

Equinix

DB5 Data Centre

Geotechnical Interpretative Report

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1 Introduction

1.1 Background

Ove Arup & Partners Ireland (trading as Arup) have been commissioned by Equinix to prepare a Geotechnical Interpretative Report (GIR) incorporating recent ground investigation works for a proposed new data centre DB5 at Blanchardstown, Dublin 15. The site location is shown in Figure 1.

1.2 Description of the Project

The proposed data centre consists of three blocks of three-storey data centre halls, 110kV substation, switch room, gas generators, water tanks and water treatment plant, above ground gas installation (AGI), and associated car parking.

The proposed site layout plan is presented in Figure 2.

1.3 Purpose of this Report

The purpose of this report is to satisfy the requirements of a ground investigation report (GIR) as defined in IS EN 1997-2:2007.

- Review all available information to the proposal development;
- Review all information provided by the site specific ground investigation (GII, 2017);
- Establish a ground model including geological cross-sections;
- Recommend geotechnical design parameters for use in foundation and car park design;
- Characterize the groundwater across the site;
- Undertake a geo-environmental assessment;
- Design recommendations for Foundations and Car Parks;
- Identify potential geotechnical risk and recommend measures to mitigate the identified risks.

This report is based on desk study information along with the recent ground investigation by Geotechnical Ireland Investigation Ltd (GII) in 2017.

2 The Site

2.1 Site Location and Description

The site is located at IDA Blanchardstown Snugborough Business Park, Blanchardstown, Dublin 15, approximately 10km northwest from Dublin city centre, as shown in Figure 1. The site is bounded by an industrial building (Clyde House 2) to the north, Blanchardstown Road North to the west, and two unnamed internal business park roads to the east and south.

Ground elevation is approximately 74mOD at the northeastern part of the site and falls gently to 71.5mOD to the southwestern corner of the site (i.e. 3-4m cross fall from north to south). A mound up to 75mOD is located in the southwest corner of the existing carpark.

2.2 Existing Structures within the Site

The site is currently occupied by an industrial building (Clyde House 1) and open space parking areas.

Clyde House 1 is a two-storey building founded on shallow spread foundations refer to JSA Architects Drawing Number PA 0151.

The buildings in the vicinity of the proposed site are mainly commercial and industrial buildings. Figure 3 showing site and the adjacent structures.

Clyde House 2 is situated to north of the site. Refer to JSA Architects Drawing Number PA 0151, it is a 3-storey building founded on shallow spread foundations.

Wonderfoods is located to the south of the site across an unnamed road. The Jelly Bean Factory and Luzern Technology Solutions are located to the west of the site. Ipsen Manufacturing Ireland Ltd is located to the northeast of the site. All are commercial and industrial buildings.

110kV overhead power line run diagonally in a southwest – northeast orientation through the centre of the site.

2.3 Site History

The publicly available information is reviewed and evaluated in table below.

Table 1: Review of Publicly available Information in Context of Proposed Structure

Year	Map/ Photograph details	General remarks relative to proposed site location	Potential geo-hazards at site location	Figure Number
1837- 1842	OSI Historic 6" map	The site was a greenfield. A road was adjacent to the site. A quarry was located to the east of the site, approximately 400m away.	Rockhead level may vary significantly. Groundwater level may be close to the ground level.	Figure 4

Year	Map/ Photograph details	General remarks relative to proposed site location	Potential geo-hazards at site location	Figure Number
		A pump was in the vicinity of the quarry. A pond was located to the northwest of the site, approximately 800m away. Few houses were located to the south and southwest of the site.		
1845	OSI Historic 6" map Cassini	No significant changes in the site. No sign of the quarry, the pump or the pond. Water is noted to the west of the site, approximately 700m away. A stream was located to the south of the proposed site, circa 150m away. A previously unknown house is presented as "Courtduff" in this map.	Perhaps "water" corresponds to a surficial aquifer or near surface groundwater.	Figure 5
1888-1913	OSI Historic 25" map	There does not appear any significant changes in the site and its vicinity.		Figure 6
1995	OSI Aerial Photograph	Part of the site was occupied by Clyde House 1. A building was located to the east of the site. Blanchardstown Road North has been constructed to the west of the site. Residential buildings to the south of the site have been built.	Unknown thickness of made ground or engineering fill placed on site. Contamination may be present.	Figure 7
2000	OSI Aerial Photograph	Industrial and residential buildings have been constructed in the vicinity of the proposed site. Significant construction activities/earthworks/site clearance have commenced adjacent to the proposed site (Clyde House 2) and opposite to Blanchardstown Road North.		Figure 8
2002	Google Earth Aerial Photograph	The construction of the adjacent building has been completed. Blanchardstown Road North has been widened.		Figure 9

Year	Map/ Photograph details	General remarks relative to proposed site location	Potential geo-hazards at site location	Figure Number
		The Institute of Technology of Blanchardstown along with same nearby roads has been constructed in the area where most of the earthworks took place during Year 2000.		
2005	OSI Aerial Photograph	No noticeable changes in the site and its vicinity.		Figure 10
2013	Google Earth Aerial Photograph	No noticeable changes in the site and its vicinity.		Figure 11
2015	Google Earth Aerial Photograph	Construction activities/earthworks have taken place to the northwest of the site. A possible expansion of an industrial development is located to the southeast of the site.		Figure 12
2016	Google Earth Aerial Photograph	No noticeable changes in the site and its vicinity.		Figure 13
2017	Google Earth Aerial Photograph	New industrial building has been constructed to the east of the proposed site. An existing industrial development, which is located to the northwest of the proposed site, has been expanded.		Figure 14

3 Geological Settings

3.1 Published Geological Information

A summary table of the published geological information is presented in

Table 2: Summary of Published Geological Information

Map/ details	General remarks relative to proposed site location	Potential geo-hazards at site location	Figure Number
GSI web viewer – Subsoil sediments	The subsoil at proposed site location is defined as “Made ground”. Till derived from limestone is recorded adjacent to the site.	Contamination may be present within the made ground.	Figure 15
GSI web viewer – Quaternary sediments	The quaternary sediments is defined as “Till derived from limestone”. Rock outcrops in vicinity of site.	Shallow rockhead.	Figure 16
GSI web viewer – Quaternary sediments and geomorphology	A mega scale glacial lineation is present to the west of the site, c. 1.6km away. Meltwater channels are adjacent to the aforementioned lineation.	Variable rockhead.	Figure 17
GSI web viewer – Bedrock Geology 100k	The underlying rock at the site include: - Argillaceous bioclastic limestone and shale (Malahide formation). - Calcareous shale, limestone conglomerate (Tober Collen Formation). - Dark limestone and shale (calp, Lucan formation).	A fault appears to cross the site. Rockhead level, rock strength, and soil strength may vary laterally.	Figure 18
GSI web viewer – Depth to Bedrock	The depth to bedrock is defined as “1-3mBGL”; shallow rock.	Rock seems to be shallow and close to ground level. Rock excavation may be required during construction.	Figure 19

Note: GSI – Geological Survey of Ireland

3.2 Regional Soils and Subsoils

The superficial geology of the area generally comprises Made Ground overlying glacial drift deposits.

According to the Teagasc subsoils map (Figure 15), the shallow overburden beneath the site comprised of Made Ground. The most recent Made Ground deposits are assumed to be associated with the most recent construction works in the site.

Drift is a general term applied to all materials (clay, silt, sand, boulders) transported by a glacier and deposited directly as till by or from the ice, or as fluvioglacial deposits by running water emanating from the glacier.

The GSI Quaternary sediment maps indicate that the site is underlain by glacial till derived from limestone. The more familiar terms 'boulder clay' or lodgement and tills are also commonly used and used to describe these consolidated poorly sorted deposits with a wide range of particle sizes and not just clay and boulders.

3.3 Regional Bedrock Geology

The Geological Survey of Ireland (GSI) Bedrock Geology 1:100,000 scale map indicates that the site is underlain by Argillaceous bioclastic limestone and shale of the Malahide formation in the northern part of the site; Calcareous shale, limestone conglomerate of the Tober Collen Formation in the southeast of the site, and Dark limestone and shale (Calp) of the Lucan formation in the southwest of the site as presented in Figure 18.

The GSI Bedrock Geology map also indicates the presence of an east-northeast to west-southwest oriented fault running across the site.

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4 Ground Investigations

4.1 Previous Site Investigations

A search was carried out on the GSI database on the existing ground investigations in the site and its vicinity. The location of the existing ground investigation is presented in Figure 20.

Only one ground investigation report is available on the GSI database. The ground investigation (GSI Report 2241) was carried out in 1978 for Industrial development at Snugborough, Blanchardstown. Both contractor and supervision engineer are unknown. One of the borehole falls within the proposed site, while three other boreholes were carried out in the vicinity of the site. The boreholes were drilled up to depth of 3.5mBGL.

The findings of this intrusive GI are relatively consistent, Topsoil overlying CLAY overlying (weathered) bedrock. It should be noted that the BH logs indicate that the BH extended up to 2.0m into rock. The drilling technique employed indicates that this is weak or highly weathered rock. Rotary drilling to prove the level of competent bedrock has not been undertaken.

4.2 Ground Investigations Ireland Ltd (2017)

A site specific ground investigation was carried out in November and December 2017 by Ground Investigations Ireland (GII) Limited.

The ground investigation comprised the following:

- 10 No. shell and auger boreholes with associated sampling and in-situ testing.
- 6 No. follow-on rotary core boreholes recover intact rock core.
- 6 No. trial pits with associated sampling and in-situ testing
- Geophysical survey (Seismic refraction and 2D resistivity).
- Standpipe installations to measure groundwater levels at 4 No. locations.
- Groundwater monitoring.
- Soil, rock, and environmental laboratory testing.

As-built exploratory locations are shown on Figure 21.

5 Ground Summary

5.1 Ground Model

The section location plan and geological sections showing the ground conditions of the site are shown in Figures 22 to 25.

The ground investigation reveals that the ground is generally underlain by Made Ground, over firm to stiff (soft in places) glacial till, weathered rock, and competent bedrock. Granular Glacial Deposits are found in one localized area.

Limestone bedrock is reasonably shallow with weathered rock (SPT N>50) encountered at depths of between 1.3m and 2.9mBGL, and competent rock encountered at depths of between 1.5m and 3.5mBGL.

A summary of the stratification encountered in the exploratory logs is shown in Table 3 below:

Table 3: Summary of Stratification Encountered in the Exploratory Logs

Stratum:	Description	Depth Range to Top of strata (where present) (mBGL)	Average Thickness (Min/Max) (m)
Made Ground	Concrete, Tarmac, sandy gravel, crushed rock fill, gravelly clay fill.	0.0 (Ground surface)	1.0m (0.4m/1.7m)
Cohesive Glacial Till Overburden	Firm to stiff (soft in places) sandy gravelly CLAY.	0.4m to 1.7m	1.1m (0.4m/2.1m)
Granular Glacial Deposits (only present at BH106 & TP104)	Loose to medium dense clayey GRAVEL	0.9m to 1.0m	0.3m to 1.2m
Weathered Rock (not present at all locations)	Recovered as cobbles and boulders of Limestone in gravelly clay matrix. (Note SPT N>50)	1.3m to 2.9m	0.75m (0.2m/1.3m)
Bedrock	Medium strong to strong dark grey LIMESTONE (occasionally medium strong black MUDSTONE).	1.5m to 3.5m	N/A

5.2 Geological Fault

A geological fault is present on GSI Maps (Figure 18) and was identified during the desk study as potentially crossing the site.

The geophysical survey and ground investigation indicate that the fault is located to the southeast of the proposed new building. The geophysical survey indicates that the location of the fault is broadly in line with the GSI Maps.

It appears to be a geological boundary only between the Malahide Formation (argillaceous limestone and shale), the Tober Colleen Formation (shale and limestone conglomerate) and the Lucan Formation (limestone and shale).

The borehole logs and geophysical survey report indicate that there are no obvious signs of variation in rockhead levels at the location of the fault across the site or any zones of highly weathered, fractured or broken bedrock. The fault is not associated with any seismic activity.

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6 Ground Properties

6.1 Made Ground

6.1.1 Description

Made Ground was encountered at all boreholes and trial pits from existing ground level. Its thickness varied from 0.4 to 1.7m. The Made Ground Stratum is mainly described as Concrete, Tarmac, sandy gravel, crushed rock fill or sandy gravelly clay (reworked glacial till).

6.1.2 Classification

Only one Atterberg test has been carried out for the Made Ground stratum. The sample was taken from TP105, 1.4mBGL. The Liquid Limit is 63%, The Plastic Limit is 33% and Plasticity Index is 30%. The results indicate that this sample corresponds to a clay to silt with high plasticity, as presented in Figure 26.

No PSD were carried out on samples of Made Ground.

Two natural moisture content (NMC) tests have been carried out. The indicate NMC of the Made Ground stratum ranges from 21 to 35% as presented in Figure 27.

6.1.3 Bulk Unit Weight

No laboratory or *in situ* testing was carried out on samples of Made Ground so reference is made to BS 8002:2015 to derive bulk unit weight values.

BS8002:2015 suggested the unit weight for medium strength clay to be 16kN/m³ to 20kN/m³ and 16kN/m³ to 20kN/m³ above and below groundwater table respectively. A bulk density of 17kN/m³ is recommended for Made Ground strata.

6.1.4 Strength

Two Standard Penetration Tests (SPT) have been carried out in the Made Ground stratum. SPT-N values versus depth are presented in Figure 28. The SPT-N values range from 12 to 27.

6.2 Granular Glacial Deposits

6.2.1 Description

Granular Glacial Deposits were only encountered at BH106 and TP104 underlying the Made Ground. Its thickness varied from 0.3 to 1.2m. The Granular Glacial Deposits are described as loose to medium dense clayey Gravel.

6.2.2 Classification

Two PSD were carried out on samples of Granular Glacial Deposits. The PSD curves indicates that the material consists of approximately 20% fines content, 20% sand, and 60% gravel. The PSD curves are presented in Figure 29.

No Atterberg test and natural moisture content tests have been carried out for the Glacial Granular Deposits stratum.

6.2.3 Bulk Unit Weight

No laboratory or in situ testing was carried out on samples of Granular Glacial Deposits. BS8002:2015 suggested the unit weight for loose to medium dense Gravel to be between 16kN/m³ and 20kN/m³ above groundwater table and between 18kN/m³ to 22kN/m³ below groundwater table. A bulk density of 18kN/m³ is recommended for the Granular Glacial Deposits.

6.3 Glacial Till

6.3.1 Description

Glacial Till was encountered in all trial pits and boreholes underlying Made Ground or Granular Glacial Deposits. Its thickness varied from 0.4 to 2.1m. The Glacial Till Stratum is mainly described as firm to stiff brown sandy gravelly CLAY.

6.3.2 Classification

12 Atterberg tests were carried out for the Glacial Till Stratum. The Liquid Limit ranges from 33% to 43% with average of 38% while the Plastic Limit ranges from 21% to 26 % with average of 24%. The Plasticity Index ranges from 11% to 17% with average of 14% as shown in Figure 30. The result shows that the material is a clay with low to intermediate plasticity as presented in Figure 31.

Ten PSD tests were carried out on samples of Glacial Till. The PSD curves indicates that the material consists of approximately 30% of fines content, 25% of sand, 45% of gravel which is consistent of a lodgement till. The PSD curves are presented in Figure 32.

21 No. natural moisture content tests were carried out and they indicate the NMC of the Glacial Till Stratum ranges from 12 to 25%, the results are presented in Figure 33.

6.3.3 Bulk Unit Weight

No density tests have been carried out on the Glacial Till strata. BS8002:2015 suggested the unit weight for clay with very high undrained shear strength to be 18.0kN/m³ to 24kN/m³ and 19kN/m³ to 24kN/m³ above and below groundwater table respectively. A bulk density of 20kN/m³ is assigned to the Glacial Till strata.

6.3.4 Strength

Total stress

Drained or undrained laboratory shear strength tests were not carried out on the Glacial Till stratum.

Standard Penetration Tests have been carried out in all boreholes. The SPT-N value of Glacial Till versus depth is presented in Figure 34. The SPT-N values range from 7 to > 67 and a conservative characteristic value of 10 is recommended.

The undrained shear strength has been derived from the Stroud and Butler (1975) correlation based on SPT N values as follows:

$$c_u = f_1 \times N \text{ [kPa]}$$

The plasticity index is 14% for the Glacial Till stratum based on the Atterberg Limit test. An f_1 coefficient of 6 has been adopted. This equates to undrained shear strength (c_u) of 60kPa.

Effective stress

Effective stress shear strength laboratory testing were not carried out on samples of Glacial Till.

The correlation suggested in BS8002:2015 for fine soils between Plasticity Index and angle of shearing resistance is referred.

$$\phi'_{cv,k} = (42^\circ - 12.5 \log I_p)$$

where I_p is soil plasticity index.

Based on plasticity index of 14%, $\phi'_{cv,k}$ is 27.6°, which is considered conservative for Glacial Till.

A design value of 30° based on the characteristic SPT-N value is recommended for the design. The effective cohesion c' has been assumed to equal 0kPa.

6.3.5 Stiffness

Lunne et al (1997) provides relationships between undrained stiffness (E_u) and c_u in the range of $E_u/c_u = 600$ to 1500 for clay with an I_p of 15%. E_u is assumed to be $600c_u$ considering the plasticity index of 14% in the Glacial Till stratum. Using this relationship and the c_u of 60kPa, E_u stiffness is estimated to be 36MPa.

The drained stiffness (E') may be estimated using:

$$E' = \frac{2(1 + \nu)}{3} E_u$$

Where ν is the Poisson's ratio and E_u the undrained stiffness. Assumed Poisson's ratio as 0.2, E' is calculated to be 29MPa.

6.4 Weathered Rock

6.4.1 Description

Weathered Rock was encountered at BH101, BH107, BH108, BH109, BH110, TP101, TP102, TP103, TP105 and TP106 underlying Glacial Till. Its thickness varied from 0.2 to 1.3m. The Weathered Rock stratum was mainly recovered as cobbles and boulders of Limestone in gravelly clay matrix.

6.4.2 Strength

Three Standard Penetration Tests (SPT) were carried out in Weathered Rock Stratum. SPT-N values versus depth are presented in Figure 35. The SPT-N values were all greater than 50. A characteristic value of 50 is recommended.

6.5 Bedrock

6.5.1 Description

Bedrock has been encountered in all rotary coreholes at the base of Glacial Till or Weathered Rock. It is described as medium strong to strong dark grey Limestone, occasionally medium strong black Mudstone.

6.5.2 Bulk Unit Weight

The unconfined compression strength (UCS) test results define a range of bulk unit weights of 26.4kN/m³ to 26.8kN/m³. A characteristic bulk unit weight of 26.5kN/m³ is recommended for design.

6.5.3 Strength

The unconfined compressive strength (UCS) results range from 39.5MPa to 137.6MPa as shown in Figure 38. The point load tests results (Is50) are presented on Figure 36. The Is50 results range from 0.43MPa to 5.02MPa. For unconfined compressive strength and Is50 samples within 0.1m in the same borehole, a plot of unconfined compressive strength against Is50 is presented on Figure 37.

Also shown on Figure 37 are trend lines suggested by Casey & Fleming (2015) for Dublin Limestone and Mudstone. Analysing the current data set, a factor of 21 is chosen. Figure 38 presents the measured unconfined compressive strength and the factored Is50 data. A characteristic unconfined compressive strength value of 20MPa is suggested for design.

6.5.4 Stiffness

The intact rock stiffness (E_i) may be estimated from the UCS of the rock by application of a “modulus ratio”, M (BS8004:2015). The relationship is given by:

$E_i = M \text{ (UCS)}$ where M can be assumed to be 150 for marly Limestone.

Rockmass stiffness derived from laboratory testing does not reflect the actual stiffness of the insitu rock as no allowance is made for the extent and nature of discontinuities. A simplified method to evaluate the modulus of deformation of rockmass (E_m) based on intact rock stiffness (E_i) is as follows:

$$E_m = j E_i$$

Where j is the “mass factor” related to the average discontinuity spacing expressed in metres with an upper limit of unity.

Based on a characteristic UCS of 20,000kPa, $E_i = 3.0$ GPa.

Based on a mass factor j of 0.2, $E_m = 0.6$ GPa.

6.6 Summary of Geotechnical Parameters

Table below presents the summary of geotechnical design parameters

Table 4: Summary of Geotechnical Design Parameters

Strata	Bulk density, γ (kN/m ³)	SPT N Value	Shear strength			E_u (MPa)	E' (MPa)
			c_u / UCS (kPa)	ϕ' (°)	c' (kPa)		
Made Ground	17	< 10	-	-	-	-	-
Granular Glacial Deposits	18	-	-	-	-	-	-
Glacial Till	20	10	60	30	0	36	29
Weathered Rock	-	50	-	-	-	-	-
Rock	26.5	>> 50	20,000	-	-	$E_i = 3.0$ GPa	$E_m = 0.6$ GPa

7 Groundwater Conditions

7.1 Hydrogeological Setting

The Geological Survey of Ireland (GSI) have designated all the major rock types in Ireland into categories based on their ability to store and transit groundwater. The Limestones which underlie the majority of the site are designated by the GSI as a locally important aquifer. This is described by the GSI as “bedrock which is moderately productive only in local zones”. Part of the site underlain by limestone conglomerate of the Tober Collen Formation has an aquifer described as “poor”, i.e. bedrock is generally unproductive except for local zones. The groundwater aquifers map is presented in Figure 39.

No gravel aquifers are shown on the GSI groundwater viewer under or in the vicinity of the site. However, this does not discount the possibility of small gravel deposits being present which could provide base flow to water features or be available for abstraction.

The GSI have designated the groundwater vulnerability of the aquifers across the country based on the thickness of the low permeability overburden and depth beneath the surface to groundwater. The groundwater vulnerability map does not account for the sensitivity of small permeable units in the drift deposits which could also provide pathways. As the aquifer vulnerability is dependent on the thickness of the overburden the vulnerability classification can be increased by excavation. The groundwater vulnerability under the site is shown to be high as shown in Figure 40. This reflects the shallow bedrock at this site.

Information on known wells and ground water supply protection zones is also presented on the GSI groundwater viewer as shown in Figure 41. No wells are present on site. One spring (Well 1) is shown to west site, circa 1.8km away of the site. It is a spring drilled in 1899, and there is no information on the depth. Two additional borehole wells (Well 2 and 3) are shown to the southeast of the site, with circa 2.1km to 3.0km away from the site.

7.2 Groundwater Monitoring

Groundwater monitoring to date is summarised in Table 5 below. Groundwater levels were at their highest in early January 2018 and again is rising back towards those values in early March 2018, ranging from 0.9m to 2.3m BGL (or 70.9mOD to 72.0mOD). Groundwater monitoring to date is shown on Figures 42 and 43.

Current information indicates that groundwater levels are a combination of infiltrated surface water perched on the bedrock (BH102) and groundwater levels within the underlying bedrock aquifer (BH103, BH106 and BH108).

It should be noted that groundwater levels can fluctuate over time.

Table 5: Summary of Groundwater Monitoring

Borehole		BH102	BH103	BH106	BH108
Ground Level	mOD	72.87	73.18	74.29	71.88
Response Zone	mBGL	0.4-1.1	2.6-3.6	2.5-3.5	1.6-2.3
01/12/2017	mBGL	1.10	1.80	2.20	1.44
	mOD	71.77	71.38	72.09	70.44
13/12/2017	mBGL	1.10	2.15	2.14	1.50
	mOD	71.77	71.03	72.15	70.38
04/01/2018	mBGL	0.90	2.00	2.10	1.06
	mOD	71.97	71.18	72.19	70.82
11/01/2018	mBGL	DRY	2.09	2.12	1.46
	mOD		71.09	72.17	70.42
18/01/2018	mBGL	1.14	2.12	2.15	1.44
	mOD	71.73	71.06	72.14	70.44
22/02/2018	mBGL	DRY	2.31	2.23	1.80
	mOD		70.87	72.06	70.08
08/03/2018	mBGL	DRY	1.90	1.97	1.25
	mOD		71.28	72.32	70.63

Reference to published flood maps indicates that there is no recorded history of groundwater flooding at this site. A site-specific Groundwater Flood Risk Assessment Report has also been prepared by Arup (Report Reference REP/GE/002-258064).

