APPENDIX B – STUDY ON AIR QUALITY IMPACT

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AIR QUALITY IMPACT OF PROPOSED EXPANSION OF CARRICKMACROSS WASTEWATER TREATMENT PLANT CO. MONAGHAN

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1.0 INTRODUCTION

An extension of the wastewater treatment plant at Carrickmacross, Co. Monaghan is proposed, to provide additional capacity for the projected increase in municipal sewage from the town and the surrounding area. As part of the evaluation of the likely environmental impact of the extended plant, an assessment of the potential impact of odours from the treatment plant was undertaken by Envirocon Ltd.

2.0 EXISTING ENVIRONMENT

2.1 Air Quality

The wastewater treatment plant site at Carrickmacross is located approximately 1 km to the south east of the town centre with the site accessed from the N2 (Ardee Road). It is located on relatively flat land at about 32m O.D. within a shallow valley with the ground rising slightly to the north and south of the site. The lands to the NW and SE are generally undeveloped with trees/mature hedgerows or pasture land. There is a new road along the NW boundary that has been constructed to service lands zoned for industrial warehousing to the north of the site. There are no significant industrial emissions within the locality of the treatment plant. The nearest houses are located along the N2 within about 75-100m of the SW site boundary. There is a recently constructed housing development along the small ridge to the north of the site, with the nearest houses about 275m from the site boundary.

Overall, the air quality in the locality is good with levels of air pollutants in the area well below the National Air Quality Standards (NAQS) specified in (SI No 244 of 1987) and the Air Quality Standards Regulations 2002 (SI No 271 of 2002). Daily concentrations of sulphur dioxide would be less than 25% of the limit value of 125 $\mu g/m^3$ specified in the 2002 Regulations. Ambient concentrations of nitrogen dioxide would be less than 40% of the future NAQS annual limit of 40 $\mu g/m^3$, which is to be met by 2010. Corresponding hourly concentrations would also well below the current NAQS hourly limit value of 200 $\mu g/m^3$. Slightly elevated levels of nitrogen dioxide may be experienced near the south-eastern site boundary, due to exhaust emissions from traffic travelling along the N2. Carbon monoxide and benzene levels, which are important components of motor vehicle exhausts, would be very low in the area and typically less than 10% of the NAQS.

Dust and airborne particulates, in particular those referred to, as PM_{10} (particulate material with a mean aerodynamic diameter of less than 10 μm) would be below the National Air Quality Standards. The limit values specified in the Regulations 2002, which entered into force in January 2005, specify a daily value of 50 $\mu g/m^3$ (as a 90.4 percentile of daily average values) and an annual average value of 40 $\mu g/m^3$. Annual levels would be typically in the region of 20-25 $\mu g/m^3$ close to the N2 roadside with vehicle exhaust emissions and roadside dust being the principal sources.

During the site visit undertaken in September 2004, no malodours could be detected near the site boundary of the wastewater treatment plant. The weather conditions were dry and sunny with light winds present during the site visit. In the past, complaints of odours have been reported by local residents. However, with the recent installation of a high efficiency odour control unit on the existing inlet works, no complaints have been reported within the past 12 months.

2.2 Climate

2.2.1 General climatology

The climate of the South Monaghan/Cavan area is characterised by the passage of Atlantic low pressure weather systems and associated frontal rain belts from the west during much of the winter period. Over the summer months, the influence of anticyclonic weather conditions will result in drier continental air over this part of Ireland, in particular when winds are from the east, interspersed by the passage of Atlantic frontal systems. Occasionally, the establishment of a high pressure area over Ireland will result in calm conditions and during the winter months these are characterised by clear skies and the formation of low level temperature inversions with slack wind conditions at night-time. If anticyclonic conditions become established for a few days or more during the summer months then high day-time temperatures may be recorded. Prolonged dry weather conditions are relatively infrequent in the area but should continental air masses dominate over Ireland then drought conditions may occur that may last up to 2 or 3 weeks.

