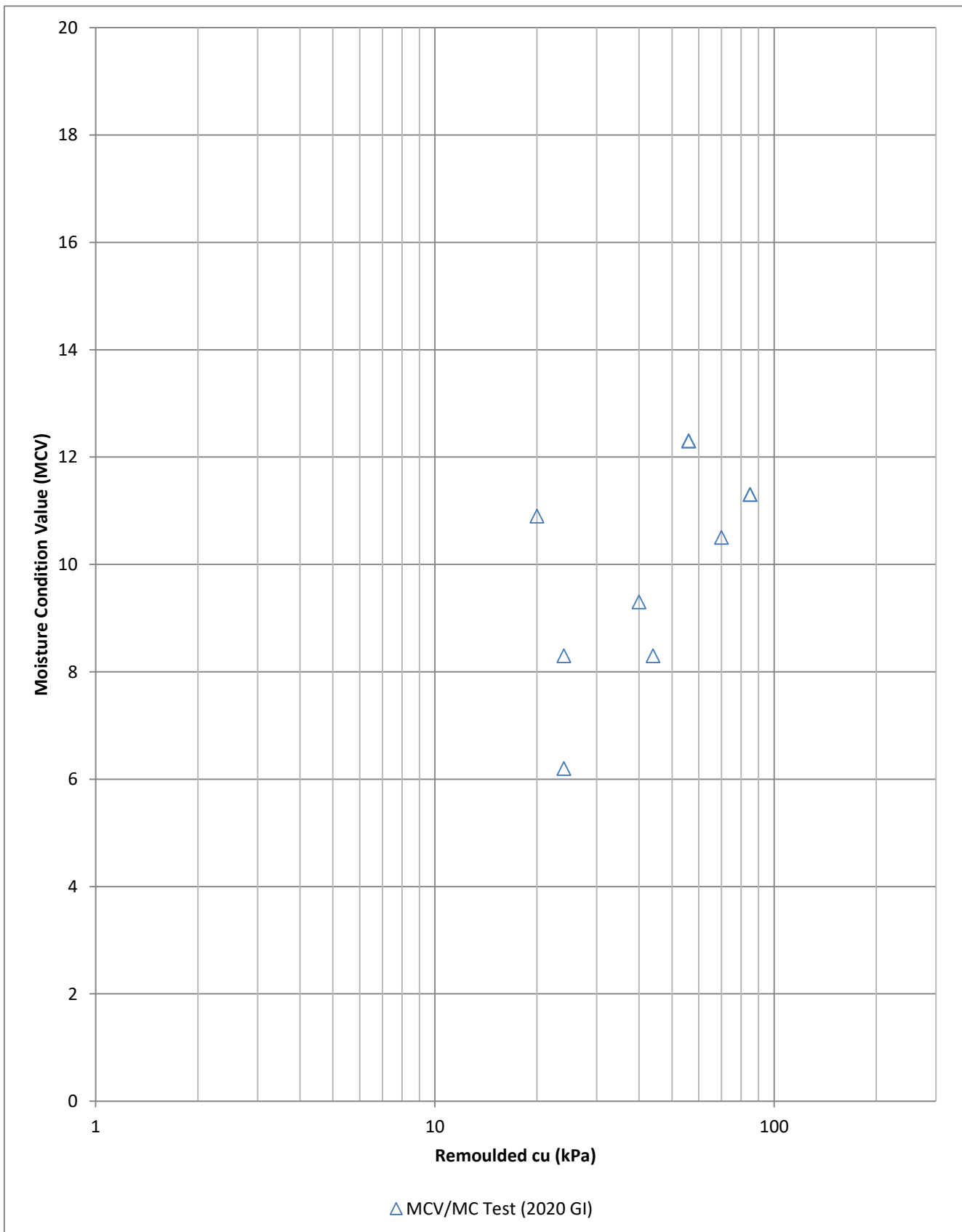
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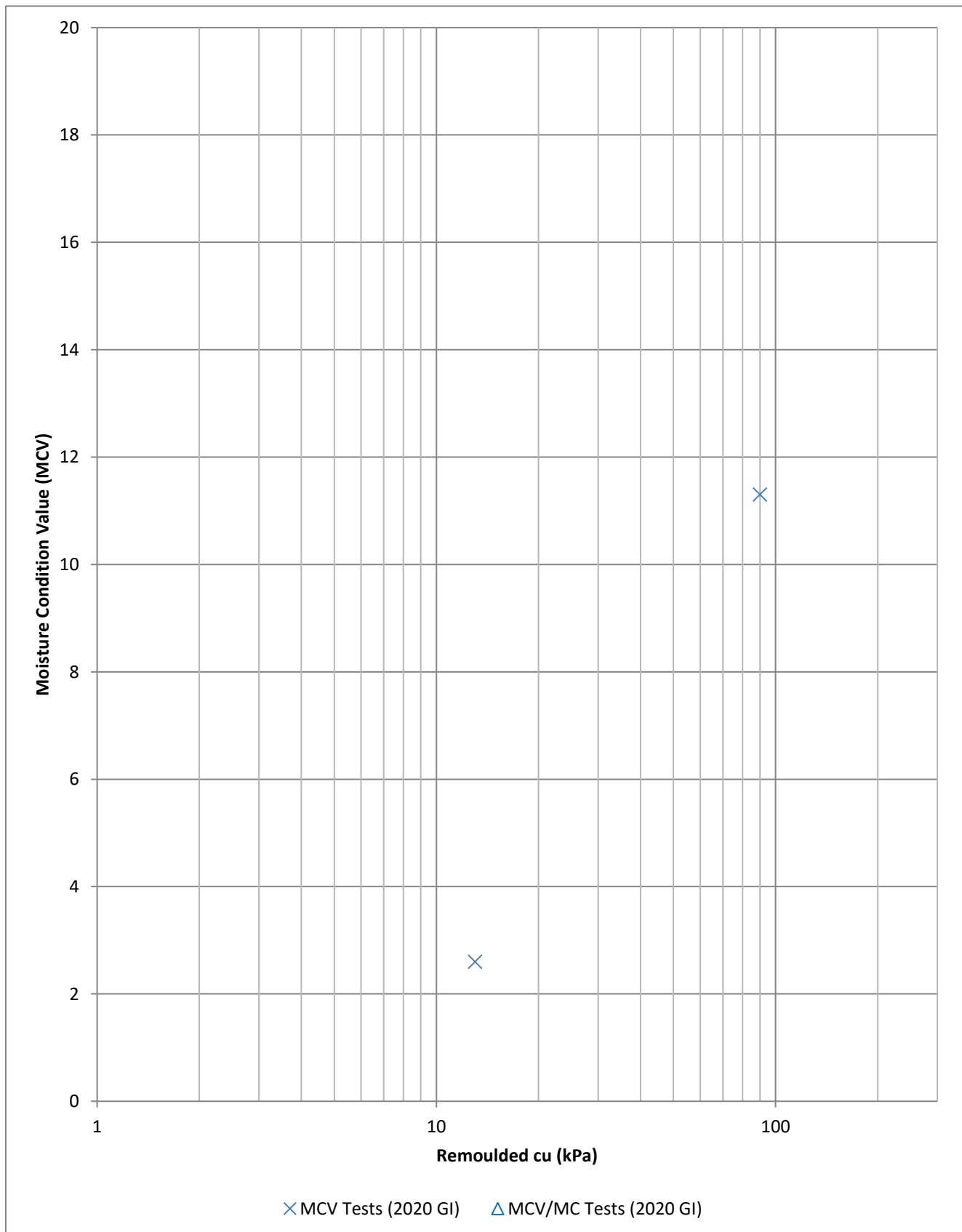
 Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Telephone: Woodcote Grove, Ashley +44 1372 726140 Road, Epsom, Surrey, KT18 5BW	Client		Title			
	Portsmouth Water		Moisture Condition Value vs Recompacted Vane Shear Strength for Head			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
	Havant Thicket Winter Storage Reservoir		A4	Date: 18/03/20	Date:25/3/20	Date: 03/4/20
		Status	Plot No		Rev	
		FINAL	16.1		P01	



