Lawnswood Roundabout

Emissions Assessment

Leeds City Council

April 2024

Delivering a better world

Quality information

Prepared by	Checked by	Verified by	Approved by
Elise Lie Graduate Consultant Amy Foulds Graduate Consultant	Jacob Hughes Senior Transport Consultant Duncan Urquhart Associate Director	Katy Thorpe Associate Director	Tom Stenhouse Technical Director

Revision History

Revision	Revision date	Details	Authorised	Name	Position
1	01 March 2024	Issue	Y	TS	Technical Director
2	14 March 2024	Issue	Y	TS	Technical Director
3	21 March 2024	Issue	Y	TS	Technical Director
4	12 April 2024	Issue	Y	TS	Technical Director

Distribution List

# Hard Copies	PDF Required	Association / Company Name
N	Y	Leeds CC

Prepared for:

Leeds City Council

Prepared by:

AECOM Limited
5th Floor, 2 City Walk
Leeds LS11 9AR
United Kingdom

Table of Contents

1. Introduction.......... 1
Objectives.......... 1
Study Area.......... 1
Assessment Scenarios.......... 2
2. Assessment Methodology.......... 1
AIMSUN Modelling.......... 1
Modelled Network.......... 1
Traffic Signals.......... 2
Vehicle Types & User Classes.......... 2
Air Quality Modelling.......... 3
NO_2 and NO_X.......... 3
LEM Fleet Profile.......... 4
Local Air Quality Monitoring.......... 5
Background Pollutant Concentrations.......... 3
Assessment Scenarios.......... 3
Do Nothing.......... 3
Do Something - Less Ambitious.......... 3
Do Something Preferred.......... 4
Do Something – More Ambitious.......... 4
3. Modelled Emissions.......... 5
Scenario comparison.......... 5
Comparison to Monitoring.......... 9
Comparison of 2023 and 2038 AM Peak Emissions.......... 10
Comparison of Core and Sensitivity Test.......... 11
4. Summary and Conclusions.......... 12
Summary.......... 12
Conclusion.......... 13
Appendix A Baseline Emissions.......... 14
Appendix B Emissions Impacts.......... 15
Appendix C Emissions Impacts of Sensitivity Tests.......... 18
Appendix D Distance Adjustment.......... 21

Figures

Figure 1 – Network Extent and Area of Interest (Green).......... 2
Figure 2 – AIMSUN Modelled Area Of Interest In Sections.......... 2
Figure 3 - Local Air Quality Monitoring Locations.......... 2
Figure 4 – Lawnswood Priority Roundabout (Left), Lawnswood Signalised Roundabout (Right).......... 3
Figure 5 – Otley Road Southbound Without Bus Lane (Left), Otley Road Southbound Including Bus Lane (Right) 4
Figure 6 – Otley Old Road Priority Junction (Left), Otley Old Road Signalised Junction (Right).......... 5
Figure 7 - Select Links with High Emissions.......... 7
Figure 8 - Daily Average NO_X Emission Rates: "2023 Do Nothing" Scenario.......... 14
Figure 9 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs “2023 Less Ambitious”, Core Tests.......... 15
Figure 10 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs “2023 Preferred”, Core Tests.......... 16
Figure 11 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs “2023 More Ambitious”, Core Tests.......... 17

Figure 12 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs “2023 Less Ambitious”, Sensitivity Test 18
Figure 13 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs “2023 Preferred”, Sensitivity Test 19
Figure 14 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs “2023 More Ambitious”, Sensitivity Test 20
Figure 15 Example of Rate of Change in Pollutant Concentrations with Distance from the Kerb 21

Tables

Table 1 - Model Scenarios 2
Table 2 - Signalised Lawnswood Roundabout Call Frequency of Exit Pedestrian / Cycle Crossings 1
Table 3 - Fleet Profile Used in AIMSUN Model, 2023 5
Table 4 - Fleet Profile Used in AIMSUN Model, 2038 5
Table 5 - Local Air Quality Monitoring 1
Table 6 - Scenario Comparison (Subset of Links with Highest Emission Rates) 6
Table 7 - NO_2 Monitoring Undertaken Near the Proposed Scheme 10
Table 8 - Subset of Links with Highest Emission Rates, AM Peak Hour in 2038 10
Table 9 Example of Distance Adjustment of Pollutant Concentrations 21

1. Introduction

The Lawnswood Roundabout improvement scheme has been developed by Leeds City Council (LCC) to address safety issues, provide more attractive active travel facilities, and allow buses to be prioritised. There are three alternative scheme options under consideration, with each option including full signalisation of the roundabout. As part of the consultation exercise concerns were raised by key stakeholders about the impact of the schemes on emissions due to the potential for traffic signal control to cause more stop/start movements on the network.

AECOM were appointed by LCC to utilise their existing Outline Business Case (OBC) AIMSUN microsimulation model to assess the potential impact of the proposed scheme options on traffic emissions and air quality at Lawnswood Roundabout and Otley Old Road. This Emissions Assessment Report details the methodology used to adapt the 2023 and 2038 Lawnswood AIMSUN model to understand the potential impact on traffic emissions and the consequent effects on local air quality between the existing network and the three alternative scheme layouts. This assessment has been undertaken using the AIMSUN London Emission Model (LEM) package.

Objectives

The objectives of this modelling assessment were to:

- Appraise the current air quality in the study area; and
- Determine the potential impact of the proposed improvement scheme options on air quality.

This was achieved by considering the following questions:

- What is the potential impact of each scheme option on traffic emissions compared with the existing layout in the 2023[1] Opening Year?
- What is the potential impact of each scheme option on traffic emissions compared with the existing layout in the 2038 AM peak?
- What would the ‘worst case’ impact of each scheme option on traffic emissions be, should all pedestrian / cycle crossings be called every cycle?

Study Area

The AIMSUN model network extents are indicated in **Figure 1** below. The area of interest is highlighted green and indicates where the Air Quality analysis has been focussed. Traffic emissions in this area are affected by two major junctions:

- Lawnswood Roundabout (All the scheme options include full signalisation); and
- Otley Old Road / Otley Road Junction.

[1] The opening year for LCC’s OBC AIMSUN model has been retained as 2023, despite provision of this Emission Assessment in 2024. The opening year provides an indicative assessment of the extent and magnitude of effects.

Figure 1 – Network Extent and Area of Interest (Green)

Assessment Scenarios

The existing AIMSUN model was developed, calibrated, and validated by LCC to existing network conditions using AIMSUN 8.4.3. The modelled scenarios used for emissions analysis within this study are outlined in **Table 1** below.

Table 1 - Model Scenarios

Scenario	Description	AM	IP	PM
2023 Do Nothing	Existing network	Yes	Yes	Yes
2023 Less Ambitious	Signalisation of Lawnswood Roundabout	Yes	Yes	Yes
2023 Preferred	Less Ambitious plus southbound Otley Road bus lane	Yes	Yes	Yes
2023 More Ambitious	Preferred plus signalisation of the Otley Old Road / Otley Road junction	Yes	Yes	Yes
2038 Less Ambitious	2023 Less Ambitious network with 2038 forecast flows	Yes	No	No
2038 More Ambitious	2023 More Ambitious network with 2038 forecast flows	Yes	No	No

The modelled peak hours were:

- AM: 07:30-08:30
- IP: 11:00-12:00 (Representative of the 10:00 – 14:00 average interpeak hour)
- PM: 16:15-17:15

Frequency of demand for the pedestrian / cycle crossings on the roundabout exit inks was modelled as shown in **Table 2** below. The modelled frequencies were based on the observed use of the existing informal pedestrian crossings, and cycle movements through the roundabout, whilst assuming a 50% uplift in pedestrian and cycle movements in response to the implementation of signalised crossing facilities and cycle infrastructure. Sensitivity tests were also run to consider the 'worst-case' scenario with all crossings activated each cycle during the modelled peak hours, without any reduction in general traffic flows.

Table 2 - Signalised Lawnswood Roundabout Call Frequency of Exit Pedestrian / Cycle Crossings

Period	A660 north	A6120 east	A660 south	A6120 west
AM (07:30-08:30)	1 in 5	1 in 1	1 in 4	2 in 3
IP (10:00 – 14:00, AVG Hr)	1 in 10	1 in 3	1 in 6	1 in 2
PM (17:15-18:15)	1 in 6	1 in 1	1 in 4	1 in 1

2. Assessment Methodology

AIMSUN Modelling

AECOM's Air Quality AIMSUN model largely retains the existing characteristics of the OBC AIMSUN model. A high-level review of the existing model parameters that could impact the LEM assessment was undertaken, with minor modelling adjustments agreed with LCC. The purpose of this was to ensure that the potential impact of the scheme options on the emissions outputs was consistently and robustly assessed.

The modelled simulations within AIMSUN have an additional 15-minute warm-up period allowing for a pre-load of vehicles so that the peak hour network conditions are representative. The peak hour matrices have been modelled as an hour using AIMSUN's exponential arrival profile throughout the peak hour.

Each scenario was run for ten seed runs, representing day-to-day variation, to form an understanding of the average model operation. Seeds represent variation in vehicle characteristics throughout the network, referred to as replications in AIMSUN. Consistent seed values have been modelled between comparable models to ensure that variation between the models relates to scheme differences only.

