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Status	**Conceptual**	Preliminary	Pre-HAZOP	Post-HAZOP	As-Fitted

Odour Control Strategy Assessment for Inspired Global Cuisine Chadderton

AIR POLLUTION CONTROL

Odour Control : VOC Abatement : Dust & Fume Capture

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1. Introduction

A.S.K. Piearcey Ltd (ASKP) were engaged by Inspired Global Cuisine Ltd (IGC) under P/O PO111080 to assess the odour control requirements for the relocation of their production from Gorton to the Lidia Becker Way facility in Chadderton.

The report, in part, draws on a previous study made on the Gorton Facility that housed the same food production processes.

1.1 Reference Documentation

The following are the documents provided for the basis of this specific project:

Ref#	Description	Issue/Ref	Date
1	Proposed Site Plan Drawing	Rev 1.9/240903-200	October 2024
2	Halton Odour Assessment	N/A /35317	10/02/25
3	ASKP site report Gorton	02/SR0722-ICE-01	01/12/22
4	Site plan with receptors	N/A /6709-072	22/1/21
5	Ground Floor plan Meller	Rev 2.7/240903-201	October 2024
6	H4 Horizontal Guidance Note	GEHO0411BTQM-E-E	March 2011
7	SLR Odour Modelling Report	440.v13945.00001/002	28/11/25*

We routinely reference other academic and Engineering books such as Perry's Chemical Engineering Handbook, ASHRAE and CIBSE Guides and these will be pointed out as appropriate.

*Reference 7 was not available at for the previous versions of this report.

1.2 Objectives of the Report

The main objectives of this report are as follows:

a) Description of Facility Location
b) Brief description of processing
c) Discussion on odorous inventory/sources
d) Outline of strategy
e) General discussion of Abatement Technologies
f) Conclusion on initial and future strategies based on Gorton Findings

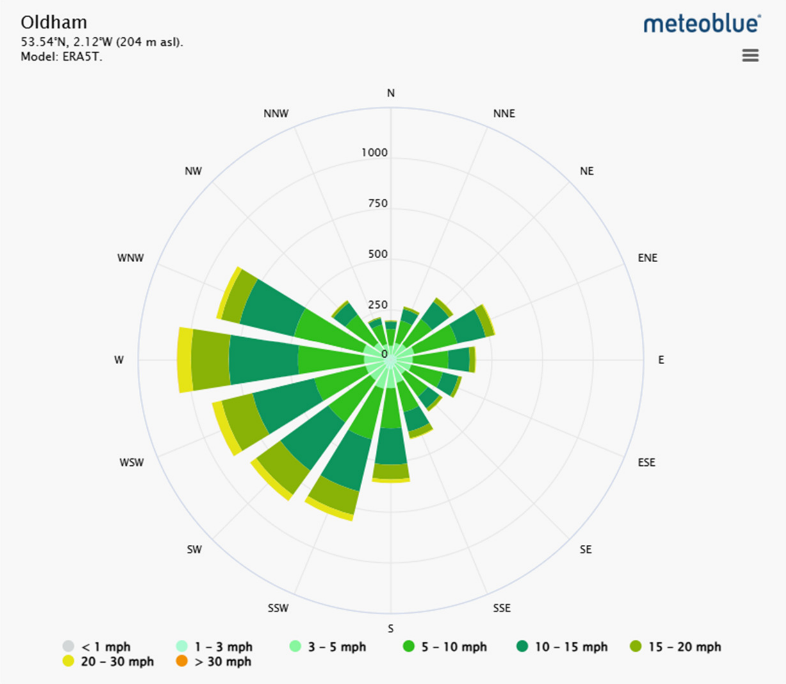
The overarching aim is to provide IGC with a reliable strategy to mitigate any potential odorous releases from the facility.

2. Facility Location

The new facility is located between the Radclyffe Athletics Centre and Lidia Becker Way. There are a number of potentially sensitive receptors close to the facility. These include but are not limited to the following:

- Radclyffe School and Athletics Centre
- Residential properties at Ferney Field and Keswick Avenue and the adjacent estates
- The Aldi and Costa Coffee outlets on the opposite side of Lidia Baker Way

The wind rose for that area is as follows:



This shows that the wind if predominantly Between a WNW direction and SSW direction. This means that the wind is blowing as per the arrows on the inset. This makes the Athletics centre and School the key receptors in this case.

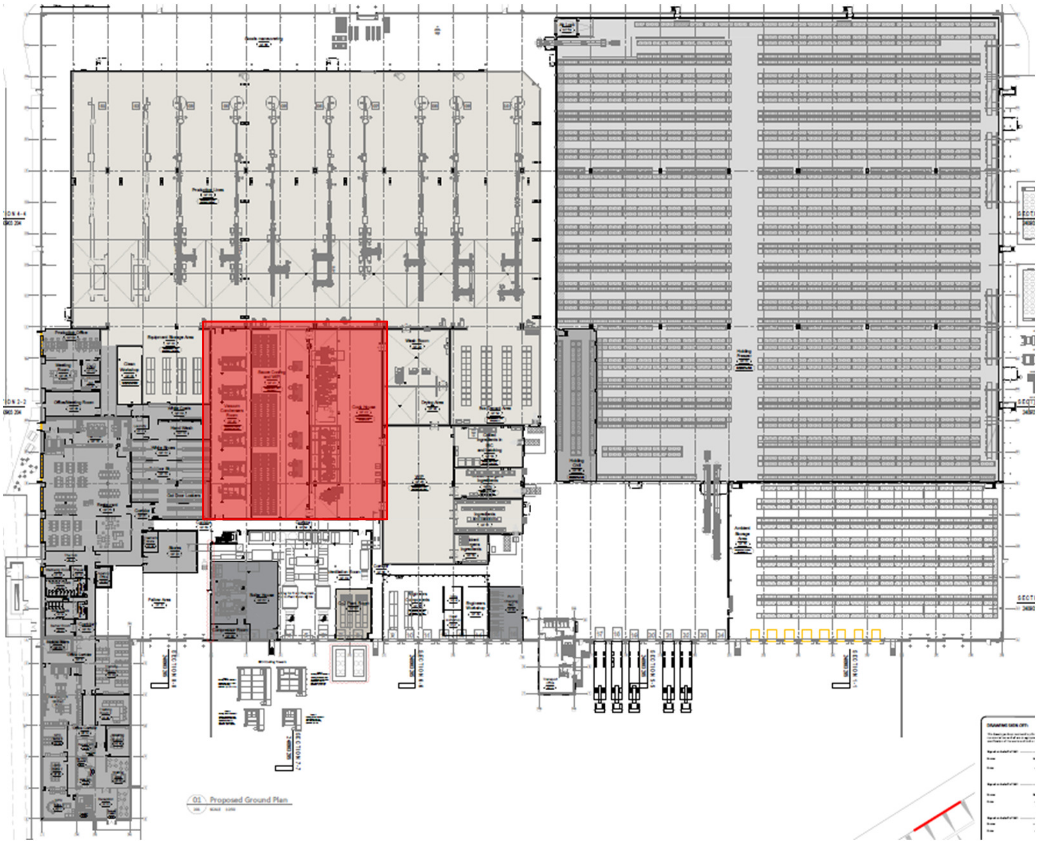
There is a reasonably high average wind (mostly between 10 and 20 mph) over 750 hours per year per key direction. This suggests that the plume from any stack emission will be significantly diluted under normal weather conditions.