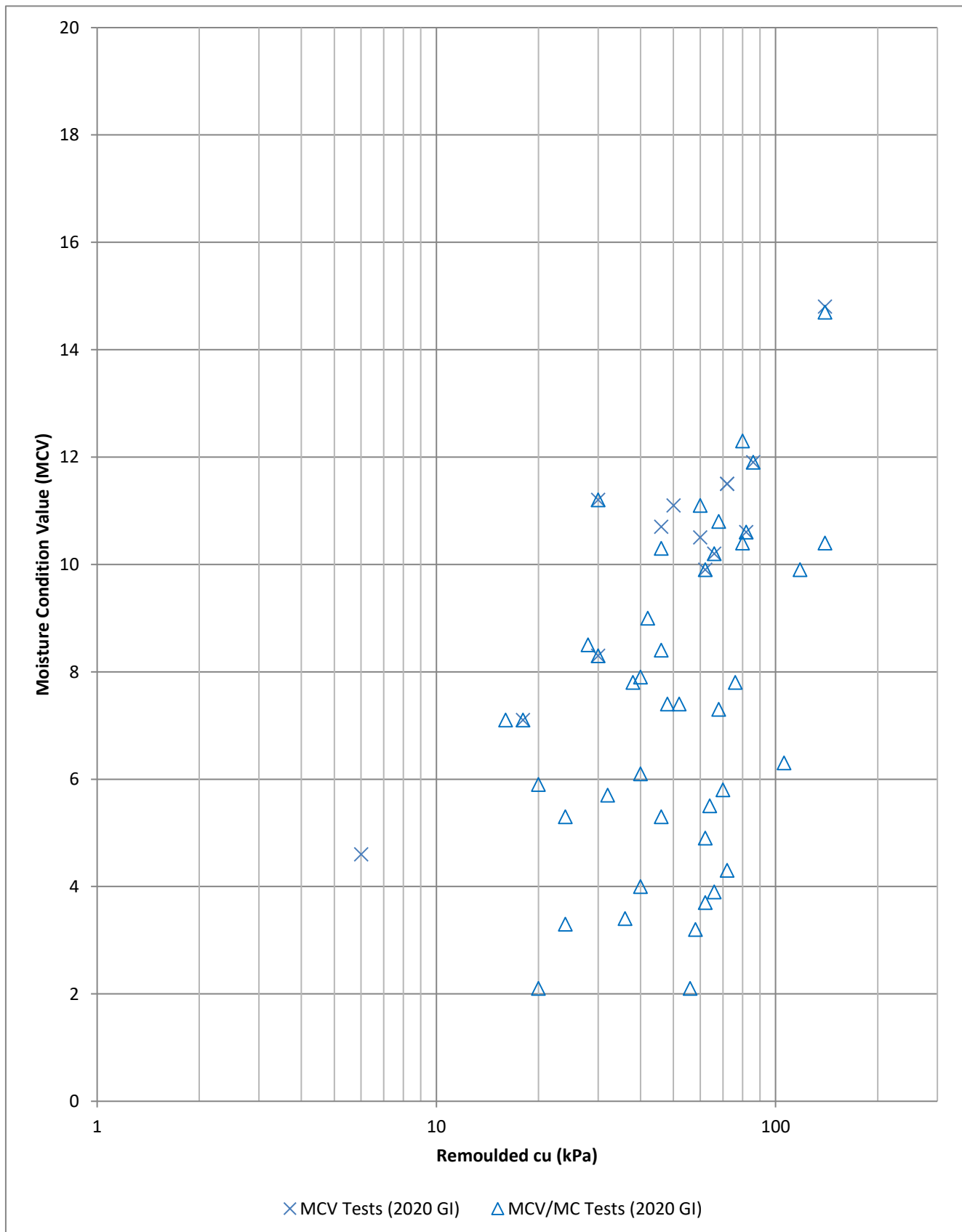
ATKINS Member of the SNC-Lavalin Group Atkins Epsom (All Offices) Telephone: Woodcote Grove, Ashley +44 1372 726140 Road, Epsom, Surrey, KT18 5BW	Client		Title			
	Portsmouth Water		Moisture Condition Value vs Recompacted Vane Shear Strength for Weathered London Clay Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir			A4	Date: 18/03/20	Date: 25/3/20	Date: 03/4/20
		Status	Plot No	Rev		
		FINAL	16.2	P01		



