



## GROUND GAS VERIFICATION PLAN FOR TRITAX PARK MERSEYSIDE, UNIT 3 AND 4

**TE1816-TE-00-XX-RP-GE-001-V01**

**23 DECEMBER 2025**

**Final**

Prepared for:

Tritax Big Box Developments Ltd

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### 1. INTRODUCTION

Tier Environmental was commissioned by Tritax Big Box to undertake a Ground Gas Verification Plan for an area of land referred to as Tritax Park Merseyside, located at Fox's Bank Lane, Cronton, L3 5SU (the "Site"). The Site is generally bounded to the north by the M62 motorway, to the south by Cronton Road and to the east by Fox's Bank Lane. (the "site").

#### 1.1. Proposed Development

This report has been written to aid planning application No. 20/00494/HYB - application for the approval of reserved matters (scale, access, appearance, layout and partial landscaping) comprising of the development of 272,091 (gia) of storage space and distribution floorspace (use class b8) and ancillary offices (use class e(g)), provision of infrastructure submitted pursuant to planning permission 20/00494/hyb. It has been assumed in the production of this report that the redevelopment is to comprise 2 No. industrial warehouses each with associated car parking areas, surface water attenuation ponds and areas of soft landscaping. The units currently proposed are:

- Unit 03 – 266,970 sq ft (24,802m<sup>2</sup>)
- Unit 04- 193,195 sq ft (17,948m<sup>2</sup>)

#### 1.2. Previous Reports

In producing this report, a number of site investigation reports pertaining to the site itself been made available to Tier Environmental:

- Site Investigation Interpretive Report by Parkman (Ref 19399/OR/02 B dated August 1999);
- Factual Report on Ground Investigation by Soil Mechanics (Ref: F3605 dated October 2003);
- Environmental interpretive Report by Mouchel Parkman(Ref: 1002574/R/02B dated March 2004)
- Desk Study Assessment and Gap Analysis Report by Mouchel (Ref: 797035/R.01A dated July 2008);
- Coal Mining Risk Assessment by Baker Barnett Ltd (Ref: -15/NSB/SB dated 12<sup>th</sup> June 2015);
- Preliminary Risk Assessment for the Former Cronton Colliery Site by Tier Environmental Ltd (Ref: TE1163PRA1 dated 4<sup>th</sup> April 2019); and,
- Preliminary Ground Investigation Report for the Former Cronton Colliery by Tier Environmental Ltd (Ref: TE1163PGIR1.2 dated 13<sup>th</sup> August 2020).
- A Ground Investigation Report for Symmetry Park Merseyside, Huyton by Tier Environmental Ltd (Ref: TE1163GIR1.5 dated 29<sup>th</sup> March 2023).

#### 1.3. Objectives

Taking into account the planned future use of the site, the objectives of this appraisal were:

- To summarise the ground gas regime at the site;
- To provide a detailed Gas Protection Verification Plan to accompany the previous Remedial Strategy, Options Appraisal and Verification Plan in order for the gas protection system to meet the required British Standard solution score (BS8485:2015+A1:2019) and to satisfy any associated planning conditions.



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This report, which was designed to meet the requirements of all relevant current guidance including 'Land contamination: risk management' (LC:RM) (which supersedes CLR11) presents the factual information available during this appraisal, interpretation of the data obtained and recommendations relevant to the defined objectives.

### 1.4. Assumptions

The following assumptions are made in this report:

- It is assumed that ground levels will not change significantly from those described in this report or as shown on proposed development drawings. If this is not the case, then amendments to the recommendations made in this report may be required.
- The ground investigations that have informed this Ground Gas Verification Plan were designed with due consideration of known or suspected constraints (including underground services and access constraints).
- Any references to observations of suspected asbestos-containing materials are for information only and should be verified by a suitably qualified asbestos specialist and/or confirmed by laboratory analysis.
- The use of the term 'Topsoil' within this report is based on a visual identification only and that these materials have not been classified in accordance with BS3882:2015.
- The use of the terms 'shallow' and 'deep' within this report (from a geotechnical perspective) assume *typically* between ground level to circa 3.00m below ground level (bgl) for 'shallow' and greater than 3.00m bgl regarded as 'deep';
- The comments and opinions presented in this report are based on the findings of the desk study and ground conditions encountered during intrusive investigation works performed by Tier Environmental and the results of tests carried out within one or more laboratories. There may be other conditions prevailing on the site which have not been revealed by these previous investigations and which have not been taken into account by this report.
- Responsibility cannot be accepted for any conditions not revealed by the previous investigations. Any diagram or opinion on the possible configuration of the findings is conjectural and given for guidance only. Confirmation of intermediate ground conditions should be undertaken if deemed necessary.

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## 2. SITE DETAILS AND DESCRIPTION

**Table 2.1 Current Site Overview.**

|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Site name</b>                            | Former Cronton Colliery                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Site address</b>                         | South of Halsnead Farm Livery Stables, Fox's Bank Lane, Cronton, L353SU. A site location plan is included as Drawing No. TE1163GIR1 within Appendix A.                                                                                                                                                                                                                                                                                                                     |
| <b>National Grid Reference (NGR)</b>        | SJ 47493 89537                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Approximate site area</b>                | The site is located south of the M62 in a predominantly agricultural area. The closest town is Whiston which is 2.3 km North of the Site.                                                                                                                                                                                                                                                                                                                                  |
| <b>Site shape</b>                           | 20.84ha                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Current land use on the site</b>         | <p>The site is currently unoccupied with no above ground structures. The site is currently occupied by grazing and agricultural land.</p> <p>There a 3 No. mine gas vent pipes located just southeast of the site (outside of the development area) overlying the 3 No. old mine shafts used by the former colliery.</p> <p>High voltage overhead electricity pylons transect the site east to west.</p> <p>Additional unrecorded services should be anticipated.</p>      |
| <b>Surrounding land uses</b>                | <p>The site is set within a mixed commercial, agricultural and residential area.</p> <p>The southern and western areas next to the site are currently occupied by immature woodland.</p> <p>The area just east of the site comprises Unit 01 of the Symmetry Park development.</p> <p>The area south of the site also contains the access road is and an area covered with concrete hardstanding with bridge/embankment structure associated with the former colliery.</p> |
| <b>General topography and ground levels</b> | The site is slopes gradually to the west with ground levels in the northeast of the site from 38m AOD falling to 24m AOD in the west.                                                                                                                                                                                                                                                                                                                                      |



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### 3. GROUND GAS REGIME PROTECTION MEASURES

#### 3.1. Remedial Objectives

The remediation objectives are to break the potentially active linkage between bulk ground gas from beneath the Site and the buildings or future Site users associated with the proposed development.

#### 3.2. Radon

Basic radon protection measures are not currently required for the proposed development on this site.

#### 3.3. Foundation and Floor Slab Design

Guidance document BS8485:2015 states that *"The construction and use of the building, together with the control of future structural changes to the building and its maintenance (the building's management) should be assessed, since potential risks posed by ground gases are strongly influenced by these factors. The assessment should lead to the categorization of the building as a whole, or each different part of the building, into one of four building types: Type A, Type B, Type C or Type D."*

The ground gas monitoring data, taken from across the Site, has categorised the ground gas regime prevailing beneath the Site as Characteristic Situation 2 – Low Risk in accordance with CIRIA C665.

It is therefore considered likely that the **ground floor** office areas of the proposed units will fall under a Type C scenario and the remainder of the warehouses would likely fall under a Type D scenario.

Type D building: *industrial style building having large volume internal space(s) that are well ventilated. Corporate ownership with building management controls on alterations to the ground floor and basement areas of the building and on maintenance of ground gas protective measures. Probably civil engineering construction. Examples are retail park sales buildings, factory shop floor areas, warehouses.*

Type C building: *commercial building with central building management control of any alterations to the building or its uses and central building management control of the maintenance of the building, including the gas protection measures. Single occupancy of ground floor and basement areas. Small to large size rooms with active ventilation or good passive ventilation of all rooms and other internal spaces throughout ground floor and basement areas. Probably civil engineering construction. Examples include offices, some retail premises, and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels).*

In accordance with Table 4 of BS8485:2015, a low hazard potential would require a points score of 1.5; however, there is a requirement to ensure at least two types of protection measures should be implemented. This is based on a Type D building as defined in Table 3 of the aforementioned British Standard. For the office areas (Type C building), a point score of 2.5 would be required.

#### For a Characteristic Situation 2 – Low Risk scenario:

A points score of 2.5 (which would satisfy both office and warehouse areas) may be attained thusly:

- Gas resistant membrane which satisfies specification of Table 7 of BS5930:2015, lapped and sealed – **2 points** and;



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- Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement)— **0.5 points**.

Or:

- Gas resistant membrane which satisfies specification of Table 7 of BS5930:2015, lapped and sealed — **2 points** and;
- Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations. — **1 or 1.5 points** (To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations).

