



Oakford Homes Ltd

Former Arundel Gasworks, Ford Road, Arundel

Geoenvironmental Site Assessment

Project no. 29780 R01 (00)

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RSK GENERAL NOTES

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Client: Oakford Homes Ltd, Hedsor Court farm, Sheepcote Lane, Hedsor, Buckinghamshire, SL1 8PE

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1 INTRODUCTION

RSK Environment Limited (RSK) was commissioned by Oakford Homes Ltd (the 'client') to prepare a Geoenvironmental Site Assessment for the former Arundel Gas Works, Ford Road, West Sussex. Initially this is to comprise the preparation of an up-to-date Preliminary Risk Assessment for the site, alongside initially appraising factual information contained in preceding Atkins reports.

This report is subject to the RSK service constraints given in **Appendix A**.

1.1 Background

To date Atkins Limited (formerly WS Atkins Environment) have prepared a number of reports for the site, all of which have been made available as redacted documents, with all associated opinions and interpretation blanked out.

In addition to the absence of interpretative information, all of the reports have been produced with a view to the site being remediated for a bulk storage scenario, rather than a more sensitive residential end-use as is being proposed.

Whilst it is proposed that Atkins and the current landowner (National Grid Property Holdings) will undertake remediation of the site, initially with respect to a proposed bulk storage scenario prior to divestment of the site, details of the proposed works are yet to be made available. Following on from this additional works are anticipated to be required to render the site suitable for a more sensitive residential end-use.

1.2 Objective

The objective of the work is to prepare an up-to-date Preliminary Risk Assessment for the site alongside initially appraising factual information contained in preceding Atkins reports with a view to identifying potentially complete pollutant linkages that will need to be addressed as part of the development proposals.

1.3 Scope

The scope of the investigation and layout of this report has been designed with consideration of CLR11 (Environment Agency, 2014) and BS 10175:2013 (BSI, 2013).

The project was carried out to an agreed brief as set out in RSK's proposal (Ref. 29780-01T, dated 1st March 2018). The scope of works for the assessment included:

- Preparation of an up-to-date Preliminary Risk Assessment (PRA) to include a review of existing reports, geological, hydrogeological and hydrological information, a commercially available environmental database and historical plans;
- A review and preparation of a summary of factual data presented within the preceding Atkins' investigation reports collected from numerous boreholes and trial pits with laboratory analysis plus subsequent groundwater, gas and vapour monitoring;

- Preparation of a generic/semi-quantitative risk assessment (GQRA) to assess theoretical risks to human health and the environment; and
- Identification of outline mitigation measures for complete pollutant linkages or recommendations for further work as required.

1.4 Existing reports

The following Atkins reports, as contained in **Appendix K**, detailing previous works at the site were made available for review:

- Ford Road, Arundel – Environmental Liability Assessment Report (for British Gas), WS Atkins Environment, document ref. E5347/LR860.NL/gp, dated April 1994;
- Ford Road, Arundel – Environmental Assessment Site Investigation Factual Report Final (for Lattice Property), document ref. A71430/GTG.2000078/R003rev1, dated December 2000. This report includes, as an appendix, a report by Harrison & Company, dated July 1993, entitled 'Desk Study on a Disused Gas Works at Ford Road, Arundel, West Sussex for British Gas (South Eastern) plc. Report No. C604a';
- Ford Road, Arundel – Environmental Groundwater Monitoring Letter Report, (for Lattice Property), document ref. A71430/GTG.2000078/R004rev0/mg, dated July 2001;
- Ford Road, Arundel – Land Contamination Site Investigation and Generic Quantitative Risk Assessment (for National Grid Property Holdings Limited), document ref. 5104362/GTG.20100923/Arundel 2011/R001v0, dated September 2011;
- Ford Road, Arundel – Detailed Quantitative Risk Assessment Report (for National Grid Property Holdings Limited), document ref. 5104362/GTG.20100923/Arundel DQRA 2012/R002v1, dated October 2012; and
- Ford Road, Arundel – Outline Remediation Strategy (Final) (for National Grid Property Holdings Limited), dated August 2017.

As part of this assessment, RSK have assumed that as part of the site acquisition agreement, Oakford Homes will have full contractual reliance upon the information contained within the aforementioned Atkins reports.

Pertinent information from these reports have been summarised in **Section 2**. Where information has been directly transcribed from the Atkins' reports, it is presented in *italics*.

The aforementioned Atkins reports for the site have all been provided as redacted documents with all associated opinions and interpretation blanked out. In addition to the absence of interpretative information, the reports have all been produced with a view to the site being assessed for a bulk storage end use rather than a more sensitive residential end use as is proposed moving forward.

1.5 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have



not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows may vary from those reported due to seasonal, or other, effects.

While asbestos-containing materials were not identified during the fieldworks or supporting laboratory analysis, the history of the site indicates that asbestos may well be present. Asbestos is often present in discrete areas. Although it may not be encountered during the site investigation, it may be found during more extensive ground works.

2 THE SITE

2.1 Site location and description

The site is located at Ford Road, Arundel, BN18 9DX, at Ordnance Survey National Grid Reference TQ014067, as shown on **Figure 1**, and covers an area of approximately 0.47 hectares, generally comprising of overgrown derelict land.

As part of RSK's scope of works, a site reconnaissance survey has not been undertaken. However, the preceding Atkins (2000) reports summarised the site setting and surrounding features as follows:

'The site footprint was, until recently, occupied by Transco who used the site to control the local gas pressure and for the addition of additives. It is bounded by houses and gardens on the south-west and to the north west by Ford Road, beyond which is a cemetery. To the south and east are grazing fields. A drain runs parallel to the north-eastern site boundary and into the River Arun via a sluice gate. The Arun flows adjacent to the south (beyond the grazing land) and is separated from the site by a narrow stretch of low-lying waterlogged land. The majority of the site is flat with the surrounding land sloping from north-west to south-east. The houses and road to the west and south-west of the site are at a higher level than the site although the gardens slope down to a similar level.'

2.2 Proposed development

It is understood that Oakford Homes are looking to redevelop the site with two separate apartment blocks containing 38 units, and that the development will be set at a raised level predominantly with open air parking or amenity space beneath (given the flood risk potential). The development proposals do not include for private gardens although areas of communal soft landscaping are included.

Copies of the proposed development plans area included in **Appendix D**.

2.3 Summary of previous reports

The aforementioned Atkins reports for the site have all been prepared as redacted documents with all associated opinions and interpretation blanked out. In addition to the absence of interpretative information, the reports have all been produced with a view to the site being assessed for a bulk storage end use rather than a more sensitive residential end use as is proposed moving forward.

Whilst the previous works have included a Controlled Waters Detailed Quantitative Risk Assessment (DQRA), the redacted nature of the document means that there is little of use contained within the report.

Atkins have also prepared an outline remediation technical note. At present, this simply states that the proposed remediation works would be limited to addressing risks posed by contaminants within the unsaturated zone and would not necessarily directly address contamination residing within the groundwater body underlying the site. Given the

absence of any interpretative information or conclusions within the groundwater DQRA, it is hard to comment upon these proposals and whether this methodology would be accepted by and supported by the Environment Agency.

It would appear that beyond these generic statements, more robust remedial proposals are yet to be established. As detailed within the Atkins remediation technical note, it is envisaged that further works will ultimately be required to fully establish the final remediation requirements. As part of these works, the existing groundwater baseline would need to be re-assessed given that the most recent quality testing was undertaken in 2012.

Given the sensitive site setting with respect to controlled waters (both groundwater in the Chalk Aquifer and adjacent watercourse), in order to firm up on the outline remedial requirements, it will be necessary to undertake a full updated controlled waters DQRA. However, at this stage this it is suggested that this should be conducted following the completion of additional groundwater monitoring to assess the existing baseline conditions.

3 PRELIMINARY RISK ASSESSMENT (PRA)

A Preliminary Risk Assessment (PRA) has been compiled from information presented in earlier Atkins' reports as detailed in **Section 1.4** and from a review of a new Environmental Database report and historical maps obtained for the site (Envirocheck Report Ref. 158393817_1_1, dated 5th March 2018), as contained in **Appendix E**.

3.1 Site setting

The site setting was most recently detailed within Atkins' 2012 report, which contained the following summary of the physical features of the site:

'The site is generally flat and set into the side of a gently sloping hill, with the surrounding land sloping from north-west to south-east. An electricity sub-station is located on the eastern site boundary adjacent to the site entrance and concrete slab foundations are located in the northern and eastern corners of the site. No other above ground structures or buildings are present on the site. A raised spoil heap and raised rectangular area (identified on the historical plans to have formerly been the location of a governor compound) are located in the southern and south-eastern portion of the site, respectively. During the most recent site investigation, the site surface was recorded as comprising approximately 25% tarmac, with the remainder comprising of either gravel, wood chippings or bare earth heavily overgrown with shrubs (e.g. buddleia), semi-mature trees and brambles.

The site boundary comprises a 2m high chain link fence in reasonable condition at the time of writing. Access to the site is gained via 2m high chain-link padlocked double gates located along an access track adjacent to the north-eastern boundary of the site (off Ford Road).'

The same Atkins' 2012 report notes the surrounding land use as follows:

- *To the south-west are residential houses with gardens;*
- *To the south-east is private grazing land. The River Arun is located beyond the private grazing land, approximately 40m from the site boundary, and flows towards the south-east being tidally influenced at (although is tidally influenced);*
- *To the north-west is Ford Road, beyond which is a cemetery with a building (assumed residential); and*
- *To the north-east is an access track leading off Ford Road, beyond which is a small surface water drain (which runs towards the River Arun via a sluice gate), and private grazing land.'*

The history of potentially contaminative activities carried out on the site were summarised in the Atkins (2000) report, thus:

'The first map published of this area in 1841 showed a small gasworks consisting of a single circular holder, a medium sized works building and a small cottage. Within the next century, three more gasholders were built, although the first one was demolished at the end of the 19th century and the buildings were expanded. However, by 1994 only the electricity substation, valve pits, toilet and a concrete base of a tank were remaining with the gas holder in the south having been only

recently decommissioned. Adjacent land-use, particularly to the south west, has changed dramatically over the years with an ironworks being present between 1899 and 1937, which was then built on by an agricultural engineering works, neither of which showed direct evidence of contamination, based on the initial site investigation carried out by Harrison and Co (1988).'

3.2 Ecological setting

3.2.1 Birds

During the Atkins' walkover survey, evidence of breeding birds was observed across the site. This included singing birds including dunnocks, common whitethroats, a chaffinch and a sighting of a recently fledged song thrush.

3.2.2 Reptiles

The preceding Atkins reports note that the River Arun is located to the southeast of the site and has a bank consisting of a 10 m wide strip of dense ruderals with a medium/high potential for reptiles. The same report notes that the site itself is of low suitability for reptiles as it consists of buddleia with little or no ground vegetation, or extremely dense scrub.

3.2.3 Great Crested Newts

The Atkins reports notes that busy roads to the north and east, and a river to the south form barriers to the movement of great crested newts (GCNs) on to the site. No ecological desk study has been carried out and therefore it is not possible to confirm whether there are ponds within 500 m of the site or whether there are GCNs present in the surrounding area.

3.2.4 Badgers

No evidence of badgers was recorded during the Atkins walkover survey. However, a raised area of ground, marked as a spoil heap on **Figure 2**, could not be inspected due to the dense scrub that covers it.

3.2.5 Other Legally Protected or Notable Species

The Atkins reports noted that there was no evidence of any other legally protected or notable species. However, a full ecological desk study was not undertaken and parts of the site were inaccessible due to the dense vegetation.

3.2.6 Japanese Knotweed

Japanese knotweed was not reported to have been identified during the previous Atkins site visits. However, Japanese knotweed is difficult to identify outside the growing season (March to September/October). It is recommended that the site be resurveyed during the growing season. Should Japanese knotweed be identified on site, there are several methods by which it can be treated/eradicated, all of which are detailed in the EA's (2006b) 'The Knotweed Code of Practice'. A competent knotweed contractor would be employed to manage and perform the works in line with this guidance.

3.3 Ground conditions

3.3.1 Geology

Published geological records for the site area (1:50,000 sheet No.317 'Chichester') and the results of earlier intrusive investigations have confirmed the geology of the site and its surroundings to be characterised by the succession recorded in **Table 1**.

Table 1: Geology at the site

Geological unit	Description (Atkins)	Proven thickness (m)
Made Ground	Variable across the site, but generally comprised firm, sandy, gravelly clay and fine to medium, gravelly, clayey sand with frequent brick, chalk and flint gravels and fragments of clinker, coal and metal.	Absent to 3.00 m
Alluvium	Stiff, silty, very gravelly clay or clayey gravel.	0.70 m to 6.30 m
Spetisbury Chalk Member (White Chalk Subgroup)	Structureless fine chalk composed of gravels and chalk cobbles in a soft off-white/grey clay matrix.	>3.80 m to >7.60 m (base not proven by previous investigation works)
Note: During the Atkins' 2011 investigation, the base of the Made Ground was not proven at TP108B (>2.5 m), TP111 (>2.3 m), VP202 (>1.0 m), VP203C (>1.2 m) or VP204 (>1.3 m).		

In view of the prevailing ground conditions, with Chalk at shallow depth beneath the site, it is normal practice to consider the potential risk of ground subsidence related to the presence of swallow holes and other natural chalk solution features or man-made cavities.

Based on the Edmund's risk assessment model for natural dissolution features referred to in CIRIA Report C574 (Lord et al. 2002), the site falls into the 'moderate anticipated subsidence risk' category. With reference to Edmund's database of known natural and man-made chalk solution features there are no such features in the immediate vicinity of the site, and the risk on site ranges from 'low' to 'no hazard'.

3.3.2 Radon

The environmental database report provides an assessment of radon risk equivalent to a stage 2 assessment undertaken by the British Geological Survey. This indicates that 15 to 3% of homes in the area are above the Action Level as defined by the Documents of the National Radiological Protection Board (Radon Atlas of England and Wales, NRPB-W26-2002). The aforementioned environmental database report states that no radon protective measures are required within new dwellings at the site.