3. Processing at the Facility

The facility has 10 production lines, 10 vacuum chilling vessels a dual purpose cook and chilling vessel for rice and the sauce kettles which are the key odour source for the processing. The production lines are handling pre-cooked ingredients and are not thought to be a source of odour.

The majority of the cooking is to make sauces for the product made in the production lines. The rest of the factory is then assigned to the following activities:

- Chilling and Packaging
- Staff Welfare facilities and change rooms
- Plant and boiler House
- Drying, washing and storage



The red highlighted areas are where we suspect the greatest amount of odour generation will take place.

There is also waste compaction and skip storage outside the bounds of the floor plan which may be an odour concern if skips containing food material are left open and exposed.

4. Outline Odour Containment Strategy

With due consideration to COP26 and COP27 as well as the various guidance produce by DEFRA and the EA (as mentioned by Halton in their document), the objective of any industrial extraction system is to efficiently capture process emissions utilising the minimum amount of air. Air movement require electricity and the more air movement the greater the associated plant is as well (with its own carbon footprint). For energy conservation and efficiency the system should aim to capture as much emission as possible **AT SOURCE**. This means appropriately designed capture hoods and ducting system compliant with **DW172** (industrial Kitchen extract systems).

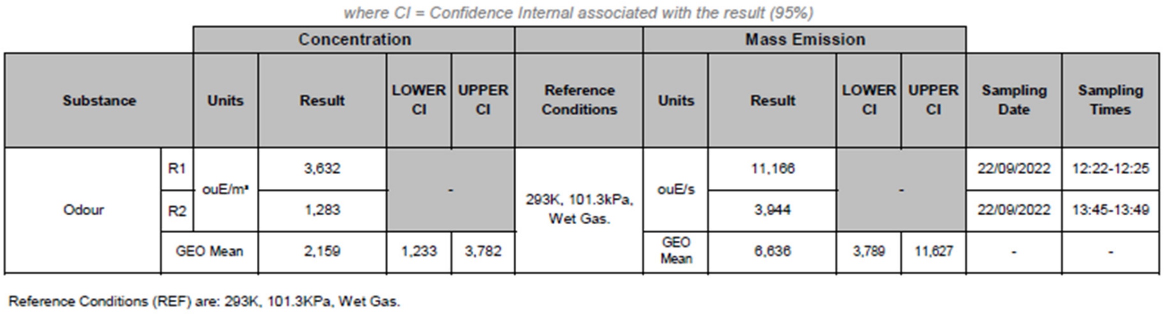
Odour containment is not the only objective of such extract systems, there is also the matter of process heat gain, solar heat gain, moisture capture and then operator safety and comfort. These are largely HVAC objectives and differ slightly from industrial odour control. In this sense there can be separate odour control extraction and HVAC extraction but they are not mutually exclusive.

Halton are the appointed experts in this field and they are experienced in the design of the capture systems required for this application. This document will therefore NOT discuss the detailed design of this extract any further.

4.1 Development of an Abatement Design Basis

Taking the basis that the installed kitchen extraction effectively captures the process emissions, then it is a case as to what to do with the captured air from the process.

The previous study of the Gorton site process extract revealed that the direct kettle extracts were of relatively low odour :



where CI = Confidence Internal associated with the result (95%)

		Concentration					Mass Emission					
Substance		Units	Result	LOWER CI	UPPER CI	Reference Conditions	Units	Result	LOWER CI	UPPER CI	Sampling Date	Sampling Times
Odour	R1	ouE/m^3	3,632	-		293K, 101.3kPa, Wet Gas.	ouE/s	11,166	-		22/09/2022	12:22-12:25
	R2		1,283					3,944			22/09/2022	13:45-13:49
	GEO Mean		2,159	1,233	3,782		GEO Mean	6,636	3,789	11,627	-	-

Reference Conditions (REF) are: 293K, 101.3KPa, Wet Gas.

The geometric mean of the odour sampling results in an odour concentration that is lower than many abated targets. It is, however, too high to release without dispersion.

As the processes are being re-located it is a reasonable basis to use these results to quantify and characterise the likely resulting emission captured by the system designed by Halton (or others).

The odour was delivered by very low concentrations of VOC and other components (less than 2 mg/Nm^3).

Halton have proposed a compliant kitchen extract with a stack that is 7m above the roof height (25m above ground level). This will provide excellent dispersion, given the average wind conditions for the area.

Taking the basis that the odour levels are the same as those measured at the Gorton facility, then it is reasonable to conclude that the extract should be exhausted directly to atmosphere via the proposed stack.

We believe however that the various combinations of emission from kettles and the process line need to be looked at in more detail (outside the scope of this report) to make sure that the highest odour load is represented by this design basis. This means drawing up a matrix of products and their anticipated odour contribution and comparing the throughput with the Gorton site.

The emission from the exhaust stack is based on 12 m/s and the stack diameter is given as 1m. This gives an extract rate of **33,929** Am^3/hr. This is considerably more than the sum of the 4 stacks at Gorton as measured but less than the flow from the 4 stack s if they were all set to the same rate. The Gorton site had the theoretical capacity of around 44,000 Am^3/hr. However, the odour and VOC results were taken at a lower flow and hence potentially more concentrated flow. So 39,929 would offer an improvement if there are no additional sources of odour contained with the overall extract.

A dispersion model should really be used to see what the impact is on the nearest receptors.

