Sheffield & Rotherham Clean Air Plan
Full Business Case
April 2022

FBC_v3.2
Date Issued: 20/04/2022

Document Controls

Document Approval			
Version Number:	FBC v3.2		
Prepared by:	Matt Driver	Date:	13/04/2022
Checked by:	David Connolly	Date:	14/04/2022
Approved by:	Tom Finnegan-Smith	Date:	14/04/2022

Issue Record			
Version	**Circulation List**	**Date Issued**	**Format Issued**
FBC_v3.2		20/04/22	
FBC_v3.1		14/04/22	
FBC_v2		17/12/21	
FBC_v1		19/11/21	
OBC	Laurie Brennan David Connolly Amanda Cosgrove Julie Kent Julie Meese Matt Reynolds Ogo Osammor Chris Robinson Jane Wilby	December 2018	

Revision History	
Version	**Nature of Revision**
FBC_v3.2	Renumbered to 3.2 and added section on choice of Baseline
FBC_v3.1	Comprehensive update with revised results and JAQU comments addressed.
FBC_v2	Updated with amended results from TUBA, but JAQU comments not addressed
FBC_v1	Initial draft for FBC

Economic Case

3 Economic Case

3.1 Introduction

The Economic Case presented in the Outline Business Case (OBC) submitted to JAQU in December 2018 compared the costs and (monetised) benefits across a set of alternative packages of measures identified during the Feasibility Study. These comparisons were used to justify the list of measures which made up the final Preferred Option.

Following the production of considerable additional analyses of the available options, public consultation on the Preferred Option, and considerable discussions with JAQU over the last three years, the key elements of that Preferred Option remain largely unchanged from that described in the OBC. A summary of this evolution of the Preferred Option is included in the Strategic Case.

To simplify the reporting within this Full Business Case (FBC), this Economic Case focusses on an analysis of the costs and (monetised) benefits of the final Preferred Option.

3.2 Purpose of the Economic Case

The role of the economic appraisal is to present the costs and benefits of the Clean Air Plan, including charging and non-charging measures. The economic indicators, including the Net Present Value (NPV) and Benefit-Cost ratio (BCR) determine whether the scheme represents good value for money. The appraisal monetises the impacts (costs and benefits) of the interventions described in Section 3.3 by comparing outputs from the Preferred Option, which includes those interventions, against those from a Business as Usual (BaU) or “Do Minimum”. This scenario includes the same assumptions about changes into the future as the Preferred Option, but excludes the proposed interventions.

For most transport schemes, the economic appraisal is used in conjunction with the other cases to determine whether an option is worthy of further consideration at an early stage in the appraisal process, or to determine whether a more developed scheme still offers value for money and should be progressed to the design stage. The scheme might be compared against other schemes competing for the same funding with the economic indicators used to inform the decision as to which schemes are pursued.

However, in this case the reason to intervene is because intervention has been mandated by government in order to deliver compliance with EU legal limits for NO_x in the shortest possible time. The role of this economic appraisal is therefore not to prove that the scheme offers good value for money relative to doing nothing, but to quantify the costs and benefits of the Preferred Option scheme which has been previously identified as the one which delivers this critical success factor (ie compliance in the shortest possible time) as cost-effectively as possible.

This Economic Case includes a description of the preferred scheme that is being appraised, an overview of how the scheme has been appraised, and the results of the appraisal. A more-detailed description of the methodology, but excluding the results, is included in the Economic Appraisal Methodology Report. Details of the behavioural

responses considered, and how these have included in the modelling, are included in a separate modelling report T4-SD01.

3.3 The Preferred Option Appraised at FBC

3.3.1 Summary of the Preferred Option

The Outline Business Case compared the costs and benefits of four options and concluded that the preferred scheme would include a CAZ C charging scheme, with the charging boundary being shown in Figure 1. The Preferred Option scheme also included other non-charging policy measures, local traffic schemes, vehicle owner incentives and other behavioural change measures designed to target NO_X emissions at a number of the air quality problem locations in central Sheffield. Further information relating to the selection of the Preferred Option is included in the Strategic Case.

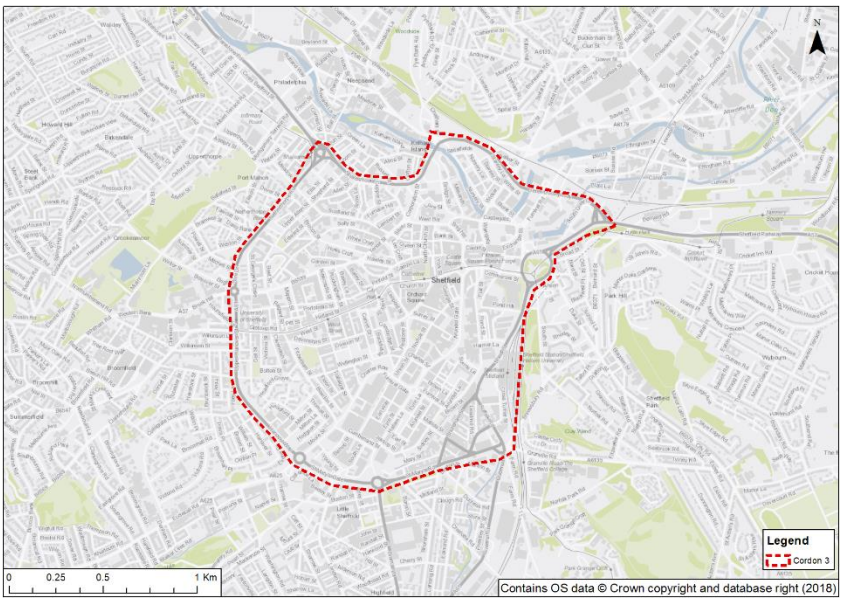

Figure 1. Potential Charging (Cordon 3)

The costs and (monetised) benefits of the full package of measures included in the Preferred Option are included in this appraisal. A full list of the components of the Preferred Option is provided in 0 below. The third column of this table describes how the scheme has been modelled and incorporated into the Cost Benefit Analysis.