3.3.3 Mining and quarrying

Evidence has been sought to identify any mining and quarrying operations, past and present, which have taken place in the vicinity of the site. The sources of information referenced in this element of the desk study include:

- Past and current environmental database reports;
- Records held by Local Authority/Environment Agency;
- Old Ordnance Survey maps and plans; and
- Geological map records.

With reference to the above sources of data, there are two recorded sand and gravel quarries within a 1.0 km radius of the site. The Waterwoods Gravel Pit is located 713 m to the north-west of the site (sand and gravel originating from Lambeth Group) with the Arundel Station Gravel Pit located 883 m to the south-east of the site (sand and gravel originating from Raised Beach Deposits).

3.3.4 Landfilling and land reclamation

Evidence has been sought to identify any landfilling or land reclamation operations, past and present, which have taken place in the vicinity of the site (using the same sources of information listed above in **Section 3.3.3**).

With reference to the above sources of data, a closed landfill site is located 86 m to the south-west of the site. The environmental database report lists the site as 'Penfold Works' which accepted inert, commercial and household waste between 1960 and 1962. The former landfill site appears to have been redeveloped to comprise garden areas associated with housing along Ford Road. Notwithstanding this, the potential exists for landfill gas generation since the household waste and, as such poses a potential risk to the site from the generation and migration beneath the site of landfill gases and/or leachate.

With respect to the former Penfold Works landfill, the preceding Atkins reports notes the following:

'The Environment, Tourism and Leisure Department of Arun District Council have limited records of a landfilling operation in the area immediately to the south west of the study site. This was essentially infilling of the former baths in the 1950s and 1960s. Materials used included bottles, timber, ash and pottery. The Council's records do not state the exact depth or volumes of wastes involved but it is believed that the maximum depth of waste is approximately 3.0 m. This area and the land further south-west (the site of Tortington Ironworks between 1899 and the early 1960s) has since been developed for 40 houses with gardens. The Council stated that a site investigation was carried out prior to development. At total of 500m³ of topsoil was removed owing to the presence of copper, nickel, lead and zinc. The site investigation report concluded that there was "no major contamination threat".'

Three other historic landfills are identified within the environmental database report within 1.0 km of the site and the also on the EA website. These comprise:

- Fagins Den landfill was situated approximately 144 m to the northeast of the site where Wheelrights Close is currently located;

- Canada Road landfill was situated approximately 163 m to the northwest of the site where the recreation ground off Canada Road is currently located; and
- Tortington Common landfill was situated approximately 750 m to the northwest of the site on Tortington Common.

The Fagins Den landfill accepted inert, commercial and household waste between 1960 and 1962. Likewise, the Canada Road landfill accepted the same waste streams between 1947 and 1973 whilst the Tortington Common landfill accepted the same waste streams until 1974, albeit with no start date recorded.

3.4 Buried structures

Based upon preceding investigation works undertaken across the site, a number of buried structures were encountered, as detailed below. Features that relate to gas works infrastructure are also shown in **Figure 2**.

3.4.1 Underground pipes

During the preceding investigation works, 300 mm (OD) cast iron pipes were encountered in TP5 and TP8 at depths of between 0.70 m and 1.20 mbgl. In TP8, the depth to the pipes reduced as they extend away from the adjacent governors.

A dry 200 mm clay land drainage pipe (breached by the excavation works), a 400 mm concrete pipe (integrity intact) and a 0.5 m² brick manhole were encountered in TP10, at approximately 1.20 mbgl. The latter drain is considered to be an old drain running across the site from the former iron works.

In addition to the above features, the more recent Atkins 2011 investigation observed the following features within excavated trial pits:

- TP104 - A series of electricity cables (previously identified as redundant during Atkins' 2000 investigation) were encountered at approximately 0.40 mbgl;
- TP108 - Three-cast iron pipes were encountered crossing the trial pit, two at 0.80mbgl and one at 1.20 mbgl;
- TP109 - A brick wall was identified at a depth of 0.30 mbgl in the northern portion of the pit, with a concrete base at a depth of 0.80 mbgl;
- TP111 - A cast iron pipe was located at the southern extent of the pit at a depth of approximately 0.50 mbgl; and
- TP115 - Three cast iron pipes were located in an initial trial hole dug adjacent to the edge of the former governor compound at approximately 0.40 mbgl. The trial pit was relocated to the centre of the former governor compound.

3.4.2 Foundations

Preceding investigation works encountered brick and concrete foundations in TT1, TT2 and TP5 at depths of between 0.20 m and 0.40 mbgl in an area that formerly contained the gas works buildings. The trial trenches were advanced to the depth of the underlying foundations, with deeper excavations in the areas between these (TT1A, TT1B, TT2A, and TT2B), to investigate the possible presence of tanks. These excavations did not

reveal the presence of any tanks. However, tarry contamination was encountered in TP5.

The Atkins works noted that the complete absence of tanks cannot be confirmed due to the limited the scope of the investigation works undertaken, nature of the excavations and because the depth of most excavations being limited due to obstructions. The works noted that full investigation of this area would have involved removing the top 0.5 m of made ground, exposing the foundations and breaking out selected areas.

In addition to the above, during the more recent Atkins 2011 investigation, the following observations were made (as marked on the constraints and hazard plan presented in the aforementioned report as Figure 3):

- TP101 – A brick wall was identified at a depth of 0.30 mbgl in the northern portion of the pit, with a concrete base at 0.80 mbgl;
- TP103 – A brick wall and concrete base were identified at approximately 0.50 mbgl;
- TP107 – A possible brick wall was encountered at the southern extent of the pit; and
- TP109 – a brick wall was identified at 0.30 mbgl in the northern portion of the pit, with a concrete base at 0.80 mbgl.

3.4.3 Gas holders

During the Atkins investigation works the base slabs of gas holders in the western and southern corners of the site were encountered at depths ranging between 0.60 m and 1.50 mbgl in TP3, TP4, TP10 and TP11. The bases of the other two holders located along the north-eastern boundary were not encountered in either TP1 or TP2. However, pieces of broken concrete were observed in TP2.

The gas holder base in the western corner of the site was noted to consist of an integral 200 mm thick mass concrete slab at 1.20 mbgl, which contained a small quantity of black stained material just above the base. This holder and the two holders close to the north-eastern boundary have been backfilled with chalk at their eastern edges. However, at their western edges fill materials comprised loose light brown or orange sandy silt with gravel, mixed with a variety of waste materials (wood, timber, brick, scrap metal, plastic, steel pipes, steel drums, car parts, glass bottles, coal, railway tracks and cast iron) along with pockets of reworked natural ground. Pockets of this material were noted to exhibit a slight 'gasworks odour'.

The gas holder base in the southern corner of the site consisted of a broken pink/light red 200 mm thick mass concrete slab, underlain by 300 mm of loose grey sand and tarmac. This was underlain by a grey integral 300 mm thick mass concrete slab at a depth of 0.90 mbgl. The holder was noted to have been backfilled with a soft dark brown-black silty clay with ash, gravel, coal, brick and timber, overlain by loose light brown clayey top soil.

The Atkins reports note that each of the holder bases encountered were founded upon natural soils in the form of a soft orange-brown clay alluvium, which did not appear to exhibit any visual or olfactory evidence of contamination.

During the more recent Atkins 2011 investigation, the bases of the gas holders were encountered in TP106 at between depths of 0.95 mbgl and 1.10 mbgl and in TP114 at

depths ranging between 0.55 mbgl to 0.85 mbgl. These depths generally correspond with those encountered during the earlier investigation works.

3.4.4 Former tanks

During the Atkins investigation works, TP14 was excavated in the eastern corner of the site to the east of a potential former tank base slab. The base slab was proven to be a 150 mm thick integral mass concrete slab present at the ground surface and underlain by two rows of red bricks. Made ground deposits and a foundation at a depth of 1.15 mbgl underlay the tank base. The base of the foundation was not proven due to the tight working space.

3.5 Hydrogeology

3.5.1 Aquifer characteristics

Based on the published geological map referred to above and ground conditions proven during previous investigation works, the hydrogeology of the site is likely to be characterised by the presence of a tidally-influenced unconfined shallow aquifer comprising the Alluvial deposits of the River Arun overlying a deeper unconfined aquifer within the White Chalk Sub-group. Given the nature of the deposits and elevation of the site, it is anticipated that the aquifers will locally be in continuity.

It is also likely that localised perched water will be present in the made ground and within any remaining structures in the ground.

Monitoring data from the preceding investigation works has confirmed groundwater to be present at a depth in the order of 2.00 mAOD at high tide dropping to approximately 0.00 mAOD at low tide.

During the excavation of trial pits, groundwater was struck at depths ranging between 1.30 m and 2.65 mbgl.

The preceding Atkins reports note that the nearby River Arun is tidally influenced in the local area, and generally flows in a southerly direction towards the English Channel, with reversal of flow during high tide. Tidal monitoring undertaken in July during the 2011 Atkins investigation indicated that there was significant tidal variation in the groundwater level at the site (up to approximately 2.00 m variance). Groundwater beneath the site is therefore anticipated to be tidally influenced and saline.

The failure to establish a groundwater flow direction during the Atkins 2001 groundwater-monitoring programme was attributed to tidal influence.

3.5.2 Vulnerability of groundwater resources

The site has been classified by the EA website to overlie the following:

- Bedrock Aquifer (White Chalk Sub-group): Principal Aquifer, i.e. layers of rock or drift deposit that have high intergranular and/or fracture permeability (usually providing a high level of water storage). They may support water supply and/or river base flow on a strategic scale; and

- Superficial Aquifer (Alluvium): Secondary A Aquifer, i.e. permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

The soils beneath the site are classified as having a High Leaching Potential (H1) - Soils which readily transmit liquid discharges because they are either shallow, or susceptible to rapid by-pass flow directly to rock, gravel or groundwater (Source: Sheet 45 West Sussex and Surrey 1:100,000).

3.5.3 Licensed groundwater abstraction

The environmental database report indicates that there are ten current licensed groundwater abstractions within a 2.0 km radius of the site. Of these, only one is located within a 1.0 km radius located approximately 730m to the north west of the site and operated by 'Arundel Estates T/A Chalk Springs Fishery' for 'Aquaculture: Fish Farm/Cress Pond Throughflow' purposes.

The nearest public water supply borehole is located 1,096 m to the north east of the site and is operated by Southern Water Services Limited.

In terms of aquifer protection, the EA generally adopts a three-fold classification of source protection zones (SPZ) for public supply abstraction wells.

- Zone 1 or 'inner protection zone' is located immediately adjacent to the groundwater source and is based on a 50-day travel time from any point below the water table to the source. It is designed to protect against the effects of human activity and biological/chemical contaminants that may have an immediate effect on the source;
- Zone 2 or 'outer protection zone' is defined by a 400-day travel time from a point below the water table to the source. The travel time is designed to provide delay and attenuation of slowly degrading pollutants; and
- Zone 3 or 'total catchment' is the area around the source within which all groundwater recharge is presumed to be discharged at the source.

Information available on the EA website indicates that the site does not lie within a currently designated groundwater Source Protection Zone. The closest SPZ (Inner Zone) is located approximately 683 m to the north west of the site.

3.6 Hydrology

3.6.1 Surface watercourses

The nearest identified surface watercourse to the site is the River Arun located 33 m to the southeast and east of the site at its closest point. The stretch of the watercourse closest to the site is known to be tidally influenced and flows in a southerly direction towards the English Channel.

The EA classification of the water quality in the stretch of the Arun nearest to the site is listed as an 'Unclassified Tidal River' with respect to river quality.

In 1994, Atkins reported that the tidal stretch of the River Arun adjacent to the site is classed as Estuary Class A (Good Quality) based on an assessment of biological, aesthetic and water quality.

The base flow of the River Arun is likely to be recharged by groundwater in the shallow aquifer in the site area. A linkage between the river and any ground or groundwater contamination beneath the site may therefore exist.

The environmental database report indicated that a discharge consent was formerly in place for the site to discharge into the 'Saline Estuary' via the drainage ditch on the site's northern boundary from 1971 to 1996.

In addition to the above, a significant 'Pollution Incident to Controlled Waters' is reported in the aforementioned Envirocheck report, namely 'Silage Liquor in Stream' (organic industrial waste) resulting from a road traffic accident immediately to the south of the site in 1995. This location is only accurate to within 100 m, which would allow for the fact that the 'stream' (or ditch) is located to the north of the site.

3.6.2 Surface water abstractions

Four current surface water abstractions have been identified within a 2.0 km radius of the site using the environmental database report.

Of the four, only two abstractions are located within 1.0 km of the site which and located between 733 m and 804 m to the north-west of the site and operated by 'Arundel Estates T/A Chalk Springs Fishery' for 'Aquaculture: Fish Farm/Cress Pond Throughflow' purposes. The surface water is reported to be abstracted from 'Springs from the Waterwoods, Park Bottom, Arundel'.

3.6.3 Site drainage

Surface drainage from the site appears to be discharged into the drainage ditches along the site's north-eastern and south-eastern boundaries.

The proceeding Atkins reports note that drainage ditch adjacent to the northern site boundary flows towards the River Arun via a sluice gate. The environmental database report describes this ditch as an inland river, with a length of 186 m on the ground surface. A discharge consent is in place for the drainage ditch approximately 40m to the southeast of the intersection with Ford Road.

In Harrison & Co.'s 1993 site reconnaissance visit, the presence of 'a tree lined drainage ditch was noted to the south-east of the site with the following observations made:

'Within the south-eastern drainage ditch water flowed quite rapidly south-westwards from a concrete culvert at the northern end of the ditch. It seems likely that this culvert connects with the sluice gate at the end of the site access land. Between the ditch and the River Arun was a river levee or embankment, 2-3 m high. The face of the embankment was armoured against erosion with concrete blocks.'

Any direct drainage connections from the site to these ditches was not visible during the Atkins 1994 site walkover, although the previous discharge consent would suggest that a connection exists.

