

GEO-ENVIRONMENTAL ASSESSMENT
LAND TO THE NORTH OF WATER LANE
ANGMERING
RYDON HOMES / GLEESON STRATEGIC LAND
GEA-19495B-17-318 REV A
FEBRUARY 2018



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EXECUTIVE SUMMARY

A Geo-Environmental Assessment was requested by Rydon Homes and Gleeson Strategic Land. The purpose of the assessment was to identify any contaminative or geotechnical issues associated with former land use at *Land to the North of Water Lane, Angmering* which might impact on the site's redevelopment.

SITE DETAILS	
Approximate site area	31.95 ha
Current/previous use	Undeveloped – agricultural/arable. Motorsports race track in northeast corner.
Proposed use	Approximately 525 residential units and employment land.

PHASE 1 NON-INTRUSIVE INVESTIGATION	
Expected geology	Superficial deposits comprising Alluvium and Head Deposits - may be locally absent across the centre of the site. Solid geology comprises London Clay Formation. The Lambeth Group (clay, silt and sand) may be encountered in the southwest corner of the site.
Groundwater	Not within a SPZ. Where present, the superficial geology is classified as a Secondary Aquifer – Undifferentiated. The underlying bedrock geology of the London Clay is classified as an Unproductive Stratum, with a Secondary (A) Aquifer (Lambeth Group) in the southwestern section of the site.
Surface water	No surface water abstraction licences are located within a 1 km radius of the site. Site lies within Zone 1. A Flood Risk Assessment has been undertaken by Idom Merebrook and is reported under separate cover.
Other	The site lies within a Radon Affected Area (between 5% and 10% of houses are above the action level). Basic radon protection measures are required.

PHASE 2 EXPLORATORY INVESTIGATION	
Ground Conditions	The site investigation revealed ground conditions generally consisting of topsoil underlain by predominantly cohesive superficial Head Deposits (0.2 - > 3.0 m thick) and London Clay (> 2.8 m thick). Locally, made ground between 0.4 and 1.4 m thick was encountered, whilst deeper made ground was revealed in two locations (2.2 and > 3.3 m thick).
Contamination	Based on the results, it is considered that general, site-wide remediation of soils is not required at the site. Localised soil remediation will be required in the area of the Motorsports Centre due to asbestos, lead, TPH and PAH contamination.



PHASE 2 EXPLORATORY INVESTIGATION

Geotechnical issues	Variable depths to competent soil revealed across the site, whilst existing / proposed trees may dictate footing depths locally. Localised areas of deep made ground and vertically persistent weak natural soils.
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RECOMMENDATIONS

Geotechnical	Traditional strip / trench footings are considered acceptable across the majority of the site. Alternative foundation solutions such as ground improvement or piles will be required in areas where deep made ground or vertically persistent weak natural soils are present.
Remediation	An allowance should be made for placement of 600 mm of suitably clean validated material (which may include site-won material) on private gardens (and 300 mm for soft landscaped areas) coincident with the Motorsports Centre, underlain by a geotextile membrane. The extent of the remedial zone will need to be delineated by further investigation. Basic radon protection comprising as a minimum a radon barrier will need to be incorporated into the proposed development.
Waste classification	Site soils can generally be expected to be classified as non-hazardous should they require disposal. A single sample submitted for WAC analysis (MWS109 at 0.50m bgl) indicates that the majority of made ground may be disposed as inert, (subject to confirmation from the landfill operator). Asbestos fibres/lagging detected within MWS107 at 0.90m bgl would render it unsuitable for disposal at inert landfill. Where disposal is necessary, asbestos quantification should be carried out to determine the waste classification of this material and limit the amount of material which may be classified as hazardous waste for disposal purposes (<0.1 %). However, where any visible fragments of asbestos are noted, materials would be classified as hazardous waste. Hydrocarbon concentrations recorded in made ground within MWS108 at 0.6 m bgl and TP112 at 0.5 m bgl would result in the materials being classified as hazardous waste.
Re-use of site-won materials	Natural as-dug soils could be classed as inert waste without the requirement for WAC testing. Materials Management Plan required for re-use of materials on site (including bunds).



SECTION 1 INTRODUCTION

- 1.1 Rydon Homes and Gleeson Strategic Land propose to develop an area of land located to the North of Water Lane in Angmering for mixed development purposes. The proposed development comprises approximately 525 residential units and employment land with private and adopted highways, soft landscaping and associated roads and parking. Idom Merebrook Limited (Merebrook) has been commissioned by Rydon Homes and Gleeson Strategic Land to undertake preliminary site investigation works and to advise on the geo-environmental implications of the redevelopment of the site for the proposed end use.
- 1.2 The objectives of the investigation are to:
- i.* Assess surface and sub-surface ground conditions present at the site;
 - ii.* Identify hazards associated with ground contamination which may place constraints on the site and the proposed development;
 - iii.* Evaluate the risks associated with any identified hazards;
 - iv.* Provide preliminary recommendations for the mitigation of any significant risks identified; and
 - v.* Provide preliminary geotechnical recommendations.
- 1.3 A Phase 1 (Non-intrusive Investigation) and a Phase 2a (Preliminary Exploratory Investigation) have been undertaken for the subject site.
- 1.4 This report presents the findings of the geo-environmental investigation and provides an interpretation of the geo-environmental conditions that exist at the site. The contaminative status of the site and the implications with respect to development have been interpreted in accordance with the current government guidance on source-pathway-receptor risk assessment. This report uses a Tier 1 risk assessment to ascribe a conservative qualitative appraisal of the hazards associated with the site.
- 1.5 This report has been prepared for Rydon Homes and Gleeson Strategic Land for the sole purpose described above and no extended duty of care to any third party is implied or offered. Third parties making reference to the report should consult Rydon Homes, Gleeson Strategic Land and Merebrook as to the extent to which the findings may be appropriate for their use.



SECTION 2 PHASE 1 (NON-INTRUSIVE INVESTIGATION)

2.1 INTRODUCTION

- 2.1.1 The non-intrusive investigation has been conducted with reference to the documents and sources detailed in Table 1 below:

Table 1: Published Data and Information Sources

SOURCE DATA	GROUNDSURE DATA (Aug 2017)
BGS 1:50,000 Series Geological Sheet 317/332 Chichester and Bognor	Ordnance Survey (OS) historical maps scaled at 1:10,560, 1:10,000, 1:2,500 and 1:1,250 dated 1876 - 2014
BGS Geology of Britain 1:50,000 online maps	Water abstraction, discharge and pollution data
Radon: guidance on protection measures for new dwellings	Registered waste management sites
Environment Agency (EA) online data maps	Mining records and natural ground stability data
UK National Air Quality Archive, online	Protected areas of environmentally sensitive land use or conservation
	Other relevant designations and/or authorisations and Trade Directory entries

- 2.1.2 The above sources are all authoritative and it is believed that they are reasonably reliable. However, independent verification of the information supplied has not necessarily been carried out and Merebrook cannot be held liable for inaccuracies or deficiencies in the information.

2.2 SITE LOCATION AND SETTING

- 2.2.1 The site is located to the north of Water Lane in Angmering, Littlehampton, West Sussex.
- 2.2.2 The site occupies an area of approximately 31.95 hectares located at National Grid Reference 507618, 105115 and indicated on drawing 19495-001-003, presented in Appendix 1 of this report.
- 2.2.3 At the time of the site investigation the subject site largely comprised agricultural farmland. The north-eastern section of the site was an active motorsports race track (Angmering Motorsports Limited) with associated garages and car storage space. The only buildings noted within the site boundary are within the motorsports area. However, there are temporary structures (stables) and the remains of greenhouses within the south-western land parcel.
- 2.2.4 No visual or olfactory evidence of contamination was noted within the farmland. No Above Ground Storage Tanks (ASTs) or Underground Storage Tanks (USTs) were



observed during the site investigation. Anecdotal evidence also states that ground levels around the racetrack area have been made up by imported 'inert waste' materials, and two bunds were noted during the walkover.

- 2.2.5 The site topography slopes downwards from the north towards an unnamed river located south of Water Lane.
- 2.2.6 Surrounding land uses comprise open fields, plant nurseries, and mixed residential and commercial properties.

2.3 SITE HISTORY

- 2.3.1 The site history, based on a review of the historic and current maps, dating from 1876 to 2014 is summarised below. Potentially contaminative land uses are shown in **bold**. Copies of key maps used in this review are provided in Appendix 2.

Table 2: Summary of the key features shown on historic maps

DATA SOURCE	SITE / SURROUNDINGS
1876 (1:10,560)	Site: The site comprises open fields. A horseshoe arrangement of buildings is present in the central western section of the site.
	Surroundings: The site is surrounded by farmland, woods and residential dwellings associated with Angmering to the south east. No significant potentially contaminative land uses are noted.
1896-1899 (1:10,560)	Site: The buildings in the central western section of the site are referenced as New Barn.
	Surroundings: An old chalk pit is present 600 m south east. A gravel pit is labelled 200 m south west.
1938-1943 (1:10,560)	Site: No significant change in land use.
	Surroundings: A gravel pit is shown approximately 10 m southwest. The previously labelled gravel pit is no longer shown and is assumed to have been backfilled. Various plant nurseries are present to the west and southwest, within 500 m.
1957 (1:10,560)	Site: No change in land use.
	Surroundings: Residential development has occurred to the west associated with Angmering.
1974-1976 (1:10,00) & 1974 (1:2,500)	Site: Large greenhouses have been added to the south west corner of the site assumed to be associated with St Deny's Nursery.



DATA SOURCE	SITE / SURROUNDINGS
	Surroundings: The 1:2,500 scale map indicates a tank is present close to the boundary of the south-western corner (St Deny's Nursery) and a Builder's Yard lies approximately 100 m south west. Land raising / ground workings are shown on land surrounding Avenals Farm. An electricity sub-station lies approximately 130 m west of the south-western corner. Further residential development associated with Angmering has occurred to the west. The A27 along the northern boundary has been widened. The gravel pit close to the south-western corner is no longer shown and is assumed to have been backfilled.
2002 (1:10,000)	Site: The site comprises the motor race circuit in the north-eastern section of the site (present on 1:2,500 scale map since 1994), with associated buildings. The buildings in the central western section of the site are no longer shown. Surroundings: No significant change in land use.
2014 (1:10,000)	The site reflects its current configuration.
Groundsure Data Search	Unspecified ground workings, unspecified pits, filled gravel pits and ponds have all been identified within close proximity to the subject site.

- 2.3.2 In summary, the historic plans show that the site comprised unreferenced open fields. Prior to 2002 (c.1990's) the north-eastern area of the site experienced a change of land use to the motor race circuit, which reflects the site's current configuration to date.
- 2.3.3 The historic maps show evidence of potentially significant land uses on site or within 250 m of the site. This includes plant nurseries and greenhouses, farm buildings, ground workings, filled gravel pits, unspecified tanks, an electricity substation and builder's yard. Given the distance to the electricity substation this is considered unlikely to have affected the subject site and is not considered further as a potential off-site source.
- 2.3.4 Given the nature of the historical mapping process (scale, representation of conditions at discrete time intervals frequency *etc.*), any such maps and plans may not provide a comprehensive account of a site's history. Identification of pertinent land uses and associated potentially contaminative activities, may therefore be absent from mapping records.
- 2.4 **GEOLOGY**
- 2.4.1 The published geological map indicates that the underlying strata across the site comprise superficial deposits of Alluvium (clay, silt, sand and gravel) and Head



Deposits - Diamicton (clay, silt, sand and gravel). These superficial drift deposits may be locally absent across the centre of the site.

2.4.2 The bedrock geology comprises the London Clay Formation (clay, silt and sand). The Lambeth Group (clay, silt and sand) may be encountered in the southwest corner of the site.