Table 1. List of Components of the Preferred Option

SCHEME	DESCRIPTION	MODELLING APPROACH
50 mph on Parkway	Reduction from national speed limit to 50 mph on section between M1 junction 33 to intersection with Handsworth Road on A630 Sheffield Parkway. West of this junction, a speed limit of 50 mph is already in place.	Coded in highway assignment model and benefits appraised using DfT TUBA software. Impacts also feed into emissions changes which are monetised in the Economic Model.
Rawmarsh Hill bus rerouting	Reduction in number of buses using Rawmarsh Hill, with 50% of buses currently on this route re-routed to using Barbers Avenue. Alongside this junction changes will be made to allow for re-prioritisation of bus routes.	Coded in highway assignment model and benefits appraised using DfT TUBA software. Impacts also feed into emissions changes which are monetised in the Economic Model.
Bus upgrade / retrofit to Euro 6	The full bus fleet in Sheffield and Rotherham is upgraded or retrofitted to Euro 6. Those which are still pre-Euro 6 have been retrofitted so that their emissions are Euro 6 equivalent or better.	Fleet impacts included in ENEVAL emissions modelling. Impacts feed into emissions changes which are monetised in the Economic Model. Upgrade costs included in Economic Model.
HGV ban on Northbound A629 Wortley Road	A full (100%) HGV ban on northbound (uphill) direction of A629 Wortley Road between the junction with Wilton Gardens and the junction with Old Wortley Road. Designed to prevent HGVs using this route to access the M1 from Rotherham Town Centre, and encourage the use of the Meadowbank Road route to M1 J34.	Coded in highway assignment model and benefits appraised using DfT TUBA software. Impacts also feed into emissions changes which are monetised in the Economic Model.
TCF9 (Arundel Gate Bus Gate Partial Scheme)	Bus gates on Arundel Gate associated with the Cross-city Bus scheme brought forward (from 2023).	Coded in highway assignment model and benefits appraised using DfT TUBA software. Impacts also feed into emissions changes which are monetised in the Economic Model

SCHEME	DESCRIPTION	MODELLING APPROACH
Taxi Upgrades	Black cabs upgrade from 21% to 90% compliant and Private Hire Vehicles (PHV) upgrade from 66% to 98% compliant, as a result of incentives, behavioural responses to the CAZ charges and changes to taxi licensing policy.	Included in ENEVAL fleet for emissions modelling
Sheffield Inner Ring Road Charging Area	CAZ C charging scheme for non-compliant vehicles, private cars are not charged.	Coded in highway assignment model and fleet input to ENEVAL. User time and vehicle operating cost changes appraised using DfT TUBA software. Impacts also feed into emissions changes which are monetised in the Economic Model. Upgrade costs, incentives, charges and infrastructure costs all included in the Economic Model.
Anti-Idling Measures on Arundel Gate	Measures to reduce bus-idling on Arundel Gate, in particular to increase compliance with a maximum 2-minute idling rule.	Included post-modelling within the AQ calculations, based on analysis of local idling data.
Clean Air Fund (CAF) Mitigation Measures	Loans and grants to facilitate upgrades available for taxis and light goods. Grants available for heavy goods, scheduled and unscheduled buses.	Included in the Economic Model via an output from the Financial Model.

3.3.2 The level of the Clean Air Zone Charges

The OBC used responses from the local behavioural research and a desire for consistency with neighbouring CAZ schemes to identify the following daily charges for the CAZ C scheme included in the Preferred Option.

Table 2. Proposed Clean Air Zone Charges

VEHICLE TYPE	DAILIY CHARGES FOR DRIVING WITHIN THE CAZ
Buses, Coaches and HGVs– CAZ-compliant[1]	£0
Buses, Coaches and HGVs – non-compliant	£50/day
Taxis, Private Hire Vehicles, Vans/LGVs – CAZ-compliant[2]	£0
Taxis, Private Hire Vehicles, Vans/LGVs – non-compliant	£10/day

3.3.3 What would the Money from Charges be Used For?

In the Cost Benefit Analysis (CBA) reported here, the charges are treated as a simple transfer of money, appearing as a disbenefit to the drivers of non-compliant vehicles together with an equal revenue gain to government (acknowledging that in practice some money accrues to local government and some to central government) , i.e. the charges paid by the non-compliant vehicles net out exactly in the Net Present Value (NPV) calculation with the money accrued by Central and Local Government.