2.2.2 Wind

Observations from the meteorological station at Clones (40km to NW) will tend to be indicative of conditions experienced in the Carrickmacross area. The long-term wind direction and speed statistics are presented in Fig 1 for the period 1968-97 inclusive. It is evident that the prevailing winds are from a south westerly direction, with 28% of the hourly observations giving a direction of 200-250 degrees. Approximately 60% of winds are from the western sector with an incidence of calm 'slack' wind conditions of about 5%. The annual average wind speed at Clones is 4.4 m/s with less than 6% of the hourly observations recording wind speeds over 9 m/s. It is the lower wind speeds of typically, 1-2 m/s that cause the maximum ground level odour concentrations and wind speeds below 2m/s are reported for about 24% of the time. At higher wind speeds, the rapid rate of dilution of any odorous emissions from sources within the wastewater treatment plant will tend to be sufficient to prevent detection of odours from beyond a few metres from the edge of the open tanks. It should be noted that these hours would not be consecutive and would tend to occur mainly during the summer period.

The greatest potential for odorous emissions is normally during the summer months when warm dry weather conditions can increase the rate of evaporation from exposed tank surfaces within the treatment plant. During the winter months with damp cool windy conditions prevailing, the potential for odours being detected more than a few metres from the side of the open tanks and odour exhaust vents would be substantially lower.

2.2.3 Air Temperature

The long-term (30 year) annual mean air temperature for the Carrickmacross area is about 8.8 °C with a range in the maximum daily average of about 6.7 °C in January to

18.6 °C in July. The absolute maximum reported at Clones in recent years is 28-30 °C, which has been reported during the months of June-August. The potential for malodours to be generated will be greatest on warm sunny days, as this is normally associated with dry anti-cyclonic weather conditions which can result in low-flow combined flow conditions into the treatment plant.

2.2.4 Rainfall

Annual rainfall rates at Carrickmacross, based on long-term measurements are about 910 mm, with maximum monthly rates of about 103mm (Table 1). Precipitation that occurs during the winter months tends to be associated with pro-longed Atlantic frontal weather depressions passing over the region compared to the summer, when rainfall is more likely to be associated with heavier showery conditions. The long-term records for Clones indicate that the number of days in the Monaghan/Cavan Region with precipitation exceeding 0.2mm (a light shower) is about 220 (60% of days). Daily rainfall amounts greater than 1mm occur on about 165 days (45% of days) during the year.

Table 1
Precipitation rates at Carrickmacross 1961-90 (mm)

Parameter	J	F	M	A	M	J	J	A	S	O	N	D	ann.
Average	103	71	72	60	63	62	56	79	78	92	83	93	910

3.0 THE PROPOSED DEVELOPMENT

3.1 Odour emissions from Wastewater Treatment Plants

Fresh sewage arriving at a wastewater treatment plant via a properly constructed sewer system has a slight smell, normally described as musty in character. As long as a certain level of dissolved oxygen is maintained in the sewage anaerobic conditions will not take place. However, if the oxygen content of the sewage is used up then gases such as hydrogen sulphide, nitrogen and sulphur based organic compounds (mercaptans, ketones, amines, indoles and skatoles) are quickly produced and a general septic condition occurs with typical pungent odours being emitted. These conditions may arise where the incoming sewage becomes septic as it is pumped along the rising main and result in strong malodours at the inlet works.

The rate of emissions of malodorous compounds from within a treatment plant depend on the freshness of the incoming sewage, exposed surface areas of treatment tanks, sludge handling procedures and presence and type of odour control measures installed. In most cases, odour nuisance problems are due to the age of the plant, septicity of sewage and overloading conditions during primary or secondary treatment. Modern technology at treatment plants such as enclosing inlet works, high efficiency odour control systems, constant monitoring of flow conditions, diffused aeration for secondary treatment and sludge treatment within enclosed buildings can result in odours being greatly reduced.

The new oxidation ditch will be located in the northern part of the existing site, with the new inlet works building situated on ground opposite the present inlet works.

3.2.2 Inlet Works

The existing inlet works will be replaced with a new preliminary works housed in a building near the entrance. The sewage will be screened through coarse (20mm) and fine (6mm) mechanical screens, with a manual rake screen used as standby. A grit trap will be installed to remove the finer sediments along with fats/grease. All the inlet channels, along with the inlet chamber will be completely covered and the foul air ducted to an odour control unit. The screened material will be washed and deposited into enclosed skips housed within the inlet works building.