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	Portsmouth Water		Moisture Condition Value vs Recompacted Vane Shear Strength for Unweathered London Clay Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir			A4	Date: 18/03/20	Date: 25/3/20	Date: 03/4/20
		Status	Plot No	Rev		
		FINAL	16.3	P01		



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	Portsmouth Water		Moisture Condition Value vs Recompacted Vane Shear Strength for Harwich Formation			
	Project		Sheet Size	Drawn: HEF	Checked: RL	Reviewed: JA
Havant Thicket Winter Storage Reservoir			A4	Date: 18/03/20	Date: 25/3/20	Date: 03/4/20
		Status	Plot No	Rev		
		FINAL	16.4	P01		



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Portsmouth Water

Project

**Havant Thicket Winter Storage
Reservoir**

Title

**Moisture Condition Value vs Recompacted
Vane Shear Strength for Reading
Formation**

Sheet Size

A4

Drawn: HEF

Date: 18/03/20

Checked: RL

Date: 25/3/20

Reviewed: JA

Date: 03/4/20

Status

FINAL

Plot No

16.5

Rev

P01

Appendix E. Geo-environmental Data Screening

Assessment Criteria :		Public Open Space (Parks) - 1% SOM Sand																												
Use MRL Values?																														
Constituent	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedances	Locations of Exceedances	Location																					
									Sample ID	Depth																				
									Date																					
									Strata	Zone																				
Exchange Ammonium AR	mg/kg	<0.5	No SSV	20	<0.5	7.1	0				0.5	0.6	0.5	1.3	7.1	0.8	6.1	0.7	2.9	4.7	3.2	1.2	1.9	3.6	0.6	<0.5	<0.5	1.2	1.9	0.7
Benzene	mg/kg	<0.01		139	20	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethyl Benzene	mg/kg	<0.01		21400	20	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
m,p Xylenes	mg/kg	<0.02		9100	20	<0.02	<0.02				<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
o Xylene	mg/kg	<0.01		9560	20	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Toluene	mg/kg	<0.01		69900	20	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Xylenes	mg/kg	<0.03	No SSV		20	<0.03	<0.03				<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
S.O.M. % (Calc)	% MM	<0.04	No SSV		20	0.38	3.48	1.07			1.4	1.07	2.97	0.85	2.24	0.38	2.83	0.53	3.38	1.86	3.48	2.02	3.45	2.71	0.64	0.86	0.4	1.21	0.86	0.86
GRO	mg/kg	< 0.200	No SSV		20	<0.2	<0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
GRO (>C5 - C6)	mg/kg	< 0.200	No SSV		20	<0.2	<0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
GRO (>C7 - C8)	mg/kg	< 0.200	No SSV		20	<0.2	<0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
GRO (>C9 - C10)	mg/kg	< 0.200	No SSV		20	<0.2	<0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
GRO (>C5-C6 Aliphatic)	mg/kg	< 0.200	109000		20	<0.2	<0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
GRO (>C5-C7 Aromatic)	mg/kg	< 0.010	139		20	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
GRO (>C6-C7)	mg/kg	< 0.200	No SSV		20	<0.2	<0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
