Public Document Pack

Cabinet

Supplementary Information

Date: Thursday, 25 February 2021

Time: 4.00 pm

Venue: Virtual Meeting - Zoom Committee Meeting with Public Access via YouTube

16. Improving Public Health - Bristol Clean Air Zone Update

FBC39 Appendices and FBC16 Appendix L **(Pages 2 - 103)**

Issued by: Corrina Haskins, Democratic Services
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Date: Thursday, 18 February 2021

Calculations - Running Costs

Core Analysis

Impacts
Discount Rate

As per HM Treasury Green Book. Used to convert future values to present values

Net Present Value
Net Present Value
Air Quality
NOx
PM
Consumer Welfare
Behvioural Response: Replace Vehicle
Behvioural Response: Cancel Trip/Avoid Zone/Re-mode
Vehicle Scrappage
Transactions
Traffic Flows
Greenhouse Gases
Set Up
Running Costs
Active Mode Appraisal Toolkit
Accidents

Aggregate of all economic impacts

END OF SHEET

return to map

Unit		Total	2018	2019	2020
			1.0000	0.9662	0.9335

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£		**-£214,417,992**	**£0**	**£0**	**-£164,326,888**
£		**£7,231,960**	£0	£0	£0
£		**£6,097,188**	£0	£0	£0
£		**£1,134,773**	£0	£0	£0
£		**-£136,171,739**	£0	£0	£0
£		**-£20,934,908**	£0	£0	£0
£		**-£115,236,830**	£0	£0	£0
£		**-£891,863**	£0	£0	£0
£		**-£134,810**	£0	£0	£0
£		**£102,309,358**	£0	£0	£0
£		**£1,447,201**	£0	£0	£0
£		**-£164,015,388**	£0	£0	-£164,015,388
£		**-£35,414,363**	£0	£0	-£311,500
£		**£11,221,650**	£0	£0	£0
£		**£35,734,298**	£0	£0	£0

2021	2022	2023	2024	2025	2026
0.9019	**0.8714**	**0.8420**	**0.8135**	**0.7860**	**0.7594**

-£39,299,970	**-£5,976,436**	**-£4,462,735**	**-£3,126,011**	**-£1,838,788**	**-£620,162**
£1,170,025	£1,062,618	£958,078	£856,345	£757,360	£661,063
£1,048,949	£943,296	£840,486	£740,457	£643,151	£548,510
£121,076	£119,321	£117,592	£115,888	£114,208	£112,553
-£45,807,082	-£13,739,586	-£12,689,035	-£11,693,952	-£10,751,481	-£9,859,539
-£20,149,533	-£100,420	-£97,321	-£94,445	-£91,475	-£88,757
-£25,657,549	-£13,639,166	-£12,591,714	-£11,599,507	-£10,660,006	-£9,770,782
-£867,421	-£2,082	-£2,306	-£2,644	-£2,774	-£3,015
-£126,478	-£1,067	-£1,033	-£1,002	-£971	-£941
£10,274,623	£10,261,212	£10,246,131	£10,231,866	£10,221,756	£10,222,134
£163,214	£158,918	£154,683	£150,512	£146,407	£142,369
£0	£0	£0	£0	£0	£0
-£5,327,931	-£4,914,406	-£4,304,622	-£3,820,438	-£3,340,579	-£2,892,159
£1,221,079	£1,197,958	£1,175,370	£1,153,301	£1,131,495	£1,109,926
£0	£0	£0	£0	£0	£0

[redacted]

2027	2028	2029	2030	Total
0.7337	**0.7089**	**0.6849**	**0.6618**	

£416,581	**£1,352,577**	**£2,277,382**	**£1,186,456**	**-£214,417,992**
£571,022	£482,582	£397,703	£315,165	£7,231,960
£460,100	£373,267	£289,973	£208,996	£6,097,188
£110,922	£109,314	£107,730	£106,169	£1,134,773
-£9,033,714	-£8,253,908	-£7,518,990	-£6,824,451	-£136,171,739
-£82,195	-£79,582	-£76,838	-£74,343	-£20,934,908
-£8,951,519	-£8,174,326	-£7,442,153	-£6,750,108	-£115,236,830
-£2,930	-£2,926	-£2,877	-£2,889	-£891,863
-£871	-£848	-£813	-£787	-£134,810
£10,217,334	£10,209,026	£10,211,548	£10,213,729	£102,309,358
£138,453	£134,654	£130,858	£127,133	£1,447,201
£0	£0	£0	£0	-£164,015,388
-£2,561,399	-£2,283,910	-£1,987,631	-£3,669,788	-£35,414,363
£1,088,686	£1,067,908	£1,047,584	£1,028,344	£11,221,650
£0	£0	£0	£0	£0

Operational Summary
Provides inputs to the 'c;Running Costs' tab. Taken from Financial Model

Revenue Streams
CAZ Income
Totals

Revenue Costs
OPERATIONS
Civil Enforcement Officer
Appeals Officers
Civil Enforcements Supervisor
Senior Appeals Officer
Senior Officer TPT
MEV software
MEV maintenance
Petrol for MEVs
Revenue payment (10%) to support ongoing operation of JAQU central payment system
DVLA database enquiries for Vehicle ID
Back office hardware and software maintenance/housekeeping
Back office system annual licence costs
Travel Plan Advisors - Staff x 4
Network management officer

MAINTENANCE
Camera replacement
Roadside equipment maintenance & VCA compliance check per camera
Camera post maintenance
B-Net communications network maintenance
Building maintenance and other related charges
Replacement/repair of CAZ boundary signs
Replacement/repair of CAZ advanced warning signs on local authority roads
Replacement/repair of diesel ban boundary signs
Replacement/repair of diesel ban advanced warning signs
Replacement/repair of wieght limit signing at boundary
Replacement/repair of weight limit advanced warning signing

COMMUNICATIONS
B-Net optical fibre network maintenance and support
4G communications service provision

POWER (ON STREET)
Power to cameras and comms equipment
Power to signage

CAZ PROJECT DELIVERY & ONGOING OPERATIONAL MANAGEMENT TEAM (staff resources)
Communications Lead (including materials) on ad hoc basis
Infrastructure Lead
Community Liaison Lead (including materials)
Site Supervision Lead
Supporting Infrastructure Lead
Operations Lead
Enforcement Lead
Financial Controller
Project management for CAF measures

MONITORING AND EVALUATION

Air quality monitoring - installations
Ongoing monitoring - Air Quality on-going
Ongoing monitoring - Traffic Levels
Ongoing monitoring - Economic Indicators
Ongoing monitoring - Active Modes (cycling / walking)
Ongoing scheme monitoring - Staff

OTHER
PCN generation
Stationery and supplies
PCN postage
Publicity and advertising
Health and wellbeing study set-up
Health and wellbeing study operation
Re-draft of Legal Charging Order
Weight restriction enforcement - Staff
Signage decommissioning [--only applies in final year of scheme--]
Camera and system decommissioning [--only applies in final year of scheme--]
Weight limit enforcement - TROs

Total Costs

Total Costs plus 5% Contingency

2018	2019	2020	2021	2022	2023	2024
£0	**£0**	**£0**	**£0**	**£0**	**£0**	**£0**

						Raw Cost
2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
£0	**£0**	**£0**	**£4,578,679**	**£4,114,608**	**£3,773,688**	**£3,150,701**
£0	£0	£0	£133,500	£106,800	£106,800	£80,100
£0	£0	£0	£107,460	£71,640	£71,640	£71,640
£0	£0	£0	£373,800	£320,400	£293,700	£240,300
£0	£0	£0	£126,800	£95,100	£95,100	£95,100
£0	£0	£0	£35,820	£35,820	£35,820	£35,820
£0	£0	£0	£18,400	£18,400	£18,400	£18,400
£0	£0	£0	£8,050	£8,050	£8,050	£8,050
£0	£0	£0	£3,450	£3,450	£3,450	£3,450
£0	£0	£0	£3,322,485	£3,006,034	£2,691,814	£2,148,927
£0	£0	£0	£115,000	£115,000	£115,000	£115,000
£0	£0	£0	£28,750	£28,750	£28,750	£28,750
£0	£0	£0	£57,500	£57,500	£57,500	£57,500
£0	£0	£0	£177,664	£177,664	£177,664	£177,664
£0	£0	£0	£70,000	£70,000	£70,000	£70,000

£0	**£0**	**£0**	**£387,780**	**£387,780**	**£387,780**	**£387,780**
£0	£0	£0	£120,750	£120,750	£120,750	£120,750
£0	£0	£0	£156,975	£156,975	£156,975	£156,975
£0	£0	£0	£12,880	£12,880	£12,880	£12,880
£0	£0	£0	£28,175	£28,175	£28,175	£28,175
£0	£0	£0	£28,750	£28,750	£28,750	£28,750
£0	£0	£0	£16,100	£16,100	£16,100	£16,100
£0	£0	£0	£16,100	£16,100	£16,100	£16,100
£0	£0	£0	£2,300	£2,300	£2,300	£2,300
£0	£0	£0	£1,150	£1,150	£1,150	£1,150
£0	£0	£0	£3,450	£3,450	£3,450	£3,450
£0	£0	£0	£1,150	£1,150	£1,150	£1,150

£0	**£0**	**£0**	**£70,990**	**£70,990**	**£70,990**	**£70,990**
£0	£0	£0	£12,202	£12,202	£12,202	£12,202
£0	£0	£0	£58,788	£58,788	£58,788	£58,788

£0	**£0**	**£0**	**£37,091**	**£37,091**	**£37,091**	**£37,091**
£0	£0	£0	£35,790	£35,790	£35,790	£35,790
£0	£0	£0	£1,301	£1,301	£1,301	£1,301

£0	**£0**	**£108,000**	**£456,000**	**£456,000**	**£244,500**	**£244,500**
£0	£0	£0	£1,500	£1,500	£0	£0
£0	£0	£0	£80,000	£80,000	£80,000	£80,000
£0	£0	£0	£80,000	£80,000	£80,000	£80,000
£0	£0	£108,000	£0	£0	£0	£0
£0	£0	£0	£62,000	£62,000	£62,000	£62,000
£0	£0	£0	£0	£0	£0	£0
£0	£0	£0	£0	£0	£0	£0
£0	£0	£0	£22,500	£22,500	£22,500	£22,500
£0	£0	£0	£210,000	£210,000	£0	£0

£0	**£0**	**£18,328**	**£172,950**	**£172,950**	**£172,950**	**£172,950**

£0	£0	£18,328	£0	£0	£0	£0
£0	£0	£0	£37,950	£37,950	£37,950	£37,950
£0	£0	£0	£57,500	£57,500	£57,500	£57,500
£0	£0	£0	£28,750	£28,750	£28,750	£28,750
£0	£0	£0	£28,750	£28,750	£28,750	£28,750
£0	£0	£0	£20,000	£20,000	£20,000	£20,000

£0	**£0**	**£182,059**	**£569,575**	**£494,214**	**£459,563**	**£400,023**
£0	£0	£0	£45,570	£41,292	£37,014	£29,664
£0	£0	£0	£217,216	£196,825	£176,434	£141,395
£0	£0	£0	£106,330	£96,348	£86,366	£69,215
£0	£0	£23,000	£23,000	£23,000	£23,000	£23,000
£0	£0	£40,710	£40,710	£0	£0	£0
£0	£0	£0	£41,400	£41,400	£41,400	£41,400
£0	£0	£23,000	£0	£0	£0	£0
£0	£0	£37,849	£37,849	£37,849	£37,849	£37,849
£0	£0	£0	£0	£0	£0	£0
£0	£0	£0	£0	£0	£0	£0
£0	£0	£57,500	£57,500	£57,500	£57,500	£57,500

£0	**£0**	**£308,387**	**£6,273,064**	**£5,733,633**	**£5,146,562**	**£4,464,034**

£0	**£0**	**£308,387**	**£6,273,064**	**£5,733,633**	**£5,146,562**	**£4,464,034**

2025	2026	2027	2028	2029	2030
£0	**£0**	**£0**	**£0**	**£0**	**£0**

2025	2026	2027	2028	2029	2030
£2,583,068	**£1,926,528**	**£1,410,229**	**£1,046,831**	**£788,985**	**£687,135**
£80,100	£53,400	£26,700	£26,700	£26,700	£26,700
£71,640	£35,820	£35,820	£35,820	£35,820	£35,820
£186,900	£133,500	£80,100	£53,400	£26,700	£26,700
£63,400	£63,400	£31,700	£31,700	£31,700	£31,700
£35,820	£35,820	£35,820	£35,820	£35,820	£35,820
£18,400	£18,400	£18,400	£18,400	£18,400	£18,400
£8,050	£8,050	£8,050	£8,050	£8,050	£8,050
£3,450	£3,450	£3,450	£3,450	£3,450	£3,450
£1,666,394	£1,125,774	£721,275	£384,577	£153,431	£51,581
£115,000	£115,000	£115,000	£115,000	£115,000	£115,000
£28,750	£28,750	£28,750	£28,750	£28,750	£28,750
£57,500	£57,500	£57,500	£57,500	£57,500	£57,500
£177,664	£177,664	£177,664	£177,664	£177,664	£177,664
£70,000	£70,000	£70,000	£70,000	£70,000	£70,000

£387,780	**£387,780**	**£387,780**	**£387,780**	**£387,780**	**£387,780**
£120,750	£120,750	£120,750	£120,750	£120,750	£120,750
£156,975	£156,975	£156,975	£156,975	£156,975	£156,975
£12,880	£12,880	£12,880	£12,880	£12,880	£12,880
£28,175	£28,175	£28,175	£28,175	£28,175	£28,175
£28,750	£28,750	£28,750	£28,750	£28,750	£28,750
£16,100	£16,100	£16,100	£16,100	£16,100	£16,100
£16,100	£16,100	£16,100	£16,100	£16,100	£16,100
£2,300	£2,300	£2,300	£2,300	£2,300	£2,300
£1,150	£1,150	£1,150	£1,150	£1,150	£1,150
£3,450	£3,450	£3,450	£3,450	£3,450	£3,450
£1,150	£1,150	£1,150	£1,150	£1,150	£1,150

£70,990	**£70,990**	**£70,990**	**£70,990**	**£70,990**	**£70,990**
£12,202	£12,202	£12,202	£12,202	£12,202	£12,202
£58,788	£58,788	£58,788	£58,788	£58,788	£58,788

£37,091	**£37,091**	**£37,091**	**£37,091**	**£37,091**	**£37,091**
£35,790	£35,790	£35,790	£35,790	£35,790	£35,790
£1,301	£1,301	£1,301	£1,301	£1,301	£1,301

£244,500	**£244,500**	**£244,500**	**£244,500**	**£244,500**	**£244,500**
£0	£0	£0	£0	£0	£0
£80,000	£80,000	£80,000	£80,000	£80,000	£80,000
£80,000	£80,000	£80,000	£80,000	£80,000	£80,000
£0	£0	£0	£0	£0	£0
£62,000	£62,000	£62,000	£62,000	£62,000	£62,000
£0	£0	£0	£0	£0	£0
£0	£0	£0	£0	£0	£0
£22,500	£22,500	£22,500	£22,500	£22,500	£22,500
£0	£0	£0	£0	£0	£0

£172,950	**£172,950**	**£172,950**	**£172,950**	**£0**	**£0**

£0	£0	£0	£0	£0	£0
£37,950	£37,950	£37,950	£37,950	£0	£0
£57,500	£57,500	£57,500	£57,500	£0	£0
£28,750	£28,750	£28,750	£28,750	£0	£0
£28,750	£28,750	£28,750	£28,750	£0	£0
£20,000	£20,000	£20,000	£20,000	£0	£0

£305,588	**£245,855**	**£200,899**	**£163,067**	**£135,002**	**£1,406,942**
£23,116	£15,742	£10,192	£5,521	£2,056	£727
£110,186	£75,034	£48,578	£26,315	£9,800	£3,461
£53,937	£36,730	£23,780	£12,882	£4,797	£1,695
£23,000	£23,000	£23,000	£23,000	£23,000	£23,000
£0	£0	£0	£0	£0	£0
£0	£0	£0	£0	£0	£0
£0	£0	£0	£0	£0	£0
£37,849	£37,849	£37,849	£37,849	£37,849	£37,849
£0	£0	£0	£0	£0	£609,960
£0	£0	£0	£0	£0	£672,750
£57,500	£57,500	£57,500	£57,500	£57,500	£57,500

£3,801,966	**£3,085,694**	**£2,524,438**	**£2,123,209**	**£1,664,347**	**£2,834,437**

£3,801,966	**£3,085,694**	**£2,524,438**	**£2,123,209**	**£1,664,347**	**£2,834,437**

Total
£0

Total	Optimism Bias		2018	2019	2020
£24,060,452			**£0**	**£0**	**£0**
£667,500	0%		£0	£0	£0
£573,120	0%		£0	£0	£0
£1,735,500	0%		£0	£0	£0
£665,700	0%		£0	£0	£0
£358,200	0%		£0	£0	£0
£184,000	200%		£0	£0	£0
£80,500	0%		£0	£0	£0
£34,500	0%		£0	£0	£0
£15,272,292	0%		£0	£0	£0
£1,150,000	200%		£0	£0	£0
£287,500	200%		£0	£0	£0
£575,000	0%		£0	£0	£0
£1,776,640	0%		£0	£0	£0
£700,000	0%		£0	£0	£0
£3,877,800			**£0**	**£0**	**£0**
£1,207,500	44%		£0	£0	£0
£1,569,750	44%		£0	£0	£0
£128,800	44%		£0	£0	£0
£281,750	200%		£0	£0	£0
£287,500	44%		£0	£0	£0
£161,000	44%		£0	£0	£0
£161,000	44%		£0	£0	£0
£23,000	44%		£0	£0	£0
£11,500	44%		£0	£0	£0
£34,500	44%		£0	£0	£0
£11,500	44%		£0	£0	£0
£709,895			**£0**	**£0**	**£0**
£122,015	200%		£0	£0	£0
£587,880	200%		£0	£0	£0
£370,910			**£0**	**£0**	**£0**
£357,903	200%		£0	£0	£0
£13,007	200%		£0	£0	£0
£2,976,000			**£0**	**£0**	**£108,000**
£3,000	0%		£0	£0	£0
£800,000	0%		£0	£0	£0
£800,000	0%		£0	£0	£0
£108,000	0%		£0	£0	£108,000
£620,000	0%		£0	£0	£0
£0	0%		£0	£0	£0
£0	0%		£0	£0	£0
£225,000	0%		£0	£0	£0
£420,000	0%		£0	£0	£0
£1,401,928			**£0**	**£0**	**£18,328**

£18,328	0%	£0	£0	£18,328
£303,600	0%	£0	£0	£0
£460,000	0%	£0	£0	£0
£230,000	0%	£0	£0	£0
£230,000	0%	£0	£0	£0
£160,000	0%	£0	£0	£0
£4,562,787		**£0**	**£0**	**£207,359**
£210,894	0%	£0	£0	£0
£1,005,244	0%	£0	£0	£0
£492,080	0%	£0	£0	£0
£253,000	0%	£0	£0	£23,000
£81,420	0%	£0	£0	£40,710
£165,600	0%	£0	£0	£0
£23,000	0%	£0	£0	£23,000
£416,339	0%	£0	£0	£37,849
£609,960	44%	£0	£0	£0
£672,750	44%	£0	£0	£0
£632,500	44%	£0	£0	£82,800
£37,959,771		**£0**	**£0**	**£333,687**
£37,959,771		**£0**	**£0**	**£333,687**

With Optimism Bias					
2021	**2022**	**2023**	**2024**	**2025**	**2026**
£4,902,979	**£4,438,908**	**£4,097,988**	**£3,475,001**	**£2,907,368**	**£2,250,828**
£133,500	£106,800	£106,800	£80,100	£80,100	£53,400
£107,460	£71,640	£71,640	£71,640	£71,640	£35,820
£373,800	£320,400	£293,700	£240,300	£186,900	£133,500
£126,800	£95,100	£95,100	£95,100	£63,400	£63,400
£35,820	£35,820	£35,820	£35,820	£35,820	£35,820
£55,200	£55,200	£55,200	£55,200	£55,200	£55,200
£8,050	£8,050	£8,050	£8,050	£8,050	£8,050
£3,450	£3,450	£3,450	£3,450	£3,450	£3,450
£3,322,485	£3,006,034	£2,691,814	£2,148,927	£1,666,394	£1,125,774
£345,000	£345,000	£345,000	£345,000	£345,000	£345,000
£86,250	£86,250	£86,250	£86,250	£86,250	£86,250
£57,500	£57,500	£57,500	£57,500	£57,500	£57,500
£177,664	£177,664	£177,664	£177,664	£177,664	£177,664
£70,000	£70,000	£70,000	£70,000	£70,000	£70,000
£602,356	**£602,356**	**£602,356**	**£602,356**	**£602,356**	**£602,356**
£173,880	£173,880	£173,880	£173,880	£173,880	£173,880
£226,044	£226,044	£226,044	£226,044	£226,044	£226,044
£18,547	£18,547	£18,547	£18,547	£18,547	£18,547
£84,525	£84,525	£84,525	£84,525	£84,525	£84,525
£41,400	£41,400	£41,400	£41,400	£41,400	£41,400
£23,184	£23,184	£23,184	£23,184	£23,184	£23,184
£23,184	£23,184	£23,184	£23,184	£23,184	£23,184
£3,312	£3,312	£3,312	£3,312	£3,312	£3,312
£1,656	£1,656	£1,656	£1,656	£1,656	£1,656
£4,968	£4,968	£4,968	£4,968	£4,968	£4,968
£1,656	£1,656	£1,656	£1,656	£1,656	£1,656
£212,969	**£212,969**	**£212,969**	**£212,969**	**£212,969**	**£212,969**
£36,605	£36,605	£36,605	£36,605	£36,605	£36,605
£176,364	£176,364	£176,364	£176,364	£176,364	£176,364
£111,273	**£111,273**	**£111,273**	**£111,273**	**£111,273**	**£111,273**
£107,371	£107,371	£107,371	£107,371	£107,371	£107,371
£3,902	£3,902	£3,902	£3,902	£3,902	£3,902
£456,000	**£456,000**	**£244,500**	**£244,500**	**£244,500**	**£244,500**
£1,500	£1,500	£0	£0	£0	£0
£80,000	£80,000	£80,000	£80,000	£80,000	£80,000
£80,000	£80,000	£80,000	£80,000	£80,000	£80,000
£0	£0	£0	£0	£0	£0
£62,000	£62,000	£62,000	£62,000	£62,000	£62,000
£0	£0	£0	£0	£0	£0
£0	£0	£0	£0	£0	£0
£22,500	£22,500	£22,500	£22,500	£22,500	£22,500
£210,000	£210,000	£0	£0	£0	£0
£172,950	**£172,950**	**£172,950**	**£172,950**	**£172,950**	**£172,950**

£0	£0	£0	£0	£0	£0
£37,950	£37,950	£37,950	£37,950	£37,950	£37,950
£57,500	£57,500	£57,500	£57,500	£57,500	£57,500
£28,750	£28,750	£28,750	£28,750	£28,750	£28,750
£28,750	£28,750	£28,750	£28,750	£28,750	£28,750
£20,000	£20,000	£20,000	£20,000	£20,000	£20,000
£594,875	**£519,514**	**£484,863**	**£425,323**	**£330,888**	**£271,155**
£45,570	£41,292	£37,014	£29,664	£23,116	£15,742
£217,216	£196,825	£176,434	£141,395	£110,186	£75,034
£106,330	£96,348	£86,366	£69,215	£53,937	£36,730
£23,000	£23,000	£23,000	£23,000	£23,000	£23,000
£40,710	£0	£0	£0	£0	£0
£41,400	£41,400	£41,400	£41,400	£0	£0
£0	£0	£0	£0	£0	£0
£37,849	£37,849	£37,849	£37,849	£37,849	£37,849
£0	£0	£0	£0	£0	£0
£0	£0	£0	£0	£0	£0
£82,800	£82,800	£82,800	£82,800	£82,800	£82,800
£7,053,402	**£6,513,970**	**£5,926,899**	**£5,244,371**	**£4,582,303**	**£3,866,031**
£7,053,402	**£6,513,970**	**£5,926,899**	**£5,244,371**	**£4,582,303**	**£3,866,031**

