TECHNICAL NOTE 1

DATE:	07 June 2024	**CONFIDENTIALITY:**	Restricted
SUBJECT:	Air Quality Technical Methodology		
PROJECT:	LUF2	**AUTHOR:**	Harry Price
CHECKED:	Sioni Hole	**APPROVED:**	Bethan Tuckett-Jones

PROJECT OVERVIEW

WSP has been commissioned by Shropshire Council (SC) to assess measures to improve air quality around the Shrewsbury town centre gyratory. Specifically, this note covers air quality impacts/improvements arising from changes to the town centre gyratory made using the UK Government Levelling Up Funding (LUF2), and the North West Relief Road (NWRR).

Figure 1: LUF2 Scheme Overview

This project aims to deliver improvements on the overall air quality of the Station Gyratory, by enhancing cycling and walking facilities. The scheme will introduce a segregated cycle lane that will eventually connect Shrewsbury Town Centre to the Flaxmill Malting, enhanced public spaces in the Station Gyratory through the use of vegetation and street furniture.

One of the aims of the funding was to improve air quality within Shrewsbury. In particular, the focus of the Scheme was to reduce pollutant concentrations where there are existing exceedances of annual mean air quality standards. Air Quality dispersion modelling has been undertaken to quantify the impact of the Scheme on pollutant concentrations affected by the Scheme.

Latterly, at the request of SC, this model has also been used to provide both a process contribution and predicted environmental concentration at specified receptors from the LUF2 Scheme, the NWRR scheme, and both Schemes in combination. This technical note covers the detailed modelling parameters and methodology used within the production of the dispersion modelling and presents the results of the model at selected receptors for each scenario.

AIR QUALITY WITHIN SHREWSBURY

In 2003, SC declared an Air Quality Management Area (AQMA) across the entirety of Shrewsbury town centre (later amended in 2006). Air quality has improved throughout the AQMA since 2003, although monitored concentrations indicate that the annual mean air quality standard for NO_2 continues to be exceeded along Castle Gates. This is likely due to a combination of traffic congestion levels and restricted airflow along Castle Gates. The latest published SC monitoring is shown in **Figure 2**, below.

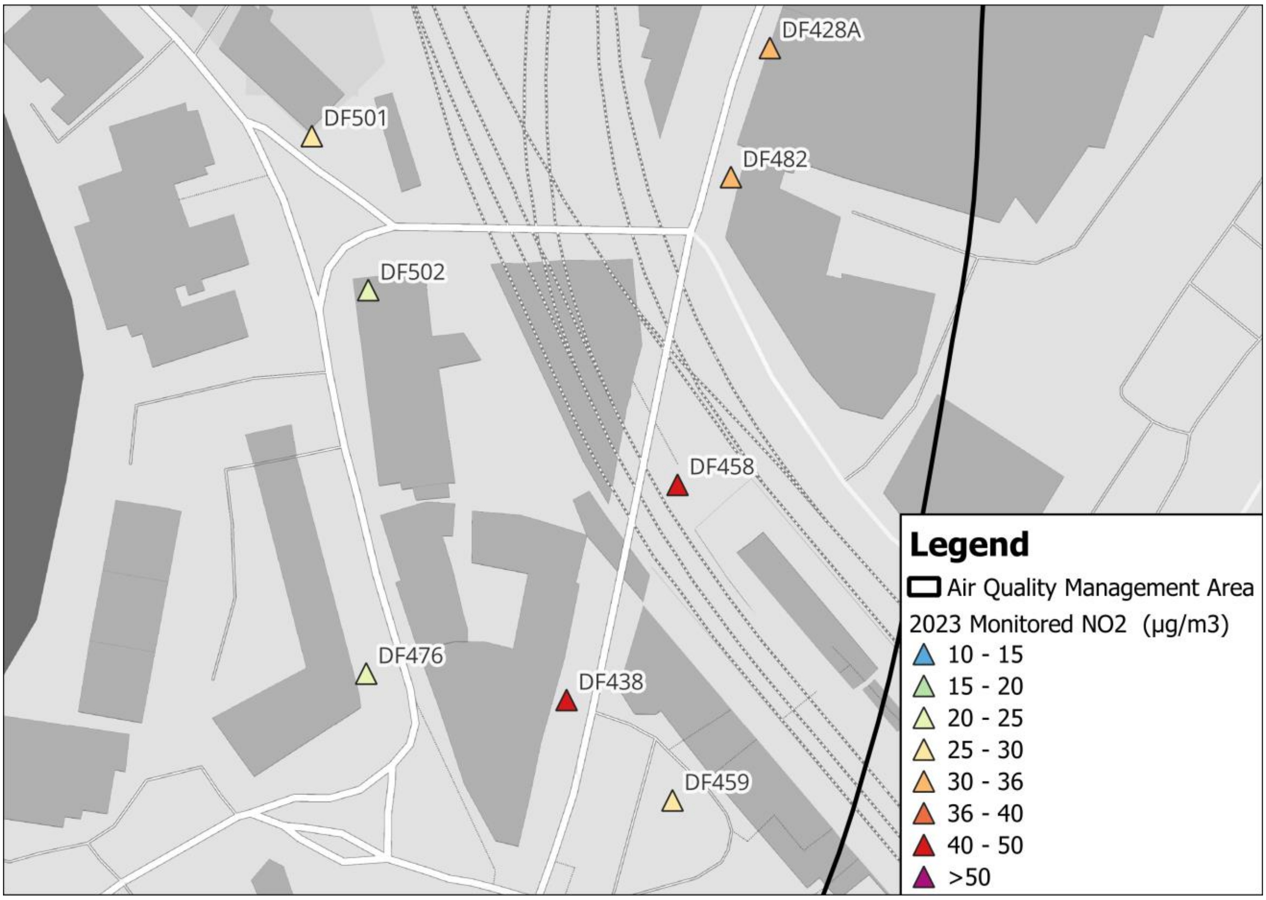


Figure 2: Locations of NO_2 monitoring points undertaken by SCC around the Shrewsbury gyratory.

The range (and standard deviation) of monitored concentrations at locations monitored by SC within Shrewsbury town centre are shown in **Figure 3**. The monitoring undertaken by SC at various locations within Shrewsbury town centre indicates a generally decreasing trend in NO_2 concentrations over time. The monitored concentrations at points on Castle Gates (SC monitoring ID DF438 and DF458) consistently show the highest recorded concentrations within Shrewsbury town centre, and also follow the decreasing trend over time. Concentrations monitored within 2020 are notably lower than expected due to the impact of lockdowns on traffic movements and have not been considered within the above analysis.

The latest data show that monitored concentrations at DF438 and DF458 (42.0 µg/m^3 and 40.1 µg/m^3) exceed the 40 µg/m^3 standard[1] in 2023, irrespective of the LUF2 development or the NWRR.