Or:

- Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations. — **1 or 1.5 points** (To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations) and;
- Passive sub floor dispersal layer. Very good performance — **2.5 points**. Good Performance - **1.5 points**. Performance criteria for methane and carbon dioxide within passive sub floor dispersal layers are shown in Figure B.6 and Figure B.7, of BS5930:2015, respectively.

The gas resistant membrane should meet the following criteria in order to achieve the necessary 2 points in accordance with Table 7 of BS8485:2015:

- Sufficiently impervious to the gases with a methane gas transmission rate  $<40.0 \text{ ml/day/m}^2/\text{atm}$  (average) for sheets and joints (tested in accordance with BS ISO 15105-1 manometric method);
- Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;
- Sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab);
- Sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools etc);
- Capable, after installation, of providing a complete barrier to the entry of the relevant gas; and
- Verified in accordance with CIRIA C735

It is considered that the combination of gas protection measures specified above would provide a sufficient 3.5 points of protection required in accordance with BS8485:2015.

The ground gas membrane installer and detailed specification for the ground gas protection measures will be confirmed in an updated version of this report.

The gas resistant membrane will conform to guidance document BS8485:2015, Table 7.

During engineering and construction activities, the ground gas data indicate that the following aspects are to be considered during the preparation of relevant site H&S plans, method statements and related documents, and appropriate working methods adopted:

- Carbon dioxide concentrations in ground gas. The measured  $\text{CO}_2$  concentrations in ground gas reported are significantly elevated relative to background and could present an asphyxiation risk in excavations and other confined spaces. The Health & Safety Executive has



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published information defining safe occupational exposure levels for CO<sub>2</sub> and the latest guidance must be consulted to determine whether the ground gas regime necessitates specific precautions during site works.

- Methane concentrations in ground gas. The measured methane concentrations in ground gas reported are significantly elevated and could give rise to explosive mixtures in confined spaces. Safe working methods should be adopted to mitigate this risk

It is understood that the proposed floor slabs will be mesh reinforced and the membrane will be protected via 'mars bar' baffles beneath the steel-work. The slabs should be poured via pumped cement where possible (to avoid vehicular movements across the slab). In addition, plywood boards should be used to protect the membrane where required and the cement should be laser levelled again to reduce the interaction between floor slab construction and the membrane and reduce the risk of damage to the membrane.



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### 4. GROUND GAS VERIFICATION PLAN

#### 4.1. General

An informed and risk-based approach has been taken as part of the verification plan, which has been produced to determine the following:

1. Decide which stakeholders are deemed suitable to undertake the necessary verification procedures;
2. How many site inspections should be undertaken; and,
3. The need for, and scope of, any integrity testing.

This risk-based system has taken into account the various factors that have influenced the scope of verification activities (including the possibility of integrity testing), which have included:

- Site-specific gas regime;
- Number of buildings to be inspected and the period over which this will take place;
- Complexity of the design and installation; and,
- Qualifications and experience of the workforce.

Figure 5.1 has been modified from CIRIA C735, with the red dots showing the relative placement of the site.

#### 4.2. Contractor and Materials Information

The installation contractor is not known at this stage and will be confirmed in an updated version of this report.

Any at any point the confirmed contractor changes, this will be subject to an updated version of this report being prepared.

It is proposed that the gas membrane used, should be defined as being BS8485: 2015 +A1: 2019 compliant as a carbon dioxide and methane barrier.



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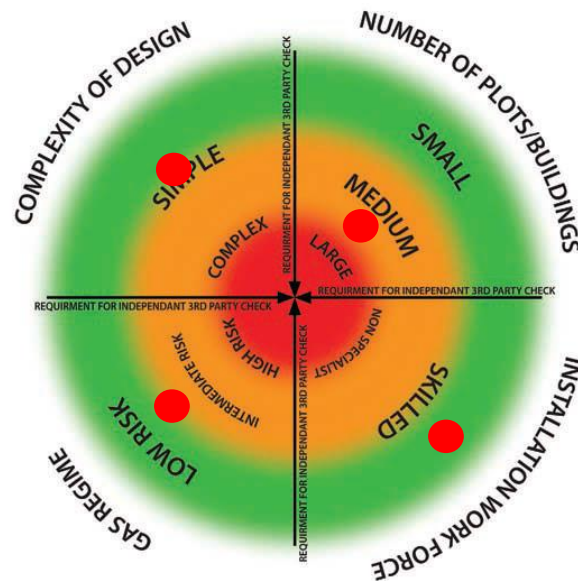


Figure 5.1 Analysis of the variables which have influenced the scope of the verification plan for this site.

### 4.3. Independence and Competence

In respect to the level of competence required in general ground remediation, the Environment Agency recommends that conflicts of interest in verification should be avoided. A contractor or gas membrane supplier certifying their own work or product is considered to be a conflict of interest and is therefore not good practice. If verification is carried out by the same company (or related company) that carried out the installation then the process, the results and report should be audited by an independent consultant.

The verification will be undertaken by Tier Environmental.

### 4.4. The Inspection Regime

The gas membrane installation should be subject to a visual verification inspection to establish the adequacy of the ground preparation and, subsequently, possible damage to the installed gas membrane. The inspection visits should fall generally in line with the following:

1. The verifier should be a suitably qualified engineer with sufficient training and experience.
2. The contractor should determine whether an area to be covered in a ground gas membrane is ready for inspection by initiating contact with verifier;
3. The verifier would then inspect all areas of interest (including sub floor ventilation) with the site manager or groundworks supervisor;
4. The inspection will cover:
  - The ground prepared for the gas membrane which should be clean and free from stones etc;
  - The installation of the membrane to an acceptable standard, and;



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- The membrane itself.
5. The verifier should also inspect the gas membrane itself over the whole floor area, paying particular attention to laps, edges and the sealing of service entries and penetrations such as vent pipes;
  6. The visual inspection should be recorded on the Gas Protection Verification Pro Forma, as presented in Appendix G of this report;
  7. Any discrepancies with the installation method recommended by the gas membrane supplier should be highlighted. These may include small or large holes and rips, tears and punctures, absence of tape (double sided or single sided tape) on the lapped areas, loose or unstuck tape, inadequate corner details, and unbounded seams such as loose edges and 'fish mouths' in the gas membrane;
  8. Tapes used to join gas membranes should be inspected to make sure they are compatible with the gas membrane being joined and are as specified by the gas membrane supplier or specifier; non-proprietary gas resistant tape should never be used to seal a gas membrane. Where welded joints are used, the verifier should ensure they are correctly tested;
  9. Repairs should be instructed and observed on the same day as the site visit or inspected at a later date. This will be documented on the Gas Protection Verification Pro Forma for that visit. The frequency and intensity of inspections should increase to reflect any lower level of competence of the workers installing the gas protection system;
  10. As the membrane may be located below reinforced slabs, inspections should take place after the installation of the membrane and also before concreting. The concrete should then be poured as soon as possible after the gas membrane has been signed off, in order to ensure that follow-on trades do not damage a gas membrane that has been signed off; and,
  11. All follow-on trades should be made aware of the presence and purpose of the gas membrane, and who they should contact if they believe their actions have had the potential to compromise it.

The final verification report will include plot specific photographs as supporting evidence. A pro forma should be completed for each inspection visit. All pro formas should be retained for inclusion within the final verification report in order to demonstrate the involvement of the verifier throughout the process and provide evidence of the appropriate installation of the gas protection measures. An example pro forma which highlights all aspects to inspect is provided in Appendix G of this report.

### 4.5. Inspection Timing and Frequency

There is currently no absolute guidance relating to the number and frequency of visits; however, for the purposes of this verification plan, reference has been made to Table A1 within Annex 1 of CIRIA C735. Whilst at this stage it is not possible to give specific dates for inspection visits, the following rules should be adhered to when attending site to make the required visual inspection (relative to the site specific risks shown in Figure 5.1).

If skilled (defined by CIRIA C735 as holding NVQ Level 2 qualification in gas protection installation). installers are the verifier is to conduct a thorough verification (visual) inspection of the membrane and installation prior to between 25 and 50 per cent of concrete pours with inspections undertaken just prior to a concrete pour event. If unskilled (no NVQ qualification) installers are the verifier is to conduct a thorough verification (visual) inspection of the membrane and installation prior to between 50 and 75 per cent of concrete pours with inspections undertaken just prior to a concrete pour event. It is proposed that inspections will be conducted on all of the 4 No. proposed units at the Site.

Inspection will be predominantly visual but may include the mechanical point stress test (this involves running a blunt instrument (e.g. a screwdriver) along the edge of the seam to identify any unbounded seams).



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The installer to supply sign off sheets (verification evidence) including photographs to the verifier.