2027	2028	2029	2030	Total
£1,734,529	**£1,371,131**	**£1,113,285**	**£1,011,435**	**£27,303,452**
£26,700	£26,700	£26,700	£26,700	£667,500
£35,820	£35,820	£35,820	£35,820	£573,120
£80,100	£53,400	£26,700	£26,700	£1,735,500
£31,700	£31,700	£31,700	£31,700	£665,700
£35,820	£35,820	£35,820	£35,820	£358,200
£55,200	£55,200	£55,200	£55,200	£552,000
£8,050	£8,050	£8,050	£8,050	£80,500
£3,450	£3,450	£3,450	£3,450	£34,500
£721,275	£384,577	£153,431	£51,581	£15,272,292
£345,000	£345,000	£345,000	£345,000	£3,450,000
£86,250	£86,250	£86,250	£86,250	£862,500
£57,500	£57,500	£57,500	£57,500	£575,000
£177,664	£177,664	£177,664	£177,664	£1,776,640
£70,000	£70,000	£70,000	£70,000	£700,000
£602,356	**£602,356**	**£602,356**	**£602,356**	**£6,023,562**
£173,880	£173,880	£173,880	£173,880	£1,738,800
£226,044	£226,044	£226,044	£226,044	£2,260,440
£18,547	£18,547	£18,547	£18,547	£185,472
£84,525	£84,525	£84,525	£84,525	£845,250
£41,400	£41,400	£41,400	£41,400	£414,000
£23,184	£23,184	£23,184	£23,184	£231,840
£23,184	£23,184	£23,184	£23,184	£231,840
£3,312	£3,312	£3,312	£3,312	£33,120
£1,656	£1,656	£1,656	£1,656	£16,560
£4,968	£4,968	£4,968	£4,968	£49,680
£1,656	£1,656	£1,656	£1,656	£16,560
£212,969	**£212,969**	**£212,969**	**£212,969**	**£2,129,685**
£36,605	£36,605	£36,605	£36,605	£366,045
£176,364	£176,364	£176,364	£176,364	£1,763,640
£111,273	**£111,273**	**£111,273**	**£111,273**	**£1,112,729**
£107,371	£107,371	£107,371	£107,371	£1,073,709
£3,902	£3,902	£3,902	£3,902	£39,020
£244,500	**£244,500**	**£244,500**	**£244,500**	**£2,976,000**
£0	£0	£0	£0	£3,000
£80,000	£80,000	£80,000	£80,000	£800,000
£80,000	£80,000	£80,000	£80,000	£800,000
£0	£0	£0	£0	£108,000
£62,000	£62,000	£62,000	£62,000	£620,000
£0	£0	£0	£0	£0
£0	£0	£0	£0	£0
£22,500	£22,500	£22,500	£22,500	£225,000
£0	£0	£0	£0	£420,000
£172,950	**£172,950**	**£0**	**£0**	**£1,401,928**

£0	£0	£0	£0	£18,328
£37,950	£37,950	£0	£0	£303,600
£57,500	£57,500	£0	£0	£460,000
£28,750	£28,750	£0	£0	£230,000
£28,750	£28,750	£0	£0	£230,000
£20,000	£20,000	£0	£0	£160,000

£226,199	**£188,367**	**£160,302**	**£1,996,634**	**£5,405,479**
£10,192	£5,521	£2,056	£727	£210,894
£48,578	£26,315	£9,800	£3,461	£1,005,244
£23,780	£12,882	£4,797	£1,695	£492,080
£23,000	£23,000	£23,000	£23,000	£253,000
£0	£0	£0	£0	£81,420
£0	£0	£0	£0	£165,600
£0	£0	£0	£0	£23,000
£37,849	£37,849	£37,849	£37,849	£416,339
£0	£0	£0	£878,342	£878,342
£0	£0	£0	£968,760	£968,760
£82,800	£82,800	£82,800	£82,800	£910,800

£3,304,775	**£2,903,546**	**£2,444,684**	**£4,179,167**	**£46,352,835**

£3,304,775	**£2,903,546**	**£2,444,684**	**£4,179,167**	**£46,352,835**

Bristol City Council Clean Air Plan Final Business Case

Sensitivity Testing Report

FBC 39

19 May 2020

Bristol City Council

Bristol City Council Clean Air Plan Final Business Case

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2	27.10.19	OBC draft	KT / KW	CB	HO	HO
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4	18.05.20	FBC draft	KT / KW	CB	HO	HO
5	19.05.20	FBC draft	KT / KW	CB	HO	HO

Contents

Acronyms and Abbreviations

ANPR	Automatic Number Plate Recognition
BCC	Bristol City Council
CAZ(s)	Clean Air Zone(s)
CAP	Clean Air Plan
CO_2	Carbon Dioxide
Defra	Department for Environment Food & Rural Affairs
DfT	Department for Transport
EFT	Emissions Factors Toolkit
Euro	European
FBC	Full Business Case
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit
LAQM	Local Air Quality Management
LGV	Light Goods Vehicle
HGV	Heavy Goods Vehicle
NOx	Nitrous Oxides
NO_2	Nitrogen Dioxide
OBC	Outline Business Case
OS	Ordnance Survey
PM	Particulate Matter
RSI	Roadside Interview
SP	Stated Preference
(Web)TAG	Transport Analysis Guidance

1. Introduction

1.1 Context

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). BCC has monitored and endeavoured to address air quality in Bristol for decade and declared their first Air Quality Management Area in 2001. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until around 2027 without intervention.

In 2017 the government published a UK Air Quality Plan for Nitrogen Dioxide[2] setting out how compliance with the EU Limit Value for annual mean NO_2 will be reached across the UK in the shortest possible time. Due to forecast air quality exceedances, BCC, along with 27 other Local Authorities, was directed by the then Minister Therese Coffey (Defra) and the then Minister Jesse Norman (DfT) in 2017 to produce a Clean Air Plan (CAP). The Plan must set out how BCC will achieve sufficient air quality improvements in the shortest possible time. In line with Government guidance BCC is considering implementation of a Clean Air Zone (CAZ), including both charging and non-charging measures, in order to achieve sufficient improvement in air quality and public health. This process requires the production of a Strategic Outline Case (April 2018), an Outline Business Case (October 2019) and a Full business Case, which this report supports.

Following the submission of the OBC, further work was undertaken to develop the scheme, which resulted in the development of a new option - the Medium area CAZ C/Small area CAZ D. This work, and the option development work undertaken as part of the OBC, is presented in an updated Option Assessment Report (Appendix C FBC-16).

Jacobs has been commissioned by BCC to produce an Outline Business Case (OBC) and Full Business Case (FBC) for the delivery of the CAP; a package of measures which will bring about compliance with the Limit Value for annual mean NO_2 in the shortest time possible in Bristol.

This report provides details of the following sensitivity tests on the Medium CAZ C/Small CAZ D scenario:

- Behavioural response to charging
- Euro 6 vehicles
- Decremental testing
- Age of transport model
- Revised boundary St Philips Causeway

The report also contains a sensitivity test in relation to the Hybrid scheme with small area diesel car ban as follows:

- Diesel ban sensitivity test

The previous sensitivity test work undertaken prior the FBC is summarised in this report.

A summary of all sensitivity tests and key findings in this report is provided in section 6.

1.2 Scheme description

The Medium CAZ C / Small CAZ D scheme includes the following components:

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[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution

[2] https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

- Small Area Class D – (charging non-compliant cars)
- Medium Area Class C (charging non-compliant buses, coaches, taxis, HGVs and LGVs);
- Closure of Cumberland Road inbound to general traffic;
- M32 Park and Ride (P&R) with bus lane inbound; and
- Holding back traffic to the city centre through the use of existing signals.

The Hybrid scheme includes the following components.

- 8-hour Small Area diesel car exclusion (7am – 3pm).
- Medium Area Class C (charging non-compliant buses, coaches, taxis, HGVs and LGVs);
- Closure of Cumberland Road inbound to general traffic;
- M32 Park and Ride (P&R) with bus lane inbound; and
- Holding back traffic to the city centre through the use of existing signals.

Full details of the modelling methodology for these schemes can be found in FBC-23 Local Plan Transport Modelling Methodology Report (T3) and transport model results can be found in FBC-27 Local Plan Transport Model Forecasting Report (T4).

2. Sensitivity testing undertaken for the Outline Business Case

2.1 Introduction

To assess the modelling uncertainty, a series of sensitivity tests were undertaken on both the models of the baseline and preferred option as part of the Outline Business Case. These were:

Traffic Modelling (Section 2)	Air Quality Modelling (Section 3)
▪ Fleet splits by fuel type: ANPR vs. NAEI(EFT) ▪ HGV adjustment factors ▪ Behavioural response to charging	▪ Euro 6 vehicles ▪ Emissions at low speeds ▪ Background concentrations ▪ Model verification ▪ Gradient ▪ Primary NO_2 Fraction

2.2 Summary of key results from the OBC sensitivity tests

Full details of this assessment are provided in OBC-31 'Sensitivity Test report' appended to this report, see Appendix A. A summary of the key results of the OBC sensitivity tests is provided below.

Test	Section Number	Summary	Key Results
Uncertainties in the Traffic Modelling			
HGV adjustment factors	2.2.1	HGV flow adjustments were made on links with significant differences in modelled flows compared to observed counts. These adjustments were carried through to future years for both the baseline and Core scenario.	The statistics indicated that removing HGV adjustment factors had a negligible impact on NO_2 concentrations at reportable receptors. The maximum NO_2 concentration increased by one tenth of a microgram resulting in the gap between exceeding the Limit Value narrowing slightly.
Fleet Composition: Splits by Fuel Type	2.2.2	A test to examine the differences in annual mean NO_2 concentrations between the Core Scenario modelled using fuel splits derived from the WebTAG Databook and new information provided in the EFT v9.1b	If the EFT V9.1b fuel splits are used then the 2027 Core scheme would be compliant by a greater margin (-2 μg/m^3), with a maximum exceedance of 38.0 μg/m^3. The revised fuel splits are considered to be more robust than the WebTAG Data Book
Behavioural Reponses to Charging	2.3.1	Defined pessimistic and optimistic response rates based on confidence intervals of SP survey statistical modelling and adjusted assumptions for other vehicle types. Compared NO_2 concentrations to Core scenario.	The results for the high and low scenarios are very similar and overall, the 'Central' scenario is most representative. The conclusion of compliance is thus considered appropriate.
Uncertainties in the Air Quality Modelling			
Euro 6 Vehicles	3.1.1	The EFT is based on COPERT 5 which predicts different NOx emissions from Euro 6 diesel vehicles registered in different years (based on the expectation that Euro 6 emissions will reduce over time). Sensitivity test outlined in JAQU's 'Supplementary Note on Sensitivity Testing' has been run.	The results indicate that the central case assumption represents with reasonable certainty the range of expectant Euro 6 variance of NOx emissions from diesel light duty vehicles.

Test	Section Number	Summary	Key Results
Emissions at Low Speeds	3.2.1	JAQU has set out a methodology to assess the uncertainty of emissions from vehicles travelling at low speeds in their 'Supplementary Note on Sensitivity Testing' which involves using a polynomial equation provided by JAQU which is based on using the COPERT emissions functions beyond their intended speed ranges.	There is little or no difference between the 'High' and 'Central' predictions, with a difference of -1.3% as a maximum percentage gap from compliance. The 'Low' scenario also predicts similar concentrations. In all three scenarios, the 2027 Core scenario is compliant.
Background Concentrations	3.3	To test the sensitivity of results to calibration adjustments made to the 2015 Defra modelled background concentrations (these being based on COPERT5 emission factors) compared with local NO_2 monitoring results.	Without a local calibration factor being applied to Defra's national pollution background maps, the predicted concentrations are generally lower than if backgrounds are calibrated, receptors remain compliant.
Model Verification	3.4	The model verification for road NOX and subsequent NO_2 on roads adjacent to monitoring sites was thoroughly tested and included comparing a zoned with a global approach. The verification factor applied to all receptors was 2.28 and was based on 85 sites. The zonal approach considered non-gradient roads, gradient roads and Rupert Street which has very specific air quality issues.	There was no justification for sensitivity testing the verification for any other parameters.
Gradients	3.5.1	JAQU has set out a methodology to assess the uncertainty of vehicles travelling on gradients in their 'Supplementary Note on Sensitivity Testing' and suggest that LAs run a sensitivity test around gradient-based emission factors by removing the impact of modelling gradients if gradients were modelled in the 'central' scenario.	The results of the sensitivity tests for a 2027 Core scenario indicate that overall gradient has little impact on the results. Clearly, were specific links to be analysed where gradients are evident the results would show greater differences. There was a slight reduction in the mean and the maximum annual mean NO_2 concentrations, all receptors remained compliant
Primary NO_2 Fraction	3.6.1	There is emerging evidence that the average primary NO_2 fraction (f-NO_2) in exhaust emissions from road vehicles has begun to decrease in recent years. This is not taken into account within the EFT, as used for the air quality modelling. To account for this, JAQU suggest that a sensitivity test be carried out whereby the f-NO_2 values are reduced by 40% in the future projected year.	If the f-NO_2 values are reduced by 40% then the predicted concentrations are slightly lower, with the maximum predicted concentration being 4 $\mu g/m^3$ lower than the 'Central' scenario. This suggests that an earlier year to the predicted 2027 could be compliant if f-NO_2 values decrease in accordance with this assumption. On this basis, the 'Central' scenario with a 2027 compliant year is considered to be robust.

In summary, a wide range of sensitivity testing was undertaken which shows both compliant and non-compliant results. Whilst this demonstrated some variability within the results (as would be expected in any modelling process), the likelihood of compliance and non-compliance occurring was fairly similar, even when taking into account cumulative aspects. There is emerging evidence that the average primary nitrogen dioxide fraction (f-NO_2) in exhaust emissions from road vehicles has begun to decrease in recent years, and the sensitivity testing has demonstrated that this may result in significantly lower concentrations; this was thus considered to be the largest uncertainty associated with the modelling.

3. Consideration of tests to be undertaken at the FBC stage

Following the submission of the BCC CAZ OBC, further work was undertaken to develop the scheme, and this work resulted in the development of a new option, the Medium area CAZ C/Small area CAZ D option. This work, and the option development work undertaken as part of the OBC is presented in an updated Option Assessment Report (Appendix C OBC-16). Further to this, JAQU have provided feedback on the OBC from the T-IRP.

Consideration has been given to the choice of sensitivity tests to support the FBC. A list of the sensitivity tests undertaken for the FBC are set out below.

Source	Description	Recommended to be undertaken for the FBC
OBC sensitivity test	Behavioural response to charging	Yes – previous pessimistic test showed slightly higher mean NO_2 when compared to the previous core scenario (the hybrid) – so redo this test
OBC sensitivity test	Euro 6 vehicles	Yes – previous high emissions test showed slightly higher mean NO_2 when compared to the previous central case – so redo this test
Analytical Assurance Statement/TIRP row 24	Decremental testing	Yes – A decremental test removing the Park and Ride site has been undertaken
Analytical Assurance Statement/TIRP row 17	Age of transport model	Yes
TIRP row 21/25	Diesel ban sensitivity test	Yes – single test being undertaken.
BCC	Revised boundary St Philips Causeway	Yes

In deriving the list above, consideration was given to other potential sensitivity tests, the rationale for not undertaking these tests is set out below.

ng these tests is set out below.

Description	Justification for not undertaking the sensitivity test in the FBC
Fleet splits by fuel type: ANPR vs.NAEI (EFT)	Latest Core Scenario uses EFT splits
HGV adjustment factors	Previous test showed slightly lower mean NO_2 when compared to the previous core scenario (the hybrid)
Emissions at low speeds	Previous high emissions test shows no difference in the mean NO_2 compared to the previous central case
Background concentrations	Assessment showed that without a local calibration factor being applied to Defras national pollution background maps, the predicted concentrations are generally lower than if backgrounds are calibrated, receptors remain compliant.
Model verification	No evidence to justify test in the OBC
Gradient	Previous test without gradients test showed slightly lower mean NO_2 when compared to the previous with gradients test
Primary NO_2 factor	Previous low test showed lower mean NO_2 when compared to the previous central case

4. Traffic Modelling

4.1 Overview

In estimating the effects of the Core Scenario, the air quality predictions are dependent upon the traffic data used in the modelling. These data are a combination of national predictions, JAQU guidance, consultations with BCC, and local studies. The data sources used in the traffic modelling have been selected to give the best possible representation of the effects of the CAZ. Like all predictions, this methodology has several uncertainties associated with it. A detailed account of the forecasting methodology and core scenario assumptions can be found in FBC-27 Transport Model Forecasting Report (T4). In this section, a series of sensitivity tests have been developed based on known uncertainties in these assumptions.

Section 4.2 considers uncertainties in the predicted behavioural response to charging by developing and analysing the most likely 'pessimistic' alternative scenario. Section 4.3 considers the impact of removing the Park and Ride (P&R) option. Section 4.4 considers the age of the transport model and adjusting model flows and speeds to up-to-date observed data. Section 4.5 considers a boundary change to the medium CAZ area to exclude St. Philips Causeway. These four variations are modelled using the Medium CAZ D + Small CAZ D option. The last model variation is compared against the Revised Hybrid option and is shown in Section 4.6, where the uncertainties in the predicted behavioural response to the 'ban' by developing and analysing the most likely 'pessimistic' (i.e. less effective) alternative scenario are considered. When appropriate, air quality testing has been performed to estimate the emissions, NO_2 concentrations, and compliance of the test scenarios and compare the results to the core scenario. Air quality modelling indicates that the Core Scenarios for both the Medium CAZ D + Small CAZ D and the Revised Hybrid will achieve total compliance in 2023.

4.2 Behavioural Response to Charging

The success of the Clean Air Zone depends largely on how it influences the behaviour of drivers in the region. The drivers of non-car vehicles are expected to respond to the charging medium area CAZ C by either avoiding the area, changing their travel mode, or changing to a compliant vehicle, all of which will help to improve NO_2 pollution in Bristol. However, some drivers will decide to pay the CAZ charge instead of changing their behaviour.

For the Core scenario, the behavioural response to charging CAZ C was predicted using a variety of sources. A stated preference (SP) survey was conducted on drivers in Bristol and the surrounding areas to determine how they would respond, and how likely they would be to upgrade their vehicle based on various CAZ charges and upgrade costs. The final response rates were based on statistical models from the SP survey and predicted costs for upgrading to a compliant vehicle. For non-compliant light goods vehicle, responses for 'vans' from the stated preference surveys were used. A full report of the SP survey and statistical modelling is provided in OBC-28 Stated Preference Surveys Report. For coaches and HGVs, the proportions from 'Table 2 – Behavioural responses to charging Clean Air Zones' within the JAQU Evidence package have been used. Bus and Taxi responses are based on talks with Bristol City Council and the service providers.

The final Core scenario response rates for the Medium CAZ C + Small CAZ D option are provided in Table 4.1. A detailed report on the methodology for calculating these response rates is available in OBC-26 Response Rates Technical Note Appendix E of the OBC.

Table 4-1: Core Scenario Primary Behavioural Response Rates – Medium CAZ C + Small CAZ D

Response	Cars Low Income	Cars Medium Income	Cars High Income	Cars Employers Business	Taxis	LGVs	HGVs	Buses	Coaches
Pay Charge	4.3%	10.4%	5.4%	6.8%	4.1%	15.9%	8.8%	0.0%	17.8%
Avoid Zone	15.6%	19.0%	15.7%	7.7%	0.0%	19.2%	4.3%	0.0%	0.0%
Cancel Journey / Change Mode	39.8%	20.4%	14.2%	30.7%	0.0%	2.6%	4.3%	6.4%	11.4%
Replace Vehicle	40.4%	50.3%	64.6%	54.8%	95.9%	62.2%	82.6%	93.6%	70.8%

4.2.1 Development of Pessimistic Scenario

Medium CAZ C

To account for uncertainties in the Core scenario response rates, an alternative scenario was developed assuming pessimistic driver responses in terms of expected air quality impacts. The pessimistic scenario accounts for the most-likely uncertainties that would cause more drivers to pay the CAZ C charge than in the Core scenario. In this case, there would be a smaller behavioural response to charging and therefore a smaller improvement to the NO_2 pollution in Bristol city centre. To develop a pessimistic scenario for the charging CAZ C, the replace vehicle response was decreased by 20% for taxis, HGVs and Coaches and the change in the replace vehicle response was compensated for by a change in the pay charge response.

For LGVs, the parameters of the SP survey statistical models were adjusted to the bottom end of their 95% confidence intervals so that more drivers would pay the charge over replacing their vehicles over a 24-hour time-period. The pessimistic response rates for the Medium CAZ C are given in Table 4-2.

Table 4-2: Pessimistic Scenario Primary Response Rates– Medium CAZ C

Response	Taxis	LGVs	HGVs	Buses	Coaches
Pay Charge	23.3%	27.2%	25.3%	0.0% *	31.9%
Avoid Zone	0.0%	19.2%	4.3%	0.0%	0.0%
Cancel Journey / Change Mode	0.0%	2.6%	4.3%	6.4%	11.4%
Replace Vehicle	76.7%	51.0%	66.1%	93.6%	56.7%

** This value was 0.0% in core scenario, so a percent change cannot be calculated.*

Small CAZ D

For the Small CAZ D, where cars are charged over the Small CAZ area, the parameters of the SP survey statistical models were adjusted to the top or bottom end of their 95% confidence intervals so that more drivers would pay the charge over the replace their vehicles over a 24-hour time-period. The pessimistic response rates for the Small CAZ D are given in Table 4-3.

Table 4-3: Pessimistic Scenario Primary Response Rates – Small CAZ D

Response	Cars Low Income	Cars Medium Income	Cars High Income	Cars Employers Business
Pay Charge	10.0%	19.8%	13.6%	8.8%
Avoid Zone	15.6%	19.0%	15.7%	7.7%
Cancel Journey / Change Mode	39.8%	20.4%	14.2%	30.7%
Replace Vehicle	35%	41%	56%	53%

4.2.2 Results from Air Quality Testing

The air quality summary statistics for the 'pessimistic' scenario are presented in Table 4-4 and as distributional box plots in Figure 4-1. In each case results are presented for the 2025 reference case, central case for the Core scenario (i.e. Medium CAZ C/Small CAZ D) and the sensitivity test. Generally, air quality is likely to be adversely affected with the mean NO_2 concentration increasing by 0.2µg/m^3 and the maximum by 0.5 µg/m^3.

In terms of the compliance year, the 'pessimistic' scenario puts compliance back to 2024 from the 2023 Core estimate. This is shown in Table 4-5 for the critical locations. The compliance year for the Core scenario is shaded green and the 'pessimistic' scenario is shaded orange.

Table 4-4 Simple Summary Statistics for Sensitivity Testing of the pessimistic scenario (µg/m^3) – Annual mean NO_2 concentration.