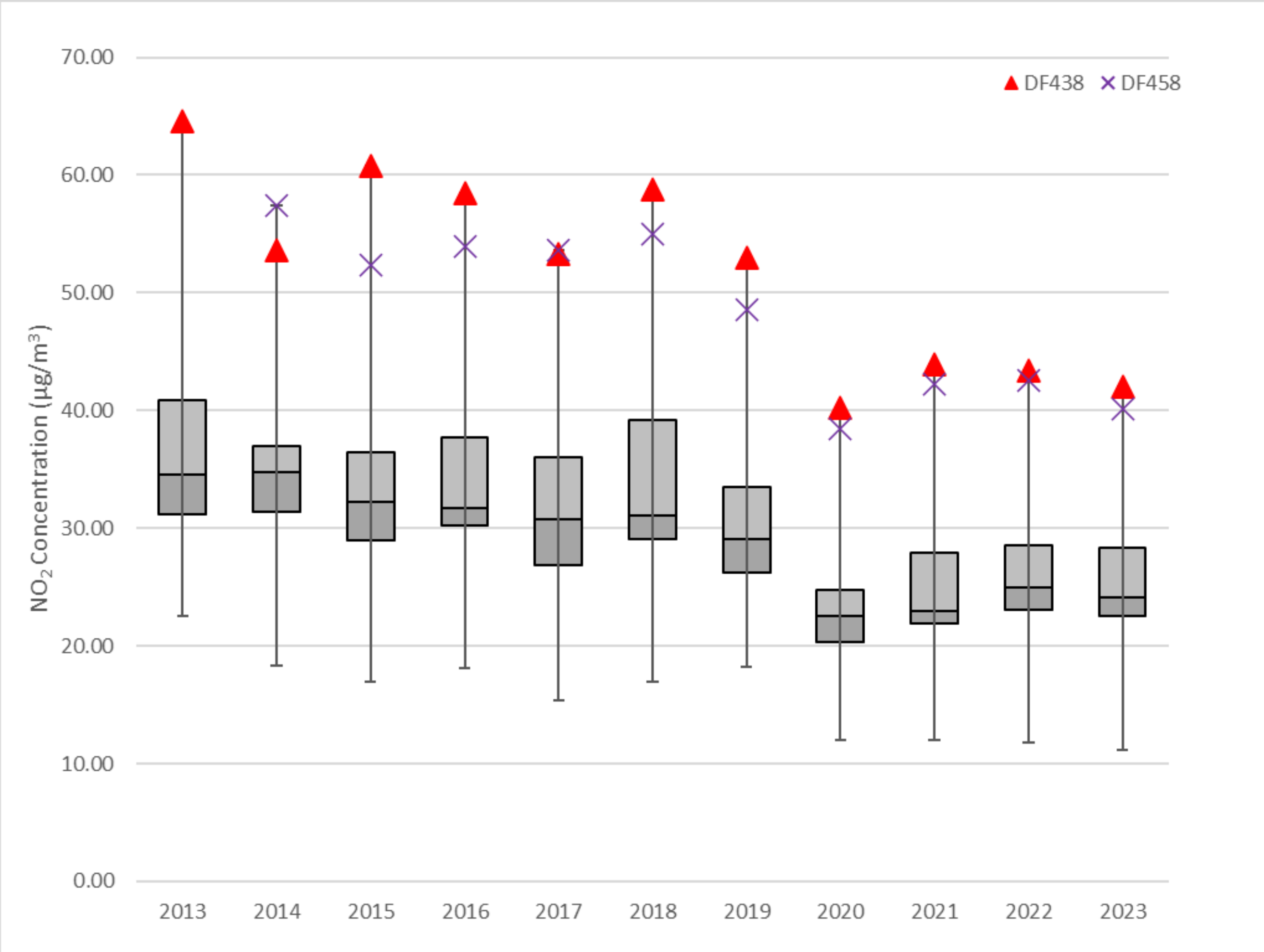


Figure 3: Box and Whisker plot showing monitored NO_2 trends in Shrewsbury town centre. The whiskers represent the highest and lowest monitored concentrations, and the box represents the median value and upper and lower quartiles.

[1] Concentrations were monitored at the location of the diffusion tube, not necessarily indicative of human exposure.

METHODOLOGY

For the prediction of potential impacts due to emissions arising from road traffic, the dispersion model ADMS Roads (version 5.0.0.1) was used. This model uses detailed information regarding traffic flows on the local road network for each diurnal period of the day (AM peak period, Inter-peak period (IP), PM peak period, and Off-peak period (OP)), surface roughness, and local meteorological and topographical conditions to predict pollutant concentrations at specific receptor locations. The model considers the dispersion of NO_x (and subsequent conversion to NO_2) only.

Traffic data has been taken from the assessment undertaken for the Shrewsbury NWRR [***planning application reference 21/00924/EIA***] and re-run using parameters to represent the LUF2 scheme.

The air quality modelling undertaken for the NWRR ES was adapted and refined to reflect the detailed dispersion modelling required for the LUF2 scheme as shown in **Figure 4**. The focus of the area of modelling includes Frankwell Roundabout, across Welsh Bridge and Smithfield Road, through the gyratory and up Coton Hill. Where elements of the dispersion modelling undertaken for the NWRR assessment have been updated to reflect the latest available information, further information on the amendments are provided below.

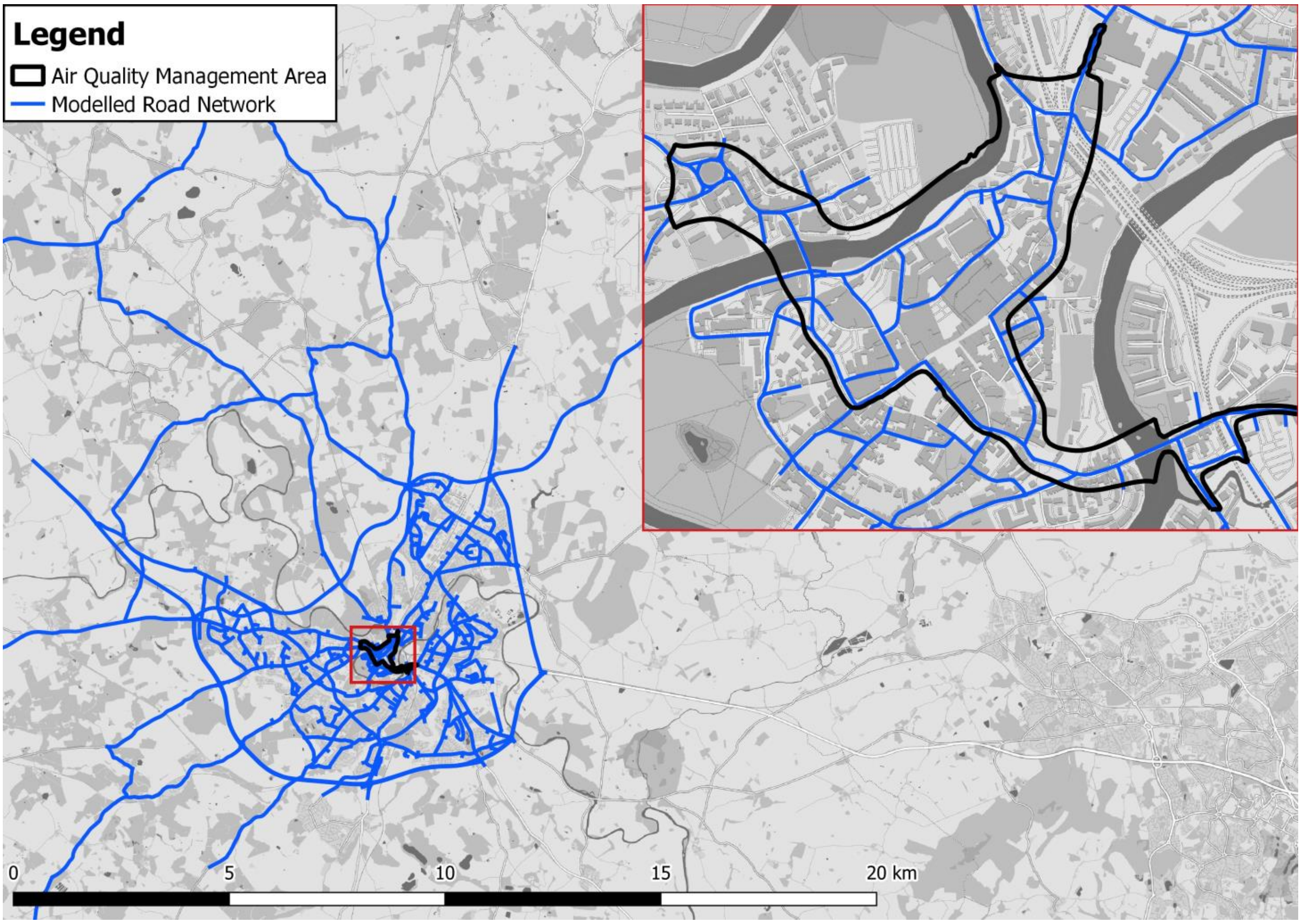


Figure 4: The modelled road network used in the air quality dispersion modelling.

SCENARIOS

Traffic flows were provided for the following modelled scenarios:

- Baseline 2023 – for model verification and baseline concentrations;
- “NWRR” 2023 – model with the Shrewsbury North West Relief Road in place;
- “LUF2” 2023 – model with the proposed scheme in place; and
- “In-Combination” 2023 – model with the proposed scheme and the Shrewsbury North West Relief Road in place.

The difference from these traffic scenarios to the originally modelled NWRR traffic data is the introduction of the LUF2 scheme, directly impacting the road infrastructure of the gyratory to improve air quality through traffic flow/congestion relief and increased uptake in active travel and public transport.

ADDITIONAL MODEL INPUTS

Due to the complex nature of dispersion parameters, particularly around the gyratory, the advanced canyon module and road tunnel module for ADMS Roads was used to replicate the dispersion conditions in the centre of Shrewsbury. The locations of advanced canyons and tunnels used in the modelling are shown in **Figure 5** below.