The Economic Case excludes the cost of setting up the central national payment portal, though does include the £2 per vehicle transaction that will be taken from the charging revenue to be retained by the Government. The Economic Case also excludes the costs and benefits of any schemes that might be funded at a later date by the revenue stream, especially since the aim is to achieve a CAZ-compliant fleet (and hence reduce the income stream) as quickly as possible.

This simplifying assumption will tend to under-estimate the benefits of any CAZ charging scheme, provided the local schemes which are funded by the charging revenue have a positive Net Present Value (NPV) i.e. generate more benefits than costs.

However, the aim is for the revenue to initially be as low as possible and for it to then fall as quickly as possible, because the aim of the scheme is to remove the non-compliant vehicles from the local traffic as quickly as possible, not to generate a revenue stream. This will limit the ability to fund other things, particularly given the ongoing maintenance and management costs of the CAZ infrastructure / back office systems and the need to fund the costs associated with the potential removal of the infrastructure from 2027. Care is therefore required when considering any potential benefits which might be generated by schemes funded by the charging revenue.

The charging revenue stream covers the operating cost of the local back office system (responsible for chasing up payment of fines from any non-compliant vehicles seen in the

[1] EURO VI Diesel or better
[2] EURO 6 diesel or EURO 4 petrol (or better)

Charging Area without having paid the daily charge) and the cost of removing the cameras at the end of the CAZ Charging period (assumed here to be December 2027)[3].

3.3.4 Timescales and Time-related Profiles

This Economic Case assumes that the Charging CAZ C scheme will 'go live' on 16th January 2023, with many of the fleet upgrades and the associated emissions reductions occurring in the second half of 2022, in response to the funding made available to vehicle owners as part of the CAZ scheme.

The appraisal of the Preferred Option currently assumes that the charging of non-compliant vehicles will continue until 31 December 2027 and the relevant signing, enforcement infrastructure and back office system will be decommissioned during 2028.

Whilst some of the scheme costs are incurred in 2022, no benefits are assumed to accrue until the CAZ scheme becomes operational in January 2023.

The appraisal also assumes that vehicle upgrades undertaken in response to the Clean Air Zone charges are simply an acceleration of business-as-usual behaviour, meaning that the money spent on upgrading is cancelled out by an equivalent saving in the future, assumed to occur in 2027 in the appraisal. However, the application of discounting means that incurring the costs in earlier years results in a net cost to the vehicle owner. This is discussed in more detail in the Economic Case Methodology Report.

The benefits (or disbenefits) of any infrastructure included in the Preferred Option which accrue beyond 2027 have not been included with this appraisal.

The Economic Appraisal has not attempted to quantify or include the costs or benefits of the (as-yet-unspecified) measures delivered by the CAZ charging revenue stream, other than the back-office system running costs and camera decommissioning costs discussed above.

Full details of the various input assumptions can be found in the Economic Case Methodology Report.

The remainder of this Case is separated into the following sections:

- A summary of the methodology used to carry out the appraisal;
- The results of the core appraisal;
- The results of the Economic Case sensitivity tests undertaken; and
- A summary of the distributional impacts

3.4 Summary of Economic Case Methodology

3.4.1 Types of costs and benefits included

This section summarises the approach to modelling the different elements of the Clean Air Plan and how they appear in the Cost Benefit Analysis. Table 3 summarises the different types of benefits and costs included, describes how they are incorporated and where they appear in the final appraisal. The schemes listed in 0 all contribute to one or more of these

[3] In reality, operation of the Charging Area might be able to end earlier than 2027, once the required fleet upgrades have achieved a sufficient level of compliance to offset any back sliding by local vehicle owners and assuming no significant increase in traffic levels or congestion. A review will be undertaken in 2025 based on the levels of compliance observed in 2023 and 2024.

categories. Further details on the methodology of each element of the appraisal can be found in the Economic Appraisal Methodology Report, E1.

Table 3. Summary of benefits and costs

BENEFIT/COST	DESCRIPTION	METHODOLOGY	WHERE IN APPRAISAL?
Emissions benefits	Monetised benefits due to change in NOX, PM_{10} and CO_2 caused by the interventions summarised in 0.	Link based flows and speeds from SCRTM1 traffic model input to ENEVAL software to calculate changes in emissions. Damage costs and non-traded carbon values applied to change in emissions.	PVB
Travel time and vehicle operating cost changes	Changes in road user travel times or vehicle operating costs as a result of changes to routing and traffic congestion generated by the various Clean Air Plan interventions summarised in 0.	Demand and cost matrices from SCRTM1[4] input to DfT TUBA software. Values of time applied to time changes to convert monetary units.	PVB
CAZ charges / revenue	CAZ charges paid by non-compliant vehicle owners who do not upgrade and drive within the CAZ charging area.	Calculated as part of the Financial Case by applying daily charges to the numbers of vehicles in the charging area forecast from the transport model, SCRTM1.	PVB (disbenefit to vehicle owners) PVC (cost offset to government)
Vehicle owner upgrade costs	The costs to owners of non-compliant vehicles of upgrading earlier than they otherwise would have done.	Upgrade costs calculated based on difference in vehicle depreciation cost over 4 years. Rule of a Half applied to account for other benefits to some owners of upgrading. Upgrade costs calculated by multiplying upgrade costs by numbers of vehicles upgrading.	PVB (disbenefit for upgrade costs offset by benefit in final year for upgrade saving)

[4] SCRTM1 is the Sheffield City Region Transport Model, a multi-modal strategic transport model used to predict the change in travel demand in response to changes in travel costs.