Statistic	2025 Reference Case	Central Case	Pessimistic scenario
Mean	20.8	19.7	19.9
Median	19.5	19.0	19.1
Maximum	43.7	36.8	37.3
Minimum	11.3	11.0	11.0
Upper Quartile	23.6	21.9	22.2
Lower Quartile	16.9	16.4	16.5
Standard Deviation	5.5	4.6	4.7
Range	32.4	25.8	26.3

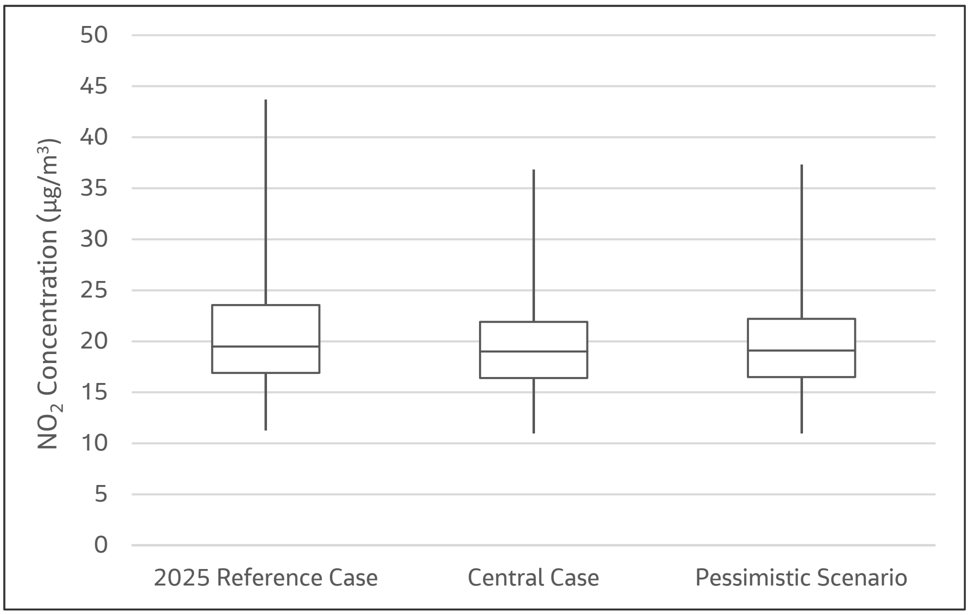

Figure 4-1 Distribution of NO_2 Concentrations for Sensitivity Testing of the pessimistic scenario

Table 4-5 Summary of Compliance Status for Sensitivity Testing of the Pessimistic Scenario

	Rupert Street	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID (Reference Case Max)	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (ug/m³)											
Reference Case (Updated Euro6 & ACR)	49.5	58.7	46.4	49.9	49.2	41.6	48.9	40.1	50.0	43.8	54.7
Medium area CAZ C/Small area CAZ D RB2	39.9	43.9	36.2	36.9	37.2	33.2	37.7	36.8	38.8	40.4	43.2
Pessimistic scenario	40.7	45.2	37.2	37.8	39.1	34.2	39.3	37.4	39.8	40.8	44.9
2025 Results (ug/m³)											
Reference Case (Updated Euro6 & ACR)	38.6	43.7	34.7	36.4	34.3	30.7	36.2	31.2	38.3	33.0	41.6
Medium area CAZ C/Small area CAZ D RB2	33.8	36.0	29.6	30.4	30.0	27.4	31.0	28.8	32.9	31.4	34.9
RB2 Pessimistic scenario	34.2	37.3	30.4	30.8	30.4	27.5	31.8	30.3	33.5	31.7	36.8
Compliance Year - Non-Linear Interpolation											
Reference Case (Updated Euro6 & ACR)	2025	2027	2023	2024	2024	2022	2024	2022	2025	2023	2026
Medium area CAZ C/Small area CAZ D RB2	2021	2023	2021	2021	2021	2021	2021	2021	2021	2022	2023
Pessimistic scenario	2022	2024	2021	2021	2021	2021	2021	2021	2021	2022	2024

4.3 P&R Decremental Testing

The M32 Park and Ride decremental test has been undertaken on the Medium CAZ C + Small CAZ D to satisfy the T-IRP request for disaggregation of the policies proposed. Full details of this test are shown in the M32 Park and Ride Sensitivity Test technical note in Appendix B.

4.3.1 Results from Air Quality Testing

The air quality summary statistics for removing park and ride facilities are presented in Table 4-6 and as distributional box plots in Figure 4-2. In each case results are presented for the 2025 reference case, central case for the Core scenario and the sensitivity test. Air quality would be adversely affected with the mean concentration increasing by 0.1µg/m^3 and the maximum by 0.4 µg/m^3. In terms of the compliance year, the 'decremental' scenario would put compliance back to 2024 from the 2023 Core estimate. This is shown in Table 4-7 for the critical locations. The compliance year for the Core scenario is shaded green and the 'decremental' scenario compliance year is shaded orange.

Table 4-6 Simple Summary Statistics for Sensitivity Testing of P&R Decremental (µg/m^3) – Annual mean NO_2 concentration.

Statistic	2025 Reference Case	Central Case	P&R Decremental
Mean	20.8	19.7	19.8
Median	19.5	19.0	19.0
Maximum	43.7	36.8	37.2
Minimum	11.3	11.0	11.0
Upper Quartile	23.6	21.9	22.0
Lower Quartile	16.9	16.4	16.5
Standard Deviation	5.5	4.6	4.6
Range	32.4	25.8	26.2

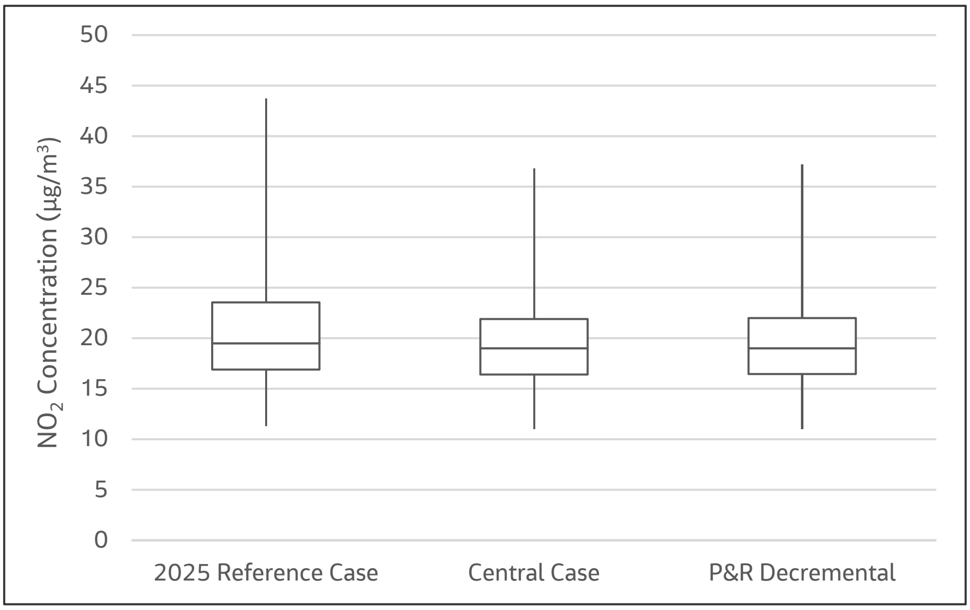

Figure 4-2 Distribution of NO_2 Concentrations for Sensitivity Testing of P&R Decremental Testing

Table 4-7 Summary of Compliance Status for Sensitivity Testing of P&R Decremental Testing

	Rupert Street	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID (Reference Case Max)	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (ug/m³)											
Reference Case (Updated Euro6 & ACR)	49.5	58.7	46.4	49.9	49.2	41.6	48.9	40.1	50.0	43.8	54.7
Medium area CAZ C/Small area CAZ D RB2	39.9	43.9	36.2	36.9	37.2	33.2	37.7	36.8	38.8	40.4	43.2
Pessimistic scenario	40.6	44.1	36.4	36.9	37.1	33.3	37.8	37.2	39.1	40.3	43.0
2025 Results (ug/m³)											
Reference Case (Updated Euro6 & ACR)	38.6	43.7	34.7	36.4	34.3	30.7	36.2	31.2	38.3	33.0	41.6
Medium area CAZ C/Small area CAZ D RB2	33.8	36.0	29.6	30.4	30.0	27.4	31.0	28.8	32.9	31.4	34.9
Decremental scenario	34.1	37.2	30.1	30.5	29.6	27.2	31.3	30.8	33.0	31.7	36.2
Compliance Year - Non-Linear Interpolation											
Reference Case (Updated Euro6 & ACR)	2025	2027	2023	2024	2024	2022	2024	2022	2025	2023	2026
Medium area CAZ C/Small area CAZ D RB2	2021	2023	2021	2021	2021	2021	2021	2021	2021	2022	2023
Decremental scenario	2022	2024	2021	2021	2021	2021	2021	2021	2021	2022	2023

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4.4 Age of the Transport Model

4.4.1 Traffic Flows

The T-IRP has raised concerns about the age of the base transport model (reference rows 17 and 20 of the T-IRP review comments). It was agreed with JAQU that as rebasing the base model would be a prohibitive task within the timescales available and therefore traffic data collected in October and November 2019 at locations of the network with critical compliance issues will be compared to the 2021 baseline transport model. Any notable differences will be corrected with adjustment factors.

Automatic Traffic Count (ATC) Data was collected in November 2019, which was then adjusted as follows to be comparable to the 2021 Baseline model.

- Normalised to October; and
- Adjusted to 2021 using TEMPRO V7.2.

4.4.2 Traffic Speeds

The Analytical Assurance Statement (AAS) stated that the transport model link speeds would be checked using TrafficMaster data along links with critical compliance issues. Any notable differences will be corrected with adjustment factors, which will made in parallel to the traffic flow adjustments.

TrafficMaster data was extracted for October 2019 along links which have critical compliance issues.

4.4.3 Critical Link Factors

The three key critical locations for Air Quality are as follows and have been assessed for both flows and speeds:

- Marlborough St (B4051)
- Rupert St (A38)
- Baldwin St (B4053)

Table 4-8 shows the adjustment factors for these critical links in terms of flows and speeds, which were then applied to the outturn AADT flows for the Medium C + Small D option.

Table 4-8: Adjustment Factors

Critical Link	Traffic Flows		Speeds
	LV Factor	HGV Factor	Factor
Marlborough St (B4051) Northbound	0.56	4.50	0.60
Marlborough St (B4051) Southbound	0.88	2.92	1.19
Rupert St (A38) Westbound	0.77	0.78	0.57
Baldwin St (B4053) Eastbound	0.64	0.46	1.02
Baldwin St (B4053) Westbound	0.85	0.82	0.78

To some extent the factors will balance each other in terms of Air Quality impacts, for example if the traffic count factor decreases flows and the traffic speed factor also decreases speeds and vice versa.

4.4.4 Results from Air Quality Testing

The air quality summary statistics for adjusting the speed and flows for the Core scenario are presented in Table 4-9 and as distributional box plots in Figure 4-3. In each case results are presented for the 2025 reference case, central case for the Core scenario and the sensitivity test. For this test, air quality is likely to improve slightly although on the whole these were marginal as shown by the mean remaining the same as the Core scenario. The maximum concentration is however, reduced by 1.4 µg/m^3.

In terms of the compliance year, the 'speed and flow' scenario brought compliance forward to 2022 from the 2023 Core estimate. This is shown in 4-10 for the critical locations. The compliance year for the Core scenario is shaded green and the 'speed and flow' scenario compliance year is shaded orange.

Table 4-9 Simple Summary Statistics for Sensitivity Testing of Speed and Flows Adjusted (µg/m^3) – Annual mean NO_2 concentration.

Statistic	2025 Reference Case	Central Case	Speed and flow adjusted
Mean	20.8	19.7	19.7
Median	19.5	19.0	19.0
Maximum	43.7	36.8	35.4
Minimum	11.3	11.0	11.0
Upper Quartile	23.6	21.9	21.9
Lower Quartile	16.9	16.4	16.4
Standard Deviation	5.5	4.6	4.5
Range	32.4	25.8	24.4

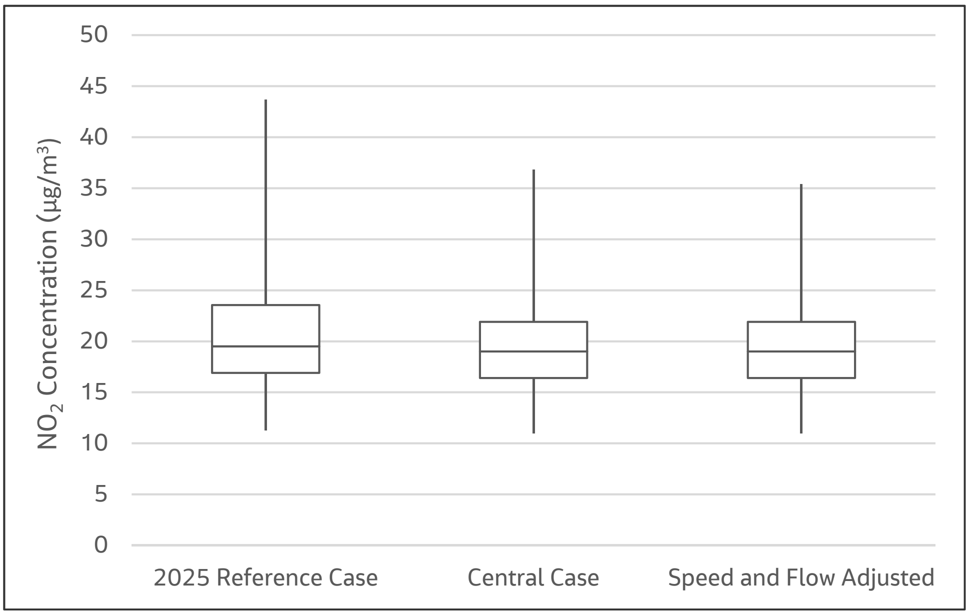

Figure 4-3 Distribution of NO_2 Concentrations for Sensitivity Testing of Speed and Flow adjusted

Table 4-10 Summary of Compliance Status for Sensitivity Testing of Speed and Flow adjusted

	Rupert Street	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID (Reference Case Max)	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (ug/m³)											
Reference Case (Updated Euro6 & ACR)	49.5	58.7	46.4	49.9	49.2	41.6	48.9	40.1	50.0	43.8	54.7
Medium area CAZ C/Small area CAZ D RB2	39.9	43.9	36.2	36.9	37.2	33.2	37.7	36.8	38.8	40.4	43.2
Speed and Flow adjusted	39.8	41.6	36.2	36.9	37.2	33.2	37.7	36.8	38.8	40.4	37.8
2025 Results (ug/m³)											
Reference Case (Updated Euro6 & ACR)	38.6	43.7	34.7	36.4	34.3	30.7	36.2	31.2	38.3	33.0	41.6
Medium area CAZ C/Small area CAZ D RB2	33.8	36.0	29.6	30.4	30.0	27.4	31.0	28.8	32.9	31.4	34.9
Speed and Flow adjusted	34.0	35.4	30.0	30.5	29.6	27.1	31.2	30.0	33.1	31.5	31.5
Compliance Year - Non-Linear Interpolation											
Reference Case (Updated Euro6 & ACR)	2025	2027	2023	2024	2024	2022	2024	2022	2025	2023	2026
Medium area CAZ C/Small area CAZ D RB2	2021	2023	2021	2021	2021	2021	2021	2021	2021	2022	2023
Speed and Flow adjusted	2021	2022	2021	2021	2021	2021	2021	2021	2021	2022	2021

4.5 Revised Boundary at St Philips Causeway

A boundary change to the Medium CAZ area has also been tested with the Medium CAZ C + Small CAZ D option, in accordance with a request from BCC. The change to the boundary is to the east of the city, where previously the medium boundary included St. Philips Causeway, it is excluded for the test. Plans for the boundary change are shown in Appendix C.

4.5.1 Results from Air Quality Testing

The air quality summary statistics for adjusting the boundary for the Core scenario are presented in Table 4-11 and as distributional box plots in Figure 4-4.. In each case results are presented for the 2025 reference case, central case for the Core scenario and the sensitivity test. For this test, air quality is likely to improve very slightly. The change in concentration across the range of statistics was approximately 0.1µg/m^3.

In terms of the compliance year, the 'revised boundary' scenario had no effect on the compliance year. This is shown in Table 4-12 for the critical locations. The compliance year for the Core scenario is shaded green and the 'revised boundary' scenario compliance year is shaded orange.

Table 4-11 Simple summary statistics for sensitivity testing of revised boundary changes (RB3) (µg/m^3)) – Annual mean NO_2 concentration.

Statistic	2025 Reference Case	Central Case	Revised boundary
Mean	20.8	19.7	19.8
Median	19.5	19.0	19.0
Maximum	43.7	36.8	36.7
Minimum	11.3	11.0	11.0
Upper Quartile	23.6	21.9	22.1
Lower Quartile	16.9	16.4	16.4
Standard Deviation	5.5	4.6	4.6
Range	32.4	25.8	25.7

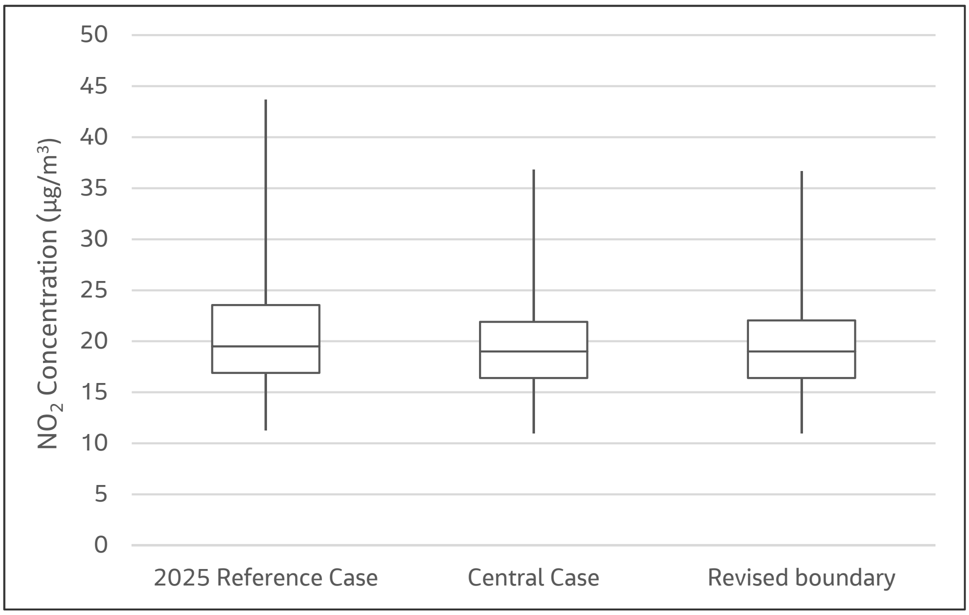

Figure 4-4: Distribution of NO_2 Concentrations for Sensitivity Testing of Revised Boundary Changes

Table 4-12 Summary of Compliance Status for Sensitivity Testing of Revised Boundary Changes

	Rupert Street	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID (Reference Case Max)	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (ug/m^3)											
Reference Case (Updated Euro6 & ACR)	49.5	58.7	46.4	49.9	49.2	41.6	48.9	40.1	50.0	43.8	54.7
Medium area CAZ C/Small area CAZ D RB2	39.9	43.9	36.2	36.9	37.2	33.2	37.7	36.8	38.8	40.4	43.2
Revised boundary change	39.8	43.5	35.9	36.6	37.1	32.9	37.6	36.7	38.6	40.4	43.0
2025 Results (ug/m^3)											
Reference Case (Updated Euro6 & ACR)	38.6	43.7	34.7	36.4	34.3	30.7	36.2	31.2	38.3	33.0	41.6
Medium area CAZ C/Small area CAZ D RB2	33.8	36.0	29.6	30.4	30.0	27.4	31.0	28.8	32.9	31.4	34.9
Revised boundary change	33.8	36.6	29.9	30.4	29.6	27.0	31.2	30.0	33.1	31.5	36.1
Compliance Year - Non-Linear Interpolation											
Reference Case (Updated Euro6 & ACR)	2025	2027	2023	2024	2024	2022	2024	2022	2025	2023	2026
Medium area CAZ C/Small area CAZ D RB2	2021	2023	2021	2021	2021	2021	2021	2021	2021	2022	2023
Revised boundary change	2021	2023	2021	2021	2021	2021	2021	2021	2021	2022	2023

4.6 Diesel Car Ban Sensitivity Test

The Diesel Car Ban sensitivity test has been undertaken on the Hybrid scheme to satisfy the T-IRP request that the tolerances of the diesel ban effectiveness assumptions are tested through sensitivity testing. It was agreed on a call with JAQU (dated 13/2/20) that due to timescale constraints a single sensitivity test would be undertaken from which the percentage change in input assumptions that would trigger a compliance year change could be estimated. Full details of this test are shown in the Diesel Car Can Effectiveness Sensitivity Test technical note in Appendix D.

The original response rates are shown in Table 4.13 below and the adjusted assumptions discussed in the technical note have yielded the sensitivity test response rates as shown in Table 4.14.

Table 4-13: 8-hour (7am-3pm) Diesel Car Exclusion Primary Response Rates

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	15.44%	14.56%	0.00%	17.47%	14.56%	0.00%
Cancel Journey / Change Mode	21.03%	21.85%	15.74%	23.79%	23.52%	22.18%
Replace Vehicle	43.04%	19.45%	31.54%	58.74%	58.07%	54.75%
Time of Day Choice	20.49%	31.94%	0.00%	0.00%	0.00%	0.00%

Table 4-14: Sensitivity Test 8-hour (7am-3pm) Diesel Car Exclusion Primary Response Rates

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	13.13%	9.15%	0.00%	17.47%	14.56%	0.00%
Cancel Journey / Change Mode	17.88%	13.92%	10.51%	23.79%	22.23%	13.59%
Replace Vehicle	40.31%	18.94%	21.46%	58.74%	54.88%	33.54%
Time of Day Choice	28.69%	44.72%	0.00%	0.00%	0.00%	0.00%

4.6.1 Results from Air Quality Testing

The air quality summary statistics for adjusting the boundary for the Core scenario are presented in Table 4-15 and as box plots in Figure 4-5. Note that for this sensitivity test the Core scenario is the **Hybrid scheme**. In each case results are presented for the 2025 reference case, central case for the Core scenario and the sensitivity test. For this test, air quality improved very slightly. The change in the annual mean concentration across the study area remained the same however the maximum concentration reduced by 0.7 μg/m^3.

In terms of the compliance year, the 'diesel ban sensitivity' scenario pushed the compliance back to 2024 from the Core scenario at Marlborough and Baldwin Street. This is shown in Table 4-16 for all critical locations. The compliance year for the Core scenario is shaded green and the 'diesel ban sensitivity' scenario compliance year is shaded orange.

Table 4-15: Simple summary statistics for sensitivity testing of modifying assumption for the diesel car ban ($\mu g/m^3$) – Annual mean NO_2 concentration.

