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Local Plan

Air Quality Modelling Report (AQ3)

Coventry City Council

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1. Introduction

1.1. Content

This deliverable (AQ3) reports the results of the air quality modelling used to inform Coventry City Council's Local Air Quality Plan.

The Air Quality Modelling Methodology Report (AQ2) outlines the methodology for and inputs to the air quality modelling.

The Analytical Assurance Statement provides an overall assessment of the uncertainty associated with the modelling and the results of sensitivity and uncertainty tests undertaken relating to air quality (emissions and dispersion) modelling.

1.2. Air Quality Model Revisions

1.2.1. June 2019 Revisions

A number of updates and improvements have been made to the air quality modelling approach compared to that employed prior to the submission of the Outline Business Case (OBC) in January 2019. These revisions have been made in the time available since the OBC was submitted and following receipt of additional monitoring data and comments from the Technical Independent Review Panel (T-IRP). These revisions include:

- the additional of more recent monitoring data for diffusion tubes on Holyhead Road and the Inner Ring Road, giving a longer period of monitoring and hence more confidence in the annual mean concentrations derived at these locations and used in model verification;
- refining the modelled geometry of a small number of sections of the A4053 Inner Ring Road so that an individual emission source is now modelled for each carriageway, as opposed to a single emission source for both carriageways. The purpose of these modifications was to better reflect the effect on roadside NO_2 concentrations of differences in traffic flows by direction, particularly in response to proposed measures; and
- Use of the advanced street canyon module in ADMS-Roads (as an enhancement to the standard street canyon modelling included in previous submissions), at the suggestion of the T-IRP (see AQ2).

These updates and revisions have resulted in improved model performance at the majority of monitoring sites used in the model verification process and consequently a reduction in the model adjustment factors applied across the model domain.

1.2.2. September 2019 Revisions

Following a discussion with JAQU[1] regarding modelled exceedances of the EU Limit Value at non-PCM receptors, a number of model refinements were made in the base, Do-Minimum and DS13L scenarios, as detailed below.

It should be noted that the modelling for Options DS2b and DS14 was not updated to include these refinements because:

a) the refinements were considered unlikely to substantially effect the modelled impact of either option and/or the modelled year of compliance, therefore re-modelling these options was not considered proportionate; and
b) not re-modelling these options allowed an updated air quality modelling report to be produced much sooner than would otherwise be the case.

1.2.2.1. Revised Base and Do-Minimum

The traffic model (which is of a regional scale) was found to potentially be misrepresenting the exact destination of certain vehicle trips within the centre of Coventry. As a result, the number of trips on Queen Victoria Road was considered likely to be substantially over-estimated. Refinements to the traffic model (including an additional connector zone) were therefore made to better represent traffic

[1] JAQU workshop on Friday 2nd August 2019.

movements within the Inner Ring Road. The air quality model was subsequently updated using these updated traffic data and annual mean NO_2 concentrations recalculated.

As part of this process, the base year air quality model was re-verified, which marginally improved overall model performance relative to the June 2019 version. The resulting changes to model adjustment factors were however very small (± 0.3%). The revised verification process is detailed in Appendix B.

Further to the base year model refinements, the Queen Victoria Road Public Realm Scheme has also been incorporated into the traffic model for the Do-Minimum future year. The scheme includes:

- Removal of one northbound lane on Queen Victoria Road, and replacing it with a cycle lane;
- Removal of two puffin crossings; and
- Cycle crossing added to the road leading to Junction 7 of the Inner Ring Road.

2. Model Verification

Outputs from the base year (2017) air quality model have been compared to the results of nitrogen dioxide (NO_2) diffusion tube and continuous monitoring adjacent to modelled roads, and a model adjustment factor derived, in accordance with the methodology described within LAQM.TG16. The locations of these monitoring sites are shown in Figure A-1.

The following steps were undertaken:

- f-NO_2 values were estimated at each monitoring site using the ratio of modelled Road-NO_2 to Road-NO_x in the 2017 base year;
- background NO_2 concentrations for 2017 were estimated from Defra background maps (for a 2015 reference year), with the "in-square" contribution from Motorways and A-roads removed using Defra's Sector Removal Tool (v 6.0), to avoid double counting;
- modelled total NO_2 was estimated at each monitoring site by entering the modelled Road-NOx concentration, f-NO_2 and background NO_2 concentration at each monitoring site into Defra's NOx to NO_2 calculator (v6.1);
- modelled and measured total annual mean NO_2 concentrations were compared, which indicated that the model tended to under predict measured NO_2 concentrations, with some areas underpredicting more than others e.g. adjacent to Holyhead Road;
- "monitored Road-NOx" was estimated at each monitoring site by entering the measured annual mean NO_2 concentration, modelled f-NO_2 and mapped background NO_2 concentration at each monitoring site into the "NO_2 to NOx" tool within Defra's NOx to NO_2 calculator (v6.1);
- Three alternative model adjustment approaches were considered to improve model performance (as described within the Analytical Assurance Statement). The approach subsequently chosen resulted in the best model performance (in terms of correlation coefficient, RMSE and fractional bias), the most sites being within ±10% of measured concentrations (34 out of 49) and the fewest sites being more than ±25% of measured values (3 out of 49). For the chosen approach, two model adjustment factors were derived for the model domain, with one 'global' factor for the majority of the overall model domain and a separate factor for Holyhead Road where elevated NO_2 concentrations are observed. These model adjustment areas were termed "Coventry-wide" and "Holyhead Road" respectively;
    - the "Coventry-wide" factor of 1.41 was derived based on linear regression of "monitored Road-NOx" vs. "modelled Road-NOx" at 44 monitoring sites across Coventry; and
    - the "Holyhead Road" factor of 2.32 was derived based on a linear regression of "monitored Road-NOx" vs. "modelled Road-NOx" at five monitoring locations on Holyhead Road (HR1, HR1c. HR4, HR5 and HR6). The model adjustment approach applied for Holyhead Road was specifically discussed and agreed with JAQU due to the elevated concentrations observed in this area.
- "adjusted modelled NO_2" concentrations were derived by factoring "modelled Road-NOx" concentrations by the relevant model adjustment factor and entering the "adjusted Road-NOx" concentration, f-NO_2 and background NO_2 concentration at each monitoring site into Defra's NOx to NO_2 calculator (v6.1); and
- "Final adjusted modelled NO_2" concentrations were subsequently derived by applying a factor of 1.01, which was derived based on linear regression of "monitored NO_2" vs. "adjusted modelled NO_2" at all monitoring sites.

The results of the model verification process are summarised in Appendix B. Sensitivity tests around model verification are reported in the Analytical Assurance Statement (AAS).

In summary, post-adjustment 94% of modelled concentrations are within 25% of monitored concentrations. The root mean square error (RMSE) is well below the threshold value of 25% of the AQS objective (i.e. 10 µg/m^3) and close to the ideal of being within 10% of the AQS objective (i.e. 4 µg/m^3). The fractional bias (FB) indicates that the model tends to very slightly under predict.

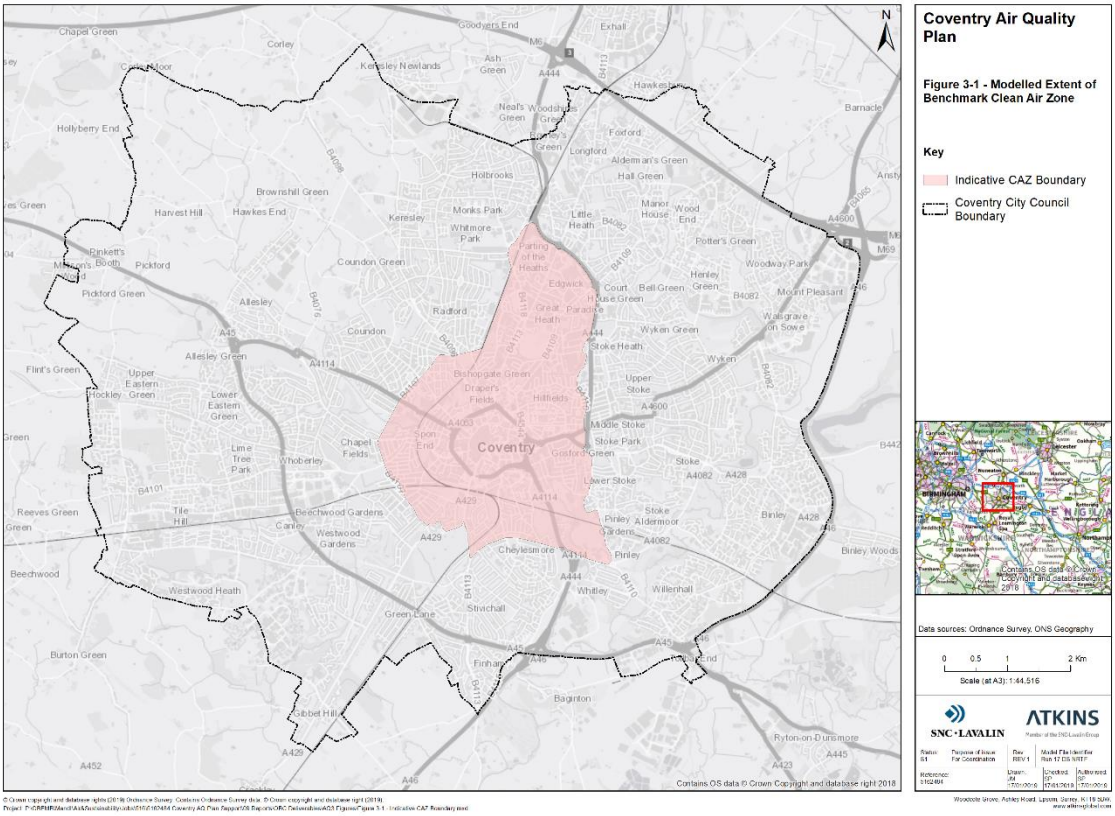
On that basis the model is deemed to perform acceptably for the use it is intended.

3. Proposed Measures

3.1. Benchmark Clean Air Zone

The benchmark Clean Air Zone (CAZ) considered consists of Class D CAZ (i.e. affecting buses, coaches, taxis, private hire vehicles, LGVs, HGVs and private cars) with a daily toll of £8.00 for Cars and LGVs and £50 for HGVs and coaches to enter the zone. The extent of the benchmark CAZ is presented in Figure 3-1 below.

Figure 3-1 – Modelled Extent of Benchmark Clean Air Zone



3.2. DS13L

Option DS13L consists of the following package of measures:

- Peak time restrictions on Holyhead Road (inbound AM, outbound PM);
- Interpeak restrictions on Holyhead Road (three hours inbound and three hours outbound);
- High quality cycle infrastructure along Coundon Road;
- Capacity improvements along Spon End;
- Redesign of Ring Road Junction 7;
- Closure of Barras Lane between Coundon Road and Holyhead Road;
- Opening of Upper Hill Street allowing a left in / left out movement with the Inner Ring Road clockwise;
- Replacement of two thirds of the bus movements on Foleshill Road with electric buses; and
- Restricting the right-hand turn movement from Cash's Lane to Foleshill Road southbound.

3.3. DS14 - Benchmark CAZ (plus additional measures)

This scenario consists of a Class D CAZ (as per the benchmark CAZ scenario described in Section 3.1) supplemented by the following measures detailed included in DS13L:

- High quality cycle infrastructure along Coundon Road;
- Capacity improvements along Spon End;
- Redesign of Ring Road Junction 7;
- Closure of Barras Lane between Coundon Road and Holyhead Road; and
- Opening of Upper Hill Street allowing a left in / left out movement with the Inner Ring Road clockwise.

An alternate upgrade response of 'no upgrade' is presented in the Analytical Assurance Statement for this scenario to account for potential uncertainties in upgrade response to a CAZ.

4. Modelling Results

4.1. Modelled Receptors

The locations of modelled receptors relative to each PCM link are shown in Figure A-2 to Figure A-34. These receptors have been selected to represent the maximum annual mean roadside NO_2 concentrations adjacent to each PCM link at locations which meet the requirements of the Air Quality Directive (Annex III: A, B, and C), and specifically at which there is public access for the duration of relevant air quality criteria.

A number of additional worst-case receptors were modelled adjacent to non-PCM links for those roads with the potential to be affected by displaced traffic as a result of each option and / or that were previously modelled to have roadside concentrations of > 36 µg/m^3 at any point along the road. These 'secondary' receptors were positioned in the same way as the discrete receptors modelled to represent PCM links (i.e. at 4m from the roadside and at 2m in height). The worst-case receptor for each link was identified using the Do-Minimum scenario results and subsequently assessed in each of the Do-Something scenarios. The locations of these receptors are shown in Figure A-35.

4.2. Summary of Results

4.2.1. Do-Minimum Scenario

4.2.1.1. PCM Compliance

The results of the air quality modelling for the Do-Minimum scenario are summarised in Table 1 and shown in Figure A-36, which indicate that, in the absence of any action, compliance with the annual mean NO_2 EU limit value is not projected to be achieved until 2028 for one link (Holyhead Road - Census ID 7647).

The EU Limit Value is also modelled to be exceeded in 2021 adjacent to a southwest section of A4053 Ring Road (Census ID 37731) with compliance projected to be achieved in 2022.

On this basis, measures are required to address non-compliance in the compliance assessment year of 2021.

Table 1 - Air Quality Modelling Results – Do-Minimum Scenario

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
6490	36.06	34.88	33.69	32.42	31.18	29.76	28.41	27.10	25.79	24.57	23.36	22.20	21.07	19.97
6491	30.42	29.38	28.33	27.23	26.19	25.23	24.34	23.46	22.61	21.81	21.02	20.27	19.56	18.87
7103	**41.97**	**40.59**	39.20	37.72	36.27	34.65	33.10	31.59	30.09	28.60	27.14	25.70	24.30	22.93
7118	35.51	33.92	32.31	30.58	28.83	27.43	26.08	24.77	23.46	22.22	20.99	19.79	18.63	17.49
7122	31.99	30.96	29.94	28.84	27.84	26.55	25.32	24.12	22.94	21.81	20.71	19.62	18.57	17.56
7631	**46.21**	**44.47**	**42.69**	**40.78**	38.92	37.21	35.60	34.01	32.46	31.01	29.59	28.21	26.89	25.61
7647	**67.44**	**65.02**	**62.44**	**59.62**	**56.74**	**54.23**	**51.79**	**49.36**	**46.96**	**44.62**	**42.28**	39.98	37.70	35.42
16446	33.92	32.81	31.69	30.51	29.41	27.97	26.57	25.20	23.85	22.55	21.26	20.01	18.78	17.57
16467	33.58	32.64	31.69	30.67	29.68	28.30	27.01	25.76	24.52	23.35	22.21	21.10	20.04	19.02
17075	28.56	27.26	25.94	24.55	23.18	22.13	21.13	20.17	19.21	18.32	17.46	16.63	15.83	15.05
17595	38.75	37.40	36.04	34.60	33.29	32.00	30.78	29.59	28.43	27.34	26.28	25.27	24.30	23.36
18006	27.88	26.99	26.12	25.19	24.33	23.28	22.29	21.33	20.40	19.51	18.64	17.80	17.00	16.23
26497	**47.54**	**45.84**	**44.11**	**42.22**	40.36	38.48	36.68	34.92	33.17	31.51	29.87	28.26	26.71	25.19
27132	37.84	36.68	35.54	34.30	33.14	31.76	30.45	29.20	27.95	26.76	25.59	24.48	23.40	22.37
27151	28.29	26.92	25.54	24.07	22.69	21.78	20.93	20.11	19.31	18.56	17.84	17.16	16.51	15.89
27693	**41.54**	39.76	37.94	36.00	34.15	32.69	31.34	30.03	28.73	27.55	26.40	25.29	24.25	23.23
27708	31.56	30.10	28.63	27.07	25.53	24.29	23.12	21.97	20.84	19.77	18.72	17.70	16.71	15.75
36482	31.57	32.27	33.02	33.73	34.63	33.11	31.67	30.24	28.83	27.47	26.12	24.80	23.52	22.26
36504	35.15	34.49	33.84	33.14	32.49	31.00	29.58	28.19	26.82	25.52	24.25	23.01	21.80	20.63
37169	**40.96**	39.30	37.62	35.81	33.99	32.53	31.15	29.81	28.49	27.20	25.94	24.71	23.54	22.39
37731	**44.19**	**43.39**	**42.60**	**41.74**	**41.13**	39.53	38.03	36.56	35.12	33.77	32.45	31.17	29.95	28.76

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
37748	**45.79**	**43.93**	**42.03**	40.02	38.21	36.71	35.29	33.91	32.55	31.29	30.05	28.86	27.70	26.60
38796	36.23	34.96	33.70	32.35	31.09	29.73	28.47	27.23	26.01	24.86	23.74	22.65	21.62	20.61
47156	40.41	39.04	37.66	36.17	34.91	33.63	32.44	31.29	30.15	29.10	28.09	27.11	26.17	25.28
47690	**43.10**	**41.39**	39.63	37.74	35.91	34.46	33.08	31.74	30.40	29.16	27.93	26.74	25.59	24.47
56791	19.19	18.86	18.53	18.19	17.99	17.30	16.64	16.00	15.38	14.79	14.22	13.66	13.14	12.63
58401	**47.18**	**45.48**	**43.60**	**41.47**	39.19	37.17	35.20	33.27	31.35	29.48	27.62	25.79	23.99	22.22
70238	38.11	36.67	35.20	33.63	32.07	30.71	29.43	28.18	26.95	25.77	24.61	23.48	22.40	21.35
74638	32.32	31.12	29.93	28.64	27.44	26.34	25.31	24.35	23.39	22.55	21.74	20.97	20.26	19.59
74639	35.28	33.75	32.20	30.55	29.11	28.09	27.16	26.26	25.38	24.60	23.85	23.13	22.46	21.83
74640	37.90	36.59	35.28	33.88	32.73	31.52	30.39	29.31	28.24	27.27	26.34	25.43	24.58	23.76
81233	34.67	33.11	31.54	29.87	28.31	27.05	25.84	24.66	23.49	22.38	21.29	20.23	19.20	18.20
99218	**40.62**	39.30	37.98	36.55	35.16	33.60	32.11	30.66	29.23	27.87	26.53	25.23	23.97	22.75

Note: Values in **bold** denote exceedances of annual mean NO_2 EU limit value

4.2.1.2. Wider Impacts

The local modelling results at the subset of secondary (i.e. non-PCM) receptors indicates that the EU Limit Value has the potential to be exceeded at three of the 413 subset[2] of modelled receptors in 2021 (i.e. 0.7%). These exceedance locations are presented in Figure A-37, but are limited to:

- Little Park Street to the north east of New Union Street off of Junction 5 of the Inner Ring Road., where tall buildings are modelled to result in a substantial canyon effect; and
- two locations on Foleshill Road (junction of Foleshill Road and George Elliot Road, and the stretch of road immediately heading north from the Inner Ring Road).

4.2.2. Benchmark CAZ D Scenario

4.2.2.1. PCM Compliance

The results of the air quality modelling for the Benchmark CAZ D scenario are summarised in Table 4, which indicate that, in this scenario, compliance with the annual mean NO_2 EU limit value is projected to be achieved in 2024 for one link (Holyhead Road - Census ID 7647).

The EU Limit Value is not modelled to be exceeded in 2021 adjacent to any other PCM links.

[2] Note this is one less than reported previously, as the Corporation Street receptor is representative of a road link <100m in length and therefore does not meet the siting criteria of the Air Quality Directive.

Table 2 - Air Quality Modelling Results – Benchmark CAZ D Scenario

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
6490	36.07	34.88	33.68	32.41	29.51	28.15	26.86	25.60	24.36	23.18	22.02	20.89	19.81	18.74
6491	30.38	29.33	28.29	27.20	25.62	24.65	23.74	22.85	21.98	21.15	20.35	19.57	18.82	18.11
7103	**41.95**	**40.57**	39.16	37.67	35.15	33.54	31.99	30.45	28.94	27.43	25.95	24.49	23.05	21.65
7118	35.50	33.92	32.30	30.58	26.38	25.11	23.90	22.71	21.54	20.44	19.34	18.29	17.26	16.26
7122	31.90	30.89	29.89	28.81	25.63	24.46	23.33	22.23	21.15	20.10	19.09	18.09	17.12	16.19
7631	**46.24**	**44.58**	**42.89**	**41.06**	32.42	31.27	30.21	29.19	28.18	27.28	26.39	25.57	24.79	24.05
7647	**67.49**	**65.10**	**62.55**	**59.78**	**43.05**	**41.77**	**40.54**	39.35	38.17	37.06	35.97	34.92	33.90	32.91
16446	33.82	32.73	31.63	30.46	28.67	27.20	25.77	24.36	22.96	21.62	20.28	18.96	17.67	16.39
16467	33.59	32.64	31.69	30.66	26.27	25.17	24.14	23.15	22.17	21.27	20.39	19.55	18.74	17.98
17075	28.56	27.25	25.94	24.54	21.40	20.45	19.56	18.69	17.86	17.07	16.31	15.58	14.88	14.22
17595	38.63	37.38	36.13	34.79	28.34	27.47	26.67	25.91	25.15	24.49	23.84	23.23	22.66	22.12
18006	27.82	26.94	26.09	25.18	23.58	22.53	21.53	20.57	19.62	18.71	17.83	16.98	16.16	15.36
26497	**47.43**	**45.75**	**44.01**	**42.13**	31.66	30.52	29.45	28.41	27.41	26.48	25.57	24.72	23.91	23.14
27132	37.89	36.73	35.56	34.31	27.32	26.43	25.60	24.82	24.06	23.34	22.65	22.00	21.38	20.81
27151	27.99	26.70	25.41	24.03	21.47	20.60	19.80	19.02	18.26	17.56	16.88	16.23	15.61	15.03
27693	**41.53**	39.78	38.01	36.13	29.22	28.18	27.24	26.34	25.46	24.69	23.94	23.24	22.59	21.98
27708	31.52	30.07	28.60	27.04	23.21	22.13	21.11	20.11	19.13	18.21	17.30	16.43	15.59	14.77
36482	31.51	32.23	32.99	33.71	34.70	33.07	31.51	29.96	28.42	26.91	25.42	23.95	22.51	21.09
36504	35.15	34.49	33.84	33.14	30.64	29.23	27.89	26.57	25.27	24.04	22.83	21.65	20.50	19.39
37169	**40.97**	39.29	37.60	35.78	30.27	29.05	27.91	26.79	25.69	24.64	23.60	22.61	21.66	20.73
37731	**44.68**	**43.94**	**43.21**	**42.41**	33.99	33.00	32.11	31.24	30.38	29.63	28.90	28.20	27.55	26.93

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
37748	**45.89**	**43.94**	**41.95**	39.85	31.52	30.57	29.70	28.87	28.05	27.33	26.64	25.98	25.36	24.78
38796	36.20	34.93	33.67	32.32	31.04	29.60	28.24	26.91	25.60	24.35	23.12	21.93	20.78	19.67
47156	40.20	38.87	37.52	36.08	28.70	27.96	27.30	26.67	26.07	25.56	25.08	24.63	24.23	23.87
47690	**43.08**	**41.42**	39.74	37.92	29.86	28.82	27.85	26.91	25.99	25.15	24.32	23.54	22.80	22.08
56791	19.09	18.77	18.48	18.15	17.42	16.72	16.06	15.41	14.79	14.20	13.61	13.05	12.51	11.98
58401	**47.07**	**45.38**	**43.52**	**41.41**	30.58	29.28	28.05	26.85	25.67	24.56	23.46	22.41	21.39	20.41
70238	38.13	36.67	35.20	33.62	27.89	26.83	25.85	24.90	23.97	23.08	22.21	21.38	20.59	19.84
74638	32.32	31.16	30.01	28.76	24.82	23.93	23.15	22.40	21.68	21.06	20.47	19.93	19.43	18.99
74639	35.27	33.72	32.14	30.45	26.04	25.27	24.59	23.95	23.32	22.80	22.31	21.84	21.42	21.05
74640	37.90	36.56	35.21	33.78	28.38	27.53	26.77	26.04	25.33	24.72	24.13	23.57	23.07	22.60
81233	34.57	33.03	31.48	29.82	28.73	27.33	25.99	24.67	23.36	22.10	20.85	19.65	18.46	17.30
99218	**40.65**	39.31	37.96	36.52	30.68	29.44	28.27	27.15	26.04	24.98	23.96	22.98	22.03	21.13

Note: Values in **bold** denote exceedances of annual mean NO_2 EU limit value

These results have not been updated to reflect the traffic model changes detailed in Section 1.2.2, and have therefore been adjusted using the model adjustment factors derived in June 2019. The values presented from 2017 to 2020 inclusive are therefore slightly different to those presented in Table 1 and Table 4 as a result.

4.2.2.2. Secondary Receptors

The local modelling of the secondary receptor subset indicates that none of the 413 modelled receptors are modelled to be in exceedance of the EU limit value in 2021. The impacts of the benchmark CAZ D at modelled receptors have been described in accordance with guidance published by Environmental Protection UK (EPUK) and the Institute of Air Quality Management (IAQM)[3], as shown in Figure A-38 and summarised in Table 3.

Table 3 - Summary of Impacts at Modelled Receptors in 2021 for Benchmark CAZ D

Impact	PCM Receptors	Secondary Receptors	Total
Substantial decrease	6	9	15
Moderate decrease	9	109	118
Slight decrease	10	112	122
Negligible	10	180	190
Slight increase	0	3	3
Moderate increase	0	0	0
Substantial increase	0	0	0
Total	35	413	448

The results in Table 3 indicate that the benchmark CAZ D has the potential to result in slight increases in annual mean NO_2 concentrations at three of the secondary receptors considered. These receptors are all located adjacent to the B4110 which runs parallel to the south eastern boundary of the CAZ, which shows this is a displacement route for vehicles. Significant benefits are modelled within the CAZ boundary, particularly within the A4053 Inner Ring Road and on Foleshill Road. Overall, the impact of the benchmark CAZ D at secondary receptors is generally positive or negligible.

No significant increases are modelled at PCM locations with the majority modelled to experience a decrease in concentration.

4.2.3. DS13L Scenario

4.2.3.1. PCM Compliance

The results of the air quality modelling for the DS13L scenario are summarised in Table 4, which indicate that, in this scenario, compliance with the annual mean NO_2 EU limit value is projected to be achieved in 2021 for all PCM links.

[3] Environmental Protection UK and Institute of Air Quality Management, 'Land-Use Planning & Development Control: Planning for Air Quality', January 2017.

Table 4 - Air Quality Modelling Results – DS13L Scenario

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
6490	36.06	34.88	33.69	32.42	30.48	29.07	27.73	26.42	25.12	23.89	22.69	21.53	20.39	19.29
6491	30.42	29.38	28.33	27.23	25.81	24.84	23.94	23.08	22.23	21.42	20.62	19.87	19.15	18.46
7103	**41.97**	**40.59**	39.20	37.72	35.24	33.66	32.15	30.66	29.19	27.73	26.28	24.87	23.50	22.15
7118	35.51	33.92	32.31	30.58	27.32	26.00	24.74	23.50	22.30	21.14	20.01	18.91	17.84	16.81
7122	31.99	30.96	29.94	28.84	27.04	25.77	24.55	23.35	22.19	21.06	19.95	18.88	17.83	16.82
7631	**46.21**	**44.47**	**42.69**	**40.78**	37.70	36.03	34.47	32.94	31.44	30.04	28.67	27.35	26.07	24.84
7647	**67.44**	**65.02**	**62.44**	**59.62**	40.03	38.29	36.61	34.97	33.35	31.80	30.28	28.80	27.36	25.95
16446	33.92	32.81	31.69	30.51	28.64	27.21	25.83	24.48	23.13	21.83	20.55	19.31	18.08	16.87
16467	33.58	32.64	31.69	30.67	28.65	27.33	26.08	24.88	23.70	22.58	21.50	20.44	19.44	18.47
17075	28.56	27.26	25.94	24.55	22.28	21.26	20.32	19.41	18.51	17.67	16.86	16.08	15.33	14.62
17595	38.75	37.40	36.04	34.60	31.43	30.21	29.05	27.94	26.84	25.83	24.84	23.90	23.00	22.13
18006	27.88	26.99	26.12	25.19	23.87	22.83	21.84	20.89	19.95	19.06	18.19	17.35	16.55	15.77
26497	**47.54**	**45.84**	**44.11**	**42.22**	39.26	37.41	35.65	33.91	32.20	30.57	28.95	27.38	25.84	24.35
27132	37.84	36.68	35.54	34.30	32.37	30.99	29.69	28.43	27.18	25.98	24.81	23.69	22.60	21.56
27151	28.29	26.92	25.54	24.07	22.03	21.13	20.29	19.49	18.71	17.98	17.28	16.61	15.97	15.37
27693	**41.54**	39.76	37.94	36.00	34.26	32.82	31.47	30.16	28.88	27.70	26.56	25.45	24.41	23.40
27708	31.56	30.10	28.63	27.07	24.07	22.90	21.78	20.69	19.63	18.63	17.63	16.67	15.74	14.84
36482	31.57	32.27	33.02	33.73	33.99	32.48	31.03	29.61	28.20	26.83	25.47	24.14	22.85	21.58
36504	35.15	34.49	33.84	33.14	31.51	30.05	28.66	27.30	25.96	24.69	23.44	22.23	21.05	19.90
37169	**40.96**	39.30	37.62	35.81	32.77	31.36	30.02	28.72	27.44	26.20	24.99	23.82	22.68	21.58
37731	**44.19**	**43.39**	**42.60**	**41.74**	40.24	38.62	37.09	35.59	34.10	32.71	31.35	30.02	28.74	27.49

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
37748	**45.79**	**43.93**	**42.03**	40.02	37.45	35.95	34.54	33.16	31.79	30.52	29.29	28.08	26.92	25.80
38796	36.23	34.96	33.70	32.35	30.88	29.52	28.23	26.98	25.76	24.58	23.43	22.32	21.25	20.22
47156	40.41	39.04	37.66	36.17	33.42	32.22	31.11	30.04	28.99	28.04	27.11	26.22	25.38	24.58
47690	**43.10**	**41.39**	39.63	37.74	34.03	32.66	31.35	30.07	28.81	27.63	26.48	25.36	24.28	23.23
56791	19.19	18.86	18.53	18.19	17.66	16.97	16.31	15.67	15.05	14.47	13.89	13.33	12.80	12.30
58401	**47.18**	**45.48**	**43.60**	**41.47**	36.61	34.23	31.91	29.62	27.33	25.09	22.85	20.63	18.43	16.25
70238	38.11	36.67	35.20	33.63	30.93	29.62	28.39	27.19	26.01	24.87	23.76	22.68	21.65	20.65
74638	32.32	31.12	29.93	28.64	26.90	25.82	24.83	23.89	22.96	22.15	21.36	20.62	19.94	19.31
74639	35.28	33.75	32.20	30.55	28.35	27.38	26.50	25.66	24.82	24.10	23.40	22.74	22.14	21.56
74640	37.90	36.59	35.28	33.88	32.34	31.13	30.02	28.93	27.87	26.90	25.96	25.06	24.20	23.38
81233	34.67	33.11	31.54	29.87	27.83	26.56	25.36	24.18	23.02	21.90	20.81	19.74	18.71	17.70
99218	**40.62**	39.30	37.98	36.55	34.46	32.90	31.42	29.97	28.54	27.17	25.82	24.51	23.24	22.00

Note: Values in **bold** denote exceedances of annual mean NO_2 EU limit value

4.2.3.2. Wider Impacts

The local modelling of the secondary receptor subset in the DS13L scenario shows none of the 413 modelled receptors are modelled to be in exceedance of the EU limit value in 2021. This is an improvement relative to the Do-Minimum scenario of three exceedances. Potential impacts have been described in accordance with IAQM impact descriptors and presented in Figure A-39 and Table 5. The key area in which measures are proposed around Spon End is shown in more detail in Figure A-40.