2.4.3 A BGS borehole log for a 200 metre deep borehole drilled on site in 1976 (TQ00NE/18 – Hammerpot, New Barn for Southern Water Authority) is provided in Appendix 3. From the records available on the BGS website this appears to be located in a verge near to the Oval Racetrack entrance. The log indicates 0.2 m topsoil to be present over London Clay (blue and grey clay) to 17.0 m bgl. This was in turn overlain by silty clay and silty sand layers attributed to the Woolwich and Reading Beds. The Upper Chalk was recorded at 70.0 m bgl. The resting water level was recorded as 27.0 m bgl. This borehole could not be found during the most recent walkover and liaison with Southern Water is recommended to determine the status of the borehole (i.e. whether it needs to be retained if present).

2.5 HYDROGEOLOGY

2.5.1 The site does not lie within an EA designated groundwater Source Protection Zone.

2.5.2 The superficial geology is classified as a Secondary Aquifer – Undifferentiated Layers. The underlying bedrock geology of the London Clay is classified as an Unproductive Stratum, with a Secondary (A) Aquifer (Lambeth Group) in the southwestern section of the site.

2.5.3 No groundwater abstraction licences are located within 500 m of the study site.

2.5.4 One groundwater abstraction licence is noted with a 1 km radius of the subject site. The historical abstraction licence is 797 m south and relates to horticultural watering.

2.6 HYDROLOGY

2.6.1 There is one record of a surface water feature located on site (to the south of Water Lane), which is referenced as a Secondary River (unnamed).

2.6.2 No surface water abstraction licences are located within a 1 km radius of the site.

2.6.3 The site lies within Flood Zone 1 (<0.1 annual risk of flooding from rivers and the sea). A flood risk assessment has been undertaken by Idom Merebrook and is reported under separate cover.

2.6.4 The highest susceptibility to groundwater flooding in the search area based on the underlying geological conditions is considered to be *potential at surface*, relating to *clearwater flooding* (unconfined aquifer). The BGS has assigned a high confidence rating to this result.



2.7 CURRENT SITE ISSUES

2.7.1 Potentially significant environmental issues have been investigated within relevant distances of the site, based on the database of records supplied by Groundsure. These relate to the following searches:

- i. Water discharge or pollution incidents within 250 m of the site;
- ii. Waste management sites within 250 m of the site;
- iii. Statutory authorisations within 50 m of the site;
- iv. Trade directory entries of possible contaminative use within 50 m of the site;
- v. Special protection or conservation areas within 50 m of the site; and
- vi. Any other relevant issues.

2.7.2 Potentially significant environmental issues identified by the above searches are summarised in Table 3 below.

Table 3: Potentially significant environmental issues

ENVIRONMENTAL CATEGORY	DESCRIPTION
Water discharge or pollution incidents within 250 m	Five licensed Discharge Consents are located within 250 m of the site, which relate to sewerage discharge. Ten pollution incidents are recorded within 250 m. Two of these occurred on site in 2003 and both related to smoke. They were both classified as no impact to water or land and minor/no impact to air. The other pollution incidents were all classified as minor or no impact to air, water and land. It is considered that these are all unlikely to impact the subject site.
Waste management sites within 250 m	No current or historic Environment Agency landfill sites or other waste sites are listed within 250 m of the study site.
Statutory authorisations within 50 m	There are no statutory authorisations listed within 50 m of the site.
Trade directory entries of possible contaminative use within 50 m	The Oval Race Club is present on site (motorsport services). A tank is present 20 m north west however further details are unknown. There are seven further potentially contaminative industrial sites within 50 m including construction completions services, construction supplies, vehicle repair and servicing and a metalworkers including blacksmiths.
Special protection or conservation areas within 50 m	An area immediately to the east of the site (Groom's Copse) is classified as Ancient and Semi-Natural Woodland. The site is adjacent to South Downs National Park.



ENVIRONMENTAL CATEGORY	DESCRIPTION
Other relevant issues	None identified.

2.8 INDICATIVE GROUND STABILITY HAZARDS

2.8.1 The following risk ratings have been applied to ground stability hazards;

- i.* Shrink-swell: moderate;
- ii.* Landslides: very low;
- iii.* Soluble Rocks: low;
- iv.* Compressible ground: moderate;
- v.* Collapsible rocks: low;
- vi.* Running sand – low.

2.9 RADON GAS

2.9.1 The site lies within a Radon Affected Area as defined by the former Health Protection Agency, now Public Health England (between 5% and 10% of houses are above the action level). Guidance issued by the Buildings Research Establishment (BRE-211) indicates that basic protection measures are necessary.

2.10 AIR QUALITY

2.10.1 The site does not lie within a designated Air Quality Management Area (AQMA) for Arun District Council.

2.11 ECOLOGY

2.11.1 Information from environmental and ecological datasets was obtained from a review of the MAGIC (Multi-Agency Geographic Information for the Countryside) website and the Groundsure report. The data assessed indicates that there are no Sites of Special Scientific Interest (SSSI), National Nature Reserves, Special Areas of Conservation, Special Protection Areas, Local Nature Reserves or Ramsar sites within 1km of the site. South Downs National Park lies immediately to the east.

2.12 PREVIOUS INVESTIGATIONS

2.12.1 No known previous investigation data exists for the site.

2.13 PRELIMINARY CONCEPTUAL SITE MODEL AND RISK ASSESSMENT

2.13.1 From the Phase 1 assessment a preliminary site conceptual model and risk assessment have been produced using the framework established in Part IIA of the



Environmental Protection Act 1990 and detailed in Contaminated Land Report CLR11 - *Model Procedures for the Management of Land Contamination*.

2.13.2 Risk from contamination has been assessed using the source-pathway-receptor and pollutant linkage methodology, whereby a risk can only exist if all elements of: source, pathway and receptor, are present.

2.13.2.1 Onsite sources:

- i.* Made Ground and garages (car maintenance) associated with the Motorsports Race Track;
- ii.* Farm buildings (no longer present);
- iii.* Greenhouses associated with plant nursery (heating oil, horticultural chemicals).

2.13.2.2 Offsite sources:

- i.* Ground workings;
- ii.* Filled Gravel Pits;
- iii.* Unspecified Tanks;
- iv.* Builder's Yard.

2.13.3 Potential Pathways

2.13.3.1 Receptors may be potentially at risk from the identified sources of contamination via the following pathways:

- i.* Ingestion and inhalation of soil and soil-derived dust;
- ii.* Consumption of home-grown produce;
- iii.* Migration of hazardous gases into buildings;
- iv.* Migration of vapours into buildings;
- v.* Vertical and lateral migration of mobile contaminants.

2.13.4 Potential Receptors

2.13.4.1 The following potential receptors have been identified:

- i.* Current and future site users;
- ii.* Construction workers;
- iii.* Controlled waters - groundwater (Secondary Aquifers) and surface waters;



- iv. Future planting schemes;
- v. Polymeric services;
- vi. Adjacent land.

2.13.5 Pollutant Linkages and Risk Ratings

2.13.6 From the Phase 1 assessment a preliminary site conceptual model has been produced as Table 4 which identifies the potential pollutant linkages. These have been used to inform the Phase 2 intrusive investigation presented in the subsequent sections.

Table 4: Preliminary Conceptual Model

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	PATHWAYS	RECEPTORS	
Heavy metals and hydrocarbons (made ground / motorsports garage)	Contact with contaminated soil	Human health (current users)	Low to Moderate risk identified Potential for made ground associated with the area of the motorsports garage, farm buildings and greenhouses which can contain elevated metals and hydrocarbons.
	Ingestion and inhalation of contaminated soil and dust	Human health (current users)	
Heavy metals and hydrocarbons (made ground / garage)	Contact with contaminated soil	Human health (future residents and construction workers)	However contact with underlying ground is likely to be largely precluded by cover of hardstanding for current users. This exposure potential would increase in the future development.
	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	
Asbestos (infilled ground / ponds)	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	Moderate risk identified Potential for made ground to contain asbestos.
Contamination (all forms)	Vertical migration to aquifer	Controlled waters	Low to moderate risk identified Potential for contamination associated with race track to affect the underlying shallow aquifer (where present), although solid geology on northern section of site comprises unproductive strata of London Clay Formation.
Contamination (all forms)	Horizontal migration to surface water	Controlled waters	Moderate risk identified Potential for contamination to affect the watercourse on site, although this is located some distance from the potential source on motorsports track.
Hydrocarbons	Direct contact	Plastic water pipes	Moderate risk identified Cannot rule out presence of localised hydrocarbon contamination at this stage.
Hazardous Gas/Vapours In soil	Ingress into buildings and voids	Human health (future residents and construction workers)	Moderate risk identified Potential for made ground /infilled ponds which could act as source of hazardous gas. Cannot rule out fuel spillages as source of vapours. Site is in a radon affected area.



POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	PATHWAYS	RECEPTORS	
<p>Surrounding land uses include:</p> <p>Ground workings, Gravel pits.</p> <p>Various contaminants including heavy metals, PAH, TPH and ground gases.</p>	<p>Lateral migration to the site</p>	<p>Human Health and Controlled Waters</p>	<p>Potentially Active – Further Investigation Required</p>

SECTION 3 SITE INVESTIGATION RATIONALE

3.1 INTRODUCTION

- 3.1.1 A site investigation rationale has been devised in accordance with the findings of the Phase 1 investigation and the resultant preliminary conceptual site model and risk assessment. Priority contaminant sources were identified as made ground and garages associated with the onsite Motorsports Centre.
- 3.1.2 Access was not available to the south-western corner where greenhouses were previously situated, and further investigation will be required in due course.
- 3.1.3 Intrusive sampling locations were chosen on the basis of providing broad spatial coverage of the site. Specific features of potential contaminative concern were identified within the Motorsports Centre. As such, the ground investigation was designed for a detailed coverage within the Motorsports Centre. At the time of the site investigation it was not possible to complete trial pits within the car parking area as the roadways were being actively used by the Motorsports Centre.

3.2 SITE INVESTIGATION METHODS

- 3.2.1 An intrusive investigation was carried out by Idom Merebrook Ltd from 2 to 4 September and 7 to 8 September 2015, which comprised the following scope of work:
- i. 15 shallow windowless sample probe holes (MWS101 to MWS115) to a depth of 3.00 m bgl;
 - ii. 17 machine dug trial holes (MTP101 to MTP117) to a maximum depth of 3.30 m bgl; and,
 - iii. Two soakaway tests (MSA101 to MSA102) at depths between 1.90 m bgl and 2.10 m bgl.
- 3.2.2 In addition, five cable percussion boreholes were advanced to 10 m bgl each from 13 to 14 September 2017 (MBH101 to MBH105).



- 3.2.3 Exploratory hole locations are indicated on drawing 19495-304-004 in Appendix 1. Logging of exploratory holes was undertaken by a Merebrook Officer. Exploratory hole logs are contained in Appendix 3.
- 3.2.4 Light cable percussion equipment was used to advance boreholes MBH101 to MBH105. Standard Penetration Tests (SPTs) were performed at regular intervals. The tests involved driving a steel cone tipped series of rods into the ground over a distance of 450 mm using the repeated blows of a 63.5 kg weight allowed to free fall over a distance of 760 mm. The total number of blows required for the final 300 mm penetration (the 'N' value) is recorded on the borehole logs.
- 3.2.5 Monitoring pipes were installed in all five borehole locations for groundwater level monitoring. The results of this water level monitoring will be reported under separate cover as the monitoring will be undertaken throughout Winter 2017-2018.
- 3.2.6 A tracked windowless sampling rig was used to advance MWS101 to MWS115. This comprised a rig-mounted drop hammer to drive a hollow steel barrel into the ground. The barrel is recovered along with a removable plastic sleeve which lines the barrel and holds a core of soil which is retracted for logging and sampling. SPTs were performed at approximate 1 m intervals in all windowless sample holes.
- 3.2.7 Seven monitoring installations were installed in the windowless sample holes to a maximum depth of 3.00 m bgl for dual purpose gas and groundwater monitoring (MWS102, MWS103, MWS104, MWS106, MWS108, MWS109 and MWS113).
- 3.2.8 Representative soil samples were taken from various depths and strata to assess the contaminative status of the site. Soil samples were submitted to an MCERTS/UKAS accredited laboratory for chemical analysis of a broad suite of potential contaminants. The results are provided in Appendix 4.
- 3.2.9 A programme of geotechnical laboratory testing was performed on selected soil samples obtained from the exploratory holes, comprising classification tests. Chemical testing was also undertaken to assess the aggressiveness of the ground with respect to buried concrete. The results are provided in Appendix 5.