Statistic	2025 Reference Case	Central Case	Modified Diesel Car Ban
Mean	20.8	19.7	19.7
Median	19.5	19.0	18.9
Maximum	43.7	36.8	36.1
Minimum	11.3	11.0	10.9
Upper Quartile	23.6	21.9	21.9
Lower Quartile	16.9	16.4	16.4
Standard Deviation	5.5	4.6	4.5
Range	32.4	25.8	25.2

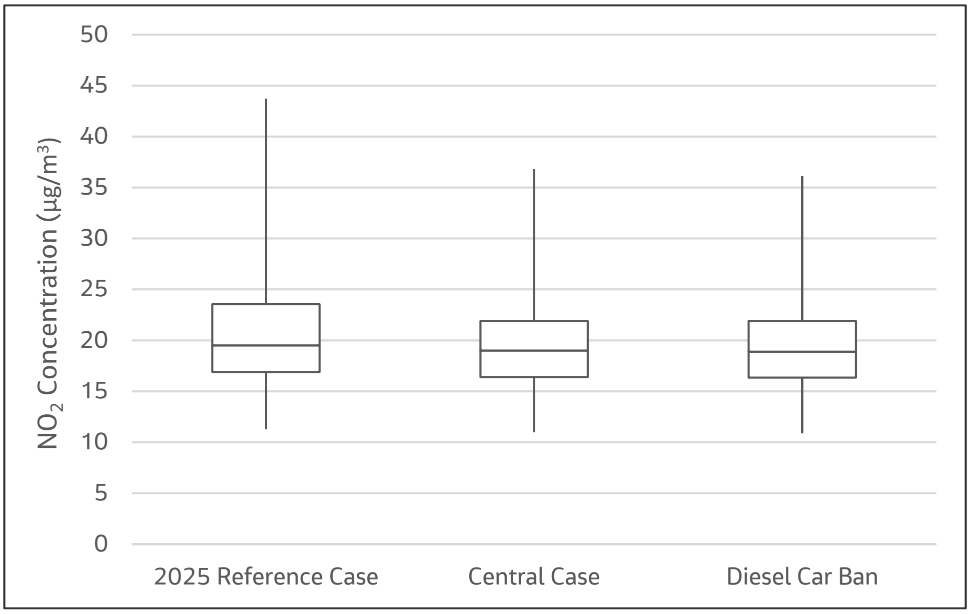

Figure 4-5 Distribution of NO_2 Concentrations for Sensitivity Testing of Revised Boundary Changes

Table 4-16: Summary of Compliance Status for Sensitivity Testing of Revised Boundary Changes

	Rupert Street	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID (Reference Max)	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (ug/m³)											
2025 Reference Case	49.5	58.7	46.4	49.9	49.2	41.6	48.9	40.1	50.0	43.8	54.7
Central Case	39.9	43.9	36.2	36.9	37.2	33.2	37.7	36.8	38.8	40.4	43.2
Diesel Car Ban	41.7	46.7	38.0	39.6	38.1	34.3	39.0	36.2	41.6	40.9	45.3
2025 Results (ug/m³)											
2025 Reference Case	38.6	43.7	34.7	36.4	34.3	30.7	36.2	31.2	38.3	33.0	41.6
Central Case	33.8	36.0	29.6	30.4	30.0	27.4	31.0	28.8	32.9	31.4	34.9
Diesel Car Ban	33.7	36.0	29.6	30.1	29.3	26.8	31.0	28.9	33.3	31.2	36.0
Compliance Year - Non-Linear Interpolation											
2025 Reference Case	2025	2027	2023	2024	2024	2022	2024	2022	2025	2023	2026
Central Case	2021	2023	2021	2021	2021	2021	2021	2021	2021	2022	2023
Diesel Car Ban	2022	2024	2021	2021	2021	2021	2021	2021	2022	2022	2024

5. Air Quality Results

5.1 Vehicle-Specific Emission Factors

5.1.1 Euro 6 Diesel Vehicles

The EFT includes NOx speed-emission coefficients taken from the European Environment Agency COPERT 5 emission calculation tool[3] and fleet and fuel compositions in line with Department for Transport projections. COPERT 5 predicts different NOx emissions from Euro 6 diesel vehicles registered in different years. This is based on a general expectation that emissions from these vehicles will reduce over time. Over a similar timeframe, new aspects of the Euro 6 emissions standards will come into force, but it is important to recognize that the Euro 6 emissions reductions assumed within COPERT 5 do not, and were not intended to, coincide precisely with specific iterations of the Euro 6 emissions standards themselves. Thus, for example, COPERT 5 does not contain emissions factors specific to Euro 6d-temp vehicles.

The JAQU suggest that local authorities run a 'low emissions' and 'high emissions' scenario for the future emissions standards in their projected reference year and 'with measures' model runs. The JAQU suggest that an appropriate 'low emissions' scenario would be to assume that Euro 6c diesel cars and LGVs achieve the same emissions level as Euro 6d vehicles. This can simply be achieved by moving the proportion of diesel cars and LGVs in the Euro 6c category of the EFT into the Euro 6d category.

For the 'high emissions' scenario the JAQU recommended that Euro 6c cars and LGVs achieve emissions halfway between Euro 6 and Euro 6c and that Euro 6d cars and LGVs achieve emissions halfway between Euro 6c and Euro 6d. This can be achieved by moving 50% of the cars and LGVs in the Euro 6c category of the EFT into the Euro 6 (non-RDE) category and moving 50% of the cars and LGVs in the Euro 6d category of the EFT into the Euro 6c category.

Table 5.1 and Figure 5-1 provide the summary statistics requested in JAQU's 'Supplementary Note on Sensitivity Testing'. Table 5.1 then presents the compliance status for each of these scenarios as well as the 'Central' case. These sensitivity tests demonstrate that the potential effect of the assumed uncertainty in future Euro 6 diesel vehicles is relatively high. The optimistic Euro 6 scenario was predicted to reduce the maximum concentration by approximately 3 $\mu g/m^3$, whereas the Euro 6 pessimistic scenario predicted a near 4 $\mu g/m^3$ increase. The mean concentration reduced and increased by approximately 1 $\mu g/m^3$ for the optimistic and pessimistic scenarios,

The results indicate that the central case is particularly sensitive to the assumptions around the categorisation of Euro 6 light duty vehicles. This would suggest that post surveying of Euro 6 C and D categorisation is should be considered.

In terms of the compliance year, the 'Euro 6 pessimistic' scenario pushed the compliance year back beyond 2025 at the Marlborough Street and Baldwin Street critical locations and forward to 2021 from 2023 at 5 critical locations. This is shown in Table 5.2. The compliance year for the Core scenario is shaded green and the 'pessimistic/optimistic' scenario compliance years are shaded in orange.

Table 5-1 Simple Summary Statistics for Sensitivity Testing of Euro 6 Diesel Vehicle Emissions ($\mu g/m^3$) – Annual mean NO_2 concentration.

Statistic	2025 Reference Case	Euro6 Pessimistic	Central Case	Euro6 Optimistic
Mean	20.8	20.8	19.7	18.9
Median	19.5	19.9	19.0	18.2
Maximum	43.7	40.5	36.8	33.7
Minimum	11.3	11.5	11.0	10.6
Upper Quartile	23.6	23.3	21.9	20.9
Lower Quartile	16.9	17.1	16.4	15.9
Standard Deviation	5.5	5.1	4.6	4.2
Range	32.4	29.0	25.8	23.1

[3] http://copert.emisia.com

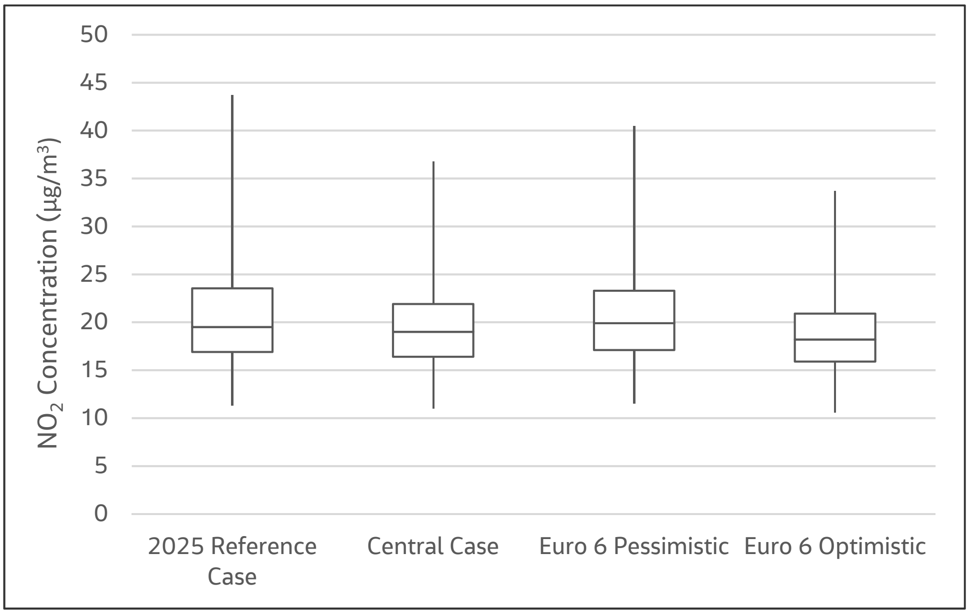

Figure 5-1 Distribution of NO_2 Concentrations for Sensitivity Testing of Euro 6 Diesel Vehicle Emissions

5.1.2 Regional Ozone

Defra's NOx to NO_2 Calculator[4] calculates NO_2 concentrations from NOx concentrations, based on the reactions of mixing of nitric oxide, nitrogen dioxide and ozone. This relies on tabulated concentrations of ozone above the surface layer for each local authority, which have been modelled for each year between 2015, 2021 and 2031. There is an uncertainty in these predictions. Other NOx to NO_2 approaches are available, but none are clearly more appropriate and the use of Defra's NOx to NO_2 Calculator, which is the recommended method in the JAQU guidance. This issue will contribute to the overall uncertainty in the conclusions of the assessment.

[4] Defra (2018) Local Air Quality Management (LAQM) Support Website. Retrieved from http://laqm.defra.gov.uk/

Table 5-2 Summary of Compliance Status for Sensitivity Testing of Euro 6 Diesel Vehicle Emissions

	Rupert Street	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID (Reference Max)	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (ug/m^3)											
Reference Case (Updated Euro6 & ACR)	49.5	58.7	46.4	49.9	49.2	41.6	48.9	40.1	50.0	43.8	54.7
Medium area CAZ C/Small area CAZ D RB2	39.9	43.9	36.2	36.9	37.2	33.2	37.7	36.8	38.8	40.4	43.2
Euro 6 Pessimistic	41.7	46.4	37.9	38.8	38.6	34.6	39.5	38.2	40.9	42.1	45.4
Euro 6 Optimistic	36.7	39.5	33.2	33.5	34.6	30.9	34.7	34.7	35.3	37.6	39.5
2025 Results (ug/m^3)											
Reference Case (Updated Euro6 & ACR)	38.6	43.7	34.7	36.4	34.3	30.7	36.2	31.2	38.3	33.0	41.6
Medium area CAZ C/Small area CAZ D RB2	33.8	36.0	29.6	30.4	30.0	27.4	31.0	28.8	32.9	31.4	34.9
Euro 6 Pessimistic	36.5	40.5	32.5	33.3	32.0	29.1	33.8	32.0	36.1	34.2	39.2
Euro 6 Optimistic	31.6	33.6	27.9	28.1	27.7	25.4	29.1	28.5	30.7	29.3	33.5
Compliance Year - Non-Linear Interpolation											
Reference Case (Updated Euro6 & ACR)	2025	2027	2023	2024	2024	2022	2024	2022	2025	2023	2026
Medium area CAZ C/Small area CAZ D RB2	2021	2023	2021	2021	2021	2021	2021	2021	2021	2022	2023
Euro 6 Pessimistic	2023	After 2025	2021	2021	2021	2021	2021	2021	2022	2022	2025
Euro 6 Optimistic	2021	2021	2021	2021	2021	2021	2021	2021	2021	2021	2021

6. Results Summary Table

For all sensitivity tests, a summary and key results is provided in Table 6-1 below:

Table 6-1 Summary of sensitivity analysis

Test	Section Number	Summary	Key Results
Behavioural Reponses to Charging	4.2	Defined pessimistic response rates based on confidence intervals of SP survey statistical modelling and adjusted assumptions for other vehicle types. Compared NO_2 concentrations to Medium C + Small D scenario.	Air quality is likely to be adversely affected with the mean concentration increasing by 0.2µg/m^3 and the maximum by 0.5 µg/m^3. In terms of the compliance year, the 'pessimistic' scenario puts compliance back to 2024 from the 2023 Core estimate
P&R Decremental Test	4.3	Removal of the M32 P&R but retained bus lane. Compared NO_2 concentrations to Medium C + Small D scenario.	Air quality would be adversely affected with the mean concentration increasing by 0.1µg/m^3 and the maximum by 0.4 µg/m^3. In terms of the compliance year, the 'decremental' scenario would put compliance back to 2024 from the 2023 Core estimate
Age of Transport Model	4.4	Traffic flow and speed adjustments were made on critical links in terms of Air Quality. Compared NO_2 concentrations to Medium C + Small D scenario.	Air quality is likely to improve slightly. However, across the study area these changes were marginal as shown by the mean remaining the same as the Core scenario. The maximum concentration is reduced by 1.4 µg/m^3. In terms of the compliance year, the 'speed and flow' scenario brought compliance forward to 2022 from the 2023 Core estimate.
Revised Boundary around St Philips Causeway	4.5	Changes made to the Medium CAZ boundary to exclude St Philips Causeway. Compared NO_2 concentrations to Medium C + Small D scenario.	Air quality is likely to improve very slightly. The change in concentration across the range of statistics was approximately 0.1µg/m^3. In terms of the compliance year, the 'revised boundary' scenario had no effect on the compliance year.
Diesel Car Ban Test	4.6	Defined adjusted response rates related to linked trip and time of day assumptions. Compared NO_2 concentrations to the Revised Hybrid	For this test, air quality improved very slightly. The change in the annual mean concentration across remained the same however the maximum concentration reduced by 0.7 µg/m^3. In terms of the compliance year, the 'diesel ban sensitivity' scenario pushed the compliance back to 2024 from the Core scenario at Marlborough and Baldwin Street.
Uncertainties in the Air Quality Modelling			
Euro 6 Vehicles	3.1.1	The EFT is based on COPERT 5 which predicts different NOx emissions from Euro 6 diesel vehicles registered in different years (based on the expectation that Euro 6 emissions will reduce over time). Sensitivity test outlined in JAQU's 'Supplementary Note on Sensitivity Testing' has been run.	The optimistic Euro 6 scenario was predicted to reduce the maximum concentration by approximately 3 µg/m^{3,} whereas the Euro 6 pessimistic scenario predicted a near 4 µg/m^3 increase. In terms of the compliance year, the 'Euro 6 pessimistic' scenario pushed the compliance year back beyond 2025 at the Marlborough Street and Baldwin Street critical locations and forward to 2021 from 2023 at 5 critical locations...The results indicate that the central case results are sensitive to the optimistic and pessimistic assumptions made for changes to Euro NOx emissions standards expected from diesel light duty vehicles.

Appendix A. OBC Sensitivity Test Report

Appendix B. M32 Park and Ride Sensitivity Test Technical Note

Appendix C. St. Philips Causeway Boundary Change for Medium CAZ

Appendix D. Diesel Car Ban Sensitivity Test Technical Note

Bristol City Council Clean Air Plan

Outline Business Case

Sensitivity Testing Report

OBC-39

October 2019

Bristol City Council

JACOBS

Bristol Clean Air Plan

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2	27.10.19	OBC draft	KT / KW	CB	HO
3	28.10.19	OBC draft	KT / KW	CB	HO

Contents

Acronyms and Abbreviations

ANPR	Automatic Number Plate Recognition
BCC	Bristol City Council
CAZ(s)	Clean Air Zone(s)
CAP	Clean Air Plan
CO_2	Carbon Dioxide
Defra	Department for Environment Food & Rural Affairs
DfT	Department for Transport
EFT	Emissions Factors Toolkit
Euro	European
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit
LAQM	Local Air Quality Management
LGV	Light Goods Vehicle
HGV	Heavy Goods Vehicle
MSOA(s)	Middle Layer Super Output Area(s)
NRMM	Non-Road Mobile Machinery
NOx	Nitrous Oxides
NO_2	Nitrogen Dioxide
OBC	Outline Business Case
OGV	Other Goods Vehicle
OS	Ordnance Survey
PM	Particulate Matter
PSV	Public Service Vehicle
RSI	Roadside Interview
SP	Stated Preference
ULEV	Ultra Low Emissions Vehicle
(Web)TAG	Transport Analysis Guidance

1. Introduction

The UK has in place legislation transposing requirements in European Union law, to ensure that certain standards of air quality are met, by setting Limit Values on the concentrations of specific air pollutants. In common with many EU member states, the EU limit value for annual mean nitrogen dioxide (NO_2) is breached in the UK and there are on-going breaches of the NO_2 limit value in Bristol. The UK government is taking steps to remedy this breach in as short a time as possible, with the aim of reducing the harmful impacts on public health. Within this objective, the government has published a UK Air Quality Plan and a Clean Air Zone Framework, both published in 2017. The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ).

Due to forecast air quality exceedances, in 2017 Bristol City Council has been directed by the Minister Therese Coffey (Defra) and Minister Jesse Norman (DfT) to produce a Clean Air Plan to achieve air quality improvements in the shortest possible time. In line with Government guidance, as part of the Plan, Bristol City Council has considered a range of options for the implementation of a Clean Air Zone (CAZ), including both charging and non-charging measures, in order to achieve sufficient improvement in air quality and public health and in line with legal requirements as set out below. Bristol City Council (BCC) have produced an Outline Business Case (OBC) for the delivery of an option including a package of measures which will be most likely to bring about compliance with the Limit Value for annual mean NO_2 in the shortest time possible in Bristol and reducing human exposure as quickly as possible.

Jacobs has been commissioned to support BCC to produce an Outline Business Case (OBC) for the delivery of the CAP; a package of measures which will bring about compliance with the Limit Value for annual mean NO_2 in the shortest time possible in Bristol. The OBC assessed the shortlist of scenarios set out in the Strategic Outline Case, and proposes a preferred scenario including details of delivery. This document is written to support the OBC, and provides a summary of sensitivity tests undertaken for the transport and air quality analysis. This has been performed according to the guidance provided by JAQU in their 'supplementary note on sensitivity testing' issued in July 2018.

The sensitivity tests reported here relate to the final model results from the Hybrid scenario which includes an 8-hour diesel car ban within a medium sized CAZ C in 2027. This is referred to throughout this document as the 'core' or 'central' scenario.

Table 1-1 lists the sensitivity tests undertaken.

Table 1-1 List of Sensitivity Tests Performed for Transport and Air Quality

Traffic Modelling (Section 2)	Air Quality Modelling (Section 3)
• Fleet splits by fuel type: ANPR vs. NAEI(EFT) • HGV adjustment factors • Behavioural response to charging	• Euro 6 vehicles • Emissions at low speeds • Background concentrations • Model verification • Gradient • Primary NO_2 Fraction

A summary of all sensitivity tests and key findings in this report is provided in section 4.

1.1 Overview and Core Scenario

The core scenario combines Options 1 and 2 that working together create a Hybrid Option.

Option 1:

- Medium Area Class C (charging non-compliant buses, coaches, taxis, HGVs and LGVs);
- Diesel car scrappage scheme;
- HGV exclusion on links within the city centre with exceedances as follows:
  - Park Row/Upper Maudlin St/Marlborough St, Rupert Street, Lewins Mead, Baldwin Street;
- Close of Cumberland Road inbound to general traffic;
- M32 Park and Ride with bus lane inbound;
- Holding back traffic to the city centre through the use of existing signals; and

Option 2: 8-hour small area diesel car exclusion (7am – 3pm)

Full details of the modelling methodology for these schemes can be found in OBC-23 Local Plan Transport Modelling Methodology Report (T3) and transport model results can be found in OBC-27 Local Plan Transport Model Forecasting Report (T4).

2. Traffic Modelling

2.1 Overview

In estimating the effects of the Core Scenario, the air quality predictions are dependent upon the traffic data used in the modelling. These data are a combination of national predictions, JAQU guidance, consultations with BCC, and local studies. The data sources used in the traffic modelling have been selected to give the best possible representation of the effects of the CAZ. Like all predictions, this methodology has several uncertainties associated with it. A detailed account of the forecasting methodology and core scenario assumptions can be found in OBC-27 Transport Model Forecasting Report (T4). In this section, a series of sensitivity tests have been developed based on known uncertainties in these assumptions. Section 2.2 considers uncertainties in the current and projected fleet composition with regards to HGV factors and fuel splits. Section 2.3 considers uncertainties in the predicted behavioural response to charging by developing and analysing the most likely 'pessimistic' and 'optimistic' alternative scenarios. When appropriate, air quality testing has been performed to estimate the emissions, NO_2 concentrations, and compliance of the test scenarios and compare the results to the core scenario. Air quality modelling indicates that the Core Scenario will achieve total compliance in 2027.

2.2 Fleet Composition

A vehicle's emissions depend on a variety of factors, such as its age and the type of fuel it consumes. Therefore, to accurately model the NO_2 pollution in Bristol, information was required regarding the composition of vehicles that enter Bristol City Centre. To accomplish this, permanent Automatic Number Plate Recognition (ANPR) camera data was obtained from BCC for a duration of six months in 2017 (February – July). In addition, a week survey was performed using ANPR cameras placed at key locations around and within the city centre to fill in the gaps, in July 2017. The captured number-plates were cross-referenced with data purchased from Carweb to gain information on the corresponding vehicle types, fuel types, and euro emissions standards. Details of the ANPR study can be found in OBC-24 ANPR Data Analysis and Application in Appendix E of the OBC. This ANPR data were used to estimate the fleet composition for the air quality verification year 2015 and the reference years 2021/31 for the Core Scenario. The fleet composition was projected into the future using tools provided by the JAQU. However, this methodology has several uncertainties associated with it. For example, number-plates are occasionally missed or misread using ANPR technology. Additionally, there is more than one method for predicting future fleet compositions. The sensitivity test, involving fuel splits initially obtained from the WebTAG Data Book[1], examined a more recent model of behaviour provided by the JAQU in version 9.1b of the Emission Factor Toolkit to test the differences this had on emissions and NO_2 concentrations for core scenario.

2.2.1 HGV adjustment factors

Light and heavy goods vehicles were not originally validated using short screenlines and grouped counts in 2013, therefore an additional technical note has been produced to report this. For full details refer to OBC-25 LGV/HGV Validation Technical Note. The key conclusions from this report are as follows:

- LGVs are generally well calibrated/validated on both the short screenline level and an individual link level screenlines and cordons;
- HGVs do not pass the WebTAG guidance for GEH statistics, but are close for the link flow difference criteria for the short screenlines and pass when each link is looked at individually;
- For both light and heavy goods vehicles, where WebTAG guidance is not met, the modelled flows are under assigned in some locations, over assigned in others; and
- The middle cordon relates closely to the medium CAZ boundary and the inner cordon relates closely to the small CAZ boundary. The calibration/validation of HGVs for the inner cordon is deemed more important than the middle cordon due the location of the compliance exceedances within Bristol. The HGV fit along the inner cordon is better than the middle cordon.

It was agreed with JAQU that HGV flow adjustments would be made on links with significant differences in modelled flows compared to observed counts. These adjustments would be carried through to future years for both the baseline and options.

The T-IRP panel has commented on this approach as follows in their feedback:

'It has been acknowledged in the report that there is an issue with the validation for HGVs specifically. This issue has been dealt with through the application of fixed factors (which will also be applied in scenario modelling). If HGVs are affected by proposed measures, doing something more complex than applying fixed factors should be considered, as these will add a lot of uncertainty into the modelling. If fixed factors are applied in the scenario modelling and HGV are targeted with measures, then at the least the implications of this assumption should be tracked through sensitivity testing and discussed in the AAS. RAG rating would be A/G if no measures affecting HGVs are being assessed.'

This test therefore involved the removal of the HGV adjustment factors applied. It should be noted that no HGV adjustment factors were applied to locations identified as critical in the air quality modelling hence there is very little effect on the results.