Modelled Network

The OBC network structure was coded by LCC using OpenStreet Map and OS mapping. The full network extents remain the same as in the received model to allow consistent arrival profiles within the area of interest. The network within the area of interest was split into short sections to facilitate micro-trips for LEM assessment. Where possible shorter links were used closer to the stopline to provide more a detailed emissions assessment. The sections included within the area of interest are shown in **Figure 2** below:

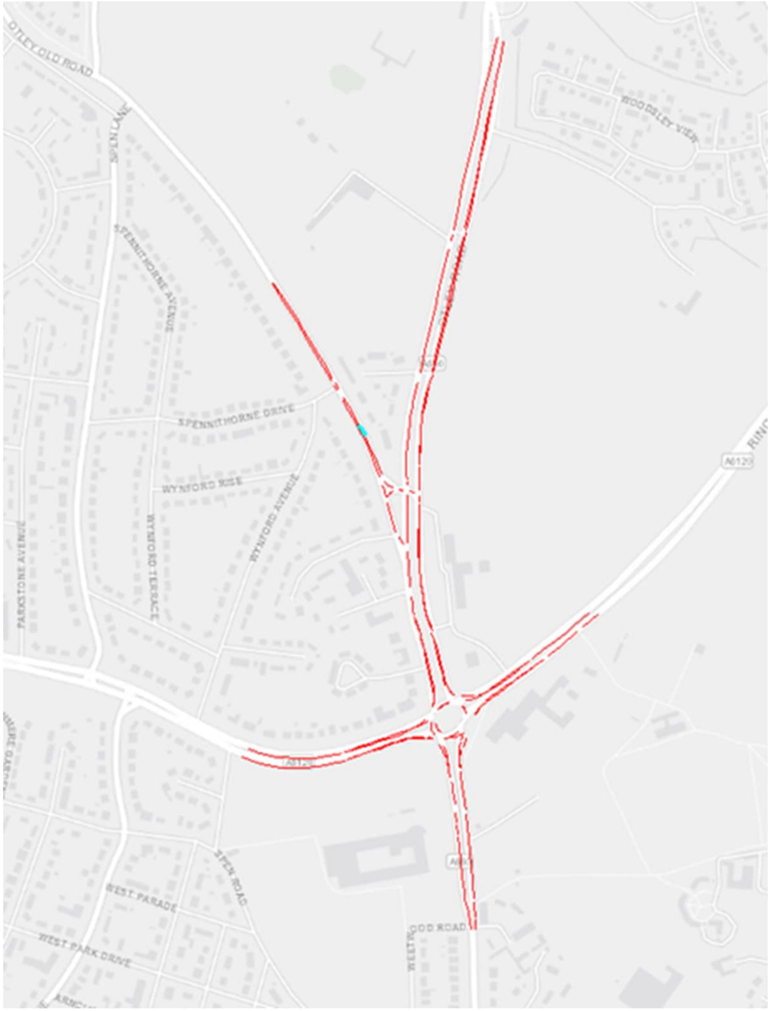

Figure 2 – AIMSUN Modelled Area Of Interest In Sections.

Traffic Signals

Fixed signal timings were retained from the OBC model of the proposed Lawnswood Roundabout and Otley Road signalised junctions. Lawnswood Roundabout pedestrian crossing call frequency on all exit lanes was modelled as shown in **Table 2**. Pedestrian / cycle crossing call frequency was adjusted on exit lanes only as the crossings on the entry arms can run in parallel with the circulatory traffic movement.

Vehicle Types & User Classes

The user classes and level of service were retained from the OBC model. The following vehicle classes were stochastically routed through the network using origin-destination matrices:

- Car
- Light Goods Vehicles (LGV)
- Heavy Goods Vehicles (HGV) - Origin-Destination (OD) Matrices.
- Pedal Cycles
- Motorcycles

Buses were statically routed through the network using public transport (PT) lines.

Heavy vehicles are not separated as OGV1 and OGV2 in the OBC model. The vehicle length modelled is more closely representative of OGV1 vehicles; the LEM model has not reviewed the impact of OGV2 vehicle types given the modelling approach from LCC. Pedal cycles and motorcycles were not included within the assessment, however their emission impact on other vehicle classes was represented by the model.

Air Quality Modelling

The AIMSUN microsimulation model incorporates the London Emission Model (LEM), which was developed by Leeds University and TfL (Transport for London) specifically in response to the need to represent emissions from queueing and congested traffic (owing to observations that average-speed models tended to under-predict emissions at low speeds and that variability of vehicle activity means that predictions based on average link speeds on short links, or for short time periods, contain significant levels of uncertainty. The approach taken by the LEM model is to derive the emissions for an individual vehicle using its average speed in a set of micro-trips that comprise its whole journey.

The software operates in a comparable way to an Instantaneous Emissions Model, using the average speed of each individual vehicle travelling through a link defined in the microsimulation model and assigning a corresponding emission rate on a continuous curve for all speeds above 0 km/hr. Where a vehicle stops within a link it is classified as a micro-trip and assigned a discrete emission rate for this part of the link.

The model outputs ‘Sections’ representing emissions on the mainline (as g/km/s), whereas junction turns are merged into ‘Links’ representing the combined total emissions (as g/s) from both the turns and corresponding Sections. Therefore, for the purposes of this study the emissions from turns have not been presented as the model cannot disaggregate them from Links.

NO_2 and NO_X

The principal air quality legislation within the United Kingdom is the Air Quality Standards Regulations (as amended 2016)[2], including amendments, such as ‘The Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020’[3].

The UK is no longer a member of the European Union, however, some types of EU legislation such as Regulations and Decisions, are directly applicable as law in an EU Member State. This meant that, as a Member State, these types of legislation applied automatically in the UK, under section 2(1) of the European Communities Act 1972 (c.68), without any further action required by the UK. These types of legislation are published by the Publications Office of the European Union on the EUR-Lex website and are now published on legislation.gov.uk as ‘legislation originating from the EU’.

In 2019, the UK government released its Clean Air Strategy 2019[4], part of its 25 Year Environment Plan. The Strategy places greater emphasis on improving air quality in the UK than has been seen before and outlines how it aims to achieve this (including the development of new enabling legislation). Air quality management focus in recent years has primarily related to one pollutant, NO_2, and its principal source in the UK, road traffic. However, the 2019 Strategy broadened the focus to other areas, including domestic emissions from wood burning stoves and from agriculture.

The Air Quality Objectives set out in the Air Quality Strategy[5] have been outlined in legislation solely for the purposes of local air quality management. Under the local air quality management (LAQM) regime, the local authority has a duty to carry out regular assessments of air quality against the objectives and if it is unlikely that they will be met in the given timescale, they must designate an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) with the aim of achieving the objectives. The boundary of an AQMA is set by the governing local authority to define the geographical area that is to be subject to the management measures to be set out in a subsequent action plan. Consequently, it is not unusual for the boundary of an AQMA to include within it, relevant locations where air quality is not at risk of exceeding an Air Quality Objective.

The UK’s national Air Quality Objectives for NO_2 in relation to human health are the same as the national objectives[6]:

[2] HM Government (2016). “The Air Quality Standards (Amendment) Regulations (2016). SI 2016 No. 1184,” Her Majesty’s Stationery Office.
[3] UK Statutory Instruments (2020). “The Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020,” Available at: https://www.legislation.gov.uk/uksi/2020/1313/regulation/2/made
[4] Department for Environment, Food and Rural Affairs (2019). UK Clean Air Strategy 2019. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf
[5] Department for Environment, Food and Rural Affairs (2023). Air Quality Strategy for England, available at: https://www.gov.uk/government/publications/the-air-quality-strategy-for-england/air-quality-strategy-framework-for-local-authority-delivery
[6] https://environment.ec.europa.eu/topics/air/air-quality/eu-air-quality-standards_en

- An annual mean concentration of 40 µg m^{-3} (micrograms per meter cubed); and
- An hourly mean concentration of 200 µg m^{-3}, to be exceeded no more than 18 times per year (99.79th percentile).

In practice, meeting the annual mean objective has been and will continue to be considerably more demanding than achieving the 1-hour objective. The annual mean objective of 40 µg/m^3 is currently widely exceeded at roadside locations throughout the UK, with exceedances also reported at urban background locations in major conurbations. Exceedances are associated almost exclusively with road source emissions.

There is considerable year-to-year variation in the number of exceedances of the hourly objective, driven by meteorological conditions which give rise to winter episodes of poor dispersion and summer oxidant episodes. Analysis of the relationship between 1-hour and annual mean NO_2 concentrations at roadside and kerbside monitoring sites indicate that exceedances of the 1-hour objective are unlikely where the annual mean is below 60 µg m^{-3}.[7]

NO_2 and nitric oxide (NO) are both oxides of nitrogen and are collectively referred to as NO_X. All combustion processes produce NO_X emissions, largely in the form of NO, which is then converted to NO_2, mainly because of its reaction with ozone in the atmosphere. Therefore, the ratio of NO_2 to NO is primarily dependent on the concentration of ozone and the distance from the emission source.

In terms of achieving annual mean objective, this is reported in two ways:

- Locations of concern regarding local air quality management include locations where people will be present, such as the facade of residential properties, schools, nurseries or care homes etc. This is used to inform local planning decisions, such as the declaration of an Air Quality Management Area.
- There is also a need to understand compliance in the context of the UK's national reporting with the annual mean NO_2 objective. For consistent reporting standards, the national reporting of compliance applies specific criteria for locations of concern (which are different to the LAQM criteria in the bullet above) – this is defined as locations that are 4m from the kerb at a location “typical of the link as a whole and more than 25 m from a junction”[8,9] where this is uninterrupted for more than 100m and there is public access.

LEM Fleet Profile

During the project inception meeting on 19th September 2023, it was agreed that the modelling should focus on the relative change, rather than an accurate calculation of absolute emissions rates, as this provides the most important measure of the scheme impact upon air quality. AECOM proposed that fuel-type breakdown and euro class emissions breakdown for Cars and LGVs would be based on regional DVLA data and the approach for HGVs and Buses would be based on ANPR analysis undertaken for a previous scheme in the district. LCC agreed with these assumptions, due to the lack of alternative data and the fact that HGVs and Buses constituted a relatively low proportion of all vehicles.

A local fleet profile for light duty vehicles (LDV; cars and LGV <3.5t) was calculated using the DVLA data for vehicles registered in West Yorkshire reported for 2022. This fleet was suitable to represent the 2023 model year without further adjustment but was projected further to 2038 using the latest DEFRA Emissions Factors Toolkit (EFT) v11 for the future assessment year.

The heavy-duty vehicle (HGV and bus) fleet breakdown was based on the ANPR survey undertaken by Leeds CC in 2016 and projected forwards to 2023 and 2038 using the EFT.

The data in **Table 3** and **Table 4** provide the Fuel Class proportional breakdown used in the AIMSUN model for the LEM assessment. The fuel class proportions are split into petrol, diesel and alternative (e.g. electric) per vehicle class. It was assumed there were no non-diesel HGVs or buses operating in either study year. Due to the low proportion of HGVs and buses, this assumption will have no significant bearing on the model outcome.

