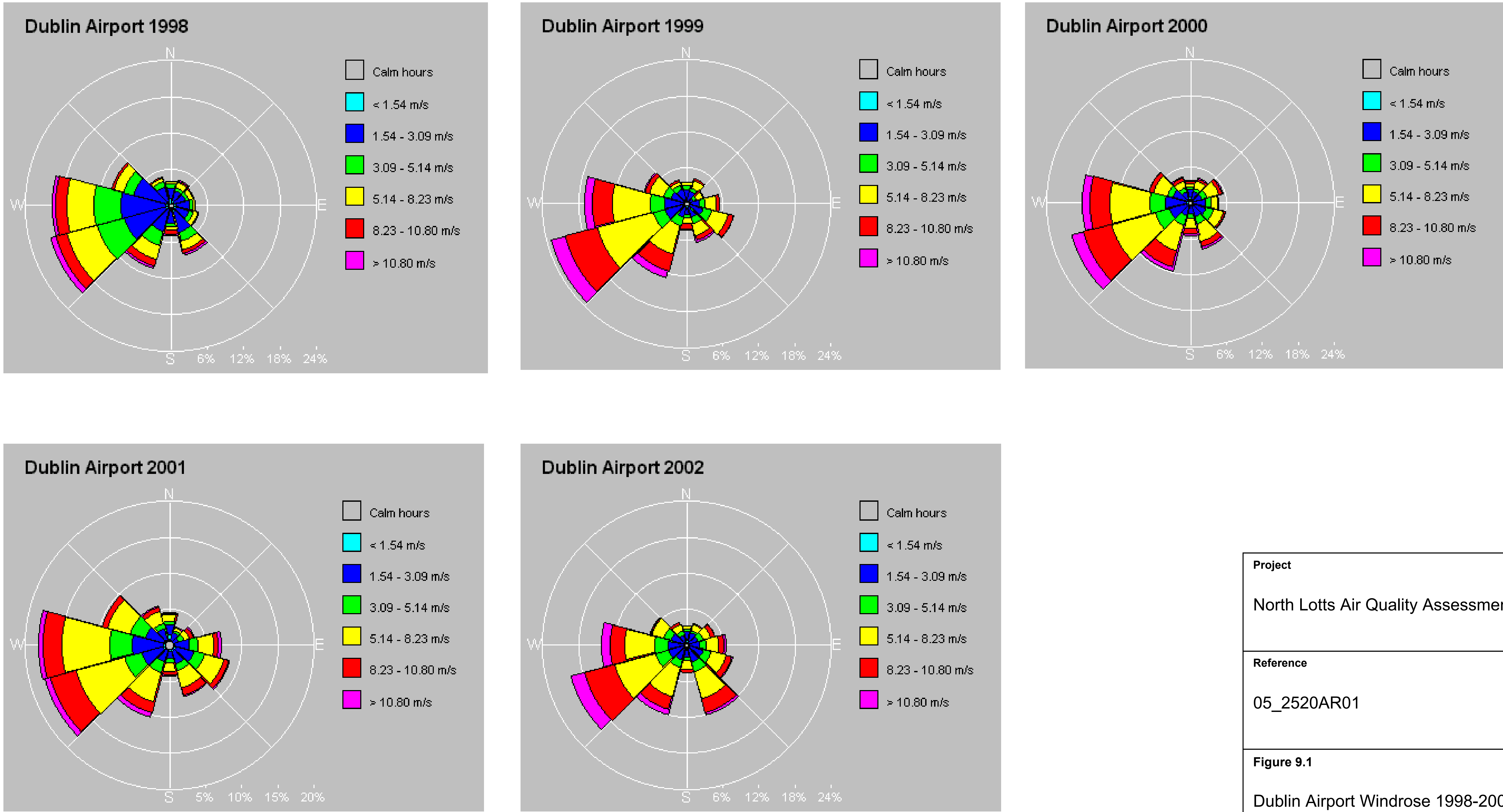


Project

North Lotts Air Quality Assessment

Reference

05_2520AR01

Figure 9.1

Dublin Airport Windrose 1998-2002

awn

consulting

The Tecpro Building, Clonshaugh Industrial Estate, Dublin 17. Tel: +353 (0)1 847 4220 Fax: +353 (0)1 847 4257

Baseline Air Quality

9.2.3 Air quality is variable and subject to both significant spatial and temporal variation. In relation to spatial variations in air quality, concentrations generally fall significantly with distance from major road sources[11]. Thus, residential exposure in urban and suburban areas will be determined by the location of sensitive receptors relative to major roads sources in the area. Temporally, air quality can vary significantly by orders of magnitude due to changes in traffic volumes, meteorological conditions and wind direction.

9.2.4 In assessing baseline air quality, two tools are generally used: ambient air monitoring and air dispersion modelling. In order to adequately characterise the current baseline environment through monitoring, comprehensive measurements would be required at a number of key receptors for PM_{10}, NO_2 and benzene. In addition, two of the key pollutants identified in the scoping study (PM_{10} and NO_2) have limit values which require assessment over time periods varying from one hour to one year. Thus, continuous monitoring over at least a one-year period at a number of locations would be necessary in order to fully determine compliance for these pollutants. Although this study would provide information on current air quality it would not be able to provide predictive information on baseline conditions[6], which are the conditions which prevail just prior to opening in the absence of the development (Year 2006). Hence the air quality in the opening year was fully assessed by air dispersion modelling[6] which is the most practical tool for this purpose. A short-term monitoring study was however carried out for NO_2, PM_{10} and benzene. The survey will allow an indicative assessment of the influence of local road sources relative to the prevailing background level of these pollutants in the area.

NO_2

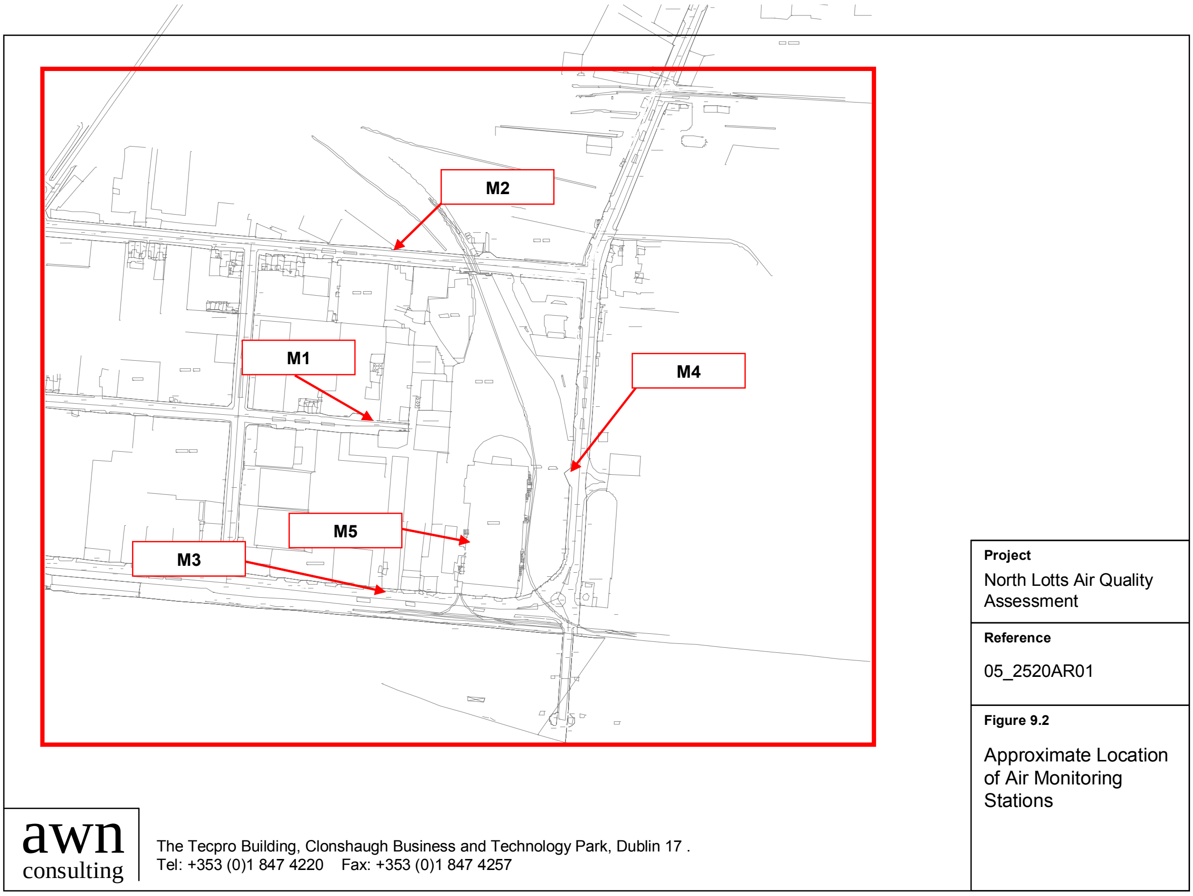
9.2.5 NO_2 was monitored, using nitrogen dioxide passive diffusion tubes, over a two-week period at four locations near the proposed scheme (M1-M4, see Figure 9.8). The locations allow an assessment of both worst-case and typical background exposure to NO_2. The results also allow an assessment of the spatial variation of NO_2 away from the main road sources in the area. The spatial variation away from roadside is particularly important for NO_2, as a complex relationship exists between NO, NO_2 and O_3 leading to a non-linear variation of NO_2 concentrations with distance from the road.

PM_{10}

9.2.6 PM_{10} was monitored, using a PM_{10} air sampling pump, over two 24-hour periods at one location near the proposed scheme (M5, see Figure 9.1). The location was positioned to allow an assessment of background concentrations in the region.

Benzene

9.2.7 Benzene was monitored, using passive diffusion tubes over a two-week period at two locations near the proposed scheme (M1 and M2, see Figure 9.2). The locations were positioned to allow an assessment of typical exposure of the residential population.



Assessment of Compliance

9.2.8 In terms of the current monitoring program, the on-site baseline level consists of the background concentration and, for each location, an additional roadside increment due to the emissions emanating from nearby (i.e. less than 300m) roads.

9.2.9 Nitrogen dioxide (NO_2) results are presented in Table 9.8. Average concentrations of nitrogen dioxide were high during the monitoring period at all four locations near the proposed development. Particularly high levels are apparent along North Wall Quay (monitoring location M3), with levels reducing way from this hot spot along Sheriff Street (M2) and East Wall Road (M4) and with much reduced levels along Mayor Street Upper (M1). Although levels were higher than the annual limit value everywhere during this two week period, a longer period of monitoring is necessary in order to determine actual long term background levels in the region. Usefully, two recent long-term monitoring programs in the region are available and have been reviewed to determine appropriate existing background levels of NO_2, PM_{10} and benzene (see "Available Baseline Data").

9.2.10 Benzene results are presented in Table 9.9. Average concentrations of benzene were significantly below the EU annual limit value of 5 µg/m^3 during the two week monitoring program averaging 30% of the annual limit value at the two residential locations (M1 and M2).

9.2.11 The results of the baseline PM_{10} monitoring are presented in Table 9.10. Average concentrations of PM_{10} were below the EU 24-hour limit value of 50 µg/m^3, averaging less than 60% of the annual limit value over the survey period at the background location (M5).

Available Baseline Data

9.2.12 Air quality monitoring programs have been undertaken in recent years by the EPA and Local Authorities. The most recent annual report on air quality "*Air Quality Monitoring Report 2003*" (EPA, 2005)[9], details the range and scope of monitoring undertaken throughout Ireland. Additionally, Dublin City Council has published a report entitled "*Air Quality Monitoring 2002-03*"[10] relating to extensive measurements carried out in 2002-03 across Dublin. A summary of the monitoring data available in Dublin and other urban areas in recent years is presented in Tables 9.11 - 9.15. In addition, two long term monitoring programs have been carried out in the area in recent years.

9.2.13 As part of the East Wall Traffic Management Scheme EIS (Arup Consulting Engineers, 2003), NO_2 monitoring was carried out over a period of eight weeks at a background location (Point Depot) in 2002. The average during this period was 40 µg/m^3 with no exceedences of the maximum one hour limit value of 200 µg/m^3. However, monitoring was carried out in winter with a lower level likely for the annual average. A second long-term monitoring program has been undertaken as part of the Poolbeg Waste To Energy (WTE) project (Dublin City Council / MCOS, 2004). NO_2 monitoring was carried out over a one year period at a roadside location (Irish Glass Ltd, Ringsend) in 2003-04. The average during this period was 33 µg/m^3 with one exceedence of the maximum one hour limit value of 200 µg/m^3. However, this sample was within 20m of a major road (Sean Moore Road) and thus consists of a background level and an additional increment due to the road traffic along Sean Moore Road.

9.2.14 NO_2 monitoring data from the EPA is available for two central Zone A stations (Winetavern Street and Coleraine Street) in 2003 with results averaging around 90 - 95% of the annual limit value with few exceedences of the one-hour limit value at either location (rarely peaking above 50% of the maximum one-hour limit value) (see Table 9.11). A extensive monitoring program has been carried out in Dublin (RESOLUTION, part of the EU LIFE program) consisting of six seven-day monitoring periods during 2000/01 at 146 locations across Dublin using diffusion tubes. Based on this spatially extensive study, a background map was produced estimating typical background concentrations of NO_2 across Dublin(8). The city-wide average background was 34 µg/m^3 whilst background concentrations(5,6) for East Wall was estimated at around 30 µg/m^3 in 2001 (see Table 9.14). Thus, taking into account available monitoring data representative of the area, a background concentration for NO_2 is estimated conservatively to be currently 27.2 µg/m^3 in 2005. Based on the expected reduction in background concentration(11), the background concentrations in 2006 and 2016 are predicted to be in the region of 26.5 µg/m^3 and 21.2 µg/m^3 respectively.

9.2.15 As part of the East Wall Traffic Management Scheme EIS (Arup Consulting Engineers, 2003), PM_{10} monitoring was carried out over a period of eight weeks at a background location (Point Depot) in 2001-02. The average during this period was 33 µg/m^3 with eleven exceedences of the maximum 24 hour limit value of 50 µg/m^3. PM_{10} monitoring was also carried out over two three-month periods at a roadside location (Irish Glass Ltd, Ringsend) in 2003-04 as part of the Poolbeg WTE project. The average during this period was 34 µg/m^3 with 24 exceedence of the maximum 24 hour limit value of 50 µg/m^3.

9.2.16 PM_{10} monitoring data from the EPA is available for two central Zone A stations (Winetavern Street and Coleraine Street) in 2003 with results averaging around 65 - 70% of the annual limit value with 28 and 38 exceedences of the 24-hour limit value respectively (see Table 9.12). Thus, taking into account available monitoring data representative of the area, a background concentration for PM_{10} is estimated to be 27.3 µg/m^3 in 2005. Based on the expected reduction in background concentration(11), the background concentrations in 2006 and 2016 are predicted to be in the region of 26.6 µg/m^3 and 23.9 µg/m^3 respectively.

9.2.17 In terms of benzene, an extensive benzene monitoring program was carried out in Dublin (RESOLUTION, part of the EU LIFE program) consisting of six seven-day monitoring periods during 2000/01 at 146 locations across Dublin using diffusion tubes(8). The city-wide average background was 1.6 µg/m^3 whilst the background concentration for the East Wall region was estimated at around 1.5 µg/m^3 (see Table 9.15). Monitoring data from the EPA is available for one central Zone A station (Winetavern Street) in 2003 with results averaging 1.6 µg/m^3 on an annual basis (see Table 9.13). Thus, taking into account available monitoring data representative of the area, a background concentration for benzene is estimated conservatively to be currently 0.85 µg/m^3 in 2005. Based on the expected reduction in background concentrations(11) in future years, the background concentrations in 2006 and 2016 are predicted to be in the region of 0.82 µg/m^3 and 0.70 µg/m^3 respectively.

9.2.18 In terms of CO, monitoring data from the EPA is available for two central Zone A stations (Winetavern Street and Coleraine Street) in 2003 with results averaging 0.2 mg/m^3 and 0.6 mg/m^3 respectively as an annual average. Based on the above information, an estimate of the background CO concentration is 0.69 mg/m^3 in 2005. Based on the expected reduction in background concentrations(11) in future years, the background concentrations in 2006 and 2016 are predicted to be in the region of 0.64 µg/m^3 and 0.43 µg/m^3 respectively.