Table 2-1 provides a summary of statistics (as recommended in JAQU's 'Supplementary Note on Sensitivity Testing') and Table 2-2 presents the compliance status for this sensitivity test as well as the 'Central' (Core scenario) modelling. Figure 2-1 shows the distribution of the resulting NO_2 concentrations. The statistics indicated that removing HGV adjustment factors had a negligible impact on NO_2 concentrations at reportable receptors. The maximum NO_2 concentration increased by one tenth of a microgram resulting in the gap between exceeding the Limit Value narrowed slightly.

Table 2-1. Simple Summary Statistics for HGV adjustment factors(µg/m^3)

Statistic	2027 Core Scenario	
	Central	HGV Removal
Mean	20.6	20.6
Median	20.0	20.0
Maximum	39.5	39.6
Minimum	11.2	11.2
Upper Quartile	23.6	23.6
Lower Quartile	17.5	17.5
Standard Deviation	5.1	5.2
Range	28.3	28.4

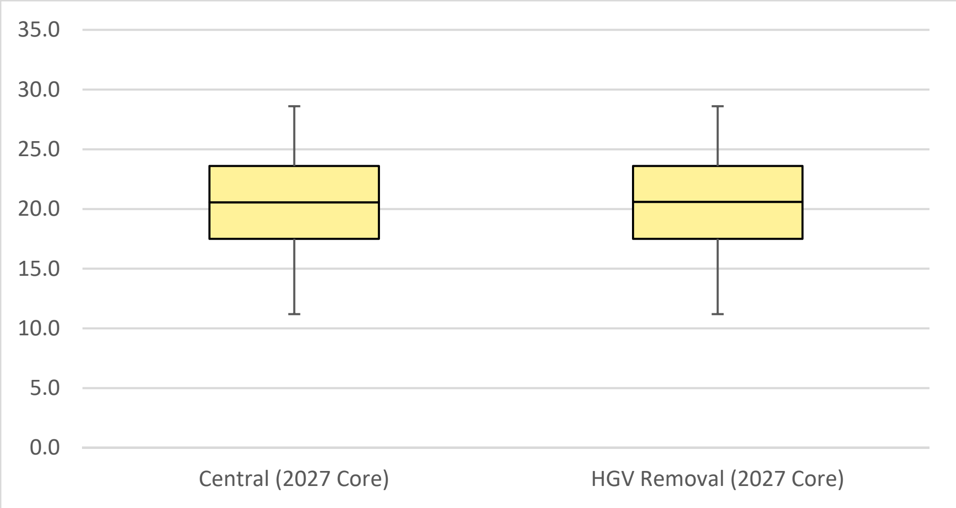

Figure 2-1 Distribution of NO_2 Concentrations for Compliance Splits by HGV factor adjustment

Table 2-2 Summary of Compliance Status for Compliance Splits by HGV factor adjustment

Statistic	2021 Core Scenario	
	Central	Fuel Splits
No. of Non-Compliance PCM Receptors	0	0
Compliance Status of Road Link with Highest NO2 Value	Compliant	Compliant
Maximum NO2 Percentage Gap from Compliance	-1.3	-1.0

2.2.2 Splits by Fuel Type: Comparison of NAEI (EFT) fleet projections

Vehicle emissions depend on the type of fuel it consumes. Petrol vehicles emit carbon dioxide (CO_2) and some nitrous oxides (NOx), while diesel vehicles emit significantly less CO_2 but significantly more NOx than petrol. In the air quality model, a diesel vehicle will cause higher NO_2 concentrations than its petrol equivalent. Therefore, the air quality model required the proportion of each vehicle type that was petrol, diesel, or electric. These splits can be obtained at a national level using the WebTAG Data Book[1] or similarly models published in the National Atmospheric Emissions Inventory (NAEI)[2] and transcribed for the Emission Factor Toolkit[3]. For the Bristol Study ANPR data were processed and aligned to the vehicle emission fleet categories issued in the EFT. This provided a 2018 fleet which could then be projected backwards or forwards using a tool incorporated in the EFT. Whilst undertaking the study JAQU issued version 9.1b of the EFT which has updated fuel split information compared to version 8.0.1a which has been applied from the onset of the study.

The sensitivity test examines the differences in annual mean NO_2 concentrations between the Core Scenario modelled using fuel splits derived from the WebTAG Databook and the new information provided in the EFT v9.1b.

Table 2-3 provides a summary of statistics and Table 2-4 presents the compliance status for this sensitivity test as well as the 'Central' (Core scenario) modelling. Figure 2-2 shows the distribution of the resulting NO_2 concentrations. If the EFT V9.1b fuel splits are used then the 2027 Core scheme would be compliant by a greater margin (-2 μg/m^3), with a maximum exceedance of 38.0 μg/m^3. The revised fuel splits are considered to be more robust than the WebTAG Data Book.

[1] https://www.gov.uk/government/publications/tag-data-book
[2] https://naei.beis.gov.uk/
[3] https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

Table 2-3 Simple Summary Statistics for Compliance Splits by Fuel Type (µg/m³)

Statistic	2027 Core Scenario	
	Central	Fuel Splits
Mean	20.6	20.2
Median	20.0	19.7
Maximum	39.5	38.0
Minimum	11.2	11.1
Upper Quartile	23.6	23.2
Lower Quartile	17.5	17.2
Standard Deviation	5.1	5.0
Range	28.3	26.9

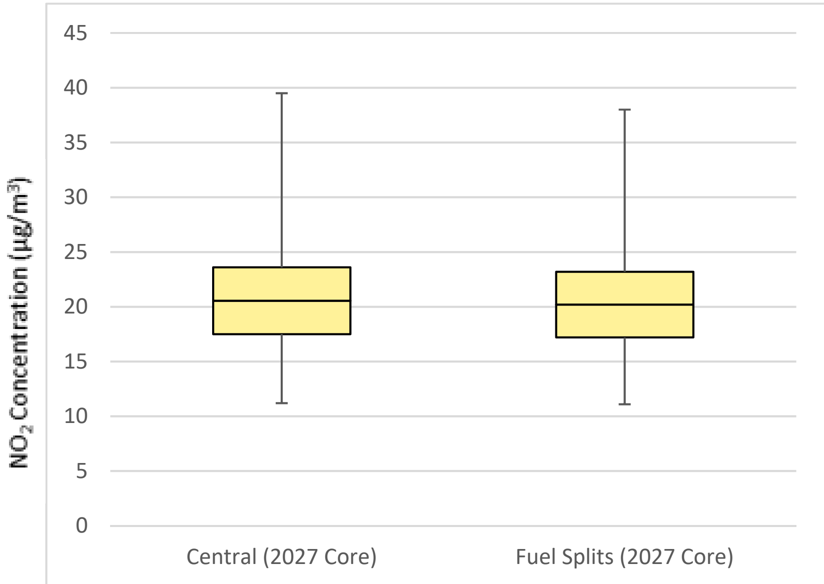

Figure 2-2 Distribution of NO_2 Concentrations for Compliance Splits by Fuel Type

Table 2-4 Summary of Compliance Status for Compliance Splits by Fuel Type

Statistic	2027 Core Scenario	
	Central	EFT Fuel Splits
No. of Non-Compliance PCM Receptors	0	0
Compliance Status of Road Link with Highest NO_2 Value	Compliant	Compliant
Maximum NO_2 Percentage Gap from Compliance	-1	-5

2.3 Behavioural Response to Charging

The success of the Clean Air Zone depends entirely on how it influences the behaviour of drivers in the region. The non-car drivers are expected to respond to the charging medium area CAZ C by either avoiding the area, changing their travel mode, or changing to a compliant vehicle, all of which will help to improve NO_2 pollution in Bristol. However, some drivers will decide to pay the CAZ charge instead of changing their behaviour. Car drivers are expected to respond to the 8-hour small area car diesel ban either by avoiding the area, changing their travel mode, or changing to a petrol car, again all of which will help to improve NO_2 pollution in Bristol.

However, some car drivers will decide to change the time of day they travel and hence continue to use their diesel car.

For the Core scenario, the behavioural response to charging CAZ C was predicted using a variety of sources. A stated preference (SP) survey was conducted on drivers in Bristol and the surrounding areas to determine how they would respond, and how likely they would be to upgrade their vehicle based on various CAZ charges and upgrade costs. The final response rates were based on statistical models from the SP survey and predicted costs for upgrading to a compliant vehicle. For non-compliant light goods vehicle, responses for 'vans' from the stated preference surveys were used. A full report of the SP survey and statistical modelling is provided in OBC-28 Stated Preference Surveys Report. For coaches and HGVs, the proportions from 'Table 2 – Behavioural responses to charging Clean Air Zones' within the JAQU Evidence package have been used. Bus and Taxi responses are based on talks with Bristol City Council and the service providers.

The methodology for calculating the primary response rates for the small area diesel car exclusion is summarised as follows:

- Calculate 24-hour car diesel exclusion response rate for the small area - the pay charge response rate was set to zero, the avoid zone, cancel trip/change mode and replace vehicle rates have been determined by the stated preference surveys for diesel cars which have been proportioned so that the total response rate totals 100 per cent;
- Calculate 8-hour (7am-3pm) car diesel ban based on the assumptions outlined in Section 6.3 OBC-26 Primary Behavioural Response Calculation Methodology. This methodology takes into account the estimated proportions of trips to change time of day (TOD response) to avoid the exclusion period and the estimated extent to which trips are linked between different time periods by trip purpose. Since not all trip purposes are modelled separately in GBATS, the relevant purposes were then re-combined using weighted averages to yield responses for each modelled trip purpose.

The final Core scenario response rates are provided in Table 2-5 and 2-6 below. A detailed report on the methodology for calculating these response rates is available in OBC-26 Response Rates Technical Note Appendix E of the OBC.

Table 2-5 Core Scenario Primary Behavioural Response Rates – Medium CAZ C

Response	Taxis	LGVs	HGVs	Buses	Coaches
Pay Charge	4.1%	15.9%	8.8%	0.0%	17.8%
Avoid Zone	0.0%	19.2%	4.3%	0.0%	0.0%
Cancel Journey / Change Mode	0.0%	2.6%	4.3%	6.4%	11.4%
Replace Vehicle	95.9%	62.2%	82.6%	93.6%	70.8%

Table 2-6 Core Scenario Primary Behavioural Response Rates – Car Diesel Exclusion

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	15.44%	14.56%	0.00%	17.47%	14.56%	0.00%
Cancel Journey / Change Mode	21.03%	21.85%	15.74%	23.79%	23.52%	22.18%
Replace Vehicle	43.04%	19.45%	31.54%	58.74%	58.07%	54.75%
Time of Day Choice	20.49%	31.94%	0.00%	0.00%	0.00%	0.00%

2.3.1 Development of Pessimistic and Optimistic Scenarios

Medium CAZ C

To account for uncertainties in the Core scenario response rates, alternative scenarios were developed assuming pessimistic and optimistic driver responses in terms of expected air quality impacts. The pessimistic scenario accounts for the most-likely uncertainties that would cause more drivers to pay the CAZ C charge than in the Core scenario. In this case, there would be a smaller behavioural response to charging and therefore a smaller improvement to the NO_2 pollution in Bristol city centre. To develop a pessimistic scenario for the charging CAZ C, the replace vehicle response was decreased by 20% and the change in the replace vehicle response was compensated for by a change in the pay charge response. The pessimistic response rates for the Medium CAZ C are given in Table 2.7

Table 2-7 Pessimistic Scenario Primary Response Rates– Medium CAZ C

Response	Taxis	LGVs	HGVs	Buses	Coaches
Pay Charge	23%	28%	25%	0.0%*	32%
Avoid Zone	0%	19%	4%	0.0%	0%
Cancel Journey / Change Mode	0%	3%	4%	6.4%	11%
Replace Vehicle	77%	50%	66%	93.6%	57%

** This value was 0.0% in core scenario, so a percent change cannot be calculated.*

The optimistic scenario accounts for the most-likely uncertainties that would lead to a higher behavioural response to CAZ charging. In this case, less drivers would pay the CAZ charge and the NO_2 pollution in the city centre would improve beyond that which was predicted in the core scenario. To develop an optimistic scenario for the charging CAZ C, the replace vehicle response was increased by 20% and the change in the replace vehicle response was compensated for by a change in the pay charge response. The optimistic response rates for the Medium CAZ C are given in Table 2.8.

Table 2-8 Optimistic Scenario Primary Response Rates– Medium CAZ C

Response	Taxis	LGVs	HGVs	Buses	Coaches
Pay Charge	0.0%	3.5%	0.0%	0.0%	3.6%
Avoid Zone	0.0%	19.2%	4.3%	0.0%	0.0%
Cancel Journey / Change Mode	0.0%	2.6%	4.3%	6.4%	11.4%
Replace Vehicle	100%	75%	91%	93.6%	85%

** This value was 0.0% in core scenario, so a percent change cannot be calculated.*

8-Hour Car Diesel Exclusion

For the 8-hour car diesel exclusion, the parameters of the SP survey statistical models were adjusted to the top or bottom end of their 95% confidence intervals so that more/less drivers would replace the vehicle over the other responses over a 24-hour time period. These responses were then run through the process for converting 24-hour car diesel exclusion to an 8-hour car diesel exclusion. The optimistic and pessimistic responses from SP survey were then reversed, as a higher replace vehicle under SP optimistic responses results in lower avoid zone, cancel trip and change mode responses and higher time of day choice, resulting in more diesels in the CAZ area compared to the core. While a lower replace vehicle under SP pessimistic responses results in higher avoid zone, cancel trip and change mode responses and higher time of day choice, resulting in fewer diesels in the CAZ area compared to the core. The pessimistic and optimistic response rates for the car diesel exclusion are given in Table 2.9 and 2-10 respectively.

Table 2-9: Pessimistic Scenario Primary Response Rates – Car Diesel Exclusion

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	15.53%	10.87%	0.00%	13.04%	10.87%	0.00%
Cancel Journey / Change Mode	18.59%	19.32%	13.92%	21.04%	20.80%	19.61%
Replace Vehicle	48.33%	21.95%	35.43%	65.92%	65.17%	61.45%
Time of Day Choice	21.55%	35.73%	0.00%	0.00%	0.00%	0.00%

Table 2-10: Optimistic Scenario Primary Response Rates – Car Diesel Exclusion

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	25.34%	23.89%	0.00%	28.67%	23.89%	0.00%
Cancel Journey / Change Mode	29.31%	30.46%	21.94%	33.16%	32.79%	30.91%
Replace Vehicle	28.01%	12.83%	20.54%	38.17%	37.73%	35.58%
Time of Day Choice	17.34%	20.58%	0.00%	0.00%	0.00%	0.00%

2.3.2 Results from Air Quality Testing

Table 2-6 provides a summary of statistics and Table 2-7 presents the compliance status for each of these scenarios as well as the ‘Central’ model results. Figure 2-3 shows the distribution of the resulting NO_2 concentrations. The 2027 Core scenario is compliant in both the ‘Low’ (Optimistic) and ‘Central’ (Core) and ‘High’ (Pessimistic) scenario, with a percentage gap of up to -1.3% (0.5 µg/m^3). It should be noted, that the results for the high and low scenarios are very similar and overall, the ‘Central’ scenario is most representative, and the conclusion of compliance is thus considered appropriate.

Table 2-6 Simple Summary Statistics for Response Rates (µg/m^3)

Statistic	2027 Core Scenario		
	Low Optimistic	Central	High Pessimistic
Mean	20.4	20.6	20.7
Median	20.0	20.0	20.0
Maximum	39.6	39.5	39.8
Minimum	11.2	11.2	11.3
Upper Quartile	23.4	23.6	24.0
Lower Quartile	17.5	17.5	17.6
Standard Deviation	5.0	5.1	5.2
Range (Max - Min)	28.4	28.3	28.5

Table 2-7 Summary of Compliance Status for Response Rates

Statistic	2027 Core Scenario		
	Low	Central	High
No. of Non-Compliance PCM Receptors	0	0	0
Compliance Status of Road Link with Highest NO_2 Value	Compliant	Compliant	Compliant
Maximum NO_2 Percentage Gap from Compliance	-1.0	-1.3	-0.5

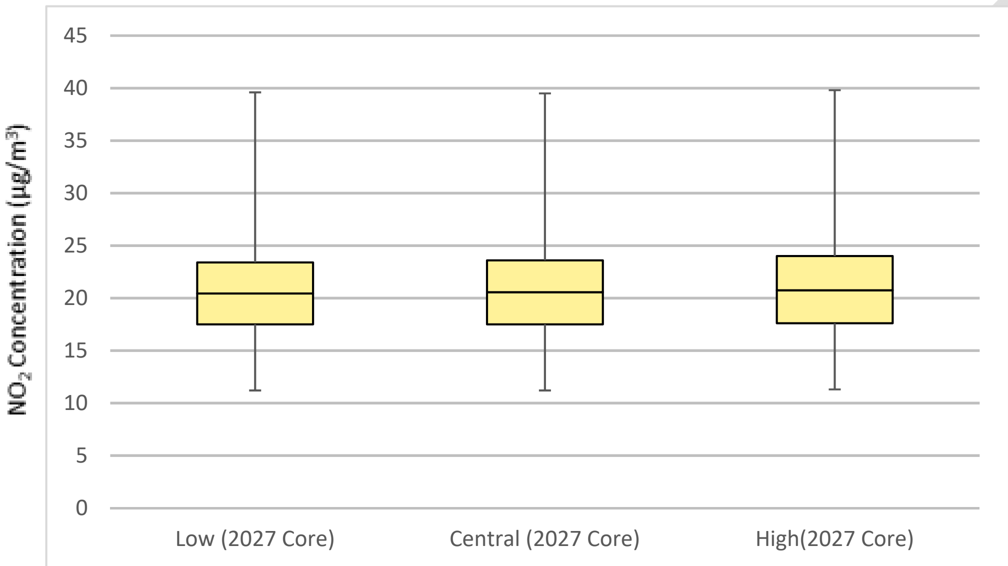

Figure 2-3 Distribution of NO_2 Concentrations for Response Rates

2.4 Diesel Car Ban Eight-hour Timing Review

In addition to the sensitivity testing set out in this chapter, work has been undertake to review the timing of the diesel ban, this work is reported in Appendix A. the report was written to review the effectiveness of an 8-hour diesel car exclusion during the 7am to 3pm time period compared to other times of day. The analysis shows that it is expected that a ‘split’ 8-hour car diesel ban would not be more effective than a ‘contiguous’ 8-hour car diesel ban scheme.

3. Air Quality Modelling

There are many components that contribute to the uncertainty of modelling air quality predictions. The road traffic emissions dispersion model used in this assessment is dependent upon the traffic data that have been input, which will have inherent uncertainties associated with them. There are then additional uncertainties, as models are required to simplify real-world conditions into a series of algorithms. The key uncertainties are explained below and where practical, sensitivity analyses have been carried out to determine the sensitivity of the model to each parameter.

The sensitivity of input parameters has been tested on the Core Hybrid scenario in year 2027.

3.1 Vehicle-Specific Emission Factors

3.1.1 Euro 6 Diesel Vehicles

The EFT includes NOx speed-emission coefficients taken from the European Environment Agency COPERT 5 emission calculation tool[4] and fleet and fuel compositions in line with Department for Transport projections. COPERT 5 predicts different NOx emissions from Euro 6 diesel vehicles registered in different years. This is based on a general expectation that emissions from these vehicles will reduce over time. Over a similar timeframe, new aspects of the Euro 6 emissions standards will come into force, but it is important to recognize that the Euro 6 emissions reductions assumed within COPERT 5 do not, and were not intended to, coincide precisely with specific iterations of the Euro 6 emissions standards themselves. Thus, for example, COPERT 5 does not contain emissions factors specific to Euro 6d-temp vehicles.

The JAQU suggest that local authorities run a 'low emissions' and 'high emissions' scenario for the future emissions standards in their projected reference year and 'with measures' model runs. The JAQU suggest that an appropriate 'low emissions' scenario would be to assume that Euro 6c diesel cars and LGVs achieve the same emissions level as Euro 6d vehicles. This can simply be achieved by moving the proportion of diesel cars and LGVs in the Euro 6c category of the EFT into the Euro 6d category.

For the 'high emissions' scenario the JAQU recommended that Euro 6c cars and LGVs achieve emissions halfway between Euro 6 and Euro 6c and that Euro 6d cars and LGVs achieve emissions halfway between Euro 6c and Euro 6d. This can be achieved by moving 50% of the cars and LGVs in the Euro 6c category of the EFT into the Euro 6 (non-RDE) category and moving 50% of the cars and LGVs in the Euro 6d category of the EFT into the Euro 6c category.

Table 3-1 and Figure 3-1 provide the summary statistics requested in JAQU's 'Supplementary Note on Sensitivity Testing'. Table 3-2 then presents the compliance status for each of these scenarios as well as the 'Central' case. These sensitivity tests demonstrate that the potential effect of the assumed uncertainty in future Euro 6 diesel vehicles is relatively low, with the maximum predicted concentrations for the Core scenario ranging from 38.4 μg/m^3 to 41.8 μg/m^3. The maximum percentage gap from compliance ranges from -4.0% to 4.5% for the 'Low' and 'High' scenarios respectively. It is noted that the 'Central' scenario lies midway between the 'High' and Low' scenarios in terms of predicted concentrations. The results indicate that the central case assumption represents with reasonable certainty the range of expectant Euro 6 variance of NOx emissions from diesel light duty vehicles.

Table 3-1 Simple Summary Statistics for Sensitivity Testing of Euro 6 Diesel Vehicle Emissions (μg/m^3)

Statistic	2027 Baseline	2027 Core		
		Low	Central	High
Mean	21.6	20.2	20.6	21.2
Median	20.6	19.7	20.0	20.6
Maximum	46.3	38.4	39.5	41.8
Minimum	11.5	11.1	11.2	11.6
Upper Quartile	25.2	23.3	23.6	24.5

[4] http://copert.emisia.com

Statistic	2027 Baseline	2027 Core		
		Low	Central	High
Lower Quartile	17.8	17.3	17.5	17.9
Standard Deviation	6.1	4.9	5.1	5.5
Range	34.8	27.3	28.3	30.2

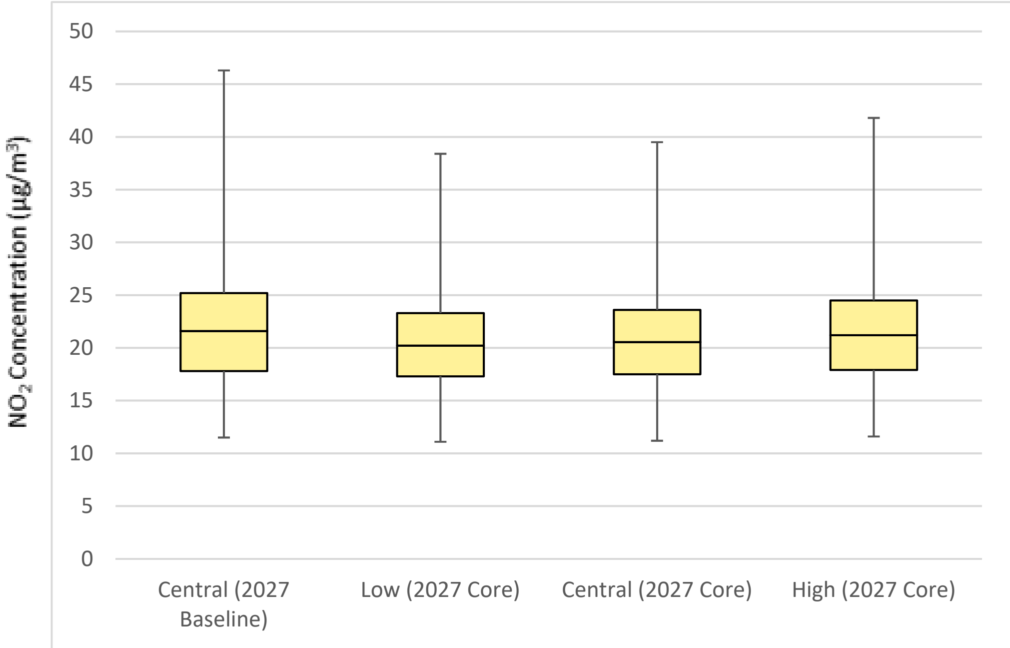

Figure 3-1 Distribution of NO_2 Concentrations for Sensitivity Testing of Euro 6 Diesel Vehicle Emissions

Table 3-2 Summary of Compliance Status for Sensitivity Testing of Euro 6 Diesel Vehicle Emissions

Statistic	2027 Baseline	2027 Core		
	Central	Low	Central	High
No. of Non-Compliance PCM Receptors	10	0	0	3
Compliance Status of Road Link with Highest NO_2 Value	Non-Compliant	Compliant	Compliant	Non-Compliant
Maximum NO_2 Percentage Gap from Compliance	15.8	-4.0	-1.3	4.5

3.2 Relationship between traffic speed and emissions

3.2.1 Emissions at low speeds

Roads with queuing traffic or lots of start/stop behaviour will in general have lower average vehicle speeds than other roads and so stop/start driving is accounted for by way of reduced average speeds in the EFT. Traffic speeds have been estimated from the SATURN (GBATS) model which was validated against journey time data. The speeds are based on the average speed along a road. In reality, the speed will very often be slower at the start and end of a road and faster in the middle. The air quality model includes an adjustment to reduce speeds at the starts and ends of roads and where congestion is most likely. The reduced speeds will lead to higher vehicle emissions and thus increased pollution. In addition, the average vehicle speed along a road will be lower than that which occurs along the middle section of the road. The model therefore assumes higher emissions along the entire road than may occur in reality. The exception to this is where significant idling occurs, so as to reduce the link-average speed (as an annual average) below the minimum of the speed range in the EFT emissions functions (i.e. <5km/h).