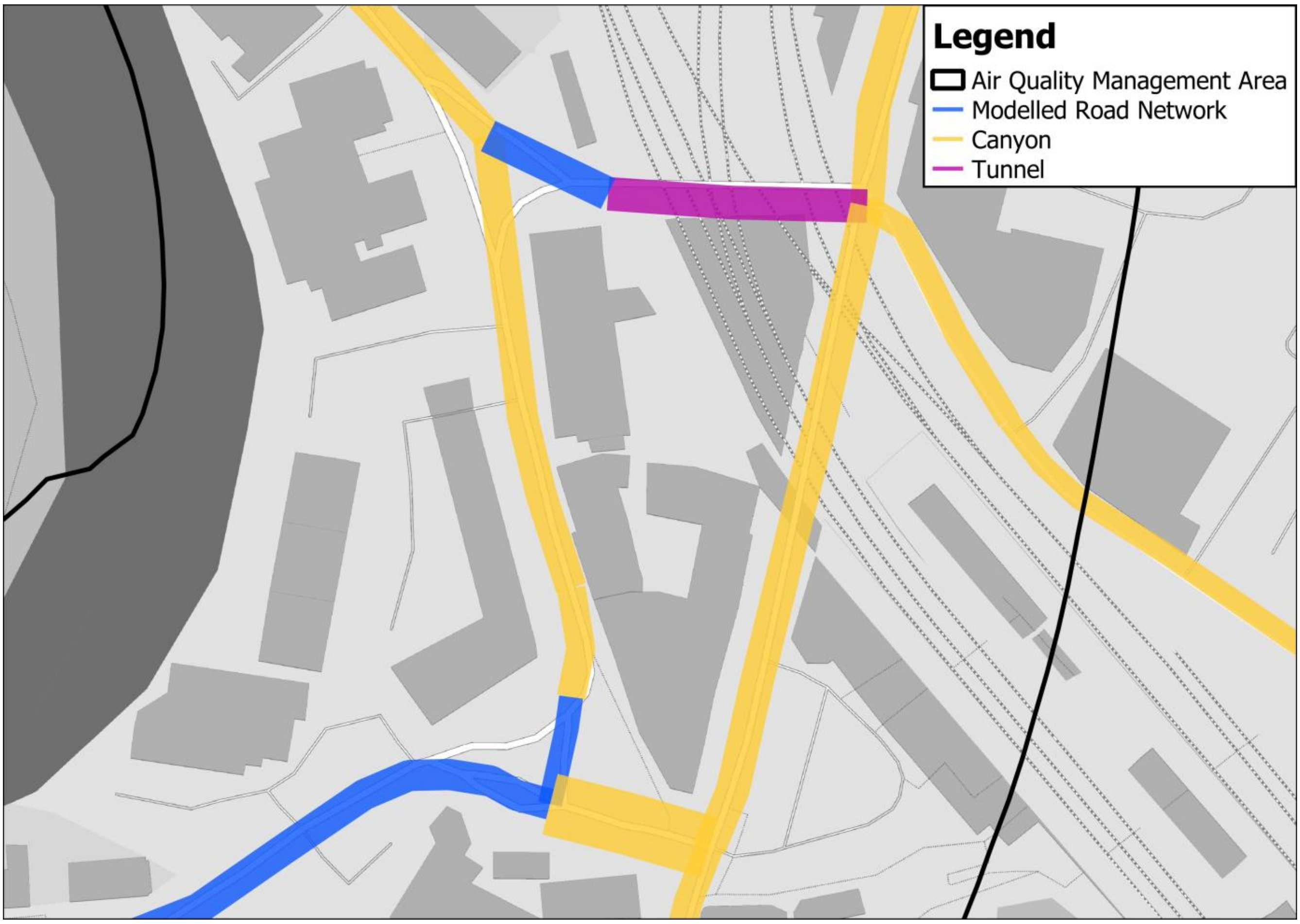


Figure 5: Modelled road canyons through the Shrewsbury gyratory using the Advanced Canyon module in ADMS Roads.

VEHICLE EMISSION FACTORS

Vehicle emission factors used in the assessment have been obtained using the Emission Factor Toolkit (EFT) version 12.0.1 available on the Defra website. The EFT allows for the calculation of emission factors for NOx and PM_{10} arising from road traffic for all years between 2018 and 2030. For the predictions of future year emissions, the toolkit considers the latest available COPERT factors to account for anticipated advances in vehicle technology and changes in vehicle fleet composition.

SELECTION OF BACKGROUND CONCENTRATIONS

Background pollutant concentrations used in the assessment have been taken from the national maps provided on the Defra website (issued in 2020 based on a 2018 reference year), where background concentrations of those pollutants included within this assessment have been mapped at a grid resolution of 1x1km for the whole of the UK. Estimated concentrations are available for all years between 2018 and 2030. The maps assume that background concentrations would improve (i.e. reduce) over time, in line with the predicted reduction in vehicle emissions and emissions from other sources.

It should be noted that for NO_x the background maps present both the 'total' estimated background concentrations and the individual contributions from a range of emission sources (for example, motorways, aircraft, domestic heating etc.). When detailed modelling of an individual sector is required as part of an air quality assessment, the respective contribution can be subtracted from the overall background estimate to avoid the potential for 'double-counting'. For this assessment, traffic data for all the motorways, trunk A roads and main A Roads within the relevant grid squares have been included in the local dispersion modelling (there are no motorways within the assessment area). Therefore, contributions from this sector have been removed from the background concentrations for these squares.

RECEPTOR SELECTION

Receptor grids with different resolutions were used to ensure extensive coverage of the Shrewsbury town centre and an appropriate level of detail where required. The grids have a 1m x 1m resolution around the gyratory, and a 10m x 10m resolution for the rest of the town centre, from Frankwell Roundabout to Coton Hill. In addition to these grids, additional receptors were placed using the ADMS source apportioned grids to better capture the decay from the roadside. This coverage allows for extensive investigation of the impacts arising within the town centre.

MODEL VERIFICATION

The ADMS Roads dispersion model has been widely validated for this type of assessment and is fit for purpose. Model validation has been undertaken at a UK-wide level by the software developer, however this would not have included local validation in the vicinity of the Proposed Scheme, nor any assessment of the accuracy of the emission rates used within it. The verification has two stages. The first is a comparison of modelled results (in the form of Road contribution to NOx concentrations) with selected monitored equivalents to determine a model verification factor. The second is a comparison of monitored and verified modelled total NO_2 concentrations, to determine the performance of the model at a local level. This combined process (called "verification") aims to address modelling uncertainty and systematic error by adjusting modelled outputs to gain greater confidence in the final results.

Model Verification was carried out following the methodology specified in Chapter 7, Section 4, of LAQM.TG(22). The receptors used in the comparison of monitored and unverified Road NOx are set out in

Table 1, below. The results of the model verification before (i.e. comparison of modelled and monitored Road NOx) and after the application of a verification factor are shown in **Figure 6** and **Figure 7**, below.

The verification process identified two distinct groups for model verification. The first group (shown in orange) covers two monitoring points on Chester Street (see DF476 and DF502 on **Figure 2**), where conservative assumptions (including the application of canyons within the modelling) have led to a lower verification factor than the other monitoring points included within the model. The second group (shown in blue) consists of all other monitoring points found within the detailed modelling which broadly follow a similar trend. Monitoring points DF438 and DF458 (along Castle Gates) sit within a modelled canyon, indicating that dispersion parameters are exceptionally constrained due to a series of tall buildings and railway tracks, creating a significant canyon effect. With the canyon included, these points fit well within the graph showing typical dispersion conditions within Shrewsbury town centre, indicating that the model is a good representation of airflow on pollutant concentrations in this location.

