# SCOTTISH AIR QUALTIY DATABASE

## Annual Report 2023

Report for: Scottish Government

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# EXECUTIVE SUMMARY

In April 2007, Ricardo was commissioned by the Scottish Government to undertake a three-year project to develop an Air Quality Database and Website for Scotland. This contract has been renewed in consecutive years, with the latest contract running from 2019-2024 (including extensions).

This report brings together all the Scottish Air Quality Database data for calendar year 2022 and associated work relating to project deliverables including: data management; QA/QC services; liaison with stakeholders; website development; spatial analysis of air quality data; trend analysis.

In addition, this year's report provides updated analysis on how the Covid-19 pandemic affected air quality in Scotland. This analysis follows on from the 2021 annual report Covid-19 analysis.

### Legislation and Policy

Air quality management is shaped by requirements of EU, UK and Scottish legislation and policies. Following the UK's exit from the EU, under retained EU law, Scotland is required to continue to meet limit and target values for a range of air pollutants and other legal obligations covered by EU directives.

In July 2021, accompanied by a Delivery Plan, and replacing "Cleaner Air for Scotland – The Road to a Healthier Future", the Scottish Government published Scotland's second air quality strategy called "Cleaner Air for Scotland 2 – Towards a Better Place for Everyone" (CAFS2). CAFS2 is shaped around 10 general themes. These are:

1. Health – A Precautionary Approach
2. Integrated Policy
3. Placemaking
4. Data
5. Public Engagement and Behavioural Change
6. Industrial Emissions Regulation
7. Tackling Non-Transport Emission Sources
8. Transport
9. Governance, Accountability and Delivery
10. Further Progress Review

### Air Quality Monitoring in Scotland

Air pollution data for 99 automatic monitoring sites throughout Scotland are available in the database for all or part of 2023. All automatic data maintained within the Scottish database are subject to the same QA/QC procedures as the UK Automatic Urban and Rural Network (AURN).

In 2023, no automatic monitoring site exceeded the annual mean or hourly Air Quality Strategy (AQS) objectives for $NO_2$. In 2023, four passive diffusion tube monitoring sites exceeded the $NO_2$ annual mean objective. These were located in Glasgow and Edinburgh.

In 2023, only one automatic monitoring site (Peth Atholl Street) measuring Particulate Matter ($PM_{10}$) measured exceedances of the Scottish 24 hour and annual mean objectives for $PM_{10}$. The reason was due to continued period of construction work next to the site.

In 2023 no sites measuring Particulate Matter ($PM_{2.5}$) exceeded the AQS objectives.

In 2023, no exceedances of AQS objectives were observed for the pollutants ozone ($O_3$), sulphur dioxide ($SO_2$), carbon monoxide (CO), benzene, 1,3-butadiene, benzo(a)pyrene, and lead (Pb).

In 2023, of the eleven sites measuring ozone in Scotland, six exceeded the AQS objective (100 $\mu gm^{-3}$ not to be exceeded more than 10 times a year (8 hourly running mean)).

### Air Quality Mapping of Scotland

The 2022 annual mean $NO_2$ concentrations for Scotland were modelled for background and roadside locations for $NO_2$, $PM_{10}$ and $PM_{2.5}$.

For $NO_2$, there were no modelled exceedances of the Scottish annual mean objective of 40 $\mu g\ m^{-3}$ at background or roadside locations.

For $PM_{10}$, there were no modelled exceedances of the Scottish annual mean $PM_{10}$ objective of 18 µg $m^{-3}$ at background or roadside locations.

For $PM_{2.5}$, there were also no modelled exceedances of the Scottish annual mean $PM_{2.5}$ objective of 10 µg $m^{-3}$ at both background and roadside locations.

### Air Quality Trends for Scotland

**$NO_2$ -** All $NO_2$ urban background sites analysed display statistically highly significant decreasing trends (at the 0.001 level) since 2007 which is consistent with the last five years trend. The exception to this is Grangemouth where the trend has switched to not statistically significant increasing trend.

All three rural sites show small but highly significant decreasing trends over the last 10 years. Over the last five years the trend has plateaued.

For urban traffic sites the trend shows highly significant decreasing trends of the 10-year trend. For the last five year trend in general is the same but to lesser extent.

**$PM_{10}$ -** All $PM_{10}$ Background sites analysed show significant decreasing trends at varying levels. The exception to this is Glasgow Anderston when looking at the five-year trend.

Urban traffic PM10 sites analysed over 10-years again show significant decreasing trends with the exception of Byres Road. The five-year trend shows that the levels are plateauing with the exception of Glasgow Byres Road which is now showing highly significant decreasing trends in recent years.

**$PM_{2.5}$** - In general, 10-year trend analysis of $PM_{2.5}$ sites data show a decreasing trend at varying level of statistical significancy. The five-year trend analysis indicates that levels are plateauing with concentrations general levelling out or showing small decreasing or increasing trends but not statistically significant.

**Ozone -** Three of Scotland's rural air quality monitoring stations have been monitoring ozone for 32 years. Two of these sites show small but highly statistically significant increasing trends over this period. The other shows a level trend over this period.

10-year trends at six ozone sites, shows that four sites have increasing trends in $O_3$ concentrations at varying levels of statistical significance. The other two sites have slight decreasing trends with no statistical significance.

### Additional Trend Analysis

Additional trend analysis was carried out at four sites located within the four major cities in Scotland. This analysis was carried out using the Openair analysis tool and compared 2023 data with data from the previous 10 years using a variety of analytical techniques.

### Emissions of Pollution Species

Emissions of **nitrogen oxides** in Scotland were estimated to be 76 kt in 2022, representing 12% of the UK total for nitrogen oxides. Emissions have declined by 63% since 2005, mainly due to changes in transport sources. $NO_x$ emissions decreased by 7% between 2021 and 2022, with a 4% decrease in emissions in this period from the transport sector. 55% of the emissions were due to the transport sector in 2022. Emissions from power stations decreased by 22% between 2021 and 2022.

Emissions of **$PM_{10}$** in Scotland were estimated to be 10 kt in 2022, declining by 48% since 2005. These emissions account for 8% of the UK total $PM_{10}$ emissions. $PM_{10}$ emissions increased by 1.2% between 2021 and 2022, led by increases in several sectors including construction and demolition (7% increase) and the transport sector (4% increase). In contrast, $PM_{10}$ emissions from power stations decreased by 39% between 2021 and 2022.

Emissions of **$PM_{2.5}$** in Scotland were estimated to be 5kt in 2022, declining by 58% since 2005. These emissions account for 8% of the UK total for $PM_{2.5}$ in 2022. The primary drivers for the decline in emissions since 2005 are the continued switch from coal to natural gas in electricity generation, and reductions in emissions from the transport sector. $PM_{2.5}$ emissions decreased by 1.9% between 2021 and 2022. From 2021 to 2022, $PM_{2.5}$ emissions decreased by 39% from the energy sector (power stations), which contributes 73% of the overall $PM_{2.5}$ trend in 2021 to 2022. There was also a 3% increase in emissions from the transport sector from 2021-2022.

Emissions of **ammonia** in Scotland were estimated to be 31 kt in 2022. These emissions have declined by 14% since 2005 and accounted for 12% of the UK total for ammonia in 2022. Agriculture sources dominate the inventory. The initial trends in $NH_3$ emissions were primarily driven by decreases in livestock numbers and declines in the use of nitrogen-based fertilisers. In 2022, ammonia emissions decreased by 2.4% since 2021, largely due to a reduction in nitrogen fertiliser use.

Emissions of **sulphur dioxide** in Scotland were estimated to be 7 kt in 2022, representing 6% of the UK total in 2022 for sulphur dioxide. Emissions have declined by 93% since 2005 because of continued changes in the power generation sector. Since 2005, $SO_2$ emissions from power stations have reduced by 99%. In 2022, $SO_2$ emissions decreased by 0.1% since 2021, which is driven by a 20% decrease in emissions from power stations.

Emissions of **carbon monoxide** in Scotland were estimated to be 86 kt in 2022 and have declined by 62% since 2005. This decline in emissions stems from changes in the contribution of transport sources. Emissions in Scotland accounted for 7% of the UK total for carbon monoxide in 2022. CO emissions decreased by 1% between 2021 and 2022, with road transport emissions decreasing by 1.7% in this period.

Emissions of **non-methane volatile organic compounds** in Scotland were estimated to be 144 kt in 2022, representing 19% of the UK total for NMVOCs. Emissions have declined by 20% since 2005. This reduction is a result of reductions in fugitive and road transport emissions which have each declined 85% since 2005. Between 2021 and 2022, emissions of NMVOCs increased by 3.9%, which is largely driven by the 3% increase in emissions from the food and drink industry. The 3% increase in the food and drink industry accounted for 46% of the overall trend in NMVOC emissions observed in 2021-2022.

# CONTENTS

# 1. INTRODUCTION

The Scottish Government undertakes considerable monitoring of a wide range of air pollutant species as part of a joint UK programme run in conjunction with Defra, the Welsh Government and the Department of the Environment in Northern Ireland. In addition, a large number of local authorities in Scotland monitor air quality within their geographical boundaries as part of the requirements of the Local Air Quality Management system. Prior to 2006, air quality data in Scotland outside of the nationally operated sites, were collected by a wide range of organisations for many purposes and were widely dispersed. Consequently, and following experience gained across the rest of the UK, it was recognised that a comprehensive centralised resource providing air quality information for Scotland would serve to improve the quality of research and data analysis required to support Scottish air quality policy. Hence, in 2006, the Scottish Government contracted AEA, now Ricardo, to undertake a pilot programme to develop an air quality database for Scotland.

The pilot study developed the initial Scottish Air Quality Database (SAQD) and Website, undertook stakeholder feedback and assessed the air quality data available across Scotland. The key recommendations that were developed from this initial study were based around the methodology for successful harmonisation of existing air quality monitoring data. It was suggested that a programme for Scotland should include the following components:

- Independent audits of every site - to include checks on both the analysers and the site calibration cylinders.
- Regular data checks; and,
- Longer term data checking and adjustment where necessary.

Following this pilot study, Ricardo were commissioned to undertake the next stage which was to further develop and extend the SAQD and website incorporating all stakeholder comments and to bring selected local authority sites in line with the national Quality Assurance and Quality Control (QA/QC) requirements. Reports relating to the earlier years of the project are available on the Air Quality Scotland website (http://www.scottishairquality.scot/).

This annual report summarises the progress made during 2023 in the on-going project tasks and also highlights the new work undertaken during 2023 and into early 2024.

Section 2 of this report provides a breakdown of the legislation and policy concerning air quality within Scotland.

Section 3 provides a summary of the latest annual Air Quality in Scotland seminar.

The network of sites within the SAQD is dynamic and regularly changing to address the requirements of the local authorities to deal with air pollution issues. Section 4 describes in detail the structure of the database in terms of number and type of sites as well as pollutants measured, and how it has changed during 2022.

QA/QC is an integral part of the SAQD project. Since conception of the SAQD project, the QA/QC programme has expanded and adapted to encompass the dynamicity of the database and the changing best practice guidance and regulations. Section five of this report provides detailed information on the QA/QC process and how this was applied to the SAQD during 2023.

A statistical summary of all the available 2023 Scottish air quality data is provided in Section 6. This includes all pollutants covered under the Air Quality Strategy as well as other monitoring networks.

As the number of monitoring sites in Scotland has significantly increased since 2006, it has become feasible to undertake pollution climate mapping of NOx, $NO_2$ and $PM_{10}$ using solely Scottish measurement data. As part of the SAQD, Ricardo Energy & Environment provide mapped concentrations of modelled background air pollutant concentrations on a 1 km x 1 km basis for the whole of Scotland. The Scottish pollution climate mapping work carried out in 2023 is described in Section 7.

Section 8 of this report provides a discussion of trends in pollutant concentrations across Scotland, based on the latest available data. The trend analysis focuses on roadside and urban background locations across Scotland and the pollutants nitrogen dioxide ($NO_2$), particulate matter ($PM_{10}$ and $PM_{2.5}$) and ozone ($O_3$).

Section 9 provides most up to date and historical data on emissions of pollutants into the atmosphere in Scotland. The data is obtained from the UK National Atmospheric Emissions Inventory (NAEI) and the Scottish Pollution Release Inventory (SPRI).

# 2. LEGISLATION AND POLICY

Air quality management is shaped by requirements of international, UK and Scottish legislation and policies. In the UK, air quality is a devolved matter, with the Scottish Government having responsibility for the development of air quality policy and legislation for Scotland. At EU level, the following air quality directives and policies are relevant:

- Directive 2008/50/EC - on ambient air quality and cleaner air for Europe (the Air Quality Directive).
- Industrial Emissions Directive 2010/75/EC – Controls emissions from industrial activities.
- National Emission Ceilings Directive 2016/2284/EU – sets emission limits for five important air pollutants.
- Clean Air Policy Package and Clean Air Programme for Europe - new air quality objectives to 2030, to improve air quality within cities.

Following the UK's exit from the EU, under retained EU law, the UK is required to continue to meet limit and target values for a range of air pollutants and other legal obligations covered by EU directives.

A substantial review of the EU's air quality policy, including the Air Quality Directive, was undertaken in 2013 with the European Commission adopting a new Clean Air Policy Package, including a new Clean Air for Europe programme with measures to ensure that existing targets are met in the short term and new air quality objectives for the period up to 2030. The Package also includes support measures to help cut air pollution, with a focus on improving air quality in cities, supporting research and innovation, and promoting international cooperation. A new ambient air quality Directive came into force in October 2024. The details of this will be covered in next year's annual report.

Domestic air quality legislation is largely derived from the requirements of the Environment Act 1995.

## 2.1 AIR QUALITY STANDARDS AND OBJECTIVES

A set of air quality standards and objectives has been developed for several pollutants of concern for human health. The objectives are derived from the standards and are a compromise between what is desirable purely on health grounds and what is practical in terms of feasibility and costs. Each objective has a date by when it must be achieved. The objectives adopted in Scotland for the purpose of Local Air Quality Management are set out in the Air Quality (Scotland) Regulations 2000, the Air Quality (Scotland) Amendment Regulations 2002 and the Air Quality (Scotland) Amendment Regulations 2016. Similar targets are set at EU level, where there are called limit or target values. These limit values are set out in the 2008 ambient air quality Directive (2008/50/EC) and transposed into Scottish legislation. It is the responsibility of EU Member States to achieve the limit and target values. A summary of the current Scottish air quality objectives is provided in Table 2-1.

Table 2-1 Summary of Scotland's Air Quality Objectives

| AQ Objective-Pollutant | Concentration | Measured as | Date to be achieved by |
|---|---|---|---|
| Nitrogen Dioxide ($NO_2$) | 200 µg $m^{-3}$ not to be exceeded more than 18 times a year | 1-hour mean | 31.12.2005 |
| | 40 µg $m^{-3}$ | Annual mean | 31.12.2005 |
| Particulate Matter ($PM_{10}$) | 50 µg $m^{-3}$, not to be exceeded more than 7 times a year | 24-hour mean | 31.12.2010 |
| | 18 µg $m^{-3}$ | Annual mean | 31.12.2010 |
| Particulate Matter ($PM_{2.5}$) | 10 µg $m^{-3}$ | Annual mean | 31.12.2020 |
| Sulphur Dioxide ($SO_2$) | 350 µg $m^{-3}$, not to be exceeded more than 24 times a year | 1-hour mean | 31.12.2004 |
| | 125 µg $m^{-3}$, not to be exceeded more than 3 times a year | 24-hour mean | 31.12.2004 |
| | 266 µg $m^{-3}$, not to be exceeded more than 35 times a year | 15-minute mean | 31.12.2005 |
| Benzene | 3.25 µg $m^{-3}$ | Running annual mean | 31.12.2010 |
| 1,3 Butadiene | 2.25 µg $m^{-3}$ | Running annual mean | 31.12.2003 |
| Carbon Monoxide | 10.0 mg $m^{-3}$ | Running 8-Hour mean | 31.12.2003 |
| Lead | 0.25 µg $m^{-3}$ | Annual Mean | 31.12.2008 |
| Poly Aromatic Hydrocarbons* | 0.25 ng $m^{-3}$ | Annual Mean | 31.12.2010 |
| Ozone* | 100 µg $m^{-3}$ not to be exceeded more than 10 times a year* | daily maximum 8-hour running mean | 31.12.2005 |

* not required to be monitored or assessed by local authorities under LAQM, however is a UK requirement under retained EU law

## 2.2 CLEANER AIR FOR SCOTLAND STRATEGY

The first "Cleaner Air for Scotland – The Road to a Healthier Future" (CAFS) strategy was published by the Scottish Government in November 2015. The purpose of CAFS was to provide a national framework which set out how the Scottish Government and its partner organisations proposed to achieve further reductions in air pollution and fulfil their legal responsibilities to achieve the air quality objectives. It recognised that although progress had been made through Scotland, areas of poorer air quality still existed within towns and cities.

Starting in late 2018 the Scottish Government commissioned an in-depth independently led review of CAFS and the findings were published in July 2019. The Scottish Government used the conclusions and recommendations arising from this review to develop a draft updated air quality strategy in the first part of 2020. In October 2020 this draft was published for consultation. Following the consultation, in July 2021, accompanied by a Delivery Plan, and replacing "Cleaner Air for Scotland – The Road to a

Healthier Future", the Scottish Government published Scotland's second air quality strategy "Cleaner Air for Scotland 2 – Towards a Better Place for Everyone" (CAFS2).

## 2.3 CLEANER AIR FOR SCOTLAND 2 (CAFS2) STRATEGY

CAFS2 sets out how the Scottish Government and its partner organisations propose to further reduce air pollution to protect human health and fulfil Scotland's legal responsibilities over the period 2021-2026. CAFS2 aims to achieve the ambitious vision for Scotland "to have the best air quality in Europe".

The CAFS2 key partner organisations are:

- Scottish Government
- Transport Scotland
- Scottish Environment Protection Agency (SEPA)
- Public Health Scotland
- Local authorities

Engagement and support from a wide range of stakeholders including representatives from the transport and planning sectors and Non-Governmental Organisations is also vital to achieving the aims of CAFS2.

Progress is supported by the CAFS2 Delivery Group, which is directly accountable to a Ministerial Group, and actions are managed by specific sub-groups and policy leads across partner organisations tasked with delivering actions across the 10 overarching policy themes set out in CAFS2.

## 2.4 CAFS2 – OVERVIEW

The ten general themes largely reflect the high-level recommendations arising from the Cleaner Air for Scotland (CAFS) review. These are:

1. Health – A Precautionary Approach

The current weight of evidence justifies adopting a precautionary public health approach to air pollution reduction. As a minimum, compliance is required with domestic and international air quality standards but, where practicable and feasible, there should be continued efforts to reduce preventable air pollution still further beyond these limits.

2. Integrated Policy

Strategies, policies and plans being developed and implemented by central government for placemaking, climate change mitigation and adaptation, and related polices such as noise reduction, should be closely coordinated and aligned with those for air quality in order to maximise co-benefits.

Local government, which is largely responsible for implementing the Local Air Quality Management system, besides its planning, transport delivery, public health and regulatory roles, also has a key role to play.

3. Placemaking

National Planning Framework 4 (NPF4) will transform how Scotland's planning system shapes our places and society over the years and decades to come. The Planning (Scotland) Act 2019 requires that the National Planning Framework must have regard to minister's national strategy for the improvement of air quality, so it will provide an important context within which further effort on air quality improvement in CAFS 2 will be delivered, supported by the Place Principle and the Place Standard tool.

4. Data

There are gaps in both quality and coverage of air quality, transport and human health data in Scotland. Addressing these gaps will help to improve public awareness and engagement, modelling, reporting and ultimately, policy implementation. A greater focus on collecting and presenting traffic data in a way that supports air pollutant emissions understanding will have similar benefits. Health data also require careful consideration so that Scotland-specific interpretations, plans and interventions are strengthened. Wider utilisation of low-cost sensor technology, including citizen science initiatives, has a role to play too.

5. Public Engagement and Behaviour Change

More research is needed to provide clear evidence on levels of knowledge, attitudes, and concern related to air pollution, as well as on willingness to change behaviours which contribute toward air pollution. Many of the key drivers and incentives/disincentives will be closely related to those associated with climate change, but at the same time there will be differences in focus and approach. Development of complementary and co-ordinated public engagement strategies is therefore essential to deliver the required behavioural change outcomes and to avoid confusing or conflicting messages.

6. Industrial Emissions Regulation

The Scottish Government has made clear its commitment to maintain or exceed EU standards, following the UK's departure from the European Union (EU). The Scottish Government is committed to ensuring that EU environmental principles continue to sit at the heart of environmental policy and law in Scotland. The UK Withdrawal from the European Union (Continuity) (Scotland) Act 2021 will bring the guiding European principles on the environment into force in Scots law, including the precautionary principle, polluter pays principle, prevention principle, rectification at source principle and the integration principle. In relation to current regulation, retained EU law will continue to apply, as will domestic regulations made to transpose EU Directives.

7. Tackling Non-Transport Emission Sources

Domestic (household) burning and agriculture are two sectors not addressed in detail in CAFS, but which make an important contribution to air pollution. Consideration is needed of performance and standards for domestic fires, stoves and fuels, and local authority powers to permit and control these, and a refreshed approach to good agricultural practice, which includes aiming for increased nitrogen use efficiency in farming. Together, these have the potential to deliver significant improvements in air quality beyond current regulatory and management approaches.

8. Transport

Increasing modal shift to active travel and public transport is key to further reductions in transport emissions. This will mean, amongst other objectives, providing a transport system that facilitates active travel choices, better public transport provision, embracing new technologies, and constraints upon private vehicle use, especially in urban centres where pollution and congestion are most acute. Establishment of Low Emission Zones in our four biggest cities is also important in this context.

The new National Transport Strategy (NTS2), published in February 2020, sets out an ambitious and compelling vision for Scotland's transport system for the next 20 years. The four NTS2 priorities – reducing inequalities, taking climate action, helping deliver inclusive economic growth and improving our health and wellbeing – will underpin our efforts to deliver additional air quality improvements in CAFS 2.

The Climate Change Plan update, published in December 2020, will also make a significant contribution to achieving this vision, including the commitment to reduce motor vehicle kilometres by 20% by 2030.

9. Governance, Accountability and Delivery

Simple and effective governance arrangements and a focus on practical joined up delivery are imperative for CAFS 2. We need to be clear on who is doing what, who is leading, who is supporting and who is ultimately responsible if CAFS 2 is to be delivered as a coherent, integrated and successful strategy.

10. Further Progress Review

As in the original version of CAFS, the intention is that CAFS 2 will have a five-year lifespan. A further review of progress on air quality improvements will commence during 2024 to track progress on delivering the actions in the new strategy, besides allowing Scotland to keep abreast of developments in the evidence base, technological advances and societal attitudes, so that new challenges and actions can be identified.

## 2.5 NATIONAL MODELLING FRAMEWORK

The National Modelling Framework (NMF) provides a two-tiered standardised approach to modelling air quality in Scotland. Detailed models for the first four cities covering Glasgow, Edinburgh, Aberdeen and Dundee provides evidence for taking direct actions at the city scale to reduce street-level emissions. The regional model provides a tool for screening and assessing the potential air quality impacts associated with large-scale planned developments across local authority areas. The NMF will help with providing evidence for actions developed through the National Low Emission Framework.

## 2.6 NATIONAL LOW EMISSION FRAMEWORK

The National Low Emission Framework (NLEF) has been developed to assist in the appraisal of air quality improvement options related to transport. Together with the National Modelling Framework, it provides guidance on the appraisal of such measures to help facilitate consistent assessment and implementation across Scotland.

The Scottish Government published the NLEF framework in January 2019 and it is available at https://www.scottishairquality.scot/technical-reports/national-low-emissions-framework-january-2019. The framework provides a methodology for local authorities to undertake air quality assessment to inform decisions on transport related actions.

## 2.7 LOW EMISSION ZONES

In September 2017, the Scottish Government in their Programme for Government, committed to the introduction of Low Emission Zones (LEZs) into Scotland's four biggest cities (Glasgow, Edinburgh, Aberdeen and Dundee) by 2020 and into all other Air Quality Management Areas (AQMAs) by 2023 where the National Low Emissions Framework appraisal advocates such mitigation. On 31st December 2018, the first Scottish LEZ was introduced into Glasgow city centre and applied to buses only (phase 1). After delays resulting from the Covid-19 pandemic LEZs were also introduced across Aberdeen, Dundee, and Edinburgh on 31st May 2022, together with an expansion in scope of the Glasgow LEZ. Local grace periods were applied until enforcement began at the following dates:

- **Glasgow (all other vehicle types) - 1st June 2023**
- **Dundee – 30th May 2024**
- **Aberdeen – 1st June 2024**
- **Edinburgh – 1st June 2024**

More information on LEZs is available here: https://www.lowemissionzones.scot/about.

## 2.8 LOCAL AIR QUALITY MANAGEMENT

The LAQM process places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where an exceedance is considered likely the local authority must:

- Declare an Air Quality Management Area (AQMA)
- Assess and identify the reasons for the problem, quantifying the sources of emissions.
- Develop an Air Quality Action Plan (AQAP) to help address the problem.

The Scottish Government and the other UK administrations have jointly produced updated Technical Guidance (TG(22)) and the Scottish Government has produced updated Policy Guidance (PG (S) (24)) for the LAQM regime in Scotland. The latest versions of the LAQM Policy and Technical Guidance are available at https://www.scottishairquality.scot/laqm/technical-guidance.

# 3. AIR QUALITY SEMINAR

As part of the Scottish Air Quality Database project, Ricardo, on behalf of the Scottish Government, organise an annual air quality seminar. The event was held online and separated into three two-hour webinars, over a three-week period. Using the MS Teams Events platform, the event was held on the 13th, 20th and 27th March 2024 and attended by between 80 - 100 delegates representing the Scottish Government, local authorities, Health Protection Scotland, SEPA, consultancy, academia and students. The objective of the seminar was to discuss some of the most recent work carried out under the Scottish Air Quality Database and Website project and consider a number of other topical air quality issues that affect Scotland.

The seminar covered a number of topical subjects in the field of air quality presented by highly respected dignitaries. These subjects included amongst others:

- Up in Smoke: Why we must rethink Wood burning stoves (Dr James Heydon, Uni of Nottingham)
- Forth Environmental Resilience Array Project (Dr Heather Price)
- Air Pollution Footprint Tool (Ella Wingard, Ricardo)
- Transport Scotland's Remote Sensing Monitoring Programme (Derek McCreadie)
- Air Pollution Assessment Service (APAS) – Delivering the CAFS Regional Air Quality Model (Mark Williams SEPA)
- Scenario Modelling Tools (Dr Scott Hamilton, Ricardo)

In addition, Professor Sir Stephen Holgate provided a talk on the wide ranging and substantial impact of air pollution on human health across the life course.

Recordings of all three webinars can be found on the Scottish air Quality website (https://www.scottishairquality.scot/news/reports/seminars). The full agendas are shown in Figure 3-1.

## 3.1 ANNUAL NEWSLETTER

In addition to this report, an annual newsletter (Air Pollution in Scotland) is also produced as part of this project. This sets out the legislative and policy background to air quality in Scotland and briefly reviews the latest available air quality monitoring and key results. Trends and mapping of air quality are also summarised along with recent developments and information on how to stay informed with regards to air quality matters (i.e. forecasts, health alerts and social media).

Figure 3-1 Agenda for the Scottish Air Quality Seminar 2024

# SCOTTISH AIR QUALITY ANNUAL SEMINAR 2024

## Wednesday 13th 20th and 27th March 2024 (13:00 – 1500 (GMT) – Via MS Teams)

### Agenda

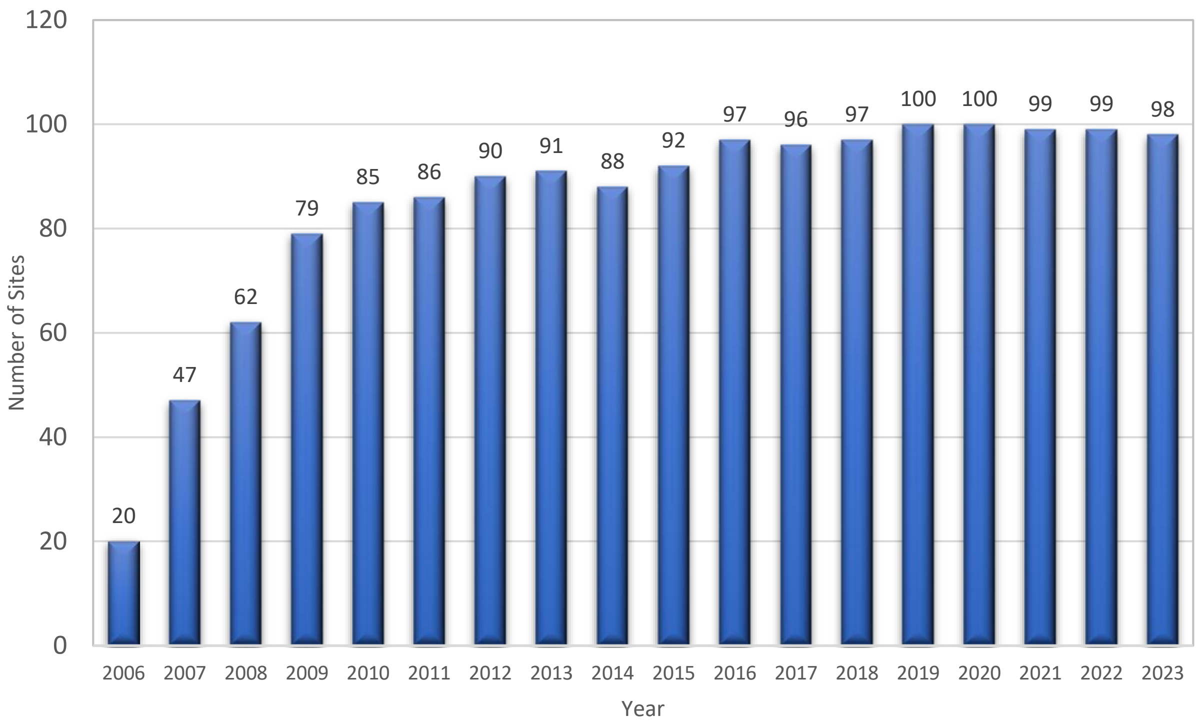
| | | |
|---|---|---|
| | **Webinar 1: Policy (13th March 2024)** | |
| 13:00 | Welcome/Introduction | Ricardo Energy and Environment |
| 13:15 | CAFS2 and Update from Scottish Government | Andrew Taylor (Scot Gov) |
| 13:30 | UK Air Pollution Assessment Service (APAS) - Delivering the CAFS Regional Air Quality Model | Mark Williams (SEPA) |
| 14:00 | National/Regional Air Quality Scenario Modelling | Dr Scott Hamilton (Ricardo) |
| 14:25 | WHO's global work on air quality and health | Dr Sophie Gumy & Dr Kerloyn Shairsingh (World Health Organisation) |
| 14:45 | Questions and Answer Session | |
| | **Webinar 2: Research and Innovation (20th March 2024)** | |
| 13:00 | Welcome/Introduction | Ricardo Energy and Environment |
| 13:10 | Forth Environmental Resilience Array Project | Dr Heather Price (University of Stirling) |
| 13:30 | Air Pollution Footprint Partnership | Martha Preater (Ricardo) |
| 14:00 | A large-scale remote sensing campaign in four major Scottish cities | Kaylin Lee (International Council on Clean Transport)<br>Derek McCreadie (Transport Scotland) |
| 14:25 | NEMO Project – Findings and Conclusions | Javier Buhigas (Opus) |
| 14:45 | Questions and Answer Session | |
| | **Webinar 3: Health and Environmental Impact (27th March 2024)** | |
| 13:00 | Welcome/Introduction | Ricardo Energy and Environment |
| 13:10 | The wide ranging and substantial impact of air pollution on human health across the life course. | Prof Sir Stephen Holgate (University of Southampton) |
| 13:30 | Healthy Air Scotland/ Asthma + Lung UK Scotland | Gareth Brown (Asthma and Lung UK) |
| 14:00 | Cleaner Cities, Healthier Children: Insights from Pilot Studies on Wood Smoke Pollution and School Exposure Reduction | Dr James Heydon (University of Nottingham) |
| 14:35 | Questions and Answer Session | |

# 4. DATA AVAILABILITY 2023

## 4.1 HOURLY DATA FOR NITROGEN DIOXIDE, CARBON MONOXIDE, SULPHUR DIOXIDE, OZONE, $PM_{10}$ AND $PM_{2.5}$

At the end of 2023 the Scottish Air Quality Database contained data for 98 automatic monitoring sites. No new monitoring site was added to the network and one site was decommissioned and removed from the network during 2023: Edinburgh Glasgow Road. Figure 4.1 shows the growth of the SAQD from 20 sites in 2006 pilot study to 98 sites during 2023.

Figure 4-1 Number of Monitoring Sites within the Scottish Air Quality Database Network 2006 – 2023




For the 22 National Network AURN monitoring stations in the Scottish Database, the data are available from the commencement of these stations, which in some cases is as long ago as 1986. However, for local authority monitoring stations, data are only available from when the station joined the database project. In many cases the stations commenced monitoring much earlier and these earlier data may be available from the relevant local authority.

Data availability for 2023, in terms of site, pollutants and months available, is summarised in Table 4.1. The full 12-figure OS grid reference and the site location classification ("Type") are also provided for each site and the monitoring network the site is affiliated to; either the Scottish Air Quality Database Network (SAQD) or the Automatic Urban and Rural Network (AURN).Table 4.1 also provides the start date for each site. However, not all pollutants are measured over the same period at all sites – measurements of some pollutants may commence or cease during the lifetime of monitoring at a particular site. The dates of availability of data for each pollutant measured at each site can be found by selecting the site of interest on the 'Latest Data' page of the air Quality in Scotland website (http://www.scottishairquality.scot/latest/) and then selecting the "site details" tab.

In addition, some sites may join a network or change network during their lifetime and hence, earlier data from a site may be available elsewhere. At a small number of sites, different pollutants are in different networks. This is due to the differing requirements of specific networks. The data from closed sites are also available (https://www.scottishairquality.scot/latest/closed-sites) in the database for their period of operation.

## Table 4-1 Scottish Air Quality Database Data Availability in 2023

| Site Name | Type | East | North | Pollutants | Network | Start Year# | Data in 2023 |
|---|---|---|---|---|---|---|---|
| Aberdeen Anderson Dr | RS | 392506 | 804186 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2004 | Jan – Dec |
| Aberdeen Errol Park | UB | 394366 | 807396 | $NO_2$ $O_3$ $PM_{10}$ $PM_{2.6}$ | AURN | 2021 | Jan - Dec |
| Aberdeen King Street | RS | 394333 | 808770 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2008 | Jan – Dec |
| Aberdeen Market Street 2 | RS | 394535 | 805687 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2009 | Jan – Dec |
| Aberdeen Union St˜ | RS | 393655 | 805984 | NO2, $PM_{10}$, $PM_{2.5}$ | AURN / SAQD | 2005 | Jan – Dec |
| Aberdeen Wellington Road | RS | 394395 | 804779 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2008 | Jan – Dec |
| Alloa A907 | RS | 288689 | 693068 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2016 | Jan – Dec |
| Angus Forfar Glamis Road | RS | 345248 | 750385 | $PM_{10}$ | SAQD | 2016 | Jan – Dec |
| Auchencorth Moss | R | 322167 | 656123 | 13BD BENZ $O_3$ $PM_{10}$ $PM_{2.5}$ TOL XYL | AURN | 2006 | Jan – Dec |
| Bush Estate | R | 324626 | 663880 | $NO_2$ $O_3$ | AURN | 1986 | Jan – Dec |
| Dumfries | RS | 297012 | 576278 | $NO_2$ | AURN | 2001 | Jan – Dec |
| Dundee Broughty Ferry Road | RS | 341970 | 730997 | $PM_{10}$ $SO_2$ | SAQD | 2006 | Jan – Dec |
| Dundee Lochee Road | KS | 330773 | 738861 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2006 | Jan – Dec |
| Dundee Mains Loan | UB | 340972 | 731893 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD / AURN | 2006 | Jan – Dec |
| Dundee Meadowside | RS | 340241 | 730654 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2011 | Jan – Dec |
| Dundee Seagate | KS | 340487 | 730446 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2006 | Jan – Dec |
| Dundee Whitehall Street | KS | 330155 | 740279 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2006 | Jan – Dec |
| East Ayrshire Kilmarnock St Marnock St | RS | 242742 | 637705 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2012 | Jan – Dec |
| East Dunbartonshire Bearsden | RS | 254269 | 672067 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2005 | Jan – Dec |
| East Dunbartonshire Bishopbriggs | RS | 260995 | 670130 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2003 | Jan – Dec |
| East Dunbartonshire Kirkintilloch | RS | 265700 | 673500 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| East Dunbartonshire Milngavie | RS | 255325 | 674115 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2011 | Jan – Dec |
| East Lothian Musselburgh N High St | RS | 333941 | 672836 | $NO_2$ $PM_{10}$ | SAQD | 2008 | Jan – Dec |
| Edinburgh Currie | UB | 317575 | 667874 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2013 | Jan – Dec |
| Edinburgh Glasgow Road | RS | 313101 | 672651 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2012 | Jan – Nov |
| Edinburgh Gorgie Road | RS | 323121 | 672314 | $NO_2$ | SAQD | 2005 | Jan – Dec |

| Site Name | Type | East | North | Pollutants | Network | Start Year# | Data in 2023 |
|---|---|---|---|---|---|---|---|
| Edinburgh Nicolson Street | RS | 326145 | 673038 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD / AURN | 2017 | Jan – Dec |
| Edinburgh Queensferry Road | RS | 318734 | 674931 | $NO_2$ $PM_{10}$ | SAQD | 2011 | Jan – Dec |
| Edinburgh Salamander St | RS | 327621 | 676342 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2009 | Jan – Dec |
| Edinburgh St John's Road | KS | 320100 | 672890 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| Edinburgh St Leonards | UB | 326250 | 673132 | CO $NO_2$ $O_3$ $PM_{10}$ $PM_{2.5}$ $SO_2$ | AURN | 2003 | Jan – Dec |
| Edinburgh Tower Street | RS | 327460 | 676531 | $PM_{10}$ $PM_{2.5}$ | SAQD | 2018 | Jan- Dec |
| Eskdalemuir | R | 323552 | 603018 | $NO_2$ O3 | AURN | 1986 | Jan – Dec |
| Falkirk Bo'ness | UI | 299827 | 681462 | $SO_2$ | SAQD | 2016 | Jan – Dec |
| Falkirk Grangemouth MC | UB | 292816 | 682009 | $NO_2$ $PM_{10}$ $PM_{2.5}$ $SO_2$ | SAQD | 2003 | Jan – Dec |
| Falkirk Grangemouth Zetland Park | UI | 292969 | 681106 | $SO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2016 | Jan – Dec |
| Falkirk Haggs | RS | 278977 | 679271 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2009 | Jan – Dec |
| Falkirk Hope St | RS | 288688 | 680218 | $NO_2$ $PM_{10}$ $PM_{2.5}$ $SO_2$ | SAQD | 2007 | Jan – Dec |
| Falkirk Main St Bainsford | RS | 288569 | 681519 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2015 | Jan – Dec |
| Falkirk West Bridge Street | RS | 288457 | 680064 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| Fife Cupar | RS | 337401 | 714572 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2005 | Jan – Dec |
| Fife Dunfermline | RS | 309912 | 687738 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| Fife Kirkcaldy | RS | 329143 | 692986 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2011 | Jan – Dec |
| Fife Rosyth | RS | 311752 | 683515 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2008 | Jan – Dec |
| Fort William | S | 210849 | 774421 | $NO_2$ $O_3$ | AURN | 2006 | Jan – Dec |
| Glasgow Anderston | UB | 257925 | 665487 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2005 | Jan – Dec |
| Glasgow Broomhill | RS | 255030 | 667195 | $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| Glasgow Byres Road | RS | 256553 | 665487 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2005 | Jan – Dec |
| Glasgow Dumbarton Road | RS | 255030 | 666608 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2012 | Jan – Dec |
| Glasgow Kerbside | KS | 258708 | 665200 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD / AURN | 1997 | Jan – Dec |
| Glasgow Great Western Road | RS | 258007 | 666650 | $NO_2$ | AURN | 2016 | Jan – Dec |
| Glasgow High Street | RS | 260014 | 665348 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | AURN | 2016 | Jan – Dec |
| Glasgow Nithsdale Road | RS | 257883 | 662673 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| Glasgow Townhead | UB | 259692 | 665899 | $NO_2$ $O_3$ $PM_{10}$ $PM_{2.5}$ | AURN | 2013 | Jan – Dec |
| Glasgow Waulkmillglen Reservoir | R | 252520 | 658095 | $NO_2$ $O_3$ $PM_{10}$ $PM_{2.6}$ | SAQD | 2005 | Jan – Dec |
| Grangemouth | UI | 293837 | 681035 | $NO_2$ $PM_{10}$ $PM_{2.5}$ $SO_2$ | AURN | 2001 | Jan – Dec |
| Grangemouth Moray~ | UB | 293469 | 681321 | $NO_2$ | AURN | 2009 | Jan – Dec |
| Grangemouth Moray Scot Gov~ | UB | 293469 | 681321 | $SO_2$ | SAQD | 2007 | Jan – Dec |
| Inverclyde Greenock A8 | RS | 229335 | 675710 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2016 | Jan – Dec |

| Site Name | Type | East | North | Pollutants | Network | Start Year# | Data in 2023 |
|---|---|---|---|---|---|---|---|
| Inverness | RS | 265720 | 845680 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | AURN | 2001 | Jan – Dec |
| Inverness Academy Street | RS | 266644 | 845440 | $NO_2$ | SAQD | 2016 | Jan – Dec |
| Inverness Academy Street 1st Floor | RS | 266644 | 845440 | $NO_2$ | SAQD | 2019 | Jan – Dec |
| Lerwick~ | R | 445337 | 1139683 | $O_3$ | AURN | 2005 | Jan – Dec |
| N Lanarkshire Airdrie Kenilworth Dr | RS | 277385 | 665831 | $NO_2$ $PM_{10}$ | SAQD | 2019 | Jan – Dec |
| N Lanarkshire Chapelhall | RS | 278174 | 663124 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2005 | Jan – Dec |
| N Lanarkshire Coatbridge Whifflet A725 | RS | 273646.2 | 663867 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2022 | Jan-Dec |
| N Lanarkshire Croy | RS | 272775 | 675738 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2006 | Jan – Dec |
| N Lanarkshire Kirkshaws | RS | 272522 | 663029 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2016 | Jan – Dec |
| N Lanarkshire Motherwell | RS | 275460 | 656785 | $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| N Lanarkshire Motherwell Adele Street | RS | 275642 | 656147 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2020 | Jan – Dec |
| N Lanarkshire Ravenscraig Plantation Rd | UB | 277307.4 | 657612 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2022 | Jan – Dec |
| N Lanarkshire Shawhead Coatbridge | RS | 273411 | 662997 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2009 | Jan – Dec |
| N Lanarkshire Uddingston New Edinburgh Rd | RS | 269145 | 661499 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2019 | Jan – Dec |
| North Ayrshire Irvine High Street | KS | 232142 | 638892 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2009 | Jan – Dec |
| Peebles | S | 324812 | 641083 | $NO_2$ $O_3$ | AURN | 2009 | Jan – Dec |
| Perth Atholl Street | RS | 311582 | 723931 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2004 | Jan – Dec |
| Perth Bridgend | RS | 312254 | 724159 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2021 | Mar – Dec |
| Perth Crieff | RS | 286363 | 721614 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2010 | Jan – Dec |
| Perth Muirton | UB | 311688 | 723625 | $PM_{10}$ $PM_{2.5}$ | SAQD | 2012 | Jan – Dec |
| Renfrew Cockels Loan | RS | 250467 | 665943 | $NO_2$ | SAQD | 2013 | Jan – Dec |
| Renfrew Inchinnan Road | RS | 250567 | 667558 | $NO_2$ | SAQD | 2019 | Jan – Dec |
| Renfrewshire Johnstone | RS | 243002 | 663183 | $PM_{10}$ $PM_{2.5}$ | SAQD | 2017 | Jan – Dec |
| Shetland Lerwick~ | R | 445337 | 1139683 | $NO_2$ $SO_2$ | SAQD | 2012 | Jan – Dec |
| South Ayrshire Ayr Harbour | RS | 233617 | 622749 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2012 | Jan – Dec |
| South Ayrshire Ayr High St | RS | 233725 | 622120 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| South Lanarkshire Blantyre | RS | 250567 | 667558 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2019 | Jan – Dec |
| South Lanarkshire Cambuslang | KS | 264340 | 660496 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2015 | Jan – Dec |
| South Lanarkshire East Kilbride | RS | 264390 | 655658 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2008 | Jan – Dec |

| Site Name | Type | East | North | Pollutants | Network | Start Year# | Data in 2023 |
|---|---|---|---|---|---|---|---|
| South Lanarkshire Hamilton | RS | 272298 | 655289 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2013 | Jan – Dec |
| South Lanarkshire Lanark | RS | 288427 | 643701 | $NO_2$ $PM_{10}$, $PM_{2.5}$ | SAQD | 2012 | Jan – Dec |
| South Lanarkshire Raith Interchange 2 | RS | 271065 | 658087 | $NO_2$ $PM_{10}$, $PM_{2.6}$ | SAQD | 2016 | Jan – Dec |
| South Lanarkshire Rutherglen | RS | 261113 | 661690 | $NO_2$ $PM_{10}$, $PM_{2.5}$ | SAQD | 2012 | Jan – Dec |
| South Lanarkshire Uddingston | RS | 269657 | 660305 | $NO_2$ $PM_{10}$, $PM_{2.5}$ | SAQD | 2013 | Jan – Dec |
| Stirling Craig's Roundabout | RS | 279955 | 693012 | $NO_2$ $PM_{10}$ | SAQD | 2009 | Jan – Dec |
| Strath Vaich | RS | 234829 | 874785 | $O_3$ | AURN | 1987 | Jan – Dec |
| West Dunbartonshire Clydebank | RS | 249724 | 672042 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2007 | Jan – Dec |
| West Dunbartonshire Glasgow Road | RS | 240234 | 675193 | $NO_2$ | AURN | 2010 | Jan – Dec |
| West Lothian Broxburn | RS | 308364 | 672248 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2008 | Jan – Dec |
| West Lothian Linlithgow High St 2 | RS | 300419 | 677120 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2013 | Jan – Dec |
| West Lothian Newton | RS | 309258 | 677728 | $NO_2$ $PM_{10}$ $PM_{2.5}$ | SAQD | 2012 | Jan – Dec |

+ Sites added to database in 2023.
* Sites changed monitoring
^Changes in number of measured pollutants or monitoring method during 2021
KS – Kerbside
R – Rural
RS – Roadside
S – Suburban
UB – Urban Background
UI – Urban Industrial

## 4.2 SUMMARY OF CHANGES TO MONITORING SITES WITHIN THE DATABASE DURING 2022

Details of changes to monitoring sites included within the SAQD are summarised below:

**No sites were opened during 2023:**

N/A

**Sites closed during 2023:**

- Edinburgh Glasgow Road - 17/11/2023

# 5. QA/QC OF THE SCOTTISH DATABASE

In order that all data within the Scottish Air Quality Database are harmonised to the same quality standard, the QA/QC procedures adopted within the UK Automatic and Rural Network (AURN) are provided for all Local Authority sites within the database.