H4 guidance (Appendix 3, page 31) provides the following bench mark ground level concentrations:

- Odour level of **1.5 OUE/m3** for the most offensive odours (e.g. Sewage, Rendering)
- Odour level of **3.0 OUE/m3** for moderately offensive odours (e.g. municipal waste)
- Odour level of **6.0 OUE/m3** for the least offensive odours (e.g. food)

The stack should be modelled with details of the buildings and topography of the surrounding area. The model will use the 5 years of metrological data obtained from the nearest weather station (unless coastal).

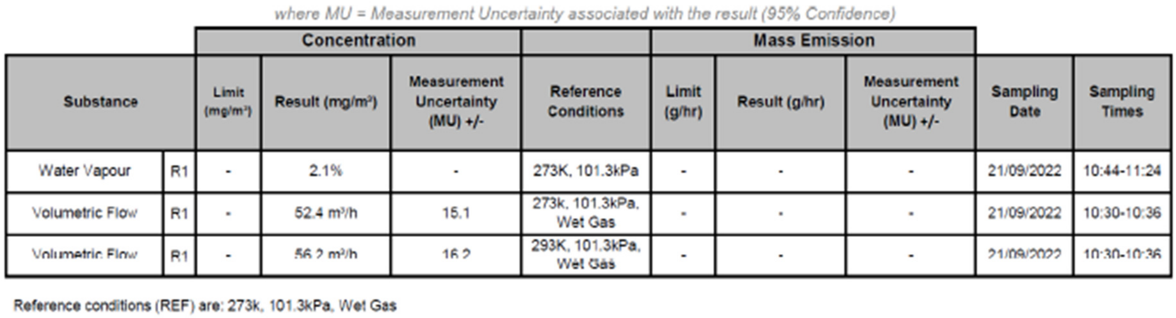
The model should then be used to determine if 2159 OU$_E$/m^3 at 12 m/s and a height of 25m in the designated stack location, will yield the result that the grid of nearest receptors will not see a ground level concentration of greater than **5 OU$_E$/m^3** for the 98th percentile of the year. This is a little lower than the 6 for least offensive odours to provide a slightly conservative approach.

Our experience leads us to believe that this will easily be achieved at the odour levels that have been measured.

4.1.1 Peripheral Odour Sources

At the Gorton site there wee some condensers with associated sumps. These sumps had dedicated odour control systems. We understand that these will be located indoors and so can just form part of the extract system. This means they will not require dedicated OCUs.

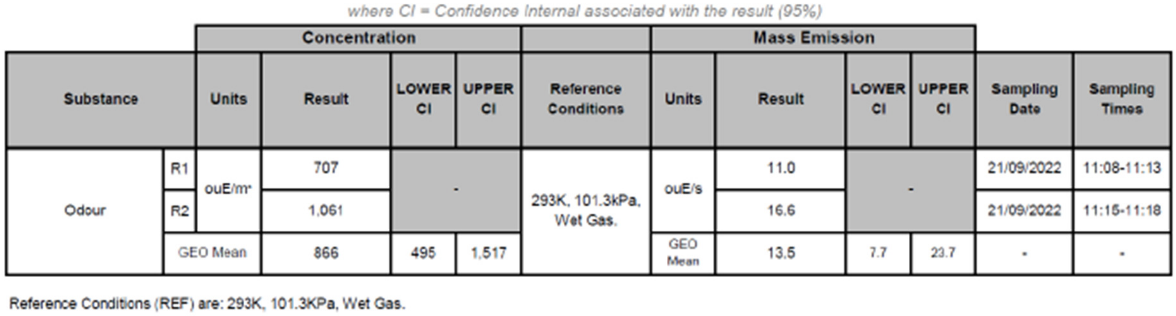
The odour levels associated with the liquors and the sump were again very low but certainly too high to just manifest as fugitive emissions (i.e. not dispersed). High level dispersion for these types of odours will easily suffice.



where MU = Measurement Uncertainty associated with the result (95% Confidence)

		Concentration				Mass Emission				
Substance		**Limit (mg/m^3)**	**Result (mg/m^3)**	**Measurement Uncertainty (MU) +/-**	**Reference Conditions**	**Limit (g/hr)**	**Result (g/hr)**	**Measurement Uncertainty (MU) +/-**	**Sampling Date**	**Sampling Times**
Water Vapour	R1	-	2.1%	-	273K, 101.3kPa	-	-	-	21/09/2022	10:44-11:24
Volumetric Flow	R1	-	52.4 m^3/h	15.1	273k, 101.3kPa, Wet Gas	-	-	-	21/09/2022	10:30-10:36
Volumetric Flow	R1	-	56.2 m^3/h	16.2	293K, 101.3kPa, Wet Gas	-	-	-	21/09/2022	10:30-10:36

Reference conditions (REF) are: 273k, 101.3kPa, Wet Gas



where CI = Confidence Internal associated with the result (95%)

		Concentration					Mass Emission					
Substance		**Units**	**Result**	**LOWER CI**	**UPPER CI**	**Reference Conditions**	**Units**	**Result**	**LOWER CI**	**UPPER CI**	**Sampling Date**	**Sampling Times**
Odour	R1	ouE/m^3	707	-		293K, 101.3kPa, Wet Gas.	ouE/s	11.0	-		21/09/2022	11:08-11:13
	R2		1,061					16.6			21/09/2022	11:15-11:18
	GEO Mean		866	495	1,517		GEO Mean	13.5	7.7	23.7	-	-

Reference Conditions (REF) are: 293K, 101.3KPa, Wet Gas.

These odour levels were also notably, at extraction levels that we believe were very low due to issues with the extract pipework. So, the levels will be even lower with a more healthy extract and sweep of the volumes (irrespective of whether they are in tanks or sumps).

So, this means that these very small flows can simply be incorporated in the main extract if required.

4.2 Design Basis for Abatement

Should Abatement be required then the following is the basis we would use based on the information provided in the Halton Document:

- Air flow 40,000 Am3/hr]
- Odour concentration Max 4000 OUE/m3
- VOC levels Max 2 mg/Nm^3
- Temperature 15-20°C

5. General Abatement Technologies

There are a number of well established abatement technologies that can be used for specific type of duty, or in some cases a wide range of duties. This section provides a description of the main technologies that could be applicable to the emission stream.

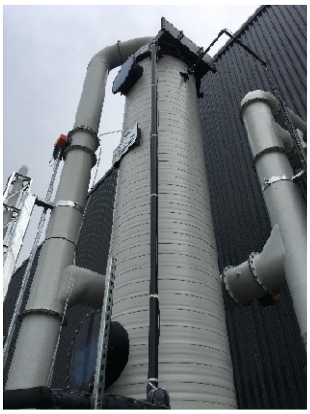
5.1.1 Chemical Scrubbers

The Chemical scrubbing of gases utilising an aqueous or solvent based liquor has been long established as an environmental abatement technique. It exploits the phenomena of MASS TRANSFER, whereby chemicals will pass across a boundary between two or more contacting phases, until *chemical potential* of the contaminants is at parity in each of the phases.