JAQU has set out a methodology to assess the uncertainty of emissions from vehicles travelling at low speeds in their 'Supplementary Note on Sensitivity Testing' and state that this methodology should be followed. This involves using a polynomial equation provided by JAQU which is based on using the COPERT emissions functions beyond their intended speed ranges. Details are provided in JAQU's 'Supplementary Note on Sensitivity Testing'. This methodology has been followed to calculate NOx emissions, and the resulting predicted NO_2 concentrations from the air quality model. This results in a 'Low' emissions scenario which uses the speed thresholds from COPERT V4 and a 'High' emissions scenario extends the speed thresholds down to 5 km/h. The 'Low' and 'High' NO_2 concentrations have then been compared to the 'Central' NO_2 concentrations (i.e. without applying the polynomial equation).

Table 3-3 and Figure 3-2 provide a summary of statistics as requested in JAQU's 'Supplementary Note on Sensitivity Testing'. Table 3-4 then presents the compliance status for each of these scenarios as well as the 'Central' modelling. There is little or no difference between the 'High' and 'Central' predictions, with a difference of -1.3% as a maximum percentage gap from compliance. The 'Low' scenario also predicts similar concentrations. In all three scenarios, the 2027 Core scenario is compliant.

Table 3-3 Simple Summary Statistics for Sensitivity Testing of Low Speeds (µg/m^3)

Statistic	2027 Baseline	2027 Core		
		Low	Central	High
Mean	21.6	20.5	20.6	20.6
Median	20.6	20.0	20.0	20.0
Maximum	46.3	39.5	39.5	39.5
Minimum	11.5	11.2	11.2	11.2
Upper Quartile	25.2	23.6	23.6	23.6
Lower Quartile	17.8	17.5	17.5	17.5
Standard Deviation	6.1	5.1	5.1	5.1
Range	34.8	28.3	28.3	28.3

Table 3-4 Summary of Compliance Status for Sensitivity Testing of Low Speeds

Statistic	2027 Baseline	2027 Core		
	Central	Low	Central	High
No. of Non-Compliance PCM Receptors	10	0	0	0
Compliance Status of Road Link with Highest NO_2 Value	Non-Compliant	Compliant	Compliant	Compliant
Maximum NO_2 Percentage Gap from Compliance	15.8	-1.3	-1.3	-1.3

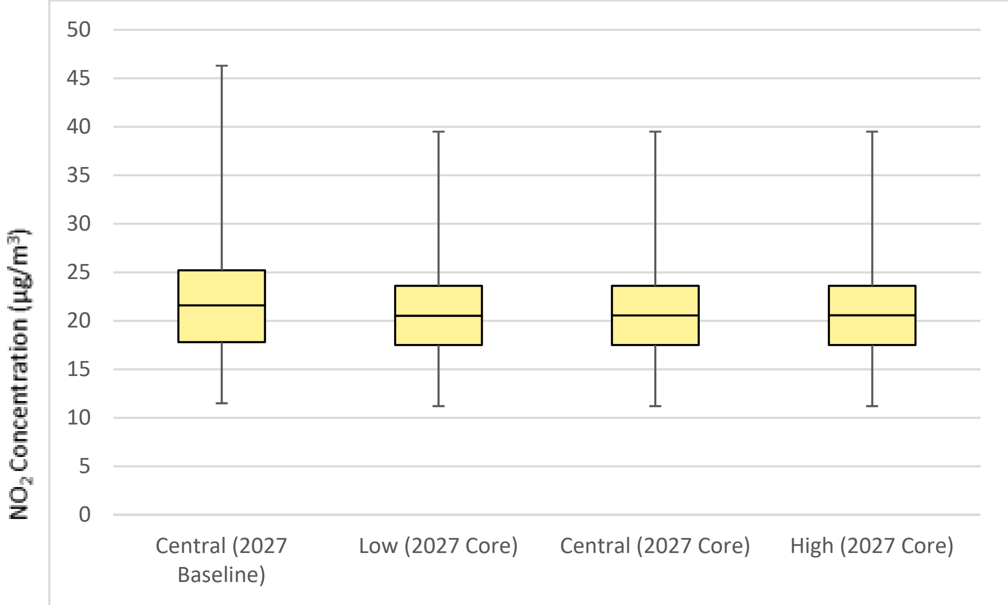

Figure 3-2 Distribution of NO_2 Concentrations for Sensitivity Testing of Low Speeds

3.3 Background Concentrations

Background NO_x, and NO_2 concentrations, for the 2015 base year, were derived from Defra's background mapped data[5] based on COPERT 5.0 emission factors. An interpolation process of background concentrations was undertaken, and results extracted to all modelled receptors. A calibration between the extracted, interpolated results with the 2015 urban background diffusion tube air quality monitoring stations was undertaken. The measured nitrogen dioxide concentration within the modelling domain was compared to the mapped background. It was found that mapped background nitrogen dioxide concentrations were lower than monitored values, and therefore all mapped background nitrogen dioxide concentrations have been calibrated by applying a factor of 3.37%.

To test the sensitivity of the results to this issue, NO_2 concentrations have been predicted for 2027 for both the baseline and Core scenario, with and without the local calibration applied to the background concentrations. In order to accurately take account of different background concentrations model verification should be re-calculated with the uncalibrated backgrounds. This is because background concentrations affect the derived 'measured' local road contributions and hence the calibration factor for the modelled local road contributions. For this test this aspect was not considered.

Table 3-5 and Figure 3-3 provide a summary of statistics as requested in JAQU's 'Supplementary Note on Sensitivity Testing'. Table 3-6 then presents the compliance status for each of these scenarios. Without a local calibration factor being applied to Defra's national pollution background maps, the predicted concentrations are generally lower than if backgrounds are calibrated, receptors remain compliant.

[5] https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2015

Table 3-5 Simple Summary Statistics for Sensitivity Testing of Background Concentrations (µg/m³)

Statistic	2027 Baseline	2027 Core	
		Without Calibration	With Calibration
Mean	21.6	20.1	20.6
Median	20.6	19.4	20.0
Maximum	46.3	39.1	39.5
Minimum	11.5	10.9	11.2
Upper Quartile	25.2	23.1	23.6
Lower Quartile	17.8	17.0	17.5
Standard Deviation	6.1	5.0	5.1
Range	34.8	28.2	28.3

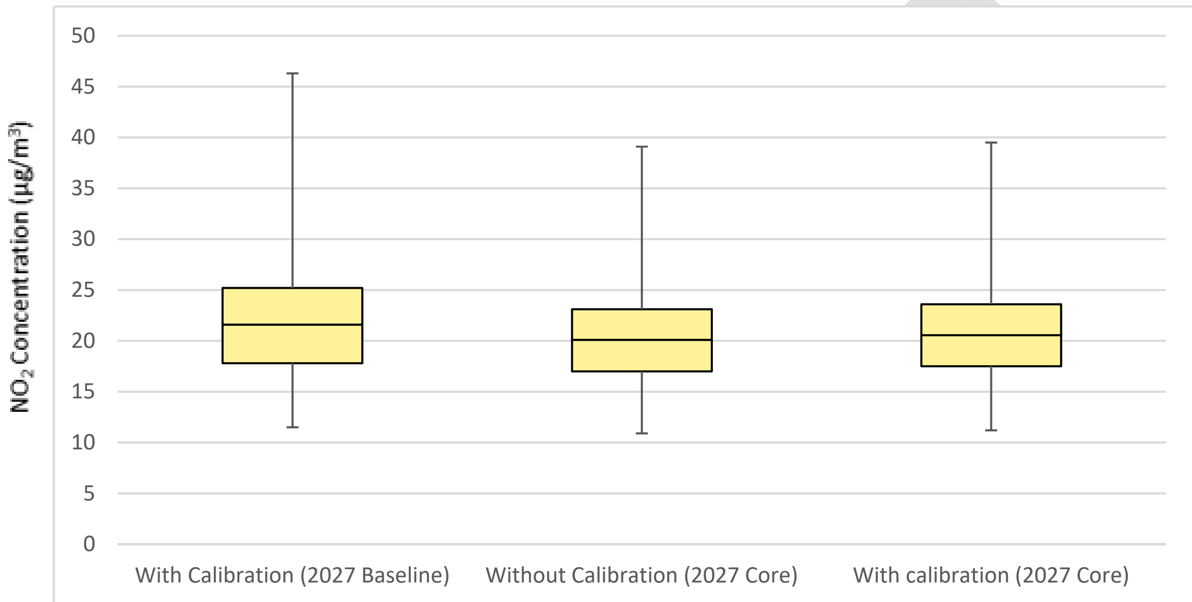

Figure 3-3 Distribution of NO_2 Concentrations for Sensitivity Testing of Background Concentrations

Table 3-6 Summary of Compliance Status for Sensitivity Testing of Background Concentrations

Statistic	2027 Baseline	2027 Core	
	With Calibration	Without Calibration	With Calibration
No. of Non-Compliance PCM Receptors	10	0	0
Compliance Status of Road Link with Highest NO_2 Value	Non-Compliant	Compliant	Compliant
Maximum NO_2 Percentage Gap from Compliance	15.8	-2.3	-1.3

3.4 Model Verification

The model verification for road NO_X and subsequent NO_2 on roads adjacent to monitoring sites was thoroughly tested and included comparing a zoned with a global approach. The verification factor applied to all receptors was 2.28 and was based on 85 sites. The zonal approach considered non-gradient roads, gradient roads and Rupert Street which has very specific air quality issues.

The analysis of Gradient Emissions reported in AQ3 and issued as Appendix D of the OBC, showed the only parameter that was found to have a systematic effect on the verification was the combined percentage of light goods vehicles and heavy-duty vehicles on hilly roads adjacent to monitoring sites. Since no other correlations were found, there was no justification for sensitivity testing the verification for any other parameters.

3.5 Dispersion Uncertainties

3.5.1 Gradients

Vehicle emissions on roads with gradients have been uplifted (as explained in the Air Quality Modelling Methodology Report (AQ2) and the decision of whether an individual road should have this adjustment applied is important. The approach taken has been to apply this uplift to all roads where the gradient is greater than 2.5%, which has been based on Environment Agency in England Lidar data. The roads have been broken into sections based on observations of gradient changes. There should, therefore, be no significant changes in gradient along any individual link; but this is based on subjective, and thus uncertain, observations. The Lidar data will also have inherent uncertainties associated with it. The data are provided at a 1 x 1 m resolution and it is possible that the camber of roads and the choice of road length may have affected the heights used to determine the gradient. It is thus possible that the gradient of some roads may have been underestimated slightly and others overestimated slightly. This would result in emissions potentially not uplifted enough or uplifted too much.

JAQU has set out a methodology to assess the uncertainty of vehicles travelling on gradients in their ‘Supplementary Note on Sensitivity Testing’ and suggest that LAs run a sensitivity test around gradient-based emission factors by removing the impact of modelling gradients if gradients were modelled in the ‘central’ scenario. Bristol is quite hilly and hence this test is applicable.

A test was undertaken to assess the sensitivity of the Core results to this uncertainty. The results have then been compared to the ‘Central’ scenario.

Table 3-7 and Figure 3-4 provide a summary of statistics as requested in JAQU’s ‘Supplementary Note on Sensitivity Testing’. Table 3-8 then presents the compliance status for each of these scenarios as well as the ‘Central’ modelling. The results of the sensitivity tests for a 2027 Core scenario indicate that overall gradient has little impact on the results. Clearly, were specific links to be analysed where gradients are evident the results would show greater differences. There was a slight reduction in the mean and the maximum annual mean NO_2 concentrations, all receptors remained compliant.

Table 3-7 Simple Summary Statistics for Sensitivity Testing of Gradients (µg/m^3)

Statistic	2027 Baseline	2027 Core	
	With Gradients	Without Gradients	With Gradients
Mean	21.6	20.5	20.6
Median	20.6	20.0	20.0
Maximum	46.3	39.4	39.5
Minimum	11.5	11.2	11.2
Upper Quartile	25.2	23.6	23.6
Lower Quartile	17.8	17.5	17.5
Standard Deviation	6.1	5.1	5.1
Range	34.8	28.2	28.3

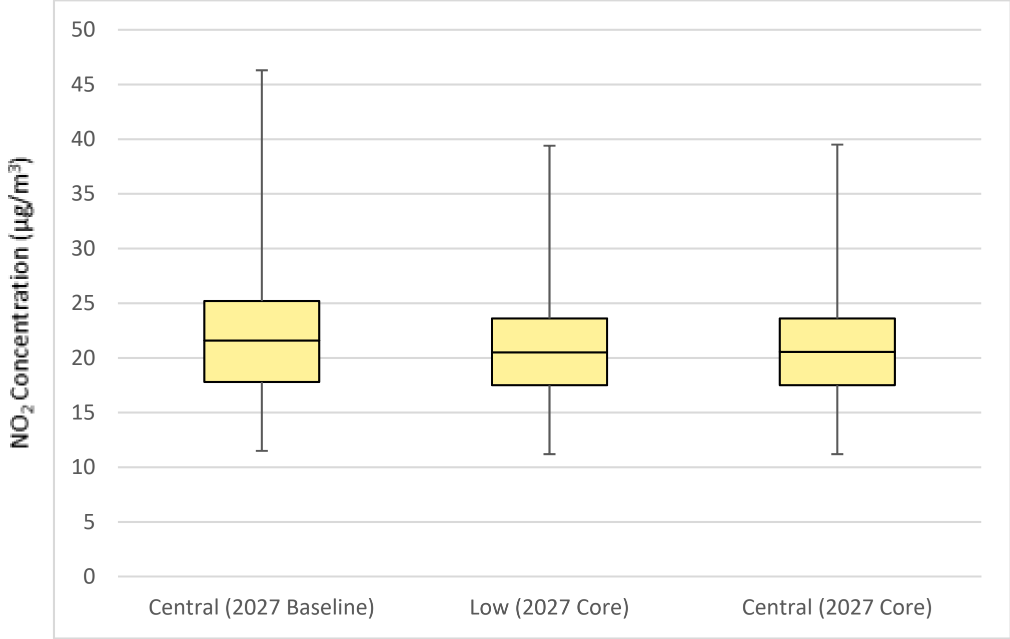

Figure 3-4 Distribution of NO_2 Concentrations for Sensitivity Testing of Gradients

Table 3-8 Summary of Compliance Status for Sensitivity Testing of Gradients

Statistic	2027 Baseline	2027 Core	
	With Gradients	Without Gradients	With Gradients
No. of Non-Compliance PCM Receptors	10	0	0
Compliance Status of Road Link with Highest NO_2 Value	Non-Compliant	Compliant	Compliant
Maximum NO_2 Percentage Gap from Compliance	15.8	-1.5	-1.3

3.6 Relationship of NOx and NO_2

3.6.1 Primary NO_2 Fraction

There is emerging evidence that the average primary NO_2 fraction (f-NO_2) in exhaust emissions from road vehicles has begun to decrease in recent years[6]. This is not taken into account within the EFT, as used for the air quality modelling. To account for this, JAQU suggest that a sensitivity test be carried out whereby the f-NO_2 values are reduced by 40% in the future projected year. Following the JAQU guidance, the f-NO_2 values have been reduced by this percentage and the NO_2 concentrations re-calculated (in Defra's NOx to NO_2 Calculator) using these reduced f-NO_2 values. The results from this 'Low' scenario have then been compared to the NO_2 concentrations without applying this reduction ('Central' scenario).

Table 3-9 provides a summary of statistics (as requested in JAQU's 'Supplementary Note on Sensitivity Testing') and Table 3-10 presents the compliance status for each of these scenarios as well as the 'Central' modelling. Figure 3-5 shows the distribution of the resulting NO_2 concentrations. If the f-NO_2 values are reduced by 40% then the predicted concentrations are slightly lower, with the maximum predicted concentration being 4

[6] Grange S. et al., (2017) Lower vehicular primary emissions of NO_2 in Europe than assumed in policy projections, Nature Geoscience, pp 914-920, ISSN 1752-0908, https://doi.org/10.1038/s41561-017-0009-0

μg/m^3 lower than the 'Central' scenario. This suggests that an earlier year to the predicted 2027 could be compliant if f-NO_2 values decrease in accordance with this assumption. On this basis, the 'Central' scenario with a 2027 compliant year is considered to be robust. It should be noted, that this is based on the assumption that current f-NO_2 values are correct. Using the f-NO_2 values from the EFT is JAQU's recommended approach.

Table 3-9 Simple Summary Statistics for Sensitivity Testing of f-NO_2 (μg/m^3)

Statistic	2027 Baseline	2027 Core	
		Low	Central
Mean	21.6	19.8	20.6
Median	20.6	19.4	20.0
Maximum	46.3	35.4	39.5
Minimum	11.5	11.1	11.2
Upper Quartile	25.2	22.7	23.6
Lower Quartile	17.8	17.1	17.5
Standard Deviation	6.1	4.6	5.1
Range	34.8	24.3	28.3

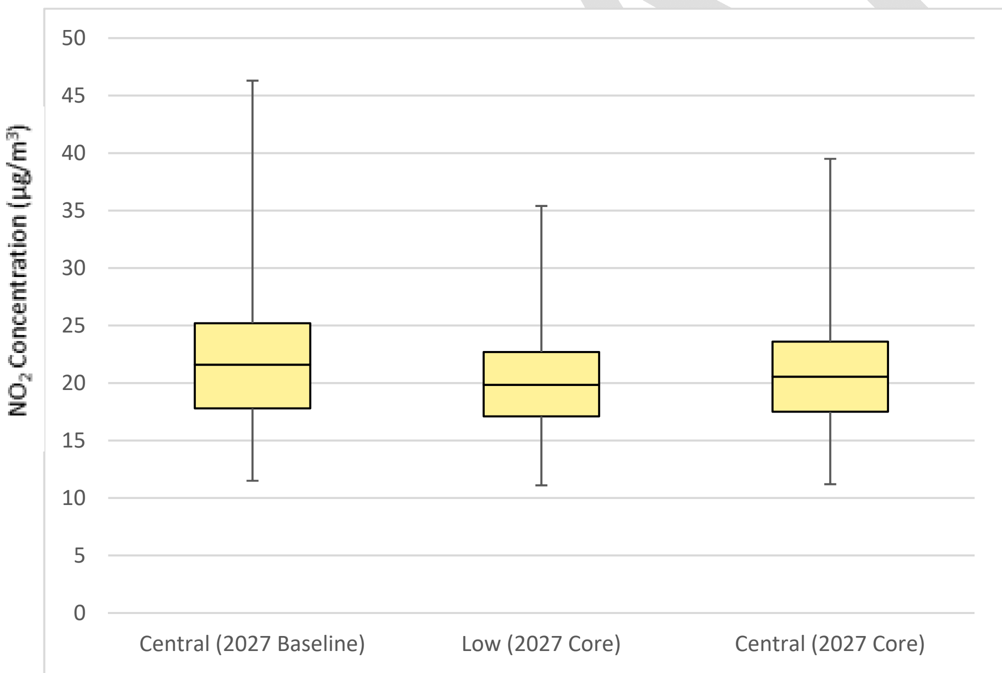

Figure 3-5 Distribution of NO_2 Concentrations for Sensitivity Testing of f-NO_2

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Table 3-10 Summary of Compliance Status for Sensitivity Testing of f-NO_2

Statistic	2027 Baseline	2027 Core	
	Central	Low	Central
No. of Non-Compliance PCM Receptors	10	0	0
Compliance Status of Road Link with Highest NO_2 Value	Non-Compliant	Compliant	Compliant
Maximum NO_2 Percentage Gap from Compliance	15.8	-11.5	-1.3

3.6.2 Regional Ozone

Defra's NOx to NO_2 Calculator[7] calculates NO_2 concentrations from NOx concentrations, based on the reactions of mixing of nitric oxide, nitrogen dioxide and ozone. This relies on tabulated concentrations of ozone above the surface layer for each local authority, which have been modelled for each year between 2015, 2021 and 2031. There is an uncertainty in these predictions. Other NOx to NO_2 approaches are available, but none are clearly more appropriate and the use of Defra's NOx to NO_2 Calculator, which is the recommended method in the JAQU guidance. This issue will contribute to the overall uncertainty in the conclusions of the assessment.

[7] Defra (2018) Local Air Quality Management (LAQM) Support Website. Retrieved from http://laqm.defra.gov.uk/

4. Results Summary Table

For all sensitivity tests, a summary and key results is provided in Table 4-1 below:

Table 4-1 Summary of sensitivity analysis

Test	Section Number	Summary	Key Results
HGV adjustment factors	2.2.1	HGV flow adjustments were made on links with significant differences in modelled flows compared to observed counts. These adjustments were carried through to future years for both the baseline and Core scenario.	The statistics indicated that removing HGV adjustment factors had a negligible impact on NO_2 concentrations at reportable receptors. The maximum NO_2 concentration increased by one tenth of a microgram resulting in the gap between exceeding the Limit Value narrowing slightly.
Fleet Composition: Splits by Fuel Type	2.2.2	A test to examine the differences in annual mean NO_2 concentrations between the Core Scenario modelled using fuel splits derived from the WebTAG Databook and new information provided in the EFT v9.1b	If the EFT V9.1b fuel splits are used then the 2027 Core scheme would be compliant by a greater margin (-2 µg/m^3), with a maximum exceedance of 38.0 µg/m^3. The revised fuel splits are considered to be more robust than the WebTAG Data Book
Behavioural Reponses to Charging	2.3.1	Defined pessimistic and optimistic response rates based on confidence intervals of SP survey statistical modelling and adjusted assumptions for other vehicle types. Compared NO_2 concentrations to Core scenario.	The results for the high and low scenarios are very similar and overall, the 'Central' scenario is most representative. The conclusion of compliance is thus considered appropriate.
Uncertainties in the Air Quality Modelling			
Euro 6 Vehicles	3.1.1	The EFT is based on COPERT 5 which predicts different NOx emissions from Euro 6 diesel vehicles registered in different years (based on the expectation that Euro 6 emissions will reduce over time). Sensitivity test outlined in JAQU's 'Supplementary Note on Sensitivity Testing' has been run.	The results indicate that the central case assumption represents with reasonable certainty the range of expectant Euro 6 variance of NOx emissions from diesel light duty vehicles.
Emissions at Low Speeds	3.2.1	JAQU has set out a methodology to assess the uncertainty of emissions from vehicles travelling at low speeds in their 'Supplementary Note on Sensitivity Testing' which involves using a polynomial equation provided by JAQU which is based on using the COPERT emissions functions beyond their intended speed ranges.	There is little or no difference between the 'High' and 'Central' predictions, with a difference of -1.3% as a maximum percentage gap from compliance. The 'Low' scenario also predicts similar concentrations. In all three scenarios, the 2027 Core scenario is compliant.
Background Concentrations	3.3	To test the sensitivity of results to calibration adjustments made to the 2015 Defra modelled background concentrations (these being based on COPERT5 emission factors) compared with local NO_2 monitoring results.	Without a local calibration factor being applied to Defra's national pollution background maps, the predicted concentrations are generally lower than if backgrounds are calibrated, receptors remain compliant.