3.2.3 Storm-water holding tanks

Incoming flows in excess of 3DWF will be stored in the open storm-water holding tanks. To provide for additional capacity a new tank will be constructed adjacent to the inlet works building. Once high flow conditions have abated, the stormwater liquor will be pumped back into the inlet works and the bottom and side-walls of the tank will be manually hosed-down by high-pressure hose to remove any debris adhering to the sides.

Prompt maintenance of the sidewalls after stormwater holding tanks are emptied will reduce the potential for malodours to be generated. Moreover, due to the limited usage of these tanks and the prompt flushing of any material deposited on the tank floor, odours will be short-term and are unlikely to be significant beyond the edge of the tanks.

3.2.4 Secondary Treatment

From the review undertaken of the available secondary treatment processes available, the recommended system is extended aeration with pre-treatment in an anoxic contact tank. The sewage from the inlet works will flow to the existing anoxic tank where denitrification of the liquor occurs. The anoxic tank also provides mixing and good settling characteristics of the sludge using a submersible mixer. The bacterial action in the anoxic tank converts nitrates to nitrogen gas, which is then released to the atmosphere. The liquor is then pumped to the oxidation ditches. The sub-surface mixing of the liquor in the anoxic tank rapidly reduces the rate of anaerobic activity and so odorous emissions are greatly reduced compared to emissions commonly associated with primary settlement tanks.

A new oxidation ditch is planned to provide sufficient capacity for the future design BOD loading. This tank will have a similar design criteria to the existing Oxidation Ditch No 2 with fine-bubble diffused aeration and submersible mixers. In addition, it is proposed that membrane filtration bioreactor units will be installed as an alternative technology to using secondary clarifiers to remove the secondary sludge from the effluent.

The proposed oxidation ditch system combines the processes of oxidation using sub-surface diffused aeration and the removal of the excess sludge with membrane bioreactor technology. The ditch is a closed oval ring-shaped with the wastewater introduced upstream of the submersible rotor/mixer. The aerobic process is relatively slow, with a typical retention time of 16-24 hours depending on influent BOD load. To achieve a high degree of biological treatment, the wastewater needs to flow at a relatively constant rate around the tank with uniform mixing of the suspended solids and the oxygen taking place to encourage microbial growth.

It is planned that the membrane filter units will be installed in a separate tank within an enclosed building and the excess sludge will be drawn off and transferred to the sludge storage tank. The remaining sludge will be returned to the oxidation ditch. The membrane filters comprise a set of very fine fibres with micro pores through which the filtrate is drawn by suction. The membrane filter units are installed in modular sections with the tank. The secondary sludge from the oxidation ditch accumulates on the external surface of the membranes in the reactor units and excess sludge is removed.

Compared to activated sludge secondary treatment with surface aerators, the generation of aerosols and malodorous emissions from the process taking place within an oxidation ditch is greatly reduced. Rapid oxidation of the tank liquor occurs with the sub-surface fine bubble diffusers and the dissolved oxygen concentration will be automatically controlled to ensure adequate levels are maintained in the ditch. This process greatly reduces anaerobic activity within the liquor and so the formation of malodorous gases is restricted. In addition, the flow of the liquor around much of the tank is laminar at a speed of less than 1 m/s. This type of flow will produce little turbulence at the surface and atmospheric emissions will be mainly restricted to the part of the tank where the diffusers and mixers are located. However, even within this section the generation of aerosols and malodours will be low, due to subsurface aeration and mixing.

3.2.5 Sludge Treatment

Odorous emissions from secondary sludge are much lower than is generated by primary sludge and so the handling of this type of sludge in a dewatering building produces lower emissions. Primary sludge collected from primary treatment of sewage can rapidly deteriorate through anaerobic processes which produce foul malodours due to hydrogen sulphide, mercaptans and other reduced sulphur compounds. On the other hand excess secondary sludge from secondary treatment systems such as oxidation ditches is relatively stable as the aerobic activity during the process of denitrification and oxidation in the tank has destroyed the majority of the odorous components.