7.3 Design Groundwater Level

Based on measured groundwater levels and existing topography on the site, the Arup Groundwater Flood Risk Assessment Report recommends that a maximum groundwater level increase of 0.7m is applied. As a result, the recommended ULS design groundwater levels are as below and accounts for this increase. It should be noted that the ULS ground water level is defined as the most unfavourable values that could occur during the design lifetime of the structure, IS EN 1997 (Eurocode 7).:

Table 6: Summary of recommended Designed Groundwater Level for ULS Design

Area	Recommended ULS Design Groundwater Level
Building 1 (and adjacent access roads)	73.0mOD
Building 2 (and adjacent access roads)	72.5mOD
Building 3 (and adjacent access roads)	72.4mOD
Car Park, Gas Generator and AGI	71.4mOD
Water Treatment and Water tanks	71.0mOD

7.4 Assessment of Greenfield Runoff Rates

Greenfield run off rates can be assessed by reference to IoH124 SOIL Values and WRAP Classes (Institute of Hydrology Report 124, 2004) and HOST Classes from IoH126 (Institute of Hydrology Report 126, 2004). The following is recommended for assessment of greenfield runoff:

- SOIL (IH124) Value of 0.4 (WRAP Class 3).
- HOST (IH126) Class of 25

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8 Geo-Environmental Assessment

8.1 Geo-Environmental Testing

Chemical and environmental testing has been undertaken as part of the GI works. Testing was undertaken to determine the presence of any elevated levels of contaminants, allow screening for disposal and Waste Acceptance Criteria (WAC) and to assess Aggressivity of site conditions for concrete.

Photoionization Detector (PID) testing of 30 No. soil samples was undertaken at various depth intervals in all exploratory hole locations. A PID allows for instantaneous detection/screening of Volatile Organic Compounds (VOC's) such as hydrocarbons, fuel, diesel etc. No obvious indications of elevated VOC's were noted.

Environmental testing was undertaken on 22 No. samples at 14 locations from depths of between 0.5mBGL and 1.7mBGL.

2 No. samples (TP105, 1.4mBGL and BH106, 1.3mBGL – both within Natural Ground) contain elevated levels of Sulphate and are classified as requiring disposal to a licensed Non-Hazardous landfill, if excavated and disposed off-site.

All other samples indicate that excavated material at these locations can be disposed of to a licensed Inert Landfill, if disposed of offsite, subject to landfill acceptance at the time of excavation and disposal.

Asbestos was not detected in any of the environmental samples tested.

8.2 Chemical Environment for Concrete

The following assessment of the chemical environment for concrete is undertaken in accordance with IS EN 206:2013. Chemical testing has been carried out on soils associated with the ground investigation works, the detailed results can be found in GII Final Factual Report (GII, 2018).

Groundwater chemical testing was not undertaken.

Sulphate testing and pH values were performed on 16 samples from 1.0 to 2.0mBGL, one sample is from the Made Ground (TP105 1.4mBGL), one sample is from Granular Glacial Deposits (TP104), and all other samples are from Glacial Till.

Sulphate contents were measured in the range of 2.8 to 177.2mg/kg. pH was measured in the range of 7.67 to 8.98.

Table 7: Summary of pH and SO₄ values

Tested Parameters	Min	Max	Characteristic Value
pH	7.67	8.98	7.67
Sulphate SO ₄ (mg/kg)	2.8	177.2	177.2

The pH and sulphate results indicate that the concrete in the ground does not require a class designation for chemical attack in accordance with Table 2 of IS EN 206.

Chemical testing indicates that the site conditions for concrete structures are classified as non-aggressive as the values are less than the minimum requirements specified in IS EN 206-1:2000. Note that the structural engineer may have concrete durability requirements in excess of the above minimum limits.

8.3 Ground Gases

The desk study did not indicate any potential sources for ground gases of concern such as methane, CO₂, CO and H₂S in the immediate vicinity of the site (e.g. landfills or infilled quarries). The ground investigation did not indicate any obvious sources that could produce such ground gases (e.g. organic soils, buried organic waste, domestic waste, construction & demolition waste etc.) or any obvious sources of VOC's or semi VOC's.

Photoionization Detector (PID) testing was undertaken testing of 30 No. soil samples taken at various depth intervals in all exploratory hole locations. No elevated levels of VOC's were noted.

On the basis of the above, no specific ground gas monitoring was undertaken during the GI.

The environmental testing indicates the only elevated contaminant was sulphate. No elevated levels (i.e. sources of ground gases) of organic matter, PAH (Polycyclic aromatic hydrocarbons), EPH (extractable petroleum hydrocarbons), Mineral Oil, GRO (Gasoline range organics), TOC (Total Organic Carbon) were detected.

The desk study and GI indicate no obvious sources that could produce ground gases and the insitu and environmental testing indicated the same. The risk of encountering ground gases of concern at this site is considered low.

8.4 Radon

Reference to the EPA Radon Map (<http://www.epa.ie/radiation/radonmap/>) indicates that the site is located in a low radon area, where less than 1% of homes are estimated to be above the radon reference level of 200 Becquerels per cubic metre (200Bq/m³).

However, it should be noted that the site is located in close proximity to an area where between 5% and 10% are estimated to be above the reference level.

The Data Centre space will be an occupied space. In accordance with the Building Regulations Technical Guidance Document C, radon protection measures should be provided.

9 Design Recommendations for Structures

9.1 Shallow Foundations

Given the shallow depth to rock encountered on this site it is expected that a shallow foundation solution is appropriate for the current development.

Current project drawings (at the time of writing) indicate that the building loads will be supported by ground beams (strip foundations). The drawings indicate 900mm deep ground beams with deeper and 1500mm beams through the centre of each building. The underside of the beams are currently indicated to be at between 71.3mOD and 70.7mOD.

Building loads (actions) have not been made available.

Figures 23, 24 and 25 indicate that the underside of the ground beams will be located within a range of materials, soft/firm/stiff glacial till, loose clayey gravel, weathered rock.

9.1.1 Bearing Capacity

Allowable bearing capacities for foundations in each material type are provided in Table 8 below. Allowable bearing capacities are based on the insitu and laboratory testing.

Allowable bearing capacities are provided to assist in sizing of foundations at scheme design phase only. A Eurocode compliant design is required to determine both the ULS and SLS stability of the foundation system, using the appropriate load and soil factors as defined by the code. The structure shall be designed to accommodate the expected total and differential settlement.

Made Ground

Since Made Ground is highly variable, it is not recommended that the ground beams are founded on Made Ground.

Glacial Till

On the basis of the characteristic SPT N value of 10, an allowable bearing capacity of 100kPa is recommended. Glacial Till is a low plasticity soil and thus any increase in water content from exposure to surface or groundwater will result in a loss of strength and stiffness.

Weathered Rock

All SPT results show SPT-N values of > 50 for the weathered rock stratum. An allowable bearing capacity for weathered rock of 250kPa is recommended.

Limestone Bedrock

The allowable bearing capacity for foundations bearing on rock is estimated from uniaxial compressive strength (UCS) and discontinuities spacing with reference to Figure 1 of BS8004:2015 (Code of for Foundations). An allowable bearing capacity for the limestone bedrock of 500kPa is recommended.

Table 8: Summary of recommended Bearing Capacity of each stratum

Materials	Allowable Bearing Capacity (kPa)
Made Ground	Not suitable as founding materials
Glacial Till	100
Weathered Rock	250
Limestone Bedrock	500

Based on discussions with the structural engineer we understand that the ground beams will need to found on either weathered rock or the underlying limestone bedrock. The glacial till may have inadequate bearing capacity.

Based on levels shown on the project drawings and Figures 23, 24 and 25, the foundations will either need to be deepened, or excavated down to the weathered rock or top of competent limestone bedrock and lean mixed back up as required.

This particularly applies to the western side of the Building 3 and along the southern end of all three buildings.

9.1.2 Design to Eurocode EC7

The detailed designer will be required to undertake ULS (bearing capacity) and SLS (serviceability and settlement) checks in accordance with the requirements of EC7.

9.2 Groundwater

Ground levels are shown on Figures 23, 24 and 25 and indicate that excavations for the ground beams and any further deepening's required will be below the groundwater table (depending on time of year excavations take place).

Reference to the project drawings also show an attenuation tank located adjacent to the southern end of Buildings 1 and 2, beneath an area of car parking.

The drawings also shows attenuation crates beneath the entrance road, located adjacent to the south eastern corner of the eastern building.

Based on nearby groundwater monitoring at BH106 (Figure 25) and water ingress noted in TP103 and TP106, excavations for the attenuation tank and crates will be **below** the water [table and below groundwater levels estimated under extreme rainfall events](#), potentially up to approximately 2m below groundwater levels recorded in BH106 (Figures 42 and 43).

Based on the above, allowance for dewatering and/or sump pumping will be required for foundation and attenuation tank excavations.

In addition, uplift checks should also be undertaken for the attenuation tanks based on the recorded groundwater levels and recommended design groundwater level. The use of infiltration drainage on this site is not recommended due to the shallow groundwater and slow percolation rates of the underlying strata.

It is fundamental that appropriate groundwater control is used to prevent water ingress and that the formation stratum is not left exposed to the weather or overnight.

It is recommended that an experienced and qualified geotechnical engineer inspects formation level prior to construction of the shallow foundations.

9.3 Ground bearing Slabs

The final level of the ground bearing slab needs to consider that there is high groundwater on the site. Waterproofing measures are required for all service pits, duct runs and localised low slab areas below the groundwater table. In addition, water ingress through pipe joints could result in flooding of service pits and also needs to be considered in the design.

The project drawings indicate a build-up beneath the 225mm ground bearing slab of 50mm concrete blinding, over 150mm sub-base over 300mm capping layer. The proposed unbound granular layers beneath the slab are not in accordance with the requirements of the following:

- I.S. 888:2016 Code of Practice for the procurement and use of unbound granular fill hardcore material for use under concrete floors.
- Annex E of S.R. 21:2014+A1:2016 Guidance on the use of I.S. EN 13242:2002+A1:2007 – Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction.

The designer should refer to the above documents to ensure compliance with all relevant standards.

Figures 23, 24 and 25 indicate that the base of the proposed underslab granular fill layers will be founding predominantly on the Glacial Till with areas possibly on Made Ground. The properties of Made Ground are used for estimation of modulus of subgrade reaction (k) as a conservative assumption.

Reference to Table 6.2 of Concrete Industrial Ground Floors – A guide to design and construction, indicates that the modulus of subgrade reaction for moist clay can be estimated as 0.03 to 0.06N/mm³.

A Modulus of subgrade reaction of 0.03N/mm³ is recommended for design.

The formation level should be protected at all times from the weather and trafficking prior to placement of subfloor granular fill layers.

The sub-formation level for all ground floor slabs (i.e. underside of the granular hardcore layer) should be proof rolled prior to placement of the any granular fill.

The proof rolling should consist of at least two passes of a static roller having a minimum mass per metre roll width of 2100kg. All soft spots should be excavated and replaced with acceptable granular material.

The current project drawings we have viewed do not show a radon barrier beneath the floor slab.

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10 Excavatability

Excavations of the Made Ground and overburden soils should be able to be carried out using conventional plant based on the trial pits excavated during the ground investigation. The trial pits were excavated with a 9.5 tonne excavator.

Based on the trial pit logs, the weathered rock should also be able to be excavated using conventional 360-degree excavation plant.

The limestone bedrock will require ripping or hydraulic breaking.

Figures 23, 24 and 25 indicate that excavation of limestone bedrock may be required along the northern side of the Building 1 to reach the underside of the ground beams.

The project drawings also show an attenuation tank adjacent to the south of Building 1 and 2, beneath an area of car parking. Based on the current drawings, the southern part of attenuation tank will be founding on boulder clay and weathered rock (which was able to be excavated on site during the GI with 9.5t excavator). Limestone bedrock becomes shallower moving northwards so the northern half of the attenuation tank will encounter weathered rock and limestone bedrock above the current invert level.

The project drawings also show an area of attenuation crates beneath the entrance road, located adjacent to the south eastern corner of the Building 1.

Based on drawings and Figure 25, the southern part of the area of attenuation crates will be founding on weathered rock. Limestone bedrock becomes shallower moving northwards so the northern portion of the area of the crates may be approximately 1m into competent limestone bedrock at invert level. Rock will require ripping or hydraulic breaking for removal.

11 Design Recommendations for Car Park

The subgrade for car parking areas will generally be on either Made Ground or Glacial Till. CBR or plate bearing tests were not undertaken during the GI as car park and access road locations were not known at the time.

The subgrade CBR design is estimated based on Table 3.1 of Volume 7 of TII DN-PAV-03021 (HD 25-26/10) - Pavement & Foundation Design.

As detailed in Section 6.1, the Made Ground varies from sandy gravelly clay to crushed rock fill. The plasticity index is 30% based on limited tests. The design groundwater level is assumed as close to existing ground level, i.e. high water table.

The recommended CBR value is 2.5% to allow for the variability of Made Ground likely to be encountered at subgrade level.

CBR values are contingent upon adequate protection from the weather and trafficking being provided to the sub-formation prior to placement of capping and construction of subgrade layers.

The sub-formation level (i.e. underside of the capping layer) should be proof rolled prior to placement of the capping. The proof rolling should consist of at least two passes of a static roller having a minimum mass per metre roll width of 2100kg. All soft spots should be excavated and replaced with acceptable granular material.

It is recommended that an experienced and qualified geotechnical engineer inspects sub-formation level prior to construction of capping layers.

CBR compliance testing should be undertaken at the sub-formation level prior to placement of capping and construction of pavement layers.

12 Geotechnical Risk Register

The geotechnical risk register (Table 8) has been compiled based on the available existing information including that gained from the desk study and from compilation of this GIR. It has also been compiled based on experience on similar projects.

It highlights the geotechnical risk and the consequence of these risks occurring, together with proposed measures to mitigate the risk (either achieved via the ground investigation, as part of the design process or proposed during the construction phase).

It does not cover health and safety risks unless specifically related to the geotechnical aspects of the works.

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Table 9: Project geotechnical risk register

Observation	Description of Hazard/Risk	Mitigation of Risk (Potential or Achieved)	Further Action by Designer or main works contractor
Unforeseen ground conditions.	Ground conditions at the site location may vary from those indicated from the factual ground investigation.	The ground investigation targeted risks identified during the desk study. Detailed interpretation of ground conditions has been undertaken. This interpretation took account of the desk study information in addition to the factual ground investigation information.	Vigilance during construction for ground conditions that vary from that indicated by the GI. Vigilance for any hotspots of contamination.
High measured groundwater level/ Excavations below the groundwater table.	Large volume of groundwater may flow into the excavation. Attenuation tanks/crates founding below the groundwater table, risk of uplift.	Allow for dewatering/sump pumping during foundation excavations. It recommended that early discussions with local authorities to agreed sources of discharge (as required) to avoid programme delays.	Finished site levels to account for recorded and recommended ULS design groundwater levels. Designer to carryout uplift checks for the attenuation tanks based on the recorded groundwater levels and recommended design groundwater level. Designer to incorporate under slab/sub-soil drainage in areas of critical plant and equipment as required.
Groundwater infiltration.	Risk of groundwater entry through services ducts/pipes into deep service trenches.	Ensure adequate waterproofing incorporated into the design. Uplift checks to be undertaken.	Inspection of waterproofing during construction.
Depth to bedrock for founding of ground beams may vary.	Based on existing ground investigation information, limestone bedrock is shallow (1.5m to 3.5mBGL), however, it may vary.	Allowance for additional rock breaking or additional excavation to competent ground and lean mixing back up to underside of ground beams.	The contractor to have appropriate equipment on site (rock breakers) to deal with shallow rock.
Exposure to weather.	Susceptibility of low plasticity glacial till to changes in water content and exposure to rainfall. Glacial till soils will rapidly lose strength if left exposed to rain.	Earthworks specification to be prepared as part of the contract documents to clearly state protection requirements.	Protect glacial till sub-formations at all times.
Limited in-situ and laboratory testing due to thin overburden cover.	Ground conditions at the site location may vary from the limited test results.	Conservative assumptions have been made.	None.

Observation	Description of Hazard/Risk	Mitigation of Risk (Potential or Achieved)	Further Action by Designer or main works contractor
Damage to neighbouring properties.	Excavation works may generate movement and hence affect the adjacent structures.	Movement of adjacent structures from the construction works shall be considered in design.	Monitoring during construction.

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13 References

- [1] Aerial Photographs and Historic Maps from Geohive web viewer <http://map.geohive.ie/>
- [2] Apex (2015). Report on the Geophysical Survey for EQUINIX (Clyde House 1) at Snugborough Business Park, Blanchardstown, Co. Dublin for Ground Investigations Ireland Ltd., AGL17266_03, Apex Geoservices, 18th December 2017.
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- [8] Concrete Society Technical Report No. 34 (2003), Concrete Industrial Ground Floors – A guide to design and construction 3rd edition
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- [10] Farrell, E. & Wall, D. (1990). The soils of Dublin. *Trans. Instn Engrs Ireland* 115, 78-97.
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- [12] Ground Investigations Ireland Ltd. (2017). DB6 – Phase 1 Ground Investigation Report, January 2018.
- [13] Long, M., and Menkiti, C., (2007). Geotechnical properties of Dublin Boulder Clay. *Geotechnique* 57, No. 7, pp. 595-611.
- [14] National Roads Authority (2010), Volume 7 Section 2 Part 2A NRA HD 25-26/10: Pavement & Foundation Design
- [15] Stroud & Butler (1975). The Standard Penetration Test and the Engineering Properties of Glacial Materials.
- [16] Skipper, J., Follet, B., Menkiti, C., Long, M. & Clarke-Hughes, J. (2005). The engineering geology and characterisation of Dublin Boulder Clay. *Q. J. Engng Geol. Hydrogeol.* **38**, No. 2, 171-187.
- [17] Tomlinson, M.J. (2001). Foundation Design and Construction.

Figures

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Figure 1: Site Location

Figure 2: Proposed Development Plan

Figure 3: Site and adjacent Structures

Figure 4: OSI Historic 6" Map (1837 – 1842)

Figure 5: OSI Historic 6" Map Cassini (1845)

Figure 6: OSI Historic 25" Map Cassini (1888 - 1913)

Figure 7: OSI Aerial Photograph 1995

Figure 8: OSI Aerial Photograph 2000

Figure 9: Google Aerial Photograph 2002

Figure 10: OSI Aerial Photograph 2005

Figure 11: Google Aerial Photograph 2013

Figure 12: Google Aerial Photograph 2015

Figure 13: Google Aerial Photograph 2016

Figure 14: Google Aerial Photograph 2017

Figure 15: GSI Subsoils Sediments

Figure 16: GSI Quaternary Sediments

Figure 17: GSI Quaternary Sediments and Geomorphology

Figure 18: GSI Bedrock Geology

Figure 19: GSI Depth to Bedrock

Figure 20: Historic Site Investigations

Figure 21: Site Specific Site Investigations

Figure 22: Sections Plan

Figure 23: Geological Cross Section A-A

Figure 24: Geological Cross Section B-B

Figure 25: Geological Cross Section C-C

Figure 26: Plasticity Chart – Made Ground

Figure 27: Natural Moisture Content – Made Ground

Figure 28: Standard Penetration Test – Made Ground

Figure 29: Particle Size Distribution – Granular Glacial Deposits

Figure 30: Plasticity Index – Glacial Till

Figure 31: Plasticity Chart – Glacial Till

Figure 32: Particle Size Distribution – Glacial Till

Figure 33: Natural Moisture Content – Glacial Till

Figure 34: Standard Penetration Test – Glacial Till

Figure 35: Standard Penetration Test – Weathered Rock

Figure 36: Point Load Test - Rock

Figure 37: UCS vs Point Load Test – Rock

Figure 38: UCS and Factored Point Load Test - Rock

Figure 39: Groundwater Aquifers

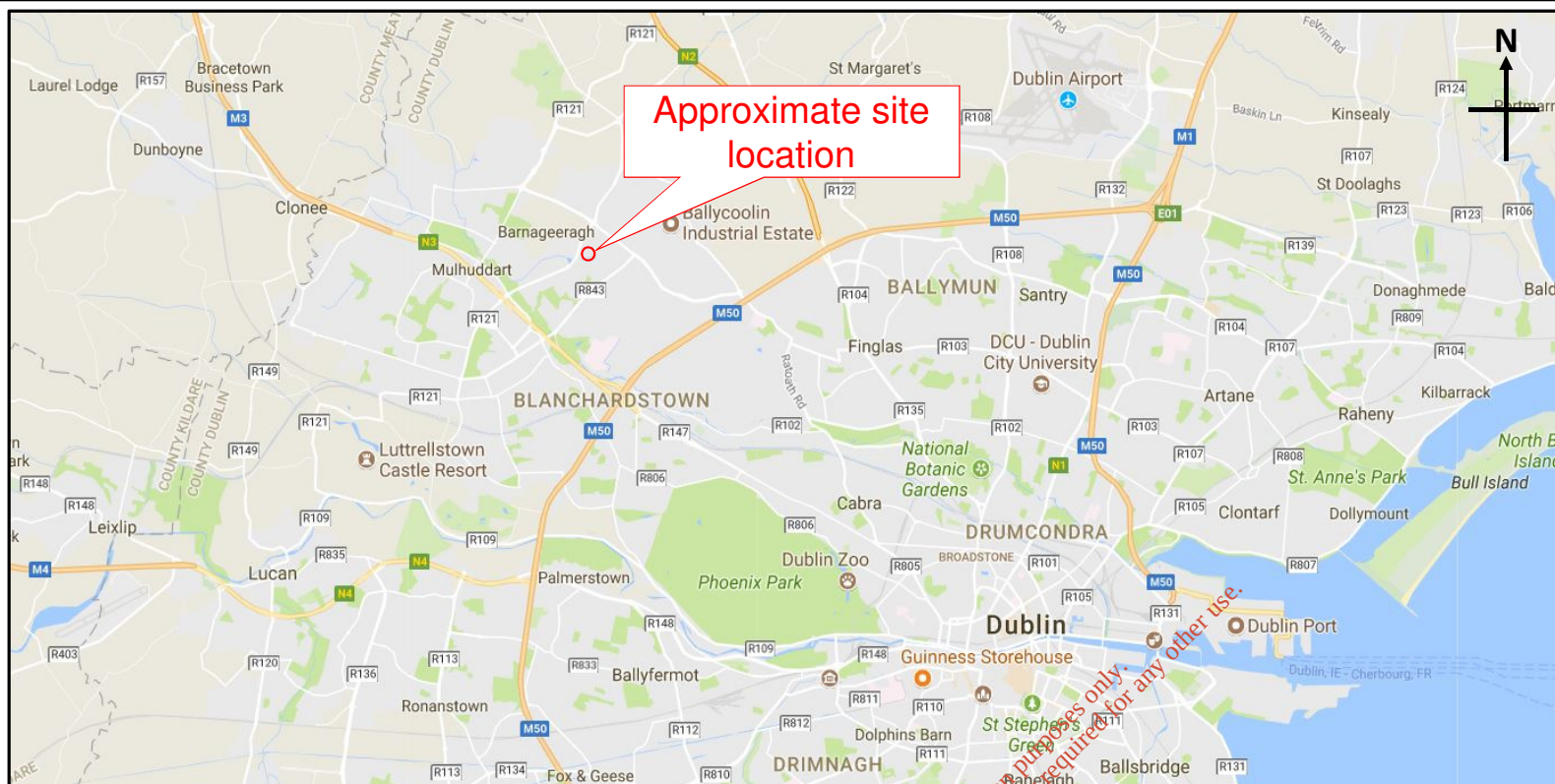
Figure 40: Groundwater Vulnerability

Figure 41: Groundwater Wells and Springs

Figure 42: Groundwater Monitoring (mBGL)