Table 5 - Impact Summary at Modelled Receptors for DS13L in 2021

Impact	PCM Receptors	Secondary Receptors	Total
Substantial decrease	1	2	3
Moderate decrease	5	28	33
Slight decrease	12	86	98
Negligible	17	289	306
Slight increase	0	6	6
Moderate increase	0	2	2
Substantial increase	0	0	0
Total	35	413	448

These results show the impact of the DS13L scenario is generally beneficial at the majority of the modelled secondary receptors. Beneficial impacts are modelled to occur at a number of receptors within the Inner Ring Road, around Holyhead Road and Foleshill Road, and more widely across Coventry (primarily as a result of upgrades to the local bus and taxi fleets). However, there are modelled to be eight receptors with an increase in the DS13L scenario, which are limited to:

- slight increases adjacent to the A46, Barker's Butts Lane, Spon End (three receptors) and St. Nicholas Street.; and
- moderate increases located on Spon End and Coundon Road.

These increases are mainly associated with the diversion of traffic associated with the Holyhead Road and Cash's Lane interventions, which suggests the spatial distribution of adverse impacts is relatively small. In addition, whilst these receptors are modelled to experience an increase in concentrations, the absolute annual mean concentrations at these receptors in this scenario are between 30.3 µg/m^3 and 38.7 µg/m^3 (the modelled increases range between 0.6 µg/m^3 and 2.2 µg/m^3). The greatest increase occurs at the receptor with the lowest absolute concentration (Coundon Road with a modelled increase of 2.2 µg/m^3 and a resulting absolute concentration of 30.3 µg/m^3).

No significant increases are modelled at PCM locations with the majority modelled to experience a decrease in concentration.

Relative to the benchmark CAZ D scenario there is a reduction in the number of beneficial impacts and an increase in the number of negligible impacts. However, given the nature and scale of the two interventions, this would be expected.

4.2.4. DS14 – Benchmark CAZ (plus additional measures)

4.2.4.1. PCM Compliance

The results of the air quality modelling for the DS14 scenario are summarised in Table 6, which indicate that, in this scenario, compliance with the annual mean NO_2 EU limit value is projected to be achieved in 2021 for all PCM links.

Table 6 - Air Quality Modelling Results – DS14 Scenario

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
6490	36.07	34.88	33.68	32.41	29.73	28.34	27.03	25.75	24.47	23.27	22.08	20.94	19.82	18.73
6491	30.38	29.33	28.29	27.20	25.89	24.88	23.95	23.04	22.14	21.29	20.45	19.65	18.89	18.14
7103	**41.95**	**40.57**	39.16	37.67	35.39	33.75	32.18	30.63	29.08	27.56	26.05	24.57	23.12	21.69
7118	35.50	33.92	32.30	30.58	26.67	25.37	24.12	22.91	21.72	20.58	19.45	18.36	17.30	16.28
7122	31.90	30.89	29.89	28.81	25.76	24.57	23.42	22.31	21.20	20.14	19.10	18.09	17.11	16.15
7631	**46.24**	**44.58**	**42.89**	**41.06**	33.01	31.81	30.72	29.65	28.61	27.66	26.75	25.89	25.07	24.28
7647	**67.49**	**65.10**	**62.55**	**59.78**	36.75	35.50	34.30	33.14	32.00	30.93	29.89	28.87	27.90	26.95
16446	33.82	32.73	31.63	30.46	28.83	27.34	25.90	24.47	23.06	21.69	20.33	18.99	17.68	16.38
16467	33.59	32.64	31.69	30.66	26.44	25.31	24.26	23.25	22.25	21.33	20.43	19.57	18.74	17.96
17075	28.56	27.25	25.94	24.54	21.56	20.59	19.69	18.81	17.95	17.15	16.38	15.63	14.92	14.24
17595	38.63	37.38	36.13	34.79	27.80	26.95	26.18	25.44	24.72	24.08	23.47	22.89	22.35	21.85
18006	27.82	26.94	26.09	25.18	23.76	22.68	21.68	20.69	19.73	18.80	17.90	17.03	16.20	15.38
26497	**47.43**	**45.75**	**44.01**	**42.13**	32.06	30.87	29.77	28.72	27.67	26.72	25.79	24.89	24.05	23.25
27132	37.89	36.73	35.56	34.31	27.63	26.70	25.85	25.02	24.22	23.47	22.74	22.05	21.41	20.79
27151	27.99	26.70	25.41	24.03	21.79	20.87	20.03	19.21	18.42	17.68	16.96	16.27	15.62	14.99
27693	**41.53**	39.78	38.01	36.13	29.63	28.58	27.61	26.70	25.80	25.00	24.23	23.51	22.84	22.22
27708	31.52	30.07	28.60	27.04	23.24	22.15	21.13	20.13	19.15	18.22	17.31	16.43	15.59	14.77
36482	31.51	32.23	32.99	33.71	34.81	33.17	31.60	30.05	28.50	26.98	25.48	24.01	22.56	21.13
36504	35.15	34.49	33.84	33.14	30.86	29.43	28.06	26.72	25.40	24.14	22.91	21.71	20.54	19.40
37169	**40.97**	39.29	37.60	35.78	30.57	29.32	28.15	27.01	25.89	24.81	23.75	22.73	21.75	20.80
37731	**44.68**	**43.94**	**43.21**	**42.41**	34.13	33.11	32.19	31.30	30.42	29.64	28.88	28.17	27.49	26.85

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
37748	**45.89**	**43.94**	**41.95**	39.85	31.59	30.64	29.76	28.92	28.10	27.37	26.67	26.00	25.38	24.79
38796	36.20	34.93	33.67	32.32	31.17	29.73	28.36	27.03	25.72	24.47	23.23	22.04	20.88	19.77
47156	40.20	38.87	37.52	36.08	29.16	28.35	27.64	26.96	26.30	25.75	25.21	24.71	24.25	23.84
47690	**43.08**	**41.42**	39.74	37.92	29.81	28.87	28.00	27.16	26.32	25.57	24.85	24.17	23.52	22.91
56791	19.09	18.77	18.48	18.15	17.53	16.82	16.15	15.50	14.86	14.25	13.66	13.09	12.54	12.02
58401	**47.07**	**45.38**	**43.52**	**41.41**	30.91	29.12	27.40	25.68	23.99	22.34	20.70	19.09	17.51	15.95
70238	38.13	36.67	35.20	33.62	28.13	27.04	26.05	25.08	24.12	23.22	22.33	21.48	20.67	19.90
74638	32.32	31.16	30.01	28.76	24.97	24.08	23.28	22.53	21.79	21.16	20.56	20.01	19.51	19.06
74639	35.27	33.72	32.14	30.45	26.16	25.38	24.70	24.05	23.42	22.88	22.39	21.92	21.49	21.11
74640	37.90	36.56	35.21	33.78	28.60	27.72	26.95	26.20	25.48	24.85	24.24	23.69	23.17	22.68
81233	34.57	33.03	31.48	29.82	28.96	27.54	26.18	24.84	23.52	22.24	20.98	19.74	18.53	17.35
99218	**40.65**	39.31	37.96	36.52	30.84	29.59	28.42	27.29	26.16	25.11	24.08	23.09	22.13	21.22

Note: Values in **bold** denote exceedances of annual mean NO_2 EU limit value

These results have not been updated to reflect the traffic model changes detailed in Section 1.2.2, and have therefore been adjusted using the model adjustment factors derived in June 2019. The values presented from 2017 to 2020 inclusive are therefore slightly different to those presented in Table 1 and Table 4 as a result.

4.2.4.2. Wider Impacts

The local modelling of the secondary receptor subset indicates that none of the 413 modelled receptors are modelled to be in exceedance of the EU limit value in 2021. The impacts of the CAZ D (plus additional measures) at modelled receptors have been described in accordance with guidance published by Environmental Protection UK (EPUK) and the Institute of Air Quality Management (IAQM), as shown in Figure A-41 and summarised in Table 7.

Table 7 - Summary of Impacts at Modelled Receptors in 2021 for CAZ D (plus additional measures)

Impact	PCM Receptors	Secondary Receptors	Total
Substantial decrease	6	9	15
Moderate decrease	9	100	109
Slight decrease	10	105	115
Negligible	10	193	203
Slight increase	0	6	6
Moderate increase	0	0	0
Substantial increase	0	0	0
Total	35	413	448

The results in Table 7 indicate that the benchmark CAZ D (plus additional measures) has the potential to result in increases in annual mean NO_2 concentrations at six of the secondary receptor subset. These receptors are located adjacent to:

- the B4110 running parallel to the south eastern boundary of the CAZ (as per the benchmark CAZ D);
- the A46 (two receptors) at the junction with Brandon Road and Rugby Road located to the south east of Coventry; and
- B4118 (Holbrook Way) at the northern point of the CAZ boundary.

Significant benefits are modelled to occur within the CAZ boundary, particularly within the A4053 Inner Ring Road and radial routes (including Spon End). Overall, the impact of the CAZ D (plus additional measures) at secondary receptors is generally positive or negligible. However, when compared to the benchmark CAZ D, there are slightly fewer beneficial impacts and slightly more negative impacts.

4.2.5. Conclusions

4.2.5.1. PCM Compliance

- In the Do Minimum scenario, the annual mean NO_2 EU limit value is modelled to be exceeded adjacent to two road links in 2021, with compliance not projected to be achieved until 2028 adjacent to one of these links (Holyhead Road);
- In the benchmark CAZ D scenario, the annual mean NO_2 EU limit value is modelled to be exceeded adjacent to one link in 2021 (Holyhead Road), with compliance not projected to be achieved adjacent to this link until 2024;
- In the DS13L scenario, compliance with the annual mean NO_2 EU limit value is modelled to be achieved adjacent to all road links in 2021; and
- In the benchmark CAZ (plus additional measures) DS14 scenario, compliance with the annual mean NO_2 EU limit value is modelled to be achieved adjacent to all road links in 2021.

4.2.5.2. Wider Impacts

- A subset of worst case secondary receptors has been modelled;
- The annual mean NO_2 EU limit value in 2021 is modelled to be exceeded at three secondary receptor locations in the Do-Minimum scenario;

- In the benchmark CAZ D scenario, the annual mean NO_2 EU limit value in 2021 is not modelled to be exceeded at any secondary receptor location. Beneficial impacts are modelled to occur at 230 secondary receptors and adverse impacts at three secondary receptors.
- In the DS13L scenario, the annual mean NO_2 EU limit value in 2021 is not modelled to be exceeded at any secondary receptor location, representing an improvement relative to the Do Minimum scenario. Beneficial impacts are modelled to occur at 116 secondary receptors and adverse impacts at eight modelled secondary receptors.
- In the benchmark CAZ (plus additional measures) scenario, the annual mean NO_2 EU limit value in 2021 is not modelled to be exceeded at any secondary receptor location. Beneficial impacts are modelled to occur at 214 secondary receptors and adverse impacts at six modelled secondary receptors.

4.2.5.3. Overall summary

- Both the Benchmark CAZ D (plus additional measures) and option DS13L are modelled to achieve compliance with the annual mean NO_2 EU Limit Value in 2021 (i.e. the 'shortest possible time').

Appendices

Appendix A. Figures

Figure A-1 – Local Air Quality Monitoring Sites

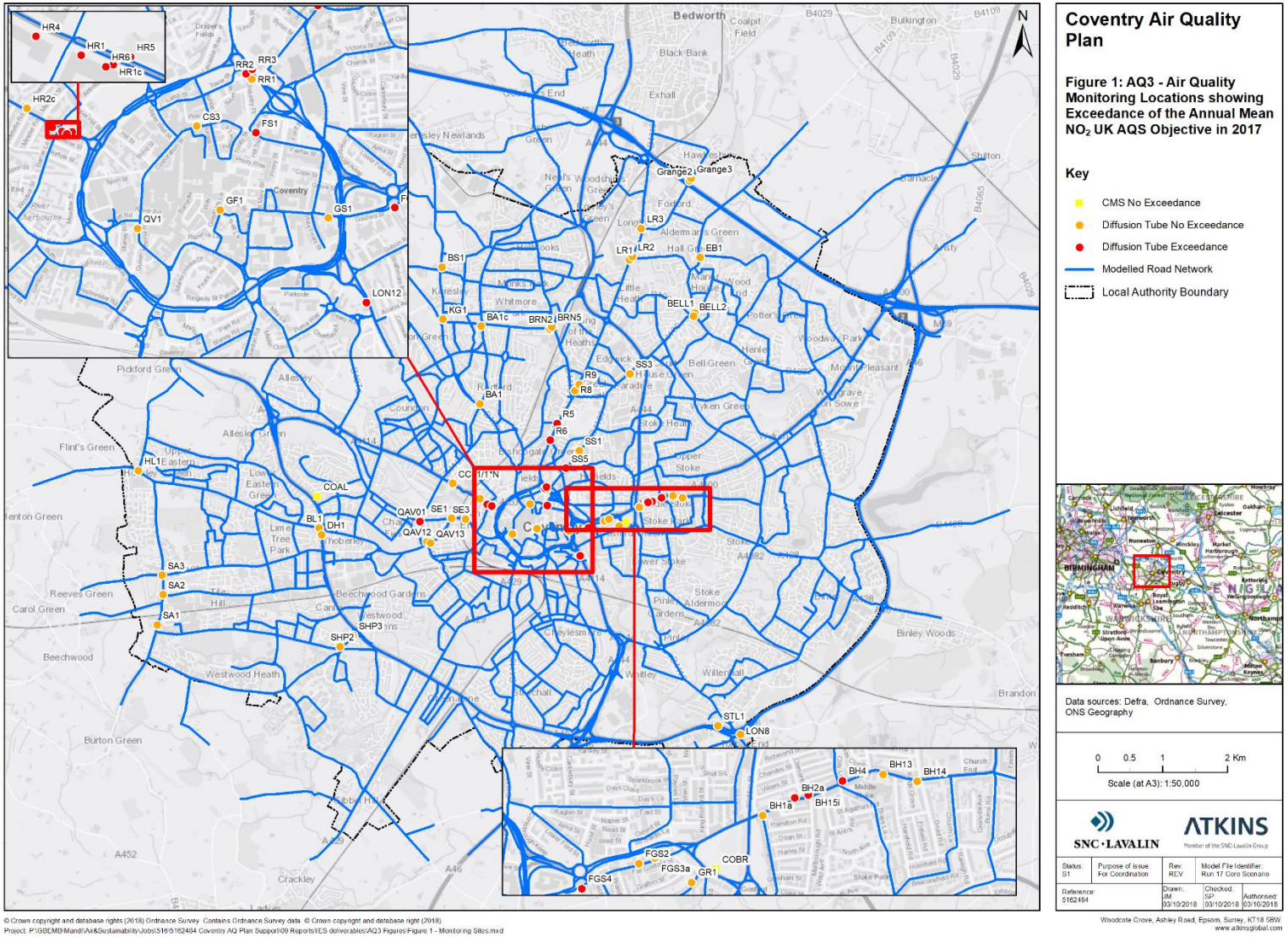


Figure A-2 – Modelled Receptor Adjacent to PCM Link with Census ID 6490

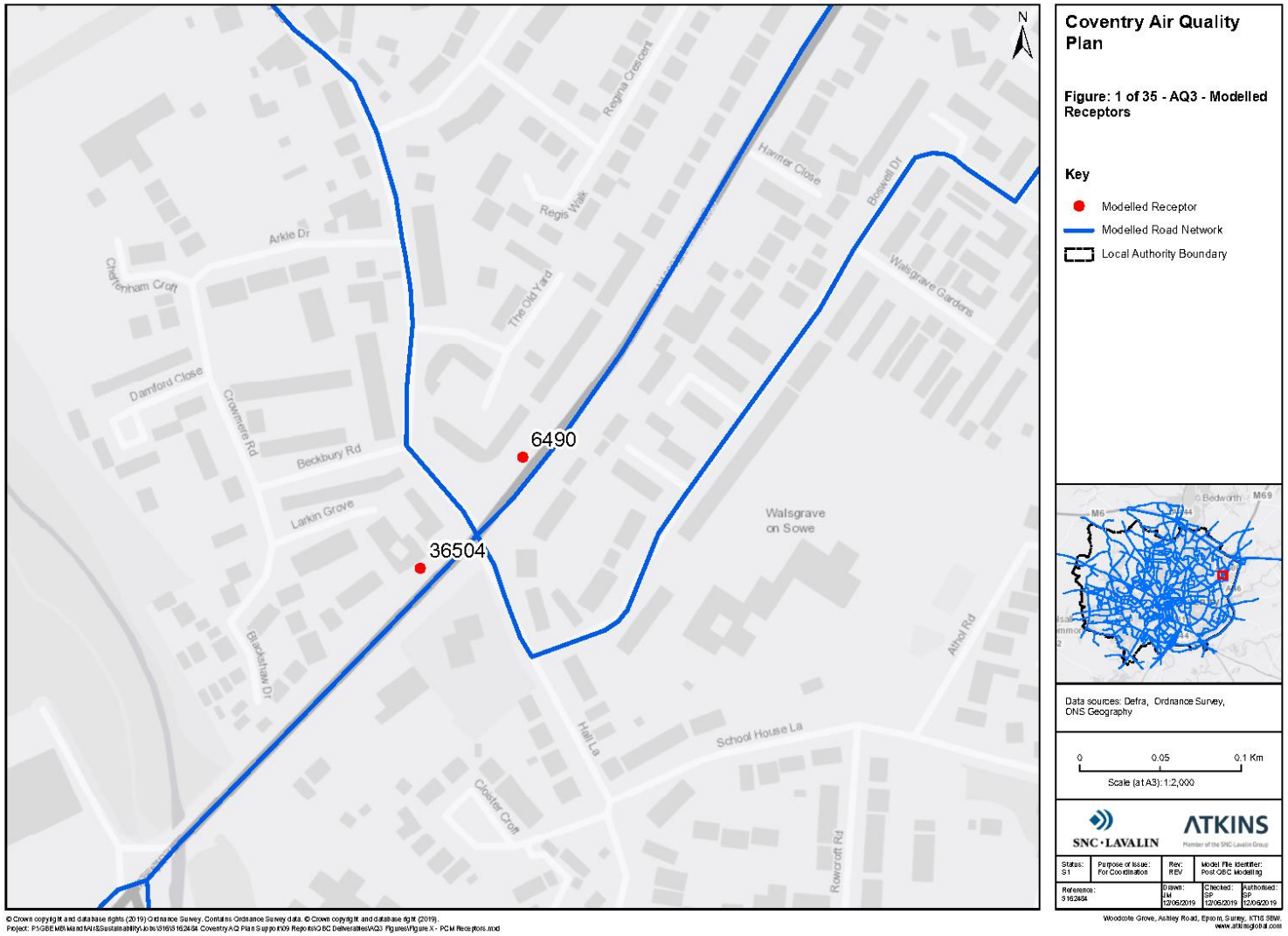


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Figure A-3 – Modelled Receptor Adjacent to PCM Link with Census ID 6491