Scrubbers bring together a gas phase (typically air) and a liquor (typically aqueous). The contacting of these two phases allows contaminant to move from the air into the liquor where it is either mineralised as a salt by reaction or purged to drain via a liquor replenishment process.

The main types of scrubber that we design are the Counter Current Packed Tower (CCPT), Spray towers and Venturi scrubbers.

The **CCPT** allows the laden air stream into the base section of the scrubber, just above the liquor sump. Here the gases rises through a packing support plate into the packing or mass transfer zone. The scrubbing liquor, which is often re-circulated, trickles down over the packing surface, counter current to the rising gas stream. This ensures that there is always a difference in concentration of contaminant in the 2 phases throughout the tower and hence mass transfer is maintained.



A **spray tower** works in much the same way but there is no packing and the mass transfer zone is just a void filled with the scrubbing liquor sprayed droplets. These tend to be less efficient in the removal of contaminant than packed towers.

A **Venturi system** utilises high velocity jets to fill an accelerated gas stream with tiny droplets of liquor. These droplets provide the surface area for mass transfer to occur. As the venturi is a co-current scrubber it is inherently less efficient than a CCPT, however, stage efficiencies of 60-80% can be achieved. The venturi scrubber is typically used where the liquor is a slurry or the gas stream has a significant solids concentration.

Venturis offer the lowest gaseous contaminant removal efficiencies of the chemical scrubbing range and are only applied where there are solids involved in the gas stream or there is an ATEX requirement in the system

Non-aqueous scrubbers (solvent based scrubbers) usually have limited available data and are typically very specific to the application, requiring pilot trials to enable full scale feasibility and subsequent design. They can be used if there is a very expensive VOC as the contaminant and it could be feasibly recovered from the solvent liquor.

For an aqueous, chemical scrubber to be the correct choice of abatement, the following criteria need to be met:

1. Enough of the contaminant load has to water soluble so that non-soluble contaminants do not exceed the limit
2. The Henry's law (volatility) or other vapour-liquid equilibrium (VLE) relationship has to be favourable enough to allow absorption of even infinitely soluble species. Species like Alcohols and ammonia are very soluble in water but very quickly saturate the liquor such that the scrubber will not remove further contaminant unless significant amounts of scrubbing liquor are purged from the scrubber and replenished with fresh water
3. Where the VLE is less favourable (as per above examples) then the contaminant needs to be reactive with a suitable chemical reagent (e.g. Sulphuric acid, Sodium hydroxide or Hydrogen Peroxide). The reaction mineralises and fixes the contaminant in solution and removes the "VLE" barrier
4. Where chemicals are utilised then operators must be of a suitable level of competence to handle the ongoing maintenance (e.g. purging, calibration of probes/instruments and interpretation of the various parameters that will require monitoring). Operators must also be trained in the safety aspects of handling the chemicals, including the reception of fresh chemicals to storage
5. The resulting use of chemical reagent and water needs to be economic compared with other abatement systems. Due consideration has to be paid to the requirement for a chemical storage facility with bunds, pumps and level monitoring in terms of capital cost and foot print.
6. The site must be able to dispose of purged liquor on site or sustain the cost of off-site disposal by a licensed waste contractor.

General Comparative Parameters

Parameter	Rating
Reliability	Very reliable if correctly designed to the well established methods
Efficiency of removal	Typically >99% (limited to the 100ppb range of emission output)
Ease of operation	Requires competent operators with suitable training and safety awareness as these are relatively sophisticated systems
Maintenance Requirements	Recirculation pumps, dosing systems and demisters require regular maintenance (which can be outsourced to specialists)
Best suited to	Medium High flows, medium load to high loads and typically inorganic contaminants
Foot-print	Typically 1.5-2 seconds contact time so relatively small footprint excluding chemical storage which can significantly affect cost and footprint

5.1.2 Biofiltration

There are 2 major categories of biological Abatement Technology: #1 Biofitration and #2 Bio-scrubbers. The key difference between the 2 is that biofilters contact the air directly with the biomass and bio-scrubbers use liquid phase bio-reactors to “clean” water recirculating around a scrubbing system.

Bio-scrubbers only work if it is possible to scrub the contaminant with water. The biological reactor needs to be able to remove the key contaminants down to below the liquid phase levels that would produce a non-compliant emission by vapour -liquid equilibrium.

The most widely used biological technology is that of Biofiltration. Here the air passes through the matrix supporting the bacteria. The matrix is usually a media of high surface area (e.g. pumice stone, expanded clay, coconut fibre (coir) or specific artificial packings). It has the advantage of continuously removing the contaminant at source where it is metabolised into mineral salts, acids or gases like CO_2.

Biofilters use biological reactions to breakdown inorganics and organic chemicals. It may take more than one type of bacteria and several reactions stages to fully break down VOCs (to CO_2 and water). This creates the need for a relatively long contact time when compared with other technologies (typically between 30 seconds and 90 seconds). Modern biofilters are seeded with specific strains of bacteria to provide the necessary reactions. These bacteria require an environment at a certain pH, moisture level, dissolved oxygen and temperature.

For this reason, all biofilters should be closed topped and have a controlled irrigation system that helps maintain the optimum conditions for the bacteria to develop and flourish. The bacteria deplete dissolved oxygen and produce byproducts that need to be purged and so the irrigation rate and frequency is critical to performance. Where possible single pass irrigation should be used to avoid the build-up of byproducts and the deterioration of the biomass liquid quality. This means minimising or avoid recirculation of liquor.

Biofilters can, when suitably designed adapt to a wide range of contaminant. They tend not to be high efficiency in terms of contaminant removal but can achieve 95-99% removal of readily biodegradable inorganics like hydrogen sulphide. For VOCs we typically see 40-70% reduction overall.

Biofilters are typically used as “roughing filters” to reduce the load burden to more efficient technologies, in particular carbon adsorbers.

Biofilters are not typically suited to higher range air flows as the contact time tends to generate very large footprint vessels. When vessels become very large then the task of evenly irrigating and also evenly spreading out the air through the media becomes very difficult and unreliable.