SECTION 4 GROUND CONDITIONS

4.1 SURFACE GROUND CONDITIONS

- 4.1.1 The intrusive locations were positioned to provide sufficient site coverage with specific locations altered to target areas of potential concern, which included the Motorsports Centre. As such, the ground investigation was designed for a detailed coverage within the Motorsports Centre (MTP112 – MTP113 and MWS107 – MWS114). The remainder of the intrusive locations were utilised to gain coverage across the agricultural land and the remainder of the site.
- 4.1.2 The surface ground conditions encountered were consistent in composition and comprised grazing and agricultural field space covered by grass. A crop cover was



noted in the location of MTP106 to MTP108. The Motorsports Centre comprised a mixed asphalt and concrete cover. Bunds were noted in the Motorsports Centre, which were located around the race track and to the north of the race track. These levels were raised to allow for a viewing platform and comprised a surface cover of grass, with an access route along the boundary of the race track.

4.2 SUB-SURFACE GROUND CONDITIONS

- 4.2.1 The ground conditions were found to be generally consistent with the published geology for the site and included cohesive Head Deposits overlying London Clay.
- 4.2.2 A summary of the ground conditions encountered is presented in Table 5, whilst a more detailed assessment of the strata is contained in the following sections of the report.

Table 5: Summary of Sub-surface Ground Conditions

STRATA	DEPTH TO TOP RANGE (m bgl)	THICKNESS RANGE (m)
Topsoil	0.0	0.15 – 0.80
Made Ground	0.0 – 0.15	0.40 – > 3.30
Head Deposits	0.0 – 0.80	0.20 – > 3.00
London Clay Formation	0.30 – 3.40	> 9.00

4.2.3 Made Ground

- 4.2.3.1 Topsoil was encountered in the majority of the exploratory holes from ground level to depths of between 0.15 and 0.8 m bgl. The stratum was fairly consistent in composition, comprising friable brown and dark brown clay with rootlets and variable amounts of flint gravel.
- 4.2.3.2 Made Ground was encountered in a small number of exploratory hole locations. Thicknesses generally ranged from 0.4 to 1.4 m, whilst greater thicknesses were revealed in windowless sample hole MWS111 (2.2 m) and trial pit MTP113 (> 3.3 m). The stratum was relatively consistent in composition comprising soft dark brown, orange brown or grey brown clay with variable amounts of flint and brick gravel.
- 4.2.3.3 Adjacent to the race track windowless sample holes MWS107 and MWS115 encountered concrete obstructions at depths of 1.1 and 1.0 m bgl, respectively.
- 4.2.3.4 In the northern area SPTs performed within granular made ground recorded 'N' values of 1 and 11, indicating the presence of very loose and medium dense ground conditions.
- 4.2.3.5 Visual and olfactory evidence of contamination was noted in trial pits MTP112 and MTP113. In MTP112 black gravel with a slight hydrocarbon odour was noted



between ground level and 1.0 m bgl, whilst in MTP113 black clay with a slight hydrocarbon odour was present between 1.5 and 3.3 m bgl.

- 4.2.3.6 Perched groundwater was not observed within the made ground in any exploratory hole locations, however, wet gravel was noted within the made ground present in MWS109.

4.2.4 Head Deposits

- 4.2.4.1 Head Deposits were encountered within the majority of exploratory holes with thicknesses ranging from 0.2 to > 3.0 m. The Head was typically comprised of orange brown, orange mottled grey or light brown sandy clay with variable amounts of flint gravel and cobbles. Locally, limited thicknesses of clayey gravelly sand were revealed, whilst clayey sandy flint gravel was encountered from 0.8 m depth in trial pits MTP107 and MTP108.

- 4.2.4.2 Atterberg limit tests carried out on a sample of clay indicates that the soil can be classified as clay of intermediate plasticity. The plasticity index of the soil was found to be 23 %, and in accordance with NHBC guidelines, this soil is of medium volume change potential. A moisture content of 8.7 was also determined for this sample.

- 4.2.4.3 SPTs performed in the windowless sample holes recorded 'N' values generally ranging from 4 to 16, indicating the presence of soft and firm (low and medium strength) ground conditions. However, locally, SPT 'N' values of between 25 and 31 were obtained, suggesting stiff high strength ground conditions.

- 4.2.4.4 SPTs performed within the boreholes recorded 'N' values in the range 4 to 11. These results are indicative of soft and firm (low and medium strength) ground conditions.

- 4.2.4.5 No visual or olfactory evidence of contamination was noted within the Head Deposits.

- 4.2.4.6 Groundwater was observed within Head Deposits encountered in two locations (MTP107 and MSA102) at depths of 2.0 and 1.9 m bgl, respectively. Wet arisings were noted at depths of between 2.25 and 2.4 m bgl in MWS116.

4.2.5 London Clay

- 4.2.5.1 The London Clay Formation was encountered below Head Deposits in the majority of exploratory holes. This stratum was revealed at depths ranging from 0.3 to 2.6 m bgl and attained a maximum proven thickness of 2.8 m. The stratum was relatively consistent in composition typically comprising grey or grey mottled orange sandy clay.

- 4.2.5.2 Atterberg limit tests carried out on five samples of clay indicate that the soil can be classified as clay of high to very high plasticity. The plasticity index of the soil was found to range from 34 to 51 %, and in accordance with NHBC guidelines, this soil is of medium and high volume change potential. Moisture contents of between 27 and 34 % were also determined for these samples.



- 4.2.5.3 SPTs undertaken within the London Clay encountered in the windowless sample holes revealed 'N' values in the range 4 to 17, indicating the presence of soft to stiff (low to high strength) ground conditions.
- 4.2.5.4 SPTs carried out in the boreholes revealed 'N' values ranging from 8 to 34, indicating the presence of firm and stiff (medium and high strength) ground conditions.
- 4.2.5.5 No visual or olfactory evidence of contamination was noted within the London Clay.
- 4.2.5.6 No groundwater was encountered in the London Clay.

SECTION 5 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

5.1 FOUNDATIONS

- 5.1.1 The development will include approximately 525 dwellings with 3 hectares of employment land, public open space, play areas, associated infrastructure and landscaping.
- 5.1.2 The site investigation revealed ground conditions generally consisting of topsoil underlain by predominantly cohesive superficial Head Deposits (0.2 - > 3.0 m thick) and London Clay (> 2.8 m thick). Locally, thicknesses of made ground between 0.4 and 1.4 m were reported, whilst thicker made ground was revealed in two locations (2.2 and > 3.3 m thick). SPTs performed within the Head Deposits recorded soft and firm (low and medium strength) ground conditions, whilst the London Clay was found to range from soft to stiff (low to high strength) in nature.
- 5.1.3 Based on the ground conditions revealed, it is envisaged that traditional strip or trench footings will be feasible across the majority of this area. Strip footings founded at a minimum depth of 1.0 m within firm / stiff (medium / high strength) clays are considered acceptable in the northern and southern portions, whilst trench footings at a minimum depth of 2.0 m (locally 2.5 m) will be required in the central portion and the south-eastern corner. Footing depths could possibly be reduced locally if firm / stiff is encountered at shallow depth.
- 5.1.4 In accordance with NHBC guidelines footings may need to be deepened where footprints are located within the zone of influence of existing or proposed trees. Existing trees are present along some field boundaries, whilst an area of woodland exists adjacent to the majority of the eastern boundary.
- 5.1.5 Allowable bearing pressures of 100 kN/m² will be achievable for footings up to 1 m wide founded within firm / stiff (medium / high strength) clay.
- 5.1.6 Vertically persistent soft (low strength) clays have been encountered in a relatively small area situated in the central portion of the site and on the western boundary. It is considered unlikely that strip / trench footings will be feasible in this area, therefore it is recommended that an alternative foundation solution, such as ground improvement (vibro stone columns or concrete columns) or piles, is adopted.



- 5.1.7 Stone columns could be installed along the lines of all load bearing walls and keyed into underlying competent clay to depths of around 5 - 6 m in order to provide a more suitable founding stratum. This would enable strip footings to be constructed on the improved ground at depths of around 1 m. Allowable bearing pressures of around 100 kN/m² are likely to be achievable for footings up to 1 m wide. Light mesh reinforcement will need to be incorporated into all footings constructed on vibro treated ground. In order to assess the suitability of using ground improvement a specialist contractor should ideally be invited to attend site to view the ground conditions for themselves.
- 5.1.8 Following consultation with a specialist contractor, if stone columns are not deemed to be feasible then consideration could be given to installing vibro concrete columns (VCC).
- 5.1.9 Alternatively, if ground improvement is not considered suitable then a piled foundation solution would need to be adopted.
- 5.1.10 It is envisaged that either driven or bored / Continuous Flight Auger (CFA) piles could be adopted at the site. Driven piles could possibly be utilised as they have the advantage that no arisings are generated, however, the effects of noise / vibrations are likely to be an issue given the proximity of the existing residential development.
- 5.1.11 The advantage of using bored / CFA piles is the low noise / vibration of the system, however, arisings are generated by bored / CFA piles. Piles would need to be taken through the made ground and / or weak natural soils to found within an underlying competent stratum. Pile lengths will depend on the thickness of made ground and / or weak natural soils, but a minimum length of 8 m is likely to be required.
- 5.1.12 It is recommended that the advice of a specialist contractor be sought in order to determine the most appropriate / cost effective system and to advise on pile diameters, depths and safe working capacity.
- 5.1.13 A preliminary foundation zoning plan, drawing 19495-311-003 is provided in Appendix 1.

5.2 EXCAVATIONS AND GROUNDWATER

- 5.2.1 Based on the ground conditions observed at the site, any shallow excavations have the potential to become unstable in the short term, therefore, if man-entry is required, excavations should be supported by shoring or otherwise battered back to a safe angle to protect the workforce from possible collapse.
- 5.2.2 Obstructions have been encountered in a couple of locations within the motorsports centre. These are possible representative of former building foundations or hardstanding and should ideally be removed and the resulting excavations backfilled with suitable granular fill.



- 5.2.3 Groundwater was generally not encountered during the intrusive investigation. In view of this, it is considered unlikely that groundwater ingress will occur in shallow excavations, however, provision for dewatering during the construction period should still be considered.

5.3 FLOOR SLABS

- 5.3.1 In view of the presence of cohesive soils at shallow depth across the vast majority of the site, it is recommended that suspended floor slabs are adopted for the proposed development. However, it is noted that basic radon protection is required and the recommendations in BR414 should be followed in any floor design.

5.4 BURIED CONCRETE

- 5.4.1 Recommendations given in BRE Special Digest 1:2005 "*Concrete in aggressive ground*" have been followed in order to give recommendations with respect to buried concrete.

- 5.4.2 Water soluble sulphate analysis was carried out on 39 soil samples obtained from depths of between 0.1 and 3.3 m bgl with soil pH determination also carried out on these samples. Water soluble sulphate contents ranged between 0.0095 and 1.8 g/l. In accordance with BRE guidelines the characteristic value is calculated by determining the mean of the highest 20 % of results. In this case the characteristic value is 0.74 g/l. On this basis the Design Sulphate Class is DS-2.

- 5.4.3 The pH values in the soil samples varied between 6.4 and 9.4. The mean of the lowest 20 % of values is 6.7 which represents the characteristic value. Mobile groundwater conditions have been assumed and on this basis the Aggressive Chemical Environment for Concrete (ACEC) class for the site is AC-2.