[7] DEFRA (2022) Local Air Quality Management Technical Guidance
[8] https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2209290933_Data_Merging_Report_Final.pdf
[9] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02008L0050-20150918&from=EN#tocId46

Table 3 - Fleet Profile Used in AIMSUN Model, 2023

Class	Lights						Class	Heavies	
	Car			LGV				HGV	Bus
	Petrol	Diesel	Alt	Petrol	Diesel	Alt		Diesel	Diesel
Fuel Class Proportion	*43%*	*48%*	*9%*	*1%*	*98%*	*1%*		*100%*	*100%*
Euro 0	0.0%	0.0%		0.0%	0.0%		Euro 0	0.0%	0.0%
Euro 1	1.4%	0.7%		9.5%	1.6%		Euro I	0.0%	0.0%
Euro 2	2.8%	1.3%		19.0%	3.2%		Euro II	0.0%	0.0%
Euro 3	4.1%	2.0%		28.5%	4.8%		Euro III	1.4%	6.1%
Euro 4	18.8%	20.0%		8.1%	15.2%		Euro IV	2.2%	4.7%
Euro 5	24.9%	39.9%		7.7%	26.1%		Euro V EGR	2.9%	1.6%
Euro 6	48.0%	24.3%		27.3%	49.1%		Euro V SCR	8.6%	4.9%
Euro 6c	-	11.9%		-	-		Euro VI	85.0%	82.7%

Table 4 - Fleet Profile Used in AIMSUN Model, 2038

Class	Lights						Class	Heavies	
	Car			LGV				HGV	Bus
	Petrol	Diesel	Alt	Petrol	Diesel	Alt		Diesel	Diesel
Fuel Class Proportion	*37%*	*22%*	*41%*	*2%*	*82%*	*16%*		*100%*	*100%*
Euro 0	0.0%	0.0%		0.0%	0.0%		Euro 0	0.0%	0.0%
Euro 1	0.0%	0.0%		0.0%	0.0%		Euro I	0.0%	0.0%
Euro 2	0.0%	0.0%		0.0%	0.0%		Euro II	0.0%	0.0%
Euro 3	0.0%	0.0%		1.0%	0.1%		Euro III	0.0%	6.1%
Euro 4	0.9%	1.4%		0.1%	1.3%		Euro IV	0.0%	4.7%
Euro 5	3.5%	16.0%		0.4%	4.4%		Euro V EGR	0.2%	1.6%
Euro 6	95.5%	14.2%		98.5%	94.3%		Euro V SCR	0.6%	4.9%
Euro 6c	-	68.4%		-	-		Euro VI	99.2%	82.7%

Local Air Quality Monitoring

Leeds City Council (LCC) undertake monitoring within the study area using passive diffusion tubes. The location of the air quality monitoring sites near the proposed scheme are shown in **Figure 3**.

Monitoring has been undertaken at several different locations near the proposed scheme. Sites have been introduced and removed over the years, and there are some partial years of data recorded, in particular 2023. The data presented for 2023 and used in the discussion of the model results were therefore seasonally adjusted using the methodologies published in DEFRA guidance LAQM.TG (22)[10] including the DEFRA Diffusion Tube Processing Tool[11]. Notably, Site 631 recorded a concentration (44 µg m^{-3}) exceeding the annual mean objective; this value was derived from 6-months of data, with an average raw concentration of 29.5 µg m^{-3}, and a factor of 1.49 applied to account for seasonal variation. Given the large factor, which indicates a strong meteorological influence in 2023, the data presented for 2023 should be treated cautiously and are primarily used in this assessment to indicate the extent and magnitude of potential effects of the modelled scenarios and compliance with the Air Quality Objectives (AQO) should be based on the final, ratified, and adjusted concentrations for the full 12-month period.

[10] https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf
[11] https://laqm.defra.gov.uk/air-quality/air-quality-assessment/diffusion-tube-data-processing-tool/

Table 5 - Local Air Quality Monitoring

ID	Coordinate		Annual Mean NO_2, µg m^{-3}						
	X	Y	2017	2018	2019	2020	2021	2022	*Indicative 2023
221	426747	437544	22	22					
222	426533	437779	18	20					
223	426536	437634	17	17	18	12	15		
330	426798	438073		36	29				**40**
331	426847	438073		38					
332	426869	438035		40	34				
333	426847	437976		30					
334	426821	437973		29					
335	426787	437997		34					33
336	426798	438048		**42**					
420	427257	438450			27	20	20	32	
421	427274	438436			**41**	28	36	23	
631	426665	437980							**44**
647	426735	438383							22
648	426661	438504							24

*Source: Leeds City Council. Data presented to 1 µg /m^3 for all years, as provided. Where greater accuracy is available, this is used in the discussion of results. Emboldened numbers refer to concentrations at or above the annual mean Air Quality Objective for NO_2 (40 µg/m^3). *2023 data seasonally adjusted but cannot be adjusted for systematic bias until later in 2024 once the appropriate bias adjustment factors are available for use.*

Figure 3 - Local Air Quality Monitoring Locations

Background Pollutant Concentrations

There are numerous emission sources, broadly divided into road transport, industrial sources and background sources. Modelled estimations of background air quality concentrations are published by Defra for each 1 km square in the UK for each year between 2015 and 2030. As part of this the contribution to the total pollutant concentration from various sources is also published.

Monitoring has also been undertaken by the Council on local roads in proximity to the assessment area, which were representative of background concentrations. The annual mean concentration recorded at site 223 on Spen Road was therefore used to inform the background contribution to the total NO_2 concentrations.

Assessment Scenarios

There are four alternative network configurations analysed within this study as outlined in **Table 1** and described below. These were all modelled with 2023 weekday AM, interpeak and PM peak flows. Two of the network configurations – ‘Less Ambitious’ and ‘More Ambitious’ were also modelled with 2038 weekday AM peak flows.

The outcome of the OBC concluded that the scheme option 'Do Something - Less Ambitious' would be progressed to delivery. The OBC assessment found that the 'Do Something - Preferred' option would cause significant additional delays for southbound traffic on Otley Old Road, including for buses, and is therefore not being progressed. The naming conventions used in the OBC have been preserved in this report despite the progression of an alternative scheme than the preferred option outlined below.

Do Nothing

The ‘Do Nothing’ scenario is the existing network configuration. This is considered the baseline assessment against which all other schemes are compared.

Do Something - Less Ambitious

The ‘Do Something – Less Ambitious scenario’ is the ‘Do Nothing’ network plus the full signalisation of Lawnswood Roundabout, with staggered crossings provided across all arms. Traffic signal coordination was retained as provided by LCC. The geometric footprint of the roundabout is more circular including increased capacity on the circulatory carriageway with three lanes provide throughout. Flare lengths are increased on the northbound and westbound approaches. A visual comparison of the scheme within AIMSUN is provided in **Figure 4** below.

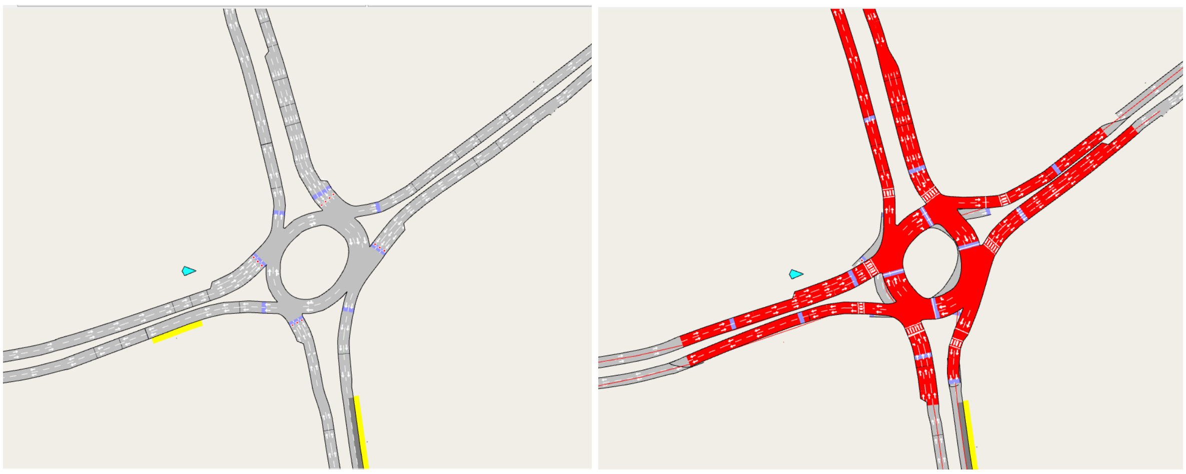

Figure 4 – Lawnswood Priority Roundabout (Left), Lawnswood Signalised Roundabout (Right)

Do Something Preferred

The ‘Do Something - Preferred scenario’ is the ‘Do Something - Less Ambitious’ network plus an 800m long southbound bus and cycle lane on Otley Road, starting at Lawnswood Cemetery and passes the priority junction with Otley Old Road, with one lane retained for general traffic. A visual comparison of the scheme within AIMSUN is provided in **Figure 5** below.

Figure 5 – Otley Road Southbound Without Bus Lane (Left), Otley Road Southbound Including Bus Lane (Right)

Do Something – More Ambitious

The ‘Do Something - More Ambitious’ scenario is the ‘Do Something – Preferred’ network plus signalisation of the Otley Old Road junction. This allows vehicles easier egress from Otley Old Road to offset some of the impact of the bus lane introduction, as well as providing safety benefits and improved facilities for pedestrians and cyclists. A visual comparison of the scheme within AIMSUN is provided in **Figure 6** below.

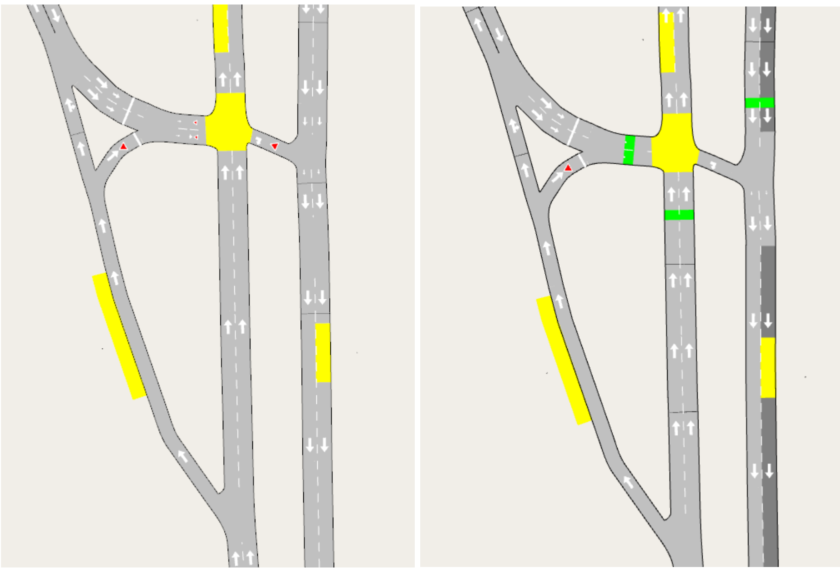

Figure 6 – Otley Old Road Priority Junction (Left), Otley Old Road Signalised Junction (Right)

3. Modelled Emissions

The emissions rates on Sections for each of the appraised scenarios were compared to the 'Do Nothing' (DN) scenario.