3.6.4 Preliminary flood risk assessment

Information available in the environmental database report indicates that the site lies within the indicative tidal floodplain of the River Arun, and the catchment area of the

River Arun and Rother, in an area of 'extreme risk of flooding from (rivers or) sea without defences'.

This report is not intended to replace a full hydrological study and it is recommended that additional specialist studies be conducted to confirm flood risks at the site.

In addition, BGS flood data reports that there is potential for groundwater flooding to occur at the surface on the site.

The preceding Atkins 1994 site reconnaissance visit noted that:

'The bund along the river appeared in good condition but anecdotal evidence suggests the land on either side of the river (including the study site) floods frequently. Retaining walls along Ford Road and between the site and houses to the west both appeared to be in good condition.'

Site layout plans for the proposed development state that the development will be set at a raised level with open air parking beneath given the flood risk potential.

3.7 History of site and surrounding area

The history of the land-use and development of the site and surrounding area has been assessed based on the following sources:

- Historical maps within past and recent environmental database reports from 1840 to 2018;
- Internet search; and
- Aerial photography.

Copies of OS and County Series maps are included in the environmental database report. Reference to historical maps provides invaluable information regarding the land use history of the site, but historical evidence may be incomplete for the period pre-dating the first edition and between successive maps.

The development history of the site and surrounding area from the above sources is summarised in **Table 2** on the following page:

Table 2: Summary of historical development

Date	Land use/features on site	Land use/features in vicinity of site (of relevance to the assessment)
1840	A single gas holder is identified in the north of the site. A works building is recorded in the central/northern portion of the site to the south of the holder. A rectangular building is identified adjacent to what is currently the site entrance.	Ford Road (unnamed on the plan) is identified along the north-western boundary of the site with open fields beyond. An access track leading to the River Arun is recorded along the north eastern boundary with open fields, a small building and drainage channels beyond. Open fields, drainage channels and the River Arun are identified to the south east of the site. Open land segregated into smaller parcels is identified to the south west.
1875	The site is recorded as a "Gas Works". The gas holder located in the north of the site is recorded to have reduced in size and a second, larger gas holder is identified on the site along the north western boundary. The works buildings are recorded to have expanded to the south and west.	Minor changes, with a small number of buildings are identified to the north, south and south west of the site.
1877	An additional small circular structure (potential gas holder or tar tank) is identified in the central portion of the site adjacent to the works buildings.	No significant changes recorded.
1897	The gas works area is recorded to have expanded to the west. The smaller possible gas holders/tar tanks previously identified in the north and central portion of the site are no longer recorded. A circular gas holder is recorded in the west of the site. The works buildings previously identified in the central portion of the site has expanded. Additional works buildings are identified in the northern corner of the site. The building previously recorded adjacent to what is now the site entrance has expanded.	A cemetery with lodge house is recorded to the north west of the site. Beyond the open fields to the south of the site "Baths", "Tortington Iron Works" and a "Sewage Works" are identified. Housing located along the south of Ford Road is identified adjacent to the site to the south-west.
1910	A small circular structure (possible chimney or tank) is identified along the north-eastern boundary.	Additional residential properties with gardens are recorded to the west and south west of the site.
1937	The site is recorded to have expanded to the south and south east with a circular gas holder structure identified in the southern corner and a rectangular building identified in the eastern corner.	No significant changes identified.

Date	Land use/features on site	Land use/features in vicinity of site (of relevance to the assessment)
1971	An electricity sub-station is identified adjacent to the site entrance along the north-eastern boundary. A rectangular tank is identified in the eastern corner of the site (a rectangular concrete slab is still present on the site at this location indicating that this may have been an above ground tank). A square structure along the south-eastern boundary is identified (recorded to be a governor compound on the plan provided from the National Grid archive).	The baths to the south of the site are no longer identified and the iron works are now recorded as an agricultural engineering works and builders yard.
1976	(British Gas drawing DE/Sx/4/200 (1976) as described by Harrison & Co. in 1993) This plan shows that the services to the site consisted of several 8" and 12" gas mains connecting the pressure reduction plant to the mains running along Ford Road. These mains went on to supply both Arundel town and Slindon.	No significant changes identified.
1979-2018	The circular tank structure in the southern corner of the site and the rectangular tank structure in the east of the site are no longer identified. The remaining features identified include the electricity sub-station and the square feature along the south eastern boundary which is recorded as a gas valve compound.	No significant changes identified.

3.8 Sensitive land uses

No national or internationally designated sensitive land uses such as sites of special scientific interest (SSSI) have been identified in the vicinity of the site. A comprehensive evaluation of ecological receptors is outside the scope of this report.

An ecology survey was undertaken during the Atkins 2011 investigation in June 2011 during vegetation clearance. Where nesting birds were encountered, the investigation locations were reportedly removed.

3.9 Initial conceptual model

The information presented in the previous sections, has been used to compile an initial conceptual model. The identified potential sources of contamination, associated contaminants and receptors have been considered with plausible pathways that may link them. The resulting potential pollutant linkages are considered in **Section 3.9.4**.

3.9.1 Summary of potential contaminant sources

Potential sources and contaminants of concern are summarised in Table 3.

Table 3: Potential sources and types of contamination

Potential sources	Contaminants of concern
On-site historical	
1. Former gas works (c.1840-pre 1994) with residual infrastructure still present	Fuel oils, lubricating oils, heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), chlorinated and other organic solvents, sulphates, asbestos, etc.
2. Electricity sub-station (adjacent to the site entrance along the north eastern boundary)	Fuel oils, lubricating oils, PCBs.
3. Former tank (identified in the eastern corner of the site)	Petroleum hydrocarbons, Unknown fill material (but potentially including heavy metals, ash, clinker, sulphates, PAHs, asbestos etc).
4. Nursery gardens (south western portion of the site)	Pesticides, herbicides, heavy metals (in particular lead and arsenic).
On-site present day	
5. Made ground (i.e. fill material)	Unknown fill material (but potentially including heavy metals, ash, clinker, sulphates, PAHs, asbestos etc).
Off-site (current and historical)	
6. The former Tortington Iron Works to the south of the site (c. 1899 - early 1960s)	Fuel oils, lubricating oils, heavy metals, polycyclic aromatic hydrocarbons (PAHs), asbestos, etc.
7. Sewage works to the south of the former iron works	Sewage sludges containing various chemicals, including: fuel oils, lubricating oils, heavy metals, PCBs, PAHs, chlorinated and other organic solvents, sulphates, pharmaceutical chemicals, surfactants, etc.
Gas sources and gas generation potential in line with BS8576	
8. Alluvium and White Chalk Sub-group underlying the site (very low gas generation potential)	Carbon dioxide.
9. Burial ground at mortuary to the west of the site (c. 1897 –present)	Carbon dioxide, methane and trace gases.
10. Landfills (1960 to 1974) off-site (low to moderate gas generation potential but potentially high if disturbed)	Carbon dioxide, methane and trace gases.

Based upon identified sources of contamination, the operation of the former gas works and presence of residual infrastructure (and to a lesser degree the electricity substation) represents the most significant source of contamination.

Within the local area, the greatest potential for contamination lies with the historical operation of local landfills and industry (particularly to the south of the site) in the form of the in-filled baths/Penfold Works landfill, the former Tortington Ironworks and the sewage works. In addition, the mortuary and cemetery neighbouring the site on the western side of Ford Road pose an on-going potential source of gaseous contamination.

3.9.2 Sensitive receptors

Sensitive receptors identified at the site include:

- Future site occupants;
- Adjacent site users;
- Vegetation;
- Potable water supply pipes;
- Groundwater beneath the site;
- Surface watercourses (including abstractions from a spring for local fish farm/cress pond operations, and the River Arun); and
- Ecological receptors groundwater in wider aquifer body (including abstractions local fish farm/cress pond operations).

Please note that construction workers have not been identified in the conceptual model as receptors because risks are considered to be managed through health and safety procedures including CDM regulations.

3.9.3 Summary of plausible pathways

The plausible pathways are summarised below:

- Direct contact (soil and dust ingestion, dermal contact, dust and fibre inhalation);
- Ground gas and soil gas inhalation;
- VOC vapour inhalation;
- Vertical and lateral migration including leaching;
- Root uptake; and
- Chemical attack of infrastructure (including water supply pipes) and buildings.

3.9.4 Data gaps and uncertainties

For the purpose of this report, RSK has relied upon the factual information contained within the reports listed in **Section 1.4**, and in doing so, has relied completely on the quality controls in place during the collection and analysis of the data presented therein.

3.9.5 Potentially complete pollutant linkages

The outline conceptual model and an estimate of the risk associated with each linkage is summarised in **Table 4**. The risk classification has been undertaken in accordance with CIRIA C552 (Rudland et al., 2001), a summary of which is included in **Appendix C**.

Table 4: Risk estimation for potentially complete pollutant linkages

Potential Contaminant	Potential receptor	Possible pathway	Likelihood	Severity	Risk and justification
Fuel oils, lubricating oils, heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), chlorinated and other organic solvents & sulphates	Future residents Neighbouring site users/residents	Direct contact (soil, dust ingestion, dermal contact, dust and fibre inhalation)	Highly likely	Moderate	Although the proposed development design option does not include private gardens and a large proportion of the ground surface would be covered by hardstanding or buildings, soft landscaping still makes up roughly a quarter of the development, thereby creating a linkage. This assumes that the landscaping does not include edible vegetation, such as fruit trees.
		Soil vapour inhalation	High likely	High	Potential for gases derived from the former gas works to have accumulated in the unsaturated zone and former underground structures, and volatilisation of compounds from groundwater, thereby causing subsequent vapour inhalation by residents while indoors (based on a 0-6 year old female child).
		Vertical and lateral migration including leaching	High likely	High	Potential for new and historical service trenches and foundations to create pathway to hydrocarbon/VOC-impacted groundwater and create a linkage. The tidally-influenced groundwater will act to transport the contaminated groundwater towards the River Arun at low tide.
	River Arun Groundwater (including local fish farm/cress pond operations)	Chemical attack of infrastructure and buildings	High	High	Potential for chemicals derived from the former gas works to have dissolved and accumulated in the saturated zone, thereby creating a linkage.
		Root uptake and sediment ingestion via pisciculture	High	High	
		Ground gas and soil gas inhalation	Medium	Moderate	Potential for gases to have accumulated in the unsaturated zone, thereby causing subsequent vapour inhalation by residents while indoors.

Potential Contaminant	Potential receptor	Possible pathway	Likelihood	Severity	Risk and justification
Methane and CO ² generated from made ground, natural soil and adjacent cemetery & former landfills	Future residents	inhalation	Medium	Moderate	Asbestos in made ground likely to be mobilised during construction works and, as in doing so, may pose risk to adjacent site users during construction works, thereby creating a linkage.
Asbestos	Future residents and also adjacent site users during construction phase	Direct contact (soil, dust ingestion, dermal contact) Root uptake	Medium	Low	Although the proposed development design option does not include private gardens and a large proportion of the ground surface would be covered by hardstanding or buildings, soft landscaping still makes up roughly a quarter of the development, thereby creating a linkage.

Potential Contaminant	Potential receptor	Possible pathway	Likelihood	Severity	Risk and justification
Pesticides & herbicides	Vegetation Ecological receptors Groundwater (including local fish farm/cress pond operations)	Sediment ingestion via pisciculture	Medium	Low	Potential for chemicals derived from the former nursery gardens to have dissolved and accumulated in the saturated zone, thereby creating a linkage.

Potentially complete pollutant linkages have been identified on site with respect the identified receptors on site and will need to be further assessed by means of appropriate site investigation. Linkages with a risk of moderate or above that will form the primary driver for the scope of site investigation works comprise:

- Chemical contamination originating from the former gas works, including fuel oils, lubricating oils, heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), chlorinated and other organic solvents & sulphates in terms of the potential risk posed by:
 - Direct contact (soil, and dust, dermal contact, dust and fibre inhalation) by future site occupants and adjacent site users;
 - Soil vapour inhalation of vapour-phase fuel oils and VOCs in the unsaturated zone in terms of the potential risk posed to future residents and adjacent site users;
 - Vertical and lateral migration including leaching via groundwater and surface water impacting ecological receptors (fish and cress farms), the River Arun and the Principal Chalk Aquifer;
 - Root uptake by future landscaping (soils) and local cress farms (via groundwater), and sediment ingestion via local pisciculture (via groundwater); and
 - Chemical attack to future infrastructure and buildings via chemicals in the soil/groundwater beneath the site originating from the former gas works, such as hydrocarbons, petroleum spirit and VOCs.
- Methane, carbon dioxide and trace gases generated from made ground, landfilling and the local cemetery in terms of the potential for gases to have accumulated in the unsaturated zone, thereby causing subsequent vapour inhalation by residents while indoors; and
- Asbestos in terms of the potential risk posed to future residents, and also to adjacent site users during construction phase, via direct contact with soil, dust or fibres (ingestion, dust and fibre inhalation).

