Shoalhaven Starches

Environmental Audit

Odour Sources

October 2007

Volume 1 - Report

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

The Manildra Group operates the Shoalhaven Starches factory at Bolong Road, Bomaderry, near Nowra, in NSW. At this factory, flour and grains are processed to produce ethanol, starch, gluten, glucose and distiller's dried grain (DDG). Shoalhaven Starches is the holder of Environment Protection Licence number 883 issued by the NSW Department of Environment and Climate Change (DECC; formerly known as the Department of Environment and Conservation (DEC) and Environment Protection Agency (EPA)).

Wastewater produced at the factory is pumped to holding ponds located on a nearby property, known as the "environmental farm". Wastewater from these ponds is reused at the environmental farm by irrigation of pasture using spray irrigators.

Members of the community have made a number of complaints to Shoalhaven Starches and the DECC regarding odours reported to have emanated from Shoalhaven Starches operations. Following investigation of odour complaints, DECC successfully prosecuted Shoalhaven Starches in the Land and Environment Court for the emission of offensive odours.

The Land and Environment Court judgement of 2 November 2006 required Shoalhaven Starches to engage a suitably qualified person to conduct a comprehensive environmental audit of the factory and environmental farm in order to identify and quantify all odours generated by the operations, and to provide recommendations for the improved management of odours. Shoalhaven Starches engaged GHD Pty Ltd to conduct the environmental audit.

2. Audit Objective

The objective of the environmental audit program was to address the requirements of Condition 2 of Annexure B to the Land and Environment Court judgment of 2 November 2006, reproduced below. Extracts from the judgement are also reproduced at the start of each relevant chapter in this report. A full copy of the Annexure is provided in Appendix A.

(2) For the purposes of ensuring no offensive odours as defined by the Protection of the Environment Operations Act 1997 are emitted from the premises, the defendant must engage a suitably qualified expert or experts to conduct an environmental audit that must:

(a) Identify and list every process, activity and substance stored or used at the premises that generates or has the potential to generate odours.

(b) Benchmark each process and activity identified at (a) against comparable international best available technology and industry best management practice relating to the control of odour from that process and activity.

(c) Identify and list every actual and every potential source of offensive odour at the premises. This must include all point, diffuse and fugitive sources.

(d) Identify for each odour source identified at (c) the cause or causes of the odour.

(e) Quantify for each odour source identified at (c) the actual and potential nature, strength and duration of occurrence of the odour in accordance with the publication "NSW DEC 2005 Approved Methods for the Sampling and Analysis of Air Pollutants in NSW".

(f) Model for each odour source identified at (c) the impacts and potential impacts of the odour at all sensitive receptors in accordance with the publication "NSW DEC 2005 Approved Methods of the Modelling and Assessment of Air Pollutants in NSW".

(g) Identify all available options to prevent the generation of offensive odour for each actual and potential odour source identified at (c).

(h) Where at (g) prevention is not possible, identify all available options to minimise the generation of offensive odour for each actual and potential odour source identified at (c).

(i) Describe, quantify and model the likely environmental impacts of implementing each option identified at (g) and (h).

(j) State for each actual and potential odour source identified at (c), the preferred option for the prevention or minimisation of the generation of offensive odour from that source.

(k) Review the adequacy of policies, procedures, standards, practices and training at the premises in relation to environmental performance and in particular odour management. Where any inadequacy is found to exist recommend options to address each inadequacy.

(l) Produce an audit report that details all of the above.

3. Audit Scope

3.1 Activity Being Audited

The audited activity is the operation of the Shoalhaven Starches facility at Bolong Road, Bomaderry NSW. The scope of the audit is described in Condition 2 of Annexure B of the Land and Environment Court judgement (refer Section 2 and Appendix A of this report). The geographic area covered by the audit is the area of operations at 36 Bolong Road (hereafter referred to as the factory) and the area occupied by the environmental farm. The location of these areas is shown in Appendix B. Consideration is also given to various receptors located on land in the vicinity of the factory and the environmental farm.

3.2 Components of the Activity Considered

The audit has considered the management of processes, activities and substances stored or used at the premises that generate or have the potential to generate odours.

The audit considered:

» every actual and every potential source of offensive odour at the premises, including all point, diffuse and fugitive sources;

» the cause or causes of odour;

» the actual and potential nature, strength and duration of occurrence of the odours;

» the impacts and potential impacts of the odour at all sensitive receptors;

» available options to prevent the generation of offensive odour;

» available options to minimise the generation of offensive odour;

» the likely environmental impacts of implementing each odour minimisation option; and

» the preferred option for the prevention or minimisation of the generation of offensive odours.

Additionally, the adequacy of policies, procedures, standards, practices and training at the premises in relation to environmental performance and in particular odour management was reviewed.

3.3 Segment of the Environment

The audit examined the air environment that is directly affected by odour emissions from the Shoalhaven Starches facility. The audit did not examine the soil, groundwater or surface water environments or the management of solid or aqueous wastes except where these generate odours or have the potential to generate odours.

The time frame to which the audit applies is the time during which the audit activities were being conducted, specifically between December 2006 and June 2007.

3.4 Audit Criteria

3.4.1 Environment Court judgement

The audit considered the requirements of Condition 2 of Annexure B to the Land and Environment Court judgement of 2 November 2006:

» review systems, plans, procedures, monitoring programs, data, records or other information relevant to the scope of the audit;

» inspect any relevant activities, processes, plan and/or equipment on site; and

» collect or model any data as the auditor sees fit.

3.4.2 Regulatory criteria and other reference documents

The audit was conducted with reference to State environment legislation and relevant policies, guidelines and standards listed below.

» *Protection of the Environment Operations Act 1997*.

» *Protection of the Environment Operations (Clean Air) Regulation 2002*.

» *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*. New South Wales Department of Environment and Conservation, 2005.

» *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW*. New South Wales Department of Environment and Conservation, 2007.

» Australian Standard AS 4323.1 – 1995: *Stationary source emissions – Selection of sampling positions*.

» Australian Standard AS/NZS 4323.3 – 2001: *Stationary source emissions – Determination of odour concentration by dynamic olfactometry*.

» *NSW EPA Technical framework: assessment and management of odour from stationary sources in NSW*.

3.5 Audit Method

3.5.1 Audit process

The environmental audit of odour emissions and associated on-site activities is described below. This method was developed to address the requirements of Annexure B to the Land and Environment Court ruling of 2 November 2006.

The audit method is based on that described in AS/NZS ISO 14015:2003 *Environmental management — Environmental assessment of sites and organisations (EASO)*, AS/NZS ISO 19011:2003 *Guidelines for quality and/or environmental management systems auditing* and the *Compliance Audit Handbook* (Department of Environment and Conservation NSW, 2006). The audit followed the overall structure of:

» plan;

» gather information;

» evaluate information; and

» report.

This process complemented the 12 requirements of Condition 2 of Annexure B.

3.5.2 Documentation reviewed

A list of documentation examined during the audit is provided in Appendix C. Apart from publicly available regulatory information, Shoalhaven Starches provided all documentation.

3.5.3 Audit activities

A timeline of audit activities is provided in Table 1.

Table 1. Audit activity timeline

7 and 8 December 2006	Audit team attended an initial site meeting with Shoalhaven Starches at Bomaderry. The audit team members conducted a familiarisation inspection of the Bolong Road facility and the environmental farm.
Week of 15 December 2007	Designed and conducted a pre-survey odour emission decay rate trial.
Week of 22 January 2007	Conducted a detailed inspection of the premises. Identified actual and potential odour sources. Identified and tagged odour emission points for sampling.
Week of 29 January 2007	Conducted an odour sampling program.
6 February 2007	Attended a meeting with DECC.
February to June 2007	Conducted odour modelling based on results from odour sampling program. Identified options to prevent or minimise odours.
April 2007	Conducted supplementary odour sampling.
8 June 2007	Preliminary draft audit report submitted to Shoalhaven Starches for comment on technical content of report.
30 July 2007	Draft audit report submitted to Shoalhaven Starches for comment on technical content of report.
12 October 2007	Final audit report submitted to Shoalhaven Starches.

3.5.4 Audit interviews and meetings

The following Shoalhaven Starches representatives were interviewed during the audit:

» General Manager, Shoalhaven Starches;

» Manager Technical & Environment, Shoalhaven Starches;

» Leading Hands (2), Packing Area;

» Leading Hands (2), Starch Plant;

» Leading Hand, Glucose Plant;

» Acting Leading Hand, DDG Plant;

» Environmental Scientist, Environmental Farm;

» Leading Hand, Environmental Farm;

» Leading Hand, Distillation Plant; and

» Leading Hand, Distillation and Ethanol Plant.

As allowed for in Annexure B, the auditor attended a meeting with representatives of the DECC to seek information regarding the audit. The meeting provided an opportunity for the audit team members to meet the Department's representatives and to discuss general issues relating to the audit. Consistent with the requirements of Annexure B, the Department did not offer any comment on the audit process, nor was any sought by the auditor.

3.5.5 Data collection and evaluation

Data collection and evaluation was conducted in the following stages:

(i) identification of all processes and activities conducted at Shoalhaven Starches;

(ii) interview of personnel associated with management and conduct of the respective processes and activities;

(iii) benchmarking of the processes or activities against comparable international best available technology and industry best management practice with relation to odour control;

(iv) identification of actual and potential sources of odour and their causes;

(v) quantification of each offensive odour source through sampling and analysis by dynamic olfactometry;

(vi) modelling of the quantified odour sources to determine the impacts and potential impacts of the odour at all sensitive receptors;

(vii) identification of options to prevent or minimise generation of odours for each modelled source;

(viii) identification, quantification and modelling of the likely environmental impacts of implementing the odour prevention or mitigation measures;

(ix) identification of the preferred option for prevention or minimisation of odour generation from the modelled sources;

(x) assessment of the adequacy or policies, procedures, standards practices and training at the premises in relation to environmental management and odour generation; and

(xi) preparation of an audit report in which the audit process and findings have been documented.

3.5.6 Odour sampling and analysis

Sampling of odour sources and olfactometry was conducted by Emission Testing Consultants (ETC) during January and February 2007. ETC is NATA accredited for both odour sample collection and odour sample analysis.

Sampling method

On-site sampling was conducted in accordance with ETC method 1. Sampling plane criteria were determined in accordance with Australian Standard AS 4323.1-1995: *Selection of sampling positions*. Methods identified in this section are described in detail in the ETC reports (see Appendix E).

Flow rate and velocity were determined using a pitot tube and differential manometer, in accordance with USEPA Method 2. Temperature was determined using a calibrated thermocouple and digital pyrometer.

Isolation flux (quiescent surfaces) was determined according to ETC method 130 using an equilibrium flux chamber.

Given the recent development of the draft Australian Standard for area source measurement (AS4323.4), quality control protocols outlined in the draft standard were adopted if not otherwise stated in ETC method 130. Isolation flux chambers (IFCs) that were compliant with the draft standard and the specifications of USEPA user guide (1986 EPA/600/8) were used.

Odour-free air (zero grade) was used where static pre-dilution was conducted.

Grab samples (stacks, ducts, fugitive and ambient samples) were collected according to Australian Standard AS4323.3, by collection into Nalophan sample bags using the 'lung' principle.

Odour analysis

All odour analyses were conducted using six-member odour panels. Odour analysis was conducted according to Australian Standard AS4323.3, by dynamic olfactometry (forced-choice technique). Panel n-butanol threshold determination was achieved by analysis against a NATA certified n-butanol gas standard. All samples were analysed within 30 hours of collection.

3.5.7 Audit team members

The following GHD personnel formed the audit team:

- Dr David Telford, Principal Environmental Consultant, Environmental Auditor appointed pursuant to Part IXD of the *Environment Protection Act 1970* (Vic);
- Scott Anderson, Senior Environmental Scientist;
- Chris Hertle, Principal Engineer, Industrial Process Engineering;
- Tim Pollock, Principal Environmental Engineer;
- Mitch Laginestra, Senior Process Engineer;
- Mike Rodd, Principal Water Engineer; and
- James Ellaway, Principal Environmental Scientist.

4. Processes, Activities and Substances with Odour Generating Potential

(a) *Identify and list every process, activity and substance stored or used at the premises that generates or has the potential to generate odours.*

4.1 General

Wheat flour and grains (sorghum and wheat) are processed to produce ethanol, starch, gluten and glucose. Solid wastes are treated to produce distiller's dried grain (DDG), with liquid wastes being transferred to the environmental farm where they are disposed of by irrigation of pasture. The main processing and materials treatment areas at Shoalhaven Starches comprise the:

- starch plant;
- glucose plant;
- ethanol and distillation plant;
- DDG plant; and
- environmental farm.

4.2 Processes

4.2.1 Starch plant

Within the starch plant, flour is processed to separate the starch from gluten (the protein component of flour). The starch is graded, dried and packed for shipment. Different grades of starch are manufactured for food and paper making applications. Starch that is not suitable for sale is used as a raw material for the ethanol plant. Gluten is dried and sold for use in the food industry.

Aqueous (water-based) wastes are reused within the plant, or are transferred to the environmental farm for disposal.

A schematic process flow diagram of the starch plant is provided in Figure 1. Processes and associated potential odour sources at the starch plant are shown in Table 2.

NB: Allotment of audit reference numbers does not necessarily correspond to the production sequence of the respective plant. Some numbers may not have been allocated due to those components of the plant being ruled out during the initial source identification and screening process. Plant numbers used by Shoalhaven Starches (e.g. BFM 132) are included in some instances to assist with identification of the plant.

Figure 1 Starch plant schematic process flow diagram

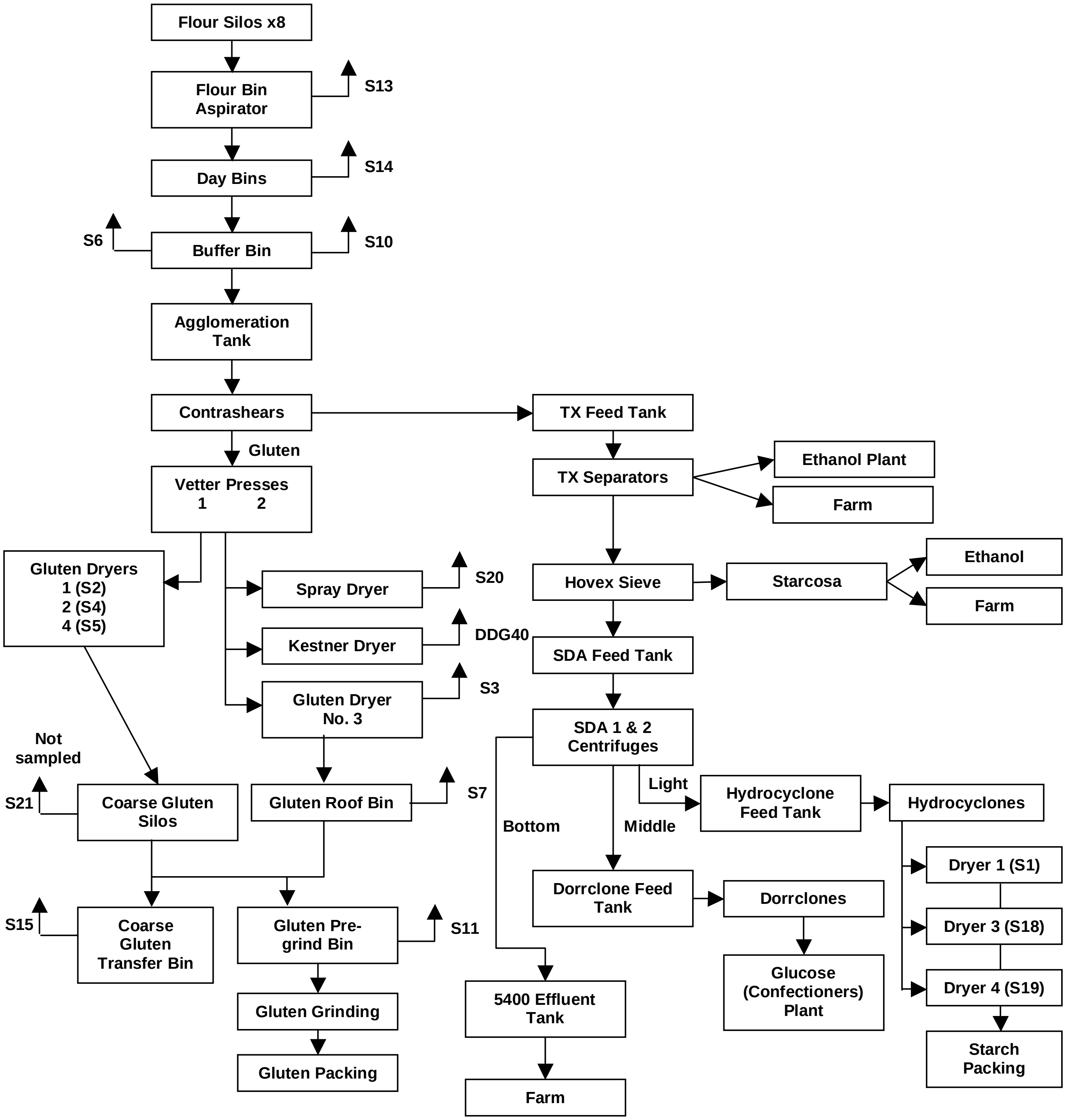


Table 2. Potential odour sources in the starch plant

Audit Ref	Equipment	Potential odour source
S1	No. 1 Starch dryer scrubber tower	Vent on roof
S2	No. 1 Gluten dryer baghouse	Vent on roof
S3	No. 3 Gluten dryer baghouse	Vent on roof
S4	No. 2 Gluten dryer baghouse	Vent on roof
S5	No. 4 Gluten dryer baghouse	Vent on roof
S6	Flour bin (BFM 160)	Vent in wall
S7	Dry gluten roof bin	Vent in wall
S8	High protein dust collector	Vent on roof
S9	Pre-separator	Vent in wall
S10	Flour bin (BFM 161)	Vent in wall
S11	No. 2 Coarse bin	Elevated vent
S12	Pellet silo	Ground level vent
S13	Flour bin aspirator (2 units) (BFM 132)	Ground level vent
S14	Day bin transfer baghouse (BFM 145)	Ground level vent
S15	Coarse gluten transfer baghouse (CGM 40)	Ground level vent
S16	Kraus Maffei starch conditioners	Internal breather
S17	Starch reactions tanks (4 units)	Vent on tank
S18	No. 3 Starch dryer scrubber tower	Vent on roof
S19	No. 4 Starch dryer scrubber tower	Vent on roof
S20	Spray dryer	Vent on roof

4.2.2 Glucose plant

The glucose plant houses two lines; the confectioners glucose line and the brewers glucose line. Confectioners glucose is distinguished by having been demineralised to remove latent odours and flavours that might be carried through to the final product by the glucose.

Both processes use starch as the raw material. The starch is broken down to its constituent glucose molecules using enzymatic and hydrolytic processes. Water is removed from the resulting glucose solutions using evaporation to produce glucose solutions of desired concentration. The glucose product is shipped to customers in bulk containers.

The glucose manufacturing process generates aqueous wastes, mostly condensate from the evaporators, which is reused during regeneration of the ion exchangers.

A schematic process flow diagram of the glucose plant is provided in Figure 2. Potential odour sources at the glucose plant are identified in Table 3.

Figure 2 Glucose plant schematic process flow diagram

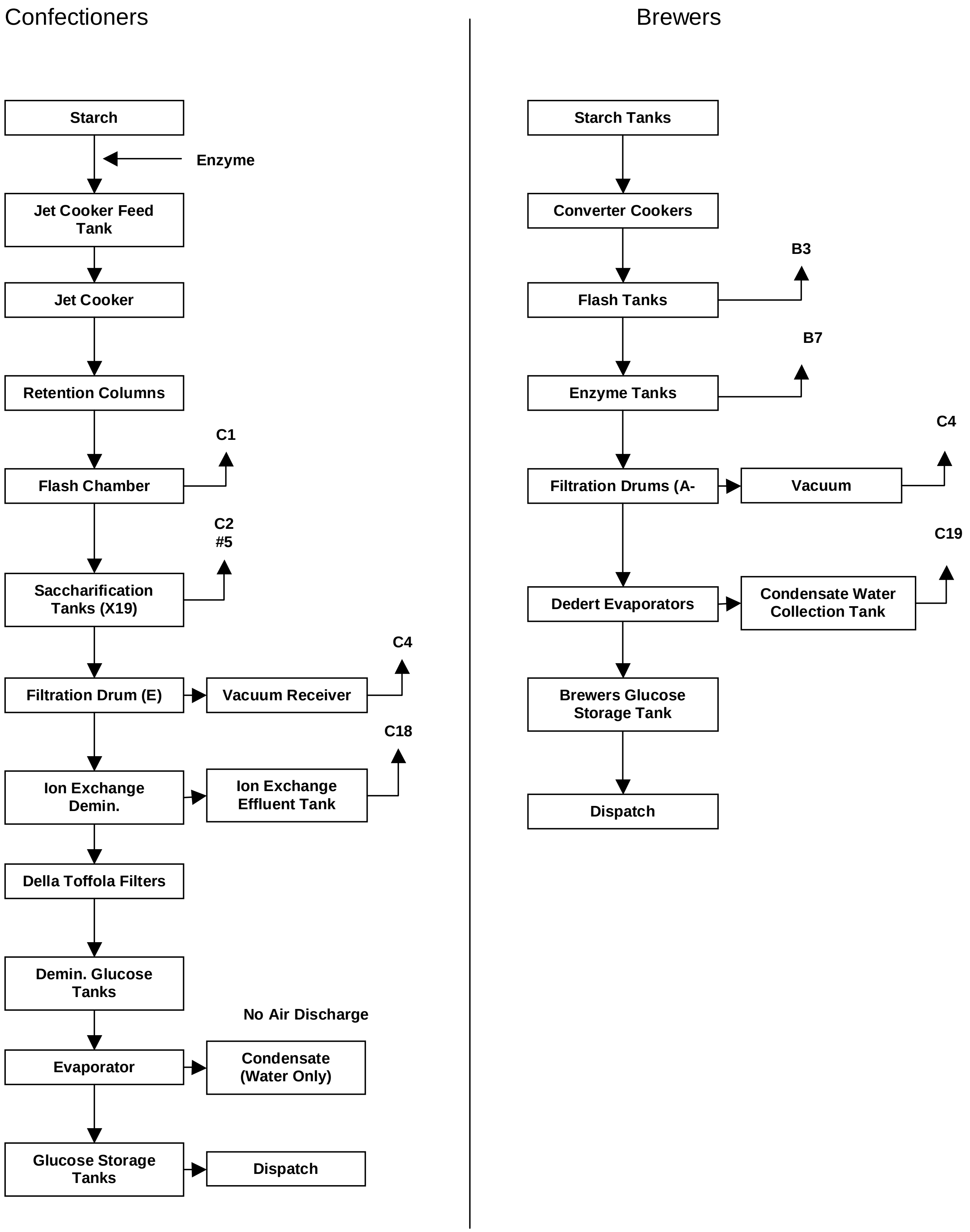


Table 3. Potential odour sources in the glucose plant

Audit Ref	Equipment	Potential odour source
Confectioners glucose line		
C1	Flash chamber	Chamber vent
C2	Saccharification tanks (19 units)	Tank vents
C3	Rotary vacuum drum filter	Nil (filter discharges to C4)
C4	Filtration drum vacuum receiver	Receiver vent
C5	Units 1 & 2 feed tank 1	Indoors vent
C6	Units 1 & 2 feed tank 2	Indoors vent
C7	Units 3, 4 and 5 feed tank 1	Indoors vent
C8	Units 3, 4 and 5 feed tank 2	Indoors vent
C9	Units 3, 4 and 5 feed tank 3	Indoors vent
C10	Della Toffola 2 & 4 feed tank	Tank vent
C11	Demin glucose buffer tank 1	Tank vent
C12	Demin glucose buffer tank 2	Tank vent
C13	Demin glucose concentrate feed tank 1	Tank vent
C14	Condenser vacuum pump (GBM23)	Pump vent
C15	Weigand evaporator vacuum pump (GBM12)	Pump vent
C16	Glucose tanks 1 - 15	Tank vent
C17	Roof vent	Rotating vent on roof
C18	Ion exchange effluent tank	Tank vent
C19	Condensate water collection tank	Tank vent
Brewers glucose line		
B1	Starch tanks 1, 2 & 3	Tank vent
B2	Hydrochloric acid tank	Tank vent
B3	Flash tanks (2 units)	Tank vent
B3	Cooker A flash tank	Roof vent
B4	Cooker B flash tank	Roof vent common with B3
B5	Storage (hydrolysis) tank	Tank vent
B6	Enzyme tanks 2 – 6	Tank vents
B7	Enzyme tanks (17 & 18)	Tank vent
B8	Drum filters A, B, C & D	Nil (filters discharge to C4)

4.2.3 Ethanol and distillation plants

The ethanol plant houses two lines, the grain line and the starch line, which are distinguished by the source of substrate for the fermentation process used to produce the ethanol. Grain, typically wheat and sorghum, is ground, mixed with water and heated in 'jet cookers' before being fermented. Starch factory rejects (described in section 4.2.1), which are in suspension, are also heated in jet cookers before being fermented.

Fermentation is carried out in six fermentation vessels using the treated substrate to which an ethanol-producing yeast inoculum has been added. The yeast inoculum is generated using five yeast propagator vessels, these being seeded using commercial strains of yeast.

Wastes from the grain line and the fermenters are transferred to the DDG plant (refer to section 4.2.4) for processing. Fermentation liquor from the ethanol plant is transferred to the distillation plant where water and other impurities are removed to produce fuel quality ethanol.

A schematic process flow diagram of the ethanol and distillation plants is provided in Figure 3. Processes and associated potential odour sources at the ethanol plant are shown in Table 4.

Figure 3 Schematic process flow diagram of the ethanol and distillation plants

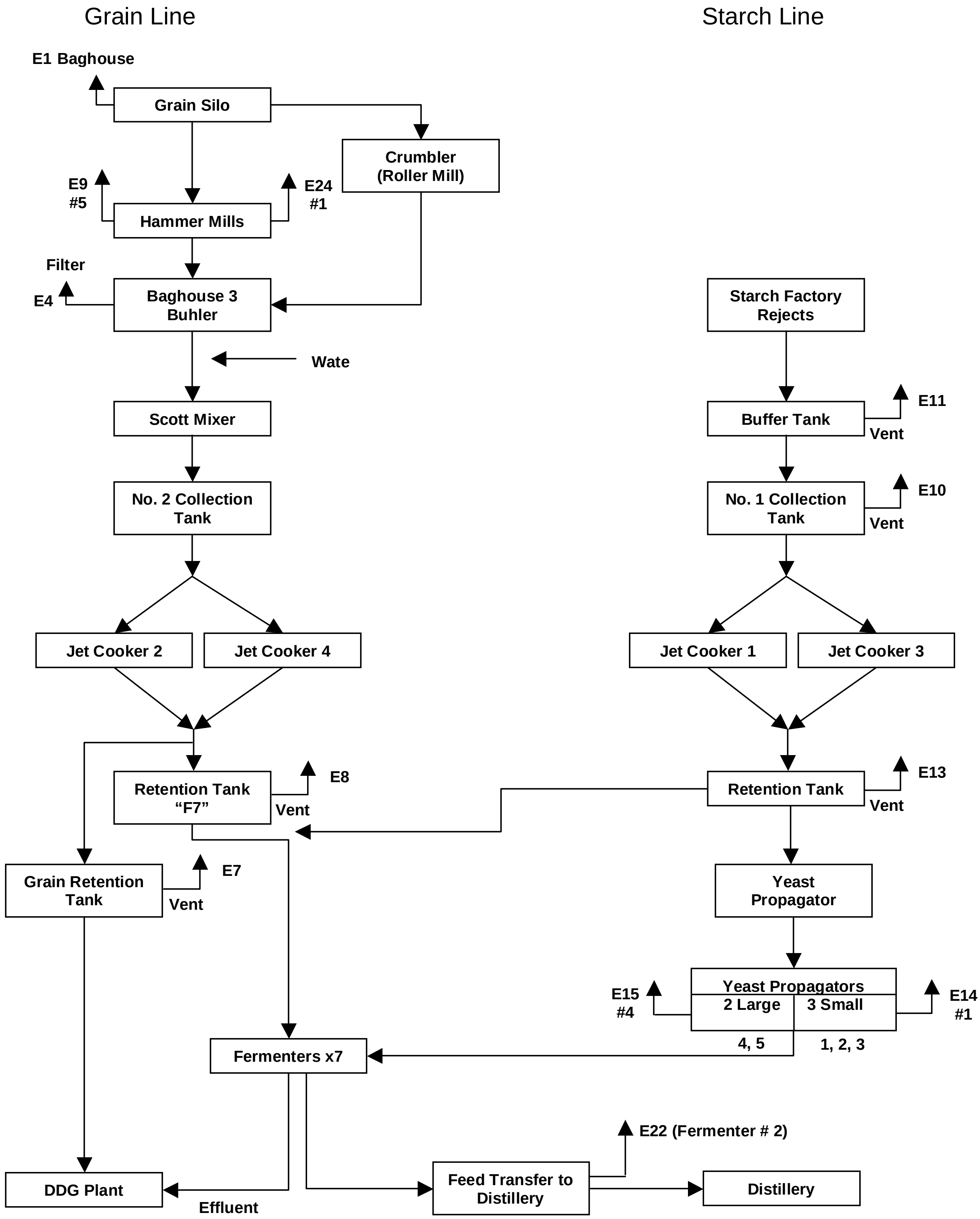


Table 4. Potential odour sources in the ethanol plant

Audit Ref	Equipment	Potential odour source
Grain line		
E1	Grain silo	Baghouse vent
E2	Grain elevators	Housed
E3	Hammer mill	Enclosed
E9, E24	Hammer mill	Baghouse exhaust vent
E4	Bühler baghouse	Baghouse exhaust vent
E5	Not assigned	—
E6	No. 2 collection tank	Vent
E7	Jet cooker 2 & 4 grain retention tank	Tank vent
E8	Jet cooker retention tank “F7”	Tank vent
Starch line		
E11	Starch factory rejects buffer tank	Tank vent
E10	No. 1 collection tank	Tank vent
E12	Ammonia storage tank	Emergency vent
E13	Jet cooker retention tank	Tank vent
E14, E15	Yeast propagators (5 units)	Tank vents
E16	Fermenter No. 1	Carbon dioxide (CO_2) collection system
E17	Fermenter No. 2	CO_2 collection system
E18	Fermenter No. 3	CO_2 collection system
E19	Fermenter No. 4	Vent to grain retention tank 2 (Source No. E8)
E20	Fermenter No. 5	Vent to source No. E8
E21	Fermenter No. 6	Vent to source No. E8
E22	Fermenters	Tank vent
E23	Cooling towers	Exhaust cooling air
Distillation plant		
D1	Stage 2 product condenser flame arrestor (E683)	Elevated vent
D2	Stage 2 vacuum drum flame arrester (D697)	Elevated vent
D3	Stage 4 product condenser flame arrestor (E563)	Elevated vent
D4	Stage 4 product cooler flame arrestor (E519)	Elevated vent
D5	Stage 4 final product drum (D569)	Elevated vent

D6	Stage 3 incondensable gases vent (E538)	Elevated vent
D7	Stage 1 condenser (E27)	Elevated vent
D8	Stage 1 condenser (E501)	Elevated vent
D9	Stage I condenser (E45/0)	Elevated vent
D10	Stage 1 condenser vent (C600)	Elevated vent
D11	Stage 1 recycled water to wastewater (ULT018)	Elevated vent
D12	DME (dimethyl ether) plant vent	Elevated vent

4.2.4 DDG plant

Wastes from the ethanol and distillation plant are dewatered in decanter centrifuges and dried in steam dryers to produce DDG. Water from the DDG decanters is evaporated to recover syrup and produce clear condensate. The syrup is added to the dryer feed for recovery of the solids. Exhaust gases from the DDG dryer are transferred to the boiler air intake in order to destroy odorous components of the gases by combustion.

A schematic process flow diagram of the DDG plant is provided in Figure 4. Processes and associated potential odour sources at the DDG plant are shown in Table 5.