For biofilter to be an appropriate choice of abatement (typically not standalone) then the following criteria need to be met:

1. The target contaminant is at least partially soluble and more importantly biodegradable
2. The loading is not too spikey or spurious -a biomass cannot instantly respond to large variations and so the peak-mean ratio should ideally be less than 2 for reliable and sustainable performance
3. The emission should be continuous for similar reasons to the above. Bacteria need to adapt and grow and flourish for the system to work and they are inhibited if left without the key contaminant (their food substrate) for long periods of time.

4. The site has a source of good, clean final effluent for irrigation or low chlorine water is available.
5. The stream cannot contain bio-inhibitors (methanoic acid, formaldehyde, halogens etc).
6. The site can dispose of the exit liquor from the biofilter or can sustain the off-site disposal of the liquor by a licensed waste contractor
7. The temperature of the inlet air to the biofilter is less than 40°C . At or above this temperature we move from the mesophilic to the thermophilic range of bacteria and it is more difficult to acquire the required biological action.
8. The site has the required footprint for the system, which is likely to be larger than other systems.

General Comparative Parameters

Parameter	Rating
Reliability	Reasonably reliable and very adaptable if the emission is consistent
Efficiency of removal	Typically between 70 and 90% but higher for hydrogen sulphide and ammonia. Many vendors limit the outlet level to no less than 0.5ppm
Ease of operation	Very easy to operate, little operator intervention required
Maintenance Requirements	Typically Nozzles require de-clogging, nutrient requires topping up but there should not be too much maintenance for a well designed and suitably applied biofilter.
Best suited to	Lower consistent flows with biodegradable content and in conjunction with other technologies (e.g. Carbon).
Foot-print	The largest foot print due to the longest require contact time.

5.1.3 Thermal Oxidisers

Thermal oxidisers vary in type in accordance with the type of heat recovery they employ:

1. Direct Fired Oxidiser (DFO) – No heat recovery.
2. Recuperative Thermal Oxidiser (“recupe”) – Mechanical Heat exchanger limited to around 75% thermal efficiency.
3. Regenerative Thermal oxidiser (RTO) – Ceramic in-line heat exchanger system capable of up to 98% thermal efficiency

Thermal oxidation is the combustion of the VOCs in excess oxygen at temperature above 730°C (gas regulations).
The VOCs are combusted yielding CO_2, water and any mineral acids (if halogenated), NOx and SOx. Combustion typically takes place in milliseconds albeit some compounds like dioxins take up to 2 seconds to fully combust. For non-dioxin applications a thermal residence time of between 0.6 and 1 second is typical.
Primary heat recovery is the recovery of heat internally, within the oxidiser to minimise the fuel usage in driving the combustion.

Secondary Heat recovery is the use of the heat from the combustion for another purpose (e.g raising steam or space heating or heating hot oil to use in a process heat exchanger). Thermal oxidisers are relatively sophisticated abatement systems due to fuel and burner control requirements. If the VOC are halogenated they may need to be constructed from more exotic materials such as Hastelloy or duplex steels to provide corrosion resistance to the resulting acid gases (some of which have low dew points).

They have very high removal efficiencies for the combustible contaminants but may require further abatement of acid gases arising from halogens or indeed NOx and SOx arising from from chemically bound nitrogen and sulphur respectively.

RTOs have a unique, cyclic flow pattern to "juggle" the heat retained by the ceramic heat exchangers and keep it in the combustion chamber. This is how they achieve their very high thermal efficiencies. However this has a destruction efficiency penalty in that the cyclic changes in flow direction yield a small pulse of untreated air which can reduce the destruction efficiency (DRE) (2 canister RTOs typically operate at 98% DRE).

Thermal oxidisers are generally most suited to high, combustible VOC loads (RTOs >500 mg/Nm^3) so that the VOC acts as a fuel source and limits the fuel consumption. They are relatively expensive from a Capex and Opex perspective unless the VOC level is high. Thermal oxidisers can be made more viable for higher flows by utilising a **concentrator** to adsorb the VOCs onto a Zeolite and then desorb with pre-heated air to feed to an oxidiser at 20% of the air flow and 5 times the concentration. This cuts fuel cost but only works whereby the VOC can be successfully desorbed within the portion of the zeolite wheel rotation time.

General Comparative Parameters

Parameter	Rating
Reliability	Very reliable if maintained well and the site has a reliable fuel supply.
Efficiency of removal	>99% for DFO and recupe and >98% for RTO
Ease of operation	Require monitoring of various parameters and specific operator training to handle abnormal events (particularly RTOs)
Maintenance Requirements	Maintenance is usually contracted out to specialists – ceramic liner repair, flame rod replacement, burner servicing every 12 months
Best suited to	High VOC loadings or where the end-user has a high heat demand on site.
Foot-print	Medium to large foot print .

5.1.4 Catalytic Oxidisers

Catalytic oxidisers have 2 main categories: #1 Earth Metal Catalysts and #2 Precious Metal Catalysts. They each work by passing the air with the VOC contaminant through a bed of catalyst media (either ceramic spheres or honeycomb (monolithic)). The gas is preheated to around 200-500°C (depending on which catalyst is utilised) and the combustion of the VOC takes place at the catalyst surface. The combustion process releases energy and this assists in maintaining the temperature of the catalyst bed.

The catalyst allows the combustion process to take place at lower temperatures and hence the construction of the catalytic oxidiser is generally much lighter and cheaper than that of the thermal oxidisers. It also means that the initial heat load is lower and it is easier to provide the start-up heat via an electrical heater rather than a fuel powered heater. Catalytic oxidisers (CATOX units) rely on the availability of catalytic surface and this makes them vulnerable to certain inhibitors and "poisons".

Phosphorus, sulphur, halogens and silicon can all coat the catalyst and render the surface inert and hence reducing the performance of the oxidiser. As the temperature is often too low to combust the VOC without contact with the active catalytic surface, the performance can quickly drop off.
The catalyst can also be sintered at high temperature (>500°C). This renders the catalyst inert below that same temperature and again performance can drop off. For this reason, CATOX units are not suited to very high loads of VOC due to the exotherm release across the bed.
CATOX units are best suited to simple VOCs (non-halogenated) and at medium to low levels. They are also suited to smaller air flow streams where electrical heating is easier. Recent developments have generated catalysts which are more resistant to acid gases like HCl and hence they can handle some amount of halogenated VOC.