4 PREVIOUS SITE INVESTIGATION METHODOLOGIES

4.1 Summary of works completed to date

A summary of the intrusive investigation works and subsequent ground gas and groundwater monitoring that has been carried out on site to date by third parties is detailed below in **Table 5**:

Table 5: Summary of previous intrusive investigation work

Year	Consultant	Works Completed	Rationale
1998	Harrison & Company	Twenty-two machine dug trial pits on the subject site & adjacent grazing field to the south	Desk study to ascertain past land use purposes, former site boundaries and presence of buildings or structures together with their approximate locations.
2000	Atkins	Five boreholes with groundwater monitoring wells (Referenced BH1-BH5) - All subsequently decommissioned	Harrison & Co. Carried out a site investigation of the site in 1988, details of which are presented in their report.
		Two linear trial trenches (Referenced TT1 and TT2)	
		Fourteen machine dug trial pits (Referenced TP1-TP14)	No specific rationale provided.
		Surface water sampling of adjacent ditch - one round	
		Groundwater sampling of monitoring wells - one round	
2011	Atkins	Five hand-dug/augured pits (Referenced VP200 to VP204) to a maximum depth of 1.30 mbgl.	To enable collection of soil & leachate samples across the site.
		Five boreholes with groundwater monitoring well (Referenced BH101-BH105) to a maximum depth of 11.00 mbgl.	Replacement wells for BH1-BH5 (2000). Due to visual evidence of hydrocarbon impact in BH101, a dual groundwater monitoring well was installed within the Alluvium (BH101S) and the Chalk (BH101D). N.B. Visual evidence of hydrocarbon impact was also noted in the Chalk during drilling).
		Seventeen trial pits (Referenced TP101 to TP115, including TP109A & B and TP108A & B) to a maximum depth of 2.70 mbgl	To enable collection of soil & leachate samples across the site & target specific historical structures (e.g. larry residues near TP5 (2000))

Year	Consultant	Works Completed	Rationale
		Surface water sampling of adjacent ditch - one round	Down-stream of the site & to the north of the sluice gate where two drainage ditches converge and join the River Arun.
		Groundwater sampling & soil vapour sampling - two rounds	Since visual and olfactory evidence of hydrocarbon impact was identified in the northern and north eastern areas of the site during vapour well installation, one vapour sample per sampling round was also collected near TP111 (VS201-temp).
		Permeability testing & tidal monitoring	Aquifer permeability testing was undertaken at BH101D, BH102 & BH103 (all installed within the Chalk Aquifer) and continuous groundwater elevation monitoring was undertaken at BH101D, BH104 and BH105 to determine the impact of tidal variation in the River Arun on the groundwater elevation beneath the site.
2012	Atkins	Passive soil vapour sampling using Tenax tubes and ambient air monitoring using SUMMA canisters.	In order to supplement the vapour data collected for the site during the 2011 investigation. Boundary and central site locations.

4.2 Sampling strategy and methodology

The specific techniques adopted for the previous investigations are detailed in the relevant reports detailed in **Section 1.4**.

4.2.1 Investigation locations

The site work was carried out by Harrison & Co. and Atkins between 1998 and 2011, and comprised the activities summarised in **Table 5**, along with the rationale for each exploratory location (where available).

4.2.2 Soil sampling, in-situ testing and laboratory analysis

Sample selection was designed to ensure a suitable spread of data, both laterally and vertically which also included samples from the deeper (natural) strata. Selected soil and leachate samples were analysed for some or all of the following analytes during the earlier investigations based on visual and olfactory indicators (including PID results):

- Asbestos screen and identification, loss on ignition, moisture and stone content;
- Inorganic parameters: pH, soil organic matter (SOM), total sulphate, sulphur, phenols, total, free and complex cyanide, thiocyanate, ammonium, chloride, boron;
- Metals: arsenic, chromium, copper, lead, selenium, zinc, cadmium, mercury and nickel;
- Polycyclic aromatic hydrocarbons (PAHs);

- Benzene, toluene, ethylbenzene and xylene (BTEX); and
- Total petroleum hydrocarbon (TPH) criteria working group (CWG) banding with aliphatic/aromatic split.

4.2.3 Groundwater monitoring and levelling

Atkins (2012) report describes the most recent groundwater monitoring, thus:

'Continuous groundwater level monitoring was conducted as part of the Atkins 2011 investigation in three boreholes (BH101D, BH104 and BH105) with response zones in the Chalk. One set of groundwater levels measured at high tide (at 00:34 on 15 July 2011) and one at low tide (at 19:24 on 7 July 2011) are presented in Table 2.3 [of the aforementioned report]. Figures 4a and 4b [presented in the aforementioned report] present groundwater contour plots inferred from the groundwater monitoring data for high tide and low tide, respectively.

'Groundwater flow at high tide is towards the west/north west, with a reversal in flow direction during low tide (flowing in a south easterly direction towards the River Arun). There is approximately 12.5 hours between peak high tides. The tidal monitoring indicates that there is significant tidal variation in the groundwater level at the site (up to approximately 2.00m variance).'

4.2.4 Groundwater developing, sampling and analysis

Details of the groundwater developing, sampling and analysis are presented in the respective reports outlined in **Section 1.4**.

The rationale for groundwater analysis during the various monitoring rounds is presented in **Table 5**.

Groundwater samples were analysed for some or all of the following analytes during the earlier investigations:

- Inorganic parameters: pH, total organic carbon (TOC), suspended solids, conductivity, total sulphate, sulphide, phenols, total, free and complex cyanide, thiocyanate, ammonium, chloride;
- Metals: arsenic, chromium, copper, iron, lead, selenium, zinc, cadmium, mercury and nickel;
- PAHs;
- BTEX; and
- TPH CWG.

4.2.5 Ground-gas and vapour monitoring

There is no record of any previous ground-gas monitoring at the site, however Atkins' 2011 and 2012 reports describes the soil vapour monitoring, thus:

2011 soil vapour sampling

'Soil vapour samples were collected from four of the five permanent vapour well locations (VP200, VP202, VP203 and VP204) on 7 and 15 July 2011. In addition,

samples were taken adjacent to TP111 using the temporary AMS vapour probe (and labelled VP201-temp). Sampling was not possible from the permanent well installation at VP201 due to water saturation of the filter block at the time of sampling. Prior to sampling, the well volume was purged using a gas syringe. A low flow air sampling pump was used to draw a fixed volume of gas through atomic thermal desorption (ATD) tubes, preprepared by Chemex Limited (a UKAS accredited laboratory) with 'Tenax' sorbant. The tubes were submitted for thermal desorption-mass spectrometry analysis of the following:

- VOCs including naphthalene, tentatively identified compounds (TICs) and speciated aliphatic; and*
- Aromatic petroleum hydrocarbons in accordance with the CWG fractionations.'*

2012 soil vapour sampling

'Passive samplers (ATD tubes) [Tenax Tube analysis carried out using an Automated Thermal Desorption (ATD) unit] were placed on the site boundaries and in the centre of the site for a period of one week on two occasions. The sampling was undertaken to coincide with settled weather conditions. The two rounds were undertaken on the following dates:

- Round 1: start date 20 February 2012, left for a period of seven days (approximately 168 hours); and*
- Round 2: start date 28 February 2012, left for a period of approximately nine days (274.5 hours).'*

'Prior to the sampling undertaken in 2012, vapour monitoring of ambient air had only been conducted on one occasion over a five minute period. It was therefore recommended that ambient air sampling be undertaken over a short to medium term (period of 8 hours) in order to gain an understanding of average conditions. Sampling was therefore undertaken using SUMMA canisters on two occasions (20 and 28 February 2012) over a period of 8 hours, both sampling rounds targeted to coincide with settled weather conditions. The SUMMA canisters were placed in the same two locations on both rounds:

- Location 1: north west/western corner of the site adjacent to the residential housing; and*
- Location 2: north eastern portion of the site in the vicinity of TP5, TP111, TP113 and VP201-temp.*

Continuous monitoring was also conducted using a PID, to provide continuous logging during the vapour sampling using SUMMA canisters. The PID was located adjacent to the SUMMA canister at Location 2. No readings above the detection limit of the instrument (0.1 ppb) were recorded during monitoring.'

4.2.6 Surface water sampling

Atkins' 2011 report details the results of one surface water sample that was obtained on 13 June 2011 from the surface water drainage ditch located to the north east of the site. The sample was taken down-stream of the site and to the north of the sluice gate where two drainage ditches converge and join the River Arun. The sample was analysed for

the same suite as the groundwater samples, with the results presented in Appendix E.4 of the aforementioned report.

4.2.7 In-situ hydraulic conductivity/infiltration testing

Aquifer permeability testing was undertaken during the Atkins' 2011 investigations at locations BH101D, BH102 and BH103 (all installed within the Chalk Aquifer) and continuous groundwater elevation monitoring was undertaken at BH101D, BH104 and BH105 to determine the impact of tidal variation in the River Arun on the groundwater elevation beneath the site.

4.2.8 Volatile organic compounds in soil gas

The Atkins (2012) report describes the soil gas VOC investigated in dedicated boreholes VP200-VP204 and VS201-temp. Construction and sampling methodology of the soil gas VOC monitoring wells is described in the Atkins' 2011 report, and the monitoring is detailed in these extracts from the Atkins' 2012 report, below:

'In order to supplement the vapour data for the site [collected during the 2011 investigation], soil vapour samples were collected on 28 February 2012 from two of the permanent vapour well locations (VP200 and VP202) and from VP201-temp using a temporary vapour probe.'

'Sampling was undertaken during a rising tide to account for any potential increase in vapour flux during this period.'

- *'Repeat soil vapour sampling from three soil vapour wells installed during the 2011 site investigation, with analysis for TPH Criteria Working Group (CWG) and VOCs (one sampling round). This sampling was undertaken to coincide with a rising/high tide.'*

4.2.9 Ambient air monitoring

The Atkins (2012) report describes the ambient air monitoring, thus:

'Passive samplers (ATD tubes) were placed on the site boundaries and in the centre of the site for a period of one week on two occasions. The sampling was undertaken to coincide with settled weather conditions.'

The monitoring was undertaken over the following time periods:

- *'Seven-day (minimum) passive ambient air sampling along the site boundaries with analysis for BTEX (two sampling rounds);*
- *'Eight-hour continuous ambient air sampling using SUMMA canisters and analysis for TPHCWG, VOCs and tentatively identified compounds (TICs) (two sampling rounds); and*
- *'Eight-hour continuous semi-quantitative ambient air VOC monitoring using a PID capable of semi-quantitative measurement of total VOCs in parts per billion (ppb) (two rounds).'*

'Prior to the sampling undertaken in 2012, vapour monitoring of ambient air had only been conducted on one occasion over a five minute period. It was therefore

recommended that ambient air sampling be undertaken over a short to medium term (period of 8 hours) in order to gain an understanding of average conditions.

Sampling was therefore undertaken using SUMMA canisters on two occasions (20 and 28 February 2012) over a period of 8 hours, both sampling rounds targeted to coincide with settled weather conditions. The SUMMA canisters were placed in the same two locations on both rounds:

- Location 1: north west/western corner of the site adjacent to the residential housing; and*
- Location 2: north eastern portion of the site in the vicinity of TP5, TP111, TP113 and VP201-temp.'*

Continuous monitoring was also conducted using a PID, to provide continuous logging during the vapour sampling using SUMMA canisters. The PID was located adjacent to the SUMMA canister at Location 2. No readings above the detection limit of the instrument (0.1 ppb) were recorded during monitoring.'

5 GROUND CONDITIONS

A summary of the ground conditions encountered during the preceding site investigation works undertaken on site are detailed in the following sections.

5.1 Soil strata

Preceding exploratory holes advanced by both Harrison and Co. and Atkins revealed that the site is underlain by a variable thickness of made ground overlying Alluvium with the White Chalk Sub-group encountered at depth. This appears to confirm the stratigraphical succession described within the initial conceptual model.

For the purpose of discussion, the ground conditions are summarised below in **Table 6** and the strata discussed in subsequent subsections:

Table 6: General succession of strata encountered

Strata	Proven Thickness (m)	Description	Additional Detail
Made Ground	Absent to 3.00 m*	Variable across the site, but generally comprised firm, sandy, gravelly clay and fine to medium, gravelly, clayey sand with frequent brick, chalk and flint gravels and fragments of clinker, coal and metal.	Greatest depths in the areas that were recorded to be formerly occupied by gas holders and pipes.
Alluvium	0.70 m to 6.30 m	Stiff, silty, very gravelly clay or clayey gravel.	-
White Chalk Sub-group	>3.80 m to >7.60 m	Structureless fine chalk composed of gravels and chalk cobbles in a soft off-white/grey clay matrix.	Base not proven.
Note: * Maximum thickness of made ground of 3.00 m was identified during the Harrison and Co. site investigation in 1988, detailed within their 1993 desk study report. Exact details of where this thickness of made ground was identified are not reported. The maximum proved thickness of made ground identified during Atkins' site investigations is 2.7 m, located at BH101 in the north of the site.			

5.1.1 Groundwater

The depth to the groundwater table at high tide has been measured (Atkins, July 2011) at approximately 2.00 m AOD, and at low tide at approximately 0m AOD. Suspected perched water was also identified in the trial pits during the 2011 investigation at depths ranging from 1.3 to 2.65 mbgl.

Tidal monitoring undertaken in July during the 2011 Atkins investigation indicated that there was significant tidal variation in the groundwater level at the site (up to

approximately 2.00 m variance). Groundwater beneath the site may, therefore, be affected by saline intrusion. The failure to establish a groundwater flow direction during the 2001 groundwater monitoring was attributed to tidal influence. It is also possible that localised perched water may also be present in the made ground.

5.1.2 Results of permeability testing

The results of the permeability testing undertaken during the Atkins' 2011 investigation were not provided for review.

5.1.3 Visual/olfactory evidence of soil and groundwater contamination

The Atkins 20112 report summarise the visual/olfactory evidence of soil and groundwater contamination throughout the numerous site investigations, thus:

'A number of visual and olfactory indicators of potential contamination have been identified in the Made Ground, Alluvium and Chalk during intrusive investigation undertaken to date. These are summarised in Table 2.2 [of the aforementioned 2012 report], which includes preliminary screening for volatile organic compound (VOC) vapours undertaken using a photoionisation detector (PID) (MiniRAE 2000 VOC detector). Figure 3 [of the aforementioned 2012 report] presents a plan identifying the spatial distribution of visual and olfactory evidence of hydrocarbon contamination across the site. Specific details of any visual and/or olfactory evidence of contamination identified during the Harrison and Co. site investigation in 1988 are not provided within their desk study report (Ref. 3) [of the aforementioned 2012 report], and therefore these details are absent from Table 2.2 [of the aforementioned 2012 report and reproduced as Table 7 below].'