Figure 4 DDG plant schematic process flow diagram

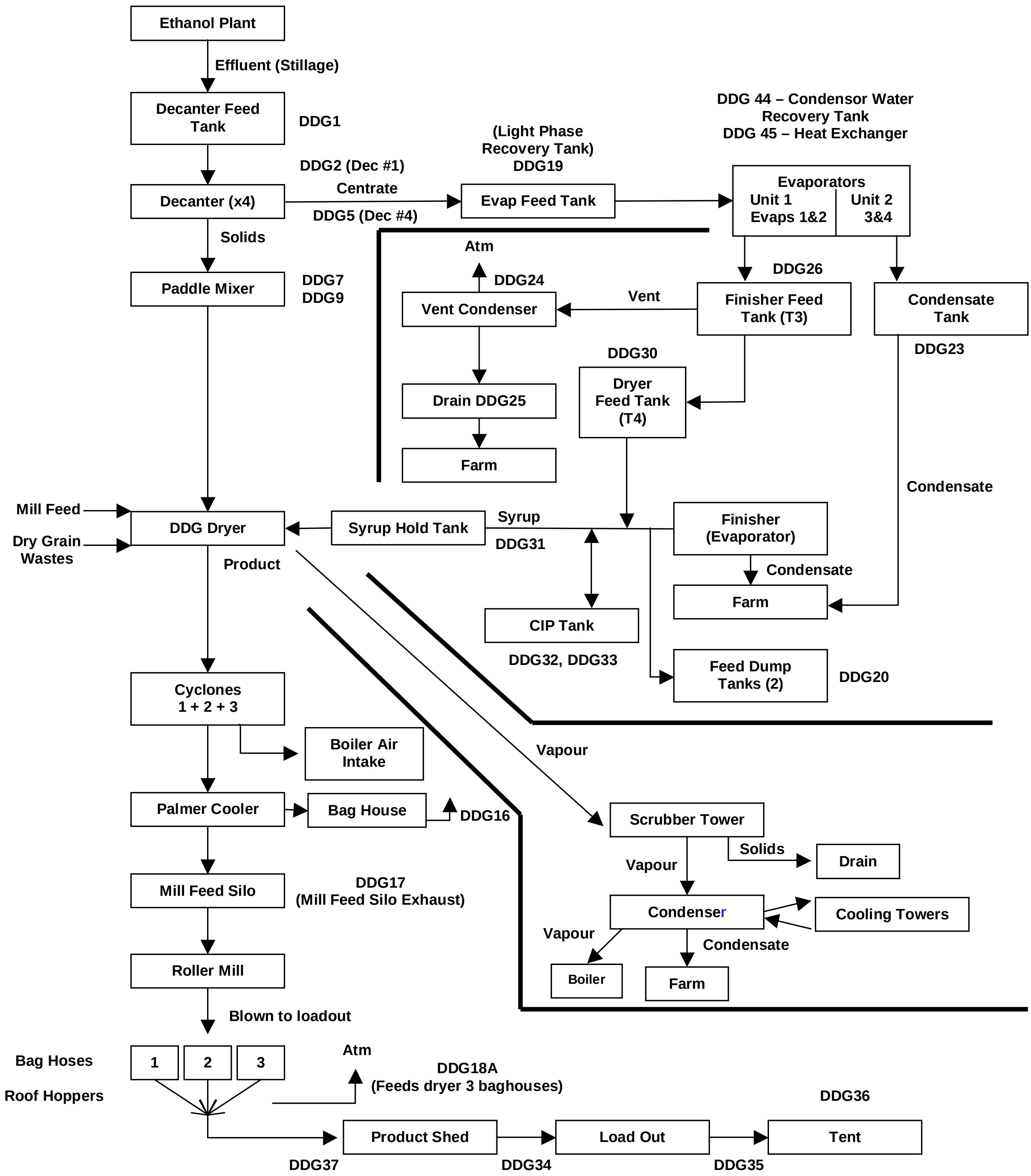


Table 5. Potential odour sources in the DDG plant

Audit Ref	Equipment	Potential odour source
Solids line		
DDG1	Decanter feed tank	Tank vent
DDG2	Decanter No. 1 (Westphalia)	Elevated vent
DDG3	Decanter No. 2 (Westphalia)	Elevated vent
DDG4	Decanter No. 3 (Alpha Laval)	Elevated vent
DDG5	Decanter No. 4 (Alpha Laval)	Elevated vent
DDG6	Inclined screw conveyors	Sealed
DDG7, DDG8, DDG9	Paddle mixers (3 units)	Fugitive (inside building)
DDG10	High speed mixer (3 units)	Enclosed
DDG11	DDG dryer No. 1	Flap at rear (inside building)
DDG12	DDG dryer No. 2	Flap at rear (inside building)
DDG13	DDG dryer No. 3	Flap at rear (inside building)
DDG14	Cyclones 1, 2 & 3	To boiler air intake
DDG15	Palmer cooler	To boiler air intake
DDG16	DDG Palmer cooler baghouse	Elevated vent
DDG17	Mill feed silo exhaust	Baghouse exhaust vent (inside building)
DDG18	Feeds dryer baghouses (3 units)	Baghouse exhaust (common) vent
DDG34	DDG product storage shed	Fugitive
DDG35	Load out awning	Fugitive
DDG36	DDG load out 'tent'	Fugitive
DDG37	Spilled product outside of product shed	Fugitive
Liquids line		
DDG19	Evaporator feed (light phase recovery) tank	Tank vent
DDG20	Feed dump tanks (2 units)	Tank vent
DDG21	Evaporators 1 & 2	Vented to condensate tank
DDG22	Evaporators 3 & 4	Vented to condensate tank
DDG23	Condensate tank	Tank vent
DDG24	Vent condenser	Condenser vent
DDG25	Vent condenser drain	Fugitive from floor drain pit
DDG26	Finisher feed tank	Tank vent

Audit Ref	Equipment	Potential odour source
DDG27	Finisher	Sealed unit
DDG28	Finisher pump tank (LT308)	Tank vent
DDG29	Not assigned	—
DDG30	Dryer feed tank	Tank vent
DDG31	Syrup hold tank	Tank vent
DDG32, DDG33	CIP tank	Tank vent
DDG38	Cooling tower	Fugitive
DDG39	Dryer building	Fugitive
DDG40	Kestner dryer (see table 2)	Baghouse exhaust vent
DDG41	Drains from heat exchanger for dryer No. 1	Floor drains
DDG42	Drains from heat exchanger for dryer No. 3	Floor drains
DDG43	Drain under dryers	Floor drains
DDG44	DDG condenser water recovery tank	Open-topped tank
DDG45	DDG heat exchanger	Vent
DDD46	Cooling towers (DDG dryer area)	Fugitive
DDD47	Cooling Towers (DDG Evaporator area)	Fugitive

4.2.5 Environmental farm

A number of wastewater streams are produced at the factory. These consist of three clear condensate streams (distillation plant condensate, evaporator condensate, DDG condensate, a small flow from the CO_2 plant and boiler blowdown) and a combined dirty stream from the starch, gluten and glucose plants. The clear condensates are pumped to storage ponds at the environmental farm, where they are acidified with sulfuric acid to limit microbial activity and hence odour generation.

The ‘dirty’ wastewater streams are acidified, combined in the farm tank (located at the factory) and pumped to a partially covered pond for storage. Prior to its reuse by irrigation of pasture at the environmental farm using spray irrigators, lime is added in the mixer tank to wastewater drawn from the ponds to raise the pH.

Processes and associated potential odour sources at the environmental farm are shown in Table 6.

Table 6. Potential odour sources at the environmental farm

Audit Ref	Equipment	Potential odour source
Solids line		
F1	Mixer tank vent	Tank vent

F2	Pond 1	Pond surface
F3	Pond 2	Pond surface
F4	Pond 3	Pond surface
F5	Pond 4 (open area)	Pond surface
F6	Pond 4 (covered area)	Pond surface
F7	Pond 5	Pond surface
F8	Pond 6	Pond surface
F9	Pivot irrigators (No 130 selected to represent pivot Nos 110, 120, 150 and 160)	Irrigation spray
F10	Pivot irrigator (No. 140 equipped with low-mist nozzles)	Irrigation spray
F11	Traveller irrigators (large and small)	Irrigation spray
F12	Pivot irrigated land	Freshly irrigated pasture (wet)
F13	Traveller irrigated land	Freshly irrigated pasture (wet)
F14	Pivot irrigated land	Freshly irrigated pasture (wet)
F15	Pivot irrigated land	Dry pasture
F16	Non-irrigated pasture (control sample)	Non-irrigated pasture
F17	Pivot irrigated land (Soper's paddock)	Dry pasture
F18	Farm tank (located at factory)	Tank vent

4.3 Other Activities

4.3.1 Product load out areas

Starch, glucose and ethanol products are loaded into road tankers from bulk storage silos and tanks. Load out of starch and glucose does not have the potential to generate odours, as these products have a low inherent odour characteristic.

Given the flammable nature of ethanol, the load out process is strictly controlled for occupational health and safety purposes. Consequently, the potential for vapour generation and for spillage being minimised.

Load out activities for these products are therefore not regarded as having the potential to be significant sources of odour for the purposes of this audit. The DDG product load out area is addressed in Section 4.2.4.

4.3.2 Cooling towers

Cooling towers operate as part of the cooling water circuit for the ethanol and DDG plants. The recirculated cooling water has the potential to absorb odours and to disperse the odours to atmosphere during the evaporative cooling (aeration) process within the cooling towers. In addition, contamination of the cooling water by product, process intermediates or wastes can introduce odorous materials direct to the cooling water, which can greatly increase its odour generating potential. The aeration process readily strips the more volatile (and potentially odorous) compounds from the water, providing a high-volume potential source of odour that is released direct to atmosphere.

Odour emissions from cooling towers located at the ethanol plant, evaporators and DDG plant were included in the audit.

4.3.3 Coal-fired boiler

Steam is generated at Shoalhaven Starches by four coal-fired boilers (Numbers 2, 4, 5 and 6). The combustion gases from these boilers are discharged via three stacks, boilers 5 and 6 having a common stack. Gases from boilers 2 and 4 are treated in separate cyclones and those from boilers 5 and 6 are treated in a baghouse prior to discharge to atmosphere.

In the immediate area of the site where the coal is handled, i.e. in the boiler houses and the coal storage bunker, the characteristic odour of black coal was discernible. When running at normal operating conditions, the operating temperatures within the boiler combustion chamber are sufficient to destroy odours associated with the coal. This odour destruction mechanism is exploited at Shoalhaven Starches for the DECC-approved destruction of odorous dryer exhaust gases from the DDG plant. The coal-fired boilers were therefore not regarded as having the potential to be significant sources of odour for the purposes of this audit.

4.4 Substances

In addition to the raw materials used in the plants described above, some bulk reagents are used in the process streams to achieve chemical modification of various process intermediates and for cleaning of equipment. These substances and their potential to generate odours are listed in Table 7.

Table 7. Potential odour generation by substances stored on site

Plant	Substance	Odour characteristic	Odour generating potential
Starch	Acetic anhydride	Vinegar-like odour	Low in storage area, added to process vessel within starch plant building. Potential emission from starch dryer exhaust has been measured.
Starch	Hydrogen peroxide	Negligible odour	Low due to negligible odour characteristic.
Starch	Sodium hydroxide (caustic soda)	Negligible odour	Low due to negligible odour characteristic.
Starch	Nitric acid	Characteristic acrid odour	Low, due to materials handling controls in place for OH&S purposes.
Starch	Sodium hypochlorite	Bleach odour	Moderate bleach odour within building.
Glucose	Hydrochloric acid	Irritating pungent odour	Low, due to materials handling controls in place for OH&S purposes.
Glucose	Sodium hypochlorite	Bleach odour	Moderate bleach odour within building.
Ethanol	Sodium hypochlorite	Bleach odour	Moderate bleach odour within building.
Ethanol	Ammonia	Characteristic pungent odour	Low in the storage area, due to materials handling controls in place for OH&S purposes. Potential emission from propagators has been measured.
DDG	Sodium hypochlorite	Bleach odour	Moderate bleach odour within building.
DDG	Phosphoric Acid	Negligible odour	Low due to negligible odour characteristic.
Environmental farm	Sulphuric acid	Negligible odour	Low, due to materials handling controls in place for OH&S purposes. Odour associated with use of this reagent is modelled as part of the inherent irrigated wastewater odour characteristic.
Environmental farm	Sodium hydroxide	Negligible odour	Low, due to materials handling controls in place for OH&S purposes. Odour associated with use of this reagent is modelled as part of the inherent irrigated wastewater odour characteristic.

5. Comparison with International Best Practice

(b) Benchmark each process and activity identified at (a) against comparable international best available technology and industry best management practice relating to control of odour from the process and activity.

5.1.1 International best available technology

Odour control methods that may be considered international best available technology for factories such as Shoalhaven Starches are outlined in Table 8.

Table 8. Comparison of current versus international best available technology

Process or activity	Current technology at Bomaderry site	International best available technology
Dryer emission control	Baghouse or wet scrubbing and discharge to air.	Dispersion via stack. Treatment in baghouse or wet scrubber and discharge to atmosphere.
Dry material storage bin vents	Ventilation to atmosphere via baghouses.	Ventilation to atmosphere via baghouses.
Wastewater storage	Ventilation of some open pits and tanks direct to atmosphere.	Enclosure of pits and tanks and ventilation to odour control systems (wet scrubber, biofilter or activated carbon).
Wastewater treatment	Maximising stillage recovery as by-product (DDG) Acidification of wastewater to minimise biological activity. Storage in uncovered open ponds. Intermittent desludging of ponds.	Recovery of other solids for reuse (e.g. to fermentation). High rate anaerobic treatment of high strength clean streams. Anaerobic treatment of high strength solid bearing wastes (if not recovered as by-product). Aerobic stabilisation of anaerobic treatment plant effluent. Storage odorous wastes in covered tanks or ponds. Tertiary treatment and reuse of a portion of water from aerobic stage (not a typical practice). Regular removal of wastewater solids from ponds.
Wastewater irrigation / management	Raising pH with lime. Irrigation of wastewater with a combination of pivot mist and pivot low mist sprays and travelling irrigators.	Irrigation with low mist irrigators. Reuse in factory.

Process or activity	Current technology at Bomaderry site	International best available technology
Fermentation	Partial recovery of CO_2 from fermenter off-gas. Direct emission to air from jet cookers, grain retention tank, some fermentation vessels, propagators.	Maximising collection and recovery of CO_2. Collection and odour reduction.
Distillation plant	Non-condensable gases vented to atmosphere. DME vented to atmosphere.	Collection of non-condensable gases and venting to boiler or other odour control system. Venting to atmosphere via stack.
DDG dewatering and drying	Partial collection of emissions from decanters and dryers. Combustion of dryer off-gas in boilers. Open building ventilated. Ventilation off feed and product tanks to atmosphere. Heat exchanger vent to atmosphere.	Maximising collection of point sources and vent to combustion or other odour control system. Enclosure of buildings and ventilation to biofilter to control fugitive emissions.
DDG product	Produce a powdered DDG from dryers.	Produce a pelletised or granular product.
DDG outloading	Product storage doors open. Outload awning open to atmosphere. Spillage of DDG on ground. Earthen areas adjacent to outloading area.	Product storage area enclosed. Enclosed loading facility. Housekeeping to minimise product on ground. Use of easily cleaned hardstand area.
Evaporators	Storage tanks vented to atmosphere. Condensers vent to atmosphere.	Tanks sealed and fitted with pressure / vacuum relief valves. Emissions collected and recycled or treated.
Cooling towers	Leaks from process fluid to cooling water. Located near to process plant – potential to pick up organic contamination from emissions.	Cooling system operated to avoid contamination of process fluid entering the cooling water system (i.e. cooling water higher pressure) and closely monitored to detect any contamination. Cooling towers protected from potentially contaminating materials.
Wastewater recycle – starch plant	Storage of wastewater in small open pits limits the opportunity to recycle wastewater.	Adequate storage available to enable collection of wastewater and recovery of valuable materials (eg. starch).

5.1.2 Industry best management practice

Practices that would be considered industry best management practice for the processes and activities undertaken at factories such as Shoalhaven Starches are identified in Table 9.

Table 9. Comparison of current with industry best management practice

Process or activity	Current practice at Bomaderry site	Best management practice
Gluten dryers	Baghouse and discharge to air and irregular duct cleaning.	Ducts are regularly cleaned and odours dispersed via a stack.
Starch dryers	Wet scrubbing.	The duct is regularly cleaned, scrubber maintained and odours dispersed via a stack.
Gluten and starch bin vents	Bins ventilated to atmosphere via baghouses.	Regular preventative maintenance is employed, with the integrity of bags monitored and bags regularly cleaned.
Wastewater storage within factory	Some open pits and tanks ventilate direct to atmosphere.	Well-benched wet wells are installed to allow complete pump out of wastewater. Pits and tanks and ventilate enclosed to odour control systems.
Wastewater treatment	Stillage recovered as by-product (DDG) Wastewater acidified to minimise biological activity. Stored in uncovered open ponds. Intermittent desludging of ponds.	Starch and other solids for fermentation and DDG are recovered. Wastewater is treated to minimise odour generation. Odorous wastes are stored in covered tanks or ponds. Wastewater solids are regularly removed from ponds.
Wastewater irrigation and management	Wastewater pH raised with lime. Wastewater reused by irrigation with a combination of pivot mist and pivot low-mist sprays and travelling irrigators.	Wastewater is irrigated using low mist irrigators. Irrigation during times of poor atmospheric dispersion (i.e. stable, light wind conditions) is avoided. Treated wastewater is reused in the factory.
Fermentation	Emission direct to air from jet cookers, grain retention tank, some fermentation vessels, propagators.	The fermentation processes are optimised to minimise the production of odorous compounds. Odorous gases are collected and treated.
Distillation plant	Non-condensable gases vented to atmosphere. DME vented to atmosphere.	Non-condensable gases are collected and vented to boiler or other odour control system. Waste gases are vented to atmosphere via stack.

Process or activity	Current practice at Bomaderry site	Best management practice
DDG dewatering and drying	Partial collection of emissions from decanters and dryers. Combustion of dryer off-gas in boilers. Open building ventilated. Ventilation of feed and product tanks to atmosphere. Heat exchanger vent to atmosphere.	Equipment is operated under negative pressure throughout the system. Point source odours are collected and vented to combustion or other odour control system. Buildings are enclosed and ventilated to biofilter to control fugitive emissions.
DDG outloading	Product storage doors open. Outload awning open to atmosphere. Spillage of DDG on ground. Earthen areas adjacent to outloading area.	Doors are kept closed during loading. Housekeeping is maintained to minimise product on ground. A hardstand area is constructed and is regularly cleaned.
Evaporators	Storage tanks vented to atmosphere. Condensers vent to atmosphere.	Emissions are minimised by sealing tanks and installing pressure / vacuum relief. Emissions are collected and recycled or treated.
Cooling towers	Leaks from process liquid to cooling water. Located near to process plant – potential to pick up organic contamination from emissions.	Cooling systems are monitored to promptly identify leaks of process fluid into cooling water. Cooling towers are protected from potentially contaminating materials.
Wastewater recycle – starch plant	Storage of wastewater in small open pits limits the opportunity to recycle wastewater.	Wastewater storage is operated and maintained to enable collection of wastewater and recovery of valuable materials (eg. starch).

6. Actual and Potential Sources of Offensive Odour

(c) *Identify and list every actual and every potential source of offensive odour at the premises. This must include all point, diffuse and fugitive sources.*

(d) *Identify for each odour source identified at (c) the cause or causes of odour.*

A list of potentially offensive odour sources was collated following identification of the processes and activities used, and substances stored, at the premises that generate or have the potential to generate odours. These odour sources are listed in the Tables 10 to 15. The cause of each odour generated at each source is also identified in the table. These odour sources reflect normal operating conditions and do not include emergency or plant upset conditions, as these conditions are transient and are actively rectified.

Some potential odour sources listed in the Tables 2 to 7 in Section 4 have not been included in the Tables 10 to 15, as it was subsequently determined during the audit that:

» they did not have an odour that could reasonably cause offence, for example glucose solutions;

» they did not have a direct point of discharge to atmosphere. In such instances, the actual point of discharge was assessed;

» there were some potential odour sources that were similar in their nature, leading to duplication of sampling not being warranted (these were, however, allowed for in the mass odour emission rates used during the odour modelling); and

» some potential odour sources were found to have a common discharge point with another source. In such cases, the combined odour discharge was assessed.

Several examples of potential odour sources that were considered to have a low likelihood of being offensive were included in the assessment to provide a reference point at the low end of the odour scale; for example, samples S17 (starch reaction tank) and C2 (saccharification tank). The low results obtained for these samples confirmed the audit team's 'in-field' assessment of the odour levels of the various sources.

A list of excluded sources is provided in Appendix D.

Table 10. Starch plant potentially offensive odour sources

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
S1	No. 1 Starch dryer scrubber tower	Vent on roof	Point	Exhaust of air used to dry starch	Continuous	Yes	EPA discharge point No. 12
S2	No. 1 Gluten dryer baghouse	Vent on roof	Point	Exhaust of air used to dry gluten	Continuous	Yes	EPA discharge point No. 8
S3	No. 3 Gluten dryer baghouse	Vent on roof	Point	Exhaust of air used to dry gluten	Continuous	Yes	EPA discharge point No. 10
S4	No. 2 Gluten dryer baghouse	Vent on roof	Point	Exhaust of air used to dry gluten	Continuous	Yes	EPA discharge point No. 9
S5	No. 4 Gluten dryer baghouse	Vent on roof	Point	Exhaust of air used to dry gluten	Continuous	Yes	EPA discharge point No. 11
S6	Flour bin (BFM 160)	Vent in wall	Point	Displacement of air from flour bin during filling	Intermittent	Yes	
S7	Dry gluten roof bin	Vent in wall	Point	Displacement of air from gluten bin during filling	Intermittent	Yes	
S8	High protein dust collector	Vent on roof	Point	Exhaust air from pneumatic gluten transfer	Intermittent	Yes	
S9	Pre-separator	Vent in wall	Point	Exhaust air from pre separator	Continuous	Yes	
S10	Flour bin (BFM 161)	Vent in wall	Point	Displacement of air from flour bin during filling	Intermittent	Yes	
S11	No. 2 Coarse bin	Elevated vent	Point	Exhaust air from flour silo	Intermittent	Yes	
S12	Pellet silo	Ground level vent	Point	Exhaust air from pellet silo	Intermittent	Yes	
S13	Flour bin aspirator (2 units) (BFM 132)	Ground level vent	Point	Exhaust air from flour silo	Intermittent	Yes	
S14	Day bin transfer baghouse (BFM 145)	Ground level vent	Point	Exhaust air from flour bin	Intermittent	Yes	
S15	Coarse gluten transfer baghouse (CGM 40)	Ground level vent	Point	Exhaust air from gluten transfer	Intermittent	Yes	

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
S17	Starch reactions tanks (4 units)	Vent on tank	Point	Displacement of air over starch suspension	Intermittent	Yes	Operating tank sampled
S18	No. 3 Starch dryer scrubber tower	Vent on roof	Point	Exhaust of air used to dry starch	Continuous	Yes	EPA discharge point No. 13
S19	No. 4 Starch dryer scrubber tower	Vent on roof	Point	Exhaust of air used to dry starch	Continuous	Yes	EPA discharge point No. 14
S20	Spray dryer	Vent on roof	Point	Exhaust of air used to dry starch	Batch	Yes	

Table 11. Glucose plant potentially offensive odour sources

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
Brewers glucose circuit							
B3	Cooker A flash tank	Roof vent	Point	Exhaust air from cooking of starch	Batch	Yes	
B7	Enzyme tanks (17 & 18)	Tank vent	Point	Displacement of air over starch suspension	Continuous	Yes	Tank 18 sampled
Confectioners glucose circuit							
C1	Glucose jet cooker flash chamber	External vent	Point	Exhaust air from cooking of starch	Continuous	Yes	
C2	Saccharification tanks (x 19)	Tank vent	Point	Displacement of air over starch suspension	Batch	Yes	Tank No. 5 sampled.
C4	Drum filter vacuum receiver (GAM48)	External vent	Point	Exhaust air from starch filtration unit	Continuous	Yes	Also received discharge from C3
C18	Ion exchange effluent tank	Tank vent	Point	Displacement of air over starch suspension	Batch	Yes	
C19	Condensate water collection tank	Tank vent	Point	Displacement of air over collected dryer condensate	Continuous	Yes	

Table 12. Ethanol plant potentially offensive odour sources

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
E1	Gain silo baghouse No. 2	Elevated vent	Point	Displacement of air in grain silo	Batch	Yes	
E4	Bühler hammer mill receiving bin baghouse	Elevated vent	Point	Exhaust from milled grain silo	Continuous	Yes	
E7	Jet cooker 2 & 4 grain retention tank	Elevated vent and tank vent	Point	Pressure relief, bleed to air.	Continuous	Yes	
E8	Grain retention tank 2 (“F7”)	Elevated vent	Point	Displacement of air in tank during filling, plus venting from fermenters 4, 5 & 6	Continuous	Yes	EPA discharge point No. 16
E9	Hammer mill baghouse (#5)	Elevated vent	Point	Pneumatic transfer air from hammermill.	Batch	Yes	
E10	Starch factory rejects collection tank	Tank vent	Point	Displacement of air in tank during filling	Continuous	Yes	
E11	Buffer tank	Tank vent	Point	Displacement of air in tank during filling	Batch	Yes	
E13	Jet cooker 1 & 3 retention tank	Tank vent	Point	Displacement of air in tank during filling	Batch	Yes	
E14	Yeast propagator tanks 1, 2 & 3	Tank vent	Point	Venting of fermentation volatiles and displacement of air during tank filling	Batch	Yes	Tank 1 sampled
E15	Yeast propagator tanks 4 & 5	Tank vent	Point	Venting of fermentation volatiles and displacement of air during tank filling	Batch	Yes	Tank 4 sampled
E22	Feed transfer to distillation plant	Tank vent	Point	Air displace during tank filling	Batch	Yes	
E23	Cooling towers 1, 2, 3, 4 & 5	Fan outlet	Point	Entrainment of odourous air and contaminated cooling water	Continuous	Yes	Cooling tower No. 1 sampled.

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
E24	Hammer mill baghouse No. 1	Ground level vent	Point	Pneumatic transfer air from hammermill.	Batch	Yes	

Table 13. Distillation plant potentially offensive odour sources

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
D2	Stage 2 vacuum drum flame arrester (D697)	Elevated vent	Point	Venting of condensate vapour	Batch	Yes	
D6	Stage 3 incondensable gases vent (E538)	Elevated vent	Point	Venting of condensate vapour	Continuous	Yes	
D11	Stage 1 recycled water to wastewater (ULT018)	Elevated vent	Point	Venting of condensate vapour	Continuous	Yes	
D12	DME vent	Elevated vent	Point	Venting of DME vapour	Occasional	Yes	Runs 8 times per year, 2 weeks per run. Sampled when running.

Table 14. DDG plant potentially offensive odour sources

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
DDG1	Decanter feed tank	Elevated vent	Point	Displacement of air during tank filling	Batch	Yes	Sampled twice.
DDG2	Decanter No. 1 (Westphalia)	Elevated vent	Point	Passive 'breathing' during operation	Continuous	Yes	Used to represent Decanter No. 2 (DDG3).
DDG5	Decanter No. 4 (Alpha Laval)	Elevated vent	Point	Passive 'breathing' during operation	Continuous	Yes	Used to represent Decanter No. 3 (DDG4).
DDG7	Paddle mixer No. 1	Vent at mezzanine level of plant	Fugitive	Passive 'breathing' during operation	Continuous	Yes	Sampled, as reflects condition late in the cleaning cycle.
DDG9	Paddle mixer No. 3	Vent at mezzanine level of plant	Fugitive	Passive 'breathing' during operation	Continuous	Yes	Sampled, as reflects condition early in the cleaning cycle.
DDG16	DDG Palmer cooler baghouse	Elevated vent	Point	Exhaust air from Palmer cooler	Continuous	Yes	
DDG17	Mill feed silo exhaust	Elevated vent	Point	Pneumatic transfer air exhaust	Continuous	Yes	
DDG18	Feeds dryer No. 3 baghouse	Elevated vent	Point	Pneumatic transfer air exhaust	Continuous	Yes	Sample collected upstream of discharge point due to unsafe access.
DDG19	Light phase recovery tank	Elevated vent	Point	Displacement of air during tank filling	Continuous	Yes	
DDG20	Evaporator feed dump tank (LT502)	Elevated vent	Point	Displacement of air during tank filling	Continuous	Yes	
DDG23	Condensate tank T5 (LT508)	Elevated vent	Point	Displacement of air during tank filling	Batch	Yes	
DDG24	Vent condenser	Elevated vent	Point	Breather vent	Continuous	Yes	
DDG25	Vent condenser drain	Floor drain	Point	Exposed open floor drain	Continuous	Yes	

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
DDG26	Finisher feed tank T3 (LT503)	Elevated vent	Point	Displacement of air during tank filling	Batch	Yes	
DDG30	Dryer feed tank T4 (LT504)	Elevated vent	Point	Displacement of air during tank filling	Batch	Yes	Results used for DDG28
DDG31	Syrup hold tank (LT501)	Elevated vent	Point	Displacement of air during tank filling	Batch	Yes	
DDG32	CIP tank C6 (LT506)	Elevated vent	Point	Displacement of air during tank filling	Batch	Yes	Sampled when holding fresh CIP solution
DDG33	CIP tank C6 (LT506)	Elevated vent	Point	Displacement of air during tank filling	Batch	Yes	Sampled when holding spent CIP solution
DDG34	DDG product storage shed	Building opening	Fugitive	Flow of air through storage area	Continuous	Yes	
DDG35	DDG load out awning	Building opening	Fugitive	Flow of air through storage area	Continuous	Yes	
DDG36	DDG load out 'tent'	Building opening	Fugitive	Flow of air through storage area	Continuous	Yes	
DDG37	Spills on ground	Open space	Diffuse area	Flow of air over spilled DDG	Continuous	Yes	
DDG39	Dryer building	Building opening	Fugitive	Passive air flow through building	Continuous	Yes	
DDG40	Kestner dryer exhaust	Elevated vent	Point	Exhaust air from dryer	Continuous	Yes	
DDG44	DDG condenser water recovery tank	Open topped tank	Point	Displacement of air during tank filling	Batch	Yes	
DDG45	DDG heat exchanger	Elevated vent	Point	Venting of DDG condensate	Continuous	Yes	
DDG46	Cooling towers near DDG dryers	Cooling tower fan outlets	Point	Entrainment of odorous air and contaminated cooling water	Continuous	Yes	
DDD47	Cooling towers near Evaporator area	Cooling tower fan outlets	Point	Entrainment of odorous air and contaminated cooling water	Continuous	Yes	

Table 15. Environmental farm potentially offensive odour sources

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
F1	Inlet mixer tank	Tank vent	Point	Displacement of air in tank	Continuous	Yes	
F2	Pond 1	Pond surface	Diffuse area	Contact of open air with pond surface	Continuous	Yes	
F3	Pond 2	Pond surface	Diffuse area	Contact of open air with pond surface	Continuous	Yes	
F4	Pond 3	Pond surface	Diffuse area	Contact of open air with pond surface	Continuous	Yes	
F5	Pond 4 (uncovered section)	Pond surface	Diffuse area	Contact of open air with pond surface	Continuous	Yes	
F7	Pond 5	Pond surface	Diffuse area	Contact of open air with pond surface	Continuous	Yes	
F8	Pond 6	Pond surface	Diffuse area	Contact of open air with pond surface	Continuous	Yes	
F9	Pivot irrigator with mist nozzle	Irrigator	Fugitive	Contact of open air with water droplets	Batch	Yes	Pivot No. 130 sampled.
F10	Pivot irrigator with low-mist nozzle	Irrigator	Fugitive	Contact of open air with water droplets	Batch	Yes	Pivot No. 140 sampled
F11	Traveller irrigator	Irrigator	Fugitive	Contact of open air with water droplets	Batch	Yes	Small traveller irrigator sampled
F12	Land recently irrigated with pivot irrigator	Land surface	Diffuse area	Contact of open air with ground surface	Batch	Yes	Pivot No. 130 paddock sampled
F13	Land recently irrigated with traveller irrigator	Land surface	Diffuse area	Contact of open air with ground surface	Batch	Yes	
F14	Land recently irrigated with pivot irrigator	Land surface	Diffuse area	Contact of open air with ground surface	Batch	Yes	Pivot No. 120 paddock sampled

Source No.	Discharging plant	Discharge point	Source type	Cause of odour	Discharge type	Sampled	Comments
F15	Dry grass in pivot irrigated land	Land surface	Diffuse area	Contact of open air with ground surface	Continuous	Yes	Sample taken in Pivot No. 120 paddock
F16	Unirrigated grass	Land surface	Diffuse area	Contact of open air with ground surface	Continuous	Yes	Odour sample 'blank'
F17	Dry grass in pivot irrigated land	Land surface	Diffuse area	Contact of open air with ground surface	Continuous	Yes	Sample taken in Pivot No. 140 paddock
F18	Farm tank	Tank vent	Fugitive	Displaced air in tank	Continuous	Yes	

7. Quantification of Odours

(e) *Quantify for each source identified at (c) the actual and potential nature, strength and duration of occurrence of the odour in accordance with the publication "NSW DEC 2005 Approved Methods for the Sampling and Analysis of Air Pollutants in NSW".* [Note that these methods have since been revised, with the most recent, 2007, revision being used during the audit.]