After all inspections are completed it is advised that the membranes are protected using insulation and/or other adequate measures to prevent any damage before the concrete pour. It is also advised that signs are displayed around the Site advising all site users of the presence of the gas membrane and noting measures to avoid damage to the membrane.

### 4.6. Integrity Testing

Consideration has been made to the use of integrity testing as part of the verification of the gas protection measures. In determining the requirement for integrity testing, reference has also been made to the diagram in Figure 5.1 and Table A1 of Annex 1 of CIRIA C735:

- The Site is a Characteristic Situation 2 - Low Risk scenario;
- The membrane is being inspected by a qualified geoenvironmental engineer; and,
- The absence of a sub floor void in some instances precludes the use of most integrity testing techniques.

As such integrity testing is not currently recommended in this verification plan. It should be noted; however, that this is dependent upon the results of the initial verification visits. If, following these initial visits, it is deemed by the verifier that the installation is of a questionable standard, the use of integrity testing may be added to this verification plan. The results of any integrity testing must therefore be included in any final verification report.

### 4.7. Non-Conformances

Non-conformances to this verification plan will be recorded and noted to the contractors. Works will be then undertaken to rectify any non-conformance either under the supervision of Tier Environmental Ltd or a subsequent inspection will be undertaken post remedial works to verify that the non-conformance has been adequately rectified. An assessment will be made, depending on the scale, nature and extent of the non-conformance as to whether the Contaminated Land Officer (or equivalent) shall be notified including agreement of any measures to be taken to rectify the situation.



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### 5. VERIFICATION REPORT

The reporting of verification activities and integrity testing of gas barriers will be in general accordance with the relevant guidance (Environment Agency, 2010a and b). The reporting requirements will reflect the type and level of verification activity and integrity testing (if deemed to be required by the verifier) carried out at this site.

The final report will inform all the relevant stakeholders (regulators, site owners, funders, the local community etc) of the verification activities/integrity testing undertaken and will provide a logical framework to demonstrate confidence in the installation of the ground gas protection measures.

The SE will maintain records of the works to ensure the Verification Report will include the following:

- Site details and reasons for carrying out remediation;
- Planning Application details;
- Details of the various parties involved in the project, i.e. client, consultant, contractor, installer, verifier;
- A summary of the original site conditions and ground gas risk assessment carried out;
- The CSM for remediation identifying each pollutant linkage to be addressed by remedial activities, and the lines of evidence to test whether the linkages are broken;
- A description of the ground gas protection measures put in place, with reference to detailed design drawings;
- A clear description of this verification plan, including the methods used for data collection and interpretation;
- A description of the inspection regime (who carried out the inspections, their competence to do so, over what period, at what frequency and supported by a written record, e.g. completed pro formas and captioned photographs presented in the appendices);
- Presentation of the manufacturer's material(s) specifications(s) for all elements of the gas protection system, including warranty information;
- A summary of progress data, such as completed pro formas and monitoring results;
- Details of non-conformances and how they were rectified;
- Where necessary, details of further works and/or long-term management (if required);
- Details of all communications held with regulatory bodies during implementation; and,
- A clear statement, based on the presentation of 'lines of evidence' and review of the CSM, of the extent to which the remedial objectives and criteria have been achieved and the presence, extent and nature of any residual hazards.



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## 6. REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigations. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other organisations for their comment and approval.



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### 8. GLOSSARY OF TERMS

|                     |                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ACEC                | Aggressive Chemical Environment for Concrete (classification)                                                                                                                                                                                                                                                                                                                                     |
| aOD                 | Above Ordnance Datum                                                                                                                                                                                                                                                                                                                                                                              |
| bgl                 | Below ground level                                                                                                                                                                                                                                                                                                                                                                                |
| BGS                 | British Geological Survey                                                                                                                                                                                                                                                                                                                                                                         |
| BRE                 | Building Research Establishment                                                                                                                                                                                                                                                                                                                                                                   |
| CBR                 | California Bearing Ratio (test)                                                                                                                                                                                                                                                                                                                                                                   |
| COMAH               | Control of Major Accident Hazards (regulations)                                                                                                                                                                                                                                                                                                                                                   |
| Designated location | Site (and the ecosystem on that site) protected under national or international legislation. A potential ecological receptor to be considered as part of the assessment of land contamination. Example designated locations include SSSIs (q.v.), SACs (q.v.), national nature reserves, Ramsar sites and bird special protection areas.                                                          |
| DQA                 | Data Quality Assessment                                                                                                                                                                                                                                                                                                                                                                           |
| DQO                 | Data Quality Objective                                                                                                                                                                                                                                                                                                                                                                            |
| DQRA                | Detailed Quantitative Risk Assessment                                                                                                                                                                                                                                                                                                                                                             |
| DWS                 | Drinking Water Standard                                                                                                                                                                                                                                                                                                                                                                           |
| EQS                 | Environmental Quality Standard                                                                                                                                                                                                                                                                                                                                                                    |
| GAC                 | Generic Assessment Criterion                                                                                                                                                                                                                                                                                                                                                                      |
| GQA                 | General Quality Assessment (Environment Agency)                                                                                                                                                                                                                                                                                                                                                   |
| GSV                 | Gas Screening Value                                                                                                                                                                                                                                                                                                                                                                               |
| HCV                 | Health Criteria Value                                                                                                                                                                                                                                                                                                                                                                             |
| IPPC                | Integrated Pollution Prevention and Control (regulations)                                                                                                                                                                                                                                                                                                                                         |
| K <sub>ow</sub>     | Octanol-water partition coefficient                                                                                                                                                                                                                                                                                                                                                               |
| LEL                 | Lower Explosive Limit                                                                                                                                                                                                                                                                                                                                                                             |
| LL                  | Liquid Limit                                                                                                                                                                                                                                                                                                                                                                                      |
| LoD                 | Limit of Detection (analytical)                                                                                                                                                                                                                                                                                                                                                                   |
| LoQ                 | Limit of Quantification (analytical)                                                                                                                                                                                                                                                                                                                                                              |
| Mean Value Test     | Statistical test (described in the CIEH Guidance) to estimate the mean value of a normally distributed population of data at a given level of confidence. Normally for contaminated land assessment, the 95th percentile (referred to as the 95%UCL or US95) is applied as a reasonable but conservative estimate of the mean concentration for comparison with the relevant assessment criteria. |
| Maximum Value Test  | Statistical test (described in the CIEH Guidance) to identify whether an elevated concentration within a normally distributed data set forms part of the underlying population from which it has been sampled or whether it is an outlier (such as a localised area of contamination) that merits further consideration.                                                                          |
| MC                  | Moisture Content                                                                                                                                                                                                                                                                                                                                                                                  |
| NGR                 | National Grid Reference                                                                                                                                                                                                                                                                                                                                                                           |
| NIHHS               | Notification of Installations Handling Hazardous Substances (regulations)                                                                                                                                                                                                                                                                                                                         |
| OS                  | Ordnance Survey                                                                                                                                                                                                                                                                                                                                                                                   |
| PI                  | Plasticity Index                                                                                                                                                                                                                                                                                                                                                                                  |
| PID                 | Photoionisation Detector                                                                                                                                                                                                                                                                                                                                                                          |
| PL                  | Plastic Limit                                                                                                                                                                                                                                                                                                                                                                                     |
| ppm                 | Parts per million                                                                                                                                                                                                                                                                                                                                                                                 |
| ppmv                | Parts per million by volume                                                                                                                                                                                                                                                                                                                                                                       |
| QA                  | Quality Assurance                                                                                                                                                                                                                                                                                                                                                                                 |
| QC                  | Quality Control                                                                                                                                                                                                                                                                                                                                                                                   |
| SAC                 | Special Area of Conservation                                                                                                                                                                                                                                                                                                                                                                      |
| SOM                 | Soil Organic Matter                                                                                                                                                                                                                                                                                                                                                                               |