Table 7: Visual and Olfactory Observations and PID Readings

Location	Strata	Depth (m bgl)	Visual/Olfactory Observation	Max VOCs (ppm)
BH1	CHK	6.5-10.0	Occasional dark grey staining and slight odour (type not specified).	-
BH3	MG	0.0-0.6	Odour (type not specified).	-
	ALV	3.2	Odour (type not specified).	-
		4.3	Slight odour (type not specified).	-
BH5	CHK	6.0-10.0	Hydrocarbon odour.	-
TP2	MG	1.5-2.2	Foul lime, black staining, pockets of tar, phenol odour.	-
		1.8	Tar stained gravel.	-
	N/A	1.8	Dark brown water with a brown foam and tar odour.	-
TP5	MG	0.1-1.0	Ash and a pocket of tar contaminated soil.	-
		1.0-1.7	Heavy tar contamination.	-

Location	Strata	Depth (m bgl)	Visual/Olfactory Observation	Max VOCs (ppm)
	ALV	1.7-2.0	Tar contamination.	-
	N/A	1.2	Tar contaminated water with sheen contained within a buried pipe.	-
TP7	MG	0.1-1.2	White ash.	-
TP8	MG	0.1-0.95	Ash, clinker and spent oxide.	-
	N/A	1.2	Dark brown/green water with a phenol/oil odour and sheen contained within a buried pipe.	-
TP10A	MG	0.1-1.9	Ash.	-
TP14	MG	0.1-1.0	Ash, clinker and a slight gas works odour.	-
TT2A	MG	0.0-1.9	Ash.	-
		1.8	Anaerobic odour and black staining.	-
TT2B	MG	1.0-1.1	Anaerobic odour and black staining.	-
BH101	MG	0.0-1.2	Clinker.	-
	ALV	1.5-2.7	Black mottling and occasional pockets of saturated black tar. Faint hydrocarbon odour from 1.5-1.8 m bgl. Strong hydrocarbon odour from 1.8-2.7 m bgl.	-
		2.8-3.4	Dark grey/black clay and gravels with strong hydrocarbon odour and saturated with free product.	-
	CHK	3.4-7.5	Pockets of free phase product and black mottling with a moderate to slight hydrocarbon odour.	-
	CHK	7.5-11.0	Slight hydrocarbon odour.	-
BH103	MG	0.0-0.5	Clinker.	-
BH105	MG	0.3-2.0	Clinker.	-
BH104	MG	0.0-1.8	Clinker.	-
		3.5-3.65	Faint hydrocarbon odour.	-
TP101	MG	0.0-0.4	Clinker.	-
		0.4-0.6	Black ash and clinker.	0.1
		0.6-0.9	Occasional clinker.	0.1
TP102	MG	0.0-0.3	Clinker.	-
TP103	MG	0.0-0.8	Clinker.	0.2
TP104	MG	0.0-0.5	Occasional clinker.	<0.1
TP105	MG	0.9-1.3	Clinker gravels and black ash.	0.1

Location	Strata	Depth (m bgl)	Visual/Olfactory Observation	Max VOCs (ppm)
TP106	MG	0.0-0.95	Clinker.	0.3
TP108A	MG	0.0-1.2	Clinker.	0.2
TP108B	MG	0.9-2.5	Occasional clinker. Slight hydrocarbon odour from 1.4-1.9 m bgl. Strong hydrocarbon odour from 1.9-2.5 m bgl. Black, hydrocarbon saturated soil from 1.9 m bgl.	0.6
TP109A	MG	0.0-0.8	Clinker. Black stained flints and faint hydrocarbon odour from 0.4-0.8 m bgl.	1.9
TP109B	MG	0.0-1.6	Clinker.	0.0
TP110	MG	0.2-0.5	Clinker.	0.2
TP111	MG	0.2-1.1	Clinker and solidified tar fragments.	0.7
	MG/ALV	1.1-2.0	Clinker and saturated tarry soils. Moderate tar odour from 1.3 m bgl. Strong tar odour from 1.4 m bgl. Slight hydrocarbon/tar odour and occasional black staining from 1.6-2.0 m bgl.	12.7
TP112	MG	0.0-0.2	Clinker.	-
		0.7-0.75	Band of black solidified tar and clinker.	-
TP113	MG	0.0-1.0	Clinker.	2.4
	ALV	0.25-2.3	Pockets of hydrocarbon saturated tarry clay. Strong hydrocarbon/tarry odour.	18.2
TP115	MG	0.9-2.0	Clinker.	0.1
VP200A	MG	0.0-0.3	Solidified tar.	-
VP201	MG	0.0-0.25	Clinker.	-
VP202	MG	0.0-1.0	Clinker.	0.2
VP203C	MG	0.1-0.6	Clinker.	0.2
VP204	MG	0.0-0.3	Clinker.	0.2
		0.85-1.3	Fragments of solidified tar.	0.6
Notes: bgl – below ground level; ppm – parts per million; “-“ PID reading not taken; MG – Made Ground; ALV – Alluvium; CHK – Chalk; N/A – not applicable.				

Atkins reports also stated that:

‘Evidence of asbestos has not been visually identified during any of the site investigations undertaken to date, and asbestos has not been positively identified within any of the soil samples submitted for analysis.’

5.2 Ground gas regime

RSK have not identified that ground gas monitoring has been undertaken at the site. Only soil vapour (VOC) sampling results were made available for review. Given the presence of alluvium at the site, the tidally-influenced groundwater regime, and the nature of the proposed residential development, there is the potential for gases to accumulate in the unsaturated zone, thereby causing a potential risk of subsequent vapour inhalation by residents while indoors.

5.3 Refinement of the initial conceptual site model

The preliminary investigation of the potential pollutant linkages identified within the initial CSM has identified that plausible linkages appear limited to the risks posed to human health, and the natural and built environment from ground, groundwater and vapour in the unsaturated zone impacted from the former gas works.

5.3.1 Uncertainty

The results of the 2011 permeability testing undertaken by Atkins have not been made available for review. No ground-gas data is available for review as part of this assessment.

6 QUANTITATIVE RISK ASSESSMENT

In line with CLR11 (EA, 2004), there are two stages of quantitative risk assessment, generic and detailed. The GQRA comprises the comparison of soil, groundwater, soil gas and ground gas results with generic assessment criteria (GAC) that are appropriate to the linkage being assessed.

6.1 Linkages for assessment

Section 5.3 presents the refined conceptual model which identified the linkages that required assessment after the findings of the site investigation had been considered. These linkages together with the method of assessment are presented in Table 8.

Table 8: Linkages for generic quantitative risk assessment

Potentially relevant pollutant linkage	Assessment method
Direct contact with impacted soil by future residents.	Human health GAC in Appendix F for a proposed residential end use without private gardens. Statistical analysis undertaken owing to majority of sampling locations being non-targeted and made ground of similar composition.
Inhalation exposure of future residents to contaminants in the vapour phase.	Human health GAC in Appendix F for soil and groundwater based on indoor inhalation exposure to vapour-phase volatile organic compounds (VOC). Modified inhalation reference concentrations for comparison with measured concentrations of VOC in soil gas.
Leaching of soil contaminants and dissolved phase migration to Principal aquifer and River Arun.	Comparison of leachate data to lowest of those recorded for transitional (estuaries) and coastal waters values in Appendix I for Controlled Waters.
Root uptake.	Comparison of soil data to GAC in Appendix H for phytotoxic effects.
Contaminants permeating potable water supply pipes.	Comparison of soil data to GAC in Appendix J for plastic water supply pipes using UKWIR (2010) guidance.
Concentrations of methane and carbon dioxide in ground gas entering and accumulating in depressions and excavations that could affect workers or enclosed spaces or small rooms in new buildings, which could affect future residents.	Data is not available for an assessment to be undertaken.

6.2 Methodology and results

The methodology and results of the GQRA are presented for each relevant pollutant linkage in turn.

6.2.1 Direct contact with impacted soil by future residents

On the basis of the above assessment, including comparison against the human health GAC (**Appendix F**), it is considered that there are potentially significant risks associated with the soil contamination and, as such, either additional risk assessment or remediation is required. Should a clean cover layer/human health separation layer (such as clean topsoil) be placed at the site in the landscaped areas, the potential risk of direct contact with the soils would sufficiently mitigated.

6.2.2 Inhalation exposure of future residents to contaminants in the vapour phase

Inhalation exposure to soil gas VOC has initially been assessed through direct measurement in the vapour-phase and compared directly to the following criteria:

- VOC in soil gas – published health criteria values multiplied by a factor of 10 as a conservative estimate of concentration reduction (attenuation) between soil gas and indoor air.

Soil gas VOC sampling was most recently undertaken by Atkins in February and March 2012, thus:

- Passive sampling was undertaken at five locations (northern, eastern, southern and western boundaries and in the centre of the site) using Tenax Tubes on 20-28th February (Round 1) and 5th March 2012 (Round 2) (ATD analysis):
 - the results of Round 1 (seven days) indicated that all five samples exceeded the Method Detection Limit (MDL) for benzene and toluene, and samples collected from the southern, northern and western boundaries exceeded the MDL for all BTEX compounds; and
 - Round 2 (nine days) indicated that all five samples exceeded the MDL for benzene.
- Ambient air sampling was undertaken at two locations (eastern and western boundaries) using SUMMA canisters on 20th and 28th February 2012 (BTEX compounds only):
 - neither of the two samples collected using the SUMMA canisters exceeded the laboratory MDL for the compounds tested.
- Soil gas VOC samples were also collected from monitoring wells VP200, VP201-temp, and VP202 on 28th and 29th February 2012:
 - All three samples exceeded the laboratory MDLs for a number of VOC compounds tested using ATD analysis of Tenax Tubes, in particular BTEX, naphthalene, trimethybenzenes, C8-C12 aliphatic hydrocarbons, and C5-C12 aromatic hydrocarbons.
 - The highest concentrations were recorded from VP201-temp located in the north of the site, close to the northeast site boundary, in particular BTEX, naphthalene, trimethybenzenes, and aromatic hydrocarbons. The concentrations also exceeded the human health soil GAC (Generic groundwater assessment criteria (GrAC) for human health: residential scenario (child receptor), and thus require an updated assessment and are likely to require remediation. Of the remaining two samples (VP200 and VP202), only VP202 located in the center of the site recorded

concentrations above the GrAC for benzene, ethylbenzene, xylenes, naphthalene, and trimethybenzenes. Both reported concentrations of C8-C12 aliphatic hydrocarbons, and C8-C12 (VP202) / C8-C10 (VP200) aromatic hydrocarbons above the respective GrACs.

Overall, the assessment of inhalation exposure risks has been undertaken on a multiple lines of evidence approach, whereby the absence of any one of the three pollutant linkages considered above is not sufficient on its own to indicate the absence of an inhalation risk.

6.2.3 Uptake of contaminants by vegetation potentially inhibiting plant growth

The results have been compared with the GAC presented in **Appendix H** for this linkage and assume that the landscaped areas will not be planted with any edible vegetation, such as fruit trees, or home-grown produce. The results indicate that a relevant pollutant may exist on site in relation to phytotoxic effects. However, given that a clean cover layer/human health separation layer is likely to be placed at the site in the landscaped areas, this would also act as a clean growing medium.

6.2.4 Impact of organic contaminants on potable water supply pipes

For initial assessment purposes, the results of the investigation have been compared with the GAC presented in **Appendix J** for this linkage, which are reproduced from *UKWIR Report 10/WM/03/21. Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites* (UKWIR, 2010).

The results indicate that a relevant linkage is likely to exist associated with organic contaminants and therefore polyvinyl chloride (PVC) water supply pipes are expected to be unsuitable for use on the development unless remedial measures are implemented that mitigate the risk.

It should be noted that at the time of this investigation the future routes of water supply pipes had not been established, hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling/analytical strategy may be required at a later date once the routes of the supply pipes are known. In addition, it is recommended that the relevant water supply company be contacted at an early stage to confirm its requirements for assessment, which may not necessarily be the same as those recommended by UKWIR.

6.2.5 Leaching of contaminants to groundwater in principal aquifer and subsequent migration to surface watercourse

The leachate results are summarised in the relevant Atkins' reports. The most recent comparison (Atkins 2011) indicates that concentrations of heavy metals (particularly cadmium, chromium, lead and zinc) in a number of samples, fluoranthene in the sample from TP111, and C10-C35 aromatic hydrocarbons in the sample from TP113, exceed the Controlled Waters GAC for 'transitional (estuaries) and coastal waters'. Cyanide concentrations also exceeded the limit of reporting (LOR) in TP102, TP105, TP108B and TP111.

The concentrations of metals, PAH and TPH, particularly the more mobile and persistent compounds, indicate that leaching to groundwater could be a relevant pollutant linkage.

6.2.6 Migration of dissolved phase contaminants to wider secondary aquifer body

Based on data from Atkins' 2011 monitoring, the comparison indicates that concentrations of naphthols, naphthalene, acenaphthylene, fluoranthene, benzene, toluene, heavy metals (specifically arsenic, chromium, lead and nickel) exceed the Controlled Waters GAC for 'transitional (estuaries) and coastal waters' in groundwater samples collected from BH101S and BH101D in the far north of the site, as illustrated on **Figure 2**.

Groundwater samples from BH101S and BH101D (and, to a lesser degree, BH102, located approximately 45 m south of BH101S/D) also recorded concentrations of aliphatic hydrocarbons (C5-C35) above the LOR of 620µg/l, 270µg/l, and 120µg/l, respectively aromatic hydrocarbons (C5-C35) above the LOR of 21,000µg/l, 30,000µg/l, and 200µg/l, respectively. All other samples reported concentrations of aliphatic and aromatic hydrocarbons below the LOR. Concentrations of heavy metals also exceeded the GACs in samples from BH102, BH104, and BH105, and the GAC for acenaphthylene was exceeded in BH103 in the centre of the site, although to a noticeably lesser degree than in BH101S/D.

The magnitude of these exceedances coupled with exceedances for numerous compounds being detected in wells screened across the shallow aquifer (BH101S) and deeper aquifer (BH101D), indicates the pollutant linkage associated with dissolved phase contaminants migrating in groundwater is complete.

It should be noted however, with respect to heavy metals, that concentrations of chromium were also detected in excess of the GACs in field blank and trip blank samples submitted with the groundwater samples.

A surface water sample (SW1) was collected during Atkins' 2011 monitoring from the surface water drainage ditch located to the north east of the site. The sample was taken down-stream of the site and to the north of the sluice gate where two drainage ditches converge and join the River Arun. The sample recorded concentrations of chromium, lead and zinc that exceed the GAC. Concentrations of all other analytes, including aromatic and aliphatic hydrocarbons, were below their respective LORs.