Figure 43: Groundwater Monitoring (mOD)

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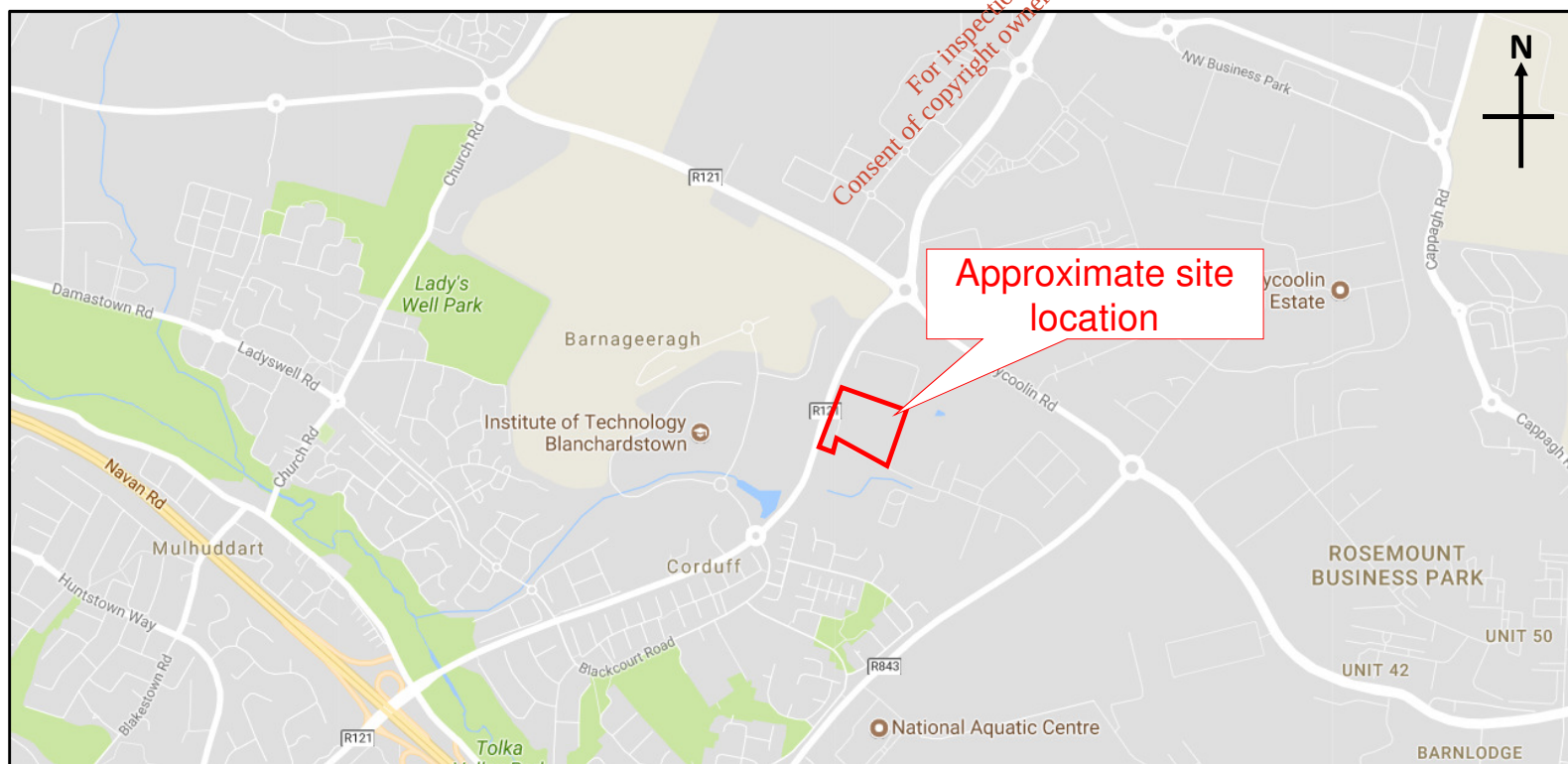


Reference:
Google maps © 2017 Google

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Issue	Date	By	Chkd	Appd
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ARUP



Client

Equinix

Job Title

Project DB5

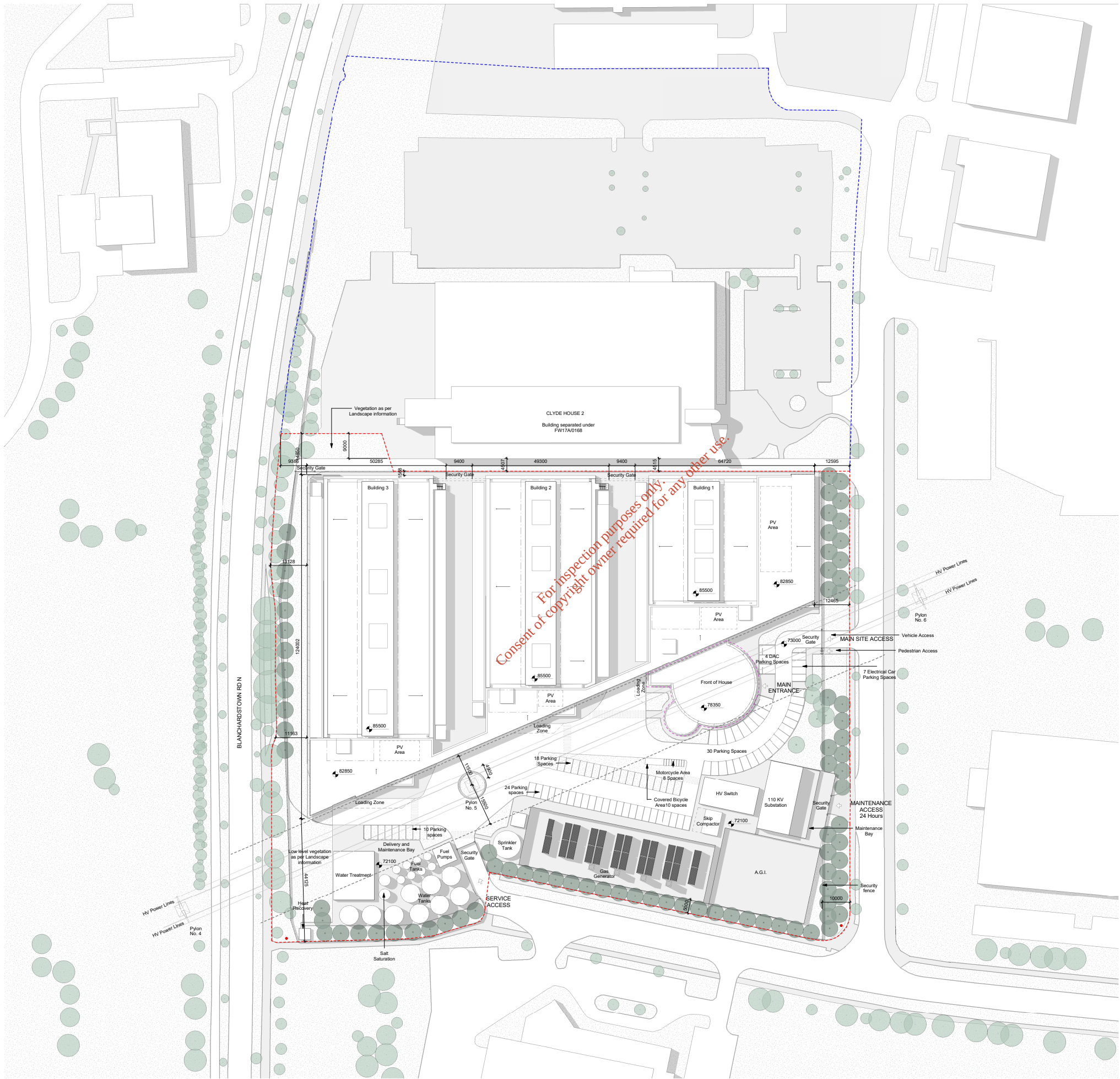
Site Location

Scale at A3

NTS

Job No	Figure Status
258064	Issue

Figure No	
1	



Client:

HAZARD IDENTIFICATION
(If none state 'none relevant')

CONTROL AND MITIGATION MEASURES

None relevant

NOTE: Hazards listed above are only those considered significant risks and:

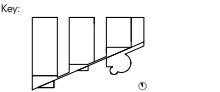
a) not likely to be obvious to a competent contractor or other designers;
b) unusual; or
c) likely to be difficult to manage effectively

DRAWINGS TO BE READ IN COLOUR AND IN SCALE. ALL DIMENSIONS AND INFORMATION SHOWN IN THESE SKETCHES ARE INDICATIVE AND SUBJECT TO CHANGE DURING THE NEXT DESIGN STAGES.

- LEGEND
- Application boundary
 - Existing Building to be retained
 - Exclusion Zone - HV Power Lines Above
 - Services gantry
 - Security Fence
 - Existing Trees
 - Proposed Trees
 - Proposed Plant Area
 - Proposed screening for external plantroom Material and extend to be confirmed
 - Location of Site Notice

P06	2018-02-05	Issue for Information	CM	CR	SG
P05	2018-02-02	Issue for Information	IR	CR	SG
P04	2018-01-31	Issue for Information	EH	CM	SG
P03	2018-01-28	Issue for Information	EH	CM	SG
P02	2018-01-18	Issue for Information	EH	CR	SG
P01	2017-12-15	Issue for Information	CR		
REV	DATE	DESCRIPTION	DWN	CHK	APP

Do not scale from this drawing. All dimensions to be verified on site prior to the commencement of any work or the production of any shop drawings. All discrepancies to be reported to Bryden Wood Technology Ltd. This drawing is to be read in conjunction with all related Consultant's drawings and any other relevant information. This drawing is the copyright of Bryden Wood Technology Ltd.



Project:
DB5 Data Centre

Drawing Title:
Proposed Site Plan

Drawing Number:
17073-BWT-A1-XX-SK-A-0002

Scale: 1:500 Paper Size: A0 Status: S2 Revision: P06



+44 (0)20-7255-4772 info@brydenwood.co.uk 100 Gray's Inn Road, London, WC1X 8AL, UK Bryden Wood Technology Ltd

Figure 2



Legend:

 Approximate
Site Boundary

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Issue	Date	By	Chkd	Appd
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Job Title

Project DB5

The Site and adjacent
structures

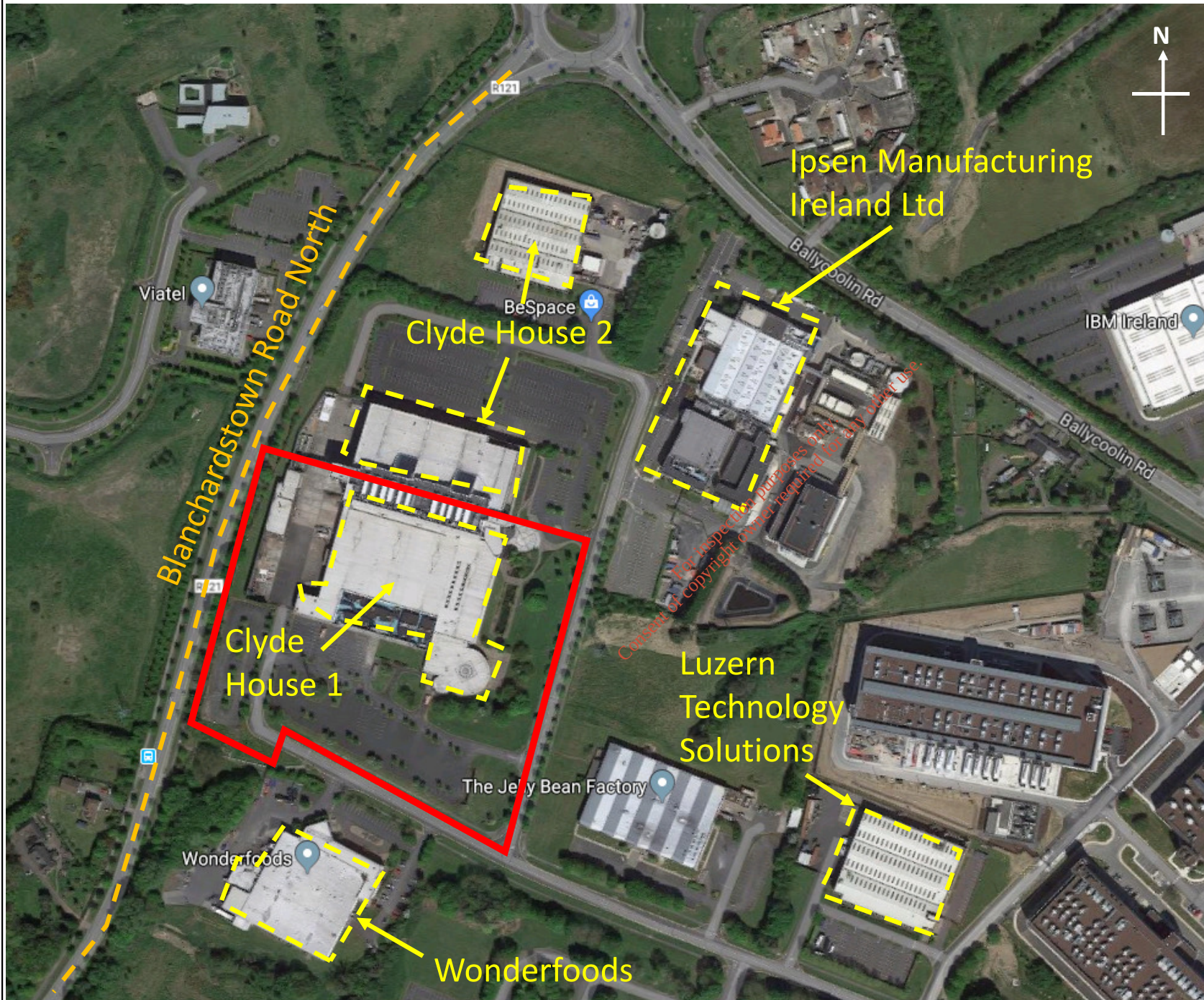
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258064

Figure Status
Issue

Figure No
3

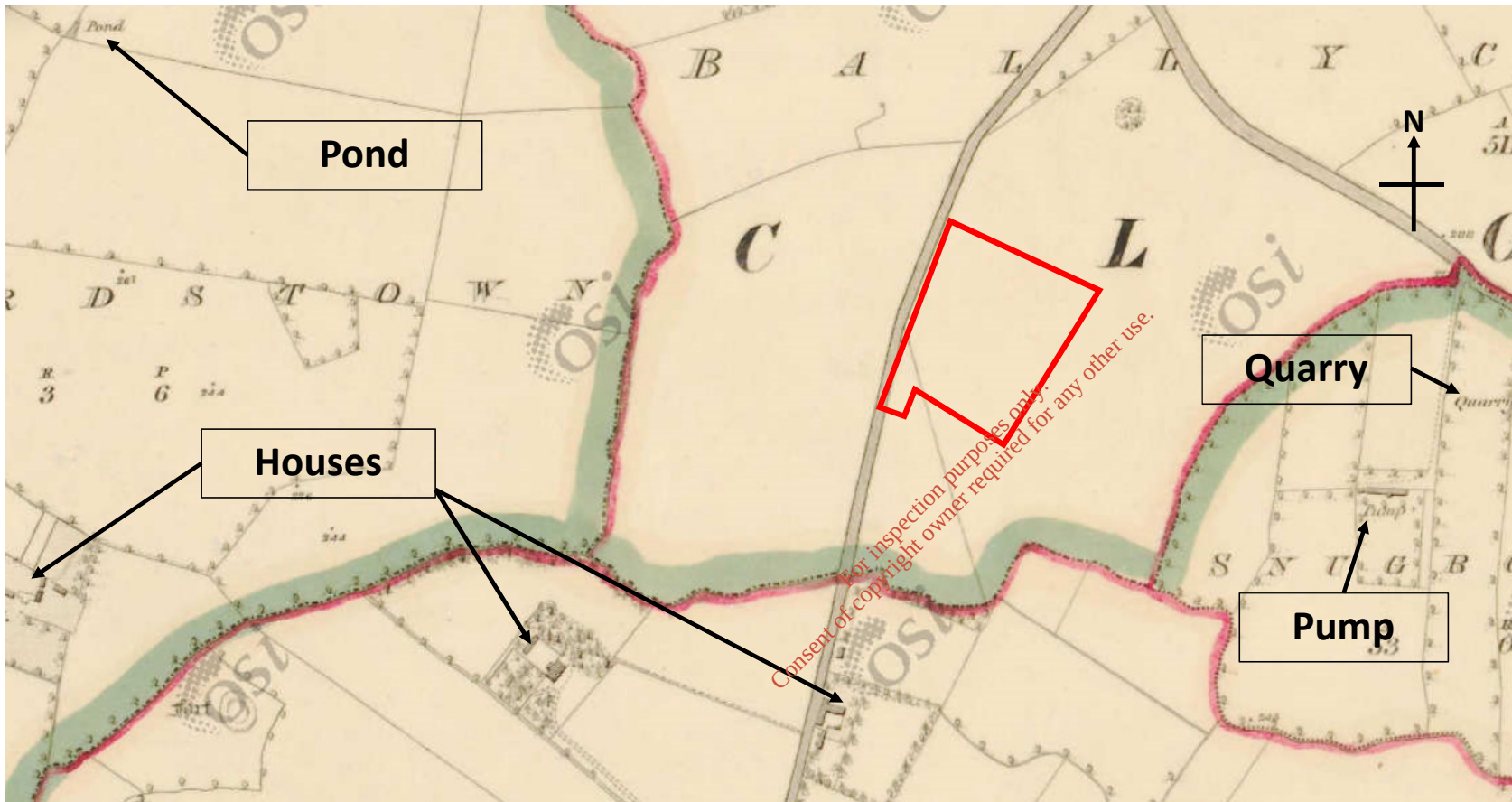


Reference:
Geohive online mapping

Legend:



Approximate
Site Boundary



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Job Title

Project DB5

OSI Historic 6" Map
(1837 – 1842)

Scale at A3

NTS

Job No 258064	Figure Status Issue
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Figure No
4

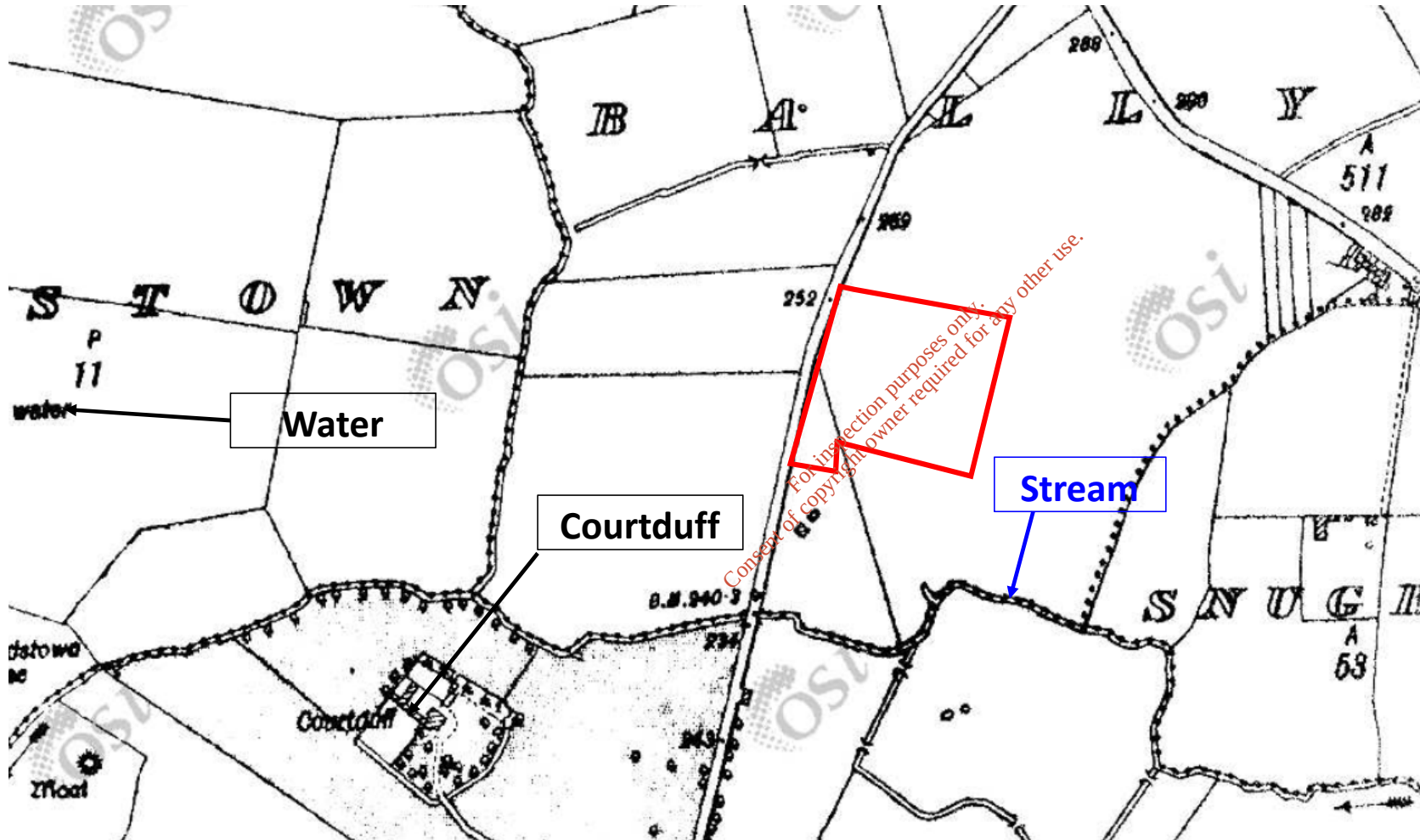


Reference:
Geohive online mapping

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Approximate
Site Boundary



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Client

Equinix

Job Title

Project DB5

OSI Historic 6" map Cassini
(1845)