9.3.0 CHARACTERISTICS OF THE DEVELOPMENT

9.3.1 Currently, road traffic is the dominant source of emissions in the region of the development (with the possible exception of PM_{10}). Detailed existing traffic flow information was obtained from the traffic consultant for the project and has been used to model pollutant levels under sufficient spatial resolution to assess whether any significant air quality impact on sensitive receptors is currently occurring or will occur in the future based on projected changes to traffic levels.

9.3.2 Cumulative effects have been assessed using the air dispersion model, as recommended in the EU Directive on EIA (Council Directive 97/11/EC) and using the methodology of the UK DEFRA(5,6). Firstly, background concentrations(11) have been included in the modelling study. These background concentrations are year-specific and account for non-localised sources of the pollutants of concern(11). The background concentrations for the current location are the ambient levels that would be present in the absence of the major roadways in the area. In order to determine baseline concentrations in 2006, the current background concentration (derived from analysis of the current survey and exsting EPA and local authority data) is added to the modelled increment for the road scheme, after correcting for the likely change in background concentration over the period 2005 – 2006. Appropriate background levels were selected based on the available urban background monitoring data provided by the EPA(3,5,6), two recent long-term surveys in the region and the current baseline survey (see Table 9.16). Once appropriate background concentrations were established, the existing baseline situation, including background levels, was assessed for the opening year (Year 2006) and the development year (Year 2016). As junction capacities are operating at or near capacity, it has been assumed that traffic levels will remain essentially unchanged with the development in place. However, "do-minimum" and "do-something" will differ for junction 1 as the worst-case residential receptors will change depending on the two scenarios from Mayor Street, currently, to the proposed residential receptors along North Wall Quay, with the scheme in place.

Air Dispersion Modelling – Screening Assessment

9.3.3 The screening assessment methodology involved air dispersion modelling using the UK DMRB Screening Model (Version 1.02)(11) and following guidance issued by the UK DEFRA(12-14). Ambient concentrations for CO, benzene, NO_2 and PM_{10} for the opening year (2006) and design year (2016), at the nearest sensitive receptors to the development, have been modelled. Modelling was carried out at the building façade of each of these receptors for all scenarios including the maximum one-hour NO_2 scenarios (as a 99.8th%ile).

Climate

9.3.4 ***Road traffic would be expected to be the dominant source of greenhouse gas emissions as a result of the scheme. Vehicles will give rise to CO_2 and N_2O emissions in the region of the proposed development.***

9.4.0 PREDICTED IMPACT OF THE PROPOSAL

"Do-Minimum" Modelling Assessment

CO and Benzene

9.4.1 The results of the "do minimum" modelling assessment for CO and benzene in the opening year are shown in Tables 9.17 – 9.18. Two receptors were modelled near the development; firstly near the junction of the East Wall Road with North Wall Quay and secondly near the junction of Sheriff Street Upper with Castleforbes Road. Concentrations are within the limit values under all scenarios at all worst-case receptors. Levels of both pollutants range from 18 – 69% of the respective limit values in 2006.

9.4.2 The temporal trend in these pollutants can be established by an examination of levels in 2006 and 2016 (see Tables 9.17 – 9.18). Future trends for the "do minimum" scenario indicate continuing low levels of CO and benzene. "Do minimum" levels of both pollutants range from 7% of the limit value for benzene to 28% of the annual limit value for carbon monoxide in 2016.

PM_{10} & $PM_{2.5}$

9.4.3 The results of the "do minimum" assessment for PM_{10} in the opening year are shown in Tables 9.17 – 9.18. Levels of PM_{10} range from 67 – 74% of the respective limit values in 2006.

9.4.4 The temporal trend in PM_{10} can be established by an examination of levels in 2006 and 2016 (see Tables 9.17 – 9.18). Future trends for the "do minimum" scenario indicate reduced levels of PM_{10}. However, Council Directive 1999/30/EC outlines more stringent PM_{10} limit values which may be applicable after 2010. These limit values are however indicative limit values which will be reviewed in the light of further information on health and environmental effects, technical feasibility etc. A comparison with these limit values indicates that "do minimum" levels will be above these indicative limit values in 2016 both in terms of the annual average and in terms of the maximum 24-hour limit values.

9.4.5 However, as previously noted, the European Commission sponsored report "Second Position Paper on Particulate Matter – Final" (December 2004) has recommended that the principal metric for assessing posure to particulates should be $PM_{2.5}$ rather than PM_{10} after 2010. The report also suggests that the $PM_{2.5}$ annual average should be in the range 12 – 20 $\mu g/m^3$ which should be compared with the PM_{10} annual limit value, to be complied with in 2005, of 40 $\mu g/m^3$. In relation to the maximum 24-hour limit value, a starting point for discussion has been set at 35 $\mu g/m^3$ as a 90^{th}%ile. These indicative limit values will be reviewed in the light of further information on health and environmental effects, technical feasibility etc. Therefore, in the current assessment it has been assumed that the appropriate parameter for determining compliance, after 2010, should be $PM_{2.5}$. A comparison with the $PM_{2.5}$ limit value in 2016 (see Table 9.19) indicates that at both locations, no exceedences of the proposed limit value will take place, assuming the limit value is set at the mid range of possible values (16 $\mu g/m^3$).

NO_2

9.4.6 The results of the "do minimum" assessment for NO_2 in the opening year are shown in Tables 9.17 – 9.18. Concentrations are below the annual limit value under all scenario at all locations. Future trends for the "do minimum" scenario indicate decreasing annual levels of NO_2. "Do minimum" annual average levels of NO_2 range from 54 – 70% of the annual limit value in 2006 (including the margin of tolerance) and 2016.

9.4.7 The EU limit value for the maximum one-hour standard for NO_2 is based on a one-hour mean not to be exceeded more than 18 times a year (99.8th%ile). "Do minimum" levels in 2006 are below this limit value, with levels at the worst-case receptor 70% of the EU limit value including the margin of tolerance. Temporally, "do minimum" levels of maximum one-hour NO_2 concentrations over the period 2006 to 2016 will decrease, with levels peaking at 63% of the limit value at the worst-case receptor in the design year (2016) (see Tables 9.17 – 9.18).

Modelled Impact of the Development Once Operational

<u>CO and Benzene</u>

9.4.8 The results of the modelled impact of the development for CO and benzene in the opening year are shown in Tables 9.17 – 9.18. Concentrations are below the ambient standards under all scenarios. Levels of both pollutants range from 19 – 75% of the respective limit values in 2006.

9.4.9 Future trends, with the development in place, indicate continuing low levels of CO, and benzene. Levels of both pollutants are below the relevant limit values under all scenarios. Levels of both pollutants range from 7 - 33% of the respective limit values in 2016.

9.4.10 The impact of the development can be assessed relative to "do minimum" levels in both the opening and design year (see Tables 9.17 – 9.18). For CO and benzene, relative to "do minimum" levels, the impact of the development will generally lead to some small increases as a result of the development. As a worst-case, levels will increase by 11% of the respective limit values.

9.4.11 Thus, using the assessment criteria outlined in Tables 9.6 and 9.7, the impact of the development in terms of CO and benzene is imperceptible.

<u>PM_{10} & $PM_{2.5}$</u>

9.4.12 The results of the "do something" assessment for PM_{10} in the opening year are shown in Tables 9.17 – 9.18. Levels of PM_{10} are predicted to be below the annual limit value at both locations. However, at the proposed receptor along North Wall Quay, an exceedence of the maximum 24-hour limit value is predicted using this screening study.

9.4.13 The temporal trend in PM_{10} can be established by an examination of levels in 2006 and 2016 (see Tables 9.17 – 9.18). Future trends for the “do something” scenario indicate reduced levels of PM_{10} although again these are above the indicative limit values in 2016 both in terms of the annual average and in terms of the maximum 24-hour limit values.

9.4.14 As previously explained, however, in the current assessment it has been assumed that the appropriate parameter for determining compliance, after 2010, should be $PM_{2.5}$. A comparison with the $PM_{2.5}$ limit value in 2016 (see Table 9.19) indicates that for the "do-something" scenario at both locations, no exceedences of the proposed limit value will take place, assuming the limit value is set at the mid range of possible values (16 □g/m^3).

9.4.15 The impact of the development can be assessed relative to "do minimum" levels in both the opening and design year (see Tables 9.17 – 9.19). For PM_{10} (in 2006) and $PM_{2.5}$ (in 2016), relative to "do minimum" levels, the impact of the development will generally lead to some modest increases as a result of the development. As a worst-case, levels will increase by 15% of the respective limit values.

9.4.16 In the event of an exceedence, as predicted using the DMRB screening study, a more advanced and detailed modelling assessment is recommended in order to determine more accurately whether there will be an exceedence of the ambient air quality standard. Thus, a detailed air dispersion modelling exercise has been carried out for PM_{10} and $PM_{2.5}$ in both 2006 and 2016 (see section "Detailed Air Modelling Assessment").

<u>NO_2</u>

9.4.17 The result of the assessment of the impact of the development for NO_2 in the opening year (2006) is shown in Tables 9.17 – 9.18. The annual average concentration is within the annual limit value for all scenarios. Future trends, with the development in place, indicate reduced annual levels of NO_2. Levels of NO_2 range from 73 - 84% of the annual limit value in 2006 and 2016. The impact of the development will account for, at most, 27% of the annual limit values in either 2006 or 2016 at any specific receptor.

9.4.18 Maximum one-hour NO_2 levels in 2006 (as a 99.8th%ile), with the development in place, will be below the limit value and margin of tolerance, with levels at the worst-case receptor 84% of the limit value. Temporally, maximum one-hour NO_2 concentrations, with the development in place, will decrease, by up to 9% of the limit value between 2006 and 2016.

9.4.19 The impact of the development on maximum one-hour NO_2 levels can be assessed relative to "do minimum" levels in both the opening and design year (see Tables 9.17 – 9.18). Levels are generally higher with the development in place, by up to 27% of the limit value. However, predicted levels will still be below the NO_2 maximum one-hour limit value, with worst-case levels peaking at 73% of the limit value in 2016.

9.4.20 Thus, using the assessment criteria outlined in Tables 9.6 and 9.7, the impact of the development in terms of NO_2 is slight.

Detailed Air Modelling Assessment

9.4.21 As the DMRB screening study has predicted an exceedence of the ambient air quality standard for PM_{10} in 2006 with the scheme in place, a more advanced and detailed modelling assessment has been carried out for these parameters(5). The assessment has also been conducted for NO_2 as levels in 2006 are predicted to be above the limit value which is applicable in 2010 (although levels are below the limit value plus margin of tolerance which is applicable in 2006).

9.4.22 The inputs to the CAL3QHCR(16) air dispersion model consist of information on road layouts, hourly traffic movements and a full year of meteorological data. Site-specific composite traffic emission factors have been derived based on an analysis of vehicle type, average speeds and model year of vehicle. Appendix 9.1 details how these emission factors have been derived for the current scheme. The year giving the highest ambient concentrations of NO_2, for the scenario with the scheme in place in the opening year (2006), over a five-year period (1998-2002) has been incorporated into the model (Dublin Airport 1998) and has been used to determine hourly concentrations for all pollutants of concern at each specified receptor in the region of North Lotts.

9.4.23 Peak, one-hour concentrations for NO_2, PM_{10} and $PM_{2.5}$ for year 2006 and 2016 ($PM_{2.5}$ in year 2016 only), at the nearest sensitive receptors to the proposed development, have been modelled using the USEPA approved CAL3QHCR(16) dispersion model, which is based on the USEPA approved CALINE3(17) dispersion model, in conjunction with the most recent European emissions database (COPERT III)(18). Detailed modelling methodology has been outlined in Appendix 9.1.

9.4.24 In the modelling assessment a number of specific sensitive receptors were identified within several hundred metres of the proposed scheme. “Do-minimum” and “do-something” modelling was carried out at the building façade of each of these receptors for all scenarios including the maximum one-hour NO_2 scenarios (as a 99.8th%ile).

Detailed Modelling - “Do-Minimum” Assessment

PM_{10} & $PM_{2.5}$

9.4.25 The results of the detailed modelling of the "do minimum" assessment for PM_{10} in the opening year is shown in Table 9.20. PM_{10} peaks at 74% of the annual limit value and at 66% of the maximum 24-hour limit values in 2006.

9.4.26 The temporal trend in PM_{10} can be established by an examination of levels in 2006 and 2016 (see Table 9.20). Future trends for the “do minimum” scenario indicate reduced levels of PM_{10} although levels will still be above the indicative limit value proposed for 2010. However, after 2010, the relevant parameter is likely to be $PM_{2.5}$. A comparison with the $PM_{2.5}$ limit value in 2016 (see Table 9.20) indicates that no exceedences of the proposed limit value will take place, assuming the limit value is set at the mid range of possible values (16 $\mu g/m^3$). $PM_{2.5}$ peaks at 74% of the annual limit value and at 37% of the maximum 24-hour limit values in 2016.

NO_2

9.4.27 The results of the detailed modelling of the "do minimum" assessment for NO_2 in the opening year are shown in Table 9.20. Concentrations are below the annual limit value under all scenario at all locations. Future trends for the “do minimum” scenario indicate decreasing annual levels of NO_2. "Do minimum" annual average levels of NO_2 range from 60 – 63% of the annual limit value in 2006 and 2016.

9.4.28 The EU limit value for the maximum one-hour standard for NO_2 is based on a one-hour mean not to be exceeded more than 18 times a year (99.8th%ile). "Do minimum" levels in 2006 are below this limit value, with levels at the worst-case receptor 54% of the EU limit value (including the margin of tolerance).

9.4.29 Temporally, "do minimum" levels of maximum one-hour NO_2 concentrations over the period 2006 to 2016 will decrease, with levels peaking at 41% of the limit value at the worst-case receptor in the design year (2016) (see Tables 9.20).

Detailed Modelling – “Do-Something Assessment”

PM_{10} & $PM_{2.5}$

9.4.30 The results of the detailed modelling of the "do something" assessment for PM_{10} in the opening year is shown in Table 9.20. PM_{10} peaks at 75% of the annual limit value and at 66% of the maximum 24-hour limit values in 2006.

9.4.31 The temporal trend in PM_{10} can be established by an examination of levels in 2006 and 2016 (see Table 9.20). Future trends for the “do something” scenario indicate reduced levels of PM_{10} although levels will still be above the indicative limit value proposed for 2010. However, after 2010, the relevant parameter is likely to be $PM_{2.5}$. A comparison with the $PM_{2.5}$ limit value in 2016 (see Table 9.20) indicates that no exceedences of the proposed limit value will take place, assuming the limit value is set at the mid range of possible values (16 $\mu g/m^3$). $PM_{2.5}$ peaks at 74% of the annual limit value and at 37% of the maximum 24-hour limit values in 2016

9.4.32 The impact of the development can be assessed relative to "do minimum" levels in both the opening and design year (see Tables 9.20). For PM_{10} (in 2006) and $PM_{2.5}$ (in 2016), relative to "do minimum" levels, the impact of the development will generally lead to some small increases as a result of the development. As a worst-case, levels will increase by 1% of the respective limit values.

9.4.33 Thus, using the assessment criteria outlined in Tables 9.6 and 9.7, the impact of the development in terms of PM_{10} (in 2006) and $PM_{2.5}$ (in 2016) is imperceptible.

NO_2

9.4.34 The results of the detailed modelling for the "do something" assessment for NO_2 in the opening year is shown in Table 9.20. The annual average concentration is within the annual limit value for all scenarios. Future trends, with the development in place, indicate reduced annual levels of NO_2. Levels of NO_2 range from 60 - 63% of the annual limit value in 2006 and 2016. The impact of the development will account for at most 1% of the annual limit values in either 2006 or 2016 at any specific receptor.

9.4.35 Maximum one-hour NO_2 levels in 2006 (as a 99.8^{th}%ile), with the development in place, will be significantly below the limit value, with levels at the worst-case receptor 62% of the limit value (including the margin of tolerance). Temporally, the maximum one-hour NO_2 concentration, with the development in place, will decrease, by up to 30% of the limit value between 2006 and 2016.

9.4.36 The impact of the development on the maximum one-hour NO_2 level can be assessed relative to "do minimum" levels in both the opening and design year (see Tables 9.20). Levels are generally higher with the development in place, by up to 8% of the limit value. However, predicted levels will still be well below the NO_2 maximum one-hour limit value, with worst-case levels peaking at 46% of the limit value in 2016.

9.4.37 Thus, using the assessment criteria outlined in Tables 9.6 and 9.7, the impact of the development in terms of NO_2 is imperceptible (this should be compared to the screening assessment which found the impact to be slight).