7.1 Odour Emission Rate Survey

Potentially significant sources of odour within the factory and environmental farm were selected for assessment during January 2007. The main odour emission rate (OER) survey was conducted over one week, from 28 January to 2 February 2007. The campaign was scheduled during the summer months, when OERs were anticipated to be at the highest due to the seasonally warmer ambient air temperatures.

Emission Testing Consultants (ETC) was used as a sub-consultant to conduct the measurements. Two ETC technicians and one GHD scientist conducted the survey. A copy of the ETC report for the main survey, "*Odour Survey: Manildra Group – January and February 2007*" is provided in Appendix E.

A supplementary round of testing of selected sources was conducted in April 2007. The purpose of this survey was to reconfirm some initial OER results and to collect additional information on the chemical composition of odours released from some key sources to assist with design of odour control processes. The chemical composition results have not been included in the emission inventory or subsequent dispersion modelling. The ETC report for the supplement survey, "*Odour Survey: Manildra Group – April 2007*" is also provided in Appendix E.

A summary of production conditions during the survey, odour sampling locations, OER measurement and OER results are described in the following sections.

7.1.1 Production conditions

Shoalhaven starches advised that the factory and environmental farm were generally running under normal operating conditions during the survey period. Minor deviations from normal operation are discussed in relevant sections below.

7.1.2 OER sampling locations

A total of 100 odour samples were taken during the main survey. These covered both point (vent or stack) and diffuse (fugitive area or volume) odour sources.

Approximately 10% of the odour samples were taken as either duplicate (i.e. concurrent with primary sample) or as repeat (i.e. same source sampled on a different day) samples to obtain a direct measure of the variation attached to singleton readings.

The sampling locations for the factory and environmental farm are presented in Figures 5 and 6 respectively. The source labels used in these figures correspond with the odour source reference numbers described in section 6 of this report.

Figure 5 Sample locations – factory

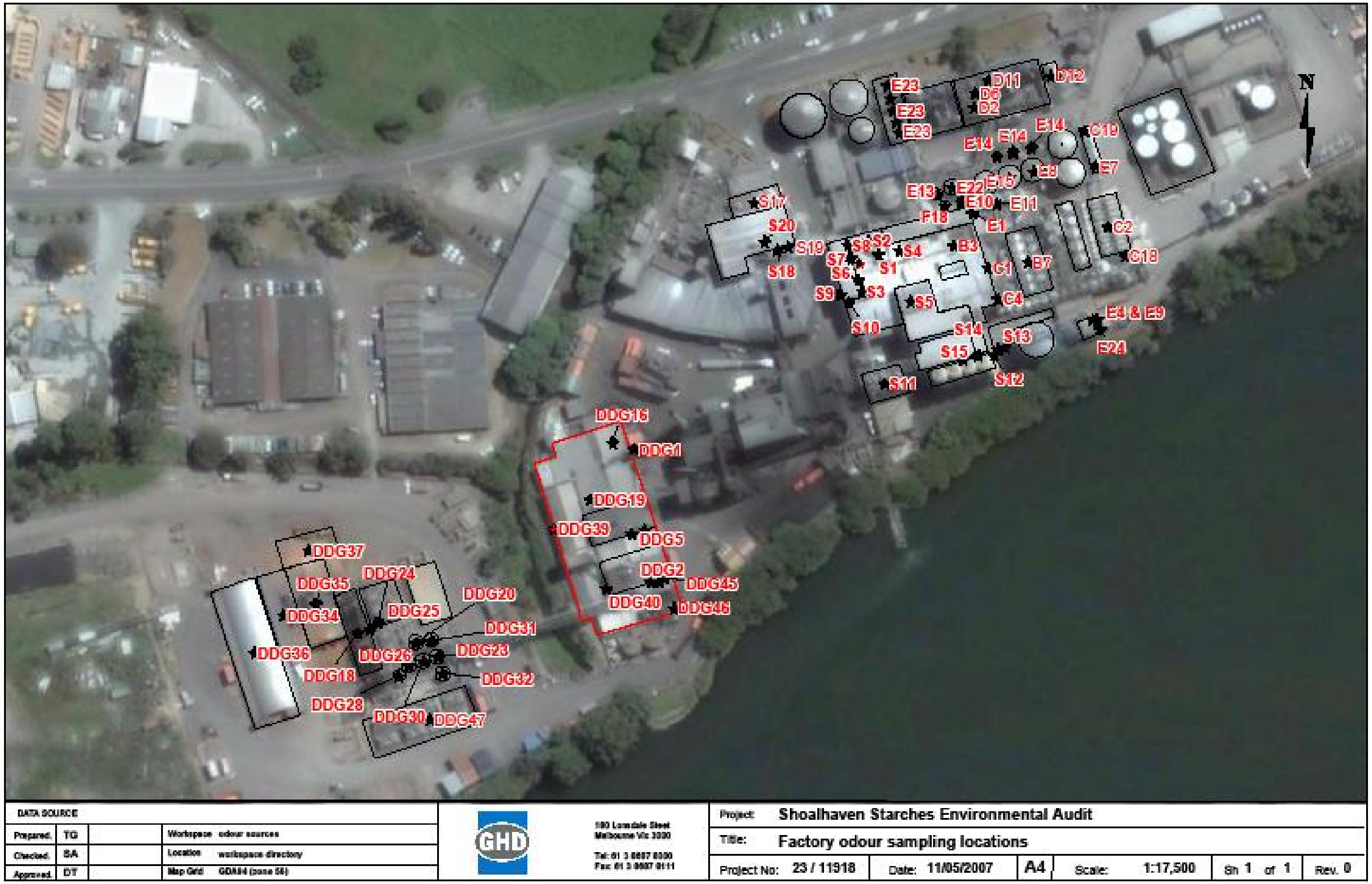
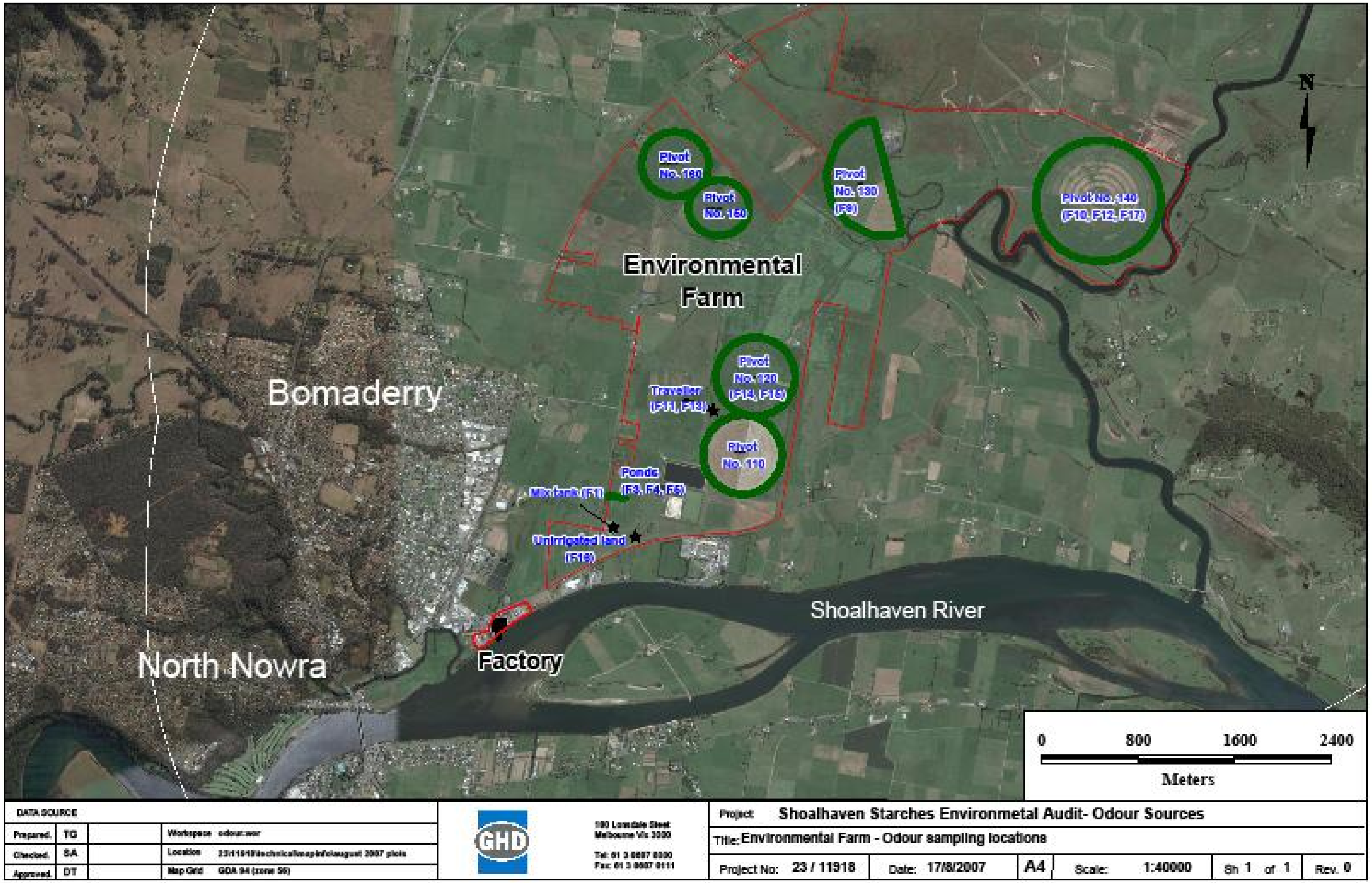


Figure 6 Sample locations – environmental farm



7.2 OER Measurement

A range of techniques is available for source sampling, sample collection and odour measurement. This section gives a brief description of the techniques employed for this survey.

Further details on the main OER survey, including photographs of the respective sampling point, are available in the ETC report, "*Odour Survey – Manildra Group"* (February 2007) and the supplementary survey (April 2007) are provided in Appendix E.

7.2.1 Source sampling

The sampling of odour sources requires the measurement of odour concentration in conjunction with the associated airflow from the emission source. The physical configuration of each source, described below, dictated the sampling method to be used.

Diffuse area sources

Diffuse area sources do not have a defined air flow rate associated with the emission of volatiles across the solid/liquid surface. Accordingly, sampling was conducted using a chamber with an odour-free airflow (sweep air) imposed over an isolated section of surface.

The emission rate is then determined by the airflow through the chamber and the odour concentration of the exhaust air. That emission rate is then expressed as an emission rate per unit surface area by dividing the area covered by the chamber, which is referred to as the specific odour emission rate (SOER). The SOER is the odour flux rate, or OER per square metre, of the emitting surface. The total OER for each specific source of odour was then determined by multiplying the SOER by the area of each source.

Sampling using this technique was conducted with consideration of the DECC OM-8 and the draft AS 4323.4 *"Area Source Sampling – Direct Measurement Techniques"*.

This technique was used to sample the effluent storage ponds and the grass areas (wet and dry) in the irrigated pasture areas at the environmental farm.

Point sources

Point sources have a defined airflow rate associated with the emission, and standard stack sampling methods were used with consideration to the DECC OM-7.

Grab samples were taken from these sources along with the exhaust airflow rate measurements.

This technique was used to sample the majority of odour sources located at the factory, including baghouse and scrubber exhaust stacks and both active and passive tank vents.

Diffuse volume sources

Diffuse volume sources refer to fugitive emissions that escape from buildings. Similarly to the point sources, both the odour concentration and the associated airflow were measured.

Diffuse volume sources measured during the survey included fugitive emissions from the DDG dryer building (DDG39), DDG product load-out awning (DDG35), DDG product storage shed (DDG34) and DDG load out 'tent' (DDG36). These buildings are naturally ventilated and therefore required suitable prevailing wind conditions where building inducts could be identified and the airflow could be readily measured at the educts of the building.

In general, the odour emission rate was determined by measuring the ventilation rate in conjunction with an integrated odour sample across the face of the outlet aperture. In cases when the odour level at the outlet was anticipated to be similar to the ambient odour level, a background odour level was concurrently measured, the result being subtracted from that measured at the exit aperture.

Mobile diffuse sources

The pivot and traveller irrigation systems created a mobile diffuse odour source that could not be measured using any of the sampling methods described above. These sources were sampled using the flux profile method, which involves the measurement of wind velocity and odour concentration along the downwind edge of the odour source. The product of the wind velocity and concentration at a particular point gives the odour flux at that given point. The emission rate was determined by averaging the point fluxes across the plume cross section[1].

For the traveller irrigators, it was assumed that there was no variation in odour concentration or wind velocity across the plume width (~20 m). An integrated odour sample was taken along the vertical profile (~3 m) at the downwind plume edge in conjunction with the wind speed measured at a height of 2 m above ground level. An odour sample was also collected at the upwind edge of the odour plume and this odour level was subtracted from the level measured downwind.

A similar approach was used to sample the pivot irrigators. The odour flux was measured at a single point at the centre of the pivot arm (the pivot arm was approximately 420 m long) on the assumption that there would not be a variation across the plume width. An odour sample was collected at a height of ~1.2 m whilst wind velocity measurements were taken at heights of 1 m and 2 m above ground level.

In both cases, the fine water droplets released from the irrigation spray provided a visible means of tracing the movement of the plume and estimate the height of the upper bound of the plume boundary layer.

[1] Sampling for the Measurement of Odours. P. Gostelow, P. Longhurst, S.A. Parsons and R.M. Stuetz, Scientific and Technical Report Series, IWA Publishing.

7.2.2 Sample collection

All odour samples were collected by the indirect ('lung') sampling method with consideration to the DECC OM-7 (AS 4323.3 2001, *Determination of odour concentration by dynamic olfactometry).*

In general, odour samples were collected using a sample pump to evacuate the air space in a 60 litre plastic barrel, causing odorous air to be drawn via a Teflon line into an inert sample bag. Where static pre-dilution of the odour sample was required, odour-free air (medical grade) was used.

7.2.3 Olfactometry

Australian Standard *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW* requires that odour sample analysis be carried out by a laboratory accredited by NATA to perform olfactometry. However, at the time of the survey, there was not a suitable laboratory in NSW that was NATA accredited for olfactometry to the Australian Standard. A number of laboratories operate in accordance with the NATA requirements, but have yet to obtain formal NATA accreditation. The Melbourne based laboratory Emission Testing Consultants (ETC) was engaged to conduct the odour sampling and analysis. ETC is accredited by NATA for both odour sampling and odour sample analysis.

The greater transport time associated with the use of a Melbourne-based laboratory was not ideal for odour measurement with respect to the potential for sample degradation. Two options were considered prior to commencement of the sampling program to address this concern. These were; (i) to relocate ETC's olfactometer to Nowra for the duration of the testing program; and (ii) to transport all samples interstate to ETC's NATA-accredited olfactometry laboratory in Melbourne. It was determined that the difficulties in finding and training a pool of local odour panellists within the short timeframe available were too great for this to be a viable option. Overnight transport of all samples to the Melbourne laboratory was identified as providing more reliable and consistent results and had the additional benefit of using an experienced odour panel.

This option meant that the elapsed time between sample collection and analysis could extend to 24 hours. While this delay is within the 30-hour limit specified in the standard, a series of odour bag trials was conducted to gain an understanding of:

1. The degree of decrease in odour level with elapsed time since sampling due to either loss of sample (bag permeability) or to chemical reaction in the odorant blend; and
2. Whether a factor can be determined by which to post-correct measured odour levels to account for the time lapse in sampling.

To test the significance of this factor for the Shoalhaven Starches emission sources, GHD conducted a pre-survey investigation in late December 2006 into the effect of elapsed time between sampling and analysis on sample degradation. The results suggested that the odour concentration for samples analysed 6 to 8 hours after sample collection can be up to three times higher than the concentration determined for the same odour sample analysed 24-hours after collection. A brief description of the methods and results of this pre-survey investigation is provided as Appendix F.

Given that the primary objective of this odour audit was to reduce the total odour emission rate from Shoalhaven Starches, the potential for odour sample degradation was set aside at this stage. The focus was therefore placed on determining the relative difference between odour samples collected prior to introducing mitigation measures (i.e. baseline odour emission survey) and the estimated and/or measured odour emission rates after source mitigation has been implemented (i.e. subsequent odour surveys). This will be achieved by ensuring that the odour sampling collection and analysis methods and, in particular, the same lapse time between sample collection and analysis, remained consistent throughout the sampling program.

Samples were transported to Melbourne using an overnight courier service and analysed at the ETC laboratory within 30 hours of sample collection. In general, onsite sampling was conducted from 6 am to 3 pm, with odour analysis conducted the following day during two separate panel sessions.

In addition to odour concentration, each odour sample was also analysed for odour character and hedonic tone (the relative pleasantness or unpleasantness of the odour).

7.3 Odour Emission Rate Inventory

The objective of the OER inventory was to derive a worst-case snap-shot of odour emissions based on the OER measurements taken during the survey. The OER inventory was used to identify principal odour sources that should be targeted for the implementation odour minimisation/prevention strategies.

In deriving the OER inventory, the following assumptions were made:

» all factory odour sources were discharged to air simultaneously and continuously; and

» a maximum irrigation rate at the environmental farm of approximately 20 ML in a given (summer) day, which involved the use of three pivot irrigators (assumed to be Nos. 110, 120 and 130) plus two small travellers and two large travellers.

Odour sources with the highest odour emission rates might not have the greatest contribution to odour impact. Numerous factors, in particular, the odour character and the inherent atmospheric dispersion properties of the emission source, affect the contribution of each odour source to offensive odour impact at nearby sensitive receptors. To gain a further understanding of the contribution of key odour sources/source groups to off-site odour impact, dispersion modelling was conducted, using the OER inventory as model input – refer to Section 8.

This section provides a summary of the OER measurement results with a discussion of the OER results for all sources, and key odour source groups, given in the following sub-sections.

A detailed list of the complete OER inventory is provided in Appendix G.

7.3.1 Factory and environmental farm sources

A breakdown of the OER contribution of each production plant and the environmental farm to the total OER for the Shoalhaven Starches facility is given in Table 16.

Table 16. Total OER contribution

Source group	OER (OU m^3/s)	Percent of total OER
Starch plant	310,000	7.3%
DDG plant	230,000	5.5%
Ethanol plant	120,000	2.9%
Glucose plant	8,900	0.2%
Distillation plant	1,900	<0.1%
Environmental farm	3,500,000	83%
Total	**4,170,800**	**100%**

These results indicate that the environmental farm, operating under the configuration conservatively assumed for this audit, is the dominant odour source, contributing 83% of the total OER associated with the operation of the Shoalhaven Starches facility. A breakdown of the contribution of the individual sources in each of the factory source groups and the environmental farm is provided in the following sub-sections.

7.3.2 Factory OER

As shown in Table 16, odours emanating from the factory contribute approximately 17% of the total OER for Shoalhaven Starches or approximately 670,800 OU m^3/s. A breakdown of the factory odour sources by plant is provided in Table 17.

Table 17. OER breakdown - factory

Plant	OER (OU m^3/s)	Percent of total OER
Starch plant	310,000	46%
DDG plant	230,000	34%
Ethanol plant	120,000	18%
Glucose plant	8,900	1%
Distillation plant	1,900	<1%
Total	**670,800**	**100%**

Results presented in Table 17 indicate that odour emissions from the starch plant account for the highest proportion of the total factory OER at 46%. The DDG plant and, to a lesser extent the ethanol plant, also make significant contributions to the factory OER, whereas, the emissions from both the glucose and distillation plants are considerably less significant under existing operating conditions.

The survey identified a number of substantial individual odour sources within the factory. The top ten individual odour sources are presented in Table 18.

Table 18. Top ten individual odour sources within the factory

Rank	Plant	Source	OER (OU m^3/s)	% Total factory OER	Hedonic tone
1	Starch	No. 4 Gluten dryer (S5)	150,000	22%	Mildly unpleasant
2	Starch	No. 3 Gluten dryer (S3)	73,000	11%	Mildly unpleasant
3	DDG	Dryer building[1] (DDG39)	71,000	10%	Very unpleasant
4	DDG	Cooling towers (DDG46)	68,000	10%	Very unpleasant [2]
5	Ethanol	Cooling towers (E23)	66,000	9.7%	Mildly unpleasant
6	Starch	No. 1 Gluten dryer (S2)	38,000	5.6%	Mildly unpleasant
7	Ethanol	Yeast propagators – tanks 4 and 5 (E15)	28,000	4.1%	Mildly unpleasant
8	DDG	Condensate tank (DDG23)	20,000	2.9%	Mildly unpleasant
9	DDG	Finish feed tank (DDG26)	18,000	2.7%	Very unpleasant
10	Starch	No. 2 Gluten dryer (S4)	18,000	2.7%	Mildly unpleasant
Sub-Total			**550,000**	**81%**	
Total Factory			**670,800**	**100%**	

1. Fugitive odour emissions from dryer building.
2. Sample not analysed for hedonic tone. However, field observations suggested a very unpleasant hedonic tone.

Results provided in Table 18 show the following key features.

» Ten individual sources account for over 80% of the total factory OER.

- All plants, with the exception of the distillation and glucose plants, contribute to odour sources ranked in the top ten.
- Odour emissions from the gluten dryers in the starch plant account for approximately 41% of the total factory OER or 279,000 OU m^3/s.
- Odour emissions from DDG sources rank lower in total OER but are the only sources in the top ten ranking to score a very unpleasant hedonic tone.

Key aspects of each plant are discussed below.

Starch plant

A total of 20 odour sources was tested in the starch plant.

The starch plant accounts for 46% of the total factory OER or 309,839 OU m^3/s, of which 90% or 279,000 OU m^3/s is comprised of emissions from the four gluten dryers.

The starch dryers (S1, S18 and S19) were the next most significant odour sources, which together equated to an OER of approximately 19,000 OU m^3/s or less than 3% of the total factory OER.

The only other noteworthy source in this group was the dry gluten roof bin (S7), which had a relatively low OER of 4,500 OU m^3/s but was the only odour source in the starch plant to have a very unpleasant hedonic tone.

The hedonic tone of for all other sources measured in the starch plant ranged from neutral to mildly unpleasant.

DDG plant

The DDG plant accounted for 34% of the total factory OER or approximately 230,000 OU m^3/s and had the highest proportion of sources that emitted an odour with a very unpleasant hedonic tone. Unlike the starch plant, odour emissions from this plant were spread out across a variety of sources.

Of the 24 sources tested in the DDG plant, 10 sources contributed 95% of the total DDG plant OER. Table 19 shows the top 10 odour sources in the DDG plant. The OERs shown in brackets represent test results from the second round of testing – these values were not used in the calculation of the OER inventory. At this stage, these test results have been used to gauge the potential dynamic range of odour emissions from this source group.

Table 19. Top ten DDG plant odour sources

Rank	Plant	Source	OER (OU m^3/s)	% Total Plant OER	Hedonic tone
1	DDG	Dryer building[1] (DDG39)	71,000 (100,000)	29%	Very unpleasant
2	DDG	Cooling towers (DDG46)	68,000 [3]	28%	Very unpleasant [2]

Rank	Plant	Source	OER (OU m^3/s)	% Total Plant OER	Hedonic tone
3	DDG	Condensate (DDG23)	20,000 (57,000)	8%	Mildly unpleasant
4	DDG	Finish feed (DDG26)	18,000 (25,000)	8%	Very unpleasant
5	DDG	DDG load out ‘tent‘ (DDG36)	13,000	5%	Neutral
6	DDG	Feed dump tank (DDG20)	8,900 (5,800)	4%	Mildly unpleasant
7	DDG	DDG Palmer cooler baghouse (DDG16)	8,800	7%	Mildly unpleasant
8	DDG	DDG product storage shed (DDG34)	6,800	3%	Mildly unpleasant
9	DDG	Vent condenser (DDG24)	3,500 (43,000)	~1%	Very unpleasant
10	DDG	Vent condenser drain (DDG25)	3,200	~1%	Mildly unpleasant
Sub-Total			**221,200**	**96%**	
Total DDG Plant			**230,000**	**100%**	

1. Fugitive odour emissions from dryer building.
2. Sample not analysed for hedonic tone. However, field observations suggested a very unpleasant hedonic tone.
3. Tested during second survey.

The results in Table 19 show the following key features.

» Ten individual sources accounted for greater than 95% of the total DDG plant OER.

» The top two sources accounted for nearly 60% of the DDG plant OER and both emit odours that were considered to be very unpleasant.

» Significant differences were found in measured OERs between the two surveys, in particular, the OER for the vent condenser (DDG24) was greater by over 12-fold.

» Odour emissions from DDG sources ranked lower in total OER than those for the Starch Plant, but were the only sources in the top ten ranking to score due to their very unpleasant hedonic tone.

Odour emissions from the dryer building (DDG39) were comprised of fugitive emissions captured within the building envelope, which are released to ambient air primarily via convective air movement, which escapes via a large opening on the 1st floor of the Eastern end of the building. The dryer building consists of two separate sections, of which, only the section housing Decanters No. 1 and No. 2 was tested as the building configuration was best suited for conducting the emission test. It was assumed that the OER from the test section would represent half the total OER from the dryer building.

In addition to measuring the overall fugitive emissions, measurements were taken from major individual odour sources within the building, these being:

» paddle mixers (DDG7 & DDG9);

» mill feed silo exhaust (DDG17); and

» condenser water recovery tank (DDG44).

The sum total of the OERs from these sources account for less than 30% of the OER measured for the section of dryer building containing these sources, which suggests that numerous minor sources (e.g. conveyors, leaks, drains) contribute to the overall emission making this source particularly difficult to mitigate.

Although only ranked the 9th highest from the results of the main survey, the OER from the vent condenser (DDG24) can potentially rank among the top odour sources with an OER of over 43,000 OU m^3/s in the second round results. It is noteworthy that high levels of hydrogen sulfide were detected in the odour sample.

Ethanol plant

A total of 13 odour sources was tested in the ethanol plant.

The ethanol plant accounts for 7% of the total factory OER or 120,000 OU m^3/s, of which 97% was comprised of emissions from five odour sources.

The top five odour sources in the ethanol plant are listed in Table 20.

Table 20. Top five odour sources – ethanol plant

Rank	Plant	Source	OER (OU m^3/s)	% Total factory OER	Hedonic tone
1	Ethanol	Cooling towers (E23) [1]	66,000	56%	Mildly unpleasant
2	Ethanol	Yeast propagators - tanks 4 & 5 (E15)	28,000	24%	Mildly unpleasant
3	Farm	Farm tank (F18; located within the ethanol plant) [2]	7,700	7%	Very unpleasant
4	Ethanol	Grain retention - tank 2 (E8)	6,500	6%	Mildly unpleasant
5	Ethanol	Yeast propagators- tanks 1, 2 & 3 (E14)	5,500	5%	Very unpleasant
Sub-Total			**113,700**	**98%**	

Rank	Plant	Source	OER (OU m^3/s)	% Total factory OER	Hedonic tone
Total Ethanol Plant			**120,000**	**100%**	

1. OER measurement from second round used.
2. Included in ethanol plant because tank located with ethanol area of factory.

Table 20 shows the following key features:

» five individual sources accounted for 98% of the total ethanol plant OER; and

» the top two sources accounted for over 80% of the ethanol plant.

Glucose and distillation plants

A total of 11 odour sources was tested in the glucose (7) and distillation (4) plants. Together, the OER from these plants accounted for less than 0.3% of the total factory OER or 10,771 OU m^3/s.

The distillation plant odour source with the highest OER was the Stage 2 molecular sieve (vacuum) drum (D2) at 1,400 OU m^3/s.

The glucose plant odour sources with the highest OER were the enzyme tank vents (B7) and vacuum drum receiver (C4) with OERs of 4,100 and 3,500 OU m^3/s respectively, which together accounted for over 85% of the glucose plant OER.

The hedonic tone for odour sources in the glucose plant ranged from neutral to very unpleasant. The unpleasant rating was associated with the cooker flash tanks (B3).

The DME (D12) and incondensable gas (D6) vents in the distillation plant both had low OERs but the emitted odour was considered to be very unpleasant.

7.3.3 Environmental farm

As shown in the previous section, odours emanating from the environmental farm contributed 84% of the total OER for Shoalhaven Starches. The odour sources comprising the environmental farm accounted for eight of the ten highest individual odour sources. However, the majority of the emitted odours had a hedonic range from mildly pleasant to mildly unpleasant, with the exception of the mixer tank vent (F1) and Pond 4 (F5), which had very unpleasant hedonic tones.

A breakdown of the environmental farm odour sources is provided in Table 21.

Table 21. OER breakdown – environmental farm

Odour Source Group	OER (OU m^3/s)	% Total OER
Mixer tank	150,000	4%
Ponds	290,000	8%
Spray irrigation	3,000,000	85%

Irrigated land	90,000	3%
TOTAL	**3,530,000**	**100%**

These results indicate that:

» spray irrigation was the dominant source of odour emissions, almost by an order of magnitude; and

» the combined ponds had an OER that was similar to the OER for the starch and DDG plant.

Key aspects of each source group are discussed under the respective source group headings.

Mixer tank

The mixer tank (F1) was characterised by a very high odour concentration (210,000 OU) with a low passive airflow rate driven primarily by the process of heat convection.

At 150,000 OU/m^3, the mixer tank ranks in the top ten highest individual odour sources, but was relatively low when compared to other odour sources at the farm.

The hedonic tone of the odour emitted from this source was scored as very unpleasant.

Ponds

Six effluent storage ponds are located at the farm. Five ponds are open to air and one pond (Pond 4) is covered, apart from a small open area (approximately 400 m^2) at one corner. Ponds 1, 5 and 6 were off-line for the duration of the survey because of the drought conditions experienced in the area before and during the audit.

Odour samples were taken using an IFC to obtain a measure of the SOER. The odour sample collected from Pond 2 was taken as being representative of Ponds 1, 5 and 6. Pond 3 was functioning as the receival pond for ‘clean’ water from the factory, with Pond 4 receiving ‘dirty’ factory water. It was observed that a layer of fat was present on Pond 3 when the sample was taken.

The measured SOERs for Pond 2 (F3), Pond 3 (F4) and Pond 4 (F5) were 9.2, 7.8 and 2.3 OU m^3/s respectively.

The storage ponds accounted for approximately 8% of total farm OER or 290,000 OU m^3/s. Pond 5 (82,892 OU m^3/s) and Pond 6 (130,667 OU m^3/s) accounted for approximately 72% of the OER, as their larger surface areas more than compensate for the lower SOER adopted.

The hedonic tone of the odour emanating from the ponds primarily ranged from mildly pleasant to mildly unpleasant, with the exception of Pond 4, which was scored as very unpleasant.

Additional SOER measurements were made at the time of the supplementary OER survey in April 2007. In general, the SOER for Pond 2 was found to be similar and the SOER for Pond 3 was found to be slightly lower than the results for the initial sampling. The greatest difference was found for Pond 4, where the results from the supplementary test were approximately three times greater than for the previous measurement. A measurement was also taken at Pond 5, which was filling at the time, and was found to be approximately 50% greater than the SOER adopted to derive the OER inventory. Although the net change from these measurements produced a slight increase in the overall OER for the farm, it was not a significant increase relative to the other odour sources and, therefore, these measurements were not included in the inventory.

Spray irrigation

Results presented in Table 21 indicated that spray irrigation was the dominant source of odour emissions from the environmental farm. Two spray irrigation systems were used at the farm; traveller and pivot sprays.

Traveller sprays operate in the areas adjacent to the irrigation area scribed by a given pivot arm. During peak irrigation periods, two small (0.4 ML/hr) and two large (0.7 ML/hr) travellers are typically in operation. OER measurements were taken during the operation of one of the small traveller irrigators (F11). The OER for the large traveller was derived on a pro rata basis on the assumption that the OER was proportional to irrigation rate.

There are six designated pivot irrigation areas at the farm. The pivot systems are equipped with two different spray nozzle types, which primarily differ in the amount of mist created during water application. The low mist nozzles have been fitted to the No. 140 pivot irrigator whereas all other pivot irrigators are fitted with standard spray nozzles.

The OER inventory assumed the continuous operation of Pivot No. 110 1 (0.18 ML/hr), Pivot No. 120 (0.18 ML/hr) and Pivot No. 130 (0.25 ML/hr). The OER was measured on Pivot No. 130 (F9) and the OERs for the remaining pivots were derived using the same pro rata approach used for the travellers. The OER from pivot No. 140 irrigator, equipped with the low-mist nozzles (F10), was also measured in order to quantify the difference in odour emission between the two nozzle types. It should be noted that both Pivots Nos. 130 and 140 are located near the end of the irrigation line and have the same irrigation rate.