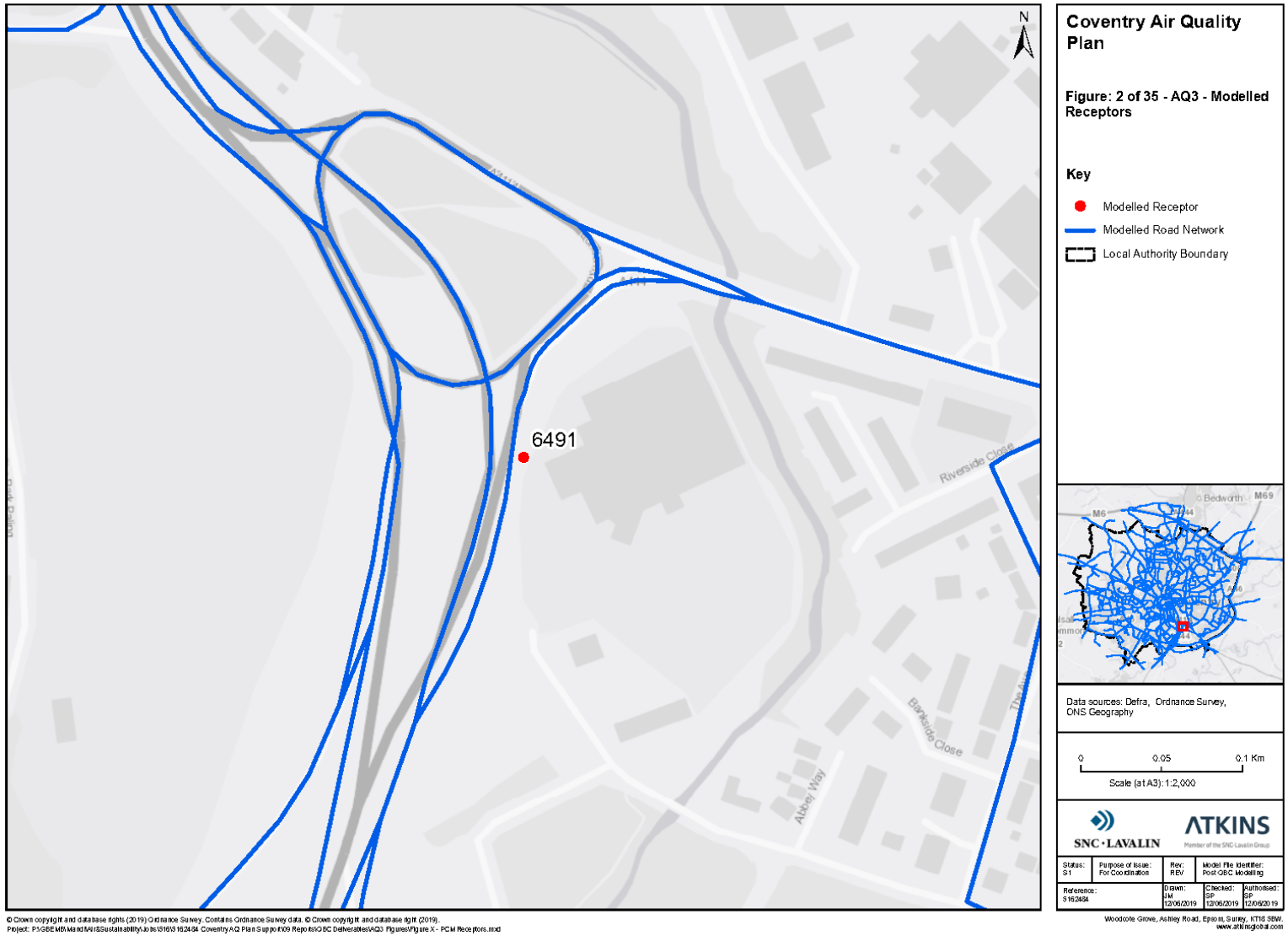

Figure A-4 – Modelled Receptor Adjacent to PCM Link with Census ID 7103

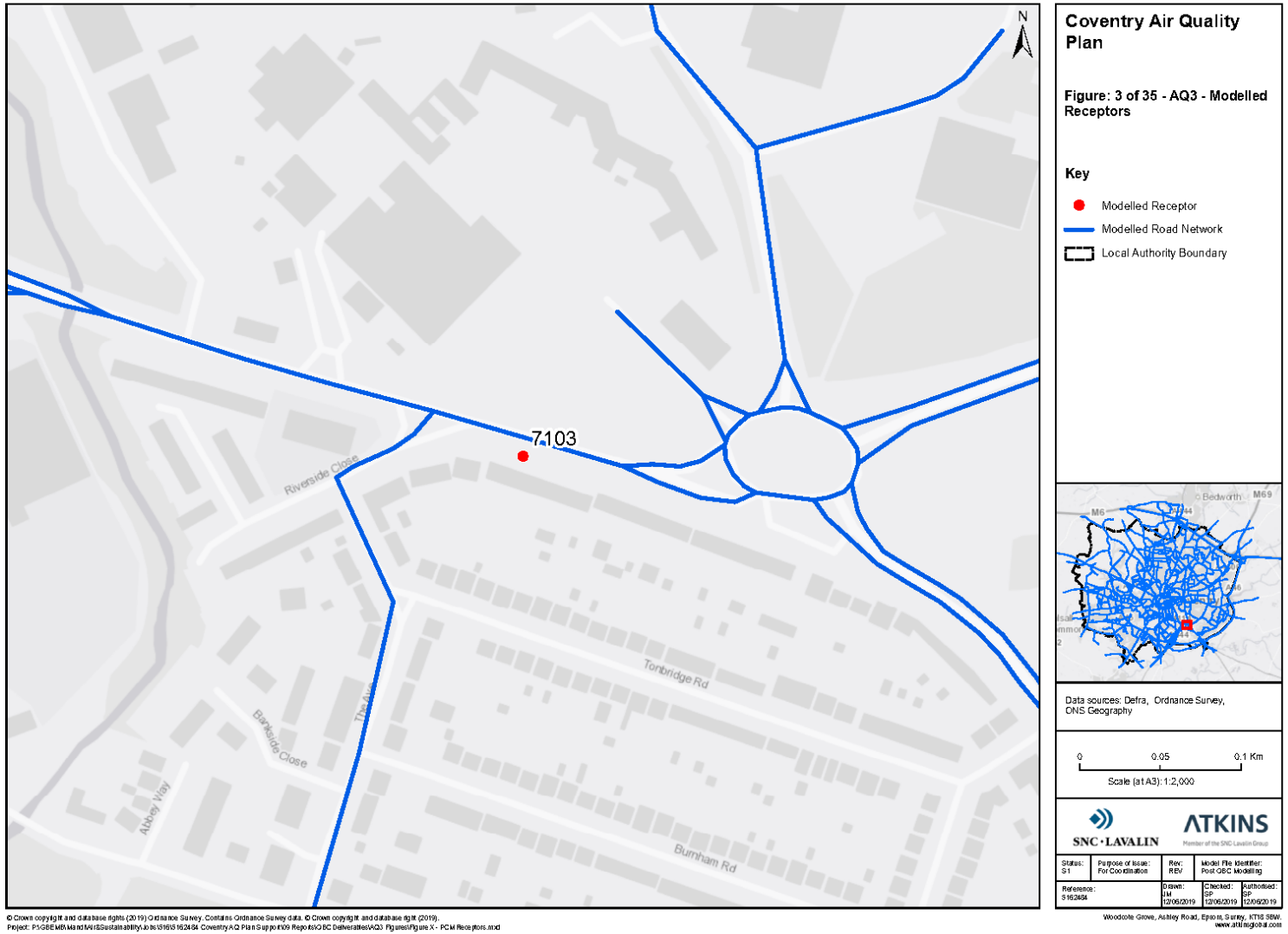

Figure A-5 – Modelled Receptor Adjacent to PCM Link with Census ID 7118

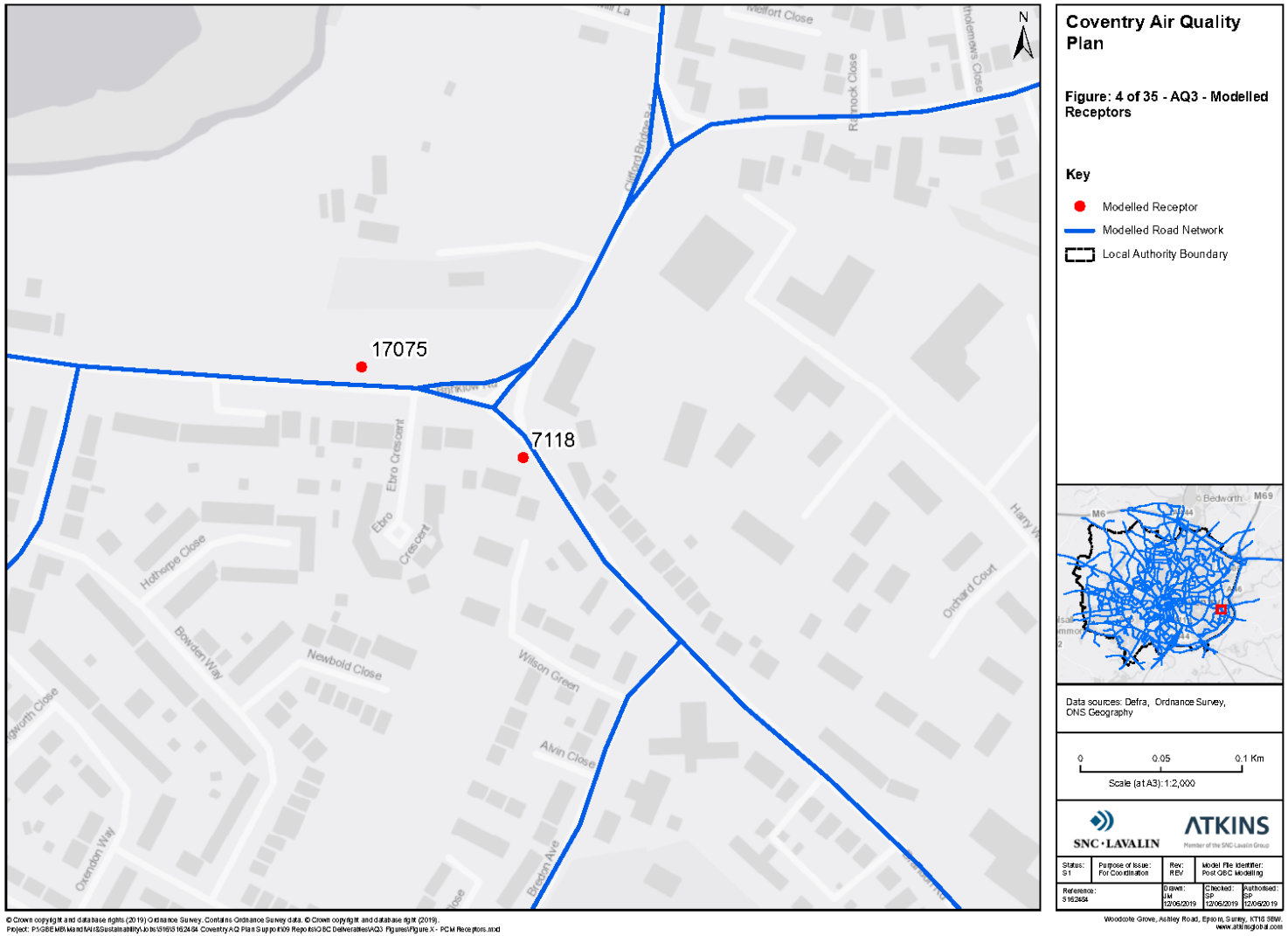

Figure A-6 – Modelled Receptor Adjacent to PCM Link with Census ID 7122

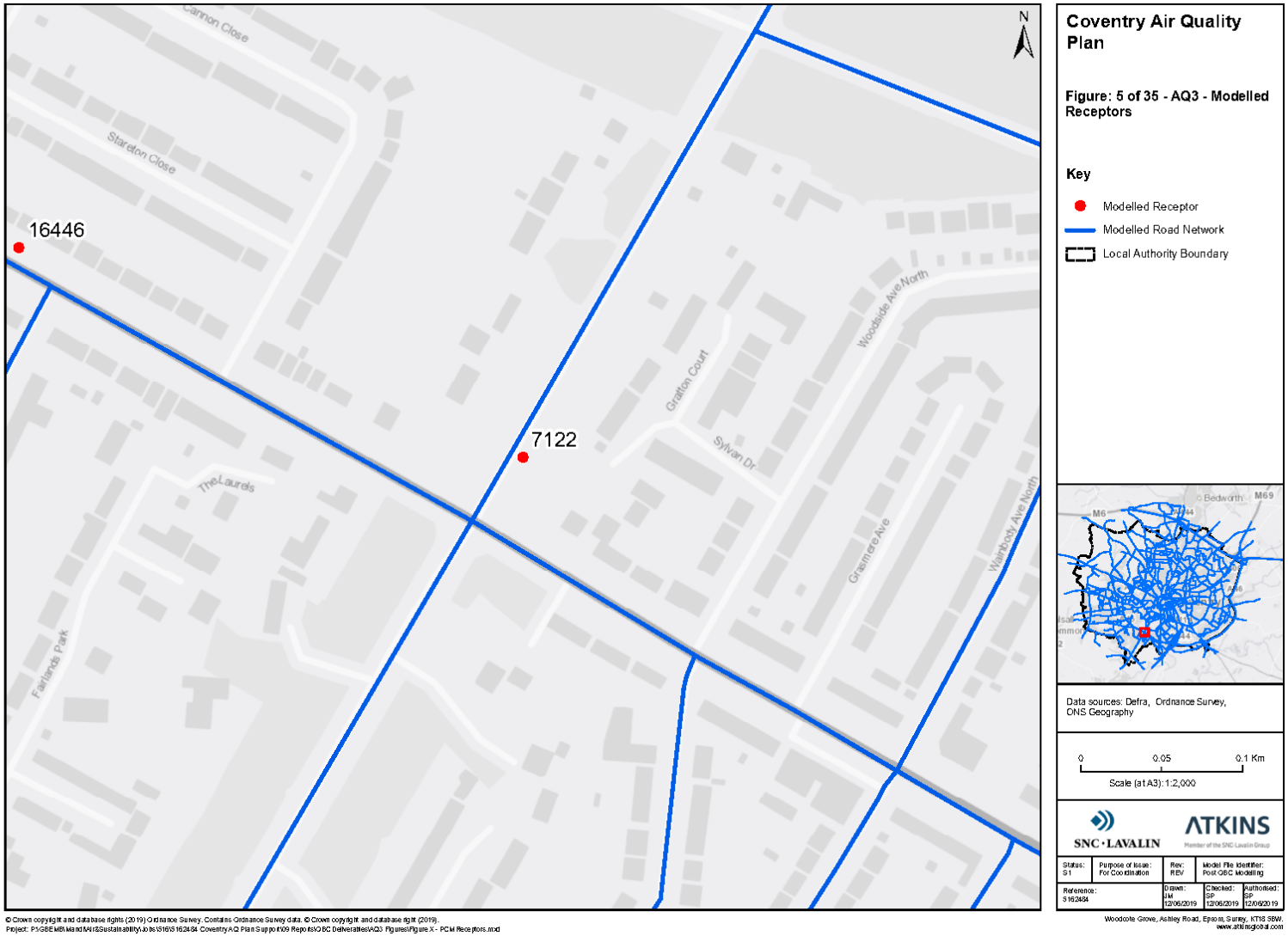

Figure A-7 – Modelled Receptor Adjacent to PCM Link with Census ID 7631

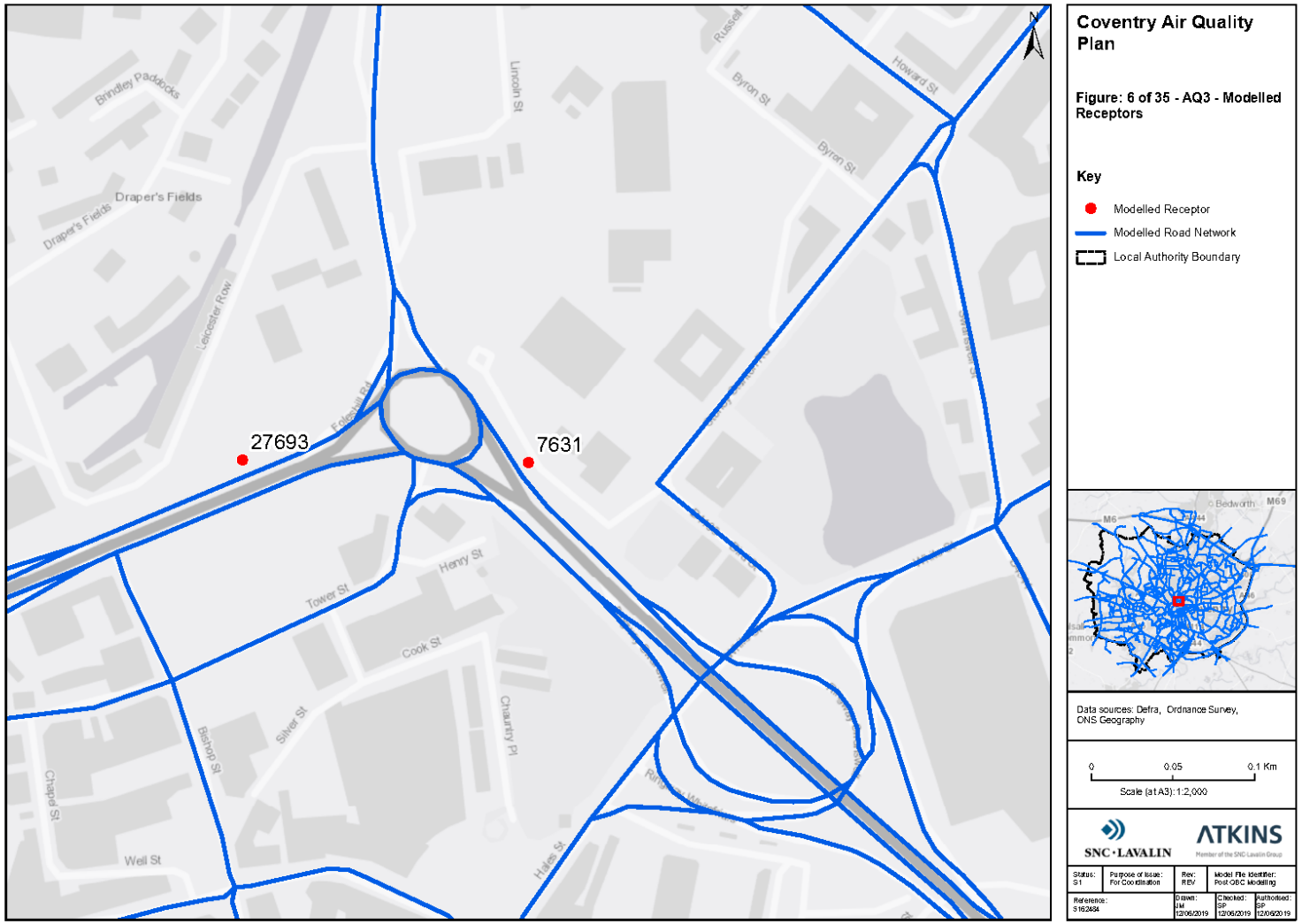

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Figure A-8 – Modelled Receptor Adjacent to PCM Link with Census ID 7647

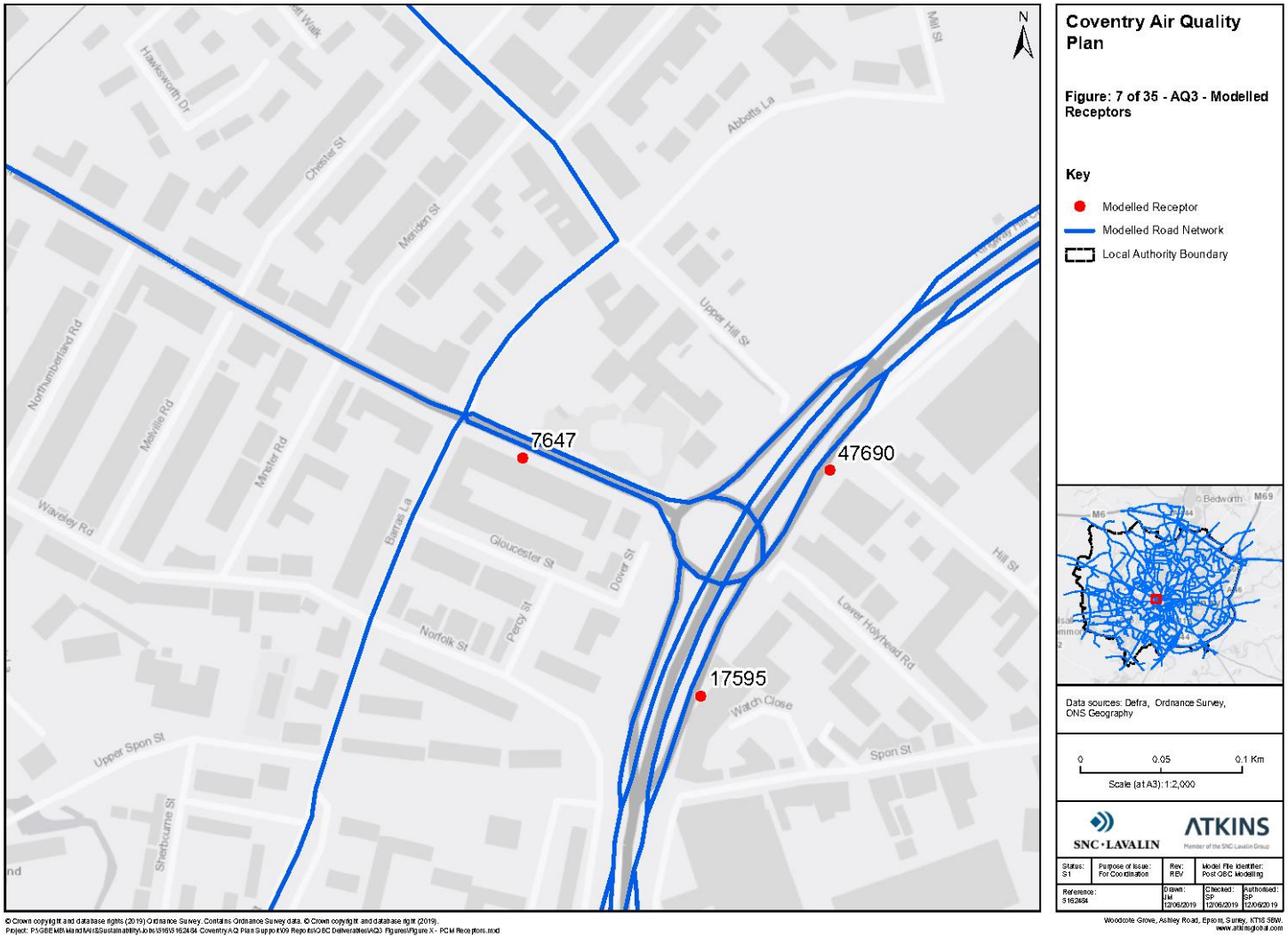
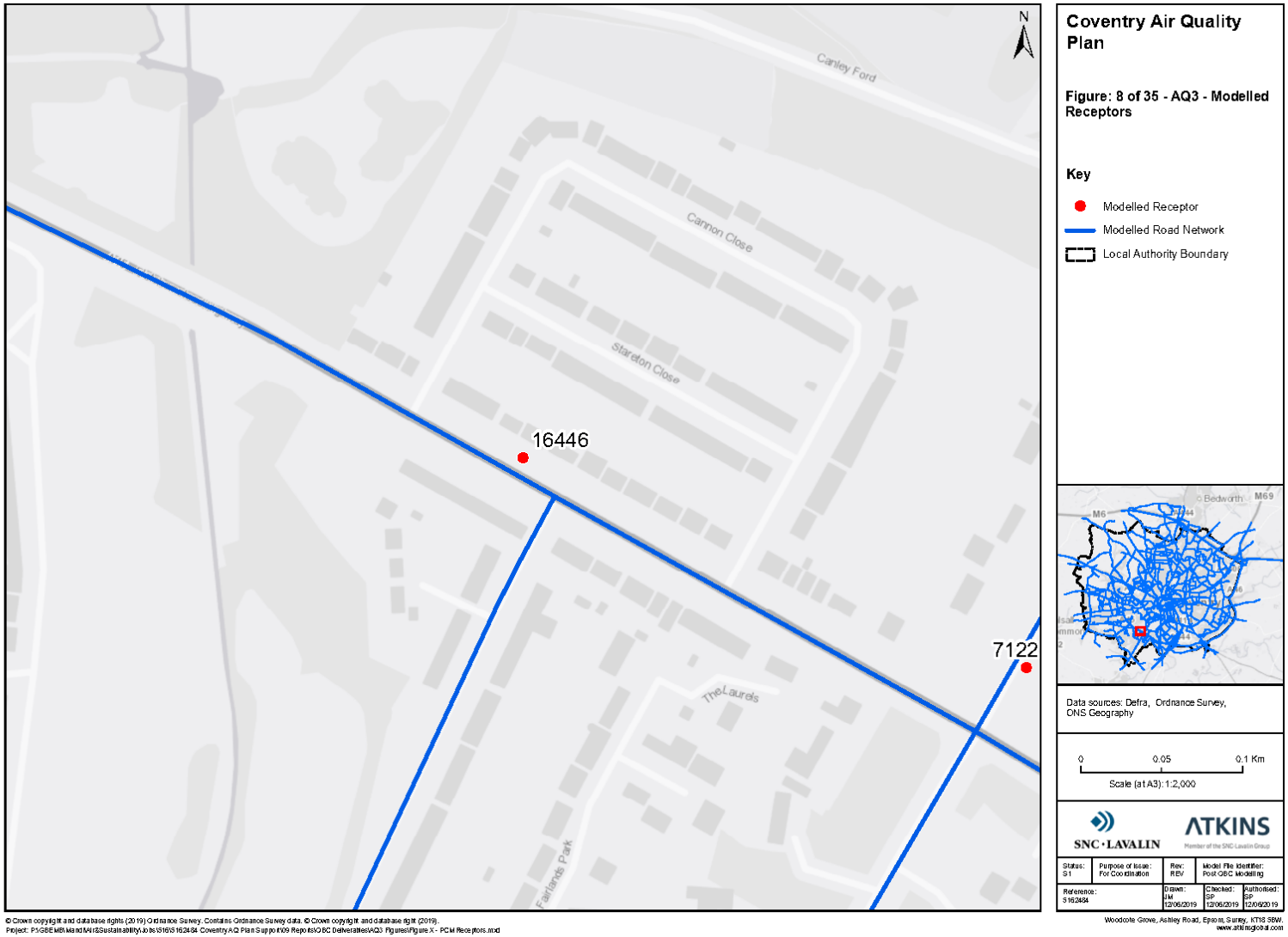


Figure A-9 – Modelled Receptor Adjacent to PCM Link with Census ID 16446



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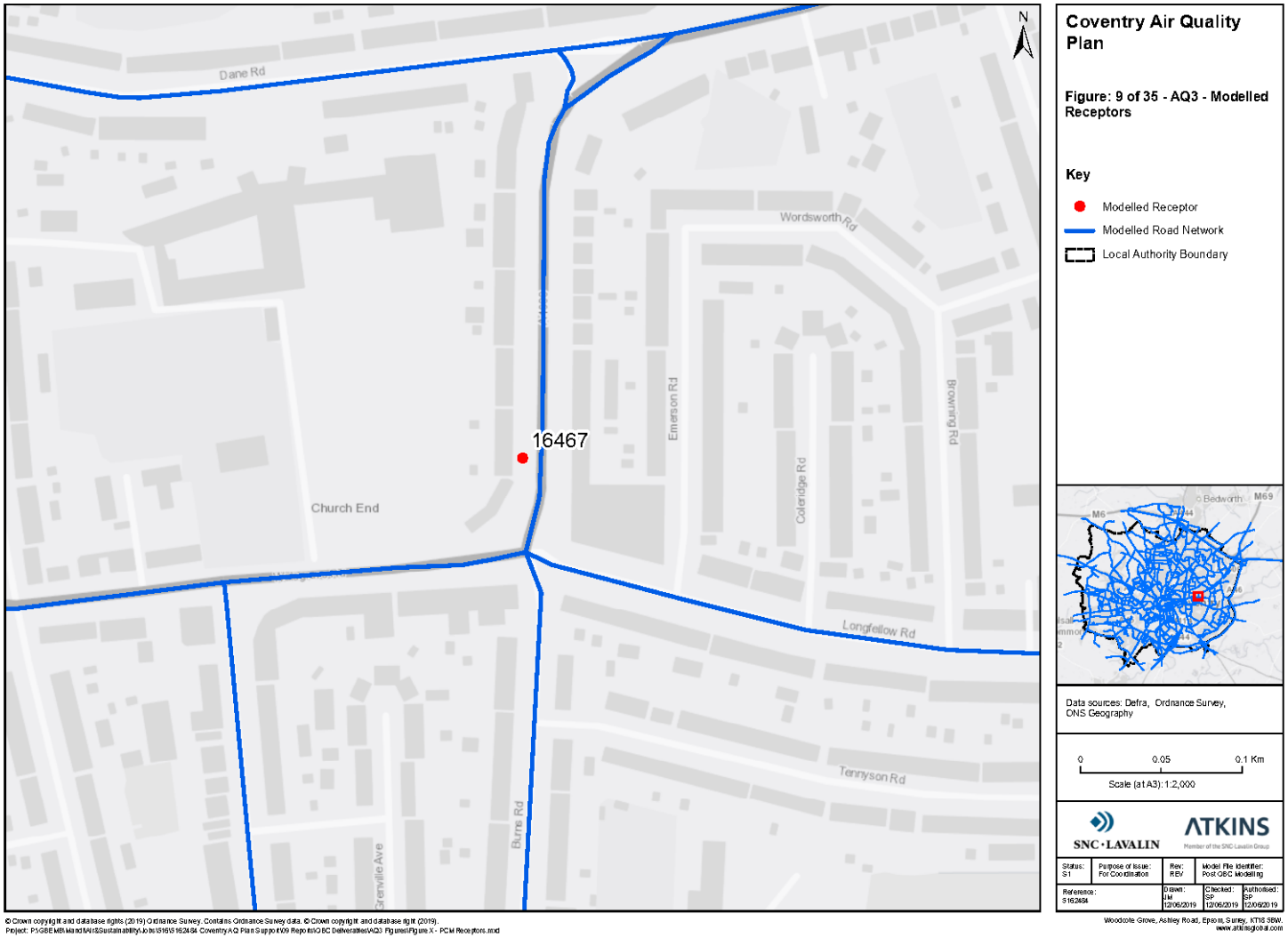
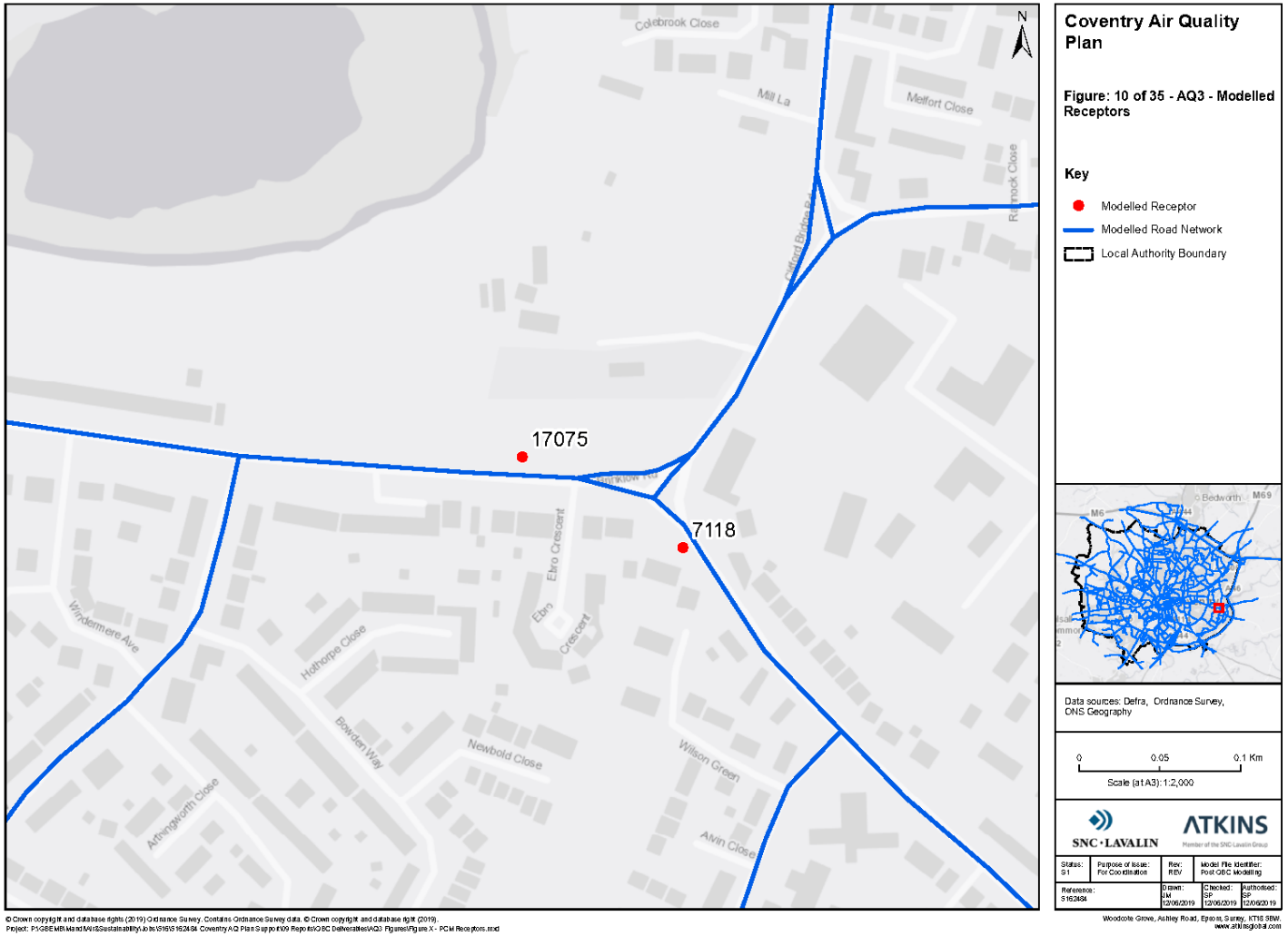


Figure A-11 – Modelled Receptor Adjacent to PCM Link with Census ID 17075



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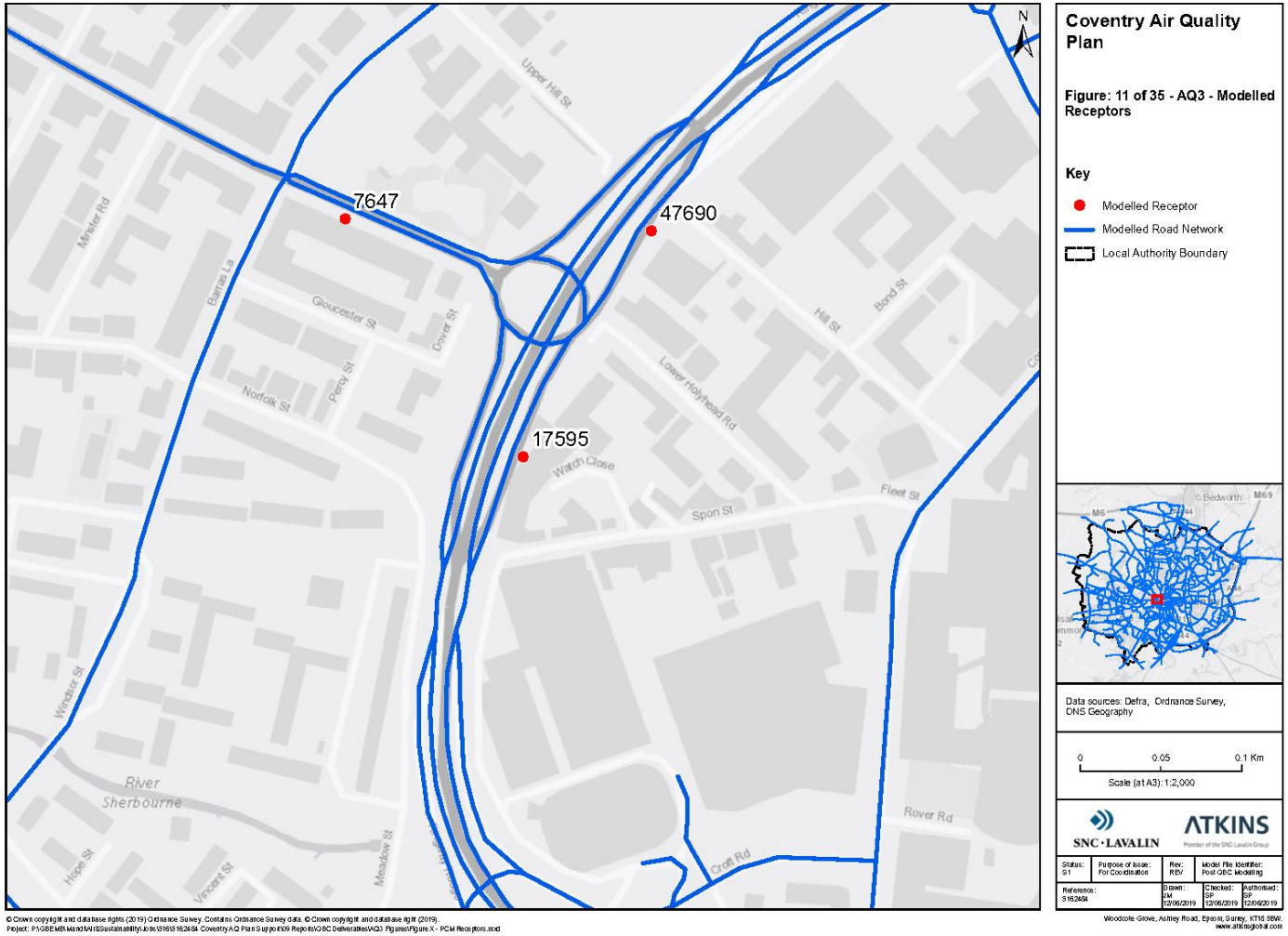