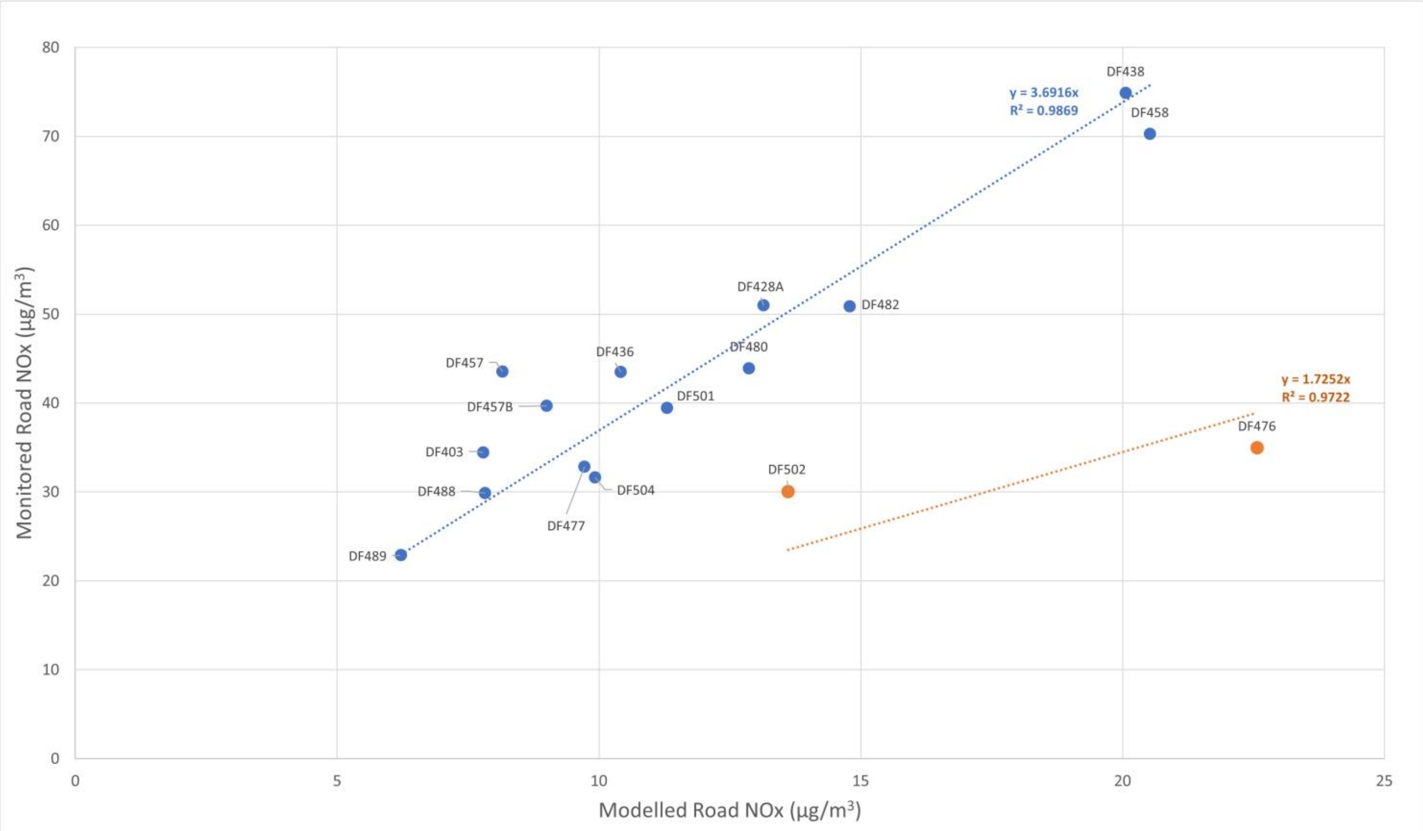


Figure 6: Air quality verification graph, plotting monitored Road NOx against unverified modelled Road NOx.

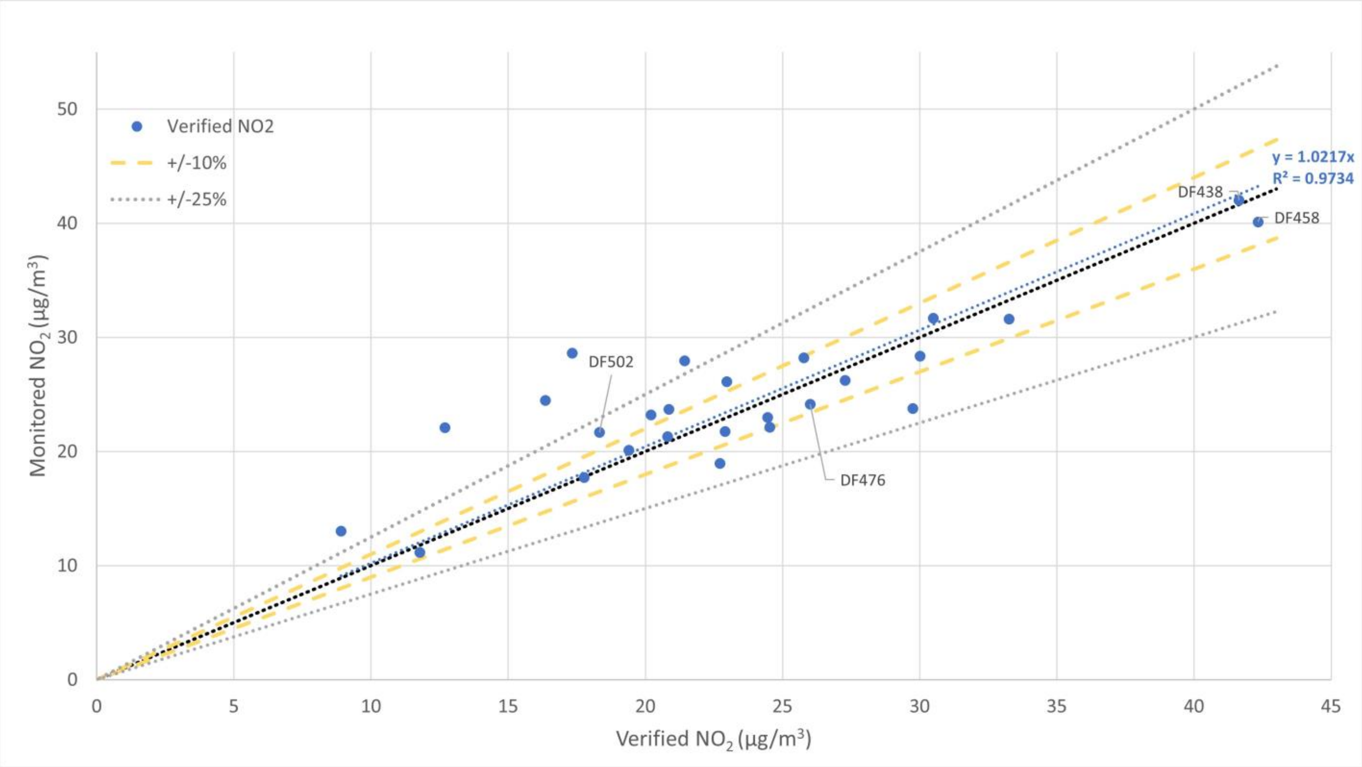


Figure 7: Air Quality verification graph, plotting total NO_2 against verified modelled total NO_2.

The verification factor for both groups indicate that the unverified model is largely under-predicting concentrations (1.73 and 3.69 for group 1 and "General Area" respectively), as shown by **Figure 6**. However, as can be seen in **Figure 7**, the verified model provides a good representation of monitored total NO_2 concentrations across Shrewsbury Town Centre, with the majority of monitored points lying within +/-10% of the monitored total NO_2 concentration, and all but 5 (4 of which were outside of the core model area) of the 26 total locations considered within +/-25%.

Table 1: Monitoring receptors used within model verification

Monitoring ID	2023 Monitored NO_2	Verification Group	Notes
DF403	23.7	General Area	
DF404	11.2	None	Monitoring Point outside of Core Model Area (Gyratory) – included within Total NO_2 graph
DF407	19.0	None	Monitoring Point outside of Core Model Area (Gyratory) – included within Total NO_2 graph
DF413	23.2	None	Monitoring Point outside of Core Model Area (Gyratory) – included within Total NO_2 graph
DF420	22.1	None	Monitoring Point outside of Core Model Area (Gyratory) – included within Total NO_2 graph

DF428A	31.7	General Area	
DF429	23.8	None	Removed to ensure a conservative assessment
DF436	28.2	General Area	
DF438	42.0	General Area	
DF457	27.9	General Area	
DF457B	26.1	General Area	
DF458	40.1	General Area	
DF459	28.6	None	Located within train station car park. Included within Total NO_2 graph.
DF461	20.1	None	Monitoring Point outside of Core Model Area (Gyratory) – included within Total NO_2 graph
DF476	24.1	1	Chester Street Verification
DF477	23.0	General Area	
DF480	28.4	General Area	
DF482	31.6	General Area	
DF485	21.7	None	Monitoring Point outside of Core Model Area (Gyratory) – included within Total NO_2 graph
DF488	21.3	General Area	
DF489	17.7	General Area	
DF490	13.0	None	Monitoring Point outside of Core Model Area (Gyratory) – included within Total NO_2 graph
DF501	26.2	General Area	
DF502	21.7	1	Chester Street Verification
DF503	24.5	None	Monitoring Point outside of Core Model Area (Gyratory) – included within Total NO_2 graph
DF504	22.1	General Area	

PROCESSING OF RESULTS

The verification factor was applied to the model road-NOx outputs prior to conversion to annual mean NO_2 concentrations utilising the NO_x to NO_2 calculator (version 8.1, released August 2020) provided by Defra.