The measured and derived OER inventory for the spray irrigators are summarised in Table 22.

Table 22. OER breakdown – spray irrigators

Odour source	Application rate (ML/hr)	OER (OU m^3/s)	OER (OU m^3/s) per 1 ML irrigation
Pivot No. 110	0.18	833,000	4,600,000
Pivot No. 120	0.18	833,000	4,600,000
Pivot No. 130 (F9)	0.25	1,160,000	4,600,000

Odour source	Application rate (ML/hr)	OER (OU m^3/s)	OER (OU m^3/s) per 1 ML irrigation
Pivot No. 140 – low-mist nozzle (F10)	0.25	520,000	2,100,000
Traveller – 2 x small (F11)	0.04	59,000	Included below.
Traveller – 2 x large	0.07	100,000	Included below.
Traveller – total	0.22	160,000	740,000

The results in Table 22 demonstrate the following key features:

» pivot irrigation is a higher source of odour emissions compared to traveller irrigation, and

» the pivot irrigator equipped with the low-mist nozzle has an OER that is less than half of its counterpart operating with a standard spray nozzle.

Prior to the installation of the DDG (stillage recovery) plant, the dominant odorant was likely the soluble solids in the wastewater, which, when spray irrigated, would have resulted in the potential generation of odours under some conditions. While the reduction in solids from the wastewater resulted in a reduction in the odours emanating from the farm, it did not eliminate the offensive odours from the farm. Instead, the primary odorants under the current operation are likely to be soluble, volatile organic compounds rather than the soluble solids. These potential odorants readily volatilise during spray irrigation because the fine water droplets that form during spraying have a greater surface area to volume ratio.

Irrigated land

For emissions from the land irrigation of wastewater, the SOERs from an area prior to irrigation (approximately 24 hours) and immediately after irrigation were measured at Pivot No. 120 (F14 & F15) and Pivot No. 140 (F12 & F17). The results of these tests show that the odour emissions from recently irrigated grass are not significantly different to dry grass, with the mean SOERs for wet and dry land irrigated using pivot irrigators being 0.17 and 0.18 OUm/s, respectively.

The SOER for land immediately following irrigation by a large traveller (F13) was found to be 0.45 OUm/s. This higher SOER relative to pivot-irrigated grass is likely to be due to the pooling of irrigation water on the surface, rather than the fine layer applied during pivot irrigation.

The SOER for an area of grass that had not been irrigated with wastewater (F16) was also measured to gauge the background odour emission for the natural grass. The measured SOER was 0.14 OUm/s, which is equivalent to over 75% of the mean SOER for irrigated land.

In deriving the OER inventory for the irrigated land, the background SOER for the grassland was subtracted from the mean SOER for irrigated land and the OER was calculated based on the irrigation areas of the total traveller and pivot irrigation areas.

The irrigated land was found to account for approximately 3% of the total farm OER or 90,000 OU m^3/s.

7.4 Principal Odour Sources

Results from the odour source identification and quantification process enable the sources that comprise the factory and environmental farm to be ranked with respect to their relative odour emission rates.

7.4.1 Principal odour sources – factory

As previously mentioned, odour sources with the highest odour emission rates may not necessarily have the greatest odour impact at ground level, rather the degree of impact might be dependent on the combination of a number of other factors such as the hedonic tone of the odour, source characteristics (e.g. point or diffuse source) and the timing and duration of the odorous emissions. To gain a further understanding of the contribution of key odour sources/source groups to off-site odour impact, dispersion modelling was also conducted – refer to Section 8.

In order to rationalise the number of sources that will be examined in the following sections of this report, the sources will be limited to the 'top fifty' sources of potentially offensive odour (Table 23), which collectively contribute to approximately 99.8% of the odour emissions measured during the survey at the factory plus two additional sources identified as having a 'very unpleasant' hedonic tone (but not in the top 50 by odour emission rate).

Management of lower ranked sources would yield such diminished returns on equipment or process modification, given the low relative contribution of each individual source, that that such modifications could not be reasonably justified.

The top 50 sources at the factory, which when combined, contributed 99.8% of all odour emissions measured at the factory during the survey, are listed in Table 23.

Table 23. Principal (top fifty) factory odour sources by odour emission rate

Rank	Sample	Discharge plant	Total odour emission rate (OU m^3/s)	Cumulative percent contribution (%)
1	S5	No. 4 gluten dryer baghouse	150,000	23%
2	S3	No. 3 gluten dryer baghouse	73,300	34%
3	DDG39	Dryer building exit	70,500*	44%
4	DDG46	Cooling towers	68,300	55%
5	E23	Cooling towers	65,800	65%

Rank	Sample	Discharge plant	Total odour emission rate (OU m^3/s)	Cumulative percent contribution (%)
6	S2	No. 1 gluten dryer baghouse	38,300	70%
7	E15	Yeast propagators (tanks 4 and 5)	28,300	75%
8	DDG23	Condensate tank	20,000*	78%
9	DDG26	Finisher feed tank	18,300*	81%
10	S4	No. 2 Gluten dryer baghouse	18,300	83%
11	DDG36	DDG load out ‘tent’	12,900	85%
12	S19	No. 4 starch dryer scrubber tower	10,200	87%
13	DDG20	Feed dump tanks (2 units)	8,900	88%
14	DDG16	DDG Palmer cooler baghouse	8,900	89%
15	F18	Farm tank	7,700	90%
16	DDG34	DDG product storage shed	6,800	91%
17	E8	Jet cooker retention tank “F7”	6,500	92%
18	E14	Yeast propagators (tanks 1,2 & 3)	5,500*	92%
19	S18	No. 3 Starch dryer	5,500	93%
20	S7	Dry gluten roof bin	4,500*	94%
21	B7	Enzyme tanks	4,100	94%
22	DDG24	Vent condenser	3,500*	95%
23	C4	Drum vacuum receiver	3,500	96%
24	DDG25	Vent condenser drain	3,200	96%
25	S1	No. 1 Starch dryer	3,200	96%
26	DDG40	Kestner dryer exhaust	3,000	97%
27	DDG45	DDG heat exchanger	2,300	97%
28	DDG5	Decanters Nos. 3 and 4	1,700	98%
29	DDG30	Dryer feed tank	1,400	98%
30	DDG28	Finisher pump tank	1,400	98%
31	D2	Molecular sieve – vacuum drum	1,350	98%
32	DDG31	Feed holding tank (syrup)	1,300*	98%
33	E7	Jet cooker 2 & 4 – grain retention	1,100*	98%
34	E13	Jet cooker 1- retention tank	1,100	99%

Rank	Sample	Discharge plant	Total odour emission rate (OU m^3/s)	Cumulative percent contribution (%)
35	S13	Flour bin aspirator	1,000	>99%
36	S20	Spray dryer	980	>99%
37	B3	Cooker A & B flash tanks	950*	>99%
38	DDG18	Feeds dryer baghouse	870	>99%
39	S8	High protein dust collector	600	>99%
40	DDG19	Light phase recover tank	450	>99%
41	DDG32	CIP tank	420	>99%
42	D6	Incondensible vent	400	>99%
43	S12	Pellet silo	350	>99%
44	S6	Flour bin motor drive	280	>99%
45	DDG2	Decanters Nos.1 & 2	260	>99%
46	C18	Ion exchange effluent tank	250	>99%
47	DDG1	Decanter feed tank	220	>99%
48	DDG37	DDG plant grounds	200	>99%
49	E10	Starch factory rejects collection tank	180	>99%
50	E1	Grain silo baghouse	180	>99%
*	E22	Feed transfer to distillation plant	170*	-
*	D12	DME vent	110*	-

* Very unpleasant hedonic tone.

7.4.2 Principal odour sources – environmental farm

Although the odour sources that comprise the environmental farm have been broken down into component sources for the purpose of attributing relative OER contributions to the total farm OER, the application of prevention/minimisation long-term strategies would be applied to the collective unit rather than to individual components. For example, the implementation of a wastewater treatment plant would reduce odour emissions from all farms odour sources and may potentially eliminate some odour sources.

Therefore, the purpose of ranking the environmental farm odour sources in this section is to identify specific sources that should be targeted for short-term odour prevention/minimisation strategies.

Long-term strategies will be assessed against the environmental farm as a whole.

The top 10 sources at the environmental farm, which, when combined, contributed 99% of all odour emissions measured at the farm during the survey, are listed in Table 24.

Table 24. Principal (top ten) farm odour sources by odour emission rate

Rank	Sample	Discharge plant	Total odour emission rate (OU m^3/s)	Cumulative percent contribution (%)
1	F9	Pivot irrigator No. 130 (mist nozzle)	1,160,000	33%
2	F9	Pivot irrigator No. 120 (mist nozzle)	833,000	56%
3	F9	Pivot irrigator No. 110 (mist nozzle)	833,000	80%
4	F11	Traveller irrigators	163,000	85%
5	F1	Mixer tank vent	147,000*	89%
6	F8	Pond 6	131,000	93%
7	F7	Pond 5	82,900	95%
8	F4	Pond 3	62,700	97%
9	F13	Traveller irrigated pasture	46,000	98%
10	F15, F17, F12, F14	Pivot irrigated pasture	44,000	99%

Note: pivot irrigators Nos. 140, 150 and 160 have the potential to be in the top 10, however, they have not been included in the "top ten" table as they are mutually exclusive with pivot irrigators 110, 120 & 130 due to them not being operated at the same time. These irrigators are considered separately in section 7.3.

8. Odour Source Modelling

(f) *Model for each source identified at (c) the impacts and potential impacts of the odour at all sensitive receptors in accordance with the publication "NSW DEC 2005 Approved Methods for the Modelling and Assessment of Air Pollutants in NSW".*

8.1 Dispersion Modelling

A Level 3 odour impact assessment was conducted with consideration to the DECC document, *Technical Framework – Assessment and management of odour from stationary sources in NSW*.

Dispersion modelling of emissions to air requires, firstly, selection of an appropriate model and assessment criteria and, secondly, selection of three general types of input. These are:

» hourly site-specific or site representative meteorological data for a period of not less than one year;

» source characterisation (which includes an OER inventory and source geometry); and

» model configuration – in which the various model settings are selected to best characterise the physical processes specific to this site and to make best use of the available emissions and meteorological data.

These inputs are described below under relevant section headings.

8.2 The Model

CALPUFF[2] version 5.7 is a three-dimensional non-steady state Gaussian puff model that is particularly suited for near-field impact assessments in complex geographical locations where there are spatially varying flows. Of significance for this study, the dispersion model can characterise:

» plume history, where the position of the airborne emissions are remembered from one hour to the next, enabling the simulation of curved, recirculating or stagnating transport of the emissions;

» odour transport during calm wind events, including build-up and fumigation;

» cumulative impacts for many sources within a spatially varying flow field;

» dispersion of the odorous emissions over a range of surfaces, such as trees, barren land, residential or urban areas, and water bodies, allowing for varying surface roughness and resultant flow shear stresses and turbulent dispersion; and

[2] Scire J.S., D.G. Strimaitis, R.J. Yamartino and X. Zhang, 1995: A User's Guide for the CALPUFF Dispersion Model. Report prepared for the USDA Forest Service by EARTH TECH, Concord, MA. See: http://www.src.com/calpuff/calpuff1.htm

» a range of emission source types including point, area, volume and line sources with time-varying emission conditions.

CALPUFF is an approved regulatory model under the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC, 2005).

8.3 Odour Assessment Criteria

An odour is defined as a sensation resulting from the reception of a stimulus by the olfactory sensory system. Complex mixtures of odorous air samples require dynamic olfactometry to quantify the odour concentration. This involves exposing a selected and controlled panel of 'sniffers' to precise dilutions of the concentrations presented to the panel, to determine the point at which only half of the panel can detect the odour – the point is called the odour threshold and by convention is defined as 1 odour unit (OU).

Odour impact assessment criteria are prescribed in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*.

The NSW DECC requires the determination of odour concentration by dynamic olfactometry to be conducted in accordance with the Australian and New Zealand (AS/NZ) standard 4323.3:2001 "*Stationary source emissions - Determination of odour concentration by dynamic olfactometry*". Therefore all OER data used in this assessment have been determined based on the odour levels measured using methods in accordance with the Australian Standard.

The impact assessment criterion for complex mixtures of odorous air pollutants, used in NSW[3] adopts a sliding scale (2 to 7 OU, 99 percentile, 1 second average) – dependent on the size of the affected population P. This is expressed in the equation:

Criterion $OU_c = (\log_{10} P - 4.5) \div -0.6$.

Application of the above equation yields a range of odour performance criteria that should be applied at the nearest off site sensitive receptor, as outlined in Table 25.

Table 25. NSW DECC odour criteria

Population of affected community	Odour criteria* (OU)
Urban (≥2000)	2
~500	3
~125	4
~30	5
~10	6

[3] Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Department of Environment and Conservation (NSW), August 2005.

Population of affected community	Odour criteria* (OU)
Single residence (≤2)	7

*Nose response time average, 99th percentile

Note that the criteria outlined in Table 25 are required to be met at the nearest off site sensitive receptors at the 99 percentile and at a 1 second peak averaging time.

Given the large number of residences located with one to two kilometres of the factory (in Nowra and Bomaderry), an odour impact assessment criterion of 2 OU was adopted. An odour criterion of 7 OU was adopted for isolated rural residences located on properties that surround the environmental farm.

The NSW odour impact criteria were devised on the basis that compliance with this criterion should ensure that people living in the vicinity are unlikely to be impacted by ‘offensive odour’. Where offensive odour means an odour that, by its concentration, nature, duration, character or quality is harmful to a person or interferes unreasonably with the comfort and/or repose of a person outside the emitting premises[4].

8.4 Local Meteorology

8.4.1 Available data

Wind data were collected at three locations within the Shoalhaven Starches facility. Of these three stations, only one station, the automated weather station (AWS) located near the storage ponds at the environmental farm (hereafter referred to as Farm AWS), is compliant with the Australian Standard for the measurement of horizontal wind for air quality applications (AS 2923:1987). Wind data have been collected at this station since 2003, with the most complete data set collected in 2004.

The nearest suitable source of additional surface meteorological data was the Bureau of Meteorology (BoM) Nowra AWS located approximately 12 km to the west at the Royal Australian Navy base at Nowra (HMAS ALBATROSS). This data source was considered to be too far from the subject area to be site-representative.

No upper air station meteorological data source was available for use in this assessment.

Advanced dispersion models, such as CALPUFF, require meteorological input from surface networks (land and over-water) and upper air stations. Given that there was only data from one surface station (Farm AWS) to cover the large subject area and no upper air station data available, a combined prognostic/diagnostic meteorological modelling approach was used to synthesise the meteorological input required by the non-steady state dispersion model CALPUFF. The local measured meteorological data that was available from the Farm AWS was taken advantage of by the process of meteorological data assimilation into the prognostic model.

[4] Protection of the Environment Operations Act 1997

8.4.2 Prognostic meteorological modelling

A regional-scale prognostic meteorological model, TAPM, was used to simulate the meteorology over the subject site with consideration to the DECC *Approved Methods*. The observations from the Farm AWS were used for model calibration and data assimilation. TAPM was used to produce representative hourly surface meteorological data at the proposed site. The use of TAPM to generate site-specific meteorology has been previously accepted at numerous NSW sites for regulatory purposes. Its configuration and use are described below.

TAPM (v 3.0.7) was developed at CSIRO Division of Atmospheric Research as a PC-based prognostic modelling system that can predict regional scale 3D meteorology. It is suitable for use with complex geographic sites and for situations when the available site representative meteorological data are not adequate (as was the case for this assessment). TAPM accesses databases of synoptic weather analyses from the Bureau of Meteorology. The model then provides the link between the synoptic large-scale flows and local climatology, which, in this case, includes characterising such factors as local land use and topography, and their influence on atmospheric stability and mixing height.

TAPM was initially configured with a nested model grid coverage designed to capture:

- Nowra and environmental farm AWSs;
- broad scale synoptic flows;
- regional to local scale wind channelling; and
- the influence of local land use.

The nested grids were then configured with surface characteristics, such as terrain elevation, surface type (land use and vegetation type), soil type and deep soil moisture content.

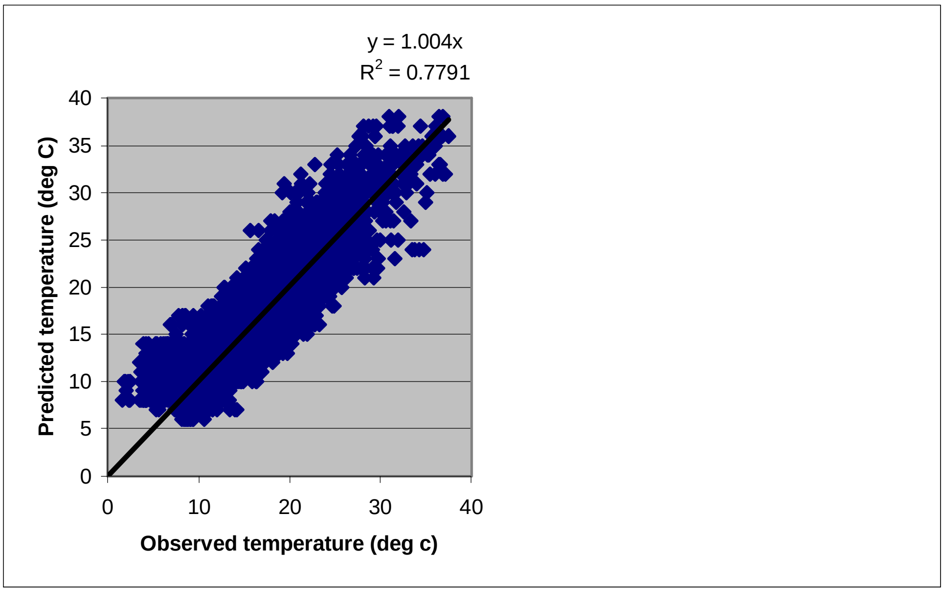
Specific model settings were:

- four nested grids at 1 000 m, 3 000 m, 10 000 m and 25 000 m resolution, with 55 x 55 grid points;
- monthly varying deep soil moisture (DSM) content values to provide the optimal degree of correlation with concurrently recorded temperature; and
- surface vegetation and precipitation processes were included, whereas, non-hydrostatic processes were not included.

Following an initial model run, the model output from the model grid point nearest to the Farm AWS was compared with data recorded at that station. Specifically, the predicted hourly ambient temperature and the annual wind rose (wind speed and direction distributions) were compared with corresponding recordings.

Figure 7 shows the scatter plot of observed and predicted ambient temperature at the Farm AWS. The determined optimal model configuration produced a correlation coefficient of 0.88 for predicted temperature. The strong correlation between predicted and recorded temperature indicates that the model is accurately calculating the surface energy balance, which, in turn, adds confidence to the hourly varying predictions made for atmospheric stability and the height of the mixed layer.

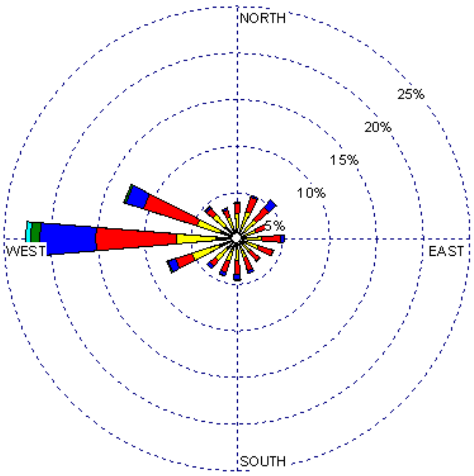
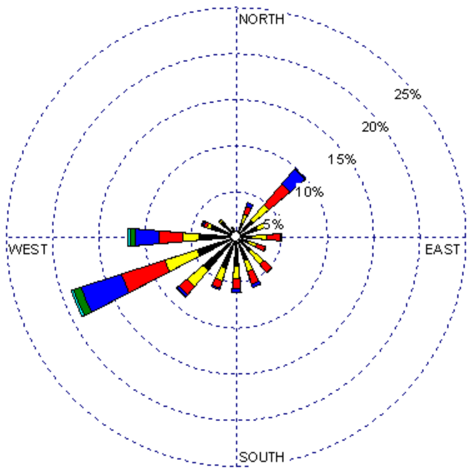
Figure 7 Scatter plot of observed and predicted ambient temperature



Wind distribution

Figure 8 shows the predicted and observed wind roses for the location of the Farm AWS. The directional distribution of winds predicted by TAPM shows reasonable agreement with the recorded observations and with the wind patterns expected for this region. However, the plots show a marked difference in the frequency of low winds. This issue is addressed in the following sub-section.

Figure 8   Annual wind roses – year 2004

Annual Wind Rose Farm TAPM	**Annual Wind Rose Farm AWS**
	

Legend	Comments:	
WIND SPEED (m/s) >= 11.1 8.8 - 11.1 5.7 - 8.8 3.6 - 5.7 2.1 - 3.6 0.5 - 2.1	Project No.: **23/11918**	CLIENTS | PEOPLE | PERFORMANCE

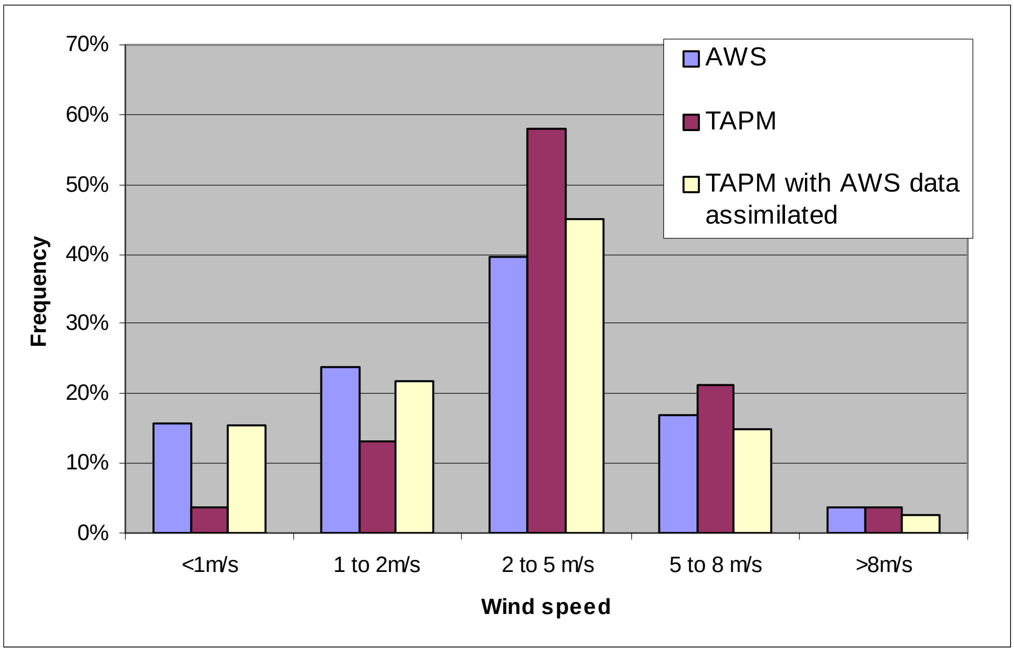
8.4.3 Meteorological data assimilation

Once good agreement between the predicted annual wind rose and corresponding observations was achieved, the wind speed and direction observations from the Farm AWS were assimilated into the model simulation to improve the ability of the model to capture the effects of local wind channelling and low wind speed conditions.

TAPM performs reasonably well at simulating low wind speeds when the atmosphere is stable but is know to perform relatively poorly during stable atmospheric conditions (e.g. clear nights), which is a critical factor in this assessment given that odour emissions occur 24-hours per day, hence, predictions of maximum odour impact will dominate during these conditions.

Figure 9 shows a histogram of wind speed distribution for observations at the Farm AWS, predictions from TAPM and predictions from TAPM after wind speed and direction data from the Farm AWS was assimilated into TAPM. It is clear from this figure that TAPM did reasonably well at predicting moderate to high wind speeds but did relatively poorly predicting low wind speeds. However, Figure 9 also shows that the representation of low winds in the TAPM output was significantly improved once the Farm AWS data were assimilated into the model simulation.

Figure 9 Wind speed distribution – TAPM and Farm AWS



A sensitivity analysis was also conducted to compare the subsequent CALPUFF model predictions using meteorological input derived with and without the assimilation of observed wind speed and wind direction data from the Farm AWS into TAPM. Good agreement was found in the general pattern of dispersion (i.e. similar directions of poor dispersion), however, the highest ground level odour concentrations were predicted when the assimilated meteorological data file was used, which was expected given the higher frequency of low wind speeds observed at the Farm AWS than that predicted by TAPM.

CALMET

The TAPM output (with assimilated data) was then passed to model CALMET (version 5.5)[5], which is the 3D meteorological diagnostic model pre-processor to the CALPUFF 3D puff based dispersion model.

Hourly varying 3D winds, at a 1000 m resolution, were extracted from the TAPM inner nested grid and passed to CALMET in their entirety as initial guess fields. These wind

[5] Scire J.S., E.M. Insley, R.J. Y a.m.artino, and M.E. Fernau, 1995: A User's Guide for the CALMET Meteorological Model. Report prepared for the USDA Forest Service by EARTH TECH, Concord, MA. See: http://www.src.com/calpuff/calpuff1.htm

data were supplemented by hourly varying cloud cover and ceiling height data, as well as hourly varying temperature and humidity profiles, which were also extracted from the TAPM output at selected locations.

CALMET was configured with a 15 km by 15 km grid at 200 m resolution and with local scale surface characteristics, such as terrain elevation and land use (e.g. forest or sparse growth, water or residential). The land use and terrain elevation information was derived from US Geological Survey and AusLig data, respectively, with adjustments based upon inspection of aerial photographs, topographical and land uses maps, and a site inspection.

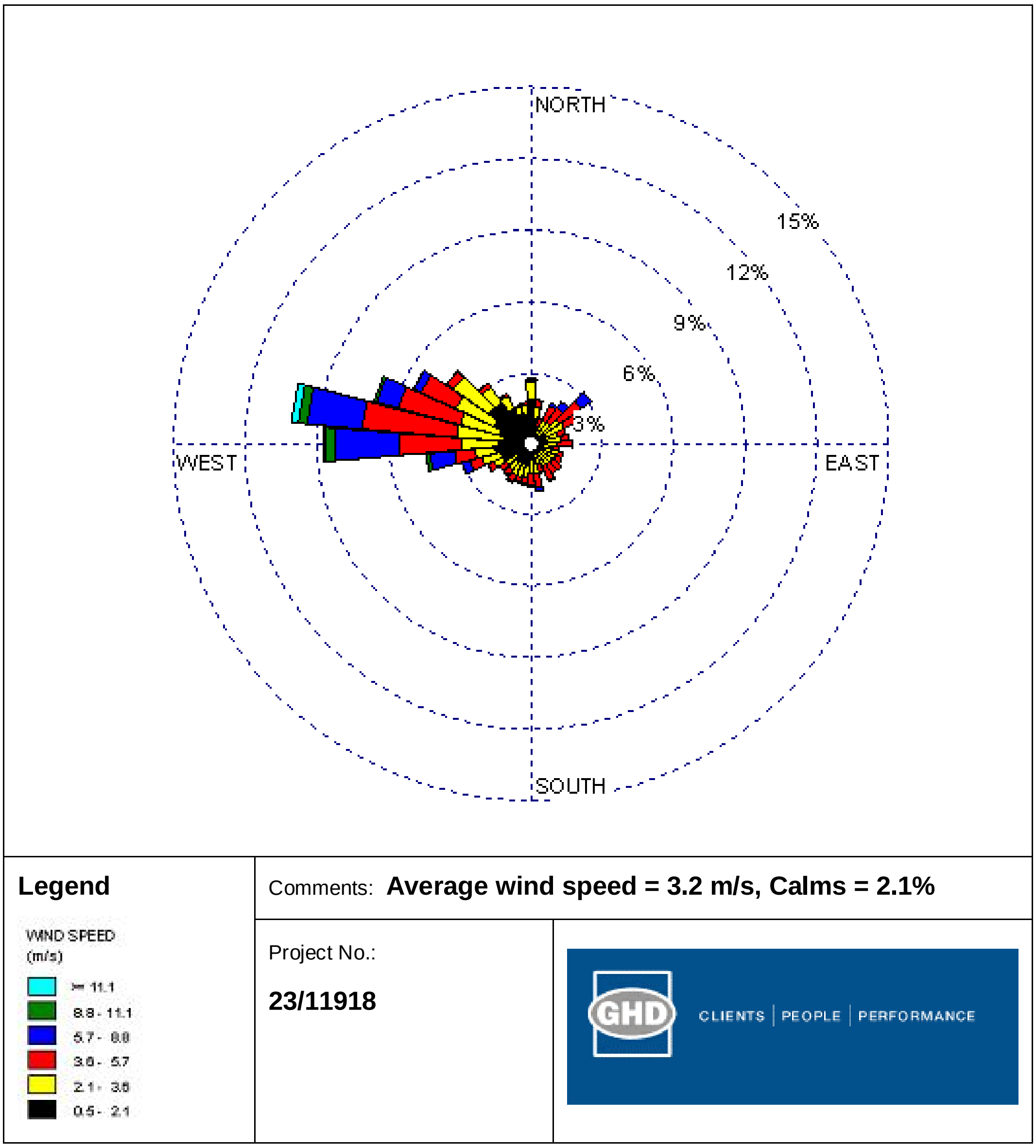
CALMET was used to produce hourly site-representative winds and micrometeorological information, which was used with the CALPUFF 3D puff-based dispersion model to assess the impacts of the odours on the surrounding land uses.

8.4.4 Dispersion model meteorology

Potential off-site odour impact would tend to be maximised when winds are light and the atmosphere is stable, conditions that typically occur during the early evening and night-time. The meteorological simulations indicated that these conditions occurred for approximately 40% of the time. During these stable periods, the regional scale cool air drainage flows down the river valley from the west would dominate the transport and disperse emissions to air from the factory and environmental farm. To a lesser extent, local slope drainage flows from the hills located to the north and west-south-west of the site would also generate these conditions for poor dispersion.

Figure 10 contains a wind rose that illustrates the distributions of wind speeds for each cardinal wind direction at the location of the factory. On an annual basis the prevailing winds are from the west with winds also from the west-north-west, north-west, west-south-west and east. In the summer westerlies and north-westerlies are dominant, while in winter the westerlies are the most common. The mean wind speed is 3.2 m/s, with higher speed winds associated with north-westerly winds with speeds up to 11 m/s; such speeds are not reached from other directions. The highest frequency of light winds occurs from the south-west, west and north.

Figure 10 CALMET synthesized annual wind rose for the Year 2004



A categorised measure of atmospheric stability is also output from the model. These can be broadly defined as listed in Table 26.

Table 26. Atmospheric stability classes

Stability Class	Description
A	Extremely unstable atmospheric conditions, occurring near the middle of day, with very light winds, no significant cloud.
B	Moderately unstable atmospheric conditions occurring during mid-morning/mid-afternoon with light winds or very light winds with significant cloud.
C	Slightly unstable atmospheric conditions occurring during early morning/late afternoon with moderate winds or lighter winds with significant cloud.
D	Neutral atmospheric conditions occurring during the day or night with stronger winds. Or during periods of total cloud cover, or during the twilight period.
E	Slightly stable atmospheric conditions occurring during the night-time with significant cloud and/or moderate winds.
F	Moderately stable atmospheric conditions occurring during the night-time with no significant cloud and light winds.

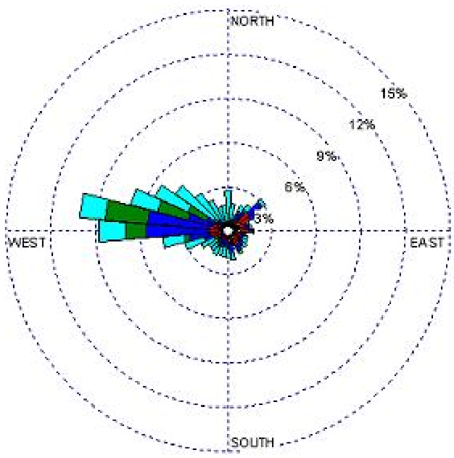
The occurrence of stable air flows is of significance as these generally provide the conditions for worst case dispersion of emissions to air, and hence potentially the highest impact to odour amenity. This is due to the limited mixing in the vertical of these light wind airflows, and hence less dilution of the emissions.

Vertical mixing of airflows can be brought about by two mechanisms. The first is mechanical mixing caused by the shear stresses as air moves over rough terrain. The second is via heat convection, which has the potential to occur significantly only during daytime. Therefore the distribution of light wind stable flows can define the directions of “poor dispersion” from the factory and farm.