6.2.7 Ground gas assessment

Although ground gas monitoring was not undertaken during the previous site investigations, given the presence of Alluvium at the site, the tidally-influenced groundwater regime, and the nature of the proposed residential development, there is the potential for gases to accumulate in the unsaturated zone, thereby causing a potential risk of subsequent vapour inhalation by residents while indoors.

6.3 Environmental assessment conclusions

Based upon an outline assessment of data from preceding phases of investigation work, relevant pollutant linkages that require further action, either in the form of further investigation or direct remediation, comprise the following:

- Chemicals originating from the former gas works, including fuel oils, lubricating oils, heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), chlorinated and other organic solvents & sulphates in terms of the potential risk posed by:
 - Direct contact (soil, and dust, dermal contact, dust and fibre inhalation) by future site occupants and adjacent site users;
 - Soil vapour inhalation of vapour-phase fuel oils and VOCs in the unsaturated zone in terms of the potential risk posed to future residents and adjacent site users;
 - Vertical and lateral migration including leaching via groundwater and surface water impacting ecological receptors (fish and cress farms), the River Arun and the Principal Chalk Aquifer; and
 - Chemical attack to future infrastructure and buildings via chemicals in the soil/groundwater beneath the site originating from the former gas works, such as hydrocarbons, petroleum spirit and VOCs.
- Methane, carbon dioxide and trace gases generated from made ground, landfilling and the local cemetery in terms of the potential for gases to have accumulated in the unsaturated zone, thereby causing subsequent vapour inhalation by residents while indoors.

7 CONCLUSIONS AND RECOMMENDATIONS

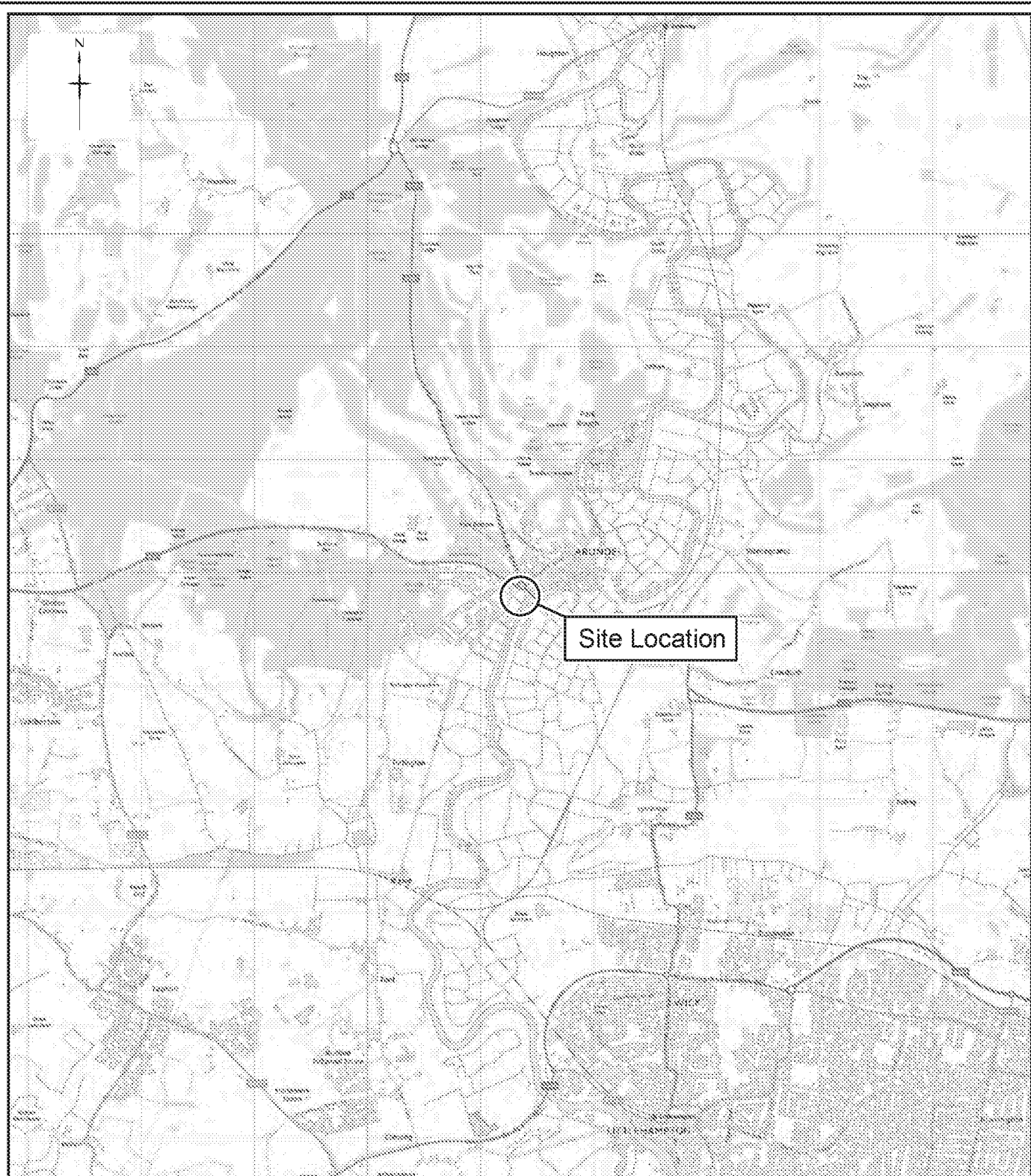
The preparation of an updated PRA has identified a number of potentially complete pollutant linkages with respect the identified receptors on site that will need to be further assessed by means of appropriate site investigation. Linkages with a risk of moderate or above that will form the primary driver for the scope of site investigation works were identified to comprise:

- Chemical contamination originating from the former gas works, including fuel oils, lubricating oils, heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), chlorinated and other organic solvents & sulphates in terms of the potential risk posed by:
 - Direct contact (soil, and dust, dermal contact, dust and fibre inhalation) by future site occupants and adjacent site users;
 - Soil vapour inhalation of vapour-phase fuel oils and VOCs in the unsaturated zone in terms of the potential risk posed to future residents and adjacent site users;
 - Vertical and lateral migration including leaching via groundwater and surface water impacting ecological receptors (fish and cress farms), the River Arun and the Principal Chalk Aquifer;
 - Root uptake by future landscaping (soils) and local cress farms (via groundwater), and sediment ingestion via local pisciculture (via groundwater); and
 - Chemical attack to future infrastructure and buildings via chemicals in the soil/groundwater beneath the site originating from the former gas works, such as hydrocarbons, petroleum spirit and VOCs.
- Methane, carbon dioxide and trace gases generated from made ground, landfilling and the local cemetery in terms of the potential for gases to have accumulated in the unsaturated zone, thereby causing subsequent vapour inhalation by residents while indoors; and
- Asbestos in terms of the potential risk posed to future residents, and also to adjacent site users during construction phase, via direct contact with soil, dust or fibres (ingestion, dust and fibre inhalation).

Where factual information from previous site investigation works has been appraised, the works have confirmed that the potentially complete pollutant linkages identified in the PRA are effectively complete, such that remedial mitigation measures will be required.

Based upon the factual information provided to date, it is evident that further site investigation will be required to fully classify the existing baseline conditions, notably with respect to assessing the nature of existing groundwater contamination and the potential for ground-gas generation. In addition, an up to date groundwater detailed quantitative risk assessment (DQRA) will also be required to fully establish potential risks to controlled waters and associated remedial requirements.

FIGURES



Contains Ordnance Survey data



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Client

OAKFORD HOMES

Project Title

FORMER ARUNDEL GASWORKS,
FORD ROAD, ARUNDEL

Drawing Title

SITE LOCATION PLAN

Rev	Drawn	Date	Checked	Date	Approved	Date
01	ASC	26.03.18	AK	26.03.18	AK	26.03.18
Dimensions		Scale		Original Size		
m		1:50,000		A4		

Project Number

29780 - R01 (00)

Drawing File

29780 - SLP.dwg

Drawing Number

FIGURE 1

[illegible]

Rev.	Date	Amendment	Drawn	Chkd.	Appd.
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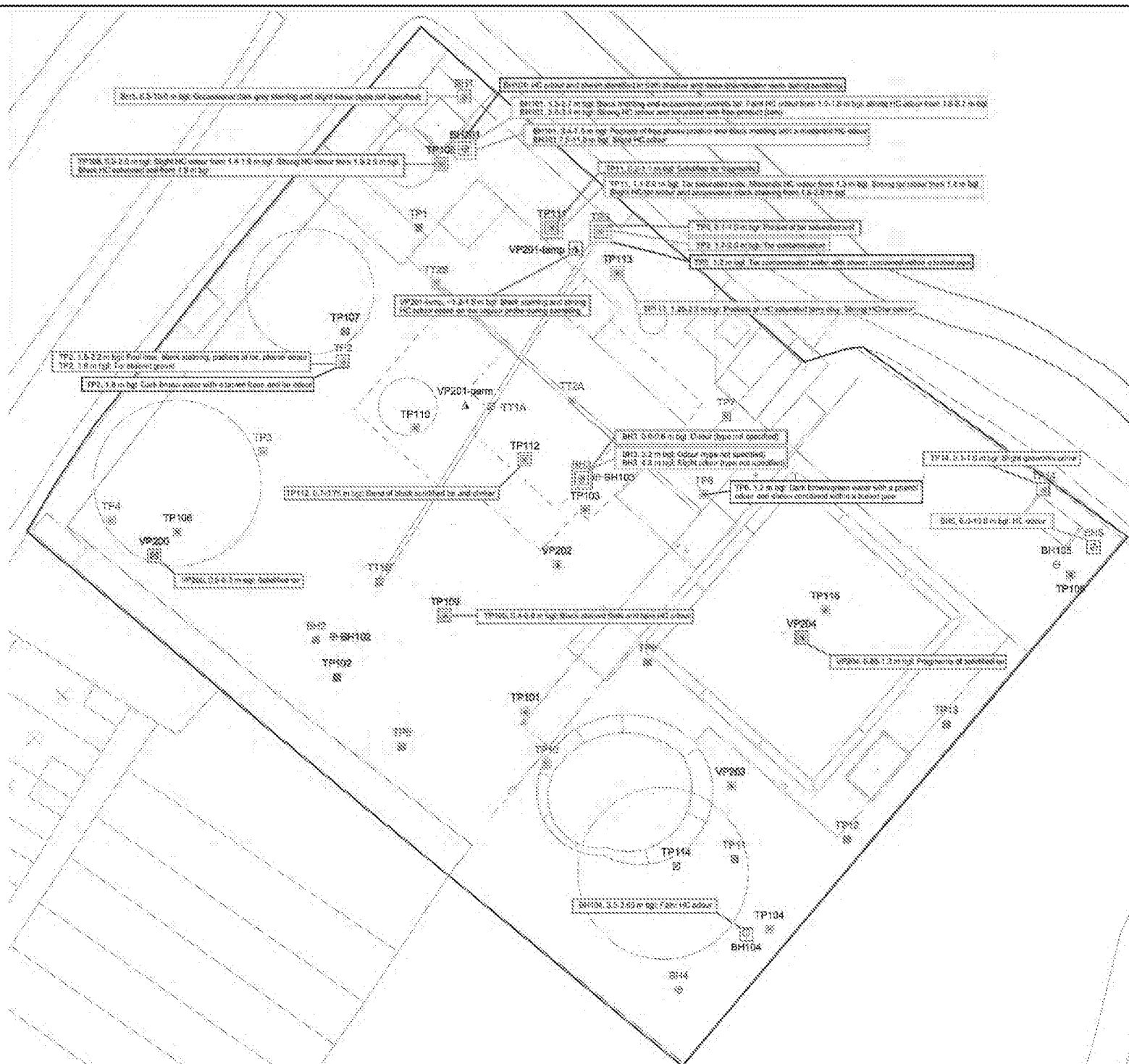
Project Title

FORMER ARUNDEL GASWORKS,
FORD ROAD, ARUNDEL

Drawing Title

ATKINS 'SITE LAYOUT PLAN,
INCLUDING HISTORIC FEATURES AND
SITE INVESTIGATION LOCATIONS'

Drawn	Date	Checked	Date	Approved	Date
ASC	26.03.18	AK	26.03.18	AK	26.03.18
Scale	Wtg Size		Dimensions		
NTS	A3		m		
Project No			Drawing File		
29780 - R01 (00)			29780 (R01-00) Figure 2.dwg		
Drawing No					Rev
FIGURE 2					P1



Rev.	Date	Amendment	Drawn	Chkd.	Appd.
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Project Title _____

FORMER ARUNDEL GASWORKS,
FORD ROAD, ARUNDEL

Drawing Title

ATKINS 'VISUAL AND/OR OLFACTORY EVIDENCE OF HYDROCARBON CONTAMINATION' PLAN

Drawn	Date	Checked	Date	Approved	Date
ASC	09.04.18	AK	09.04.18	AK	09.04.18

Scale NTS	Orig Size A3	Dimensions m
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Project No. 29780 - R01 (00)	Drawing File 29780 (R01-00) Figure 3.dwg
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Drawing No. FIGURE 3	Rev. P1
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APPENDIX A

SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Oakford Homes Ltd (the "client") in accordance with the terms of a contract [RSK Group Standard Terms and Conditions] between RSK and the "client", dated 1st March 2019. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.
2. Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed in writing the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials, unless specifically identified in the Services.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of information, including documentation, obtained from third parties and from the client on the history and usage of the site, unless specifically identified in the Services or accreditation system (such as UKAS ISO 17020:2012 clause 7.1.6):
 - a. the Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely
 - b. the Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection
 - c. the Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services.

RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together with the position of any current structures and underground utilities and facilities, and natural and other activities on-site. In addition, chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on-site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B

SUMMARY OF LEGISLATION AND POLICY RELATING TO CONTAMINATED LAND

Part IIA of the Environmental Protection Act 1990 (EPA) and its associated Contaminated Land Regulations 2000 (SI 2000/227), which came into force in England on 1 April 2000, formed the basis for the current regulatory framework and the statutory regime for the identification and remediation of contaminated land. Part IIA of the EPA 1990 defines contaminated land as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused'. Controlled waters are considered to include all groundwater, inland waters and estuaries.

In August 2006, the Contaminated Land (England) Regulations 2006 (SI 2006/1380) were implemented, which extended the statutory regime to include Part IIA of the EPA as originally introduced on 1 April 2000, together with changes intended chiefly to address land that is contaminated by virtue of radioactivity. These have been replaced subsequently by the Contaminated Land (England) (Amendment) Regulations 2012, which now exclude land that is contaminated by virtue of radioactivity.

The intention of Part IIA of the EPA is to deal with contaminated land issues that are considered to cause significant harm on land that is not undergoing development (see Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance, April 2012). This document replaces Annex III of Defra Circular 01/2006, published in September 2006 (the remainder of this document is now obsolete).

Water Framework Directive (WFD)

The Water Framework Directive 2000/60/EC is designed to:

- enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands that depend on the aquatic ecosystems
- promote the sustainable use of water
- reduce pollution of water, especially by 'priority' and 'priority hazardous' substances
- ensure progressive reduction of groundwater pollution.

The WFD requires a management plan for each river basin be developed every six years.

Groundwater Directive (GWD)

The 1980 Groundwater Directive 80/68/EEC and the 2006 Groundwater Daughter Directive 2006/118/EC of the WFD are the main European legislation in place to protect groundwater. The 1980 Directive is due to be repealed in December 2013. The European legislation has been transposed into national legislation by regulations and directions to the Environment Agency.

Environmental Permitting Regulations (EPR)

The Environmental Permitting (England and Wales) Regulations 2010 provide a single regulatory framework that streamlines and integrates waste management licensing, pollution prevention and control, water discharge consenting, groundwater authorisations, and radioactive substances regulation. Schedule 22, paragraph 6 of EPR 2010 states: 'the regulator must, in exercising its relevant functions, take all necessary measures - (a) to prevent the input of any hazardous substance to groundwater; and (b) to limit the input of non-hazardous pollutants to groundwater so as to ensure that such inputs do not cause pollution of groundwater.'

Water Resources Act (WRA)

The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009 updated the Water Resources Act 1991, which introduced the offence of causing or knowingly permitting pollution of controlled waters. The Act provides the Environment Agency with powers to implement remediation necessary to protect controlled waters and recover all reasonable costs of doing so.

Priority Substances Directive (PSD)

The Priority Substances Directive 2008/105/EC is a 'Daughter' Directive of the WFD, which sets out a priority list of substances posing a threat to or via the aquatic environment. The PSD establishes environmental quality standards for priority substances, which have been set at concentrations that are safe for the aquatic environment and for human health. In addition, there is a further aim of reducing (or eliminating) pollution of surface water (rivers, lakes, estuaries and coastal waters) by pollutants on the list. The WFD requires that countries establish a list of dangerous substances that are being discharged and EQS for them. In England and Wales, this list is provided in the River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. In order to achieve the objectives of the WFD, classification schemes are used to describe where the water environment is of good quality and where it may require improvement.

Planning Policy

Contaminated land is often dealt with through planning because of land redevelopment. This approach was documented in Planning Policy Statement: Planning and Pollution Control PPS23, which states that it remains the responsibility of the landowner and developer to identify land affected by contamination and carry out sufficient remediation to render the land suitable for use. PPS23 was withdrawn early in 2012 and has been replaced by much reduced guidance within the National Planning Policy Framework (NPPF).

The new framework has only limited guidance on contaminated land, as follows:

- *"planning policies and decisions should also ensure that:*
 - *the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including*



land remediation or impacts on the natural environment arising from that remediation;

- *after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and*
- *adequate site investigation information, prepared by a competent person, is presented”.*

APPENDIX C

RISK ASSESSMENT METHODOLOGY

CLR11 outlines the framework to be followed for risk assessment in the UK. The framework is designed to be consistent with UK legislation and policies including planning. Under CLR11, three stages of risk assessment exist: preliminary, generic quantitative and detailed quantitative. An outline conceptual model should be formed at the preliminary risk assessment stage that collates all the existing information pertaining to a site in text, tabular or diagrammatic form. The outline conceptual model identifies potentially complete (termed possible) pollutant linkages (contaminant–pathway–receptor) and is used as the basis for the design of the site investigation. The outline conceptual model is updated as further information becomes available, for example as a result of the site investigation.

Production of a conceptual model requires an assessment of risk to be made. Risk is a combination of the likelihood of an event occurring and the magnitude of its consequences. Therefore, both the likelihood and the consequences of an event must be taken into account when assessing risk. RSK has adopted guidance provided in CIRIA C552 for use in the production of conceptual models.

The likelihood of an event can be classified on a four-point system using the following terms and definitions based on CIRIA C552:

- highly likely: the event appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution
- likely: it is probable that an event will occur or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term
- low likelihood: circumstances are possible under which an event could occur, but it is not certain even in the long term that an event would occur and it is less likely in the short term
- unlikely: circumstances are such that it is improbable the event would occur even in the long term.

The severity can be classified using a similar system also based on CIRIA C552. The terms and definitions relating to severity are:

- severe: short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short-term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000)
- medium: chronic damage to human health ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem
- mild: pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on

Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment

- minor: harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Once the probability of an event occurring and its consequences have been classified, a risk category can be assigned according to the table below.

		Consequences			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/low
	Likely	High	Moderate	Moderate/low	Low
	Low likelihood	Moderate	Moderate/low	Low	Very low
	Unlikely	Moderate/low	Low	Very low	Very low

Definitions of these risk categories are as follows together with an assessment of the further work that may be required:

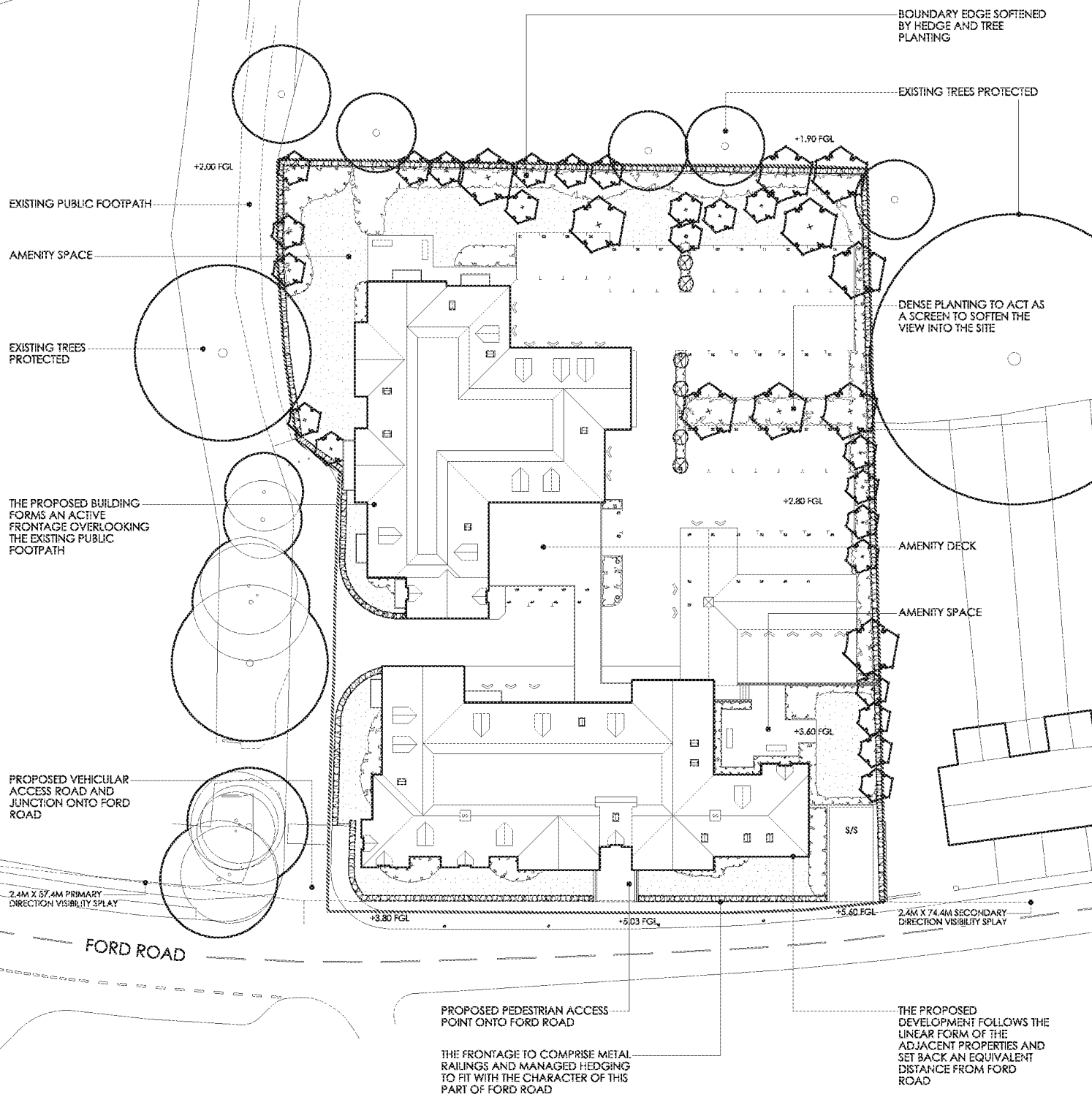
- Very high: there is a high probability that severe harm could occur or there is evidence that severe harm is currently happening. This risk, if realised, could result in substantial liability; urgent investigation and remediation are likely to be required.
- High: harm is likely to occur. Realisation of the risk is likely to present a substantial liability. Urgent investigation is required. Remedial works may be necessary in the short term and are likely over the long term.
- Moderate: it is possible that harm could arise, but it is unlikely that the harm would be severe and it is more likely that the harm would be relatively mild. Investigation is normally required to clarify the risk and determine the liability. Some remedial works may be required in the longer term.
- Low: it is possible that harm could occur, but it is likely that if realised this harm would at worst normally be mild.
- Very low: there is a low possibility that harm could occur and if realised the harm is unlikely to be severe.



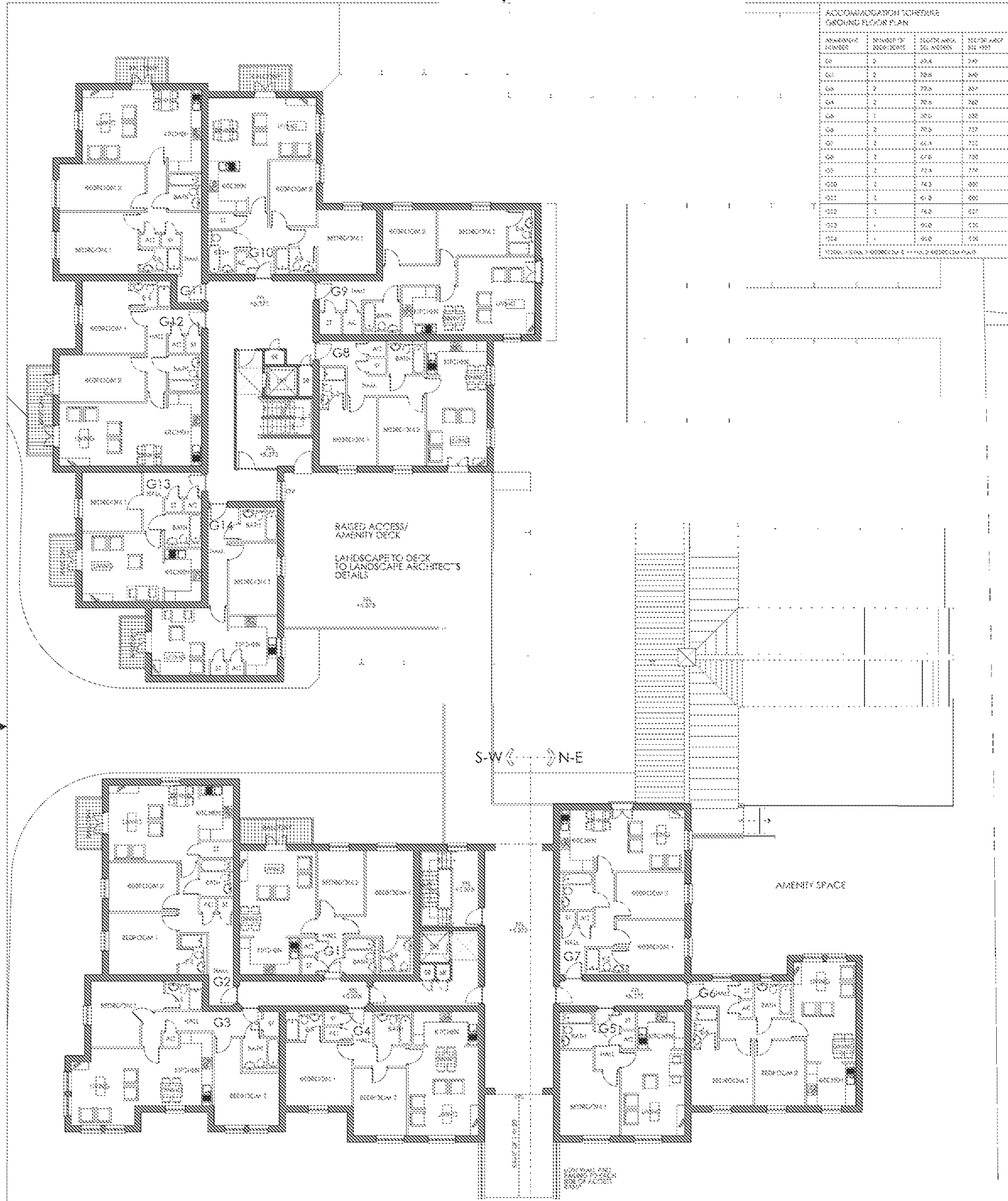
APPENDIX D

PROPOSED DEVELOPMENT PLANS

RIVER ARUN



ACCOMMODATION SCHEDULE GROUND FLOOR PLAN			
APARTMENT NUMBERS	NUMBER OF BEDROOMS	FLOOR AREA SQ. METRES	FLOOR AREA SQ. FEET
G0	2	29.4	317
G01	2	70.6	760
G02	2	77.5	839
G04	2	70.6	760
G05	1	30.6	330
G06	2	70.6	760
G07	2	66.5	717
G08	2	67.6	728
G09	1	72.8	787
G10	2	74.3	802
G11	1	21.8	234
G12	1	74.8	809
G13	1	91.0	978
G14	1	91.0	978
TOTAL: 15 UNITS: 1 BEDROOM 1 + 14 x 2 BEDROOM PLANS			