Table 2: Parameters used within the dispersion model

Model Inputs	Version/Detail	Comments
ADMS Roads	5.0.0.1	
Emissions Factor Toolkit	12.0.1	Released December 2023
NOx to NO2 Calculator	8.1	Released August 2020
Background Concentrations	Defra 2018 Reference Year – 2023 Background Map	Released December 2023
Model Verification Year	2023	Using latest monitoring data provided by Shropshire Council.
Meteorological Data	No change from ES Assessment	No updates to the meteorological parameters have been made from the original assessment. Additional meteorological years were tested however, data validity at the Shawbury site decreases over time, making 2017 the most viable year.
	Scenarios	
Baseline	2023 used as both baseline and opening year	The same traffic data was used in these scenarios as was provided for the original NWRR assessment.
NWRR		
LUF2		These additional scenarios were adapted from the original NWRR traffic model to generate scenarios with only the LUF2 scheme and both the LUF2 scheme and NWRR in operation
In-Combination		
	Receptor Grids	
1m x 1m	300m extent across the gyratory	Variable resolution used across the site – detailed resolution provided across the gyratory and Castle Gates in particular.
10m x 10m	Across entire modelled area	
	Additional Model Inputs	
Advanced Canyon Module	Canyons generated, with a particular focus on the gyratory	Run using Network mode enable – ensures adjoining canyons are modelled together.
Road Tunnel Module	Tunnel under bridge	Represents tunnel along Cross Street

RESULTS

A summary of the results of the air quality modelling is provided below. Due to the quantity of data modelled, results for every grid point are not explicitly provided (although this is available if required) but are visualised within the heat mapping shown in **Figures 9 - 12**. Instead, data will be provided with reference to the monitoring points located in Shrewsbury Town Centre, including the areas of concern – along Castle Gates (DF438, DF458) and Chester Street (DF476 and DF502). All results are presented in **Table 3**, below, as an NO_2 concentration from a 2023 opening year scenario.

Table 3: Air quality modelling results for Shrewsbury Town Centre monitoring locations

SC Monitoring ID	2023 Monitored NO_2 Concentration ($\mu g/m^3$)	2023 Modelled NO_2 Concentration ($\mu g/m^3$)			
		Baseline	LUF2 Scenario	NWRR Scenario	In-combination Scenario
DF403	23.7	20.9	20.0	18.5	18.2
DF404	11.2	11.8	11.8	11.7	11.7
DF407	19.0	22.7	22.7	22.6	22.6
DF413	23.2	20.2	20.1	19.3	19.2
DF420	22.1	12.7	12.6	12.5	12.4
DF428A	31.7	30.5	26.9	29.1	27.1
DF429	23.8	29.8	27.6	24.4	23.5
DF436	28.2	25.8	26.7	22.5	23.9
DF438	**42.0**	**41.6**	27.8	36.7	26.5
DF458	**40.1**	**42.3**	26.5	37.4	25.6
DF459	28.6	17.3	15.1	15.8	14.3
DF461	20.1	19.4	19.4	19.3	19.3
DF476	24.1	26.0	27.6	22.7	24.4
DF477	23.0	24.5	23.2	21.1	20.1
DF480	28.4	30.0	26.8	28.8	27.0
DF482	31.6	33.3	28.7	31.6	29.1
DF485	21.7	22.9	21.4	18.6	18.2

DF501	26.2	27.3	24.5	23.9	22.3
DF502	21.7	18.3	18.0	16.4	16.6
DF503	24.5	16.4	16.2	15.8	15.7
DF504	22.1	24.5	23.5	20.9	20.3

Additional model results for building facades along key routes in Shrewsbury Town Centre (shown in **Figure 8**) have been provided in **Table 4** below. These results are presented as a maximum modelled concentration along the aforementioned routes at a height of 1.5m above ground level. It should be noted that the maximum modelled concentration presented below may occur at a retail property façade and therefore is not representative of relevant long-term (annual mean) exposure.

Table 4: Maximum modelled concentrations at selected facades

Place Name	DM Scenario	LUF2 Scenario	NWRR Scenario	In-combination Scenario
Meadow Place	20.6	27.1	18.6	26.7
The Alb	31.2	35.5	26.2	30.1
Chester Street	26.4	26.7	23.2	23.9
Severn Terrace	39.7	34.1	32.6	28.9
Castle Gates (North of Smithfield Road)	**56.8**	35.5	**50.1**	34.2
Castle Gates (South of Smithfield Road)	36.8	39.5	35.0	38.6

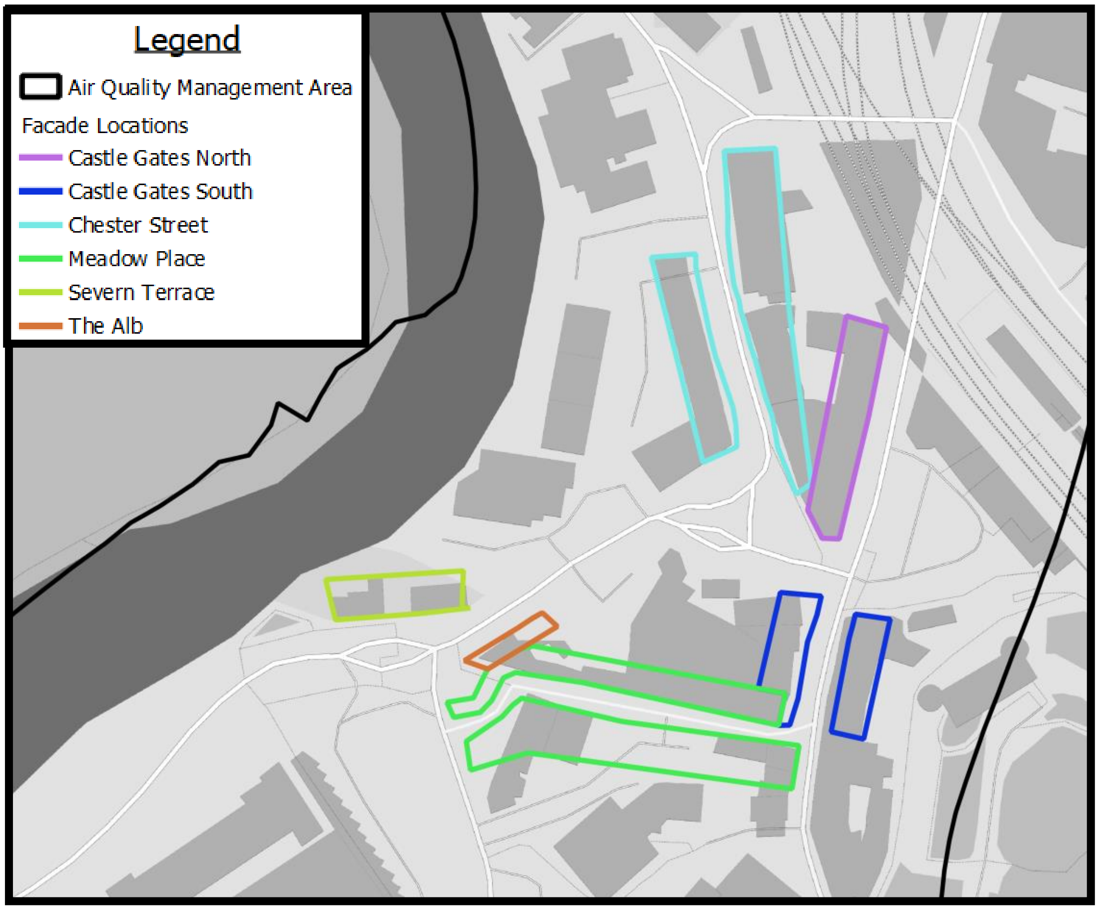


Figure 8: Showing the facades used to provide the maximum modelled concentrations along key routes through the Shrewsbury gyratory