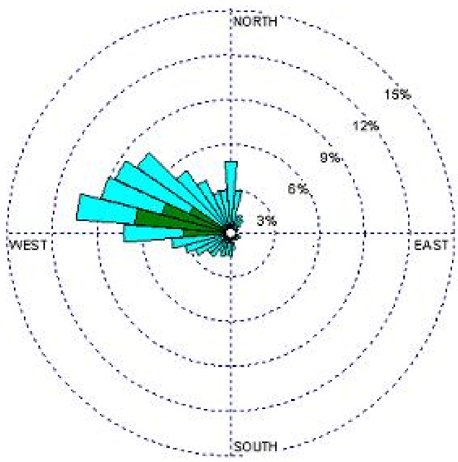
A rose that illustrates the directional distribution of the predicted atmospheric stability is shown in Figure 11. This rose indicates that stable flows are predominantly linked to the overall wind distribution, with a higher proportion coming from the west and north-west (which is linked to the higher proportion of nocturnal hours during winter when flows are predominately from this direction).

Figure 11 CALMET synthesized annual stability rose for the Year 2004

Annual Stability Rose – All stability classes



Annual Stability Rose – E & F Stability classes



Legend

Stability Class

- F
- E
- D
- C
- B
- A

Comments: Location of Factory for year 2004

Project No.:

23/11918

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8.5 Odour Source Characterisation

Section 7 details the OER inventory used for model input. The source geometries and release parameters used for model input are provided in Appendix H. Odour sources were modelled as point (i.e. stack), area or volume sources. Each area source was characterised as an integrated polygon area source with dimensions representative of the emitting surface.

Fugitive emissions from the DDG dryer, product buildings and some storage tanks were characterised by a surface based volume source with the initial spread representative of the dimensions of the building/structure enclosing the respective process. Diffuse emissions from the traveller and pivot irrigations systems were also characterised as surface based volume sources, with the initial spread representative of the dimensions of the initial spray release. In the case of the pivot irrigators, the pivot arm was divided into a series of sub-volume sources, with the total pivot OER proportioned between the sub-volume sources. It is not possible to model a moving source within CALPUFF and, therefore, the pivot arm was fixed to produce an alignment with the direction of poorest dispersion (i.e. alignment with the drainage flow to the south-east) in order to provide a worst-case scenario.

All point sources located at the factory were considered to be wake-affected stacks. In cases where the vent stack was oriented horizontally or faced downwards, the exhaust velocity was set at a nominal, minimum (vertical) velocity of 0.1 m/s.

Emissions can be characterised as constant or varying diurnally and/or seasonally (i.e. linked to a particular mechanical process or ambient conditions).

All source odour emissions were assumed to be constant, emitting 24 hours per day every day of the year. The odour survey was confined to the summer period at this stage. Therefore, in order to conduct simulations covering a full year, winter emission rates were assumed to be equal to summer.

This approach is generally representative of the factory OERs because it typically operates continuously for most of the year with only some activities restricted to a given shift, such as DDG product load-out, which only occurs during the day. However, sources such as this are generally low odour sources and as such have little or no influence on the model outcome.

With respect to the environmental farm, this approach is highly conservative, as 24-hour irrigation typically only occurs during the hotter months. The OER input is based on emission measurements taken during the daytime in summer, whereas, winter/night-time OERs are likely to be less as a result of the decreased volatilisation of odorous compounds during the cooler conditions that occur in winter and at night. As discussed in Section 7.3.3, the actual OER associated with spray irrigation is likely to be dependent on ambient conditions at the time of irrigation, such air temperature and wind speed. Lower OERs will likely occur under conditions typically associated with poor dispersion (calm stable winds which typically occur at night) and higher OERs are more likely to occur under conditions that are more conducive to good atmospheric dispersion (i.e. hot and wind conditions during the day). Hence, the application of the OER measured during the survey to all meteorological conditions is likely result in an over-estimate of odour impact. However, in the absence of additional seasonal and diurnal emission rate data this was considered to be the best available approach.

8.6 Model Configuration

The emissions for each component source detailed within the emissions inventory described in Section 7 were characterised as either point (i.e. stack), area or volume sources within the model, with initial release geometries representative of each source.

The model was then configured to run for 2004, using the meteorology described in Section 8.3, with the following main configuration features:

» the 200 metre resolution 3D winds generated by CALMET were used to characterise the transport of the odorous emissions to air from the factory and environmental farm;

- dispersion in the horizontal and vertical was characterised directly using the hourly and spatially varying micrometeorological parameters generated by CALMET, in conjunction with the spatially varying geophysical information used in that model;
- ground level odour was predicted on a 8 km by 8 km Cartesian receptor grid, with a grid resolution of 200 m. This grid was fine enough for the peak ground level odour concentration to be captured in the model results while still maintaining a reasonable model processing time for the large model domain; and
- Peak to Mean (P/M60) scaling factors for each Pasquill stability category, for each relevant source type, and for far field odour assessment, were factored into the component emission rates so that model output (1-hour average) corresponded to Peak 1-second average odour concentration.

Further information on model configuration can be provided in the form of model input control files attached as Appendix **I**.

8.7 Dispersion Model Results

The model odour predictions at each grid receptor were then ranked from highest to lowest and the 88th highest (99%ile) predictions at each receptor were then contoured. These contours (or concentration isopleths) were overlaid upon a scaled aerial photograph of the area for interpretation and comparison with the odour criteria.

Odour contour plots were prepared showing the predicted impact for the following source groups:

- factory only (Figure 12);
- environmental farm only (Figures 13 and 14); and
- factory plus environmental farm (Figure 15).

8.7.1 Factory

The predicted ground level odour concentrations for the factory under normal operating conditions is shown Figure 12. These predicted odour concentrations indicate that the 2 OU (99%ile, 1-second average) criterion is not met, with odour levels of approximately 40 OU on the southern fringes of Bomaderry and 30 OU on the northern fringes of Nowra. This result shows good agreement with GHD's understanding of the odour complaint history, which is dominated by complaints from residents located in Bomaderry and Nowra. The factory odour emissions are a significant odour source contributing to off-site odour impact, particularly in the residential areas immediately adjacent to the factory.

This figure also shows that the maximum excursion of elevated odour (i.e. direction of poor dispersion) is to the east, which reflects the high incidence of stable drainage flows (light winds) channelled by the hills and river valley to the west of the factory.

A breakdown of the contribution of each odour source or source group to the predicted ground level odour concentration at specific receptor locations is provided in Table 27.

Table 27. Factory only – Source contribution to predicted off-site odour impact (refer to Figure 12)

Plant	Source group	Bomaderry (R1 = 30 OU)	North Nowra (R2 = 17 OU)	Nowra (R3 = 26 OU)	Terara (R4 = 23 OU)	Black Forest (R5 = 2.5 OU)	Jaspers Brush (R6 = 1 OU)	Berry (R7 = <1 OU)
DDG	DDG liquids line [1]	18%	17%	17%	15%	12%	10%	<1%
DDG	DDG solids line [2, 4]	15%	14%	14%	12%	8%	4%	<1%
DDG	Fugitive emissions from dryer building [3]	27%	28%	26%	26%	15%	20%	<1%
Distillery	All sources [5]	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Starch	Starch & gluten dryers [6]	27%	28%	26%	31%	46%	60%	>99%
Starch	Minor sources [7]	1%	1%	1%	1%	<1%	<1%	<1%
Glucose	All sources [8]	1%	1%	2%	1%	<1%	<1%	<1%
Ethanol	Minor sources [9]	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Ethanol	Fermentation – grain retention and farm tank [10]	1%	1%	1%	1%	<1%	<1%	<1%
Ethanol	Fermentation propagator [11]	6%	5%	7%	7%	8%	<1%	<1%
Ethanol & DDG	Cooling towers [12]	5%	6%	7%	6%	12%	10%	<1%

(1) DDG 18, 24, 23, 20, 30, 26, 28, 32, 31, 25

(2) DDG 34 – 37

(3) DDG 39

(4) DDG 2, 5, 16, 1, 19

(5) D2, D6, D11, D12

(6) S2, S3, S4, S5, S1, S18, S19, S20

(7) S6 – S15, S17

(8) C1, C2, C4, C18, C19, B3, B7

(9) E1, E4, E9 – E11, E22, E24

(10) E7, E8, E13, F18

(11) E14, E15

(12) E23, DDG 46

Table 27 shows the following key features:

- » DDG plant contributes the greatest to the predicted odour impact at receptors adjacent to the factory (Nowra, North Nowra, Bomaderry and Terara). In general, the DDG plant contributes approximately 50 to 60% of the predicted odour concentration at these receptors, which is up to double the contribution from the Starch plant at ~28%. It is noteworthy that total OER from the DDG plant (230,000 OU m^3/s) was slightly less than that of the starch plant (310,000 OU m^3/s);
- » fugitive odour emissions from the DDG dryer building make a significant contribution to the predicted odour impact at all receptor locations adjacent to the factory, and also contribute significantly at receptors farther away, such Black Forest and Jaspers Brush;
- » odour emissions from the glucose, ethanol and distillation plants do not make a significant contribution to the predicted odour impact at nearby receptors. This is consistent with the low odour emission rates identified in the odour emission rate inventory relative to the DDG and starch plants; and
- » at greater distances from the factory, the dominance of the DDG plant contribution to odour impact diminishes in favour of the starch plant contribution. Note that at receptors such as Black Forest, Jaspers Brush and Berry the contribution from the starch plant sources is <1 OU, hence, odour emissions from the environmental farm dictate odour impact at these locations.

8.7.2 Environmental farm

The predicted ground level odour concentrations for the environmental farm under worst case operating conditions (as defined in the odour emission inventory represented in Section 7) are shown in Figure 13. These predicted odour concentrations indicate that the 7 OU (99%ile, 1-second average) criterion is also not met at rural residences, with odour levels ranging from 25 to 100 OU at rural residences located in all directions surrounding the environmental farm.

It is noteworthy that odour emissions from the environmental farm alone are capable of exceeding odour levels typically associated with the onset of odour nuisance/complaint at the townships of both Bomaderry and Nowra. Odour emissions associated with irrigation (spray irrigation and irrigated pasture) make the greatest contribution (~80%) to the predicted odour levels at Bomaderry (R1) and Nowra (R3) shown on Figure 13. The storage ponds are the next greatest contributing source at these receptors at approximately 15%.

As mentioned in Section 8.4, the arm of each pivot irrigator included in the model was oriented towards the south-east. The influence of this setting on plume dispersion can be seen from the orientation of the 100 OU contour, which is skewed towards the south-east in Figure 13.

The number of irrigators operating and the time of day that they operate will have the most significant effect on the predicted odour impact. Operation of three pivot irrigators is typically confined to hot and windy conditions, however, continuous operation can occur during any season throughout the year, although, it most typically occurs during hotter conditions. To gain an understanding of the predicted odour impact under various operation regimes the following scenarios were modelled:

» Pivot Nos. 120 and 130 and four traveller irrigators operating continuously;

» Pivot Nos. 120 and 130 and four traveller irrigators operating between 5 a.m. and 5 p.m. daily; and

» Pivot No 130 and four traveller irrigators operating between 5 a.m. and 5 p.m. daily.

The model results show the following key features:

» the extent of off-site odour impact is slightly reduced towards the south when Pivot No. 110 is excluded from the model but the degree of off-site odour impact remains essentially the same in all other directions when compared to when compared to the predicted odour impact under continuous operation of pivots Nos 110, 120 and 130 (as per odour emission inventory);

» the effect of confining the operation of Pivot Nos. 120 and 130 to daytime operation has reduced the predicted off-site impact by approximately 50% when compared to the predicted odour impact under continuous operation of these two pivots. This result is a refection of the better dispersive conditions that typically occur during the daytime when the atmosphere is generally unstable as a result of thermal turbulence formed via heat convection; and

» as expected, operation of a single pivot irrigator (No. 130) during the daytime results in the lowest predicted off-site impact, with predicted levels up to 80% less than the other modelled scenarios but still above the odour assessment criterion of 7 OU. The model results for this scenario are shown in Figure 14.

The above results suggest that the odour model could be refined to better represent the actual odour impact under different operating conditions throughout a given year. However, at this stage, the odour emission inventory and the initial model results are sufficient to identify the the key odour sources that need to be addressed. Refinement of the odour model should be considered at a later stage once mitigation actions have been implemented to control key odour sources.

8.7.3 Combined factory and environmental farm

The predicted ground level odour concentrations for the combined operation of the factory and environmental farm under peak operating conditions are shown in Figure 15. The pattern and magnitude of the predicted odour concentrations is very similar to that shown in Figure 12 due to the dominance of the contribution of the environmental farm to overall OER.

The predicted ground level odour concentration near the site boundary of the factory is in the order of 100 OU, which fits well with the results of ambient odour level measurements taken around the factory over the course of the OER survey during light wind conditions.

Figure 12   Maximum predicted ground level odour concentration – factory before odour control

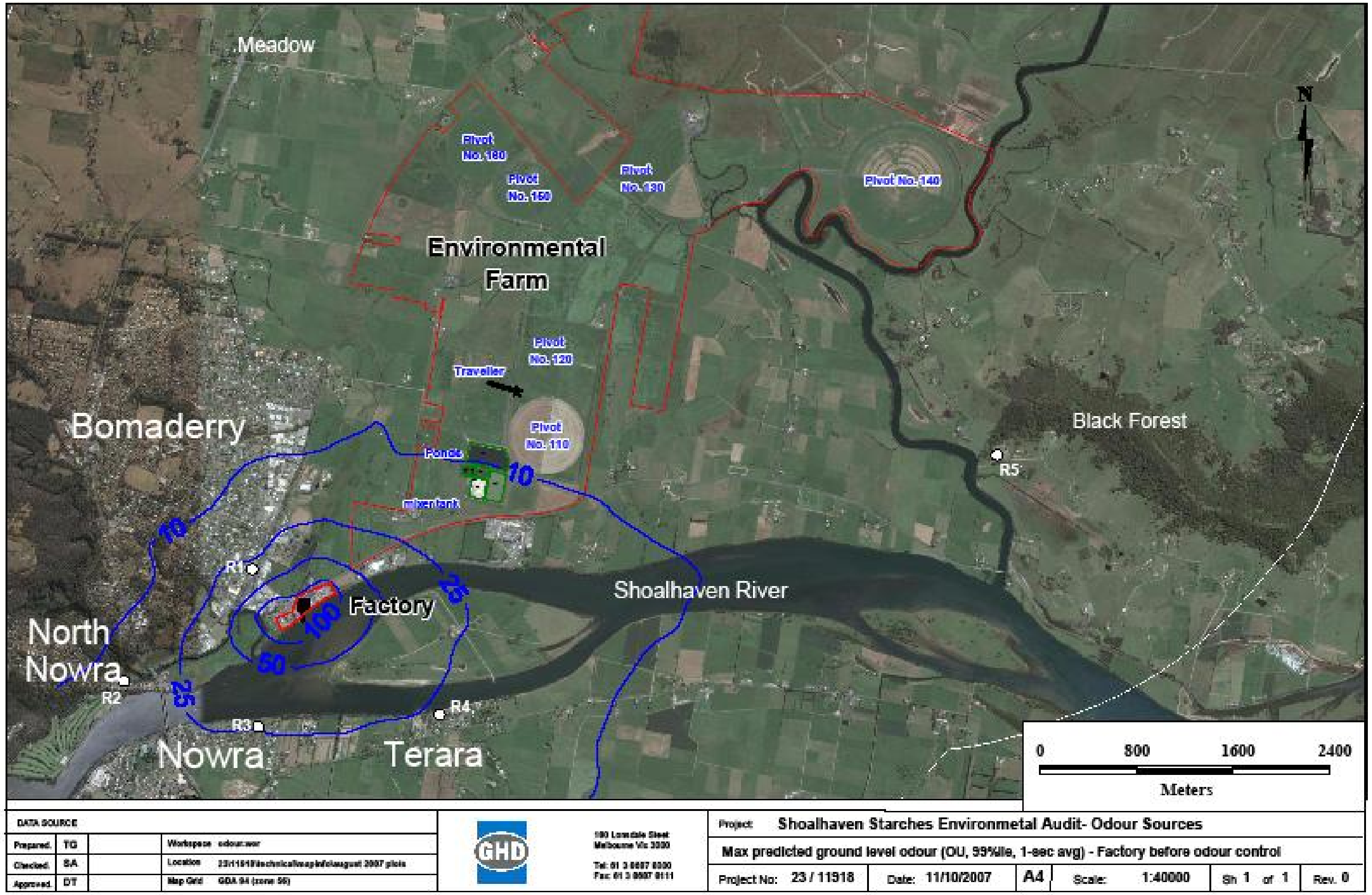


Figure 13 Maximum predicted ground level odour concentration – environmental farm (3 pivots operating) before odour control

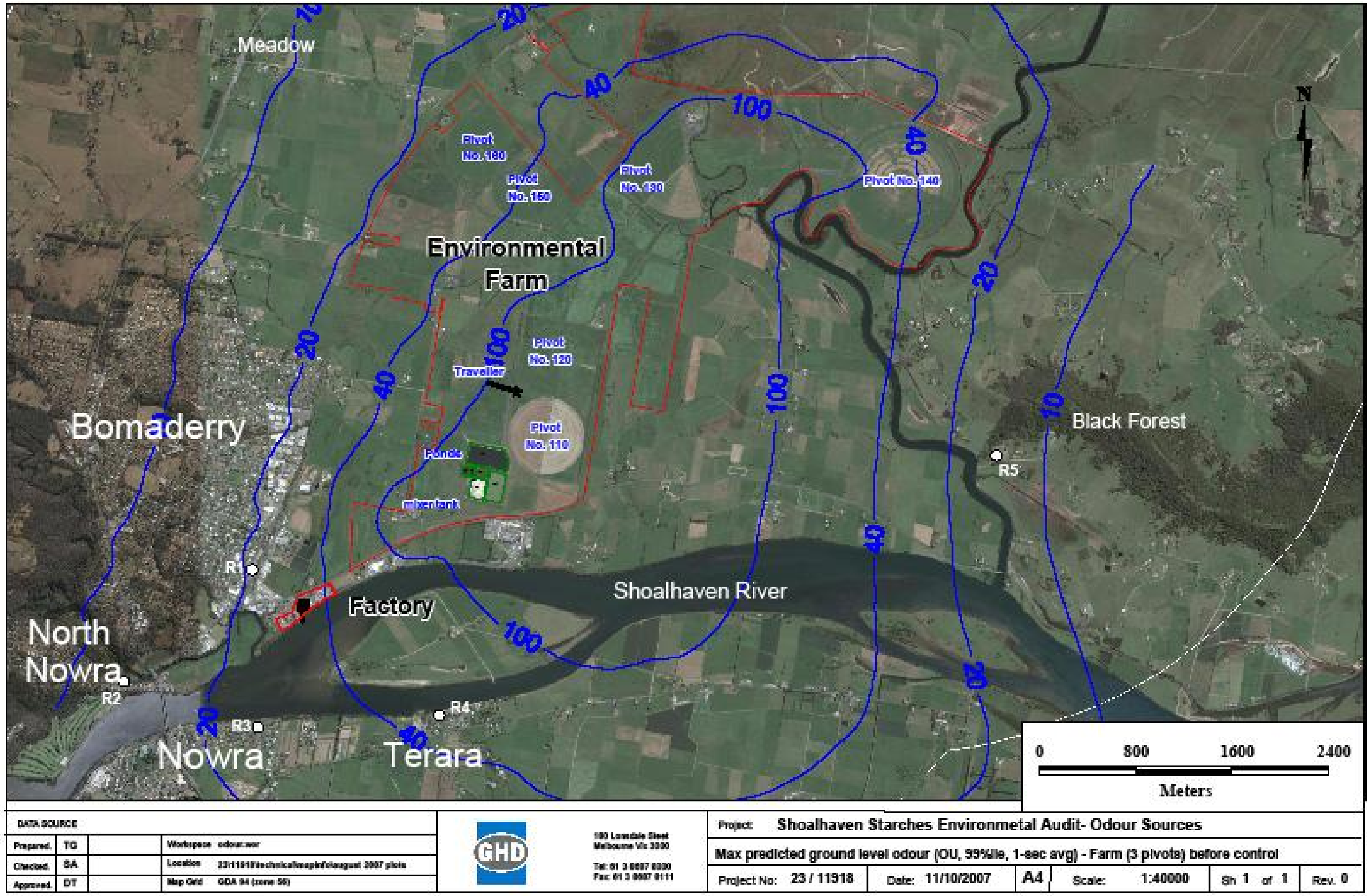


Figure 14 Maximum predicted ground level odour concentration – environmental farm (1 pivot operating) before odour control

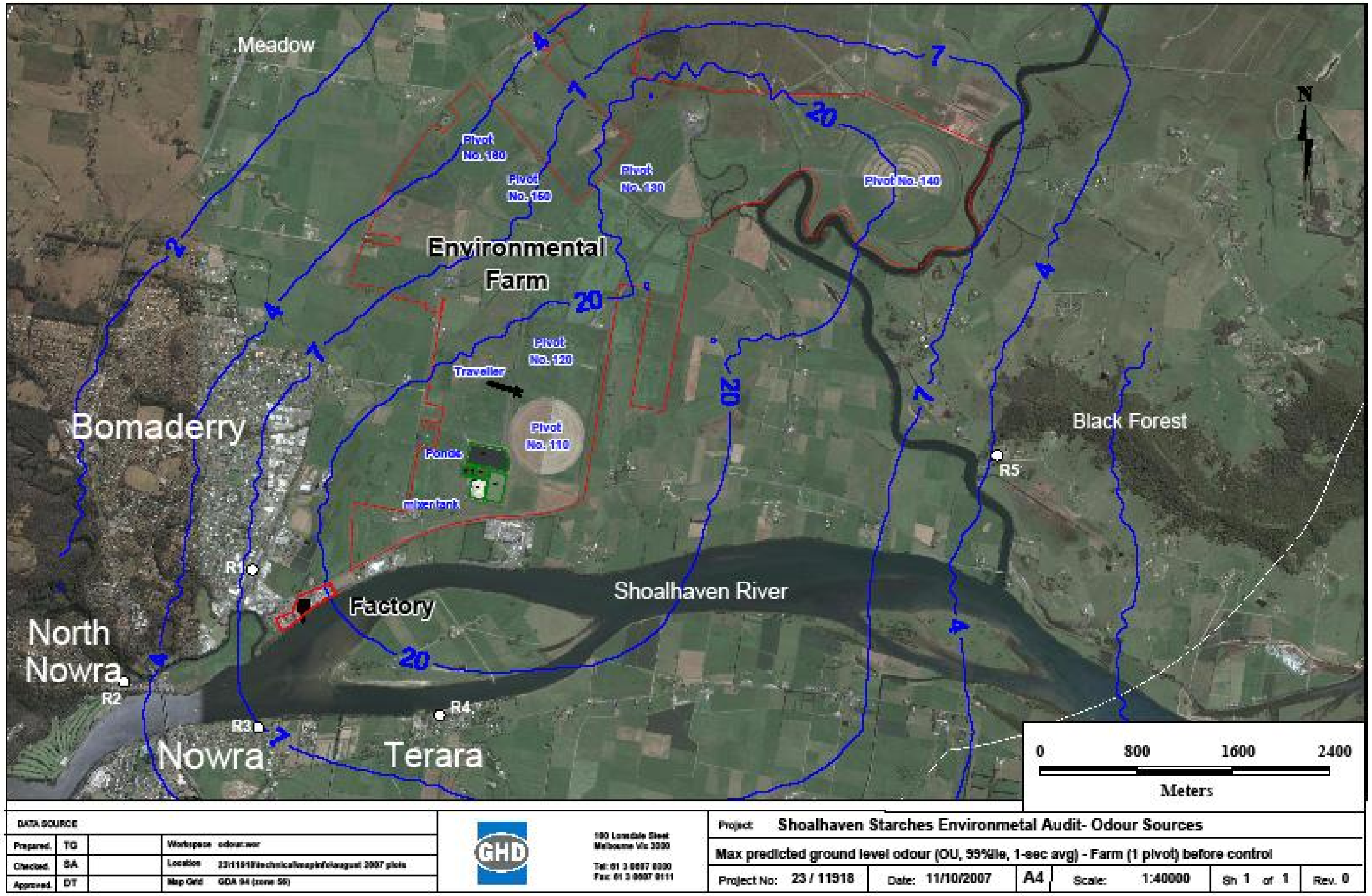
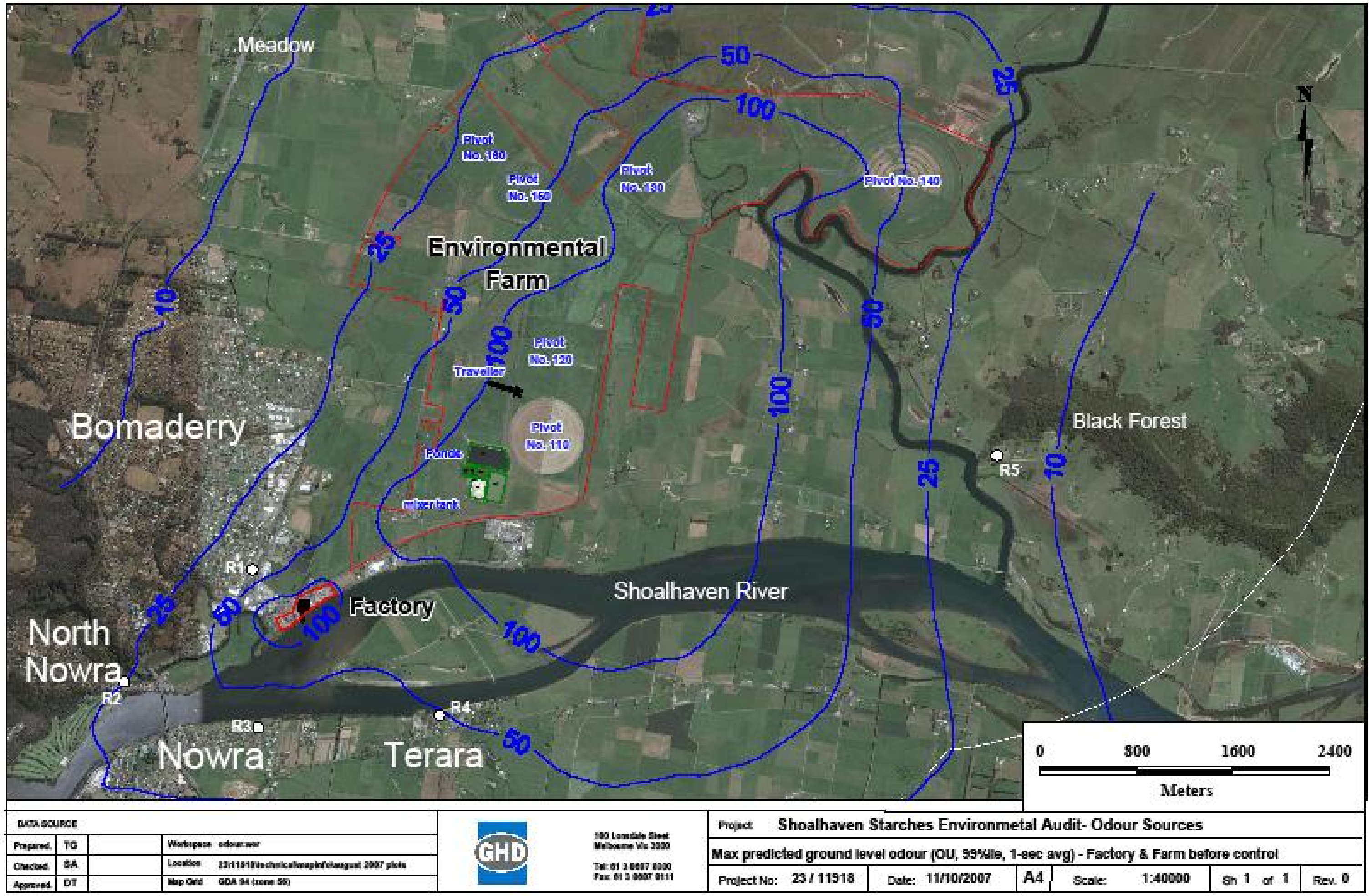


Figure 15 Maximum predicted ground level odour concentration – factory and environmental farm before odour control



9. Odour Prevention

(g) *Identify all available options to prevent the generation of offensive odour for each actual and potential odour source identified at (c).*

Odour prevention measures that may be applied to the potential sources of offensive odours are identified in the following tables. The sources considered below are limited to the 'top fifty' sources of potentially offensive odour (Table 23), which collectively contribute to over 99% of the odour emissions from the factory and the environmental farm, or have been identified as having a 'very unpleasant' hedonic tone.

Prevention of odour emissions from equipment such as baghouses and tank air vents is problematic due to the equipment being designed to discharge high volumes of air. This type of equipment numerically forms the majority of potential sources from Shoalhaven Starches and is reflected in the repetitive nature of the information provided in the following tables.

9.1 Starch plant

Table 28. Potential offensive odour prevention measures for the starch plant

Audit Ref	Equipment	Odour prevention measure
S1	No. 1 Starch dryer	High volume air exhaust cannot be prevented. Odour minimisation measures would be more practicable.
S2	No. 1 Gluten dryer baghouse	As above
S3	No. 3 Gluten dryer baghouse	As above
S4	No. 2 Gluten dryer baghouse	As above
S5	No. 4 Gluten dryer baghouse	As above
S6	Flour bin motor drive	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
S7	Dry gluten roof bin	As above
S8	High protein dust collector	As above
S12	Gran processing pellet silo	As above
S13	Flour bin aspirator	As above
S18	No. 3 Starch dryer scrubber tower	High volume air exhaust cannot be prevented. Odour minimisation measures would be more practicable.
S19	No. 4 Starch dryer scrubber tower	As above
S20	Spray dryer	As above

9.2 Glucose Plant

Table 29. Potential offensive odour prevention measures for the glucose plant

Audit Ref	Equipment	Odour prevention measure
Brewers glucose line		
B3	Flash tanks (2 units)	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
B7	Enzyme tanks	As above
C4	Drum vacuum receiver	As above
C18	Ion exchange effluent tank	As above

9.3 Ethanol Plant

Table 30. Potential offensive odour prevention measures for the ethanol plant

Audit Ref	Equipment	Odour prevention measure
Grain line		
E1	Grain silo -baghouse	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
E7	Jet cooker 2 & 4 grain retention tank	As above
E8, E13	Jet cooker retention tanks 1 & 2	As above
Starch line		
E10	Starch factory rejects collection tank	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
E14, E15	Yeast propagators (5 units)	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
E22	Fermenters	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
E23	Cooling towers	High volume air exhaust cannot be prevented. Odour minimisation measures would be more practicable.

9.4 Distillation Plant

Table 31. Potential offensive odour prevention measures for the distillation plant

Audit Ref	Equipment	Odour prevention measure
D2	Molecular sieve – vacuum drum	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
D6	Stage 3 incondensable gases vent (E538)	As above
D12	DME plant vent	As above.

9.5 DDG Plant

Table 32. Potential offensive odour prevention measures for the DDG plant

Audit Ref	Equipment	Odour prevention measure
Solids line		
DDG1	Decanter feed tank	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG2 & DDG 5	Decanters	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG16	DDG dryer baghouse	High volume air exhaust cannot be prevented. Odour minimisation measures would be more practicable.
DDG18	Feed dryer baghouse	As above
DDG34	DDG product storage shed	Open-fronted building, odour emissions cannot be reasonably prevented. Odour minimisation measures would be more practicable.
DDG36	DDG load out 'tent'	Open-fronted building, odour emissions cannot be reasonably prevented. Odour minimisation measures would be more practicable.
Liquids line		
DDG19	Light phase recover tank	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable

Audit Ref	Equipment	Odour prevention measure
DDG20	Feed dump tanks (2 units)	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG23	Condensate tank	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG24	Vent condenser	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG25	Vent condenser drain	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG26	Finisher feed tank	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG28	Finisher pump tank	As above
DDG30	Dryer feed tank	As above
DDG31	Feed holding tank (syrup)	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG32 & DDG33	CIP tank	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
DDG39	Dryer building	Open-fronted building, odour emissions cannot be reasonably prevented. Odour minimisation measures would be more practicable.
DDG40	Kestner dryer	High volume air exhaust cannot be prevented. Odour minimisation measures would be more practicable.
DDG45	Heat exchanger	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.

Audit Ref	Equipment	Odour prevention measure
DDD46	Cooling towers	High volume air exhaust cannot be prevented. Odour minimisation measures would be more practicable.