The road alignment was altered in some of the scenarios and so, where alignments changed relative to the DN, Sections were aligned as closely as possible between each scenario to ensure the comparison was representative of the actual effects.

The primary areas of concern for exposure, where residential properties are close to the modelled road sections, were:

- Otley Old Road west of the junction with Otley Road;
- Otley Road, northbound exit from junction with Otley Old Road;
- Properties north-west of Lawnswood roundabout and on northbound exit, near monitoring sites 330 and 336;
- Former police station on the northeast corner of Lawnswood roundabout, currently including office and commercial space but may be subject to further future residential development; and,
- Property to the southwest of Lawnswood roundabout, near monitoring sites 332 and 333.

As outlined above, the traffic model calculated emissions data for the AM, IP, and PM peak periods. The emissions rates for these periods were adjusted to an equivalent 24-hour average (for a better comparison with the annual air quality objectives) the off-peak (OP) period (which was not modelled) was nominally assumed to be equivalent to the IP (as this period would have lower hourly flows).

The model results are interpreted in terms of the absolute rate of emissions without the scheme going ahead compared to the proprotional change in emissions resultant from each of the modelled scenarios. Therefore, it is important to recognise that large percentage changes in emissions do not necesarily indicate a significant effect, and so the links selected for deatiled disscuion in the following sections are intended to focus on those areas of greatest concern.

Scenario comparison

Table 1 shows an overview of the modelled scenarios, with **Table 6** and **Figure** 7 highlighting selected links with high emissions rates that were more significantly affected by the proposed scenarios, and so have been presented here to demonstrate the key outcomes from the modelling. These links have been highlighted specifically for discussion and interpretation of the effects of the proposed scheme. It is recognised that there are other effects of lesser significance in terms of absolute concentrations and magnitude of change, therefore, this discussion is intended to focus on the key outcomes.

The proposed scheme option scenarios were compared to the 'Do Nothing' for the AM peak, Interpeak and PM peak periods in 2023.

The 'Do Something – Less Ambitious' and 'Do Something - More Ambitious' scheme options were also modelled and compared to the corresponding 'Do Nothing' scenario for the AM 2038 period and presented in the subsequent section of this report.

Table 6 below presents the links on the network in the "2023 Do Nothing" scenario with the highest modelled NO_X emission rates. These are also presented in **Appendix A**. The table shows that the highest emissions are modelled on the southbound entry, the Lawnswood Roundabout northbound entry stop-line and eastbound entry stop-line.

The table also presents the percentage change in NO_X emissions rates on these same links when compared to the "2023 Less Ambitious", "2023 Preferred" and "2023 More Ambitious" scenarios. These indicate that predicted scheme impacts on these links were generally 'small'[12] (within approximately 5% change), with a few incidences of 'moderate' (ranging between approximately 5 and 10% change) and 'large' impacts (over 10%). These changes were associated with the small number of links with a subjectively notable change in emissions. The model predicted large increases at the northbound and eastbound entry stop-line, and a particularly large change on the southbound entry. The model predicted large decreases on the westbound entry stopline.

Table 6 - Scenario Comparison (Subset of Links with Highest Emission Rates)

Link ID	Location	NO_X Emission Rate ($g\ km^{-1}\ s^{-1}$)	Relative Change in NO_X Emission Rate vs "2023 Do Nothing" (%)		
		"2023 Do Nothing"	"2023 Preferred"	"2023 Less Ambitious"	"2023 More Ambitious"
19991	Southbound entry	0.202	+136.9%	+141.3%	+130.1%
16767	Southbound exit	0.084	-3.6%	+4.7%	+2.7%
19921	Northbound entry stop-line	0.190	+27.0%	+32.1%	+24.9%
19879	Eastbound entry stop-line	0.192	+33.3%	+31.2%	+30.6%
20024	Southbound on Otley Rd near the Otley Old Rd Junction	0.078	-7.4%	+4.4%	-1.1%
20372	Far end eastbound exit	0.078	-1.8%	-2.7%	-1.8%
20369	Far end eastbound exit	0.076	-2.1%	-3.0%	-2.1%
16290	Westbound entry stop-line	0.164	-10.5%	-16.6%	-14.5%
1967	Far end westbound entry	0.076	-0.5%	-0.4%	-0.4%
19978	Far end westbound entry	0.075	-0.4%	-0.2%	-0.2%
20421	Westbound exit	0.062	-2.8%	-2.0%	-2.8%

[12] Note that small, moderate and large definitions are purely to aid the discussion.

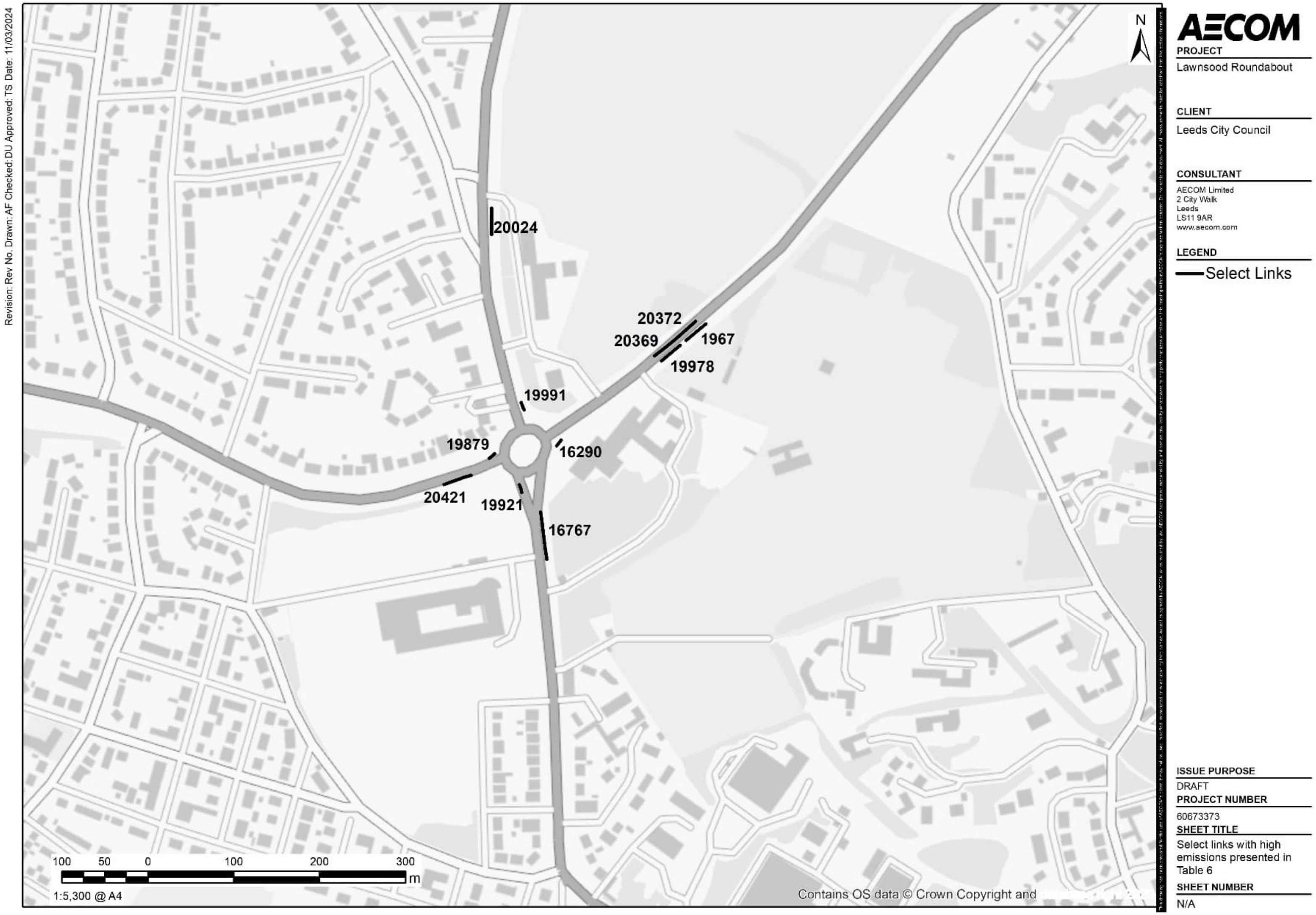

Figure 7 - Select Links with High Emissions

Do Nothing vs Less Ambitious

Figure 9 (see **Appendix B**) illustrates the impacts associated with the “2023 Do Nothing vs Less Ambitious” comparison.

In the “Do Nothing vs Less Ambitious” comparison, the model predicted small detrimental effects on Otley Old Road. For example, as presented in **Table 6**, NO_X daily emission rates on link 20024 (on Otley Road near the Otley Old Road Junction) increased by 4.4% compared with the “Do Nothing” scenario.

At the Lawnswood roundabout, the model predicted a large detrimental effect (increased emissions) at the end of the northbound entry (as seen by the 32.1% increase at link 19921 in **Table 6**). Detrimental effects were also predicted on the eastbound entry, with large impacts in this area driven by the introduction of the controlled stop line.

NO_X emissions associated with the southbound entry (link 19991) were notably high in the “Do Nothing” scenario, with a large increase in the “Do Nothing vs Less Ambitious” comparison (as seen by the 141.3% increase in **Table 6**). This is a result of a more defined queue caused by the signalisation of the roundabout and is the largest impact on a link with high emissions. Link 19991 is located on the opposite carriageway to the nearest sensitive receptors, and it is also downwind of the receptors with the prevailing winds in a south-westerly direction. To the northeast of Lawnswood Roundabout, a planning application has been submitted for a residential development within the former police station site, although there are currently no buildings in use within the site which are within 50 metres of the carriageway, and the proposed development is not expected to change this. Therefore, at 50m from the road any new receptors would be unlikely to be exposed to concentrations above the annual objective.