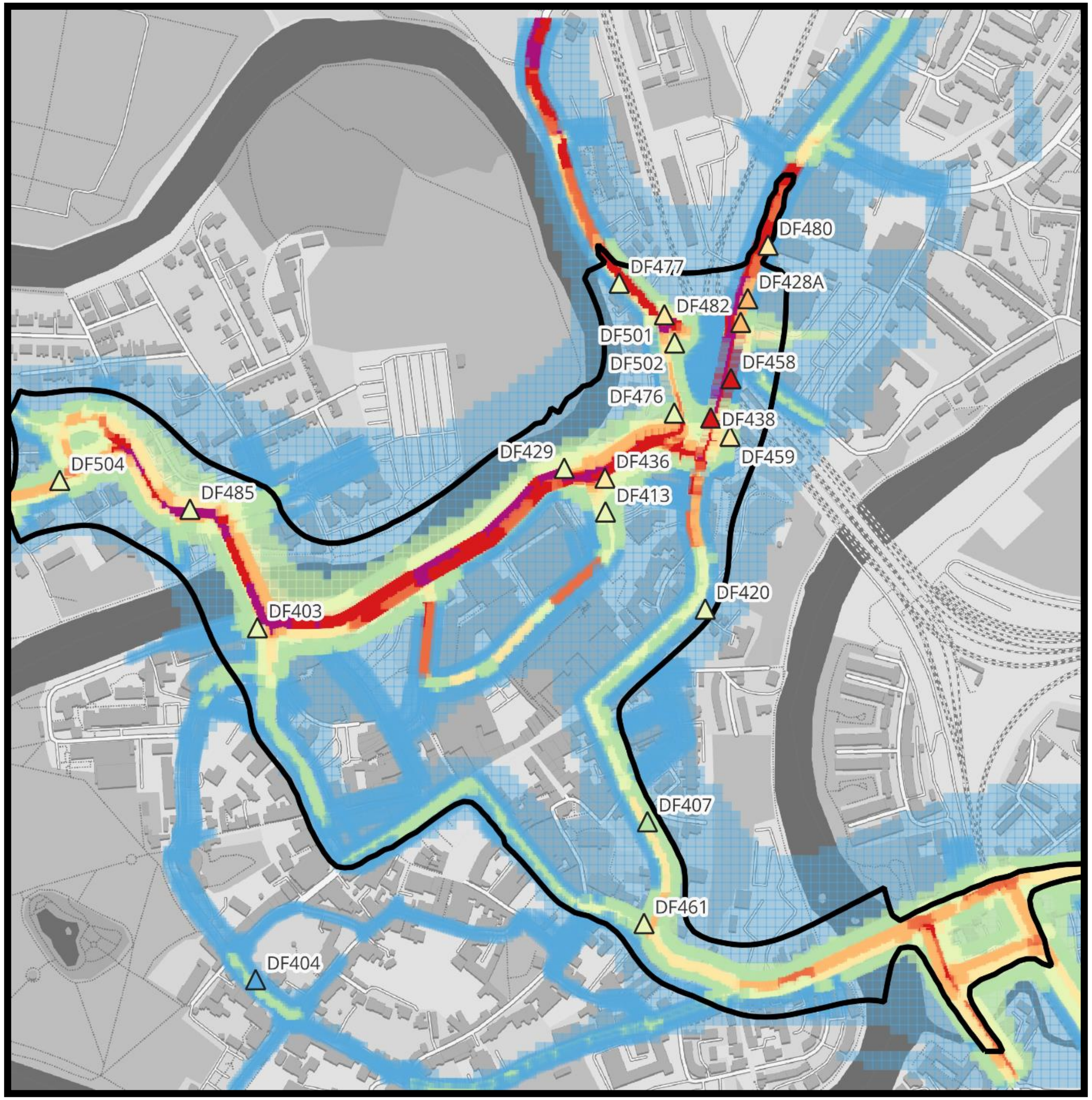
Modelled outputs of all scenarios are shown in **Figures 9 - 11**. These figures present modelled NO_2 concentrations across a Shrewsbury Town Centre and have a focus on the 1mx1m grid over the gyratory. **Figure 12 and 13** present the impact of the LUF2 scheme and the In-Combination scenario.

Complex dispersion around the east of the Shrewsbury gyratory (along Castle Street) limit the dispersion of pollutants leading to elevated concentrations within the street canyons. **Figure 13** shows that the LUF2 scheme decreases NO_2 concentrations substantially along Castle Gates. The large increase shown at the junction of Chester Street and Smithfield Road is as a result of the change in traffic routing following the removal of the dedicated left hand turn link. This is highlighted by the simultaneous increase in concentrations to the south of Smithfield Road, and decrease to the north.

As can be seen in the table above, concentrations at DF476 are predicted to increase for the LUF2 Scheme alone, but decrease with the introduction of the NWRR. This is due to changes in traffic flow along Chester Street with the LUF2 Scheme increasing flows, but the NWRR causing a reduction in flows.

At the point at which Chester Street and Cross Street meet (i.e. DF502), there are competing effects arising from increased traffic along Chester Street offset by decreased flows through Cross Street (as well as dispersion from the tunnel entrance). At DF502, the impact of the reduction in traffic flows through Cross Street (and associated tunnelling) is greater than the increased flow along Chester Street.

It is noted that all modelled concentrations will fall or remain below the relevant standards with the LUF2 and Schemes.



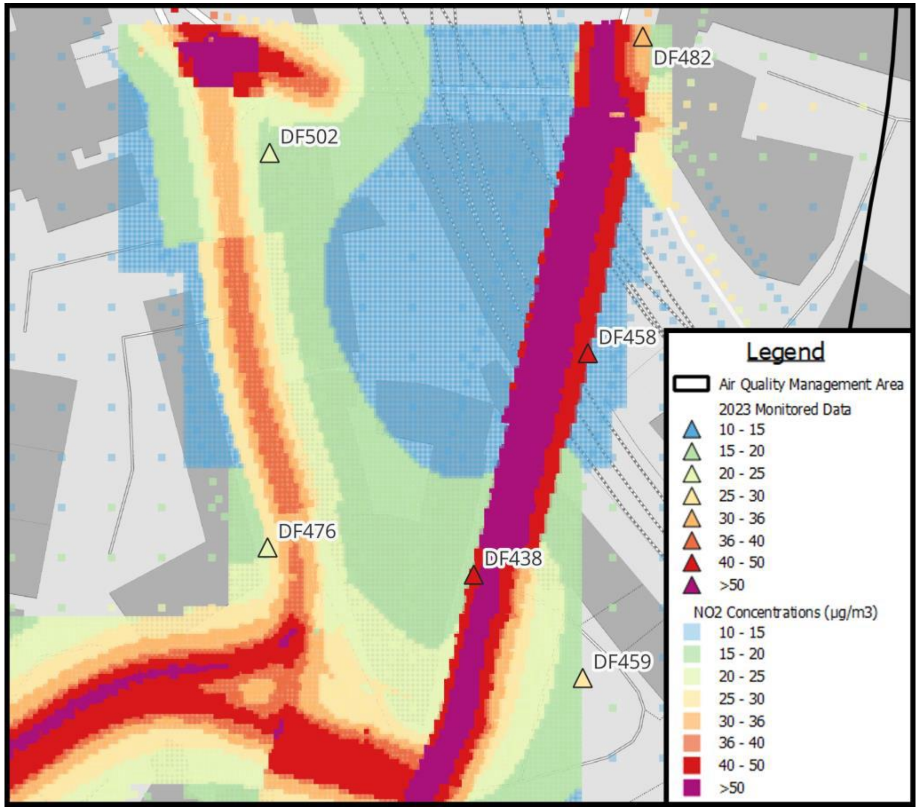
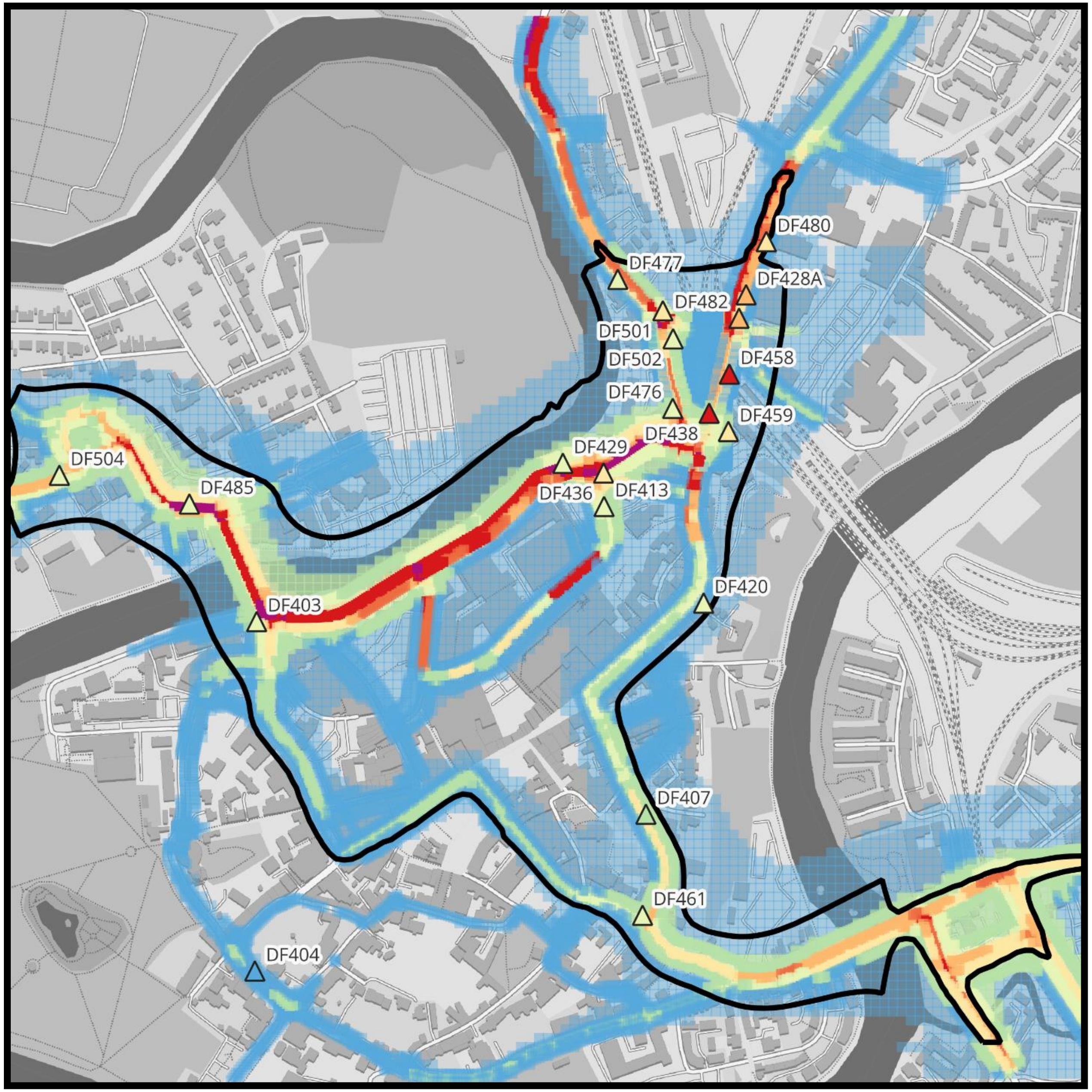