5.5 ROADS AND PAVED AREAS

- 5.5.1 For preliminary design purposes it is recommended that a California Bearing Ratio (CBR) value of < 2% is assumed for the shallow natural soils and made ground. Once the positions of proposed roads and areas of hardstanding have been finalised, *in situ* testing could be undertaken to determine an appropriate design CBR value.

5.6 SOAKAWAYS

- 5.6.1 Soakage tests were carried out in two machine dug trial pits to a maximum depth of 2.10 m bgl using a JCB 3CX. The sides and bases of the pits were squared off prior to filling with water from a 3000 gallon water tanker. Soakage tests were carried out over a maximum period of twenty-four hours.
- 5.6.2 The trial pit soakage tests were performed as far as possible in accordance with BRE document 365. The accompanying data sheets in Appendix 9 show that the water level fell by a maximum of 910 mm in MSA102, whilst in MSA101 the water level fell by 110 mm over a period of four hours.



- 5.6.3 The BRE methodology for calculation of soil infiltration rate requires measurement of the volume outflowing from between 75% and 25% of the effective depth of the trial pit (height of water in the pit), *i.e.* three-quarters of the water should soak away. If due to low levels of infiltration the water level does not fall from between 75% to 25% of the total water height, it may be possible to extrapolate from a curve derived from the plots of the actual depth of water against time elapsed. The test in MSA101 did not achieve 75 % effective depth, whilst in MSA102 the test achieved between 75 and 50 % effective depth. Due to the limited data obtained, extrapolation was not possible for these tests and based on this, infiltration rates are likely to be in the order of 10^{-7} or 10^{-8} m/s.
- 5.6.4 The trial pit soakage tests demonstrate that the site has low permeability and as such soakaways could not be installed within other areas.

SECTION 6 ENVIRONMENTAL ASSESSMENT

6.1 SOIL QUALITY

- 6.1.1 A total of 36 soil samples were submitted to the laboratory for chemical analysis, including eight samples from natural ground and 28 samples from made ground. The laboratory chemical analysis certificates are contained in Appendix 4. The results of the analysis are summarised in Table 6.
- 6.1.2 An initial screening exercise has been undertaken whereby contaminant concentrations recorded in soils have been assessed against *Suitable for Use Levels* (S4ULs) published in 2015 by LQM/CIEH¹. These precautionary screening levels are designed to be representative of minimal risk to human health in a number of land use scenarios. In this report S4ULs have been selected for a residential land use where the possibility of consumption of homegrown produce exists and assuming a soil organic matter of 2.5 %. For lead the DEFRA Category 4 Screening Level² has been used as this is based on updated toxicological data and a low risk to human health.
- 6.1.3 An additional set of phytotoxin screening levels have been adopted from 'The Code of Agricultural Practice for the Protection of Soil' Ministry of Agriculture, Fisheries and Food (MAFF), 1993, which are protective of healthy plant growth.

Table 6: Summary of Soils Chemical Analysis Results

CONTAMINANT	UNITS	MAX	MEAN	No of Tests	SCREENING LEVEL (SL)	No > SL*
HUMAN HEALTH RISK ASSESSMENT						
Asbestos in soil	-	Detected	n/a	7	Detected	1

¹ Nathanail, C. P., McCaffrey, C., Gillett, A. G., Ogden, R. C. and Nathanail, J. F. 2015. *The LQM/CIEH S4ULs for Human Health Risk Assessment*. Land Quality Press, Nottingham. Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3100. All rights reserved. Including August 2015 nickel update.

² SP1010 *Development of Category 4 Screening Levels Main Report* (Dec 2013) and SP1010 *Policy Companion Document* (Mar 2014).



CONTAMINANT	UNITS	MAX	MEAN	No of Tests	SCREENING LEVEL (SL)	No > SL*
HUMAN HEALTH RISK ASSESSMENT						
pH	-	6.4 - 9.4 (range)	7.64	33	5 – 9	2
Arsenic	mg.kg ⁻¹	19	9.78	33	37	0
Cadmium	mg.kg ⁻¹	<0.2	<0.2	33	11	0
Chromium (total)	mg.kg ⁻¹	49	29.88	33	910	0
Hexavalent Chromium	mg.kg ⁻¹	<4	<4	33	6	0
Lead	mg.kg ⁻¹	240	42.88	33	200	2
Mercury	mg.kg ⁻¹	<0.3	<0.3	33	40	0
Nickel	mg.kg ⁻¹	45	19.56	33	130	0
Selenium	mg.kg ⁻¹	4.4	1.48	33	250	0
TPH Aliphatic >EC ₅ - EC ₆	mg.kg ⁻¹	<0.1	<0.1	33	78	0
TPH Aliphatic >EC ₆ - EC ₈	mg.kg ⁻¹	<0.1	<0.1	33	230	0
TPH Aliphatic >EC ₈ - EC ₁₀	mg.kg ⁻¹	<0.1	<0.1	33	65	0
TPH Aliphatic >EC ₁₀ - EC ₁₂	mg.kg ⁻¹	<1	<1	33	330	0
TPH Aliphatic >EC ₁₂ - EC ₁₆	mg.kg ⁻¹	10	2.30	33	2400	0
TPH Aliphatic >EC ₁₆ - EC ₂₁	mg.kg ⁻¹	23	9.24	33	92000	0
TPH Aliphatic >EC ₂₁ - EC ₃₅	mg.kg ⁻¹	120	27.20	33	92000	0
TPH Aromatic >EC ₅ - EC ₇	mg.kg ⁻¹	<0.1	<0.1	33	140	0
TPH Aromatic >EC ₇ - EC ₈	mg.kg ⁻¹	<0.1	<0.1	33	290	0
TPH Aromatic >EC ₈ - EC ₁₀	mg.kg ⁻¹	<0.1	<0.1	33	83	0
TPH Aromatic >EC ₁₀ - EC ₁₂	mg.kg ⁻¹	5.4	1.18	33	180	0
TPH Aromatic >EC ₁₂ - EC ₁₆	mg.kg ⁻¹	250	10.23	33	330	0
TPH Aromatic >EC ₁₆ - EC ₂₁	mg.kg ⁻¹	1200	54.30	33	540	1
TPH Aromatic >EC ₂₁ - EC ₃₅	mg.kg ⁻¹	1300	103.76	33	1500	0
Benzene	mg.kg ⁻¹	<0.001	<0.001	33	0.17	0
Toluene	mg.kg ⁻¹	<0.001	<0.001	33	290	0
Ethylbenzene	mg.kg ⁻¹	<0.001	<0.001	33	110	0
Xylene	mg.kg ⁻¹	<0.001	<0.001	33	130	0
Acenaphthene	mg.kg ⁻¹	14	0.9	34	510	0
Acenaphthylene	mg.kg ⁻¹	2	0.21	34	420	0
Anthracene	mg.kg ⁻¹	33	2.2	34	5400	0
Benz(a)anthracene	mg.kg ⁻¹	73	4.34	34	11	2
Benzo(a)pyrene	mg.kg ⁻¹	69	3.51	34	2.7	3
Benzo(b)fluoranthene	mg.kg ⁻¹	79	4.06	34	3.3	3
Benzo(ghi)perylene	mg.kg ⁻¹	48	2.21	34	340	0
Benzo(k)fluoranthene	mg.kg ⁻¹	43	2.34	34	93	0
Chrysene	mg.kg ⁻¹	75	3.83	34	22	2
Dibenz(ah)anthracene	mg.kg ⁻¹	5.5	0.39	34	0.28	3
Fluoranthene	mg.kg ⁻¹	170	10.35	34	560	0
Fluorene	mg.kg ⁻¹	14	0.94	34	400	0
Indeno(123-cd)pyrene	mg.kg ⁻¹	41	1.95	34	36	1
Naphthalene	mg.kg ⁻¹	2.9	0.22	34	5.6	0



CONTAMINANT	UNITS	MAX	MEAN	No of Tests	SCREENING LEVEL (SL)	No > SL*
HUMAN HEALTH RISK ASSESSMENT						
Phenanthrene	mg.kg ⁻¹	120	7.23	34	220	0
Pyrene	mg.kg ⁻¹	140	8.43	34	1200	0
Phenol	mg.kg ⁻¹	<1	<1	35	200	0
PHYTOTOXICITY RISK ASSESSMENT						
	Units	Max	Mean	No of Test	Screening Level (SL)	No > SL
Copper	mg.kg ⁻¹	95	19.95	33	200	0
Nickel	mg.kg ⁻¹	45	19.56	33	110	0
Zinc	mg.kg ⁻¹	170	66.03	33	300	0

Notes: * Number of samples exceeding screening level

nd = not detected

6.1.4 Zootoxic Metals (harmful to human health)

6.1.4.1 Of the zootoxic metals tested during the site investigation, the majority of samples recorded concentrations below the respective screening levels. Two elevated concentrations of lead were detected within samples retrieved from MWS115 at 0.25 m bgl and 0.90 m bgl. The exceedances at this location are within the Motorsports site boundary and are within an area where the ground level has been raised for motorsport viewing purposes. The base of the made ground was not encountered in this location but it is in excess of 3.30 m bgl.

6.1.5 Phytotoxic Metals (harmful to plant health)

6.1.5.1 Phytotoxic metals were not recorded at concentrations in excess of the screening criteria.

6.1.6 Organic Contaminants

6.1.6.1 The majority of the samples retrieved from the site investigation recorded concentrations below the screening level for organic contaminants. However, there were exceedances of the assessment criteria for speciated PAHs in the samples retrieved from MWS107 (0.50 m bgl), MWS108 (0.60 m bgl), TP112 (0.50 m bgl) and TP113 (3.30 m bgl). MWS107 and MWS108 were located within soft landscaped areas of the motorsports race track.

6.1.6.2 TP112 was located within the motorsports site boundary within an area that has been built up for storage of cars. A noticeable hydrocarbon odour was detected within the made ground during the site investigation at this location. TP113 was located within the raised area around the race track, and a hydrocarbon odour was detected within the made ground during the site investigation. However, speciated petroleum hydrocarbons did not exceed their respective screening levels in either sample.

6.1.6.3 Speciated hydrocarbons in the aromatic C₁₆-C₂₁ band were recorded in excess of the respective screening level in one sample from MWS108 at 0.6 m bgl. No staining or odours were recorded in this location, although the exploratory hole record noted possible clinker.



6.1.6.4 No organochlorine, organophosphorus or organonitrogen pesticides were detected in the samples analysed.

6.1.7 Inorganic Contaminants

6.1.7.1 The majority of the samples analysed returned concentrations below the screening level for inorganic contaminants, however asbestos containing material (ACM) was detected in a single sample. The soil sample received for MWS107 at 0.90 m bgl was found to contain insulation lagging (chrysotile fibres). No visible asbestos was noted during the intrusive investigation.

6.1.8 Summary

6.1.8.1 In summary, the majority of samples recorded concentrations below the screening levels. All exceedances were limited to the made ground within the site boundary of the motorsports centre.

6.1.8.2 No samples recovered from natural ground exceeded the relevant screening levels.

6.2 GROUNDWATER

6.2.1 Groundwater level monitoring and sampling was undertaken in the windowless sample boreholes on one occasion in 2015. Resting waters levels were recorded between 0.23 – 2.66 m bgl.

6.2.2 The results of water level monitoring undertaken on the cable percussion boreholes will be reported under separate cover as the monitoring will be undertaken throughout Winter 2017-2018.

6.2.3 Samples from MWS104, MWS108 and MWS109 were submitted to the laboratory for analysis of a broad contamination suite. Screening levels for groundwater have been derived from the Maximum Allowable Concentrations (MAC) in the Water Supply (Water Quality) Regulations 2010 where prescribed, or for those determinands not included, the 1989 regulations. The laboratory chemical analysis certificate is contained in Appendix 6 and groundwater level data is contained in Appendix 7. A summary of groundwater contaminant concentrations is contained in Table 7.