The main elements of the QA/QC programme are sites six-monthly audits (which includes on-site analyser testing and calibration gas inter-calibrations), daily automatic data collection and validation and data ratification in three-monthly blocks.

## 5.1 ON-SITE ANALYSER AND CALIBRATION GAS AUDITS

The automatic air quality monitoring stations located throughout Scotland employ a wide variety of different analyser types and site infrastructure. Intercalibration of the stations provides essential input to the data management process, to ensure that data across Scotland are harmonised, consistent in quality and traceable to a recognised gas calibration standard.

Monitoring station audits evaluate analysers to obtain an assessment of their performance level on the date of test. This information, in conjunction with the full analyser data set and additional calibration and service records, helps ensure data quality specifications have been met during the preceding data period.

During the audit, the site sampling and calibration systems are assessed and tested to ensure their integrity.

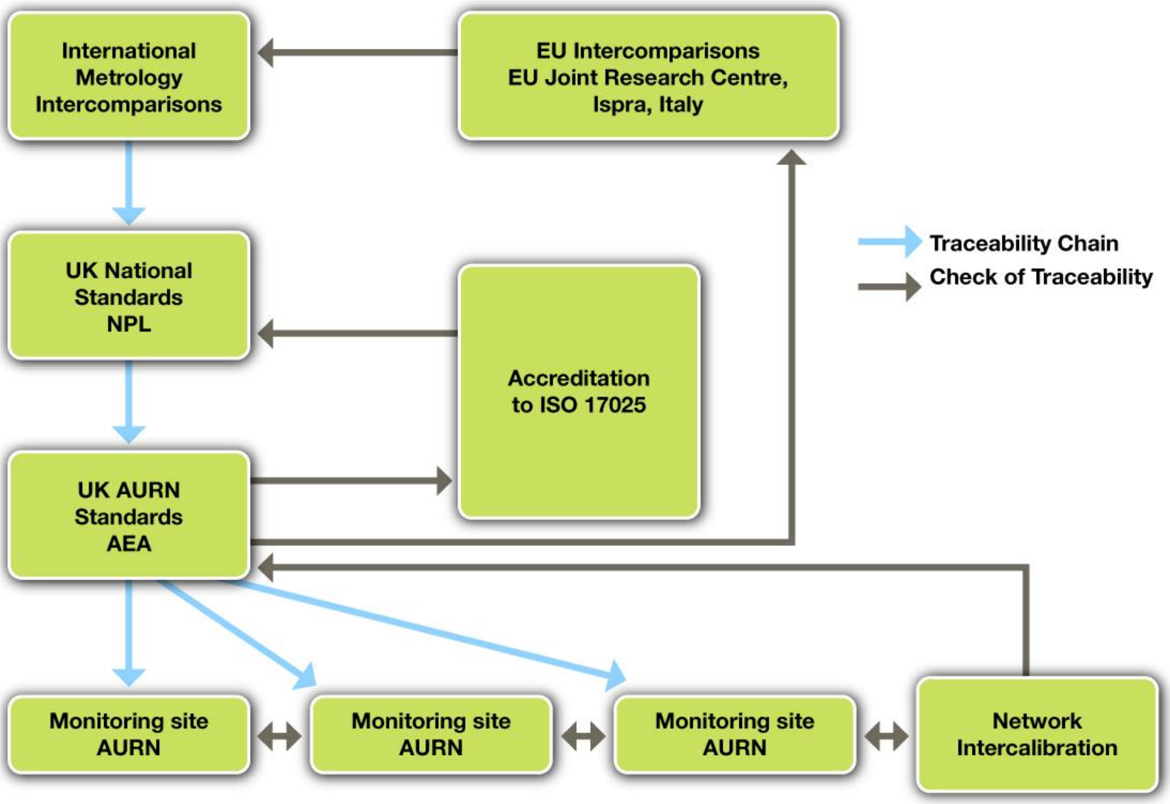
The assessment of the on-site calibration cylinder concentrations against accredited and traceable Ricardo Energy & Environment (Ricardo) gas standard cylinders provides the essential final link in the measurement traceability chain (Figure 5-1). This process ensures that all monitoring stations in Scotland are traceable to reference gas standards held at Ricardo. These in turn are traceable to UK national reference standard gases held by the National Physical Laboratory who, in turn regularly inter-compare these standards internationally. Ricardo also participates in EU level inter-comparisons at the EU Joint Research Centre. Hence, there is an unbroken traceability chain from each monitoring site in Scotland to internationally agreed gas calibration standards. This check also enables the identification of any unstable or erroneous gas cylinders which may need to be recertified or discarded.

The aims and objectives of the audit and intercalibration exercise can be summarised as follows:

- Ensure the correct operation of analysers and sampling systems at each monitoring station.
- Ensure harmonisation of data throughout the network (i.e., that a $NO_X$ analyser at one station measuring 40 µg $m^{-3}$ of $NO_2$ would also measure 40 µg $m^{-3}$ of $NO_2$ at any other site).
- Ensure traceability of all stations in the network to national and international standards.
- Provide information on any necessary adjustments to data into the ratification process.
- Report any faults found to the site operator.

Detailed audit procedures are provided in Appendix 2.

Figure 5-1 Traceability chain for the SAQD monitoring stations




## 5.2 DATA MANAGEMENT

The following sections describe the data management package applied to the data from the Scottish local authority monitoring stations. This is the same data management package, using the same data ratification procedures, that is applied to the AURN network stations across the UK.

The process includes the following tasks:

- Data acquisition
- Data validation
- Ratification

The data acquisition and management system consist of a central computer and telemetry facility that has been developed by Ricardo specifically for the UK's air quality monitoring programmes. The database used in this system is backed-up on a 24-hour basis to independent network servers to ensure data security.

A wide range of data management activities are routinely performed, and these are integrated into the streamlined automatic data management system. Data are retrieved automatically from the Scottish air quality monitoring stations (*data acquisition*). The data are then rapidly processed by applying the latest available calibration factors (*data scaling*) and carefully screened using specifically developed computer algorithms to identify suspect data or equipment faults (*data validation*). These validated data are then appended to the site database and uploaded to the Scottish Database and Website. These operations are carried out automatically by computer systems, with all outputs manually checked by data management experts.

The validated data are then updated to the Scottish Air Quality Database – and accessible via the air quality in Scotland website (https://www.scottishairquality.scot/latest) - as provisional data. These data are therefore available to all users on a day-to-day basis. This gives the local authority the opportunity to easily view both their own data and data from other stations throughout Scotland on a near real time basis. This will assist in dealing with day-to-day requests for information on specific data or the overall pollution situation either locally or throughout Scotland. In addition the automatic data summary bulletin, available by email from the website, plotting package incorporated into this, the AQ Scotland App, and data analysis facilities, are useful to authorities to rapidly evaluate their data against that from other stations and identify data errors.

## 5.3 DATA RATIFICATION

The validated data, which have been screened and scaled, are fit for day-to-day use and provide a good indication of pollution levels. However, the final stage of data management is a comprehensive and detailed critical review of the data and is generally termed ‘ratification’. Note that ratification necessarily includes the results from the site audits and inter-calibrations – ratified data must be shown to be traceable to national gas standards.

The aim of data ratification is to make use of all of the available information to identify and remove any faulty data, ensuring that remaining measurement data meet the accuracy and precision specifications of the Scottish Government for local authority review and assessment (LAQM.TG(22)).

The policy on data rejection opted by Ricardo is that all data are assumed to be correct unless there is good evidence to suggest otherwise. This prevents the ratification process from erroneously removing any important air pollution episode data. The ratification process is comprehensive and is outlined step-by-step in Appendix 2.

Data ratification of the Scottish local authority station data is undertaken on a three-monthly basis, based on calendar year timetables (January through to December). The process of ratification can take up to six weeks - we therefore aim to have the finalised datasets from all network sites ready by 31st March of the following year. This fits in with the timetable for local authority reporting under the LAQM review and assessment process.

The ratified data are uploaded to the Scottish Database and overwrite the provisional data. Summary statistics (i.e. https://www.scottishairquality.scot/latest/site-info/DUN7) and annual statistic reports (https://www.scottishairquality.scot/laqm/statistics) of these ratified data are available from the website to assist local authorities complete their LAQM review and assessment reports. The data selector function on the website (https://www.scottishairquality.scot/data/data-selector) also provides all the relevant datasets and statistics required.

## 5.4 QA/QC DURING 2023

As discussed above, site inter-calibrations and audit visits are undertaken at 6-monthly intervals. However, where a site joins the database part way through a year then it is possible that only one audit will be conducted during the year. Appendix 2 shows the full list of inter-calibrations and audits undertaken on air quality sites in the Scottish Database during 2023.

The majority of analysers and sites were found to be operating satisfactorily during the audits. However, inevitably some problems were identified at some sites; these are summarised in Table 5.1.

Table 5-1 Monitoring site faults identified during the 2023 audits

| Site Faults Identified 2023 | Number of Monitoring Sites Winter 2022/23 | Number of Monitoring Sites Summer 2023 |
|---|---|---|
| Particulate Analyser* flow out by >10% | 14 | 11 |
| $NO_x$ analyser converter <97% efficiency | 5 | 4 |
| NO cylinder out by >10% | 6 | 10 |
| $SO_2$ cylinder out by >10% | 0 | 0 |
| CO cylinder out by >10% | 0 | 0 |
| O3 Analyser out by >5% | 1 | 0 |

* These include TEOM, FDMS, FIDAS and Beta Attenuation Monitors (BAM)

These are all typical faults that are found during audit and intercalibration exercises and as can be seen from the 2023 figures.

In many cases, the results from the audit and intercalibration visits provide the information necessary to correct for these issues at the data ratification stage so that the data can be corrected and retained, rather than being deleted as erroneous data. Appendix 2 summarises the site inter-calibrations and audits undertaken during 2023, where the period Winter 2022/23 corresponds to Dec-2022 to Mar-2023 and Summer 2023 corresponds to Jun-2023 to Aug-2023.

## Data Ratification

Data ratification is carried out in three-monthly intervals in line with the AURN schedule. Hence, as with the inter-calibrations and site audits, if the site joins the database part way through a year, then data can only be ratified from the date of the site joining the database.

All ratified data for 2023 has been uploaded to the Scottish Air Quality website. A summary of all the data ratification undertaken during 2023 is provided in Appendix 2.

# 6. AIR POLLUTION IN SCOTLAND IN 2023

In this section we present a statistical summary of the available air quality data for Scotland as follows:

- Section 6.1 - Automatic monitoring of the pollutants $NO_2$, $PM_{10}$, $PM_{2.5}$ CO, $SO_2$ and $O_3$ summary data for 2022.

- Section 6.2 - Other pollutants covered by the Air Quality Strategy – PAH (benzo[a]pyrene), Benzene, 1,3-butadiene and lead and summary statistics for 2023.

- Section 6.3 - Other pollutants and/or other methods of monitoring:
    1. $NO_2$ Diffusion Tube Samplers
    2. Non-methane Volatile Organic Compounds (NMVOC)
    3. Poly-aromatic Hydrocarbons (PAH)
    4. Toxic Organic Micropollutants (TOMPS)
    5. Metals (Urban network)
    6. Metals (Rural and deposition network)
    7. United Kingdom Eutrophying & Acidifying Pollutants Network:
        i. The Precipitation Network
        ii. $NO_2$ Rural Diffusion Tube Network
        iii. Acid Gases and Aerosol Network (AGANET)
        iv. National Ammonia Monitoring Network

## 6.1 AUTOMATIC MONITORING OF POLLUTANTS $NO_2$, $PM_{10}$, $PM_{2.5}$, CO, $SO_2$ AND $O_3$

Table 6-1 to Table 6-7 show the 2023 annual average data statistics for $NO_2$, $PM_{10}$, $PM_{2.5}$, CO, $SO_2$ and $O_3$ for the ratified automatic data from monitoring sites included in the SAQD. These are shown along with the corresponding data capture for the year.

These data will have been used by local authorities to assess air quality within their area as part of the review and assessment process. Where any of the air quality objectives for Scotland have been exceeded, at locations where there is relevant exposure of the general public, then the authority will need to carry out a more detailed assessment as an addendum to their Annual Progress Report to confirm the exceedance and estimate its extent. Where the exceedance is confirmed then the authority will declare an Air Quality Management Area (AQMA). At the time of writing, 12 local authorities in Scotland have declared a total of 24 AQMAs (see https://www.scottishairquality.scot/laqm/aqma). Based on the data in the database, a summary of the air quality situation throughout Scotland, is provided in the following sections for each separate pollutant.

### 6.1.1 Nitrogen Dioxide

Table 6-1 shows nitrogen dioxide data for 89 sites utilising automatic monitoring during 2023. Although, data for 17 of these are only available for part of the year with the overall data capture less than 75%. These include sites which opened or closed during the year and sites which were closed for part of the year due to instrument problems.

Of the remaining 72 sites with 75% data capture or more, no sites exceeded the annual mean objective for $NO_2$ (40 µg $m^{-3}$). The objective of not more than 18 exceedances of 200 µg $m^{-3}$ for the hourly mean was also not exceeded at any site.

The highest annual average concentrations were measured at Glasgow Kerbside (Hope Street), with a measured concentration of 39.0 µg $m^{-3}$. There were no exceedances of the hourly mean objective at any site.

Table 6-1 Ratified data annual average concentration and data capture for $NO_2$ in 2023 for monitoring sites in the SAQD

| Site Name | Type | Annual Average $NO_2$ 2023 (mg $m^{-3}$) | No. hours >200 mg $m^{-3}$ | Data capture $NO_2$ 2023 (%) |
|---|---|---|---|---|
| Aberdeen Anderson Dr | RS | 11.3 | 0 | 79.2 |
| Aberdeen Erroll Park | UB | 14.7 | 0 | 99.2 |
| Aberdeen King Street | RS | 14.7 | 0 | 99.9 |
| Aberdeen Market Street 2 | RS | 24.1 | 0 | 99.9 |
| Aberdeen Union Street Roadside | RS | 24.5 | 0 | 99.8 |
| Aberdeen Wellington Road | RS | 27.0 | 0 | 68.9 |
| Alloa A907 | RS | 14.4 | 0 | 98.3 |
| Bush Estate | RB | 3.8 | 0 | 99.6 |
| Dumfries | RS | 22.1 | 0 | 98.3 |
| Dundee Broughty Ferry Road | RS | 11.8 | 0 | 99.0 |
| Dundee Lochee Road | RS | 28.5 | 0 | 99.8 |
| Dundee Mains Loan | UB | 7.3 | 0 | 99.0 |
| Dundee Meadowside | RS | 24.7 | 0 | 72.9 |
| Dundee Seagate | RS | 28.7 | 0 | 95.3 |
| Dundee Whitehall Street | RS | 21.3 | 0 | 99.0 |
| E Ayrshire Kilmarnock St Marnock St | RS | 18.2 | 0 | 90.7 |
| East Dunbartonshire Bearsden | RS | 19.7 | 0 | 77.8 |
| East Dunbartonshire Bishopbriggs | RS | 16.2 | 0 | 99.6 |
| East Dunbartonshire Kirkintilloch | RS | 17.6 | 0 | 99.7 |
| East Dunbartonshire Milngavie | RS | 17.4 | 0 | 39.9 |
| East Lothian Musselburgh N High St | RS | 17.2 | 0 | 46.6 |
| Edinburgh Currie | UB | 5.3 | 0 | 99.6 |
| Edinburgh Gorgie Road | RS | 17.7 | 0 | 98.0 |
| Edinburgh Nicolson Street | RS | 25.1 | 0 | 96.0 |
| Edinburgh Queensferry Road | RS | 26.0 | 0 | 99.7 |
| Edinburgh Salamander St | RS | 16.5 | 0 | 87.6 |
| Edinburgh St John's Road | RS | 29.8 | 0 | 99.7 |
| Edinburgh St Leonards | UB | 11.4 | 0 | 97.9 |
| Eskdalemuir | RB | 1.2 | 0 | 38.6 |
| Falkirk Grangemouth MC | UB | 13.5 | 0 | 99.1 |
| Falkirk Haggs | RS | 17.5 | 0 | 95.6 |
| Falkirk Hope St | RS | 17.1 | 0 | 94.5 |
| Falkirk Main St Bainsford | RS | 18.0 | 0 | 96.7 |
| Falkirk West Bridge Street | RS | 28.5 | 0 | 98.6 |
| Fife Cupar | RS | 19.4 | 0 | 97.8 |
| Fife Dunfermline | RS | 15.1 | 0 | 97.9 |

| Site Name | Type | Annual Average $NO_2$ 2023 (mg m$^{-3}$) | No. hours >200 mg m$^{-3}$ | Data capture $NO_2$ 2023 (%) |
|---|---|---|---|---|
| Fife Kirkcaldy | RS | 13.0 | 0 | 96.8 |
| Fife Rosyth | RS | 17.1 | 0 | 99.7 |
| Fort William | S | 6.6 | 0 | 93.0 |
| Glasgow Anderston | UB | 20.5 | 0 | 99.6 |
| Glasgow Burgher St. | RS | 15.8 | 0 | 68.7 |
| Glasgow Byres Road | RS | 21.4 | 0 | 93.9 |
| Glasgow Dumbarton Road | RS | 20.2 | 0 | 99.6 |
| Glasgow Great Western Road | RS | 18.2 | 0 | 98.8 |
| Glasgow High Street | RS | 18.4 | 0 | 99.5 |
| Glasgow Kerbside | RS | 39.0 | 0 | 79.8 |
| Glasgow Nithsdale Road | UB | 21.2 | 0 | 99.5 |
| Glasgow Townhead | RB | 15.6 | 0 | 99.5 |
| Glasgow Waulkmillglen Reservoir | UI | 6.6 | 0 | 68.2 |
| Grangemouth | UB | 13.3 | 0 | 87.9 |
| Grangemouth Moray | RS | 10.9 | 0 | 77.8 |
| Inverclyde Greenock A8 | RS | 19.4 | 0 | 99.7 |
| Inverness | RS | 12.3 | 0 | 98.7 |
| Inverness Academy Street | RS | 20.1 | 0 | 99.4 |
| Inverness Academy Street 1st Floor | RB | 21.2 | 0 | 63.1 |
| Lerwick | RS | 2.6 | 0 | 99.3 |
| N Lanarkshire Airdrie Kenilworth Dr | RS | 12.4 | 0 | 90.7 |
| N Lanarkshire Chapelhall | UB | 19.7 | 0 | 67.4 |
| N Lanarkshire Coatbridge Whifflet A725 | RS | 17.1 | 0 | 99.3 |
| N Lanarkshire Croy | RS | 9.4 | 0 | 64.3 |
| N Lanarkshire Kirkshaws | RS | 16.6 | 0 | 74.2 |
| N Lanarkshire Motherwell | RS | 12.3 | 0 | 74.4 |
| N Lanarkshire Motherwell Adele St. | RS | 12.7 | 0 | 99.9 |
| N Lanarkshire Ravenscraig Plantation Road | RS | 9.2 | 0 | 76.3 |
| N Lanarkshire Shawhead Coatbridge | RS | 15.5 | 0 | 73.9 |
| N Lanarkshire Uddingston New Edinburgh Rd | RS | 16.6 | 0 | 77.7 |
| North Ayrshire Irvine High St | RS | 10.2 | 0 | 99.2 |
| Peebles | S | 3.8 | 0 | 99.2 |
| Perth Atholl Street | RS | 32.9 | 0 | 99.4 |
| Perth Bridgend | RS | 17.8 | 0 | 99.4 |
| Perth Crieff | RS | 11.3 | 0 | 95.5 |
| Renfrew Cockels Loan | RS | 21.9 | 0 | 44.4 |
| Renfrew Inchinnan Road | RS | 23.6 | 0 | 89.7 |
| South Ayrshire Ayr Harbour | RS | 6.8 | 0 | 94.3 |

| Site Name | Type | Annual Average $NO_2$ 2023 (mg m$^{-3}$) | No. hours >200 mg m$^{-3}$ | Data capture $NO_2$ 2023 (%) |
|---|---|---|---|---|
| South Ayrshire Ayr High St | RS | 9.6 | 0 | 89.2 |
| South Lanarkshire Blantyre | RS | 18.2 | 0 | 99.8 |
| South Lanarkshire Cambuslang | RS | 18.5 | 0 | 89.1 |
| South Lanarkshire East Kilbride | RS | 20.7 | 0 | 98.7 |
| South Lanarkshire Hamilton | RS | 18.7 | 0 | 47.7 |
| South Lanarkshire Lanark | RS | 12.7 | 0 | 93.2 |
| South Lanarkshire Raith Interchange 2 | RS | 13.6 | 0 | 97.5 |
| South Lanarkshire Rutherglen | RS | 21.9 | 0 | 78.9 |
| South Lanarkshire Uddingston | RS | 15.8 | 0 | 99.8 |
| Stirling Craig's Roundabout | RS | 16.4 | 0 | 65.5 |
| West Dunbartonshire Clydebank | RS | 14.8 | 0 | 99.6 |
| West Dunbartonshire Glasgow Road | RS | 13.0 | 0 | 85.8 |
| West Lothian Broxburn | RS | 22.7 | 0 | 95.2 |
| West Lothian Linlithgow High Street 2 | RS | 20.5 | 0 | 95.0 |
| West Lothian Newton | RS | 13.0 | 0 | 94.4 |

Shaded sites indicate data only available for part year and/or <75% data capture.
Highlighted figures (in yellow) indicate exceedances of Scottish Air Quality Objectives.

#### *6.1.1.1 $NO_2$ Diffusion Tube data 2023*

The $NO_2$ diffusion tube database and map provide bias corrected annual mean data. and bring together local authority diffusion tube monitoring for each year. This enables the user to easily identify where monitoring has been carried out, what the concentrations are for the current year and compare it against historical data and identify which sites have exceeded the annual mean objective of 40 µg m$^{-3}$.

Using the data available at the time of writing this report, in 2023, four diffusion tube sites exceeded the annual mean objective for $NO_2$ - these are listed in Table 6-2. For more information on the 2023 data and historical diffusion tube data, go the Diffusion Tube site map on the Air Quality in Scotland website (http://www.scottishairquality.scot/latest/diffusion-sites). The diffusion tube data can also now be downloaded via the data selector tool (http://www.scottishairquality.scot/data/data-selector).

It should be noted that it is the responsibility of the local authority to provide the Scottish Government with the data to be included in the map. Therefore, it could be the case that there was additional diffusion tube monitoring during 2023 or any other year that is not represented in the database. To identify if this is the case, please refer to the local authority's Annual Progress Report for the year in question.

Figure 6-1 Number of $NO_2$ diffusion tube sites exceeding the Annual Mean Objective 2013 - 2023

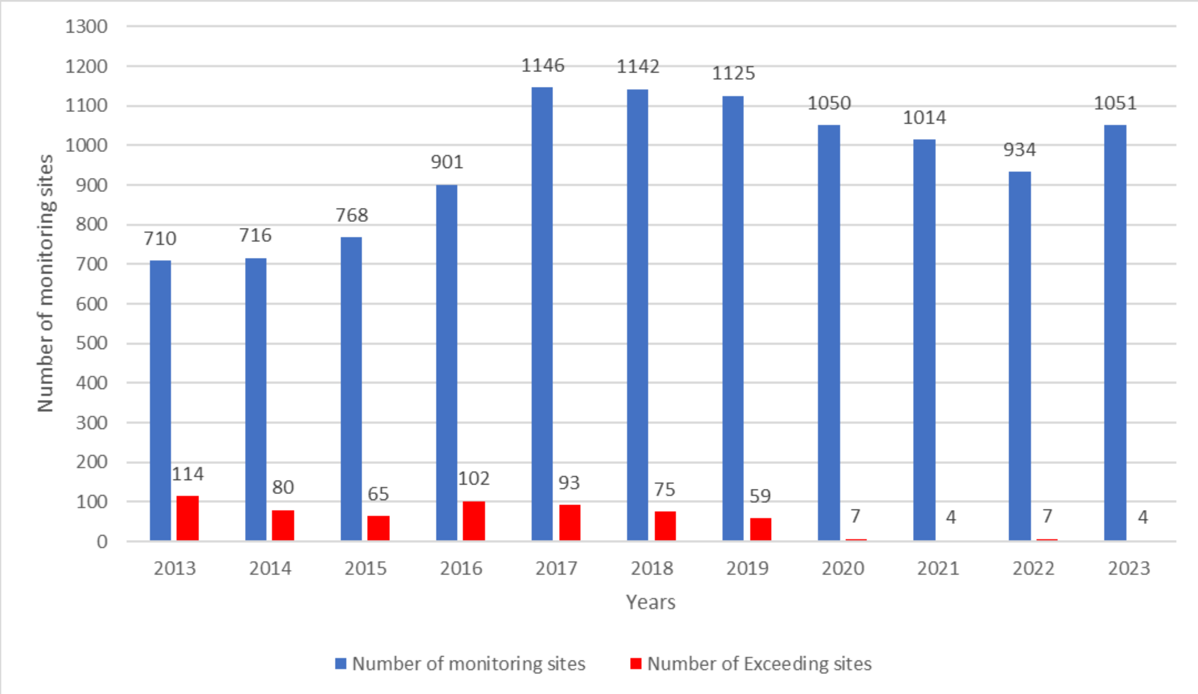



Table 6-2 $NO_2$ diffusion tube sites exceeding the Annual Mean Objective in 2023

| Site Name | Annual Mean Concentration (µg m-3) | Local Authority Name |
|---|---|---|
| Queensferry Road 550 | 42.2 | City of Edinburgh |
| Hope Street 3 | 41.2 | Glasgow City |
| Heilanmans Umbrella | 40.9 | Glasgow City |
| Gordon Street | 42.1 | Glasgow City |

(Data sourced from http://www.scottishairquality.scot/latest)

### 6.1.2 Particulate Matter – $PM_{10}$

Table 6-3 shows the 2023 $PM_{10}$ data and gravimetric equivalent from 85 sites utilising automatic monitoring. Of these sites, nine have less than 75% data capture. Also provided in Table 6-3 is the SAQD specific corrected Fidas data which is used for LAQM reporting in Scotland. This data has a correction factor (divided by 0.909) applied as recommended in a guidance note issued by Scottish Government[1].

Of the 76 sites with 75% or greater data capture, one sites exceeded the annual average $PM_{10}$ objective of 18 µg $m^{-3}$: Perth Atholl Street with an annual mean concentration 23.4 µg $m^{-3}$. The daily mean objective of 50 µg $m^{-3}$ not to be exceeded more than seven times in a year was also exceeded at this site with 15 exceedances measured during 2023. Investigations carried out during the data ratification process found that the exceedance were due to building works being carried out near to the site.

[1] https://www.scottishairquality.scot/technical-reports/local-authority-guidance-note-laqm-reporting-scottish-pm-data

Table 6-3 Ratified data annual average concentration and data capture for $PM_{10}$ in 2023 for monitoring sites in the Scottish Air Quality Database

| Site Name | Type | $PM_{10}$ Analyser Type* | Annual Average $PM_{10}$ 2023 (mg $m^{-3}$) | Corrected Fidas $PM_{10}$ annual mean 2023 (μg $m^{-3}$) | No. Days > 50 mg $m^{-3}$ | Data Capture (%) |
|---|---|---|---|---|---|---|
| Aberdeen Anderson Dr | RS | Fidas | 9.4 | 10.4 | 0 | 98.4 |
| Aberdeen Erroll Park | UB | Fidas | 10.2 | 11.2 | 1 | 95.7 |
| Aberdeen King Street | RS | Fidas | 12.1 | 13.3 | 1 | 99.9 |
| Aberdeen Market Street 2 | RS | Fidas | 11.9 | 13.1 | 1 | 99.8 |
| Aberdeen Union Street Roadside | RS | Fidas | 12.9 | 14.1 | 1 | 99.8 |
| Aberdeen Wellington Road | RS | Fidas | 12.0 | 13.1 | 0 | 99.7 |
| Alloa A907 | RS | Fidas | 9.4 | 10.4 | 0 | 98.3 |
| Angus Forfar Glamis Rd | RS | Fidas | 9.1 | 10.0 | 0 | 97.9 |
| Auchencorth Moss | RB | Fidas | 5.7 | 6.3 | 0 | 99.9 |
| Dundee Broughty Ferry Road | RS | Fidas | 10.2 | 11.2 | 0 | 99.0 |
| Dundee Lochee Road | RS | Fidas | 10.8 | 11.9 | 1 | 99.8 |
| Dundee Mains Loan | UB | Fidas | 7.6 | 8.4 | 0 | 98.4 |
| Dundee Meadowside | RS | Fidas | 10.7 | 11.8 | 0 | 97.3 |
| Dundee Seagate | RS | Fidas | 13.2 | 14.5 | 0 | 99.1 |
| Dundee Whitehall Street | RS | Fidas | 9.8 | 10.8 | 0 | 98.9 |
| E Ayrshire Kilmarnock St Marnock St | RS | Fidas | 9.5 | 10.5 | 0 | 99.6 |
| East Dunbartonshire Bearsden | RS | Fidas | 9.9 | 10.9 | 0 | 95.1 |
| East Dunbartonshire Bishopbriggs | RS | Fidas | 10.1 | 11.1 | 0 | 74.5 |
| East Dunbartonshire Kirkintilloch | RS | Fidas | 9.4 | 10.3 | 0 | 97.6 |
| East Dunbartonshire Milngavie | RS | Fidas | 8.3 | 9.1 | 0 | 97.1 |
| East Lothian Musselburgh N High St | RS | BAM | 10.3 | n/a | 0 | 91.7 |
| Edinburgh Currie | UB | Fidas | 7.7 | 8.5 | 0 | 99.8 |
| Edinburgh Glasgow Road | RS | Fidas | 11.3 | 12.5 | 0 | 87.0 |
| Edinburgh Nicolson Street | RS | Fidas | 10.9 | 12.0 | 0 | 99.8 |
| Edinburgh Queensferry Road | RS | Fidas | 11.5 | 12.6 | 0 | 82.3 |
| Edinburgh Salamander St | UB | Fidas | 12.7 | 14.0 | 0 | 98.2 |
| Edinburgh St John's Road | UB | Fidas | 11.1 | 12.2 | 0 | 98.9 |
| Edinburgh St Leonards | RS | Fidas | 8.6 | 9.4 | 0 | 99.9 |
| Edinburgh Tower Street | RS | Fidas | 9.2 | 10.1 | 2 | 99.9 |
| Falkirk Grangemouth MC | UB | Fidas | 9.1 | 10.1 | 0 | 99.8 |
| Falkirk Grangemouth Zetland Park | UI | Fidas | 8.3 | 9.2 | 0 | 98.7 |
| Falkirk Haggs | RS | Fidas | 10.1 | 11.1 | 0 | 87.6 |
| Falkirk Hope St | RS | Fidas | 8.6 | 9.4 | 0 | 99.4 |

| Site Name | Type | $PM_{10}$ Analyser Type* | Annual Average $PM_{10}$ 2023 (mg m$^{-3}$) | Corrected Fidas $PM_{10}$ annual mean 2023 (µg m$^{-3}$) | No. Days > 50 mg m$^{-3}$ | Data Capture (%) |
|---|---|---|---|---|---|---|
| Falkirk Main St Bainsford | RS | Fidas | 10.1 | 11.2 | 0 | 99.0 |
| Falkirk West Bridge Street | RS | Fidas | 10.1 | 11.1 | 0 | 92.5 |
| Fife Cupar | RS | Fidas | 11.7 | 12.9 | 0 | 96.7 |
| Fife Dunfermline | RS | Fidas | 10.6 | 11.6 | 2 | 99.7 |
| Fife Kirkcaldy | RS | Fidas | 9.3 | 10.2 | 0 | 99.7 |
| Fife Rosyth | RS | Fidas | 9.0 | 9.9 | 0 | 99.2 |
| Glasgow Anderston | UB | Fidas | 10.4 | 11.5 | 0 | 99.6 |
| Glasgow Broomhill | RS | Fidas | 10.2 | 11.2 | 0 | 99.9 |
| Glasgow Burgher St | RS | Fidas | 8.0 | 8.8 | 0 | 38.0 |
| Glasgow Byres Road | RS | Fidas | 9.7 | 10.7 | 0 | 63.5 |
| Glasgow Dumbarton Road | RS | Fidas | 11.5 | 12.6 | 0 | 96.7 |
| Glasgow High Street | RS | Fidas | 9.6 | 10.5 | 0 | 99.9 |
| Glasgow Kerbside | RS | Fidas | 12.0 | 13.2 | 0 | 90.7 |
| Glasgow Nithsdale Road | RS | Fidas | 11.0 | 12.1 | 0 | 99.7 |
| Glasgow Townhead | UB | Fidas | 9.0 | 9.9 | 0 | 99.5 |
| Glasgow Waulkmillglen Reservoir | RB | Fidas | 8.2 | 9.1 | 0 | 64.7 |
| Grangemouth | UI | BAM (heated) | 8.7 | n/a | 0 | 96.6 |
| Inverclyde Greenock A8 | RS | Fidas | 9.9 | 10.9 | 0 | 99.7 |
| Inverness | RS | Fidas | 8.6 | 9.4 | 0 | 97.5 |
| N Lanarkshire Airdrie Kenilworth Dr | RS | BAM | 10.0 | n/a | 0 | 22.2 |
| N Lanarkshire Chapelhall | RS | Fidas | 9.7 | 10.7 | 1 | 99.7 |
| N Lanarkshire Coatbridge Whifflet A725 | RS | Fidas | 9.1 | 10.0 | 0 | 99.3 |
| N Lanarkshire Croy | RS | Fidas | 8.8 | 9.7 | 0 | 97.3 |
| N Lanarkshire Kirkshaws | RS | Fidas | 8.7 | 9.6 | 0 | 98.8 |
| N Lanarkshire Motherwell | RS | Fidas | 9.3 | 10.3 | 0 | 99.8 |
| N Lanarkshire Motherwell Adele St. | RS | Fidas | 7.9 | 8.7 | 0 | 99.8 |
| N Lanarkshire Ravenscraig Plantation Road | RS | Fidas | 10.1 | 11.1 | 0 | 88.6 |
| N Lanarkshire Shawhead Coatbridge | RS | Fidas | 8.6 | 9.4 | 0 | 98.6 |
| N Lanarkshire Uddingston New Edinburgh Rd | RS | Fidas | 10.4 | 11.4 | 0 | 95.6 |
| North Ayrshire Irvine High St | RS | Fidas | 11.6 | 12.8 | 0 | 99.7 |
| Perth Atholl Street | RS | Fidas | 21.3 | 23.4 | 15 | 99.6 |
| Perth Bridgend | RS | Fidas | 9.7 | 10.6 | 0 | 99.9 |
| Perth Crieff | RS | Fidas | 9.8 | 10.8 | 0 | 91.6 |
| Perth Glasgow Road | RS | Fidas | 8.6 | 9.5 | 0 | 18.8 |
| Perth Muirton | RS | Fidas | 9.1 | 10.0 | 0 | 52.9 |

| Site Name | Type | $PM_{10}$ Analyser Type* | Annual Average $PM_{10}$ 2023 (mg m$^{-3}$) | Corrected Fidas $PM_{10}$ annual mean 2023 (µg m$^{-3}$) | No. Days > 50 mg m$^{-3}$ | Data Capture (%) |
|---|---|---|---|---|---|---|
| Renfrewshire Johnstone | RS | Fidas | 13.4 | 14.7 | 3 | 98.9 |
| South Ayrshire Ayr Harbour | RS | Fidas | 11.3 | 12.5 | 0 | 95.8 |
| South Ayrshire Ayr High St | RS | Fidas | 13.0 | 14.3 | 3 | 95.2 |
| South Lanarkshire Blantyre | RS | Fidas | 9.6 | 10.5 | 0 | 99.8 |
| South Lanarkshire Cambuslang | RS | Fidas | 10.7 | 11.8 | 0 | 99.5 |
| South Lanarkshire East Kilbride | RS | Fidas | 9.0 | 9.8 | 0 | 76.7 |
| South Lanarkshire Hamilton | RS | Fidas | 7.7 | 8.5 | 0 | 53.8 |
| South Lanarkshire Lanark | RS | Fidas | 8.8 | 9.6 | 0 | 98.9 |
| South Lanarkshire Raith Interchange 2 | RS | Fidas | 8.6 | 9.5 | 0 | 99.3 |
| South Lanarkshire Rutherglen | RS | Fidas | 11.0 | 12.1 | 0 | 99.6 |
| South Lanarkshire Uddingston | RS | Fidas | 10.3 | 11.3 | 0 | 88.1 |
| Stirling Craig's Roundabout | RS | Fidas | 9.5 | 10.5 | 0 | 98.7 |
| Strath Vaich | RB | Fidas | 4.5 | 5.0 | 0 | 35.5 |
| West Dunbartonshire Clydebank | RS | Fidas | 9.1 | 10.0 | 0 | 99.6 |
| West Lothian Broxburn | RS | Fidas | 10.2 | 11.2 | 0 | 99.4 |
| West Lothian Linlithgow High Street 2 | RS | Fidas | 9.1 | 10.0 | 0 | 99.2 |
| West Lothian Newton | RS | Fidas | 9.6 | 10.6 | 0 | 88.6 |

Shaded sites indicate data only available for part year and/or <75% data capture.
Highlighted figures (in yellow) indicate exceedance of a Scottish Air Quality Objectives.

### 6.1.3 Particulate Matter – $PM_{2.5}$

Table 6-4 shows the 2023 $PM_{2.5}$ data and gravimetric equivalent from 84 sites utilising automatic monitoring. Data capture rates of less than 75% were measured at eight sites. Also provided in Table 6-4 is the SAQD specific corrected Fidas data which is used for LAQM reporting in Scotland. This data has a correction factor (multiplied by 1.06) applied as recommended in a guidance note issued by Scottish Government[2].

Of the 76 sites with more than 75% data capture none exceeded the annual mean objective of 10 µg m$^{-3}$. The highest concentration (7.3 µg m$^{-3}$) measured during 2023 was at Perth Atholl Street. Figure 6-2 illustrated the 2023 annual mean $PM_{2.5}$ and $PM_{10}$ concentrations for all SAQD monitoring sites compared against their respective annual mean objectives.