Scale at A3

NTS

Job No 258064	Figure Status Issue
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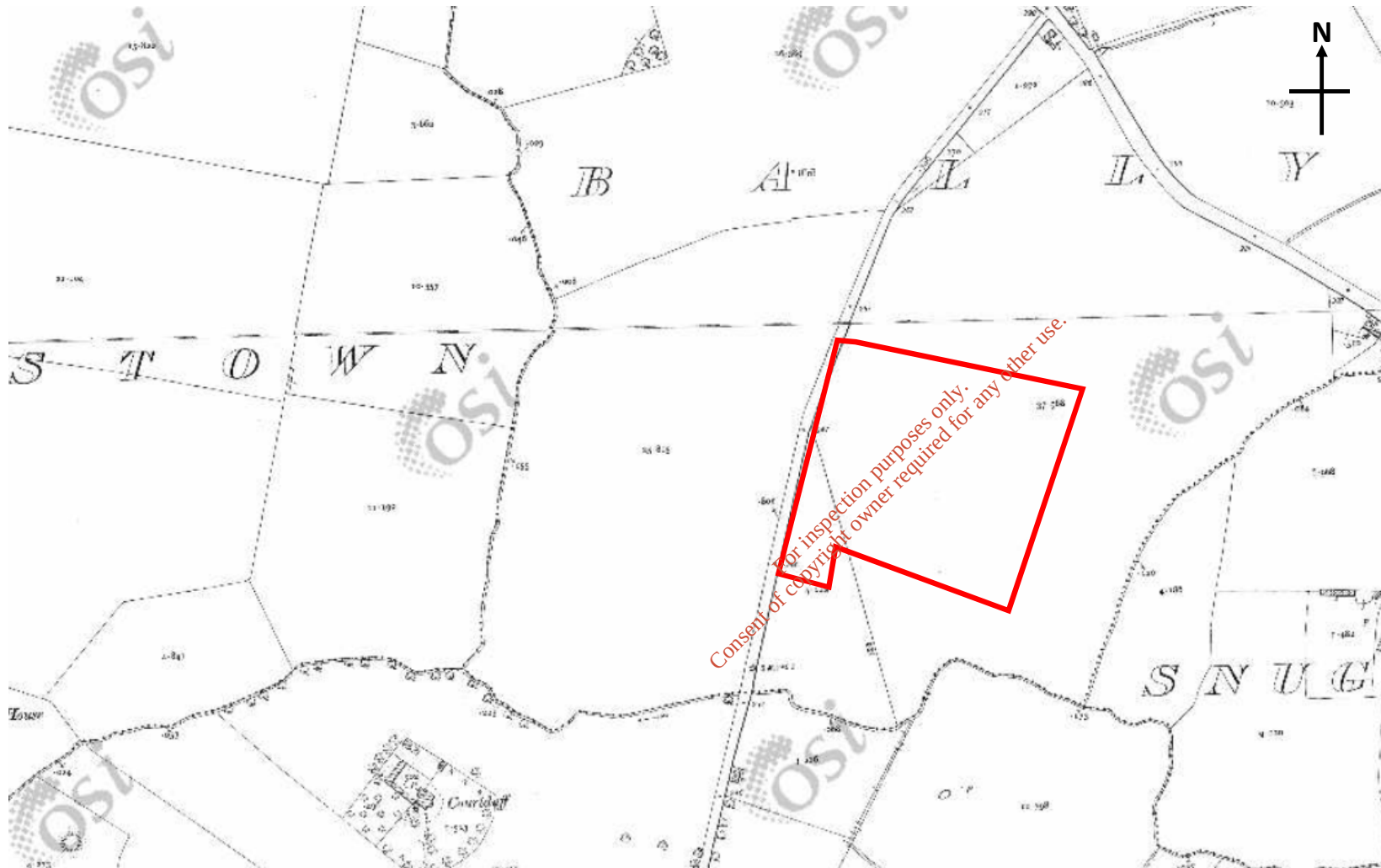
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Geohive online mapping

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Approximate
Site Boundary



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Equinix

Job Title

Project DB5

OSI Historic 25" map
(1888 - 1913)

Scale at A3

NTS

Job No 258064	Figure Status Issue
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Figure No
6

Reference:
Geohive online aerial
photograph

Legend:



Approximate
Site Boundary



P1	31/01/18	CC	RT	
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Equinix

Job Title

Project DB5

OSI Aerial Photograph 1995

Scale at A3

NTS

Job No 258064	Figure Status Issue
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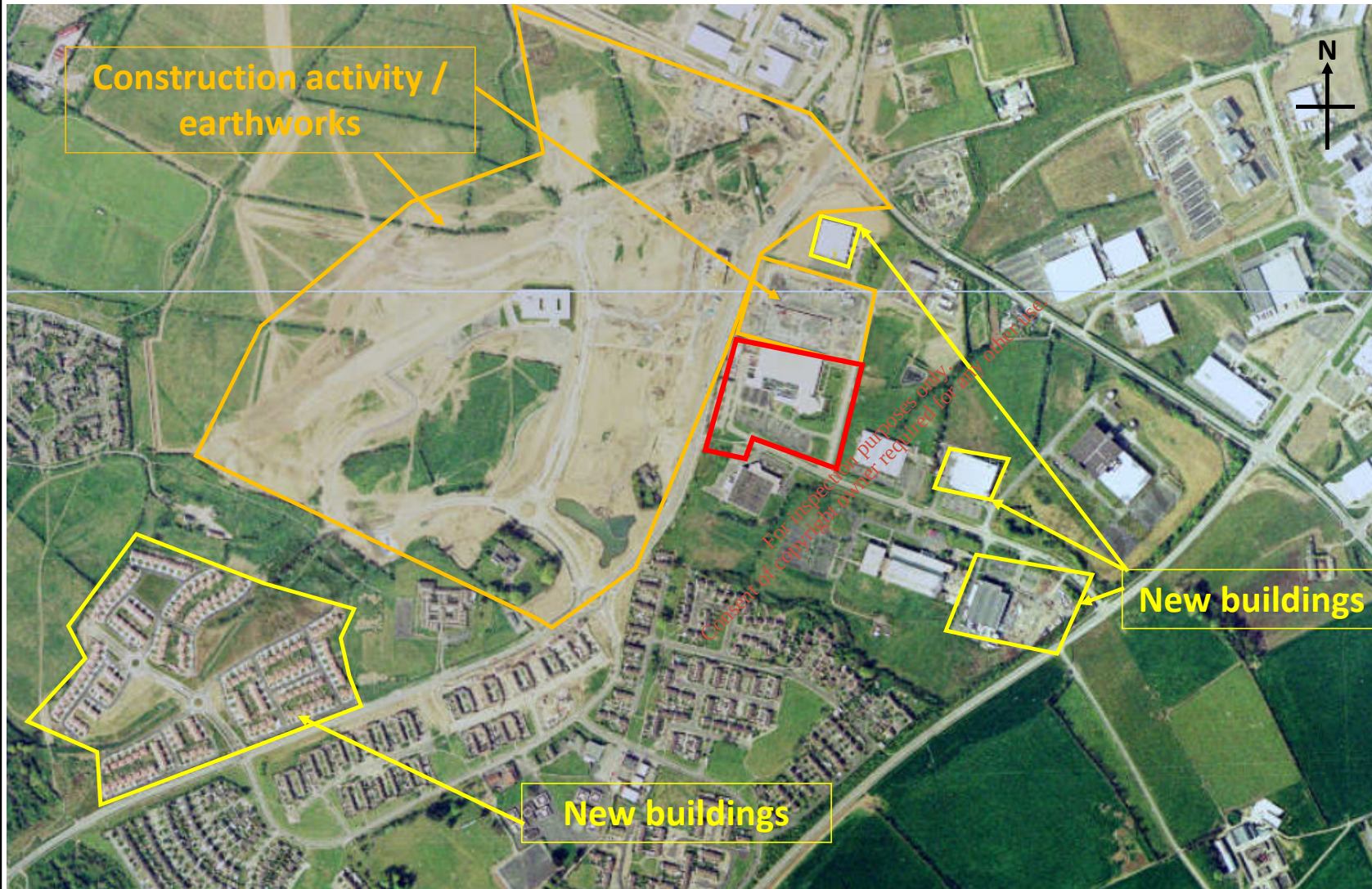
Figure No
7

Reference:
Geohive online aerial
photograph

Legend:



Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

OSI Aerial Photograph 2000

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

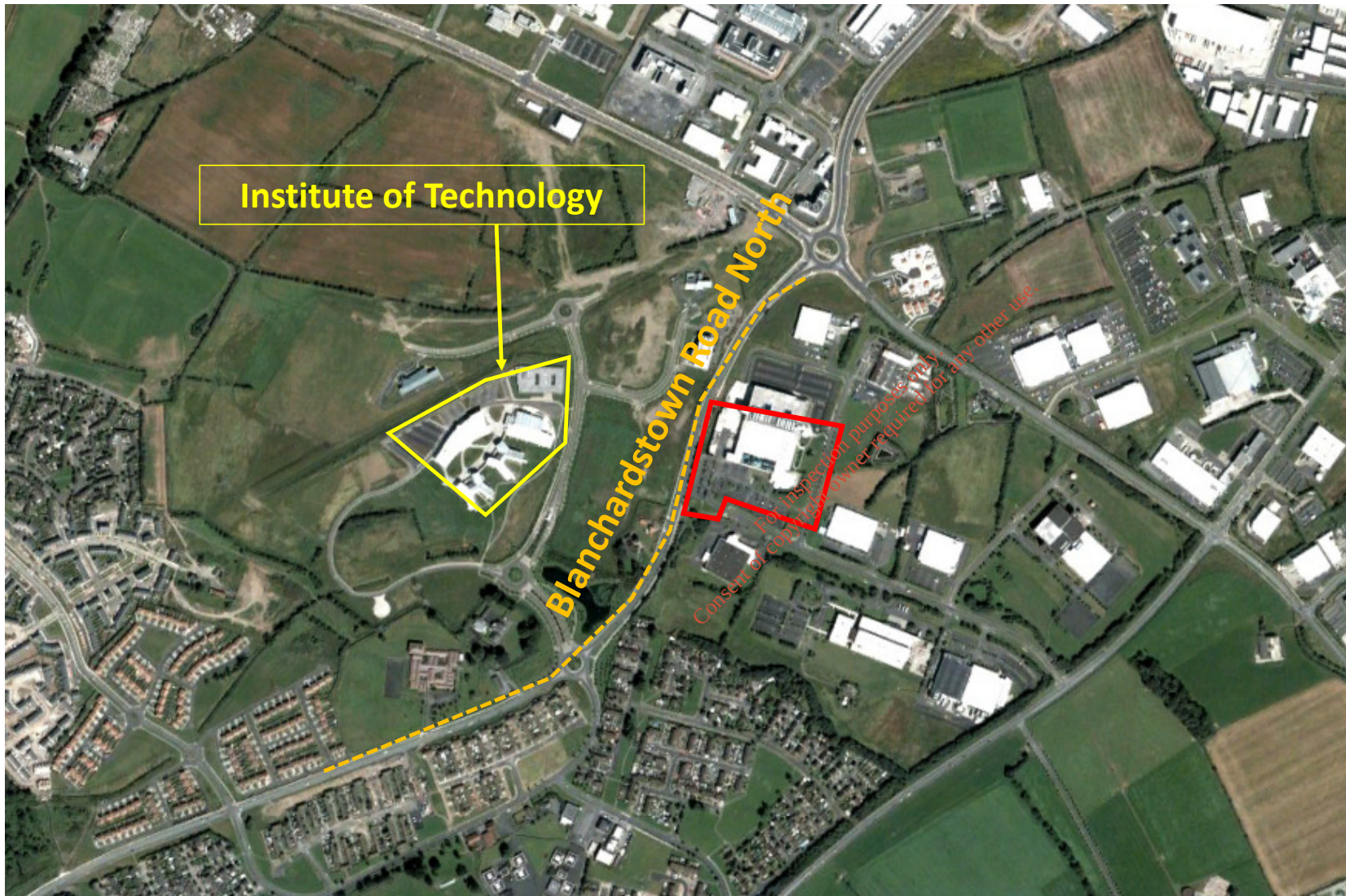
Figure No
8

Reference:
Google Earth aerial photograph

Legend:



Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
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ARUP

Client

Equinix

Job Title

Project DB5

Google Earth Aerial
Photograph 2002

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
9



Reference:
Geohive online aerial
photograph

Legend:



Approximate
Site Boundary

P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
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ARUP

Client

Equinix

Job Title

Project DB5

OSI Aerial Photograph 2005

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No 10	
------------------------	--

Reference:
Google Earth aerial photograph

Legend:



Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Google Earth Aerial
Photograph 2013

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
11

Reference:
Google Earth aerial photograph

Legend:



Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
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ARUP

Client

Equinix

Job Title

Project DB5

Google Earth Aerial
Photograph 2015

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
12

Reference:
Google Earth aerial photograph

Legend:



Approximate
Site Boundary

P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Google Earth Aerial
Photograph 2016

Scale at A3

NTS

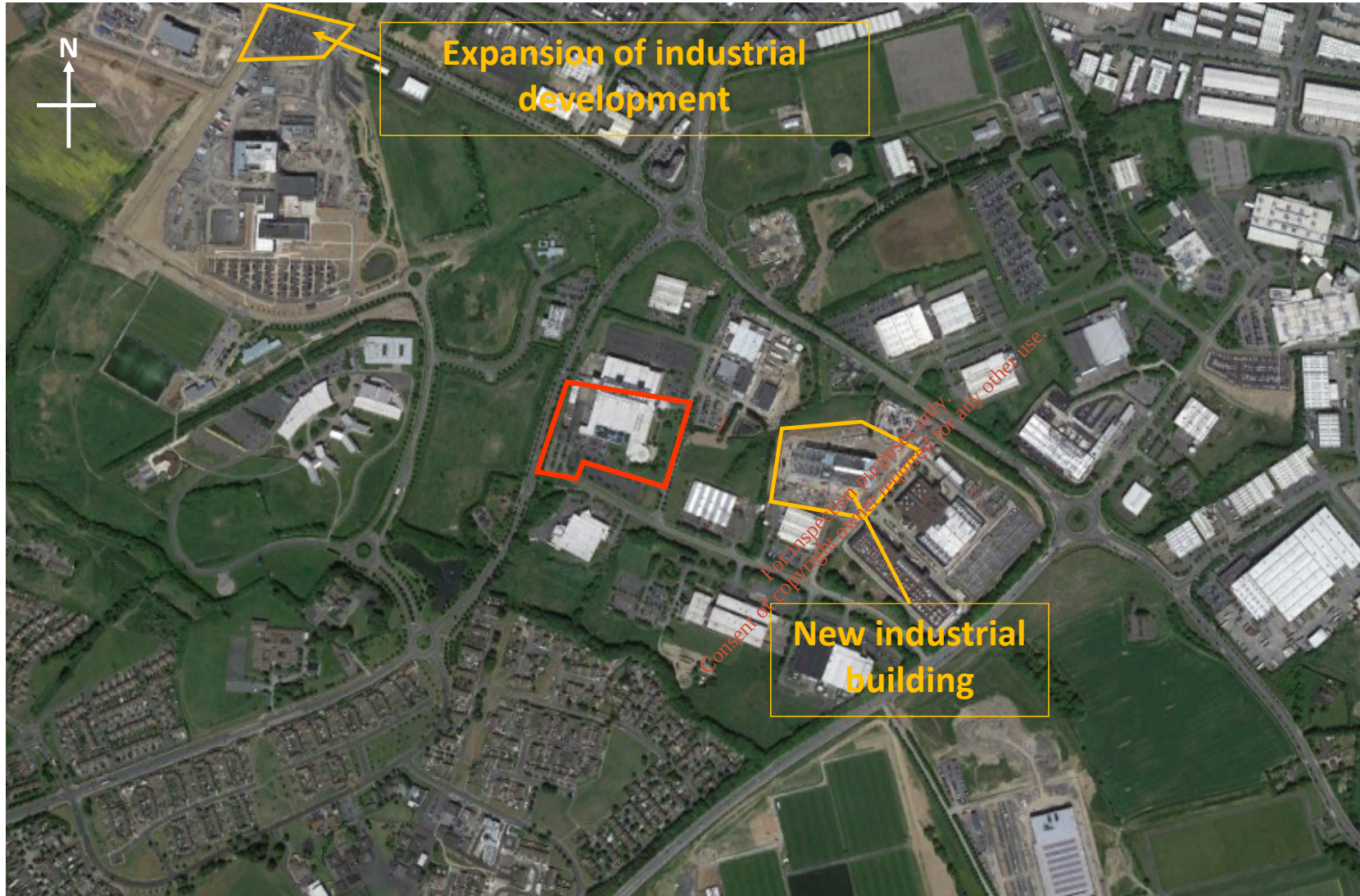
Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
13

Reference:
Google Earth aerial photograph

Legend:

 Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
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ARUP

Client

Equinix

Job Title

Project DB5

Google Earth Aerial
Photograph 2017

Scale at A3

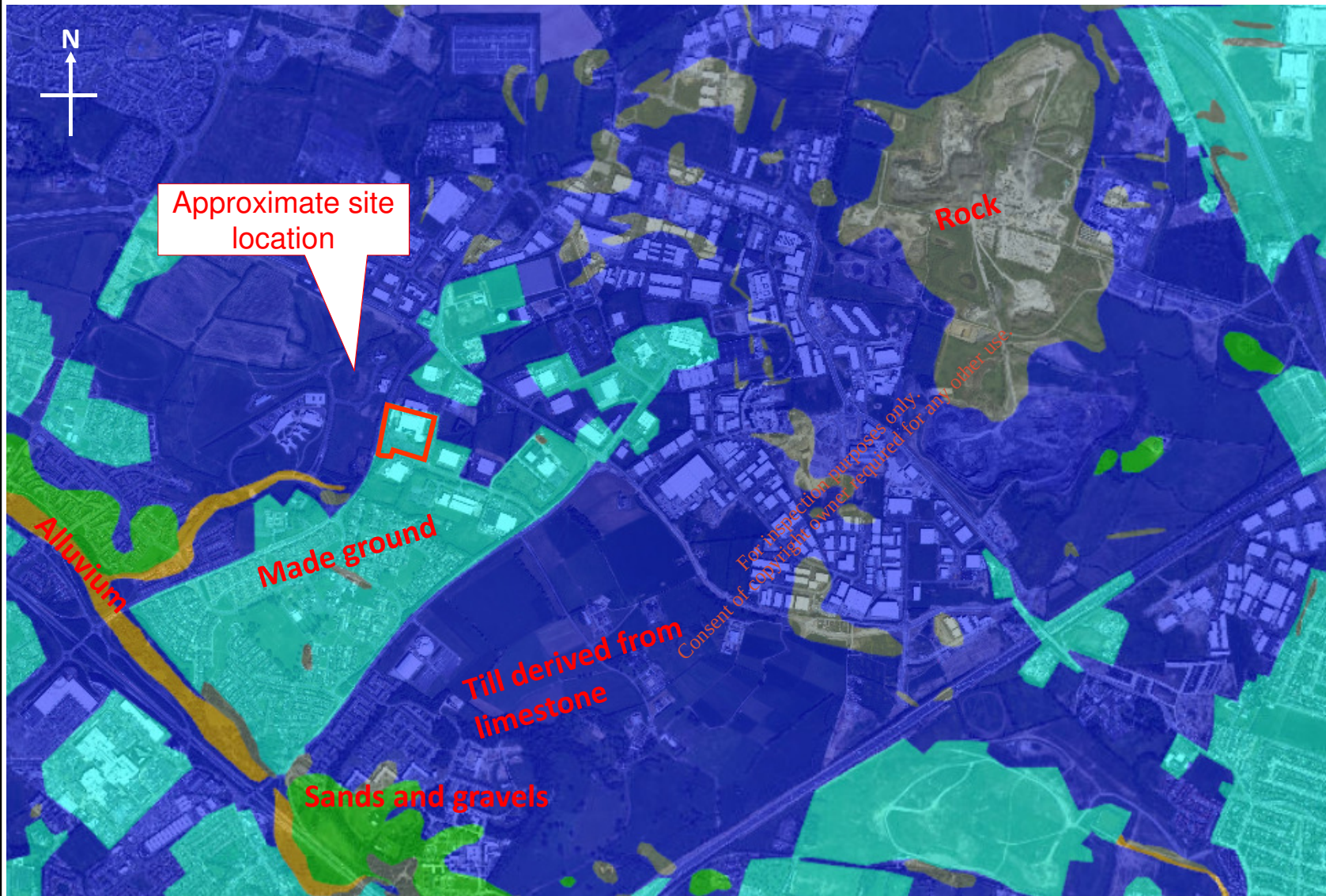
NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
14

Legend:

 Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
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ARUP

Client

Equinix

Job Title

Project DB5

Subsoil sediments

Scale at A3

NTS

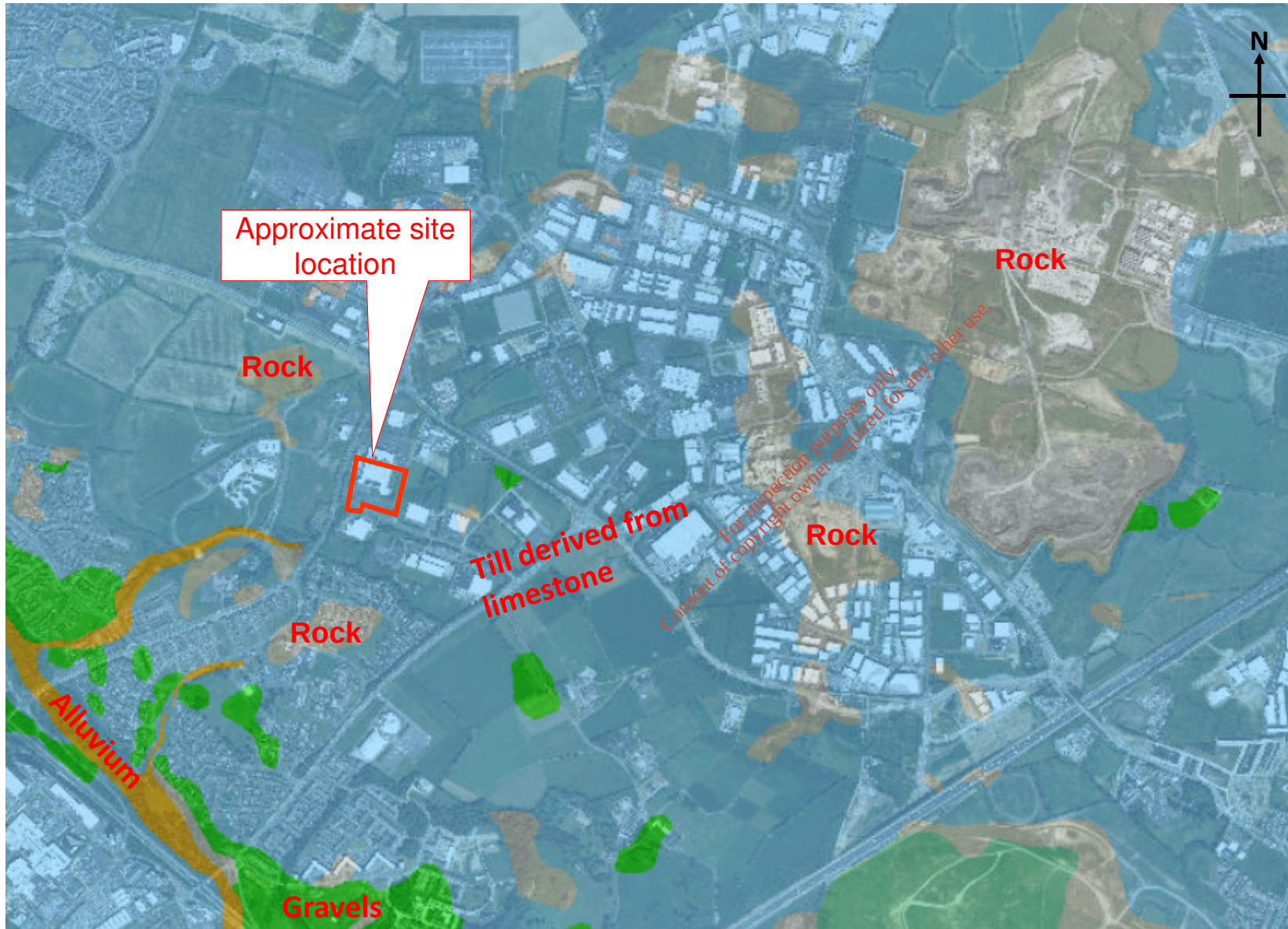
Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
15

Reference:
GSI online mapping

Legend:

 Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Quaternary sediments

Scale at A3

NTS

Job No
258064

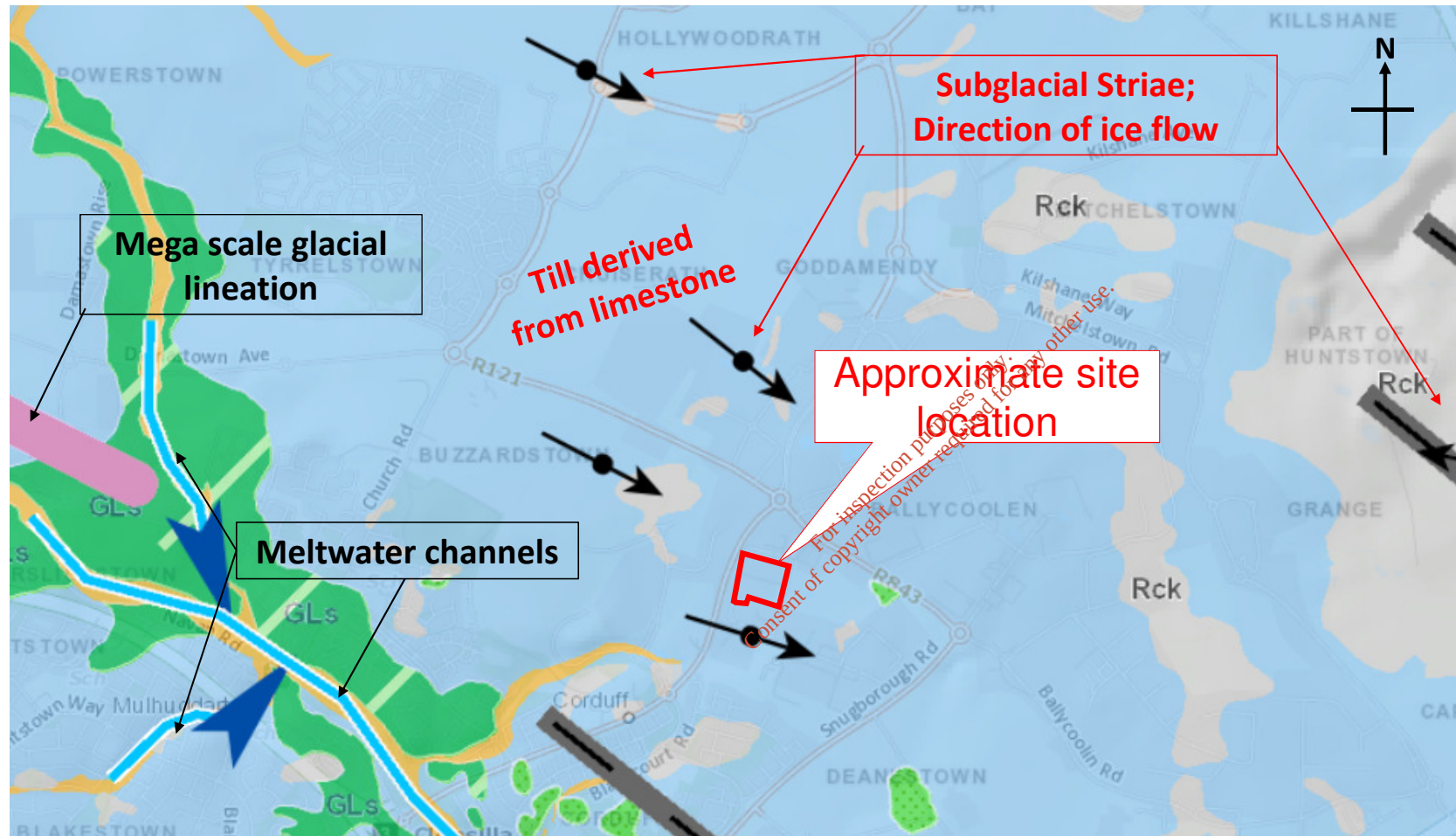
Figure Status
Issue

Figure No
16

Reference:
GSI online mapping

Legend:

 Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Quaternary sediments and
Geomorphology

Scale at A3

NTS

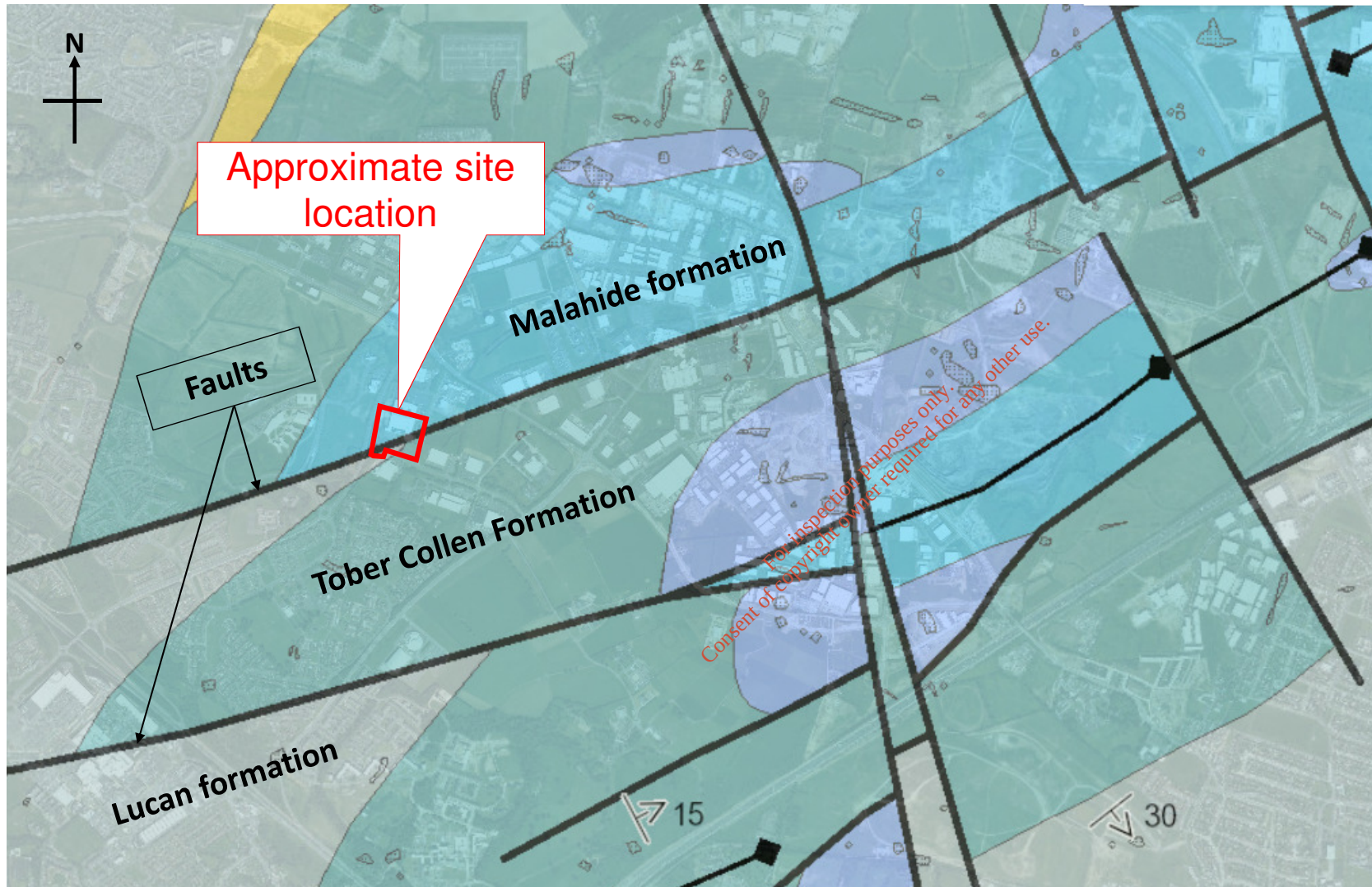
Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
17

Reference:
GSI online mapping

Legend:

 Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Bedrock Geology 100k

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

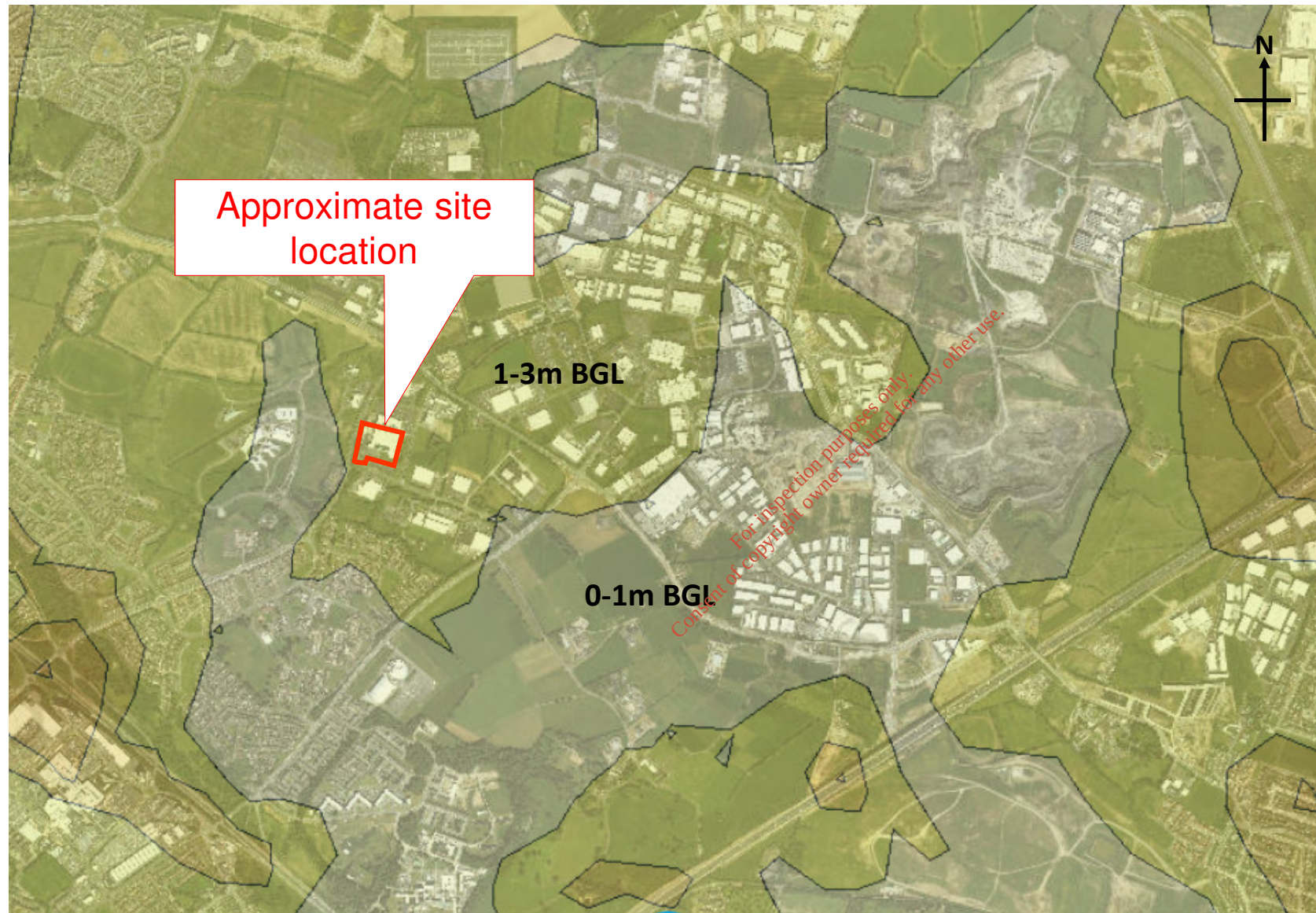
Figure No
18

Reference:
GSI online mapping

Legend:



Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Depth to Bedrock

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
19

Reference:
GSI online mapping

Legend:

 Approximate Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

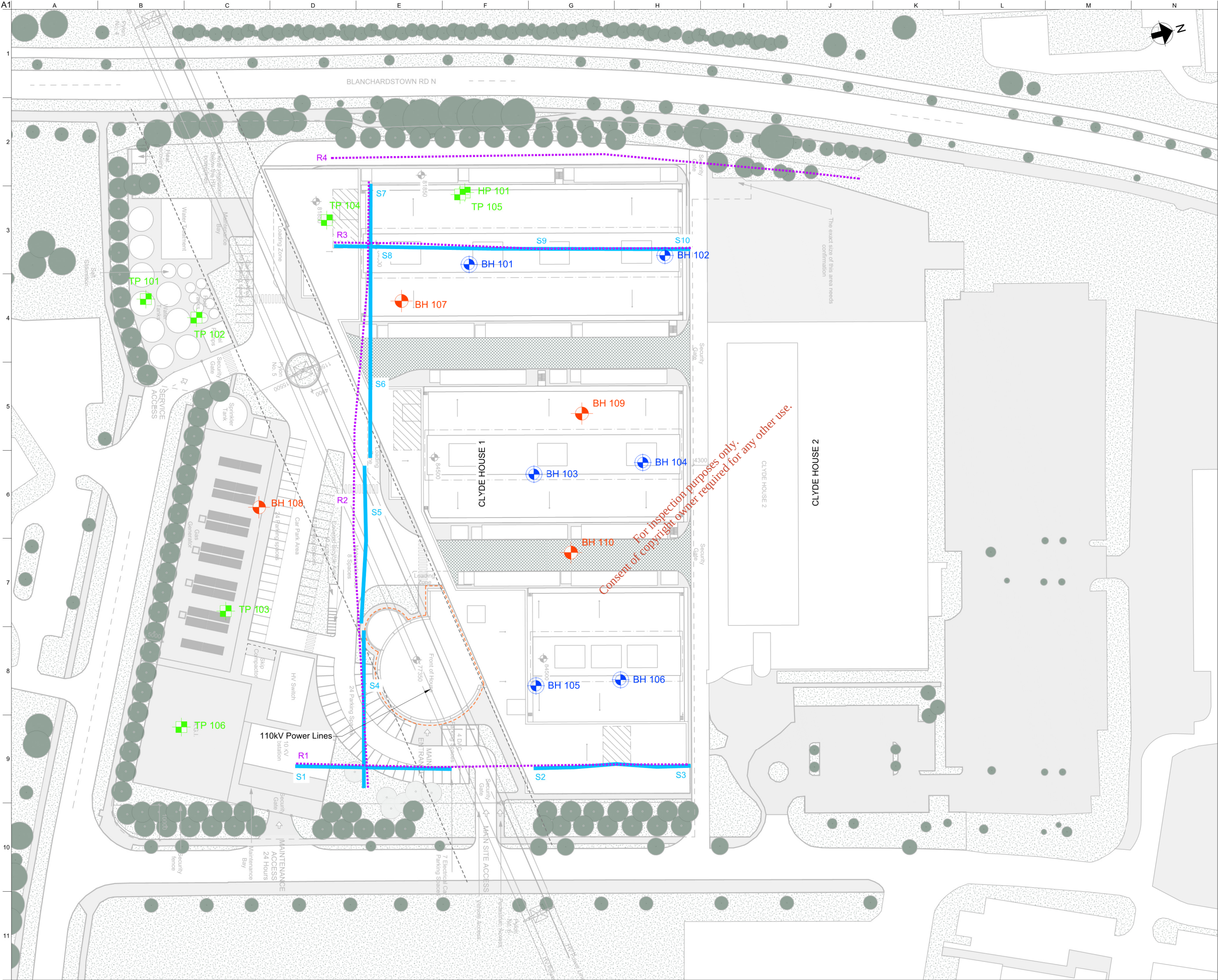
Previous Site Investigations

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
20



NOTE: Refer to Ground Investigation Ireland Ltd.'s Ground Investigation Factual Report for full details of exploratory logs, laboratory testing and results of geophysical survey.
This drawing is based on Bryden Wood Drawing No. 17073-BWT-A1-XX-S-A-0002 dated 31 Jan 2018

- LEGEND:
- BH # Cable Percussive Borehole
 - BH # Cable Percussive Borehole with follow-on Rotary Coring
 - TP # Trial pit
 - R# ERT 2d resistivity profile
 - S# Seismic refraction profile

I2	08/02/18	EAM	LM	JB
I1	04/01/18	SR	LM	JB
Issue	Date	By	Chkd	Appld

ARUP

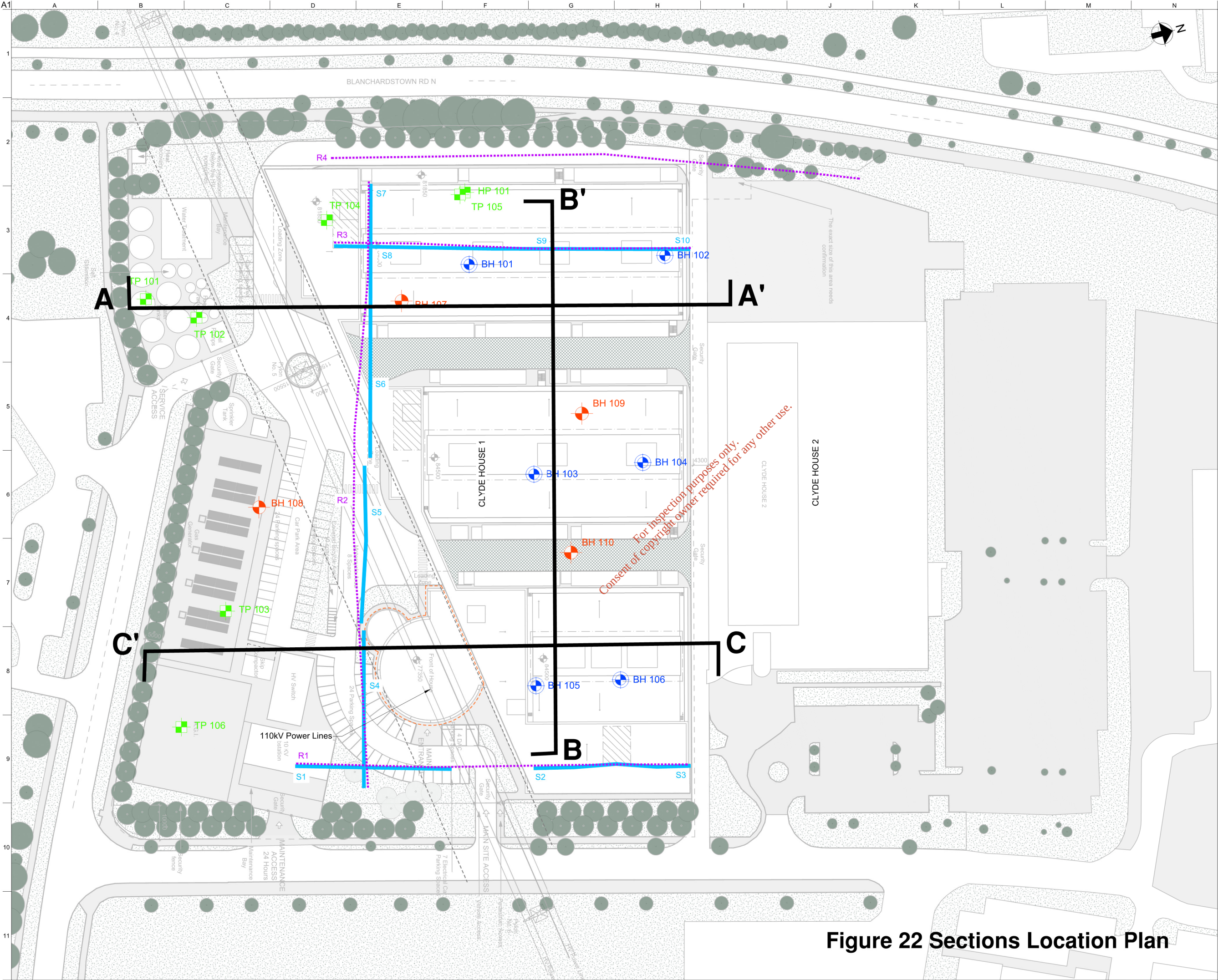
Arup, 50 Ringsend Road
Dublin, D04 T6X0
www.arup.ie
Tel +353(0)1 233 4455 Fax +353(0)1 668 3169

Figure 21

Job Title
DB6

Drawing Title
As Builts
Ground Investigation
Exploratory Location
With Current Building Layout

Scale at A1 1:500	Discipline Geotechnical	Job No 258064	Drawing Status For information
Drawing No G-001	Issue I2		



NOTE: Refer to Ground Investigation Ireland Ltd.'s Ground Investigation Factual Report for full details of exploratory logs, laboratory testing and results of geophysical survey.
This drawing is based on Bryden Wood Drawing No. 17073-BWT-A1-XX-S-A-0002 dated 31 Jan 2018

- LEGEND:
- BH # Cable Percussive Borehole
 - BH # Cable Percussive Borehole with follow-on Rotary Coring
 - TP # Trial pit
 - R# ERT 2d resistivity profile
 - S# Seismic refraction profile

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I2	08/02/18	EAM	LM	JB
I1	04/01/18	SR	LM	JB
Issue	Date	By	Chkd	Appl

ARUP

Arup, 50 Ringsend Road
Dublin, D04 T6X0
www.arup.ie
Tel +353(0)1 233 4455 Fax +353(0)1 668 3169

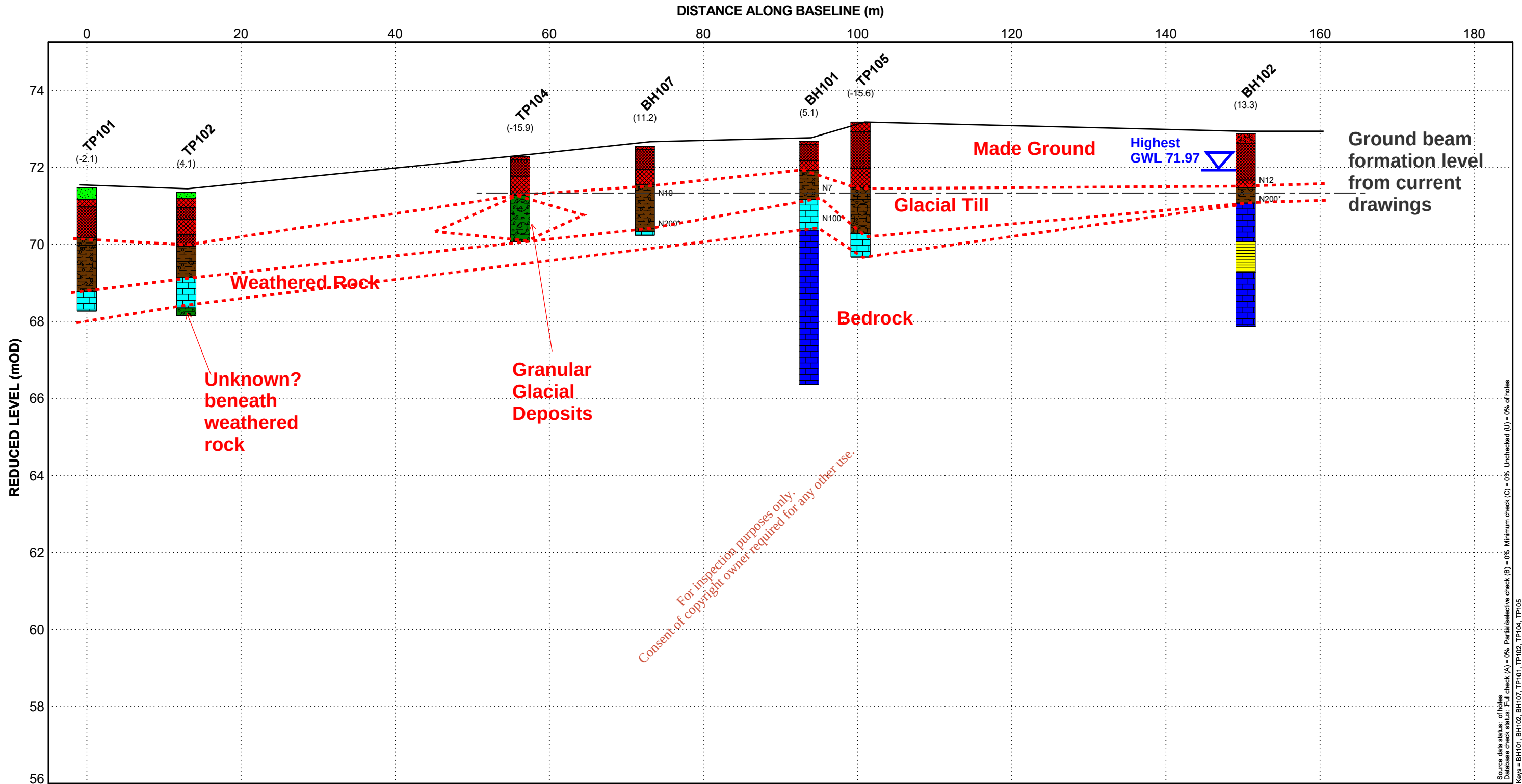
Job Title
DB6

Drawing Title
As Builts
Ground Investigation
Exploratory Location
With Current Building Layout