Table 7: Summary of Groundwater Chemical Analysis Results

CONTAMINANT	UNITS	MAX	MEAN	SCREEN LEVEL (SL)	>SL*
pH	-	7.0 – 7.7	7.3	6.5**	0
Arsenic	µg.l ⁻¹	19.1	9.85	10	1
Cadmium	µg.l ⁻¹	0.03	0.02	5	0
Chromium (total)	µg.l ⁻¹	0.8	0.47	50	0
Copper	µg.l ⁻¹	3.6	3.17	2000	0
Lead	µg.l ⁻¹	0.9	0.6	10	0



CONTAMINANT	UNITS	MAX	MEAN	SCREEN LEVEL (SL)	>SL*
Mercury	µg.l ⁻¹	0.49	0.27	1	0
Nickel	µg.l ⁻¹	13	9.7	20	0
Selenium	µg.l ⁻¹	7.5	5.0	10	0
Zinc	µg.l ⁻¹	5	3.03	5000	0
Cyanide	µg.l ⁻¹	<10	<10	50	0
Sulphate	mg.l ⁻¹	328	263	250	2
TPH	µg.l ⁻¹	1300	440	10	1
BTEX	µg.l ⁻¹	<1	<1	-	-
PAH (total)	µg.l ⁻¹	119	39.8	-	-
PAH****	µg.l ⁻¹	25.3	8.44	0.1	1
Benzo(a)pyrene	µg.l ⁻¹	8.9	2.97	0.01	1
Naphthalene	µg.l ⁻¹	7.3	2.44	-	-
Phenols	µg.l ⁻¹	<10	<10	0.5	***

Notes: * Samples exceeding screen level

** Minimum value applies (i.e. most acid)

*** Screening level exceeded by laboratory limit of detection but not detected above laboratory limit of detection

**** sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene & indeno(1,2,3-cd)pyrene

6.2.4 With the exception of sulphate, which was detected above the screening level in both MWS108 and MWS109, all other contaminant exceedances were noted in the sample from MWS109. The water sample is considered to represent perched water within the made ground (described as “*Wet dark brown/black crushed tarmac small medium and large gravels with occasional fine to coarse angular and subangular flint gravels*”) and is not representative of wider groundwater quality. The absence of arsenic and organic contamination in the sample from adjacent borehole MWS108 indicates that this perched water body is not in hydraulic continuity with groundwater within the superficial deposits or solid geology.

6.3 HAZARDOUS GAS

6.3.1 Gas monitoring has been undertaken on three occasions – 10, 17 September and 2 October 2015. Levels of methane, carbon dioxide and oxygen were recorded in each standpipe, together with associated parameters including borehole flow and ambient air pressure. The results of these gas monitoring rounds are contained in Appendix 7.

6.3.2 The monitoring rounds were undertaken at barometric pressures ranging from 981 to 1027 mb. Positive borehole gas flow was recorded in several locations, to a maximum of 3.7 l.hr⁻¹ in MWS108, however the response zone in this location was submerged and the result is not considered to be representative. Elsewhere, a maximum flow of 0.7 l.hr⁻¹ was recorded in MWS113. Over the three monitoring rounds methane (CH₄) was not detected, carbon dioxide (CO₂) was detected to a maximum of 4.6 % by volume (% v/v) in MWS109 (although the response zone was submerged), with a corresponding depleted oxygen concentration of 8.3 % v/v.



6.4 WASTE CLASSIFICATION, OFF-SITE DISPOSAL OR RE-USE

6.4.1 Waste Considerations

6.4.2 Based on the contaminant concentrations recorded, site soils can generally be expected to be classified as non-hazardous should they require disposal. A single sample submitted for WAC analysis (MWS109 at 0.50 m bgl) indicates that the *majority* of made ground may be disposed as inert, subject to confirmation from the landfill operator as the leachable fluoride concentration slightly exceeds inert limits.

6.4.3 However, where asbestos fibres were encountered within MWS107 at 0.90m bgl this material would likely be unsuitable for disposal at inert landfill. Asbestos fibre quantification has not been undertaken. Where disposal is necessary, asbestos quantification should be carried out to determine the waste classification of this material – materials would be classed as hazardous where the asbestos content by mass exceeds 0.1%. Where any visible fragments of asbestos are noted, materials would be classified as mixed waste and potentially hazardous.

6.4.4 The hydrocarbon concentrations recorded in made ground within MWS108 at 0.6 m bgl and TP112 at 0.5 m bgl would result in the materials being classified as hazardous waste.

6.4.5 Natural as-dug soils could be classed as inert waste without the requirement for WAC testing.

6.4.6 Materials, including waste soils which are not to be retained on site, should be removed and disposed of in accordance with all relevant statutes including the *Environmental Protection Act 1990* as amended, *The Controlled Waste Regulations 2012* as amended, *The Waste Regulations 2011* as amended, *The Hazardous Waste Regulations 2005* as amended, *The Waste Management Regulations 2006*, *The Environmental Permitting Regulations 2010* as amended and *The Hazardous Waste (Miscellaneous Amendments) Regulations 2015*.

6.4.7 It is a requirement of these regulations that waste sent to landfill should have been subject to measures to reduce the amount of waste, reduce harmful or hazardous properties and facilitate recycling. These requirements may be satisfied by measures such as segregation and screening of wastes to recover suitable fill and material for crushing, segregation of inert materials and putrescible wastes.

6.4.8 Re-use Considerations

6.4.8.1 As a sustainable alternative to off-site disposal, it may be possible to re-use site-won soils provided the following criteria are met:

- i.* Use of the material will not create an unacceptable risk of pollution to the environment or harm to human health;
- ii.* The material must be chemically and geotechnically suitable without further treatment;



- iii. There must be certainty of use within the scheme;
- iv. Material should only be used in the quantity necessary for that use.

6.4.8.2 Provided these criteria are met, the re-use of site-won materials is unlikely to be deemed a waste activity. Production of a *Materials Management Plan* under the industry *CL:AIRE Code of Practice on the Definition of Waste* represents a robust method of demonstrating that proposed re-use of materials meets the criteria.

SECTION 7 RISK ASSESSMENT

- 7.1 The potential sources of contamination at the site and the implications with respect to development have been interpreted in accordance with the current government guidance on source-pathway-receptor risk assessment.
- 7.2 The investigations demonstrate that the former uses of the site have resulted in elevated contaminant concentrations limited solely to the made ground within the motorsports centre area, comprising asbestos, lead, TPH and PAHs. These materials are considered for their potential to act as sources for a number of pollutant linkages.
- 7.3 The potential impacts of contamination sources have been considered with respect to the following receptors:
 - i. The general public and present site users,
 - ii. Residents of future development,
 - iii. Groundwater,
 - iv. Surface water,
 - v. Construction workers,
 - vi. Adjacent land, and
 - vii. Infrastructure.
- 7.4 In each case the existence of a pollutant linkage requires a pathway by which the receptor could be exposed to the source. A qualitative assessment of risk is thus considered in the first instance with respect to the site in its current condition and is summarised in the sections below.
- 7.5 **The general public and present site users**
 - 7.5.1 The site assessment indicates the presence of elevated concentrations of lead in MWS115 (0.25 m and 0.9 m), speciated PAHs at MWS107 (0.50 m), MWS108 (0.6 m), TP112 (0.50 m) and TP113 (3.30 m), and TPH (aromatic C₁₆-C₂₁) in MW108 (0.6 m). These are all within the area of the Motorsports centre. TP112 is covered by asphalt hardstanding/compacted fill material which effectively breaks any



potential contamination pathway to the current site users. The remainder of the exceeding values are located within areas of grass, however current site users are unlikely to access these areas regularly or disturb the ground and the risk is therefore considered to be low.

- 7.5.2 Asbestos containing material (ACM) was identified in a single sample retrieved during the site investigation. The sample was recovered from MWS107 (0.90 m) where a significant thickness of made ground was identified (>1.1 m). This area is located within the motorsports race track and is unlikely to pose a risk unless the area is excavated and material at this depth becomes exposed. As such, the risk from the site for current site users is considered to be low.

7.6 Residents of future development

7.6.1 Soil contamination (chemical)

- 7.6.1.1 Soil contamination has been identified within the area of the motorsports centre. The preliminary development plan has indicated that this area is proposed for residential development. These exceedances are therefore considered to represent 'outliers', relating to localised pockets of contamination and are considered separately in order to assess the risks to human health. The elevated concentrations of these contaminants represent a low to moderate risk to future residents via ingestion and inhalation of soil and soil-derived dust, and via dermal contact.

7.6.2 Asbestos

- 7.6.2.1 Asbestos-containing insulation lagging fragments were encountered at MWS107 within the motorsports race track. However, no asbestos fibres were detected within close proximity to MWS107. It is therefore considered that the asbestos encountered in the made ground in this area was an isolated occurrence and, being identified during laboratory screening is anticipated to be present at a low concentration by mass. This potential for exposure is therefore considered to be low. However, as the consequence of exposure can be significant a Low-to-Moderate risk level has been assigned.

7.6.3 Hazardous Soil Gas/Vapours (including hydrocarbon vapours/radon)

- 7.6.3.1 CIRIA 665 guidance has been followed to assess the recorded soil gas concentrations and borehole flow conditions. Calculations are presented in Appendix 8 which suggest that on the basis of the three monitoring rounds undertaken the site would be classified as 'green' and 'Characteristic Situation 1'. However, the site lies within a Radon Affected Area as defined by the Health Protection Agency (between 5 % and 10 % of houses are above the action level). Guidance issued by the Buildings Research Establishment (BRE-211) indicates that basic protection measures are necessary.



7.7 Controlled waters

7.7.1 Limited contamination has been identified in soils, localised to made ground within the area of the Motorsports centre. It is noted that this is a considerable distance from the watercourse along Water Lane and the risk to surface waters is considered to be low.

7.7.2 Groundwater monitoring indicates that perched water in MWS109 has been contaminated by hydrocarbons (TPH and PAH) and arsenic, considered to be attributed to the made ground in this location which contains frequent tarmac fragments. The made ground in this location extended to 1.4 m bgl and was underlain by grey and orange sandy clay which is considered to prevent vertical migration. Groundwater samples recovered nearby did not record elevated concentrations and no risk to wider groundwater quality is therefore considered to exist.

7.8 Construction workers

7.8.1 Potentially, construction workers are initially at the greatest risk from exposure to hazardous contamination due to excavation works and during the handling of materials including imported soils. Providing that dust levels are kept within statutory limits and appropriate health and safety procedures are adhered to during the construction phase, the levels of chemical contamination recorded to date are not considered to present an acute risk to human health.

7.8.2 Potentially, further asbestos contamination may be identified during the demolition and redevelopment of the site. There is a scope for fibres to be created from the disturbance of ACM in the vicinity of MWS107 and therefore the risk is low to moderate.

7.8.3 Any removal of suspected ACM should be undertaken by specially trained contractors and specific mitigation measures will be necessary for those undertaking any potential clearance of suspected ACM.

7.9 Adjacent land

7.9.1 No elevated concentrations were detected in the samples retrieved from both the trial pits and windowless sample holes in the surrounding field space adjacent to the motorsports centre indicating that potential on-site contaminants have not migrated to the adjacent land or off site residential receptors. No elevated concentrations were detected in the underlying natural strata indicating that the contaminants have not leached to the underlying natural strata.

7.9.2 The risk to / from the adjacent land is therefore considered very low.

7.10 Infrastructure

7.10.1 No exceedances of phytotoxic screening levels were recorded and no risk to plant growth has been identified. However made ground surrounding the Motorsports



Centre would be cosmetically unsuitable for retention in the upper profile of gardens and soft landscaped areas.

7.10.2 Limited contamination with the potential to permeate polymeric services has been identified by this investigation in the vicinity of the Motorsports Centre, however it is recommended that the utility provider is consulted with respect to their requirements for water supply pipes.