GRO (>C6-C8 Aliphatic)	mg/kg	< 0.200	163000		20	<0.2	<0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
GRO (>C7-C8 Aromatic)	mg/kg	< 0.010	69900		20	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SO4-- (acid sol)	mg/kg	<20	No SSV		20	64	1310				984	208	725	1310	127	349	266	103	427	222	440	370	342	319	311	558	173	64	663	242
Boron (H2O Soluble)	mg/kg	<0.5	No SSV		20	0.8	1.7				1.4	0.8	0.9	1.2	1.4	1.3	1.1	0.9	1.2	1.1	0.9	1.1	1.7	1.5	1.5	0.9	1	1.6	1.5	1.4
Arsenic (MS)	mg/kg	<0.3	168		20	0.7	20.6				6.4	7.1	11.2	10.3	7.4	9.5	5.7	3.2	13	7.9	12.4	9.5	8	20.6	9	14.8	4	0.7	10.9	9.2
Cadmium (MS)	mg/kg	<0.1	892		20	<0.1	0.43	0.22			0.43	<0.1	0.22	0.3	<0.1	0.1	0.12	<0.1	<0.1	<0.1	0.2	<0.1	0.1	0.14	0.16	0.23	<0.1	<0.1	0.11	0.15
Chromium (MS)	mg/kg	<0.5	83500		20	3.8	41.6				19	20.4	36.9	41.6	15	24.2	15.4	17.5	22.9	15.8	14.4	18.3	21.3	22.8	31	28.9	35.5	3.8	41	33.3
Copper (MS)	mg/kg	<0.5	45200		20	4.4	46.3				19.5	7.2	13.8	16.7	9.2	12.8	4.4	4.9	12.7	4.5	46.3	9	10.8	9.8	12.4	22.9	38.7	25.2	17.1	20.4
Lead (MS)	mg/kg	<0.5	1340		20	2.5	44.4				27.1	14.3	32.8	13.1	21.3	10.9	20.9	7.9	30.7	21.8	29.8	24.4	44.4	39.8	14.2	12	12.2	2.5	15.6	15
Manganese (MS)	mg/kg	<1	No SSV		20	8.4	785.2				124.9	90.9	203.8	97.1	270.9	165.9	136.6	129.8	785.2	251	85.9	82.2	344.7	612.1	131.1	130.2	8.4	52.1	43.5	
Mercury (MS)	mg/kg	<0.1	No SSV		20	<0.1	0.32				<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	0.32	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel (MS)	mg/kg	<0.5	804		20	0.7	49.8				7.6	7.8	47.7	26.7	5.1	16.6	8	9.2	17.6	5.8	6.6	7.1	9	10.8	16.8	49.8	8.9	0.7	14.4	15.8
Selenium (MS)	mg/kg	<0.5	2550		20	<0.5	1.8				<0.5	<0.5	0.6		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Vanadium (MS)	mg/kg	<0.6	1550		20	32.8	60.1	37			32.8	37	42.8	50.1	23.5	38.2	21.6	20.3	39.5	25.9	33	39.2	34.3	44.5	48.5	52.1	6.6	63.4	46.5	
Zinc (MS)	mg/kg	<3	201000		20	8.3	105.7	70.2	37		59.2	105.7	29.8	52	35.2	30.9	59	29.6	94.1	33	40.3	49.5	59.7	72.3	26.1	8.3	57.5	58.5		
Iron	mg/kg	<36	No SSV		20	4020	41200	22200	20700	23000	21900	14700	20400	13700	11500	39900	14700	22400	27900	23000	23200	28900	27400	37400	4020	41200	28900			
Chromium vi.	mg/kg	<0.1	251		20	<0.1	0.1				<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	< 0.08	28000		20	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Acenaphthylene	mg/kg	< 0.08	No SSV		20	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Anthracene	mg/kg	< 0.08	150000		20	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Benzo(a)anthracene	mg/kg	< 0.08	BaP Surrogate		20	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Benzo(a)pyrene	mg/kg	< 0.08	21.4		20	<0.08	0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Benzo(b)fluoranthene	mg/kg	< 0.08	BaP Surrogate		20	<0.08	0.09	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Benzo(ghi)perylene	mg/kg	< 0.08	BaP Surrogate		20	<0.08	<0.08																							