Link 19879 has been flagged in **Table 6** because there is a detriment on approach to the stop line on the westbound entry. However, the links to the east of the roundabout (and particularly westbound) generally demonstrated a notable reduction in emissions.

Detrimental effects were also predicted by the model on the exits from the roundabout, due to vehicles stopping at the new signalised pedestrian crossings.

2023 Do Nothing vs Preferred

Figure 10 (see **Appendix B**) illustrates the impacts associated with the “2023 Do Nothing vs Preferred” comparison.

In the “Do Nothing vs Preferred” comparison, the ‘Preferred’ model predicted detrimental effects on a large section southbound on Otley Old Road due to the introduction of the new bus lane on Otley Road Southbound which compacts vehicles in the offside lane and causes less gap opportunities for vehicles egressing from Otley Old Road. The model predicted benefits on Otley Road southbound with a 7.4% decrease in NO_X emissions on link 20024 in **Table 6.** Impacts similar to the “2023 Less Ambitious” scenario were predicted at links near the roundabout.

The model predicted relatively large detriments on links within the roundabout. The model predicted large detrimental effects on the northbound entry (as seen by the 27% increase in daily NO_X emissions at link 19921 in **Table 6**), and small to moderate detriments on the westbound entry with similar observations to the ‘Do Something – Less Ambitious’ on the westbound extent. There was a large detriment predicted by the model on the southbound entry. Although still an impact to consider, this was marginally less than that predicted by the model in the “Do Nothing vs Less Ambitious” comparison.

Do Nothing vs More Ambitious

Figure 11 (see **Appendix A**) illustrates the impacts associated with the “2023 Do Nothing vs More Ambitious” comparison.

In the “Do Nothing vs More Ambitious” comparison, the model predicted detrimental effects on Otley Road near the approaches to the junction (due to the new traffic signal control) and detrimental effects on Otley Old Road close to the junction only.

Near the Lawnswood roundabout, similar impacts to the “Less Ambitious” scenario were predicted by the model. Small effects were predicted on Otley Old Road at the junction with **Figure 11** also showing that the model predicted general improvements in air quality on this road.

The model predicted large detrimental effects near the roundabout on the westbound entry and eastbound entry, as well as moderate-to-large detriments on eastbound and westbound exits, and on links within the roundabout. There was a large detriment predicted on the southbound entry, consistent with the “Do Nothing vs Less Ambitious” and “Do Nothing vs Preferred” comparisons discussed above (as seen by the 24.9% increase in daily NO_X emissions at link 19921 in **Table 6**). Although notable, the impact at this link was marginally less than that predicted by the model in the “Do Nothing vs Less Ambitious” and “Do Nothing vs Preferred” comparisons.

Comparison to Monitoring

Monitoring has been undertaken by the local authority near the study area. These data were adjusted where appropriate to determine an indicative annual mean NO_2 concentration for the 2023 study year, to allow comparison. These data are presented in **Table 8**.

As discussed above, the data presented here are used in this assessment only to indicate the extent and magnitude of potential effects due to the modelled scenarios.

The monitored pollutant concentrations were compared to the modelled change in emissions rates at the Sections closest to each monitoring site. It was assumed, for the purpose of this assessment, and to allow estimation of the impact of the Scheme on concentrations, that this would be the predominant source contributing to the total pollutant concentration in each location.

Adjustment of the monitoring data to remove the background contributions was undertaken using standard tools published by DEFRA[13]. The road-source NO_X (R-NO_X) was used to estimate the concentration impact resultant from the change in emissions from the nearest road links resultant from the tested scenarios.

Monitoring site 336, to the north-west of the roundabout, recorded annual mean concentrations that exceeded the annual mean objective in 2018. However, this site was closed, and no further data recorded in this location. Therefore, to indicate the potential magnitude of effects at this location in 2023, the concentration recorded in 2018 was used as a proxy for conditions in 2023. Furthermore, site 336 was a kerbside location, where adjusting the monitored concentration using the DEFRA distance adjustment calculator[14] (see example in **Appendix D**) indicated that the concentration at the façade of the nearest residential property (approximately 16m further from the road) would be significantly lower.

Concentrations have generally reduced since 2018, in part due to falling vehicle emissions, as best illustrated by Site 223 (refer to **Table 5**).

The adjusted annual mean NO_2 monitored concentrations in 2023 and the resultant change associated with the scenarios are presented in **Table 7** below. These data indicate that concentrations were all well below the annual mean objective, apart from that monitored at site 336 where, as discussed above, the concentration at the nearest relevant exposure, which is the façade of the nearby properties, would be much lower.

High concentrations were recorded at site 631 although this is an indicative concentration based on 6-months of data and the final ratified and adjusted concentration (when available) should be used to inform whether this may be a location of exceedance, which should be interpreted in the context of the impacts presented in **Table 6**. Furthermore, this site was at the extent of the modelled network and so the slight increase in concentrations (particularly in the “Less Ambitious” and “More Ambitious” scenarios) should be treated cautiously as there was limited modelling intervention here from the OBC model received.

Site 330 was also predicted to exceed the annual mean objective in each of the options. However, as with site 336, concentrations will be much lower at increased distance from the carriageway, at the façade of properties.

Site 331 was not presented in the data below; a concentration slightly lower than the annual mean objective was recorded in 2018 but, as with 336 and 330 it is close to the carriageway and concentrations further back will be significantly lower. However, it is recognised that future development may occur in this area to the northeast of the roundabout and the most significant impacts to emissions were identified on the southbound entry carriageway. Therefore, there may be value to undertaking further monitoring in this area in the future to verify baseline conditions.

[13] https://laqm.defra.gov.uk/air-quality/air-quality-assessment/no2-adjustment-for-nox-sector-removal-tool/

[14] https://laqm.defra.gov.uk/air-quality/air-quality-assessment/no2-falloff/

Overall, the smallest changes in annual mean NO_2 concentrations were generally predicted to occur in the 'More Ambitious' scenario. Although the effects are generally detrimental, it is not considered likely that exceedance of the annual mean NO_2 objective will occur at locations of relevant exposure (e.g. residential façades) or at locations relevant to reporting compliance (i.e. a location "typical of the link as a whole and >25m from a junction" where there is >100m of public access), due to the proposed scheme.

Table 7 - NO_2 Monitoring Undertaken Near the Proposed Scheme

Monitor ID	Location	2023 Monitored Annual Mean NO_2, µg m^{-3}		2023 Estimated Annual Mean NO_2, µg m^{-3} (impact in parentheses)		
		Actual	Adjusted to Facade	2023 Preferred	2023 Less Ambitious	2023 More Ambitious
330	NW of Lawnswood Roundabout	39.7	-	40.7 (+1.0)	41.2 (+1.5)	40.5 (+0.8)
335	SW of Lawnswood Roundabout	33.4	-	35.3 (+1.9)	35.3 (+2.2)	35.2 (+1.9)
631	W of Lawnswood Roundabout	44.1	-	44.6 (+0.5)	44.2 (+0.1)	44.3 (+0.2)
647	Otley Old Rd, East	22.4	-	34.2 (+11.9)	24.3 (+2.0)	21.2 (-1.1)
648	Otley Old Rd, West	24.2	-	23.9 (-0.4)	24.5 (+0.3)	24.4 (+0.1)
336	NW of Lawnswood Roundabout	42 *	22.7	45.9 (+3.9)	45.8 (+3.8)	45.2 (+3.2)

*Note: * Value recorded at site 336 in 2018 used as a proxy for conditions in 2023 to indicate potential magnitude of effects due to the modelled scenarios. It is also likely that concentrations will be lower in 2023 compared to 2018, with reference to wider trends, so using the 2018 value will be a cautious assessment.*

Comparison of 2023 and 2038 AM Peak Emissions

AM peak emissions for the "2023 Do Nothing" scenario have been compared against respective AM peak emissions in 2038 for the less ambition and more ambition scenarios, which demonstrate the rate at which emissions are predicted to reduce in future years due to fleet improvements and adoption of low emissions technologies.

This 2023 and 2038 comparison is intended to be indicative, and to outline the magnitude of change within the AM peak period as a proxy for the wider future trends and does not recognise the whole 24-hour period. It should therefore be noted that this is not directly comparable with the analysis presented in previous sections above.

The data in **Table 8** are a selected subsets of the highest emissions links identified in the baseline. These data indicate that emissions will generally decrease in future, as expected, by approx. 50% overall. The decrease due to the improvement to the fleet will also tend to exceed the magnitude of potential detriments due to the modelled scenarios, although it is recognised that there may be a few selected links where highly localised effects due to the proposed scheme may lead to relatively lower benefits due to future improvements (particularly in the peak hours, which may be more congested).

Table 8 - Subset of Links with Highest Emission Rates, AM Peak Hour in 2038

Link ID	Location	Relative Change in NO_X AM Peak Emission Rate	Relative Change in NO_X Emission Rate vs "2023 Do Nothing" (%)	
		2023 vs 2038	"2038 Less Ambitious"	"2038 More Ambitious"
19991	Southbound entry	-49%	+30%	-11%
16767	Southbound exit	-39%	-23%	-62%
19921	Southbound entry stop-line	-51%	-14%	-20%
19879	Eastbound entry stop-line	-61%	+7%	+7%
20024	Southbound on Otley Rd near the Otley Old Rd Junction	-37%	+4%	-61%

Comparison of Core and Sensitivity Test

In addition to the results presented above, a sensitivity test was undertaken to consider the effects of a higher frequency of pedestrian and cycle crossings calls, as a ‘worst-case’ assumption. It is presented here for the purposes of a sensitivity test to compare against the main assessment and to indicate the potential extent and magnitude of effects.

The crossings would only be called every cycle if there were a large increase in pedestrians and cyclists. The main assessment assumes a 50% uplift to existing pedestrian frequency. If there is significant modal shift toward active travel in future years, it is likely that there would be a corresponding reduction in private car use, which in turn would reduce vehicular emissions. The modelling undertaken for the sensitivity tests does not assume a reduction in car use, therefore this sensitivity test represents a worst-case assessment. The results of these sensitivity tests are presented in **Table 9**, below, and **Figure 12, Figure 13** and **Figure 14** (Appendix B).