[2] https://www.scottishairquality.scot/technical-reports/local-authority-guidance-note-laqm-reporting-scottish-pm-data

Table 6-4 Ratified data annual average concentration and data capture for $PM_{2.5}$ in 2023 for monitoring sites in the Scottish Air Quality Database

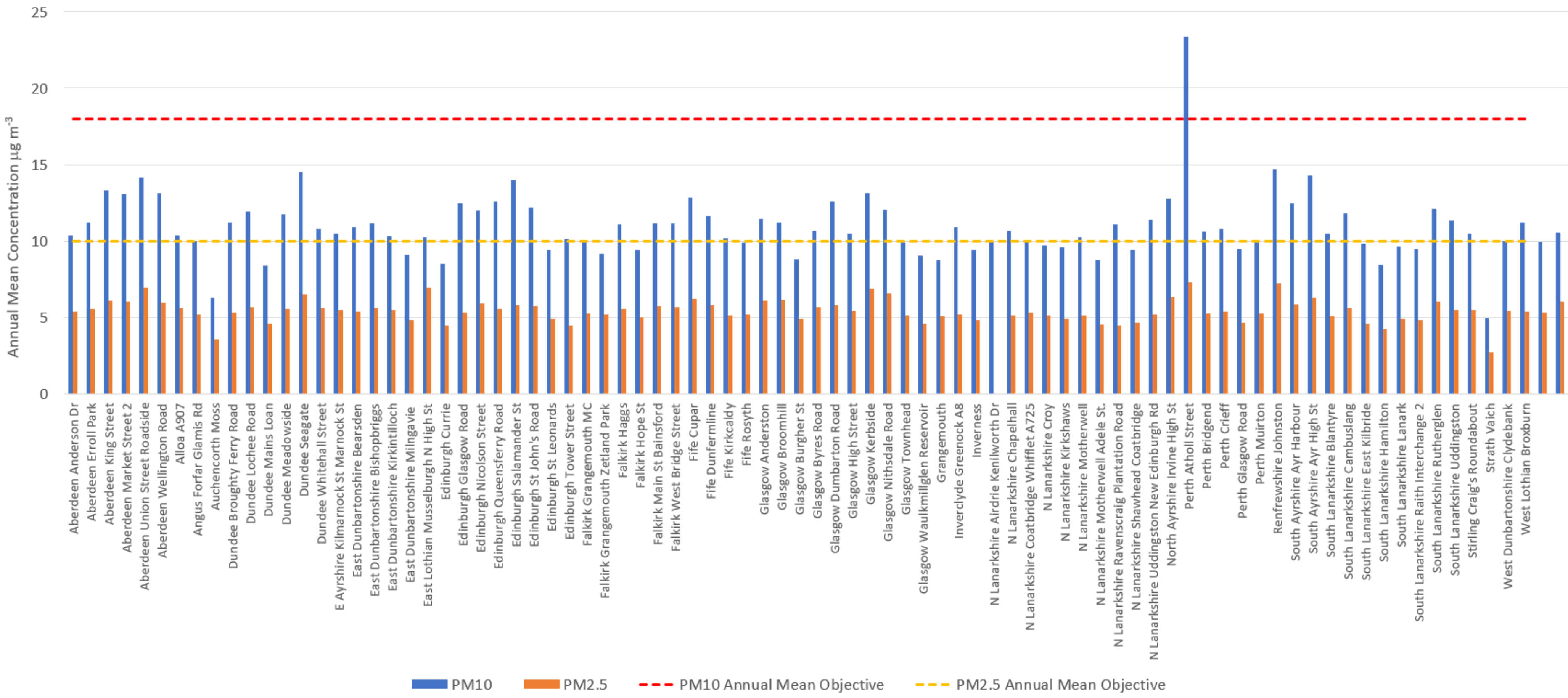
| Site Name | Type | $PM_{2.5}$ Analyser Type* | Annual Average $PM_{2.5}$ 2023 (mg $m^{-3}$) | Corrected Fidas $PM_{2.5}$ annual mean 2023 (µg $m^{-3}$) | Data Capture (%) |
|---|---|---|---|---|---|
| Aberdeen Anderson Dr | RS | Fidas | 5.1 | 5.4 | 98.4 |
| Aberdeen Erroll Park | UB | Fidas | 5.2 | 5.5 | 95.7 |
| Aberdeen King Street | RS | Fidas | 5.8 | 6.1 | 99.9 |
| Aberdeen Market Street 2 | RS | Fidas | 5.7 | 6.0 | 99.8 |
| Aberdeen Union Street Roadside | RS | Fidas | 6.6 | 6.9 | 99.8 |
| Aberdeen Wellington Road | RS | Fidas | 5.6 | 6.0 | 99.7 |
| Alloa A907 | RS | Fidas | 5.3 | 5.6 | 98.3 |
| Angus Forfar Glamis Rd | RS | Fidas | 4.9 | 5.2 | 97.9 |
| Auchencorth Moss | RB | Fidas | 3.4 | 3.6 | 99.9 |
| Dundee Broughty Ferry Road | RS | Fidas | 5.0 | 5.3 | 99.0 |
| Dundee Lochee Road | RS | Fidas | 5.4 | 5.7 | 99.8 |
| Dundee Mains Loan | UB | Fidas | 4.3 | 4.6 | 98.4 |
| Dundee Meadowside | RS | Fidas | 5.3 | 5.6 | 97.3 |
| Dundee Seagate | RS | Fidas | 6.2 | 6.6 | 99.1 |
| Dundee Whitehall Street | RS | Fidas | 5.3 | 5.6 | 98.9 |
| E Ayrshire Kilmarnock St Marnock St | RS | Fidas | 5.2 | 5.5 | 99.6 |
| East Dunbartonshire Bearsden | RS | Fidas | 5.1 | 5.4 | 95.1 |
| East Dunbartonshire Bishopbriggs | RS | Fidas | 5.3 | 5.6 | 74.5 |
| East Dunbartonshire Kirkintilloch | RS | Fidas | 5.2 | 5.5 | 97.6 |
| East Dunbartonshire Milngavie | RS | Fidas | 4.6 | 4.9 | 97.1 |
| East Lothian Musselburgh N High St | RS | BAM | 6.9 | 6.9 | 80.5 |
| Edinburgh Currie | UB | Fidas | 4.2 | 4.5 | 99.8 |
| Edinburgh Glasgow Road | RS | Fidas | 5.0 | 5.3 | 87.0 |
| Edinburgh Nicolson Street | RS | Fidas | 5.6 | 5.9 | 99.8 |
| Edinburgh Queensferry Road | RS | Fidas | 5.3 | 5.6 | 82.3 |
| Edinburgh Salamander St | UB | Fidas | 5.5 | 5.8 | 98.2 |
| Edinburgh St John's Road | UB | Fidas | 5.4 | 5.8 | 98.9 |
| Edinburgh St Leonards | RS | Fidas | 4.6 | 4.9 | 99.9 |
| Edinburgh Tower Street | RS | Fidas | 4.3 | 4.5 | 99.9 |
| Falkirk Grangemouth MC | UB | Fidas | 5.0 | 5.3 | 99.8 |
| Falkirk Grangemouth Zetland Park | UI | Fidas | 4.9 | 5.2 | 98.7 |
| Falkirk Haggs | RS | Fidas | 5.2 | 5.6 | 87.6 |
| Falkirk Hope St | RS | Fidas | 4.8 | 5.0 | 99.4 |
| Falkirk Main St Bainsford | RS | Fidas | 5.4 | 5.7 | 99.0 |
| Falkirk West Bridge Street | RS | Fidas | 5.3 | 5.7 | 92.5 |
| Fife Cupar | RS | Fidas | 5.9 | 6.2 | 96.7 |

| Site Name | Type | $PM_{2.5}$ Analyser Type* | Annual Average $PM_{2.5}$ 2023 (mg $m^{-3}$) | Corrected Fidas $PM_{2.5}$ annual mean 2023 (µg $m^{-3}$) | Data Capture (%) |
|---|---|---|---|---|---|
| Fife Dunfermline | RS | Fidas | 5.5 | 5.8 | 99.7 |
| Fife Kirkcaldy | RS | Fidas | 4.9 | 5.2 | 99.7 |
| Fife Rosyth | RS | Fidas | 4.9 | 5.2 | 99.2 |
| Glasgow Anderston | UB | Fidas | 5.7 | 6.1 | 99.6 |
| Glasgow Broomhill | RS | Fidas | 5.8 | 6.2 | 99.9 |
| Glasgow Burgher St | RS | Fidas | 4.6 | 4.9 | 38.0 |
| Glasgow Byres Road | RS | Fidas | 5.3 | 5.7 | 63.5 |
| Glasgow Dumbarton Road | RS | Fidas | 5.5 | 5.8 | 96.7 |
| Glasgow High Street | RS | Fidas | 5.1 | 5.4 | 99.9 |
| Glasgow Kerbside | RS | Fidas | 6.5 | 6.9 | 90.7 |
| Glasgow Nithsdale Road | RS | Fidas | 6.2 | 6.6 | 99.7 |
| Glasgow Townhead | UB | Fidas | 4.9 | 5.2 | 99.5 |
| Glasgow Waulkmillglen Reservoir | RB | Fidas | 4.4 | 4.6 | 64.7 |
| Grangemouth | UI | BAM (heated) | 5.1 | n/a | 97.8 |
| Inverclyde Greenock A8 | RS | Fidas | 4.9 | 5.2 | 99.7 |
| Inverness | RS | Fidas | 4.5 | 4.8 | 97.5 |
| N Lanarkshire Chapelhall | RS | Fidas | 4.9 | 5.2 | 99.7 |
| N Lanarkshire Coatbridge Whifflet A725 | RS | Fidas | 5.0 | 5.3 | 99.3 |
| N Lanarkshire Croy | RS | Fidas | 4.9 | 5.2 | 97.3 |
| N Lanarkshire Kirkshaws | RS | Fidas | 4.6 | 4.9 | 98.8 |
| N Lanarkshire Motherwell | RS | Fidas | 4.9 | 5.2 | 99.8 |
| N Lanarkshire Motherwell Adele St. | RS | Fidas | 4.3 | 4.5 | 99.8 |
| N Lanarkshire Ravenscraig Plantation Road | RS | Fidas | 4.2 | 4.5 | 88.6 |
| N Lanarkshire Shawhead Coatbridge | RS | Fidas | 4.4 | 4.7 | 98.6 |
| N Lanarkshire Uddingston New Edinburgh Rd | RS | Fidas | 4.9 | 5.2 | 95.6 |
| North Ayrshire Irvine High St | RS | Fidas | 6.0 | 6.4 | 99.7 |
| Perth Atholl Street | RS | Fidas | 6.9 | 7.3 | 99.6 |
| Perth Bridgend | RS | Fidas | 5.0 | 5.3 | 99.9 |
| Perth Crieff | RS | Fidas | 5.1 | 5.4 | 91.6 |
| Perth Glasgow Road | RS | Fidas | 4.4 | 4.7 | 18.8 |
| Perth Muirton | RS | Fidas | 5.0 | 5.3 | 52.9 |
| Renfrewshire Johnstone | RS | Fidas | 6.8 | 7.2 | 98.9 |
| South Ayrshire Ayr Harbour | RS | Fidas | 5.5 | 5.9 | 95.8 |
| South Ayrshire Ayr High St | RS | Fidas | 5.9 | 6.3 | 95.2 |
| South Lanarkshire Blantyre | RS | Fidas | 4.8 | 5.1 | 99.8 |
| South Lanarkshire Cambuslang | RS | Fidas | 5.3 | 5.6 | 99.5 |
| South Lanarkshire East Kilbride | RS | Fidas | 4.4 | 4.6 | 76.7 |
| South Lanarkshire Hamilton | RS | Fidas | 4.0 | 4.2 | 53.8 |

| Site Name | Type | $PM_{2.5}$ Analyser Type* | Annual Average $PM_{2.5}$ 2023 (mg m$^{-3}$) | Corrected Fidas $PM_{2.5}$ annual mean 2023 (µg m$^{-3}$) | Data Capture (%) |
|---|---|---|---|---|---|
| South Lanarkshire Lanark | RS | Fidas | 4.6 | 4.9 | 98.9 |
| South Lanarkshire Raith Interchange 2 | RS | Fidas | 4.6 | 4.9 | 99.3 |
| South Lanarkshire Rutherglen | RS | Fidas | 5.7 | 6.1 | 99.6 |
| South Lanarkshire Uddingston | RS | Fidas | 5.2 | 5.5 | 88.1 |
| Stirling Craig's Roundabout | RS | Fidas | 5.2 | 5.5 | 98.7 |
| Strath Vaich | RB | Fidas | 2.6 | 2.8 | 35.5 |
| West Dunbartonshire Clydebank | RS | Fidas | 5.1 | 5.4 | 99.6 |
| West Lothian Broxburn | RS | Fidas | 5.1 | 5.4 | 99.4 |
| West Lothian Linlithgow High Street 2 | RS | Fidas | 5.0 | 5.3 | 99.2 |
| West Lothian Newton | RS | Fidas | 5.7 | 6.0 | 88.6 |

Shaded sites indicate data only available for part year and/or <75% data capture.

Figure 6-2 Annual Average $PM_{10}$ and $PM_{2.5}$ concentrations ($\mu g\ m^{-3}$) for all SAQD sites in 2023



### 6.1.4 Carbon monoxide

Table 6-5 shows carbon monoxide was monitored using automatic techniques at one SAQD site during 2023. Edinburgh St Leonard's did not exceed the Running 8-hour mean of 10 mgm$^{-3}$ and had a data capture of 86.7%.

Table 6-5 Ratified data and data capture statistics for CO in 2023 for monitoring sites in the Scottish Air Quality Database

| Site Name | Type | Annual Average CO 2023 (mg m$^{-3}$) | Max. Running 8hr Mean CO 2023 (mg m$^{-3}$) | Data Capture (%) |
|---|---|---|---|---|
| Edinburgh St Leonards | UB | 0.12 | 0.74 | 86.7 |

### 6.1.5 Sulphur dioxide

Table 6-6 shows sulphur dioxide data from the eight sites utilising automatic monitoring for 2023 of which one (Lerwick) did not achieve a data capture rate of greater than 75%. Of the remaining seven sites, all met the requirements of the Air Quality Strategy as there were no exceedances for the 15-minute (266 µg m$^{-3}$ not to be exceeded more than 35 times per year), 1-hour (350 µg m$^{-3}$ not to be exceeded more than 24 times per year) and 24-hour mean (125 µg m$^{-3}$ not to be exceeded more than 3 times per year) $SO_2$ objectives in 2023.

Table 6-6 Ratified data and data capture Statistics for $SO_2$ in 2023 for monitoring sites in the Scottish Air Quality Database

| Site Name | Type | Annual Average $SO_2$ 2023 (µg m-3) | No. 15 min $SO_2$ > 266µg m$^{-3}$ 2023 | No. 1 hr $SO_2$ > 350µg m$^{-3}$ 2023 | No. 24 hr $SO_2$ > 125µg m$^{-3}$ 2023 | Data Capture (%) |
|---|---|---|---|---|---|---|
| Edinburgh St Leonards | UB | 0.5 | 0 | 0 | 0 | 97.3 |
| Falkirk Bo'ness | UI | 0.9 | 0 | 0 | 0 | 95.1 |
| Falkirk Hope St | RS | 1.4 | 0 | 0 | 0 | 97.6 |
| Falkirk Grangemouth Zetland Park | UI | 1.1 | 1 | 0 | 0 | 99.0 |
| Falkirk Grangemouth MC | UB | 1.7 | 6 | 0 | 0 | 99.1 |
| Grangemouth Moray | UB | 2.7 | 16 | 1 | 0 | 99.5 |
| Grangemouth | UI | 2.4 | 16 | 0 | 0 | 93.1 |
| Lerwick | RB | 1.7 | 0 | 0 | 0 | 46.4 |

Shaded sites indicate data only available for part year and/or <75% data capture.

### 6.1.6 Ozone

Table 6-7 shows ozone data from 11 sites utilising automatic monitoring for 2023, all achieving a data capture rate of greater than 75%. Ozone ($O_3$) is a secondary pollutant formed by reactions involving other pollutant gases in the presence of sunlight and over several hours; it may persist for several days and be transported over long distances. This means that individual local authorities have little control over ozone levels in their area. In 2023, the Air Quality Strategy objective of 100 µg m$^{-3}$ as the daily maximum 8-hour running mean not to be exceeded more than 10 time at a 8-hour running mean, was exceeded at six of the 11 sites.

Table 6-7 Ratified data and data capture statistics for $O_3$ in 2023 for monitoring sites in the Scottish Air Quality Database

| Site Name | Type | Annual Average $O_3$ 2023 ($\mu g\ m^{-3}$) | No of days with Maximum running 8-hr mean >100 ug $m^{-3}$ | Data capture $O_3$ 2023 (%) |
|---|---|---|---|---|
| Aberdeen Erroll Park | UB | 56.2 | 8 | 99.5 |
| Auchencorth Moss | RB | 58.6 | 12 | 99.4 |
| Bush Estate | RB | 60.4 | 11 | 99.7 |
| Edinburgh St Leonards | UB | 54.4 | 1 | 98.9 |
| Eskdalemuir | RB | 58.2 | 11 | 96.8 |
| Fort William | S | 56.4 | 16 | 99.8 |
| Glasgow Townhead | UB | 51.0 | 9 | 98.0 |
| Glasgow Waulkmillglen Reservoir | RB | 60.5 | 8 | 69.5 |
| Lerwick | RB | 70.1 | 7 | 85.6 |
| Peebles | S | 58.8 | 15 | 99.4 |
| Strath Vaich | RB | 68.5 | 18 | 88.5 |

## 6.2 OTHER POLLUTANTS COVERED BY THE AIR QUALITY STRATEGY – PAH (BENZO[A]PYRENE), BENZENE, 1,3-BUTADIENE AND LEAD

In this section, we present a summary of data from a range of national monitoring networks. Summaries are provided for pollutants covered by the Air Quality Strategy. As some of these networks are based on sampler measurement techniques and subsequent chemical analysis there is often a considerable delay in the availability of data. Where other pollutants are also monitored in these networks, these pollutants are listed, but the data are not provided in this report. Data, Statistics and site information on these networks sites can be accessed via the Air Quality In Scotland Website “other Networks” interactive map (https://www.scottishairquality.scot/latest) and also the data selector function (https://www.scottishairquality.scot/data/data-selector).

### 6.2.1 PAH Monitoring Network[3]

The UK Monitoring and Analysis Network monitor some 39 Polycyclic Aromatic Hydrocarbon (PAH) species at 33 sites (see Table A.3 3, Appendix 4). Monitoring of the PAH benzo[a]pyrene is undertaken to provide data in compliance with retained EU law. An air quality objective for this PAH is also set in the Air Quality Strategy. A wide range of other PAH species are also monitored in the particulate phase and in the gaseous phase at some sites, for research purposes.

The airborne PAH monitoring is undertaken using Digitel DHA-80 Air Sampling System with $PM_{10}$ inlet. Particulate collection is undertaken on a filter and at some sites, vapour-phase collection is also undertaken using polyurethane foam in addition to filter. At two sites, deposition samplers are also used to determine deposited PAH material.

[3] Conolly C. et al Final Contract Report for the UK PAH Monitoring and Analysis Network (2004-2010) [online] Available at http://uk-air.defra.gov.uk/reports/cat05/1103040911_AEA_PAH_Network_Report_2010_Final_v3.1.pdf [Accessed no 30/05/2012]

The PAH monitoring sites in Scotland are shown in Table 6-8. The sites at Edinburgh and Glasgow are co-located with the Edinburgh St Leonards and Glasgow Townhead AURN sites respectively. The site at Kinlochleven is located close to the closed aluminium works and the site at Auchencorth Moss is a rural EMEP site as discussed in the automatic hydrocarbon section.

Table 6-8 PAH monitoring sites in Scotland

| Site | Address | Grid Reference |
|---|---|---|
| Auchencorth Moss | Rural site in Scotland, south of Edinburgh | 322167,656123 |
| Edinburgh | 145 Pleasance, Edinburgh, EH8 9RU | 326265, 673136 |
| Glasgow Townhead | Not available | 259692, 665899 |
| Kinlochleven | Electrical Substation, Kinlochleven | 219305,761905 |

Annual average concentrations for Benzo(a)pyrene (B(a)P) for 2021 to 2023 are shown in Table 6-9. As can be seen, the Air Quality objective for B(a)P of 0.25 ng $m^{-3}$ as an annual average or the EU Directive target value of 1 ng $m^{-3}$ was not exceeded at any site in 2023.

Table 6-9 Annual Mean Benzo(a)Pyrene concentrations for 2021 - 2023 at four sites in Scotland

| Site | 2021 Annual Mean B(a)P Concentration (ng $m^{-3}$) | 2022 Annual Mean B(a)P Concentration (ng $m^{-3}$) | 2023 Annual Mean B(a)P Concentration (ng $m^{-3}$) |
|---|---|---|---|
| Auchencorth Moss | 0.029 | 0.015 | 0.010 |
| Edinburgh St Leonards | 0.049 | 0.061 | 0.048 |
| Glasgow Townhead | 0.075 | 0.078 | 0.050 |
| Kinlochleven | 0.220 | 0.140 | 0.110 |

### 6.2.2 Benzene

#### *6.2.2.1 Non-automatic hydrocarbon monitoring*

Monitoring of benzene is undertaken on a two-weekly basis with pumped tube samplers at 36 sites throughout the UK – The UK Non-automatic Hydrocarbon Network. Two of these sites are located in Grangemouth and Glasgow Kerbside and are co-located with the Grangemouth and Glasgow Kerbside AURN sites. The non-automatic monitoring network provides benzene data for compliance with retained EU law and Scottish objective of 16.25 µg $m^{-3}$ as a running annual mean.

The benzene monitoring method used in this network involves pumping ambient air at a rate of 10 ml $min^{-1}$ through nominally duplicate tubes containing the sorbent Carbopack X, with subsequent laboratory analysis of the benzene content of the tubes. Results for this site for 2021 to 2023 are provided in Table 6-10.

Table 6-10 Annual Mean Benzene concentrations for 2021 - 2023 at two sites in Scotland in the UK Non-Automatic Hydrocarbon Network

| Site Name | Annual Mean benzene for 2021 (µg $m^{-3}$) | Annual Mean benzene for 2022 (µg $m^{-3}$) | Annual Mean benzene for 2023 (µg $m^{-3}$) |
|---|---|---|---|
| Glasgow Kerbside | 0.50 | 0.44 | 0.57 |

| Site Name | Annual Mean benzene for 2021 ($\mu g\ m^{-3}$) | Annual Mean benzene for 2022 ($\mu g\ m^{-3}$) | Annual Mean benzene for 2023 ($\mu g\ m^{-3}$) |
|---|---|---|---|
| Grangemouth | 0.68 | 0.66 | 0.77 |

*6.2.2.2 Automatic Hydrocarbon Monitoring*

Table 6-11 gives the site details for the one automatic hydrocarbon monitoring station in Scotland - Auchencorth Moss: a rural site south of Edinburgh. The data from this site are used both to provide data for ozone precursor hydrocarbon species, in compliance with retained EU law. In addition, this site is one of the two European Monitoring and Evaluation Programme (EMEP) level II sites (EMEP "supersites") in the UK. The other EMEP supersite is located at Chilbolton in Hampshire. A much wider range of hydrocarbon species is monitored at Auchencorth Moss. However, the rural nature of this site means that often the concentrations are below the detection limit and hence, the data capture is low. Data for the full range of hydrocarbon species monitored at Auchencorth Moss can be downloaded from https://www.scottishairquality.scot/.

Table 6-11 Location of Automatic Hydrocarbon Monitoring Sites in Scotland

| Site Name | Site Type | Species Measured |
|---|---|---|
| Auchencorth Moss | RURAL | Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species* |

*EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.

Table 6-12 indicates that it is unlikely that the EU limit value for benzene of 5 $\mu g\ m^{-3}$ and the Scottish Objective of 3.25 $\mu g\ m^{-3}$ for the annual running mean concentration have been exceeded at Auchencorth Moss during 2023.

Table 6-12 Annual Mean & Max. Running Annual Mean Benzene Concentration at Auchencorth Moss in the UK Automatic Hydrocarbon Network, for 2023

| Site | Benzene Annual mean concentration for 2023 ($\mu g\ m^{-3}$) | Benzene Maximum running annual concentration for 2023 ($\mu g\ m^{-3}$) |
|---|---|---|
| Auchencorth Moss | 0.184 | 0.184 |

### 6.2.3 1,3-Butadiene

The species 1,3-butadiene is also measured as part of the UK Automatic Hydrocarbon Network at the same sites as for Benzene. Table 6-13 shows that 1,3-butadiene concentrations less than the Scottish Air Quality objective of 2.25 $\mu g\ m^{-3}$ were measured during 2023. There is no EU Directive target for 1,3-butadiene.

Table 6-13 Annual Average & Max. Running Annual Mean 1,3-butadiene Concentration at Auchencorth Moss in the UK Automatic Hydrocarbon Network, for 2023

| Site | 1,3-butadiene Annual mean concentration for 2023 ($\mu g\ m^{-3}$) | 1,3-butadiene maximum running annual concentration for 2023 ($\mu g\ m^{-3}$) |
|---|---|---|
| Auchencorth Moss | 0.029 | 0.029 |

### 6.2.4 Heavy Metals

Lead and a wide range of other metals are monitored in two UK networks – the UK Heavy Metals Monitoring Network (mainly urban sites) and the National Monitoring Network for Heavy Metals (mostly rural sites). The urban network determines airborne particulate concentrations of 15 metals, including the metals lead, nickel, arsenic, cadmium and mercury which are covered by the EU Directive (Directives 2008/50/EC for lead and Directive 2004/107/EC for other metals). The rural network determines the concentration of more than 20 metals both as airborne particulate matter and as deposited material in rainwater samples. Results for all metals monitored in the UK Heavy Metals Monitoring Network and for a selection of metals monitored in the National Monitoring Network for Heavy Metals are available from the data selector on the Air Quality in Scotland website https://www.scottishairquality.scot/data/data-selector.

#### *6.2.4.1 Rural Heavy Metals*

In the National Monitoring Network for Heavy Metals, particles are collected using either single sample or multiple-sample FH95 samplers which draw air through a $PM_{10}$ head at a flow rate of 1 $m^3$ $h^{-1}$. Particulate metals are collected on a filter paper for subsequent analysis. The sampling period is normally one week. Rainwater collectors are used to collect samples for rainwater analysis of metals to determine metal deposition. Details of the two rural sites in Scotland are provided in Table 6-14 and data for the measurement of lead, nickel, arsenic and cadmium in 2023 are provided in Table 6-15.

The results from these networks show that the EU limit value for lead (0.5µg $m^{-3}$ as an annual mean), and the target values for nickel (20 ng $m^{-3}$), arsenic (6 ng $m^{-3}$) and cadmium (5 ng $m^{-3}$) were not exceeded at any site in Scotland. The air quality objectives for lead (500 ng $m^{-3}$ for 2004 and 250 ng $m^{-3}$ for 2008) were also not exceeded at any site in Scotland.

Table 6-14 Rural Network metals monitoring sites in Scotland

| Site | Address | Grid Reference |
|---|---|---|
| Auchencorth Moss | Rural site, SE Scotland | 322167,656123 |
| Eskdalemuir | The Met Office Eskdalemuir Observatory, Langholm, Dumfries & Galloway, DG13 0QW | 323552,603018 |

Table 6-15 Annual mean metal concentrations 2023 (Rural Network)

| Site | Annual Mean Arsenic Concentration (ng $m^{-3}$) | Annual Mean Cadmium Concentration (ng $m^{-3}$) | Annual Mean Nickel Concentration (ng $m^{-3}$) | Annual Mean Lead Concentration (ng $m^{-3}$) |
|---|---|---|---|---|
| Auchencorth Moss | 0.20 | 0.020 | 0.15 | 0.77 |
| Eskdalemuir | 0.16 | 0.016 | 0.15 | 0.60 |

## 6.3 DISCUSSION OF ADDITIONAL POLLUTANTS MONITORED AND/OR OTHER METHODS OF MONITORING

This section discusses other air pollution measurements made in Scotland. Detailed results are not provided but are available in the annual reports of the various networks. The following additional pollutants or additional monitoring methods are discussed:

1. $NO_2$ diffusion tube samplers
2. Non- methane Volatile Organic Compounds (NMVOC)
3. Poly aromatic hydrocarbons (PAH)
4. Toxic Organic Micropollutants (TOMPS)
5. Metals (Urban network)
6. Metals (Rural and deposition network)
7. United Kingdom Eutrophying & Acidifying Pollutants Network:
    i. The Precipitation Network

ii. $NO_2$ rural diffusion tube Network
iii. Acid Gases and Aerosol Network (AGANET)
iv. National Ammonia Monitoring Network

### 6.3.1 Non-Methane Volatile Organic Compounds (NMVOC)

At Auchencorth Moss a much wider range of NMVOCs are monitored to provide ozone precursor pollutant concentrations in compliance with retained EU law. The following compounds are monitored:

- Ethane
- Ethene
- Propane
- Propene
- Ethyne
- 2-Methylpropane
- n-Butane
- trans-2-Butene
- 1-Butene
- cis-2-Butene
- 2-Methylbutane
- n-Pentane
- 1,3-Butadiene
- trans-2-Pentene
- 1-Pentene
- 2-Methylpentane
- n-Hexane
- Isoprene
- Benzene
- 2,2,4-trimethylpentane
- n-Heptane
- n-Octane
- Toluene
- Ethylbenzene
- (m+p)-Xylene
- o-Xylene
- 1,3,5-Trimethylbenzene
- 1,2,4-Trimethylbenzene
- 1,2,3-Trimethylbenzene

Hourly data for all these species are available on the Scottish Air Quality Database website.

### 6.3.2 Polycyclic Aromatic Hydrocarbons (PAH)

As discussed in Section 6.2.1, a wide range of particulate and gaseous PAH compounds are monitored within the UK PAH network. The following PAH species are sampled on a daily basis (but bulked into monthly results after analysis) at the four PAH sites in Scotland:

- Benzo(c)phenanthrene
- Benzo(a)anthracene
- Chrysene
- Cyclopenta(c,d)pyrene
- Benzo(b)naph(2,1-d)thiophene
- 5-Methyl Chrysene
- Benzo(b+j)fluoranthene
- Benzo(k)fluoranthene
- Benzo(e)pyrene
- Benzo(a)pyrene
- Perylene
- Indeno(1,2,3-cd)pyrene
- Dibenzo(ah.ac)anthracene
- Benzo(ghi)perylene
- Dibenzo(al)pyrene
- Dibenzo (ae)pyrene
- Dibenzo(ai)pyrene
- Dibenzo(ah)pyrene
- Coronene
- Cholanthrene
- Dibenzo(al)pyrene

### 6.3.3 Toxic Organic Micropollutants

Toxic Organic Micropollutants (TOMPs) include Polychlorinated Dibenzo-p-Dioxins, Polychlorinated Dibenzofurans (PCDD/Fs), PAHs, and Polychlorinated Biphenyls (PCBs). PCDD/Fs and PAHs are formed as unwanted by-products during various industrial, chemical and combustion processes. PCBs were formerly manufactured for use in a wide range of electrical and other products until 1986. These highly toxic and persistent species are ubiquitous in the environment, but are normally present at extremely low concentrations, the atmosphere being the principal route for their redistribution in the environment. The TOMPs network provides data on concentrations of these species in the air throughout the UK. There were six sites in the TOMPs network during 2023: one in Scotland at Auchencorth Moss.

The TOMPs network samples are analysed for PCDD/Fs and PCBs. Portions from the extracts of samples are also analysed for PAHs as part of the PAH network. The sampling method is based around the use of a modified Andersen GPS-1 sampler with subsequent chemical analysis requiring the use of a range of sophisticated chemical analysis techniques. These include gas chromatography coupled with high-resolution mass spectrometry for the PCDD/Fs and for those PCBs with dioxin-like effects and low-resolution mass spectrometry for the other PCBs.

### 6.3.4 Heavy Metals Network

As discussed in Section 6.2.5 a wide range of metals are monitored in both air and rainwater within the National Monitoring Network for Heavy Metals. At the two sites in Scotland, Auchencorth Moss and Eskdalemuir, the following metals are monitored:

Arsenic (As), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Nickel (Ni), Selenium (Se), Vanadium (V) and Zinc (Zn).

### 6.3.5 United Kingdom Eutrophying & Acidifying Pollutant Network (UKEAP)

This network focuses on the measurement of Eutrophying & Acidifying Pollutants in rural areas. The number of sites in Scotland is different for the various species measured.

The UKEAP has four component networks:

- The Precipitation Network (PrecipNet),
- Rural $NO_2$ network ($NO_2$-Net),
- Acid Gas and Aerosol Network (AGANET),
- National Ammonia Monitoring Network (NAMN),
- Automatic Mercury Network.

Each network functions on a national scale, however with differing spatial and temporal resolution which reflects the spatial and temporal heterogeneity of the atmospheric pollutant concerned.

### 6.3.6 The Precipitation Network (Precip-Net)

There are 41 sites in PrecipNet at which the chemical composition of precipitation (i.e., rainwater) is measured. Six of the sites, Lochnagar, Llyn Llagi, Scoat Tarn, Loch Chon/Tinker, River Etherow, Beaghs Burn and Crai Reservoir (Head of the Valleys) were specifically located within sensitive ecosystems. The network allows estimates of wet deposition of sulphur and nitrogen chemicals.

Fortnightly precipitation samples are collected at 41 sites throughout the UK, of which 10 are in Scotland (see Table A.3 6, Appendix 4). Sampling is undertaken with using a bulk rainwater collector. The collected rainwater samples are analysed for sulphate, nitrate, chloride, phosphate, sodium, magnesium, calcium, potassium, pH and conductivity.

### 6.3.7 Rural $NO_2$ Network ($NO_2$-Net)

The nitrogen dioxide measurements are made at 24 of the Precip-Net composition sites. Diffusion tubes are used to measure nitrogen dioxide. The tubes are mounted on the upright of the rain collector stand and exposed for four or five-week periods throughout each year.

Triplicate nitrogen dioxide diffusion tube measurements are run at three AURN sites with co-located automatic instruments (Yarner Wood, Harwell and Eskdalemuir). The annual average $NO_2$ concentration measured at the Eskdalemuir automatic monitoring site was 1.7 μg $m^{-3}$ in 2023 with a data capture rate of 100%. Nitrogen dioxide is measured with diffusion tube samplers at nine sites in Scotland. The annual average concentrations measured in 2023 are provided in Table 6-16.

Table 6-16 $NO_2$ annual average concentrations 2023 at rural monitoring sites

| Site | Annual Mean $NO_2$ for 2023 (ug $m^{-3}$) | Data Capture for 2023 (%) |
|---|---|---|
| Allt a'Mharcaidh | 0.600 | 100 |
| Balquhidder 2 | 1.329 | 87.3 |
| Eskdalemuir | 1.234 | 100 |
| Forsinard RSPB | 0.798 | 100 |
| Glensaugh | 1.303 | 100 |
| Loch Dee | 1.234 | 84.7 |
| Polloch | 0.551 | 100 |
| Strath Vaich | 0.619 | 86.0 |

| Site | Annual Mean $NO_2$ for 2023 (ug $m^{-3}$) | Data Capture for 2023 (%) |
|---|---|---|
| Whiteadder | 1.987 | 100 |

### 6.3.8 Acid Gas and Aerosol Network (AGANET)

The UK Acid Gases and Aerosols Monitoring Network has been in operation since September 1999, providing monthly measurement data of acid gases and aerosols.

An extension of the CEH Denuder for Long Term Atmospheric sampling (DELTA) system at the network sites is used to additionally sample gaseous $HNO_3$, $SO_2$, HCl and particulate $NO_3^-$, $SO_4^{2-}$, $Cl^-$, $Na^+$, $Ca^{2+}$, $Mg^{2+}$. The new expanded network includes measurements of gaseous $SO_2$ and particulate $SO_4^{2-}$ .

The nine sites in this network located in Scotland are listed in Table A.3 7 in Appendix 4.

### 6.3.9 National Ammonia Monitoring Network (NAMN)

Established in 1996, the objectives of the network are to quantify temporal and spatial changes in air concentrations and deposition in $NH_3$ and $NH_4^+$ (included since 1999) on a long-term basis. The monitoring provides a baseline in the reduced nitrogen species ($NH_3$ + $NH_4^+$), which is necessary for examining responses to changes in the agricultural sector and to verify compliance with targets set by international agreements. The 17 sites in this network located in Scotland are listed in Table A.3 7 in Appendix 4.

# 7. AIR QUALITY MAPPING FOR SCOTLAND

As part of the Scottish Air Quality Database project, Ricardo provides mapped concentrations of modelled background air pollutant concentrations on a 1 km x 1 km basis for the whole of Scotland. Modelled roadside air pollutant concentrations are provided for urban major road links in Scotland. The air pollution maps are derived from a combination of measurements from Scotland's network of air quality monitoring stations, and spatially disaggregated emissions information from the UK National Atmospheric Emissions Inventory (NAEI). They provide estimated pollutant concentrations for the whole of Scotland. The methodology for producing the Scottish maps is based on the UK Pollution Climate Mapping (PCM) approach, used for producing air pollution maps for the whole of the UK for the purposes of annual compliance reporting under the Air Quality Standards Regulations 2010.

The PCM methodology has been applied to provide pollution maps of Scotland for the Scottish Government for 2022 using measurements exclusively from Scottish air quality monitoring sites. The maps provide spatial representation of the annual mean concentrations of:

- $PM_{10}$ (gravimetric equivalent)
- $PM_{2.5}$ (gravimetric equivalent)
- $NO_X$ and $NO_2$.

The air pollution measurements used to prepare the maps presented here consists of $PM_{10}$ and $PM_{2.5}$ monitoring data (FIDAS and Beta Attenuated Monitors (BAM)) and automatic monitoring measurements for $NO_X$ and $NO_2$ from the model year. The model also uses meteorology data from the Weather Research and Forecasting (WRF) model to create the Scotland-specific maps.

In 2009 Ricardo undertook a short study[4] on behalf of the Scottish Government which demonstrated the use of Scotland-specific air quality maps for Local Air Quality Management Review and Assessment (LAQM) purposes. This study recommended the use of air pollutant source apportionment data and forward-projected concentrations of air pollutants using Scotland-specific data. Updates to these Scotland-specific air pollutant source apportionment data and forward-projected concentrations have been made and are available for LAQM from a base year of 2018 at: https://www.scottishairquality.scot/data/mapping/data. Please note the available projections from a base year of 2018 are based on assumptions that were applicable prior to the Covid-19 pandemic, and as such, do not reflect short- or long-term impacts of the pandemic and associated lockdowns on emissions in 2020 and beyond.

## 7.1 AIR QUALITY MAPS FOR SCOTLAND 2021

The details of the methodology and full results of the mapping study are provided in a separate report[5]. In this report, we summarise the main findings of this work.

### 7.1.1 $NO_2$ maps for 2022

The 2022 annual mean $NO_2$ concentrations for Scotland were modelled for background and roadside locations. Figure 7.1 and Figure 7.2 show modelled annual mean $NO_2$ concentrations in Scotland, for background and roadside locations respectively.

[4] Stevenson, K., Kent, A.J., and Stedman, J. (2010). Investigation of the possible effect of the use of Scottish specific air quality maps in the LAQM process in four selected Local Authorities. AEA Report AEAT/ENV/R/2948. https://www.scottishairquality.scot/sites/default/files/orig/publications/reports2/258100203_la_mapping_report_issue_1_final.pdf

[5] Wareham, J., Stedman, J., Morris, R. and Hector, D. (2024). Scottish Air Quality Maps. Annual mean $NO_X$, $NO_2$, $PM_{10}$ and $PM_{2.5}$ modelling for 2022. https://www.scottishairquality.scot/sites/default/files/publications/2024-10/Scottish_mapping_report_2022.html

Table 7.1 shows that there were no modelled exceedances of the Scottish annual mean $NO_2$ objective of 40 µg $m^{-3}$ at background locations. Table 7.2 shows that there were no modelled exceedances of the Scottish annual mean $NO_2$ objective of 40 µg $m^{-3}$ at roadside locations.

Figure 7.1 Background $NO_2$ map for 2022, µg $m^{-3}$ (Scotland-specific model)

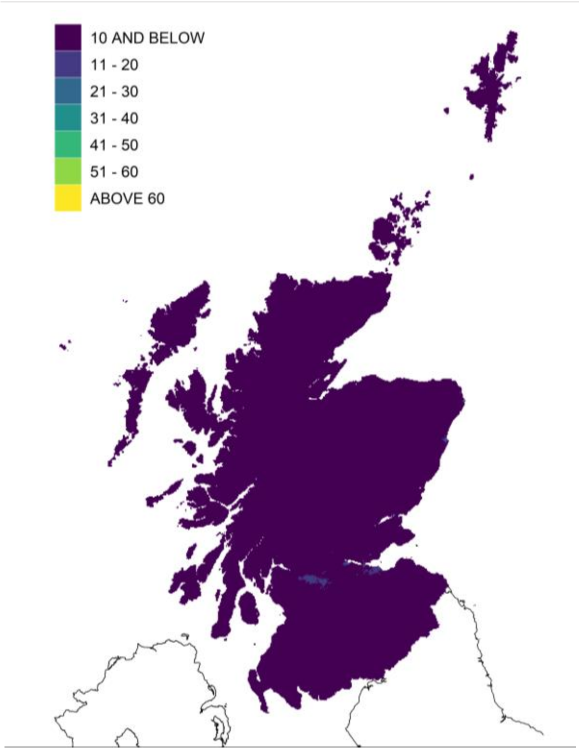



Figure 7.2 Roadside $NO_2$ map for 2022, µg $m^{-3}$ (Scotland-specific model)

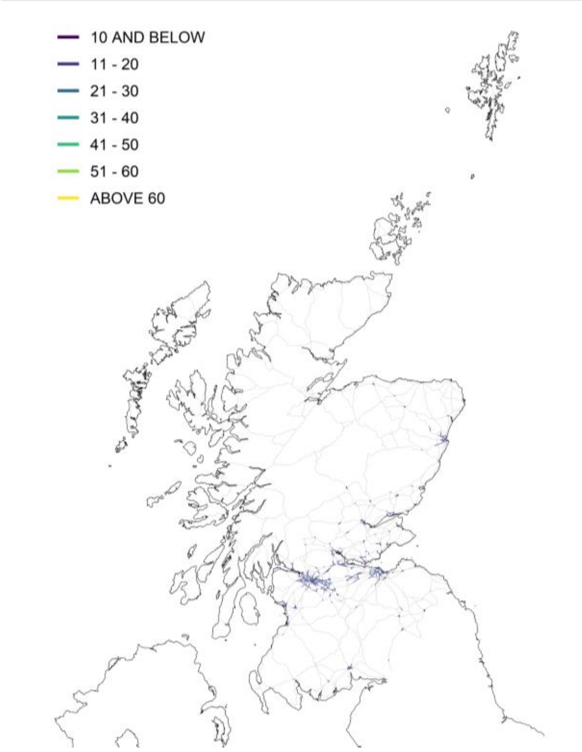



Table 7.1 Annual mean exceedance statistics for background $NO_2$ in Scotland based on the Scotland-specific model, 2022.[1]

| Zone or agglomeration | Total | | >40 µg $m^{-3}$ | |
|---|---|---|---|---|
| | Area ($km^2$) | Population | Area ($km^2$) | Population |
| Glasgow Urban Area | 367 | 1,145,391 | 0 | 0 |
| Edinburgh Urban Area | 134 | 512,576 | 0 | 0 |
| Central Scotland | 10,064 | 2,011,449 | 0 | 0 |
| North East Scotland | 19,066 | 1,149,406 | 0 | 0 |
| Highland | 44,091 | 396,347 | 0 | 0 |
| Scottish Borders | 11,437 | 264,354 | 0 | 0 |
| **Total** | **85,141** | **5,479,523** | **0** | **0** |

[1] Note: Totals may differ from sum of individual sub-totals due to rounding.