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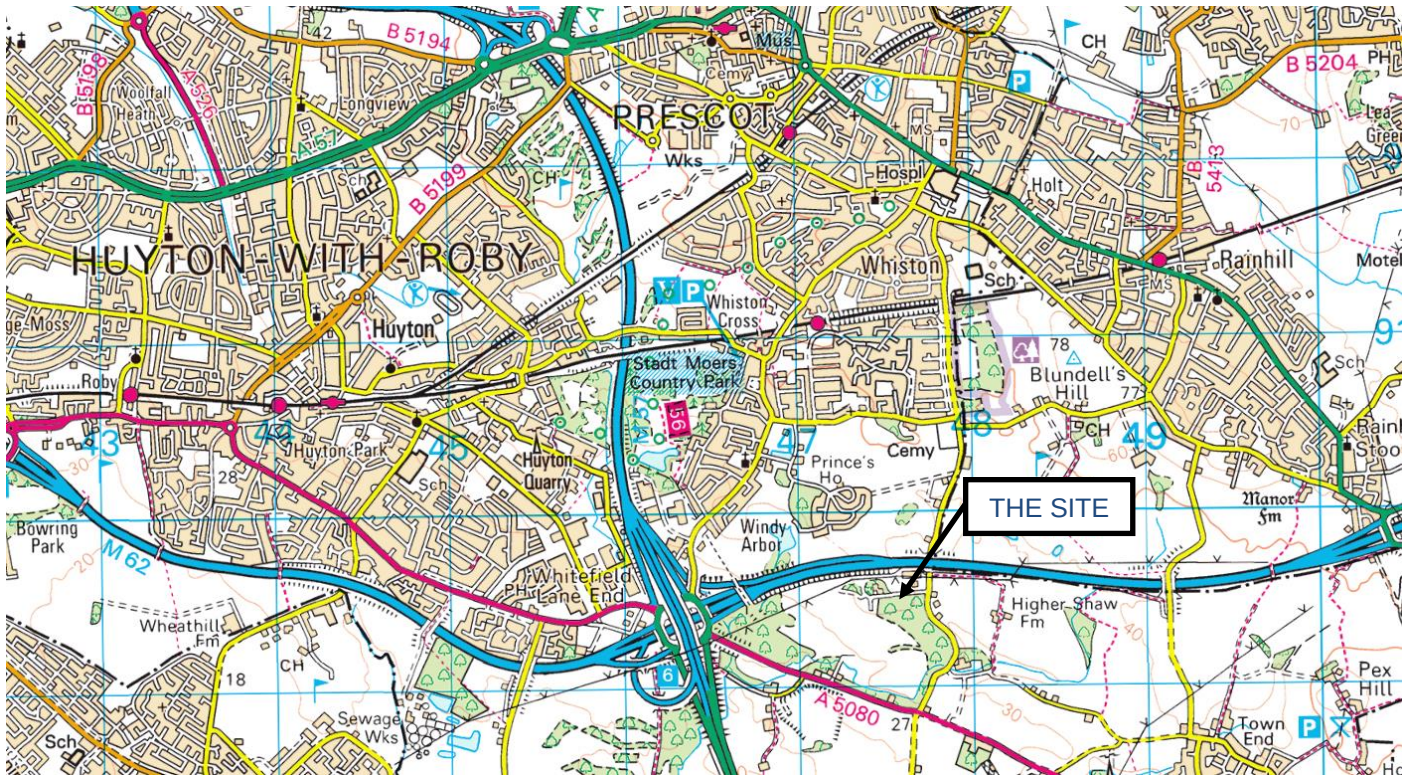
|      |                                                                                                          |
|------|----------------------------------------------------------------------------------------------------------|
| SPT  | Standard Penetration Test                                                                                |
| SPZ  | Source Protection Zone                                                                                   |
| SSAC | Site-Specific Assessment Criterion                                                                       |
| SSSI | Site of Special Scientific Interest                                                                      |
| SVOC | Semi-Volatile Organic Compound                                                                           |
| TEF  | Toxicity Equivalent Factor                                                                               |
| TPH  | Total Petroleum Hydrocarbons                                                                             |
| TWA  | Time Weighted Average                                                                                    |
| US95 | 95 <sup>th</sup> percentile estimate of the true mean value of a data population (also known as 95%UCL). |
| VOC  | Volatile Organic Compound                                                                                |

## **APPENDIX A – DRAWINGS**



|                 |                              |
|-----------------|------------------------------|
| Contract Number | TE1163                       |
| Contract        | Former Cronton Colliery Site |
| Client          | DB Symmetry                  |

## Site Location Plan



Reproduced from the Ordnance Survey map with the permission of The Controller of Her Majesty's Stationary Office, © Crown Copyright. All rights reserved.

|                |            |          |    |
|----------------|------------|----------|----|
| Scale          | NTS        |          |    |
| Drawn by       | JC         | Approved | SL |
| Drawing Number | TE1163GIR1 |          |    |

## **APPENDIX B – ASSESSMENT CRITERIA APPLIED FOR GROUND GAS**

## Ground Gas Monitoring Methodology

Monitoring for the following is generally performed as part of ground gas assessment:

- Methane (CH<sub>4</sub>): an odourless, flammable gas. Mixtures of methane with air containing between 5 and 15% v/v methane are explosive.
- Carbon dioxide (CO<sub>2</sub>): an asphyxiant at elevated concentrations. Denser than air, it can accumulate in excavations, and within low points inside buildings
- Oxygen (O<sub>2</sub>): important in the assessment of the potential formation of explosive mixtures with methane. Monitoring normally measures both methane and oxygen concentrations in ground gas to derive an indication of the risk of explosive mixture formation, expressed as a percentage of the Lower Explosive Limit (LEL). Low concentrations of oxygen in ground gas can also exacerbate the risk of CO<sub>2</sub> asphyxiation.
- Hydrogen sulphide (H<sub>2</sub>S): odorous and toxic, capable of forming flammable mixtures with air.

In addition, depending on the Conceptual Site Model, monitoring may also include for measurements of Volatile Organic Compounds (VOCs); present as chemical contaminants of soil and sometimes also biologically produced in low concentrations.

### Assessment of methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>)

Methane and carbon dioxide can arise from natural geological sources, mine workings, rotting organic matter (peat, landfilled materials, etc.) and/or contaminant biodegradation. Assessment of ground gas composition and flows is therefore an essential part of site assessment. The need to adequately address potential risks from ground gas on development sites is therefore required under the planning regime.

In order to appropriately assess the site risks, the Construction Industry Research and Information Association (CIRIA) and others have issued several guidance documents on landfill and ground gas that are intended to provide advice on how to investigate and deal with gas contaminated ground with respect to development. These are:

- Report 149: 'Protecting Development from Methane' (CIRIA, 1995a)
- Report 150: 'Methane Investigation Strategies' (CIRIA, 1995b)
- Report 151: 'Interpreting Measurement of Gas in the Ground' (CIRIA, 1995c)
- Report 152: 'Risk Assessment for Methane and Other Gases from the Ground' (CIRIA, 1995d)

More recent guidance has been published to update the documents detailed above to collaborate and promote industry 'good practice'. These are:

- CIRIA Report 665: 'Assessing risks posed by hazardous ground gases to buildings (CIRIA, 2008)
- BS8485:201+A1:2019: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (BSI Group, 2019)
- BS8576:2013: Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds (VOCs) (BSI Group, 2013)
- SoBRA Report Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater (Feb 2017)
- CL:AIRE Technical Bulletin TB17 Ground Gas Monitoring and 'Worst Case' Conditions (CL:AIRE Aug 2018)

The earlier CIRIA 149 approach is now considered to be too conservative. A more realistic measure of the risk posed by methane and CO<sub>2</sub> in ground gas can be established by determining an appropriate Gas Screening Value (GSV), using the methods described in the NHBC and CIRIA 659 documents. These values are based upon earlier work undertaken by Wilson and Card (1999).

GSVs are calculated by multiplying the borehole flow rate (l/hr) by the percentage (% v/v) concentration in the gas stream of the specific component, i.e.:

$$\text{GSV} = (\text{Concentration} / 100) \times \text{Flow rate.}$$

A risk-based methodology for deriving GSVs is defined for two situations (designated A and B), which are adequate for the great majority of site cases (as per CIRIA 665 Section 8.3):

- **Situation A:** Any development other than Situation B, e.g. factories, shops, commercial, warehouses, schools, cinemas, sports centres, stadiums, high rise housing, housing with basements, etc
- **Situation B:** Low rise building with minimum ventilated under floor void (min 150 mm)

Under Situation A, classification of the scope of protection required is determined from the site GSV, summarised in Table 1. For Situation B, GSVs derived are used in a 'Traffic Light' classification (summarised in Table 2) which determines the required level and scope of protection measures. Tables 1 and 2 are summaries only: the details provided in the body text, footnotes and appendices of the above-referenced documents should be read in conjunction with the results to determine the appropriate level of protection.

For conservatism, Tier Environmental **initially** uses the maximum concentration and gas flow rate of methane detected in any borehole during all of the monitoring visits in deriving recommendations on appropriate protection measures. This represents the worst-case risk of forming an explosive mixtures. For carbon dioxide, steady state concentrations and flow data are applied, as these determine the development of an asphyxiating mixture. All values are selected whether or not they occurred in the same borehole or during the same monitoring event.

Exceedances of the maximum concentrations used in a Tier 1 Gas Risk Assessment can be tolerated, when the conceptual site model indicates that it is safe to do so. However, appropriately derived GSV values must never be exceeded - where site-specific circumstances permit the derivation of alternative GSVs according to the defined conceptual model, then the appropriate GSV values should be applied.