Test	Section Number	Summary	Key Results
Model Verification	3.4	The model verification for road NOX and subsequent NO2 on roads adjacent to monitoring sites was thoroughly tested and included comparing a zoned with a global approach. The verification factor applied to all receptors was 2.28 and was based on 85 sites. The zonal approach considered non-gradient roads, gradient roads and Rupert Street which has very specific air quality issues.	There was no justification for sensitivity testing the verification for any other parameters.
Gradients	3.5.1	JAQU has set out a methodology to assess the uncertainty of vehicles travelling on gradients in their 'Supplementary Note on Sensitivity Testing' and suggest that LAs run a sensitivity test around gradient-based emission factors by removing the impact of modelling gradients if gradients were modelled in the 'central' scenario.	The results of the sensitivity tests for a 2027 Core scenario indicate that overall gradient has little impact on the results. Clearly, were specific links to be analysed where gradients are evident the results would show greater differences. There was a slight reduction in the mean and the maximum annual mean NO_2 concentrations, all receptors remained compliant
Primary NO_2 Fraction	3.6.1	There is emerging evidence that the average primary NO_2 fraction (f-NO_2) in exhaust emissions from road vehicles has begun to decrease in recent years. This is not taken into account within the EFT, as used for the air quality modelling. To account for this, JAQU suggest that a sensitivity test be carried out whereby the f-NO_2 values are reduced by 40% in the future projected year.	If the f-NO_2 values are reduced by 40% then the predicted concentrations are slightly lower, with the maximum predicted concentration being 4 µg/m^3 lower than the 'Central' scenario. This suggests that an earlier year to the predicted 2027 could be compliant if f-NO_2 values decrease in accordance with this assumption. On this basis, the 'Central' scenario with a 2027 compliant year is considered to be robust.

Appendix A Diesel Car Ban Eight-hour Timing Review

Bristol City Council Clean Air Plan

Outline Business Case

Diesel Car Ban Eight-hour Timing Review

OBC-39 – Appendix A

October 2019

Bristol Clean Air Plan

Project No:	673846.ER.20
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Revision:	2
Date:	October 2019
Client Name:	Bristol City Council
Project Manager:	HO
Author:	KW

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Document history and status

Revision	Date	Description	By	Review	Approved
1	12/09/2019	Draft 1	KW	CB	HO
2	24/10/2019	Draft 2	KW	CB	HO

Contents

1. Introduction

Jacobs has been commissioned to support BCC to produce an Outline Business Case (OBC) for the delivery of the CAP; a package of measures which will bring about compliance with the Limit Value for annual mean NO_2 in the shortest time possible in central Bristol. The OBC assesses the shortlist of options set out in the Strategic Outline Case[1], and proposes a preferred option including details of delivery. The OBC forms a bid to central government for funding to implement the CAP. This report provides information about the diesel car ban timing which is appended to the sensitivity test report that supports the OBC.

1.1 Purpose of this Report

This report is written to review the effectiveness of an 8-hour diesel car exclusion during the 7am to 3pm time period compared to other times of day.

[1] Bristol City Council Clean Air Plan: Strategic Outline Case, April 2018 (https://www.cleanairforbristol.org/wp-content/uploads/2018/05/Strategic-Outline-Case_BCC_Final_05.04.18.pdf)

2. Behavioural Response Methodology

2.1 Calculated Response Rates for Diesel Car Exclusion 7am-3pm (Option 2)

Full details of the calculation of the behavioural responses is provided in the OBC-23 Bristol Clean Air Plan: Transport Modelling Methodology Report and the OBC-26 Bristol Clean Air Plan: Primary Behavioural Response Calculation Methodology in Appendix E of the OBC.

The methodology for calculating the primary response rates for the small area diesel car exclusion (7am-3pm) is summarised as follows:

- Calculate 24-hour car diesel exclusion response rate for the small area - the pay charge response rate was set to zero, the avoid zone, cancel trip/change mode and replace vehicle rates have been determined by the stated preference survey diesel car responses which have been normalised so that the total response rate totals 100 per cent, as shown in Table 2-1;

Table 2-1: 24-hour Primary Behavioural Response Rates for Diesel Car Exclusion

Response	Cars Low Income	Cars Medium Income	Cars High Income	Cars Employers Business
Pay Charge	0.0%	0.0%	0.0%	0.0%
Avoid Zone	17.5%	17.5%	17.5%	17.5%
Cancel Journey / Change Mode	23.8%	23.8%	23.8%	23.8%
Replace Vehicle	58.7%	58.7%	58.7%	58.7%

- Calculate 8-hour (7am-3pm) car diesel ban responses based on the assumptions outlined in Table 2-2, with final response rates shown in Table 2-3. This methodology takes into account the estimated proportions of trips to change time of day (TOD response) to avoid the exclusion period and the estimated extent to which trips are linked between different time periods by trip purpose.

Table 2-2: 8-hour (7am-3pm) Car Diesel Exclusion Methodology

Time Period	Commute	Education	Other	Business
AM (7-10)	TOD - shift to pre 7am, based on calcluated % that travel in 30 mins post 7am compared to 7am-10am CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - shift to post 3pm (as per SP RV) CTCM - from SP AZ - from SP RV - 0% SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%
IP (10-3)	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - shift to post 3pm (as per SP RV) CTCM - from SP AZ - from SP RV - 0% SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%
PM (3-7)	TOD - 0% CTCM - some linked to earlier trips - PA/OD factors used from RSI surveys AZ - 0% RV/SV - some linked to earlier trips - PA/OD factors used from RSI surveys	TOD - 0% CTCM - some linked to earlier trips - PA/OD factors used from RSI surveys AZ - 0% RV/SV - some linked to earlier trips - PA/OD factors used from RSI surveys	TOD - shift from pre 3pm CTCM - some linked to earlier trips - PA/OD factors used from RSI surveys AZ - 0% RV - 0% SV - some linked to earlier trips - PA/OD factors used from RSI surveys	TOD - 0% CTCM - some linked to earlier trips - PA/OD factors used from RSI surveys AZ - 0% RV - some linked to earlier trips - PA/OD factors used from RSI surveys

Key:
SP – Stated Preference Surveys
TOD – Time of Day Choice
CTCM – Cancel Trip / Change Mode
AZ – Avoid Zone
RV – Replace Vehicle
SV – Switch Vehicle

Table 2-3: Final 8-hour (7am-3pm) Car Diesel Exclusion Primary Response Rates

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	15.44%	14.56%	0.00%	17.47%	14.56%	0.00%
Cancel Journey / Change Mode	21.03%	21.85%	15.74%	23.79%	23.52%	22.18%
Replace Vehicle	43.04%	19.45%	31.54%	58.74%	58.07%	54.75%
Time of Day Choice	20.49%	31.94%	0.00%	0.00%	0.00%	0.00%

2.2 Calculated Response Rates for Diesel Car Exclusion (7am-10am and 2pm-7pm)

An alternative timing for the 8-hour exclusion was identified based on a review of hourly traffic count data for the central Bristol area. This identified that a ‘split‘ time period of 7am-10am and 2pm-7pm would cover the highest traffic flows.

The methodology for calculating the primary response rates for the small area 8-hour split diesel car exclusion (7am-10am and 2pm-7pm) is summarised as follows:

- Use the 24-hour car diesel exclusion response rate for the small area, as shown previously in Table 2-1;
- Calculate the split 8-hour diesel car ban responses based on the assumptions outlined in Table 2-4, with final response rates shown in Table 2-5. Again, this methodology takes into account the estimated proportions of trips to change time of day (TOD response) to avoid the exclusion period and the estimated extent to which trips are linked between different time periods by trip purpose.

Table 2-4: Split 8-hour Car Diesel Exclusion Methodology

Time Period	Commute	Education	Other	Business
AM (7-10)	TOD - shift to pre 7am, based on calcluated % that travel in 30 mins post 7am compared to 7am-10am CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - shift to post 10am (as per SP RV) CTCM - from SP AZ - from SP RV - 0% SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%
IP (10-2)	TOD - shift from after 2pm CTCM - some linked to earlier/later trips - PA/OD factors used from RSI surveys AZ - 0% RV/SV - some linked to earlier/later trips - PA/OD factors used from RSI surveys	TOD - 0% CTCM - some linked to earlier trips - PA/OD factors used from RSI surveys AZ - 0% RV/SV - some linked to earlier trips - PA/OD factors used from RSI surveys	TOD - shift from before 10am/after 2pm CTCM - some linked to earlier/later trips - PA/OD factors used from RSI surveys AZ - 0% RV - 0% SV - some linked to earlier/later trips - PA/OD factors used from RSI surveys	TOD - 0% CTCM - some linked to earlier/later trips - PA/OD factors used from RSI surveys AZ - 0% RV - some linked to earlier/later trips - PA/OD factors used from RSI surveys
IP (2-4)	TOD - shift to pre 2pm, based on calcluated % that travel in 30 mins post 2pm compared to 2pm-4pm CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - shift to pre 2pm (as per SP RV) CTCM - from SP AZ - from SP RV - 0% SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%
PM (4-7)	TOD - shift to post 7pm, based on calcluated % that travel in 30 mins pre 7pm compared to 4pm-7pm CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%	TOD - shift to pre 2pm (as per SP RV) CTCM - from SP AZ - from SP RV - 0% SV - from SP Percentages above proportioned so total equal 100%	TOD - 0% CTCM - from SP AZ - from SP RV - from SP SV - from SP Percentages above proportioned so total equal 100%

Key:
SP – Stated Preference Surveys
TOD – Time of Day Choice
CTCM – Cancel Trip / Change Mode
AZ – Avoid Zone
RV – Replace Vehicle
SV – Switch Vehicle

Table 2-5: Final Split 8-hour Car Diesel Exclusion Primary Response Rates

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	15.44%	5.44%	15.55%	17.47%	5.82%	17.47%
Cancel Journey / Change Mode	21.03%	13.04%	21.18%	23.79%	15.59%	23.79%
Replace Vehicle	43.04%	10.87%	34.05%	58.74%	38.49%	58.74%
Time of Day Choice	20.49%	14.96%	29.22%	0.00%	0.00%	0.00%

3. Results and Conclusion

3.1 Results

The response rates calculated above for each 8-hour diesel car exclusion scenario have been applied to Baseline car diesel trips within the Small CAZ area for each time period. This gives an indication of how many diesel car trips will be 'removed' from the CAZ over a 12-hour time period for each scenario i.e. either avoid the zone, cancel trip / change mode or be replaced with a non-diesel vehicle. Tables 3-6 and 3-7 show the results for both scenarios for 2021 and 2031 respectively.

Table 3-6: 2021 Diesel Cars Removed from Zone

Diesel cars	Cars Low-High Inc			Cars Emp Bus			Total
	AM (7-10)	IP (10-4)	PM (5-7)	AM (7-10)	IP (10-4)	PM (5-7)	
Baseline	356,073	581,942	406,315	36,489	102,758	22,674	1,506,250
Removed 7am-3pm:	283,106	325,084	192,122	36,489	98,807	17,443	953,051
Removed 7am-10am and 2pm-7pm:	283,106	170,781	287,573	36,489	61,552	22,674	862,174

Table 3-7: 2031 Diesel Cars Removed from Zone

Diesel cars	Cars Low-High Inc			Cars Emp Bus			Total
	AM (7-10)	IP (10-4)	PM (5-7)	AM (7-10)	IP (10-4)	PM (5-7)	
Baseline	332,159	571,461	384,347	34,537	100,686	21,682	1,444,872
Removed 7am-3pm:	264,093	319,229	181,735	34,537	96,815	16,680	913,088
Removed 7am-10am and 2pm-7pm:	264,093	167,705	272,025	34,537	60,311	21,682	820,353

The results indicate that the 'contiguous' 7am-3pm 8-hour diesel car exclusion would remove more diesel cars from the exclusion zone on a daily basis than the 'split' diesel car exclusion, by around 10%. This is intuitively explained by a number of factors, as follows:

- the split diesel car exclusion allows more opportunity for time of day choice, with less significant changes to travel times required, meaning it will be easier for some drivers to avoid the exclusion times;
- the inter-peak 10am-2pm time period where there is no exclusion offers a significant time frame for 'other' trips to access the Small CAZ with a diesel car;
- the 7am-3pm exclusion covers a significant proportion of the day capturing journeys from home, therefore trips during the 3pm-7pm time period are likely to include a high proportion of linked 'return journey' trips which would therefore also be impacted by the diesel car exclusion earlier in the day.

3.2 Conclusion

Based on the above preliminary analysis it is expected that a 'split' 8-hour car diesel ban would not be more effective than a 'contiguous' 8-hour car diesel ban scheme. Additional work is proposed to verify this conclusion, in particular, since the expected effectiveness of the exclusion scheme would be particularly sensitive to assumptions regarding the extent to which trips are linked between different times of day.

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TECHNICAL NOTE

Bristol City Council Clean Air Plan – Final Business Case
M32 Park and Ride Sensitivity Test

Prepared for: Bristol City Council

Prepared by: Jacobs

Date: 7 April 2020

Project Number: 673846.ER.20

1. Introduction

JAQU's T-IRP have requested the disaggregation of the policies proposed to demonstrate the need for each component. The Medium CAZ/Small CAZ D, has been derived through the development of a number of options. This work shows the air quality benefit of particular groups of components. The Outline Business Case submission presented information about the compliance of Option 1 (which contained a Medium CAZ C and complementary measures). It was demonstrated that the Option 1 scheme helped to reduce emissions but was not sufficient on its own to deliver air quality improvements in the shortest possible time. Hence schemes targeting cars were subsequently considered.

Due to timescales it was agreed that one decremental sensitivity test would be undertaken, without the M32 Park and Ride (P&R) scheme.

The purpose of this Technical Note is to address T-IRP comments regarding the M32 P&R scheme as part of the package of transport management measures to enhance the Clean Air Zone (CAZ).

2. Modelling Approach

The M32 P&R decremental test has been undertaken on the Medium CAZ C + Small CAZ D option, for the years 2021 and 2025. The Medium CAZ C + Small CAZ D option includes the following components:

- Small Area Class D – (charging non-compliant cars)
- Medium Area Class C (charging non-compliant buses, coaches, taxis, HGVs and LGVs);
- Closure of Cumberland Road inbound to general traffic;
- M32 P&R with bus lane inbound; and
- Holding back traffic to the city centre through the use of existing signals.

The decremental test removes the M32 P&R but retains the bus lane along the M32. This test has been modelled using the same methodology as the other option tests, as discussed in Chapter 5 of the FBC-23 Transport Modelling Methodology Report in Appendix E of the FBC.

However, due to the removal of the M32 P&R, the M32 bus lane has been modelled within the SATURN highway model and run through the Variable Demand Model (VDM), together with the Cumberland Road inbound lane closure to general traffic. This allows the demand model to determine the traffic response to this physical measure of removing highway capacity, rather than a matrix adjustment to represent the P&R and bus lane together, as previously modelled.

3. Transport Model Results

The compliance splits at the Medium CAZ cordon level for the Medium CAZ C + Small CAZ D option with and without the M32 P&R are the same as the P&R does not specifically target non-compliant vehicles. The compliance splits are shown in Chapter 6 of the FBC-27 Transport Modelling Forecasting Report in Appendix E of the FBC. They show that the compliance of the fleet within Bristol city centre improves with the implementation of this option.

The highway model network statistics have been extracted for 2021 and 2025 Medium CAZ C + Small CAZ D with and without M32 P&R. Tables 3-1 to 3-2 compares the statistics for the two options, for 2021 and 2025 respectively.

Table 3-1: 2021 Highway Network Statistics

Measure	2021 Medium CAZ C + Small CAZ D			2021 Medium CAZ C + Small CAZ D no M32 P&R			Difference		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Transient Queues	7441	4788	7261	7633	4812	7416	2.6%	0.5%	2.1%
Over-Capacity Queues	1123	22	707	1303	30	806	16.0%	37.2%	14.0%
Link Cruise Time	19093	15176	19266	19282	15186	19487	1.0%	0.1%	1.2%
(Free Flow	18520	14842	18717	18700	14851	18912	1.0%	0.1%	1.0%
Delays	574	335	549	582	335	575	1.4%	0.1%	4.8%
Total Travel Time	27658	19986	27234	28218	20027	27710	2.0%	0.2%	1.7%
Travel Distance	1187726	968240	1213890	1198075	968783	1227396	0.9%	0.1%	1.1%
Overall Average Speed	42.90	48.40	44.60	42.50	48.40	44.30	-0.9%	0.0%	-0.7%
Total Trips Loaded	130064	112285	128762	130717	112386	129671	0.5%	0.1%	0.7%

Table 3-2: 2025 Highway Network Statistics

Measure	2025 Medium CAZ C + Small CAZ D			2025 Medium CAZ C + Small CAZ D no M32 P&R			Difference		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Transient Queues	7955	5187	7757	8213	5198	7950	3.2%	0.2%	2.5%
Over-Capacity Queues	1414	62	895	1691	64	1024	19.6%	3.4%	14.4%
Link Cruise Time	19901	16110	20135	20090	16124	20367	1.0%	0.1%	1.2%
(Free Flow	19229	15706	19476	19409	15719	19681	0.9%	0.1%	1.0%
Delays	672	404	659	681	405	687	1.4%	0.2%	4.2%
Total Travel Time	29270	21359	28787	29994	21386	29341	2.5%	0.1%	1.9%
Travel Distance	1231259	1026751	1266222	1241712	1027568	1279589	0.8%	0.1%	1.1%
Overall Average Speed	42.10	48.10	44.00	41.40	48.00	43.60	-1.7%	-0.2%	-0.9%
Total Trips Loaded	135529	118161	134251	136216	118258	135156	0.5%	0.1%	0.7%

The Medium CAZ D + Small CAZ D without the M32 P&R has an increase in trips compared to the with M32 P&R option, as expected. This results in an increase in queues, delays and travel time and a decrease in the overall speed throughout the network.

4. Air Quality Model Results

The primary objective of the CAP is to bring compliance with the European Union (EU) Limit Value across Bristol in the shortest possible timeframe, and the key success factor is therefore the earliest year where all modelled annual mean NO_2 concentrations are below 40 µg/m^3 (i.e. at PCM equivalent reportable receptors). For both scenarios, the compliance year at PCM equivalent receptors within Bristol City Council region was calculated by interpolating modelled NO_2 concentrations between 2021 and 2025.

Table 4-1 provides a summary of the resulting air quality receptor compliance between 2021 and 2025. The results indicate that, with the M32 P&R, a compliance year of 2023 is expected. Without the M32 P&R, compliance is delayed by one year to 2024, as the result of 2 receptors that remain non-compliant in 2023.

Table 4-1 Number of Non-Compliant Receptors per Year for Both Scenarios

Year	Number of Non-Compliant Receptors in Each Scenario	
	Medium CAZ C + Small CAZ D	Medium CAZ C + Small CAZ D no M32 P&R
2021	11	14
2022	7	7
2023	0	2
2024	0	0
2025	0	0

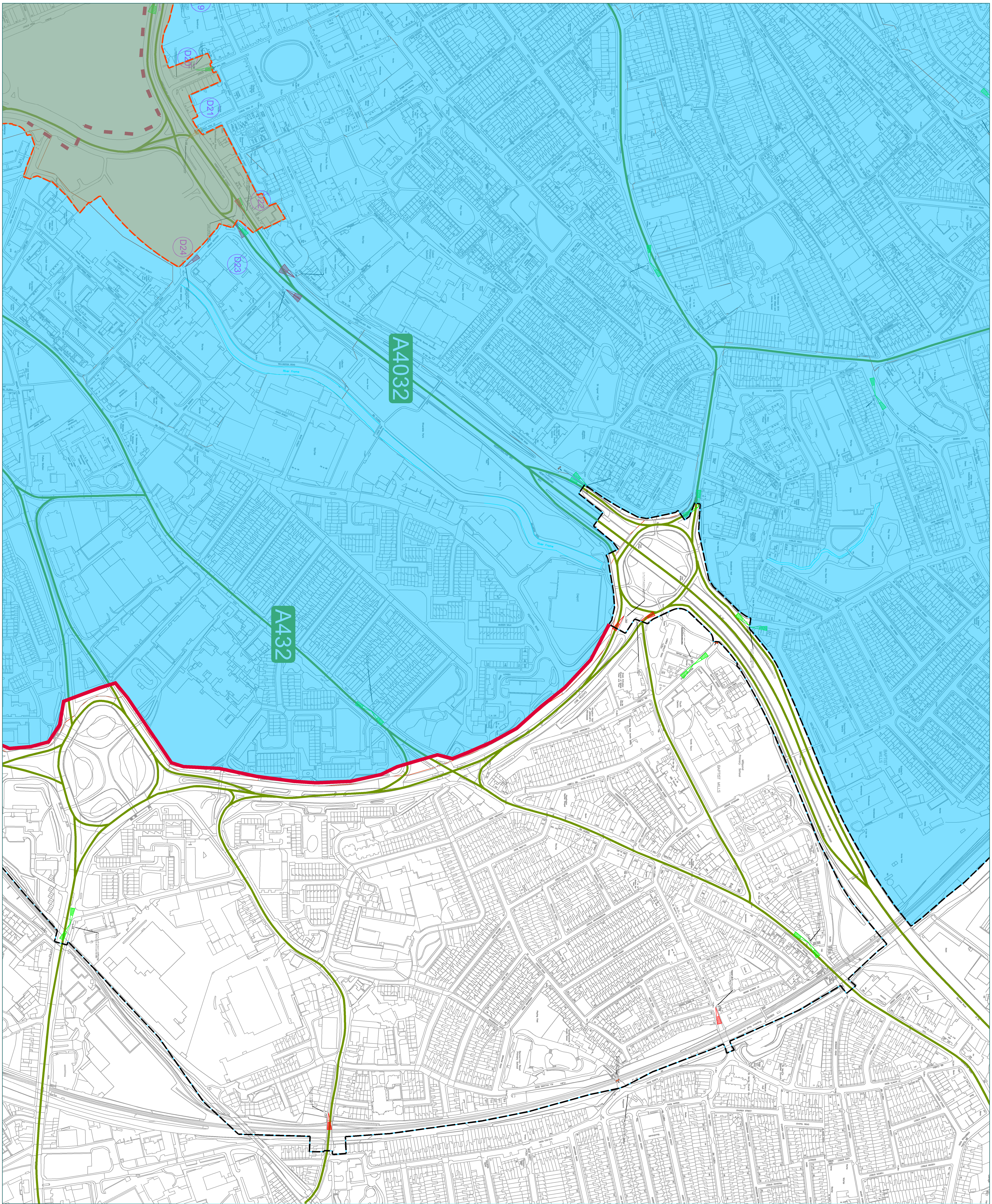
Table 4-2 shows the compliance year in focus areas that are known to control the compliance across Bristol. This shows that with the M32 P&R, the one-year delay in compliance is caused by 2 receptors located on Marlborough Street. Without the P&R, the compliance at Rupert Street is also delayed by one year, but this does not affect the total compliance. The compliance year in other focus areas is unaffected by the M32 P&R.