Table 7.2 Annual mean exceedance statistics for roadside $NO_2$ in Scotland based on the Scotland-specific model, 2022.[2]

| | | | | |
|---|---|---|---|---|
| | Road links | Length (km) | Road links | Length (km) |
| Glasgow Urban Area | 293 | 410.0 | 0 | 0 |
| Edinburgh Urban Area | 71 | 119.1 | 0 | 0 |
| Central Scotland | 327 | 526.1 | 0 | 0 |
| North East Scotland | 180 | 271.6 | 0 | 0 |
| Highland | 58 | 96.7 | 0 | 0 |
| Scottish Borders | 57 | 58.8 | 0 | 0 |
| **Total** | **986** | **1,482.3** | **0** | **0** |

[2] Note: Totals may differ from sum of individual sub-totals due to rounding.

### 7.1.2 $PM_{10}$ maps for 2022

2022 annual mean $PM_{10}$ concentrations for Scotland were modelled for background and roadside locations. The modelling methodology used to calculate the annual mean $PM_{10}$ concentration was similar to that used in previous years and used a mixture of $PM_{10}$ monitoring (FIDAS and Beta Attenuated Monitors (BAM)) data. Many of the chemical components of the $PM_{10}$ model are not affected by the Scotland-specific changes to the UK PCM model. This includes the contribution to the total $PM_{10}$ mass from the following components:

- secondary inorganic aerosols (SIA, e.g., sulphate, nitrate, ammonium-based particles)
- secondary organic aerosols (SOA)
- primary particles from long-range transport
- sea salt aerosol, and
- iron and calcium-rich dusts.

Maps of the modelled 2022 annual mean $PM_{10}$ concentrations for Scotland's background and roadside locations are shown in Figures 7.3 and 7.4, respectively.

Table 7.3 shows that there were no modelled exceedances of the Scottish annual mean $PM_{10}$ objective of 18 µg $m^{-3}$ at background locations. Table 7.4 shows that there were no modelled exceedances of the Scottish annual mean $PM_{10}$ objective of 18 µg $m^{-3}$ at roadside locations.

Figure 7.3 Background $PM_{10}$ map for 2022, µg $m^{-3}$ (Scotland-specific model)

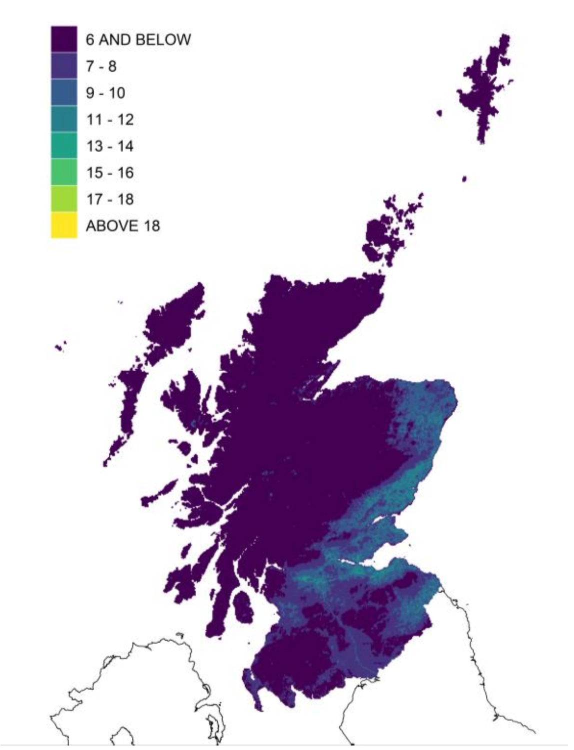



Figure 7.4 Roadside $PM_{10}$ map for 2022, µg $m^{-3}$ (Scotland-specific model)

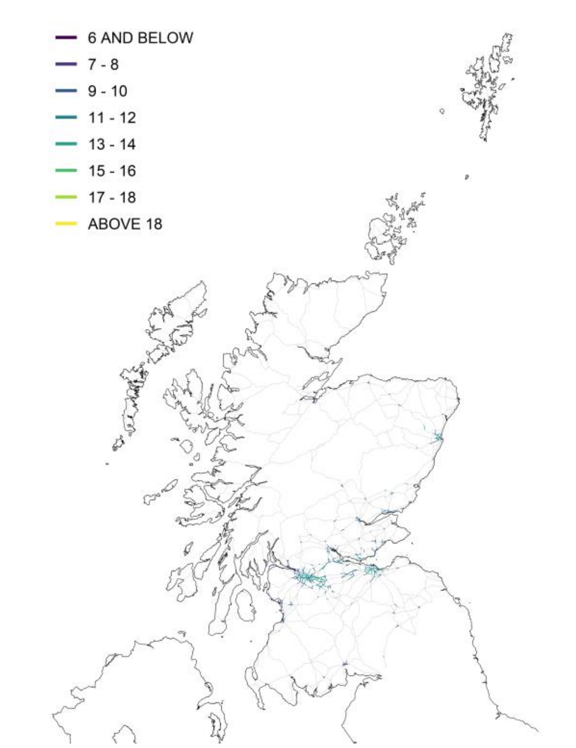



Table 7.3 Annual mean exceedance statistics for background $PM_{10}$ in Scotland based on the Scotland-specific model, 2022.[3]

| | | | | |
|---|---|---|---|---|
| | Area (km$^2$) | Population | Area (km$^2$) | Population |
| Glasgow Urban Area | 367 | 1,145,391 | 0 | 0 |
| Edinburgh Urban Area | 134 | 512,576 | 0 | 0 |
| Central Scotland | 10,064 | 2,011,449 | 0 | 0 |
| North East Scotland | 19,066 | 1,149,406 | 0 | 0 |
| Highland | 44,091 | 396,347 | 0 | 0 |
| Scottish Borders | 11,437 | 264,354 | 0 | 0 |
| **Total** | **85,141** | **5,479,523** | **0** | **0** |

[3] Note: Totals may differ from sum of individual sub-totals due to rounding.

Table 7.4 Annual mean exceedance statistics for roadside $PM_{10}$ in Scotland based on the Scotland-specific model, 2022.[4]

| | | | | |
|---|---|---|---|---|
| | **Road links** | **Length (km)** | **Road links** | **Length (km)** |
| Glasgow Urban Area | 293 | 410.0 | 0 | 0 |
| Edinburgh Urban Area | 71 | 119.1 | 0 | 0 |
| Central Scotland | 327 | 526.1 | 0 | 0 |
| North East Scotland | 180 | 271.6 | 0 | 0 |
| Highland | 58 | 96.7 | 0 | 0 |
| Scottish Borders | 57 | 58.8 | 0 | 0 |
| **Total** | **986** | **1,482.3** | **0** | **0** |

[4] Note: Totals may differ from sum of individual sub-totals due to rounding.

### 7.1.3 $PM_{2.5}$ maps for 2022

2022 annual mean concentrations of $PM_{2.5}$ were modelled for Scotland at background and roadside locations. The modelling methodology used is consistent with the $PM_{10}$ model and further detail can be found in the 2022 UK mapping report[6]. The 2022 maps have been calibrated using measurements from sites for which co-located $PM_{10}$ measurements are also available.

Maps of the modelled 2022 annual mean $PM_{2.5}$ concentrations for Scotland's background and roadside locations are shown in Figures 7.5 and 7.6, respectively.

Table 7.5 shows that there were no modelled exceedances of the Scottish annual mean $PM_{2.5}$ objective of 10 µg $m^{-3}$ at background locations. Table 7.6 shows that there were no modelled exceedances of the Scottish annual mean $PM_{2.5}$ objective of 10 µg $m^{-3}$ at roadside locations.

[6] Pugsley, K. L., Stedman, J. R., Brookes, D. M., Kent, A. J., Morris, R. J., Whiting, S. L., Wareham, J. V., Pepler, A., Thorp, T. M., Gorji, S. and Marshall, O., 2023. "Technical Report on UK Supplementary Modelling Assessment Under the Air Quality Standards Regulations 2010 for 2022." Ricardo Energy & Environment. https://uk-air.defra.gov.uk/library/reports?report_id=1116.

Figure 7.5 Background $PM_{2.5}$ map for 2022, µg $m^{-3}$ (Scotland-specific model)

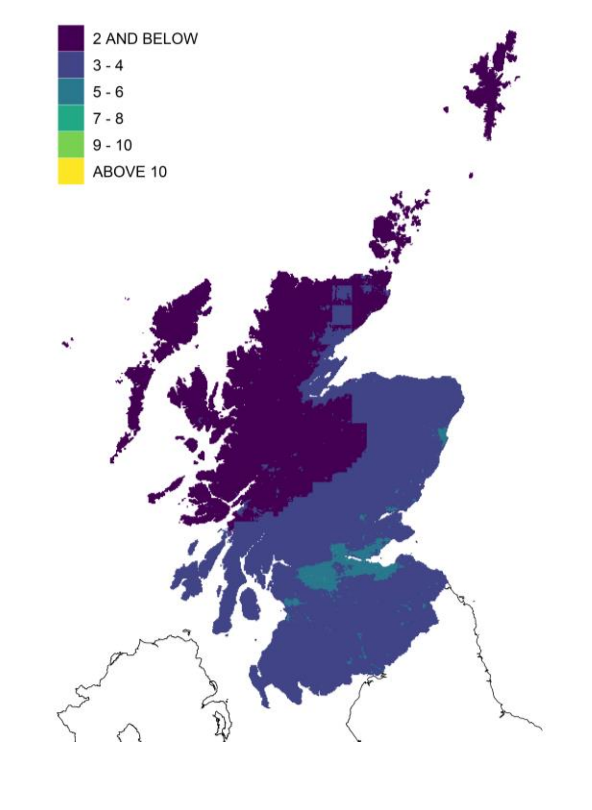



Figure 7.6 Roadside $PM_{2.5}$ map for 2022, µg $m^{-3}$ (Scotland-specific model)

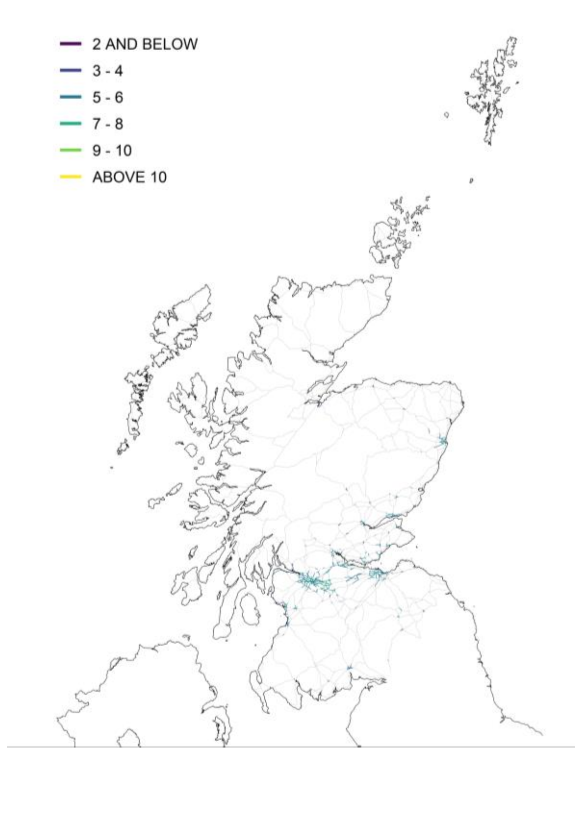



Table 7.5 Annual mean exceedance statistics for background $PM_{2.5}$ in Scotland based on the Scotland-specific model, 2022.[5]

| | | | | |
|---|---|---|---|---|
| | **Area (km$^2$)** | **Population** | **Area (km$^2$)** | **Population** |
| Glasgow Urban Area | 367 | 1,145,391 | 0 | 0 |
| Edinburgh Urban Area | 134 | 512,576 | 0 | 0 |
| Central Scotland | 10,064 | 2,011,449 | 0 | 0 |
| North East Scotland | 19,066 | 1,149,406 | 0 | 0 |
| Highland | 44,091 | 396,347 | 0 | 0 |
| Scottish Borders | 11,437 | 264,354 | 0 | 0 |
| **Total** | **85,141** | **5,479,523** | **0** | **0** |

[5] Note: Totals may differ from sum of individual sub-totals due to rounding.

Table 7.6 Annual mean exceedance statistics for roadside $PM_{2.5}$ in Scotland based on the Scotland-specific model, 2022.[6]

| | | | | |
|---|---|---|---|---|
| | Road links | Length (km) | Road links | Length (km) |
| Glasgow Urban Area | 293 | 410.0 | 0 | 0 |
| Edinburgh Urban Area | 71 | 119.1 | 0 | 0 |
| Central Scotland | 327 | 526.1 | 0 | 0 |
| North East Scotland | 180 | 271.6 | 0 | 0 |
| Highland | 58 | 96.7 | 0 | 0 |
| Scottish Borders | 57 | 58.8 | 0 | 0 |
| **Total** | **986** | **1,482.3** | **0** | **0** |

[6] Note: Totals may differ from sum of individual sub-totals due to rounding.

### 7.1.4 Forward projections

Forward projections of air pollutant concentrations to future years are not produced annually. The most recently available forward projections are from a base year of 2018. Background maps of $PM_{10}$, $NO_X$ and $NO_2$ for the years 2018 to 2030 are provided to assist Scottish local authorities in support of the Review and assessment of local air quality. These are available for download from the Data for Local Authority Review and Assessment purposes page on the Air Quality in Scotland website[7]. Please note the available projections from 2018 are based on assumptions that were applicable prior to the Covid-19 pandemic, and as such, do not reflect short- or long-term impacts of the pandemic and associated lockdowns on emissions in 2020 and beyond. LAQM maps from a base year of 2021 are in progress and will replace the 2018 maps in 2025.

[7] https://www.scottishairquality.scot/data/mapping/data

# 8. AIR POLLUTION TRENDS FOR SCOTLAND

This section of the report summarises how air quality in Scotland has changed in recent years. It focuses on those pollutants which have exceeded their Air Quality Strategy objectives in recent years in Scotland. These pollutants are $NO_2$ and $PM_{10}$. As well as $PM_{10}$, trend analysis will also be carried out for $PM_{2.5}$. Ozone will also be analysed as previous trend analysis has indicated an increasing trend in some instances.

Automatic monitoring of oxides of nitrogen and of ozone has been routinely carried out in Scotland since 1987, with automatic $PM_{10}$ monitoring carried out since the 1990s. However, until 2000 there were relatively few automatic monitoring sites. Subsequent years have seen the number of monitoring sites in the Scottish Air Quality database increase from 20 sites (in 2000) to the current total of 100 sites (as of May 2022). The data produced by these monitoring sites have improved our understanding of Scotland's pollution climate. However, the increase in site numbers potentially complicates the investigation of trends in air quality. If trend investigation is based on all available data, the apparent trends we see may not reflect real changes in Scotland's air quality; instead, they may be due to the changes in the number of sites (and their distribution). Therefore, in reports in this series from 2010 onwards, investigation of trends has been based on subsets of long-running sites.

These subsets are separated by site type classification as stated in the LAQM Technical Guidance (TG22). The subsets are Urban Background (UB), Rural Background (RB), and Urban Traffic (UT). Other site classifications used within this analysis also include Urban industrial (UI) and Suburban (S). There are two set of site classification used within the UK networks, the LAQM description and the 2008 Air Quality Directive description. A description of these classifications is provided in Table 8-1.

Table 8-1 Site classifications

| AQS Regulations 2010 Classification | LAQM Description | AQD 2008 Description |
|---|---|---|
| Urban Traffic | Roadside or Kerbside | Sites in an urban area at least 25 metres from the edge of major junctions and no more than 10 metres from the kerbside |
| Urban Background | Urban Background or Urban Centre | Sites in an urban area away from major roads that are representative of exposure of the general population. Urban background sites should not be dominated by single sources and should be representative of a wide area |
| Suburban Background | Suburban | Sites in a suburban area away from major roads that are representative of exposure of the general population. A suburban area is defined as a location type situated in a residential area on the outskirts of a town or city. Suburban background sites should not be dominated by single sources and should be representative of a wide area |
| Rural Background | Rural | Sites in a rural area away from roads that are representative of exposure of the general population. Rural background sites should not be influenced by agglomerations or industrial sources and should be representative of a wide area |
| Urban Industrial | Industrial | Site in an urban residential area downwind of specific industrial source |
| Suburban Industrial | Industrial | Site in a suburban area downwind of specific industrial source. A suburban area is defined as a location type situated in a residential area on the outskirts of a town or city |

*(Local Air Quality Management Technical Guidance (TG22), Feb 2022)*

All the sites featured in this section have been in operation for a minimum of five consecutive years, as this is usually considered to be the minimum required in order to assess long-term trends at a monitoring site. In most cases it is now possible to do trend analysis for longer periods, for example 10 years.

The trend analysis presented in this section has been carried out using Openair: a free, open-source software package of tools for analysis of air pollution data. Openair was initially funded by the Natural Environment Research Council (NERC), with additional funds from Defra[8]. The Openair project is now maintained by Dr David Carslaw, of Ricardo Energy & Environment/ University of York and Dr Karl Ropkins of the University of Leeds. A range of Openair tools are available on the "Air Quality in Scotland" website: for more information on the tools and how to use them, please see:

https://www.scottishairquality.scot/data/openair

For this and previous reports the Openair "TheilSen" analysis tool was used. This uses the Theil-Sen statistical method to determine trends in pollutant concentrations over several years. The trend analysis is based on monthly mean pollutant concentrations. Openair includes an option to "de-seasonalise" the data (i.e. statistically modify the plotted data to remove the influence of seasonal cycles, thus providing a clearer indication of the overall trend over the relevant time). The "de-seasonalise" option has been used in all the Theil-Sen trend graphs presented here. When the de-seasonalise option is used, Openair fills in any gaps in the data using a linear interpolation method.

In these plots the trend line is shown by a solid red line, with 95% confidence intervals for the trend shown by dotted red lines. The trend is given at the top of the plot in green, with confidence intervals shown in square brackets. The trend is given as units (i.e. $\mu g\ m^{-3}$) per year, over the period shown. This may be followed by a number of stars, with * indicating that the trend is statistically significant at the 0.05 level (low significance), ** indicating significance at the 0.01 level (significant) and *** indicating significance at the 0.001 level (highly significant). The symbol + indicates that the trend is significant at the 0.1 level.

## 8.1 NITROGEN DIOXIDE

In Scotland (as elsewhere in the UK) the largest number of Air Quality Management Areas (AQMAs) has been declared in response to exceedances of objectives for nitrogen dioxide ($NO_2$). This is also reflected in the number of monitoring stations (both automatic and passive) historically reporting exceedances (in particular the annual mean $NO_2$ objective of 40 $\mu g\ m^{-3}$) for this pollutant. It is therefore important to understand how concentrations of this pollutant are varying with time.

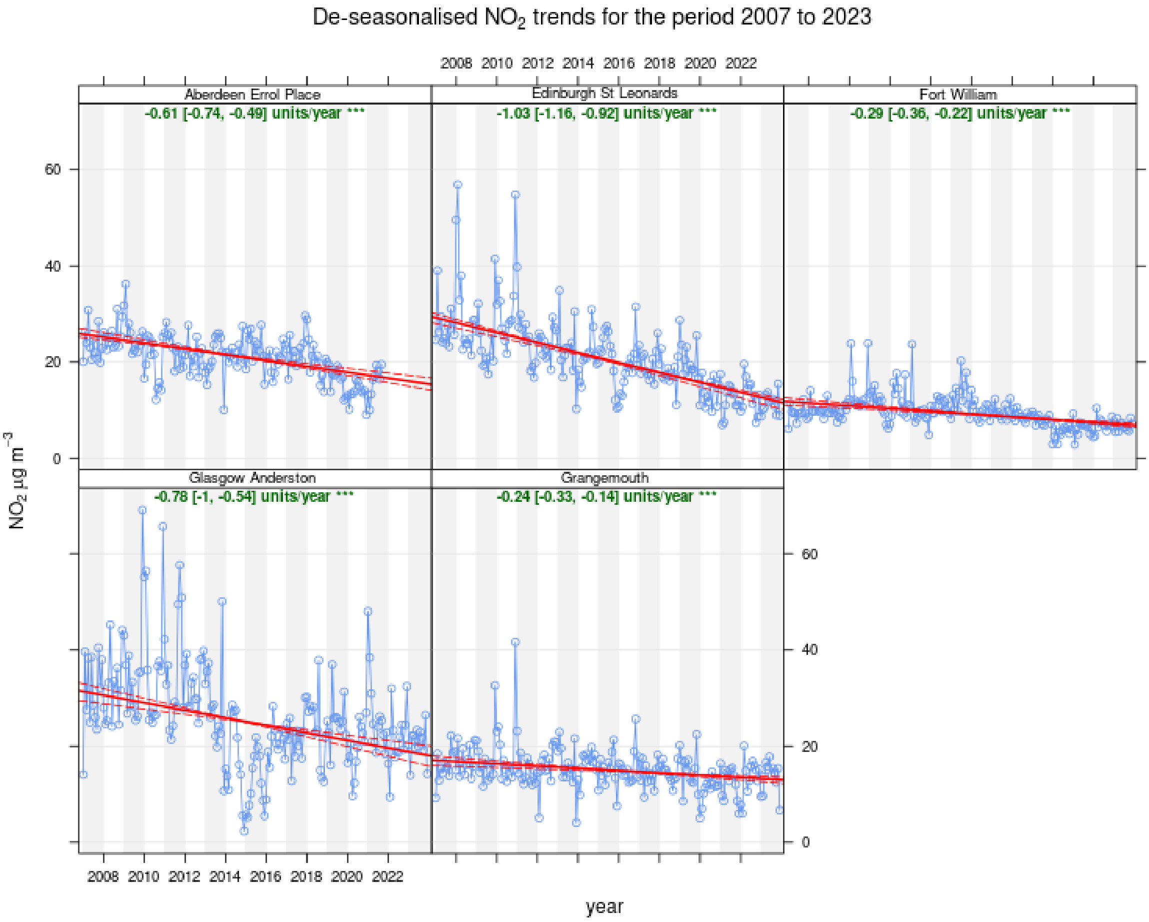
### 8.1.1 $NO_2$ at Urban Background Sites

There are relatively few long-running urban background monitoring stations in Scotland. Five urban background sites have been in operation for the past 16 years. These are as follows: Aberdeen Errol Place, Edinburgh St Leonards, Fort William, Glasgow Anderston and Grangemouth. Fort William is classified as a 'suburban' site, Grangemouth is an 'urban industrial' site, and the other three are 'urban background'. It should be noted that Aberdeen Errol Place was closed in 2021 and replaced by Aberdeen Errol Park, which is located several meters from the Errol Place sites so considered a new site. We have continued to use Errol place data even though there is no 2022 or 2023 data to show background trends for Urban background locations in the northeast region.

The Openair Theil-Sen function has been used to quantify trends in $NO_2$ at these five urban non-roadside monitoring stations, over the period 2007-2023: the trend plots for $NO_2$ are shown in Figure 8-1. Please note that both Edinburgh St Leonards and Glasgow Anderston have large gaps in their 2014 and 2015 datasets: where there are gaps in the data, Openair fills these in using an interpolation method.

[8] Carslaw DC and Ropkins K (2012). "Openair — An R package for air quality data analysis." Environmental Modelling & Software, 27–28(0), pp. 52–61. ISSN 1364-8152, doi: 10.1016/j.envsoft.2011.09.008.

Figure 8-1 Trends in $NO_2$ concentrations at five long-running Urban background sites, 2007-2023

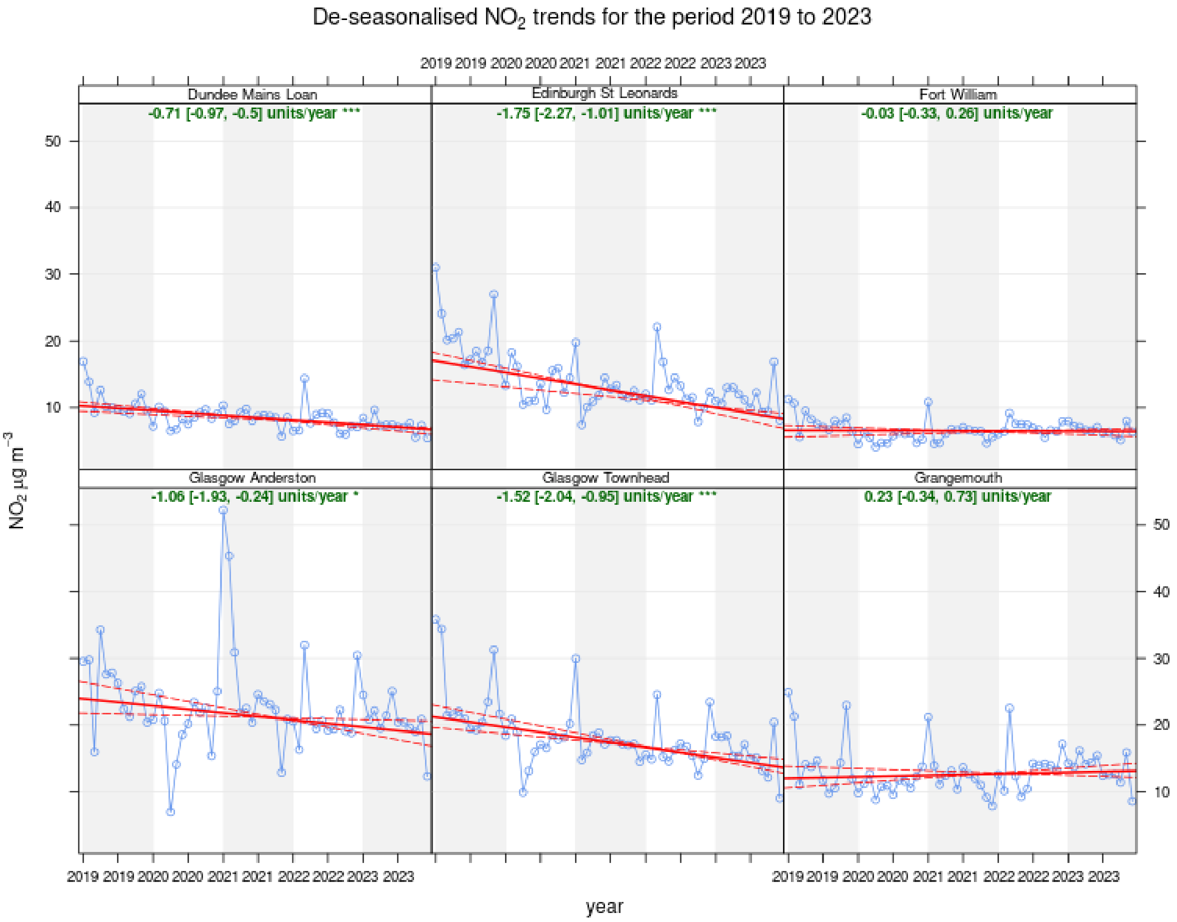



All sites display highly significant decreasing trends (at the 0.001 level) since 2007.

Figure 8-2 takes into consideration all urban background sites in Scotland over the past five years, including the sites at Dundee Mains Loan and Glasgow Townhead. The more recent years analysis shows that the decreasing trend is consistent with the long-range trend, however the statistical significancy in more variable. The exception to this is Grangemouth where the trend has switched from a highly significant decreasing to and increase trend though not statistically significant.

The impact of the Covid-19 lockdowns was a dramatic decrease in concentrations in the first half of 2020 and early 2021. Concentrations then quickly returned to what could be considered pre-lockdown levels once restrictions were lifted.

Figure 8-2 Trends in $NO_2$ concentrations at all Urban Background sites, 2019 -2023




### 8.1.2 $NO_2$ at Rural Sites

There are three long-running rural sites which have monitored oxides of nitrogen for more than 10 years: Bush Estate (to the south of Edinburgh close to the Pentland Hills Regional Park), Eskdalemuir and Glasgow Waulkmillglen Reservoir. Figure 8-3 shows trends in $NO_2$ concentration at these sites since 2007.

All three sites show small but highly significant decreasing trends. In previous years Glasgow Waulkmillglen Reservoir showed no significant downward trend however there is now a highly significant decreasing trend. The drop in concentrations seen in 2020 and 2021, due to the lockdown restrictions may have influenced this change. It should be noted that Eskdalemuir has been off-line since 2021 due to power issues.

Figure 8-4 shows trends in $NO_2$ provides the trend over the last five years to illustrate what trends are like over more recent years and a shorter period of time. It shows that the decreasing trend is plateauing at all sites and no longer statistically significant. For Glasgow Waulkmillglen Reservoir the trend has changed to an increasing trend (but not statistically significant).

Figure 8-3 Trends in $NO_2$ concentrations at three Rural sites, 2007 – 2023

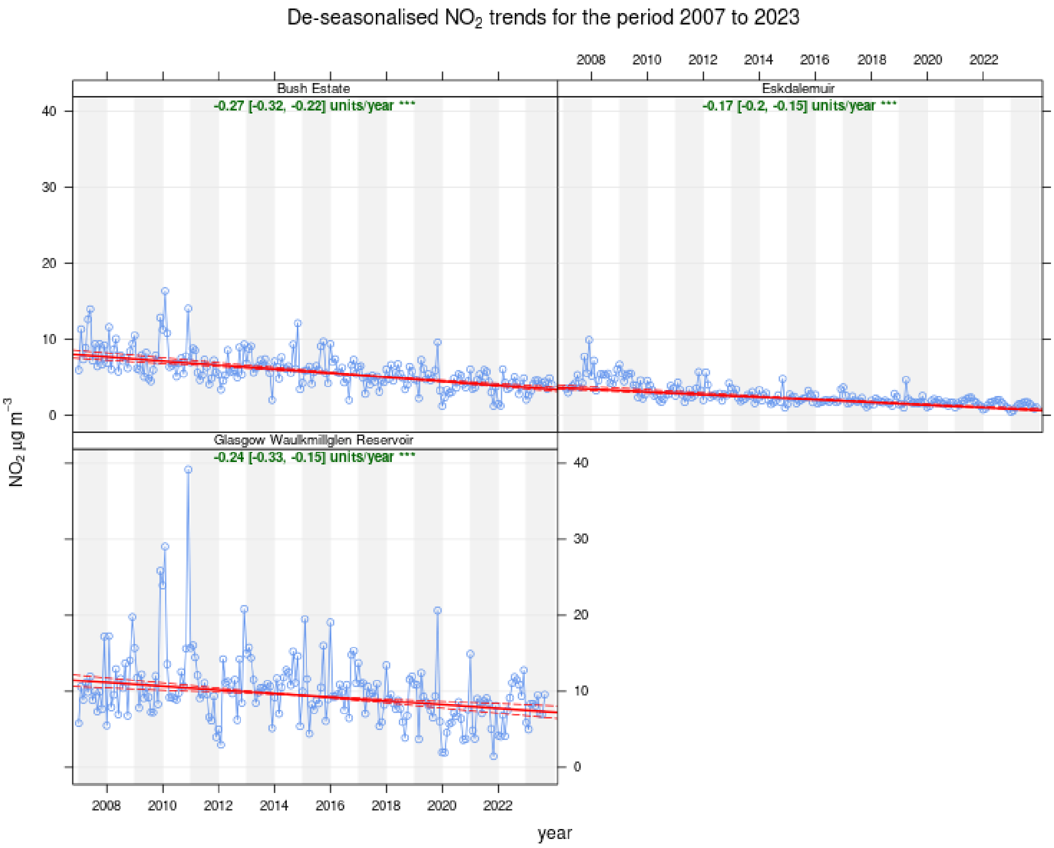
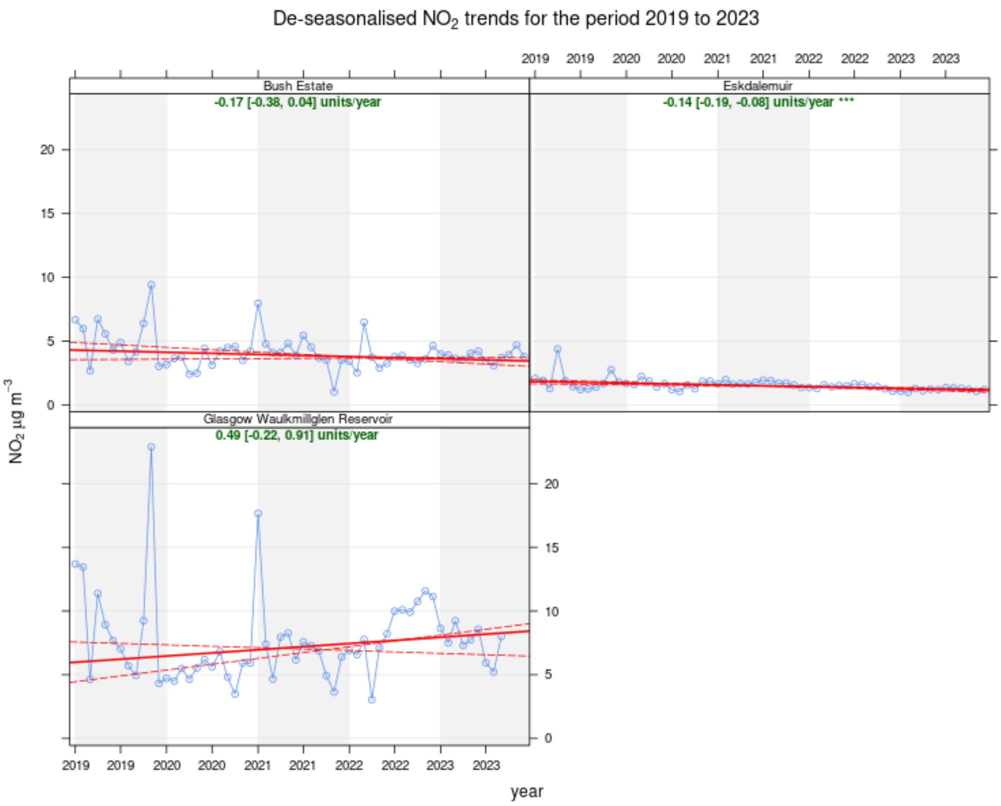



Figure 8-4 Trends in $NO_2$ concentrations at three Rural sites, 2019 – 2023



### 8.1.3 $NO_2$ at Urban Traffic Sites

There are now over 52 urban traffic (roadside and kerbside) monitoring stations that have been in operation for 10 years or more and are still in operation. These are as follows:

- Aberdeen Anderson Dr
- Aberdeen King Street
- Aberdeen Market Street 2
- Aberdeen Union Street Roadside
- Aberdeen Wellington Road
- Dundee Lochee Road
- Dundee Meadowside
- Dundee Seagate
- Dundee Whitehall Street
- East Dunbartonshire Bearsden
- East Dunbartonshire Bishopbriggs
- East Dunbartonshire Kirkintilloch
- East Dunbartonshire Milngavie
- East Lothian Musselburgh N High St
- Edinburgh Glasgow Road
- Edinburgh Gorgie Road
- Edinburgh Salamander St
- Edinburgh St John's Road
- Falkirk Grangemouth MC
- Falkirk Haggs
- Falkirk Hope St
- Falkirk Park St
- Falkirk West Bridge Street
- Fife Cupar
- Fife Dunfermline
- Fife Kirkcaldy
- Fife Rosyth
- Glasgow Anderston
- Glasgow Burgher St.
- Glasgow Byres Road
- Glasgow Dumbarton Road
- Glasgow Kerbside
- Inverness
- N Lanarkshire Chapelhall
- N Lanarkshire Croy
- N Lanarkshire Moodiesburn
- N Lanarkshire Shawhead Coatbridge
- North Ayrshire Irvine High St
- Perth Atholl Street
- Perth Crieff
- South Ayrshire Ayr Harbour
- South Ayrshire Ayr High St
- South Lanarkshire Hamilton
- South Lanarkshire Lanark
- South Lanarkshire Raith Interchange
- South Lanarkshire Rutherglen
- South Lanarkshire Uddingston
- Stirling Craig's Roundabout
- West Dunbartonshire Clydebank
- West Dunbartonshire Glasgow Road
- West Lothian Broxburn
- West Lothian Newton

There are a large number of long-running sites in operation, therefore for the purposes of this report eight were selected based on measured exceedances of the Air Quality Strategy Objective for annual mean $NO_2$ (40 µg m$^{-3}$) in recent years. These are as follows: Aberdeen Union Street, Aberdeen Wellington Road, Dundee Lochee Road, Dundee Seagate, Edinburgh St John’s Road, Glasgow Kerbside (Hope Street), N Lanarkshire Chapelhall and Perth Atholl Street.

Figure 8-5 provides the 10-year trend analysis for these selected sites. It shows that all eight sites have statistically highly significant decreasing trends (at the 0.001 level).

Trends over the most recent five complete years, 2019 – 2023, have also been examined for these sites. These are shown in Figure 8-6. The analysis show that the sites are still decreasing but to a lesser extent across the board.

Figure 8-5 Trends in $NO_2$ concentrations at eight long-running Urban Traffic sites with exceedances, 2014 – 2023

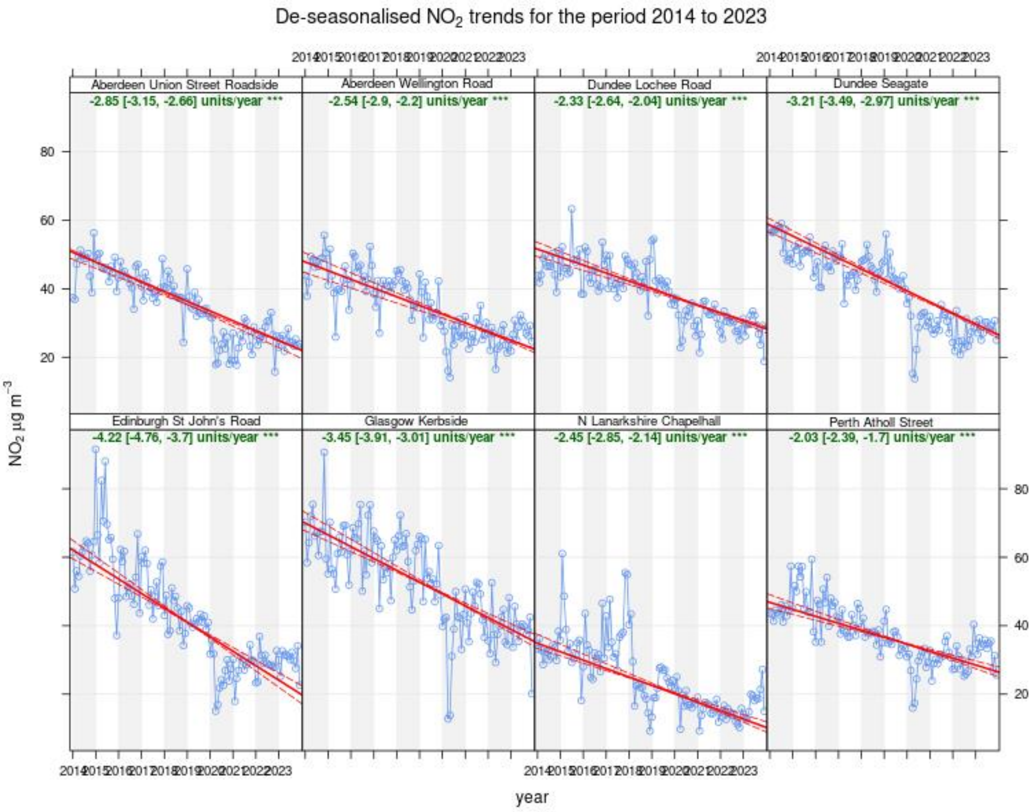
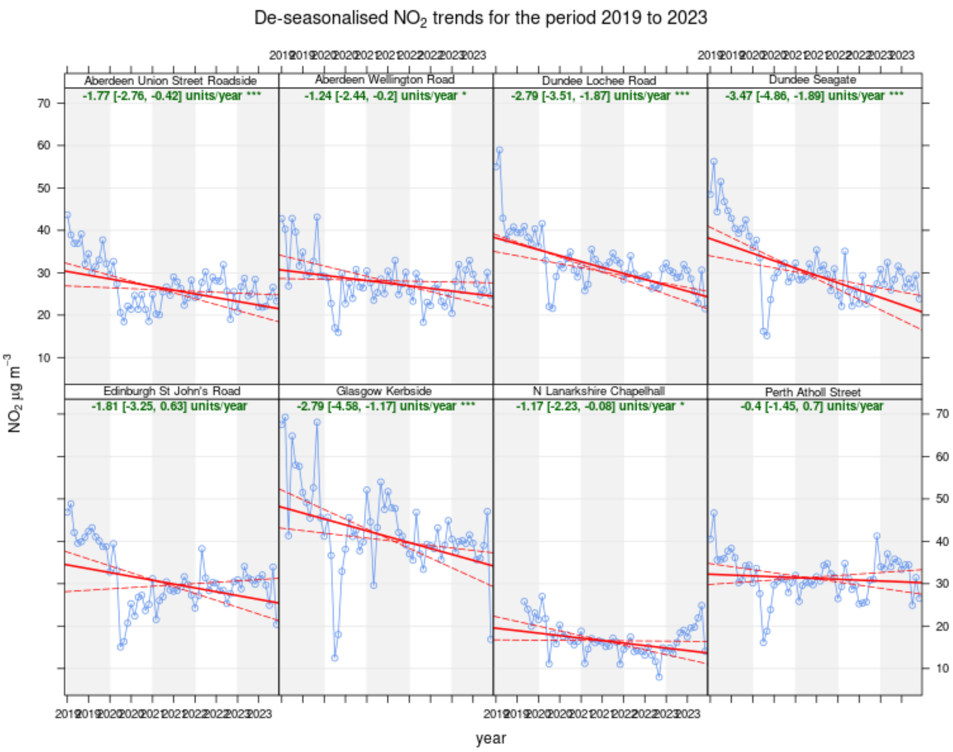



Figure 8-6 Recent trends in $NO_2$ concentrations at eight long-running Urban Traffic sites with exceedances, 2019 - 2023



## 8.2 PARTICULATE MATTER AS $PM_{10}$

This pollutant is of particular interest because current evidence suggests that there is no safe level of particulate matter in terms of human health effects.