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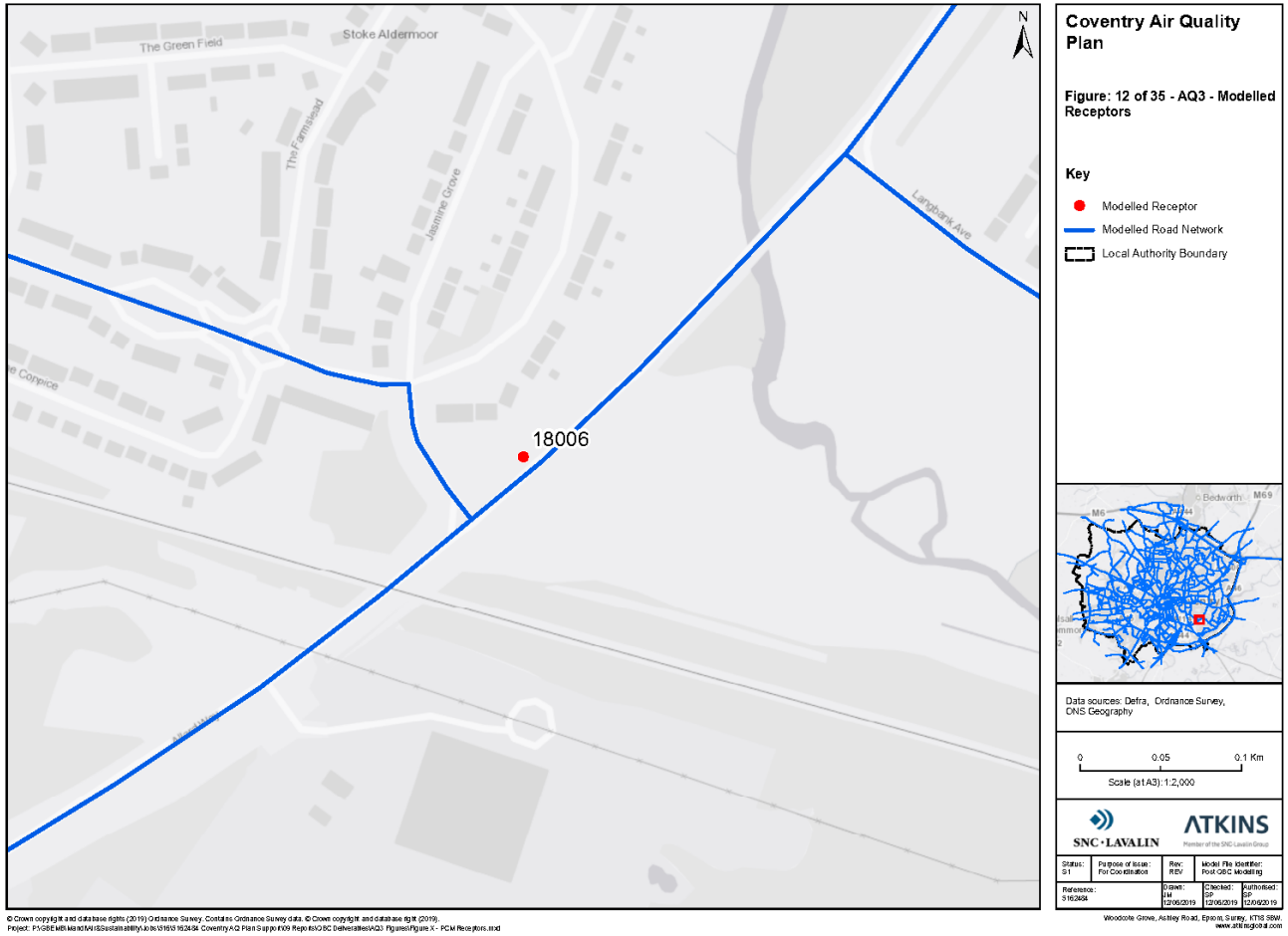

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Figure A-14 – Modelled Receptor Adjacent to PCM Link with Census ID 26497

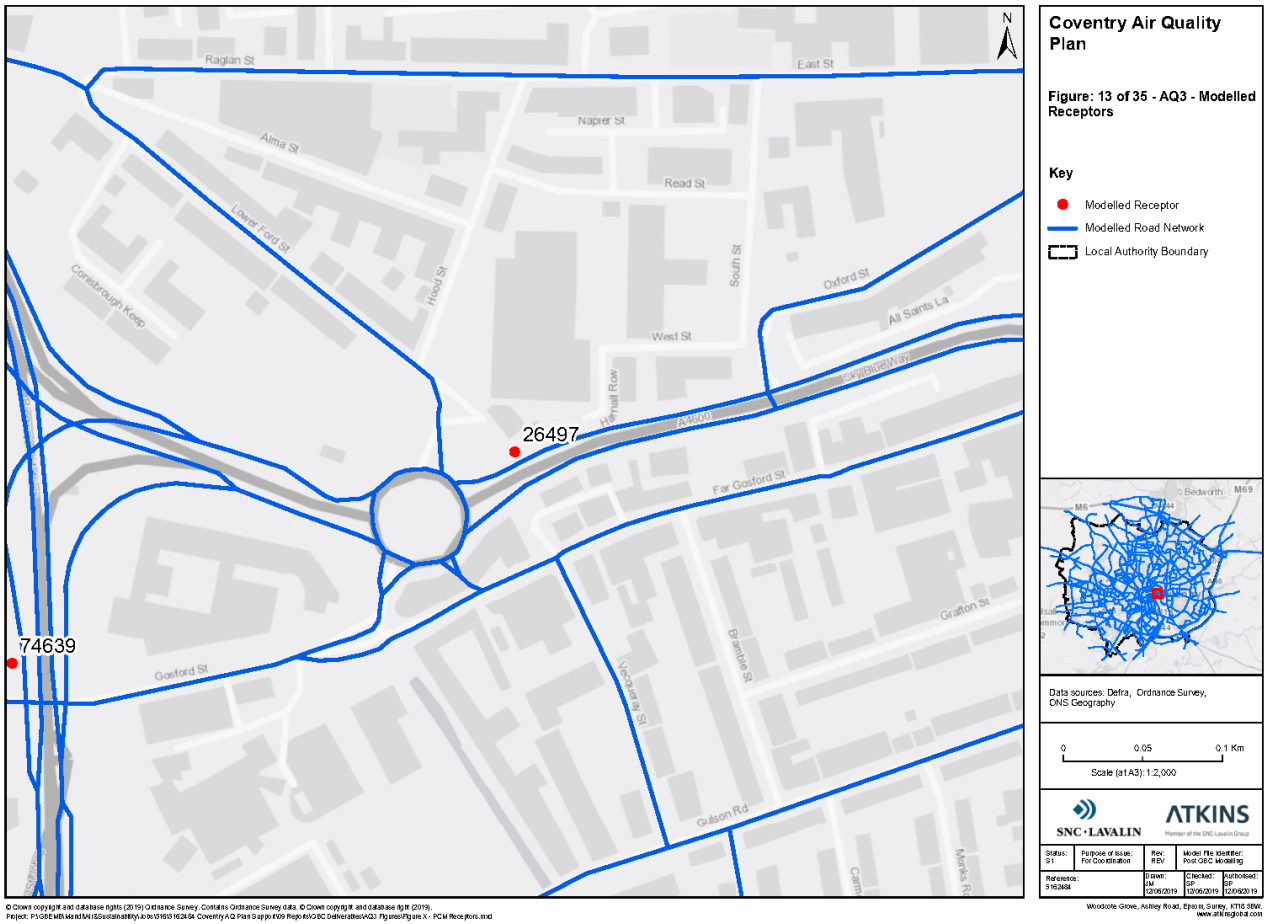

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Figure A-15 – Modelled Receptor Adjacent to PCM Link with Census ID 27132

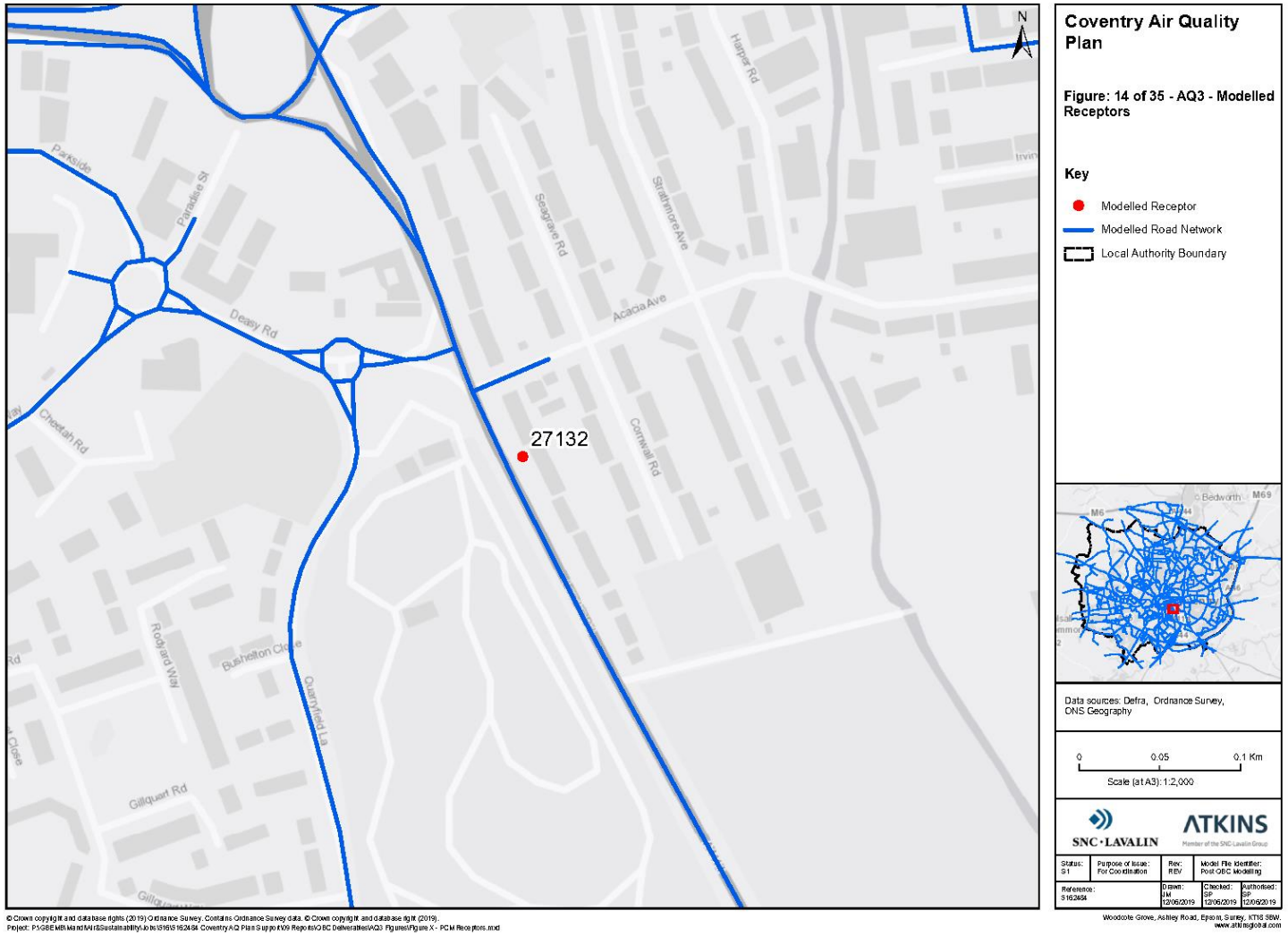

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Figure A-16 – Modelled Receptor Adjacent to PCM Link with Census ID 27151

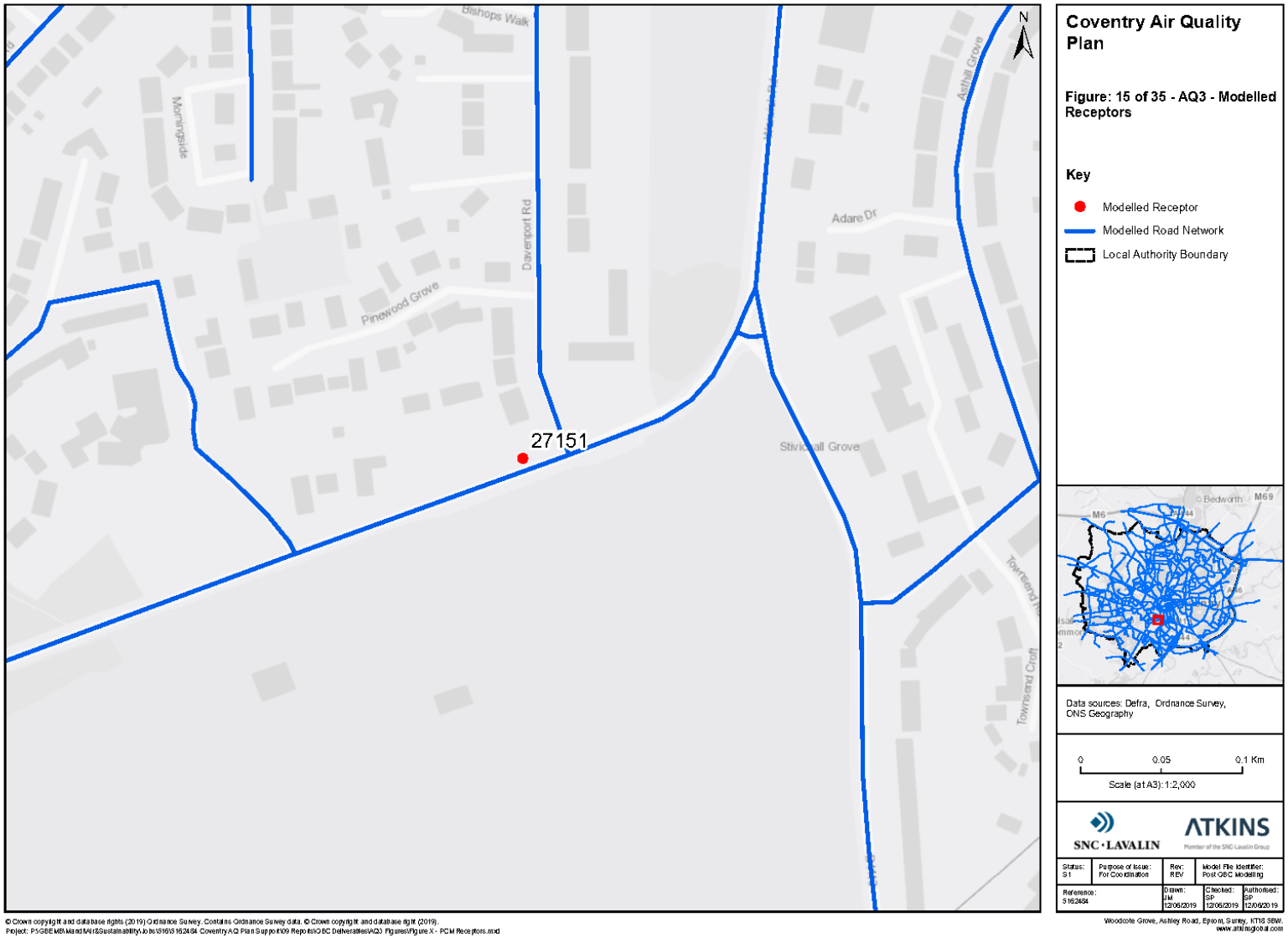

Figure A-17 – Modelled Receptor Adjacent to PCM Link with Census ID 27693

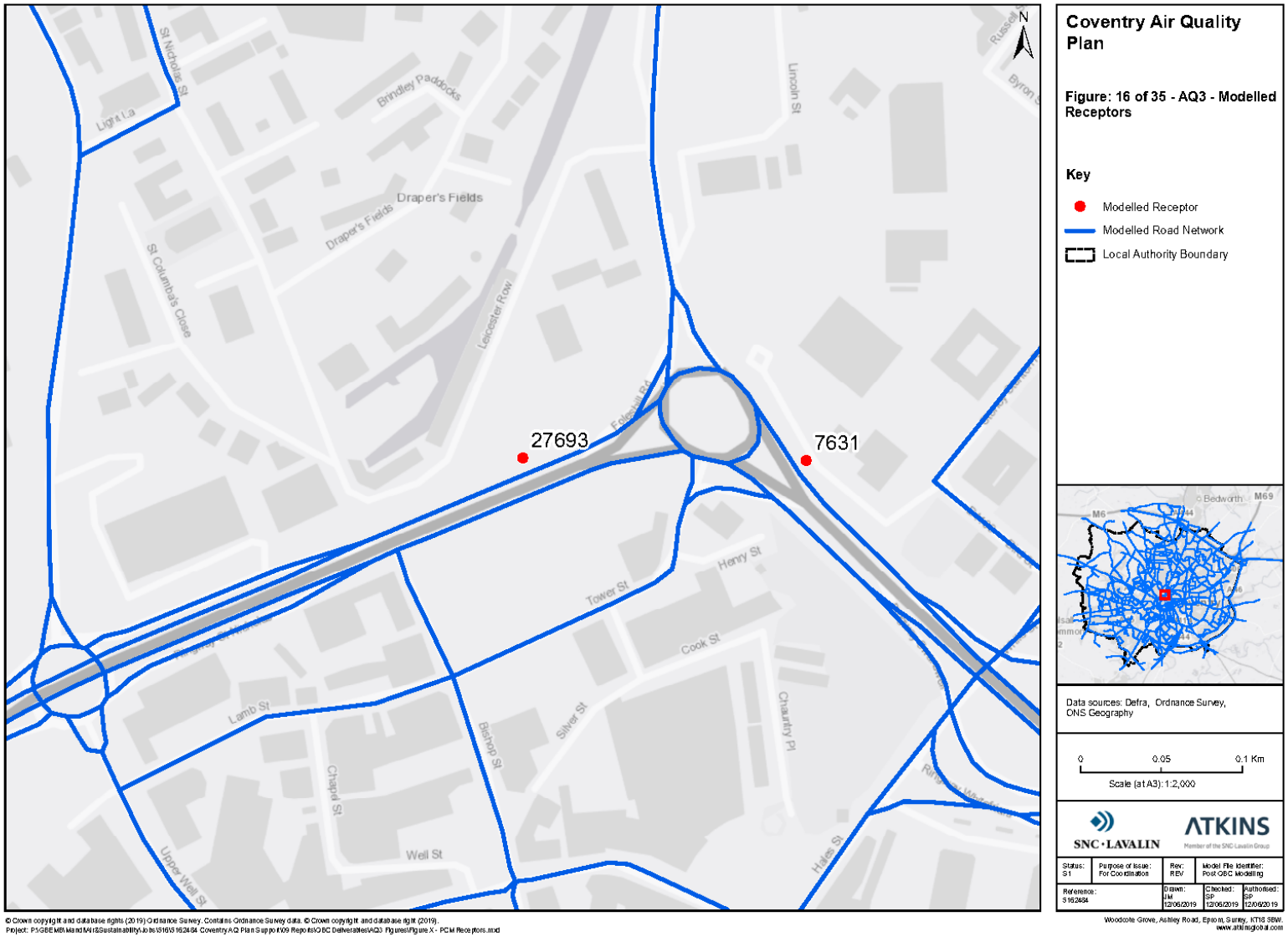

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Figure A-18 – Modelled Receptor Adjacent to PCM Link with Census ID 27708

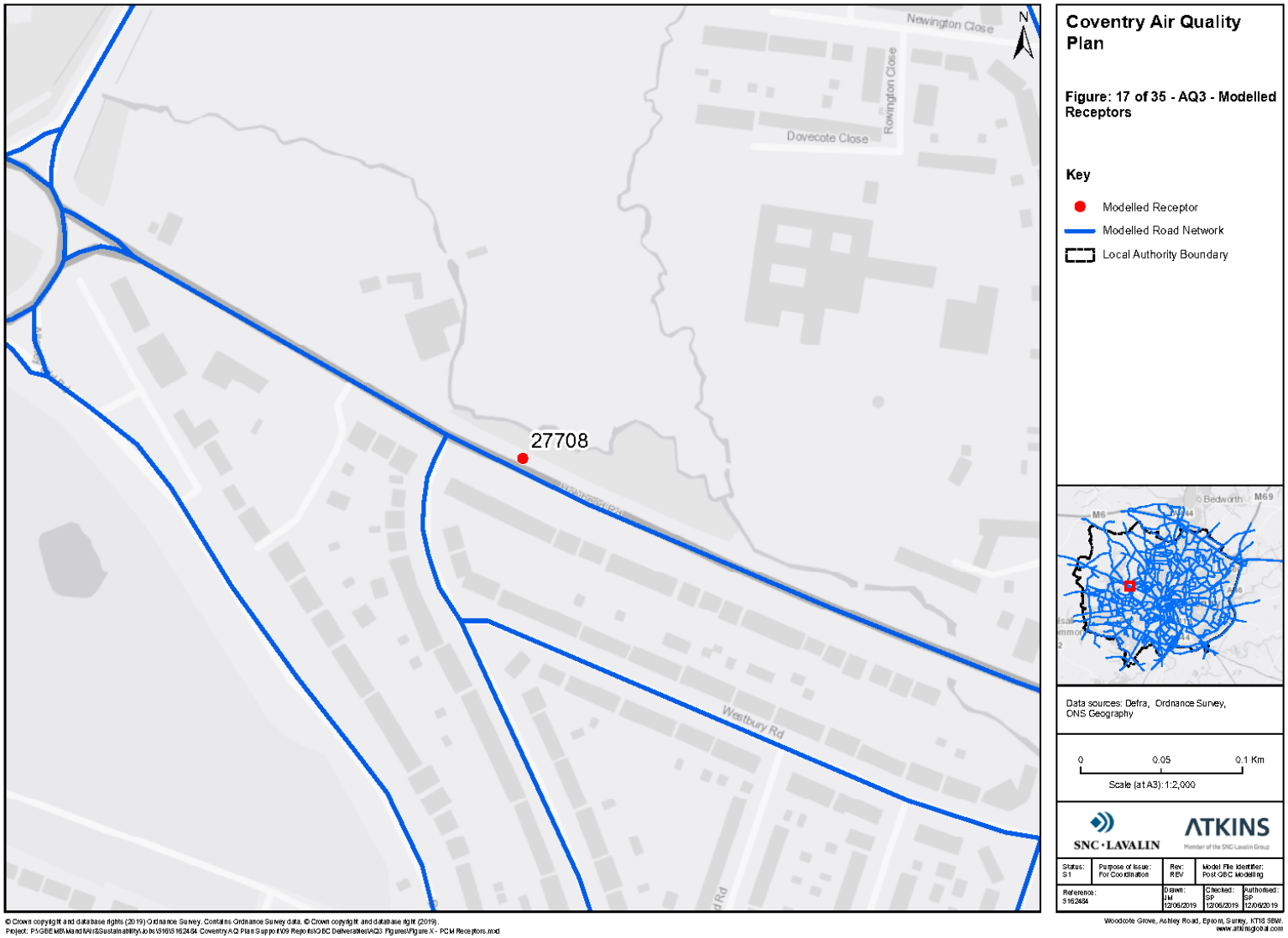

Figure A-19 – Modelled Receptor Adjacent to PCM Link with Census ID 36482

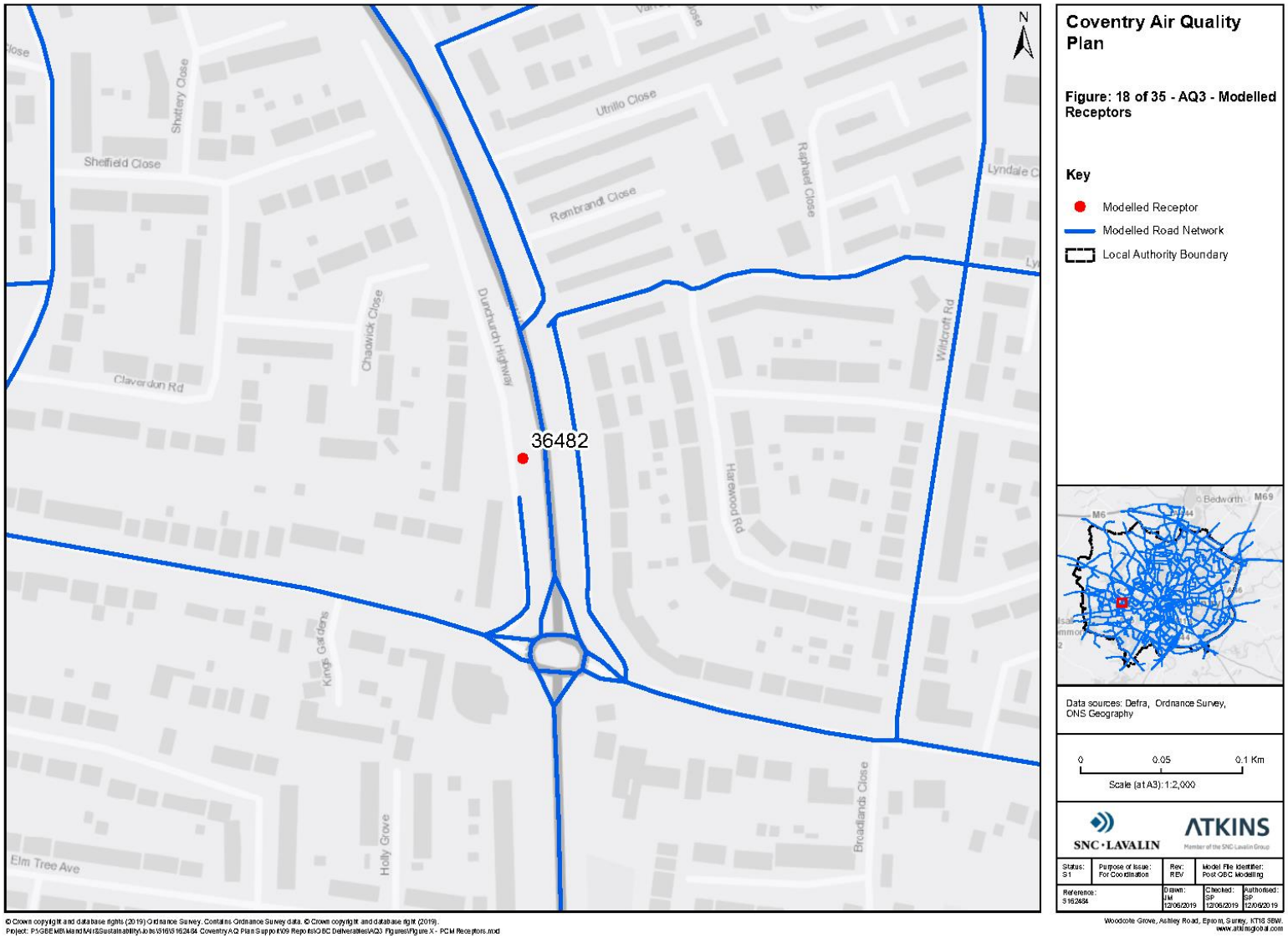

Figure A-20 – Modelled Receptor Adjacent to PCM Link with Census ID 36504

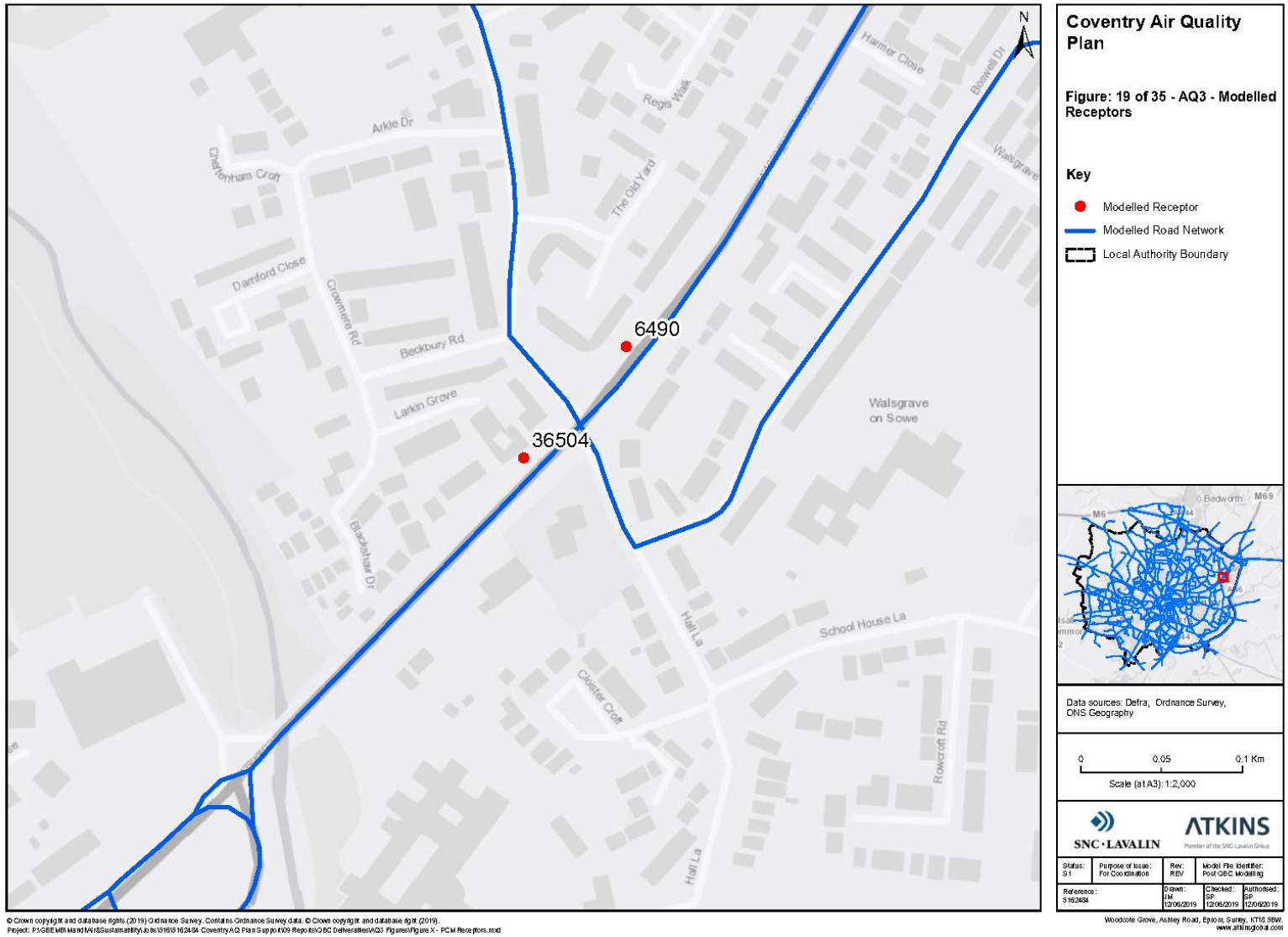

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Figure A-21 – Modelled Receptor Adjacent to PCM Link with Census ID 37169