Scale at A1 1:500	Discipline Geotechnical
Job No 258064	Drawing Status For information
Drawing No G-001	Issue I2

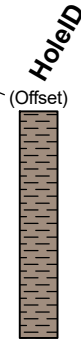
Figure 22 Sections Location Plan

gINT v8.30.004. Licensed to Arup
Project: c:\users\leonidas.malanis\desktop\check-db5.gip, (Template: 3.0), Library: c:\gint\arup_utilities_3-0-002-8.gip
Penet: 2.4.01 SECTION WITH PLOTTED DATA (A3) (rev 5Jan16)
gINT output page 1 of 1. Made 31Jan18 12:46

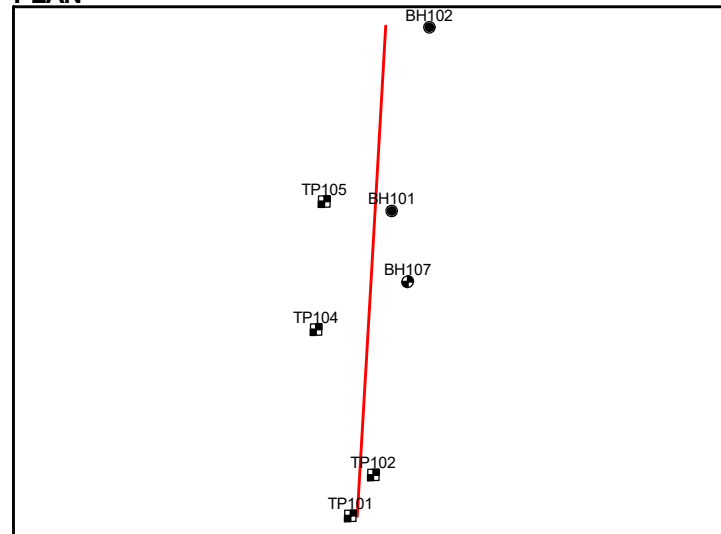


LEGEND

Hole offset is +ve to the RIGHT of the baseline



PLAN



- Topsoil [TOP]
- Made Ground [MG]
- Brown Boulder Clay [GTD]
- Gravel [GR]
- Weathered Rock [WrR]
- Limestone [RCK]
- Obstruction [Obs]
- Mudstone [Mud]

- Fill (MADE GROUND)
- Made Ground - FILL
- Silty sandy gravelly CLAY
- LIMESTONE
- CONCRETE
- Sandy gravelly cobbly CLAY
- MUDSTONE
- TOPSOIL
- Silty sandy gravelly cobbly CLAY
- Sandy gravelly CLAY
- Clayey sandy GRAVEL
- Clayey bouldery GRAVEL
- Sandy gravelly cobbly bouldery CLAY

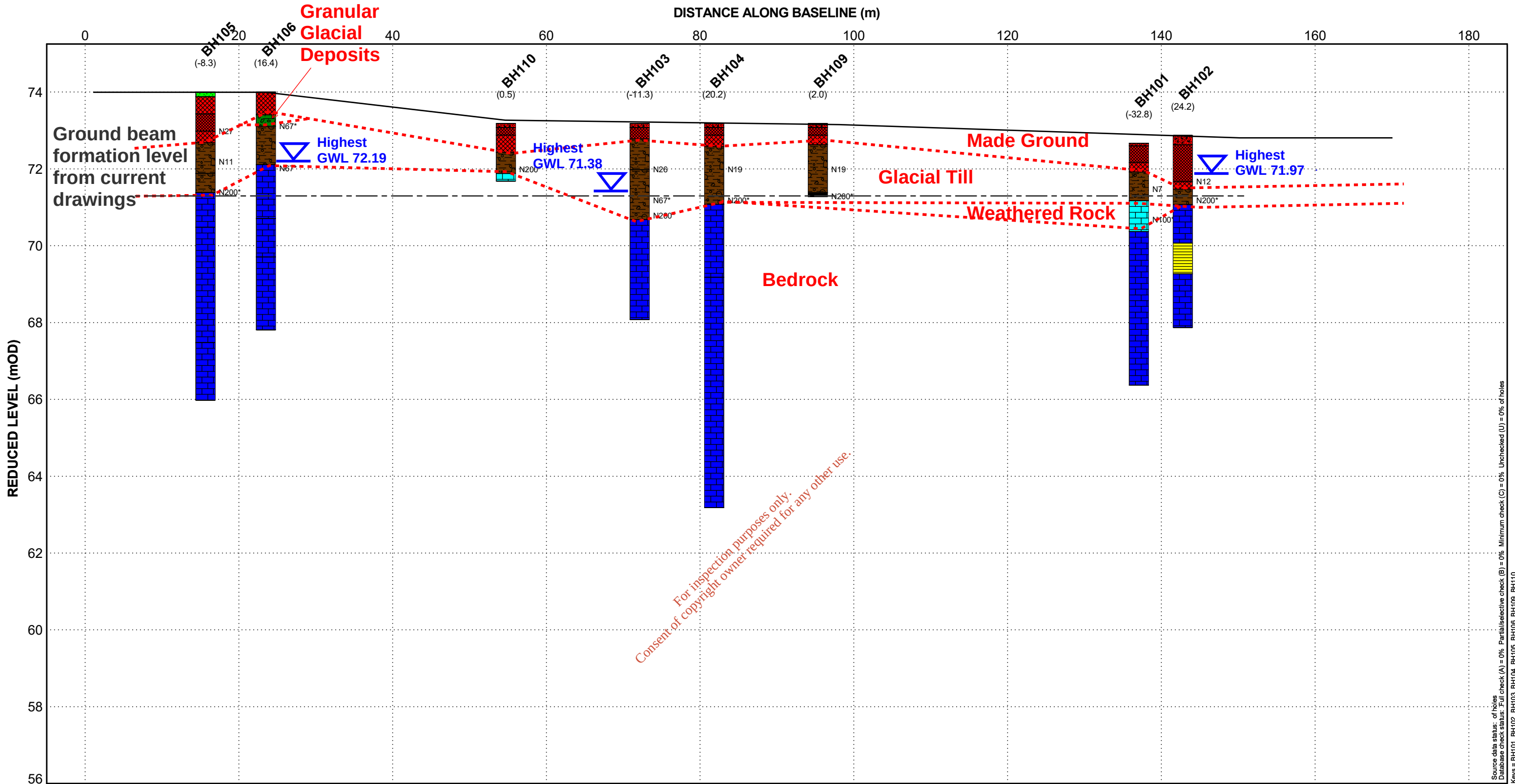
SCALE 1:100V 1:500H @ A3L

***** DRAFT *****

**DB5
GEOLOGICAL CROSS SECTION
Figure 23**

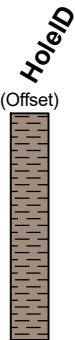
258064-00

gINT v8.30.004. Licensed to Arup
Project: c:\users\leonidas.malanis\desktop\check-dbf6.gpj (Template: 3.0). Library: c:\gint\arup_utilities_3-0-002-8.glb
Penet: 2.4.01 SECTION WITH PLOTTED DATA (A3) (rev 5Jan16)
gINT output page 1 of 1. Made 31Jan18 12:51

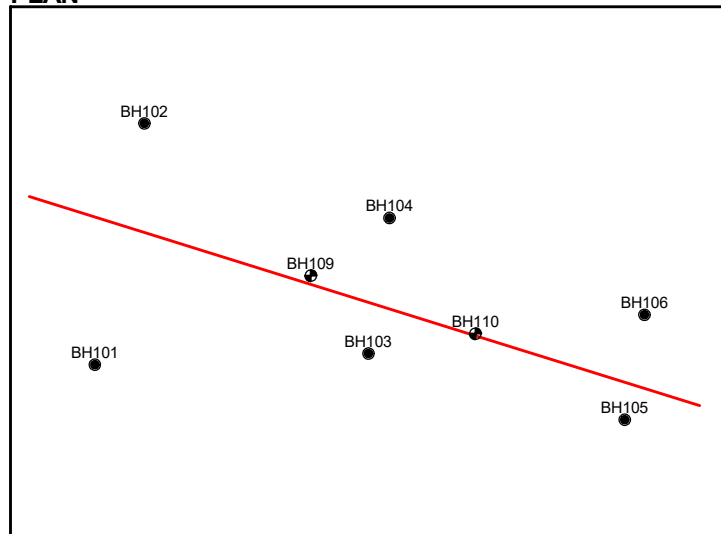


LEGEND

Hole offset is +ve to the RIGHT of the baseline



PLAN



- Topsoil [TOP]
- Made Ground [MG]
- Brown Boulder Clay [GTD]
- Gravel [GR]
- Weathered Rock [WrR]
- Limestone [RCK]
- Obstruction [Obs]
- Mudstone [Mud]

- Fill (MADE GROUND)
- Made Ground - FILL
- Silty sandy gravelly CLAY
- LIMESTONE
- CONCRETE
- Sandy gravelly cobbly CLAY
- MUDSTONE
- TOPSOIL
- Clayey sandy GRAVEL

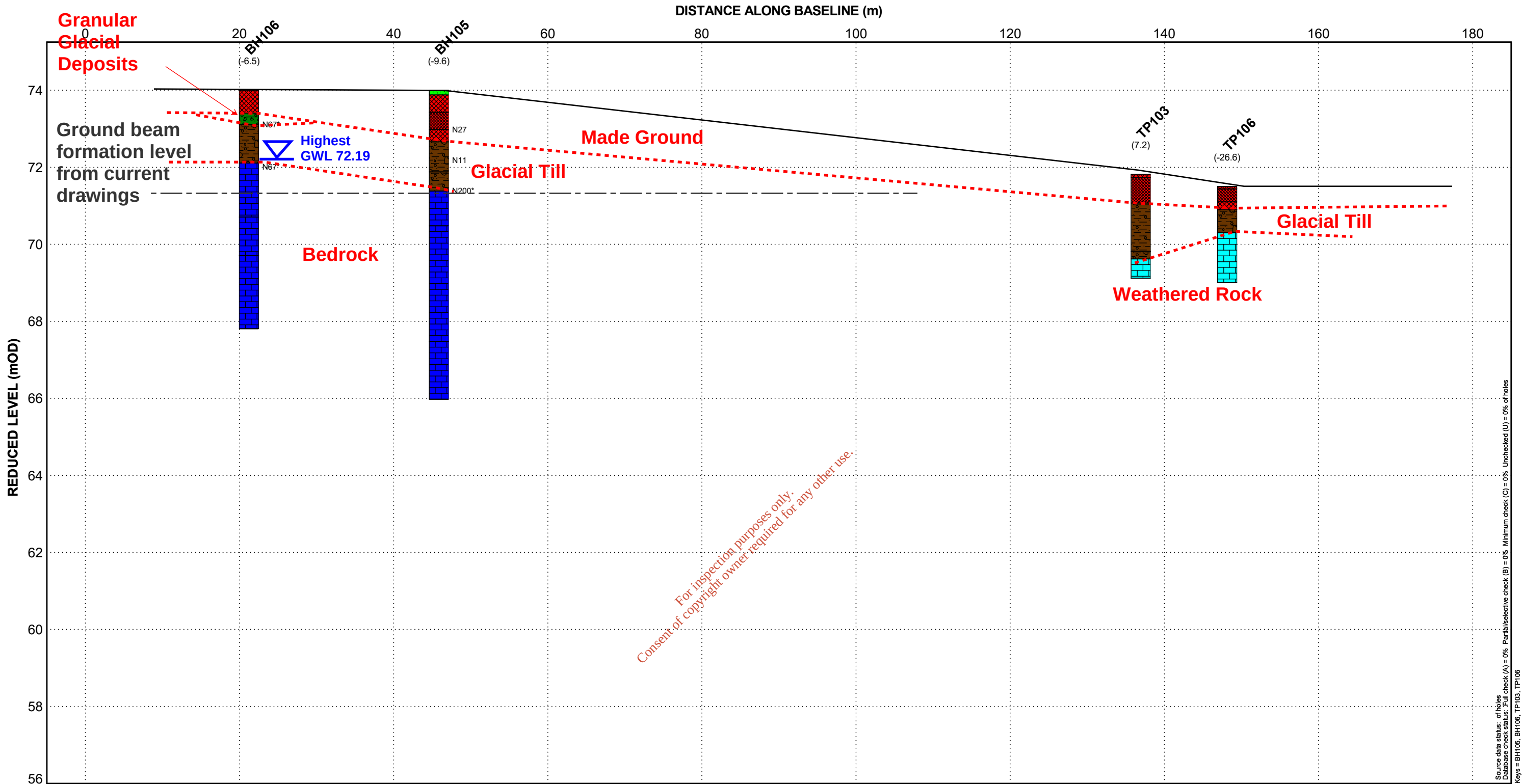
SCALE 1:100V 1:500H @ A3L

*** DRAFT ***

DB5
GEOLOGICAL CROSS SECTION
Figure 24

258064-00

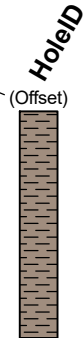
gINT v8.30.004. Licensed to Arup
Project: c:\users\leonidas.malanis\desktop\check-df6.gpj (Template: 3.0). Library: c:\gint\lup_utils_3-0-002-8.glb
Penet: 2.4.01 SECTION WITH PLOTTED DATA (A3) (rev 5Jan16)
gINT output page 1 of 1. Made 31Jan18 12:48



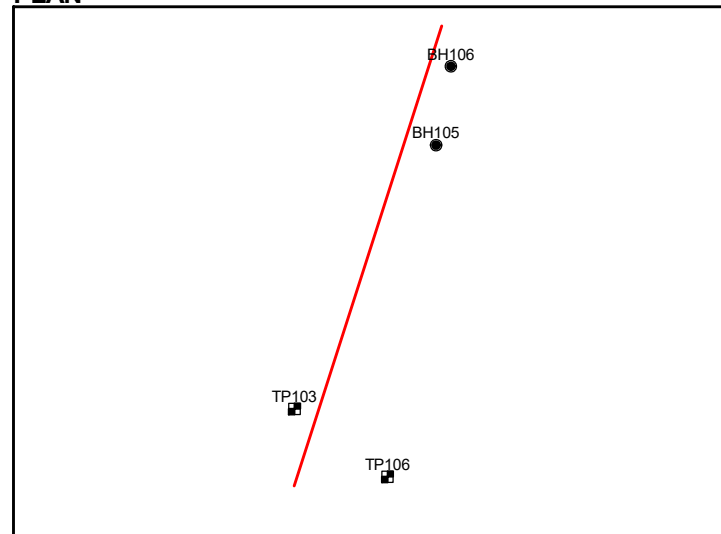
Source data status: of holes
Database check status: Full check (A) = 0% Partial/selective check (B) = 0% Minimum check (C) = 0% Unchecked (U) = 0% of holes
Keys = BH105, BH106, TP103, TP106

LEGEND

Hole offset is +ve to the RIGHT of the baseline



PLAN



- Topsoil [TOP]
- Made Ground [MG]
- Brown Boulder Clay [GTD]
- Gravel [GR]
- Weathered Rock [WrR]
- Limestone [RCK]
- Obstruction [Obs]
- Mudstone [Mud]

- TOPSOIL
- FILL (MADE GROUND)
- Made Ground - FILL
- Sandy gravelly cobbly CLAY
- LIMESTONE
- Clayey sandy GRAVEL
- Sandy gravelly CLAY

SCALE 1:100V 1:500H @ A3L

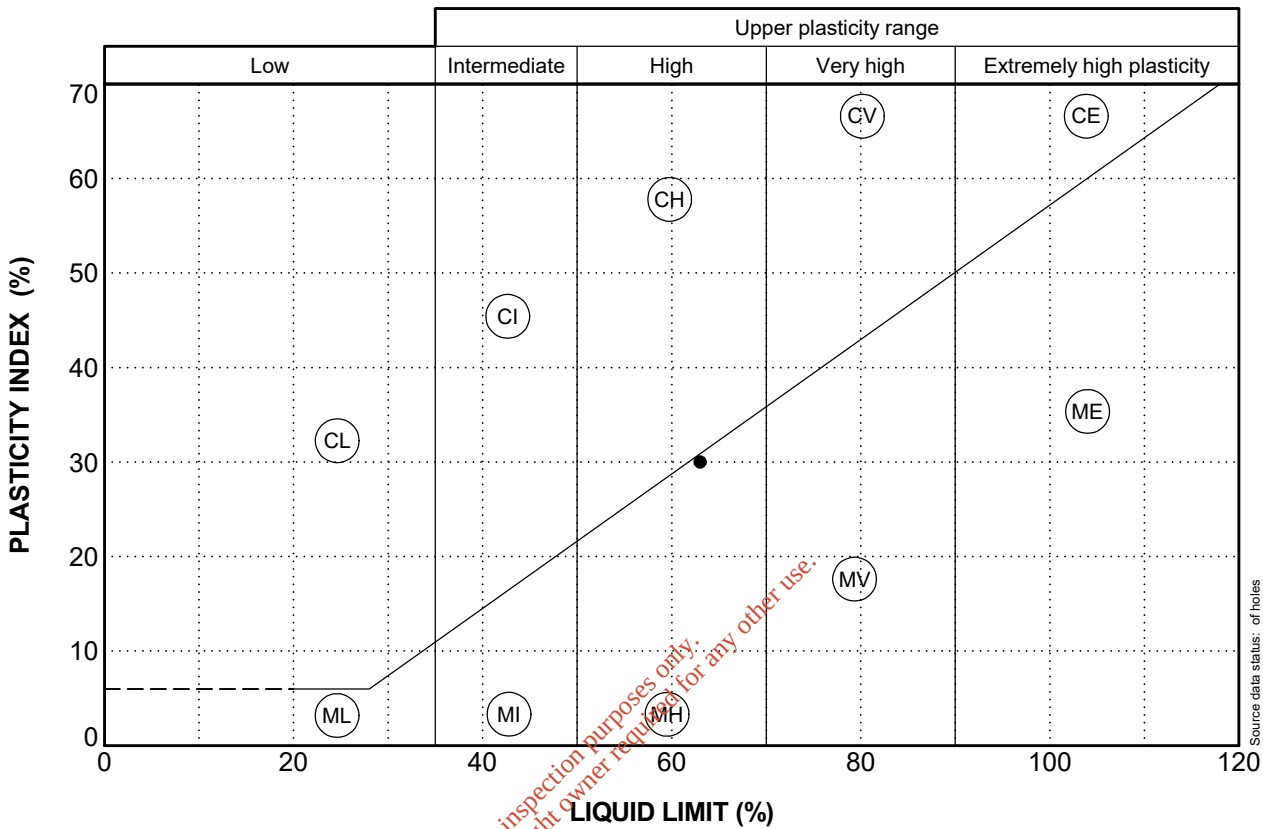
***** DRAFT *****

**DB5
GEOLOGICAL CROSS SECTION**

Figure 25

258064-00

<<DrawingFileSpec>>

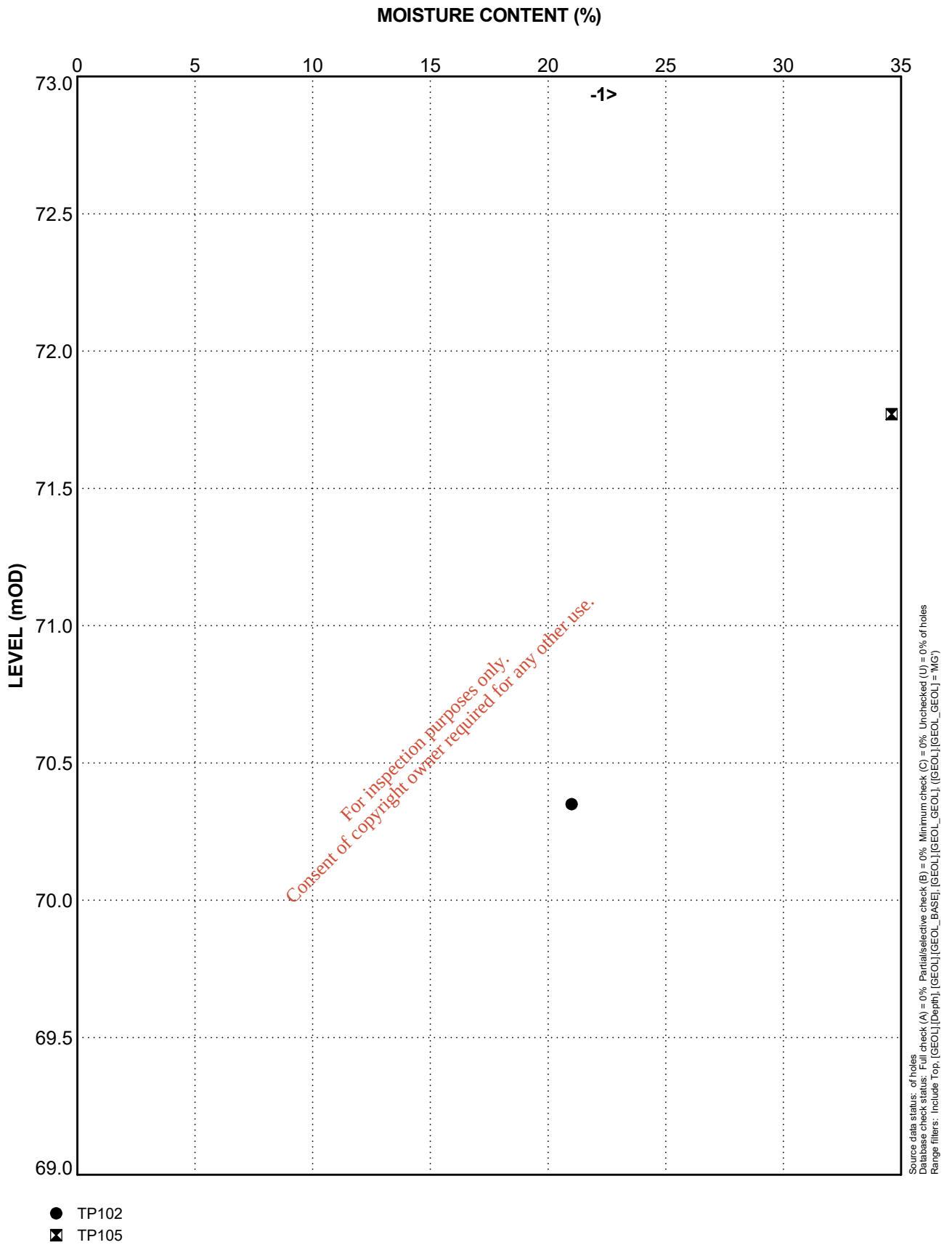


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*** DRAFT ***

DB5
PLASTICITY CHART
Made Ground
Figure 26
258064-00

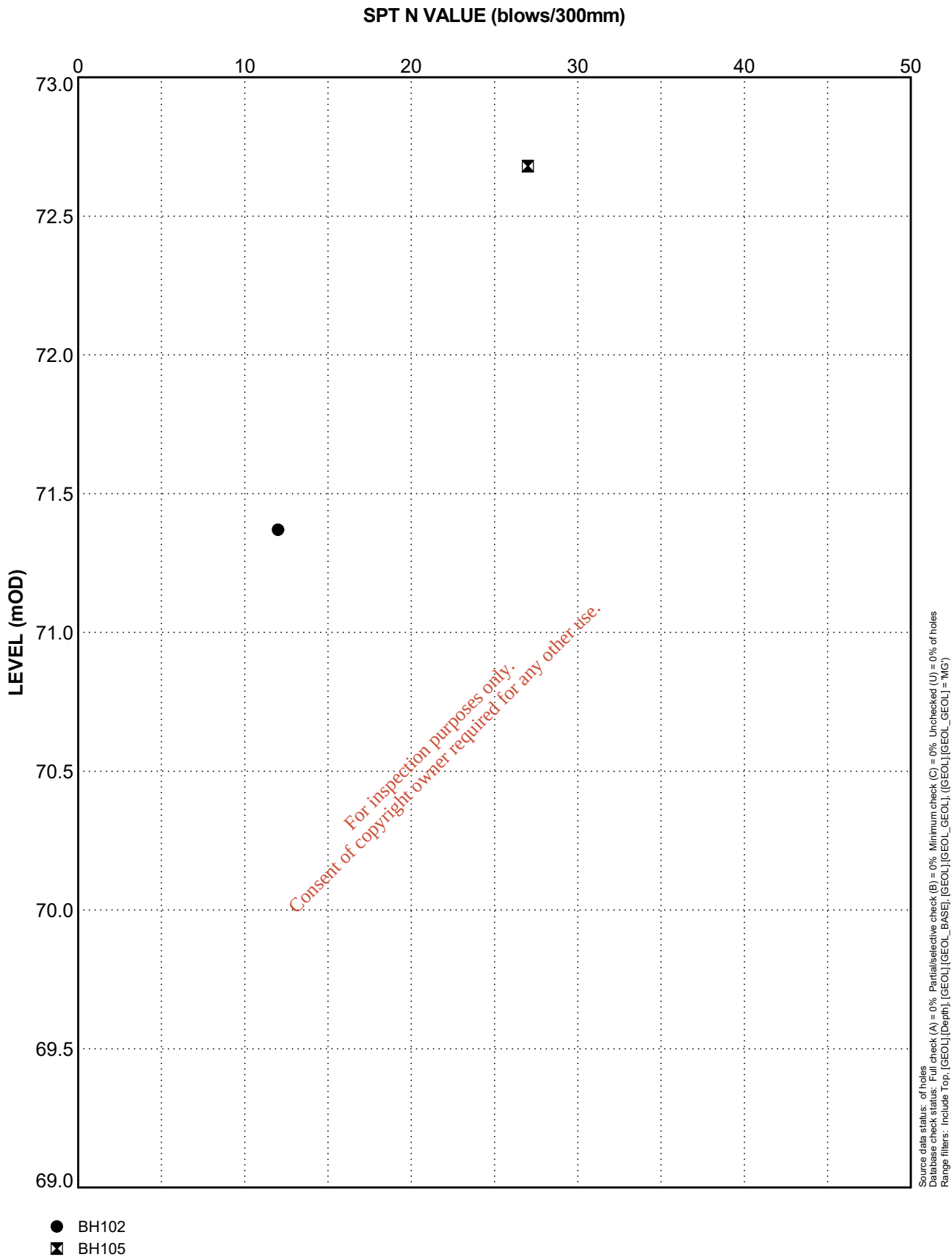
gINT v8.30.004 Licensed to Arup
Project : c:\users\leonidas.malme\desktop\check-db6.gpi (Template : 3.0); Library : c:\gint\arup_uklib_3-0-002-8.glb
Graph: 3.3.01.L MOISTURE CONTENT (ALL TABLES) (rev 9Feb11)
gINT output page 1 of 1. Made 3 Jan18 10:30