BENEFIT/COST	DESCRIPTION	METHODOLOGY	WHERE IN APPRAISAL?
		Offset by equivalent upgrade cost saving in 2027 to reflect the fact that non-compliant vehicle owners would have upgraded in the future under Business as Usual.	
Vehicle owner incentives	Incentives paid from local government to vehicle owners to contribute towards or cover the cost of upgrading a vehicle.	Calculated as part of the Financial Case based on assumptions about the number of vehicles funded and average funding per vehicle.	PVB (benefit to vehicle owners) PVC (cost to government)
Scheme setup and running costs	Upfront and ongoing costs of setting up and running the CAZ and complimentary measures	Calculated as part of the Financial Case	PVC

3.4.2 Choice of Economic Case Baseline

For this Economic Case work an alternative Baseline has been used compared to the Baseline used in the technical documents to describe the change in emissions. On the Parkway between Sheffield and Rotherham there are three situations which could exist:

- 2 lanes, 70mph, no improvements to J33 with M1 – this is the situation as it was in 2017 (i.e. the Base Year);
- 3 lanes, 50mph, with improvements to J33 – this is the situation when the Parkway widening scheme is in place by late 2022. The 50mph element is part of the CAP, whereas the move to 3 lanes is the widening scheme, but they are being implemented at the same time; and
- 2 narrow lanes, 50mph without improvements to J33 – widening roadworks underway scenario. This is the situation currently in place and will be for the majority of 2022.

In the main modelling we have included this final with 'roadwork' scenario in the Preferred Option testing. Since this set of roadworks is so strategic and will be in place for the majority of 2022 it is important we included this when assessing compliance in 2022. However, it is not standard modelling practice to include with roadwork scenarios within the economic appraisal of a scheme and it is not appropriate to include the effects of the roadworks in the economic case. As a result, we have used a version of the Baseline and Preferred Option with the widening in place (2nd bullet above) to generate the economic case results.

3.4.3 Price base and discounting

Economic appraisals are presented in real terms, net of inflation. That means that the effects of inflation from one year to the next are removed from the numbers such that two numbers in different years can be compared without being distorted by the effects of inflation, which usually make values in later years greater. When carrying out an economic appraisal, it is therefore necessary to select an appraisal year, which is the year in which all prices are presented. For this appraisal, the appraisal year is 2018, meaning that all costs and benefits are converted to units of 2018 prices. As recommended in DfT's Transport Analysis Guidance (TAG), this conversion is done using the GDP deflator series published in the TAG Databook.

TAG also specifies that costs and benefits should be further adjusted to account for the phenomenon known as social time preference, which describes people's preference to consume goods and services now, rather than in the future, and prefer to incur costs in the future, rather than now. This is accounted for by applying an annual adjustment and is referred to as discounting. TAG specifies a discount rate of 3.5% per annum, and this is applied to all costs and benefits in the appraisal to discount them back to the appraisal year of 2018. Once the discount rates have been applied, the cost or benefit is referred to as "discounted".

The monetary values referred to in the remainder of this report are presented in 2018 prices and have been discounted back to the appraisal year of 2018.

3.5 Appraisal Results

3.5.1 Emissions benefits

Most of the interventions proposed as part of the Clean Air Plan lead to a change in vehicle emissions in some way – either due to changes in travel behaviour or route choice due to the charging scheme, changes in emissions per vehicle due to fleet upgrades or changes in infrastructure, e.g. a lower speed limit. This section summarises how those changes in emissions have been calculated and monetised for inclusion in the appraisal and presents the results.

SCRTM1 and SYSTRA's ENEVAL emissions software have been used to estimate the annual change[5] in emissions of NO_X, PM_{10} and $CO_2(e)$[6] for the final Preferred Option on a link-by-link basis for the set of roads included in the SCRTM1 model (excluding zone centroid connectors) for 2022 and 2024.

These emissions have been aggregated for presentation into the 4 geographic sectors:

- Sheffield inside the CAZ charging area (within the Inner Ring Road)
- Rotherham district;
- Rest of Sheffield district; and
- the motorway network.

These sectors were mapped to JAQU area types in order to apply appropriate damage cost values – see Economic Appraisal Methodology Report for this mapping.

[5] relative to the Business as usual

[6] i.e. total greenhouse gases, expressed as the equivalent weight of CO_2

The change in emissions between the BaU and Preferred Option by area and year is shown in Table 4 below.

Table 4. Emissions changes (%)

AREA	NO_X 2022	NO_X 2024	PM_{10} 2022	PM_{10} 2024	CO_2 2022	CO_2 2024
Sheffield IRR	-20.1%	-20.6%	-9.7%	-7.8%	-2.7%	-3.0%
Rest of Sheffield	-6.1%	-5.4%	-2.1%	-1.8%	-0.3%	+0.6%
Rotherham	-5.6%	-5.8%	-0.8%	-1.5%	-0.3%	-0.3%
Motorway	-0.8%	-1.3%	+0.9%	+0.1%	+0.7%	+0.2%
TOTAL	**-5.1%**	**-4.9%**	**-1.0%**	**-1.3%**	**-0.1%**	**+0.1%**

The impact of the scheme results in significant decreases in NO_X, particularly in central Sheffield and across the area as a whole. Ultimately this was the aim of the scheme from the beginning. There is also a reduction in particulate matter (PM_{10}) across the whole area, apart from a very small (0.1%) increase on the motorway.