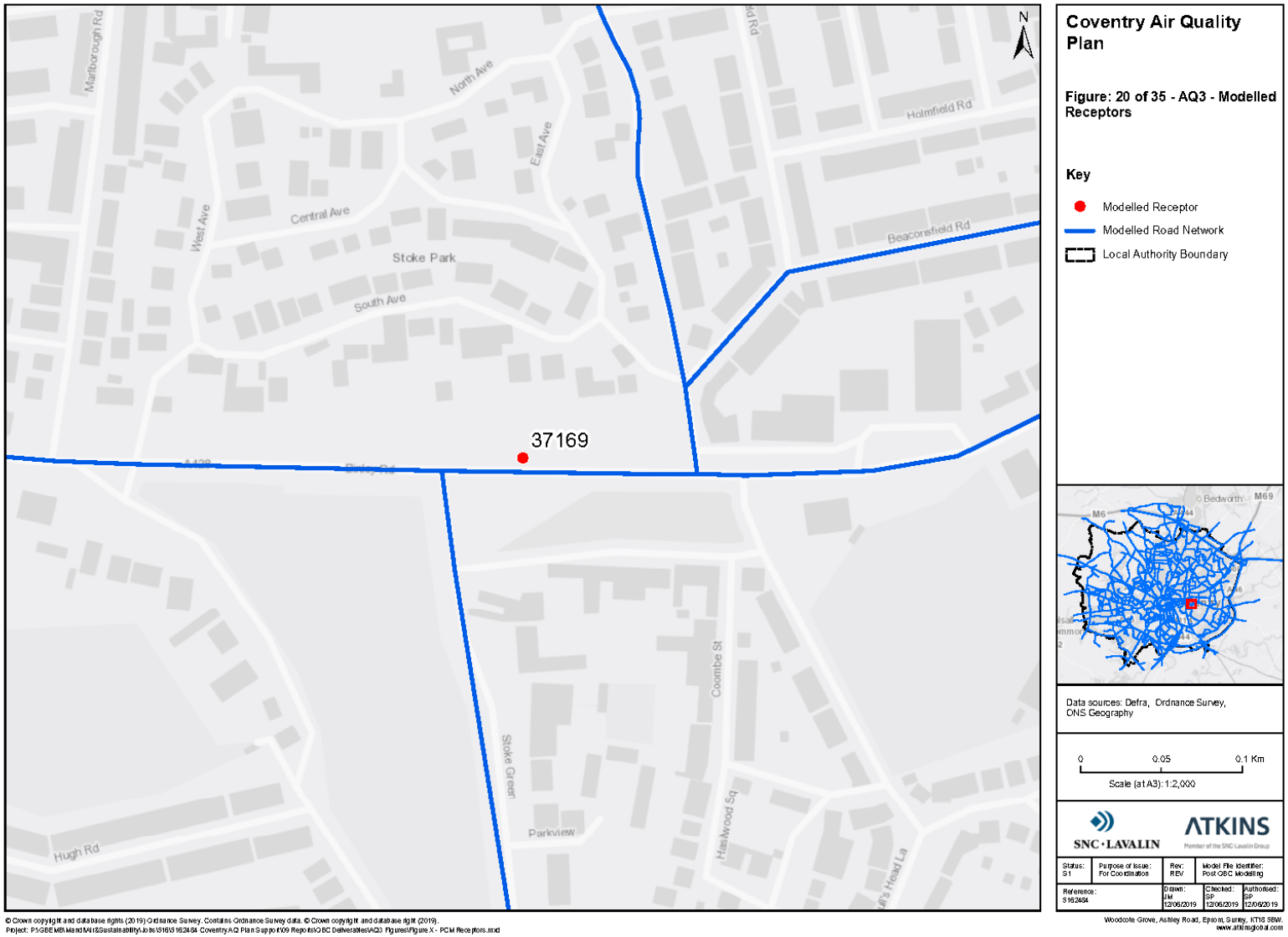

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Figure A-22 – Modelled Receptor Adjacent to PCM Link with Census ID 37731

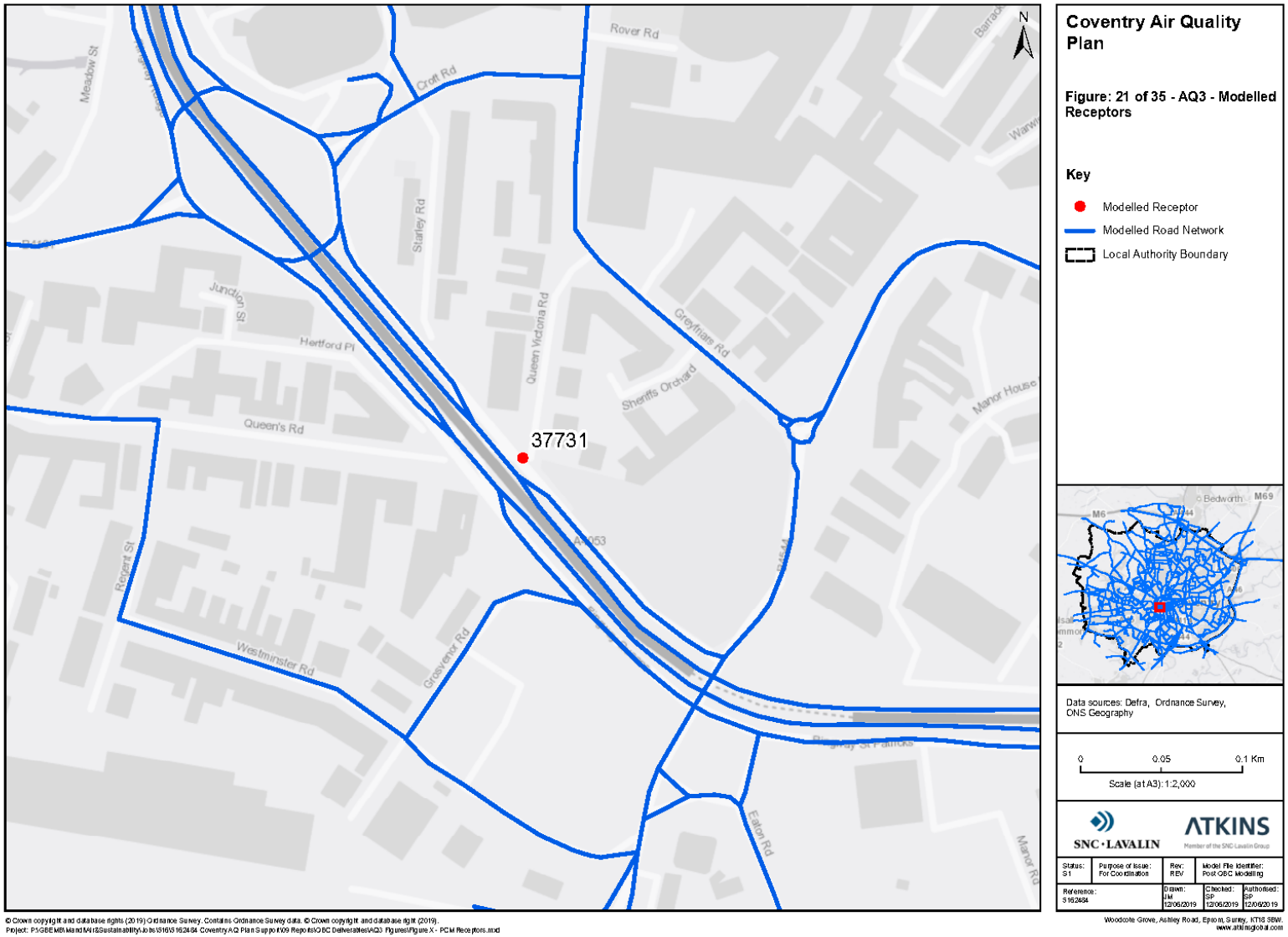

Figure A-23 – Modelled Receptor Adjacent to PCM Link with Census ID 37748

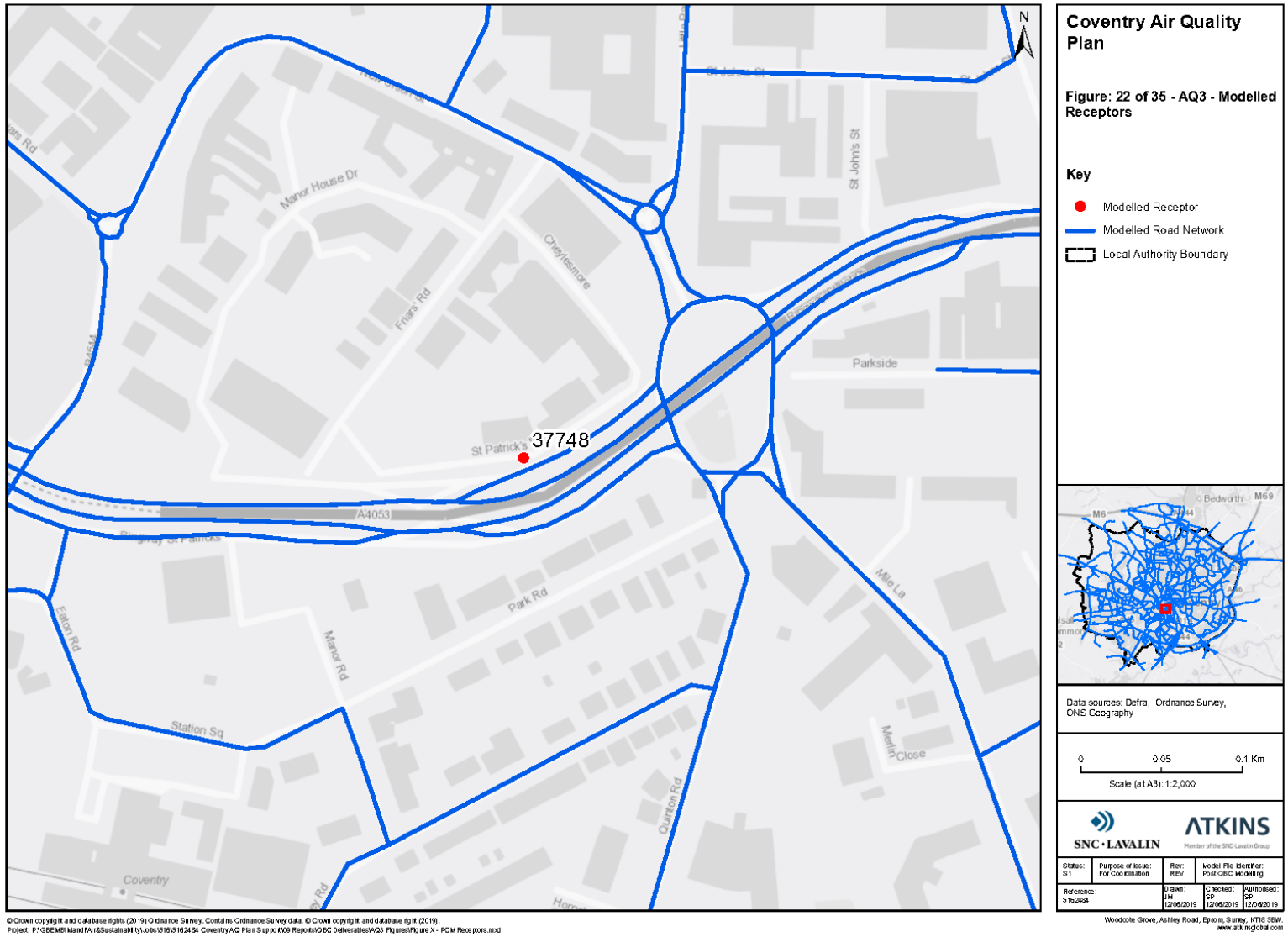

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Figure A-24 – Modelled Receptor Adjacent to PCM Link with Census ID 38796

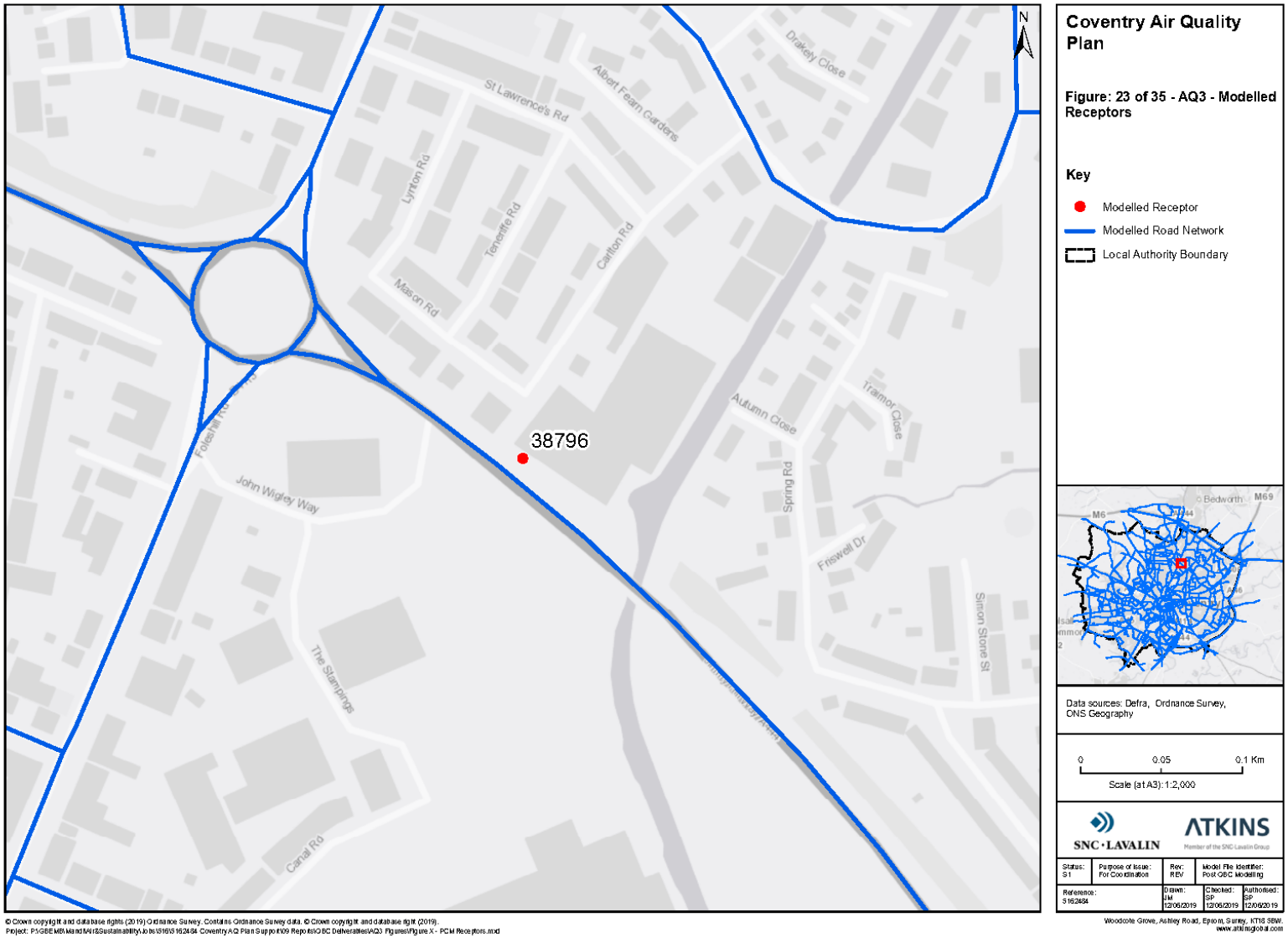

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Figure A-25 – Modelled Receptor Adjacent to PCM Link with Census ID 47156

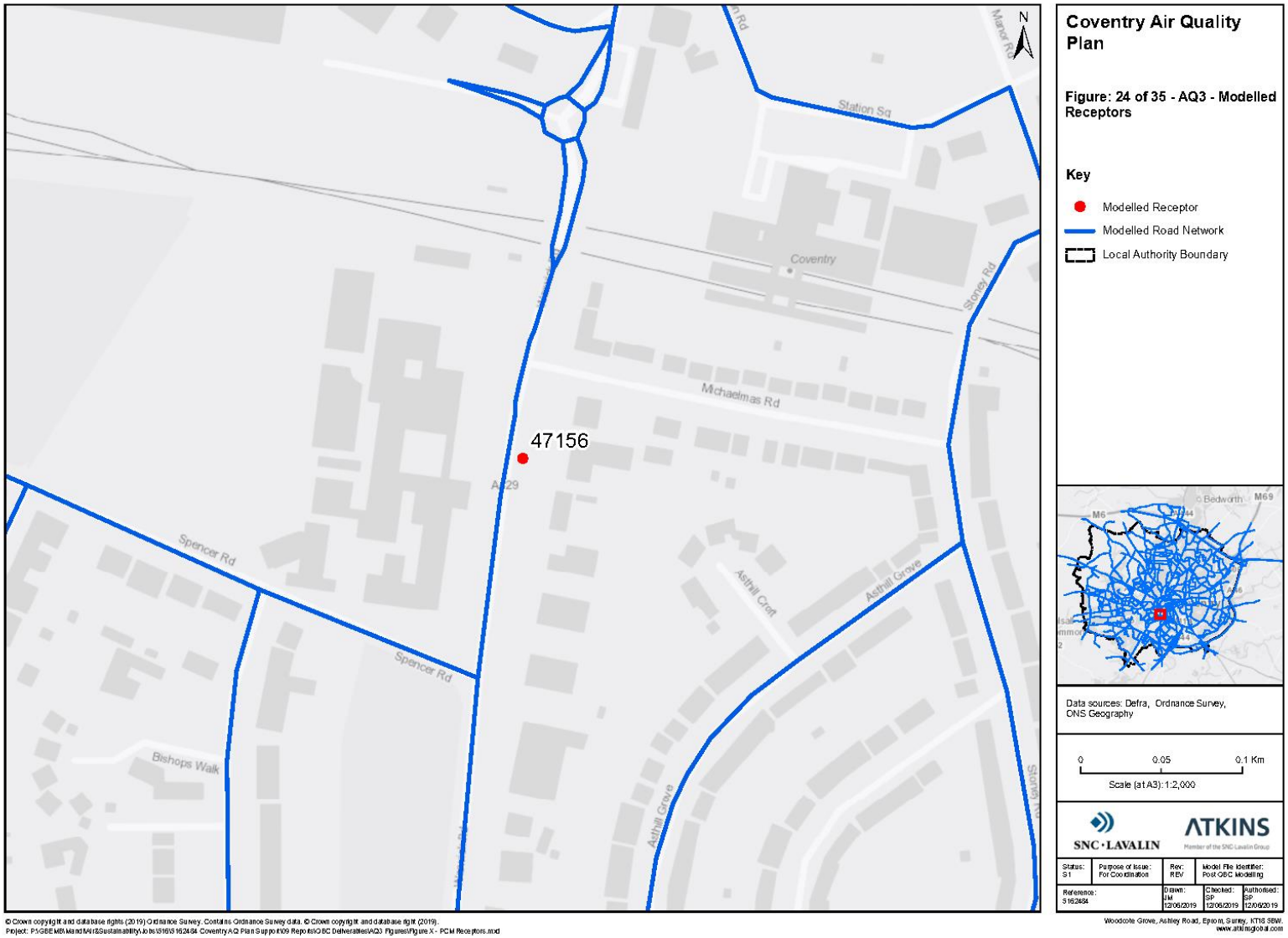

Figure A-26 – Modelled Receptor Adjacent to PCM Link with Census ID 47690

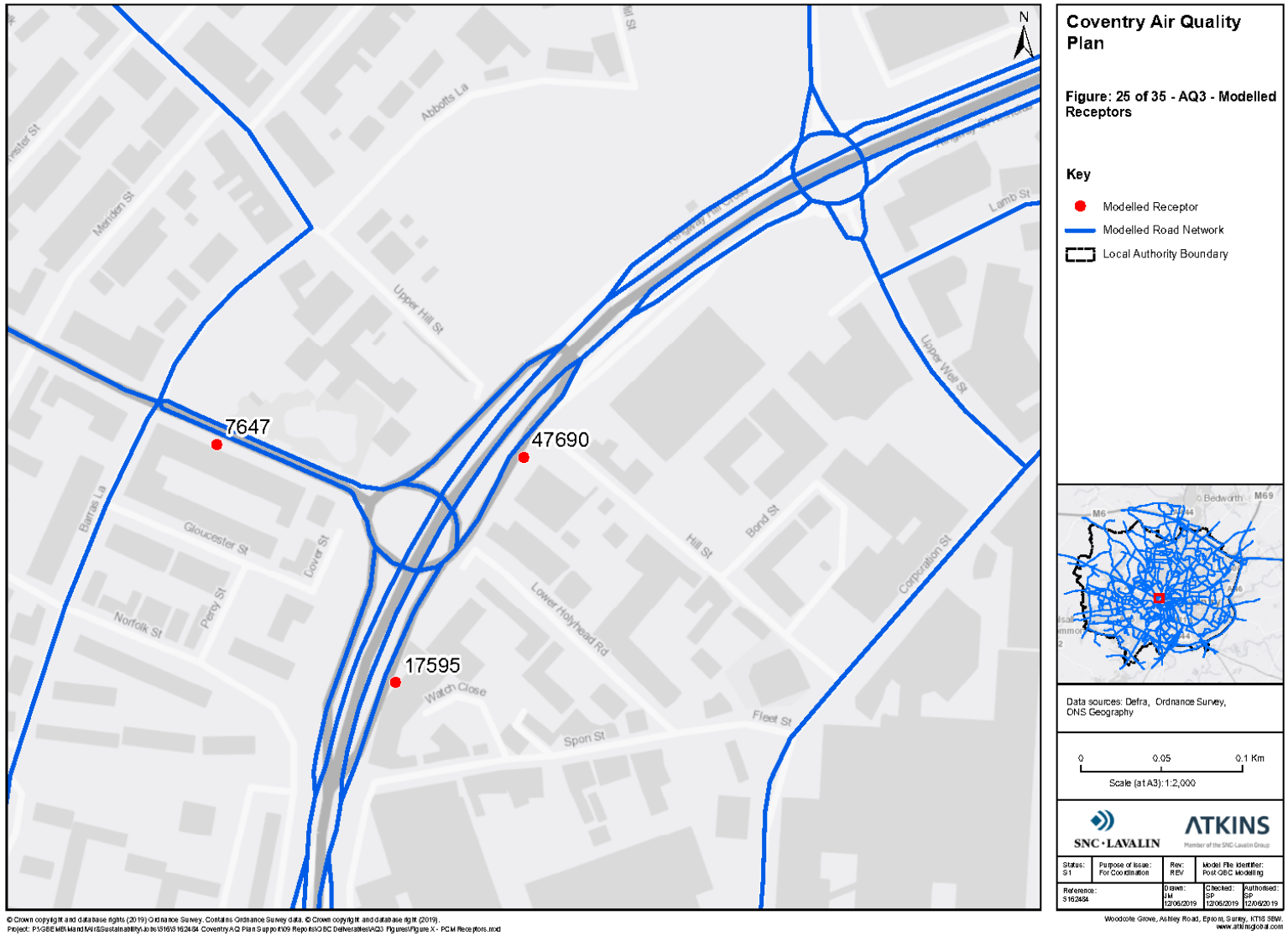

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Figure A-27 – Modelled Receptor Adjacent to PCM Link with Census ID 56791