***** DRAFT *****

**DB5
MOISTURE CONTENT
Made Ground
Figure 27
258064-00**

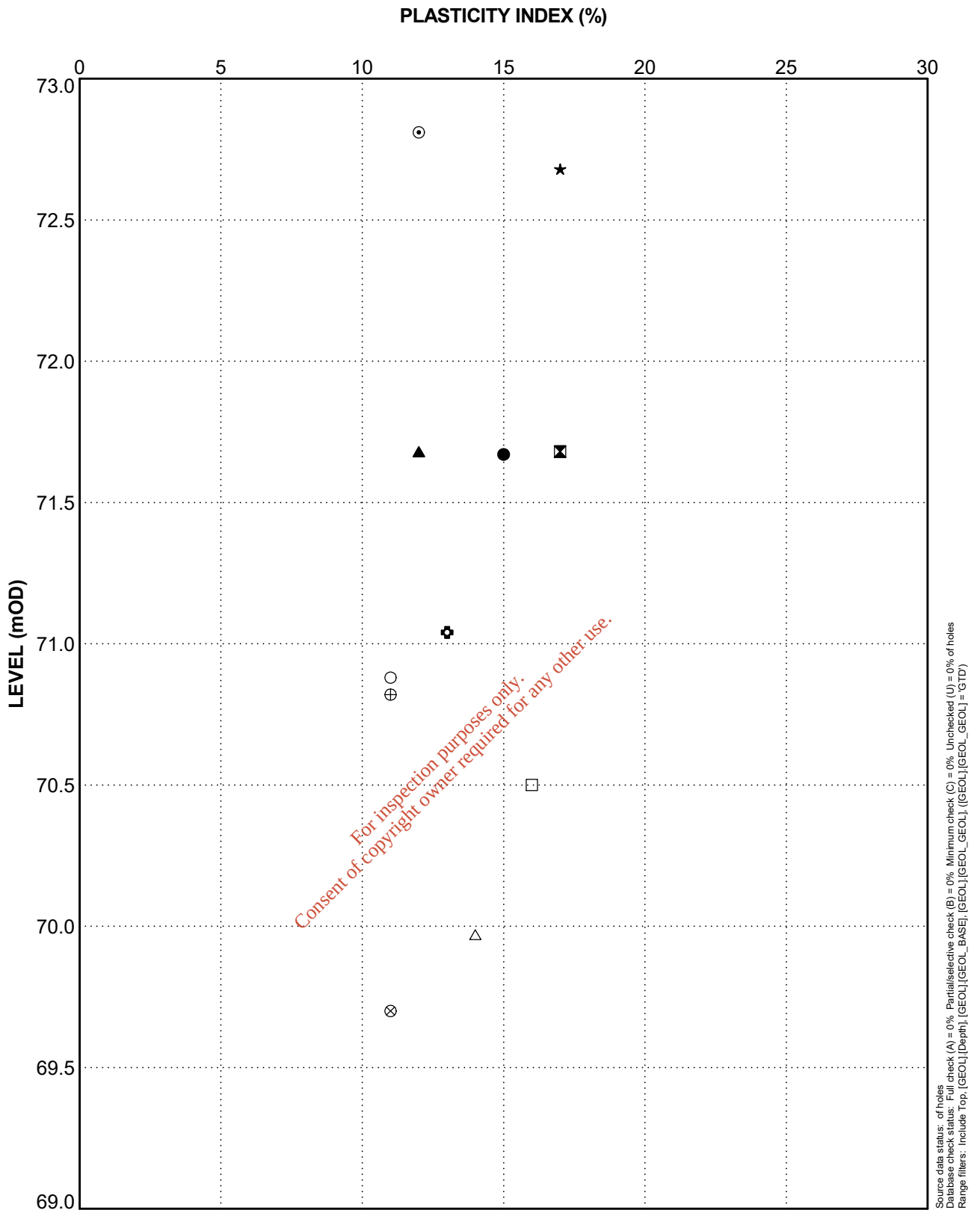
gINT v8.30.004 Licensed to Arup
Project : c:\users\leondas.malams\desktop\check-db6.gpi, (Template : 3.0), Library : c:\gint\arup_uklib_3-0-002-8.glb
Graph: 3.4.01.LL SPT N VALUE (rev 3 Aug 11)
gINT output page 1 of 1. Made 3 Jan 18 10:00



Source data status: of holes
Database check status: Full check (A) = 0% Partial/selective check (B) = 0% Minimum check (C) = 0% Unchecked (U) = 0% of holes
Range filters: Include Top, [GEOU].[Depth], [GEOU].[GEOL_BASE], [GEOU].[GEOL_GEOU], [GEOU].[GEOL_GEOU] = "MG"

*** DRAFT ***

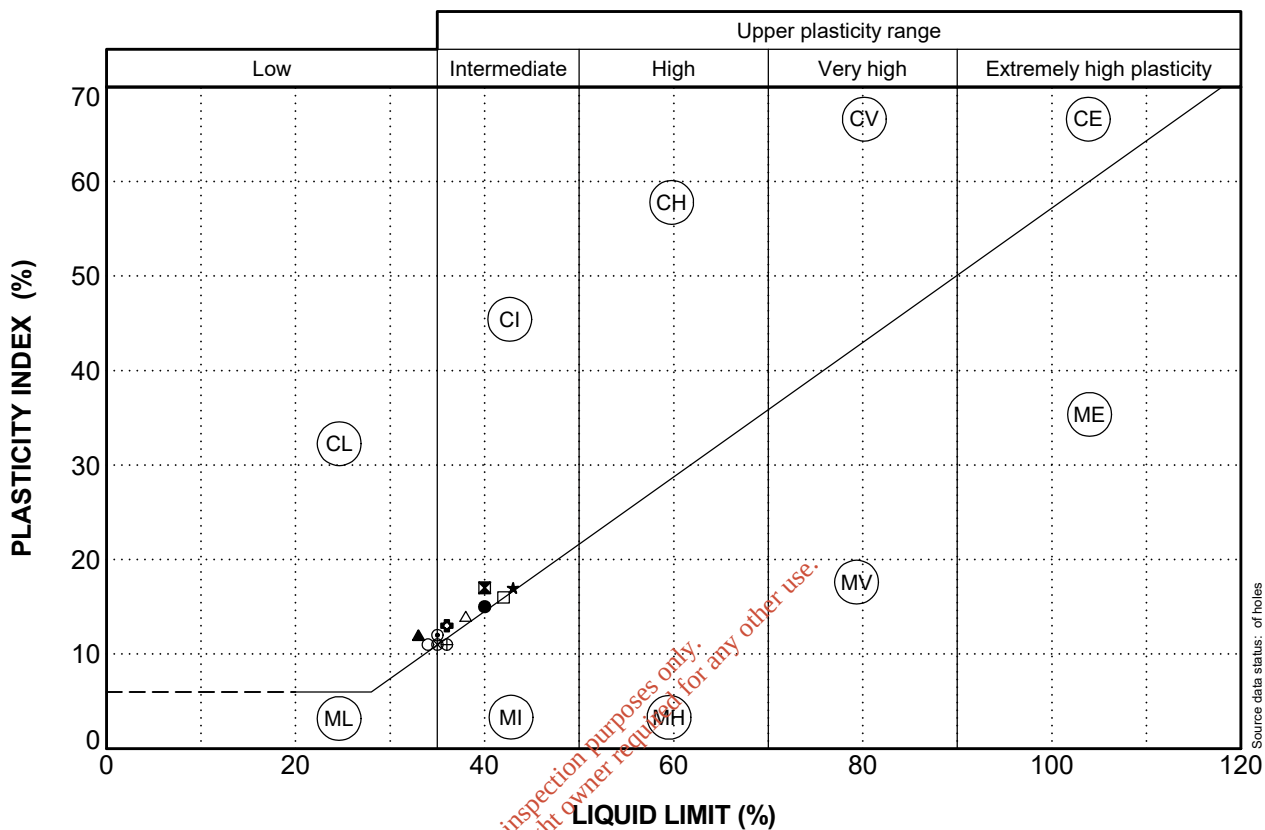
DB5
STANDARD PENETRATION TESTS
Made Ground
Figure 28
258064-00



- BH101
- BH103
- ▲ BH104
- ★ BH105
- ⊙ BH106
- ⊕ BH107
- BH108
- △ TP101
- ⊗ TP102
- ⊕ TP103
- TP106

***** DRAFT *****

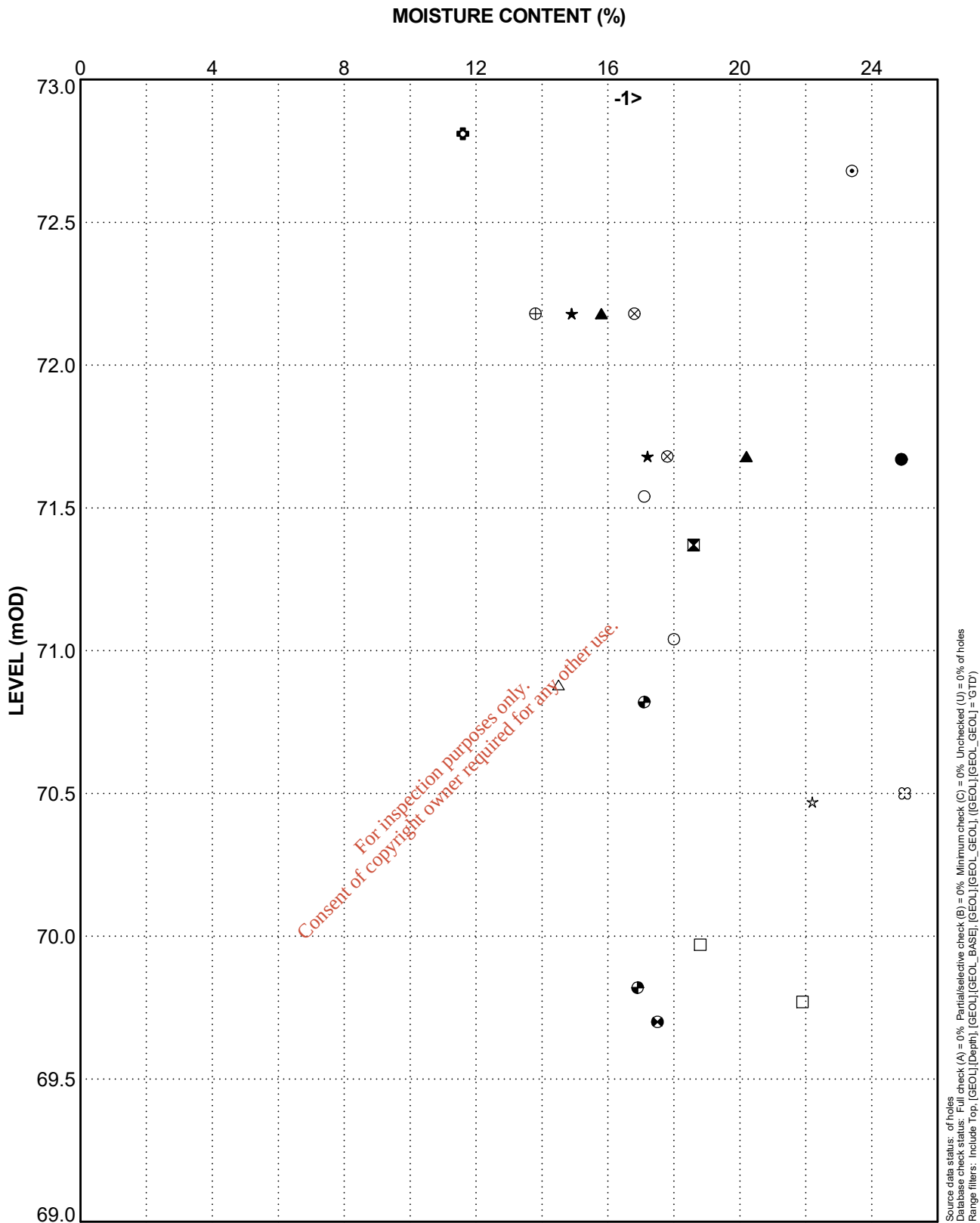
**DB5
 PLASTICITY INDEX
 Glacial Till
 Figure 30
 258064-00**



- BH101, 1.00m
- ⊠ BH103, 1.50m
- ▲ BH104, 1.50m
- ★ BH105, 1.50m
- ⊙ BH106, 1.50m
- ⊕ BH107, 1.50m
- BH108, 1.00m
- △ TP101, 1.50m
- ⊗ TP102, 1.65m
- ⊕ TP103, 1.00m
- TP106, 1.00m

***** DRAFT *****

DB5
PLASTICITY CHART
Glacial Till
Figure 31
258064-00

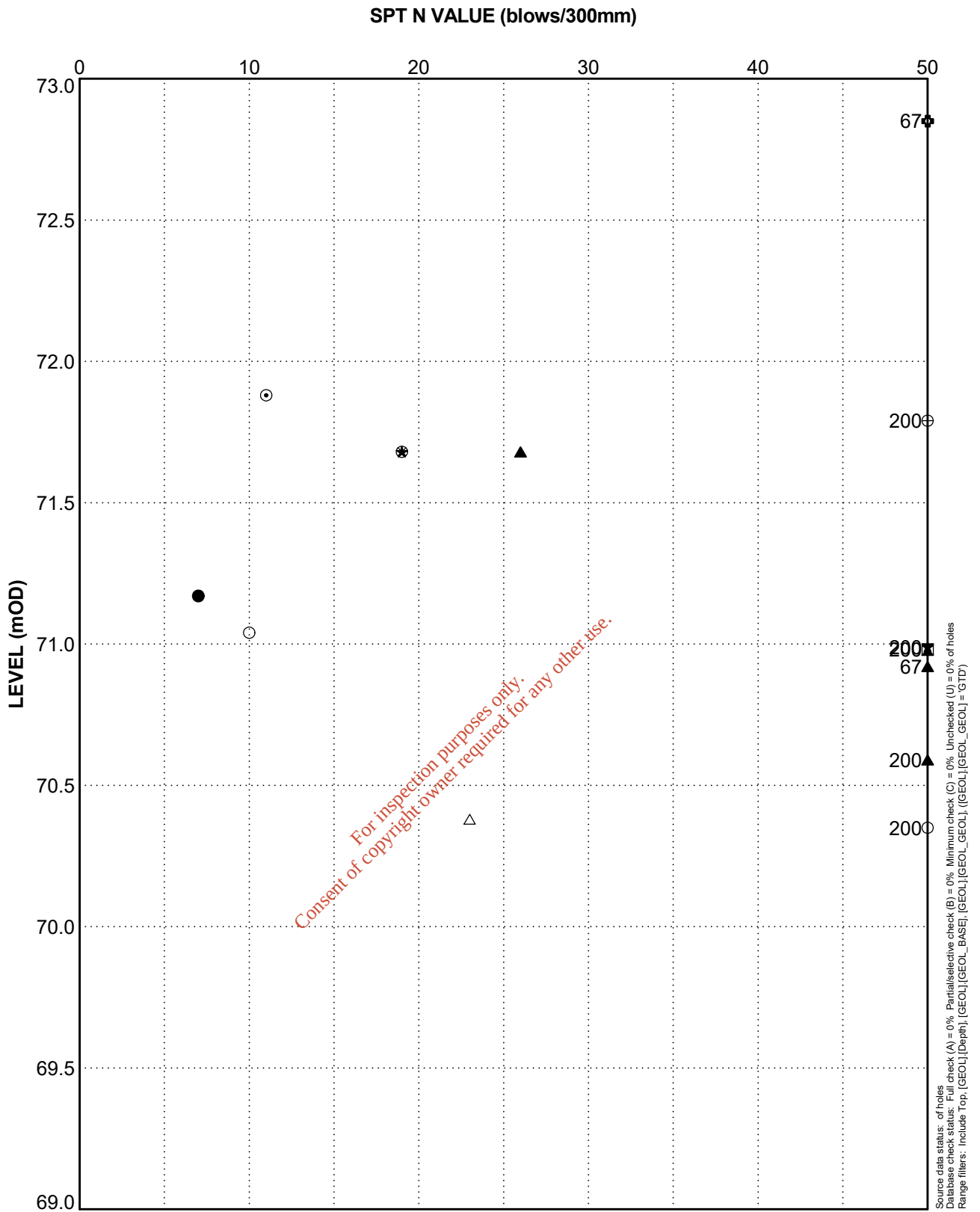


- BH101
- ⊠ BH102
- ▲ BH103
- ★ BH104
- ⊙ BH105
- ⊕ BH106
- BH107
- △ BH108
- ⊗ BH109
- ⊕ BH110
- TP101
- TP102
- TP103
- ★ TP105
- ⊠ TP106

*** DRAFT ***

DB5
MOISTURE CONTENT
Glacial Till
Figure 33
258064-00

gINT v8.30.004 Licensed to Arup
Project : c:\users\leondas.malams\desktop\check-db6.gpi, (Template : 3.0), Library : c:\gint\arup_uklib_3-0-002-8.glb
Graph: 3.4.01.LL SPT N VALUE (rev 3 Aug 11)
gINT output page 1 of 1. Made 3 Jan 18 10:02



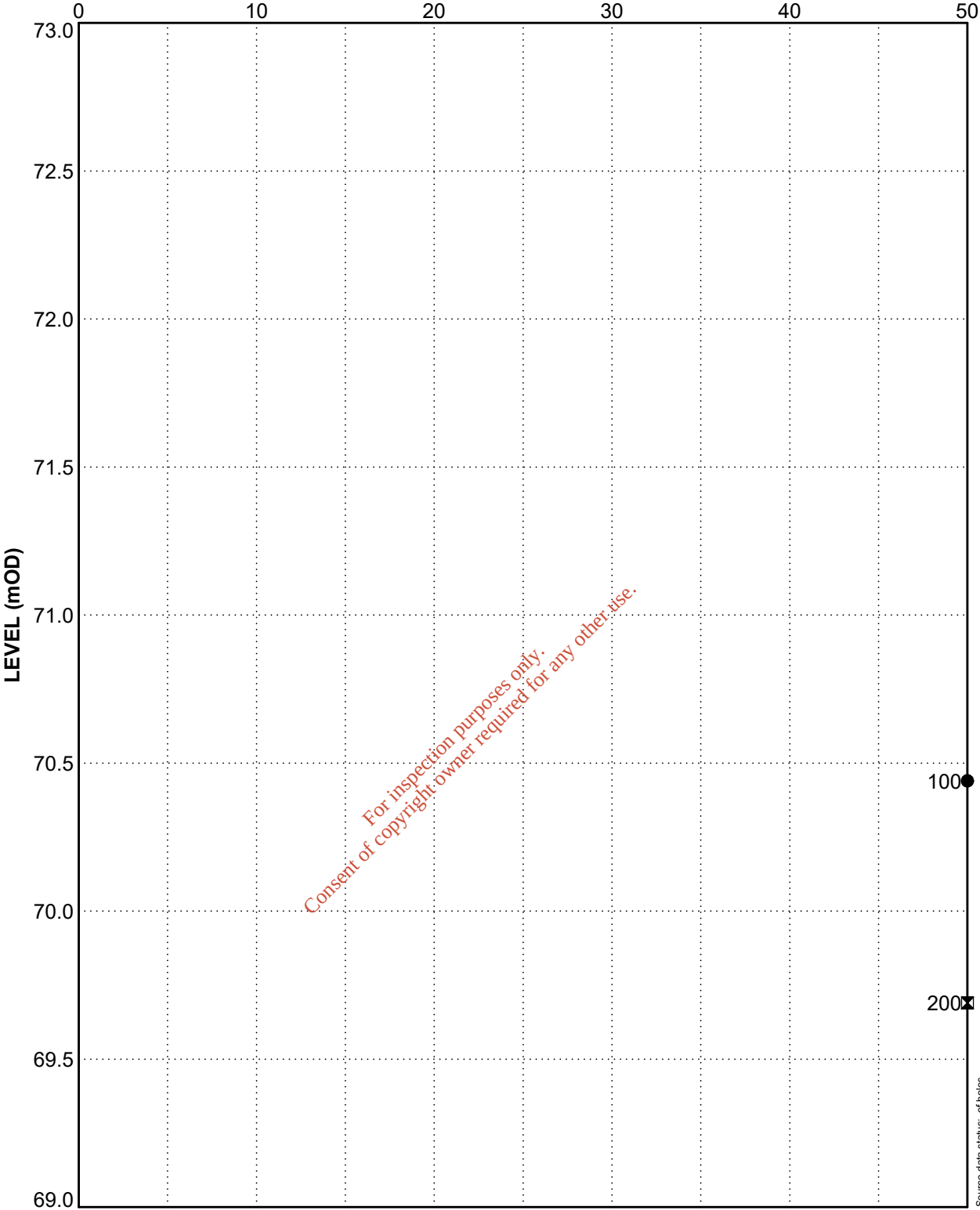
- BH101
- BH102
- ▲ BH103
- ★ BH104
- ⊙ BH105
- ⊕ BH106
- BH107
- △ BH108
- ⊗ BH109
- ⊕ BH110