Summary of Modelling Assessment

9.4.38 "Do minimum" screening modelling assessments for CO and benzene indicate that concentrations will be significantly within the ambient air quality standards under all scenarios. In addition, the impact of the development will account for at most 11% of the respective limit values. Cumulatively, levels will still be well within the ambient air quality limit values under all scenarios. Levels of all three pollutants range from 7 - 75% of the respective limit values in 2006 and 2016. Thus, the impact of the development for these two pollutants is imperceptible.

9.4.39 The detailed modelling assessment for NO_2 indicates that annual concentrations will be within the air quality standard under all scenarios. Levels of NO_2, with the development in place, will range from 60 - 63% of the annual limit value in 2006 and 2016. The maximum one-hour modelling assessment for NO_2 also indicates that levels will be within the applicable limit value in 2006 and 2016 for all scenarios. The impact of the development on NO_2 levels will be to increase levels by, at most, 8% of the respective maximum one-hour limit values in either 2006 or 2016. However, predicted levels will still be below the NO_2 maximum one-hour limit value, with worst-case levels peaking at 62% of the limit value in 2006 and at 46% of the limit value in 2016. Thus, the impact of the development, in terms of NO_2, is deemed imperceptible.

9.4.40 The detailed modelling assessment for PM_{10} indicates that annual concentrations will be within the air quality standard under all scenarios. Levels of PM_{10}, with the development in place, will be 75% of the annual limit value in 2006. The maximum 24-hour modelling assessment for PM_{10} also indicates that levels will be within the applicable limit value in 2006. The impact of the development on PM_{10} levels will be to increase levels by, at most, 1% of the respective maximum 24-hour limit value in 2006. However, predicted levels will still be below the PM_{10} maximum 24-hour limit value, with worst-case levels peaking at 66% of the limit value in 2006. Thus, the impact of the development, in terms of PM_{10}, is deemed imperceptible.

9.4.41 The detailed modelling assessment for $PM_{2.5}$ indicates that annual concentrations will be within the air quality standard under all scenarios. Levels of $PM_{2.5}$, with the development in place, will be 74% of the annual limit value in 2016. The maximum 24-hour modelling assessment for $PM_{2.5}$ also indicates that levels will be within the applicable limit value in 2016. The impact of the development on $PM_{2.5}$ levels will be to increase levels by, at most, 1% of the respective maximum 24-hour limit value in 2016. However, predicted levels will still be below the $PM_{2.5}$ maximum 24-hour limit value, with worst-case levels peaking at 37% of the limit value in 2016. Thus, the impact of the development, in terms of $PM_{2.5}$, is deemed imperceptible.

9.4.42 In summary, levels of traffic-derived air pollutants will not exceed the ambient air quality standards both with and without the development in place. Thus, using the assessment criteria outlined in Tables 9.6 and 9.7, the impact of the development in terms of NO_2, PM_{10}, $PM_{2.5}$, CO and benzene is imperceptible.

Macroclimate Impact

9.4.43 Greenhouse gas emissions, as a result of this scheme, will be insignificant in terms of Ireland's obligations under the Kyoto Protocol[(1,2)].

Modification Of Atmospheric Conditions

9.4.44 The size and nature of the development and the nature and volume of emissions will have no significant impact.

Modification Of The Existing Heat Balance In The Area

9.4.45 Mesoscale meteorological modelling results indicate that heat islands in US cities may lead to 1.5-3ºC increases relative to the suburbs in the afternoon in summer[19]. Relative to this kind of increase, the size and nature of the proposed development and the nature and volume of emissions will have no significant impact.

9.5.0 MITIGATION MEASURES

9.5.1 Mitigation measures in relation to traffic-derived pollutants have focused generally on improvements in both engine technology and fuel quality. Recent EU legislation, based on the EU sponsored Auto-Oil programmes, has imposed stringent emission standards for key pollutants (Euro III and Euro IV (98/69/EC) for passenger cars to be complied with in 2002 and 2006 respectively and Euro III, IV and V for diesel HGVs to be introduced in 2001, 2006 and 2008). In relation to fuel quality, a recent EU Fuel Directive (98/70/EC) has introduced significant reductions in both sulphur and benzene content of fuels.

9.5.2 In relation to design and operational aspects of road schemes, emissions of pollutants from road traffic can be controlled most effectively by either diverting traffic away from heavily congested areas or ensuring free flowing traffic through good traffic management plans and the use of automatic traffic control systems[12]. Improvements in air quality are likely over the nt few years as a result of the introduction of a comprehensive vehicle inspection and maintenance program, fiscal measures to encourage the use of alternatively fuelled vehicles and the introduction of cleaner fuels.

Macroclimate

9.5.3 CO_2 emissions will be reduced to 120 g/km by 2012 through EU legislation. This measure will reduce CO_2 emissions from new cars by an average of 25% in the period 1995 to 2008/2009 whilst 15% of the necessary effort towards the overall climate change target of the EU will be met by this measure alone[20]. Additional fuel efficiency measures include VRT and Motor Ta9 rebalancing to favour the purchases of more fuel-efficient vehicles, the National Car Test and Fuel Economy Labelling[20,21].

9.6.0 CONSTRUCTION IMPACTS AND MITIGATION MEASURES

Local Construction Impacts

9.6.1 There is the potential for a number of emissions to the atmosphere during the construction of the development. In particular, the construction activities may generate quantities of dust. Construction vehicles, generators etc., will also give rise to some haust emissions.

9.6.2 There is the potential for a number of greenhouse gas emissions to atmosphere during the construction of the development. Construction vehicles, generators etc., may give rise to CO_2 and N_2O emissions.

Predicted Impacts

9.6.3 If a satisfactory dust minimisation plan is implemented, the effect of construction on air quality will not be significant.

Mitigation Measures

9.6.4 A dust minimisation plan will be formulated for the construction phase of the project, as construction activities are likely to generate some dust emissions (detailed in Appendix 9.2).

9.7.0 FORECASTING METHODS

9.7.1 The air quality assessment has been carried out following procedures described in the publications by the EPA[22,23] and using the methodology outlined in the guidance documents published by the UK DEFRA [5-6,11-14]. Long term monitoring was carried out through the use of continuous posure of NO_2 and benzene diffusion tubes over a period of two weeks and PM_{10} over 2 days using the methodology recommended by the WHO (WHO (1999))[15] and the UK DEFRA[5].

9.7.2 Prediction of traffic derived pollutants was carried out using the UK DMRB Screening Model (Version 1.02 (Nov. 2003))[11] and following guidance issued by the UK DEFRA[12-14] and the EPA[19,20]. Detailed prediction of traffic-derived pollutants was carried out, using the USEPA approved CAL3QHCR[16] Gaussian air dispersion model which is specifically formulated for compl and over-capacity traffic junctions.

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Pollutant	Regulation	Limit Type	Margin of Tolerance	Value
Nitrogen Dioxide	1999/30/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	40% until 2003 reducing linearly to 0% by 2010	200 µg/m^3 NO_2
		Annual limit for protection of human health	40% until 2003 reducing linearly to 0% by 2010	40 µg/m^3 NO_2
		Annual limit for protection of vegetation	None	30 µg/m^3 NO + NO_2
Lead	1999/30/EC	Annual limit for protection of human health	60% until 2003 reducing linearly to 0% by 2005	0.5 µg/m^3
Sulphur dioxide	1999/30/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	90 µg/m^3 until 2003, reducing linearly to 0 µg/m^3 by 2005	350 µg/m^3
		Daily limit for protection of human health - not to be exceeded more than 3 times/year	None	125 µg/m^3
		Annual & Winter limit for the protection of ecosystems	None	20 µg/m^3
Particulate Matter Stage 1	1999/30/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	30% until 2003 reducing linearly to 0% by 2005	50 µg/m^3 PM_{10}
		Annual limit for protection of human health	12% until 2003 reducing linearly to 0% by 2005	40 µg/m^3 PM_{10}
Particulate Matter Stage 2[1]	1999/30/EC	24-hour limit for protection of human health - not to be exceeded more than 7 times/year	Not to be exceeded more than 28 times until 2006, 21 times until 2007, 14 times until 2008, 7 times until 2009 and zero times by 2010.	50 µg/m^3 PM_{10}
		Annual limit for protection of human health	50% from 2005 reducing linearly to 0% by 2010	20 µg/m^3 PM_{10}

[1]EU 1999/30/EC states "Indicative limit values to be reviewed in the light of further information on health and environmental effects, technical feasibility and perience in the application of Stage 1 limit values in the Member States".

Table 9.1 Air Quality Standards Regulations 2002 (based on EU Council Directive 1999/30/EC)

Pollutant	Regulation	Limit Type	Margin of Tolerance	Value
Benzene	2000/69/EC	Annual limit for protection of human health	100% until 2006 reducing linearly to 0% by 2010	5 $\mu g/m^3$
Carbon Monoxide	2000/69/EC	8-hour limit (on a rolling basis) for protection of human health	60% until 2003 reducing linearly to 0% by 2005	10 mg/m^3 (8.6 ppm)

Table 9.2 Air Quality Standards Regulations 2002 (based on EU Council Directive 2000/69/EC)

Pollutant	Regulation	Type	Period	Value
Nitrogen Dioxide	85/203/EEC	Limit Value	98th percentile of yearly mean hourly concentrations	200 µg/m^3
		Guide Value		135 µg/m^3
		Guide Value	50th percentile of yearly mean hourly concentrations	50 µg/m^3
Lead	82/884/EEC	Limit Value	Annual mean	2 µg/m^3
Sulphur dioxide	80/779/EEC	Limit Value	98th percentile of yearly mean hourly concentrations	250-350[1] µg/m^3
		Limit Value	Winter (medium of daily values)	130 or 180[1] µg/m^3
		Limit Value	One year (medium of daily values)	80 or 120[1] µg/m^3
		Guide Value	98th percentile of yearly mean hourly concentrations	135 µg/m^3
		Guide Value	50th percentile of 1-hour means	50 µg/m^3
Smoke	80/779/EEC	Limit Value	One year (medium of daily values)	80 µg/m^3
		Limit Value	Winter (medium of daily values)	130 µg/m^3
		Limit Value	98th percentile of daily values	250 µg/m^3

[1] The lower daily values refer to the situation with corresponding high levels of black smoke.

Table 9.3 Existing European Union Air Standards

Pollutant	Averaging Period	Primary & Secondary Standard [Note 1] ($\mu g/m^3$)	PSD Increment Class II [Note2] ($\mu g/m^3$)
PM_{10}	Annual – Average over 3 years	50	17
	24-Hour – as a 99th%ile over 3 years	150	30
NO_2	Annual Mean	100	25
CO	8-Hour – 3-year average of annual 4th highest daily maximum 8-hour conc.	10,000	-
	1-Hour – not to be exceeded more than 3 times in 3 consecutive years	40,000	-
Hydrocarbon (Benzene)	3 Hours (6-9 AM) (corrected for methane)	160	-

[Note 1] Primary standards to protect public health whilst secondary standards are set to protect public welfare
[Note 2] Class I areas are national parks and similar areas. Class II are all areas not originally classified as Class I.

Table 9.4 US National Ambient Air Quality Standards (NAAQS) & PSD Increments

Substances	Time-weighted Average	Averaging Time
Lead	0.5 µg/m^3	1 year
Nitrogen dioxide	200 µg/m^3 40-50 µg/m^3	1 hour annual
Carbon monoxide	100 µg/m^3 60 µg/m^3 30 µg/m^3 10 µg/m^3	15 minutes 30 minutes 1 hour 8 hour
Benzene	[Note 1]	
Particulate matter (PM_{10})	[Note 2]	

[Note 1] No safe level recommended owing to carcinogenicity.
[Note 2] No specific guideline recommended because no obvious posure concentration and duration that could be judged a threshold and decreased by uncertainty factors to avoid risk.

Table 9.5 WHO Air Quality Guidelines For Europe 2000.

Degree of Impact	**Definition**
Profound	Exceedance of Alert Threshold as detailed in any EU Air Quality Directive or equivalent as assessed by detailed air quality modelling
Severe	Exceedance of any EU Air Quality Directive and Margin of Tolerance as

	assessed by detailed air quality modelling
Significant	Exceedance of EU Air Quality Directive (although below the Margin of Tolerance) and exceedance of PSD Increment as assessed by detailed air quality modelling
Moderate	Exceedance of EU Air Quality Directive (although below the Margin of Tolerance) but no exceedance of PSD Increment as assessed by detailed air quality modelling
Slight	Exceedance of Upper Assessment Threshold (although below the EU Air Quality Directive) and exceedance of PSD Increment as assessed by detailed air quality modelling
Imperceptible	Below the EU Air Quality Directive with no exceedance of PSD Increment as assessed by detailed air quality modelling
Slight Beneficial	Improvement to below the Upper Assessment Threshold as detailed in any EU Air Quality Directive by a margin greater than the PSD Increment as assessed by detailed air quality modelling
Moderate Beneficial	Improvement to below the EU Air Quality Directive as detailed in any EU Air Quality Directive by a margin greater than the PSD Increment as assessed by detailed air quality modelling

Table 9.6 Criteria to Quantify the Potential Impact of Development

Table 9.7 Criteria to Quantify the Potential Impact of Development – Specific Pollutant Guidance

Degree of Significance	Criteria (as assessed by detailed air quality modelling)	**Carbon Monoxide (mg/m³)**	**Benzene (□g/m³)**	**Nitrogen Dioxide (□g/m³)**		**Particulates (PM_{10}) (□g/m³)**	
		Maximum 8-hour[Note 1]	Annual mean[Note 1]	Maximum 1-hr NO_2[Note 2]	Annual average NO_2[Note 2]	Annual average[Note 2]	Maximum 24-hr values[Note 2]
Profound	Exceedance of Alert Threshold as detailed in EU Air Quality Directive	>20[Note 3]	>15[Note 3]	>400	>80[Note 3]	>80[Notes 3,4]	>100[Notes 3,4]
Severe	Exceedance of any EU Air Quality Directive and Margin of Tolerance	>15	>10	>300	>60	>48	>75
Significant	Exceedance of EU Air Quality Directive (although below the Margin of Tolerance) and exceedance of PSD Increment	>10 >2[Note 5]	>5.0 >1.3[Note 5]	>200 >50[Note 5]	>40 >10[Note 6]	>40 >13[Note 6]	>50 >10[Note 6]
Moderate	Exceedance of EU Air Quality Directive (although below the Margin of Tolerance) but no exceedance of PSD Increment	>10 <2[Note 5]	>5.0 <1.3[Note 5]	>200 <50[Note 5]	>40 <10[Note 6]	>40 <13[Note 6]	>50 <10[Note 6]
Slight	Exceedance of Upper Assessment Threshold (although below the EU Air Quality Directive) as detailed in any EU Air Quality Directive and exceedance of PSD Increment	>7 >2[Note 5]	>3.5 >1.3[Note 5]	>140 >50[Note 5]	>32 >10[Note 6]	>28 >13[Note 6]	>30 >10[Note 6]
Imperceptible	Below the EU Air Quality Directive as detailed in any EU Air Quality Directive with no exceedance of PSD Increment	10 2[Note 5]	5.0 1.3[Note 5]	200 50[Note 5]	40 10[Note 6]	40 13[Note 6]	50 10[Note 6]
Slight Beneficial	Improvement to below the Upper Assessment Threshold as detailed in any EU Air Quality Directive by a margin greater than the PSD Increment	7 2Note 5	3.5 1.3Note 5	140 50Note 5	32 10Note 6	28 13Note 6	30 10Note 6

Moderate Beneficial	mprovement to below the EU Air Quality Directive as detailed in any EU Air Quality Directive by a margin greater than the PSD Increment	10 2Note 5	5.0 1.3Note 5	200 50Note 5	40 10Note 6	40 13Note 6	50 10Note 6

Note 1 EU Council Directive 2000/69/EC Note 2 EU Directive 1999/30/EC

Note 3 No alert threshold set – limit relative to the alert threshold for NO_2 Note 4 Alert threshold to be considered by end of 2003 – Council Directive 1999/30/EC

Note 5 No PSD Increment Available – based on average of other PSD increments Note 6 Relative PSD Increment, USEPA Limit Values vary from EU Limits

Location	Sampling Period	NO_2 Concentration (□g/m^3)
Mayor Street Upper (M1)	22/05/05 - 08/03/05	47
Sheriff Street Upper (M2)	22/05/05 - 08/03/05	82
North Wall Quay (M3)	22/05/05 - 08/03/05	122
Point Depot Entrance (M4)	22/05/05 - 08/03/05	81
Limit Value		40[1]

(1) EU Council Directive 1999/30/EC (as an annual average).