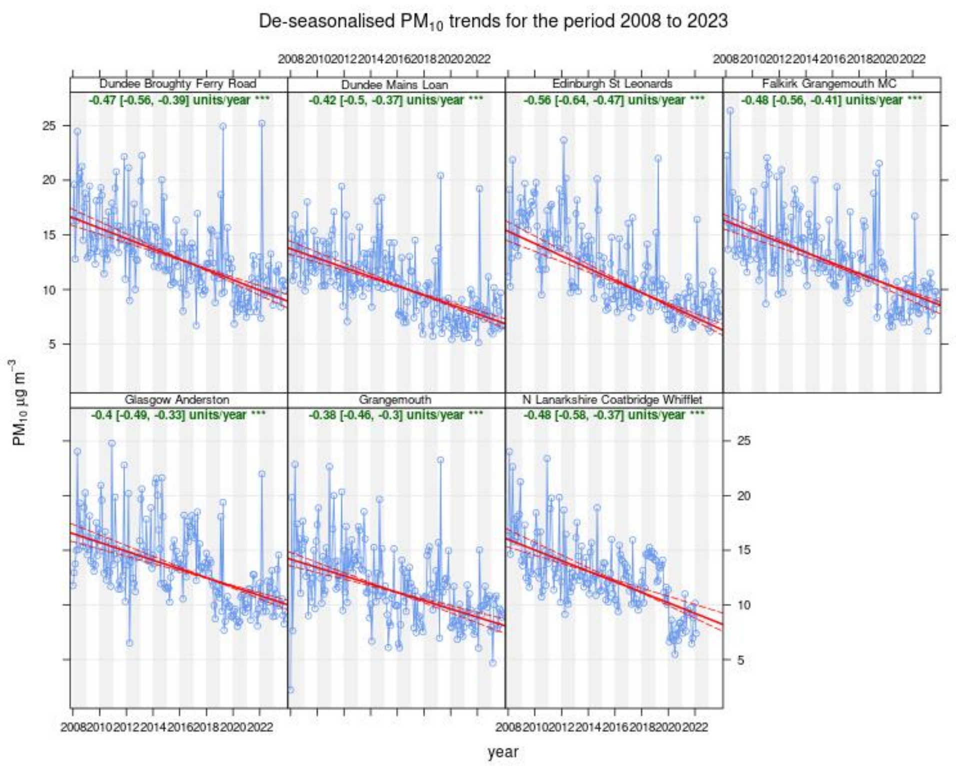
It should be highlighted that FIDAS data used within this trend analysis for both $PM_{10}$ and $PM_{2.5}$ has not been adjusted using correction factors identified by the Scottish Government report "Equivalence Study to Investigate Monitoring in Scotland Using the FIDAS 200[9]". A guidance note[10] issued by the Scottish Government regarding this, states that particulate matter data should only be corrected within the local authorities LAQM report system as the correction factors identified do not supersede the UK equivalence results.

### 8.2.1 $PM_{10}$ at Urban Background Sites

There are now six urban background sites in Scotland that have been monitoring $PM_{10}$ for 10 years or longer. These are: Dundee Broughty Ferry Road, Dundee Mains Loan, Edinburgh St Leonards, Glasgow Anderston, Grangemouth, Falkirk Grangemouth MC. Dundee Broughty Ferry Road and Grangemouth are urban industrial; the rest are urban background.

Figure 8-7 shows trends in de-seasonalised monthly mean $PM_{10}$ at this subset of long-running sites. All seven sites show statistically highly significant (at the 0.001 level) decreasing trends. Trends in the most recent five years are also examined in Figure 8-8. Although the decreasing trend is still evident at all sites over the past five years it is no longer highly significant across the board. The exception to this is Glasgow Anderston, which now shows a slight increasing trend with no statistical significancy rather than a decrease trend. This analysis indicates that concentrations have plateaued over recent years at these locations.

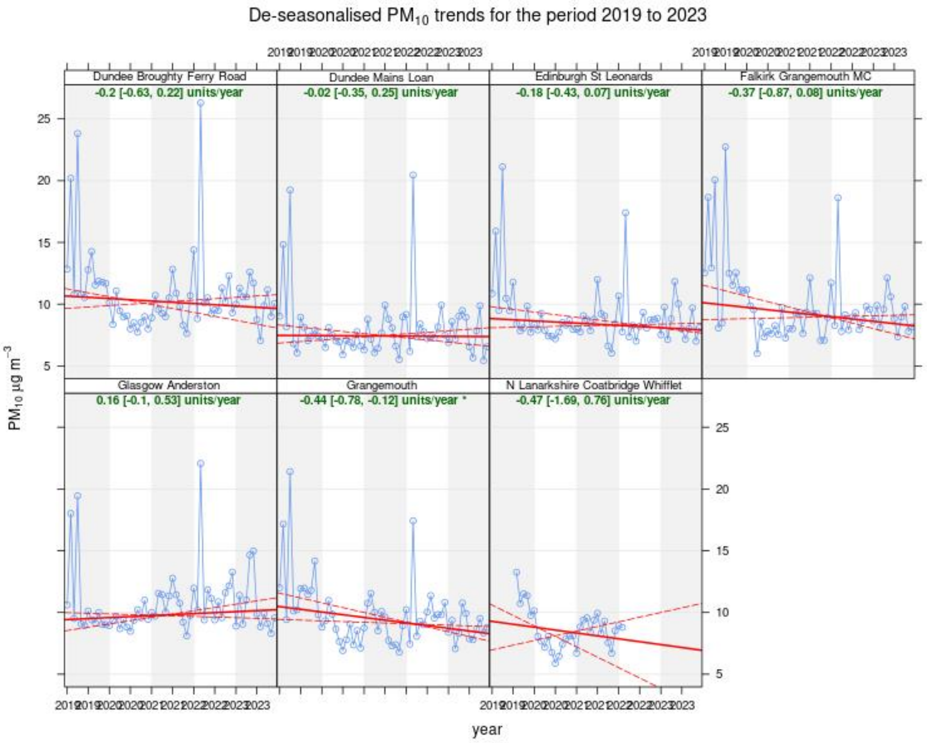
Figure 8-7 Trends in $PM_{10}$ concentrations at six long-running Urban Background and Urban Industrial sites, 2008 – 2023




[9] https://www.scottishairquality.scot/technical-reports/equivalence-study-investigate-particulate-matter-monitoring-scotland-using-fidas

[10] https://www.scottishairquality.scot/technical-reports/local-authority-guidance-note-laqm-reporting-scottish-pm-data

Figure 8-8 Trends in $PM_{10}$ concentrations at six long-running Urban Background and Urban Industrial sites, 2019 – 2023




### 8.2.2 $PM_{10}$ at Urban Traffic Sites

There are 51 $PM_{10}$ monitoring sites in Scotland that have been monitoring for over 10 years. These are as follows:

- Aberdeen Anderson Dr
- Aberdeen King Street
- Aberdeen Market Street 2
- Aberdeen Union Street Roadside
- Aberdeen Wellington Road
- Alloa
- Dundee Broughty Ferry Road
- Dundee Lochee Road
- Dundee Meadowside
- Dundee Seagate
- Dundee Union Street
- E Ayrshire Kilmarnock St Marnock St
- East Dunbartonshire Kirkintilloch
- East Dunbartonshire Milngavie
- East Lothian Musselburgh N High St
- Edinburgh Glasgow Road
- Edinburgh Queen Street
- Edinburgh Queensferry Road
- Edinburgh Salamander St
- Falkirk Banknock
- Falkirk Grangemouth MC
- Falkirk Haggs
- Falkirk Park St
- Falkirk West Bridge Street
- Fife Dunfermline
- Fife Kirkcaldy
- Fife Rosyth
- Glasgow Abercromby Street
- Glasgow Anderston
- Glasgow Broomhill
- Glasgow Burgher St.
- Glasgow Dumbarton Road
- Glasgow Kerbside
- Inverclyde Greenock Dunlop Street
- N Lanarkshire Chapelhall
- N Lanarkshire Croy
- N Lanarkshire Moodiesburn

- N Lanarkshire Motherwell
- N Lanarkshire Shawhead Coatbridge
- North Lanarkshire Cumbernauld
- Perth Atholl Street
- Perth Crieff
- Perth High Street
- Perth Muirton
- South Ayrshire Ayr High St
- South Lanarkshire East Kilbride
- South Lanarkshire Rutherglen
- Stirling Craig's Roundabout
- West Lothian Broxburn
- West Lothian Newton

Trends in de-seasonalised monthly mean $PM_{10}$ concentrations for eight traffic-related sites in operation since 2014 or earlier are shown in Figure 8-9. The sites selected for this analysis are Aberdeen Wellington Road, East Dunbartonshire Bearsden, Edinburgh Salamander, Fife Cupar, Glasgow Dumbarton Road, Glasgow Byres Road, Perth Crieff and West Lothian Broxburn. These sites were selected for analysis because of the length of time they have been monitoring (10 years or more), historical exceedances of the annual mean objective and geographical coverage.

All sites showed statistically highly significant decreasing trends (at the 0.001 level), with the exception of Glasgow Byres Road. The analysis indicates that $PM_{10}$ over the past 10 years is decreasing year on year at all sites except Glasgow Byres Road where analysis shows that concentrations, though fluctuating significantly over the years, have not changed.

Trends in monthly mean $PM_{10}$ concentrations for the same eight sites (plus Edinburgh Queensferry Road), for the most recent five complete years 2019 – 2023, are shown in Figure 8-10. The analysis shows that the decreasing trend is plateauing at a number of sites with varying levels of statistical significancy. At Bearsden, Queensferry road and Crieff the trend is actually increasing over the past five years. In contrast to the 10-year analysis, the five-year analysis for Glasgow Byres Road shows that concentrations are now decreasing with high statistical significancy.

Figure 8-9 Trends in $PM_{10}$ concentrations at eight long-running Urban Traffic sites, 2014 – 2023

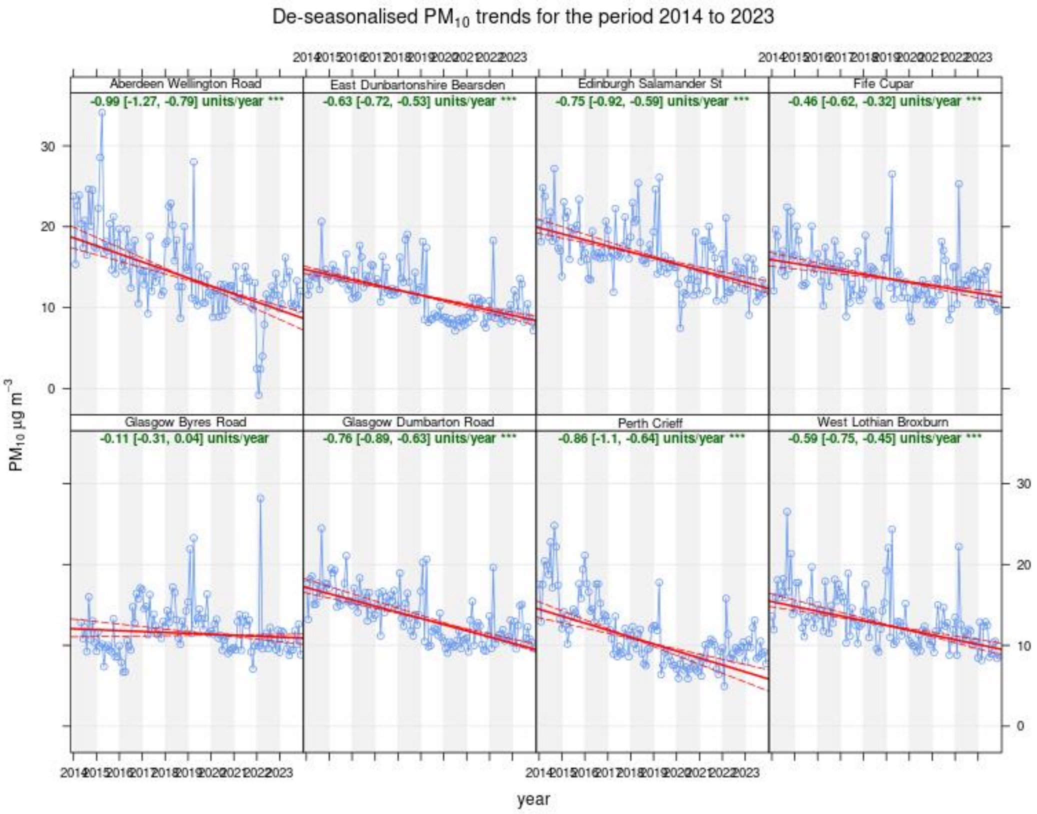
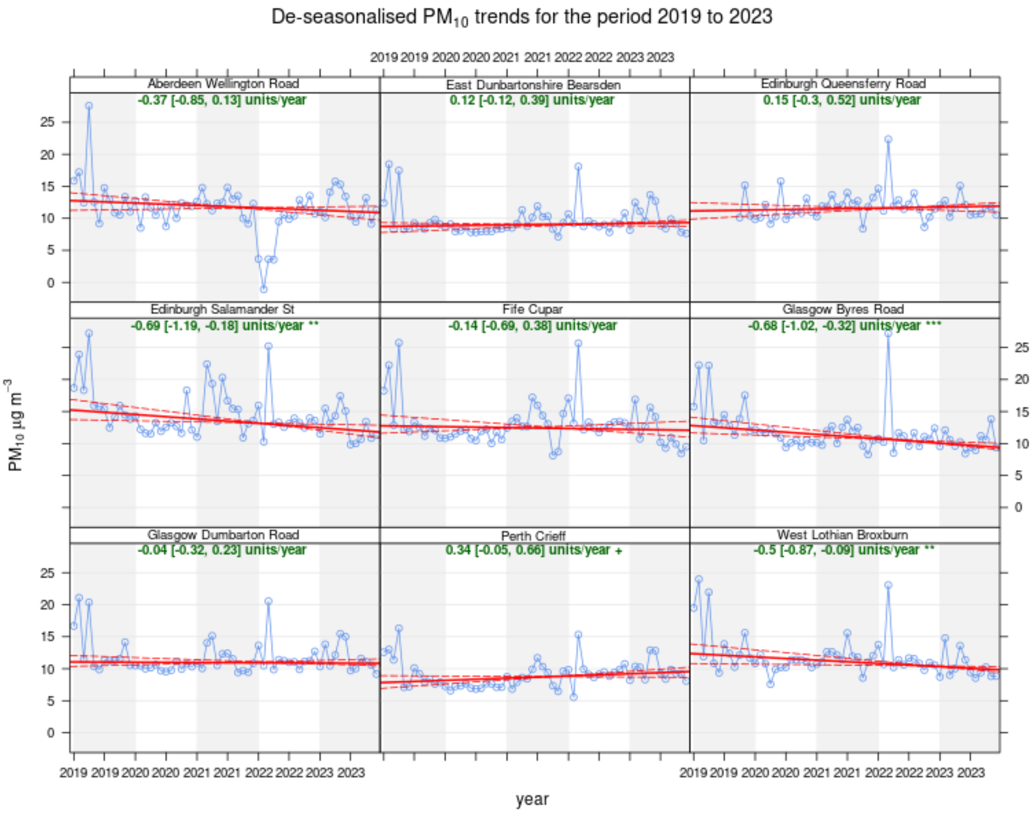


Figure 8-10 Trends in $PM_{10}$ concentrations at eight long-running Urban Traffic sites, 2019 – 2023



## 8.3 PARTICULATE MATTER AS $PM_{2.5}$

In earlier years, most monitoring of particulate air pollution was focused on the $PM_{10}$ size fraction. However, the finer fractions such as $PM_{2.5}$ are now of more interest in terms of health effects. Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of the condition of people with heart and lung diseases. They may also carry harmful compounds, adsorbed on their surfaces, into the lungs.

At the time of writing this report there are 84 sites monitoring $PM_{2.5}$ in Scotland. However, the vast majority of these sites started monitoring in the last six years with the introduction of the $PM_{2.5}$ objective and the requirement for local authorities to measure the pollutant. By the end of 2023 there were three sites with 10 consecutive years of $PM_{2.5}$ data. These sites are as follows: Auchencorth Moss (RB), Edinburgh St Leonards (UB), and Grangemouth (UI). The trend plot for these sites is shown in Figure 8-11.

The analysis shows that Edinburgh St Leonards and Grangemouth have decreasing trends with high statistical significancy over the 10-year time period. Auchencorth Moss, the rural background site, showed less of a decreasing trend with no statistical significancy.

As of the end of 2023, there were an additional 56 sites (all urban traffic) with more than five years' worth of data, the minimum required for this type of trend analysis. The sites are:

- Aberdeen Errol Place
- Aberdeen King Street
- Aberdeen Market Street 2
- Aberdeen Wellington Road
- Alloa A907
- Auchencorth Moss
- Dundee Lochee Road
- Dundee Mains Loan
- Dundee Seagate
- Dundee Whitehall Street
- E Ayrshire Kilmarnock St Marnock St
- East Dunbartonshire Bearsden
- East Dunbartonshire Bishopbriggs
- East Dunbartonshire Kirkintilloch
- Edinburgh St John's Road
- Edinburgh St Leonards
- Edinburgh Tower Street
- Falkirk Banknock
- Falkirk West Bridge Street
- Fife Cupar
- Fife Dunfermline
- Fife Kirkcaldy
- Fife Rosyth
- Glasgow Anderston
- Glasgow Broomhill
- Glasgow Byres Road
- Glasgow Dumbarton Road
- Glasgow High Street
- Glasgow Nithsdale Road
- Glasgow Townhead
- Glasgow Waulkmillglen Reservoir
- Grangemouth
- Inverclyde Greenock A8
- Inverness
- N Lanarkshire Chapelhall
- N Lanarkshire Croy
- N Lanarkshire Kirkshaws
- N Lanarkshire Motherwell
- N Lanarkshire Shawhead Coatbridge
- Perth Atholl Street
- Perth Crieff
- Perth High Street
- Perth Muirton
- Renfrewshire Johnstone
- South Ayrshire Ayr Harbour
- South Ayrshire Ayr High St
- South Lanarkshire Blantyre
- South Lanarkshire Cambuslang
- South Lanarkshire East Kilbride
- South Lanarkshire Lanark
- South Lanarkshire Raith Interchange 2
- South Lanarkshire Rutherglen
- Stirling Craig's Roundabout
- West Dunbartonshire Clydebank
- West Lothian Broxburn
- West Lothian Linlithgow High Street 2

For this report, nine sites that represent a good geographical coverage of Scotland were selected to carry out trend analysis for $PM_{2.5}$. Figure 8-12 illustrates the trend for the nine $PM_{2.5}$ sites selected. As can be seen, all nine sites are very similar with the majority show slight decreasing trends at varying statistical significance. Perth Atholl Street and Renfrewshire Johnstone show very slight increasing trends but at no statistical significancy. Figures 8-11 and 8-12 indicate no real change in $PM_{2.5}$ concentrations over the years analysed.

Figure 8-11 Trends in $PM_{2.5}$ concentrations at four long-running monitoring sites, 2014 – 2023

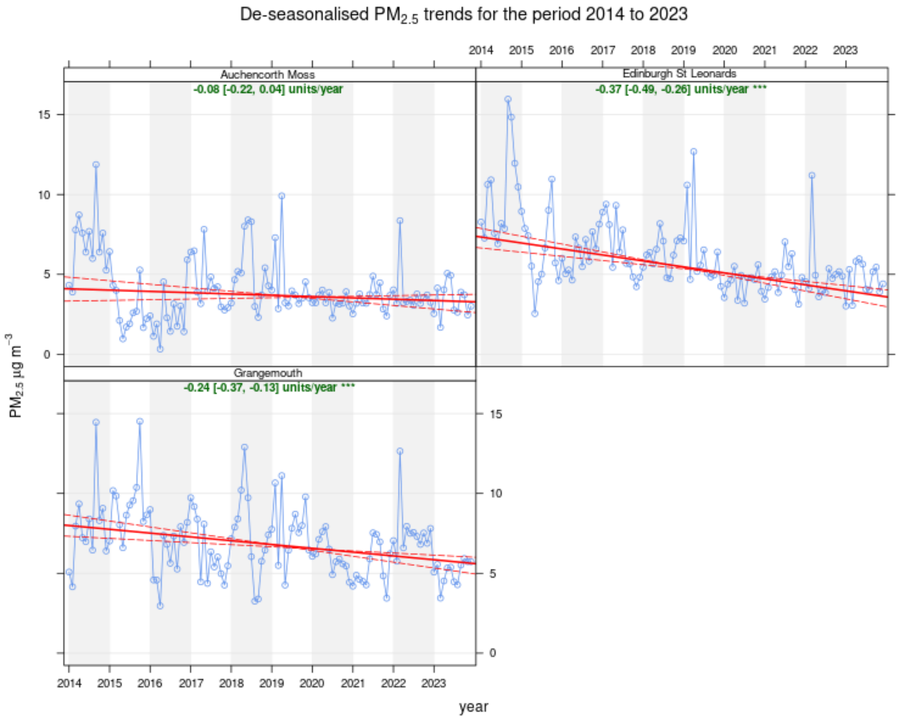
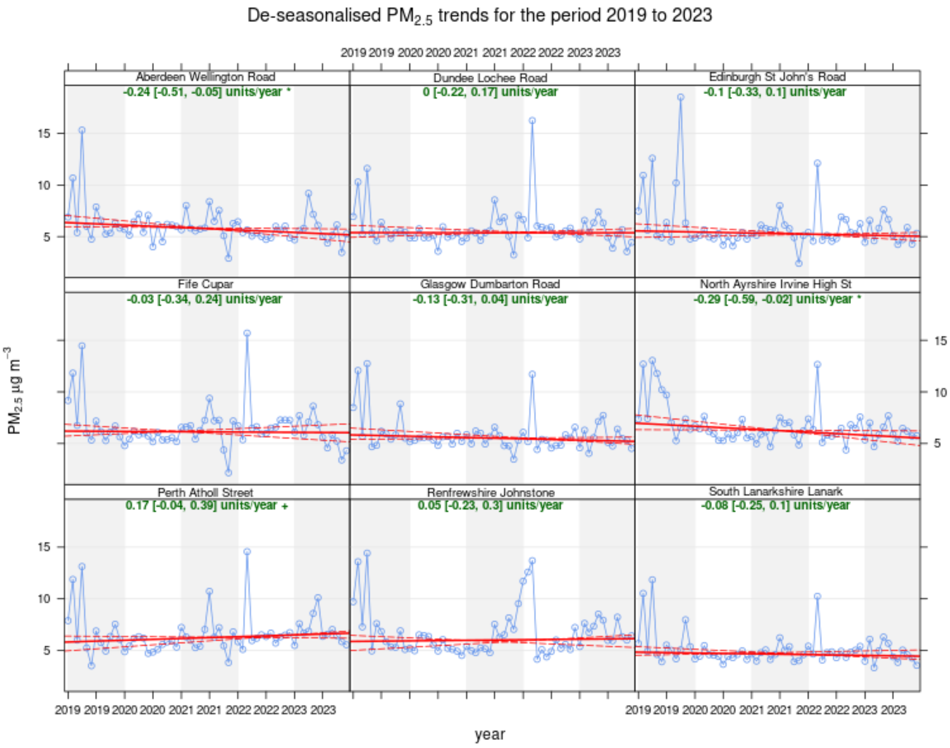



Figure 8-12 Trends in $PM_{2.5}$ concentrations at nine Urban traffic monitoring sites, 2019 – 2023



## 8.4 OZONE

### 8.4.1 Rural Ozone

Three of Scotland's rural air quality monitoring stations have been monitoring ozone for 32 years, 1986 – 2023. These are Bush Estate, Eskdalemuir and Strath Vaich. Figure 8-13 shows long-term trends in de-seasonalised monthly mean ozone ($O_3$) concentrations at these three exceptionally long-running rural monitoring sites. Bush Estate and Eskdalemuir both show small but highly statistically significant increasing trends in rural ozone concentrations over this period. For Strath Vaich, there has been neither an increasing or decreasing trend over the same period with concentrations generally staying the same. The charts also show a significant amount of fluctuation; this may reflect the fact that ozone is formed by reactions involving other pollutant gases, in the presence of sunlight. Thus, ozone concentrations depend substantially on weather conditions. There is also evidence that the "hemispheric background" concentration of $O_3$ has increased since the 1950s due to the contribution from human activities.[11]

Six sites have been in operation for over 10 years. These are the above three sites, plus Auchencorth Moss, Glasgow Waulkmillglen Reservoir and Lerwick. Trends in ozone concentration at these six sites are shown in Figure 8-14. The ten-year trend analysis shows that four sites have increasing trends in $O_3$ concentrations at varying levels of statistical significance. The other two sites (Lerwick and Strath Vaich) have slight decreasing trends with no statistical significance.

[11] See the APIS webpage "Ozone" at http://www.apis.ac.uk/overview/pollutants/overview_O3.htm

Figure 8-13 Trends in $O_3$ concentrations at long-running rural sites, 1986 – 2023

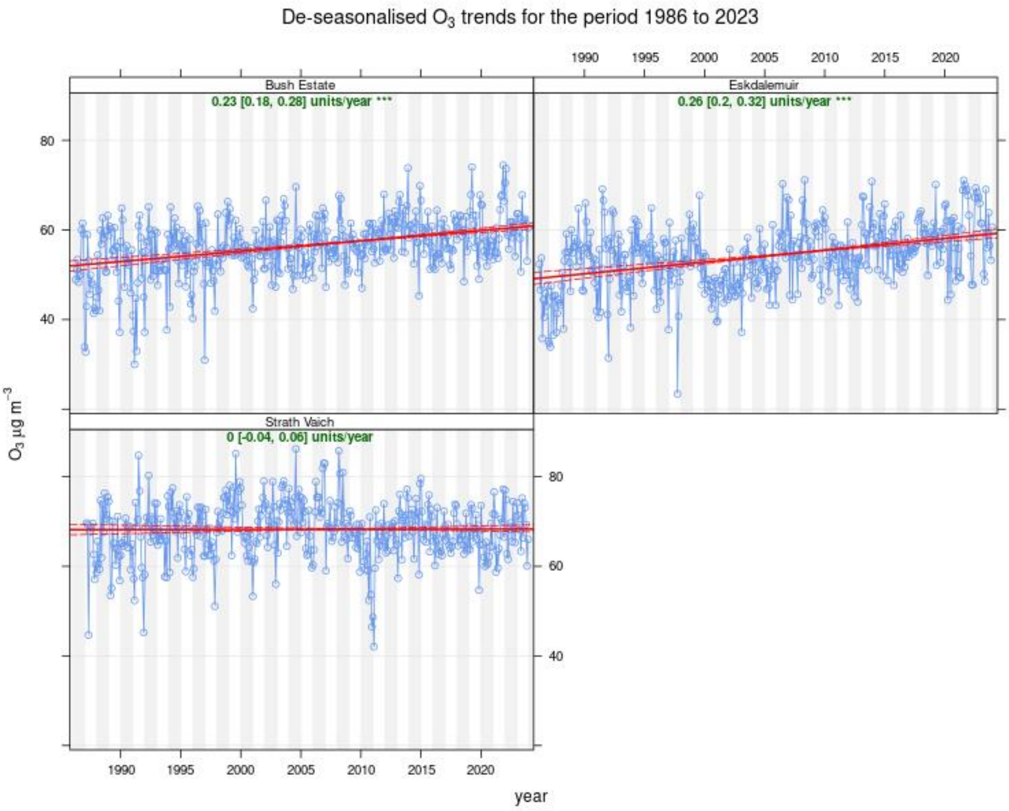
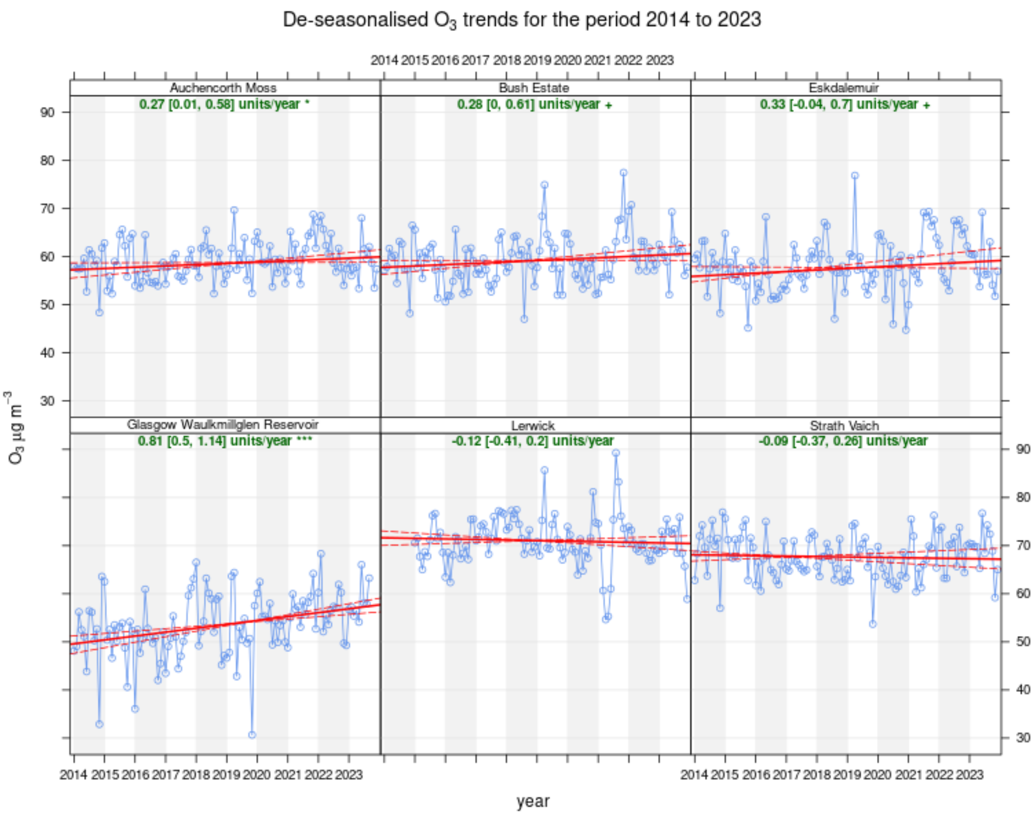



Figure 8-14 Trends in $O_3$ concentrations at six long-running Rural sites, 2014 – 2023



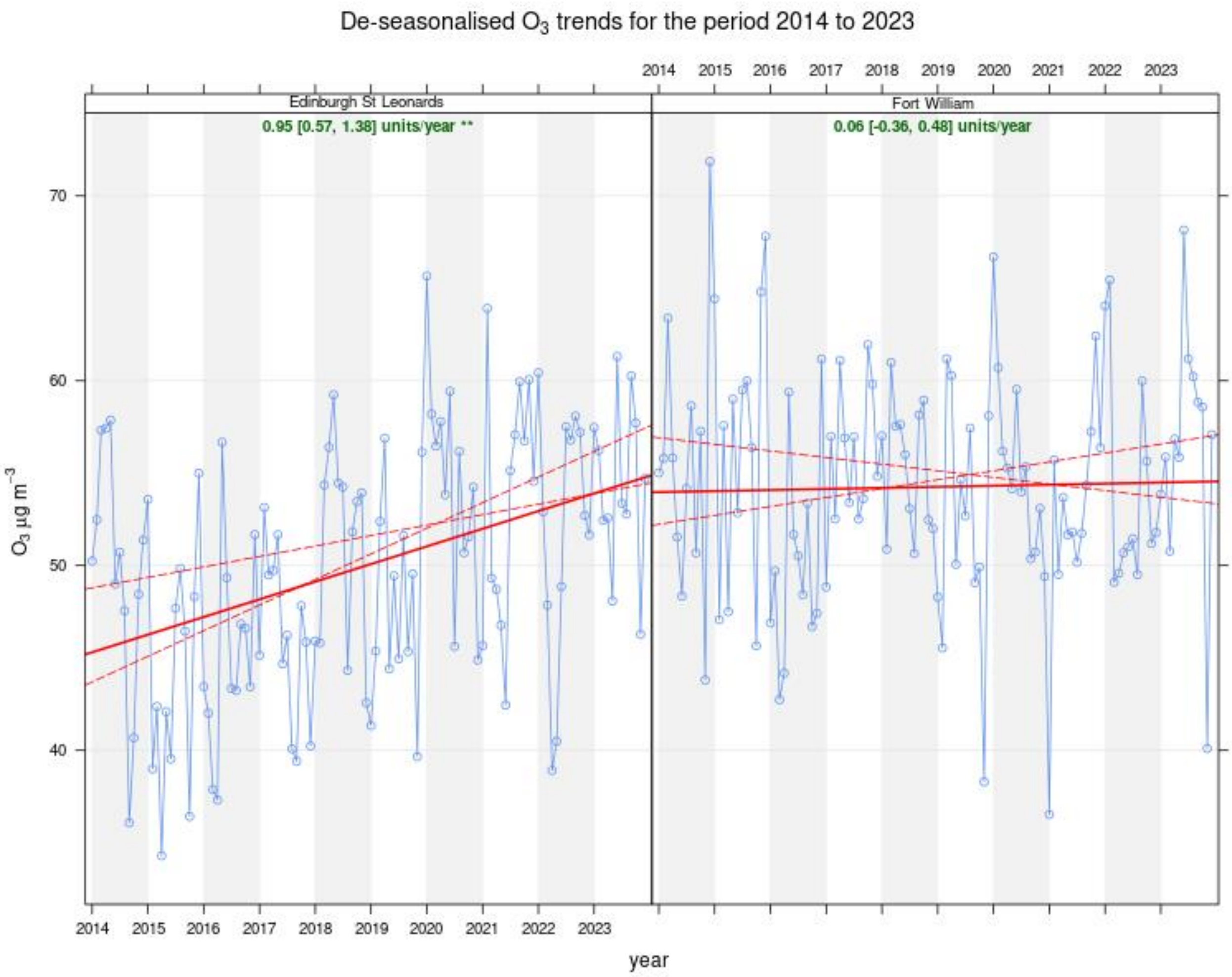
### 8.4.2 Urban Background Ozone

Figure 8-15 shows trends in de-seasonalised monthly mean ozone concentrations at the two Scottish urban background monitoring sites which have been monitoring ozone for the past 10 years, 2014-2023: Edinburgh St Leonards and Fort William.

Analysis shows that there is increasing trends at both sites at varying statistical significancy.

Contrary to other pollutants analysed in this section, there appears to be more of an (though not always statistically significant) increasing trend in ozone concentrations. This is consistent with previous years' reports.

Figure 8-15 Trends in $O_3$ concentrations at two long-running Urban Background sites, 2014 – 2023



## 8.5 ADDITIONAL TREND ANALYSIS

Additional analysis can be carried out on the SAQD monitoring data using analysis tools such as Openair. Openair provides free, open-source and innovative tools to analyse, interpret and understand air pollution data using R a free and open-source programming language designed for the analysis of data (https://www.r-project.org/). The Openair tools available on the Air Quality in Scotland website (http://www.scottishairquality.scot/data/openair) can be used to readily perform complex and innovative analysis of current and archived air pollutant data, allowing powerful data visualisation and interrogation capabilities. This annual analysis is also now provided in the local authority's annual statistical reports in an interactive format. These can be found here https://www.scottishairquality.scot/laqm/statistics. For this annual report a snapshot of this analysis has been carried out for four $NO_2$ automatic monitoring sites, located in the largest Scottish cities, that have historically measured exceedances. These sites are Aberdeen Wellington Road, Dundee Lochee Road, Edinburgh St Johns Road, and Glasgow Kerbside (Hope Street).

The analysis carried for this report includes polar plots, time variation plots, and calendar plots. An array of additional analysis techniques is available via the Openair tool.

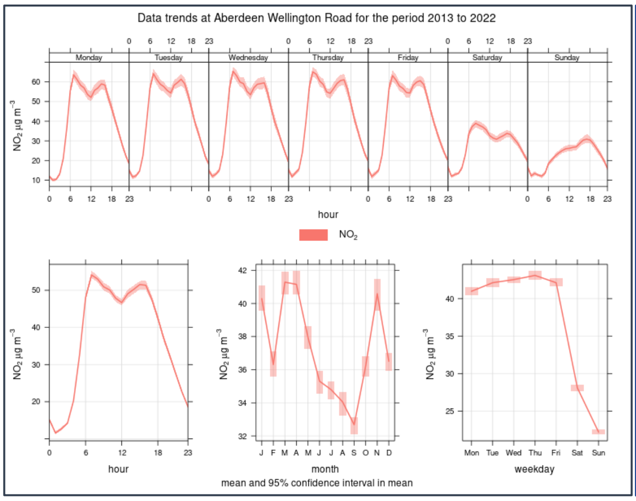
Time variation analysis produces four separate panes combined into a single plot: The plotted output shows the average variation by day of the week and hour of the day combined (the top-most pane), hour of the day (diurnal variation, shown in the lower left pane), month of the year (seasonal variation in the lower middle pane) and day of week (lower right pane). The variation of a pollutant by time of day and day of week can reveal useful information concerning the likely sources at a particular site. In this report, time variation plots created using 2023 $NO_2$ data is compared to data from the previous 10 years.

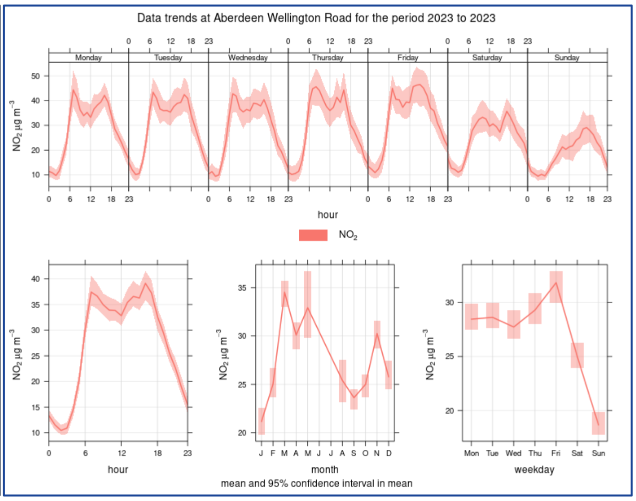
Polar plots are useful to gain a quick graphical representation of the relationship between pollutant concentrations and the meteorological conditions. This can be useful in identifying potential sources of pollution affecting the location, for example particle suspension is increased at higher wind speeds. As with the time variation plots, polar plots created using 2023 $NO_2$ data are compared to plots generated using data from the previous 10 years. It should be noted that when comparing polar plots, the colour index can change so concentrations may relate to different colours in different plots.

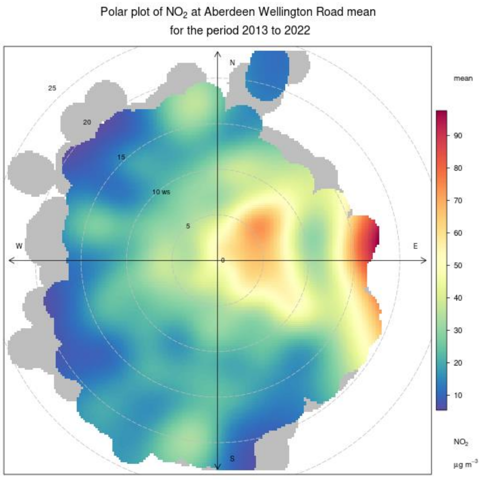
Calendar plot analysis provides a way of visualising trends in daily pollutant concentrations across a year in the familiar form of a calendar. Concentrations are represented with a colour scale and the meteorological conditions can be represented using arrows giving the vector averaged modelled wind direction. In this way pollution episodes can be identified by date and sources potentially indicated by the combination of pollutant and meteorological conditions.

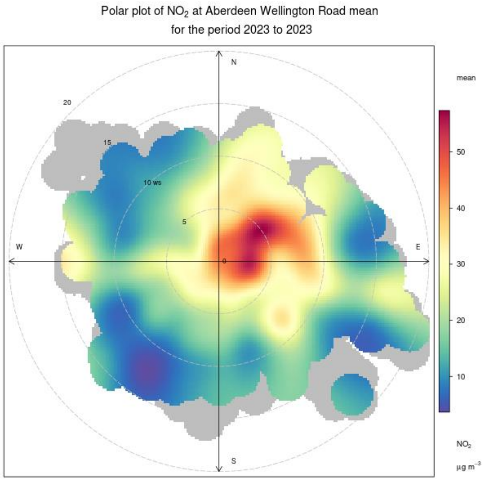
Figures 8-16 to 8-19 illustrate this analysis for the four sites discussed.