General Comparative Parameters

Parameter	Rating
Reliability	Very reliable if maintained well and the site has a reliable fuel supply.
Efficiency of removal	98-99% dependant on catalyst type and temperature
Ease of operation	Require monitoring of various parameters and specific operator training to handle abnormal events (particularly RTOs). Requires CO monitoring by law.
Maintenance Requirements	Maintenance is usually contracted out to specialists – ceramic liner repair and catalyst replacement (7-10 years)
Best suited to	Medium to light, non halogenated VOCs
Foot-print	small to medium foot print .

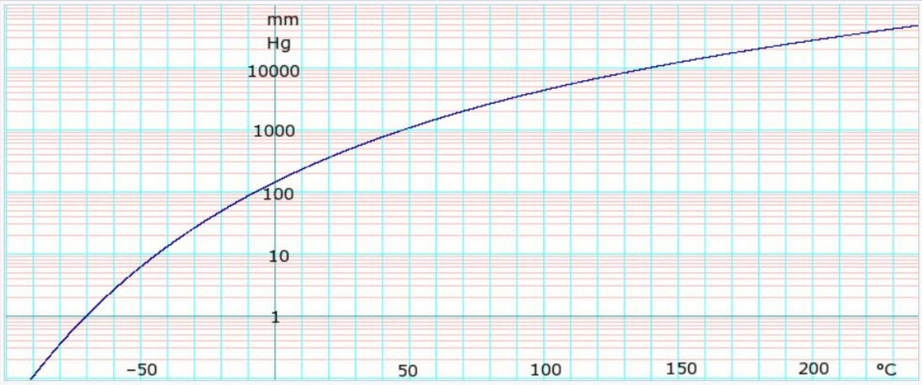
5.1.5 Recovery- Cryogenic Condensation

Some VOCs have lower vapour pressures than others and relatively high boiling points. It is sometimes feasible to cool a stream down to promote the condensation of the VOCs (and possibly inorganics) to remove them from the air stream.
The air stream is passed through 2 stages of cooling: 1st stage is cooling to close to the freezing point of water to remove water vapour and hence the ice load on the chilling stage;

2nd is the cryogenic cooling stage where temperatures down to -80°C are often the target. Cooling media are thermal oils, CO_2, glycol, brine, liquid nitrogen or other refrigerants. This tends to be only feasible relatively small streams (<500 m^3/hr) or up to 3000 m^3/hr when the site uses liquid nitrogen to provide a site nitrogen supply.

The reason for this is that many VOCs are still volatile at temperatures below -50°C and so if a stream is at say 20°C then there is a 70°C sensible cooling load as well as the latent heat of vaporisation of the contaminant that is to be condensed. Cooling and chilling processes tend to be less thermally efficient than heating processes so cryogenic cooling can be relatively energy intensive and chilling plant for even small flows can be quite large.

Cryogenic condensation is best suited to very high solvent loadings of condensable VOC, particularly where there is a single VOC that could be recovered. Mixed solvents tend to be waste solvents that must be disposed of via a licensed waste operator. It is suited to low flows where the cooling energy is low. This type of recovery still tends to yield a non-compliant emission if the site emissions are concentration based.
An example of this is Dichloroemthane (DCM):



log$_{10}$ of Dichloromethane vapor pressure. Uses formula: $\log_e P_{mmHg} = \log_e(\frac{760}{101.325}) - 10.08632 \log_e(T+273.15) - \frac{6030.610}{T+273.15} + 80.87786 + 9.812512 \times 10^{-6}(T+273.15)^2$ obtained from CHERIC[6]

Its VP curve shows that at -50°C the vapour pressure is around 5mmHg. Atmospheric pressure is around 760 mmHg so based on ideal gas law the mole fraction of DCM is 5/760 = 0.00659. To convert to ppm this would be 6,579 ppm (multiply by 1 million). This would not be compliant as an emission and would constitute a high load for any downstream technology.
It is important with this approach that the loading of exhaust, saturate air with the VOC is considered in terms of downstream removal. Note the above concentration is the equilibrium concentration of DCM with its liquid (condensate). Clearly if there is less than this in the inlet air then condensation will not really be effective.

General Comparative Parameters

Parameter	Rating
Reliability	Requires moderate attention with de-icing and compressor maintenance

Efficiency of removal	Typically poor removal efficiency (10-50%) depending on vapour pressure of solvent.
Ease of operation	Requires monitoring of various parameters and specific operator training to handle abnormal events
Maintenance Requirements	Many moving parts and bearing so there is significant maintenance with this approach
Best suited to	Very high loadings (condensable) and low flow
Foot-print	Medium footprint for small flows

5.1.6 Recovery-Thermal/Pressure Swing

This recovery method used adsorption followed by desorption and then condensation to recover the solvent/VOC. Typically the air stream is passed through a carbon adsorber and there is a very high efficiency of removal >99%. Sometimes there is also a requirement for a sacrificial guard-bed to catch any residual VOC that slips through. This would be a standard carbon adsorber in series with the adsorb/desorb system, polishing the emission before exhausting to atmosphere.
The adsorbers work on a cycle:

- Adsorption phase
- Desorption phase
- Cooling/Drying phase

When adsorbers work in this sort of cycle the carbon settles to what is known as the **working charge**. This is due to the fact that the initial fill of carbon will hold onto a significant inventory of VOC that will always remain on the carbon, even after numerous desorb phases. This “redundant” carbon is called “the heel”. As an example, toluene can easily be adsorbed up to 30% by weight capacity on a suitable, high quality activated carbon. However in a cyclic operation you will only achieve a working charge of around 4% by weight capacity. The adsorb/desorb vessels therefore need to be sized at the lower capacity. The vessels need to hold enough VOC so that that off-line vessels can complete their desorb and cooling/drying cycles before significant breakthrough occurs on the adsorbing vessels.

Thermal swing desorption is effectively the use of a heating medium (hot inert gas or steam) to desorb the adsorbed VOC by raising its vapour pressure and driving off the more loosely bound VOC. The hot stream (usually steam) is then cooled/chilled to condense out the desorbed solvent into a decanter vessel. Here (if steam is used) the solvent separates from the aqueous phase and each layer can be recovered.

Pressure swing desorption involves the pulling of a vacuum on the adsorber and applying some heat to improve the rate at which the VOC can be desorbed.
Each option requires vessels that are pressure vessels (some rated to full vacuum).
Adsorb/desorb systems can be used on higher flows than condensation systems but are best suited to where there is a single and valuable solvent that is very useful to recover or

where there is a very high solvent consumption in the process and it is possible to off-set the operational costs against purchasing new solvent.

This abatement approach is probably the most engineering design heavy and sophisticated of all the technologies. If the solvent is very valuable but is NOT a single solvent then it may be feasible to recover the valuable solvent by adding a distillation stage to the recovered mixed solvent.