9.6 Environmental Farm

Table 33. Potential offensive odour prevention measures for the environmental farm

Audit Ref	Equipment	Odour prevention measure
F1	Mixer tank vent	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.
F2	Pond 1	Install cover or store liquids with a low inherent odour.
F3	Pond 2	Install cover or store liquids with a low inherent odour.
F4	Pond 3	Install cover or store liquids with a low inherent odour.
F5	Pond 4	Install cover or store liquids with a low inherent odour.
F7	Pond 5	Install cover or store liquids with a low inherent odour.
F8	Pond 6	Install cover or store liquids with a low inherent odour.
F9	Pivot irrigator spray (mist nozzle)	Odour emission cannot be prevented using this form of wastewater distribution. Odour minimisation measures would be more practicable.
F11	Traveller irrigator spray	As above.
F12	Pivot irrigated land	As above.
F13	Traveller irrigated land	As above.
F14	Pivot irrigated land	As above.
F15	Pivot irrigated land	As above.
F17	Pivot irrigated land	As above.

F18	Farm tank	Low volume exhaust cannot readily be prevented. Odour minimisation measures would be more practicable.

10. Odour Minimisation

(h) Where at (g) prevention is not possible, identify all available options to minimise the generation of offensive odour for each actual and potential odour source identified at (c).

10.1 Available Odour Control Methods

A range of odour control options is available for treatment of organic odours. These technologies are described in this section, with the potential for application of these to the selected potential sources of offensive odour being identified in section 10.6.

The European Commission publication *Integrated Pollution Prevention and Control - Reference Document on Best Available Techniques in the Food, Drink and Milk Industries* (European Commission, 2006), was used as a reference to identify the most appropriate control technologies for the odours currently experienced at Shoalhaven Starches.

The major classes of odour control technologies covered in this section are:

- dispersion;
- chemical absorption (scrubbing);
- adsorption;
- biological treatment and
- thermal treatment.

In addition to the control technology options listed above, best practice industrial ventilation design and maintenance has been included in this section because it has been identified, from the audit process, as a highly relevant odour minimisation measure for Shoalhaven Starches.

A brief description of each of these classes of odour control technology is provided in the following sections.

10.2 Atmospheric Dispersion

The use of elevated emission points (stacks) can reduce odour concentration at downwind ground level receptors because of atmospheric dispersion (i.e. dilution with ambient air).

The technical framework document for the assessment and management of odour from stationary sources in NSW (DEC, 2006) states that good control practice for any stack should:

» be at high enough to minimise building downwash. The minimum stack height should be calculated with consideration to Good Engineering Practice guidelines for stack heights or based on computer dispersion modelling. As a minimum, the stack height should be at least 3 m above the building ridgeline;

» have a minimum exhaust velocity 15 m/s to avoid stack-tip downwash;

» have a final vertical discharge directed vertically upwards; and

» have a free vertical discharge (i.e. rain caps should not restrict the upward flow).

10.3 Chemical Absorption

Chemical absorption provides removal of odour by the mass transfer of odorous compounds from foul gases using a liquid solvent. Packing or plates are used to facilitate gas-liquid contact and improve mass transfer efficiency. Typical process configurations for packed bed and plate absorbers are illustrated in Figure 16.

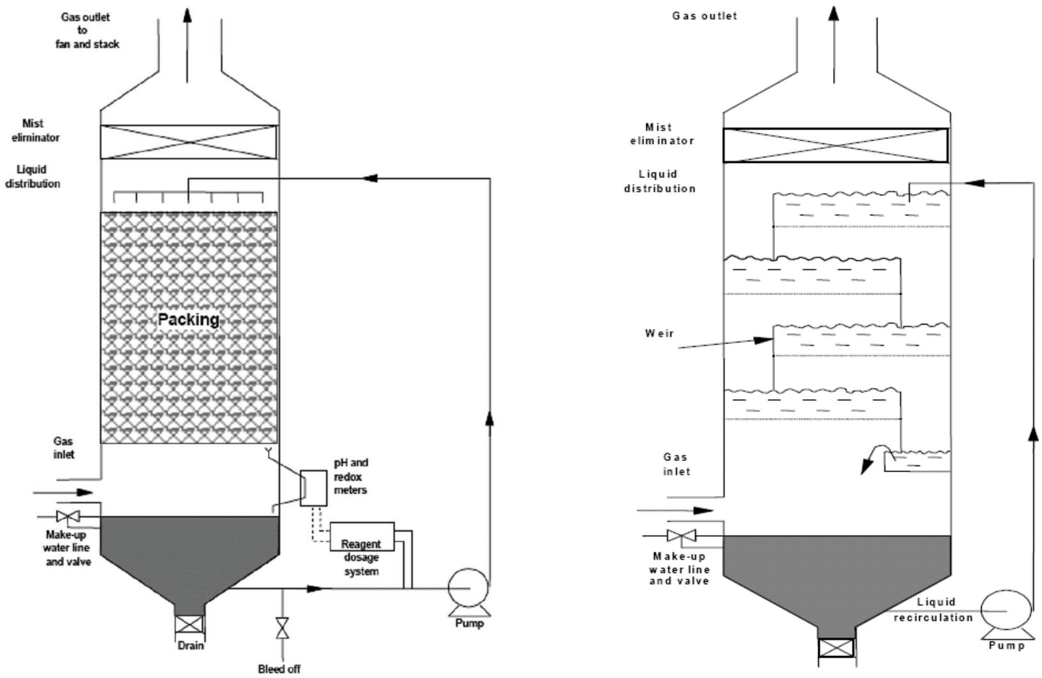


Figure 16 Packed bed and plate absorber

A number of absorbing agents can be used with preference given to those that react with odour producing compounds present in the airstream. Absorbing agents are typically oxidising in nature and include sodium hypochlorite, hydrogen peroxide, ozone and potassium permanganate. Of these, sodium hypochlorite is the most common agent. Acid/alkali solutions are often used as absorbing agents. Water can also be used, however the odour removal performance for water scrubbing systems is poor. Given the wide variety of compounds that can be present in the foul air stream, multistage scrubbing processes are often employed incorporating an alkali and/or acidic stage followed by an oxidising stage.

Chemical absorbers are compact devices with relatively low capital and operational expenses. They are not as temperature sensitive as adsorption or biological processes and can handle a wide range of air flow rates. Such systems, however, are only effective at removing specific compounds such as hydrogen sulfide and ammonia but are not particularly effective at removing volatile organic compounds. In the food industry, overall removal efficiencies of 70-80% are typical.

It should be noted that chemical absorption is suitable only for relatively low odour concentrations and that wastewater is generated in the process.

10.4 Carbon Adsorption

Adsorption is a process by which odorous compounds are removed from the foul air stream by adhering to a particulate surface (adsorbent) with a large surface area. The compounds adhere to the adsorbent either by physical or chemical forces. The most common adsorbent used for odour removal is activated carbon. Once the adsorption capacity of the unit has been reached, the activated carbon medium must be replaced or regenerated. There are three major types of activated carbon adsorbers available and a description of each is presented below in Table 34.

Table 34. Adsorber configuration summary

Adsorber Type	Description
Fixed Bed Unsteady State Adsorber	The contaminated gas passes through a stationary bed of adsorbent
Fluidised Bed Adsorber	The contaminated gas passes through a suspension of adsorbent
Continuous Moving Bed Adsorber	The adsorbent falls by gravity through the rising stream of gas

The process set up for activated carbon adsorption is relatively simple, consisting only of an extraction fan and the adsorption vessel. Activated carbon adsorption typically has a high removal efficiency (80-90%), however, its use is limited to streams with low odour concentration and moisture content.

The use of adsorption is limited to situations where the air flow rates are below 10 000 m^3/hr and the temperature and relative humidity are below 40°C and 75% respectively. Furthermore, dust in the air stream must be avoided as it can greatly reduce the removal efficiency of the adsorber. For acidic gases, the activated carbon is often impregnated with an alkaline material such as sodium hydroxide to provide a longer life of the carbon.

Activated carbon adsorption has relatively low capital costs, however, operational costs are relatively high as the spent carbon beds must be replaced or regenerated.

10.5 Biological Treatment

Biological treatment involves the use of micro-organisms to degrade odorous compounds contained with the foul air stream. The two major types of biological odour control technologies are biofilters and bioscrubbers.

10.5.1 Biofilter

In a biofilter (soil beds, compost filter), foul air is passed through a fixed filter medium consisting of organic material such as wood chips, solid and peat/heather. For acidic gases, lime is used in the bed. Bed depths typically do not exceed 1.5 m.

Micro-organisms colonise the filter medium and degrade odorous compounds as they are absorbed into the filter medium. Dust present in the foul gas must be removed prior to the filter and the foul gas stream must also be humidified. A typical layout of a biofilter system is shown below in Figure 17.

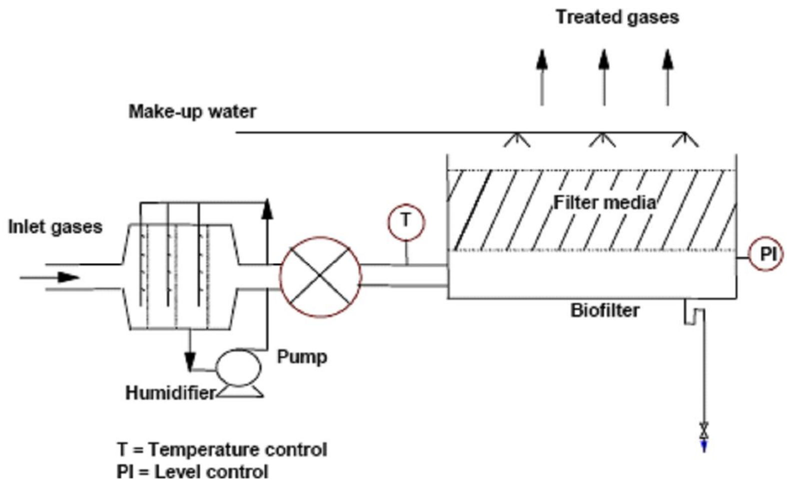


Figure 17 Biofilter process layout

Biofilters have low capital and operating costs and offer the advantage of being able to handle relatively high foul air flow rates (>10 000 m^3/hr), moisture content and odour concentrations. They are also effective in handling peak loads due to high residence times. Biofilters can provide removal efficiencies up to 99.5% (90-95% typical) and are capable of removing a wide range of odorous compounds as the microbial population adapt to the feed stream. The odorous compounds must be biodegradable to be removed.

Given, the biological nature of the treatment process, foul gas temperatures in excess of 40°C are not suitable unless cooling is provided prior to the filter. Biofilters are also not suitable for sites with minimal space available, as the filters have long residence times (approximately two minutes) that result in large land requirements.

10.5.2 Bioscrubbers

A bioscrubber is essentially a packed bed absorber that contains micro-organisms in the packing and sump. The packing must be kept moist to sustain the bacterial population. A typical layout of a bioscrubber system is shown in Figure 18.

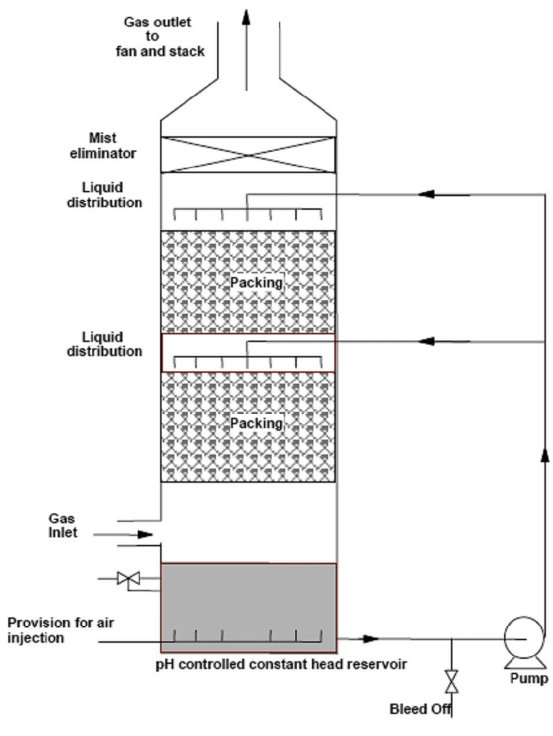


Figure 18 Bioscrubber process layout

Bioscrubbers offer similar advantages and disadvantages to biofilters, however they occupy much less area than biofilters. It should be also noted that bioscrubbers have higher operational costs than biofilters, due to the higher power demand required by the recirculation of liquid. The ability to handle shock loads is not as good as biofilters due to the shorter residence time (approximately 4 seconds). Bioscrubbers have relatively low capital costs and offer the advantage of being able to handle relatively high foul air flow rates (>10 000 m^3/hr), moisture content and odour concentrations. They are also effective in handling peak loads due to high residence.

10.6 Thermal Treatment

Thermal treatment can provide removal of odorous compounds via oxidation at high temperatures (combustion). All organic and some inorganic compounds such as carbon monoxide and ammonia can be oxidised at high temperatures. The composition of the product gas depends on the degree of combustion. Following complete combustion, carbon dioxide and water are formed. However, if incomplete combustion occurs new pollutants such as carbon monoxide and totally or partially unoxidised organic compounds are formed. Furthermore, if elements such as sulfur, nitrogen, halogens or phosphorus are present, the product gas contains pollutants such as oxides of sulphur and nitrogen and hydrogen halides that must be later removed if the concentrations are too high. The viability and effectiveness of thermal treatment is adversely affected by the presence of moisture in foul air streams.

There are three thermal treatment methods:

- thermal oxidation;
- thermal oxidation in an existing boiler; and
- catalytic oxidation.

10.6.1 Thermal oxidation

Thermal oxidation involves combustion of the odorous air in the presence of an external fuel (natural gas, oil or LPG) and air. The incoming odorous air is often preheated using the heat available in the flue gas. A typical thermal oxidiser layout is shown in Figure 19.

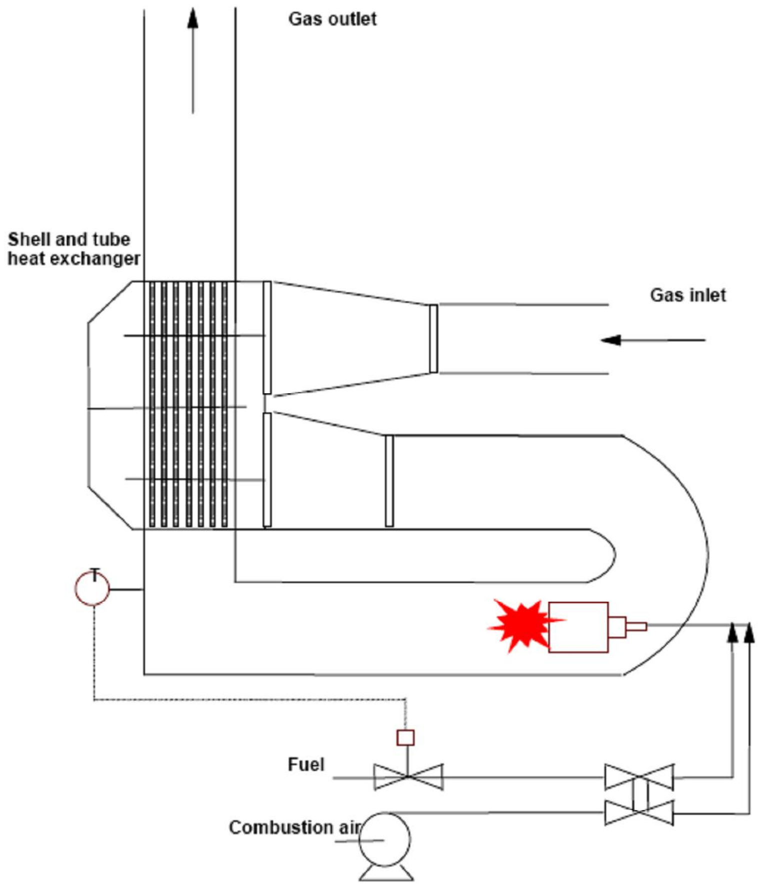


Figure 19 Thermal oxidiser layout

The odour removal performance of thermal oxidation approaches 100%, with an output gas VOC level of <1 – 20 mg/m^3. Depending on the explosion potential of the gas either a direct flame or flameless system is used. The operation temperature for a direct flame system is usually 700-900°C. Thermal oxidation is only suitable for low flows below 10 000 Nm^3/h, requires a high capital investment, a high fuel cost and has high greenhouse gas (carbon dioxide) emissions. This system can handle variations in contaminant concentrations and volumetric flow.

10.6.2 Thermal oxidation in existing boiler

To decrease capital costs of thermal treatment, existing boilers can be utilised to provide thermal oxidation of foul air. This is achieved by ducting the foul air to the combustion airflow fan of the boiler. This system is suitable for low volumes of high concentration foul air. The viability of this method depends on;

- the volume of foul air relative to the boiler combustion air requirements, in which a lower ratio of foul gas is desirable;
- safety factors;
- the operation of the boiler compared to the production of foul air (i.e. the boiler is operating when the foul air is produced); and

» the oxygen content of the foul air.

10.6.3 Catalytic oxidation

Catalytic oxidation is similar to thermal oxidation processes such as that described above, with the main difference being that combustion takes place in the presence of a catalyst rather than free air. The catalyst has the effect of reducing the operational temperature of thermal oxidiser to approximately 250-300°C. An illustration of a typical catalytic oxidation process layout is provided in Figure 20.

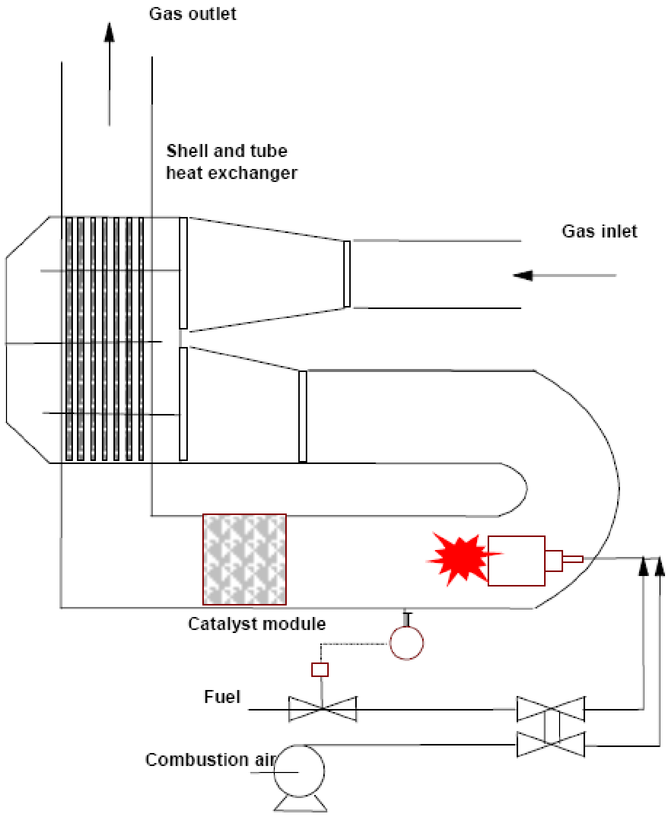


Figure 20 Catalytic oxidation layout

The magnitude of the temperature decrease depends on the amount of catalyst and consequently the corresponding residence time (which is usually 0.03-0.1 s). The lifetime of the catalyst is usually 2 to 5 years (as the catalyst is regenerated by exposure to temperatures of 500°C). The pressure drop across the system is usually 500 mm. Catalytic oxidation can achieve gas VOC levels of <1-20 mg/Nm^3 and CO levels of <100 mg/Nm^3. However, NO_x has been reported to reach approximately 1000 mg/Nm^3.

Catalytic oxidation is appropriate only for low dust concentrations (approximately 50 mg/Nm^3 or below), although it can operate with variable temperatures and odour load. The fuel costs are lower than for a normal thermal oxidation system, however, the catalyst costs GBP 50 000 (approximately $125,000) per cubic metre. The odour removal performance is greater than 95%, which is less than normal thermal oxidation, which can approach 100%.

10.7 Industrial Ventilation

10.7.1 Ductwork

The operational efficiency of the odour control technologies described in the above sections is dependent on the design and maintenance of the industrial ventilation system used to capture and transport the contaminated air to the control equipment. There is added importance in the food industry where putrescent contamination in the ductwork can lead to malodorous emissions, which are either exhausted untreated or unnecessarily add to the odour load on downstream odour control systems.

Good practice ductwork design and maintenance should give consideration to the following:

» Fans and ductwork should be designed to achieve the required air velocity to entrain the emissions (i.e. capture velocity) and move them into and through the ductwork. Capture velocities are dependent on the particular application and emission;

» Horizontal ductwork should be avoided or its run length minimised where practicable;

» Air velocity for transporting particulate matter through ductwork should be high enough that the particles will not settle and plug the ducts. The minimum transport velocity is dependent on the particle size but is typically 18 to 20 m/s;

» Access hatches and ports should be kept closed at all times and system leaks should be repaired;

» Ductwork should be fitted with hose-points or retractable spray nozzles and sufficient drain-points to allow the inside of the ductwork to be cleaned;

» Ductwork should be lined with a suitable liner to inhibit the adherence of materials to the walls of the ductwork (e.g. epoxy liner); and

» Rainwater ingress should be prevented at the duct discharge point (stack–tip) using a method that does not restrict the upward flow of exhaust gases (e.g. butterfly valve).

10.7.2 Cooling Towers

Good practice cooling tower design and maintenance should give consideration to the following:

» protection from potentially contaminating materials;

» regular monitoring of cooling water and replacement of contaminated cooling water; and

» relocation of the tower to a clean, shaded area of the premises where practicable.

10.8 Technology Summary

Key aspects of the different odour control systems (excluding dispersion and industrial ventilation) are summarised in Table 35. Due to the low dust concentration of the gases containing the offensive odours, dust requirements were not included within this summary.

Table 35. Odour control systems summary

System	Flow	Concen-tration	Temper-ature	Humidity	Removal	Relative cost
Chemical Adsorption	Wide range	Low (approx. <100 OU)	<100ºC	Low	70-80%	Low (higher for high water content)
Carbon adsorption	<10 000 m^3/hr	<50 mg/Nm^3	<40ºC	<75% humidity	80-99%	Low capital, high OPEX
Biofilter	Up to and greater than 10 000 m^3/hr	High (max 1000 mg/Nm^3)	<40ºC	>95%	Up to 99.5% (best output 150 OU/m^3)	Low
Bioscrubber	Up to and greater than 10 000 m^3/hr	High (max 1000 mg/Nm^3)	<40ºC	NR	85% to 99.5% (best output 150 OU/m^3)	Low but higher than biofilter
Thermal oxidation	<10 000 Nm^3/h	High	High	Low	Approach 100%	High capital and fuel cost
Thermal oxidation using existing boiler	Boiler dependent	High	High	Low	Approach 100%	Lower capital cost than thermal oxidation
Catalytic oxidation	<10 000 Nm^3/h	High	High	Low	>95%	High (catalyst)

10.9 Selected Sources

Odour minimisation measures that may be used for the selected sources of potentially offensive odour are identified in Tables 36 to 41. Selection of control systems for a particular odour source would be subject to individual assessment at an engineering level. Some of the sources listed below could be linked to a common treatment system to improve capture and treatment efficiency. In some instances, where factors such as close proximity provide an opportunity, sources other than those listed below could be included in the common capture systems.

NB: the sources considered below are limited to the 'top fifty' factory sources of potentially offensive odour and all odour sources at the environmental farm.

10.10 Starch Plant

Table 36. Potential offensive odour minimisation measures for the starch plant

Audit Ref	Equipment	Odour minimisation measures
S1	No.1 Starch dryer	High volume air exhaust cannot be readily treated. Clean ducting to remove built up solids that can become odorous. Modify ducting to provide free vertical discharge to improve dispersion.
S2	No. 1 Gluten dryer baghouse	As above
S3	No. 3 Gluten dryer baghouse	As above
S4	No. 2 Gluten dryer baghouse	As above
S5	No. 4 Gluten dryer baghouse	As above
S6	Flour bin motor drive	Low volume air exhaust cannot be readily treated. Clean ducting to remove built up solids that can become odorous. Modify ducting to provide free vertical discharge to improve dispersion.
S7	Dry gluten roof bin	As S1
S8	High protein dust collector	As S6
S12	Gran processing pellet silo	As S6
S13	Flour bin aspirator	As S6
S18	No. 3 Starch dryer scrubber tower	As S1
S19	No. 4 Starch dryer scrubber tower	As S1
S20	Spray dryer	As S1

10.11 Glucose Plant

Table 37. Potential offensive odour minimisation measures for the glucose plant

Audit Ref	Equipment	Odour minimisation measure
B3	Cooker A and B flash tanks	Capture discharge and direct to chemical absorption, adsorption, biological or thermal treatment.
B7	Enzyme tanks	As above
C4	Drum vacuum receiver	As above
C18	Ion exchange effluent tank	No control recommended due to intermittent discharge and isolation from common control system.

10.12 Ethanol Plant

Table 38. Potential offensive odour prevention measures for the ethanol plant

Audit Ref	Equipment	Odour minimisation measure
E1	Grain silo - baghouse	Capture discharge and direct to chemical absorption, adsorption biological or thermal treatment
E7	Jet cooker 2 & 4 grain retention tank	As E1
E8	Jet cooker retention tank “F7”	As E1
E10	Starch factory rejects collection tank	As E1
E14, E15	Yeast propagators (5 units)	As E1
E22	Fermenters	Capture discharge not already used for carbon dioxide recovery and direct to chemical absorption, adsorption biological or thermal treatment
E23	Cooling towers	Protect from potentially contaminating materials, regularly monitor and replace dirty water. Relocate to a clean area of the premises where practicable.

10.13 Distillation Plant

Table 39. Potential offensive odour minimisation measures for the distillation plant

Audit Ref	Equipment	Odour minimisation measure
D2	Molecular sieve – vacuum drum	Capture discharge and direct to chemical absorption, adsorption, biological or thermal treatment.
D6	Stage 3 incondensable gases vent (E538)	As D2
D12	DME plant vent	No change recommended due to intermittent use and low discharge rate.

10.14 DDG Plant

Table 40. Potential offensive odour minimisation measures for the DDG plant

Audit Ref	Equipment	Odour minimisation measures
DDG1	Decanter feed tank	Capture discharge and direct to chemical absorption, adsorption biological or thermal treatment
DDG2 & DDG5	Decanters Nos. 1 to 4	As DDG1
DDG16	DDG dryer baghouse	As DDG1
DDG18	Feeds dryer baghouse	As DDG1
DDG20	Feed dump tanks (2 units)	Stage 1: Seal and install 'wet-legs'. Stage 2: As DDG1
DDG19	Light phase recover tank	As DDG1.
DDG23	Condensate tank	As DDG1
DDG24	Vent condenser	As DDG1
DDG25	Vent condenser drain	As DDG1
DDG26	Finisher feed tank	Stage 1: Seal and install 'wet-legs'. Stage 2: As DDG1
DDG28	Finisher pump tank	As DDG1
DDG30	Dryer feed tank	As DDG1
DDG31	Feed holding tank (syrup)	As DDG1
DDG33 & DDG32	CIP tank	As DDG1

Audit Ref	Equipment	Odour minimisation measures
DDG34	DDG product storage shed	Pelletise DDG. Fit heavy plastic curtains to openings, place building under slight negative pressure and discharge air via fabric filter baghouse or biofilter.
DDG36	DDG load out 'tent'	As for DDG34.
DDG37	DDG plant grounds	Housekeeping
DDG39	Fugitive emissions from DDG Dryer building	As for DDG34. Install larger exhaust fans on dryers to increase volume of air directed to boilers for thermal oxidation from 10% bleed to 15-20% bleed. Install separate lines to convey air to the boiler from each dryer.
DDG40	Kestner dryer	High volume air exhaust cannot be readily treated. Clean ducting to remove built up solids that can become odorous. Modify ducting to provide free vertical discharge to improve dispersion.
DDG45	Heat exchanger	Capture discharge and direct to chemical absorption, adsorption, biological or thermal treatment.
DDD46	Cooling towers	Protect from potentially contaminating materials, regularly monitor and replace dirty water. Relocate to a clean area of the premises where practicable.

10.15 Environmental Farm

Table 41. Potential offensive odour minimisation measures for the environmental farm

Audit Ref	Equipment	Odour minimisation measures
F1	Mixer tank vent	Stage 1: Repair roof. Vent through a pressure relief valve. Stage 2: Decommission after installation of WWTP.
F2	Pond 1	Reline and convert to aerobic polishing pond.
F3	Pond 2	Reline and convert to aerobic polishing pond.
F4	Pond 3	Use to store treated wastewater

Audit Ref	Equipment	Odour minimisation measures
F5	Pond 4	Repair cover. Modify to covered anaerobic lagoon (CAL). Reduce quantity of solids reaching pond.
F7	Pond 5	Keep pond empty and use to store treated wastewater only.
F8	Pond 6	Keep pond empty and use to store treated wastewater only.
F9	Pivot irrigator spray (mist nozzle)	Stage 1: Fit low mist nozzles to irrigators. Stage 2: Treat wastewater using a wastewater treatment plant and reuse water in production process. Irrigation system required for surplus treated effluent and treatment 'reject' water.
F11	Traveller irrigator spray	Stage 2 (see F9).
F12	Pivot irrigated land	Stage 2 (see F9).
F13	Traveller irrigated land	Stage 2 (see F9).
F14	Pivot irrigated land	Stage 1 and Stage 2 (see F9).
F15	Pivot irrigated land	Stage 1 and Stage 2 (see F9).
F17	Pivot irrigated land	Stage 2 (see F9).
F18	Farm tank (located at factory)	Capture discharge and direct to bioscrubber.

11. Preferred Options for Odour Control

(j) State for each actual and potential odour source identified at (c), the preferred option for the prevention or minimisation of the generation of offensive odour from that source.

Condition 2 of Annexure B to the Land and Environment Court judgement specifies that (in summary) the impacts of each option identified for prevention or minimisation of odour sources be described, quantified and modelled (see section 2 and Appendix A of this report). In order to avoid an inordinate amount of quantification and modelling, the audit process has identified the preferred methods to control approximately 99% of odour emissions and then quantified and modelled the estimated impacts of those methods. Hence, conditions 2(i) and 2(j) of Annexure B have been addressed in reverse order to that specified in the annexure.

11.1 On Farm Odour Control

11.1.1 Current operating regime

Wastewater generated in the plant is currently delivered to the environmental farm for reuse by irrigation of pastures for cropping and grazing. The wastewater can only be irrigated during periods of low rainfall, which is confined to the warmer months of the year (i.e. summer and parts of spring and autumn). Wastewater is stored in lined ponds and accumulated over the cooler months of the year for reuse during the warmer months.

The storage capacity of the pond system is approximately 920 ML. Up to approximately 20 ML of wastewater can be applied to a total of 110 hectares land per day on hot, dry days. Due to these limitations and climatic conditions at Bomaderry (i.e. a significant number of rainy days) the capacity of this management system is limited to receipt of about 4 - 5 ML/day (as a yearly average) from the plant. Odour management on the farm is currently managed by:

» direct irrigation of wastewater where feasible;

» acidification of wastewater to a pH of about 2 using sulfuric acid if the wastewater is to be stored (this minimises biological activity whilst the wastewater is being stored);

» storage of acidified condensate in open ponds;

» storage of acidified solid bearing waste in covered pond No. 4; and

» neutralisation of wastewater with lime prior to irrigation.

As noted in Section 7 of this report, odour generation from the farm is the most significant odour source, with approximately 85% of the emissions coming from this area. Shoalhaven Starches is currently considering options for treating wastewater for recycling into the factory. By recycling, the volume of water requiring irrigation on the farm will be reduced.

Wastewater the factory is delivered to the farm for irrigation through three separate wastewater pipelines that run from the factory to the environmental farm. Sources of wastewater are:

- wash-down (farm tank water);
- starch and gluten plant wash downs and wastewaters;
- glucose plant wastewaters and CIP;
- miscellaneous floor wastes;
- ‘clear’ condensate;
- DDG dryer condensate (termed ‘DDG dryer condensate);
- distillation plant wastewater;
- condensate from the DDG stillage evaporators (termed ‘stillage evaporator condensate’);
- carbon dioxide plant; and
- utilities area - boiler blowdown water.

The characteristics for each stream, determined from historical data, are listed in Table 42.

Wash-down wastewaters are characterised by high solids and COD content (containing residual starch and gluten and glucose). The condensates are characterised by low pH and nutrient content and moderate to high COD (containing residual fermentation and distillation plant products and by-products -alcohols, acids, aldehydes and ketones). These wastewaters are highly amenable to biological degradation (anaerobically or aerobically).