Table 9.8 Results Of NO_2 Diffusion Tube Monitoring Carried Out Near The Site Of The Proposed North Lotts Mi9ed-Use Development

Location	Sampling Period	Benzene Concentration (□g/m^3)
Mayor Street Upper (M1)	22/05/05 - 08/03/05	1.5
Sheriff Street Upper (M2)	22/05/05 - 08/03/05	1.5
Limit Value		5[1]

(1) EU Council Directive 2000/69/EC (as an annual average).

Table 9.9 Results Of Benzene Diffusion Tube Monitoring Carried Out Near The Site Of The Proposed North Lotts Mi9ed-Use Development

Location	Sampling Period	PM_{10} Concentration (□g/m^3)
Point Depot (M5)	31/05/05-01/06/05	28
	01/06/05-02/06/05	18
Two day Average		**23**
Limit Value (Compliance Date 2005)		Maximum 24-Hour = 50[1] Annual = 40[1]

(1) EU Council Directive 1999/30/EC

Table 9.10 Results Of PM_{10} Monitoring Carried Out Near The Site Of The Proposed North Lotts Mi9ed-Use Development

Table 9.11 Trends In Dublin City Air Quality - Nitrogen Dioxide (μg/m^3)[7-10]

Station	Station Classification Council Directive 96/62/EC	Averaging Period	**Year** 1999	2000	2001	2002	2003	**Average**
Rathmines	Urban Traffic	Annual average NO_2	17	19	32	22	-	**23**
	Distance From Road = 3 m	Maximum 1-hr NO_2	64 (42)	554 (55)	155 (85)	118 (71)	-	**63**
Whitehall (Beaumont)	Urban Background	Annual average NO_2	18	N.A.	N.A.	-	-	**18**
	Distance From Road = 200 m	Maximum 1-hr NO_2	94 (53)	N.A.	N.A.	-	-	**53**
Crumlin	Suburban	Annual average NO_2	22 (over a 6 month program)	24	22		-	
	Distance From Road = 8 m	Maximum 1-hr NO_2	111 (68)	149 (78)	117 (74)		-	
Coleraine Street	Urban Traffic	Annual average NO_2	-	41	39	38	37	**39**
	Distance From Road = 3 m	Maximum 1-hr NO_2	-	208 (101)	193 (92)	-	117	**103**
Ballyfermot	Urban Background	Annual average NO_2	-	-	-	-	26	**26**

		Maximum 1-hr NO_2	-	-	-	-	124	**124**
Winetavern Street	Urban Traffic	Annual average NO_2	-	≈32	33	35	38	**35**
	Distance From Road = 50 m	Maximum 1-hr NO_2	-	≈155-	1235 (214)	-	150	**173**
Background Concentration At Current Location	NO_2 Background Concentration	Annual average NO_2	**Year 2005 = 27.2 □g/m³, Year 2006 = 26.5 □g/m³, Year 2016 = 21.24 □g/m³(1)**					

(1) Based on a background NO_2 level for 2005 and using the DEFRA[5] background methodology to extrapolate to 2006 and 2016.
( ): represent the 98th%Ile of maximum 1-hour concentrations.
≈: Indicates appro9imate value from a graph reproduced in the EPA report " Preliminary Assessment Under Article 5 of Council Directive 96/62/EC – Ireland"[24].

Table 9.12 Trends In PM_{10} and $PM_{2.5}$ ($\mu g/m^3$)(7-10)

Station	Station Classification Council Directive 96/62/EC	Averaging Period	**Year** 1999	2000	2001	2002	2003	**Average**
Rathmines	Urban Traffic	Annual average PM_{10}	18	19	28	19	23	**21**
	Distance From Road = 3 m	24-hr PM_{10} > 50 $\mu g/m^3$	3	6	23	12	27	**14**
Wood Quay / Winetavern St	Urban Traffic	Annual average PM_{10}	35	N.A.	28	23	26	**28**
	Distance From Road = 7 m	24-hr PM_{10} > 50 $\mu g/m^3$	45	N.A.	28	14	28	**29**
Phoeni9 Park	Suburban Background	Annual average PM_{10}	16	16	18	15	13	**16**
	Distance From Road = 250 m	24-hr PM_{10} > 50 $\mu g/m^3$	6	4	12	8	9	**8**
Coleraine Street	Urban Traffic	Annual average PM_{10}		19	27	21	28	**24**
	Distance From Road = 3 m	24-hr PM_{10} > 50 $\mu g/m^3$	-	5	26	10	38	**20**
Marino	Suburban Background	Annual average PM_{10}	-	21	23	24	23	**23**
	Distance From Road = 250 m	24-hr PM_{10} > 50 $\mu g/m^3$	-	1	23	12	20	**14**
Drogheda	Zone C	Annual average PM_{10}	-	-	-	32	-	**32**

		24-hr PM_{10} > 50 □g/m^3	-	-	-	11	-	**11**
Drogheda	Zone C	Annual average $PM_{2.5}$	-	-	-	12.1	-	**12**
		24-hr $PM_{2.5}$ > 35 □g/m^3	-	-	-	1	-	**1**
Dundalk	Zone C	Annual average PM_{10}	-	-	-	20.3	-	**20**
		24-hr PM_{10} > 50 □g/m^3	-	-	-	3	-	**3**
Dundalk	Zone C	Annual average $PM_{2.5}$	-	-	-	7.0	-	**7**
		24-hr $PM_{2.5}$ > 35 □g/m^3	-	-	-	0	-	**0**
Background Concentration At Current Location	PM_{10} Background Concentration	Annual average PM_{10} Annual average $PM_{2.5}$	**PM_{10}: Year 2005 = 27.3 □g/m^3, Year 2006 = 26.6 □g/m^3, Year 2016 = 23.9 □g/m^3** **$PM_{2.5}$(2): Year 2005 = 12.3 □g/m^3, Year 2006 = 12.0 □g/m^3, Year 2016 = 10.8 □g/m^3**					

(1) Based on a background PM_{10} level for 2005 and using the DEFRA(5) background methodology to extrapolate to 2006 and 2016.

(2) Based on a $PM_{2.5}/PM_{10}$ conversion ratio of 0.45.

N.A. Not Available

Table 9.13 Urban Air Quality In Ireland - Benzene (µg/m^3)[7-10]

Station	Station Classification	Averaging Period	**Year 2002**	**Year 2003**
Crumlin	Zone A Suburban Distance From Road = 8 m	Average over 4 months	1.3	-
Winetavern Street	Zone A Urban Traffic Distance From Road = 50 m	Annual	3.8	1.6
Rathmines	Zone A Urban Background	Annual	-	1.1
Drogheda	Zone C	Average over 2.5 months	1.3	-
Background Conc. At Current Location	**Year 2005 = 0.85 µg/m^3, Year 2006 = 0.82 µg/m^3, Year 2016 = 0.70 µg/m^3**			

Table 9.14 Results of EU/LIFE RESOLUTION[7] NO_2 monitoring campaign at locations near North Lotts, as measured by passive diffusion tubes.

Location	**Period I 24/9/00 - 1/10/00 NO_2 ($\mu g/m^3$)**	**Period II 26/11/00 - 3/12/01 NO_2 ($\mu g/m^3$)**	**Period III 28/1/01 - 4/2/01 NO_2 ($\mu g/m^3$)**	**Period IV 25/3/01 - 1/4/01 NO_2 ($\mu g/m^3$)**	**Period V 27/5/01 - 3/6/01 NO_2 ($\mu g/m^3$)**	**Period VI 22/7/01 - 29/7/01 NO_2 ($\mu g/m^3$)**	**Average ($\mu g/m^3$)**
Dublin Port	51.4	34.2	50.8	-(2)	31.9	-(2)	42
Church St. East , East Wall Rd	-(2)	33.4	41.6	43.9	25.0	24.3	34
Limit Value							40(1)

(1) EU Council Directive 1999/30/EC (as an annual average).
(2) Sample lost in the field.

Table 9.15 Results of EU/LIFE RESOLUTION[7] benzene monitoring campaign at locations near North Lotts, as measured by passive diffusion tubes.

Location	**Period I 24/9/00 - 1/10/00 Benzene ($\mu g/m^3$)**	**Period II 26/11/00 - 3/12/01 Benzene ($\mu g/m^3$)**	**Period III 28/1/01 - 4/2/01 Benzene ($\mu g/m^3$)**	**Period IV 25/3/01 - 1/4/01 Benzene ($\mu g/m^3$)**	**Period V 27/5/01 - 3/6/01 Benzene ($\mu g/m^3$)**	**Period VI 22/7/01 - 29/7/01 Benzene ($\mu g/m^3$)**	**Average ($\mu g/m^3$)**
Dublin Port	1.4	1.0	1.7	-(2)	0.9	2.3	1.5
Church St. East , East Wall Rd	-(2)	2.3	1.7	3.2	0.9	1.8	2.0
Limit Value							5(1)

(1) EU Council Directive 2000/76/EC (as an annual average).
(2) Sample lost in the field.

Summary of background concentrations used in the air dispersion model.

Background Values	**Nitrogen O9ides (□g/m^3)**	**Nitrogen Dioxide (□g/m^3)**	**Benzene (□g/m^3)**	**Particulates (PM_{10}) (□g/m^3)**	**Particulates ($PM_{2.5}$) (□g/m^3)**	**Carbon Monoxide (mg/m^3)**
Year 2005	46.7	27.2	0.85	27.3	12.3	0.69
Year 2006	44.9	26.5	0.82	26.6	12.0	0.64
Year 2016	32.4	21.2	0.70	23.9	10.9	0.43

Table 9.17 Air Quality Assessment, Proposed North Lotts Mi9ed-Use Development. Summary Of Predicted Air Quality At Worst-Case Receptors Located Near The North Wall Quay / East Wall Road.

Scenarios	Traffic Speed (km/hr)	Carbon Monoxide (mg/m^3)		Hydrocarbons (□g/m^3)		Nitrogen Dioxide (□g/m^3)		Particulates (PM_{10}) (□g/m^3)	
		Maximum 1-Hour	Maximum 8-hour	Annual mean benzene	Running annual mean benzene	99.8th %ile of 1-hr NO_2	Annual average NO_2	Annual average	Exceedences of Maximum 24-hr Limit Value
2006 Do Minimum	**40**	0.64	6.4	0.82	0.90	135.1	27.0	26.8	17
2006 Do Something	**40**	0.75	7.5	0.94	1.03	202.0	40.4	32.9	39
Standards		-	**10**[(1)]	**-**	**10**[(1)]	**240**[(2,3)]	**48**[(2)]	**40**[(2)]	**35**[(2,4)]
2016 Do Minimum	**40**	0.24	2.4	0.28	0.31	107.4	21.5	24.0	10
2016 Do Something	**40**	0.33	3.3	0.39	0.43	146.3	29.3	26.2	15
Standards		-	**10**[(1)]	**-**	**5**[(1)]	**200**[(2,3)]	**40**[(2)]	**20**[(2,5)]	**7**[(2,5)]

1 EU Council Directive 2000/69/EC
2 EU Council Directive 1999/30/EC
3 1-hr limit of 200 □g/m^3 not to be exceeded > 18 times/year (99.8th %ile)
4 24-Hr limit of 50 □g/m^3 not to be exceeded > 35 times/year in 2005 (90th %ile)
5 Indicative limit values, applicable after 2010, to be reviewed in the light of further information on health and environmental effects, technical feasibility and experience in the application of Stage 1 limit values in the Member States

Table 9.18 Air Quality Assessment, Proposed North Lotts Mi9ed-Use Development. Summary Of Predicted Air Quality At Worst-Case Receptors Located Near The Sheriff Street Upper / Castleforbes Road Junction.

Scenarios	Traffic Speed (km/hr)	Carbon Monoxide (mg/m^3)		Hydrocarbons (□g/m^3)		Nitrogen Dioxide (□g/m^3)		Particulates (PM_{10}) (□g/m^3)	
		Maximum 1-Hour	Maximum 8-hour	Annual mean benzene	Running annual mean benzene	99.8th %ile of 1-hr NO_2	Annual average NO_2	Annual average	Exceedences of Maximum 24-hr Limit Value
2006 Do Minimum	**40**	0.69	6.9	0.87	0.95	168.9	33.8	29.5	26
2006 Do Something	**40**	0.69	6.9	0.87	0.95	168.9	33.8	29.5	26
Standards		-	**10$^{(1)}$**	**-**	**10$^{(1)}$**	**240$^{(2,3)}$**	**48$^{(2)}$**	**40$^{(2)}$**	**35$^{(2,4)}$**
2016 Do Minimum	**40**	0.28	2.8	0.32	0.35	126.1	25.2	25.0	12
2016 Do Something	**40**	0.28	2.8	0.32	0.35	126.1	25.2	25.0	12
Standards		-	**10$^{(1)}$**	**-**	**5$^{(1)}$**	**200$^{(2,3)}$**	**40$^{(2)}$**	**20$^{(2,5)}$**	**7$^{(2,5)}$**

3 EU Council Directive 2000/69/EC
4 EU Council Directive 1999/30/EC
3 1-hr limit of 200 □g/m^3 not to be exceeded > 18 times/year (99.8th %ile)
4 24-Hr limit of 50 □g/m^3 not to be exceeded > 35 times/year in 2005 (90th %ile)
5 Indicative limit values, applicable after 2010, to be reviewed in the light of further information on health and environmental effects, technical feasibility and experience in the application of Stage 1 limit values in the Member States

Table 9.19 Air Quality Assessment, Proposed North Lotts Mi9ed-Use Development. Summary Of Predicted $PM_{2.5}$ At Worst-Case Receptors Located Near The Development.

Scenarios	Traffic Speed (km/hr)[1]	Particulates ($PM_{2.5}$) (µg/m^3) Annual average	Particulates ($PM_{2.5}$) (µg/m^3) Exceedences of Maximum 24-hr Limit Value of 35 µg/m^3
2016 Do Minimum	**40**	9.4	10
2016 Do Something	**40**	11.6	15
Standards		16 [2,3]	35[2,4]

[1] European Commission sponsored report "Second Position Paper on Particulate Matter – Final" (2004)

[2] Proposed annual limit value likely to be in the range 12 – 20 µg/m^3 and is assumed to be in the mid-range for this assessment.

[3] Proposed 24-Hr limit of 35 µg/m^3 not to be exceeded > 35 times/year in 2010 (90th %ile)

Table 9.20 Air Quality Assessment, Proposed North Lotts Mi9ed-Use Development. Detailed Air Quality Assessment Using CAL3QHCR.

Scenarios	**Traffic Speed (km/hr)(1)**	**Nitrogen Dioxide (□g/m^3)**		**PM_{10} (□g/m^3)**			
		99.8th% ile of 1-hr NO_2	**Annual Average**	**90th%ile of 24-hr PM_{10}**	**Annual Average**		
2006 Do Nothing	**40**	132.8	30.7	32.8	29.6		
2006 Do Something	**40**	152.2	31.0	32.8	29.8		
Standards		246(1,2)	49.1(1,3)	50(1)	40(1)		
Scenarios	**Traffic Speed (km/hr)(1)**	**Nitrogen Dioxide (□g/m^3)**		**PM_{10} (□g/m^3)**		**$PM_{2.5}$ (□g/m^3)**	
		99.8th% ile of 1-hr NO_2	**Annual Average**	**98th%ile of 24-hr PM_{10}**	**Annual Average**	**90th%ile of 24-hr $PM_{2.5}$**	**Annual Average**
2016 Do Nothing	**40**	81.4	23.8	29.8	26.0	12.9	11.9
2016 Do Something	**40**	91.3	23.9	29.8	26.1	12.9	11.9

Standards	200[1,2]	40[1,3]	50[1,4]	20[1,4]	35[5,7]	16[5,6]

1 Council Directive 1999/30/EC

2 1-hr limit of 246 µg/m^3 not to be exceeded > 18 times/year (99.8th %ile) in 2006.

3 Annual limit of 49.1 µg/m^3 in 2006 and annual limit of 40.0 µg/m^3 in 2016.

4 EU 1999/30/EC states "Indicative limit values to be reviewed in the light of further information on health and environmental effects, technical feasibility and experience in the application of Stage 1 limit values in the Member States".

5 European Commission sponsored report "Second Position Paper on Particulate Matter – Final" (2004)

6 Proposed annual limit value likely to be in the range 12 – 20 µg/m^3 and is assumed to be in the mid-range for this assessment (16 µg/m^3).