These systems are usually the highest capital cost option but potentially represent a route to recycling of solvent and hence avoidance of secondary pollution.

General Comparative Parameters

Parameter	Rating
Reliability	Requires moderate attention with multiple pneumatic valves and compressor maintenance
Efficiency of removal	>99% (with guard bed)
Ease of operation	Requires monitoring of various parameters and specific operator training to handle abnormal events. It is the most sophisticated of the abatement technologies.
Maintenance Requirements	Many moving parts and bearings so there is significant maintenance with this approach
Best suited to	Very high loadings (condensable) and medium to high flow with single, valuable solvents and if the site has steam as a utility already available
Foot-print	Large footprint: Adsorbers, guard beds, ducting for many interconnections and possible distillation after decanting and phase separation

5.1.7 Carbon or Alumina Dry Scrubbing

Activated Carbon or Activated Alumina are dry porous media that have exceptionally high surface area within their pore structure.

This area is also electrostatically active and this allows the media to adsorb contaminants that can be attracted to this surface. Both media types can have surface areas of over 1000 m^2/gram of media.

Adsorbers work by simply passing the contaminated air through a bed (vertical or radial) of the media and it can then be exhausted to atmosphere.

Dry scrubbing can achieve the lowest outlet concentrations for any current technology when handling suitable contaminants.

Dry scrubbing media (of which activated carbon I the most popular) is very expensive (Ranging from £2000-£25,000 per tonne depending on the base material, any impregnates and the media form). The media can be granular, pelletised, beaded or powder and the type and form are selected to suit the duty.

Whilst dry scrubbing can handle almost any type of contaminant, its expense and limited capacity limit its use as a stand alone technology to very low levels of contaminant (odour control uses dry scrubbing extensively). Dry scrubbing is best suited to low concentration applications or as a polishing stage to meet limits from the exhaust of other abatement technologies (often biofilters or scrubbers).

Powdered Activated Carbon and powdered lime are often used in flue gas treatment to remove acid gases and VOCs (including dioxins).
Impregnated carbons (e.g., alkaline, copper oxide or phosphoric acid) are used for inorganic treatment and in more humid applications. Virgin carbon can be adversely affected by high humidity.

General Comparative Parameters

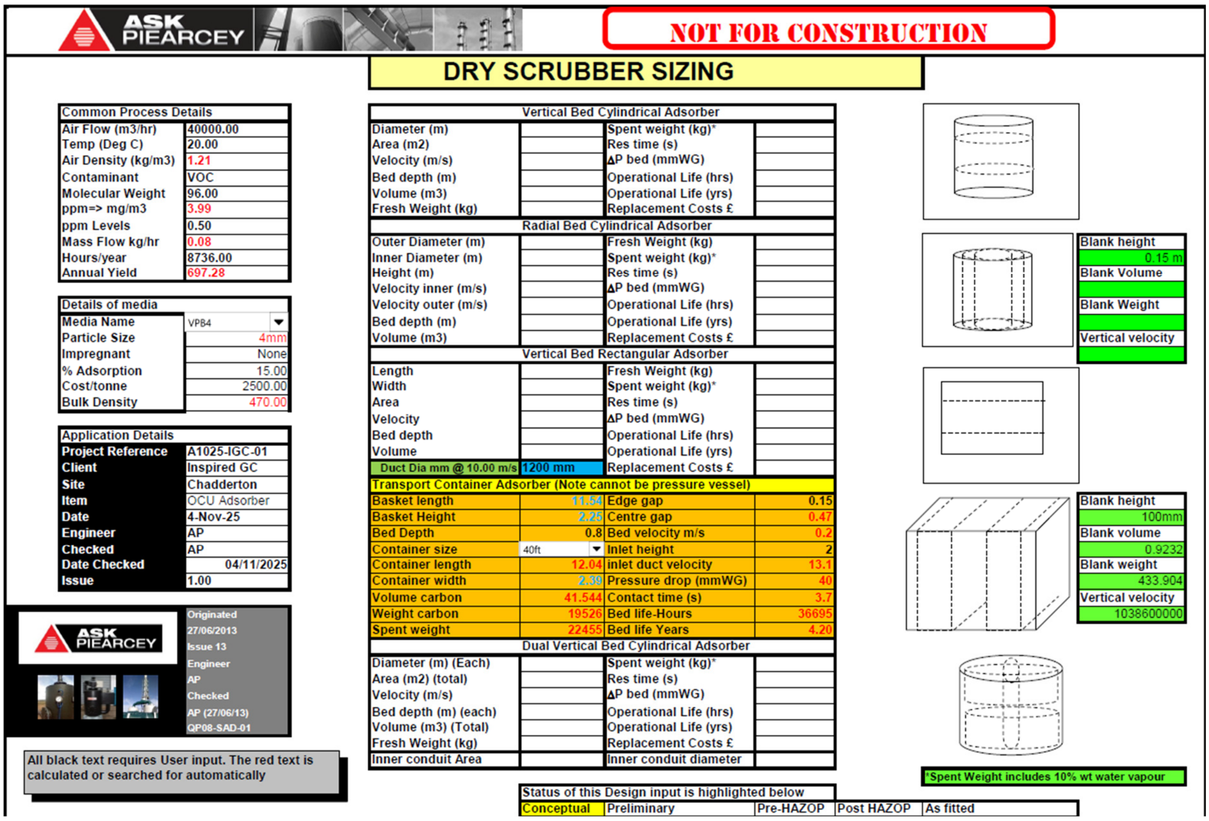
Parameter	Rating
Reliability	Arguably, the most reliable of all technologies currently available
Efficiency of removal	>99%
Ease of operation	Relatively easy to operate, very little intervention required
Maintenance	Carbon changes are typically carried out by specialists who remove the spent carbon and replace it with fresh carbon
Best suited to	Very low VOC or inorganic concentrations and temperatures below 45°C (unless powdered carbon is used in Flue gas treatment).
Foot-print	Small to medium footprint, typically operating at 2-6 seconds contact time

5.1 Choice of Abatement

The basis we have taken, which is based on our Gorton Survey, is that there is likely no requirement for abatement.

We previously concluded that if abatement were to be required (e.g. the stack model does not give 98th percentile compliance at 6 OU_E/m^3 ground level concentration at the grid of identified receptors), then the only suitable technology would be a carbon adsorber.