The excess secondary sludge from the membrane bioreactor units will be removed to the existing picket fence thickening tank located adjacent to the sludge thickening plant. The headspace from this covered tank will be extracted and exhausted to atmosphere via a high efficiency odour control unit. This will minimise emissions from the storage of the secondary sludge.

The thickened secondary sludge will be pumped to the sludge conditioning tank and belt press, which will produce a sludge cake of about 14-16% dry solids. The existing de-watering belt presses are housed in the sludge treatment building. This building will be enclosed with the extraction of malodours from the headspace above the belt presses extracted to the atmosphere via a high efficiency odour control unit. The dewatered sludge cake will be discharged into a covered skip via an enclosed screw conveyor and transported off-site for disposal.

3.2.8 Odour Control Units

High efficiency single or two stage odour control units will be installed to treat the malodorous air from the new inlet works building and the sludge treatment building. Each unit will have a very high removal efficiency rate, with odour reduction levels in excess of 95%. Acceptable methods of odour control include charcoal scrubbers, biofiltration and ozone scrubber systems.

4.0 ODOUR IMPACT OF WWTP EXPANSION

4.1 Introduction

Short-term ground level odour ground level concentrations downwind of the wastewater treatment plant were computed using the ADMS3 (Version 3.2, September 2004) advanced air quality dispersion model developed in the U.K. by CERC (Cambridge Environmental Research Consultants). This prediction model is used by Regulatory Authorities and the Environment Agency in the United Kingdom and has been approved by the Environmental Protection Agency for modelling studies supporting IPCL applications. It has been widely used in Ireland for evaluating the impact of odours from wastewater treatment plants.

The ADMS3 model takes account of the substantially improved understanding of the plume dispersion within the atmospheric boundary layer by the use of more complex parameterisation, than used in previous generation prediction models. It uses boundary layer theory based on the Monin-Obukhov length and boundary layer height instead of the categories of atmospheric stability used in the older U.S. EPA dispersion models including the ISC3.

Hourly climatological data from Clones meteorological station, for the years 1989 and 1990 were used to predict the 99.5 and 98 percentile hourly odour concentration values. These percentile calculations give the odour concentration at each receptor location that is predicted to be exceeded for 2% of the year or 175 hours in the case of the 98 percentile. The 99.5 percentile value is the concentration predicted to be exceeded for 0.5% of the time, or 45 hours. The pattern of predicted odour concentration around the plant reflects the annual incidence of certain wind speeds and directions coupled with the different types of atmospheric stability close to the ground.

4.2 Odour emission estimates

The wastewater treatment plant operates using an extended aeration process for secondary treatment and so there are no primary tanks, which are commonly found to be major potential sources of malodours at treatment plants. In addition, no primary sludge is produced and so the sludge that is recovered and de-watered is secondary sludge from the oxidation ditch process. Transfer and handling of primary sludge can be a major cause of malodours at a treatment plant and so this potential source is also not present at the Carrickmacross plant. On the other hand, recovered secondary sludge has a much lower organic content and due to the aerobic activity that takes place during aeration in the oxidation ditch has a lower odour potential. This results in lower emissions from de-watering the sludge in the sludge handling building and storage, compared to treatment plants where primary sludge is de-watered.

The emission rates used in the odour prediction model were expressed in terms of odour release per second. For emissions from the exhaust stacks of the odour control units the odour emission rate was calculated in terms of o.u/s. In the case of the secondary treatment oxidation ditches, the emission rates were expressed in terms of the odour emission rate per unit area per second (o.u./m^2.s).

The odour emission sources included in the odour prediction model are as follows:-

Secondary Treatment tanks

- Oxidation Ditches – These are the existing oxidation ditch (No 2) and the new ditch (No 3). The emission characteristics used in the odour model for each oxidation ditch are given in Table 2. These dimensions are equivalent side lengths that approximate to the size of the proposed oxidation ditches, based on the planned site layout information drawings. The new ditch is orientated with the longest side at 140 degrees from north. An emission rate of 0.5 o.u./m^2.s has been applied to the whole of the area of the oxidation ditch in the odour prediction model. However, odour emissions from the surface of the liquor will only be significant in the zone where sub-surface diffusers and mixers are operating. This zone is typically less than 20% of the total oval path of the liquor as it moves around the oxidation ditch.