Higher NO_2 concentrations without the M32 P&R scenario reflect the traffic data, which showed an increase in trips, subsequent increase in queues and decrease in speed over the network in this scenario.

Table 4-2 Focus area compliance years for both scenarios.

Focus Area	Receptor ID	Focus Area Compliance Years for Each Scenario	
		Medium CAZ C + Small CAZ D	Medium CAZ C + Small CAZ D no M32 P&R
Rupert Street	15160	2021	2022
Marlborough Street	12649	2023	2024
Upper Maudlin Street	12636	2021	2021
Park Row	12014	2021	2021
Park Street	6925	2021	2021
Queen's Road	7098	2021	2021
College Green	11949	2021	2021
Cheltenham Road	12708	2021	2021
Newfoundland Way	13742	2021	2021
Church Road	24587	2022	2022
Baldwin Street	11589	2023	2023

Note: Colour shading shows the earliest year (green) and latest year (red) that areas become compliant for each scenario



Key

- Medium CAZ Boundary
- Changed Medium CAZ Boundary
- Small CAZ Boundary

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BRISTOL CLEAN AIR ZONE

Drawing

CAZ BOUNDARY PLAN
EASTON

Drawn by: CC Date: 04.07.2018
Checked by: - Date: -
Approved by: - Date: -

Drawing No. 673846.CD.55.01-005 Revision -

Drawing Scale: 1:2500 @ A1

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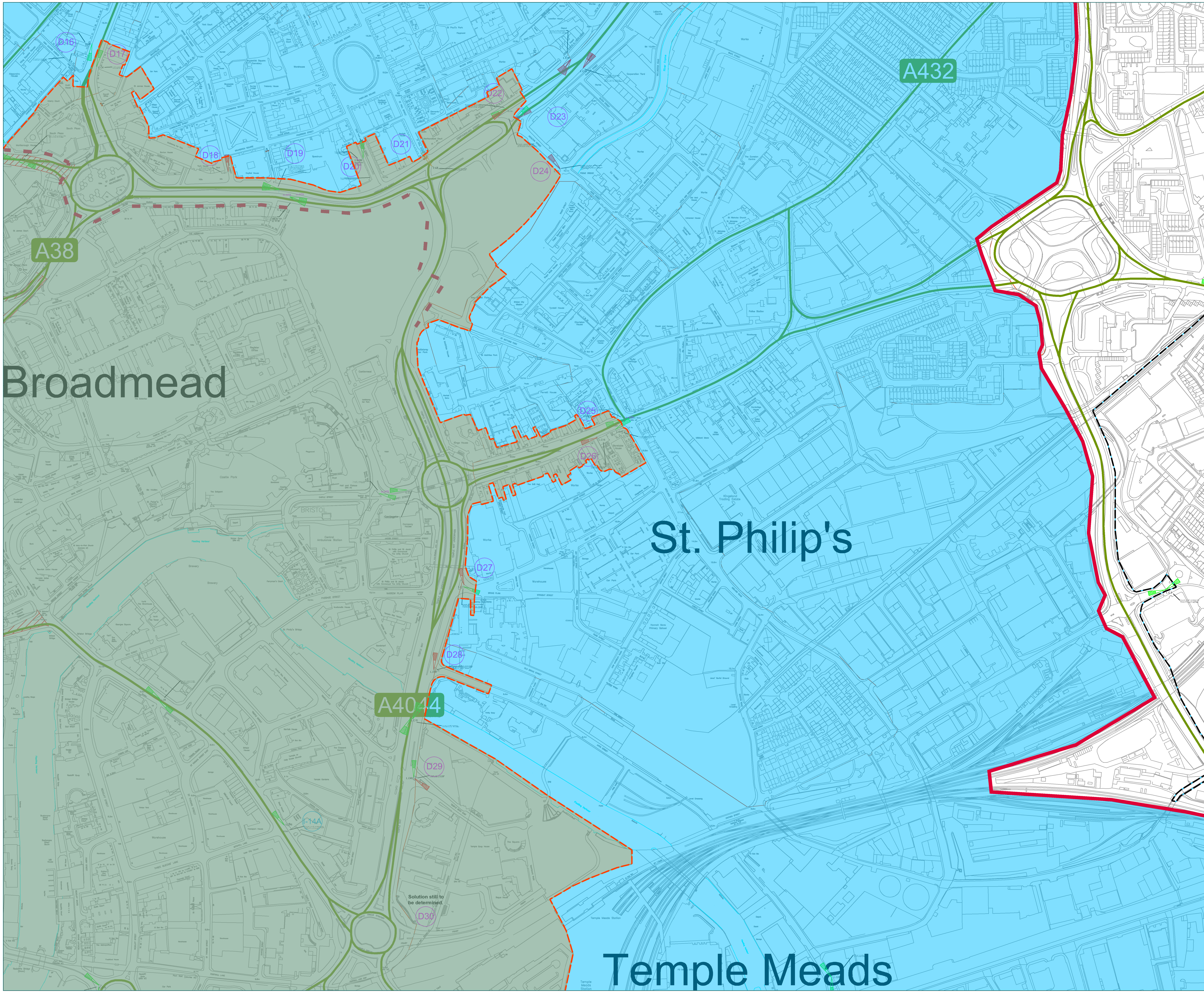

Key

- Medium CAZ Boundary
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Drawing: CAZ BOUNDARY PLAN
ST. PHILIPS/BARTON HILL

Drawn by: CC Date: 04.07.2018
Checked by: - Date: -
Approved by: - Date: -

Drawing No.: 673846.CD.55.01-006 Revision: -

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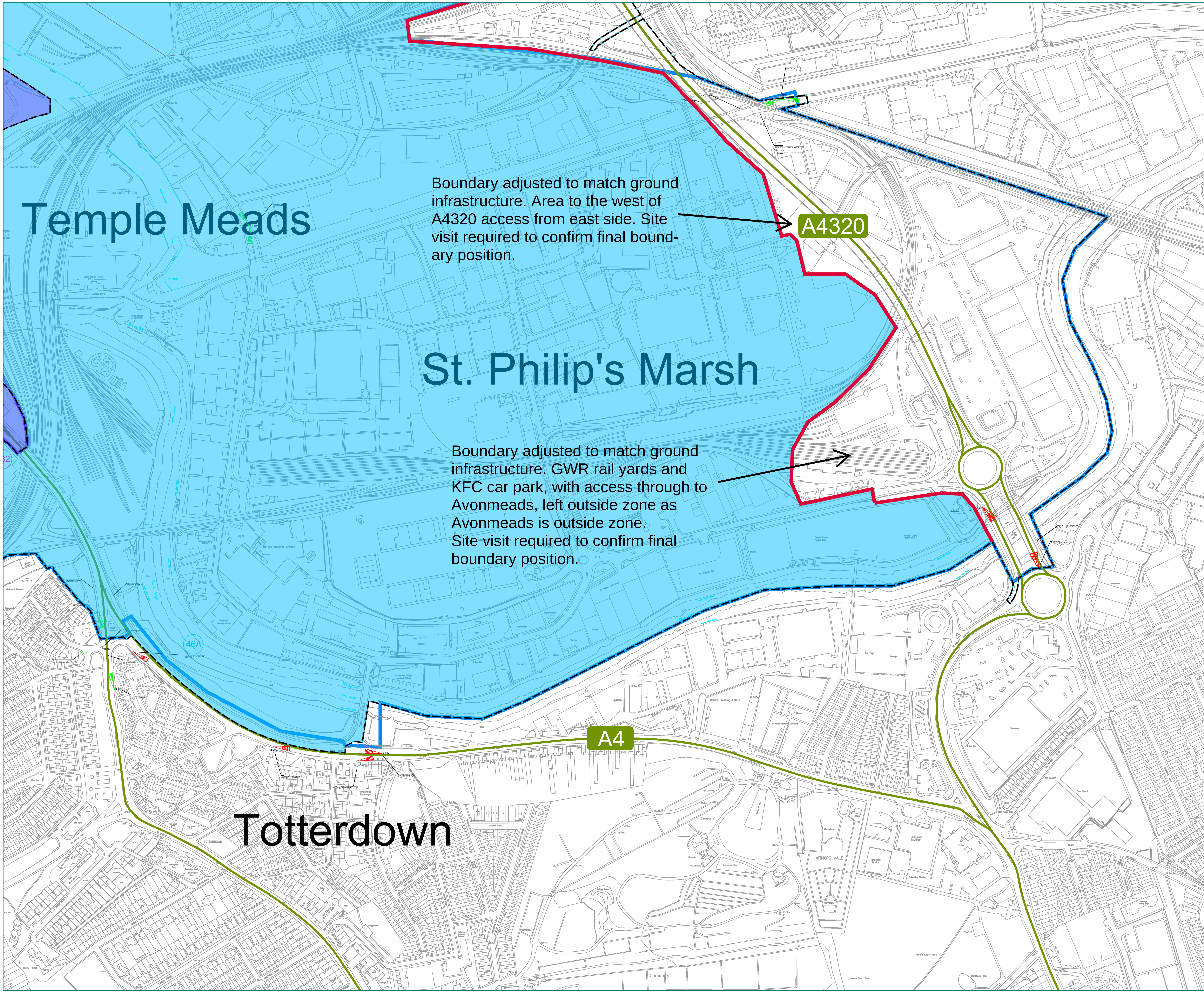

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Drawing: CAZ BOUNDARY PLAN ST. PHILIPS MARSH

Drawn by: CC Date: 04.07.2018
Checked by: - Date: -
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User and Plot Date :

Jacobs

TECHNICAL NOTE

Bristol City Council Clean Air Plan – FBC

Diesel Car Ban Effectiveness Sensitivity Test

Prepared for: Bristol City Council

Prepared by: Jacobs

Date: May 2020

Project Number: 673846.ER.20

1. Introduction

This Technical Note is written in response to JAQUs TIRP comments regarding the effectiveness of the diesel car ban component of the Bristol Clean Air Plan Hybrid option, as described in the T4 Transport Model Forecasting Report submitted as part of the Outline Business Case in October 2019.

The Hybrid scheme includes:

- 8-hour Small Area diesel car exclusion (7am – 3pm);
- Medium Area Class C (charging non-compliant buses, coaches, taxis, HGVs and LGVs);
- Closure of Cumberland Road inbound to general traffic;
- M32 Park and Ride (P&R) with bus lane inbound; and
- Holding back traffic to the city centre through the use of existing signals.

Since the OBC, the Hybrid option has been revised with boundary changes as described in the FBC-27 T4 Transport Model Forecasting Report, dated April 2020. This is the option used in this assessment and is referred to as the Revised Hybrid.

The TIRP have requested that the tolerances of the diesel ban effectiveness assumptions are tested through sensitivity testing (reference rows 21 and 25 of the TIRP review comments), It was agreed on a call with JAQU (dated 13/2/20) that due to timescale pressures, a single sensitivity test would be undertaken from which the percentage change in input assumptions that would trigger a compliance year change could be estimated.

This Technical Note documents the sensitivity test undertaken and resulting conclusions re compliance year.

2. Diesel Car Ban Assumptions

The assumptions for modelling the diesel car ban scheme are set out in FBC-23 T3 Transport Modelling Methodology Report.

The key assumptions are:

- Age of petrol car bought to replace a diesel car;
- Replace vehicle / cancel trip/change mode / avoid zone;
- Time of day choice (resulting in re-timing of diesel car trips to avoid the ban); and
- Extent to which trips are linked by time of day (resulting in scheme impacts outside the operating hours of 0700-1500).

The sensitivity test undertaken has been based on adjusting the assumptions most likely to affect compliance, namely:

- Extent to which trips are linked by time of day; and
- Time of day choice.

The discussion below explains why these responses were tested, as agreed with JAQU.

Assumptions regarding the age of petrol car bought to replace a diesel car were not adjusted since the assumptions used to date already assume 75% of petrol cars bought are second-hand and reflect a range of older vehicles.

Proportions of responses (replace vehicle vs cancel trip/change mode vs avoid zone) were not adjusted since the assumptions used to date are already conservative in this regard with 'replace vehicle' forming the highest proportion. The term conservative is used here to mean erring on the side of under-estimating scheme effectiveness in relation to these responses. This is because if higher proportions were assumed to cancel trip / change mode or avoid the zone then emissions would be lower within the zone area since these responses would simply remove diesel car trips from the zone, whereas the 'replace vehicle' response switches diesel car trips to petrol car trips.

It was not considered that it would be helpful to use the variable demand model (VDM) to examine the time of day choice response since the VDM doesn't represent all potential choices available in relation to a CAZ (e.g. omits 'replace vehicle' response) and hence is not expected to give a better assessment to CAZ / diesel ban measures than those already used in the assessment.

The original modelling of the extent to which people change journey timings to avoid the ban was based on judgement due to the lack of relevant available data. The assumptions were:

- No re-timing of trips for Education and Employers Business trips;
- For Commute trips, people will re-time their trip up to 30 minutes earlier to avoid the ban and hence re-time from 0700-0730 to before 0700; and
- For Other trips, people will re-time their trip after 1500

Given not all Other trips are likely to be able to re-time their trip (and continue to drive diesel cars in the zone) in practice, the above journey timing assumptions are considered reasonably conservative in terms of the effectiveness of the ban. However, there is still some uncertainty around this assumption due to the lack of available supporting data.

In order to examine the extent to which trips are linked by time of day, new evidence has been used for this response in that further analysis of the Bristol ANPR data has been undertaken. This has indicated a slightly lower proportion of trips are linked across times of day than assumed. However, the modelling did not account for any linkage between the ban period and off-peak journeys (1900-0700) which is conservative in terms of the effectiveness of the ban.

Based on the above it was considered that the assumptions most likely to affect scheme compliance are:

- The extent to which trips are linked between different times of day and hence the extent to which the scheme will reduce diesel car trips outside the 0700-1500 scheme hours due to cancel trip / change mode and replace vehicle effects; and
- The extent to which trips will re-time to avoid the ban operating period.

Adjustments to these assumptions in the sensitivity test were identified as follows:

- The extent to which trips are linked by time of day: the sensitivity test used the ANPR linked trip assumptions directly. This resulted in 26% fewer linked trips than in the original modelling; and
- The time of day choice: a 40% increase in trip re-timing was included, which was estimated to bring about a change in compliance year with sufficient confidence from which to estimate the actual change in compliance year tipping point.

The original response rates are shown in Table 2-1 below.

Table 2-1: 8-hour (7am-3pm) Diesel Car Exclusion Primary Response Rates

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	15.44%	14.56%	0.00%	17.47%	14.56%	0.00%
Cancel Journey / Change Mode	21.03%	21.85%	15.74%	23.79%	23.52%	22.18%
Replace Vehicle	43.04%	19.45%	31.54%	58.74%	58.07%	54.75%
Time of Day Choice	20.49%	31.94%	0.00%	0.00%	0.00%	0.00%

The effects on the modelled response rates of the adjusted linked trip and time of day choice assumptions are explained as follows:

- Fewer linked trips: if fewer linked trips are assumed this results in lower Cancel trip / Change mode and Replace Vehicle response outside the hours of scheme operation e.g. in the PM peak. For example, with fewer linked trips between different time periods, a trip using a replaced vehicle in the AM is less likely to result in a corresponding trip with a replaced vehicle in the PM.
- Increased Time of day choice / re-timing of trips: if a higher Time of Day choice % is assumed this results in lower %'s for Avoid Zone, Cancel trip / Change mode and Replace Vehicle responses during the hours of scheme operation e.g. in the AM peak and IP. I.e. this relates to more trips being re-timed to use their non-compliant vehicle outside the hours of scheme operation, rather than resulting in Avoid Zone, Cancel trip / Change mode or Replace Vehicle responses.

Note, the modelled IP time period is 1000-1600 and therefore does not coincide directly with the proposed end of scheme operating hours (at 1500), hence the responses have been calculated as a weighted average for the IP based on when the scheme is operating versus not operating.

The above adjusted assumptions yielded the sensitivity test response rates as shown in Table 2.2.

Table 2-2: Sensitivity Test 8-hour (7am-3pm) Diesel Car Exclusion Primary Response Rates

Response Rate	Cars Low-High Inc			Cars Emp Bus		
	AM	IP	PM	AM	IP	PM
Pay Charge	NA	NA	NA	NA	NA	NA
Avoid Zone	13.13%	9.15%	0.00%	17.47%	14.56%	0.00%
Cancel Journey / Change Mode	17.88%	13.92%	10.51%	23.79%	22.23%	13.59%
Replace Vehicle	40.31%	18.94%	21.46%	58.74%	54.88%	33.54%
Time of Day Choice	28.69%	44.72%	0.00%	0.00%	0.00%	0.00%

3. Transport Model Results

The highway model network statistics have been extracted for 2021 and 2025 Revised Hybrid Option and the sensitivity test. Tables 3-1 to 3-2 compares the statistics for the two options, for 2021 and 2025 respectively.

Table 3-1: 2021 Highway Network Statistics

Measure	2021 Revised Hybrid Option			2021 Revised Hybrid Option Sensitivity Test			Difference		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Transient Queues	7385	4784	7284	7426	4829	7426	0.6%	0.9%	1.9%
Over-Capacity Queues	1106	26	726	1128	21	820	2.0%	-16.9%	12.9%
Link Cruise Time	19040	15172	19260	19069	15219	19393	0.2%	0.3%	0.7%
(Free Flow	18468	14837	18711	18495	14883	18834	0.2%	0.3%	0.7%
Delays	573	334	549	574	336	558	0.2%	0.5%	1.6%
Total Travel Time	27531	19981	27270	27624	20069	27639	0.3%	0.4%	1.4%
Travel Distance	1184780	967963	1213493	1186282	970339	1220567	0.1%	0.2%	0.6%
Overall Average Speed	43.00	48.40	44.50	42.90	48.30	44.20	-0.2%	-0.2%	-0.7%
Total Trips Loaded	129809	112257	128800	129994	112612	129525	0.1%	0.3%	0.6%

Table 3-2: 2025 Highway Network Statistics

Measure	2025 Revised Hybrid Option			2025 Revised Hybrid Option Sensitivity Test			Difference		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Transient Queues	7767	5123	7667	7795	5167	7717	0.4%	0.9%	0.7%
Over-Capacity Queues	1253	58	810	1276	65	852	1.9%	11.5%	5.2%
Link Cruise Time	19737	16040	20025	19763	16082	20078	0.1%	0.3%	0.3%
(Free Flow	19073	15639	19375	19098	15679	19424	0.1%	0.3%	0.3%
Delays	664	402	650	665	403	654	0.2%	0.4%	0.6%
Total Travel Time	28757	21221	28502	28834	21314	28647	0.3%	0.4%	0.5%
Travel Distance	1222794	1023130	1260285	1224044	1025284	1262972	0.1%	0.2%	0.2%
Overall Average Speed	42.50	48.20	44.20	42.50	48.10	44.10	0.0%	-0.2%	-0.2%
Total Trips Loaded	134710	117627	133689	134879	117954	134026	0.1%	0.3%	0.3%

The Revised Hybrid sensitivity test has a slight increase in trips compared to the with the Revised Hybrid Option, as expected. This results in a slight increase in queues, delays and travel time and a decrease in the overall speed throughout the network.

4. Air Quality Results

The above revised response rates were applied in the transport model and yielded air quality results as shown in Table 4-1.

Table 4-1: Air Quality Results

	Rupert Street	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (ug/m3)											
Baseline	49.5	58.7	46.4	49.9	49.2	41.6	48.9	40.1	50	43.8	54.7
Revised Hybrid (RH)	40.3	44.6	36.5	37.9	37.8	33.6	38.1	35.7	39.4	40.6	44.4
RH Sensitivity Test	41.7	46.7	38	39.6	38.1	34.3	39	36.2	41.6	40.9	45.3
2025 Results (ug/m3)											
Baseline	38.6	43.7	34.7	36.4	34.3	30.7	36.2	31.2	38.3	33	41.6
Revised Hybrid (RH)	33	35	28.9	29.4	28.8	26.4	30.3	28.7	32.6	31	35.2
RH Sensitivity Test	33.7	36	29.6	30.1	29.3	26.8	31	28.9	33.3	31.2	36
2031 Results (ug/m3)											
Baseline	31.3	34.9	27.9	29.8	30	25.7	28.3	26.1	29.9	25.3	31.8
Revised Hybrid (RH)	0	0	0	0	0	0	0	0	0	0	0
RH Sensitivity Test	0	0	0	0	0	0	0	0	0	0	0
Compliance Year - Non-Linear Interpolation											
Baseline	2025	2027	2023	2024	2024	2022	2024	2022	2025	2023	2026
Revised Hybrid (RH)	2022	2023	2021	2021	2021	2021	2021	2021	2021	2022	2023
RH Sensitivity Test	2022	2024	2021	2021	2021	2021	2021	2021	2022	2022	2024

The above results show that for the Revised Hybrid scheme the critical locations are Marlborough Street and Baldwin Street. In particular, at these locations the compliance year for the Revised Hybrid scheme is 2023 whereas the compliance year in the sensitivity test is 2024.

By interpolation, Table 4-2 shows the estimated concentrations in 2023 for the critical locations and the percentage of the sensitivity test change in assumptions that would be required to trigger an increase to over 40 ug/m^3 in 2023 (and hence trigger a change in compliance year).

Table 4-2: Compliance year threshold calculations

	Marlborough St	Baldwin St
Revised Hybrid (Est. 2023 ug/m3)	39.8	39.8
Revised Hybrid Sensitivity Test (Est. 2023 ug/m3)	41.35	40.65
Compliance threshold (ug/m3)	40	40
% of assumption change needed to trigger compliance change	13%	24%

This shows that the limiting location in the analysis is Marlborough Street where a lower change in assumptions would bring about a change in compliance year. This estimates that 13% of the modelled change in assumptions would trigger a change in compliance year.

Table 4-3 calculates the corresponding change in input assumptions required to trigger a change in compliance year (i.e. reach tipping point).

Table 4-3: Tipping point calculations for Marlborough Street

	Sensitivity test change	% of change required to reach tipping point	Change in assumption to reach tipping point
Linked trips	-26%	13%	-3.4%
Trip re-timing	40%	13%	5.2%

5. Conclusion

The work presented in this Technical Note indicates that reducing the linked trip assumption by 3.4% and increasing the trip re-timing response by 5.2% would be enough to reach the tipping point and trigger a compliance year change in the Revised Hybrid scheme assessment.

It should be noted the diesel ban component of the Revised Hybrid scheme assessment is conservative in terms of its effectiveness in the following respects:

- Proportions of responses (replace vehicle vs cancel trip/change mode vs avoid zone) originally used are conservative with 'replace vehicle' forming the highest proportion;
- Not all Other trips are likely to be able to re-time their trip (and continue to drive diesel cars in the zone) in practice, the original modelled journey timing assumptions are considered conservative in terms of the effects of the ban; and
- The modelling did not account for any linkage between the ban period and off-peak journeys (1900-0700) which is conservative in terms of the effects of the ban.