**Table 1. GSV Categories Defined for Situation A (Summarised from CIRIA Report 665).**

| Risk classification | GSV (CH <sub>4</sub> or CO <sub>2</sub> ; l/hr) | Additional factors                                                                               | Characteristic Situation |
|---------------------|-------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------|
| Very low            | <0.07                                           | Typically methane <=1% and/or CO <sub>2</sub> <=5%, otherwise consider increase to Low Risk.     | 1                        |
| Low                 | <0.7                                            | Typically borehole ground gas flow rate <=70 l/hr; otherwise consider increase to Moderate Risk. | 2                        |
| Moderate            | <3.5                                            | ---                                                                                              | 3                        |
| Moderate to high    | <15                                             | QRA required to evaluate scope of remediation measures.                                          | 4                        |
| High                | <70                                             | ---                                                                                              | 5                        |
| Very high           | >70                                             | ---                                                                                              | 6                        |

**Table 2. GSV Categories Defined for Situation B (Summarised from NHBC, 2007).**

| Methane                    |            | CO <sub>2</sub>            |            | "Traffic light" classification |
|----------------------------|------------|----------------------------|------------|--------------------------------|
| Typical max. conc. (% v/v) | GSV (l/hr) | Typical max. conc. (% v/v) | GSV (l/hr) |                                |
|                            |            |                            |            | Green                          |
| 1                          | 0.13       | 5                          | 0.78       | Amber 1                        |
| 5                          | 0.63       | 10                         | 1.60       |                                |
|                            |            |                            |            | Amber 2                        |
| 20                         | 1.60       | 30                         | 3.10       | Red                            |
|                            |            |                            |            |                                |

## Assessment of hydrogen sulphide (H<sub>2</sub>S)

H<sub>2</sub>S is toxic and highly odorous ("rotten eggs") gas. It is often a minor component within mine gases, in ground gas within or overlying strata rich in pyrites or other sulphide-rich ores, and in most natural gas fields.

H<sub>2</sub>S can be generated biologically in significant concentrations by the decomposition by sulphate-reducing bacteria of natural or anthropogenic organic matter under oxygen-free conditions. Its potential generation will be greater in environments containing elevated sulphate concentrations (including sea water). H<sub>2</sub>S is therefore common within the gas arising from estuarine and marine sediments, pond sediment, stagnant water bodies, bogs and marshlands and landfilled waste, for example.

It must be noted that H<sub>2</sub>S normally occurs together with other potentially hazardous ground gases. The measures adopted for protection against these will prove equally protective against H<sub>2</sub>S.

There are no standards by which H<sub>2</sub>S concentrations in ground gas can be assessed directly. Therefore, the significance of measured H<sub>2</sub>S concentrations in ground gas must be evaluated on a case-by-case basis, taking into account the measured concentrations of other components and the specific conceptual site and exposure models. To assist in this process, the following standards and guidance may be applied.

### General protection of land users

There are no UK air quality standards for general exposure to H<sub>2</sub>S. The World Health Organisation has derived ambient air quality standards (WHO, 2000) for this gas, which may be used to inform risk assessment and decision-making:

The 24 hour average exposure guideline value for ambient air: 0.15 mg/m<sup>3</sup> (0.1 ppmv, approx.; this was derived by the application of a 100x safety factor to the LOAEL for long-term exposure).

This is significantly above the odour threshold, which is typically around 0.01 mg/m<sup>3</sup>. To avoid substantial nuisance odour complaints, WHO (2000) recommends that the 30 minute average H<sub>2</sub>S concentration in ambient air should not exceed: 0.007 mg/m<sup>3</sup> (0.005 ppmv, approx.).

### Occupational exposures

For occupational exposure, the HSE (2005) limits for H<sub>2</sub>S are applicable:

- 8 hour time weighted average occupational exposure limit: 5 ppmv (7 mg/m<sup>3</sup>).
- Short-term exposure limit (15 minute reference period): 10 ppmv (14 mg/m<sup>3</sup>).

## VOC Data Collection, Sampling and Assessment

### BS8576 Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs).

Volatile organic compounds (VOCs) include, for example, halogenated hydrocarbons such as trichloroethene, non-halogenated hydrocarbons such as benzene, and organosulfur compounds such as thiols (mercaptans). They can occur as a component of ground gas originating from historically contaminated ground, spills and leaks from industry, commercial or residential properties (e.g. from pipelines, storage facilities, and at the point of use or dispensing), land-filled wastes and from naturally occurring sources.

The migration of VOCs in ground gas can be via three primary mechanisms:

- diffusive flow (movement of constituent along a concentration gradient);
- advective flow (movement of constituent due to motion of a transporting fluid);
- dispersion (transport resulting from local variations in fluid flow, e.g. due to friction effects in the matrix).

The choice of sampling and monitoring techniques should be based upon the conceptual model and be designed to achieve the objectives of the investigation, bearing in mind the requirements of any subsequent analytical procedures and the need to provide relevant data of sufficient quantity and quality. Consideration should also be given to the nature of ground under investigation, as well as the nature and distribution of contamination, the geology and the hydrogeology. Every effort should be made to avoid cross-contamination and at no point should underlying aquifers be put at risk.

Where the response zone extends below the water table, gas present in the groundwater will tend to produce an equilibrium concentration in the well headspace. This applies to both permanent gases and VOCs but can be particularly misleading in the latter case. Testing for dissolved gases in groundwater is useful to help interpret monitoring results in such a situation. Similarly, any VOCs in a floating non-aqueous hydrocarbon layer will produce an equilibrium concentration in the well headspace.

The monitoring period and frequency of monitoring for VOCs in ground gases should be developed on a site-specific basis from the conceptual site model and investigation data quality objectives.

Ground gas samples can be collected from the unsaturated zone adjacent to, or above, the known or suspected source of VOCs in ground gas through installation of a ground gas monitoring point in the unsaturated zone (see 10.2), and from a near-surface location beneath hardstanding or a floor or foundation slab through installation of a near- or sub-slab monitoring point (see 10.3). For monitoring of VOCs in ground gas the monitoring well should be installed into unsaturated ground to allow sampling for VOCs to take place. The borehole should not be progressed below the groundwater table or the surface of any floating non-aqueous layer. The borehole should be progressed to the target sampling depth within the unsaturated zone. Full details can be found in BS8576 Section 10.2 onwards.

Assessment of VOC concentrations have been made for limited number of VOCs by SoBRA with the Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater in Feb 2017.

The assessment of VOC concentrations is not covered by above-referenced reports. These data can be used to inform the human health risk assessment for site occupants but should not be relied upon to assess human health risk due to uncertainties in the ground gas flow regime, variability in the (generally low) contaminant concentrations measured and inaccuracies in the concentrations measured by PID instruments.

Data on the VOC concentration in ground gas can also help inform potential occupational exposure risks to construction and similar workers. For this purpose, the measured values can be compared to the relevant occupational exposure limit (OEL) for the contaminant(s) of concern, as given in HSE (2005). In cases of doubt as to the identity of the organic contaminants within the ground gas or when these are present as a complex mixture, then the 8 hour time-weighted average (TWA) exposure limit for benzene (1 ppmv) will be applied for screening purposes. This is a reasonably conservative approach since the OEL for benzene is lower than that for the great majority of organic contaminants commonly encountered in soil and groundwater at contaminated sites

## **APPENDIX C – GROUND GAS PROTECTION VERIFICATION PROFORMA**



## VISUAL INSPECTION OF GAS PROTECTION MEASURES

VISIT: 1 of X

|             |            |                                   |                   |
|-------------|------------|-----------------------------------|-------------------|
| Site name:  | [Keywords] | Gas characteristic situation:     | [Category]        |
| Job number: | [Company]  | Type of development and building: | [Company Address] |
| Date:       |            | Building description:             | [Manager]         |
| Visit by:   |            | Foundation type:                  | [Status]          |
| Weather:    |            | Gas protection type:              | [Subject]         |

| No.               | Item                                                    | Comments |
|-------------------|---------------------------------------------------------|----------|
| <b>1</b>          | <b><i>Gas membrane</i></b>                              |          |
| 1.1               | Condition of sub-grade and/or underside of gas membrane |          |
| 1.2               | Gas membrane type                                       |          |
| 1.3               | Gas membrane condition                                  |          |
| 1.4               | Joining tape product                                    |          |
| 1.5               | Lapping design                                          |          |
| 1.6               | Laps, welds and joint seals                             |          |
| 1.7               | Service entries seals                                   |          |
| 1.8               | Other features                                          |          |
| <b>2</b>          | <b><i>Passive venting</i></b>                           |          |
| 2.1               | Sub-floor void                                          |          |
| 2.2               | External wall airbricks                                 |          |
| 2.3               | Internal sleeper walls                                  |          |
| 2.4               | External vent trenches/ducts                            |          |
| <b>3</b>          | <b><i>Active venting</i></b>                            |          |
| 3.1               | System details                                          |          |
| Additional notes: |                                                         |          |