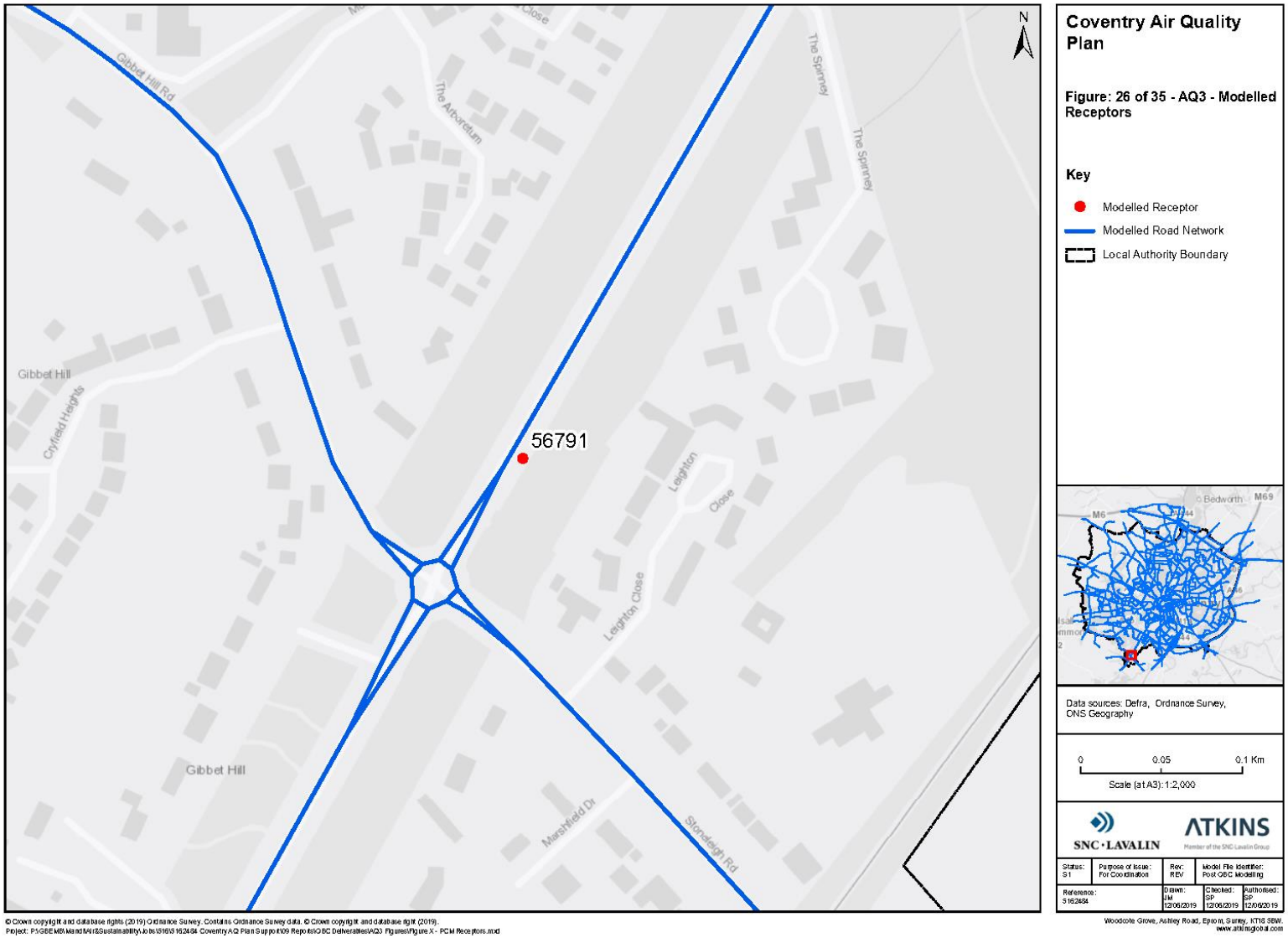

Figure A-28 – Modelled Receptor Adjacent to PCM Link with Census ID 58401

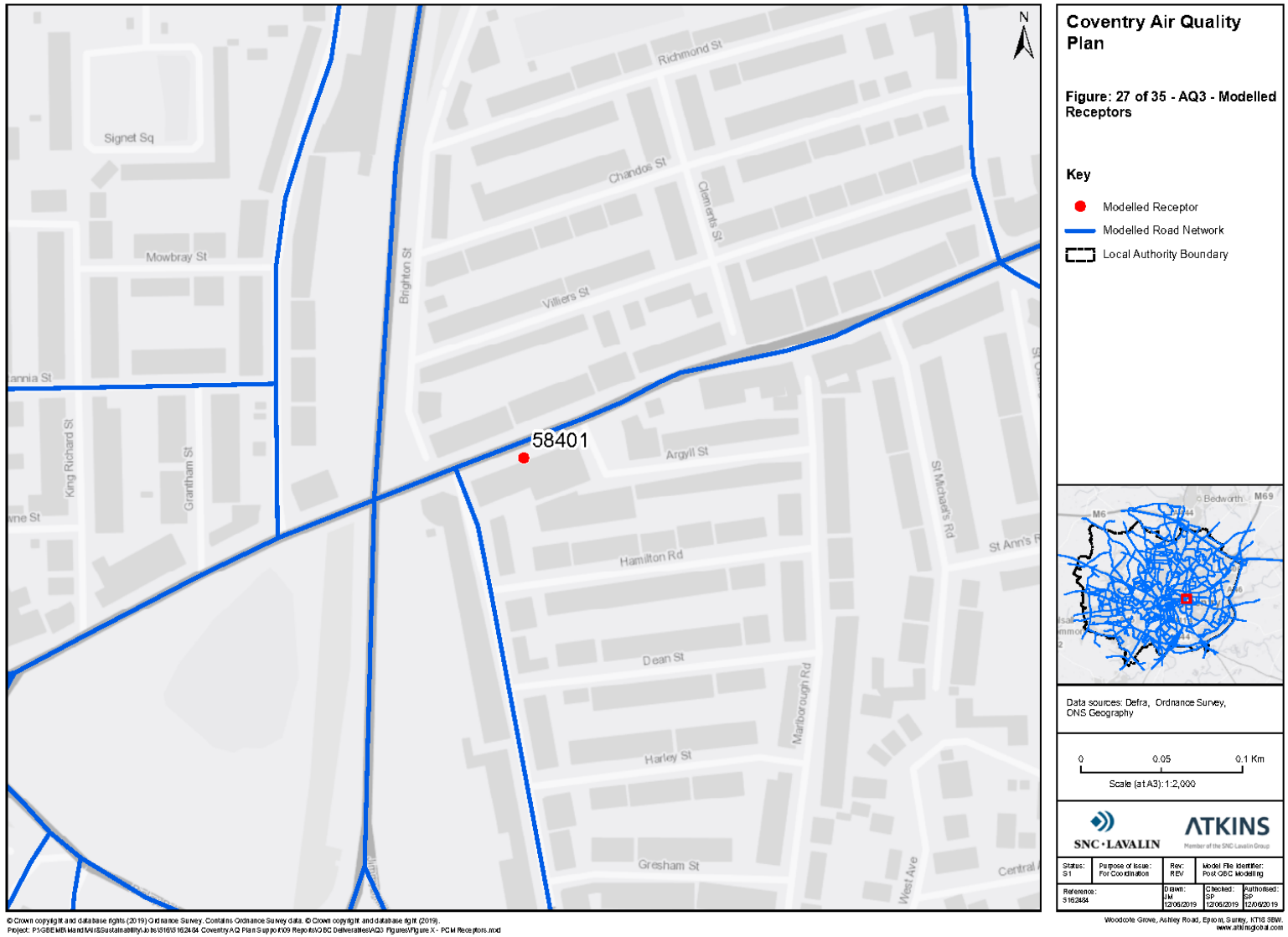

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Figure A-29 – Modelled Receptor Adjacent to PCM Link with Census ID 70238

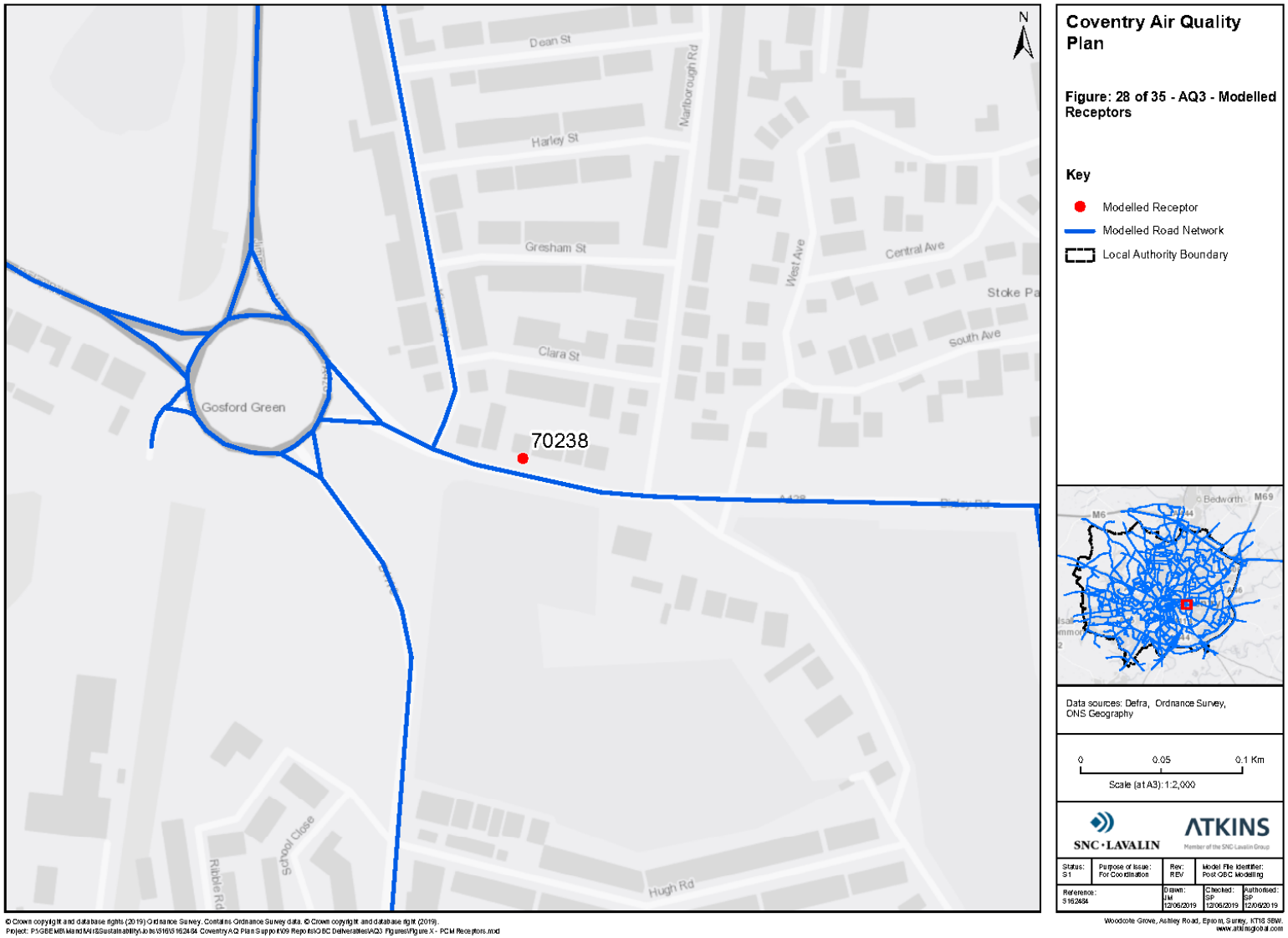

Figure A-30 – Modelled Receptor Adjacent to PCM Link with Census ID 74638

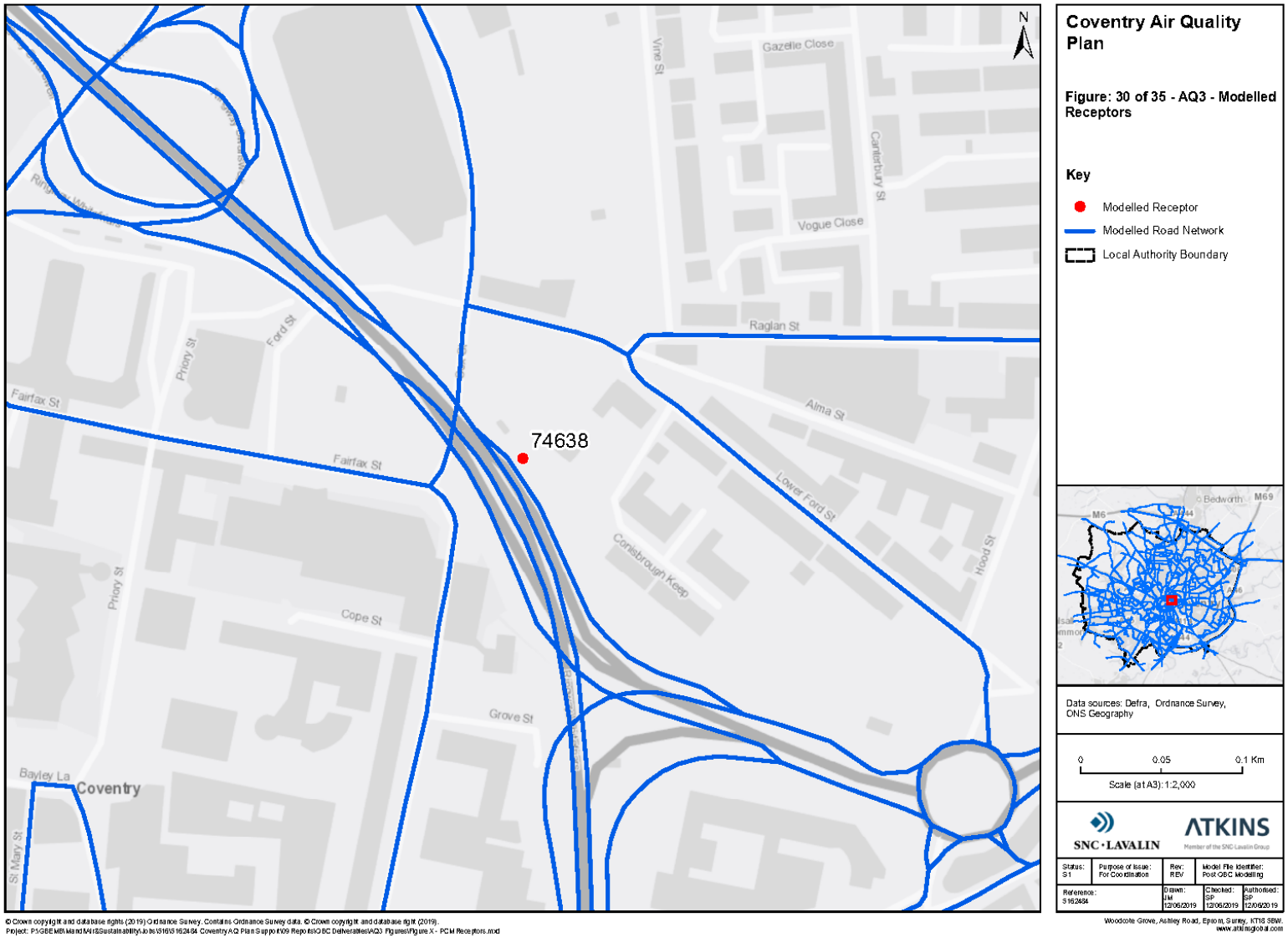

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Figure A-31 – Modelled Receptor Adjacent to PCM Link with Census ID 74639

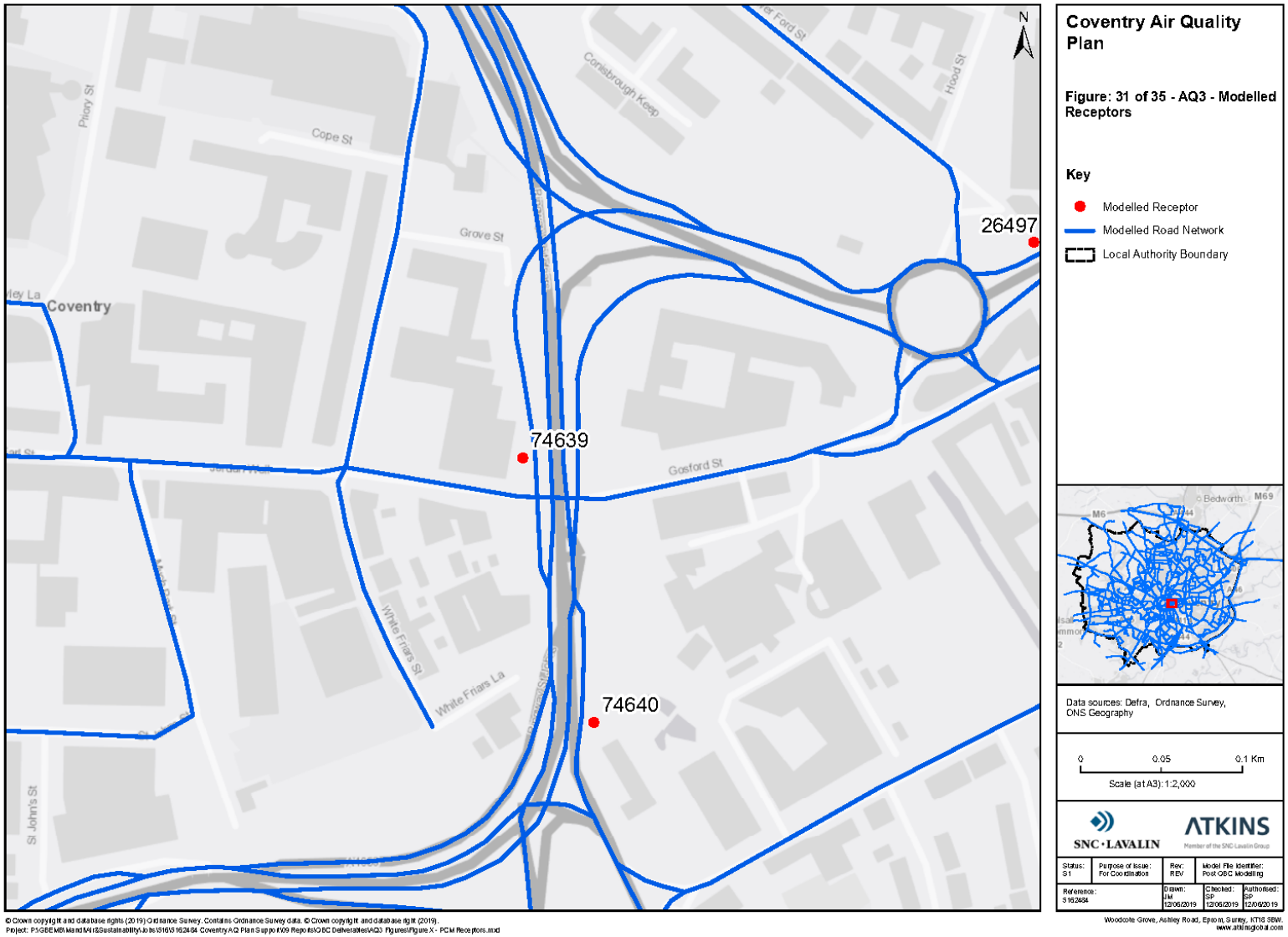

Figure A-32 – Modelled Receptor Adjacent to PCM Link with Census ID 74640

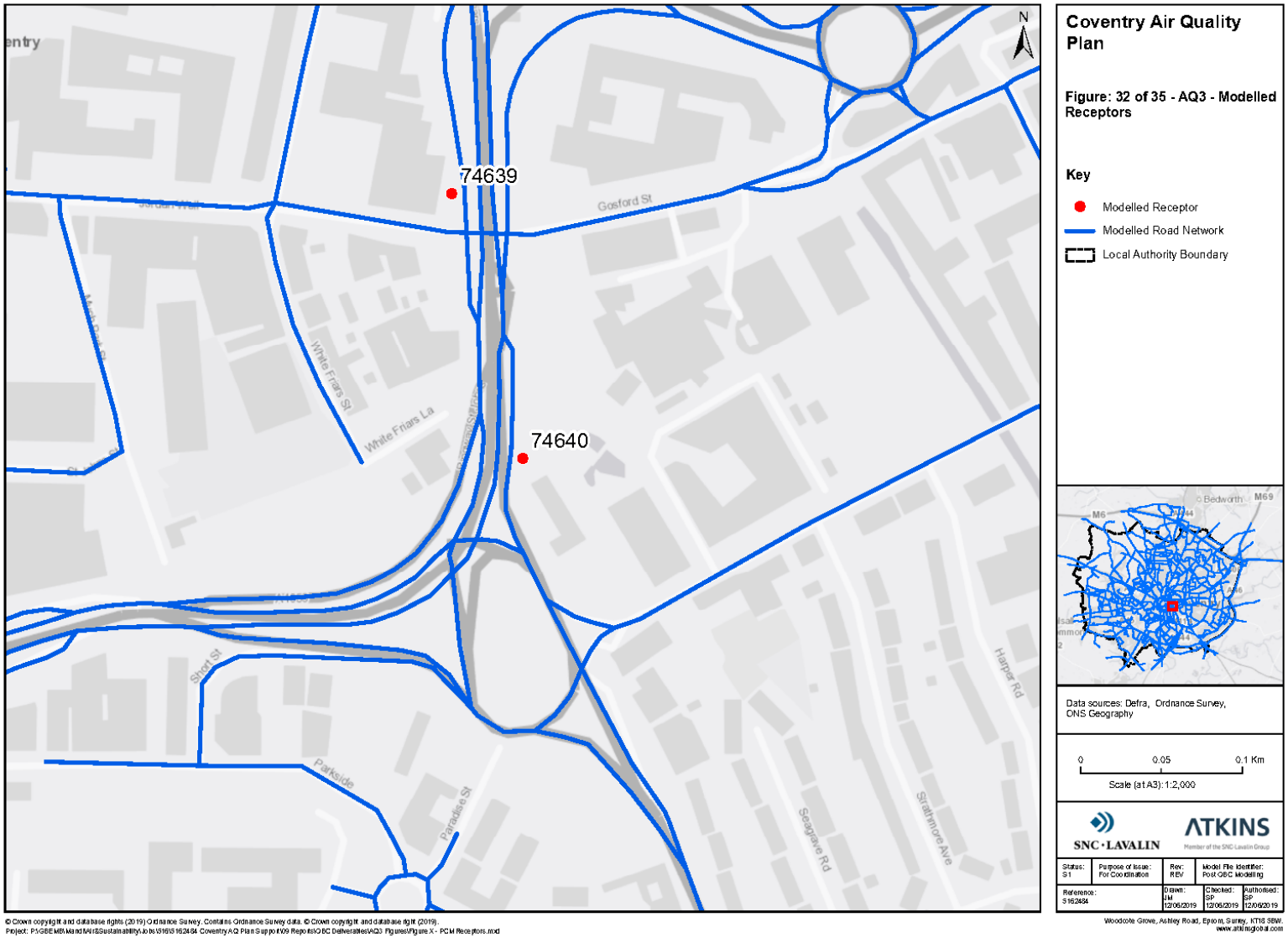

Figure A-33 **– Modelled Receptor Adjacent to PCM Link with Census ID 81233**

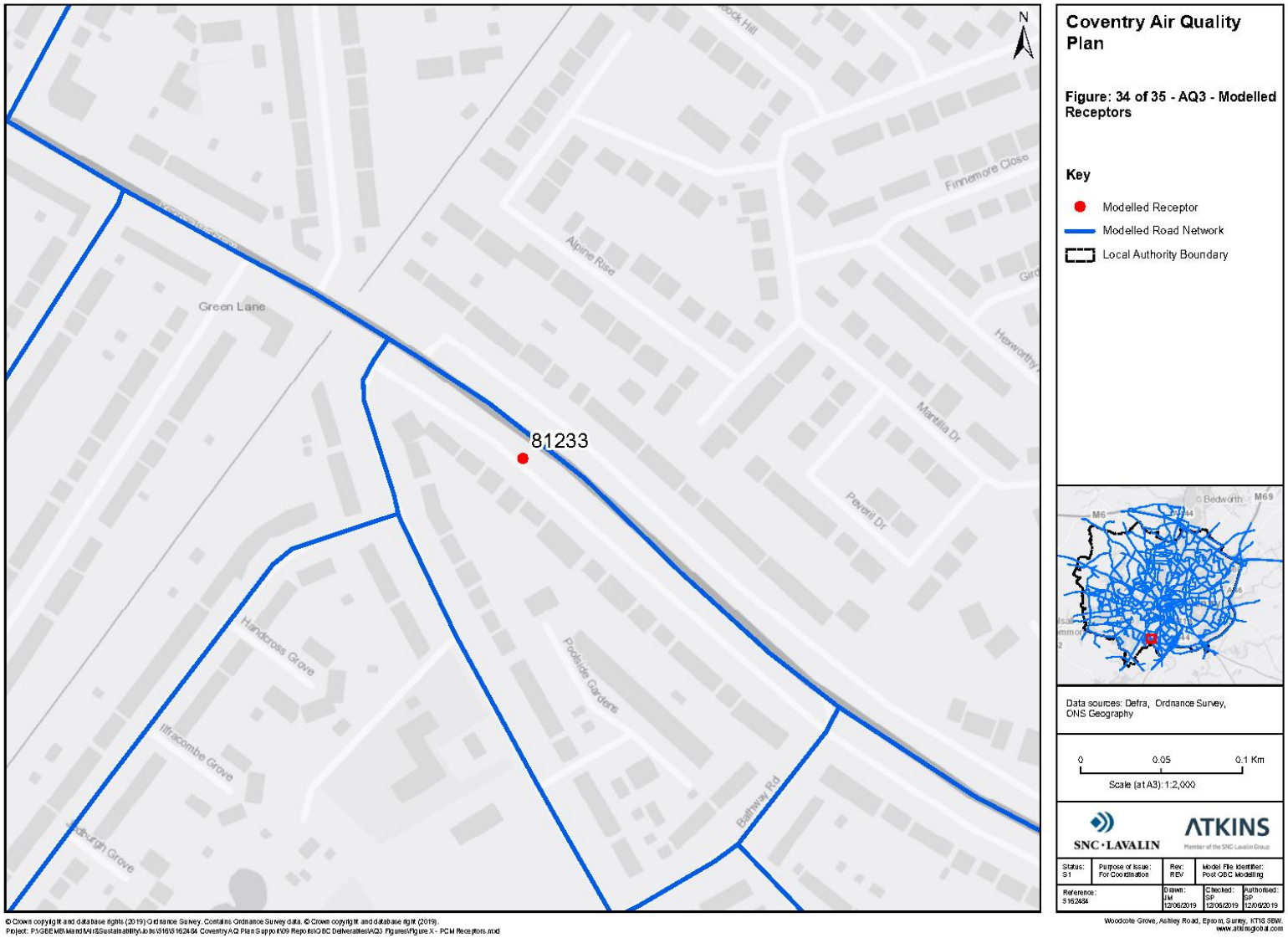

Figure A-34 – Modelled Receptor Adjacent to PCM Link with Census ID 99218

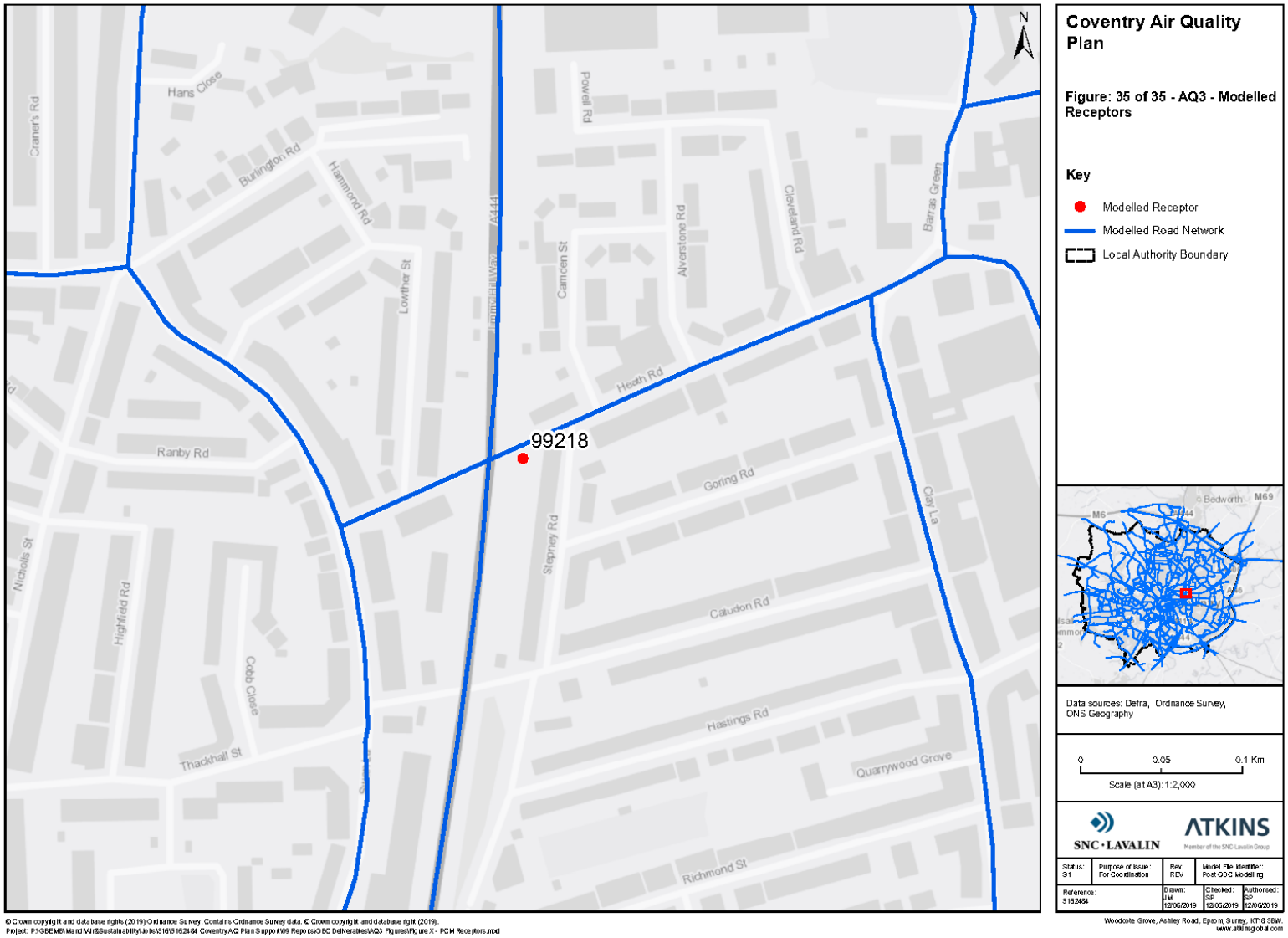

Figure A-35 – Modelled Secondary Receptors

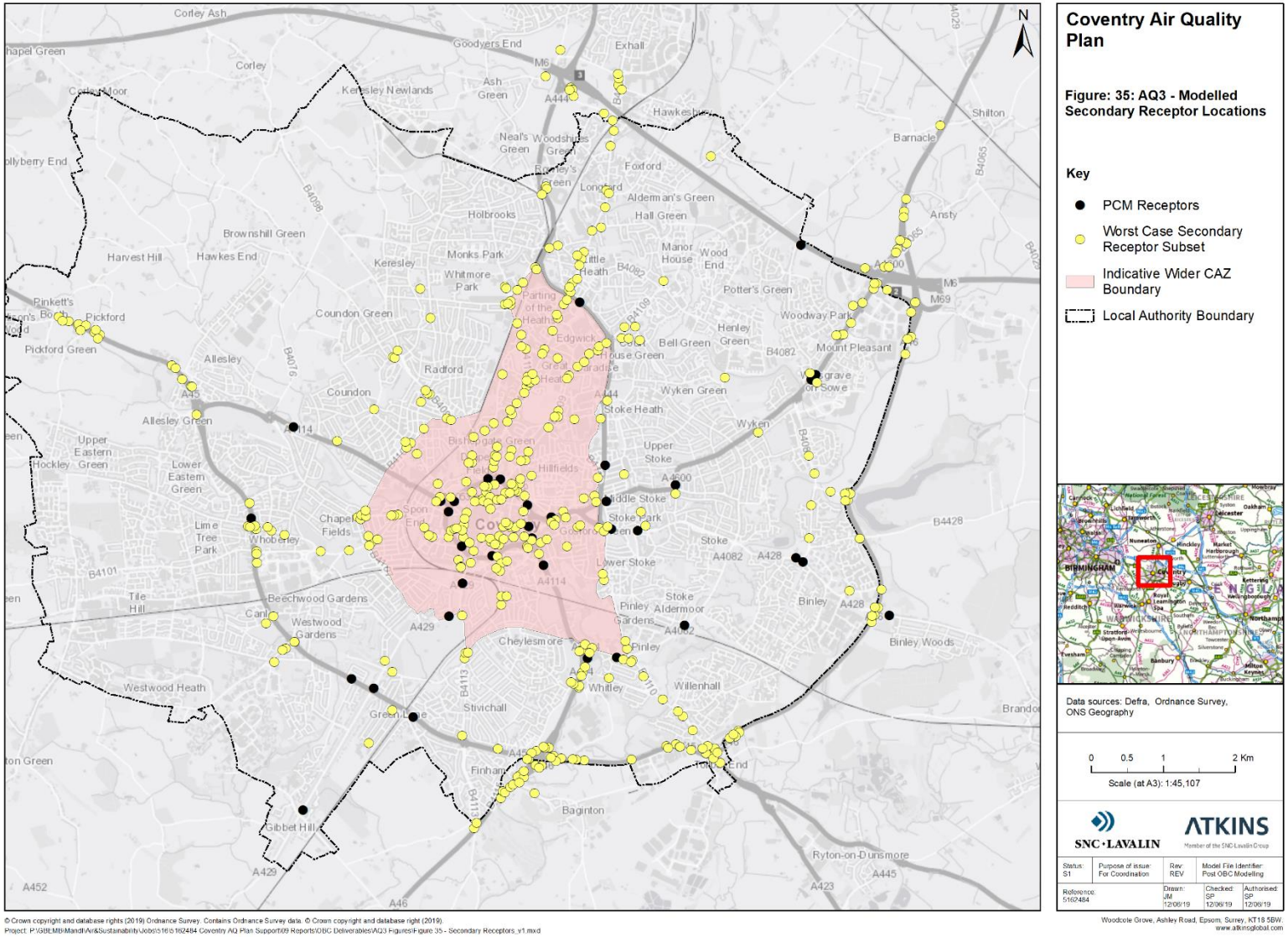

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Figure A-36 – Local Modelled NO_2 Concentrations (µg/m³) Mapped to the Defra PCM Network 2021 – Do-Minimum