Greenhouse gas emissions (CO_2) decrease in central Sheffield, but a mixed picture elsewhere, with the key points to note being:

- In Rotherham there are decreases in carbon emissions in the centre, along Wortley Road, on Rawmarsh Hill and on Fitzwilliam Rd. There are some small increases on Meadowbank and some of the radial routes, but the net impact is a small reduction;
- In Sheffield there are decreases in the central area (with a little localised variation due to the bus gate effects) and decreases on most radial routes, but small increases on several orbital routes (in line with the predicted rerouting); and
- The reduced speed limit on the Parkway generates an 8% reduction in CO_2 emitted on the sections with the lower speed limit, as fuel consumptions (and hence CO_2 emissions) are lower at 50mph speed than at 70mph

These impacts result in a number of positives and negatives and have different impacts in the two modelled years as a result of the different components of the Preferred Option coming online, particularly the parkway widening. The combined changes in total carbon emissions lie within ±0.15% in both modelled years, which is at the limit of the traffic modelling accuracy and should therefore be treated as 'No Net Impact' within any carbon appraisal of the Preferred Option.

The modelled years are 2022 and 2024, hence these are the years presented above. Linear interpolation was applied to calculate the change in emissions for year 2023, i.e. the midpoint between the modelled 2022 and 2024 values. For 2025, 2026 and 2027, linear interpolation was applied between the 2024 modelled values and a value of zero for 2028, making the assumption that by 2028 there would be no difference between the Business as Usual and Preferred Scheme options. As the scheme opening date is not until 2023, benefits derived from the change in emissions modelled for 2022 were excluded from the appraisal.

The changes in annual emissions were then monetised by applying the NO_X and PM_{10} damage cost values published by JAQU, and the CO_2 non-traded values published by DfT as part of the TAG Databook (table A3.4). Appropriate price base conversions and annual

uplifts were applied to these values – further details are included in the Economic Appraisal Methodology Report.

The total monetised emissions benefits and disbenefits, summed over all years and discounted to present values are presented in Table 5 0below.

Table 5. Total emissions benefits over all years (£000, 2018 prices, discounted)

AREA	NO_X	PM_{10}	CO_2	TOTAL
Sheffield IRR	1,051	105	916	2,072
Rest of Sheffield	1,249	156	(1086)	318
Rotherham	539	56	442	1,036
Motorway	64	(5)	(545)	(486)
TOTAL	**2,903**	**311**	**(274)**	**2,940**

Overall, there is a benefit due to the reduction in NO_x of £2.9m and a smaller benefit of £0.31m due to the reduction in PM_{10}. This is offset by a small disbenefit of £0.27m due to the increase in CO_2, although as noted above to all intents and purposes this is a net neutral effect, giving an overall contribution to the Present Value of Benefits of £2.9m.

3.5.2 Travel time and vehicle operating cost benefits

Many of the elements of the Clean Air Plan lead to changes in people's travel behaviour, for example changing route to avoid the charging zone, changing mode of travel or changing their choice of destination. In addition, the interventions will lead to changes in congestion and this will vary across the network. All these lead to a change in travel time and vehicle operating costs incurred by transport users, including those who have not changed their behaviour. This section summarises how those changes have been calculated and monetised for inclusion in the appraisal and presents the results.

The DfT's TUBA software (version v1.9.11) has been used to take outputs from the SCRTM1 multi-modal model for 2022 and 2024 to estimate the benefits and disbenefits associated with the Preferred Option for compliant and non-compliant vehicles. The inputs to TUBA are demand and "cost" (distance and time) matrices output from the transport model – SCRTM1. The matrices are separate for car, LGV and HGV, and separate between compliant and non-compliant vehicles. Separate matrices are input for the Do Minimum (or Business as Usual) and Preferred Option.

TUBA applies vehicle operating costs per kilometre to the distances and applies values of time to the travel time matrices to calculate travel costs in monetary terms. The difference between the Do Minimum and Preferred Option travel cost is multiplied by the demand to calculate the benefit.

Disbenefits from TUBA associated with vehicles paying tolls, usually labelled as "user charges" in TUBA, have not been included in the appraisal, since these disbenefits are included separately based on the calculation of charges as described in Section 3.5.3.

The time and vehicle operating cost benefits are presented in Table 6.

Table 6. Total travel time and operating cost benefits over all years (£000, 2018 prices, discounted)

VEHICLE TYPE	TIME	VEHICLE OPERATING COST	TOTAL
Car – compliant	2,893	(55)	2,838
Car – non-compliant	474	(49)	425
Freight – compliant	(45)	(779)	(824)
Freight – non-compliant	(4,384)	(1,788)	(6,171)
Total	**(1,062)**	**(2,670)**	**(3,733)**

These impacts make sense in light of the scheme, with the effects explained as follows:

- Car trips each experience very small levels of benefits due to small improvements in travel time as a result of reduced congestion, notably in Rotherham around rerouted HGV and bus schemes and in central Sheffield, where the small decrease in goods vehicle traffic has created slight reductions in car journey times;
- Compliant goods vehicles are subject to rerouting effects due to the HGV ban in Rotherham and hence see a VOC disbenefit. Those goods vehicles which reroute due to the HGV ban also experience a time disbenefit, but this is offset by improvements in time in and around central Sheffield for compliant goods vehicles, leading to a net neutral time impact;
- A proportion of the non-compliant goods vehicles which do not upgrade (and do not start or finish within the charging zone) reroute around the CAZ and hence experience a time disbenefit;
- Non-compliant HGV's are also impacted by the Wortley Road ban in Rotherham giving additional VOC disbenefits; and
- Bus and taxi experience no change, as they are assumed to follow their Business as Usual routes.