### Photographs

| No. | Description |
|-----|-------------|
| 1   |             |
| 2   |             |
| 3   |             |
| 4   |             |
| 5   |             |
| 6   |             |
| 7   |             |
| 8   |             |
| 9   |             |
| 10  |             |

Photo 1

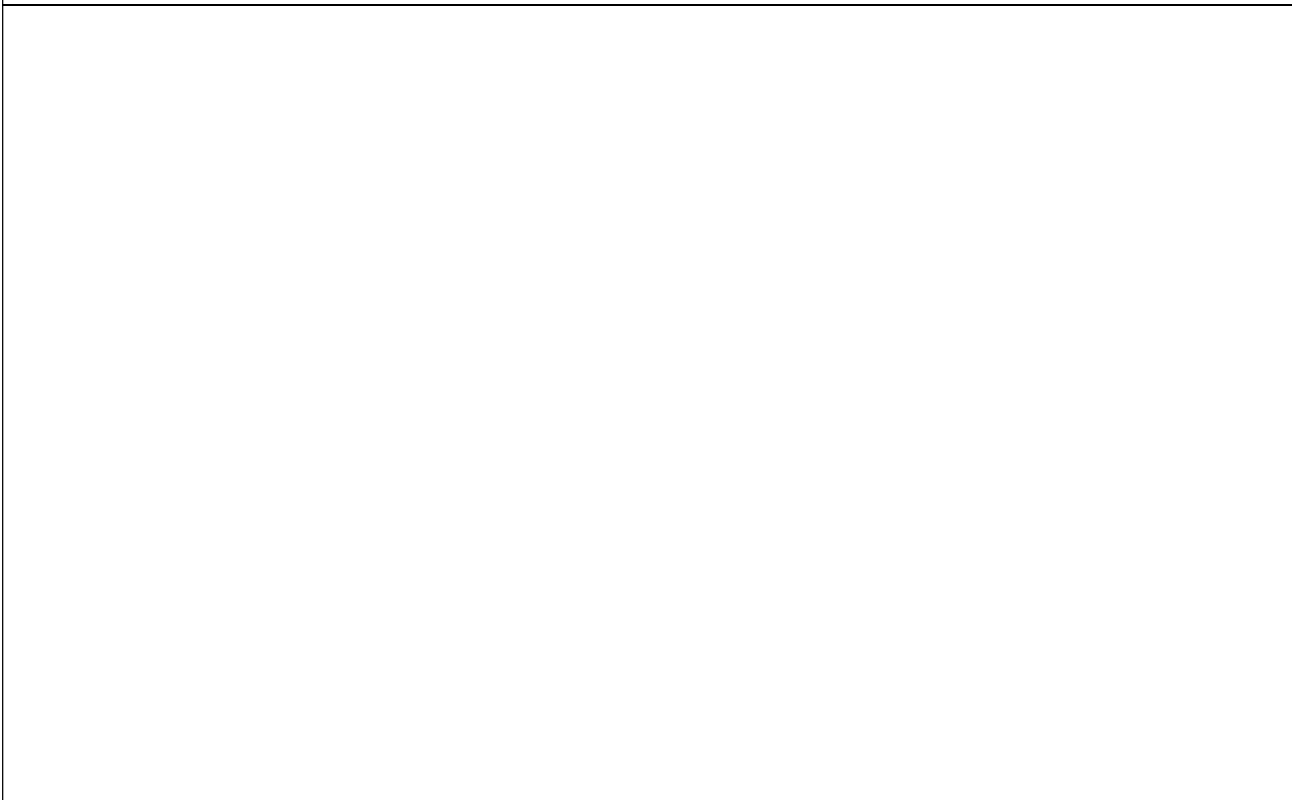


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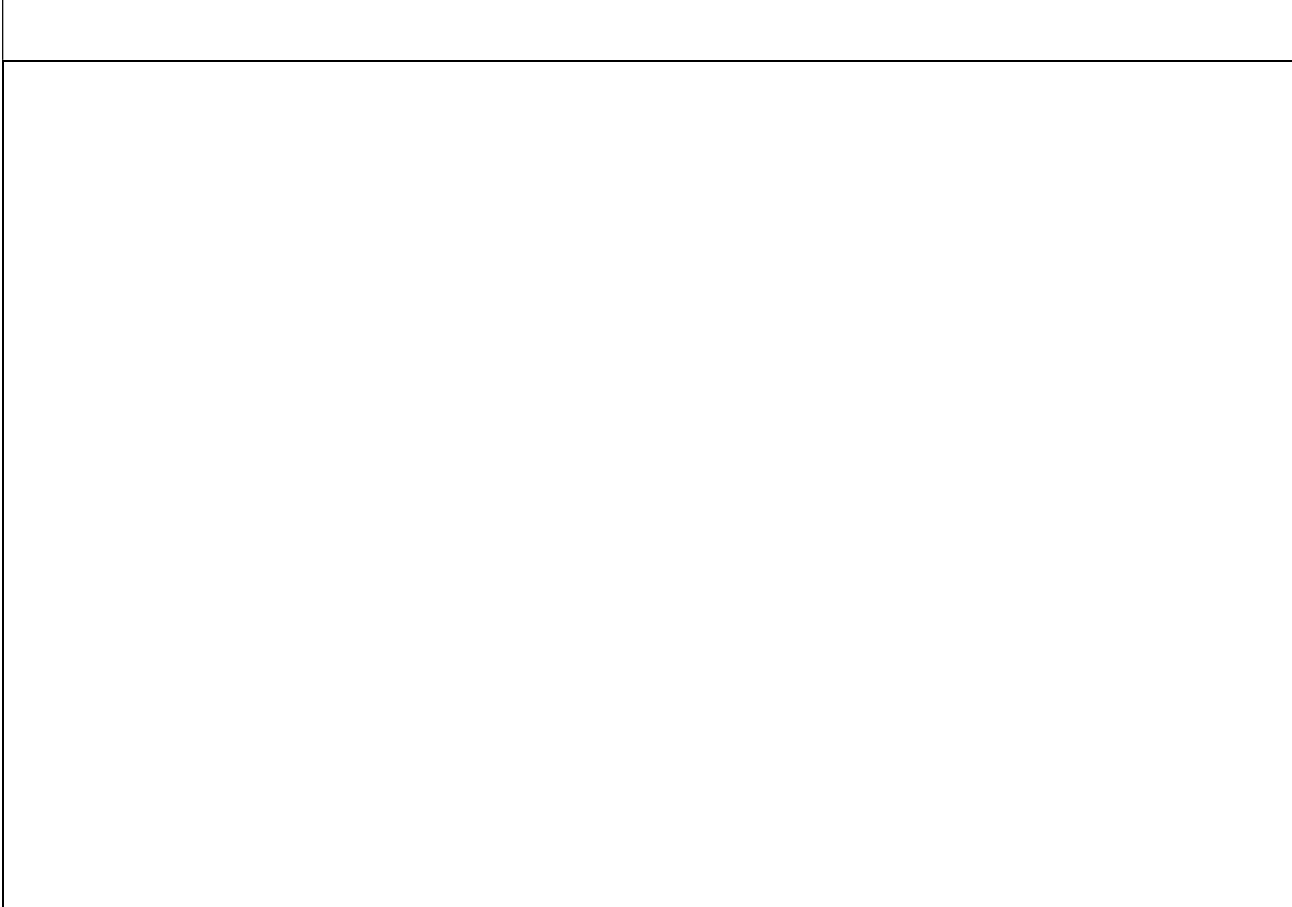