Table 42. Collective wastewater streams design parameters

	Washdown		Distillation plant		Stillage		Condensate		Utilities		CO_2 plant	
	Nominal	Peak	Nominal	Peak	Nominal	Peak	Nominal	Peak	Nominal	Peak	Nominal	Peak
Q, m^3/day	862	1,161	539	693	3,141	3,651	472	593	34	41	25	NA
COD, mg/L	22,730	50,220	5745	11,490	2,832	4,094	7,452	14,967	NA	NA	727	1,023
COD sol, mg/L	16,006	38,872	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOD, mg/L	6,243	12,486	NA	NA	1,737	2,330	3,951	6,810	NA	NA	452	720
%TS	2.8	4.5	NA	NA	NA	NA	0.8	1.7	NA	NA	NA	NA
%SS	0.6	1.4	NA	NA	NA	NA	0.1	0.3	NA	NA	NA	NA
Temp, ºC	NA	NA	NA	NA	45	60	35	NA	NA	NA	NA	NA
pH	5.7	2.9	NA	NA	3.2	2.8	8.6	6.7	NA	NA	5.0	4.6
TP, mg/L	21.5	365.7	NA	NA	1.4	0.2	26.8	56.0	NA	NA	NA	NA
TKN, mg/L	98.0	995.0	NA	NA	3.9	0.8	37.4	140.0	NA	NA	NA	NA
FOG, * mg/L	NA	NA	NA	NA	45	130	150	NA	NA	NA	NA	NA

* Fats, oils and greases.

A report from Food Science Australia (2007) indicated that the main volatile (and therefore potentially odorous) compounds in the condensate waters are:

- furfural;
- phenyl ethyl alcohol;

- acetic acid; and
- 2-furanone.

There are also significant concentrations of ethanol (which acts as a carrier for odours) and acetic and lactic acid. There are other compounds present, which are regarded as 'minor compounds'.

11.1.2 Overall treatment strategy

A description of the chemical properties of these major volatile components, with a summary of the proposed treatment strategy provided in Table 43.

Table 43. Volatile odorous compounds with proposed treatment strategy

Volatile compound	Description	Strategy
Furfural	» Soluble in organic solvents e.g. alcohols. » With heat and acid will solidify. » Readily biodegradable. » Almond-like odour.	Raise pH to near neutral and cool the wastewater in the biological process to prevent solidification. Bacteria will metabolise these compounds in the selector zone.
Phenyl ethyl alcohol	» Phenyl group is aromatic. » Readily biodegradable.	Bacteria will readily metabolise these compounds in the selector zone.
Acetic acid	» Forms an equilibrium in solution. » Readily biodegradable.	Raising the pH to above 7 will make this compound non-volatile. Bacteria will readily metabolise this compound in the selector zone.
2-furanone	» Biodegradable.	Bacteria will readily metabolise these compounds in the selector zone.

The pH will need to be near neutral prior to the biological process and this will correspondingly assist to reduce odour from acetic acid and possible solidification of furfural. The selector zone will allow for bacteria to uptake and metabolise the majority of the volatile compounds that are all biodegradable. In this way, odour should be contained quite effectively.

One of the sources of odour was suggested to be the fats, oils and greases (FOG). The chemical composition of FOG has not been analysed by Shoalhaven Starches.

11.1.3 Short term strategy

To reduce the amount of wastewater transferred to the environmental farm, Shoalhaven Starches has been investigating methods of treating condensate streams to allow recovery of water. This has focused on recovery of water from the stillage stream, which is the largest flow and has the lowest strength of the condensate streams. Methods investigated included:

» anaerobic followed by aerobic treatment with filtration and reverse osmosis;

» direct aerobic treatment with filtration and reverse osmosis;

» direct aerobic treatment with filtration and advanced oxidation using ultraviolet light and hydrogen peroxide; and

» oil and grease removal, pH adjustment and direct treatment with reverse osmosis followed by activated carbon.

The first three options are proven in this type of application but the fourth is unproven at pilot or full scale. Shoalhaven Starches is currently running bench scale tests and a pilot plant with 3 000 L/h capacity, testing the direct reverse osmosis option. The aim is to have a full-scale system in operation, recycling about 3 ML/d. The major concern with this option is the recovery of the system and the life of the membranes.

Shoalhaven Starches should also consider methods to reduce the amount of waste going to the farm tank. Where possible, fermentable materials should be directed to the fermentation system to reduce the load on this stream. This has been done in the past with limited success due to interference from other microbiological agents in the wastewater effecting fermentation.

11.1.4 Long term strategy overview

The long-term strategy considered most optimal for the wastewater characteristics shown in Table 41 is to:

1. Maximise transfer of wastewaters to evaporation plant to recover dissolved solids as syrup (i.e. increase stillage wastewater flow but decrease other flows).
2. Maximise recovery of solids for fermentation.
3. Anaerobic treatment of high strength wastewaters (> 1,000 mg/L COD).
4. Polish COD removal with an aerobic process.
5. Filter and desalinate with reverse osmosis for reuse in the plant.
6. Recycle biological solids to the DDG.

The proposed wastewater treatment plant could involve a combination of high rate anaerobic treatment (HRAT) at the factory of clean condensates or treatment at the farm in a covered anaerobic lagoon (CAL) with a recycle system. The aerobic process could be achieved using modified pond systems at the farm. This would significantly reduce the generation of odours from the ponds. Reuse of treated wastewater in the plant would significantly reduce the need for land irrigation and the odour emissions associated with the irrigation processes at the farm. Approximately 1 to 3 ML/day of wastewater would need to be managed at the environmental farm after implementing the long-term strategy described above.

11.2 Factory Odour Control

Odour minimisation measures that may be used for the principal sources of potentially offensive odour are identified in Tables 36 to 40.

Given that the identified sources would be linked to a common treatment system based on factors such as proximity or source characteristics, the principal sources identified in Tables 36 to 40 have been grouped into the following odour control groups:

» DDG plant – solids line;
» DDG plant – liquids line;
» DDG plant – product handling;
» DDG plant – dryer building (fugitive);
» Starch plant – starch and gluten dryers;
» Ethanol plant;
» Glucose plant; and
» Distillation plant.

The following sections provides a preliminary analysis of potential odour control processes based on the results of the odour audit and from the findings of the technology summary provided in Section 10.

11.2.1 DDG plant – solids line

The DDG (solids line) plant produces the highest quantity of foul air, however, the odour concentration of these streams is much less than in streams from the other DDG plant process (i.e. liquids line). A summary of the emissions from the contributing units in the DDG (solids line) plant is provided in Table 44.

Table 44. DDG odour emission summary

Discharge plant	Audit ref	Normal flow rate (Nm^3/min)	Odour concentration (OU)	Temperature (^oC)	Total odour rate (OU m^3/s)
Decanter feed tank	DDG1	0.5	31,000	63	220
Decanters 1 + 2	DDG2	0.6	14,000	56	260
Decanters 3 + 4	DDG5	3.4	15,000	74	1,700
Paddle mixer	DDG7	-	19,000	-	-
DDG dryer baghouse (palmer cooler)	DDG16	300	1,700	62	8,800
Mill feed silo exhaust	DDG17	45.0	380	35	280
Light phase recovery tank	DDG19	1.2	23,000	89	450
DDG heat exchanger	DDG45	4.1	34,000	36	2,300

Discharge plant	Audit ref	Normal flow rate (Nm^3/min)	Odour concentration (OU)	Temperature (^oC)	Total odour rate (OU m^3/s)
Total/average		310	19,000 (ave)	63 (ave)	11,830

Due to the high flow rate of foul gas (approximately 19 000 Nm^3/h) thermal oxidation and activated carbon adsorption would not be suitable. Incineration of the foul air in the existing boilers may be viable given the close proximity of the boilers to the DDG plant, however, the high moisture content in the foul air stream may affect the cost-effectiveness of this option.

Chemical absorption is not likely to be viable, given the high VOC concentration in the foul air.

Biological treatment is likely to be suitable for the high flow rate and odour concentration of foul gas from the DDG plant. Biological treatment would not be feasible, however, unless the foul gas is cooled to below 40°C prior to treatment. A water scrubber is suitable for this purpose and would also provide the additional benefit of humidifying and removing any particulates contained in the foul air. A biofilter would require an area in the order of 600 m^2 (assuming a residence time of 2 min, 50% fill and bed height of 1.3 m). Due to space constraints, a bioscrubber would be preferred.

For the reasons given above, biological treatment, in particular a bioscrubber, is the preferred option for odour control at the DDG (solids line) plant.

It is anticipated that the implementation of this type of odour control would achieve an odour removal efficiency of greater than 85%.

11.2.2 DDG plant – liquid line

The DDG (liquid line) evaporator plant produces a small quantity of gas with a high odour concentration with a high proportion of emissions with a very unpleasant hedonic tone relative to the other factory sources. A summary of the emissions from the contributing units in the evaporator facility is provided in Table 45.

Table 45. DDG plant (liquids line) evaporator odour emission summary

Discharge plant	Audit ref	Normal flow rate (Nm^3/min)	Odour concentration (OU)	Temperature (ºC)	Total odour rate (OU m^3/s)
Feeds dryer 3 baghouse	DDG18	48.0	1,100	47	870
Feed dump	DDG20	3.9	136,500	86.5	8,900
Condensate	DDG23	5.1	240,000	85	20,000
Vent condenser	DDG24	0.7	300,000	17	3,500

Discharge plant	Audit ref	Normal flow rate (Nm^3/min)	Odour concentration (OU)	Temperature (°C)	Total odour rate (OU m^3/s)
Vent condenser drain	DDG25	1.6	120,000	27	3,200
Finish feed	DDG26	5.5	200,000	91	18,300
Finisher pump tank	DDG28	0.8	110,000	96	1,400
Dryer feed tank	DDG30	0.8	110,000	96	1,400
Syrup holding tank	DDG31	2.1	38,000	56	1,300
Clean in place (CIP) tank - fresh caustic	DDG32	0.8	32,000	73	400
Total/average		69.3	117,055	61	60,000

Due to the relatively low flow rate of approximately 4 200 Nm^3/h, thermal oxidation may be possible. The existing boiler is not as close to the evaporators as to the other plants and consequently incineration using the existing boiler may be less viable.

Activated carbon adsorption without pre-treatment would not be appropriate due to the high odour concentration and moisture content of the foul air. Ventilation of these emissions back into the evaporator circuit via a floating variable volume vessel may, however, be viable.

Chemical absorption is not likely to be viable, given the high VOC concentration in the foul air.

Biological treatment would be suitable for the flow rate and odour concentration of odorous gas from the evaporator plant. However, the foul gas would require cooling to below 40°C prior to treatment. A water scrubber is suitable for this purpose and would also provide the additional benefit of humidifying and removing any particulates contained in the foul air. Due to the low flow rate the land area required for a biofilter would be approximately 125 m^2 (assuming a residence time of 2 minutes, 50% fill and bed height of 1.3 m). Due to space constraints, a bioscrubber would be preferred.

For the reasons given above, biological treatment, in particular a bioscrubber, fitted with an activated carbon filter is the preferred option for odour control.

It is anticipated that the implementation of this type of odour control would achieve an odour removal efficiency of greater than 95%.

11.2.3 DDG Plant – Product handling

Shoalhaven Starches plans to install a pelletiser plant to pelletise existing granular DDG produced at the site. The pelletiser plant would consist of:

» a pellet mill, housed in an extension to an existing structure. The pellet mill machinery would include two discharges to atmosphere (through baghouses) each with a discharge rate of 534 m^3/min;

» an internal mill conveyor under negative pressure and vented through a baghouse at a discharge rate of 12 m^3/min;

» an enclosed product conveyor to transport the pelletised DDG from the pellet mill to the existing DDG storage facility; and

» a pellet out-load system, which would be aspirated through a baghouse with a nominal discharge rate of 20 m^3/min.

It is anticipated that the implementation of this type of odour control would achieve an odour removal efficiency of greater than 85%.

11.2.4 DDG plant – Dryer building

Reducing odours emitted by the DDG dryer building could be more readily achieved by minimising fugitive emissions inside the building by installing larger exhaust fans on the dryers to increase the volume of air directed to the boilers for thermal oxidation from the existing 10% bleed to 15-20% bleed. Separate lines could also be installed to convey the air to the boiler from each dryer. These measures would assist in keeping the dryers under negative pressure and would prevent or otherwise minimise the dryers ‘puffing’ odours into the building.

It is anticipated that the implementation of this type of odour control would achieve an odour removal efficiency of greater than 50%.

11.2.5 Starch plant

The starch plant produces a high volume of foul air when compared to the other plants. A summary of the emissions from the starch and gluten dryers is provided in Table 46.

Table 46. Starch Plant –odour emission summary

Discharge plant	Audit Ref	Normal flow rate (Nm^3/min)	Odour concentration (OU)	Temperature (^oC)	Total odour rate (OU m^3/s)
No.1 Starch dryer	S1	520	380	45	3,200
No. 1 Gluten dryer baghouse	S2	940	3,300	74	38,000
No. 3 Gluten dryer baghouse	S3	1,700	2,500	67	73,000

Discharge plant	Audit Ref	Normal flow rate (Nm³/min)	Odour concentration (OU)	Temperature (°C)	Total odour rate (OU m³/s)
No. 2 Gluten dryer baghouse	S4	740	1,400	55	18,000
No. 4 Gluten dryer baghouse	S5	1,800	5,000	77	150,000
Flour bin motor drive	S6	54	320	34	280
Dry gluten roof bin	S7	250	1,100	55	4,500
High protein dust collector	S8	73	490	43	600
Gran processing pellet silo	S12	110	190	31	350
Flour bin aspirator	S13	160	190	33	1,000
No. 3 Starch dryer scrubber tower	S18	1,400	230	45	5,500
No. 4 Starch dryer scrubber tower	S19	1,300	470	46	10,000
Spray dryer	S20	480	120	62	980
Total/average		9,527	1,121 (ave)	48 (ave)	305,410

Due to the high flow rate of foul gas thermal oxidation, chemical absorption and activated carbon adsorption would not be suitable.

Biological treatment is likely to be suitable for the high flow rate and odour concentration of foul gas from the starch plant. However, biological treatment would not be feasible unless the foul gas is cooled to below 40°C prior to treatment.

A biofilter would require an area in the order of 29 310 m^2 (assuming a residence time of 2 minutes, 50% fill and bed height of 1.3 m). Due to this inordinately large area requirement, a biofilter would not be feasible.

The existing ductwork and discharge points that service the odour sources listed in Table 46 have the following features in common:

» extensive runs of horizontal ductwork with air velocities below 18 m/s, which has led to particles settling-out;

» visible build-up of putrescible material and organic growth along the inside walls of the ductwork and at the exhaust aperture;

» absence of hose-points and drain-points to facilitate duct cleaning;

» short stacks that are not high enough to avoid building downwash; and

» final exhaust discharge directed horizontally rather than vertically.

For the reasons given above, duct maintenance coupled with improved dispersion is the preferred option for odour control at the starch plant at this stage.

It is certain what degree of odour emission reduction can be achieved through the cleaning and maintenance of the starch plant ductwork. It is recommended that trials be conducted to ascertain reduction efficiencies that can be achieved. Although improved dispersion will not reduce the mass odour emission rate from each source, it will reduce the odour impact at ground level.

11.2.6 Glucose and distillation plants

There are only a few principal odour sources are associated with the glucose (B3, B7 & C4) and distillation (D2 & D6) plants. Given the relatively low odour emissions from the these sources and their close proximity to the ethanol plant, the principal odour sources from these two plants have been include with the odour control for the ethanol plant (refer to following section).

11.2.7 Ethanol plant

The ethanol plant produces a mid range odour load and quantity of foul gas when compared to the other plants. A summary of the emissions from the contributing units in the ethanol plant is provided in Table 47.

Table 47. Ethanol plant odour emission summary

Discharge plant	Audit Ref	Normal flow rate (Nm^3/min)	Odour concentration (OU)	Temperature (^oC)	Total odour rate (OU m^3/s)
Brewers cooker A & B flash tanks	B3	6.1	9,400	100	950
Brewer enzyme tanks	B7	2.8	12,000	54	4,100
Drum vacuum receiver	C4	33	6,500	41	3,500
Vacuum drum	D2	3.1	26,000	64	1,350
Incondensable gases vent	D6	1.2	21,000	36	400
Grain silo baghouse	E1	37.0	310	31	183
Jet cooker 2 + 4 - grain retention	E7	3.8	18,000	100	1,100
Grain retention - tank 2 (fermenter no. 7)	E8	25.0	16,000	87	6,500

Discharge plant	Audit Ref	Normal flow rate (Nm^3/min)	Odour concentration (OU)	Temperature (^oC)	Total odour rate (OU m^3/s)
Starch factory rejects collection tank	E10	0.5	23,000	35	180
Jet cooker retention tank	E13	3.7	17,000	89	1,100
Yeast propagator	E14	5.5	21,000	33	5,500
Yeast propagator	E15	32.0	27,000	29	28,000
Feed transfer to distillation plant	E22	1.7	6,100	27	170
Farm tank	F18	15	30,000	28	7,700
Total/average		170.4	15,554 (ave)	50 (ave)	60,733

Due to the relatively low foul gas flow rate of approximately 10 200 Nm^3/h, thermal oxidation may be viable. However, this would involve a high capital and operating cost.

Catalytic oxidation may be considered to defray fuel costs, however, this would be offset by high catalyst costs and reduced odour removal. To lower capital costs, incinerating the foul air in the existing boilers may be viable given the close proximity of the boilers to the ethanol plant, however, the high moisture content in the foul air stream would affect the cost effectiveness of this option.

Chemical absorption would not be suitable, given the high VOC concentration in the foul air.

Carbon adsorption would be also unlikely to be appropriate as the concentration of contaminants is anticipated to be greater than 50 mg/Nm^3.

Biological treatment would be suitable for the flow rate and odour concentration of foul gas from the ethanol plant. However, the foul gas would require cooling to below 40°C prior to treatment. A water scrubber is suitable for this purpose and would also provide the additional benefit of humidifying and removing any particulates contained in the foul air. Due to the low flow rate of foul gas, the land area required for a biofilter would be approximately of 200 m^2 (assuming a residence time of 2 minutes, 50% fill and height of 1.3 m). A bioscrubber would be preferred due to space constraints.

For the reasons given above, biological treatment, in particular a bioscrubber, is the preferred option for odour control for the ethanol plant.

It is anticipated that the implementation of this type of odour control would achieve an odour removal efficiency of greater than 85%.

11.3 Summary of Recommended Actions for Odour Control

From the preliminary odour control selection the biological treatment and thermal treatment options should be further investigated. Of the thermal treatment options available, incineration of foul gas in the existing boilers is likely to represent the most cost effective option, due to the lower capital investment. It is important to consider the moisture content contained in the foul air when evaluating the suitability of incineration, as a high moisture content would adversely affect the costs of this option.

Biological treatment appears to be the most favourable option for the DDG (liquids and solids line) and ethanol plants, as this treatment option attracts relatively low capital and operational costs and is capable of effectively treating high flows and loads. Where space constraints are not limiting, a biofilter is favoured, as it can handle shock loads better than bioscrubbers. Air treated using a biological treatment system would be discharged to atmosphere. Blowdown from the bioscrubber could be plumbed to the evaporators, DDG plant or wastewater, depending on the location of the unit.

12. Impacts of Implementing Odour Control Options Selected for Modelling

(i) Describe, quantify and model the likely environmental impacts of implementing each option identified at (g) and (h).

12.1 Projected Odour Emissions Following Implementation of Odour Control Options Selected for Modelling

Specific odour control options identified in section 10 have been assessed during odour emission modelling to determine the impact of implementing those odour control measures. Note that the options selected for modelling might not represent the measure that will be ultimately implemented by Shoalhaven Starches. As allowed for in the recommendations made (section 14.2), analysis of various odour control options may identify other control measures that are at least as efficacious as those modelled.

Projected odour emissions that would occur following implementation of selected odour control measures are summarised in Tables 48 and 49.

Table 48. Projected factory odour emissions before and after implementation of odour control options selected for modelling †

Rank	Audit ref	Discharge plant	Existing (OU m^3/s)	Summary of odour control options selected for modelling (refer to Section 9, 10 and 11 for more detail)	Projected OER (OU m^3/s)
1	S5	No. 4 gluten dryer baghouse	150,000	Clean ducting and improve dispersion	150,000
2	S3	No. 3 gluten dryer baghouse	73,300	Clean ducting and improve dispersion	73,300
3	DDG39	Dryer building exit	70,500*	Increase volume of foul air directed to boilers for destruction	35,250
4	DDG46	Cooling towers	68,300	Protect from contamination, monitor and relocate to clean area (i)	Nil
5	E23	Cooling towers	65,800	As above	Nil
6	S2	No. 1 gluten dryer baghouse	38,300	Clean ducting and improve dispersion	38,300
7	E15	Yeast propagators (tanks 4 and 5)	28,300	Capture discharge and duct to bioscrubber located at ethanol plant	4,250

Rank	Audit ref	Discharge plant	Existing (OU m^3/s)	Summary of odour control options selected for modelling (refer to Section 9, 10 and 11 for more detail)	Projected OER (OU m^3/s)
8	DDG23	Condensate tank	20,000 *	Capture discharge and duct to bioscrubber with activated carbon filter located at DDG evaporator plant	1,000
9	DDG26	Finisher feed tank	18,300*	As above	920
10	S4	No. 2 Gluten dryer baghouse	18,300	Clean ducting and improve dispersion	18,300
11	DDG36	DDG load out 'tent'	12,900	Pelletise DDG and capture fugitive emissions for discharge via baghouse (ii)	1,900
12	S19	No. 4 starch dryer scrubber tower	10,200	Clean ducting and improve dispersion	10,200
13	DDG20	Feed dump tanks (2 units)	8,900	Capture discharge and duct to bioscrubber with activated carbon filter located at DDG evaporator plant	450
14	DDG16	DDG Palmer cooler baghouse	8,900	Capture discharge and duct to bioscrubber located at DDG dryer plant	1,300
15	F18	Farm tank	7,700	Capture discharge and duct to bioscrubber located at ethanol plant	1,150
16	DDG34	DDG product storage shed	6,800	Pelletise DDG and capture fugitive emissions for discharge via baghouse (ii)	1,000
17	E8	Jet cooker retention tank "F7"	6,500	Capture discharge and duct to bioscrubber located at ethanol plant	980
18	E14	Yeast propagators (tanks 1,2 & 3)	5,500*	As above	825
19	S18	No. 3 Starch Dryer	5,500	Clean ducting and improve dispersion	5,500
20	S7	Dry gluten roof bin	4,500*	Clean ducting and improve dispersion	4,500

Rank	Audit ref	Discharge plant	Existing (OU m^3/s)	Summary of odour control options selected for modelling (refer to Section 9, 10 and 11 for more detail)	Projected OER (OU m^3/s)
21	B7	Enzyme tanks	4,100	Capture discharge and duct to bioscrubber located at ethanol plant	610
22	DDG24	Vent condenser	3,500*	Capture discharge and duct to bioscrubber with activated carbon filter located at DDG evaporator plant	175
23	C4	Drum vacuum receiver	3,500	Capture discharge and duct to bioscrubber located at ethanol plant	525
24	DDG25	Vent condenser drain	3,200	Capture discharge and duct to bioscrubber with activated carbon filter located at DDG evaporator plant	160
25	S1	No. 1 Starch dryer	3,200	Clean ducting and improve dispersion	3,200
26	DDG40	Kestner dryer exhaust	3,000	Clean ducting and improve dispersion	3,000
27	DDG45	DDG heat exchanger	2,300	Capture discharge and duct to bioscrubber located at DDG dryer plant	350
28	DDG5	Decanters Nos. 3 and 4	1,700	As above	260
29	DDG30	Dryer feed tank	1,400	Capture discharge and duct to bioscrubber with activated carbon filter located at DDG evaporator plant	72
30	DDG28	Finisher pump tank	1,400	As above	72
31	D2	Molecular sieve – vacuum drum	1,350	Capture discharge and duct to bioscrubber located at ethanol plant	200
32	DDG31	Feed holding tank (syrup)	1,300*	Capture discharge and duct to bioscrubber with activated carbon filter located at DDG evaporator plant	66
33	E7	Jet cooker 2 & 4 – grain retention	1,100*	Capture discharge and duct to bioscrubber located at ethanol plant	170

Rank	Audit ref	Discharge plant	Existing (OU m^3/s)	Summary of odour control options selected for modelling (refer to Section 9, 10 and 11 for more detail)	Projected OER (OU m^3/s)
34	E13	Jet cooker 1-retention tank	1,100	As above	160
35	S13	Flour bin aspirator	1,000	Clean ducting and improve dispersion	1,000
36	S20	Spray dryer	980	As above	980
37	B3	Cooker A & B flash tanks	950*	Capture discharge and duct to bioscrubber located at ethanol plant	140
38	DDG18	Feeds dryer baghouse	870	Capture discharge and duct to bioscrubber with activated carbon filter located at DDG evaporator plant	43
39	S8	High protein dust collector	600	Clean duct work	600
40	DDG19	Light phase recover tank	450	Capture discharge and duct to bioscrubber located at DDG dryer plant	68
41	DDG32	CIP tank	420	Capture discharge and duct to bioscrubber with activated carbon filter located at DDG evaporator plant	21
42	D6	Incondensible vent	400	As above	60
43	S12	Pellet silo	350	Clean ductwork	350
44	S6	Flour bin motor drive	280	As above	280
45	DDG2	Decanters Nos.1 & 2	260	Capture discharge and duct to bioscrubber located at DDG dryer plant	39
46	C18	Ion exchange effluent tank	250	No further control recommended	250
47	DDG1	Decanter feed tank	220	Capture discharge and duct to bioscrubber located at DDG dryer plant	33
48	DDG37	DDG plant grounds	200	Clean area and maintain adequate housekeeping	Nil

Rank	Audit ref	Discharge plant	Existing (OU m^3/s)	Summary of odour control options selected for modelling (refer to Section 9, 10 and 11 for more detail)	Projected OER (OU m^3/s)
49	E10	Starch factory rejects collection tank	180	Capture discharge and duct to bioscrubber located at ethanol plant	28
50	E1	Grain silo baghouse	180	As above	28
*	E22	Feed transfer to distillation plant	170*	As above	25
*	D12	DME vent	110*	No further control recommended	110

i. It was assumed that odorous emission would be negligible if the cooling water supply was adequately protected from potentially contaminating materials and the tower was relocated to a low risk area with respect to the entrainment of odorous air where practicable. This assumption is supported by odour testing conducted at the cooling tower bank located near the DDG evaporators (DDG 47), which were found to have odour levels below detection.

ii. Pelletise DDG product and fit heavy plastic curtains to openings, place building under slight negative pressure and discharge air via fabric filter baghouse

† Stage 2 odour controls if staged.

Table 49. Projected farm odour emissions before and after implementation of odour controls †

Rank	Audit ref	Discharge plant	Existing OER (OU m^3/s)	Summary of odour control (refer to section 10 for more detail)	Projected OER (OU m^3/s)
1	F9	Pivot irrigator No. 130	1,160,000	Irrigation of treated wastewater effluent using low mist sprays and reduced operation hours	22,400[iii]
2	F9	Pivot irrigator No. 120 (mist nozzle)	833,000	As above	16,100[iii]
3	F9	Pivot irrigator No. 110 (mist nozzle)	833,000	As above	16,100[iii]
4	F11	Traveller irrigators (2 large & 2 small)	163,000	Irrigation of treated wastewater and reduced operation hours	7,000 [iiii]

Rank	Audit ref	Discharge plant	Existing OER (OU m^3/s)	Summary of odour control (refer to section 10 for more detail)	Projected OER (OU m^3/s)
5	F1	Mixer tank vent	147,000	Decommissioned after treatment plant installed	Nil
6	F8	Pond 6	131,000	As above or retrofitted to accommodate treatment plant components if possible	5,600 [iii]
7	F7	Pond 5	82,900	As above	3,600 [iii]
8	F4	Pond 3	62,700	As above	800 [iii]
9	F13	Traveller irrigated land	46,000	Irrigated with treated wastewater effluent	2,000 [iii]
10	F15, F17	Pivot irrigated land	44,400	As above	1,920 [iii]

iii. Treated effluent storage pond for new WWTP. Adopted SOER = 0.1 OU/m^2/s for treated effluent storage ponds (assumed to be ponds 3, 5 & 6) and adopted SOER = 0.2 OU/m^2/s for aerobic ponds for new WWTP (assumed to be ponds 1 & 2). Pro rata OERs for irrigation sources were derived on the ratio of the effluent pond SOERs to the measured SOER for the old storage ponds (2.3 OU/m^2/s) with the added reduction of low-mist sprays where applicable.

The projected odour emission rates for all sources included in the odour emission rate inventory are tabulated in Appendix G.

The projected odour emission rates for each odour source should be verified by odour emission testing following installation and commission of odour control measures to confirm performance against projected odour emission rates.

12.2 Projected Odour Emission Rate Inventory Following Implementation of Odour Control

A revised OER inventory was derived to represent a worst-case snap-shot of odour emissions based on the projected OER following the implementation of odour control. In deriving the inventory, the following assumptions were made:

- all factory odour sources were discharging to air simultaneously; and
- a peak irrigation rate at the environmental farm of approximately 5 to 6 ML in a given day, which is assumed to comprise the use of pivot irrigator No. 130 plus two small travellers and two large travellers.

A breakdown of the OER contribution of each production plant and the environmental farm to the total OER for the Shoalhaven Starches facility following implementation of (stage 2) odour controls is given in Table 50.

Table 50. Total OER contribution following implementation of odour control

Source Group	OER (OU m^3/s) prior to implementation odour control	OER (OU m^3/s) following implementation odour control	% Total OER reduction
Starch plant	310,000	310,000	- [1]
DDG plant	230,000	43,000	80%
Ethanol plant	120,000	7,900	93%
Glucose plant	8,900	1,600	82%
Distillation plant	1,900	390	79%
Total - Factory	**670,800**	**362,890**	**46%**
Environmental Farm	3,500,000	39,000	99%
Total – factory and environmental farm	**4,170,800**	**401,890**	**90%**

(1) Odour reduction resulting from duct cleaning cannot be estimated at this stage.

The following key features are enumerated in Table 50:

» starch plant odour emissions have remained unchanged, however, the potential for odour impact from these sources will be reduced as a result of improved atmospheric dispersion;

» odour emissions from the factory have been almost halved from present levels;

» environmental farm is no longer the dominant source of odour emissions and has achieved the greatest reduction in OER; and

» odour emissions overall have been reduced by 90%.

12.3 Projected Odour Impact Following Implementation of Odour Controls

In practice, once a facility is operational, the benchmarks for odour emissions from the facility are no longer the odour assessment criteria (refer to Section 8.3), but whether the emission of odour is; (i) offensive (i.e. causing off-site complaint), or (ii) is being prevented or minimised using the best management practices.

Dispersion modelling has been used predict the odour impact after implementing the odour controls in order to gauge the potential for further odour complaint.

The model set-up and input used in this model were the same as defined in Section 8 except where specified below. The source release parameters and odour emission rates for each modelled source are provided in Appendix H and key aspects of the model set-up and input are summarised below:

- reduced odour emission rates were used for both principal and minor odour sources based on the implementation of all Stage 2 odour control summarised in Table 41;
- a peak irrigation rate at the environmental farm of approximately 5 - 6 ML in a given day, which is assumed to comprise the use of pivot irrigator No. 130 plus two small travellers and two large travellers operating from 5 am to 5 pm daily;
- Point sources added at the ethanol plant (Bioscrubber No. 1), DDG plant (liquids line - Bioscrubber No. 2 & solids line - Bioscrubber No. 3). The designation of individual odour sources to each bioscrubber and the subsequent bioscrubber odour emission rates are detailed in Appendix K; and
- starch plant odour sources that discharged horizontally or downward were adjusted so that they had a vertical exhaust velocity of 15 m/s . No adjustments were made to the stack heights.

The model odour predictions at each receptor were then ranked from highest to lowest and the 88th highest (99%ile) predictions at each receptor were then contoured. These were overlaid upon a scaled aerial photograph of the area for interpretation and comparison with the odour criteria.

The predicted ground level odour concentrations for the combined operation of the factory and environmental farm after implementing odour control are shown in Figure 21. These predicted odour concentrations indicate that the predicted odour impact has reduced by up to 80% at some locations, however, the 2 OU (99%ile, 1-second average) criterion is still not met, with odour levels of approximately 7 OU on the southern fringes of Bomaderry and the northern fringes of Nowra. The odour concentration at the site boundary of the factory is about 25 OU and about 5 OU at the southern edge of the farm boundary near the ponds (future WWTP).