Assessment Criteria :		Drinking Water Standard England and Wales/WHO																									
CaCO (mg/l):		0.00	pH		0.00																						
Calcium (mg/l):		0.00	DOC (mg/l)		0.00	Catchment area:		Drinking Water Standard																			
Constituents	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedences	Locations of Exceedences	Location		Sample ID	Depth	Date	Strata	Zone	ATK-CP-01	ATK-CP-05	ATK-CP-06	ATK-CP-12	ATK-CP-01	ATK-CP-05	ATK-CP-06	ATK-CP-12	ATK-CP-01	ATK-CP-05	ATK-CP-06	ATK-CP-12
Benzene	mg/l	0.005	0.001	12	<0.005	<0.005	0					3m	14/01/2020			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ethylbenzene	mg/l	0.005	0.3	12	<0.005	<0.005	0					6m	14/01/2020			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
m & p-Xylene	mg/l	0.01	See Xylenes (total)	12	<0.01	<0.01	0					1m	14/01/2020			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o-Xylene	mg/l	0.005	See Xylenes (total)	12	<0.005	<0.005	0					1m	14/01/2020			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Toluene	mg/l	0.005	0.7	12	<0.005	<0.005	0					1m	14/01/2020			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Xylenes	mg/l	0.015	No WSV	12	<0.015	<0.015	0					1m	14/01/2020			<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Ammonia (Free) as N calc a	mg/l	0.01	0.39	12	<0.01	<0.01	0						29/01/2020			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia (Free) as NH3	mg/l	0.02	No WSV	12	<0.02	<0.02	0						29/01/2020			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammoniacal Nitrogen as NH4	mg/l	0.02	0.5	12	0.01	0.2572	0						29/01/2020														
GRO >C5->C6	mg/l	0.1	No WSV	12	<0.1	<0.1	0						29/01/2020			0.07716	0.21862	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.01	0.09	0.01	0.22
GRO >C5->C6 Aliphatic	mg/l	0.1	15	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
GRO >C5->C7 Aromatic	mg/l	0.005	0.01	12	<0.005	<0.005	0						29/01/2020			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
GRO >C6->C7	mg/l	0.1	No WSV	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
GRO C6->C8 Aliphatic	mg/l	0.1	15	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
GRO >C7->C8	mg/l	0.1	No WSV	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
GRO >C7->C8 Aromatic	mg/l	0.005	0.7	12	<0.005	<0.005	0						29/01/2020			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
GRO >C8->C10	mg/l	0.1	No WSV	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
>C8-C10 Aliphatic	mg/l	0.1	0.3	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
>C8-C10 Aromatic	mg/l	0.02	0.3	12	<0.02	<0.02	0						29/01/2020			<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