7.10.3 Utility companies apply strict guideline levels on use of polymeric pipes and may consider all made ground unsuitable for typical plastic pipe materials to be used.

SECTION 8 UPDATED CONCEPTUAL MODEL

8.1 Following completion of phases 1 and 2 of the investigation and a qualitative risk assessment, the conceptual model for the site, with relation to pollutant linkages, has been updated. The revised model is presented in Table 8 below.

Table 8: Revised Conceptual Model

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	PATHWAYS	RECEPTORS	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (current users)	Low risk identified Limited contamination recorded, associated with made ground in area of Motorsports Centre. Contact with made ground is limited based on site activities and risks to current site users is considered to be low.
	Ingestion and inhalation of contaminated soil and dust	Human health (current users)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (future residents and construction workers)	Low to Moderate risk identified Localised lead, TPH and PAH contamination identified within made ground around the Motorsports Centre. Risk to future site users can be mitigated by use of clean cover systems which break contact with underlying made ground.
	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	
Asbestos (made ground)	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	Low to Moderate risk No asbestos containing materials noted during site investigation. Of the samples analysed, only one (MWS107) contained asbestos as insulation lagging. Risks are low but rising to moderate in the vicinity of MWS107 with an increased risk of fibre release should the materials be disturbed.
Contamination (all forms)	Vertical migration to aquifer	Controlled waters	Low risk identified Whilst elevated arsenic, TPH and PAH were identified in the sample from MWS109, this is considered to represent perched water in made ground and not in continuity with, or affecting the quality of, the wider groundwater.



POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	PATHWAYS	RECEPTORS	
Contamination (all forms)	Horizontal migration to surface water	Controlled waters	Low risk identified Significant distance to watercourse along Water Lane from any identified contamination.
Hydrocarbons	Direct contact	Plastic water pipes	Moderate risk identified Hydrocarbon contamination identified in the vicinity of the Motorsports Centre and liaison will be required with the utility company regarding the use of upgraded pipes.
Hazardous Gas/Vapours In soil	Ingress into buildings and voids	Human health (future residents and construction workers)	Moderate risk identified Negligible methane and low to moderate levels of carbon dioxide have been recorded to date, with flow generally absent. Nonetheless the site lies in an area where basic radon protection is required.
Adjacent Land	Lateral migration	Adjacent land/residents	Low risk identified Low levels of contamination have been identified across the wider site and contamination associated with the Motorsports Centre does not appear to be affecting adjacent land. Similarly there is no evidence of contamination on site which is not site-derived.

SECTION 9 PRELIMINARY REMEDIATION STRATEGY

- 9.1 The identified risks at the site can be mitigated by removal of either the source, pathway or receptor. With reference to the conceptual model for the site a remediation strategy, based on source or pathway removal, has been designed.
- 9.2 Based on the results, it is considered that large scale remediation of soils is not required at the site. Limited soil remediation will be required in the area of the Motorsports Centre due to the lead, TPH, PAH and asbestos identified. It is also recommended that suitable topsoil is ensured in all soft areas of the site to provide a suitable medium for healthy plant growth. Clean cover is therefore recommended to any plots within the area of the Motorsports Centre, which may be formed from site-derived natural topsoil/subsoil. This should be comprised of 600 mm topsoil and subsoil in private gardens, and 300 mm topsoil and subsoil in communal gardens/public open space. Outside the area of the Motorsports Centre no specific soil remediation is considered necessary but any visible fragments of deleterious materials should be removed including brick.
- 9.3 It is envisaged that site-derived topsoil will be re-used on site. This is considered to be acceptable in terms of contaminant concentrations. Any material imported for the formation of domestic gardens and landscaped areas should be obtained from a validated source. The validation should incorporate an assessment of the provenance of the material and chemical analysis.



- 9.4 Basic radon protection will be required in all properties (commercial and residential). This is considered sufficient to mitigate against any risks from other possible hazardous gas ingress (carbon dioxide).
- 9.5 Potential risks to construction workers have been identified and the adoption of appropriate Health and Safety procedures will ensure that risks to operatives from hazardous materials at the site are minimised. Operatives should not be allowed to eat, drink or smoke on site except in designated areas and should be required to wash all exposed skin at the end of each shift. Operatives should be informed of the potential hazards at the site and should be required to report any observations of suspect material.
- 9.6 Materials, including waste soils which are not to be retained on site, should be removed and disposed of in accordance with all relevant statutes including the *Environmental Protection Act 1990* as amended, *The Controlled Waste Regulations 2012* as amended, *The Waste Regulations 2011* as amended, *The Hazardous Waste Regulations 2005* as amended, *The Waste Management Regulations 2006*, *The Environmental Permitting Regulations 2010* as amended and *The Hazardous Waste (Miscellaneous Amendments) Regulations 2015*.
- 9.7 It is recommended that this report is submitted to the regulators (Local Authority EHO and Planners, Environment Agency Planning Liaison and NHBC) for approval prior to commencement of the works.
- 9.8 Any observations of ground conditions atypical of those already described should be reported to Merebrook immediately so that an assessment of appropriate action can be made.

SECTION 10 CONCLUSIONS

- 10.1 The site investigation revealed ground conditions generally consisting of topsoil underlain by predominantly cohesive superficial Head Deposits (0.2 - > 3.0 m thick) and London Clay (> 2.8 m thick). Locally, thicknesses of made ground between 0.4 and 1.4 m were reported, whilst deeper made ground was revealed in two locations (2.2 and > 3.3 m thick). SPTs performed within the Head Deposits recorded soft and firm (low and medium strength) ground conditions, whilst the London Clay was found to range from soft to stiff (low to high strength) in nature.
- 10.2 Based on the ground conditions encountered it is envisaged that traditional strip or trench footings will be feasible across the vast majority of the site. An alternative solution, such as ground improvement or piles, will need to be considered where vertically persistent weak natural soils have been revealed in an area adjacent to the western boundary of the site.
- 10.3 Site investigation will be required in the south-western corner of the site when access is available to confirm ground conditions and determine any remedial requirements.



- 10.4 Localised risks to future residents are considered to exist from lead, TPH, PAH and asbestos. Exceedances were limited to made ground encountered within exploratory locations undertaken in the area of the Motorsports Centre. These exceedances are therefore considered to represent 'outliers', relating to localised pockets of contamination. The elevated concentrations of these contaminants represent a low to moderate risk to future residents via ingestion and inhalation of soil and soil-derived dust, and via dermal contact. Clean cover is recommended to any plots within the area of the Motorsports Centre, which may be formed from site-derived natural topsoil/subsoil. This should be comprised of 600 mm topsoil and subsoil in private gardens, and 300 mm topsoil and subsoil in communal gardens/public open space.
- 10.5 Basic radon protection will be required in all properties (commercial and residential).
- 10.6 As the investigation has indicated that large quantities of topsoil are present and that this may in part be displaced by the site construction activities it is recommended that a pre-start material movement plan is prepared to enable all usable topsoil resources to be reserved for on-site or offsite usage. It is important that such usable resources are not discarded or treated in such a manner as may indicate an intention to discard them.
- 10.7 It may be possible to re-use soil arisings which may otherwise be classed as waste on site, provided that there is a requirement for the material and that it does not represent a potential risk to human health or the environment once it has been placed. Materials to be re-used should be managed through a Materials Management Plan produced under the Contaminated Land: Applications in Real Environments (CL:AIRE) Code of Practice: Definition of Waste.



APPENDIX 1 ▪ Drawings



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Tel: +44(0)1773 506006 email: info@merebrook.co.uk

Rydon Homes & Gleeson Strategic Land
Land to North of Water Lane,
Angmering

Amended border	02-10-2017			-
	SC	SJ	SJ	
Based on OS	20-08-2015			-
	GLJ	-	-	
Issue Details				
Job No.	19495	Dwg No.	001-003	Revision
Scale	NTS	Date	October 2017	Frame Dimensions mm (A4) 250x181
Drawn	SNC	Checked	SJ	Approved SJ



- Legend
- Site boundary
 - Merebrook trial pit with location reference
 - Merebrook window sample with location reference
 - Merebrook soakage test pit with location reference

Based on IM drawing ref: 19495-304-001		22-08-2017	-
SC	RH	LGS	
Issue Details		Dwn	Chd App'd
Client			
Rydon Homes & Gleeson Strategic Land			
Project			
Water Lane, Angmering			
Dwg Title			
Approximate Site Investigation Locations Land to the North of Water Lane			
Job No.	Dwg No.	Revision	
19495	304-004	-	
Scale	Date	Frame Dimensions mm	
1:2500	August 2017	(A1) 791 x 544	
Drawn	Checked	Approved	
SC	RH	LGS	
<div>London</div> <div>Kent</div> <div>Derby</div> <div>Cardiff</div> <div>Manchester</div>			
<div></div> <div>Unit 108, Riverside, Angmering, East Sussex, England, TN33 7JH Tel: +44(0)1779 420609 Fax: +44(0)1779 420610 email: info@dommerebrook.co.uk</div>			



	Strip footings at minimum depth of 1.0m founded in firm/stiff clay
	Strip footings at minimum depth of 0.75m founded in sand/gravel
	Trench footings at minimum depth of 2.0m (locally 2.5m) founded in firm/stiff clay
	Ground improvement or piles

	Merebrook trial pit with location reference
	Merebrook window sample with location reference
	Merebrook soakage test pit with location reference
	Merebrook cable percussion borehole installed for water level monitoring

Site investigation required in new area once access is possible.

Client

Rydon Homes
&
Gleeson Strategic Land

Dwg Title

Preliminary Foundation Zoning Plan

Idom merebrook

London
Kent
Derby
Cardiff
Manchester



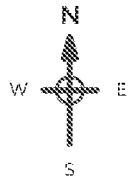
APPENDIX 2 ▪ Historic Plans

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NORTH PARCEL, WATER LANE, ANGMERING

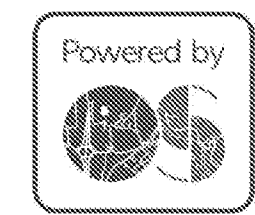
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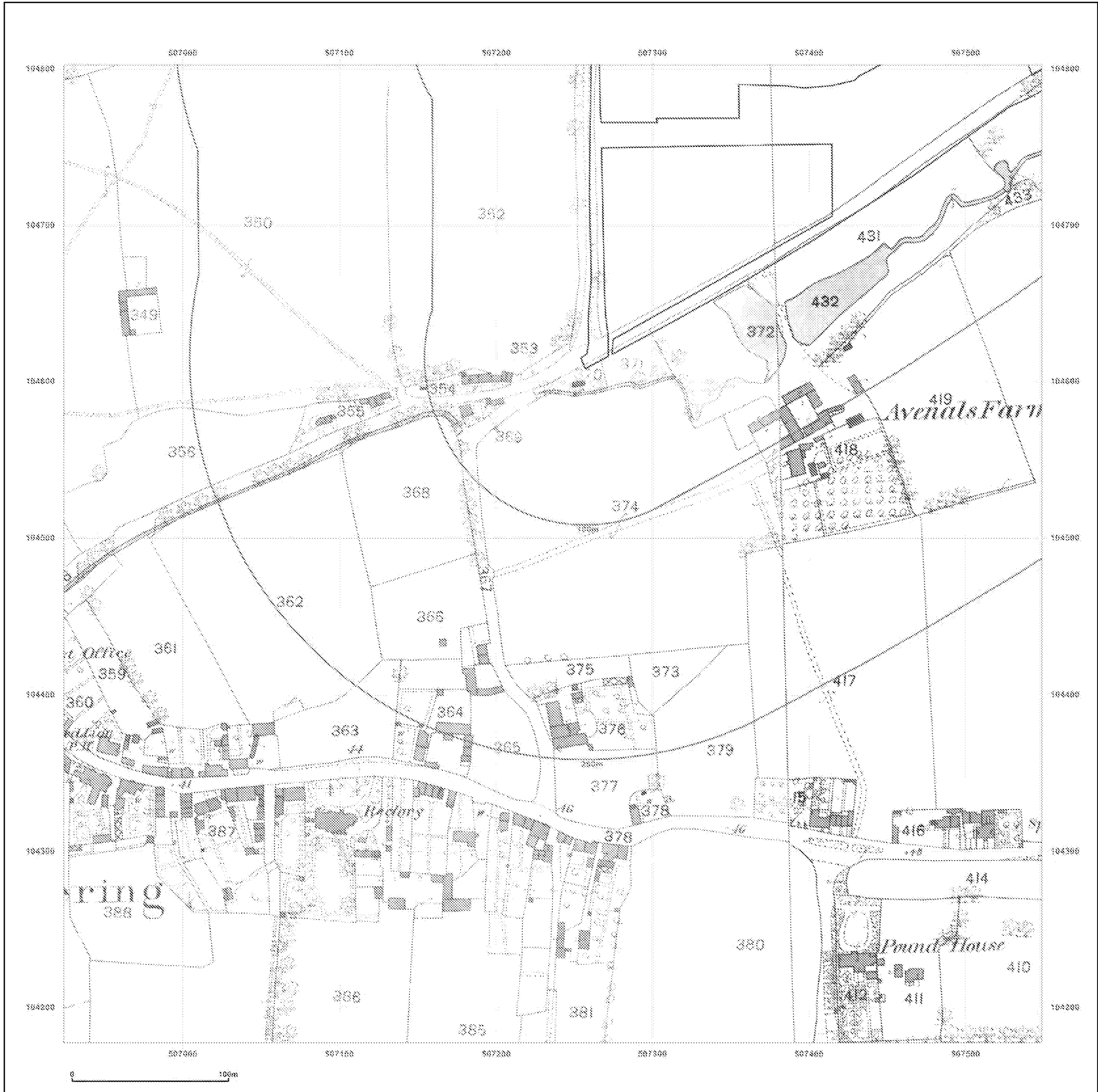
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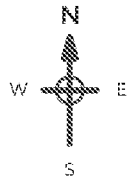