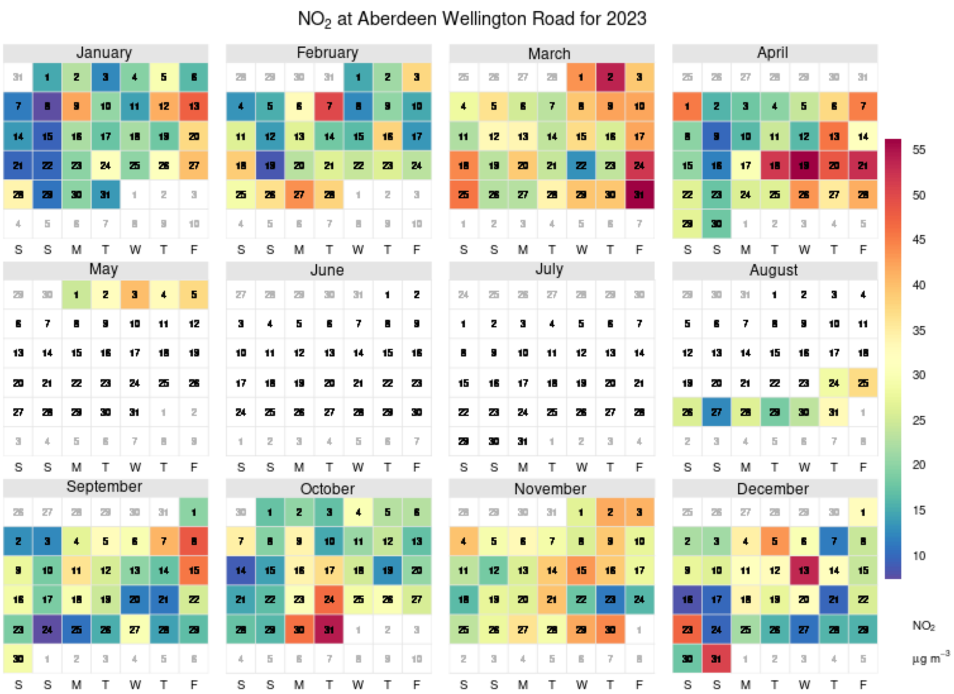
## Figure 8-16 Openair analysis – Aberdeen Wellington Road



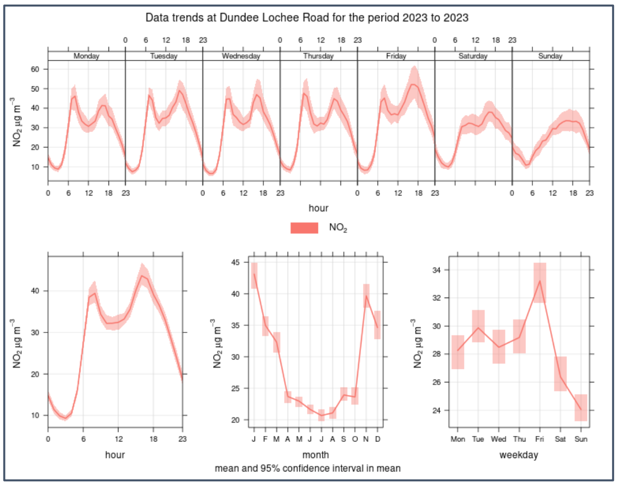



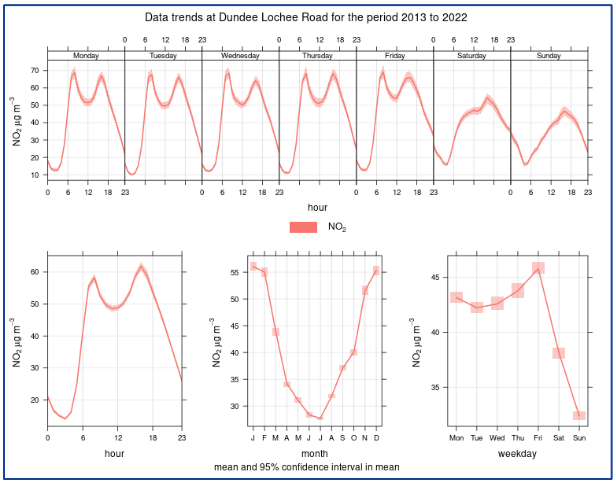



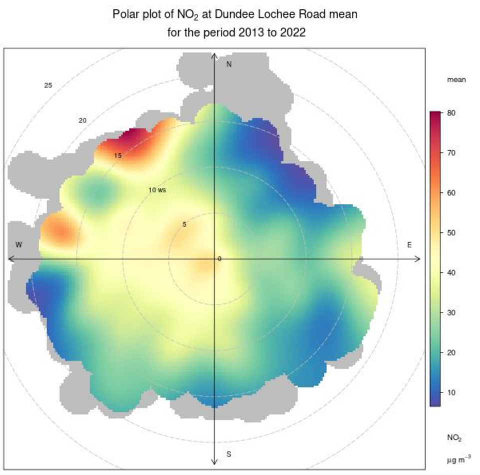



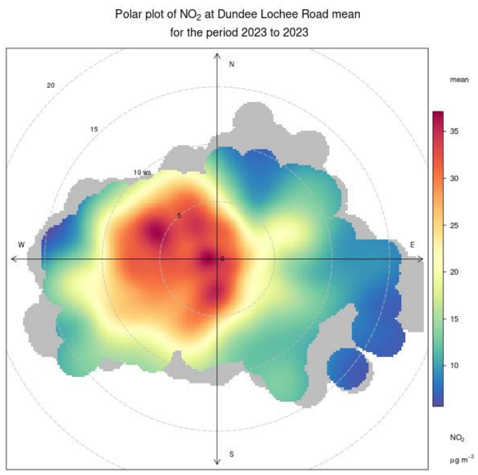



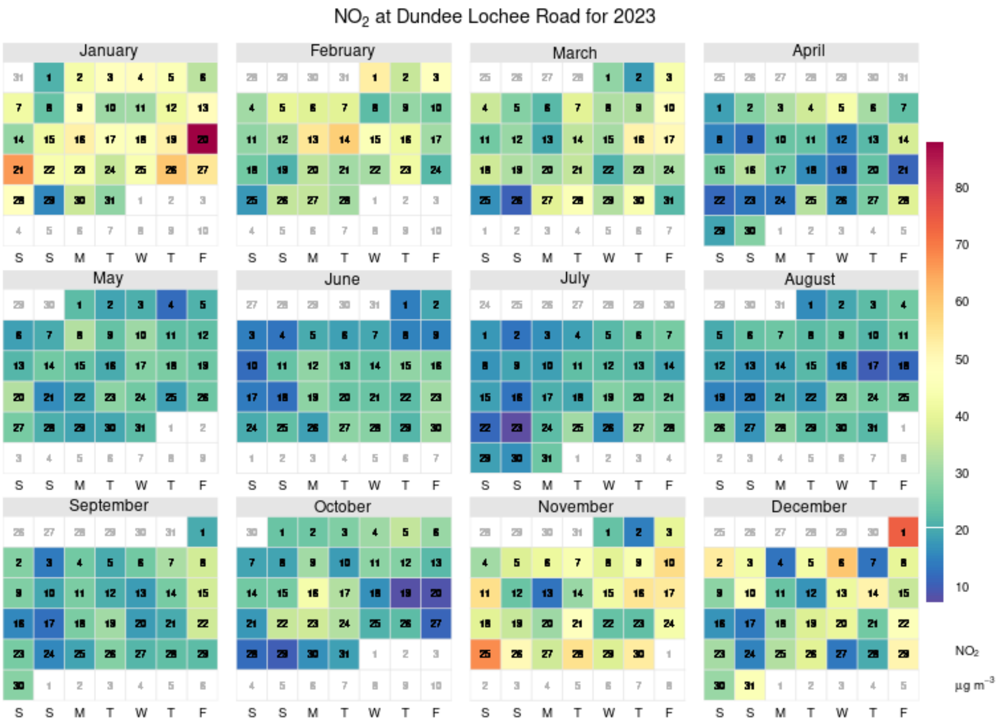
## Figure 8-17 Openair Analysis – Dundee Lochee Road



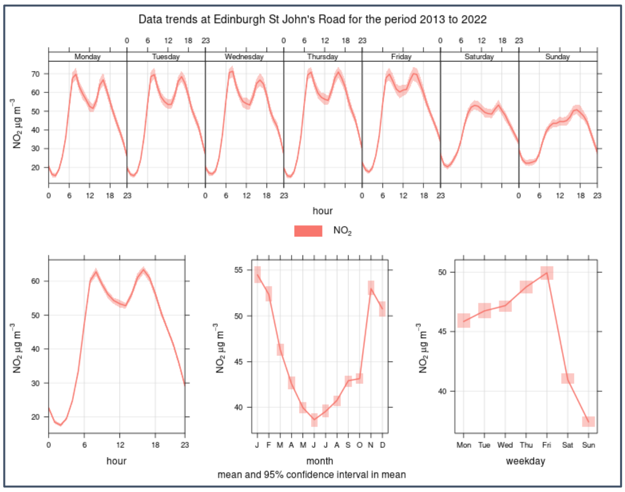



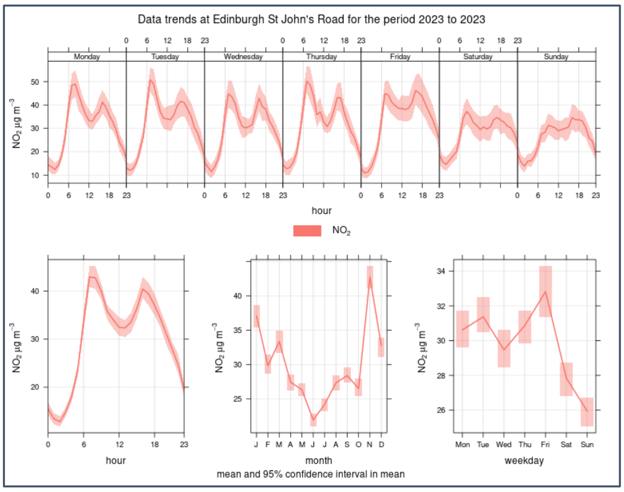



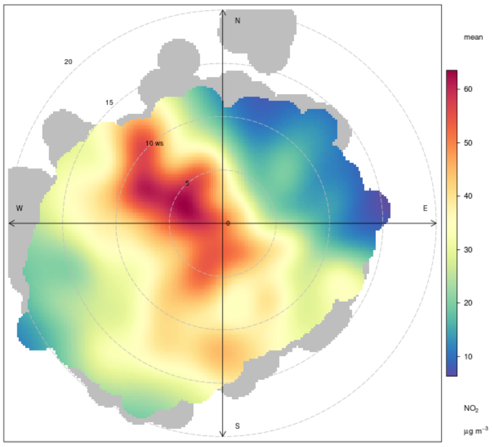



## Figure 8-18 Openair Analysis – Edinburgh St Johns Road

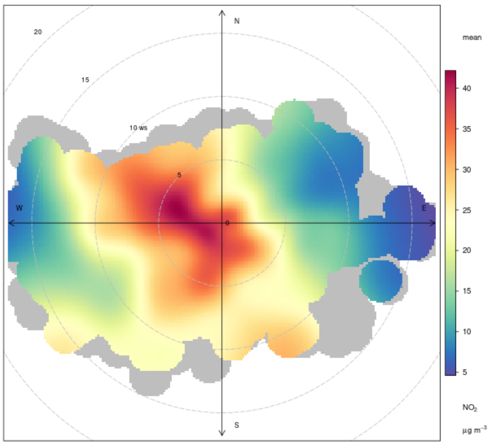


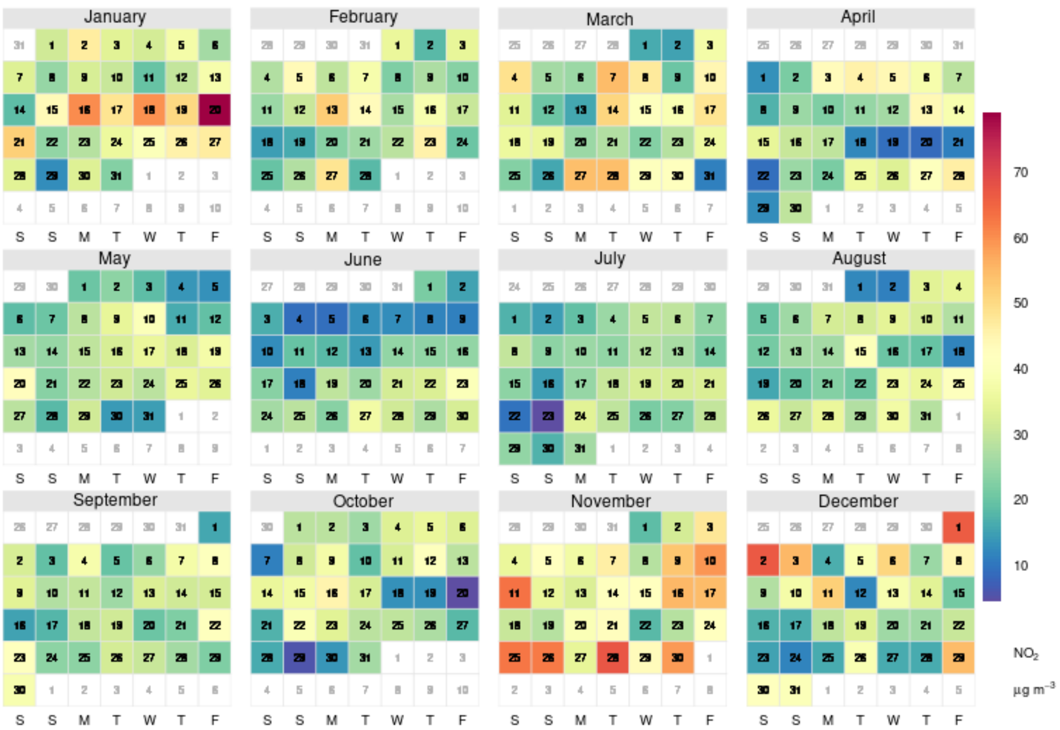

Polar plot of NO2 at Edinburgh St John's Road mean for the period 2013 to 2022



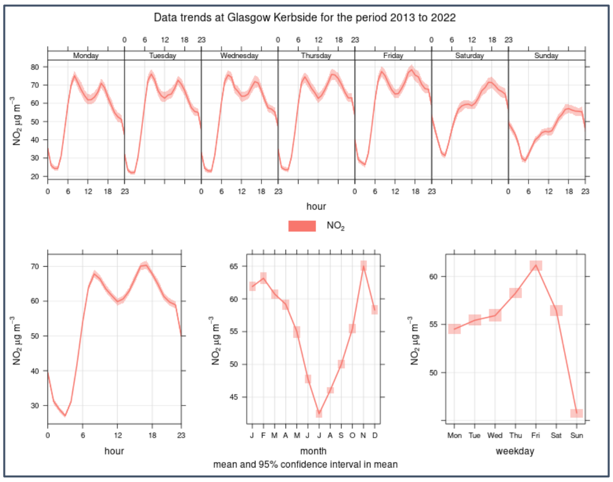

Polar plot of NO2 at Edinburgh St John's Road mean for the period 2023 to 2023

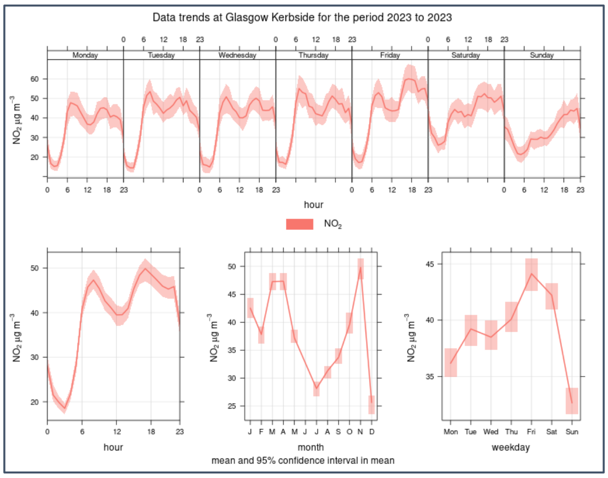


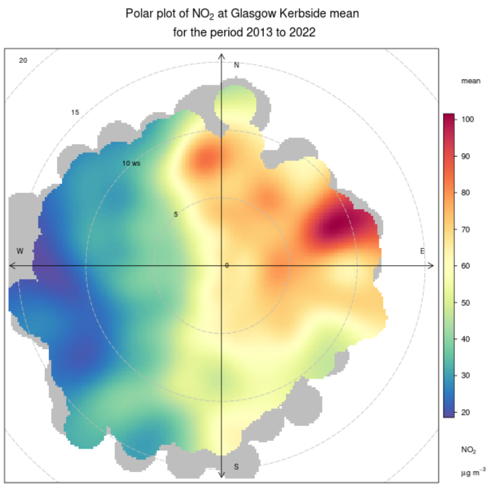

NO2 at Edinburgh St John's Road for 2023

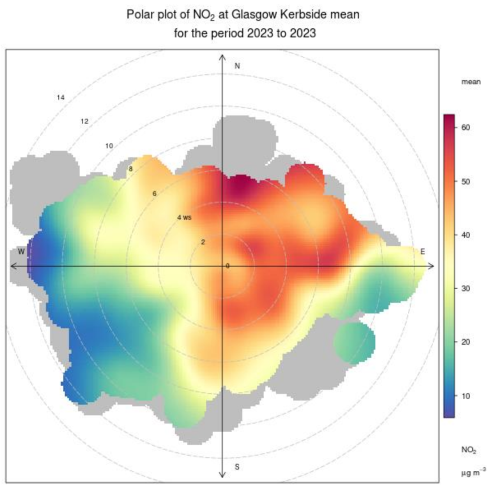


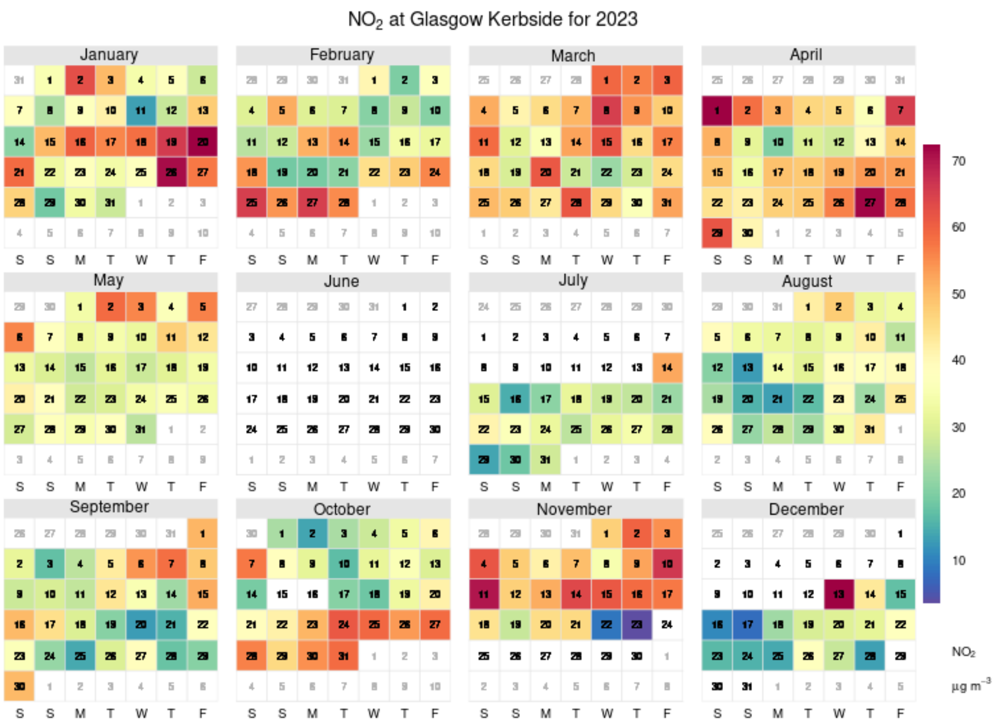
## Figure 8-19 Openair Analysis – Glasgow Kerbside



# 9. EMISSION OF POLLUTION SPECIES

In this chapter we provide information on emissions of pollutants into the atmosphere in Scotland. The UK National Atmospheric Emissions Inventory (NAEI) calculates total emissions for the UK from a comprehensive range of sources including industry, domestic, transport etc. The UK inventory is now disaggregated into the UK constituent countries . The inventory covers a wide range of pollutants. This report the focus will be on NOx, Particulate Matter ($PM_{10}$, and $PM_{2.5}$), Ammonia, CO, $SO_2$ and VOC. Data on Benzene (a) Pyrene (B(a)p), Dioxins, lead (Pb), and Mercury (Hg) can be found in appendix 4. Information on other pollutants can be found at www.naei.org.uk.

Within Scotland, SEPA collates the detailed information on emissions from industrial sources into the Scottish Pollution Release Inventory (SPRI); this includes emissions to water and soil as well as air. Full details are available on the SEPA SPRI database:

http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx

There is also a link to the SEPA SPRI website on the home page of http://www.scottishairquality.scot/data/emissions. The data from SPRI form the basis of the industrial emission data for Scotland which are incorporated into the NAEI.

Information provided in Section 9.1 of this report on the main industrial emissions in Scotland has been compiled from the information presented on SEPA's SPRI database, with permission from SEPA. The data provided is up to 2022, which is the most recent data available at the time of writing this report.

In previous iterations of this report, data has been provided back to 1990. However, due to changes in the NAEI requirements and the fact that UK emission reduction targets for these air quality pollutants, under CLRTAP (Convention on Long-Range Transboundary Air Pollution) and the EU's NECD (National Emission Ceilings Directive) are based on a 2005 baseline, it was decided that reporting data from 1990 to 2004 was no longer required. This historic data was considered to be no longer relevant to either targets or policy.

For information on data back to 1990 and more detailed explanatory description of what is happening with individual emissions please refer to the "Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland" report series (Reports | National Atmospheric Emissions Inventory) and also the Scottish Air Quality Database Annual Report series (https://www.scottishairquality.scot/news/reports/technical).

## 9.1 NAEI DATA FOR SCOTLAND

The NAEI data for Scotland are reported using the Nomenclature for Reporting (NFR) format. The Nomenclature for Reporting is a reporting structure that was introduced in 2001 and is used for submitting data to international organisations such as the United Nations Economic Commission for Europe (UNECE) and the European Monitoring and Evaluation Programme (EMEP).

Emissions of $PM_{2.5}$ are more uncertain than other pollutants due to an increased number of factors involved in the calculation of emissions. $PM_{2.5}$ is calculated as a fraction of $PM_{10}$ emissions for some sources, and thus uncertainty arises from i) activity data, ii) $PM_{10}$ emission factor, iii) the fraction of $PM_{10}$ that is $PM_{2.5}$. This is evident through the uncertainties presented in Section 1.4, and in Appendix E of "Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022"[12].

When comparing previously reported emissions with the most recent data, there may be a difference in the figures stated. This is because the emissions dataset is recalculated each year and a revision of historic time series is carried out if a more accurate and applicable data source becomes available.

Data and graphs provided in this report can also be found as interactive figures within the Air Quality in Scotland website Emissions Inventory page.

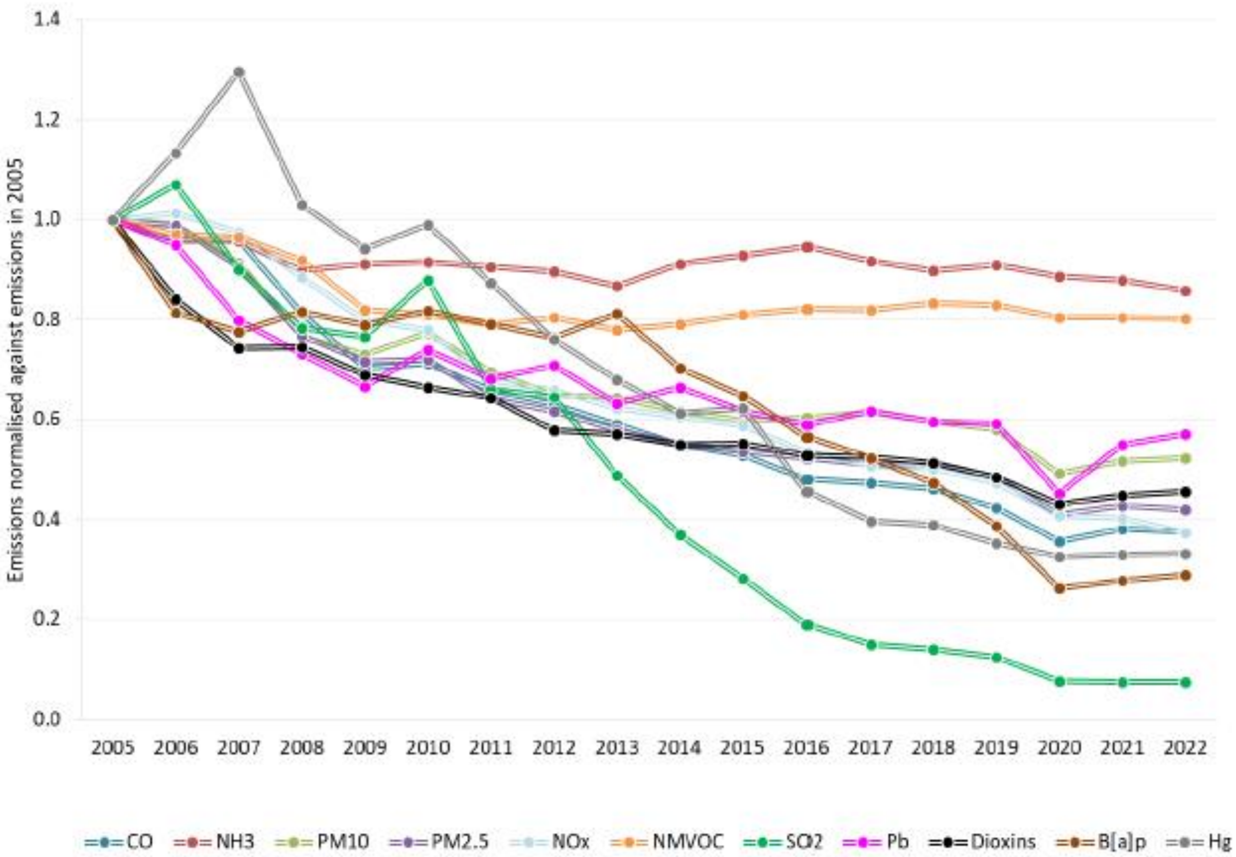
Figure 9-1 illustrates the change in emissions since 2005 of the eight pollutants stated, normalised to provide a relative rate of change. It shows that in general all emission levels have declined since 2005, however this decline has plateaued in recent years and in some cases begun to increase. This is evident with VOC and Ammonia emission levels, which have increased slightly since 2013. In terms of ammonia ($NH_3$), emission

[12] https://naei.beis.gov.uk/reports/index

levels have not significantly changed at all since 2005 when compared to other pollutants and has seen no reduction since 2008.

It is worth noting that emissions across all sectors were impacted by the Covid-19 pandemic in 2020, due to various changes in activity by individuals, business, and industrial processes. As a result, greater emission increases are seen across most sectors between 2020 and 2021 than for other consecutive years in the time series. This is particularly true for pollutants for which the transport sector is a significant source, such as lead, as the lifting of travel restrictions resulted in an increase in traffic.

**Figure 9-1 Scotland normalised trends for all monitored pollutants**

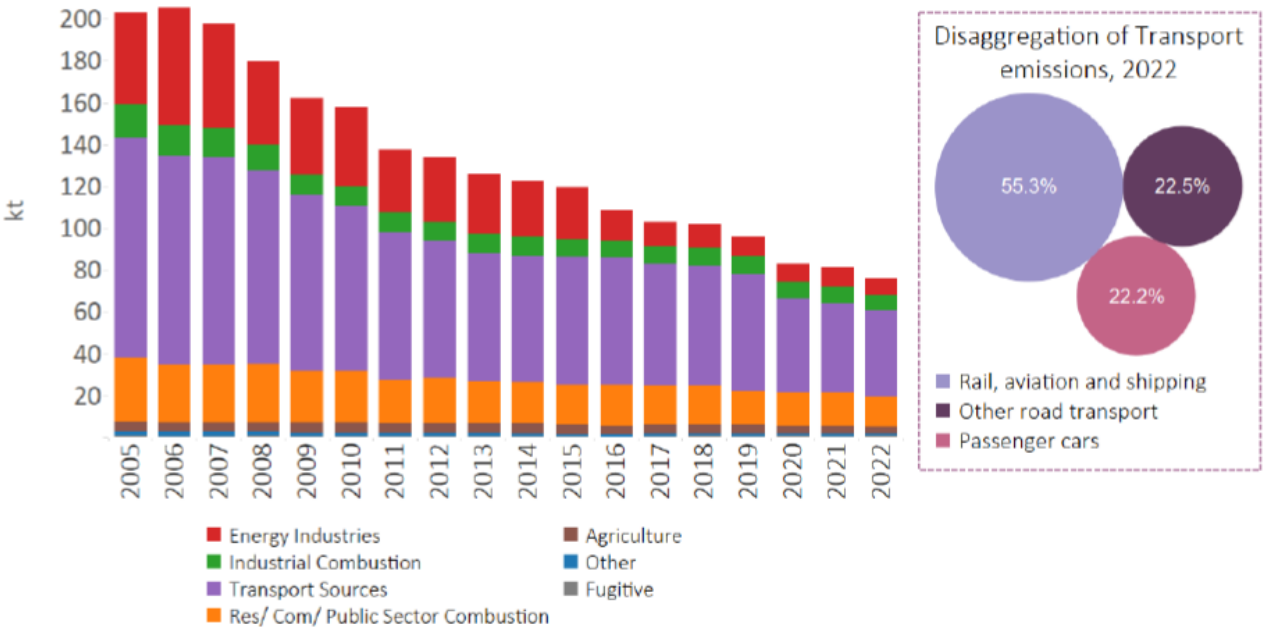



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

## 9.3 NOX EMISSION ESTIMATES FOR SCOTLAND 2005 - 2022

Figure 9.2 provides a summary of $NO_x$ emission estimates for Scotland by category. The detailed data are available in the report and website citied in the introduction to this chapter.

**Figure 9-2 Scotland $NO_x$ emissions 2005-2022**

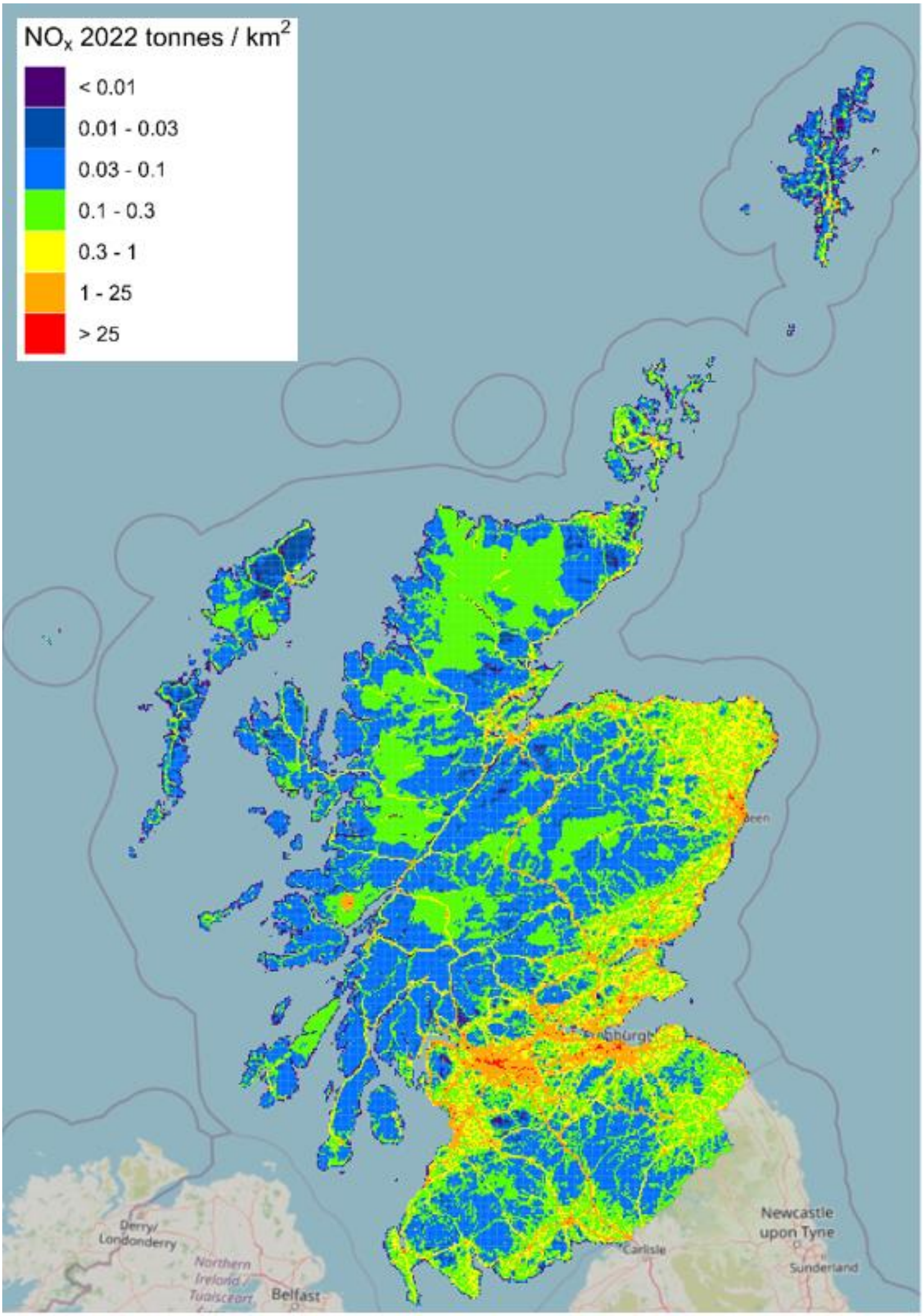



*Units: kilotonnes (kt)*
*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of nitrogen oxides in Scotland were estimated to be 76 kt in 2022, representing 12% of the UK total for nitrogen oxides. Emissions have declined by 63% since 2005, mainly due to changes in transport sources, particularly in road transport. This decline is driven by the successive introduction of tighter Euro emission standards, and the continued penetration of vehicles which comply with these standards. In addition, improvements in catalyst repair rates resulting from regulations controlling the sale and installation of replacement catalytic converters and particle filters for light-duty vehicles contributes to the decline since 2008. However, the recent preferred uptake of diesel cars over petrol cars partly offsets these emissions reductions because diesel cars emit higher $NO_X$ relative to their petrol counterparts. The peak in $NO_X$ emissions in 2006 is due to the increased use of coal at power stations that year. There was also a small increase in coal-fired generation in 2012 due to a UK-wide shift in the fuel mix used for power generation from gas to coal in that year. Energy industry emissions have declined across the time series, linked to Boosted Over-Fire Air (BOFA) abatement systems which were fitted to all four of Longannet's units, to reduce $NO_X$ emissions from coal-fired generation by up to 25%. BOFA systems were also fitted on all four units at Cockenzie power station which then closed in 2013. Longannet power station closed in March 2016 marking the end of coal combustion for power generation in Scotland and causing a step-change in emissions between 2015 and 2016. $NO_X$ emissions decreased by 7% between 2021 and 2022, with a 4% decrease in emissions in this period from the transport sector. 55% of the $NO_X$ emissions were due to the transport sector in 2022. In addition, emissions from power stations decreased by 22% between 2021 and 2022. This sector contributed 36% of NOx emissions in Scotland in 2022.

Figure 9-3 shows a map of Scotland's NOx emissions in 2022.

**Figure 9-3 Map of $NO_x$ Emissions in Scotland, 2022**

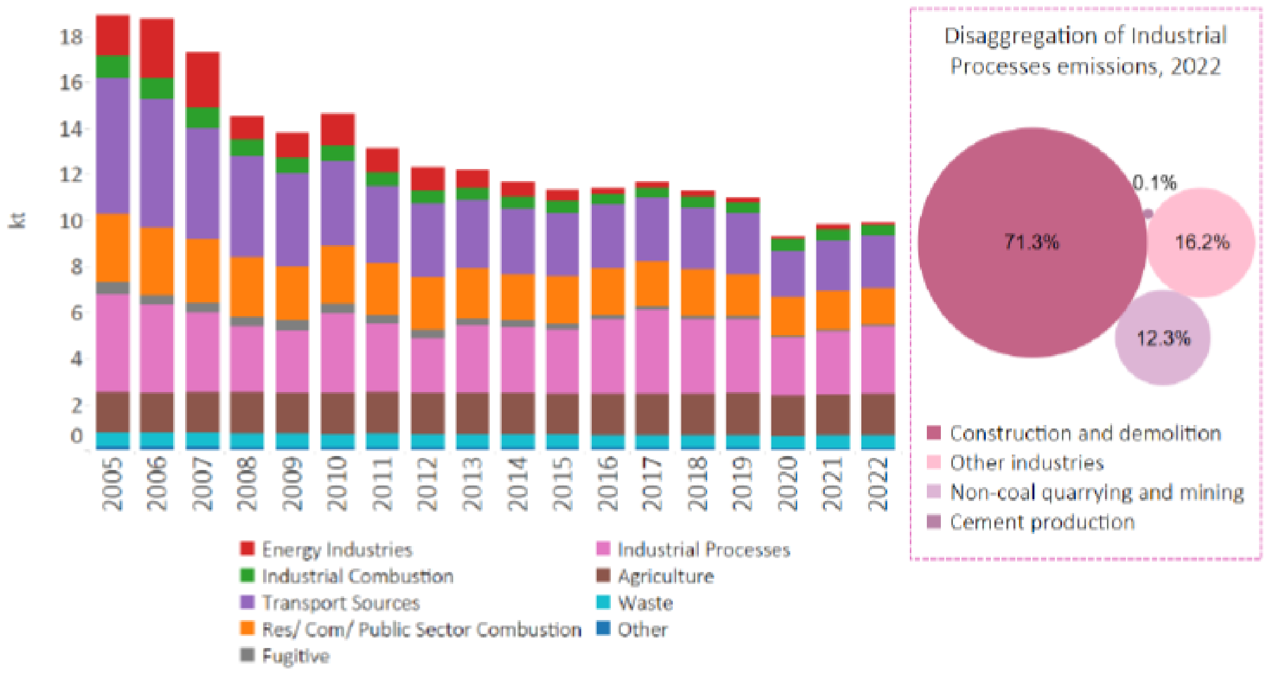



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

## 9.4 $PM_{10}$ EMISSIONS IN SCOTLAND

Figure 9-4 provides a summary of $PM_{10}$ emission estimates for Scotland by category. The detailed data are available in the report and website cited in the introduction to this Chapter.

**Figure 9-4 Scotland $PM_{10}$ emissions 2005-2022**



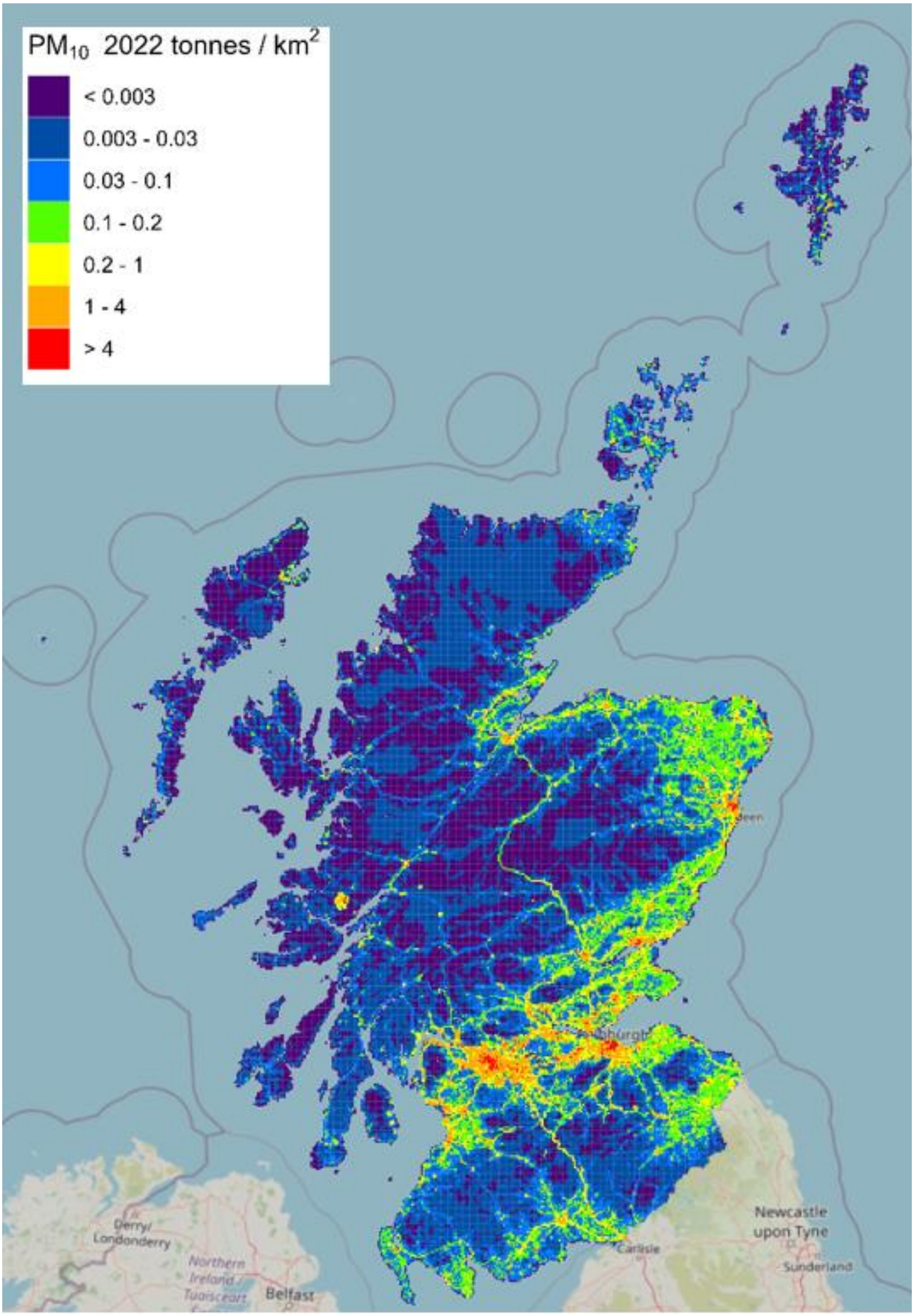

*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of $PM_{10}$ in Scotland were estimated to be 10 kt in 2022, declining by 48% since 2005. These emissions account for 8% of the UK total $PM_{10}$ emissions. Unlike most other pollutants, the emissions profile of $PM_{10}$ is diverse. In order of % contribution to emissions in 2022, these sources include: industrial processes (30%), transport sources (23%), and residential combustion (12%). Emissions from industrial processes are dominated by other industries which aggregates a large number of industrial sectors such as other chemical industry, construction and demolition, aluminium production and wood processing. The reduction in emissions over the time series is primarily due to abatement at coal-fired stations, the increase in nuclear and renewable energy sources and the increase in the use of natural gas in energy generation (which has negligible $PM_{10}$ emissions) in place of coal, as well as the continued increasing share of renewables in the energy mix. $PM_{10}$ exhaust emissions from diesel-fueled vehicles have been decreasing due to the continued fleet penetration of vehicles complying with more recent and more stringent Euro emissions standards. Increasingly non-exhaust sources of $PM_{10}$ (for example tyre wear) have become more important to consider as exhaust $PM_{10}$ has been reduced. In fact, in 2022, 89% of emissions from the road transport sector were related to non-exhaust sources. In recent years, emissions from the residential and other combustion sector have slightly increased, and this is due to an increasing quantity of wood fuel use, primarily in the residential sector.

$PM_{10}$ emissions increased by 1.2% between 2021 and 2022, led by increases in several sectors including construction and demolition with a 7% increase and the transport sector with a 4% increase. In contrast, $PM_{10}$ emissions from power stations decreased by 39% between 2021 and 2022.

Figure 9-5 shows a map of Scotland's $PM_{10}$ emissions in 2022.