Photo 3



Photo 4

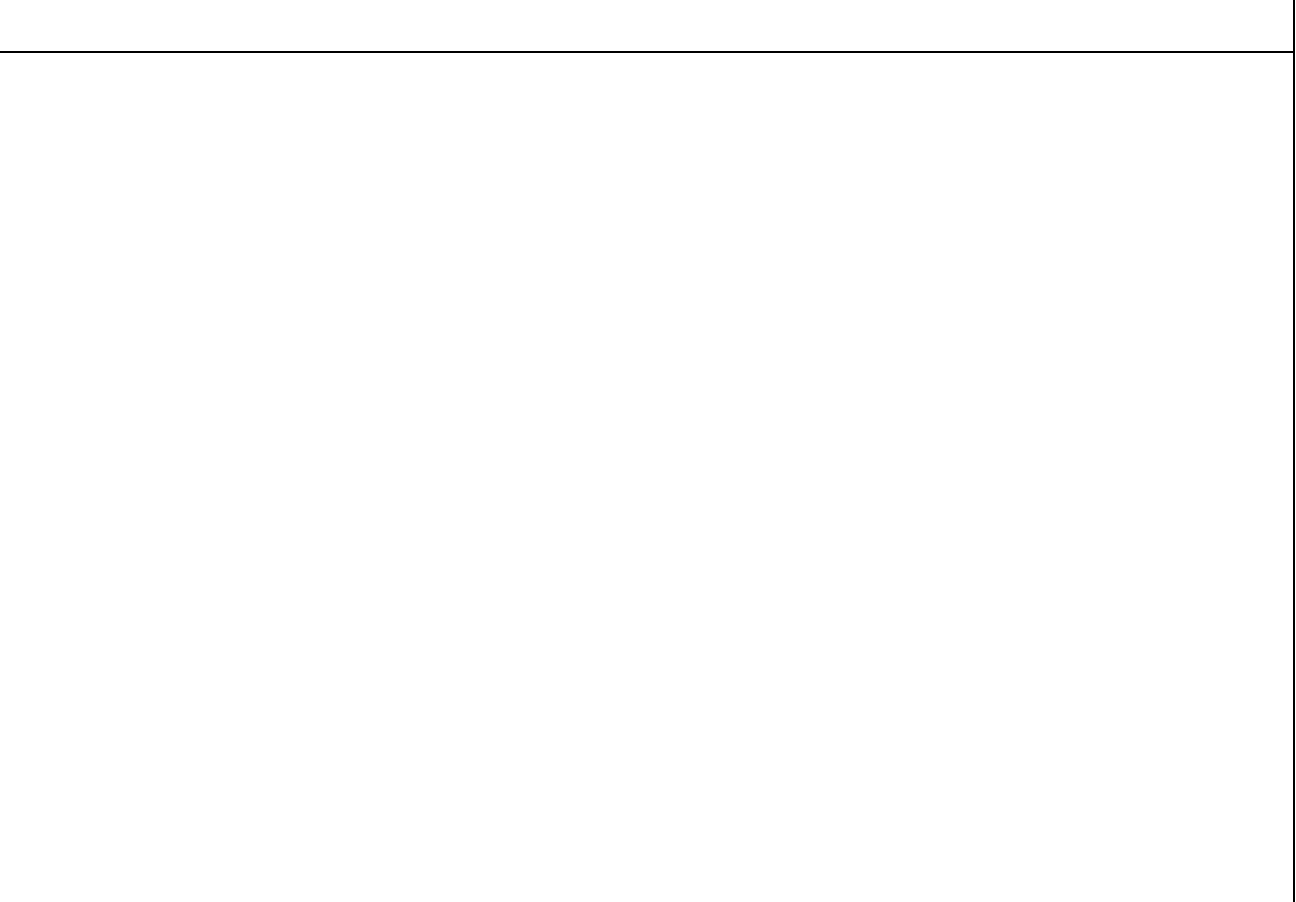


Photo 5



Photo 6

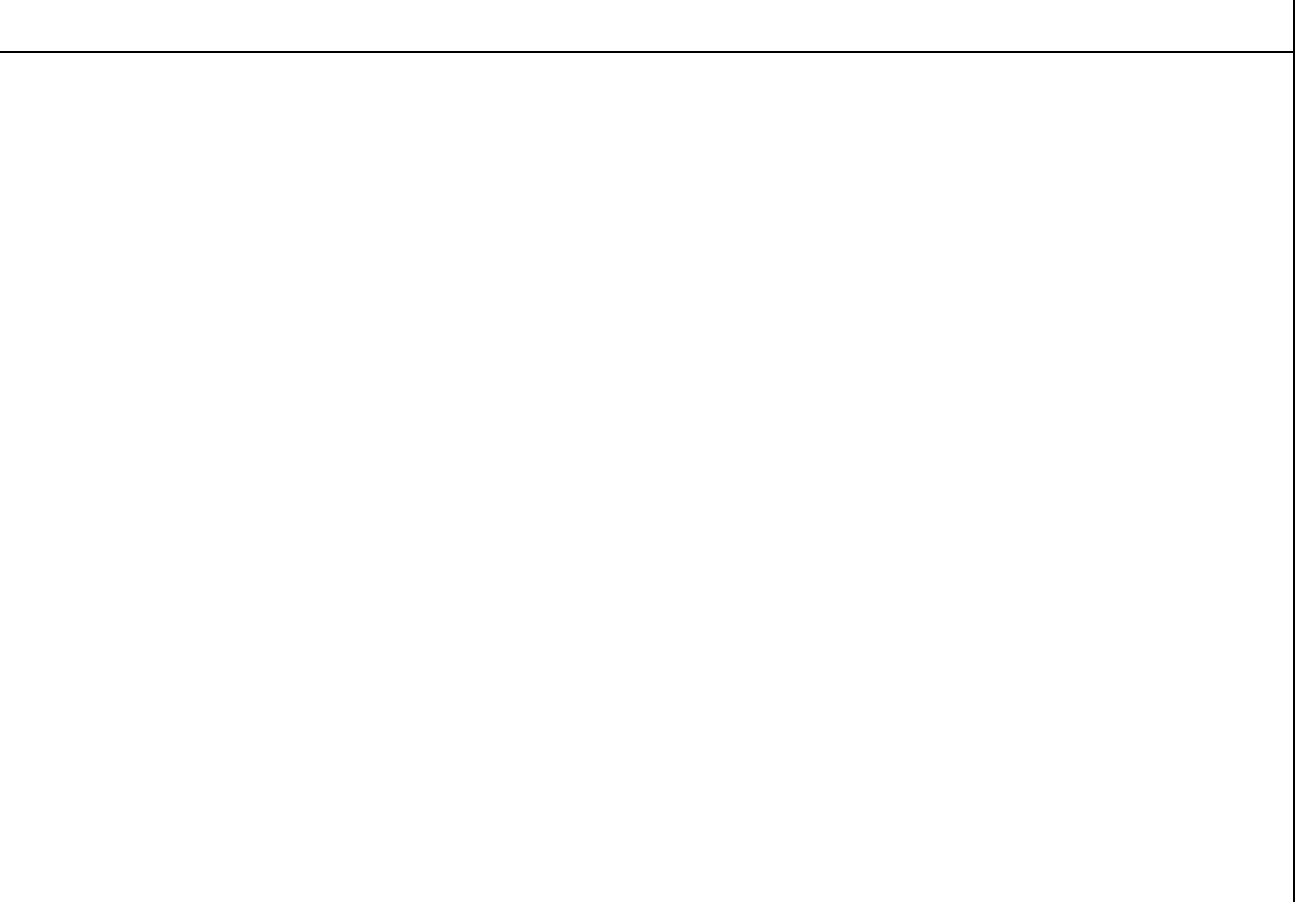


Photo 7

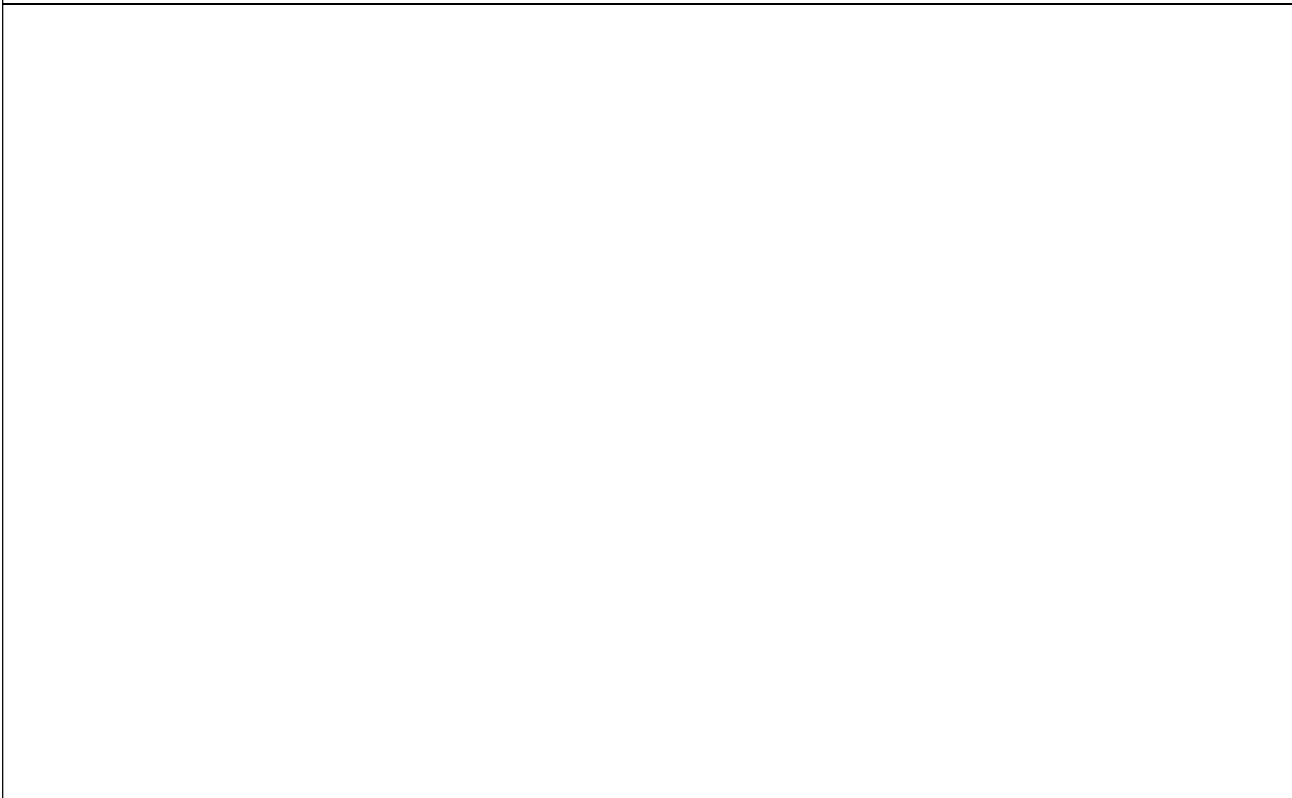


Photo 8

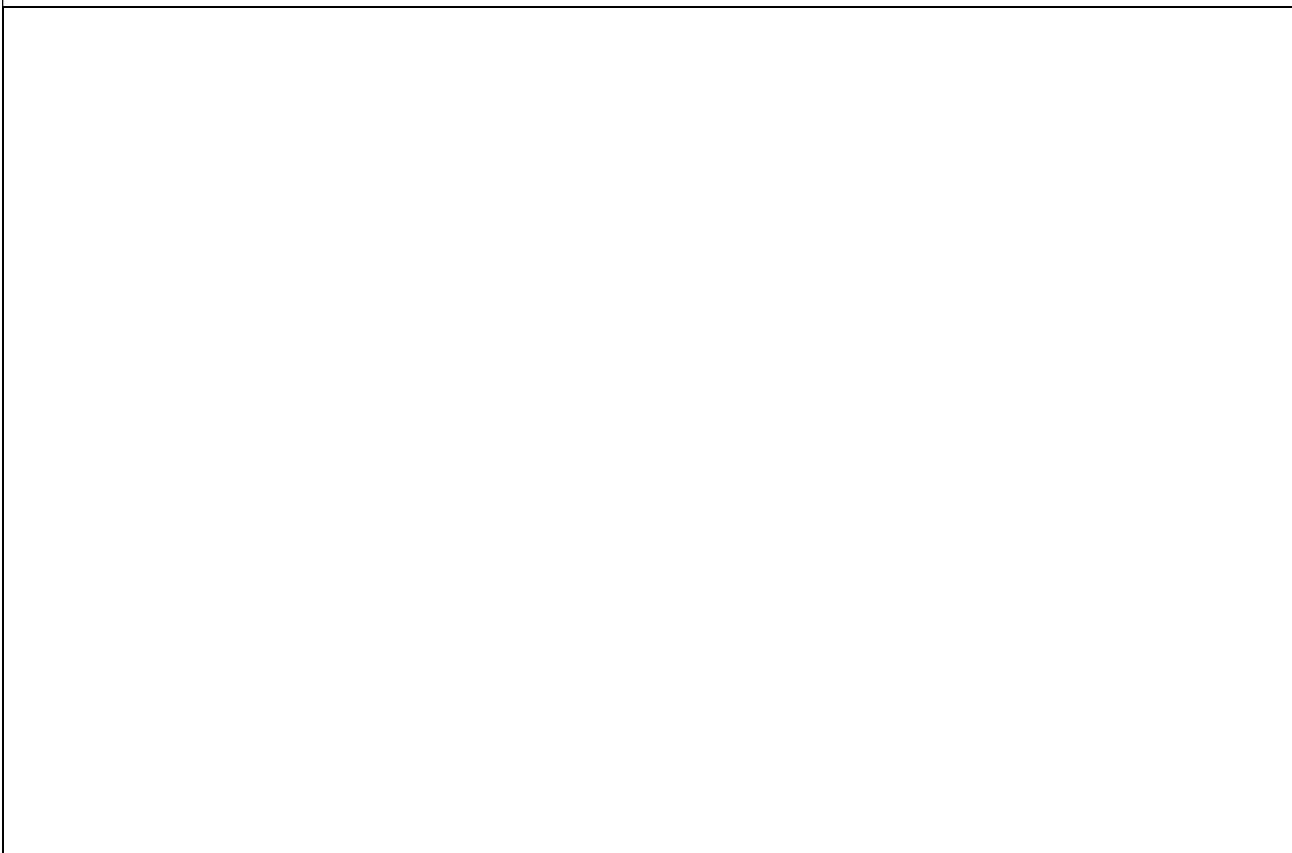
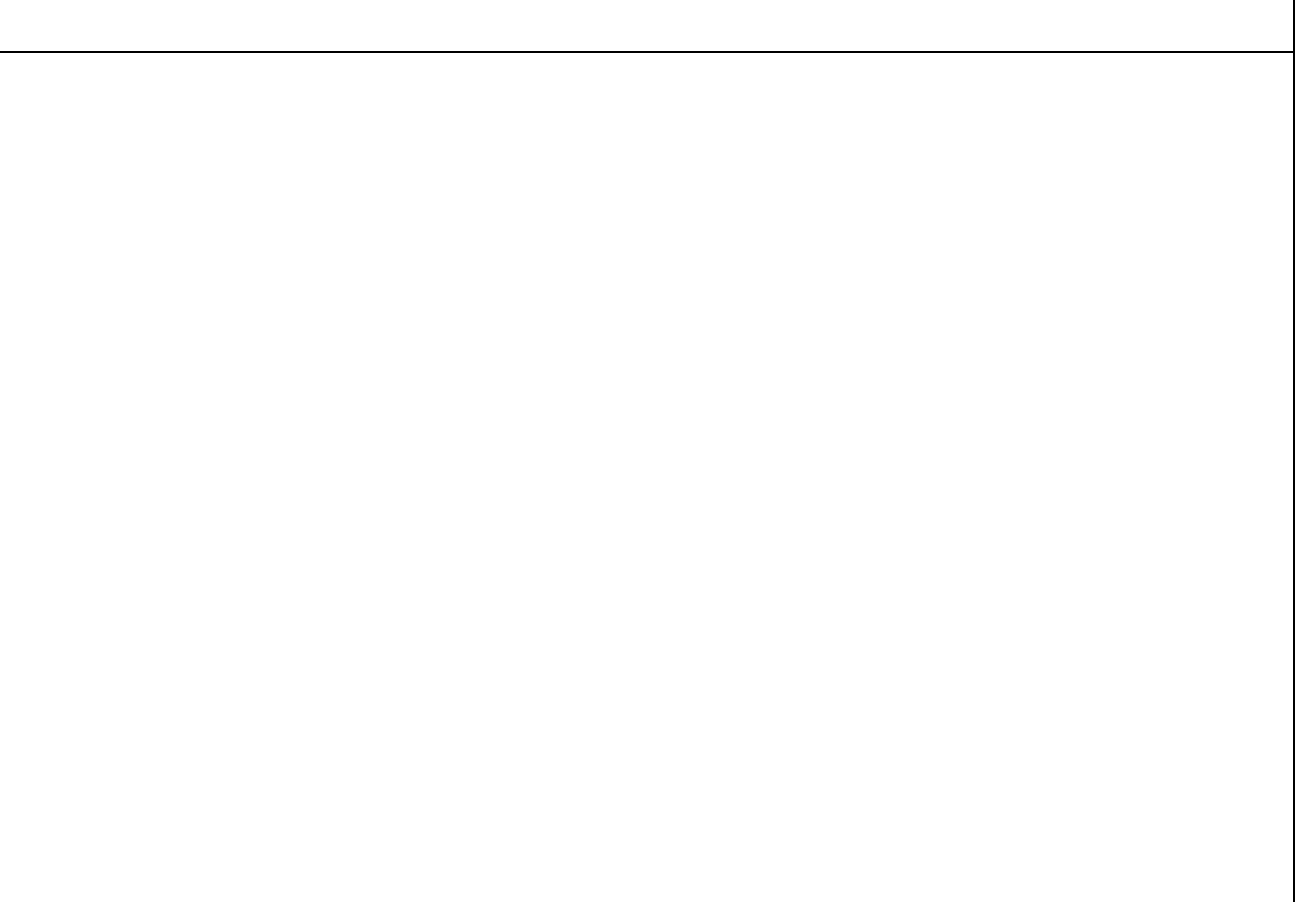


Photo 9



Photo 10



|                                            |  |
|--------------------------------------------|--|
| The gas protection measures inspected are: |  |
|--------------------------------------------|--|

**Name:**

**Signature:**

**Position:**

**Date:**