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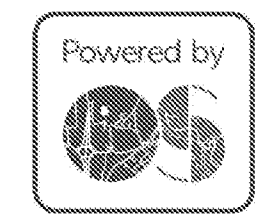
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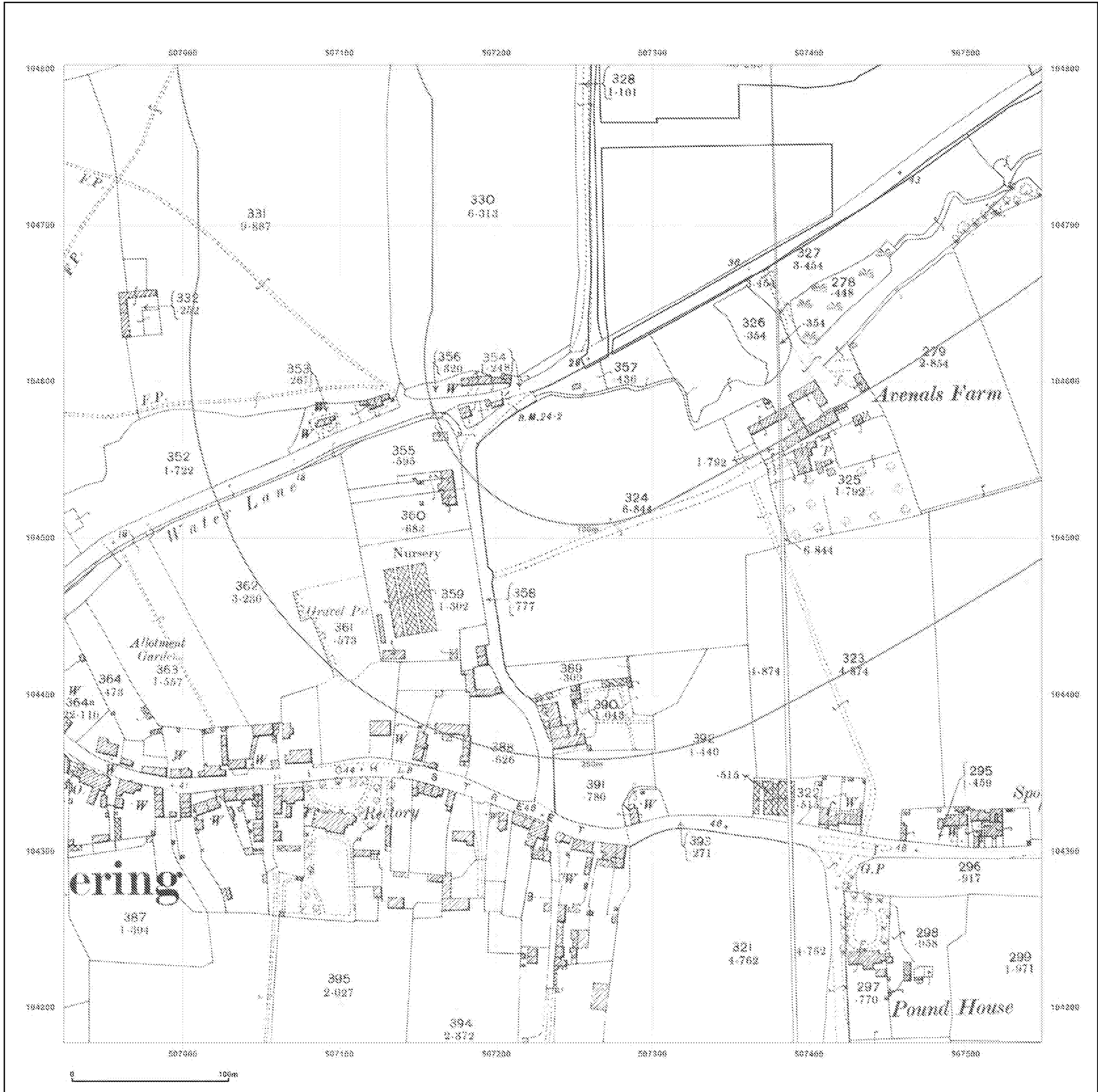


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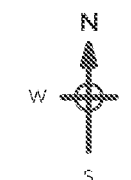
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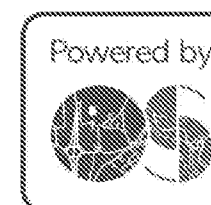
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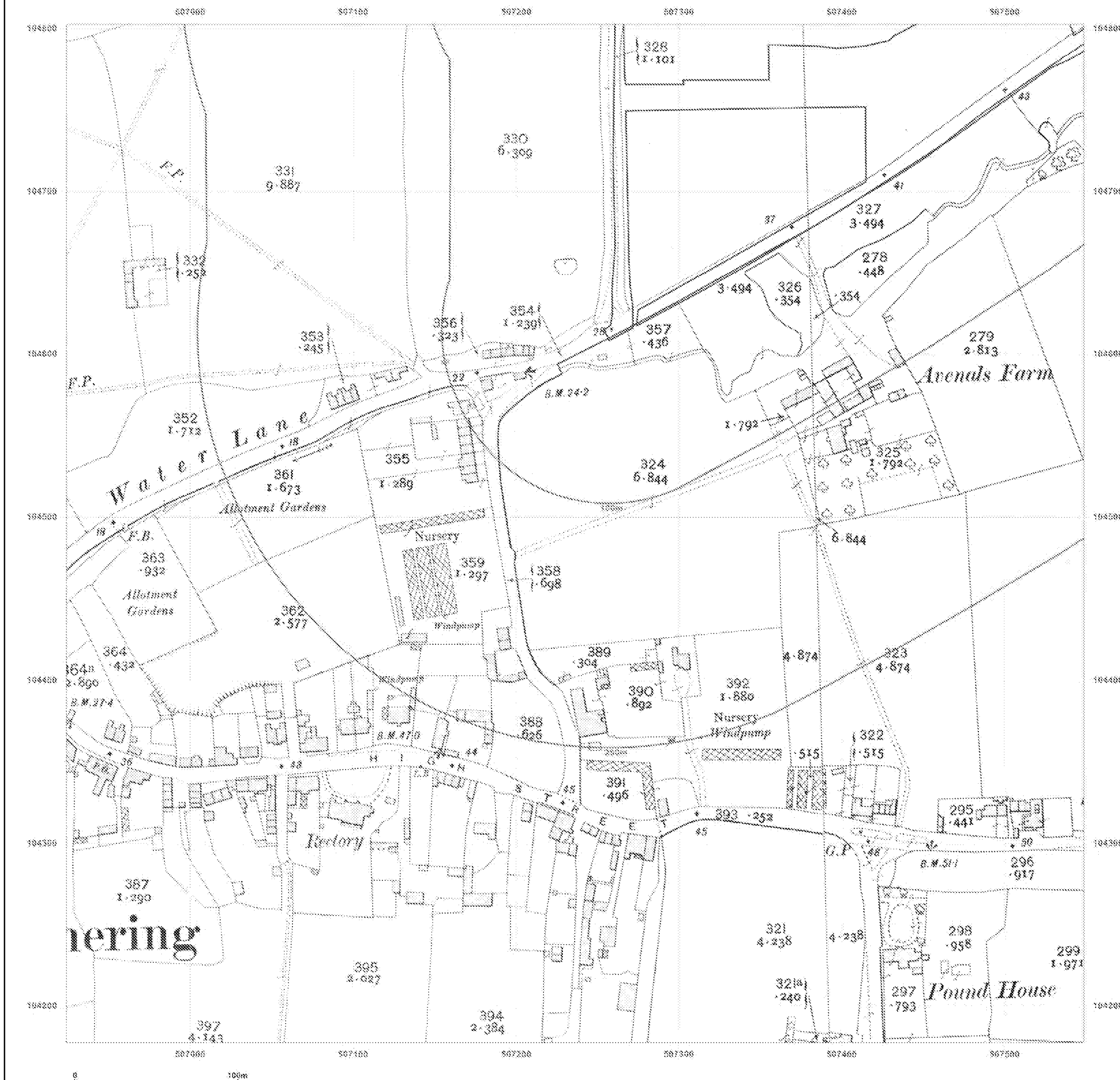