Figure 9: 2023 Do Minimum Scenario NO_2 Concentrations across Shrewsbury Town Centre



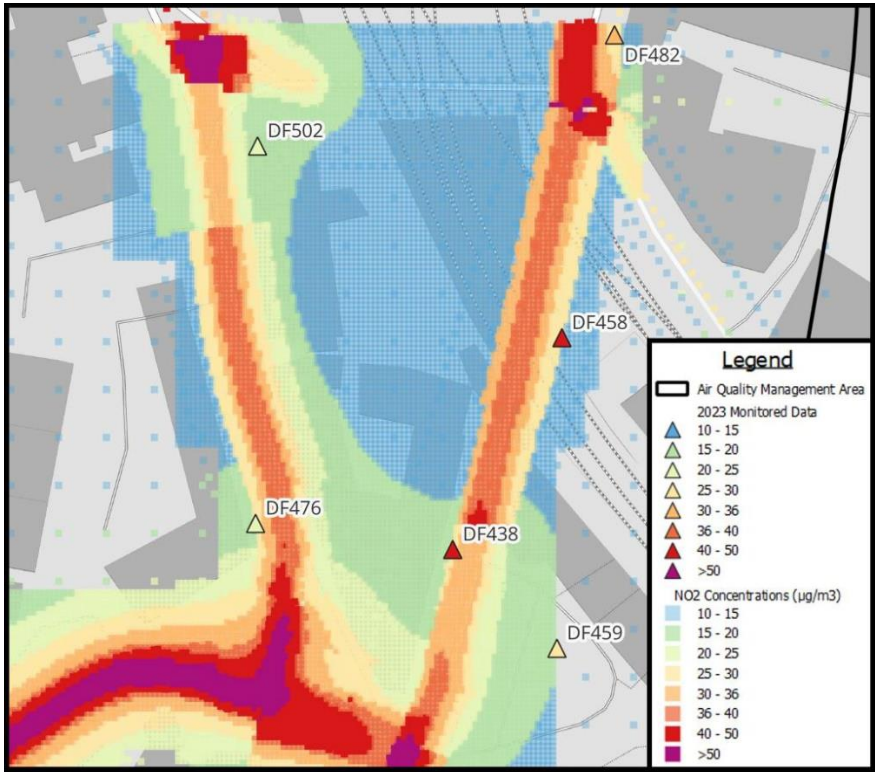


Figure 10: 2023 LUF2 Scenario NO_2 Concentrations across Shrewsbury Town Centre

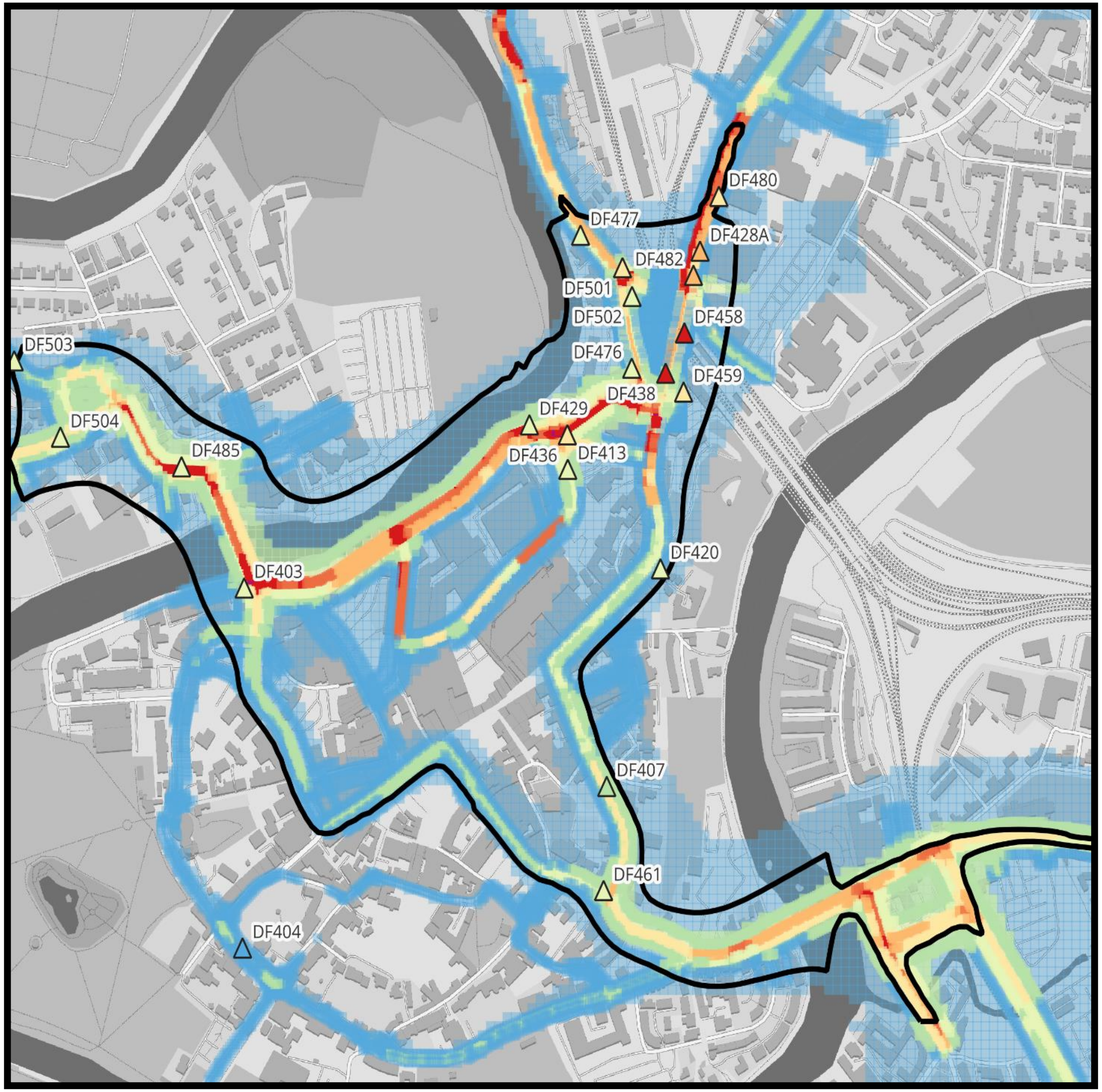
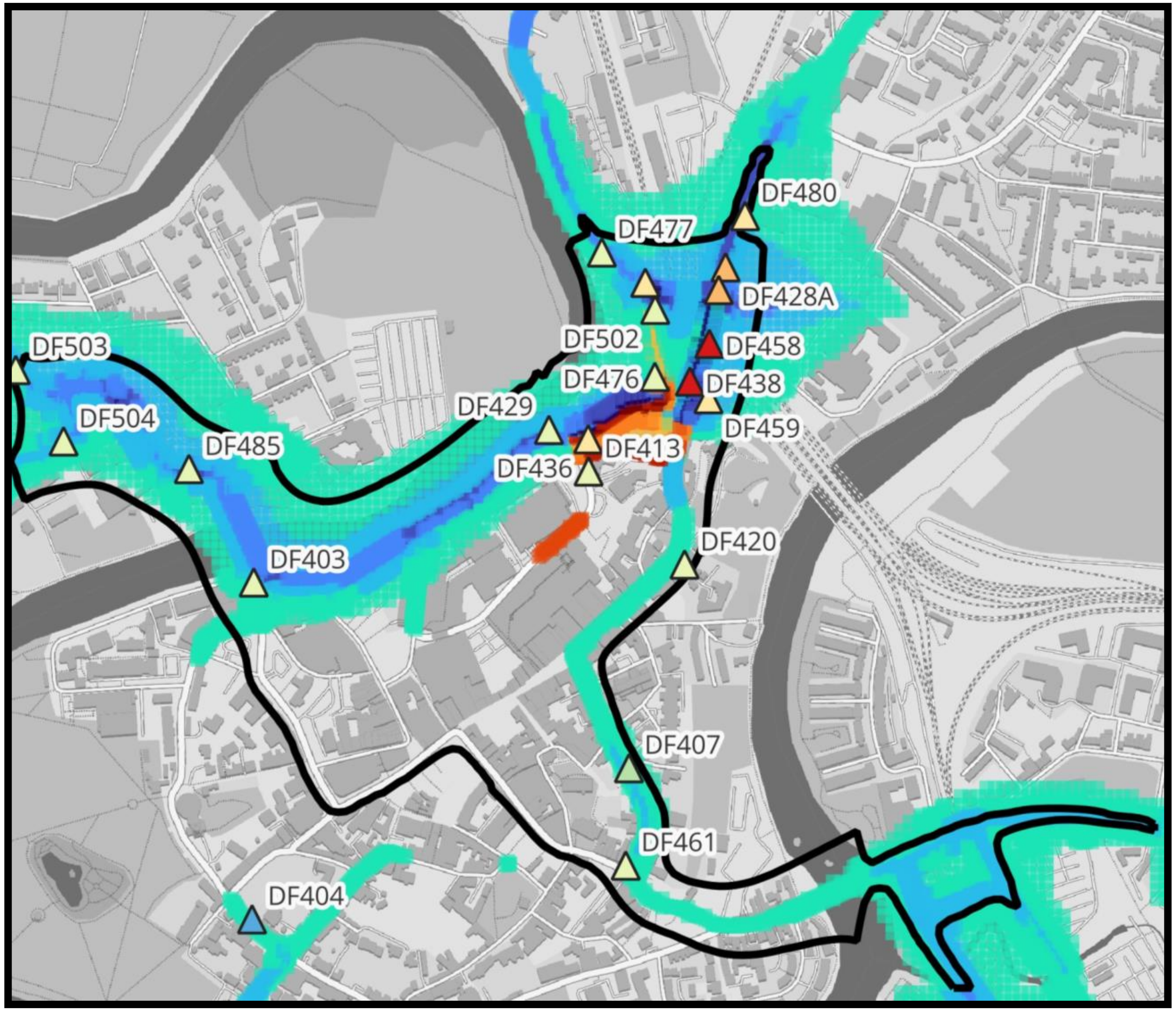