7 Proposed 24-Hr limit of 35 µg/m^3 not to be exceeded > 35 times/year after 2010 (90th %ile)

APPENDIX 9.1

Ambient Air Quality Standards

National standards for ambient air pollutants in Ireland have generally ensued from Council Directives enacted in the EU (& previously the EC & EEC) (see Table 9.1 – 9.3). The initial interest in ambient air pollution legislation in the EU dates from the early 1980s and was in response to the most serious pollutant problems at that time. In response to the problem of acid rain, sulphur dioxide, and later nitrogen dioxide, were both the focus of EU legislation. Linked to the acid rain problem was urban smog associated with fuel burning for space heating purposes. Also apparent at this time were the problems caused by leaded petrol and EU legislation was introduced to deal with this problem in the early 1980s.

In recent years the EU has focused on defining a basis strategy across the EU in relation to ambient air quality. In 1996, a Framework Directive, Council Directive 96/62/EC, on ambient air quality assessment and management was enacted. The aims of the Directive are fourfold. Firstly, the Directive's aim is to establish objectives for ambient air quality designed to avoid harmful effects to health. Secondly, the Directive aims to assess ambient air quality on the basis of common methods and criteria throughout the EU. Additionally, it is aimed to make information on air quality available to the public via alert thresholds and fourthly, it aims to maintain air quality where it is good and improve it in other cases.

As part of these measures to improve air quality, the European Commission has adopted proposals for daughter legislation under Directive 96/62/EC. The first of these directives to be enacted, Council Directive 1999/30/EC, has been passed into Irish Law as S.I. No 271 of 2002 (Air Quality Standards Regulations 2002), and has set limit values which came into operation on 17th June 2002. Council Directive 1999/30/EC, as relating to limit values for sulphur dioxide, nitrogen dioxide, lead and particulate matter, is detailed in Table 9.1. The Air Quality Standards Regulations 2002 detail margins of tolerance, which are trigger levels for certain types of action in the period leading to the attainment date. The margin of tolerance varies from 60% for lead, to 30% for 24-hour limit value for PM_{10}, 40% for the hourly and annual limit value for NO_2 and 26% for hourly SO_2 limit values. The margin of tolerance commenced from June 2002, and will start to reduce from 1 January 2003 and every 12 months thereafter by equal annual percentages to reach 0% by the attainment date. A second daughter directive, EU Council Directive 2000/69/EC, has recently published limit values for both carbon monoxide and benzene in ambient air as set out in Table 9.2. This has also been passed into Irish Law under the Air Quality Standards Regulations 2002.

Although the EU Air Quality Limit Values are the basis of legislation, other thresholds outlined by the EU Directives are used which are triggers for particular actions. The Alert Threshold is defined in Council Directive 96/62/EC as "a level beyond which there is a risk to human health from brief exposure and at which immediate steps shall be taken as laid down in Directive 96/62/EC". These steps include undertaking to ensure that the necessary steps are taken to inform the public (e.g. by means of radio, television and the press).

The Margin of Tolerance is defined in Council Directive 96/62/EC as a concentration which is higher than the limit value when legislation comes into force. It decreases to meet the limit value by the attainment date. The Upper Assessment Threshold is defined in Council Directive 96/62/EC as a concentration above which high quality measurement is mandatory. Data from measurement may be supplemented by information from other sources, including air quality modelling. These various thresholds have been incorporated into the significance criteria for the development and will be appropriate for assessing the significance of the combined impact of the development plus the background environment.

An annual average limit for both NO_9 (NO and NO_2) is applicable for the protection of vegetation in highly rural areas away from major sources of NO_9 such as large conurbations, factories and high road vehicle activity such as a dual carriageway or motorway. Annex VI of EU Directive 1999/30/EC identifies that monitoring to demonstrate compliance with the NO9 limit for the protection of vegetation should be carried out distances greater than:

- 5 km from the nearest motorway or dual carriageway
- 5 km from the nearest major industrial installation

- 20 km from a major urban conurbation

As a guideline, a monitoring station should be indicative of appro9imately 1000 km^2 of surrounding area.

Under the terms of EU Framework Directive on Ambient Air Quality (96/62/EC), geographical areas within member states have been classified in terms of zones. The zones have been defined in order to meet the criteria for air quality monitoring, assessment and management as described in the Framework Directive and Daughter Directives. Zone A is defined as Dublin and its environs, Zone B is defined as Cork City, Zone C is defined as 16 urban areas with a population greater than 15,000 and Zone D is defined as the remainder of the country. The Zones were defined based on among other things, population and existing ambient air quality.

EU Council Directive 96/62/EC on ambient air quality and assessment has been adopted into Irish Legislation (S.I. No. 33 of 1999). The act has designated the Environmental Protection Agency (EPA) as the competent authority responsible for the implementation of the Directive and for assessing ambient air quality in the State. Other commonly referenced ambient air quality standards include the World Health Organisation. The WHO guidelines differ from air quality standards in that they are primarily set to protect public health from the effects of air pollution. Air quality standards, however, are air quality guidelines recommended by governments, for which additional factors, such as socio-economic factors, may be considered.

Screening Air Dispersion Modelling

The inputs to the DMRB model input data consists of detailed information on physical environment (including building dimensions and terrain features), design details from all emission points on-site road layouts, receptor locations, annual average daily traffic movements, annual average traffic speeds and background concentrations(11). Using this input data the model predicts ambient ground level concentrations beyond the site boundary at the worst-case sensitive receptor using generic meteorological data.

The DMRB has recently undergone an extensive validation exercise(14) as part of the UK's Review and Assessment Process to designate areas as Air Quality Management Areas (AQMAs). The validation exercise was carried out at 12 monitoring sites within the UK DEFRAs national air quality monitoring network. The validation exercise was carried out for NO_9, NO_2 and PM_{10}, and included urban background and kerbside/roadside locations, "open" and "confined" settings and a variety of geographical locations(14).

In relation to NO_2, the model generally over-predicts concentrations, with a greater degree of over-prediction at "open" site locations. The performance of the model with respect to NO_2 mirrors that of NO_9 showing that the over-prediction is due to NO_9 calculations rather than the NO_9:NO_2 conversion. Within most urban situations, the model overestimates annual mean NO_2 concentrations by between 0 to 40% at confined locations and by 20 to 60% at open locations. The performance is considered comparable with that of sophisticated dispersion models when applied to situations where specific local validation corrections have not been carried out.

The model also tends to over-predict $PM_{10.}$ Within most urban situations, the model will over-estimate annual mean PM_{10} concentrations by between 20 to 40%. The performance is comparable to more sophisticated models, which, if not validated locally, can be expected to predict concentrations within the range of ±50%.

Thus, the validation exercise has confirmed that the model is a useful screening tool for the Second Stage Review and Assessment, for which a conservative approach is applicable(14).

Detailed Air Dispersion Modelling

Detailed air dispersion modelling accurately maps the physical environment and derives site-specific traffic emission factors based on an analysis of vehicle age, %HGV, vehicle speeds and model year of vehicle. Furthermore, meteorological data was incorporated into the model using representative data from the nearest weather station and used to determine hourly concentrations for pollutants of concern at each specified receptor in the region.

Peak, one-hour concentrations for CO, benzene, NO_2 and PM_{10} for the years of 2006 and 2016, at the nearest occupational receptors to the scheme, have been modelled using the USEPA approved CAL3QHCR[16] dispersion model in conjunction with the most recent European emissions database from the CORINAIR working group COPERT III (Version 2.2, June 2001)[18]. In 1991 and 2000, the USEPA issued a notice of proposed rulemaking identifying CAL3QHC as the recommended model for estimating carbon monoxide concentrations in the vicinity of intersections[25]. CAL3QHC Version 2 (Released 1995) replaces the original version with the additional capability of analysing particulate matter impacts[26]. The model combines CALINE-3 (a Gaussian line source dispersion model) with a traffic model to calculate delays and queues that occur at signalised intersections. The model also incorporates the Industrial Source Complex (ISC) mi9ing height algorithm while also allowing the conversion of NO_9 to NO_2 using CALINE4 algorithms[27]. In 1995, CAL3QHCR was created by the USEPA by enhancing the basic algorithms of CAL3QHC to allow the capability to process a year of hourly meteorological, traffic and signalisation data, to incorporate the complete ISCST3 mi9ing height algorithm and to incorporate various concentration averaging algorithms[22].

Thereafter, the conversion to nitrogen dioxide followed the UK DEFRA's empirical relationship between NO_9 and NO_2 derived from monitoring data from the UK over the period 1998-2001[5, 28]:

NO_2 ROADSIDE INCREMENT (□g/m^3) = NO_9 ROADSIDE INCREMENT (□g/m^3, as NO_2)*(-0.068*ln(total roadside NO_9 concentration (□g/m^3, as NO_2)) + 0.53)

The above equation is appropriate for use at roadside/kerbside locations (i.e. locations within about 10 metres of the kerb) and for annual mean NO_9 concentrations exceeding 50 □g/m^3[5, 28]. These conditions were satisfied at worst-case locations for most of the modelling scenarios undertaken. In order to extrapolate from the NO_2 annual concentration to the NO_2 99.8th%Ile of maximum one-hour concentrations, it can be assumed that the 99.8th%ile will not exceed 5 times the annual mean concentration at background sites and 3.5 times the annual mean at roadside/kerbside sites[5, 28].

Model Accuracy

The CAL3QHC model has been extensively validated by the USEPA[26]. A major air quality monitoring study was conducted in 1989-90 at Route 9A in New York City at two background stations and si9 different intersections. Site-specific meteorological data and videos recording traffic data were used continuously over three months. Si9 different models were compared with this exensive database. This extensive monitoring data was compared with the modelling results under worst-case conditions. CAL3QHC gives the best agreement by a factor of two over other models using the composite model comparison measure (CM). On February 13, 1991, EPA issued a notice of rulemaking identifying CAL3QHC as the recommended model for estimating carbon monoxide concentrations in the vicinity of intersections and stated that the model is a reliable tool for estimating the air quality impact from traffic sources.

As the model has been previously validated, the USEPA has stated that site-specific validation of the model is not necessary for each assessment[26]. However, due to some concerns that variations between USA and Irish road conditions (notably the presence of roundabouts in Ireland) the EPA is currently funding an extensive validation exercise of this model and similar models. Results are not currently available from this project but should be available within the next year.

Emission Formulation

The vehicle fleet for the current scheme was assumed to be in line with the national fleet[(29)] for petrol and diesel LVs. Cold starts were assumed to be 75% for all model scenarios. Worst-case assumptions were used throughout the formulation to ensure the emission rates were over-estimates.

Emission rates have been derived from COPERT III (Version 2.2, June 2001)[(18)] which has been developed by the CORINAIR working group and follows on from extensive work carried out by the MEET program (Methodologies for Estimating Air Pollutant Emissions from Transport) and COST 319 – "Estimating of Pollutant Emissions From Transport"[(30)].

Emission rates for CO, VOC, NO_2 and PM_{10} used to predict air pollutant concentrations for the year 2006 were calculated assuming a vehicle fleet breakdown in 2006 as predicted from the National Fleet age breakdown in 2003 & by applying the emissions factors outlined in COPERT III[(18)]. In addition, emission factors for NO_2 and PM_{10} were compared with revised emission factors from the Transport Research Laboratory (TRL) in the UK which was published in March 2002[(31)]. For the purposes of deriving the worst-case emission factors, the higher of each comparable emission factor for each category of vehicle was selected from an analysis of both databases.

In relation to PM_{10}, both the tail-pipe emissions and fugitive emissions from re-suspended dust were included in the calculation. Although COPERT III does not assess fugitive dust, this will be a significant fraction of measured PM_{10} for all roads. Detailed calculations have been carried out by the USEPA (AP-42, 1997)[(32)] on fugitive dust emissions from paved roads and other sources. The calculation is based on the average weight of the vehicles, the number of vehicles and the silt loading of the road. Reductions in future years will be related to the reduction in background concentrations[(5)] as this will be the dominant source of the re-suspended $PM_{10.}$

Idling emission factors were derived from COPERT III using a traffic speed of 5 km/hr and apply a factor of two in order to allow for any inaccuracies in the formulation[(33)]. Future year emission factor reductions, for both LV and HGV, were assumed to be in accordance with the relative reductions cited in COPERT III.

APPENDIX 9.2

Dust Minimisation Plan

A dust minimisation plan will be formulated for the construction phase of the project, as construction activities are likely to generate some dust emissions. The potential for dust to be emitted depends on the type of construction activity being carried out in conjunction with environmental factors including levels of rainfall, wind speeds and wind direction. The potential for impact from dust depends on the distance to potentially sensitive locations and whether the wind can carry the dust to these locations. The majority of any dust produced will be deposited close to the potential source and any impacts from dust deposition will typically be within several hundred metres of the construction area.

In order to ensure that no dust nuisance occurs, a series of measures will be implemented. Site roads shall be regularly cleaned and maintained as appropriate. Hard surface roads shall be swept to remove mud and aggregate materials from their surface while any un-surfaced roads shall be restricted to essential site traffic only. Furthermore, any road that has the potential to give rise to fugitive dust must be regularly watered, as appropriate, during dry and/or windy conditions.

Vehicles using site roads shall have their speed restricted, and this speed restriction must be enforced rigidly. Indeed, on any un-surfaced site road, this shall be 20 km per hour, and on hard surfaced roads as site management dictates. Vehicles delivering material with dust potential shall be enclosed or covered with tarpaulin at all times to restrict the escape of dust.

All vehicles exiting the site shall make use of a wheel wash facility, preferably automatic, prior to entering onto public roads, to ensure mud and other wastes are not tracked onto public roads. Public roads outside the site shall be regularly inspected for cleanliness, and cleaned as necessary.

Material handling systems and site stockpiling of materials shall be designed and laid out to minimise exposure to wind. Water misting or sprays shall be used as required if particularly dusty activities are necessary during dry or windy periods.

Furthermore, during movement of the soil both on and off-site, trucks will be stringently covered with tarpaulin at all times. Before entrance onto public roads, trucks will be adequately inspected to ensure no potential for dust emissions.

At all times, the procedures put in place will be strictly monitored and assessed. In the event of dust emissions occurring outside the site boundary, movement of these soils will be immediately terminated and satisfactory procedures implemented to rectify the problem before the resumption of the operations.

The dust minimisation plan shall be reviewed at regular intervals during the construction phase to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust through the use of best practise and procedures.

APPENDIX 9.3

Assessment of Environmental Wind Conditions at North Lotts, Dublin Docklands

Environmental Wind Conditions at the North Lotts Development, Dublin

AWN Consulting

5th July , 2005

Project Reference #05-026-1B(FINAL)

OBJECTIVE

The objective of this project was to review drawings of the proposed development of the North Lotts Scheme in Dublin and to carry out a desk-based assessment of the expected wind conditions around the site at street level.

VERSION HISTORY

INDEX	*DATE*	*PAGES*	*AUTHOR*	*SIGNATURE*
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		Checked by:	W. Pearce	W P

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FIGURES

INTRODUCTION

This report is an analysis of the wind conditions expected around the proposed development at North Lotts in Dublin, EIRE. RWDI Anemos were instructed by AWN Consulting to perform the wind study. A quantitative assessment of the landmark tower using the method of Maruta is presented and tempered by our experience with other similar schemes and expert knowledge of the interaction of wind with the built environment.

The site description is used mainly to identify building massing and features that are pertinent to the wind microclimate on site. The discussion describes meteorological conditions and the expected main flow interactions around the site.

The term tolerable to describe the likely wind conditions is used in a specific technical sense and is defined in Table 1 and Table 2 for different pedestrian activities. These tables summarise the Lawson comfort criteria which RWDI Anemos uses in wind tunnel investigations of pedestrian level wind environment. Within the report conditions are sometimes described as being tolerable for (say) standing *or better*. The *or better* qualifier reflects the general guideline that during the summer months wind conditions are typically one criterion lower than the windiest winter time results.

Site DEscription

The project concerns the construction of a new development in the North Lotts area of Dublin Docklands. The co-ordinates of the site are latitude 53:20:51N and longitude 6:13:42W.

The site is bounded by the River Liffey to the south, East Wall Road to the east, Sheriff Street to the north, and Benson Street to the west. The existing site consists of low rise buildings and the Point Depot music venue. A 3-D block model of the development is shown in Figure 1 and Figure 2 is a plan of the proposed development.