3.5.3 Vehicle owner costs and benefits

Owners of non-compliant vehicles who would ordinarily enter the charging area have a range of choices including not travelling, travelling elsewhere, travelling via a different route (if their trip is a through trip), upgrading their vehicle or paying the CAZ charge. The effects of rerouting and change of travel behaviour has been covered via the time and vehicle operating cost benefits and disbenefits described in the previous section. This section deals with the impact on vehicle owners who either choose to upgrade or pay the CAZ charge. There are three potential sources of benefits and disbenefits to these vehicle owners:

- Upgrade costs associated with buying a new vehicle (offset by BaU upgrade savings in later years when upgrades would have occurred under BaU);
- CAZ charges paid; and
- Incentives received to incentivise upgrades.

These are discussed in turn below.

Upgrade Costs

Most non-compliant vehicle owners are assumed to upgrade their vehicles and incur the associated cost, in many cases earlier than they otherwise would have done. This cost is included as a disbenefit in the appraisal. However, in line with JAQU guidance, it is also assumed that the vehicle owners would replace their vehicles in any case as part of their "Business As Usual" (BAU) activity, before the end of the appraisal period in 2027, and this cost saving is therefore included as a benefit in the final year of the appraisal to those who have upgraded early. This means that before discounting is applied, the net cost of vehicle upgrades (excluding retrofits which would not otherwise be carried out as part of BAU activity) is zero when summed across all years and the CAZ just results in vehicle owners upgrading earlier than they would have done otherwise.

However, the application of discounting factors in the appraisal accounts for the fact that consumers would prefer benefits sooner rather than later and vice-versa for costs. The costs to vehicle owners who upgrade early are therefore discounted less than the benefits they receive in 2027 for not having to upgrade under BAU, hence there is a net cost or disbenefit associated with upgrading early.

The costs of upgrading vehicles have been calculated based on the difference in depreciation experienced over a four-year period (from 2022 to 2026) between a new or used compliant vehicle and an average aged non-compliant vehicle. The price of new vehicles is obtained from a combination of JAQU guidance and research. Depreciation rates from JAQU guidance are applied to the new vehicle prices to calculate residual values that are used to determine the difference in depreciation. The 'Rule of a Half' is then applied (i.e. the upgrade cost is halved), to reflect the fact that the newer vehicle provides additional benefits aside from simply being CAZ compliant, for example fuel cost savings, lower maintenance costs and improved vehicle quality or reliability. Further details of this methodology are provided in the Economic Appraisal Methodology Report.

CAZ Charges

Some non-compliant vehicle owners are assumed to not upgrade their vehicle and instead pay the CAZ charge. The money paid by these users represents a cost to the vehicle owner (a disbenefit in the PVB) and a revenue to the public sector (a cost offset in the PVC), a proportion of which will go to Central Government with the rest being retained by the Local Council. It therefore makes no contribution to the NPV.

These costs and revenues have been calculated within the Future Operating Cost Model required by the Financial Case. The number of non-compliant vehicles entering the CAZ is multiplied by the daily charge.

Upgrade incentives

Grants will be paid to vehicle owners to incentivise the purchase of compliant vehicles. These grants appear as a cost to the public sector and contribute to PVC, but also appear as a benefit to vehicle owners and contribute to the PVB. These two items cancel each other out and therefore make no contribution to the NPV. The spend on grants has been calculated as part of the Financial Case and is input to the Economic Model as part of the Financial Model interface.

Summary of Impacts

Table 7 summarises the vehicle owner impacts split across the categories identified above. Positive numbers represent costs, which ultimately feed into the appraisal as disbenefits, whilst negatives are income, which feed in as benefits.

For each mode except bus, the upgrade costs are offset by the BaU upgrade savings. However, because the saving appears in the final year of the appraisal, the discounting applied is greater, which results in a net cost associated with upgrading earlier than would be the case under BaU. When the incentive benefit is added to the BaU saving, the net benefit is positive for owners of all vehicles who choose to upgrade. For buses, the upgrades are assumed to be paid for directly by local government and therefore no upgrade saving is applied, resulting in a neutral overall impact.

A relatively large number of LGVs are assumed not to upgrade, resulting in a higher CAZ charge disbenefit for this group and an overall disbenefit on average, i.e. the disbenefit to those paying the charge outweighs the small benefit to those upgrading. For taxi, coach and HGV owners the disbenefit from CAZ charges is less than the net benefit to those upgrading, resulting in an overall benefit.