*** DRAFT ***

DB5
STANDARD PENETRATION TESTS
Glacial Till
Figure 34
258064-00

<<DrawingFileSpec>>

SPT N VALUE (blows/300mm)

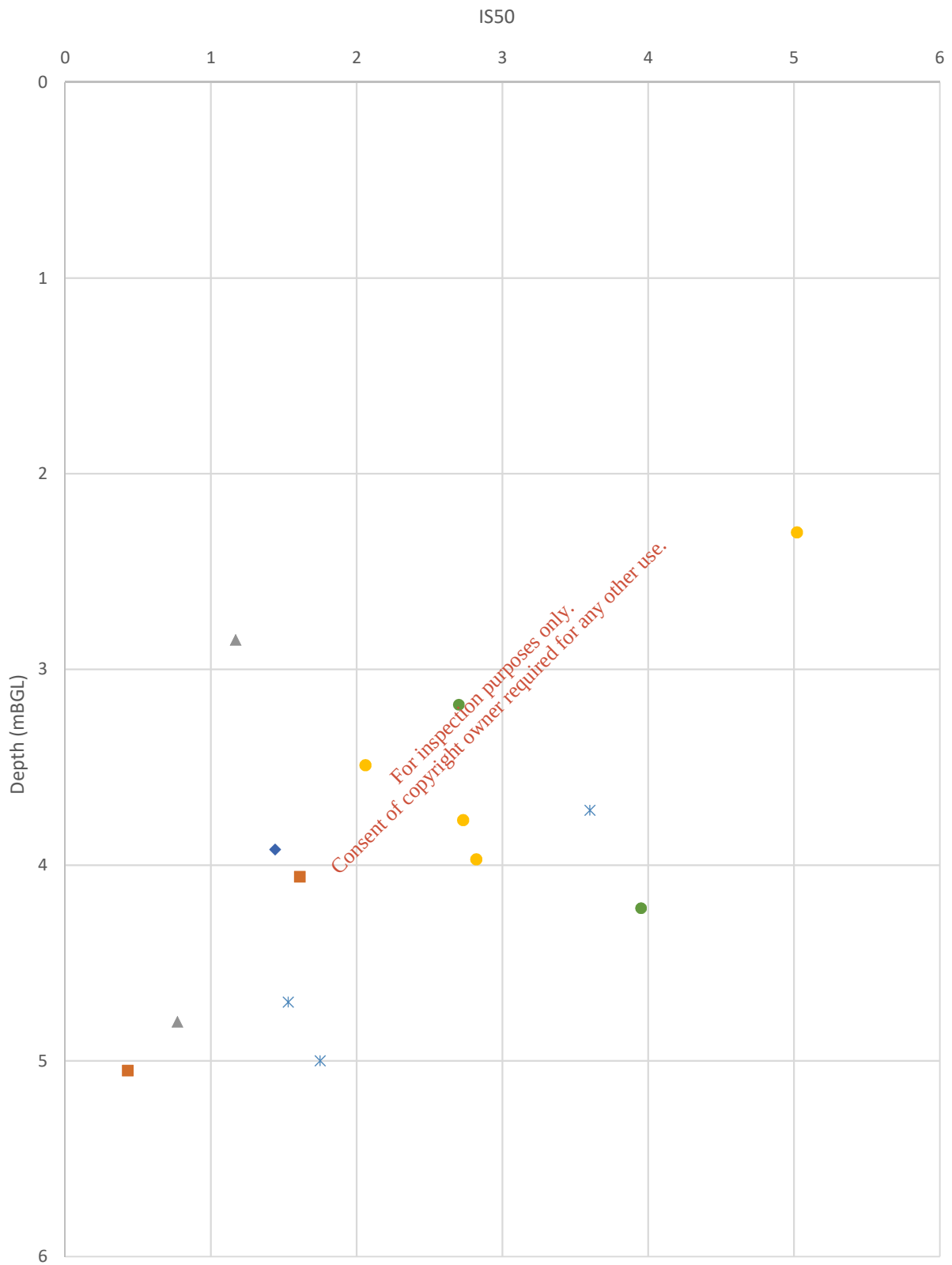


- BH101
- ✕ BH108

*** DRAFT ***

DB5
STANDARD PENETRATION TESTS
Weathered Rock
Figure 35
258064-00

Point Load Test



● BH101 ◆ BH102 ● BH103 ■ BH104 ▲ BH105 ✕ BH106

Figure 36
DB5
Point Load Test Results

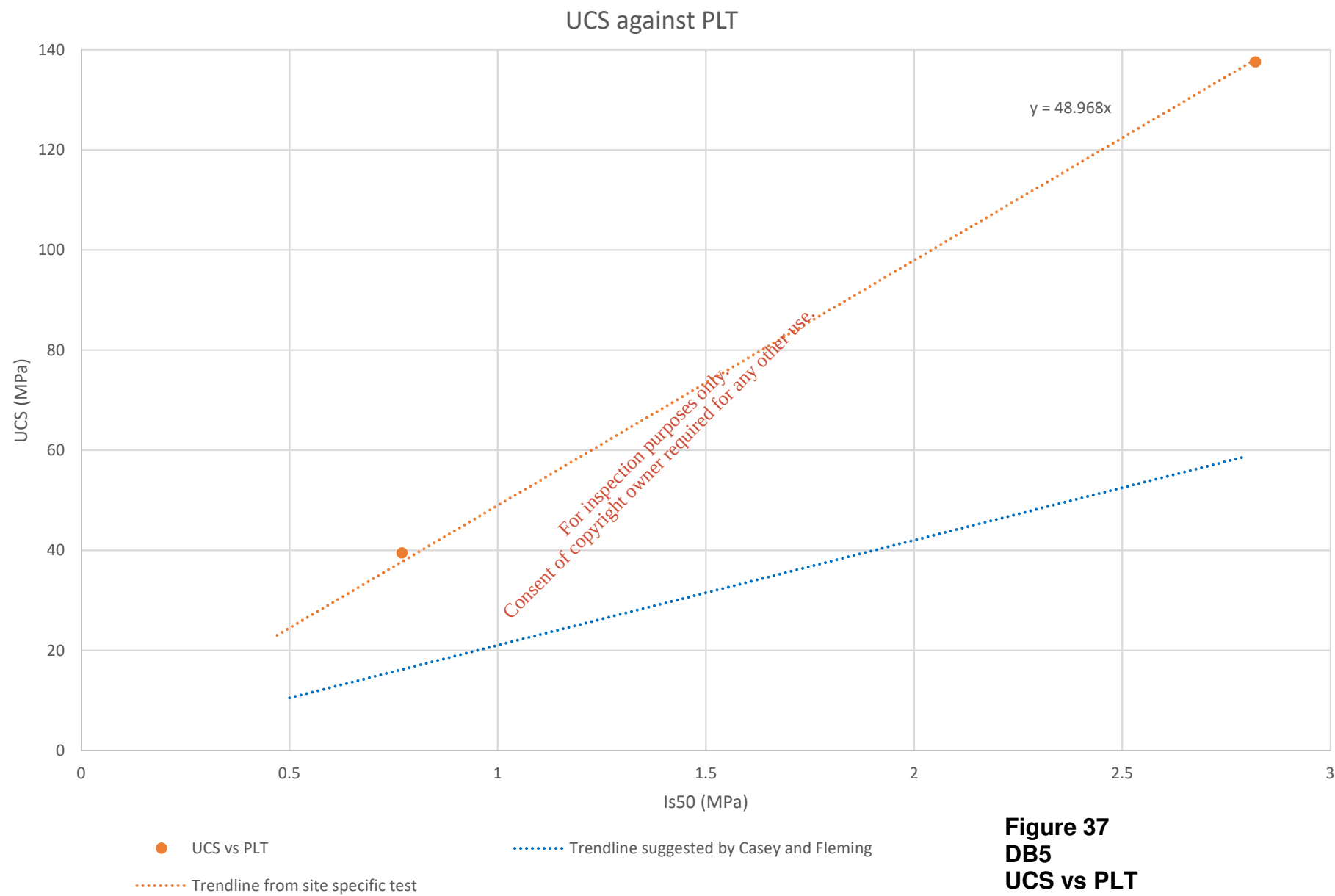


Figure 37
DB5
UCS vs PLT

Point Load Test

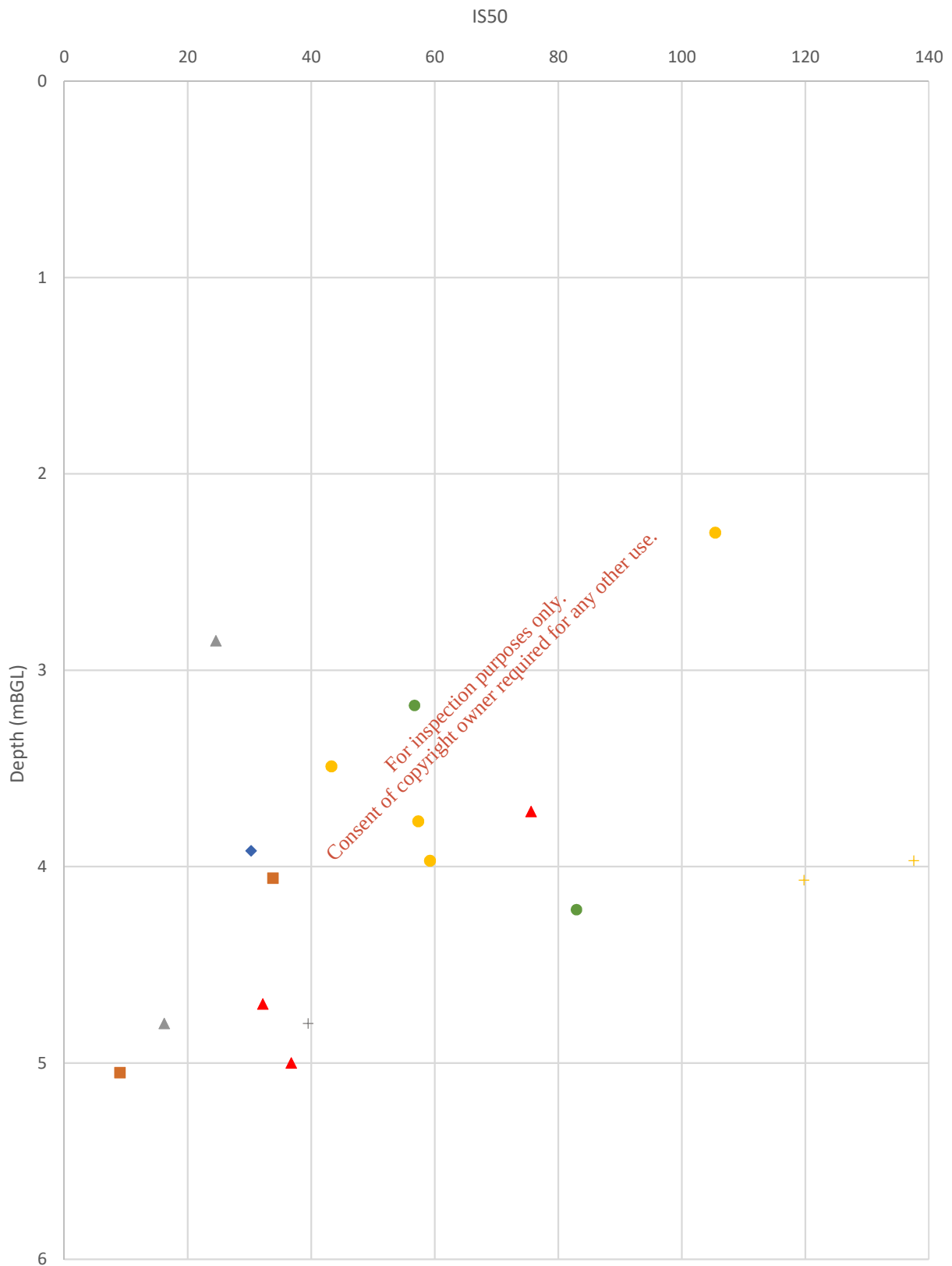


Figure 38
DB5
UCS and Corrected UCS
from Point Load Test
Results

Legend:

 Approximate
Site Boundary

P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Groundwater Aquifers Map

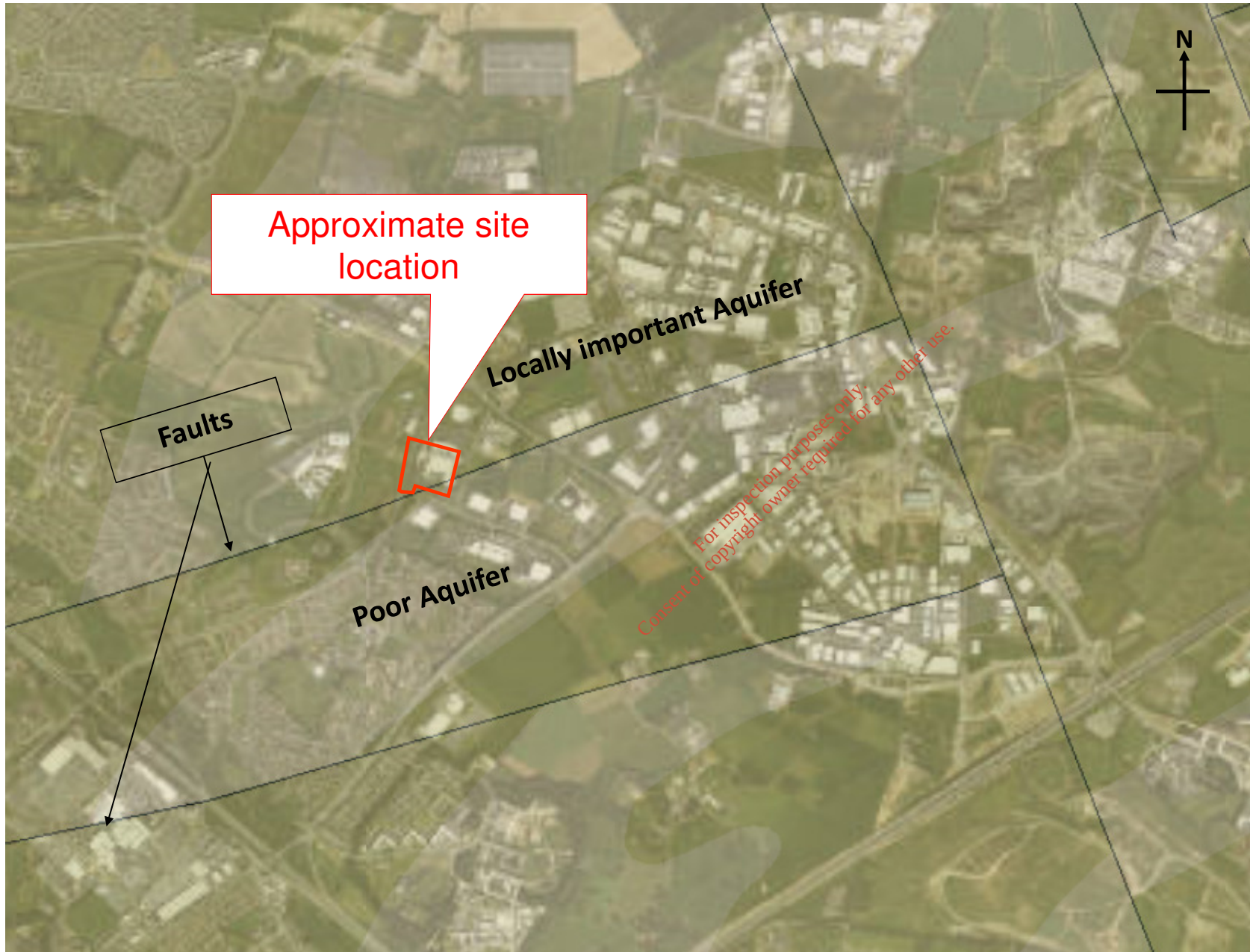
Scale at A3

NTS

Job No
258064

Figure Status
Issue

Figure No
39



Reference:
GSI online mapping

Legend:



Approximate
Site Boundary



P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Groundwater Vulnerability

Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No
40

Legend:

 Approximate
Site Boundary

P1	31/01/18	CC	RT	
----	----------	----	----	--

Issue	Date	By	Chkd	Appd
-------	------	----	------	------

ARUP

Client

Equinix

Job Title

Project DB5

Groundwater Aquifers Map



Scale at A3

NTS

Job No 258064	Figure Status Issue
-------------------------	-------------------------------

Figure No 41	
------------------------	--

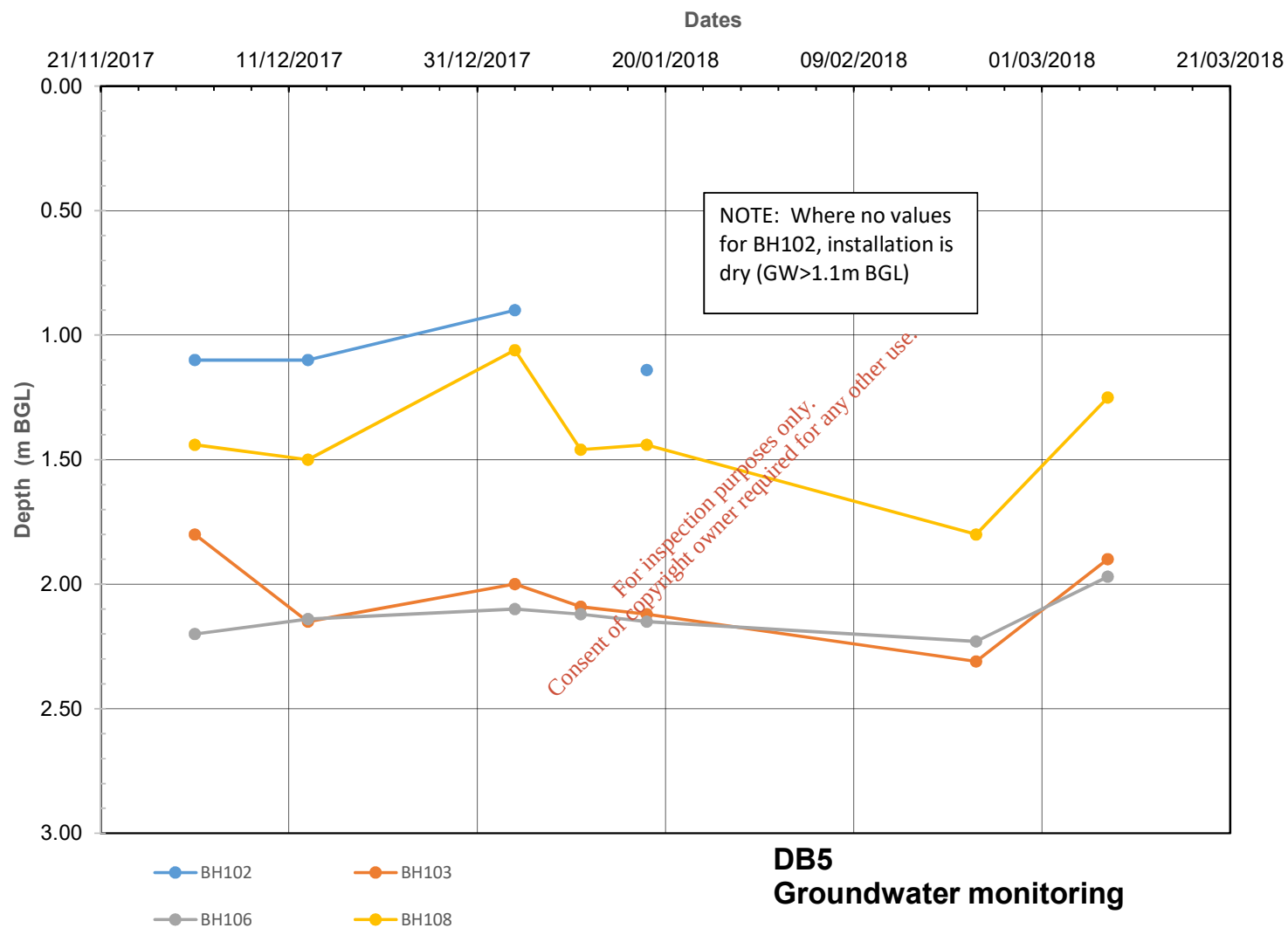
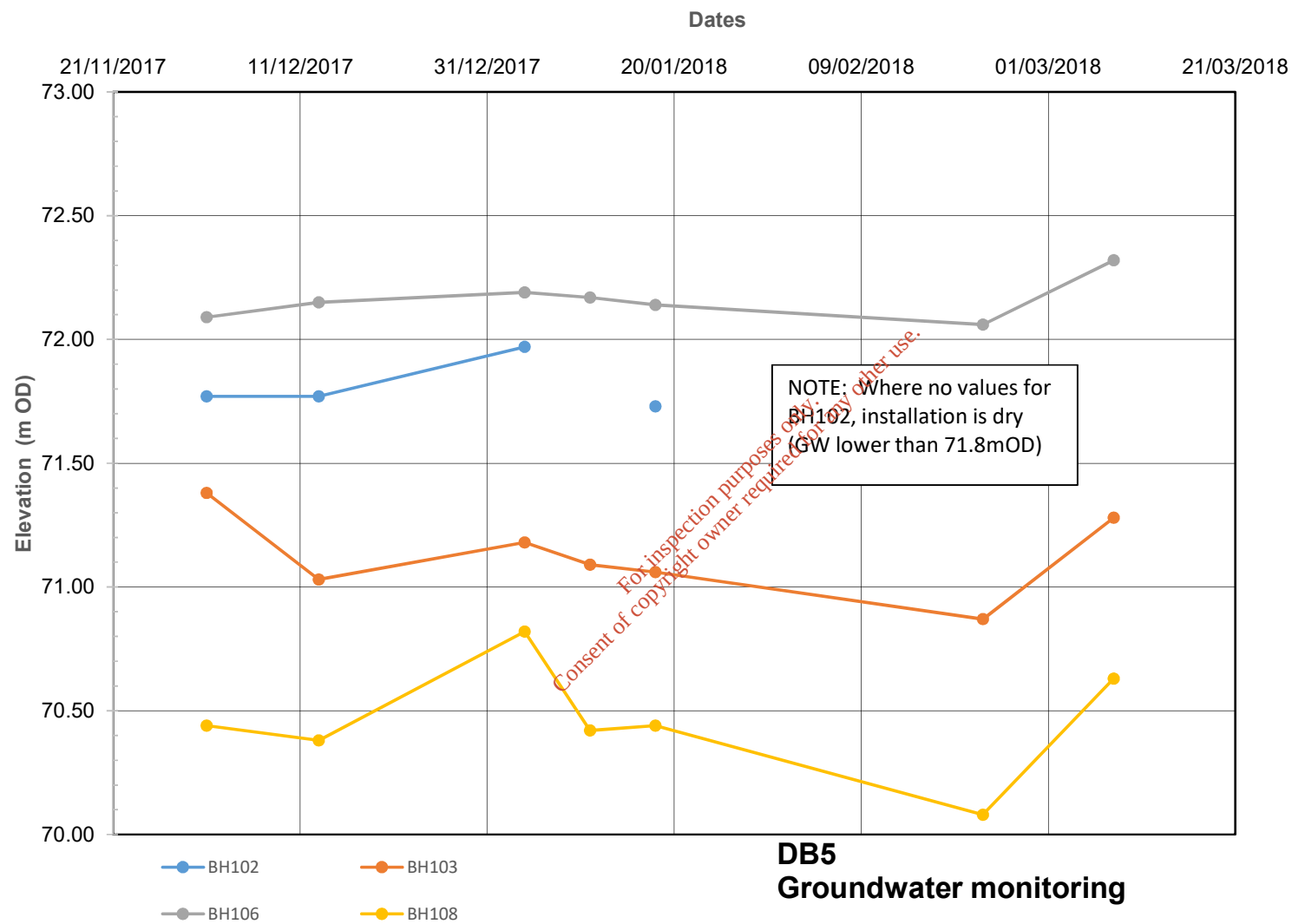


Figure 42



258064

Figure 43