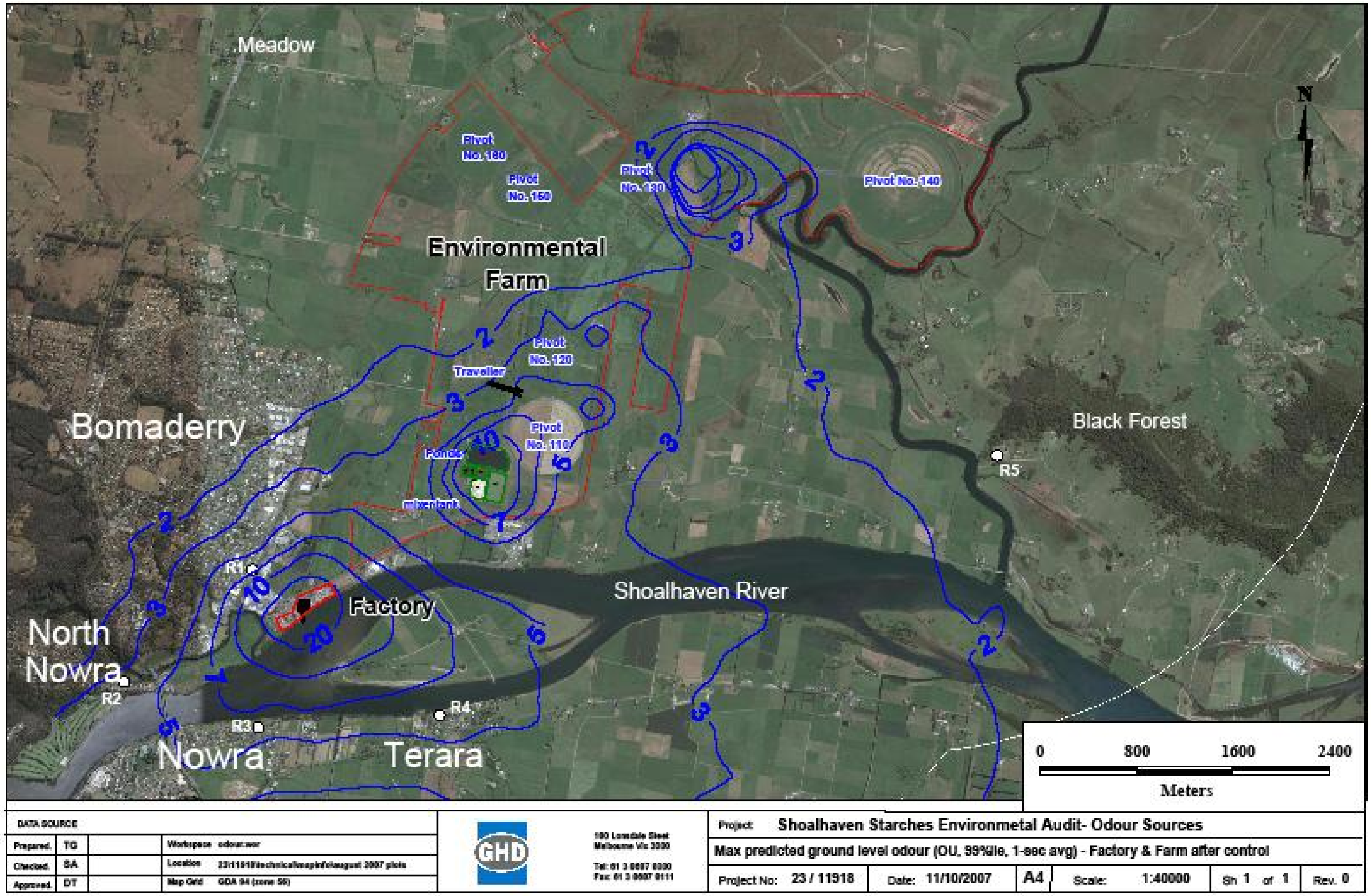
Figure 21 also shows that the maximum excursion of the 2 OU contour from the active pivot irrigator (in this case Pivot No. 130 and associated irrigated land) is approximately 500 metres from the edge of the paddock.

The factory is, by almost an order of magnitude, the dominant source of odour after the implementation of odour control at the factory and environmental farm. Odour emission from the starch plant account for approximately 85% of the total odour emissions from the factory and these emissions comprise approximately 70% of the predicted off-site odour impact. It is noteworthy that the potential reduction in odour emissions from the Starch plant as a result of ductwork cleaning and maintenance has not been taken into account in this model.

The majority of the starch plant odour sources had a hedonic tone ranging from neutral to mildly unpleasant and relatively low in-stack odour concentrations but with very large associated air flow rates, for these reasons, increased atmospheric dispersion coupled with odour preventative measures were recommended in preference to at-source odour control.

A comparison of model output from model runs conducted with and without emissions from the starch/gluten dryers being discharged vertically revealed that predicted off-site odour impact could be reduced by approximately 25% if emissions were assumed to be discharged vertically. Given that all of these odour sources are wake affected point sources, further improvement to atmospheric dispersion can be achieved by reducing the potential for plume interaction with the building wake, formed as wind passes over/around the buildings, by increasing the height of discharge (i.e. increase stack height) or by further increasing the vertical exhaust velocity (where practicable). This option could be implemented on a per stack basis or through the installation of a common roof-top stack. However, before further consideration is given to modifying the discharge points, investigations should be conducted into the odour reduction that could be achieved as a result of duct cleaning and maintenance.

Figure 21 Predicted ground level odour concentrations – factory and environmental farm following implementation of odour control



13. Odour Management Processes

(k) *Review the adequacy of policies, procedures, standards, practices and training at the premises in relation to environmental performance and in particular odour management. Where any inadequacy is found to exist recommend options to address each inadequacy.*

13.1 Environmental Management

Environmental management at Shoalhaven Starches is under the control of the Technical & Environment Manager, who reports to the General Manager, Shoalhaven Starches. The Environment Manager is responsible for overall environmental performance, compliance with the environmental licence and implementation of environmental controls at the Shoalhaven Starches factory and environmental farm. Operation of each plant within the factory is managed by leading hands on a rotating shift basis. In addition to their production responsibilities, the leading hands are responsible for environmental performance of their plant.

With the competing demands for the attention of the Technical & Environment Manager, environmental management of day-to-day issues tends to be reactive and not systematic. Shoalhaven Starches should consider developing and implementing an environmental management system (EMS) that is consistent with AS/NZS ISO 14001:2004. Shoalhaven Starches should also consider employing an environmental professional to support the Technical & Environment Manager. The roles of this person could include responsibility for the EMS and, through that process, to foster a systematic approach to proactive environmental management at Shoalhaven Starches.

13.2 Shoalhaven Starches Policies

A suite of 18 policies has been prepared for the Shoalhaven Starches factory and the environmental farm. These policies address activities ranging from food safety through to confined space entry.

Environmental performance commitments for Shoalhaven Starches Pty Ltd have been specified in the Environmental Policy, which is signed by the General Manager and the Technical & Environment Manager (March 2007). These commitments are as follows.

» Conducting its operations in compliance with statutory requirements.

» Actively seeking and giving due consideration to community expectations regarding the Company's environmental performance.

» Embrace continuous improvement, seek out ways to enhance our energy efficiency, minimise waste and not cause environmental impacts on land, air and water.

» Providing appropriate training for all employees on environmental matters relevant to their workplace and ensure that employees, contractors, supervisors and managers accept responsibility for their own actions and work according to appropriate environmental practices.

» Having an on-going program of communication on environmental matters throughout the Company.

These commitments generally address the environmental management elements described in Australian Standard AS/NZS ISO 14001:2004 *Environmental management systems – Requirements with guidance for use*, which is the generally accepted standard for environmental management in Australia. In order to fully meet the requirements of the standard, however, the policy should be made available to the public, ideally on a relevant website hosted by Shoalhaven Starches or the Manildra Group. A copy of the environmental policy is posted in the administration office and in all control rooms.

13.3 Procedures

13.3.1 General

Procedures have been prepared for operation of the starch, syrups (glucose), ethanol and DDG plants, for packaging areas and for maintenance, quality assurance, quality control, safety, training and environmental activities. The dates of initial preparation of these procedures range from the 1990s (for example; various syrup, ethanol and environmental procedures) through to 2007, when many of the policies were written.

13.3.2 Plant

The plant procedures address activities such as general operation, start-up, shut-down, operational problems, packaging, cleaning, hygiene, raw material receival and product dispatch. These procedures typically provide information to operators that is designed to maintain nominal plant operation and to avoid or address problems with plant operations. Through this, the procedures have the effect of maintaining odour emissions from equipment within the respective plants to a nominal level, being the level assessed during the audit.

Apart from having secondary effects on odour control, the procedures do not specifically address odour emissions or their minimisation. Once adopted, the various odour minimisation controls identified during and after this audit should be incorporated into the respective plant procedures.

13.3.3 Environment

Environmental procedures address monitoring and management of water quality, soil quality, vegetation, groundwater bores, irrigation, wastewater storage ponds, preparation of licence reports and management of complaints, non-conformances. A list of these procedures is provided in Table 51. The earlier procedures were written in 1997, with the more recent procedures written in 2005 and 2006.

Table 51. Environmental procedures

Procedure	Title	Odour Control
EN-P-0010	Complaint Handling Procedure	—
EN-P-0020	Filling Out and Using the Environmental Farm 24 Hour Report	—
EN-P-0030	Monthly Water Quality Monitoring	—
EN-P-0040	Environmental Farm Surface Soil Monitoring	—
EN-P-0050	Cooling Water Release Monitoring	—
EN-P-0060	Soil Profile Monitoring	—
EN-P-0070	Vegetation Monitoring	—
EN-P-0080	Environmental Licence Monitoring Quarterly Report	—
EN-P-0090	Environmental Farm – Pre Irrigation Checks	—
EN-P-0100	Irrigation with Pivot Irrigators	—
EN-P-0120	Flushing Irrigation Lines and Pivots	Yes
EN-P-0130	Noise Reduction Programme	—
EN-P-0140	Performing the Monthly bore Measurements and Water Sampling on the Approved Irrigation Area	—
EN-P-0150	Storage Protocol for Waste Water Ponds	Yes
EN-P-0160	Odour Reduction at Irrigation Start-up	Yes
EN-P-0170	Clean up of Liquid or Chemical Spills at Factory and Farm	—
EN-P-0171	Main Line Recirculation	Yes
EN-P-0180	Procedure for Rainwater/stormwater Management	—
EN-P-0231	Road Traffic & Noise Management Protocol	—
EN-P-0232	Operational Instructions For Train Movements At the Manildra Group Site Nowra	—

The majority of these procedures pertain to operations at the environmental farm. Of these, four contain a specific reference to control of offensive odours from wastewater that has been held for some time under conditions that may have led to anaerobic conditions. These procedures sought to address what were considered at the time of their preparation (2003 to 2006) to be the main sources of offensive odours at Shoalhaven Starches. While the generation of anaerobic conditions within the wastewater has a high potential to result in offensive odours, the procedures need to be modified to control the distribution of wastewater odours in general during spray irrigation.

The irrigation and wastewater management procedures should be modified to take into account the results of the odour emission modelling conducted during this audit; in particular, the high odour emission rate associated with spray irrigation.

13.4 Standards and Practices

As noted above, there is a requirement to operate the plants present within Shoalhaven Starches at a level that achieve the target productivity. Operational upsets and breakdowns are promptly identified and are rectified as soon as is practicable in order to minimise down time. Hence, the pattern of odour emissions, where operationally practicable, reflects the pattern associated with nominal operating standards of each plant.

There can be creep in the generation of fugitive and point source odours, however, where housekeeping or maintenance activities do not attend to areas of the plant or plant components that have the potential to generate odours. These include, for example, build-up of materials such as gluten or starch on the internal surfaces of exhaust ducts, insufficient flushing of pump wells and drains, spillage of DDG in the load-out area and contamination of the cooling water in the cooling towers.

The overall contribution of these sources to the odour emissions from the factory will vary according to the odour generation rate. For example, there might be little air exchange in some pump wells, whereas materials within exhaust ducts will have a comparatively high rate of odour generation.

A procedure for plant housekeeping should be prepared and implemented, with the primary aim of controlling odour generation by equipment and infrastructure including exhaust ducts, drains and pump wells, in areas where spilled raw materials and product might accumulate and for the protection of cooling tower water.

13.5 Personnel Training

All personnel being employed by Shoalhaven Starches receive a site induction prior to commencing work. This induction includes instruction on spill, odour and noise management. Refresher training includes similar instruction. All personnel are given a copy of the EPL and, where appropriate, are alerted to clauses that affect them in their workplace.

Personnel are required to receive annual refresher training. Not all personnel, however, receive refresher training contrary to the Shoalhaven Starches training requirements. This training requirement should be more stringently met.

Specific induction and refresher training is provided for personnel employed at the environmental farm. This training is closely based on the environmental licence due to recognition of the importance of appropriate operating practices with meeting associated licence requirements.

13.6 Recommended Actions for Environmental Management

The following actions are suggested for improvement of environmental management at Shoalhaven Starches.

- Develop and implement an environmental management system that is consistent with AS/NZS ISO 14001:2004.
- Prepare and implement a procedure for plant housekeeping. The primary aim of the procedure would be to control odour generation from equipment and infrastructure including exhaust ducts, drains and pump wells and in areas where spilled raw materials and product might accumulate.
- Prepare and implement a complaints-management system, which would be incorporated into the EMS;
- Modify the respective plant procedures to incorporate adopted odour minimisation controls identified during the audit.
- Modify the irrigation and wastewater management procedures to take into account the results of the odour emission modelling conducted during the audit. In particular, consider procedures to control the high odour emission rate associated with spray irrigation.
- Ensure that all personnel receive annual refresher training in accordance with Shoalhaven Starches training requirements.
- Consider employing an environmental professional to support the Technical & Environment Manager. The roles of this person could include responsibility for the EMS and, through that process, foster a systematic approach to proactive environmental management at Shoalhaven Starches.

14. Conclusions and Recommendations

14.1 Conclusions

The Manildra Group operates the Shoalhaven Starches factory at Bolong Road, Bomaderry, near Nowra, NSW, where flour and grains are processed to produce ethanol, starch, gluten, glucose and distiller's dried grain. Wastewater produced at the factory is pumped to holding ponds at the environmental farm, where it is reused for irrigation of pasture using spray irrigators.

An environmental audit of odour sources at Shoalhaven Starches was conducted between December 2006 and June 2007 to address the requirements of Condition 2 of Annexure B to the Land and Environment Court judgment of 2 November 2006. The audit considered the management of processes, activities and substances stored or used at the premises that generate or have the potential to generate odours.

The main processing and materials treatment areas at Shoalhaven Starches comprise the starch plant, glucose plant, ethanol and distillation plant, DDG plant and environmental farm. Each of these plants was examined to identify processes, activities and substances stored that were potential sources of odour. The audit identified 20 potential sources in the starch plant, 27 in the glucose plant, 36 in the ethanol and distillation plants, 48 in the DDG plant and 18 at the environmental farm.

Odour control methods that may be considered international best available technology and industry best management practice for factories such as Shoalhaven Starches were identified and compared with those in use at the factory.

The potential odour sources identified during the initial stage of the audit were examined to determine which of those a reasonable person might regard as being offensive. Some sources were excluded from the survey as they; did not have an odour that could reasonably cause offence, did not have a direct point of discharge, were similar to other sources, or had a combined discharge point with another source that was being sampled. This resulted in; 20 starch, 7 glucose, 13 ethanol, 6 distillation, 28 DDG and 17 environmental farm odour sources being included in the survey. Overall, 100 odour samples were taken during the main survey; the additional samples comprising duplicate and repeat samples.

Analysis of the samples determined that, of the overall odour emissions from the factory and environmental farm, the environmental farm generated 84% of the emissions, the starch plant around 7%, the DDG plant 6%, ethanol plant 3% and the glucose and distillation plants contributing less than 1%. Of the emissions from the environmental farm, the spray irrigators generated 85% of the odour emissions. This was attributed to release of the volatile odorous compounds from the wastewater by the use of mist nozzles.

Dispersion modelling of odour emissions to air from the sampled sources was conducted using CALPUFF three-dimensional non-steady state Gaussian puff model software. The model predicted ground level odour concentrations near the site boundary of the factory in the order of 100 OU, ground level odour concentrations at

Bomaderry of approximately 40 OU, and ranging from 25 to 100 OU at rural residences located in all directions surrounding the environmental farm. Following the survey and analysis of the results, a list of principal sources was identified for further assessment within the audit. These were distinguished by being the top fifty mass emission rate odour sources and sources with a very unpleasant hedonic tone.

Prevention of odour emissions from equipment such as baghouses and tank air vents was identified as being problematic due to the equipment being designed to discharge, in many instances high volumes of, air. This type of equipment numerically forms the majority of potential sources from Shoalhaven Starches.

Potential odour control systems were identified for the fifty selected sources of potentially offensive odour. These controls principally involved treatment of emissions using biofilters, and containment of the DDG plant and DDG dry product storage buildings by more complete enclosure of the buildings and application of a negative air pressure.

14.2 Recommendations

The following recommended actions have been provided for consideration by Shoalhaven Starches.

1. Develop and implement an environmental management system that is consistent with AS/NZS ISO 14001:2004. Incorporate the recommendations of this audit into the environment management plan to be prepared as part of the EMS.
2. Consider employing an environmental professional to support the Technical & Environment Manager. The roles of this person could include responsibility for the EMS and, through that process, foster a systematic approach to proactive environmental management at Shoalhaven Starches.
3. Use an existing wastewater treatment plant, or install a wastewater treatment plant, that meets or betters the projected odour emission reductions listed in Table 49 in Section 12 of this report. Reuse treated effluent in the factory where practicable and where consistent with applicable hygiene controls.
4. Prepare and implement a complaints-management system, which would be incorporated into the EMS.
5. Prepare and implement a procedure for plant housekeeping. The primary aim of the procedure would be to control odour generation from equipment and infrastructure including exhaust ducts, drains and pump wells and in areas where spilled raw materials and product might accumulate.
6. Modify the respective plant procedures to incorporate odour minimisation controls identified during the audit.
7. Modify the irrigation and wastewater management procedures to take into account the results of the odour emission modelling conducted during the audit. In particular, consider procedures to control the high odour emission rate associated with spray irrigation.

8. Ensure that all personnel receive annual refresher training in accordance with Shoalhaven Starches training requirements.
9. Implement, following confirmation of efficacy using source-specific modelling of more detailed engineering design, the odour control measures for the starch plant identified in Table 36 in Section 10 of this report, as amplified in Section 11.2 of this report.
10. Implement, following confirmation of efficacy using source-specific modelling of more detailed engineering design, the odour control measures for the glucose plant identified in Table 37 in Section 10 of this report, as amplified in Section 11.2 of this report.
11. Implement, following confirmation of efficacy using source-specific modelling of more detailed engineering design, the odour control measures for the ethanol plant identified in Table 38 in Section 10 of this report, as amplified in Section 11.2 of this report.
12. Implement, following confirmation of efficacy using source-specific modelling of more detailed engineering design, the odour control measures for the distillation plant identified in Table 39 in Section 10 of this report, as amplified in Section 11.2 of this report.
13. Implement, following confirmation of efficacy using source-specific modelling of more detailed engineering design, the odour control measures for the DDG plant identified in Table 40 in Section 10 of this report, as amplified in Section 11.2 of this report.
14. Implement, following confirmation of efficacy using source-specific modelling of more detailed engineering design, the odour control measures for the environmental farm identified in Table 41 in Section 10 of this report, as amplified in Section 11.1 of this report.
15. If source-specific modelling of more detailed engineering design of any of the odour control measures recommended in this report determines that the efficacy of the control measure is substantially less than was modelled in Section 12 of this report, identify an alternative control measure that achieves a reduction in odour emissions that, at a minimum, meets the modelled emission rate.
16. Shoalhaven Starches may identify an odour minimisation option for a specific source that differs from that identified in this audit report. Such an option may be considered as being a suitable control measure provided that it is a sustainable means of odour minimisation that meets or betters the projected odour emission reductions listed in Tables 48 and 49 in Section 12 of this report.

15. Glossary and Abbreviations

AWS	Automatic Weather Station
BoM	Bureau of Meteorology
CIP	Clean-in-place. A process of internally cleaning tanks, pipes and fittings using a cleaning solution pumped through the equipment to be cleaned.
CO_2	Carbon dioxide
DDG	Distiller's dried grain
DEC	NSW Department of Environment and Conservation
DECC	NSW Department of Environment and Climate Change
DME	Dimethyl ether
EPA	New South Wales Environment Protection Authority
ETC	Emission Testing Consultants
FOG	Fats, oils and greases
Hedonic tone	Hedonic tone is a property of an odour relating to its pleasantness or unpleasantness. A distinction should be made between the acceptability and the hedonic tone of an odour. When an odour is evaluated in the laboratory for its hedonic tone in the neutral context of an olfactometric presentation, the panellist is exposed to a controlled stimulus in terms of intensity and duration. The degree of pleasantness or unpleasantness is determined by each panellist's experience and emotional associations. Reference: *NSW EPA Information for Authorised Officers; Odour Control*.
IFC	Isolation flux chamber
ML	Megalitre (1,000,000 litres)
NATA	National Association of Testing Authorities, which is Australia's national laboratory accreditation authority.
Nm^3	Normal cubic metre; the volume of dry gas that occupies a volume of 1 m^3 at a temperature of 273°K and an absolute pressure of 101.3 kPa. Reference: *DEC Approved methods for the modelling and assessment of air pollutants in NSW*.

Odour unit	The number of odour units is the concentration of a sample divided by the odour threshold or the number of dilutions required for the sample to reach the threshold. This threshold is the numerical value equivalent to when 50% of a testing panel correctly detect an odour. Reference: *NSW DEC Technical framework: assessment and management of odour from stationary sources in NSW*.
OER	Odour emission rate The odorant flow rate (odour emission rate) is the quantity of odorous substances passing through a defined area at each time unit. It is the product of the odour concentration, c_{od}, the outlet velocity, v, and the outlet area, A, or the product of the odour concentration, c_{od}, and the pertinent volume flow rate, V. Its unit is OU.m^3/h (or OU.m^3/min or OU.m^3/s, respectively.) NOTE: The odorant (emission) flow rate is the quantity equivalent to the emission mass or volume flow rate, for example in dispersion models. From AS 4323.3-2001.
Offensive odour	Offensive odour means an odour: (a) that, by reason of its strength, nature, duration, character or quality, or the time at which it is emitted, or any other circumstances: (i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or (ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or (b) that is of a strength, nature, duration, character or quality prescribed by the regulations or that is emitted at a time, or in other circumstances, prescribed by the regulations. Reference: *Protection of the Environment Operations Act 1997*.
SOER	Specific odour emission rate (see section 7.2.1). The odour flux rate of the emitting surface, expressed as an emission rate per unit surface area (OER per square metre). Calculated by dividing the airflow through the chamber and the odour concentration of the exhaust air by the area covered by the chamber. The total OER for each specific source of odour was then determined by multiplying the SOER by the area of each source.
VOC	Volatile organic compound. This class of organic compounds includes chemicals that can produce offensive odours.

Appendix A

Annexure B

Appendix B

Location Map

Appendix C

Documents Reviewed

Documents Reviewed

Document Ref	Document Title	Stated purpose
Environmental procedures		
EN-P-0010	Complaint Handling Procedure	Effective investigation of environmental complaints for any corrective action.
EN-P-0020	Filling Out and Using the Environ. Farm 24hr Report	Details methods to record and monitor daily irrigation operations.
EN-P-0030	Monthly Water Quality Monitoring	Details the requirements for the Environmental Farm Water Quality Monitoring
EN-P-0040	Environmental farm surface Soil Monitoring	Assess the impact of irrigation on the soil on an annual and a 3 yearly basis.
EN-P-0050	Cooling Water Release Monitoring	Details the monitoring and review actions required for cooling water release to Shoalhaven River
EN-P-0060	Soil Profile Monitoring	Assess the impact of applying waste waters to the approved irrigation area
EN-P-0070	Vegetation Monitoring	This document details the method utilised to perform the annual Vegetation Monitoring of the approved irrigation area
EN-P-0080	Environmental Licence Monitoring Quarterly Report	This document details the requirements of the Monitoring Quarterly Report that must be submitted to the Environmental Protection Authority
EN-P-0090	Environmental Farm – Pre Irrigation Checks	Details checks required prior to commencement of irrigation on the Approved Irrigation Area
EN-P-0100	Irrigation with Pivot Irrigators	Details the safe and correct method of irrigating using pivot Irrigators
EN-P-0110	Irrigation with Travelling Irrigators	Details the safe and correct method of irrigating using travelling irrigators and proper roll-up of irrigators
EN-P-0120	Flushing Irrigation Lines and Pivots	Details the safe and correct method of flushing irrigation lines and pivot irrigators
EN-P-0130	Noise Reduction Programme	Details the Company's policy for conformation of the EPA Licence and guidelines to maintain appropriate noise level criteria.

EN-P-0140	Performing the Monthly Bore Measurements and Water Sampling on the Approved Irrigation Area	Explains the correct method of checking the bore levels and obtaining samples of the bore water and the surface drains containing water
EN-P-0150	Storage Protocol for Waste Water Ponds	To maintain storage ponds in an acid environment to inhibit microbial activity and reduce potential odour generation.
EN-P-0160	Odour Reduction at Irrigation Start-up	Neutralise start-up odours using an oxidant
EN-P-0170	Clean up of Liquid or Chemical Spills at Factory and Farm.	Details the response by employees and contractors to liquid or chemical spills
EN-P-0171	Main Line Recirculation	Details the safe and correct method of recirculation of effluent in the main irrigation lines.
EN-P-0180	Procedure for Rainwater/Stormwater Management	To prevent rainwater contaminated with product, from being released into Abernethy Creek.
EN-P-0231	Road Traffic & Noise Management Protocol	This document details the company's policy for Licence and guidelines to maintain appropriate Road Traffic movements and Noise level criteria both within and on approaches to the premises.
EN-P-0232	Operational Instructions for Train Movements at the Manildra Group Site Nowra	To establish safe, efficient and effective working standards for the interaction of rail traffic between Australia Railroad Group and The Manildra Group Nowra site.
EN-WI-0010	Environmental Farm Hand Main Duties	Outlines the main duties that the Environmental Farm Hand carries out

Appendix D

Excluded Sources

Reasons for not sampling potential odour sources

Starch plant

Audit Ref	Equipment	Reason for exclusion
S16	Kraus Maffei starch conditioners	Vent is located within the building and has a low odour generating potential.

Glucose Plant

Audit Ref	Equipment	Reason for exclusion
Brewers glucose line		
B1	Starch tanks 1, 2 & 3	Starch suspension at ambient temperature with negligible odour.
B2	Hydrochloric acid tank	Tank has low odour generating potential, due to containment controls in place for OH&S purposes.
B4	Cooker B flash tank	Discharges via a common roof vent with B3, which was sampled.
B5	Storage (hydrolysis) tank	Odour represented by sample (B7).
B6	Enzyme tanks 2 – 6	Sample (B7) taken of Tank 18 to represent all tanks. Tank 18 reported to have a slightly greater odour.
B8	Drum filters A, B, C & D	Drum filters discharge via common vacuum receiver vent sampled as C4.
Confectioners glucose line		
C3	Rotary vacuum drum filter	Discharges via common external vent with C4, which was sampled.
C5	Units 1 & 2 feed tank 1	Receives demineralised glucose, which has negligible odour.
C6	Units 1 & 2 feed tank 2	Receives demineralised glucose, which has negligible odour.
C7	Units 3, 4 and 5 feed tank 1	Receives demineralised glucose, which has negligible odour.
C8	Units 3, 4 and 5 feed tank 2	Receives demineralised glucose, which has negligible odour.
C9	Units 3, 4 and 5 feed tank 3	Receives demineralised glucose, which has negligible odour.
C10	Della Toffola 2 & 4 feed tank	Receives raw glucose, which has negligible odour.
C11	Demin glucose buffer tank 1	Receives demineralised glucose, which has negligible odour.
C12	Demin glucose buffer tank 2	Receives demineralised glucose, which has negligible odour.
C13	Demin glucose concentrator feed tank 1	Receives demineralised glucose, which has negligible odour.

Audit Ref	Equipment	Reason for exclusion
C14	Condenser vacuum pump (GBM23)	Receives vacuum air from demineralised glucose pre-evaporators, which has negligible odour.
C15	Weigand evaporator vacuum pump (GBM12)	Receives vacuum air from demineralised glucose pre-evaporators, which has negligible odour.
C16	Glucose tanks 1 - 15	Demineralised glucose product storage tanks, which have negligible odour.
C17	Roof vent	Could not be sampled due to configuration of rotative vent. Vented air from plant had a slight bleach odour form the cleaning processes.

Ethanol Plant

Audit Ref	Equipment	Reason for exclusion
Grain line		
E2	Grain elevators	Similar discharge to E1, which was sampled.
E3	Hammer mill	Similar discharge to E4, which was sampled.
E5	Not assigned	—
E6	No. 2 collection tank	Receives ground flour mixed with water in the Scott mixer under an open system, which is located indoors. Has negligible odour generation.
Starch line		
E12	Ammonia storage tank	Tank has low odour generating potential, due to containment controls in place for OH&S purposes.
E16	Fermenter No. 1	Vent from fermenter connected to carbon dioxide collection system.
E17	Fermenter No. 2	Vent from fermenter connected to carbon dioxide collection system.
E18	Fermenter No. 3	Vent from fermenter connected to carbon dioxide collection system.
E19	Fermenter No. 4	Vent from fermenter connected to grain retention tank “F7” which was sampled as E8.
E20	Fermenter No. 5	Vent from fermenter connected to grain retention tank “F7” which was sampled as E8.
E21	Fermenter No. 6	Vent from fermenter connected to grain retention tank “F7” which was sampled as E8.

Distillation Plant

Audit Ref	Equipment	Reason for exclusion
D1	Stage 2 product condenser flame arrestor (E683)	No emission under normal operating conditions.
D3	Stage 4 product condenser flame arrestor (E563)	No emission under normal operating conditions.
D4	Stage 4 product cooler flame arrestor (E519)	No emission under normal operating conditions.
D5	Stage 4 final product drum (E569)	No emission under normal operating conditions.
D7	Stage 1 condenser vent (E27)	No emission under normal operating conditions.
D8	Stage 1 condenser vent (E501)	No emission under normal operating conditions.
D9	Stage 1 condenser vent (E45/0)	No emission under normal operating conditions.
D10	Stage 1 condenser vent (C600)	No emission under normal operating conditions.

DDG Plant

Audit Ref	Equipment	Reason for exclusion
Solids line		
DDG3	Decanter No. 2 (Westphalia)	Represented by DDG2.
DDG4	Decanter No. 3 (Alpha Laval)	Represented by DDG5.
DDG6	Inclined screw conveyors	Sealed units.
DDG8	Paddle mixers (3 units)	Represented by DDG7 and DDG9.
DDG10	High speed mixer (3 units)	Sealed units.
DDG11	DDG dryer No. 1	Vapour captured, condensed and added to boiler air intake for destruction of residual odour.
DDG12	DDG dryer No. 2	Vapour captured, condensed and added to boiler air intake for destruction of residual odour.
DDG13	DDG dryer No. 3	Vapour captured, condensed and added to boiler air intake for destruction of residual odour.
DDG14	Cyclones 1, 2 & 3	Vapour captured and added to boiler air intake for destruction of residual odour.
DDG15	Palmer cooler	Air transferred to mill feed silo, from which the exhaust was sampled as DDG17.
Liquids line		
DDG21	Evaporators 1 & 2	Vents to finisher feed tank, sampled as DDG26.
DDG22	Evaporators 3 & 4	Vents to condensate tank, sampled as DDG23.
DDG27	Finisher	Vents to syrup hold tank, sampled as DDG31.
DDG28	Finisher pump tank (LT308)	Result from dryer feed tank (DDG30) used.
DDG29	Not assigned	—
DDG38	Cooling tower	Sampled as DDG46.
DDG41	Drains from heat exchanger for dryer No. 1	Odour emission rate from sample F18 used.
DDG42	Drains from heat exchanger for dryer No. 3	Odour emission rate from sample F18 used.
DDG43	Drain under dryers	Odour emission rate from sample F19 used.

Environmental Farm

Audit Ref	Equipment	Reason for exclusion
Solids line		
F6	Pond 4 covered section	Not expected to be a significant source due to presence of cover.

Appendix E

ETC Odour Survey Reports

Odour Survey: Manildra Group – January and February 2007

Odour Survey: Manildra Group – April 2007

Appendix F

Pre-survey Trial

Appendix G

Odour Emission Rate Inventory

Appendix H

Dispersion Model Output

Appendix I

Odour Model Input Control Files

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
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