When comparing the ‘2023 Do Nothing’ and the ‘2023 Less Ambitious’ scenarios, the pattern of emission changes is broadly similar, with the magnitude of change being the main difference. The most notable changes were:

- Links within the Lawnswood roundabout;
- Before the stop line on the northbound and southbound entry, with the southbound entry being particularly notable due to the absolute emission rate and extent of the queueing. It is noted that the link immediately after the stop line indicates relatively lower changes in emissions; and
- Before the stop line on the eastbound entry, which is notable where the detrimental effects occur specifically due to the proximity to residential properties (as in the discussion around the core scenario).

Selected links have been highlighted specifically for discussion and interpretation of the effects of the proposed scheme (as presented in **Table 6** for the core scenario tests); although it is recognised that there are wider effects of lesser importance in terms of absolute concentrations and magnitude of change. **Table 9** presents the relative change in NO_X emission rates between the core and sensitivity tests and the absolute difference in percentage for these select links.

The difference in emission rates in the core scenario compared to the sensitivity test for these selected links is generally less than 1%, apart from links near the southbound entry and exit, northbound entry and eastbound entry. These links are associated with the pedestrian crossings, and so it is expected that increased calls would lead to relatively higher emissions at these locations. It is noted that link 19991 (leading to the southbound entry) indicates a relatively lower change in the sensitivity test in the “Preferred vs Do Nothing” comparison, which indicates a behavioural link between traffic leaving the roundabout northbound and the junction of Otley Old Road with Otley Road.

As expected, the change at link 20024, near the junction of Otley Road and Otley Old Road has negligible difference. Similarly, the links further from the roundabout on the westbound entry (links 1967 and 19978) also have negligible differences, although links 20372 and 20369, at the far end eastbound exit indicate relatively beneficial outcomes.

Overall, the test indicates small differences between the core and sensitivity tests, although it does specifically indicate that lower emissions would occur in the areas which are most sensitive in terms of relevant exposure with fewer crossing calls, as represented in the core scenario.

Table 9 - Comparison of Core and Sensitivity Test

Link ID	Location	Relative Change in NO_X Emission Rate vs "2023 Do Nothing" (%)			Difference in NO_X Emission Rate vs Core Tests*		
		"Preferred" Sensitivity Test	"Less Ambitious" Sensitivity Test	"More Ambitious" Sensitivity Test	"Preferred" Sensitivity Test	"Less Ambitious" Sensitivity Test	"More Ambitious" Sensitivity Test
19991	Southbound entry	+134.6	+144.8	+131.8	-2.3	+3.5	+1.7
16767	Southbound exit	-2.7	+5.8	+3.6	+0.9	+1.1	+0.9
19921	Northbound entry stop-line	+27.8	+33.3	+25.4	+0.8	+1.2	+0.5
19879	Eastbound entry stop-line	+33.8	+32.7	+31.6	+0.5	+1.5	+1.0
20024	Southbound on Otley Rd near the Otley Old Rd Junction	-7.4	+4.5	-1.1	0.0	+0.1	0.0
20372	Far end eastbound exit	-2.5	-3.4	-2.4	-0.7	-0.7	-0.6
20369	Far end eastbound exit	-2.8	-3.8	-2.9	-0.7	-0.8	-0.8
16290	Westbound entry stop-line	-11.4	-16.5	-14.3	-0.9	+0.1	+0.2
1967	Far end westbound entry	-0.6	-0.5	-0.4	-0.1	-0.1	0.0
19978	Far end westbound entry	-0.4	-0.2	-0.2	0.0	0.0	0.0
20421	Westbound exit	-2.5	-1.5	-2.4	+0.3	+0.5	+0.4

*Note: Difference is presented as absolute change in percentage; e.g. a value of 10% vs 9% would be presented as a difference of -1

4. Summary and Conclusions

Summary

A microsimulation modelling study was undertaken to appraise the effects of signalisation of the Lawnswood roundabout, and associated improvements to the junction of Otley Road with Otley Old Road. The model was used to predict the change in emissions associated with the proposed scheme, and to indicate the potential effects on local air quality.

The objectives of the study to '*appraise the current air quality in the study area*' and '*Determine the potential impact of the proposed improvement scheme options on air quality*' were achieved by answering the following questions:

- What is the potential impact of each scheme option on traffic emissions compared with the existing layout in the 2023 Opening Year?
  - 'Less Ambitious' indicated increased emissions at the entries to the roundabout due to signalisation stop lines. Small detrimental effects were also predicted by the model on the east, north and west exits from the roundabout, due to vehicles stopping at the new signalised pedestrian crossings. There is a derelict building on the southbound entry to the roundabout, i.e. at the same side of the carriageway as link 19991. A relevant air quality assessment should be recommended for any future land use changes on the Northeast of the junction.

  - ‘Preferred’ indicated similar effects on the Lawnswood roundabout as for the ‘Less Ambitious’ scenario, but with detrimental effects on a large section of Otley Old Road southbound due to the introduction of the new bus lane. The model predicted small detrimental effects on Otley Road northbound, with small-to-moderate beneficial effects predicted southbound on approach to Otley Old Road junction.
  - ‘More Ambitious’ indicated detrimental effects on Otley Road and Otley Old Road on approach to the Otley Old Road junction due to the new traffic signal control. Nonetheless, this scenario showered improvements in air quality along the majority of Otley Old Road, compared with the “Do Nothing” and improvement from the ‘Preferred’ scenario as vehicles are controlled egressing from Otley Old Road. Near the Lawnswood roundabout, similar impacts to the “Less Ambitious” scenario were predicted by the model, although they tended to be marginally smaller.
- What is the potential impact of each scheme option on traffic emissions compared with the existing layout in the 2038 AM peak?
  - The model indicated that emissions would be lower in the future due to improvements to the fleet and, generally this improvement would exceed the magnitude of potential effects (either positive or negative) due to the modelled scenarios.
- What would the ‘worst case’ impact of each scheme option on traffic emissions be if all pedestrian / cycle crossings be called every cycle?
  - The impact of crossings being run every cycle was predicted to be increased emissions on links approaching, within and exiting Lawnswood roundabout.

Conclusion

Overall, the models estimate that the proposed scheme will show some detrimental impacts through increased emissions rates, particularly for the scenarios that increase stop/start movements on approach to the junctions.

The existing local air quality monitoring has recorded concentrations of NO_2 close to the annual mean objective on the ring road. However, pollutant concentrations fall rapidly with distance from edge of carriageway and so concentrations at sensitive receptor locations, such as residential properties, will be significantly lower than measured at the roadside.

Therefore, the potential increased emissions were not predicted to be sufficient to lead to an exceedance of the annual mean objectives at any location of relevant exposure.

Appendix A Baseline Emissions

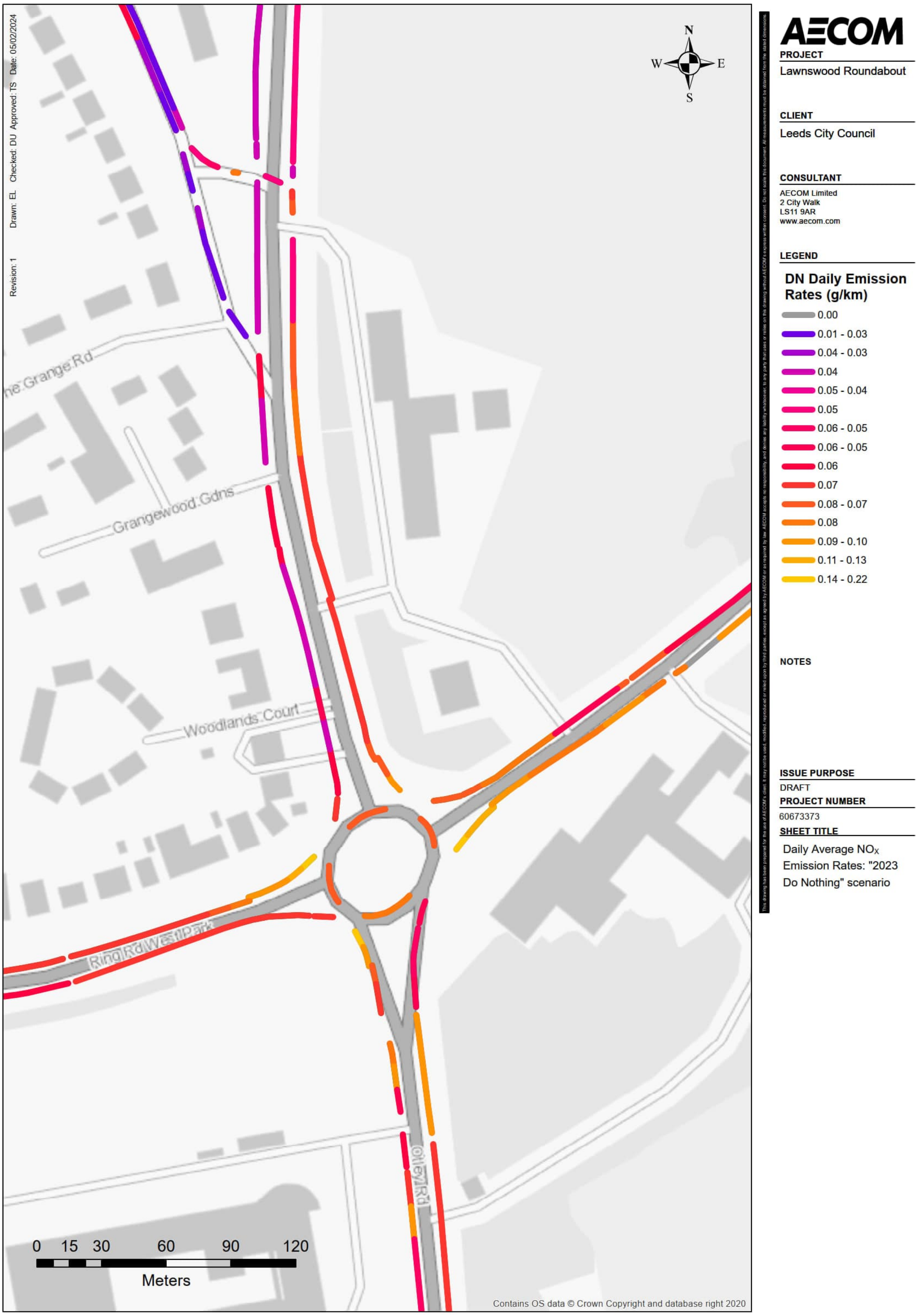

Figure 8 - Daily Average NO_X Emission Rates: "2023 Do Nothing" Scenario

Appendix B Emissions Impacts

Figure 9 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs "2023 Less Ambitious", Core Tests