The proposed development comprises five and six storey buildings along the northern and western boundaries of the site with six/seven storey buildings to the southwest. To the east of the venue a commercial or retail building is proposed with a maximum height one-storey less than the eastern elevation of the Point Depot. To the northeast of the venue and in the middle of the east perimeter of the site is the proposed landmark tower which will stand 120m above street level, with the top 20m comprising of services for the building and for the purposes of this investigation the plan dimensions of the tower have been assumed to be 25m × 25m. An LUAS light rail transit stop is proposed northwest of the Point Depot.

Meteorological Data

Knowledge of the prevailing wind direction allows us to focus attention on the likely impact of these winds on the site except where the building massing/layout indicates that winds from other directions are likely to be important. This means that, taking account of other design constraints, it is desirable that the site is arranged so that the maximum acceleration of the wind due to the building massing occurs for the lightest and most infrequent wind speeds and directions. In this way pedestrian comfort is optimised.

General Meteorological Conditions

The wind climate in the Dublin area has prevailing winds from the southwest quadrant throughout the year which typically account for around 48% of all wind. The most frequent and the strongest winds tend to occur from these directions. The polar plot of annual meteorological data from Dublin Airport at 10m above open flat country terrain is shown in Figure 3. The data indicate the expected peak from direction 240˚.

Surface Roughness

The ground roughness in each wind direction, or fetch, significantly affects the wind flow characteristics. For example, a wide-open space permits the wind to blow down to ground level generating conditions similar to that of open countryside, e.g. lower turbulence and higher mean wind speeds, even within a built-up area. An assessment of the ground roughness for the proposed site was conducted using the BREVe2[3] software. Table 3 presents the ‘mean factors’ for the proposed sites where the mean factor represents the ratio of wind speed on site, at the stated reference height, as a fraction of the wind speed in open, flat countryside at a height of 10m. The factors for 10m height vary from 0.536 to 1.011. The Dublin Docklands area has quite marked

[3] *BREVe2 – A publicly available software implementation of the design wind speed rules of BS6399-2 sold by BSI, BRE and RWDI-Anemos. The program includes terrain and topography information from BRE and Ordnance Survey.*

variations in exposure with the city extending to the west and the influence of the Irish Sea to the east.

Lawson Comfort Criteria

The criteria are derived for open air conditions where it is expected that pedestrians will be suitably dressed for the season. If the measurement location is beneath an open canopy then we advise caution in the interpretation of the Lawson criteria as the canopy may change users' expectations of shelter.

Pedestrian Comfort

The assessment of the wind conditions requires a standard against which the measurements can be compared. RWDI-Anemos use the Lawson criteria[4] which have been established for some thirty years and have been widely used on building developments across the U.K. and Ireland. Lawson defined a twelve-point scale to represent equal increments of pedestrian annoyance to the wind (not shown here) This scale forms the basis of the comfort criteria which seek to define the reaction of an average pedestrian to the wind.

The criteria set-out six pedestrian activities and reflect the fact that less active pursuits require more benign wind conditions (Table 1). The six categories are sitting, standing, entering/leaving a building, leisure walking, business walking and roadway/car-park, in ascending order of activity level.

For each of these categories an upper threshold is defined, beyond which conditions are unacceptable for the stated activity. If the wind conditions are below the threshold then conditions are described as tolerable for the stated activity. An unacceptable result implies that remedial action should be taken to mitigate wind conditions or that the proposed pedestrian activity at that location should be redefined.

Pedestrian Safety

The Lawson Criteria also specify a lower limit safety criterion when winds exceed Beaufort Force 6. If this safety criterion is exceeded then there may be a need for mitigation measures or a careful assessment of the expected use of that location, e.g. is

[4] Lawson T.V., "Building Aerodynamics", Imperial College Press, April 2001. [ISBN 1-86094-187-7]

it reasonable to expect vulnerable pedestrians to be present at the location on the windiest day of the year?

In order to ascribe a measure of significance to wind speeds greater than Beaufort 6, RWDI-Anemos defines three threshold levels above Beaufort 6 but these cannot be resolved in a study of this kind. As a general rule-of-thumb business walking and roadway conditions are associated with wind speeds in excess of the B6 safety criterion.

wind in the built environment – General Comments

Urban Airflow

As the wind approaches a built-up area it is displaced upwards to roof level and tends to blow across the roof tops with gusts down to street level that are a function of the relative heights-to-width of the street canyon. When the height-to width ratio of the street canyon is greater than 0.7 the skimming flow regime dominates and the wind blows across the top of the street with little penetration down to ground level, whereas a height-to-width ratio less than 0.4 produces conditions similar to the isolated building scenario[5]. However, when there is an increase in building height across the street this can reinforce the rotating, or vortex, air movements within the street. Relatively open spaces, even inside a city, can be windy as the wind blows down from roof level into the open space.

Calm areas are generally desirable for pedestrian comfort. However, very slow air movement can result in poor ventilation of pollutants and in these areas it is desirable that pollutant sources are limited.

Seasonal Variability

Pedestrian activity differs during the summer and winter months when other climatic conditions, for example air temperature, have a marked impact. Comfort criteria generally assume that pedestrians will be suitably dressed for the season and when making a worst-case assessment it is reasonable to assume that pedestrians will not be sitting at a street-side café on the windiest days of the year.

[5] T. R. Oke, 'Boundary Layer Climates', Routledge, © 1987

Typically there is a one category difference between the worst-case wind conditions and those experienced during the summer, e.g. business walking conditions become leisure walking during the summer and leisure walking conditions become standing/entrance conditions.

Entrances

Pedestrians are particularly sensitive to wind conditions at entrances because of the potentially marked change between the controlled environment inside the building and external conditions. For this reason it is important that conditions immediately adjacent to an entrance are relatively benign or that there is a sheltered 'buffer' zone, which allows pedestrians time to acclimatise. For recessed entrances the recess creates a buffer zone but is also prone to accumulating wind-blown debris because of the trapped vortex, or rotational, flows that can occur in the recess. Entrances are also used throughout the year so that even during the windiest days of the year the entrance should be relatively sheltered.

Entrances on different building elevations are also susceptible to pressure-driven through flows when opened simultaneously. The windward façade is generally positively pressurised whereas the side and/or downwind façades are at a lower pressure. If the entrances are into a central atrium then the different external surface pressures can be directly connected when doors are opened simultaneously. This can lead to nuisance draughts and in extreme cases difficulty in opening doors or whistling as the pressure difference forces the doors slightly ajar. Revolving doors eliminate the problem because the pressure seal across the building envelope is maintained. The extent of any potential nuisance is in part related to the footfall through the entrances because this will affect the probability of doors being opened simultaneously. Lobby doors are another means of limiting the impact of nuisance draughts, although the likelihood of both sets of lobby doors being opened simultaneously should be considered when specifying this option.

Landscaping

Planting is a very useful means of softening the streetscape and creating naturalised shelter within and around the site. There are generally two ways in which planting works; relatively dense lines of planting act like a solid screen deflecting the wind, whereas more open planting removes energy from the wind as it flows through the screen. In both cases shelter is created but for the case of the more solid screen winds can remain relatively strong at the extreme ends of the screen. If we consider the case of street canyons in UK towns and cities, the tree canopy minimises the penetration of vertical gusts down to pedestrian level and horizontal winds are displaced upwards by the canopy.

Another consideration is the seasonal variation of the species. Deciduous varieties create a denser screen during the summer months but during the winter months offer limited protection due to the bare branches. Evergreen varieties offer more consistent shelter throughout the year. When considering seasonal variability, account should be taken of the more transient pedestrian activity during the winter months where other climatic factors, e.g. air temperature, impact upon the way in which pedestrians will use a site. Finally, the maturity of the planting is significant; semi-mature species offer reasonable protection from an early stage in the life of the development, whereas immature planting will take time to establish.

More structural landscaping in the form of earth mounds or screens have the advantage of offering year-round shelter.

Balconies

If there are buildings with recessed balconies then in general these will be sheltered unless they are particularly long balconies when the wind can blow along and into the balcony. Partition walls/screens between the balconies of adjoining properties are usually sufficient to eliminate this potential wind nuisance.

Protruding balconies are potentially more susceptible to wind nuisance because the main flow along the surface of the building can blow directly across the balcony. This condition is exacerbated if the protruding balcony skirts around a corner of the building where the strong corner winds will blow across the balcony. There is usually a requirement to screen the ends of the protruding balconies in order to displace the wind away from the balcony.

Colonnades

In this discussion a colonnade is defined as a covered walkway where the cover is generally provided by overhanging upper storeys of the building. In other words the building footprint at ground level is set-back. Colonnades create shelter from the direct effects of downdraught but are exposed to horizontal winds which can be channelled along the colonnade. If the colonnade connects windward and leeward elevations of the building then a pressure-driven flow is generated through the colonnade. If the building façade at ground level is curved then this can also be expected to accelerate the winds through the colonnade.

Colonnades do not necessarily provide shelter from the wind. Consequently, it may be necessary to increase resistance to air movement along the colonnade, and/or to prevent penetration of wind into the colonnade, by suitable screening.

Maruta Method

General Description

The Maruta Method is a prediction model developed from parametric wind tunnel tests on isolated rectangular-plan models. An output from the RWDI Anemos implementation of this method is shown in Figure 4. The implementation of the Maruta data developed by RWDI Anemos gives a speed-up factor at head height which is the ratio of the wind speed affected by the presence of the building to the corresponding wind speed for a clear site. Values greater than unity, the red zone in Figure 4, indicate accelerated flow while values less than unity indicate shelter. The Maruta Method always indicates shelter immediately upwind of the building, whereas other design guidance suggests that tall buildings can increase the wind speeds in this area and our experience confirms this. Also the presence of neighbouring buildings may steer and funnel the wind. Accordingly, the Maruta Method results need to be interpreted and adjusted, where necessary, utilising previous experience.

The wind speed ratios from the Maruta method are combined with the wind speed and frequency data for Dublin and compared with the Lawson Comfort Criteria to establish the expected comfort levels around the development.

Site Specific Description

The proposed site layout design depicts the landmark tower at the east end of the site with surrounding low rise buildings to the north, northwest, south, and southwest directions. This includes the existing Point Depot and possible expansions to the venue.

For the Maruta analysis, the landmark tower was modelled as an isolated, rectangular prism with the proposed 25m × 25m plan dimensions and 120m height.

baseline conditions

It is often the case that a new development dramatically alters the pedestrian activity on site and consequently a comparison of the original wind conditions with those on the developed site can be meaningless. For example wind conditions currently suitable for pedestrian walking and which remain suitable for pedestrian walking after development leads to the conclusion that there is negligible impact due to the development. However, if on the new development the location of interest is outside a main entrance then the impact is adverse and will require remedial action. This is an important consideration when defining and applying baseline conditions.

The Current Wind Conditions on Site

Analysis of the meteorological data for the existing open site indicates that the existing conditions on site are likely to be tolerable for standing or entrance usage or better. The implication of this result is that, after development, if the site has a number of locations where the conditions are tolerable for (say) leisure walking, then these are likely to be perceived to be ‘windy’ relative to general conditions in the area.

The Current Wind Conditions around the Site (on Neighbouring Properties)

Although it is our understanding that the ‘right of light’ has no equivalent for wind it is desirable, as part of a good neighbour policy, to minimise adverse changes to the wind conditions on neighbouring buildings due to a development. In general the development may lead to increased wind speeds on adjacent properties for some wind directions but increased shelter for other directions.

Comparison of the Wind Conditions with the Desired Conditions

In the assessment of the proposed development, comparison is made between the wind conditions expected on the developed site and the desired wind conditions. This is generally the most useful baseline for comparison because it is an assessment which indicates whether the wind conditions are suitable for the intended pedestrian activity at a location.

Conditions Throughout the Proposed Development

Landmark Tower

The wind conditions around the Landmark Tower, computed using the Maruta analysis are plotted in Figure 5. The conditions range from standing/entrance usage to business walking.

At the northwest and southeast corners of the tower, positions 5 and 7, business walking conditions are shown, which is attributed to the exposure of the building to prevailing winds. Positions 6 and 8 are at the remaining corners where conditions were suitable for leisure walking.

The results confirm that the corners are windy areas and consequently it is desirable that the entrances to the tower are situated in the more sheltered central areas of either the east or west facades of the tower. Locations 1 and 3 are found at the centres of the north and south facades of the tower and are exposed to the corner winds from the tower with conditions tolerable for leisure walking.

The analysis presented above assumes an isolated tower, whereas the masterplan shows lower buildings around the tower. There is a gap to the west of the tower through which wind is expected to be channelled but with the expectation of helical winds blowing along this gap for winds from the southwest and northwest. The cavities created between the lower rise buildings and the tower also generate a low pressure zone which can induce wind down the windward face of the tower leading to increased wind speeds around the windward corner. However, these effects are not expected to significantly alter the conditions presented in Figure 5.

Lower-Rise Surround Buildings

The wind conditions around the lower-rise elements of the site are expected to range from leisure walking to standing/entrance usage or better. The west elevation of the site is exposed to prevailing winds, whereas the east side of the development is exposed to winds from the Irish Sea. The expectation is that conditions around the north and south corners of these elevations will be tolerable for leisure walking. The open area west of the tower and surrounding the LUAS station, is likely to experience gusty conditions with winds intermittently blowing down to street level, however, conditions are expected to be tolerable for standing or entrance usage. Overall the microclimate within the development is expected to be tolerable for standing or better.

The more active frontages are designated around the north and southwest buildings, along the riverfront, near the LUAS light rail stop, and outside the Point Depot venue and the Point Square courtyard. The general conditions described above are therefore compatible with the intended use of the site, but entrances should be located away form the windy corners.

Conclusions

In conclusion:

- Analysis of the wind conditions around the landmark tower show a range from business walking to standing or entrance usage. Windier conditions occur at the northwest and southeast corners which are most exposed to prevailing winds. The analysis indicates that the preferred location for entrances would be on the east and west elevations.
- Consideration of the lower-rise buildings to the west of the site is expected to increase the downward flow into the public square to the west of the tower, because of the low pressure zone created in the public square. The presence of the open space is therefore expected to increase the wind speeds around the tower, but with an overall assessment similar to that presented in Figure 5.
- Leisure walking conditions are expected along the south elevations of the site adjacent to the river
- The microclimate in the public square west of the landmark tower is expected to be suitable for standing or entrance usage.
- No specific mitigation measures are required or recommended at this stage because of the generic form of the of the masterplan buildings.
- By incorporating planting throughout the masterplan, it is expected to provide additional shelter particularly during the summer months when trees are in full leaf.
- Due to the complexity of the overall development, wind tunnel testing should be conducted when the final detailed design of the development is agreed. This process will be capable of resolving the detail to optimise the locations of entrances and public/leisure areas which is important to the success of the development.