Table 7. Summary of vehicle owner costs (£m, 2018 prices, discounted)

VEHICLE TYPE	UPGRADE COST	BAU UPGRADE SAVING	CAZ CHARGES	INCENTIVES	TOTAL
Taxi	6.5	(4.8)	1.0	(5.9)	(3.3)
Bus	2.4	-	-	(2.4)	-
Coach	2.6	(2.2)	-	(0.9)	(0.5)
LGV	14.2	(12.1)	24.1	(10.4)	15.9
HGV	12.1	(10.3)	1.9	(3.2)	0.4
Total	37.8	(29.4)	27.0	(22.8)	12.6

3.5.4 Public Sector Costs

The costs of setting up and running the Clean Air Plan are calculated as part of the Financial Case. These costs are separated into the following categories:

- Enforcement and infrastructure – including ANPR systems, back office and signage;
- Road schemes to be introduced as part of the CAP;
- Finance and management – staff costs associated with running the CAP;
- Communications – the cost of developing and implementing a communications strategy;
- Monitoring and evaluation – the cost of tracking the impact of the CAP on emissions and analysing the profile of vehicles paying charges;
- The cost of providing incentives to vehicle owners; and
- Revenue received as a result of the charging zone which offsets some of the cost.

The costs are estimated as part of the Financial Case in nominal terms, i.e. the prices that will actually be paid, based on a combination of quotes from suppliers and other assumptions and inputs. These costs are deflated to 2018 prices and discounted like the other costs and benefits discussed in previous sections.

In addition, the prices are factored up from the "factor cost" unit of account to the "market price" unit of account as per Section 2.5 of TAG Unit A1.1, which specifies that costs and benefits should be presented in market prices, which effectively requires an uplift to scheme costs and revenues.

Cost estimates from the Financial Case include a certain amount of contingency where appropriate, for example where firm quotes have not been obtained from suppliers and costs have been estimated. Nevertheless, the Economic Case applies optimism bias to the costs of setting up and running the Clean Air Plan in line with TAG unit A1.2 section 3.5 and the Green Book. This involves factoring up costs by a percentage to account the fact that scheme promotors are known to be overly optimistic when estimating scheme costs. An optimism bias factor of 10% is used in the Economic Appraisal – further details are provided in the Economic Appraisal Methodology Report.

Table 8 summarises the scheme costs by category after discounting and the uplifts for market prices and optimism bias have been applied.

Table 8. Public sector costs by category (£m, 2018 prices, discounted)

CATEGORY	COST
Enforcement & Infrastructure	16.1
Roads	3.1
ULEV Infrastructure	1.1
Finance & Management	3.0
Communication Strategy	0.5
Monitoring & Evaluation	1.0
Taxi incentives	5.9
Bus incentives	2.4
Coach incentives	0.9
LGV incentives	10.4
HGV incentives	3.2
Revenue	-27.0
Total (excl. Revenue)	47.7
Total (incl. Revenue)	20.7

3.5.5 Combined Economic Appraisal Results

This section brings together the different elements discussed so far in this section and presents the results of the combined cost-benefit analysis, including the key metrices – the Benefit Cost Ratio (BCR) and the Net Present Value (NPV). This is presented in 0.

The combined benefits (PVB) are negative, due to the travel time, the vehicle operating cost disbenefits and the vehicle owner disbenefits (largely accrued by LGV owners). This means the NPV and BCR are also negative. However, as noted earlier, the Critical Success Factor for the Clean Air Plan is to bring the level of NO_x within acceptable limits in the shortest possible time, rather than to produce a scheme with a positive NPV (relative to doing nothing). This legal requirement (and the cost of failing to achieve it) are not adequately reflected in the average default damage costs attributed to each Kg of NO_X emissions within the appraisal process

Table 9. Economic Appraisal Summary (£m, 2018 prices, discounted)

ITEM	VALUE (£M, 2018 PRICES, DISCOUNTED)	DESCRIPTION
Emissions Total	2.9	Total emissions benefits (section 3.5.1)
Travel time and operating costs	(3.7)	Vehicle travel time savings and operating cost savings due to rerouting and changes in congestion, calculated from the transport model and TUBA appraisal software (section 3.5.2). Excludes CAZ charges.
Vehicle Owner Total	(12.6)	Net of vehicle owner costs and benefits (section 3.5.3)
Present Value of Benefits (PVB)	**(13.4)**	Total benefits (emissions + TUBA + vehicle owner)
Public sector costs excluding incentives	24.9	All public sector costs including infrastructure, back office, management, finance and monitoring/evaluation (section 3.5.4). Excludes incentives and revenue from CAZ charges.
Incentives paid to vehicle owners	22.8	Incentives paid to vehicle owners from CAF. Split out to show that this is equal to incentives received in vehicle owner benefits (section 3.5.3 and 3.5.4).
Revenue from charges	(27.0)	Revenue received from CAZ charges (cost offset). Equal to CAZ charges paid by vehicle owners (section 3.5.3 and 3.5.4).
Present Value of Costs (PVC)	**20.7**	Total costs (all public sector costs offset by revenue received)
NPV	**(34.1)**	PVB - PVC
BCR	**(0.65)**	PVB / PVC

3.6 Sensitivity Testing

It is recognised that many of the inputs to the Economic Appraisal have varied levels of certainty around them. For this reason, a number of sensitivity tests are recommended in a separate JAQU guidance document – *Supplementary note on sensitivity testing.*

Table 10 describes the sensitivity tests that have been carried out on the Economic Case, and the methodology used to implement them.