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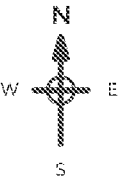
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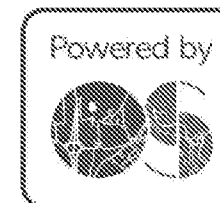
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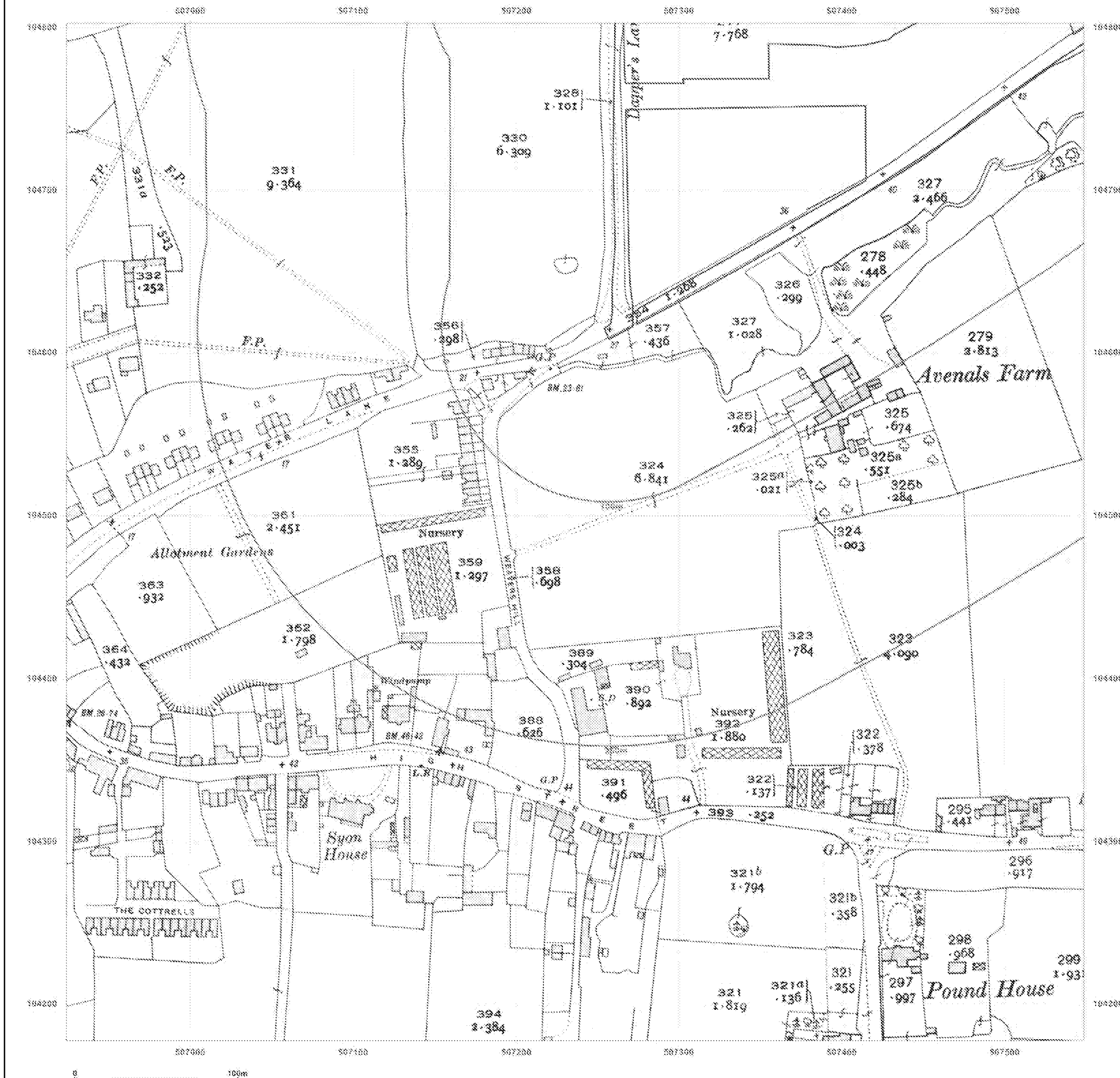


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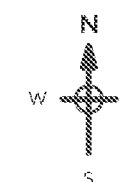
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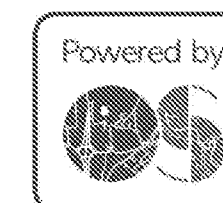
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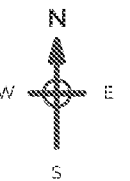
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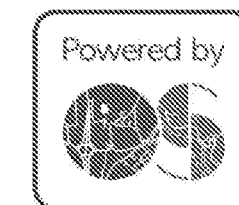
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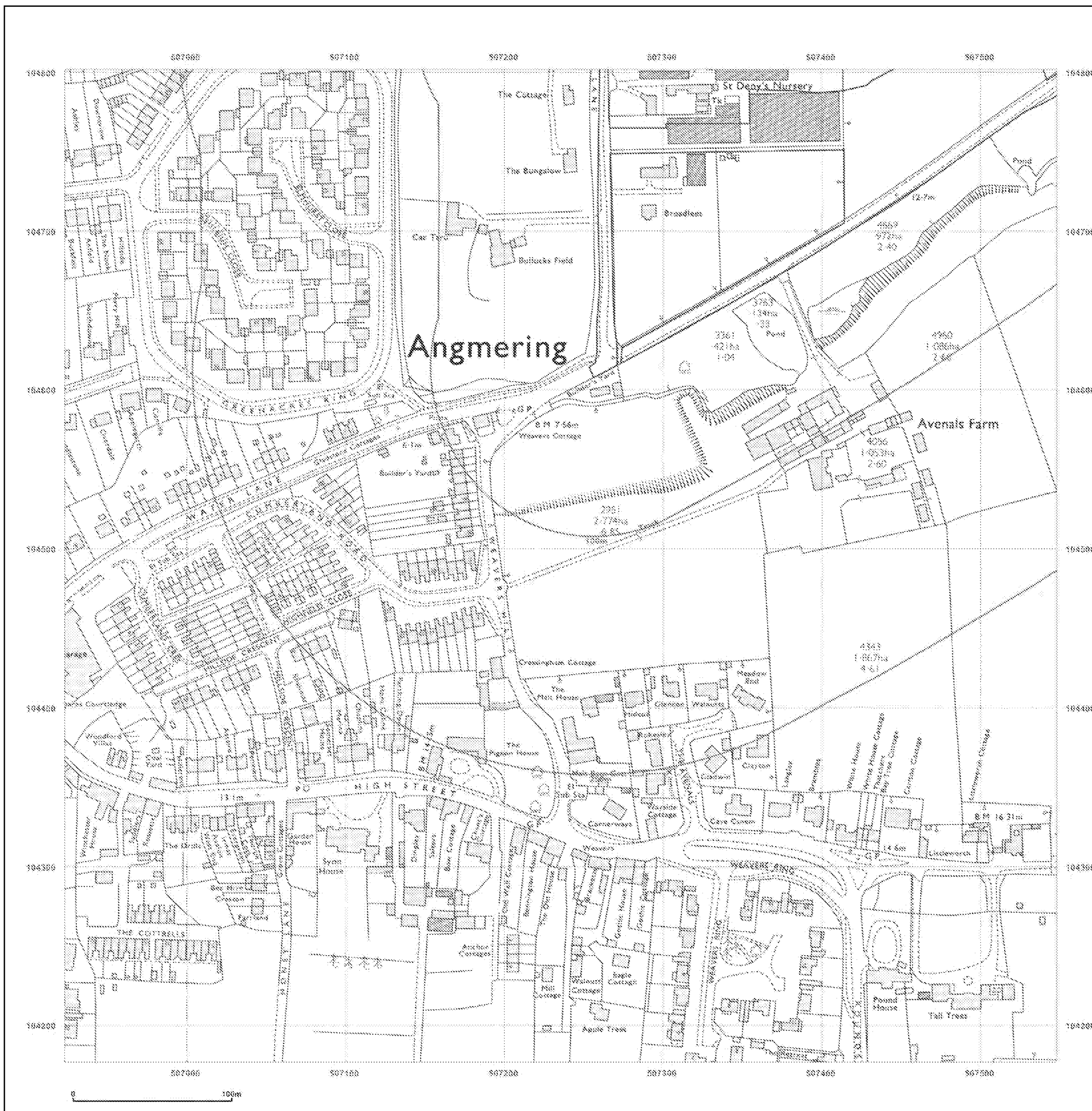


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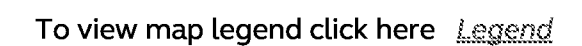
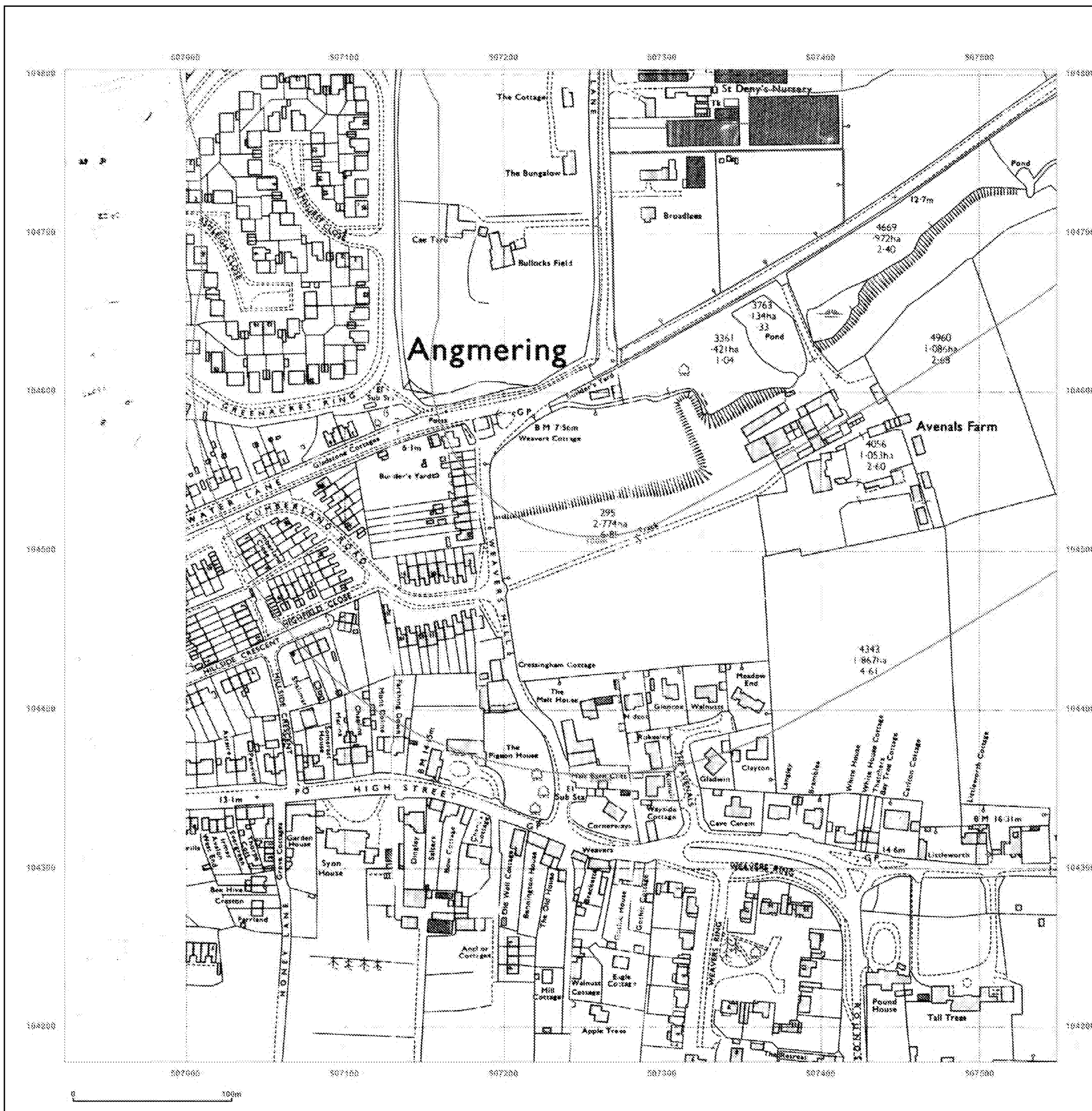
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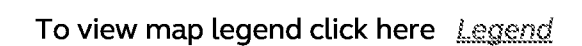
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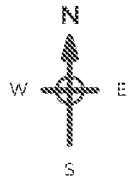


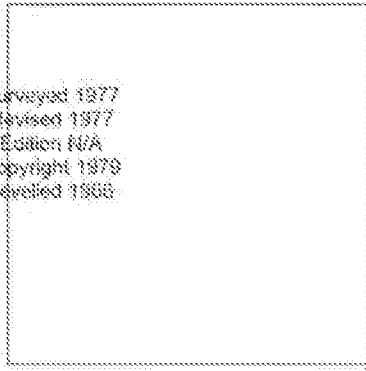
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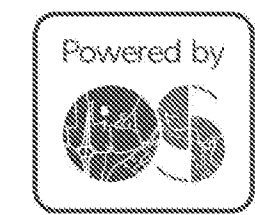
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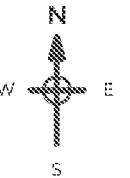
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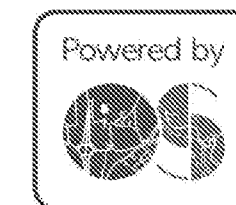
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