DESCRIPTION	LETTER	THRESHOLD
Roads and Car Parks	A	6% > B5
Business Walking	B	2% > B5
Pedestrian Walk-through	C	4% > B4
Pedestrian Standing	D	6% > B3
Entrance Doors	E	6% > B3
Sitting	F	1% > B3

Table 1: Lawson comfort criteria

BEAUFORT FORCE	HOURLY-AVERAGE WIND SPEED (m/s)	DESCRIPTION OF WIND	NOTICEABLE WIND EFFECT
0	< 0.45	Calm	Smoke rises vertically
1	0.45 - 1.55	Light Air	Direction shown by smoke drift but not by vanes
2	1.55 - 3.35	Gentle Breeze	Wind felt on face; leaves rustle; wind vane moves
3	3.35 - 5.60	Light Breeze	Leaves & twigs in motion; wind extends a flag
4	5.60 - 8.25	Moderate Breeze	Raises dust and loose paper; small branches move
5	8.25 – 10.95	Fresh Breeze	Small trees, in leaf, sway
6	10.95 - 14.10	Strong Breeze	Large branches begin to move; telephone wires whistle
7	14.10 - 17.20	Near Gale	Whole trees in motion
8	17.20 - 20.80	Gale	Twigs break off; personal progress impeded
9	20.80 - 24.35	Strong Gale	Slight structural damage; chimney pots removed
10	24.35 - 28.40	Storm	Trees uprooted; considerable structural damage
11	28.40 - 32.40	Violent Storm	Damage is widespread; unusual in the U.K.
12	> 32.40	Hurricane	Countryside is devastated; only occurs in tropical countries

Table 2: The Beaufort force land scale

Height	Direction											
	0	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**
10	0.553	0.755	0.794	1.011	0.996	0.867	0.576	0.536	0.563	0.778	0.664	0.664
2	0.405	0.612	0.644	0.655	0.646	0.467	0.422	0.392	0.412	0.419	0.419	0.419

Table 3: BREVe2 mean factors at 2m and 10m above ground at the site

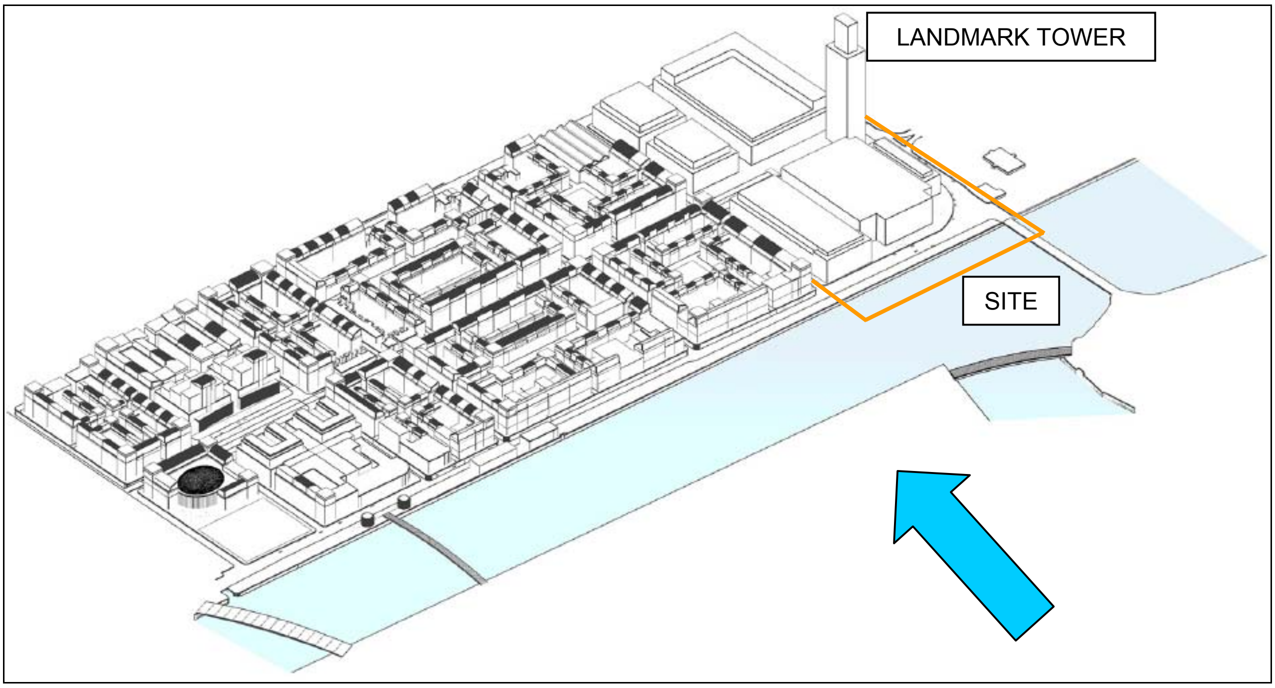

Figure 1: 3-dimensional model of the proposed North Lotts scheme

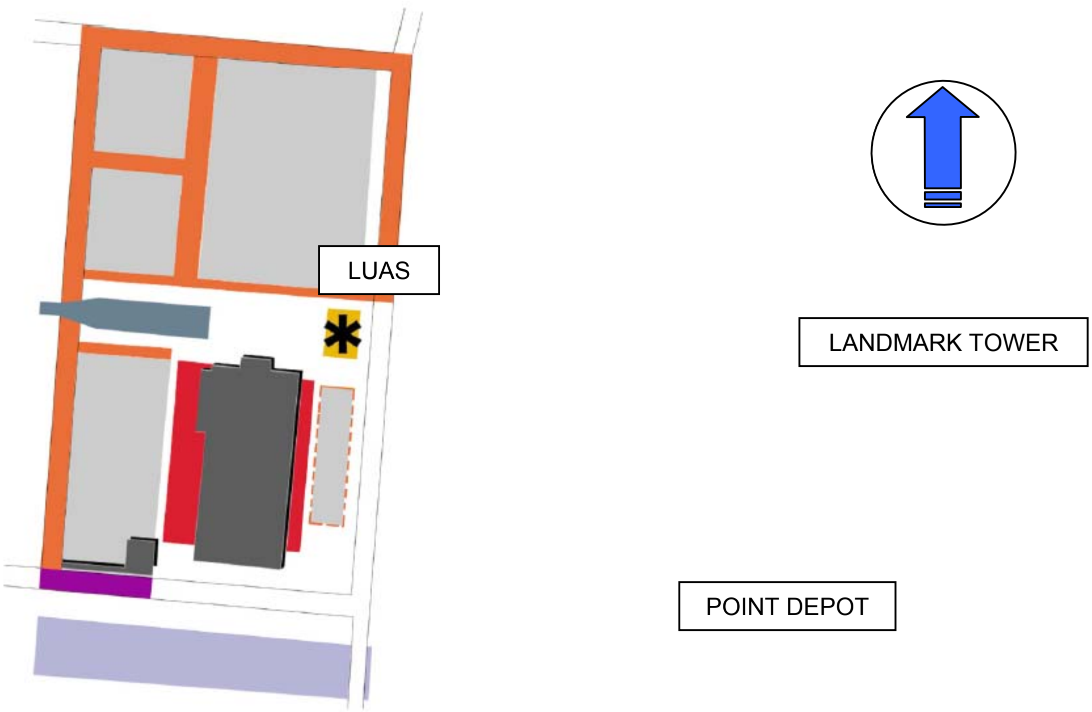

Figure 2: Plan layouts of the proposed North Lotts scheme

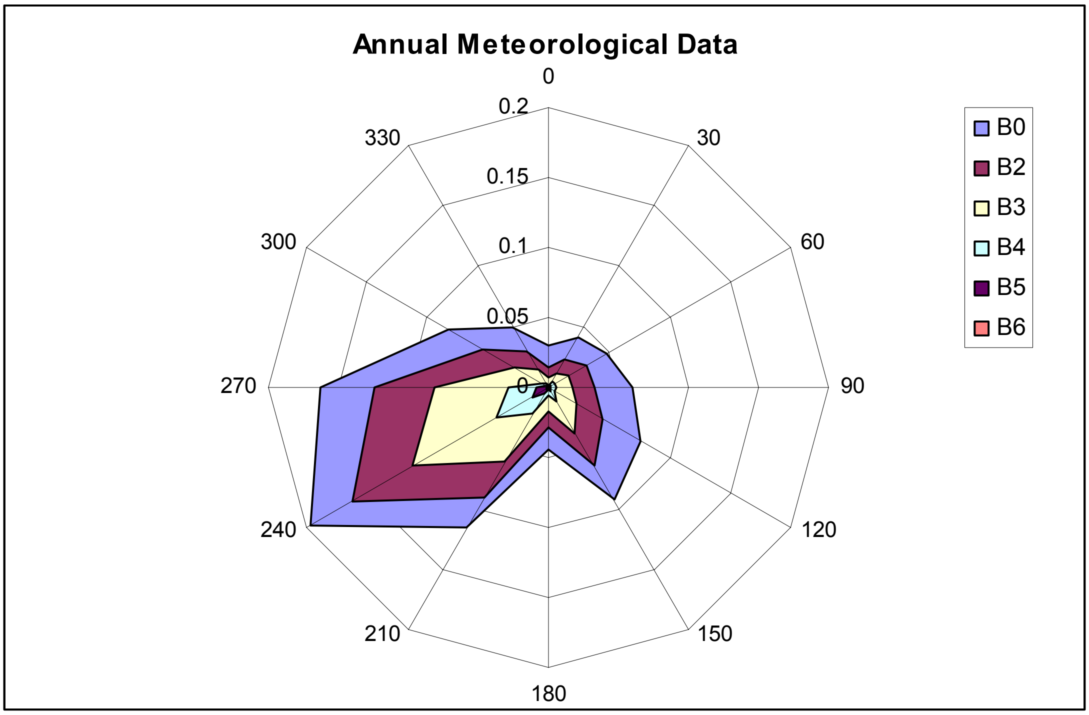

Figure 3: Annual wind rose for Dublin Airport data (in Beaufort force)
(Hours of wind the stated Beaufort range is exceeded)

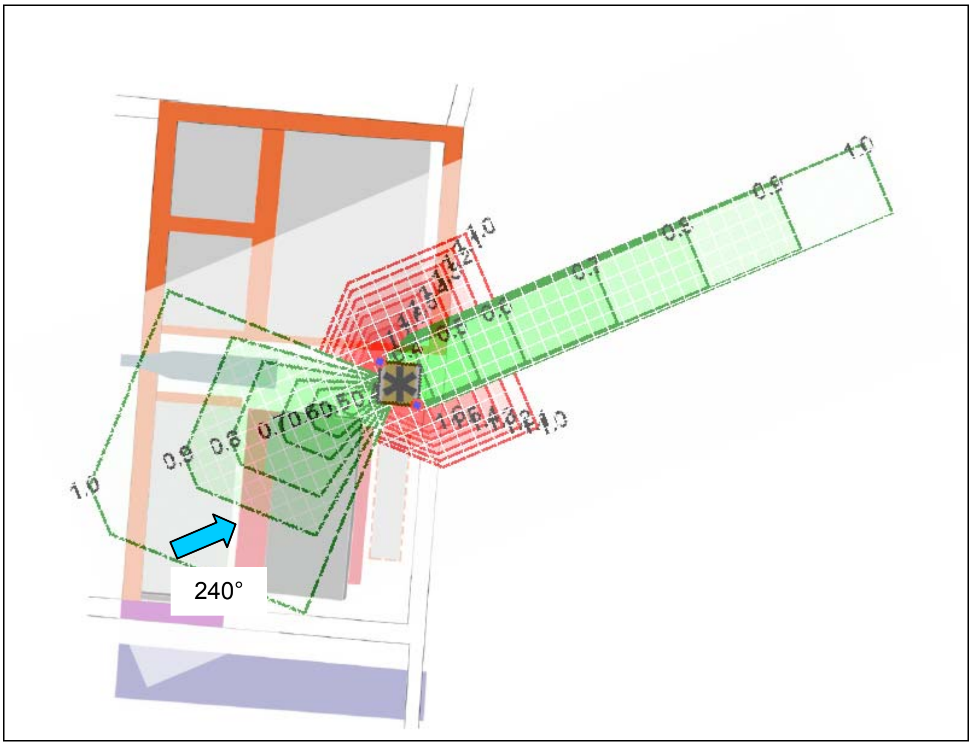

Figure 4: Maruta method output of North Lotts site

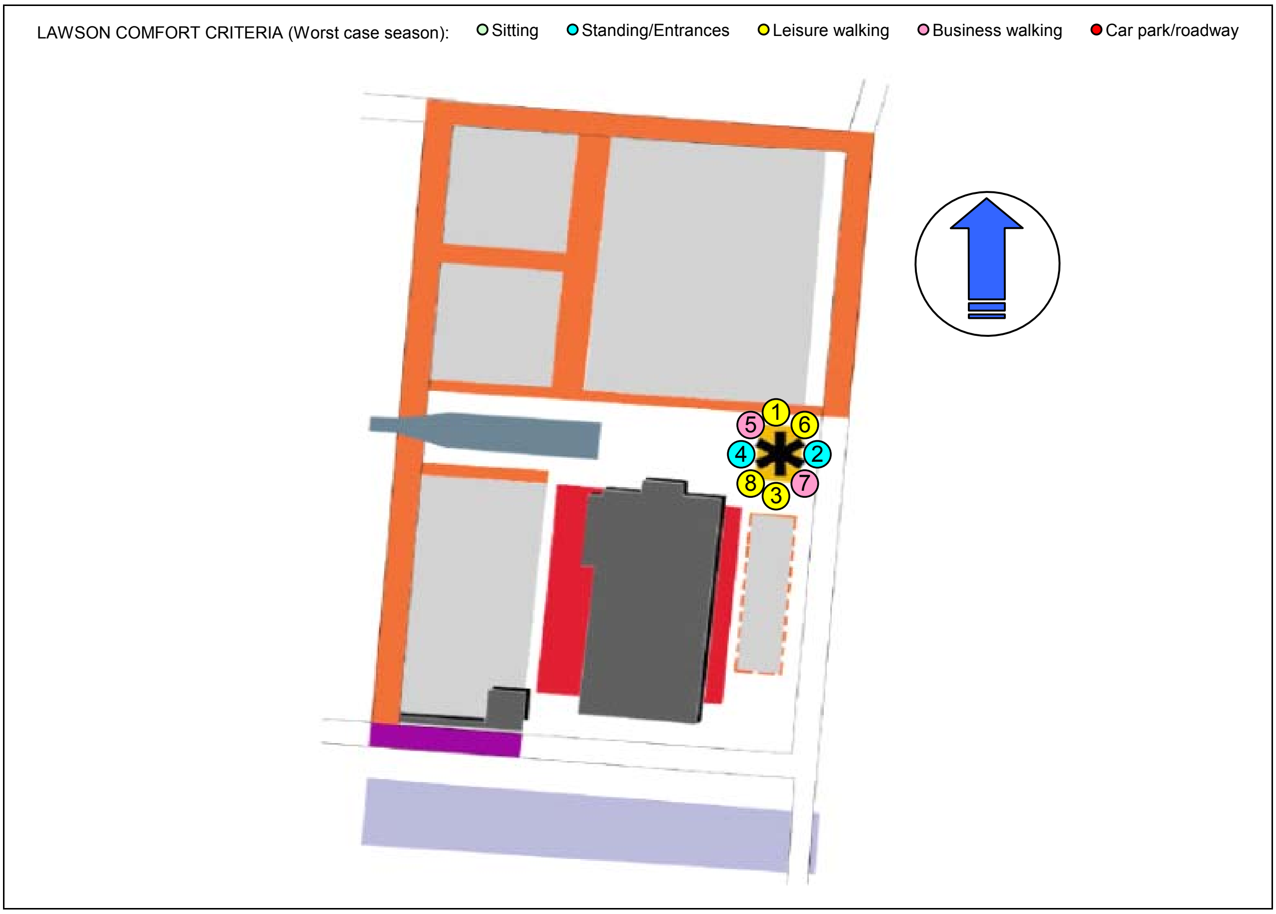

Figure 5: Expected comfort levels based on Maruta analysis

10.0.0 EFFECTS ON THE ENVIRONMENT: NOISE AND VIBRATION

10.1.0 INTRODUCTION

AWN Consulting Limited has been commissioned to conduct an assessment into the likely noise impact associated with the proposed development.

10.2.0 THE RECEIVING ENVIRONMENT

An environmental noise survey was conducted in order to quantify the existing noise environment. The survey was conducted generally in accordance with ISO 1996: 1982: *Acoustics – Description and measurement of environmental noise*. Specific details are set out below.

A list of forecasting methods is contained in Appendix 10.1

Choice of Measurement Locations

Three measurement locations were selected; refer to Appendix 10.2 for their approximate positions. Each is discussed in turn below.

Position 1 is located to the southeast of the site at the western end of York Road, Ringsend.

Position 2 is located towards the east end of Sheriff Street near the level crossing.

Position 3 is located on East Wall Road near an existing petrol station.

Survey Periods

Measurements were conducted over the course of the survey periods as follows:

- 10:30hrs to 13:30hrs on 11 February 2005,
- 23:20hrs to 02:30hrs on 7 – 8 March 2005.

The daytime measurements therefore cover a typical busy period, and the night-time measurements cover a typical period when people are preparing for sleep.

The weather throughout the survey periods was dry with light to moderate winds (<5m/s).

Personnel and Instrumentation

Louis Smith (AWN) conducted the noise level measurements during both daytime and night-time periods.

The measurements were performed using a Brüel and Kjær Type 2260 Sound Level Analyser. Before and after the survey the measurement apparatus was check calibrated using a Brüel and Kjær Type 4231 Sound Level Calibrator.

Procedure

Measurements were conducted over 15-minute periods, taking in all of the locations described previously. The measurement results were noted onto survey record sheets immediately following each measurement and also stored in the instrument's internal memory for subsequent analysis. Notes were taken in relation to weather conditions and the primary contributors to noise build-up at each location.

Measurement Parameters

The survey results are presented in terms of the following five parameters:

L_{Aeq} is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period.

L_{AMax} is the instantaneous maximum sound level measured during the sample period.

L_{AMin} is the instantaneous minimum sound level measured during the sample period.