**Figure 9-5 Map of $PM_{10}$ Emissions in Scotland, 2022**

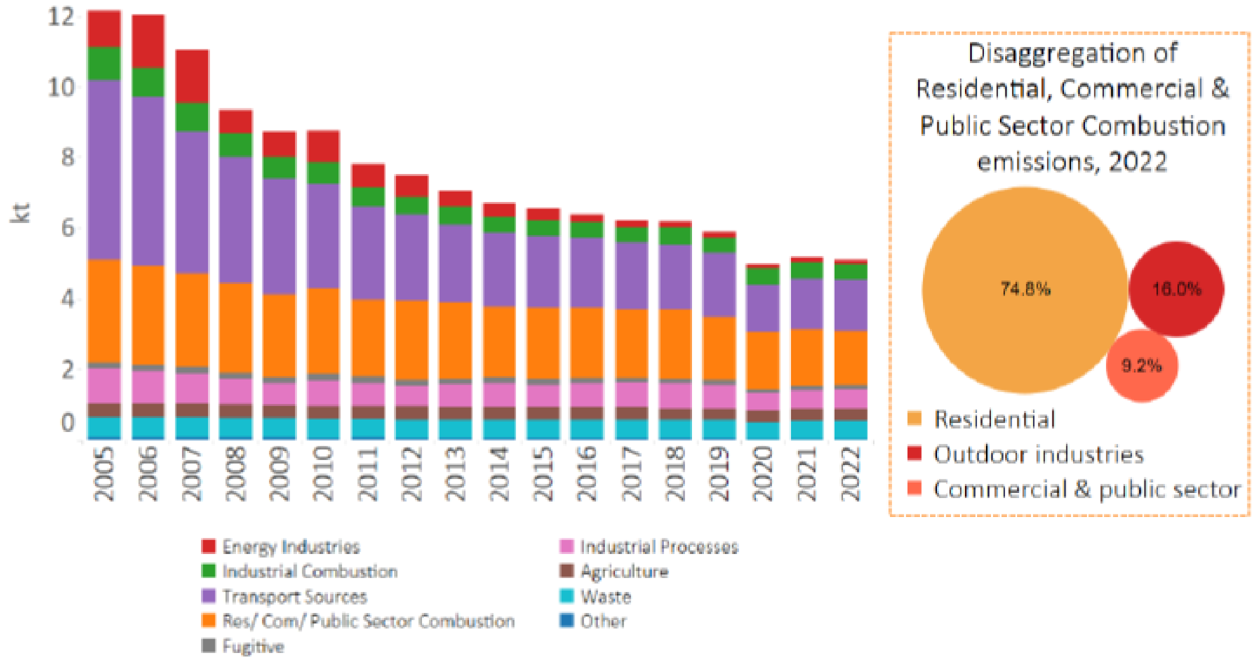



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

## 9.5 $PM_{2.5}$ EMISSIONS IN SCOTLAND

Figure 9-6 provides a summary of $PM_{2.5}$ emission estimates for Scotland by category. The detailed data are available in the report and website citied in the introduction to this chapter.

**Figure 9-6 Scotland $PM_{2.5}$ emissions 2005-2022**



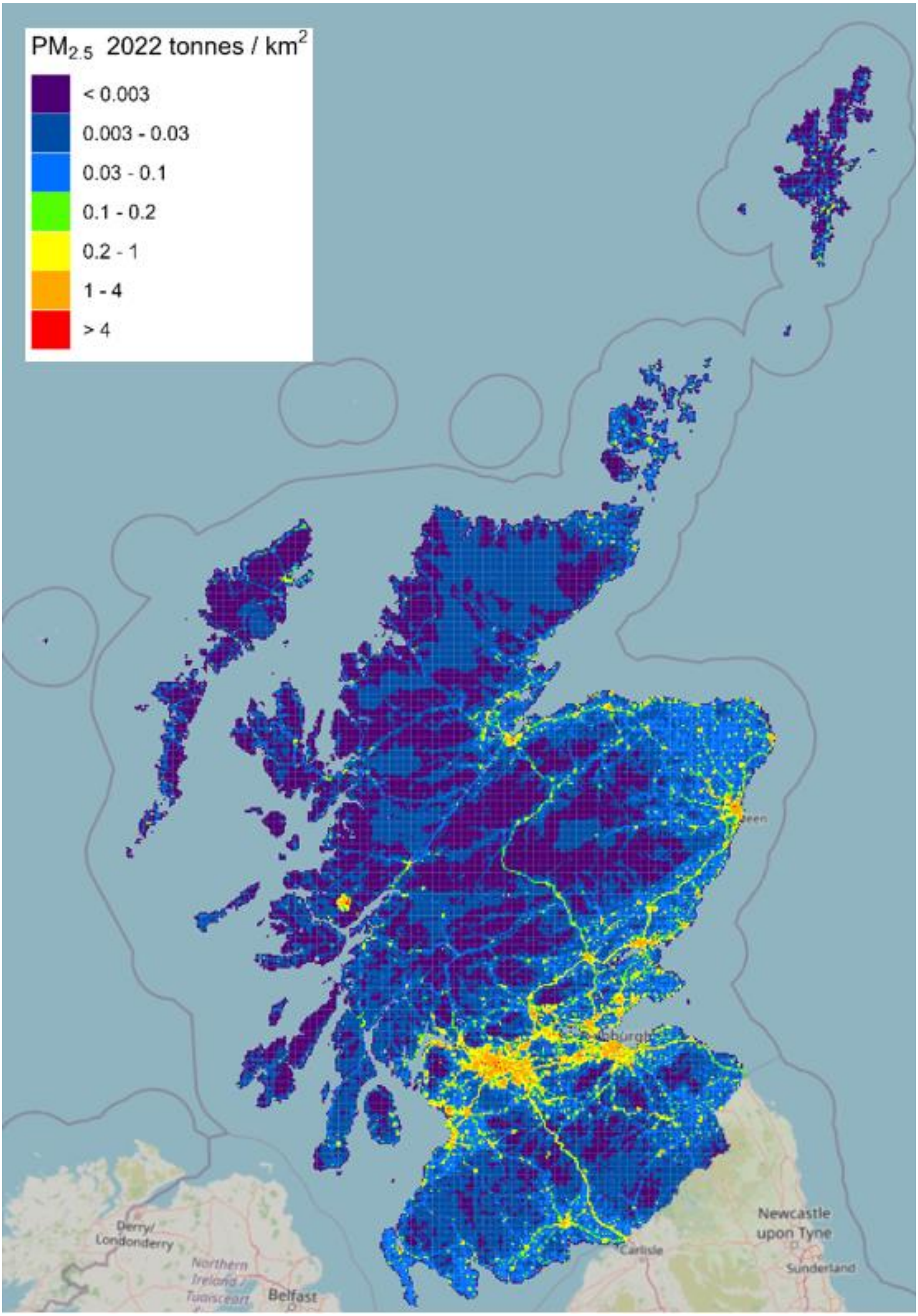

*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of $PM_{2.5}$ in Scotland were estimated to be 5 kt in 2022, declining by 58% since 2005. These emissions account for 8% of the UK total for $PM_{2.5}$ in 2022. As with $PM_{10}$, $PM_{2.5}$ emissions have a large number of significant sources. However, process emissions tend to produce coarser PM fractions and as such, combustion emissions are of greater importance for $PM_{2.5}$ compared to $PM_{10}$. For $PM_{2.5}$, the residential, commercial, and public sector combustion category accounts for 30% of 2022 emissions. The primary drivers for the decline in emissions since 2005 are the continued switch from coal to natural gas in electricity generation, and reductions in emissions from the transport sector due to the introduction of progressively more stringent emissions standards through time.

$PM_{2.5}$ emissions decreased by 1.9% between 2021 and 2022, led by increases in several sectors. From 2021 to 2022, $PM_{2.5}$ emissions decreased by 39% from the energy sector (power stations), which contributes 73% of the overall $PM_{2.5}$ trend in 2021 to 2022. There was also a 3% increase in emissions from the transport sector from 2021-2022.

Figure 9-7 shows a map of Scotland's $PM_{2.5}$ emissions in 2022.

**Figure 9-7 Map of $PM_{2.5}$ Emissions in Scotland, 2022**

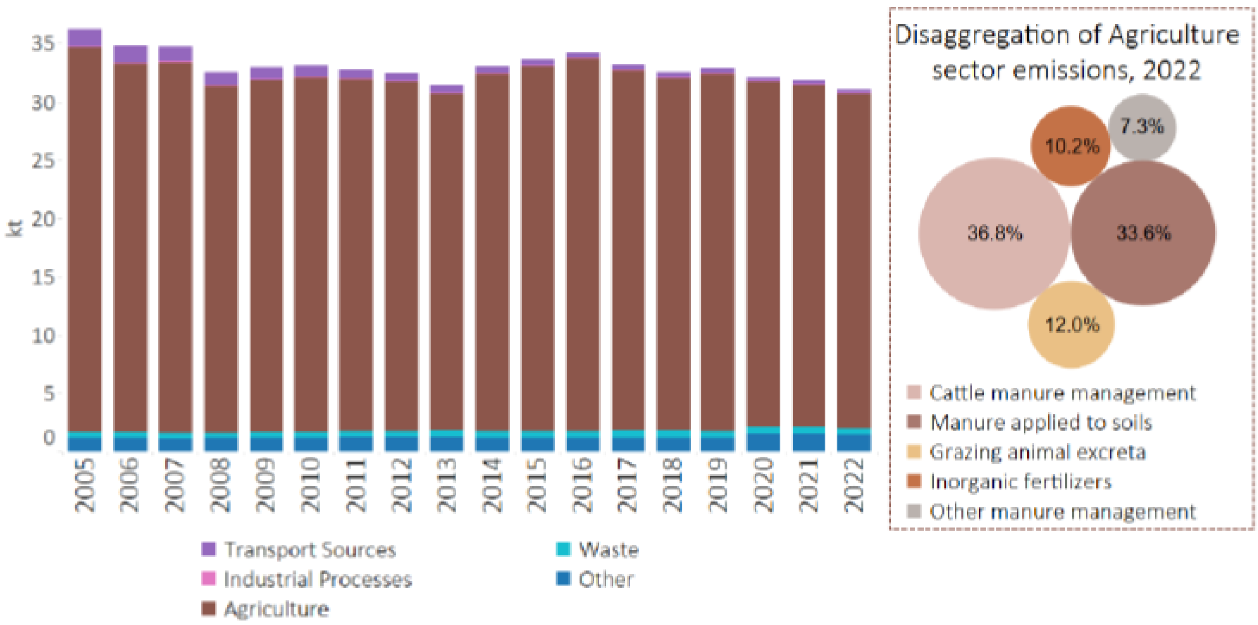



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

## 9.6 AMMONIA EMISSIONS IN SCOTLAND

Figure 9-8 provides a summary of ammonia emission estimates for Scotland by category. The detailed data are available in the report and website citied in the introduction to this chapter.

**Figure 9-8 Scotland Ammonia emissions 2005-2022**



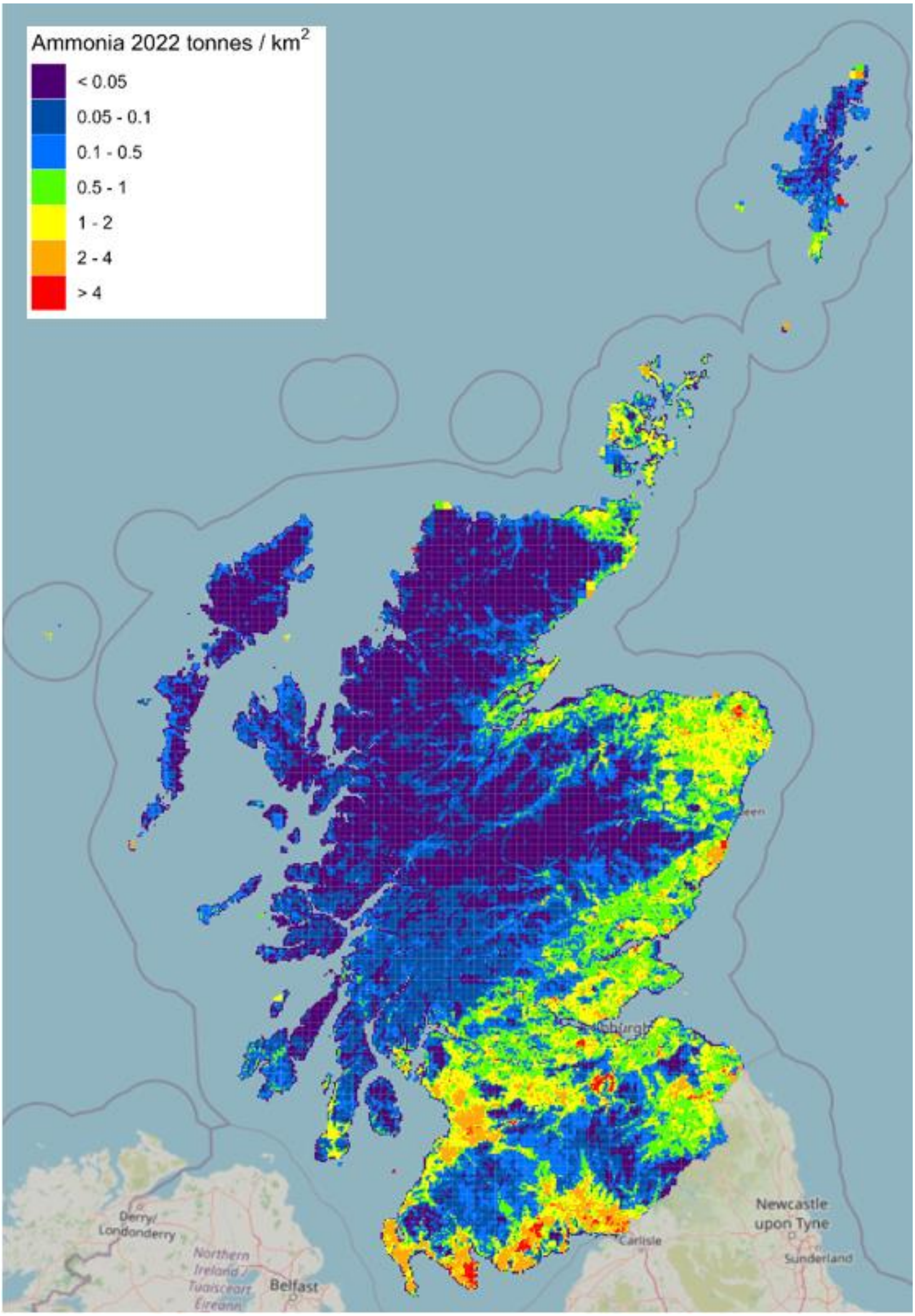

*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of ammonia in Scotland were estimated to be 31 kt in 2022. These emissions have declined by 14% since 2005 and accounted for 12% of the UK total for ammonia in 2022. Agriculture sources have dominated the inventory throughout the time series, with cattle manure management accounting for 34% of the emissions from this sector in 2022. The initial trends in $NH_3$ emissions were primarily driven by decreases in livestock numbers (except for poultry) and declines in the use of nitrogen-based fertilisers. After 2010, however, the decline began to be offset by increased application of urea-based and organic fertilisers such as digestate to agricultural soils causing fluctuating emissions totals since 2008, with no significant trends across these years.

In 2022, ammonia emissions decreased by 2.4% since 2021, largely due to a reduction in nitrogen fertiliser use.

Figure 9-9 shows a map of Scotland's ammonia emissions in 2022.

**Figure 9-9 Map of Ammonia Emissions in Scotland, 2022**

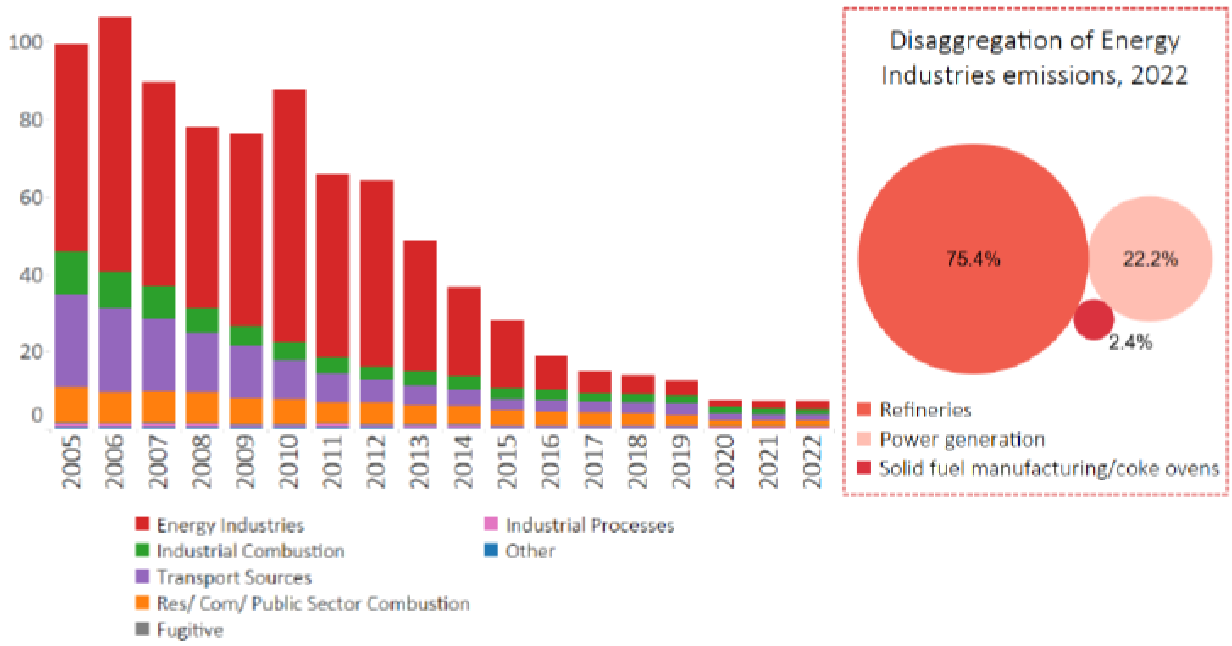



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2021*

## 9.7 $SO_2$ EMISSIONS IN SCOTLAND

Figure 9-10 provides a summary of sulphur dioxide ($SO_2$) emission estimates for Scotland by category. The detailed data are available in the report and website citied in the introduction to this chapter.

**Figure 9-10 Scotland $SO_2$ Emissions 2005-2022**



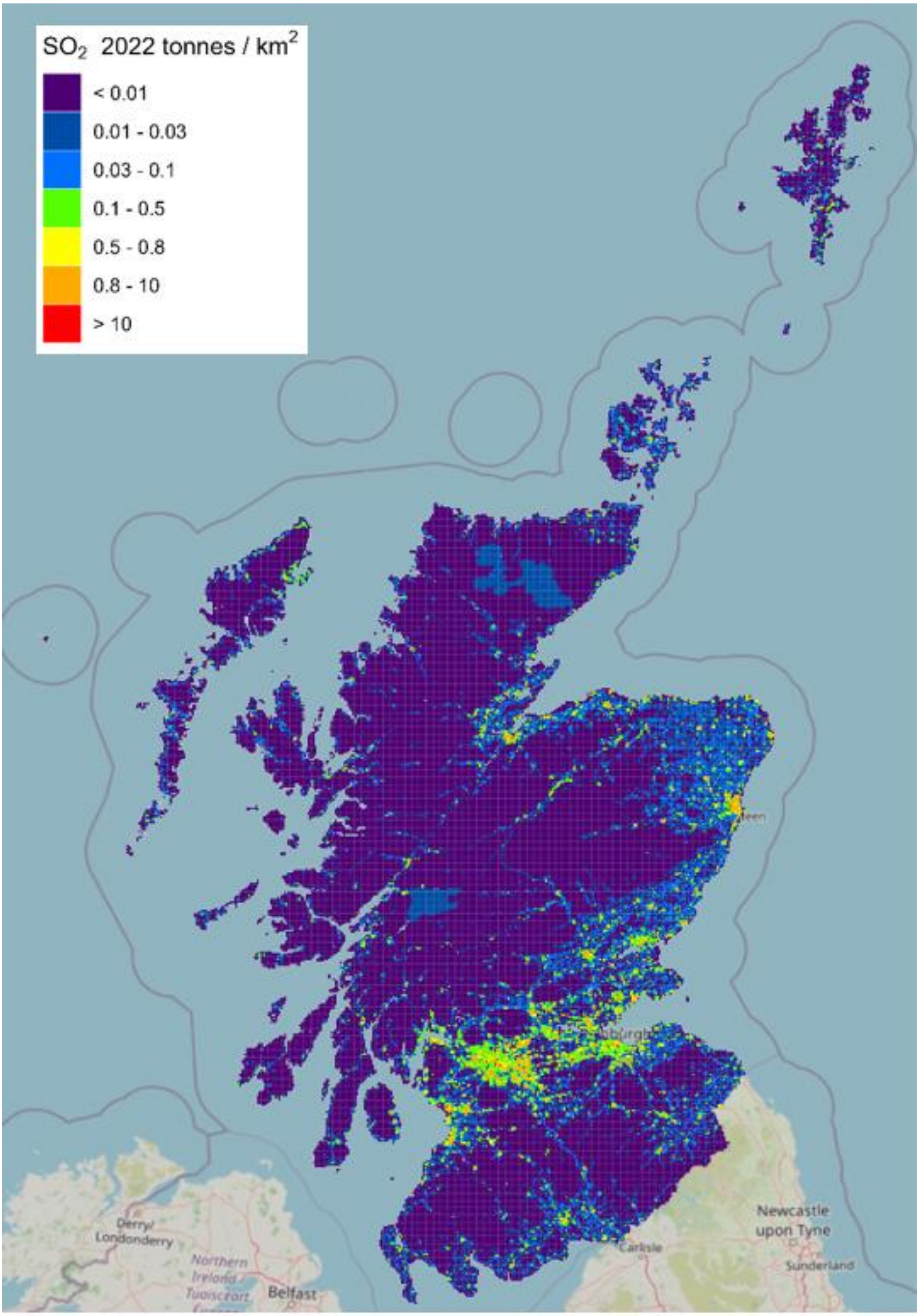

*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of sulphur dioxide in Scotland were estimated to be 7 kt in 2022, representing 6% of the UK total in 2022 for sulphur dioxide. Emissions have declined by 93% since 2005 because of continued changes in the power generation sector. Since 2005, $SO_2$ emissions from power stations have reduced by 99%. Such changes include the reduction in coal fired power relative to other sources; improved emission controls on some large coal fired plants such as the installation of an FGD (flue-gas desulphurization) plant at Longannet power station; the use of coal of lower sulphur content in later years to Cockenzie before its closure in March 2013, and finally the complete cessation of coal combustion for power generation in Scotland in 2016 after the closure of Longannet.

In 2022, $SO_2$ emissions decreased by 0.1% since 2021, which is driven by a 20% decrease in emissions from power stations.

Figure 9-11 shows a map of $SO_2$ emissions in Scotland for 2021.

**Figure 9-11 Map of $SO_2$ Emissions in Scotland, 2022**

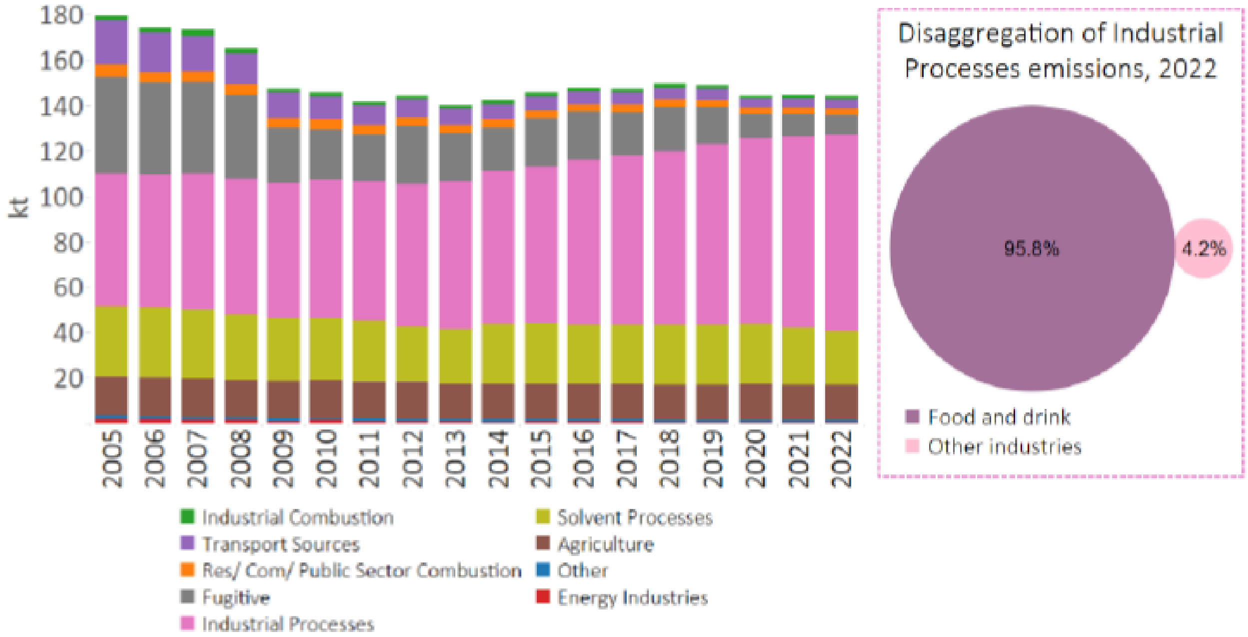



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

## 9.8 NMVOC EMISSIONS IN SCOTLAND

Figure 9-12 provides a summary of Non- Methane Volatile Organic Compounds (NMVOC) emission estimates for Scotland by category. The detailed data are available in the report and website citied in the introduction to this chapter.

**Figure 9-12 NMVOC Emissions in Scotland**

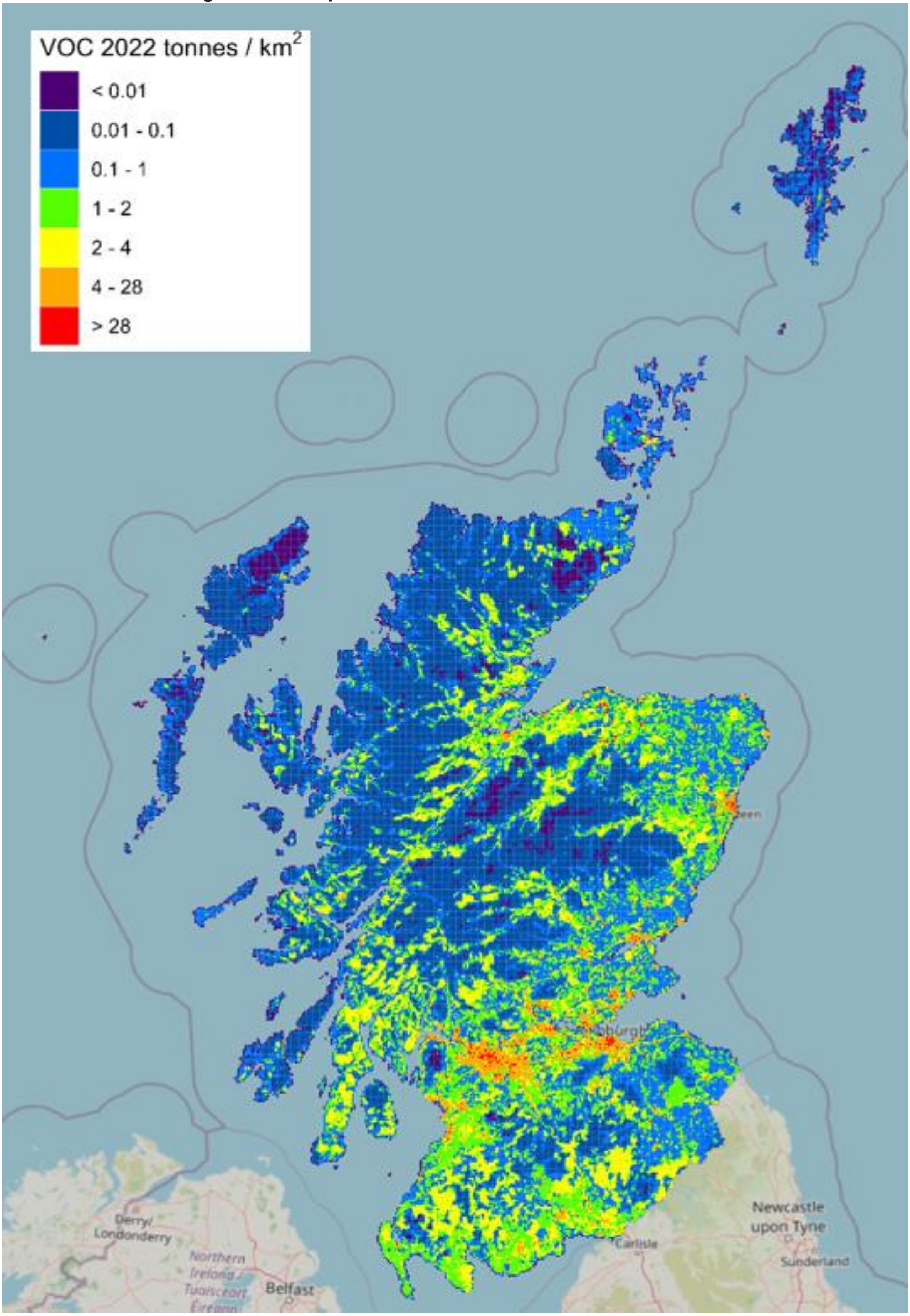



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of non-methane volatile organic compounds in Scotland were estimated to be 144 kt in 2022, representing 19% of the UK total for NMVOCs. Emissions have declined by 20% since 2005. This reduction is a result of reductions in fugitive and road transport emissions which have each declined 85% since 2005. The decrease in road transport account for 41% of the overall NMVOC trend. The declining trend seen in fugitive emissions is due to the decrease in emissions from the exploration, production, and transport of oil, specifically emissions from the onshore loading of oil (note offshore emissions are not allocated to the DAs). The decrease between 2008 and 2009 was due to reductions in fugitive NMVOC emissions from oil loading at the Sullom Voe terminal in Shetland. Emissions from the food and drink industry (which accounts for around 58% of NMVOC emissions in Scotland in 2022) have increased since 2009 due to the increased production and storage of whisky. In total, spirit manufacture contributed approximately 56% of NMVOC emissions in Scotland in 2022. Emissions from road transport sources, including evaporative losses of fuel vapour from petrol vehicles have also declined over time due to emission control technologies that have progressively been introduced in new petrol vehicles since the early 1990s. The reduction in emissions also occurs to a lesser extent due to the introduction of petrol vapour recovery systems at filling stations. Between 2021 and 2022, emissions of NMVOCs increased by 3.9%, which is largely driven by the 3% increase in emissions from the food and drink industry. The 3% increase in the food and drink industry accounted for 46% of the overall trend in NMVOC emissions observed in 2021-2022.

Figure 9-13 shows a map of NMVOC emissions in Scotland for 2022.

**Figure 9-13 Map of NMVOC Emissions in Scotland, 2022**

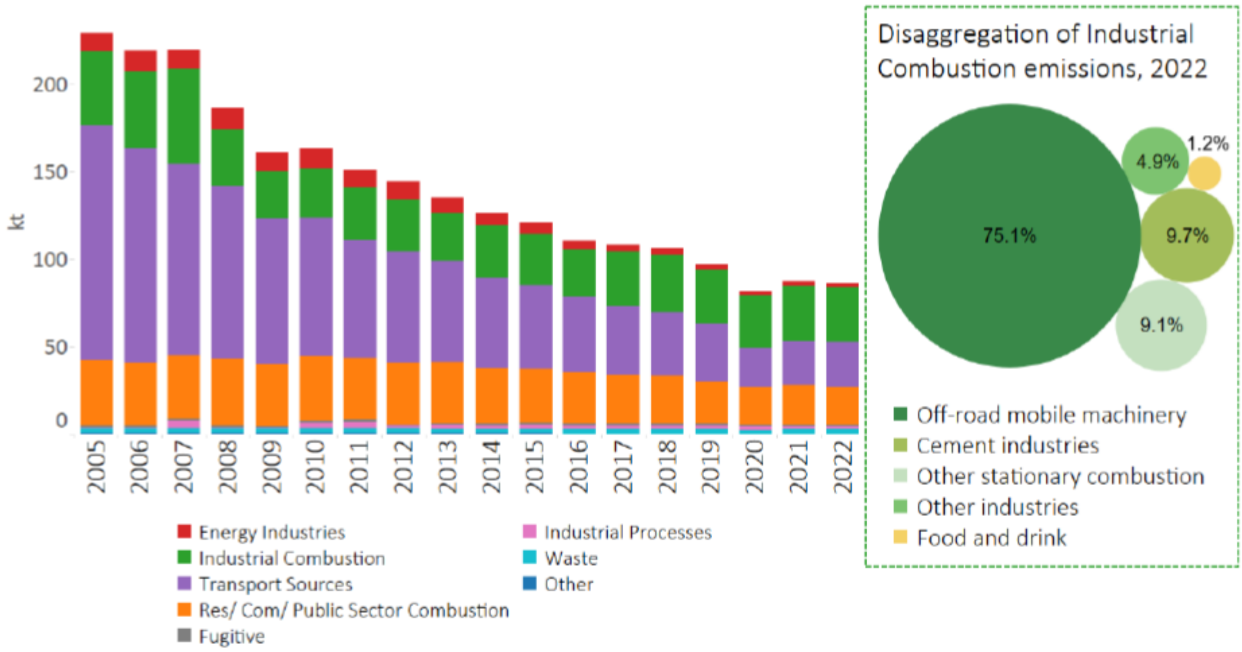



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

## 9.9 CO EMISSIONS IN SCOTLAND

Figure 9-14 provides a summary of Carbon Monoxide (CO) emission estimates for Scotland by category. The detailed data are available in the report and website citied in the introduction to this chapter.

**Figure 9-14 CO Emissions in Scotland**



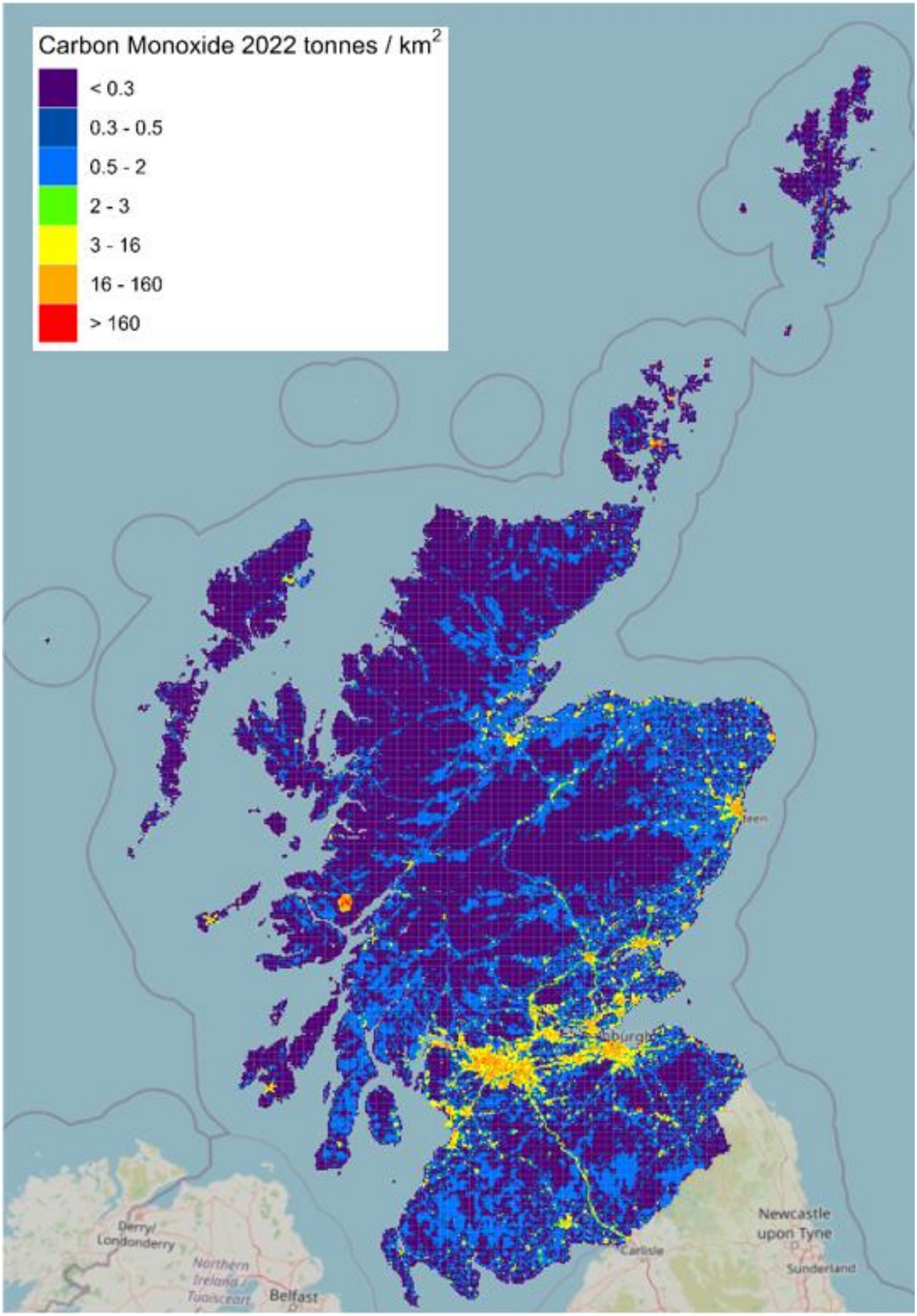

*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of carbon monoxide in Scotland were estimated to be 86 kt in 2022 and have declined by 62% since 2005. Emissions in Scotland accounted for 7% of the UK total for carbon monoxide in 2022. This decline in emissions stems from changes in the contribution of transport sources, particularly in the road sector where emissions have declined by 85% since 2005 (contributing to 73% of the national trend in CO emissions). This decline is primarily due to the increased proportion in the fleet of vehicles compliant with more recent Euro standards, which required the fitting of emission controls (e.g. three-way catalytic converters) in new petrol vehicles. Improved catalyst repair rates resulting from regulations controlling the sale and installation of replacement catalytic converters and particle filters for light-duty vehicles in 2008 also contribute to the trend. More recently, the switch from petrol cars to diesel cars, which have lower associated CO emissions rates, has also contributed to the observed trend.

CO emissions decreased by 1% between 2021 and 2022, with road transport emissions decreasing by 1.7% in this period.

Figure 9-15 shows a map of CO emissions in Scotland for 2022.

**Figure 9-15 Map of CO Emissions in Scotland, 2022**




*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

# 10. SUMMARY AND CONCLUSIONS

In April 2007, Ricardo was commissioned by the Scottish Government to undertake a three-year project to develop an Air Quality Database and Website for Scotland. This contract has been renewed in consecutive years, with the latest contract running from 2019-2024 (including extensions).

This report brings together all the Scottish Air Quality Database data for calendar year 2022 and associated work relating to project deliverables including: data management; QA/QC services; liaison with stakeholders; website development; spatial analysis of air quality data; trend analysis.

In addition, this year's report provides updated analysis on how the Covid-19 pandemic affected air quality in Scotland. This analysis follows on from the 2021 annual report Covid-19 analysis.

### Legislation and Policy

Air quality management is shaped by requirements of EU, UK and Scottish legislation and policies. Following the UK's exit from the EU, under retained EU law, Scotland is required to continue to meet limit and target values for a range of air pollutants and other legal obligations covered by EU directives.

In July 2021, accompanied by a Delivery Plan, and replacing "Cleaner Air for Scotland – The Road to a Healthier Future", the Scottish Government published Scotland's second air quality strategy called "Cleaner Air for Scotland 2 – Towards a Better Place for Everyone" (CAFS2). CAFS2 is shaped around 10 general themes. These are:

1. Health – A Precautionary Approach
2. Integrated Policy
3. Placemaking
4. Data
5. Public Engagement and Behavioural Change
6. Industrial Emissions Regulation
7. Tackling Non-Transport Emission Sources
8. Transport
9. Governance, Accountability and Delivery
10. Further Progress Review

### Air Quality Monitoring in Scotland

Air pollution data for 99 automatic monitoring sites throughout Scotland are available in the database for all or part of 2023. All automatic data maintained within the Scottish database are subject to the same QA/QC procedures as the UK Automatic Urban and Rural Network (AURN).

In 2023, no automatic monitoring site exceeded the annual mean or hourly Air Quality Strategy (AQS) objectives for $NO_2$. In 2023, four passive diffusion tube monitoring sites exceeded the $NO_2$ annual mean objective. These were located in Glasgow and Edinburgh.

In 2023, only one automatic monitoring site (Peth Atholl Street) measuring Particulate Matter ($PM_{10}$) measured exceedances of the Scottish 24 hour and annual mean AQS objectives for $PM_{10}$. The reason was due to continued period of construction work next to the site.

In 2023 no sites measuring Particulate Matter ($PM_{2.5}$) exceeded the AQS objectives.

In 2023, no exceedances of AQS objectives were observed for the pollutants ozone ($O_3$), sulphur dioxide ($SO_2$), carbon monoxide (CO), benzene, 1,3-butadiene, benzo(a)pyrene, and lead (Pb).

In 2023, of the eleven sites measuring ozone in Scotland, six exceeded the AQS objective (100 $\mu gm^{-3}$ not to be exceeded more than 10 times a year (8 hourly running mean)).

### Air Quality Mapping of Scotland

The 2022 annual mean $NO_2$ concentrations for Scotland were modelled for background and roadside locations for $NO_2$, $PM_{10}$ and $PM_{2.5}$.

For $NO_2$, there were no modelled exceedances of the Scottish annual mean objective of 40 $\mu g\ m^{-3}$ at background or roadside locations.

For $PM_{10}$, there were no modelled exceedances of the Scottish annual mean $PM_{10}$ objective of 18 µg $m^{-3}$ at background or roadside locations.

For $PM_{2.5}$, there were also no modelled exceedances of the Scottish annual mean $PM_{2.5}$ objective of 10 µg $m^{-3}$ at both background and roadside locations.

## Air Quality Trends for Scotland

### *$NO_2$*

All $NO_2$ urban background sites analysed display statistically highly significant decreasing trends (at the 0.001 level) since 2007 which is consistent with the last five years trend. The exception to this is Grangemouth where the trend has switched to not statistically significant increasing trend.

All three rural sites show small but highly significant decreasing trends over the last 10 years. Over the last five years the trend has plateaued.

For urban traffic sites the trend shows highly significant decreasing trends of the 10-year trend. For the last five-year trend in general is the same but to lesser extent.

### *$PM_{10}$*

All $PM_{10}$ Background sites analysed show significant decreasing trends at varying levels. The exception to this is Glasgow Anderston when looking at the five-year trend.

Urban traffic $PM_{10}$ sites analysed over 10-years again show significant decreasing trends with the exception of Byres Road. The 5-year trend shows that the levels are plateauing with the exception of Glasgow Byres Road which is now showing highly significant decreasing trends in recent years.

### $PM_{2.5}$

In general, 10-year trend analysis of $PM_{2.5}$ sites data show a decreasing trend at varying level of statistical significancy. The five-year trend analysis indicates that levels are plateauing with concentrations general levelling out or showing small decreasing or increasing trends but not statistically significant.

### *Ozone*

Three of Scotland's rural air quality monitoring stations have been monitoring ozone for 32 years. Two of these sites show small but highly statistically significant increasing trends over this period. The other shows a level trend over this period.

10-year trends at six ozone sites, shows that four sites have increasing trends in $O_3$ concentrations at varying levels of statistical significance. The other two sites have slight decreasing trends with no statistical significance.

## Additional Trend Analysis

Additional trend analysis was carried out at four sites located within the four major cities in Scotland. This analysis was carried out using the Openair analysis tool and compared 2023 data with data from the previous 10 years using a variety of analytical techniques.