Table 2
Oxidation Ditch emission characteristics

Source	Width (m)	Length (m)	Ditch Area (m^2)	Emission Rate (o.u./m^2.s)
Oxidation Ditch No 2 (Existing)	15	36	470	0.5
Oxidation Ditch No 3	12	31	374	0.5

The vertical exit velocities from the surface of the liquor in the oxidation tanks will be very low and typically well below 0.01 m/s and so the emission rates are mainly related to the evaporative capacity of the air layer at the air/liquid interface. The hourly temperature of the emissions for the surface of the tanks was set equivalent to the ambient air temperature used in the odour prediction model.

Odour Control Units

It is proposed that two high efficiency odour control units, one for the inlet works and another for the sludge treatment plant, will be installed. These two emission points will be located close to the inlet works building and the sludge treatment buildings respectively. It is likely that the units will be sited on the ground with the scrubbed outlet air from the unit ducted to a vertical stack. The emission rates for these proposed odour control stacks were set equivalent to 500 o.u./s in the odour prediction model.

This odour emission rate is substantially higher than is likely to occur when the odour control units are in normal operation. Typical emission measurements obtained from similar high efficiency odour control units at wastewater treatment plants in Ireland indicate rates of less than 100 o.u./s for both inlet works and sludge treatment odour control systems. The treated air will be discharged to atmosphere from each odour control unit via a stack, with a minimum height of 5m and typical stack exit diameter of 0.5m. An exhaust flow rate of 8 m/s and exit temperature of 15°C were used in the odour prediction model for both odour control units.

4.3 Results of odour dispersion model

The results of the odour impact modelling study based on the planned expansion of the existing wastewater treatment plant are presented as odour concentration contour plots in Figs 2-3. These plots show the pattern of the 99.5 percentile and 98 percentile odour concentrations in the locality of the plant and are based on the maximum value predicted at each receptor location over the two years that were modelled.

The intensity of the odour at some point downwind of the site boundary will depend on the strength of the initial odour concentration from the surfaces of the various secondary treatment tanks or odour control exhaust vents and the distance downwind at which the prediction, or indeed measurement, is being made. Where the odour emission plumes from several of these sources combine downwind, the predicted odour concentration may be significantly higher than that predicted for an individual source.

An odour concentration of 1 o.u./m^3 is defined as the level at which there is a 50% probability that, under laboratory conditions using a panel of qualified observers, an odour may be detected. At odour levels below 1 o.u./m^3, the concentration of the gaseous compound causing the odour in the air will be less than the detection level and so although the gas is still present in the air no odour may be detected. Sensitivity to an odour also depends on the location; for example, an odour from agricultural related activities is likely to be tolerated by the community longer in a rural setting than in an urban area.

The predicted 99.5 percentile odour concentrations that are predicted for the planned expansion are shown in Fig 2 and the pattern of odour levels indicates that the maximum level at the nearest houses to the SW boundary will be between 1-1.5 o.u./m^3. At the houses to the north of the site boundary, the predicted 99.5 percentile odour concentration is less than 1 o.u./m^3. In other words, the odour prediction model predicts that odour levels will generally be below the odour detection level for 99.5 percent of the time at the nearest houses to the site. At the site boundary the predicted 99.5 percentile odour concentration is predicted to be 3-4 o.u./m^3. This is due to the proximity of the new oxidation ditch close to the northern site boundary.

The predicted 99.5 odour concentrations at the nearest private properties are very low and although there are no National Standards the predicted odour concentrations would meet the Standards required in other European Countries such as the Netherlands. In the Netherlands a maximum concentration of 1 o.u./m^3, which should be met for 99.5% of the year has been used as a limit value downwind of new wastewater treatment plants for sensitive locations.

The odour concentrations in the locality of the wastewater treatment plant that are predicted to be exceeded for 2% of the year, or 175 hours during the year, referred to as the 98 percentile, are shown in Fig 3. At the nearest houses to the south and north of the site, the predicted 98 percentile odour concentration is less than 1 o.u/m^3. The odour levels are predicted to be less than 3 o.u./m^3 along all boundaries around the site.