Figure 10 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs "2023 Preferred", Core Tests

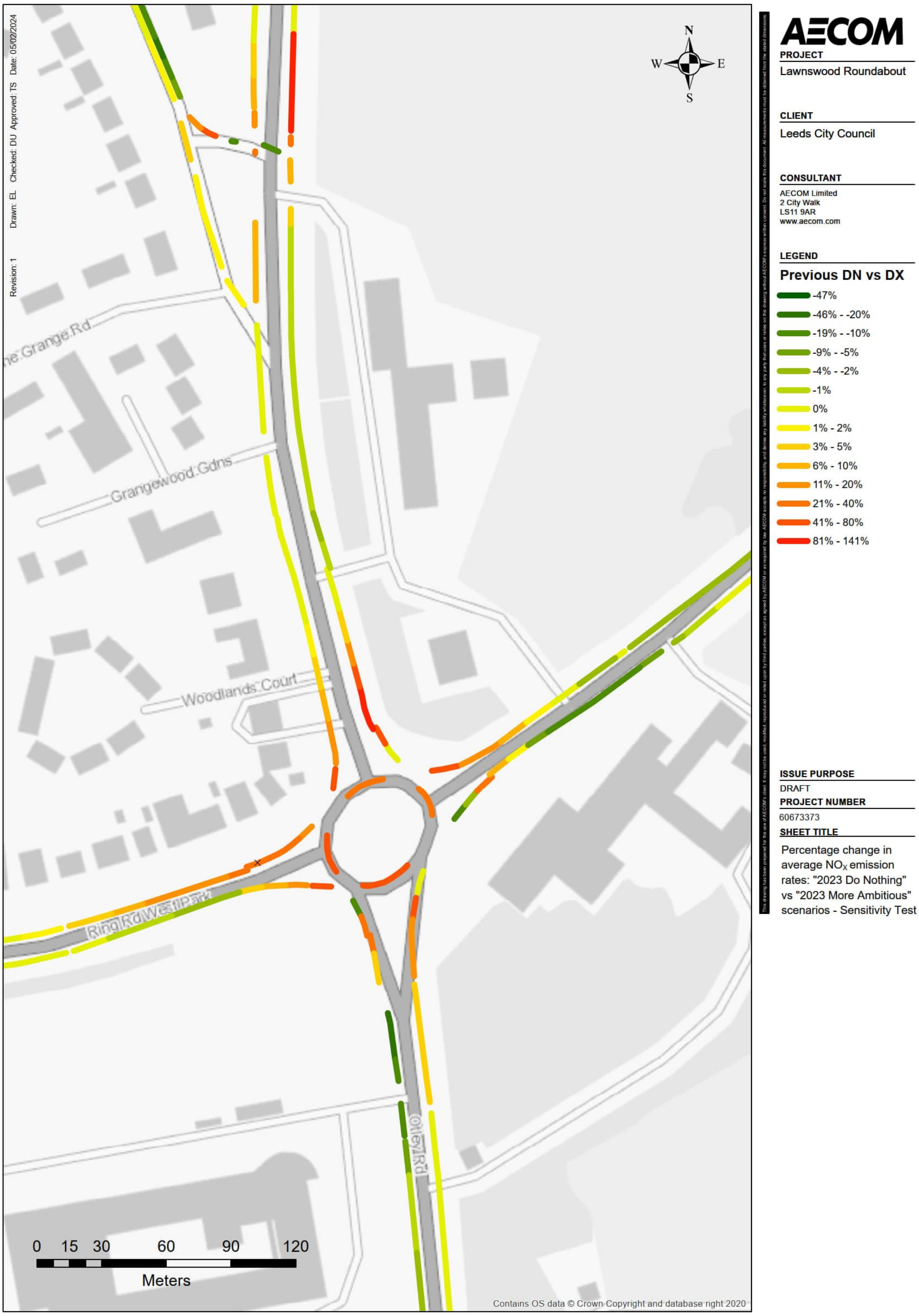

Figure 11 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs “2023 More Ambitious”, Core Tests

Appendix C Emissions Impacts of Sensitivity Tests

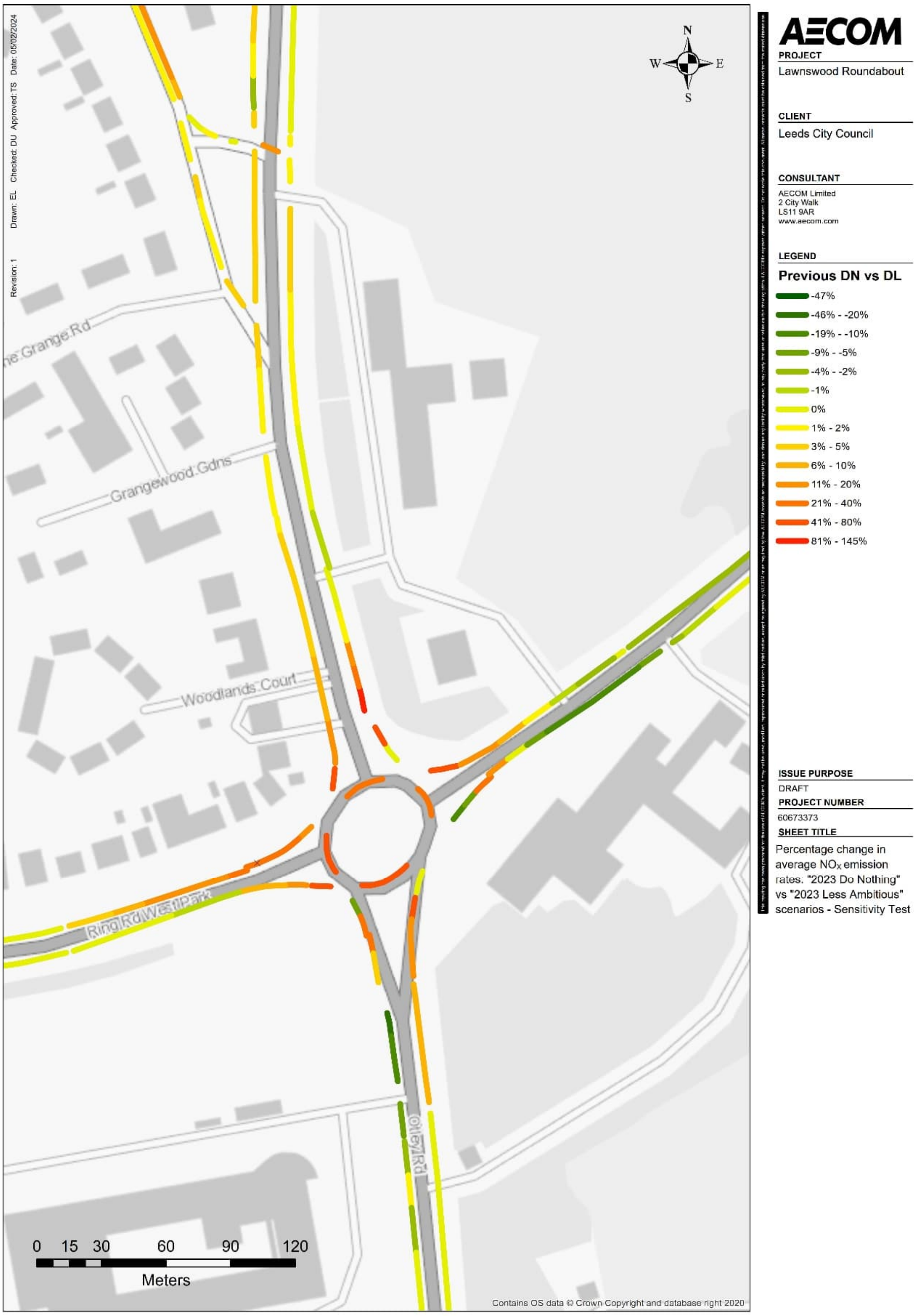

Figure 12 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs "2023 Less Ambitious", Sensitivity Test