As we are taking the same design basis then the conclusion is obviously the same. However in this case it can be see that there is a boiler house and so it may be worth exploring the option of taking some of the more odorous air and using it as combustion air for the boiler. This is only viable if the air demand is reasonably continuous and also that it is of a flow rate that can accommodate a worthwhile portion of the total flow. This means that it can accept enough air flow so that any additional ducting requirements and cost are fully mitigated by the reduction and size of the main abatement plant or its ongoing operational cost.



NOT FOR CONSTRUCTION

DRY SCRUBBER SIZING

Common Process Details	
Air Flow (m3/hr)	40000.00
Temp (Deg C)	20.00
Air Density (kg/m3)	1.21
Contaminant	VOC
Molecular Weight	96.00
ppm=> mg/m3	3.99
ppm Levels	0.50
Mass Flow kg/hr	0.08
Hours/year	8736.00
Annual Yield	697.28

Details of media	
Media Name	VPB4
Particle Size	4mm
Impregnant	None
% Adsorption	15.00
Cost/tonne	2500.00
Bulk Density	470.00

Application Details	
Project Reference	A1025-IGC-01
Client	Inspired GC
Site	Chadderton
Item	OCU Adsorber
Date	4-Nov-25
Engineer	AP
Checked	AP
Date Checked	04/11/2025
Issue	1.00

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27/06/2013
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Engineer
AP
Checked
AP (27/06/13)
QP08-SAD-01

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Vertical Bed Cylindrical Adsorber			
Diameter (m)		Spent weight (kg)*	
Area (m2)		Res time (s)	
Velocity (m/s)		ΔP bed (mmWG)	
Bed depth (m)		Operational Life (hrs)	
Volume (m3)		Operational Life (yrs)	
Fresh Weight (kg)		Replacement Costs £	
Radial Bed Cylindrical Adsorber			
Outer Diameter (m)		Fresh Weight (kg)	
Inner Diameter (m)		Spent weight (kg)*	
Height (m)		Res time (s)	
Velocity inner (m/s)		ΔP bed (mmWG)	
Velocity outer (m/s)		Operational Life (hrs)	
Bed depth (m)		Operational Life (yrs)	
Volume (m3)		Replacement Costs £	
Vertical Bed Rectangular Adsorber			
Length		Fresh Weight (kg)	
Width		Spent weight (kg)*	
Area		Res time (s)	
Velocity		ΔP bed (mmWG)	
Bed depth		Operational Life (hrs)	
Volume		Operational Life (yrs)	
Duct Dia mm @ 10.00 m/s	1200 mm	Replacement Costs £	
Transport Container Adsorber (Note cannot be pressure vessel)			
Basket length	11.54	Edge gap	0.15
Basket Height	2.25	Centre gap	0.47
Bed Depth	0.8	Bed velocity m/s	0.2
Container size	40ft	Inlet height	2
Container length	12.04	inlet duct velocity	13.1
Container width	2.39	Pressure drop (mmWG)	40
Volume carbon	41.544	Contact time (s)	3.7
Weight carbon	19526	Bed life-Hours	36695
Spent weight	22455	Bed life Years	4.20
Dual Vertical Bed Cylindrical Adsorber			
Diameter (m) (Each)		Spent weight (kg)*	
Area (m2) (total)		Res time (s)	
Velocity (m/s)		ΔP bed (mmWG)	
Bed depth (m) (each)		Operational Life (hrs)	
Volume (m3) (Total)		Operational Life (yrs)	
Fresh Weight (kg)		Replacement Costs £	
Inner conduit Area		Inner conduit diameter	

Blank height	0.15 m
Blank Volume	
Blank Weight	
Vertical velocity	

Blank height	100mm
Blank volume	0.9232
Blank weight	433.904
Vertical velocity	1038600000

*Spent Weight includes 10% wt water vapour

Status of this Design input is highlighted below				
Conceptual	Preliminary	Pre-HAZOP	Post HAZOP	As fitted

The adsorber would be best built from a standard or even “Hi-Cube” freight container (many adsorber suppliers now do this). This would house over 20 tonnes of carbon and would last at least 4 years between changes.

6. Future Checks

6.1 Duty Validation

The flows and loads we measured at Gorton may not have contained all of the emission points that may be present at Chadderton. This means that once the extract is fully designed, some analysis of the total emission contribution has to be made to check that the basis of our assessment is valid. It may be for instance that the production line extract would also be included in this flow or that additional kettles are being used or that different products with different emission characteristic are being made.

6.2 Dispersion Modelling and OMP

For completeness 2 items should really be in place:

#1 An Odour Management Plan (OMP)

This is a document that needs to be approved by the relevant authority and is described in detail in the H4 horizontal guidance. It is a set of procedures for handling odorous inventory, managing odours on site, maintaining any control measures and also carrying out regular monitoring of the facility to manage odorous emissions.

#2 Dispersion Model

This is a CFD model using Aermod or some other approved software to show that a stack emission at 12 m/s with the odour levels mentioned in this report will result in an acceptable ground level concentration (<=5OU_E/m^3) at the designated receptors.

This provides definitive evidence that your process will not generate an odour nuisance from its exhausted extract.

This will need to be backed up with some olfactometric testing of the emission during representative production to confirm that the odour levels are at or below those stated and previously measured at Gorton.

This in turn will decide if you then require the above abatement or not.

6.3 Action Summary Table

Action	Description of Action
#1	Check that there are no additional odour sources (compared to Gorton) at this new facility
#2	Develop and odour Management Plan (OMP) – see H4 guidance. This needs to be approved by the authority managing your permit
#3	Carry out olfactometric testing on the combined extract to validate using the Gorton basis but to also provide a firm and representative basis for item #4.
#4	Carry out Dispersion Model with known data to establish that the likely stack emission will meet the ground level odour consent (probably 6 OU_E/m^3)
#5	Check that any waste skips that contain food waste are either sealed or kept indoors

We note that the site is having odour mapping carried out which will determine the validity of taking the basis that the key odour source is the sauce cookhouse.

6.4 Addendum to Issue 2 of this Report

Since the last issue of our report the SLR report for dispersion modelling based on 5 OU_E/m^3 Has been released and the report concludes that the site is unlikely to generate emissions that will give rise to ground level concentrations at 5 OU_E/m^3 at designated receptors for the 98th percentile. Only a single receptor, E17, may periodically see a GLC of 5.4 OU_E/m^3

And this is highly unlikely to give rise to complaints as it is still below the 6 OU_E/m^3 for what we would expect will be relatively inoffensive odour.

On this basis, there is no requirement to augment the extraction with abatement.