An odour concentration of greater than 5 o.u./m^3 has been widely used as a criteria for determining possible nuisance complaints, typically as a predicted hourly average 98 percentile limit value. This predicted odour concentration has been adopted in the past as an acceptable approach in Ireland and the U.K. to demonstrate that no odour nuisance would occur beyond the site boundary of planned wastewater treatment plants.

Ambient odour limits proposed by the EPA in a report (Odour Impacts and Odour Emissions Control Measures for Intensive Agriculture, EPA 2002) regarding odorous emissions from pig production units propose a more stringent condition in relation to a limit value around new pig production units of 3 o.u./m^3 as a 98 percentile of predicted hourly concentrations. A target value of 1.5 o.u./m^1 also as a 98 percentile has also been proposed to provide a general level of protection against odour nuisance for the general public. A predicted odour concentration of 1.5 o.u./m^3, expressed as a 98 percentile of hourly values, is recommended by the Environment Agency in the U.K. (IPPC H4 Horizontal Guidance for Odour Part 1, 2003) for sources with a potential for offensive odours, including wastewater treatment plants.

It is evident from the analysis of the modelled odour impact due to emissions from the proposed treatment plant that the potential for significant malodours to be detected beyond the boundary to the plant will be very low. No significant impact, likely to result in an odour nuisance in the locality of the nearest private properties is predicted as a result of the planned expansion to the wastewater treatment plant.

5.0 ODOUR CONTROL MEASURES

The following measures to control and reduce potential sources of malodours are proposed for the expansion programme of the wastewater treatment plant at Carrickmacross: -

- The inlet works channels and screening equipment will be housed in a purpose designed building

- Screened coarse material and grit from the grit trap will be washed and transferred into covered skips located within the inlet works building.

- Diffused fine-bubble aeration and sub-surface mixers will be used in the oxidation ditches to improve mixing and reduce the turbulence and hence the potential for generating malodours and aerosols from the tank liquor surface. In addition, the level of dissolved oxygen will be continuously monitored to prevent anaerobic conditions forming in the mixed liquor.

- Odorous emissions from the sludge dewatering building will be vented to atmosphere via a high efficiency odour control unit.

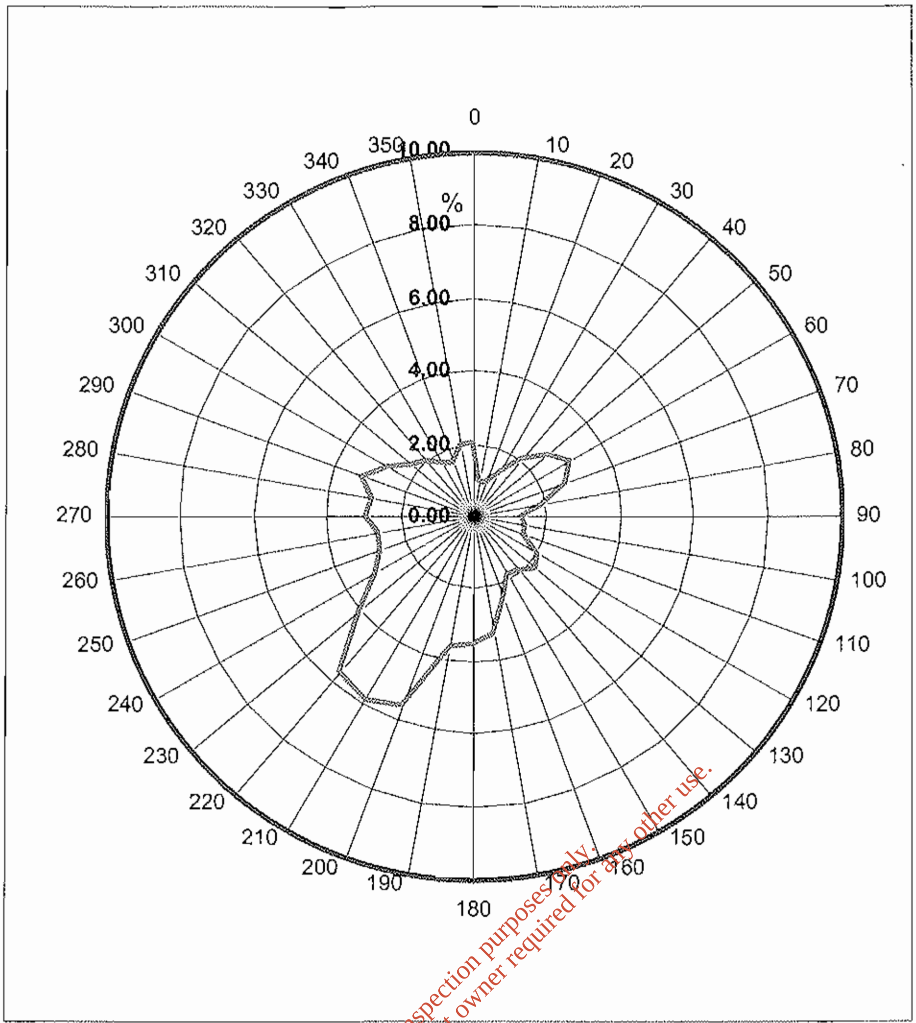
- The secondary sludge thickening tank will be covered and the headspace air in the tank ducted to the sludge treatment building odour control unit.