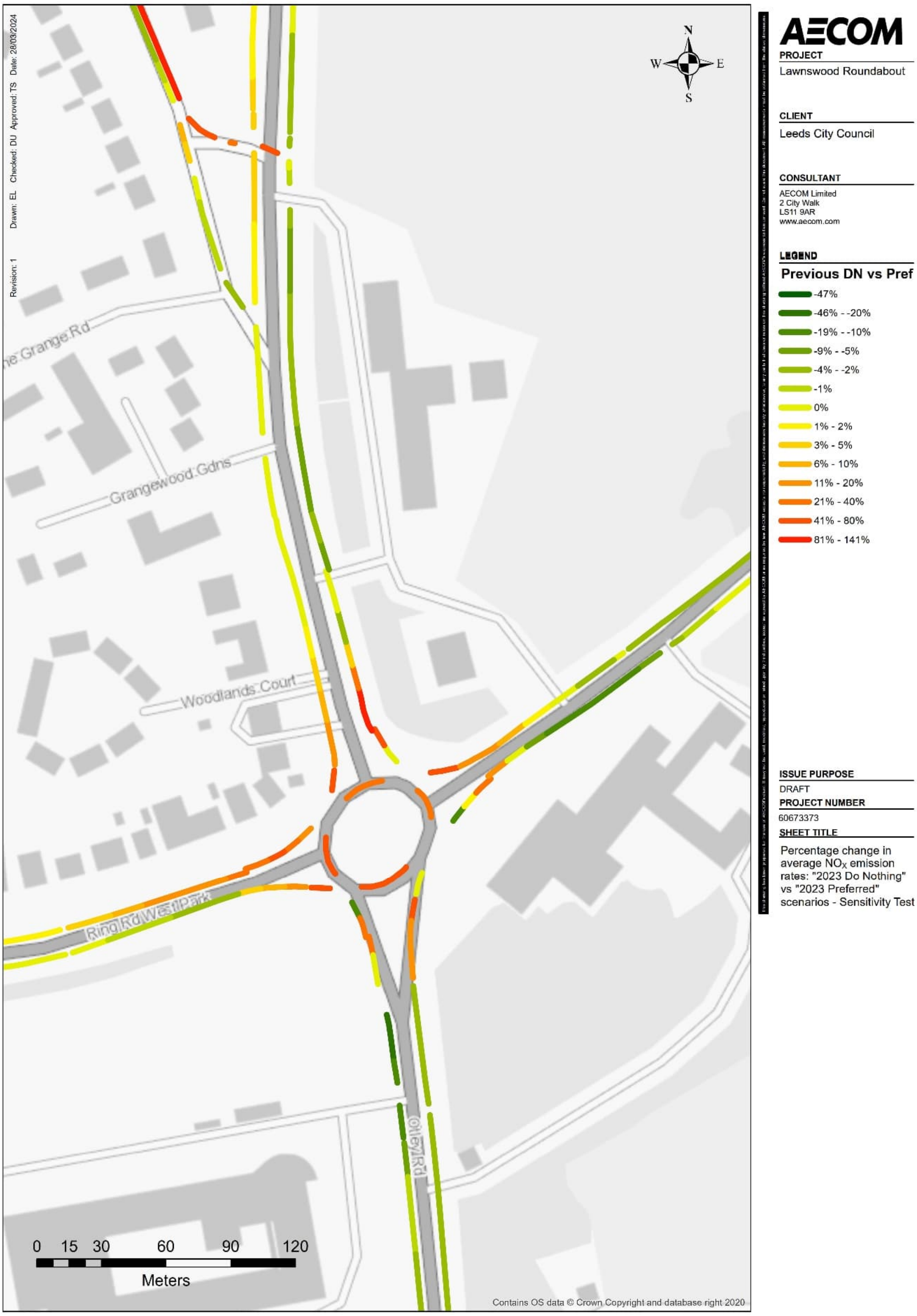

Figure 13 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs “2023 Preferred”, Sensitivity Test

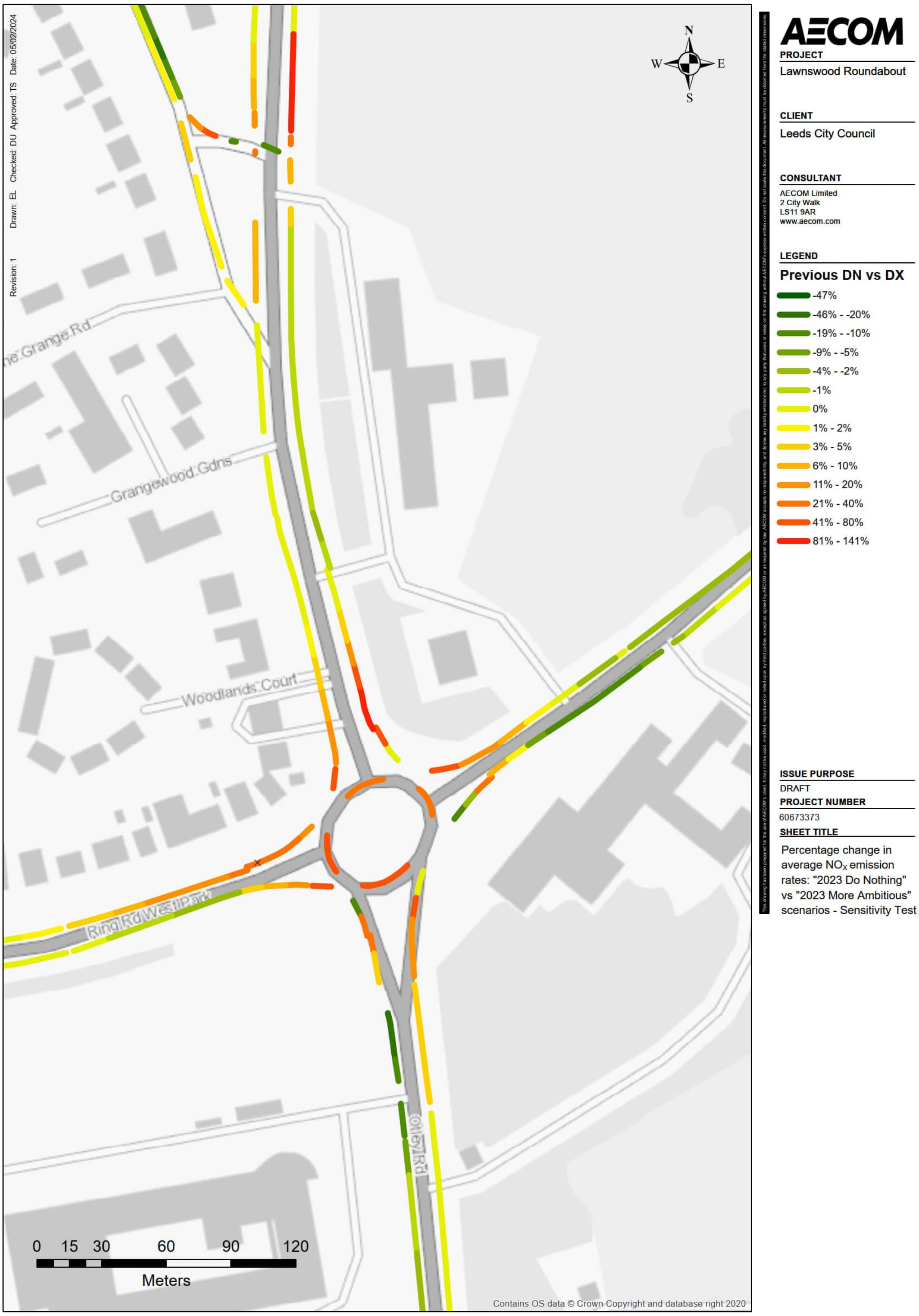

Figure 14 - Percentage change in average NO_X emission rates: "2023 Do Nothing" vs "2023 More Ambitious", Sensitivity Test

Appendix D Distance Adjustment

Road-source pollutant concentrations decrease with distance from the carriageway. DEFRA publish the ‘NO_2 Fall-Off with Distance Calculator (v 4.2)’ as part of the LAQM tools to calculate this effect[15].

The data in **Table 10** indicate the rate of decrease in total annual mean NO_2 concentration that may be expected with increased distance from the kerb; using nominal monitored concentrations equal to the annual mean NO_2 objective, and a background concentration representative of the Lawnswood study area in 2023.

Table 10 Example of Distance Adjustment of Pollutant Concentrations

Enter data into the pink cells

Step 1	How far from the KERB was your measurement made (in metres)?	0.1	metres
Step 2	How far from the KERB is your receptor (in metres)?	20	metres
Step 3	What is the local annual mean background NO_2 concentration (in µg/m³)?	12	µg/m³
Step 4	What is your measured annual mean NO_2 concentration (in µg/m³)?	40	µg/m³
Result	The predicted annual mean NO_2 concentration (in µg/m³) at your receptor	19.6	µg/m³

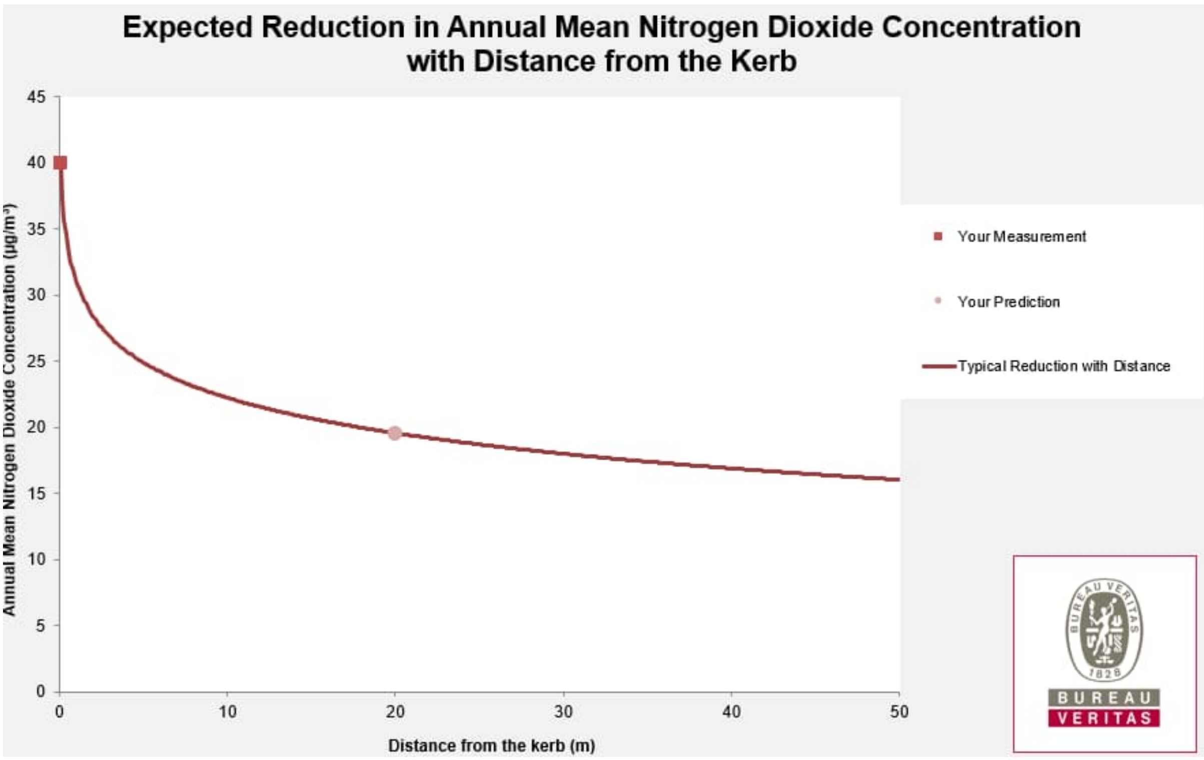

Figure 15 Example of Rate of Change in Pollutant Concentrations with Distance from the Kerb

[15] DEFRA (2016) NO2 Fall Off With Distance Calculator https://laqm.defra.gov.uk/air-quality/air-quality-assessment/no2-falloff/

aecom.com