L_{A10} is the sound level that is exceeded for 10% of the sample period. It is typically used as a descriptor for traffic noise.

L_{A90} is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.

The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the non-linear nature of human hearing. All sound levels in this report are expressed in terms of decibels (dB) relative to $2x10^{-5}$ Pa.

Results and Discussion

Position 1 York Road

The survey results for Position 1 are summarised in Table 10.1 below.

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)				
		L_{Aeq}	L_{AMax}	L_{AMin}	L_{A10}	L_{A90}
Daytime	11:30 – 11:45	61	71	57	62	59
	11:45 – 12:00	61	71	57	62	59
	13:17 – 13:32	64	79	58	67	59
Night-time	23:16 – 23:31	51	59	43	54	45
	00:20 – 00:35	51	65	41	54	44
	01:20 – 01:35	48	59	39	53	42

Table 10.1 Summary of survey results for Position 1

During the daytime survey periods, noise levels were in the range 61 to 64dB L_{Aeq} and of the order of 59dB L_{A90}. The dominant source of noise was traffic on surrounding roads. Other sources included construction noise in the distance and a degree of wind-generated noise.

During the night-time survey periods, noise levels were in the range 48 to 51dB L_{Aeq} and 42 to 45dB L_{A90}. Dominant sources of noise were traffic on surrounding roads and in the distance along with occasional vehicle movements on the East Link. Pedestrian activity was also noted as a source of noise at this location during this period.

No significant source of vibration was observed.

Position 2 East Wall Road

The results for Position 2 are summarised in Table 10.2 below.

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)				
		L_{Aeq}	L_{Amax}	L_{AMin}	L_{A10}	L_{A90}
Daytime	10:58 - 11:13	70	79	58	73	63
	12:02 - 12:17	70	81	59	73	64
	12:55 - 13:10	70	84	57	73	63
Night-time	23:37 - 23:52	64	79	42	68	44
	00:40 - 00:55	61	78	38	64	40
	01:40 - 01:55	60	77	37	62	38

Table 10.2 Summary of results for Position 2

Daytime noise levels were of the order of 70dB L_{Aeq} and in the range 63 to 64dB L_{A90}. The dominant source of noise was traffic on East Wall Road.

Night-time noise levels were in the range 60 to 64dB L_{Aeq} and 38 to 44dB L_{A90}. The dominant source of noise was intermittent traffic on East Wall Road.

No significant source of vibration was observed.

Position 3 Sheriff Street

The results for Position 3 are summarised in Table 10.3 below.

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)				
		L_{Aeq}	L_{Amax}	L_{AMin}	L_{A10}	L_{A90}
Daytime	10:39 - 10:54	67	89	56	68	58
	12:21 - 12:36	65	81	55	67	58
	12:36 - 12:51	68	87	55	70	59
Night-time	23:58 - 00:13	50	65	43	54	45
	01:00 - 01:15	46	64	39	45	41
	01:58 - 02:13	42	62	37	44	38

Table10.3 Summary of results for Position 3

Daytime noise levels were in the range 65 to 68 L_{Aeq} and 58 to 59dB L_{A90}. Audible sources of noise included construction activity nearby, traffic noise on Sheriff Street and train movements on nearby railway lines.

Night-time noise levels were in the range 42 to 50dB L_{Aeq} and 38 to 45dB L_{A90}. Distant traffic was the main source of noise. During the initial night time monitoring period, train movements along a nearby rail line resulted in an increase in measured ambient levels when compared to other night time monitoring carried out at this location.

No significant source of vibration was observed.

10.3.0 CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

When considering a development of this nature, the potential noise and vibration impact on the surroundings must be considered for each of two distinct stages: the short term impact of the construction phase and the longer term impact of the operational phase.

The construction phase will involve scrub clearance, landscaping and construction of the main building and surfacing the site roads.

There are five primary sources of noise in the operational context as follows:

- building services plant;
- car parking;
- deliveries in the service yard;
- additional vehicular traffic on public roads; and
- expansion of the Point Depot.

10.4.0 PREDICTED IMPACT OF THE PROPOSAL

Operational Phase

Noise Criteria

Due consideration must be given to the nature of the primary noise sources when setting criteria. In this instance, there are three primary sources of noise associated with the development once operational. Criteria for noise from the vehicular access and building services the will be set in terms of $L_{Aeq,T}$, the equivalent continuous sound level. Noise impact of additional traffic will be assessed using the L_{A10} parameter, which typically used to quantify traffic noise.

There is no Irish Standard containing guidance that is applicable in this instance. In the absence of such standards, best practice dictates that the potential noise impact of the proposed development be assessed against appropriate British and/or International Standards.

There are a number of noise sensitive properties in the vicinity of the development, i.e. private residences. Appropriate guidance is contained within BS8233: 1999: *Sound Insulation and Noise Reduction for Buildings – Code of Practice*. This British Standard sets out recommended noise limits for indoor ambient noise levels in Table 10.4 below.

Criterion	Typical situation	Design range $L_{Aeq,T}$ (dB)	
		Good	Reasonable
Reasonable resting /sleeping conditions	Living rooms	30	40
	Bedrooms	30	35

Table 10.4 Recommended indoor ambient noise levels from BS8233: 1999

Given built-up nature of the area, it is considered appropriate to select a 'reasonable' criterion of 35dB $L_{Aeq,T}$ for night-time. This represents an acceptable target in relation to the residences.

Considering the existing noise environment in the area, it is appropriate to adopt a 'reasonable' standard for daytime, i.e. 40dB $L_{Aeq,T}$. This corresponds to the upper end of the reasonable range for noise sensitive locations.

For the purposes of this study, it is appropriate to derive external limits based on the internal criteria given in Table 6 above. This is done by factoring in the degree of noise reduction afforded by an open window. This is nominally 10dB.

A shorter assessment time period (T) is adopted for night-time in order to reflect the increased potential for disturbance. Appropriate periods are 1 hour for daytime (07:00hrs to 23:00hrs) and 5 minutes for night-time (23:00hrs to 07:00hrs).

In summary, the following criteria apply at the façades of those noise sensitive properties closest to the development:

Daytime (07:00hrs to 23:00hrs) 50dB $L_{Aeq,1hr}$
Night-time (23:00hrs to 07:00hrs) 45dB $L_{Aeq,5min}$

These criteria are also in compliance with the following guidance taken from the World Health Organisation publication “Community Noise”.

To protect the majority of people from being moderately annoyed during the daytime, the sound pressure level should not exceed 50dB L_{Aeq}.

At night-time outdoors, sound pressure levels should not exceed 45dB L_{Aeq}, so that people may sleep with bedroom windows open.

In order to assist with interpretation of traffic noise, Table 10.5 offers guidance as to the likely impact associated with any particular change in traffic noise level.

Change in Sound Level (dB L_{A10})	Subjective Reaction	Impact
< 3	Imperceptible	Neutral
3 – 5	Perceptible	Minor
6 – 10	Up to a doubling of loudness	Moderate
11 – 15	Over a doubling of loudness	Major
> 15	-	Severe

Table 10.5 Likely Impact Associated With Change In Traffic Noise Level

Vibration Guidelines

Vibration standards come in two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. In both instances, it is appropriate to consider the magnitude of vibration in terms of Peak Particle Velocity (PPV).

It is acknowledged that humans are particularly sensitive to vibration stimuli and that any perception of vibration may lead to concern. In the case of road traffic, vibration is perceptible at around 0.5mm/s and may become disturbing or annoying at higher magnitudes. However, higher levels of vibration are typically tolerated for single events or events of short duration. For example, blasting and piling, two of the primary sources of vibration during construction, are typically tolerated at vibration levels up to 12mm/s and 5mm/s respectively. This guidance is applicable to the daytime only; it is unreasonable to expect people to be tolerant of such activities during the night-time.

Guidance relevant to acceptable vibration within buildings is contained in the following documents:

- British Standard BS 7385 (1993): *Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration*, and;

- British Standard BS 5228 (1992): *Noise control on construction and open sites* Part 4 *Code of practice for noise and vibration control during piling*.

BS 7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15mm/s at low frequencies rising to 20mm/s at 15Hz and 50mm/s at 40Hz and above. These guidelines relate to relatively modern buildings and should be reduced to 50% or less for more critical buildings.

BS 5228 recommends that, for soundly constructed residential property and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak particle velocity of 10mm/s for intermittent vibration and 5mm/s for continuous vibration. Below these vibration magnitudes minor damage is unlikely, although where there is existing damage these limits may be reduced by up to 50%. For light and flexible industrial and commercial structures threshold limits of 20mm/s for intermittent and 10mm/s for continuous are recommended, whilst for heavy and stiff buildings higher thresholds of 30mm/s for intermittent and 15mm/s for continuous are recommended.

Construction Phase

There is no published Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Local authorities normally control construction activities by imposing limits on the hours of operation and consider noise limits at their discretion.

In the absence of specific noise limits, appropriate criteria relating to permissible construction noise levels for a development of this scale may be found in the National Roads Authority (NRA) publication Guidelines for the Treatment of Noise and Vibration in National Road Schemes6 which indicates the following criteria and hours of operation. The majority of the construction activity is expect to occur during normal working hours.

Table 10.6 indicates the maximum permissible noise levels at the facade of dwellings during the construction period as recommended by the NRA.

Days and Times	Noise Levels (dB re. $2x10^{-5}$ Pa)	
	$L_{Aeq(1hr)}$	L_{Amax}
Monday to Friday 07:00 to 19:00hrs	70	80
Monday to Friday 19:00 to 22:00hrs	60*	65*
Saturdays 08:00 to 16:30hrs	65	75*
Sundays & Bank Holidays 08:00 to 16:30hrs	60*	65*

Table10. 6 Maximum Permissible Noise Levels At The Facade of Dwellings During Construction

Note * Construction activity at these times, other than that required for emergency works, will normally require the explicit permission of the relevant local authority.

A variety of items of plant will be in use, such as excavators, lifting equipment, dumper trucks, compressors and generators. There will be vehicular movements to and from the site that will make use of existing roads.

Due to the nature of the activities undertaken on a large construction site, there is potential for generation of significant levels of noise. The flow of vehicular traffic to and from a construction site is also a potential source of relatively high noise levels. The potential for vibration at neighbouring sensitive locations during construction is typically limited to excavation works and lorry movements on uneven road surfaces. Due to the

6 *Guidelines for the Treatment of Noise and Vibration in National Road Schemes, Revision 1, 25 October 2004* , National Roads Authority.

proximity of sensitive locations to potential site access points, the more significant of these is likely to be uneven road surfaces. However, there is little likelihood of structural or even cosmetic damage to existing neighbouring dwellings.

Due to the fact that the construction programme has been established in outline form only, it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, Table 10.7 indicates typical noise levels that would be expected from the proposed construction site during the various phases of the construction project.

For the purposes of the calculation, it is assumed that equipment will be operating at the western boundary at a distance of 15 metres from the residential dwellings proposed as part of the neighbouring section of the Docklands redevelopment. It must be stated that for the majority of the construction programme, plant and equipment will be a greater distance from the nearest residential dwelling than that used for the calculations in Table 10.7 and consequently will have lesser impact. Our assessment is therefore representative of a "worst-case" scenario.

The following assumptions have been made in the preparation of these construction noise predictions:

- a utilisation of equipment of 66% over a working day;
- construction site will be screened by 2.5 metre high hoarding.

Phase	Item of Plant	L_{Aeq} at 10m[7] (dB)	L_{Aeq} at NSL (dB)
Site clearance /excavation	Track Excavator plus lorry (C3.92)	76	63
Foundations	Compressor (C6.19)	72	69
	Poker Vibrator (C6.20)	81	
	Cement Mixers (C6.5)	74	
Steel Erection	Crane (C7.116)	80	67
	Lorry (C7.121)	70	
General Construction	Compressor (C7.27)	72	68
	Diesel Hoist (C7.98)	76	
	Pneumatic Circular Saw (C7.79)	75	
	Generator (C7.49)	76	
Road works/landscaping	Surfacing (C8.30)	73	60

Table10.7 Typical Noise Levels at nearest residential property during Different Construction Phases. The numbers in parentheses refer to tables in BS5228 from which the levels are quoted.

There is no relevant item of plant that would be expected to give rise to noise levels that would be considered out of the ordinary or in excess of the levels outlined in Table 10.6 above.

Assessment of Operational Noise

There are five primary sources of noise in the operational context:

- building services plant;

[7] Sound Pressure Level data from BS5228 – 1: 1997

- car parking;
- deliveries in the service yard;
- additional vehicular traffic on public roads; and,
- expansion of the Point Depot

Each of these primary noise sources is addressed in turn.

Building Services Plant

Once a development of this nature becomes fully operational, a variety of electrical and mechanical plant will be required to service the various buildings. Most of this plant will be capable of generating noise to some degree. Some of this plant may operate 24 hours a day, and hence would be most noticeable during quiet periods (i.e. overnight). Noisy plant with a direct line-of-sight to noise sensitive properties would potentially have the greatest impact.

Noise from building services plant will be controlled such that it does not exceed a level of 45dB $L_{Aeq,T}$ at a distance of 5m from the façade of any building associated with the development.

The closest noise sensitive properties are the proposed residential units which lie to the west of this section of the development, at a distance of 15 meters. The predicted maximum plant noise level at the façade these residences is 35dB $L_{Aeq,T}$. This is within both the daytime criterion of 50dB $L_{Aeq,1hr}$ and the night-time criterion of 45dB $L_{Aeq,5min}$.

Car Parking on Site

The proposed buildings have associated underground car parks beneath them. The enclosed nature of the car parks will ensure that the impact at noise-sensitive residences both within the development and in the surrounding areas is negligible.

Service Yard Activity

Deliveries to a service yard can be a source of noise disturbance, with the greatest potential impact begin at night-time. At the detailed design stage, the location and configuration of any service yards will be chosen to minimise the noise impact on residences within and in the vicinity of the development. Means of reducing the potential noise impact of service yard activities include careful selection of the location and orientation of the yard, erection of barriers and enclosing the yard.

Additional vehicular traffic on public roads

Traffic noise levels along public roads in the vicinity of the development are in the range of 62 to 67dB and 68 to 70dB L_{A10} along York Road and Sheriff Street respectively. Along the East Wall Road traffic noise levels of the order of 73dB L_{A10} have been monitored during daytime periods.

A doubling of existing traffic volumes would be required in order to result in a corresponding increase in noise levels that would be audible to the human ear. In this instance it would be expected that increase in traffic volumes associated with the development will be of a magnitude that will result in a traffic noise increase of the order of 1dB along existing public roads. Reference to Table 5 confirms that such an increase is imperceptible and the associated noise impact is not significant.

Expansion of the Point Depot

The expansion of the Point Deport from 8,500 to 12,000 capacity is part of the overall development of the area under study. During the detailed design of the expanded venue consideration will be given to limiting music noise break out to noise sensitive locations in the vicinity of the development. The building envelope will be designed and constructed such that noise emissions associated with entertainment events will be within the recommended criteria of 55dB L_{Aeq} and 45dB L_{Aeq}.

Building services noise associated with the redeveloped Point Depot will adhere to advice detailed in the previous section.

As a result of the increase capacity of the redeveloped Point Depot increased traffic movements would be expected to occur to and from the venue during periods when entertainment events are taking place.

Assuming the increase in traffic movements associated with a Point Depot event will be equivalent to the increase in capacity of the venue (i.e. 8,500 to 12,000) it will result in an increase of traffic noise along existing public roads of order of 1.5dB. Reference to Table 10.5 confirms that such an increase is imperceptible and the associated noise impact is not significant.

10.5.0 MITIGATION MEASURES

Construction Phase

With regard to construction activities, reference will be made to BS5228: *Noise control on construction and open sites*, which offers detailed guidance on the control of noise and vibration from demolition and construction activities. In particular, it is proposed that various practices be adopted during construction, including:

- limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- establishing channels of communication between the contractor/developer, Local Authority and residents;
- appointing a site representative responsible for matters relating to noise and vibration;
- monitoring typical levels of noise and vibration during critical periods and at sensitive locations;
- site access roads will be kept even so as to mitigate the potential for vibration from lorries.

Furthermore, it is envisaged that a variety of practicable noise control measures will be employed. These may include:

- selection of plant with low inherent potential for generation of noise and/ or vibration;
- erection of barriers as necessary around items such as generators or high duty compressors;
- siting of noisy / vibratory plant as far away from sensitive properties as permitted by site constraints and the use of vibration isolated support structures where necessary;