Table 10. List of sensitivity tests

TEST ID	**TEST** NAME	**METHOD**
1	Behavioural response	Revised run of the transport model (SCRTM1), emissions model (ENEVAL) and TUBA appraisal software assuming that no non-compliant vehicle owners upgrade their vehicles.
2	Implementation costs	Increase the optimism bias rate applied to the scheme costs to 20%
3 and 4	High and low NO_x and PM_{10} damage costs	Use high and low range estimates of damage costs from JAQU guidance applied to core emissions changes
5 and 6	High and low CO_2 non-traded values	Use high and low non-traded values from TAG Databook applied to core emissions changes
7	Upgrade costs / welfare impacts	Assume that vehicle upgrade costs are not reduced by a factor of a half, i.e. remove the rule of a half calculation and assume the upgrade cost is the full difference in depreciation.

Table 11 presents the results of the sensitivity tests using the same breakdown as presented in the previous section for the core case.

ST1 (zero upgrades) gives a small benefit from reduced emissions and a much larger vehicle owner cost due to a much larger number of vehicles paying the CAZ charge and no incentives for vehicle upgrades. This is offset slightly by vehicle owners not having to pay to upgrade vehicles, but the net result is a PVB approximately three times less than the core case. The PVC is reduced, since there are no incentives paid out, as no vehicle upgrades are undertaken and there is a lot of revenue from CAZ charges, resulting in a negative PVC. The resulting NPV is similar to the core case, but with a negative PVB and PVC, the NPV and BCR are fairly meaningless.

ST2 simply increases the scheme costs so the PVC increases whilst the PVB remains constant. This gives a slightly worse NPV and BCR than the core case.

ST3-6 (high and low emissions valuations) yield higher and lower emissions benefits as expected, whilst all other elements remain the same as the core case. Using the higher damage costs for NO_X and PM_{10} (ST3) gives the highest PVB of all the tests, but this is still not large enough to outweigh the vehicle owner, travel time and operating cost disbenefit, so the outcome is still a negative PVB. Slightly counter-intuitively, using the higher valuations for carbon (ST5) gives a slightly smaller emissions benefit overall. This is because the carbon changes actually give a small disbenefit (see Table 5), so using a higher valuation makes these disbenefits larger. Similarly, ST6 gives a slightly larger overall emissions benefit.

ST7 (higher upgrade costs) gives a larger disbenefit to vehicle owners as would be expected, leading to a more negative PVB, and more negative NPV.

These sensitivity test results show a range of results but none of them change the conclusion that the scheme will deliver a small economic disbenefit. As noted previously, the Preferred Option is not about delivering value for money relative to doing nothing, but bringing emissions down to the required levels as quickly and cost-effectively as possible.

Table 11. Results of sensitivity testing (£m, 2018 prices, discounted)

ITEM	CORE	ST1	ST2	ST3	ST4	ST5	ST6	ST7
Emissions Total	2.9	1.6	2.9	11.9	0.0	2.8	3.1	2.9
Travel time and operating costs	(3.7)	(3.5)	(3.7)	(3.7)	(3.7)	(3.7)	(3.7)	(3.7)
Vehicle Owner Total	(12.6)	(43.8)	(12.6)	(12.6)	(12.6)	(12.6)	(12.6)	(17.8)
Present Value of Benefits (PVB)	**(13.4)**	**(45.7)**	**(13.4)**	**(4.4)**	**(16.3)**	**(13.5)**	**(13.2)**	**(18.5)**
Public sector costs excluding incentives	24.9	26.6	27.1	24.9	24.9	24.9	24.9	24.9
Incentives paid to vehicle owners	22.8	2.4	22.8	22.8	22.8	22.8	22.8	22.8
Revenue from charges	(27.0)	(43.8)	(27.0)	(27.0)	(27.0)	(27.0)	(27.0)	(27.0)
Present Value of Costs (PVC)	**20.7**	**(14.8)**	**22.9**	**20.7**	**20.7**	**20.7**	**20.7**	**20.7**
NPV	**(34.1)**	**(30.9)**	**(36.3)**	**(25.1)**	**(37.0)**	**(34.2)**	**(33.9)**	**(39.2)**
BCR	**(0.65)**	**n/a**	**(0.58)**	**(0.21)**	**(0.79)**	**(0.65)**	**(0.64)**	**(0.90)**

3.7 Conclusions from the Economic Case

Although the Preferred Option achieves compliance in the shortest possible time, the overall economic benefit of the scheme is still negative, as indicated by the Net Present Value for the core case of -£34m. This is largely made up of travel time and vehicle operating cost disbenefit accrued by non-compliant goods vehicles and HGV's in Rotherham and the charges paid by the owners of the non-compliant LGV owners who chose not to upgrade their (high-polluting) vehicles.

These disbenefits more than offset the monetised benefits generated by the reduced emissions, based on average damage cost values applied to these emissions.

The sensitivity tests undertaken lead to a range of NPVs between -£25m and £-39m. Using the higher damage cost values leads to the highest PVB but this is still a small negative value (-£4m) as the higher emissions benefits are not large enough to outweigh the travel time, operating cost and LGV vehicle owner disbenefits. The sensitivity tests merely change the scale of the economic disbenefit generated by the Preferred Option.

However, as noted earlier, the reason to intervene is not to deliver the best value for money (relative to doing nothing), but because intervention has been mandated by government to deliver compliance with EU legal limits for NO_x in the shortest possible timeframe.