GRO-HSA o	mg/l	0.1	No WSV	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total GRO	mg/l	0.1	No WSV	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Antimony	mg/l	0.001	0.005	12	0.001	0.002	0						29/01/2020			0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	0.001
Arsenic	mg/l	0.001	0.01	12	0.001	0.004	0						29/01/2020			0.004	0.002	0.003	0.002	0.002	0.002	0.002	0.003	0.002	0.001	0.002	0.001
Cadmium	mg/l	0.00002	0.005	12	<0.00002	0.00022	0						29/01/2020			0.00022	0.00006	0.00007	0.00004	0.00003	0.00005	0.00005	0.00006	0.00003	<0.00002	<0.00002	<0.00002
Chromium	mg/l	0.001	0.05	12	0.001	0.001	0						29/01/2020			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/l	0.001	2	12	0.001	0.006	0						29/01/2020			0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	0.001
Lead	mg/l	0.001	0.01	12	<0.001	0.02	1	ATK-CP-01, 3m					29/01/2020			0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
Mercury	mg/l	0.00003	0.001	12	<0.00003	0.00009	0						29/01/2020			<0.00003	0.00009	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Nickel	mg/l	0.001	0.02	12	0.001	0.011	0						29/01/2020			0.011	0.002	0.006	0.007	0.004	0.002	0.004	0.003	0.007	0.002	0.006	0.004
Selenium	mg/l	0.001	0.01	12	<0.001	0.006	0						29/01/2020			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/l	0.001	N/A	12	0.001	0.006	0						29/01/2020			0.006	0.001	<0.001	0.003	0.003	0.001	<0.001	0.004	0.004	<0.001	0.001	0.001
Zinc	mg/l	0.002	3	12	0.005	0.412	0						29/01/2020			0.401	0.077	0.027	0.012	0.031	0.152	0.174	0.159	0.412	0.005	0.173	0.174
Aluminium	mg/l	0.01	0.2	12	0.01	0.77	2	ATK-CP-01, 2.5m; ATK-CP-06, 1m					29/01/2020			0.01	0.01	<0.01	0.01	0.01	<0.01	<0.01	0.01	0.77	0.01	0.54	0.19
Boron	mg/l	0.01	1	12	0.04	0.32	0						29/01/2020			0.04	0.04	0.15	0.06	0.12	0.07	0.1	0.07	0.32	0.04	0.16	0.14
Iron	mg/l	0.01	0.2	12	0.01	0.84	3	ATK-CP-06, 1m; ATK-CP-01, 2.5m; ATK-CP-06, 1m					29/01/2020			0.04	0.01	0.34	<0.01	0.02	0.01	0.01	<0.01	0.84	0.05	0.31	0.15
Phosphorus	mg/l	0.1	N/A	12	<0.1	<0.1	0						29/01/2020			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Sulphur as SO4	mg/l	3	No WSV	12	18	472	0						29/01/2020			472	123	18	302	326	120	18	303	374	101	29	297
Ammoniacal Nitrogen as N	mg/l	0.01	0.39	12	0.01	0.6	2	ATK-CP-06, 1m; ATK-CP-12, 1m					29/01/2020			0.04	0.14	0.4	0.6	0.06	0.17	<0.01	0.2	0.23	0.07	0.01	0.17
Chloride as Cl w	mg/l	1	250	12	38	110	0						29/01/2020			88	92	60	109	86	91	43	107	86	91	38	110
Chromium VI as Cr	mg/l	0.003	See Total Chromium	12	<0.003	0.006	0						29/01/2020			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.003
Nitrate as N	mg/l	0.2	50	12	<0.2	1.8	0						29/01/2020			<0.2	0.4	0.4	<0.2	<0.9	<0.9	1.8	<0.9	<0.2	<0.2	0.3	<0.2
Acenaphthene	mg/l	0.00001	See BaP	12	<<0.00001	<0.00004	0						29/01/2020			<0.00004	<0.00001	<0.00001	<0.00001	<0.00001	<0.000.						