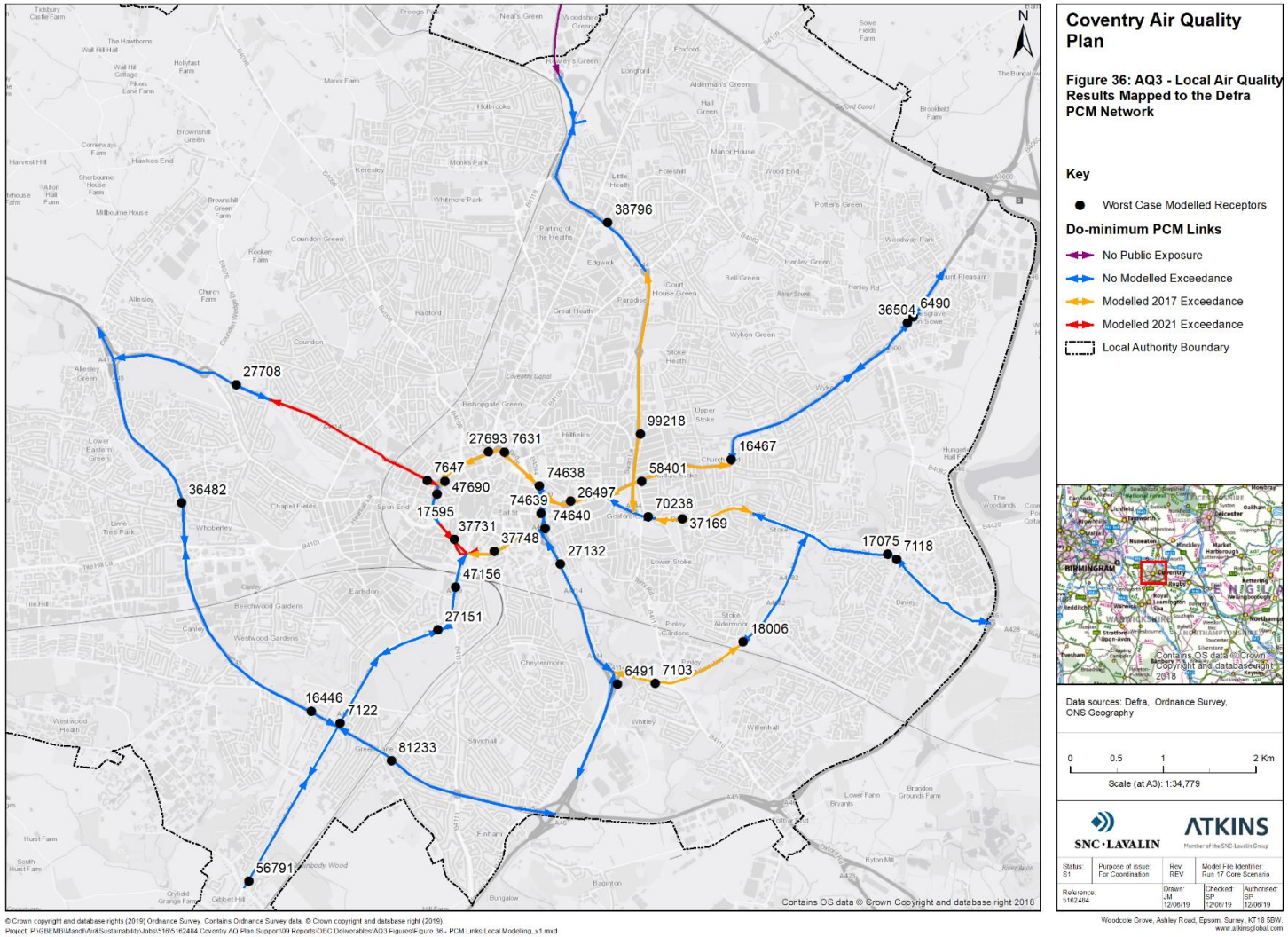

Figure A-37 – Local Modelled NO_2 Concentrations (µg/m³) at Secondary Receptors in 2021 – Do-Minimum

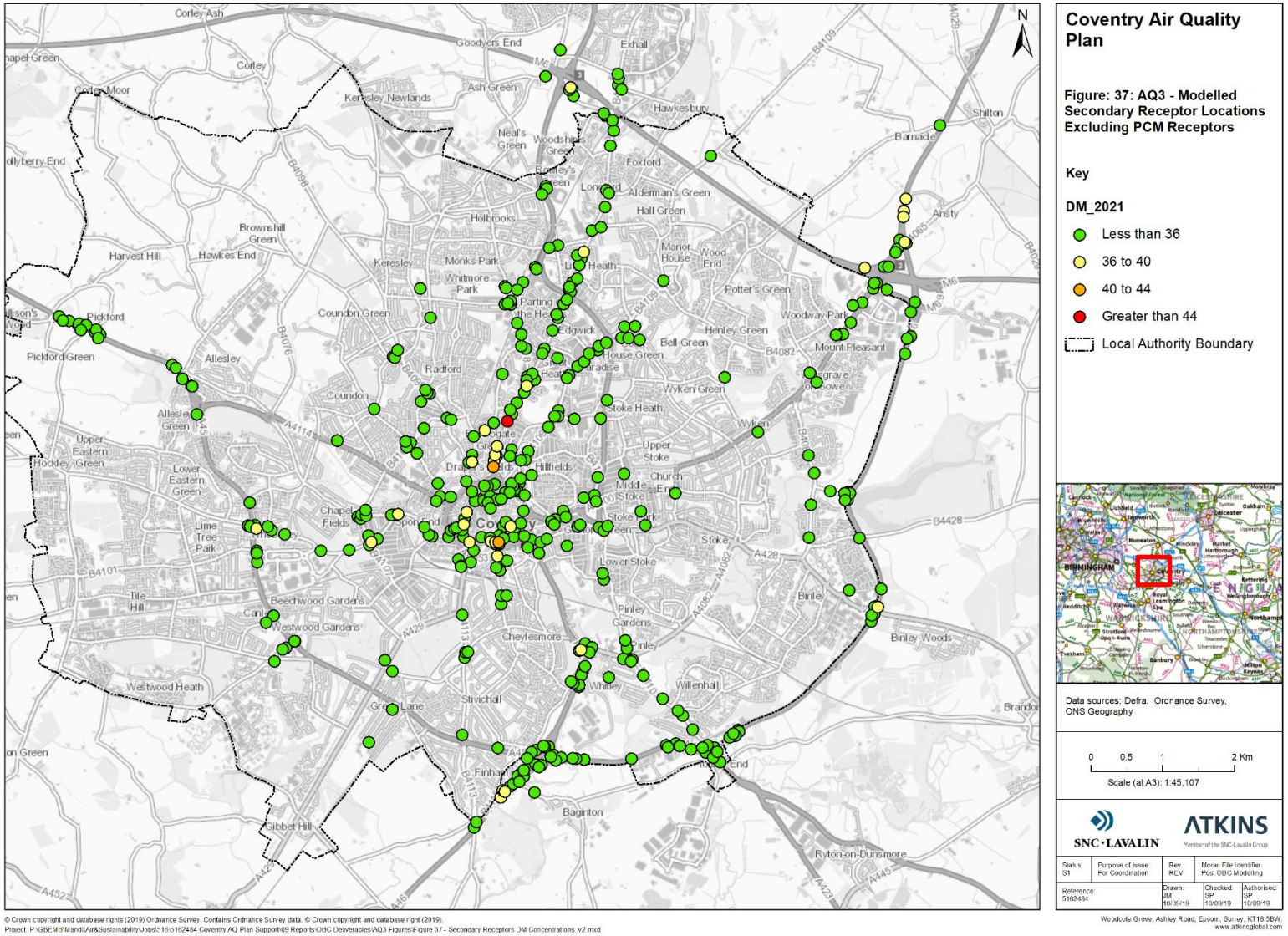

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Figure A-38 –Impact at Modelled Secondary Receptors 2021 – CAZ D (West Midlands Upgrade)

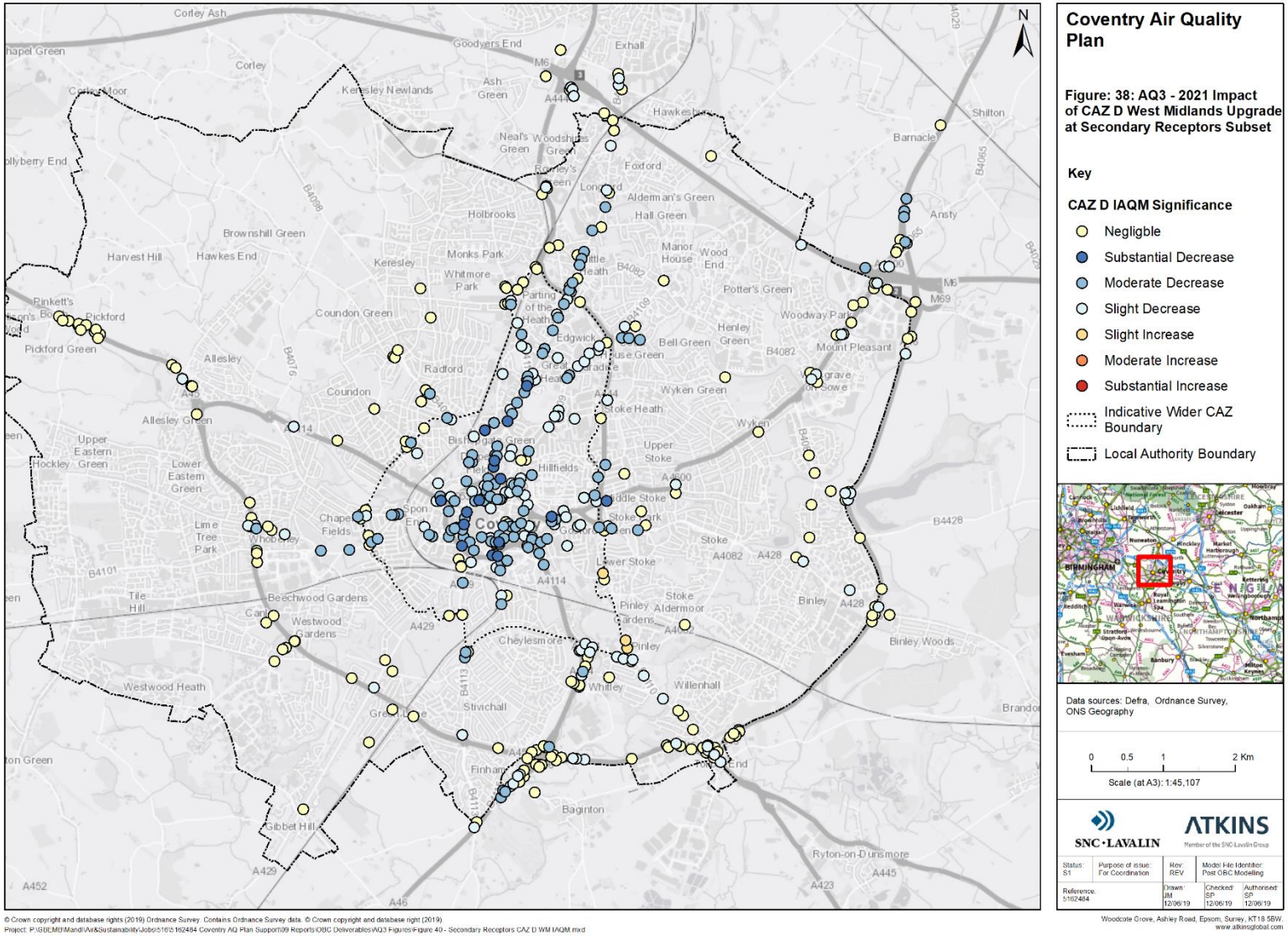


Figure A-39 –Impact at Modelled Secondary Receptors 2021 – DS13L

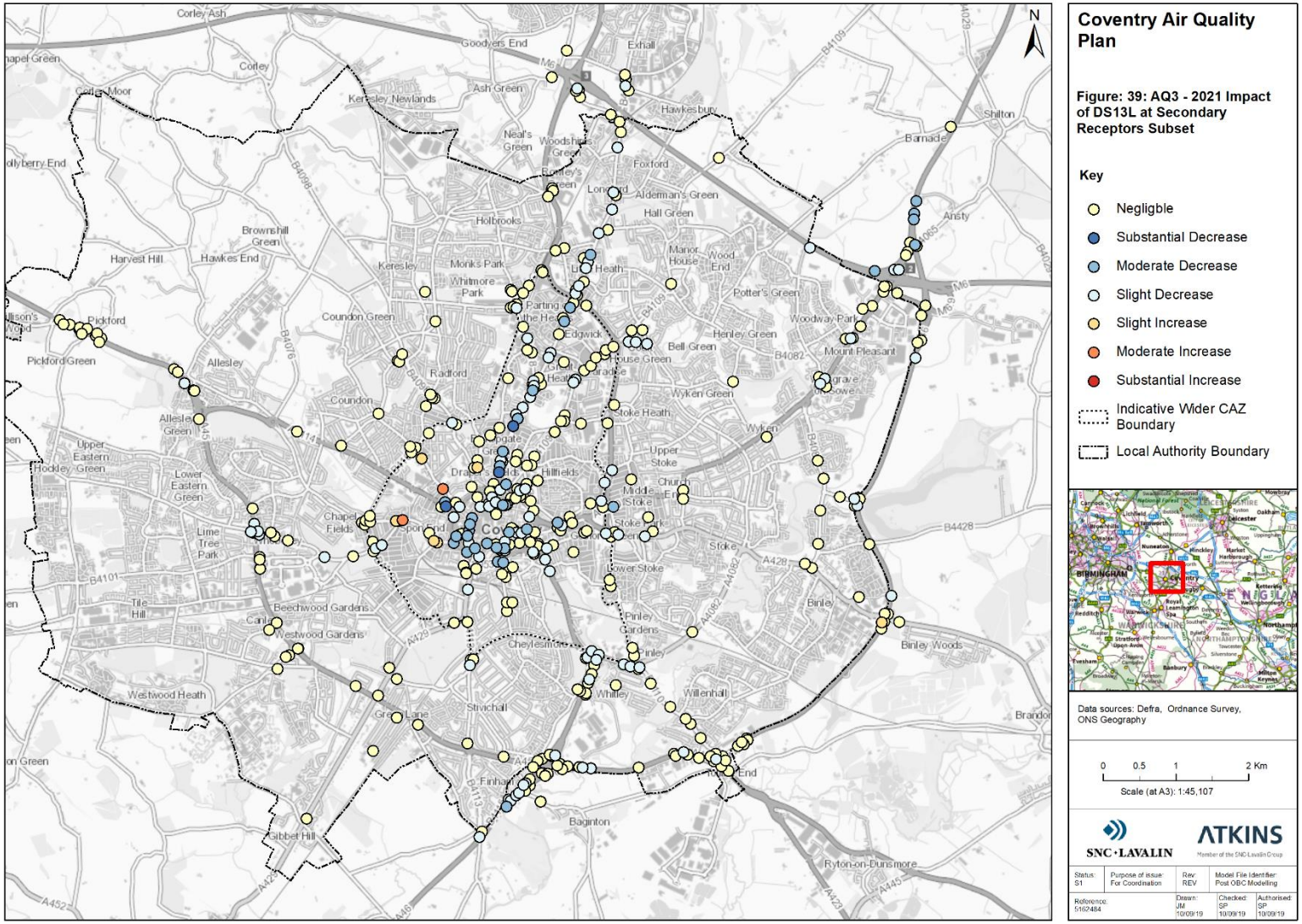


Figure A-40 –Impact at Modelled Secondary Receptors 2021 – DS13L – Spon End (difference in AADT)

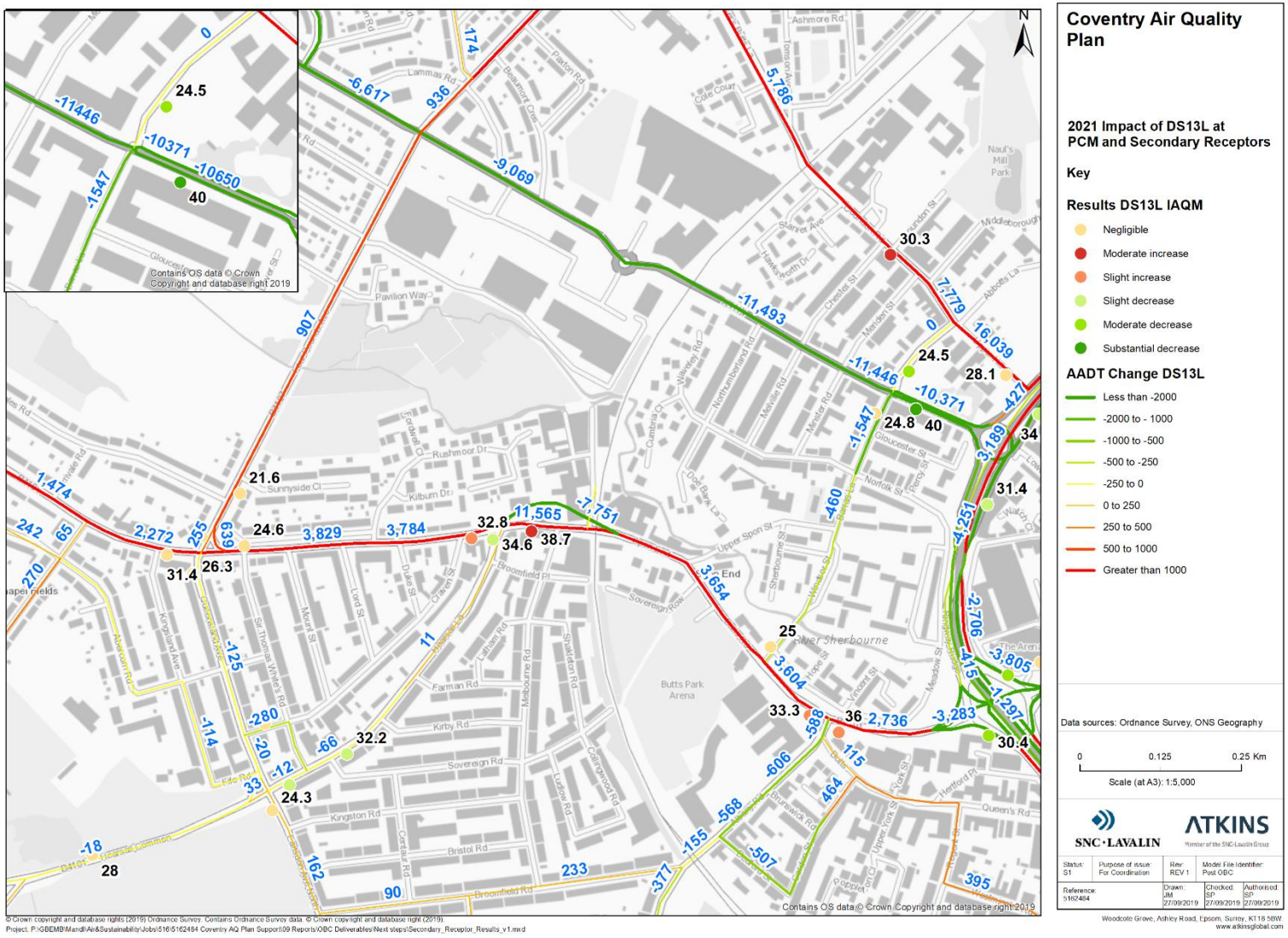
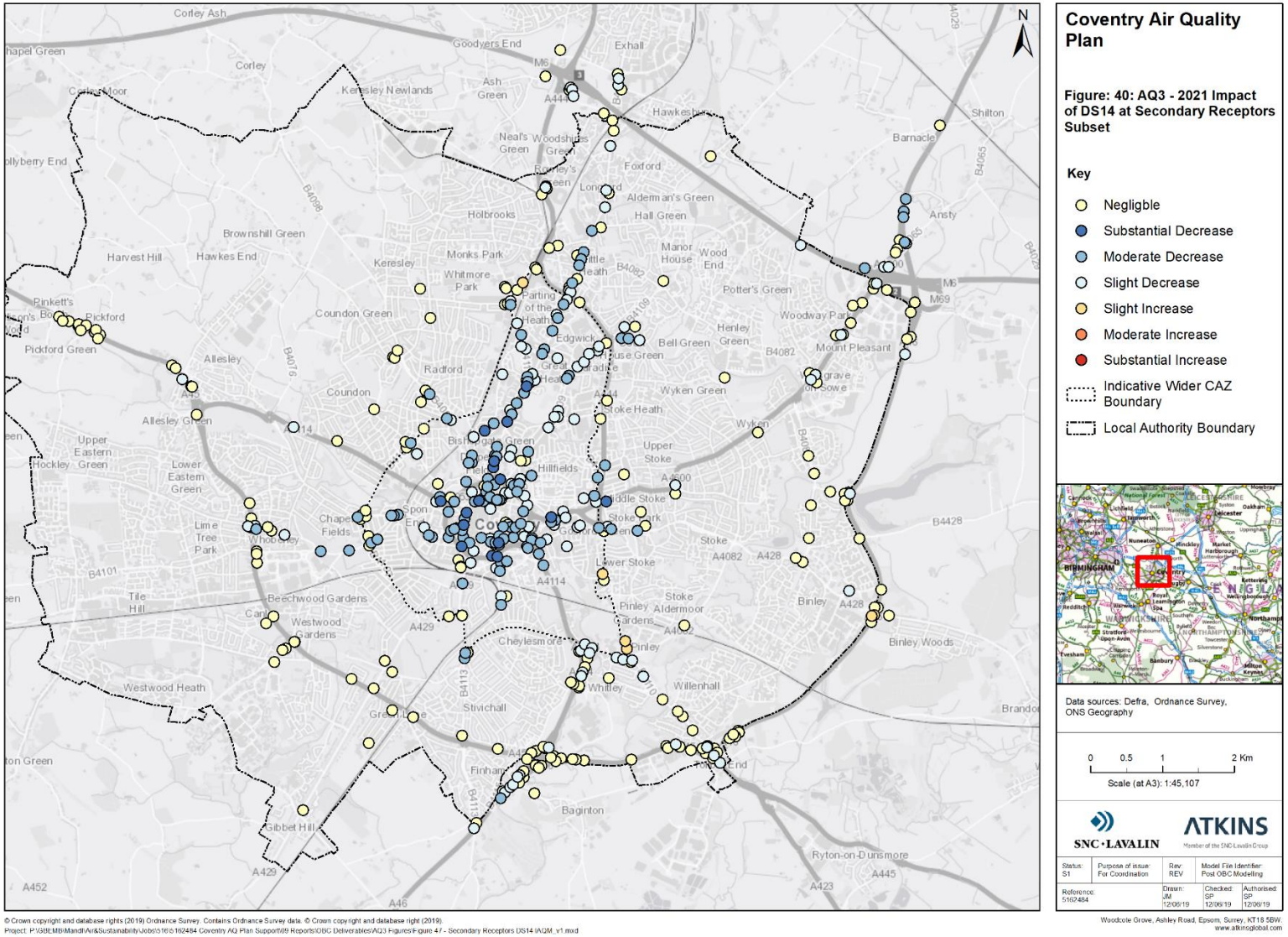


Figure A-41 –Impact at Modelled Secondary Receptors 2021 – DS14



Appendix B. Model Verification Results

It is good practice to compare modelled estimates of pollutant concentrations with real-world monitoring to assess the model's performance for a base year and to inform the interpretation of model results for future years. Verification of the 2017 base year scenario has been undertaken by comparison of modelled concentrations against those derived from monitoring at fifty monitoring sites located in the study area.

A total of 16 monitoring sites for which data were available were not used in the model verification process for the following reasons:

- HR2c – this monitoring site is located on the façade of a property adjacent to Holyhead Road, but further away from the inner ring road and the diffusion tubes used to derive the "Holyhead Road" adjustment factor. The monitored NO_2 concentrations at this site are significantly lower than those measured elsewhere on Holyhead Road and as a result the model overpredicts rather than under predicts at this location without adjustment;
- LON8, STL1, QV1 and BL1 – the geometry of the road network in the 2017 base model (which is based on a 2013 model) does not correspond with the geometry of the real-work road network when the 2017 annual mean was recorded due to recent changes to the local road network at these locations (not reflected in CASM);
- GF1 – an adjacent road link is not included in the CASM traffic model;
- CS3, FGS4, KG1, EB1, SA1, SA2, SA3, HL1 and BS1 – only three months of monitoring data are available for these sites. Whilst these data have been annualised so as to be representative of a 2017 annual mean, it is considered that insufficient confidence can be placed in the results obtained at these sites; and
- QAV01 – this diffusion tube is located on a traffic light pole (<1m from the kerbside) at a junction between the B4106 and B4107. Such a location is difficult to replicate in the air quality model being within the model turbulence zone and as such the model performs poorly at this location. As this site is not representative of pollutant concentrations at 4m from the roadside where the EU Limit Value is assessed, this diffusion tube has been omitted from the verification process.

An air quality model can be considered to perform reasonably well where modelled concentrations are within 25% of monitored concentrations at 94% of sites, in accordance with DEFRA's Technical Guidance LAQM.TG(16). The root mean square error (RMSE) is acceptable if it is well below 25% of the AQS objective at 10 µg/m^3 (a requirement), and is ideal if below 10% of the AQS objective i.e. an RMSE of 4 µg/m^3.

Step 1

Firstly, unadjusted modelled estimates of total annual mean NO_2 concentrations have been compared against monitored annual mean concentrations as shown in Table B-1. These results indicate that the model tended to underestimate compared to monitored concentrations, by up to 40%. Unadjusted model statistics are shown in Table B-2. The RMSE is under 25% of the AQS objective, whilst the Fractional Bias (FB) is well above the ideal value of 0, indicating that the model tends to under estimate. The correlation coefficient suggests the model is not reflecting the measured position well.