UPPER GROUND FLOOR PLANS

ARCHITECT:

ARCHITECTURAL & ENGINEERING CONSULTANTS

RESIDENTIAL DEVELOPMENT

77-80 ROAD

ARUN DISTRICT COUNCIL

UPPER GROUND FLOOR PLANS

77-80 ROAD

ARUN DISTRICT COUNCIL

77-80 ROAD

ARUN DISTRICT COUNCIL

77-80 ROAD

PRELIMINARY ISSUE

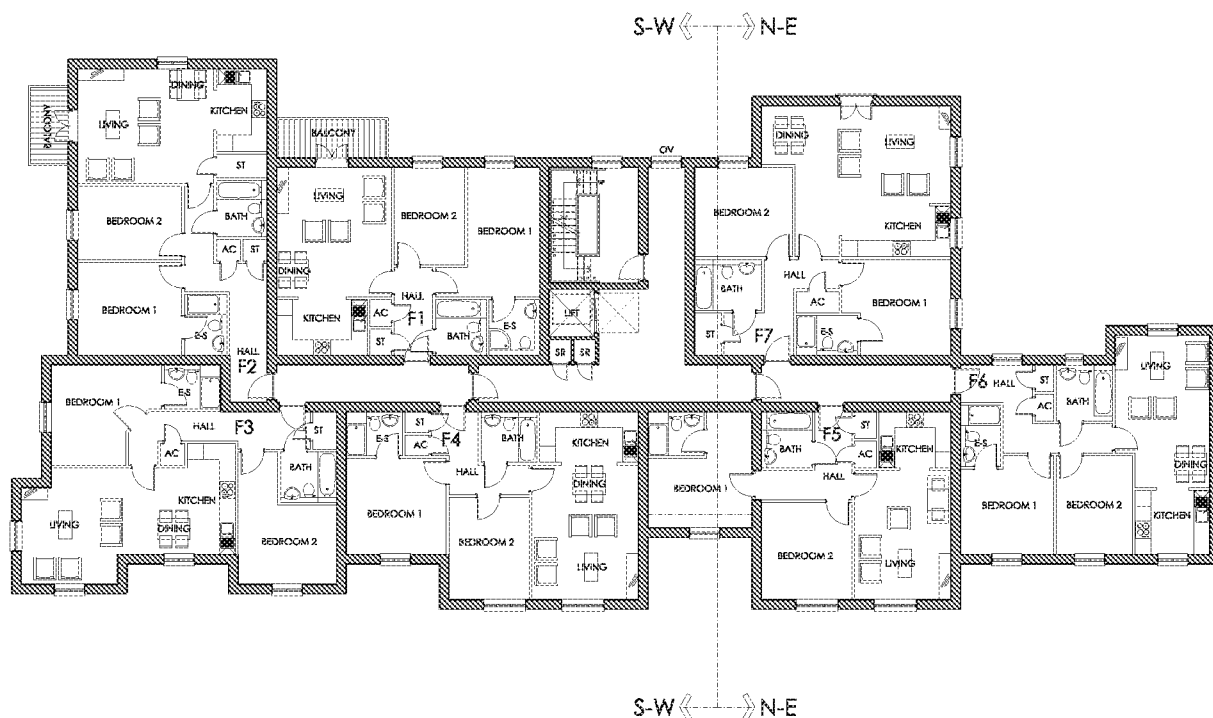
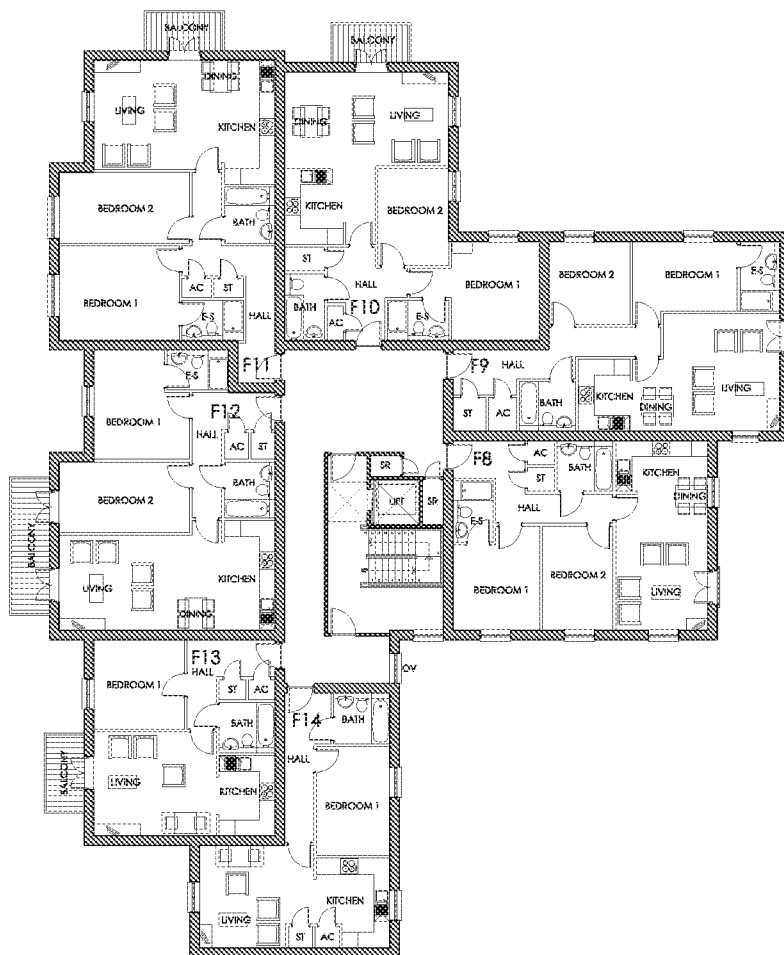
ARUN DISTRICT COUNCIL

77-80 ROAD

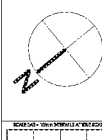
ARUN DISTRICT COUNCIL

77-80 ROAD

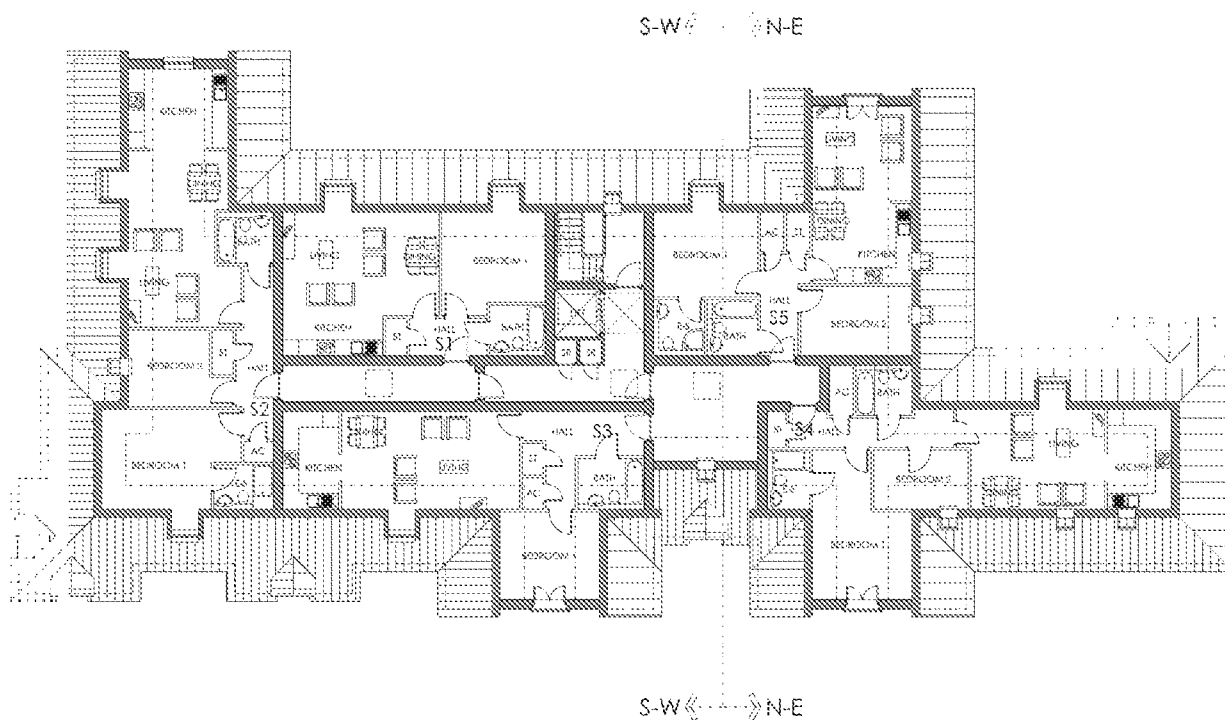
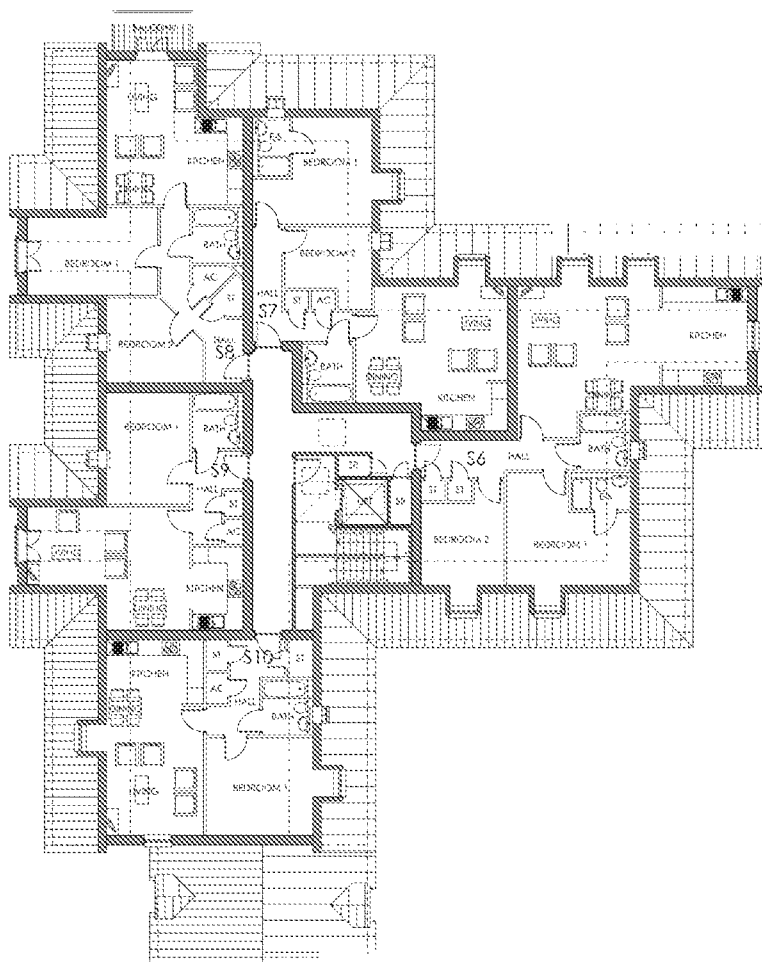
ACCOMMODATION SCHEDULE FIRST FLOOR PLAN			
APARTMENT NUMBER	NUMBER OF BEDROOMS	FLOOR AREA SQ. METRES	FLOOR AREA SQ. FEET
P1	2	69.4	747
P2	2	78.8	848
P3	2	79.3	854
P4	2	70.6	760
P5	2	68.5	737
P6	2	70.3	757
P7	2	84.0	904
P8	2	67.8	730
P9	2	72.4	779
P10	2	74.3	803
P11	2	61.8	669
P12	2	76.8	827
P13	1	90.0	968
P14	1	90.0	968
TOTAL = 2 No. 1 BEDROOM & 12 No. 2 BEDROOM FLATS			



FIRST FLOOR PLANS



ACCOMMODATION SCHEDULE SECOND FLOOR PLAN			
APARTMENT NUMBERS	NUMBER OF BEDROOMS	FLOOR AREA SQ. METERS	FLOOR AREA SQ. FEET
S1	1	24.5	265
S2	2	26.5	286
S3	1	42.1	453
S4	2	24.5	265
S5	2	27.6	296
S6	2	26.5	286
S7	2	27.5	295
S8	2	27.0	291
S9	1	24.3	262
S10	1	26.5	286
TOTAL: S1+S2+S3+S4+S5+S6+S7+S8+S9+S10			



SECOND FLOOR PLANS

ARCHITECT:		
INTERIOR DESIGNER:		
REPRESENTATIVE:		
DATE:		
PROJECT NAME:		
PROJECT ADDRESS:		
PROJECT PHONE:		
PROJECT FAX:		
PROJECT EMAIL:		
PROJECT WEBSITE:		
PROJECT SOCIAL MEDIA:		
PROJECT OTHER:		
PROJECT NOTES:		
PROJECT COMMENTS:		
PROJECT SCHEDULE:		
PROJECT BUDGET:		
PROJECT RISK:		
PROJECT QUALITY:		
PROJECT SAFETY:		
PROJECT SECURITY:		
PROJECT LEGAL:		
PROJECT FINANCIAL:		
PROJECT OPERATIONAL:		
PROJECT MAINTENANCE:		