- The odour control units will operate with removal efficiencies of over 95%. It is planned that one odour control unit will treat foul air from the inlet works, with a second unit for treating headspace air from the sludge treatment plant. These units may be stand-alone systems installed at ground level or emission vents located on the buildings. The location and design of the exhaust stacks to these units will ensure that adequate vertical release of emissions is achieved. The odour control systems to be installed will ensure that no malodours occur beyond the site boundary from the exhaust stacks.

6.0 CONCLUSION

The design and operation of the proposed expansion of the wastewater treatment plant at Carrickmacross minimises the potential for malodours to be detected beyond the site boundary. Based on the results of the odour dispersion modelling study carried out, no significant impact on the ambient air quality of the area is predicted due to odour emissions from the wastewater treatment plant.

FIGS 1-3
WIND ROSE AND ODOUR DISPERSION MODELLING RESULTS



HOURLY WIND DIRECTION FREQUENCY - ALL WIND SPEEDS

Direction	Percentage Occurrence of Wind Speeds (m/s)						
	<2	2-3	3-5	6-8	9-11	>11	All
350-10	1.01	1.11	1.31	1.11	0.21	0.0	4.74
20-40	1.31	1.21	1.21	0.71	0.12	0.0	4.55
50-70	2.82	2.92	1.91	0.81	0.03	0.0	8.49
80-100	1.61	1.21	0.91	0.60	0.03	0.0	4.36
110-130	1.31	1.31	1.71	1.11	0.21	0.0	5.76
140-160	0.91	1.01	1.61	1.70	0.71	0.01	6.07
170-190	1.31	1.61	2.72	3.30	1.01	0.03	10.20
200-220	2.72	3.32	4.43	4.00	1.01	0.03	15.64
230-250	2.32	2.92	3.73	3.02	0.6	0.03	12.62
260-280	1.61	1.81	2.22	2.02	0.5	0.02	8.29
290-310	1.31	1.61	2.62	2.32	0.6	0.02	8.59
320-340	1.11	1.31	1.81	1.20	0.3	0.0	5.84
Calms	4.80						4.8
Total	**24.1**	**21.3**	**26.1**	**21.9**	**5.3**	**0.15**	**100.0**

FIG 1: FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR HOURLY OBSERVATIONS AT CLONES, CO. MONAGHAN (1968-97)

FIG2-995%.jpg

1
1.5
2
2.5
32.9
32.5
ENVIROCON
Air Pollution
and Environmental Consultancy
Kilcarn Bridge
Navan, Co. Meath
Phone: 353-46-9074135, Fax: 353-46-9074055
0
50
100
150
200
tres

FIG3-98% (1).jpg


0.5
1
1.5
2
2.5
0.5
1
1.5
0.5
0.5
ENVIROCON
Air Pollution
and Environmental Consultancy
Kilcarn Bridge
Navan, Co. Meath
Phone: 353-46-9074135, Fax: 353-46-9074055
0
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