Figure 11: 2023 In-combination Scenario NO_2 Concentrations across Shrewsbury Town Centre



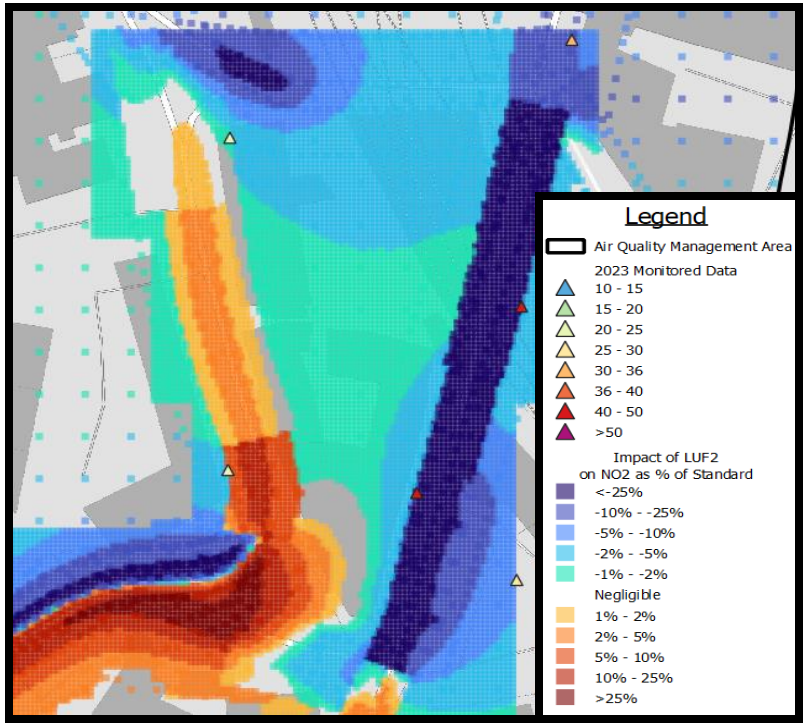


Figure 12: NO_2 Impact of LUF2 Scenario alone as a percentage of air quality standards

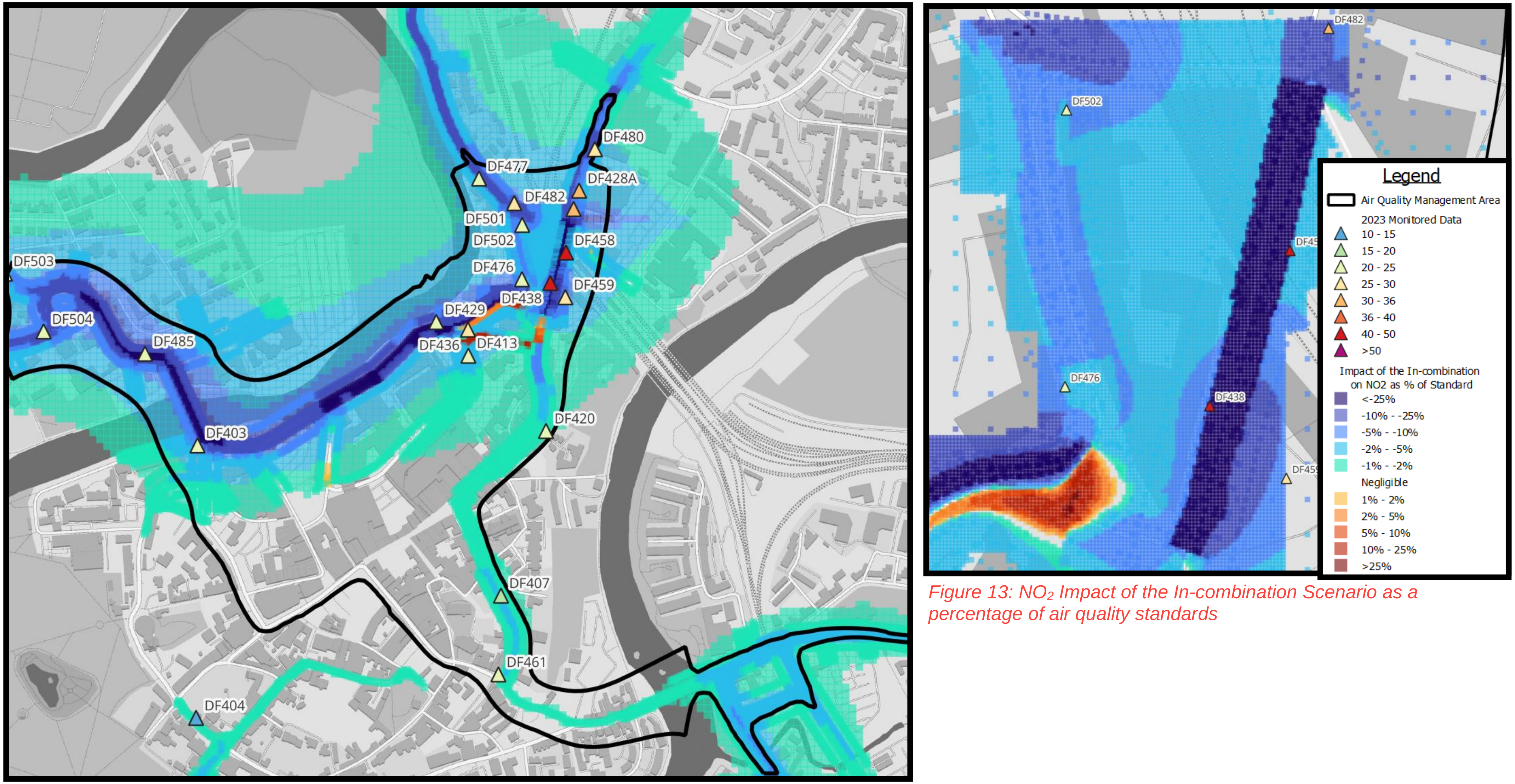


Figure 13: NO_2 Impact of the In-combination Scenario as a percentage of air quality standards