Table B-1 – Comparison of Modelled and Measured NO_2 Concentrations (µg/m³), Unadjusted

Site Name	Background Annual Mean NO_2 (µg/m³)	Monitored Annual Mean Total NO_2 (µg/m³)	Unadjusted Modelled Annual Mean Total NO_2 (µg/m³)	Unadjusted Modelled NO_2 Minus Monitored NO_2 (µg/m³)	% Difference (unadjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
BA1	18.7	33.8	27.2	-6.6	-20%
BA1c	15.0	25.2	21.9	-3.3	-13%
BELL1	17.7	38.2	24.7	-13.4	-35%
BELL2	17.7	35.2	25.6	-9.6	-27%
BH13	18.6	34.1	31.5	-2.6	-7%
BH14	18.6	37.5	33.1	-4.4	-12%
BH15i	18.6	**40.9**	37.3	-3.5	-9%
BH1a	20.7	37.6	**42.9**	5.3	14%
BH2a	18.6	**43.5**	35.7	-7.8	-18%
BH4	18.6	**45.3**	32.4	-12.9	-29%
BRN2	20.3	36.0	27.6	-8.4	-23%
BRN5	20.3	32.6	26.7	-5.9	-18%
CC01/1*N	22.1	36.8	30.5	-6.2	-17%
COAL	16.0	21.9	19.0	-2.9	-13%
COBR	19.6	33.4	26.5	-7.0	-21%
DH1	18.3	29.9	28.1	-1.8	-6%
FGS2	20.7	32.7	29.0	-3.7	-11%
FGS3a	20.7	33.8	28.6	-5.2	-15%
FS1	22.8	**45.9**	39.1	-6.8	-15%
GR1	19.6	33.5	25.5	-8.0	-24%
GS1	24.1	35.3	35.5	0.2	1%
LON12	19.6	**48.8**	**41.8**	-7.0	-14%
LR1	17.1	37.8	33.1	-4.7	-13%
LR2	17.1	37.2	32.2	-5.0	-13%
LR3	17.6	38.7	30.7	-8.0	-21%
QAV12	17.9	31.1	25.2	-5.9	-19%
QAV13	17.9	37.3	35.5	-1.8	-5%
R5	21.5	40.1	37.4	-2.7	-7%
R6	21.5	**50.7**	**41.9**	-8.8	-17%
R8	20.3	37.3	28.2	-9.0	-24%
R9	19.6	36.9	28.0	-8.9	-24%
RR1	22.8	38.4	31.1	-7.3	-19%

Site Name	Background Annual Mean NO_2 ($\mu g/m^3$)	Monitored Annual Mean Total NO_2 ($\mu g/m^3$)	Unadjusted Modelled Annual Mean Total NO_2 ($\mu g/m^3$)	Unadjusted Modelled NO_2 Minus Monitored NO_2 ($\mu g/m^3$)	% Difference (unadjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
RR2	22.8	**40.4**	32.4	-8.0	-20%
SHP2	16.8	28.6	24.3	-4.3	-15%
SHP3	16.8	34.0	29.1	-4.9	-14%
Grange2	18.1	36.5	30.8	-5.7	-16%
Grange3	18.1	34.6	32.1	-2.5	-7%
RR3	22.8	**48.5**	39.6	-8.9	-18%
SE1	22.1	35.4	39.3	3.9	11%
SE3	22.1	36.6	34.1	-2.6	-7%
SS1	19.9	34.3	28.1	-6.1	-18%
SS2	22.8	31.3	30.3	-1.0	-3%
SS3	19.6	36.1	28.4	-7.7	-21%
SS5	22.8	**45.8**	34.7	-11.1	-24%
HR4	22.1	**47.7**	35.8	-11.9	-25%
HR1	22.1	**52.8**	**40.6**	-12.2	-23%
HR1c	22.1	**79.2**	**47.5**	-31.8	-40%
HR5	22.1	**55.1**	38.6	-16.5	-30%
HR6	22.1	**56.8**	39.7	-17.1	-30%

Table B-2 – Model Statistics Pre-Adjustment

RMSE [i]	FB [ii]	r [iii]
8.81	0.19	0.805

Notes:

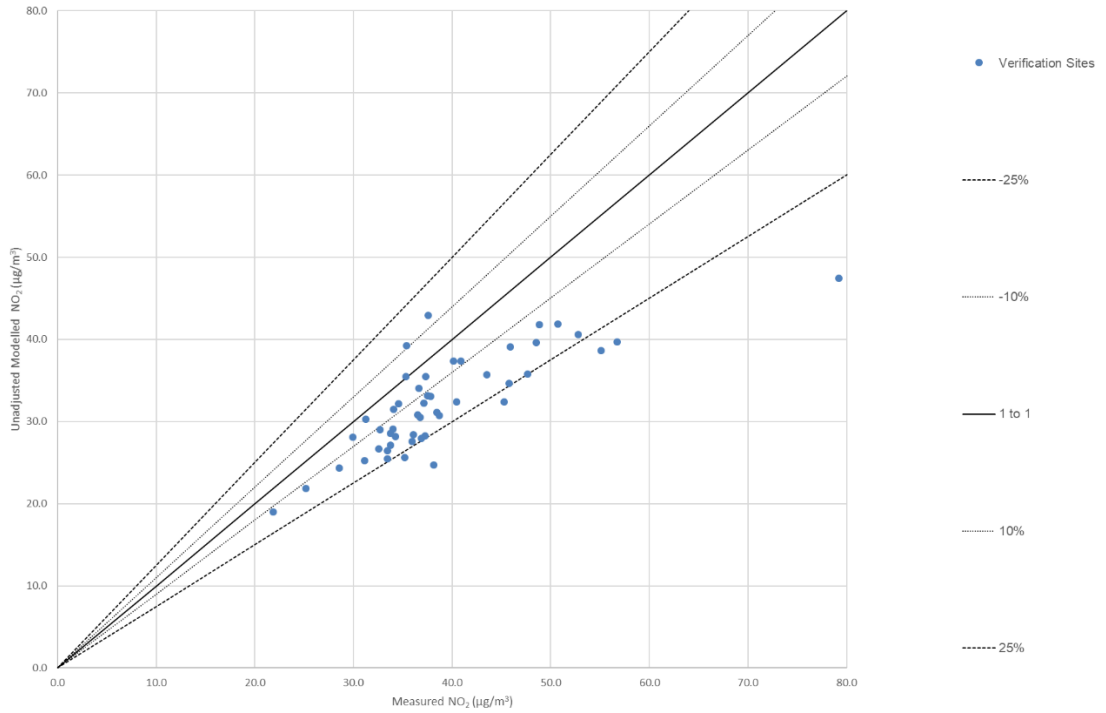
[i] Root Mean Square Error: RMSE is used to define the average error or uncertainty of the model (units = $\mu g/m^3$). In the case of modelled annual mean NO_2 a value of less than 10 is acceptable and less than 4 is the ideal

[ii] Fractional Bias: FB is used to identify if the model shows a systematic tendency to over or under estimate. Ideal value is 0

[iii] Correlation coefficient: r is used to measure the linear relationship between modelled and observed data. Ideal value is 1

A comparison of measured and modelled (unadjusted) annual mean NO_2 concentrations is shown below in Figure B-1.

Figure B-1 – Measured NO_2 vs Modelled (Unadjusted) NO_2



Step 2

The model itself does not provide annual mean NO_2, this is determined using DEFRA LAQM.TG(16) methods. The second comparison is thus of directly modelled estimates of road contributed annual mean NOx with the road NOx component derived from monitoring data, as presented in Table B-3. This analysis requires the estimation of the monitored road NOx component from the measured total annual mean NO_2 concentration. This was undertaken using DEFRA's NOx to NO_2 calculator (version 6.1).

Table B-3 – Comparison of Modelled and Measured NO_x Concentrations (µg/m³), Unadjusted

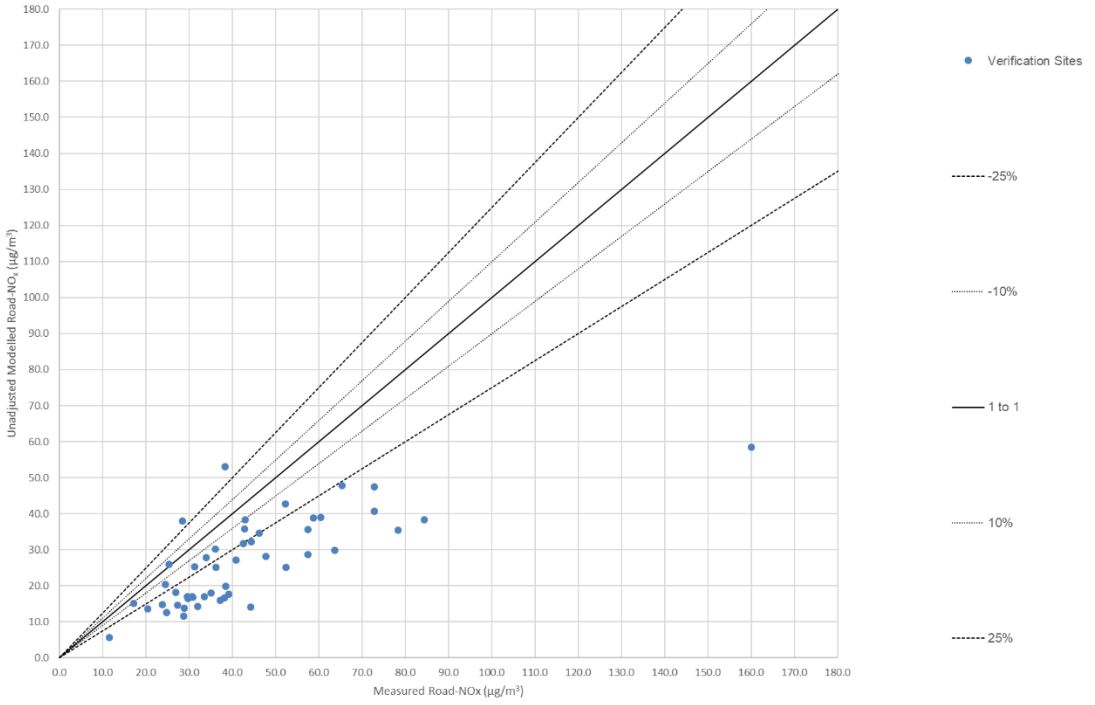
Site Name	Modelled Annual Mean Road NO_x (µg/m³)	Monitored Annual Mean Road NO_x (µg/m³)	Modelled Road NO_x Minus Monitored Road NO_x (µg/m³)	Monitored Road NO_x / Modelled NO_x	% Difference (modelled Road NO_x - monitored Road NO_x) / monitored Road NO_x * 100
BA1	16.8	30.9	-14.1	1.84	-46%
BA1c	13.5	20.4	-6.9	1.51	-34%
BELL1	14.0	44.2	-30.2	3.15	-68%
BELL2	16.0	37.2	-21.2	2.33	-57%
BH13	27.9	33.9	-6.1	1.22	-18%
BH14	31.8	42.6	-10.8	1.34	-25%
BH15i	42.8	52.3	-9.4	1.22	-18%
BH1a	53.1	38.4	14.7	0.72	38%
BH2a	39.0	60.5	-21.5	1.55	-36%

Site Name	Modelled Annual Mean Road NO_x (µg/m^3)	Monitored Annual Mean Road NO_x (µg/m^3)	Modelled Road NO_x Minus Monitored Road NO_x (µg/m^3)	Monitored Road NO_x / Modelled NO_x	% Difference (modelled Road NO_x - monitored Road NO_x) / monitored Road NO_x * 100
BH4	29.8	63.6	-33.8	2.13	-53%
BRN2	14.3	32.0	-17.7	2.24	-55%
BRN5	12.6	24.9	-12.3	1.98	-50%
CC01/1*N	17.1	30.8	-13.7	1.80	-44%
COAL	5.7	11.5	-5.8	2.03	-51%
COBR	13.7	28.9	-15.2	2.11	-53%
DH1	20.5	24.6	-4.1	1.20	-17%
FGS2	18.1	26.9	-8.8	1.48	-33%
FGS3a	17.0	29.7	-12.6	1.74	-43%
FS1	38.9	58.8	-19.8	1.51	-34%
GR1	11.6	28.7	-17.1	2.47	-59%
GS1	26.0	25.3	0.6	0.98	3%
LON12	47.8	65.4	-17.7	1.37	-27%
LR1	34.6	46.3	-11.7	1.34	-25%
LR2	32.3	44.4	-12.1	1.37	-27%
LR3	28.1	47.8	-19.7	1.70	-41%
QAV12	14.7	27.4	-12.7	1.86	-46%
QAV13	38.4	42.9	-4.5	1.12	-11%
R5	35.8	42.8	-7.0	1.20	-16%
R6	47.5	72.8	-25.4	1.53	-35%
R8	16.7	38.2	-21.5	2.29	-56%
R9	17.7	39.1	-21.4	2.21	-55%
RR1	17.0	33.6	-16.5	1.97	-49%
RR2	19.9	38.5	-18.5	1.93	-48%
SHP2	14.8	23.8	-8.9	1.60	-38%
SHP3	25.2	36.3	-11.0	1.44	-30%
Grange2	27.1	40.9	-13.8	1.51	-34%
Grange3	30.2	36.1	-5.9	1.20	-16%
RR3	35.6	57.5	-21.8	1.61	-38%
SE1	38.0	28.5	9.5	0.75	33%
SE3	25.4	31.3	-6.0	1.24	-19%
SS1	16.5	29.7	-13.2	1.80	-45%
SS2	15.1	17.3	-2.2	1.14	-12%

Site Name	Modelled Annual Mean Road NO_x (µg/m^3)	Monitored Annual Mean Road NO_x (µg/m^3)	Modelled Road NO_x Minus Monitored Road NO_x (µg/m^3)	Monitored Road NO_x / Modelled NO_x	% Difference (modelled Road NO_x - monitored Road NO_x) / monitored Road NO_x * 100
SS3	18.0	35.1	-17.1	1.95	-49%
SS5	25.2	52.4	-27.2	2.08	-52%
HR4	28.6	57.5	-28.9	2.01	-50%
HR1	40.6	72.9	-32.3	1.79	-44%
HR1c	58.5	160.0	-101.5	2.74	-63%
HR5	35.4	78.4	-43.0	2.21	-55%
HR6	38.3	84.4	-46.1	2.20	-55%

A comparison of measured and modelled (unadjusted) annual mean Road-NO_x concentrations is shown below in Figure B-2.

Figure B-2 – Measured Road-NO_x vs Modelled (Unadjusted) Road-NO_x

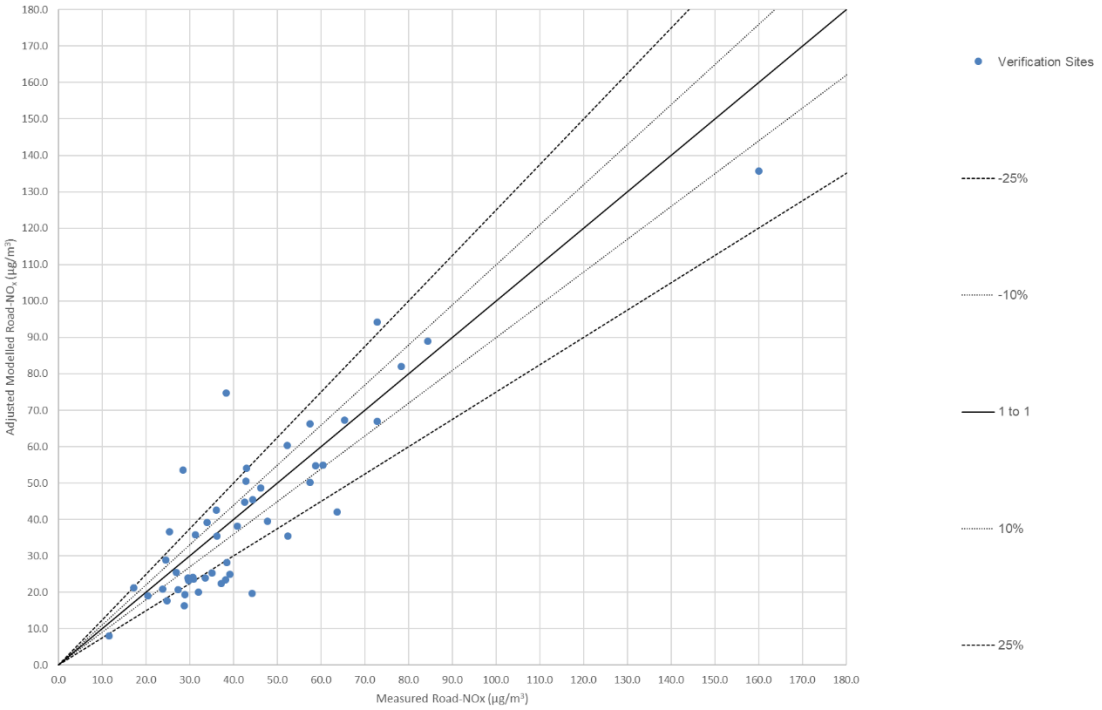


The results from the comparisons above have been used to derive the following model adjustment factors:

- the “Holyhead Road” factor of 2.32 was derived based on a linear regression of “monitored Road-NOx” vs. “modelled Road-NOx” at five monitoring locations along Holyhead Road (HR1, HR1c. HR4, HR5 and HR6); and
- the “Coventry-wide” factor of 1.41 was derived based on linear regression of “monitored Road-NOx” vs. “modelled Road-NOx” at the remaining 44 monitoring sites.

A comparison of measured and modelled (adjusted) annual mean Road-NO_x concentrations is shown below in Figure B-3.

Figure B-3 – Measured Road-NO_x vs Modelled (Adjusted) Road-NO_x



Step 3

A comparison of the post-adjustment modelled estimates of total annual mean NO_2 with monitored concentrations is presented in Table B-4. The model statistics post-adjustment are presented in Table B-5. The majority of modelled concentrations (94%) are within 25% of monitored concentrations at monitoring sites, and therefore in line with the recommended value given in DEFRA's Technical Guidance LAQM.TG(16). The overall RMSE is much improved, being well below the threshold value of 25% of the AQS objective (i.e. 10 µg/m^3) and close to the ideal of being within 10% of the AQS objective (i.e. 4 µg/m^3) and is therefore considered acceptable. The FB is much improved and quite small, although still slightly above the ideal value (0), indicating that the model tends to very slightly under predict.

Table B-4 – Comparison of Modelled and Measured NO_2 Concentrations (µg/m^3), Adjusted

Site Name	Background Annual Mean NO_2 (µg/m^3)	Monitored Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled NO_2 Minus Monitored NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
BA1	18.7	33.8	30.9	-2.9	-9%
BA1c	15.0	25.2	24.9	-0.3	-1%
BELL1	17.7	38.2	27.8	-10.3	-27%
BELL2	17.7	35.2	29.1	-6.1	-17%
BH13	18.6	34.1	36.7	2.6	8%

Site Name	Background Annual Mean NO_2 (µg/m^3)	Monitored Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled NO_2 Minus Monitored NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
BH14	18.6	37.5	38.9	1.4	4%
BH15i	18.6	**40.9**	**44.3**	3.4	8%
BH1a	20.7	37.6	**50.8**	13.3	35%
BH2a	18.6	**43.5**	**42.1**	-1.4	-3%
BH4	18.6	**45.3**	37.8	-7.4	-16%
BRN2	20.3	36.0	30.9	-5.1	-14%
BRN5	20.3	32.6	29.6	-3.0	-9%
CC01/1*N	22.1	36.8	34.3	-2.5	-7%
COAL	16.0	21.9	20.4	-1.5	-7%
COBR	19.6	33.4	29.5	-3.9	-12%
DH1	18.3	29.9	32.2	2.3	8%
FGS2	20.7	32.7	32.5	-0.1	0%
FGS3a	20.7	33.8	31.9	-1.9	-6%
FS1	22.8	**45.9**	**45.2**	-0.8	-2%
GR1	19.6	33.5	28.2	-5.3	-16%
GS1	24.1	35.3	40.2	4.9	14%
LON12	19.6	**48.8**	**50.3**	1.4	3%
LR1	17.1	37.8	39.3	1.5	4%
LR2	17.1	37.2	38.1	1.0	3%
LR3	17.6	38.7	36.0	-2.7	-7%
QAV12	17.9	31.1	28.5	-2.7	-9%
QAV13	17.9	37.3	**42.3**	4.9	13%
R5	21.5	40.1	**43.5**	3.4	9%
R6	21.5	**50.7**	**49.4**	-1.3	-3%
R8	20.3	37.3	31.7	-5.6	-15%
R9	19.6	36.9	31.5	-5.3	-14%
RR1	22.8	38.4	34.7	-3.7	-10%
RR2	22.8	40.4	36.6	-3.9	-10%
SHP2	16.8	28.6	27.6	-1.0	-3%
SHP3	16.8	34.0	34.2	0.2	1%
Grange2	18.1	36.5	35.9	-0.6	-2%
Grange3	18.1	34.6	37.7	3.1	9%
RR3	22.8	**48.5**	**46.3**	-2.2	-5%

Site Name	Background Annual Mean NO_2 (µg/m^3)	Monitored Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled NO_2 Minus Monitored NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
SE1	22.1	35.4	**45.9**	10.6	30%
SE3	22.1	36.6	39.0	2.4	6%
SS1	19.9	34.3	31.8	-2.5	-7%
SS2	22.8	31.3	33.6	2.3	8%
SS3	19.6	36.1	32.3	-3.8	-11%
SS5	22.8	**45.8**	39.6	-6.2	-13%
HR4	22.1	**47.7**	**51.7**	4.1	9%
HR1	22.1	**52.8**	**60.8**	8.0	15%
HR1c	22.1	**79.2**	**73.3**	-5.9	-7%
HR5	22.1	**55.1**	**57.2**	2.1	4%
HR6	22.1	**56.8**	**59.1**	2.3	4%

Table B-5 – Model Statistics Post-Adjustment

RMSE [i]	FB [ii]	r [iii]
4.50	0.01	0.897

Notes:

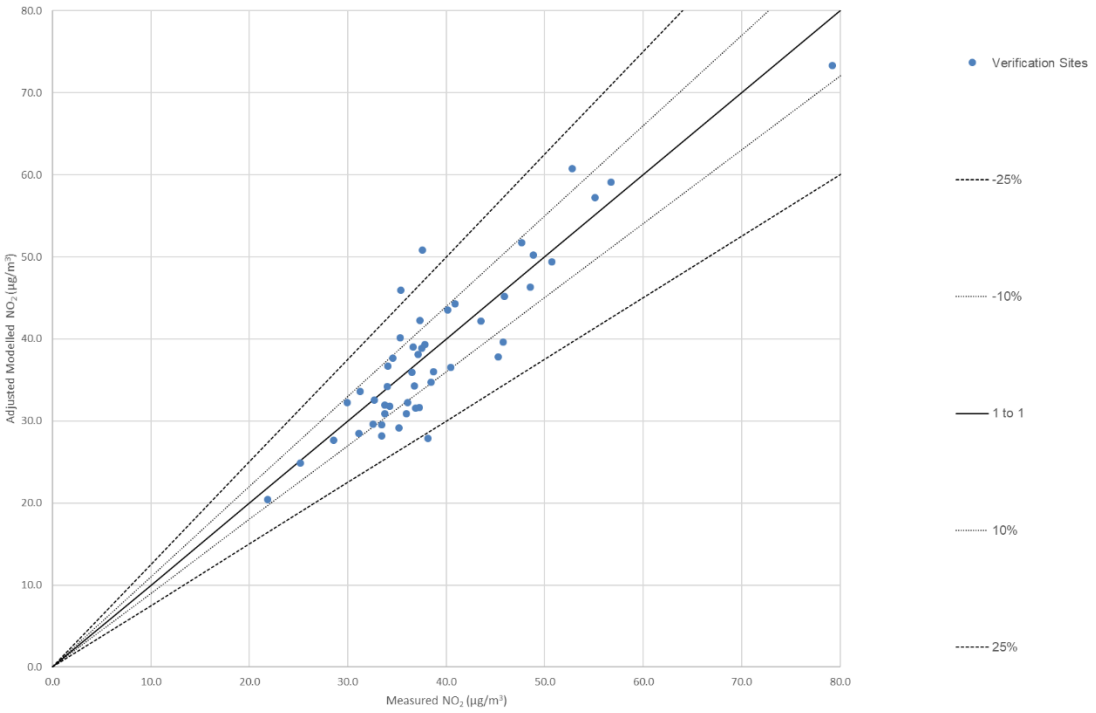
[i] Root Mean Square Error: RMSE is used to define the average error or uncertainty of the model (units = µg/m^3). In the case of modelled annual mean NO_2 a value of less than 10 is acceptable and less than 4 is the ideal

[ii] Fractional Bias: FB is used to identify if the model shows a systematic tendency to over or under estimate. Ideal value is 0

[iii] Correlation coefficient: r is used to measure the linear relationship between modelled and observed data. Ideal value is 1

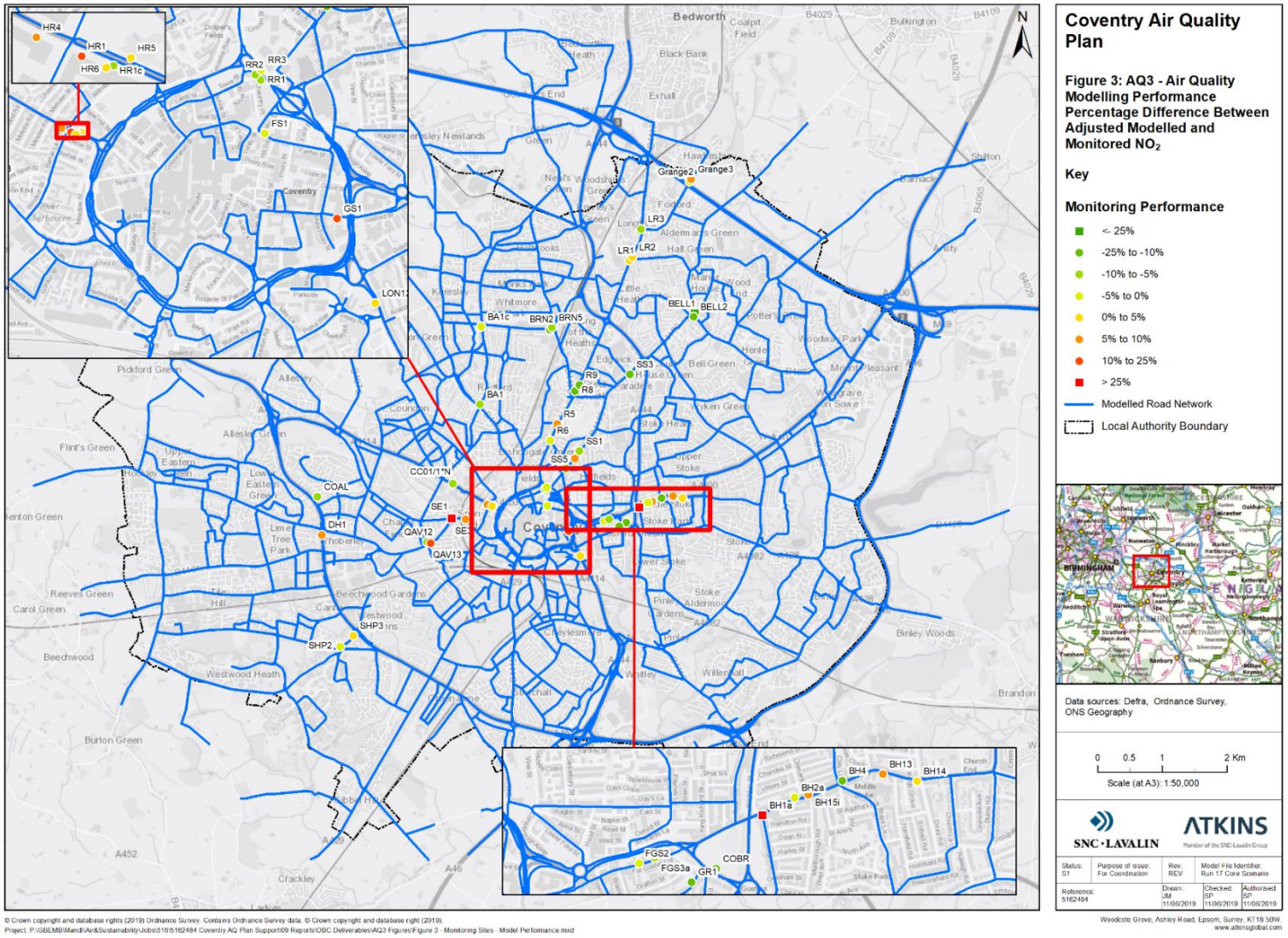
A comparison of measured and modelled (adjusted) annual mean NO_2 concentrations is shown below in Figure B-4.

Figure B-4 – Measured NO_2 vs Modelled (Adjusted) NO_2



The spatial variation in model performance between adjusted modelled NO_2 and monitored NO_2 is presented in Figure B-5.

Figure B-5 – Local Air Quality Model Performance



END