Assessment Criteria :				Freshwater EQS																			
CaCO (mg/l):		pH		DOC (mg/l)		Catchment area:		Freshwater not listed															
Calcium (mg/l):		0.00		0.00																			
Constituents	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedences	Locations of Exceedences															
								Location															
								Sample ID															
								Depth															
								Date															
Strata								Zone															
Benzene	mg/l	0.005	0.01	12	<0.005	<0.005	0		ATK-CP-01	ATK-CP-05	ATK-CP-06	ATK-CP-12	ATK-CP-01	ATK-CP-05	ATK-CP-06	ATK-CP-12	ATK-CP-01	ATK-CP-05	ATK-CP-06	ATK-CP-12			
Ethylbenzene	mg/l	0.005	0.02	12	<0.005	<0.005	0		3m	6m	1m	1m	14/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
m & p-Xylene	mg/l	0.01	See Xylenes (total)	12	<0.01	<0.01	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
o-Xylene	mg/l	0.005	See Xylenes (total)	12	<0.005	<0.005	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Toluene	mg/l	0.005	0.074	12	<0.005	<0.005	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Xylenes	mg/l	0.015	No WSV	12	<0.015	<0.015	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Ammonia (Free) as N calc a	mg/l	0.01	0.2	12	<0.01	<0.01	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Ammonia (Free) as NH3	mg/l	0.02	No WSV	12	<0.02	<0.02	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Ammoniacal Nitrogen as NH4	mg/l	0.02	0.26	12	0.01	0.2572	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO >C5->C6	mg/l	0.1	No WSV	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO >C5->C6 Aliphatic	mg/l	0.1	0.01	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO >C5->C7 Aromatic	mg/l	0.005	0.01	12	<0.005	<0.005	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO >C6->C7	mg/l	0.1	No WSV	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO C6->C8 Aliphatic	mg/l	0.1	0.01	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO >C7->C8	mg/l	0.1	No WSV	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO >C7->C8 Aromatic	mg/l	0.005	0.01	12	<0.005	<0.005	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO >C8->C10	mg/l	0.1	No WSV	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
>C8-C10 Aliphatic	mg/l	0.1	0.01	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
>C8-C10 Aromatic	mg/l	0.02	0.01	12	<0.02	<0.02	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
GRO-HSA o	mg/l	0.1	No WSV	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Total GRO	mg/l	0.1	No WSV	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Anlimony	mg/l	0.001	N/A	12	0.001	0.002	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Arsenic	mg/l	0.001	0.05	12	0.001	0.004	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Cadmium	mg/l	0.00002	0.00008	12	<0.00002	0.00022	1	ATK-CP-01, 3m	14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Chromium	mg/l	0.001	See Cr VI as first pass	12	0.001	0.001	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Copper	mg/l	0.001	0.001	12	0.001	0.006	2	ATK-CP-01, 3m; ATK-CP-01, 2.5m	14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Lead	mg/l	0.001	0.0012	12	<0.001	0.02	2	ATK-CP-01, 3m; ATK-CP-01, 2.5m	14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Mercury	mg/l	0.00003	0.00007	12	<0.00003	0.00009	1	ATK-CP-05, 6m	14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Nickel	mg/l	0.001	0.004	12	0.002	0.011	5	ATK-CP-01, 3m; ATK-CP-06, 1m; ATK-CP-12, 1m; ATK-CP-01, 2.5m; ATK-CP-06, 1m	14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Selenium	mg/l	0.001	N/A	12	<0.001	0.006	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Vanadium	mg/l	0.001	0.02	12	0.001	0.006	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Zinc	mg/l	0.002	0.0123	12	0.005	0.412	10	ATK-CP-01, 3m; ATK-CP-05, 6m; ATK-CP-06, 1m; ATK-CP-01; ATK-CP-05; ATK-CP-06; ATK-CP-12; ATK-CP-01, 2.5m; ATK-CP-06, 1m; ATK-CP-12, 2.5m	14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Aluminium	mg/l	0.01	N/A	12	0.01	0.77	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Boron	mg/l	0.01	2	12	0.04	0.32	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Iron	mg/l	0.01	1	12	0.01	0.84	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Phosphorus	mg/l	0.1	calculate as per Schedule 3 Part 1 of 2015 WFD Directions	12	<0.1	<0.1	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Total Sulphur as SO4	mg/l	3	No WSV	12	18	472	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Ammoniacal Nitrogen as N	mg/l	0.01	0.2	12	0.01	0.6	3	ATK-CP-06, 1m; ATK-CP-12, 1m; ATK-CP-01, 2.5m	14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	12/02/2020	12/02/2020	12/02/2020			
Chloride as Cl w	mg/l	1	250	12	38	110	0		14/01/2020	14/01/2020	14/01/2020	14/01/2020	29/01/2020	29/01/2020	29/01/2020	29/01/2020	12/02/2020	1					

Site Name	Havant Thicket Winter Storage
Location	
Site ID	
Job Number	
Date	4/15/2020
User Name	Charlotte.Hidson@atkinsglobal.com
Company Name	Atkins

[illegible]



Atkins
The Hub
500 Park Avenue
Aztec West
Bristol
BS32 4RZ