## Emissions of Pollution Species

Emissions of **nitrogen oxides** in Scotland were estimated to be 76 kt in 2022, representing 12% of the UK total for nitrogen oxides. Emissions have declined by 63% since 2005, mainly due to changes in transport sources. $NO_x$ emissions decreased by 7% between 2021 and 2022, with a 4% decrease in emissions in this period from the transport sector. 55% of the emissions were due to the transport sector in 2022. Emissions from power stations decreased by 22% between 2021 and 2022.

Emissions of **$PM_{10}$** in Scotland were estimated to be 10 kt in 2022, declining by 48% since 2005. These emissions account for 8% of the UK total $PM_{10}$ emissions. $PM_{10}$ emissions increased by 1.2% between 2021 and 2022, led by increases in several sectors including construction and demolition (7% increase) and the transport sector (4% increase). In contrast, $PM_{10}$ emissions from power stations decreased by 39% between 2021 and 2022.

Emissions of **$PM_{2.5}$** in Scotland were estimated to be 5 kt in 2022, declining by 58% since 2005. These emissions account for 8% of the UK total for $PM_{2.5}$ in 2022. The primary drivers for the decline in emissions since 2005 are the continued switch from coal to natural gas in electricity generation, and reductions in emissions from the transport sector. $PM_{2.5}$ emissions decreased by 1.9% between 2021 and 2022. From 2021 to 2022, $PM_{2.5}$ emissions decreased by 39% from the energy sector (power stations), which contributes 73% of the overall $PM_{2.5}$ trend in 2021 to 2022. There was also a 3% increase in emissions from the transport sector from 2021-2022.

Emissions of **ammonia** in Scotland were estimated to be 31 kt in 2022. These emissions have declined by 14% since 2005 and accounted for 12% of the UK total for ammonia in 2022. Agriculture sources dominate the inventory. The initial trends in $NH_3$ emissions were primarily driven by decreases in livestock numbers and declines in the use of nitrogen-based fertilisers. In 2022, ammonia emissions decreased by 2.4% since 2021, largely due to a reduction in nitrogen fertiliser use.

Emissions of **sulphur dioxide** in Scotland were estimated to be 7 kt in 2022, representing 6% of the UK total in 2022 for sulphur dioxide. Emissions have declined by 93% since 2005 because of continued changes in the power generation sector. Since 2005, $SO_2$ emissions from power stations have reduced by 99%. In 2022, $SO_2$ emissions decreased by 0.1% since 2021, which is driven by a 20% decrease in emissions from power stations.

Emissions of **carbon monoxide** in Scotland were estimated to be 86 kt in 2022 and have declined by 62% since 2005. This decline in emissions stems from changes in the contribution of transport sources. Emissions in Scotland accounted for 7% of the UK total for carbon monoxide in 2022. CO emissions decreased by 1% between 2021 and 2022, with road transport emissions decreasing by 1.7% in this period.

Emissions of **non-methane volatile organic compounds** in Scotland were estimated to be 144 kt in 2022, representing 19% of the UK total for NMVOCs. Emissions have declined by 20% since 2005. This reduction is a result of reductions in fugitive and road transport emissions which have each declined 85% since 2005. Between 2021 and 2022, emissions of NMVOCs increased by 3.9%, which is largely driven by the 3% increase in emissions from the food and drink industry. The 3% increase in the food and drink industry accounted for 46% of the overall trend in NMVOC emissions observed in 2021-2022.

# APPENDICES

# APPENDIX 1 RATIFICATION PROCEDURES

## A1.1 Intercalibration and Audit procedures

The audit and intercalibration procedures adopted by Ricardo Energy & Environment rely upon the principle that a set of recently certified gas cylinders (called "audit gas") is taken to all the stations in a monitoring network. This gas is certified at the Ricardo Energy & Environment Gas Calibration Laboratory. At each station, analyser response to audit gas is recorded to check if the expected concentration (i.e. the certified value for the cylinder) is obtained. The analyser response to audit gas is obtained using calibration factors obtained from the site operator. The audit procedure checks the validity of the provisional data, the correct overall operation of the analyser and the reliability of calibrations undertaken routinely at that station. These site audit procedures are compliant with the requirements of the CEN standard methods of measurement and are used throughout the UK AURN network.

The results of the audit exercises form an integral part of the data management system and are fed directly into the data ratification process. After the audit exercise, data from all the stations visited are traceable to recently calibrated UKAS accredited gas calibration standards (the audit gas).

### A1.1.1 Detailed instrumentation checks

The following instrument functional checks are undertaken at an audit:

- Analyser accuracy and precision, as a basic check to ensure reliable datasets from the analysers.
- Instrument linearity, to check that doubling a concentration of gas to the analyser results in a doubling of the analyser signal response. If an analyser is not linear, data cannot be reliably scaled into concentrations.
- Ozone analyser calibration against a traceable ozone photometer
- Instrument signal noise, to check for a stable analyser response to calibration gases.
- Analyser response time, to check that the analyser responds quickly to a change in gas concentrations.
- Leak and flow checks, to ensure that ambient air reaches the analysers, without being compromised in any way.
- $NO_X$ analyser converter efficiency, via gas phase titration, to ensure reliable operation. The converter must be more than 95% efficient to ensure that the $NO_2$ data are of the required accuracy.
- TEOM $k_0$ evaluation. The factor is used to calculate particulate mass concentrations.
- Particulate analyser flowrates. Any error in the flow through these particulate analysers is directly reflected in an error in the final measure of particulate concentration.
- $SO_2$ analyser hydrocarbon interference, certain hydrocarbons are known to interfere with the $SO_2$ detector.
- Evaluation of site cylinder concentrations, with reference to the certified audit gas taken to the stations. This procedure allows for the correction of data from stations where the site calibration cylinder concentration is slowly changing and for identification of any unstable cylinders that require replacement.
- Assessing changes in local site environment. During the visit, a record of any changes in the site environment, for example any increase or decreased traffic flow due to road layout changes, construction activity, encroachment of the site by vegetation etc.
- Assessment of station infrastructure and operational procedures. Any deficiencies in site infrastructure or operational procedures, which may affect data quality or safe operation of the site, are noted.
- Ensure Local Site Operators (LSO) understand calibration procedures correctly. It is the calibrations by the LSOs that are used to scale pollution datasets and hence, it is important to check that these are undertaken reliably.

The procedures used to determine instrument performance are documented in Ricardo Energy & Environment Work Instructions. These methods are regularly updated and improved and have been evaluated by the United Kingdom Accreditation Service (UKAS). Tests are performed on the analysers, cylinders and ambient air inlet systems. Checks are made on the environment around the site, including the continued representative nature of the site and safety assessments. The data collected from the instrument and cylinder tests are collated on site, using a controlled and protected Excel spreadsheet, which automatically undertakes all calculations and alerts the audit staff to any unusual results. The completed spreadsheets are then returned for further checking, before being used within the data management process and in production of accredited Certificates of Calibration.

### A1.1.2 UKAS Accreditation

Ricardo Energy & Environment holds UKAS accreditation to ISO 17025 for the on-site calibration of the gas analysers ($NO_X$, CO, $SO_2$, $O_3$), for flow rate checks on particulate ($PM_{10}$) analysers and for the determination of the spring constant, $k_0$, for the TEOM analyser.

ISO17025 accreditation provides complete confidence that the analyser calibration factors are traceable to national metrology standards, that the calibration methods are sufficient and fit for purpose, and that the uncertainties are appropriate for data reporting purposes. Ricardo Energy & Environment also holds ISO17025 accreditation for laboratory certification of NO, $NO_2$, CO and $SO_2$ gas cylinders.

### A1.1.3 Zero air

The reliability of the zero-air supply at each station is of fundamental importance in the determination of ambient concentrations. A reference zero air source is held at the Ricardo Energy & Environment Gas Calibration Laboratory, which is traceable to international standards. A transfer standard, checked against this standard, is used to evaluate the site zero sources at the QA/QC audits. The zero-air supply at a site will be either:

- A zero-air cylinder.
- A series of chemical scrubbers, connected to a pumped delivery system.
- A pollutant specific chemical scrubber system to connect directly into the analyser.

### A1.1.4 Ozone Photometers

Ozone photometers are calibrated every six months against the NIST Reference Photometer, held at NPL, before use at the station audits.

## A1.2 Data Acquisition and Processing

The Scottish local authority monitoring stations are polled three times a day to retrieve 15-minute averages of raw output from instruments. This is a balance between regular updating of the database and web site yet minimising the associated telecoms costs. UK National network stations are polled hourly as these data are used for the air quality forecast system.

The data are transmitted via MODEM or internet connection, depending on type of logging system used at the site, and automatically appended to the air quality site database. The results of automatic overnight autocalibration checks are also retrieved and databased. Appropriate scaling factors based on the most recent calibration information are applied to the pollutant measurements to produce concentrations in the relevant units.

From the 15-minute values, the hourly averaged results are calculated. This is the averaging period used for the reporting of both validated and ratified data for all pollutants. Additionally, the 15-minute data files are provided for $SO_2$ to allow direct comparison with the 15-minute objective. Once the raw data from the stations has been acquired the next step in the data management process is data validation.

### A1.2.1 Validation of Data

All incoming data from the monitoring station are automatically screened prior to the release of validated data sets. Experienced staff will check the data daily, to monitor satisfactory data acquisition and to investigate instances of suspect data. This daily checking ensures rapid diagnosis of any instrument malfunctions.

The automatic screening procedures, and the many years of experience held by our team, enables us to ensure that only the highest quality data are released to the Scottish Air Quality Database and Website as validated data.

Should equipment or site problems be identified, it is possible for data management staff to contact the monitoring station manually, in order to access further information. If necessary, the relevant LSO is contacted to undertake further investigation.

## A1.3 Data Ratification

This section provides details of the procedures and the software tools we use for data ratification.

Our software runs a number of protocols to automatically flag data anomalies in the provisional data received from the stations, these are examined in detail during the ratification process. These include identifying the following:

- Negative data
- High data peaks
- Calibrations which are more than 5% different from previous values
- Peaks with a maximum 15-minute concentration significantly above the hourly mean value
- Measurements which are outside the normal range of expected data e.g. elevated ozone concentrations during the winter months
- Long periods of constant or zero concentrations
- Data gaps of more than six hours.

### A1.3.1 Ratification tasks and output

When ratifying data, the following are closely examined:

- Issues that have been flagged up automatically by the software.
- Zero and sensitivity factors used on each day.
- General review of the result to make sure that there are no other anomalies.

### A1.3.2 Ratified Data Checking

Once the data have been initially ratified proforma reports is produced and passed to the data checker The role of the data checker is to:

- Assess if there are any station problems if not the data can be marked as ratified.
- Return the station to the data ratifier if there are any issues requiring further action by the data ratifier.
- Forward the report to the project Quality Circle if there are data quality issues which require a group discussion to resolve.

Following the Quality Circle meeting the data are then corrected if required and uploaded as ratified to the database and web site.

# APPENDIX 2 SITES AUDITED, AND DATA RATIFICATION UNDERTAKEN DURING 2022

A2 1. Air quality site intercalibration and audits conducted during 2022

| Site Name | Winter 2021/22 | Summer 2022 | Site Name | Winter 2021/22 | Summer 2022 |
|---|---|---|---|---|---|
| Aberdeen Anderson Dr | ü | ü | Glasgow Kerbside | ü | ü |
| Aberdeen Errol Park | ü | ü | Glasgow Great Western Road | ü | ü |
| Aberdeen King Street | ü | ü | Glasgow High Street | ü | ü |
| Aberdeen Market Street 2 | ü | ü | Glasgow Nithsdale Road | ü | ü |
| Aberdeen Union Street Roadside~ | ü | ü | Glasgow Townhead | ü | ü |
| Aberdeen Wellington Road | ü | ü | Glasgow Waulkmillglen Reservoir | ü | ü |
| Alloa A907 | ü | ü | Grangemouth | ü | ü |
| Angus Forfar Glamis Road | ü | ü | Grangemouth Moray~ | ü | ü |
| Auchencorth Moss | ü | ü | Grangemouth Moray Scot Gov~ | ü | ü |
| Bush Estate | ü | ü | Inverclyde Greenock A8 | ü | ü |
| Dumbarton Roadside | ü | ü | Inverness* | ü | ü |
| Dumfries | ü | ü | Inverness Academy Street | ü | ü |
| Dundee Broughty Ferry Road | ü | ü | Inverness Academy Street 1st Floor | ü | ü |
| Dundee Lochee Road | ü | ü | Lerwick~ | ü | ü |
| Dundee Mains Loan | ü | ü | N Lanarkshire Airdrie Kenilworth Dr | ü | ü |
| Dundee Meadowside | ü | ü | N Lanarkshire Chapelhall | ü | ü |
| Dundee Seagate | ü | ü | N Lanarkshire Coatbridge Whifflet | ü | - |
| Dundee Whitehall Street | ü | ü | N Lanarkshire Coatbridge Whifflet A725 | ü | ü |

| Site Name | Winter 2021/22 | Summer 2022 | Site Name | Winter 2021/22 | Summer 2022 |
|---|---|---|---|---|---|
| East Ayrshire Kilmarnock St Marnock St | ü | ü | N Lanarkshire Croy | ü | ü |
| East Dunbartonshire Bearsden | ü | ü | N Lanarkshire Kirkshaws | ü | ü |
| East Dunbartonshire Bishopbriggs | ü | ü | N Lanarkshire Motherwell | ü | ü |
| East Dunbartonshire Kirkintilloch | ü | ü | N Lanarkshire Motherwell Adele Street | ü | ü |
| East Dunbartonshire Milngavie | ü | ü | N Lanarkshire Ravenscraig Plantation Rd | ü | ü |
| East Lothian Musselburgh N High St | ü | ü | N Lanarkshire Shawhead Coatbridge | ü | ü |
| Edinburgh Currie | ü | ü | N Lanarkshire Uddingston New Edinburgh Rd | ü | ü |
| Edinburgh Glasgow Road | ü | ü | North Ayrshire Irvine High Street | ü | ü |
| Edinburgh Gorgie Road | ü | ü | Paisley Gordon Street | ü | ü |
| Edinburgh Nicolson Street | ü | ü | Peebles | ü | ü |
| Edinburgh Queensferry Road | ü | ü | Perth Atholl Street | ü | ü |
| Edinburgh Salamander St | ü | ü | Perth Bridgend | ü | ü |
| Edinburgh St John's Road | ü | ü | Perth Crieff | ü | ü |
| Edinburgh St Leonards | ü | ü | Perth Muirton | ü | ü |
| Edinburgh Tower Street | ü | ü | Renfrew Cockels Loan | ü | ü |
| Eskdalemuir | ü | ü | Renfrew Inchinnan Road | ü | ü |
| Falkirk Banknock | ü | ü | Renfrewshire Johnston | ü | ü |
| Falkirk Bo'ness | ü | ü | Shetland Lerwick~ | ü | ü |
| Falkirk Grangemouth MC | ü | ü | South Ayrshire Ayr Harbour | ü | ü |
| Falkirk Grangemouth Zetland Park | ü | ü | South Ayrshire Ayr High St | ü | ü |
| Falkirk Haggs | ü | ü | South Lanarkshire Blantyre | ü | ü |
| Falkirk Hope St | ü | ü | South Lanarkshire Cambuslang | ü | ü |
| Falkirk Main St Bainsford | ü | ü | South Lanarkshire East Kilbride | ü | ü |
| Falkirk West Bridge Street | ü | ü | South Lanarkshire Hamilton | ü | ü |
| Fife Cupar | ü | ü | South Lanarkshire Lanark | ü | ü |
| Fife Dunfermline | ü | ü | South Lanarkshire Raith Interchange 2 | ü | ü |
| Fife Kirkcaldy | ü | ü | South Lanarkshire Rutherglen | ü | ü |
| Fife Rosyth | ü | ü | South Lanarkshire Uddingston | ü | ü |
| Fort William | ü | ü | Stirling Craig's Roundabout | ü | ü |
| Glasgow Abercromby Street | ü | ü | Strath Vaich | ü | ü |
| Glasgow Anderston | ü | ü | West Dunbartonshire Clydebank | ü | ü |
| Glasgow Broomhill | ü | ü | West Lothian Broxburn | ü | ü |
| Glasgow Burgher Street | ü | ü | West Lothian Linlithgow High St 2 | ü | ü |
| Glasgow Byres Road | ü | ü | West Lothian Newton | ü | ü |
| Glasgow Dumbarton Road | ü | ü | | | |

The column headings labelled Q1 – Q4 refer to the quarter periods of the calendar year:

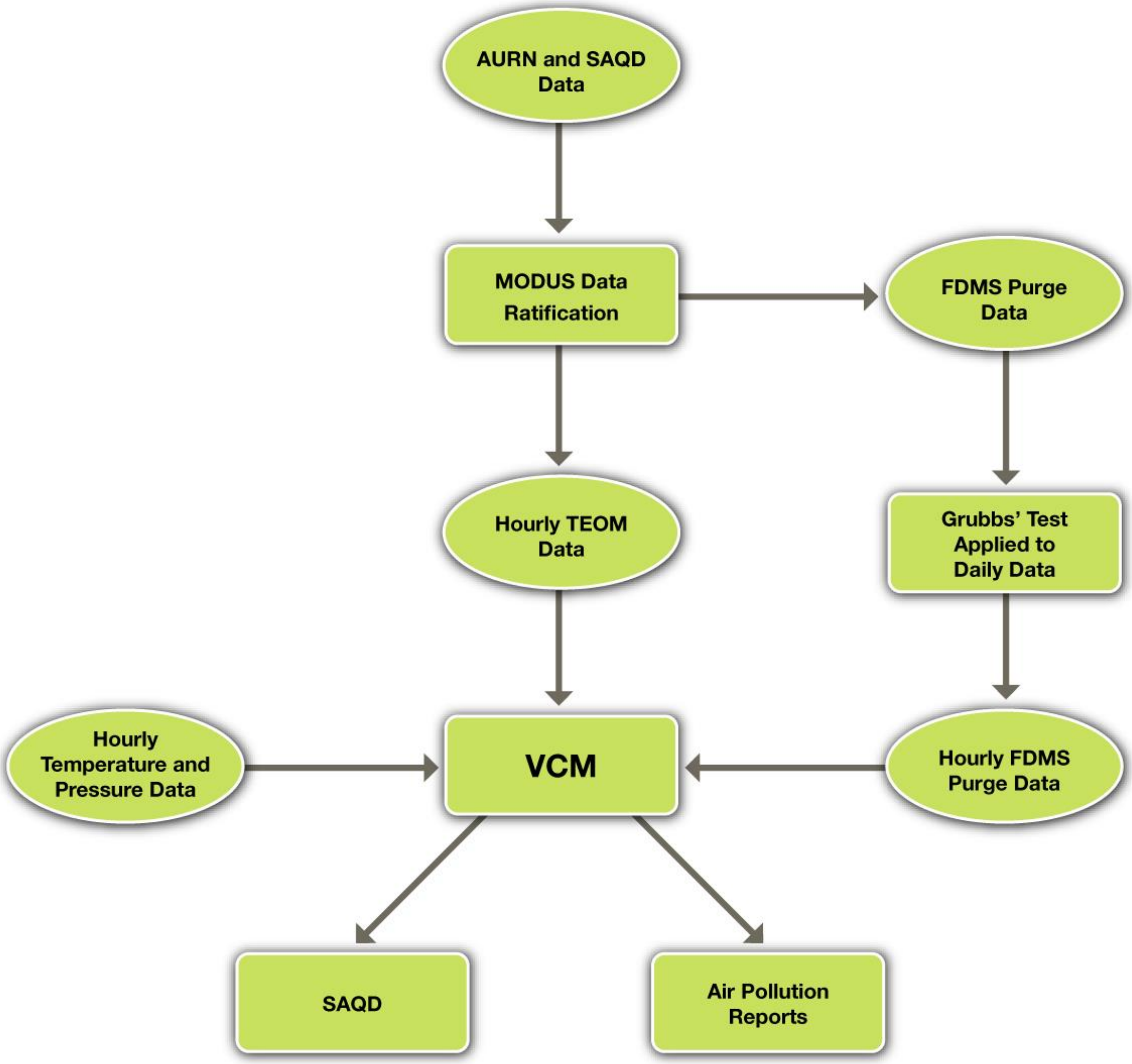
- Q1 = January to March
- Q2 = April to June
- Q3 = July to September
- Q4 = October to December

## A2 2. Data ratification undertaken during 2022

| Site Name | Q1 | Q2 | Q3 | Q4 | Site Name | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|---|---|---|---|---|
| Aberdeen Anderson Dr | ü | ü | ü | ü | Glasgow Great Western Road | ü | ü | ü | ü |
| Aberdeen Errol Park | ü | ü | ü | ü | Glasgow High Street | ü | ü | ü | ü |
| Aberdeen King Street | ü | ü | ü | ü | Glasgow Nithsdale Road | ü | ü | ü | ü |
| Aberdeen Market Street 2 | ü | ü | ü | ü | Glasgow Townhead | ü | ü | ü | ü |
| Aberdeen Union Street Roadside~ | ü | ü | ü | ü | Glasgow Waulkmillglen Reservoir | ü | ü | ü | ü |
| Aberdeen Wellington Road | ü | ü | ü | ü | Grangemouth | ü | ü | ü | ü |
| Alloa A907 | ü | ü | ü | ü | Grangemouth Moray~ | ü | ü | ü | ü |
| Angus Forfar Glamis Road | ü | ü | ü | ü | Grangemouth Moray Scot Gov~ | ü | ü | ü | ü |
| Auchencorth Moss | ü | ü | ü | ü | Inverclyde Greenock A8 | ü | ü | ü | ü |
| Bush Estate | ü | ü | ü | ü | Inverness* | ü | ü | ü | ü |
| Dumfries | ü | ü | ü | ü | Inverness Academy Street | ü | ü | ü | ü |
| Dundee Broughty Ferry Road | ü | ü | ü | ü | Inverness Academy Street 1st Floor | ü | ü | ü | ü |
| Dundee Lochee Road | ü | ü | ü | ü | Lerwick~ | ü | ü | ü | ü |
| Dundee Mains Loan | ü | ü | ü | ü | N Lanarkshire Airdrie Kenilworth Dr | ü | ü | ü | ü |
| Dundee Meadowside | ü | ü | ü | ü | N Lanarkshire Chapelhall | ü | ü | ü | ü |
| Dundee Seagate | ü | ü | ü | ü | N Lanarkshire Coatbridge Whifflet | ü | - | - | - |
| Dundee Whitehall Street | ü | ü | ü | ü | N Lanarkshire Coatbridge Whifflet A725 | ü | ü | ü | ü |
| East Ayrshire Kilmarnock St Marnock St | ü | ü | ü | ü | N Lanarkshire Croy | ü | ü | ü | ü |
| East Dunbartonshire Bearsden | ü | ü | ü | ü | N Lanarkshire Kirkshaws | ü | ü | ü | ü |
| East Dunbartonshire Bishopbriggs | ü | ü | ü | ü | N Lanarkshire Motherwell | ü | ü | ü | ü |
| East Dunbartonshire Kirkintilloch | ü | ü | ü | ü | N Lanarkshire Motherwell Adele Street | ü | ü | ü | ü |
| East Dunbartonshire Milngavie | ü | ü | ü | ü | N Lanarkshire Coatbridge Whifflet A725 | ü | ü | ü | ü |
| East Lothian Musselburgh N High St | ü | ü | ü | ü | N Lanarkshire Ravenscraig Plantation Rd | ü | ü | ü | ü |
| Edinburgh Currie | ü | ü | ü | ü | N Lanarkshire Shawhead Coatbridge | ü | ü | ü | ü |
| Edinburgh Glasgow Road | ü | ü | ü | ü | N Lanarkshire Uddingston New Edinburgh Rd | ü | ü | ü | ü |
| Edinburgh Gorgie Road | ü | ü | ü | ü | North Ayrshire Irvine High Street | ü | ü | ü | ü |
| Edinburgh Nicolson Street | ü | ü | ü | ü | Paisley Gordon Street | ü | ü | ü | ü |
| Edinburgh Queensferry Road | ü | ü | ü | ü | Peebles | ü | ü | ü | ü |
| Edinburgh Salamander St | ü | ü | ü | ü | Perth Atholl Street | ü | ü | ü | ü |
| Edinburgh St John's Road | ü | ü | ü | ü | Perth Bridgend | - | ü | ü | ü |
| Edinburgh St Leonards | ü | ü | ü | ü | Perth Crieff | ü | ü | ü | ü |
| Edinburgh Tower Street | ü | ü | ü | ü | Perth Muirton | ü | ü | ü | ü |
| Eskdalemuir | ü | ü | ü | ü | Renfrew Cockels Loan | ü | ü | ü | ü |
| Falkirk Banknock | ü | ü | ü | ü | Renfrew Inchinnan Road | ü | ü | ü | ü |
| Falkirk Bo'ness | ü | ü | ü | ü | Renfrewshire Johnstone | ü | ü | ü | ü |
| Falkirk Grangemouth MC | ü | ü | ü | ü | Shetland Lerwick~ | ü | ü | ü | ü |
| Falkirk Grangemouth Zetland Park | ü | ü | ü | ü | South Ayrshire Ayr Harbour | ü | ü | ü | ü |
| Falkirk Haggs | ü | ü | ü | ü | South Ayrshire Ayr High St | ü | ü | ü | ü |
| Falkirk Hope Street | ü | ü | ü | ü | South Lanarkshire Blantyre | ü | ü | ü | ü |
| Falkirk Main St Bainsford | ü | ü | ü | ü | South Lanarkshire Cambuslang | ü | ü | ü | ü |
| Falkirk West Bridge Street | ü | ü | ü | ü | South Lanarkshire East Kilbride | ü | ü | ü | ü |
| Fife Cupar | ü | ü | ü | ü | South Lanarkshire Hamilton | ü | ü | ü | ü |
| Fife Dunfermline | ü | ü | ü | ü | South Lanarkshire Lanark | ü | ü | ü | ü |
| Fife Kirkcaldy | ü | ü | ü | ü | South Lanarkshire Raith Interchange 2 | ü | ü | ü | ü |
| Fife Rosyth | ü | ü | ü | ü | South Lanarkshire Rutherglen | ü | ü | ü | ü |

| Site Name | Q1 | Q2 | Q3 | Q4 | Site Name | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|---|---|---|---|---|
| Fort William | ü | ü | ü | ü | South Lanarkshire Uddingston | ü | ü | ü | ü |
| Glasgow Abercromby Street | ü | ü | ü | ü | Stirling Craig's Roundabout | ü | ü | ü | ü |
| Glasgow Anderston | ü | ü | ü | ü | Strath Vaich | ü | ü | ü | ü |
| Glasgow Broomhill | ü | ü | ü | ü | West Dunbartonshire Clydebank | ü | ü | ü | ü |
| Glasgow Burgher Street | ü | ü | ü | - | West Dunbartonshire Glasgow Road | ü | ü | ü | ü |
| Glasgow Byres Road | ü | ü | ü | ü | West Lothian Broxburn | ü | ü | ü | ü |
| Glasgow Dumbarton Road | ü | ü | ü | ü | West Lothian Linlithgow High St 2 | ü | ü | ü | ü |
| Glasgow Kerbside | ü | ü | ü | ü | West Lothian Newton | ü | ü | ü | ü |

## A3.1. Process used for VCM correcting SAQD TEOM data



# APPENDIX 3 NATIONAL MONITORING NETWORKS IN SCOTLAND 2022

## Table A.3 1 AURN Measurement Sites in Scotland 2022

| Site Name | Site Type | Species Measured | Grid Reference |
|---|---|---|---|
| Aberdeen Erroll Park | URBAN BACKGROUND | $NO$ $NO_2$ $NO_x$ $O_3$ $PM_{10}$, $PM_{2.5}$ | 394416,807408 |
| Aberdeen Union St Roadside | ROADSIDE | $NO$ $NO_2$ $NO_x$ | 396345,805947 |
| Aberdeen Wellington Road | ROADSIDE | $NO$ $NO_2$ $NO_x$ | 394397, 804779 |
| Auchencorth Moss | RURAL | $O_3$ $PM_{10}$ $PM_{2.5}$ | 322167, 656123 |
| Bush Estate | RURAL | $NO$ $NO_2$ $NO_x$ $O_3$ | 324626,663880 |
| Dumbarton Roadside | ROADSIDE | $NO$ $NO_2$ $NO_x$ | 240234,675193 |
| Dumfries | ROADSIDE | $NO$ $NO_2$ $NO_x$ | 297012,576278 |
| Dundee Mains Loan | URBAN BACKGROUND | $NO$ $NO_2$ $NO_x$ | 340971, 731892 |
| Edinburgh Nicolson St | ROADSIDE | $NO$ $NO_2$ $NO_x$ | 326150, 673046 |
| Edinburgh St Leonards | URBAN BACKGROUND | $CO$ $NO$ $NO_2$ $NO_x$ $O_3$ $PM_{10}$ $PM_{2.5}$ $SO_2$ | 326265, 673136 |
| Eskdalemuir | RURAL | $NO$ $NO_2$ $NO_x$ $O_3$ | 323552,603018 |
| Fort William | RURAL | $NO$ $NO_2$ $NO_x$ $O_3$ | 210830,774410 |
| Glasgow Great Western Road | ROADSIDE | $NO$ $NO_2$ $NO_x$ | 258007,666651 |
| Glasgow High Street | URBAN TRAFFIC | $NO$ $NO_2$ $NO_x$ $PM_{10}$, $PM_{2.5}$ | 260014,665349 |
| Glasgow Kerbside | KERBSIDE | $NO$ $NO_2$ $NO_x$ $PM_{10}$, $PM_{2.5}$ | 258708,665200 |
| Glasgow Townhead | KERBSIDE | $NO$ $NO_2$ $NO_x$ $PM_{10}$, $PM_{2.5}$ | 259692,665899 |
| Grangemouth | URBAN INDUSTRIAL | $NO$ $NO_2$ $NO_x$ $PM_{10}$, $PM_{2.5}$, $SO_2$ | 293840,681032 |
| Grangemouth Moray | URBAN BACKGROUND | $NO$ $NO_2$ $NO_x$ | 296436,681344 |
| Greenock A8 Roadside | ROADSIDE | $NO$ $NO_2$ $NO_x$ | 229332, 675715 |
| Inverness | ROADSIDE | $PM_{10}$, $PM_{2.5}$, $NO$ $NO_2$ $NO_x$ | 265720,845680 |
| Lerwick | RURAL | $O_3$ | 445337,113968 |
| Peebles | SUBURBAN | $NO$ $NO_2$ $NO_x$ $O_3$ | 324812,641083 |
| Strath Vaich | REMOTE | $O_3$ | 234787,875022 |

## Table A.3 2 Automatic Hydrocarbon Network Sites in Scotland 2022

| Site Name | Site Type | Species Measured | Grid Reference |
|---|---|---|---|
| Auchencorth Moss | RURAL | Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species* | 322167, 656123 |

### Table A.3 3 Non-Automatic Hydrocarbon Network Sites in Scotland 2022

| Site Name | Site Type | Species Measured | Grid Reference |
|---|---|---|---|
| Glasgow Kerbside | KERBSIDE | Benzene | 258708, 665200 |
| Grangemouth | URBAN INDUSTRIAL | Benzene | 293840, 681032 |

EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.

### Table A.3 4 PAH Monitoring Sites in Scotland 2022

| Site | Address | Grid Reference |
|---|---|---|
| Auchencorth Moss | Rural site in Scotland, South of Edinburgh | 322167, 656123 |
| Edinburgh | 145 Pleasance<br>Edinburgh<br>EH8 9RU | 326265, 673136 |
| Glasgow Townhead | Townhead<br>Glasgow<br>G4 0PH | 259692, 665899 |
| Kinlochleven 2 | Electrical Substation<br>Kinlochleven | 219280, 761986 |

### Table A.3 Five Heavy Metals Monitoring Network Sites in Scotland 2022

| Site Name | Site Type | Species Measured | Grid Reference |
|---|---|---|---|
| Auchencorth Moss | Rural | As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Se, V, Zn | 322167, 656123 |
| Eskdalemuir | Rural | As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Se, V, Zn | 323552, 603018 |

### Table A.3 5 Rural Metal Deposition Monitoring sites in Scotland 2022

| Site | Location Grid Ref. | Heavy metals | | | Mercury | |
|---|---|---|---|---|---|---|
| | | In Particles | In Rain | In Cloud | In Air | In Rain |
| Inverpolly | 218776, 908833 | | ✓ | | | |
| Banchory | 367694, 798519 | ✓ | ✓ | | ✓ | ✓ |
| Bowbeat | 328289, 647302 | | ✓ | ✓ | | |
| Auchencorth Moss | 322167, 656123 | ✓ | ✓ | | ✓ | ✓ |

# United Kingdom Eutrophying & Acidifying Network (UKEAP)

Table A.3 6 The Precipitation Network (PrecipNet) Sites in Scotland 2022

| Site Name | Grid Reference | Species Monitored |
|---|---|---|
| Auchencorth Moss | 322167, 656123 | $Na^{+}$, $Ca^{2+}$, $Mg^{2+}$, $K^{+}$, $PO_4^{3-}$, $NH_4^{+}$, $NO_3$, $SO_4^{2-}$, $Cl^{-}$ |
| Allt a'Mharcaidh | 287691, 805223 | |
| Balquhidder 2 | 254465, 720706 | |
| Eskdalemuir | 323552, 603018 | |
| Forsinard RSPB | 289309, 942826 | |
| Glensaugh | 366329, 780027 | |
| Loch Dee | 246907, 577768 | |
| Polloch | 179244, 768951 | |
| Strathvaich | 234787, 875022 | |
| Whiteadder | 366180, 663116 | |

Table A.3 7 Acid Gas and Aerosol Network (AGANet) and Ammonia Network (NAMN) Sites in Scotland 2022

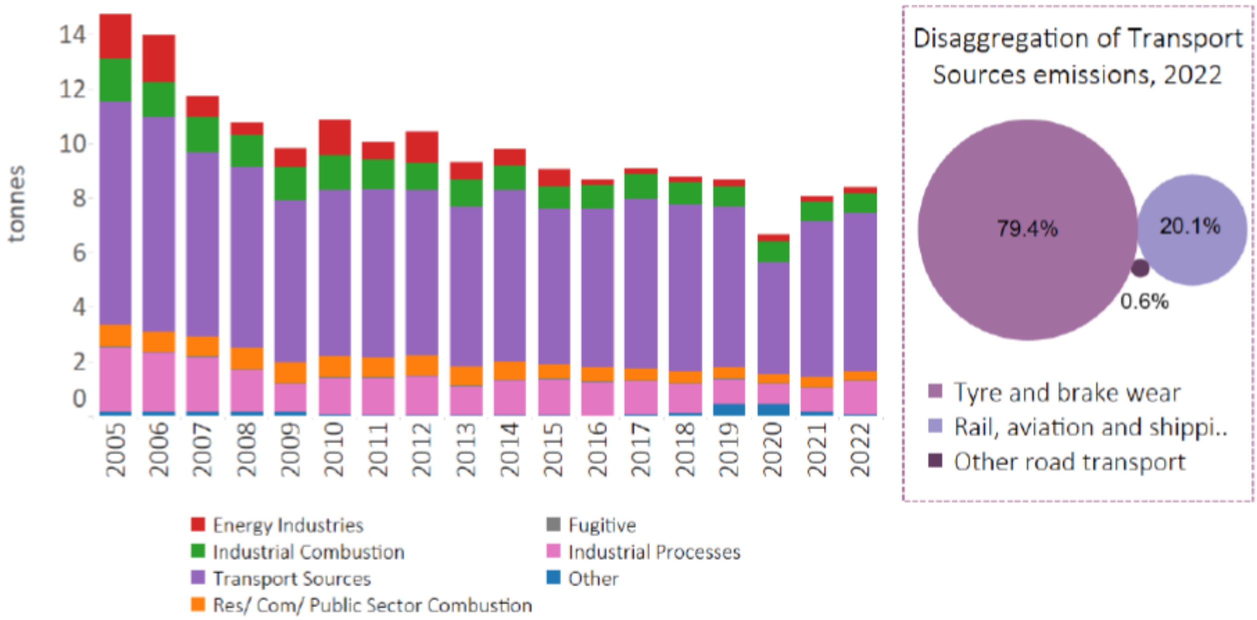
| Name | Grid Ref | Ammonia | Nitric Acid |
|---|---|---|---|
| Allt a Mharcaidh | 287691, 805223 | □ | □ |
| Allt a Mharcaidh ECN | 289160, 804162 | □ | |
| Auchencorth Moss | 322188, 656202 | □ | □ |
| Auchincruive | 238018, 623382 | □ | |
| Bush | 324629, 663891 | □ | □ |
| Carradale | 179870, 637801 | □ | □ |
| Eskdalemuir | 323588, 602997 | □ | □ |
| Forsinard RSPB | 289309, 942826 | □ | □ |
| Glensaugh | 366329, 780027 | □ | □ |
| Glen Shee Dalmunzie Estate | 312187, 769016 | □ | |
| Inverpolly | 218695, 908820 | □ | |
| Loch Awe | 96537, 711570 | □ | |
| Loch Dee | 246801, 577889 | □ | |
| Oldmeldrum | 383297, 827323 | □ | |
| Polloch | 179244, 768951 | □ | □ |
| Sourhope | 386796 621798 | □ | |
| Strathvaich | 234787, 875022 | □ | □ |

# APPENDIX 4: POLLUTION EMISSIONS DATA FOR PB, B(A)P, DIOXINS, HG

## Scotland lead (pb) Inventory by NFR Sector 2005 – 2022

Figure A4.1 provides a summary of Lead (Pb) emission estimates for Scotland by category. The detailed data are available in the report and website citied in the introduction to chapter 9 of this report.

**A4.1 Scotland's Pb Emissions 2005-2022**




*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

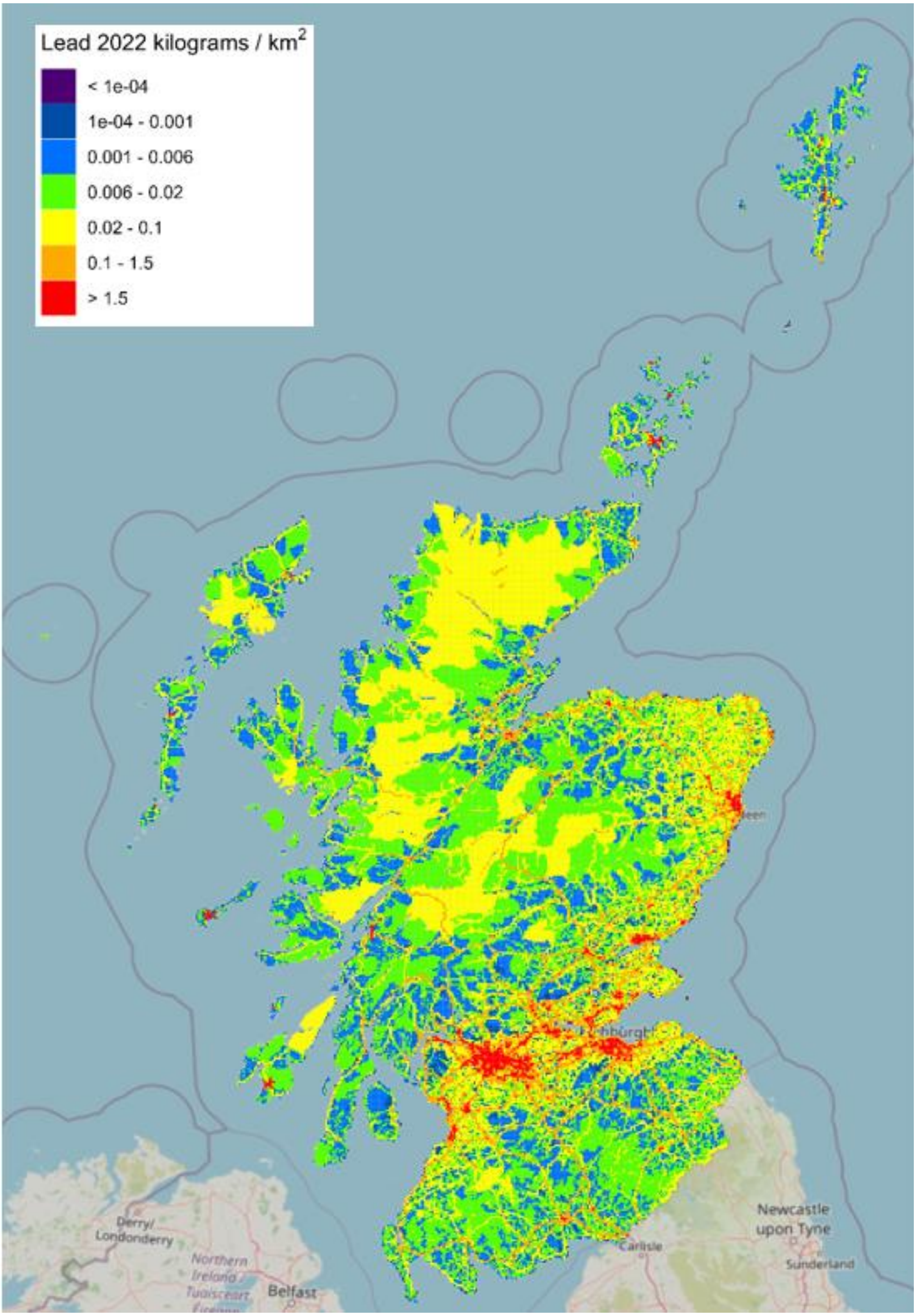
Emissions of lead in Scotland were estimated to be 8.4 tonnes in 2022, representing 6% of the UK total in 2022 for lead. Emissions have declined by 43% since 2005 due to changes in energy sources, industrial combustion, and industrial processes. Emissions from power stations have decreased by 85% since 2005, due to the phase out of coal from the energy generation mix, with the closure of Longannet in 2016 marking the end of the use of coal in energy generation in Scotland. Transport emissions account for 69% of the total in 2022. Unlike exhaust emissions which have been subject to the continued implementation of more stringent European regulation, non-exhaust emissions are not regulated and are strongly linked to the v-km driven on Scotland's roads. Non-exhaust emissions have increased by 12% since 2005. Industrial combustion accounts for 8% in 2022, and use of fireworks contributes a further 9%. Three of the seven sites in the UK which manufacture fibreboard, chipboard and oriented strand board are located in Scotland, and are key sites for lead emissions due to the burning of waste wood as fuel.

In 2019 and 2020, there is an increase in lead emissions from the 'Other' category. This is driven by variations in lead emissions associated with different aviation fuel types used in military aircraft at a UK level.

Lead emissions have increased by 4% since 2021, primarily due to a 7% increase in emissions due to tyre and break wear in the transport sector. This was likely influenced by reduced road traffic during COVID-19 restrictions in 2020 and an increase in road traffic in 2021 as restrictions eased.

Figure A4.2 shows a map of Scotland's Lead emissions in 2021.

**Figure A4.2 Map of Lead Emissions in Scotland, 2022**

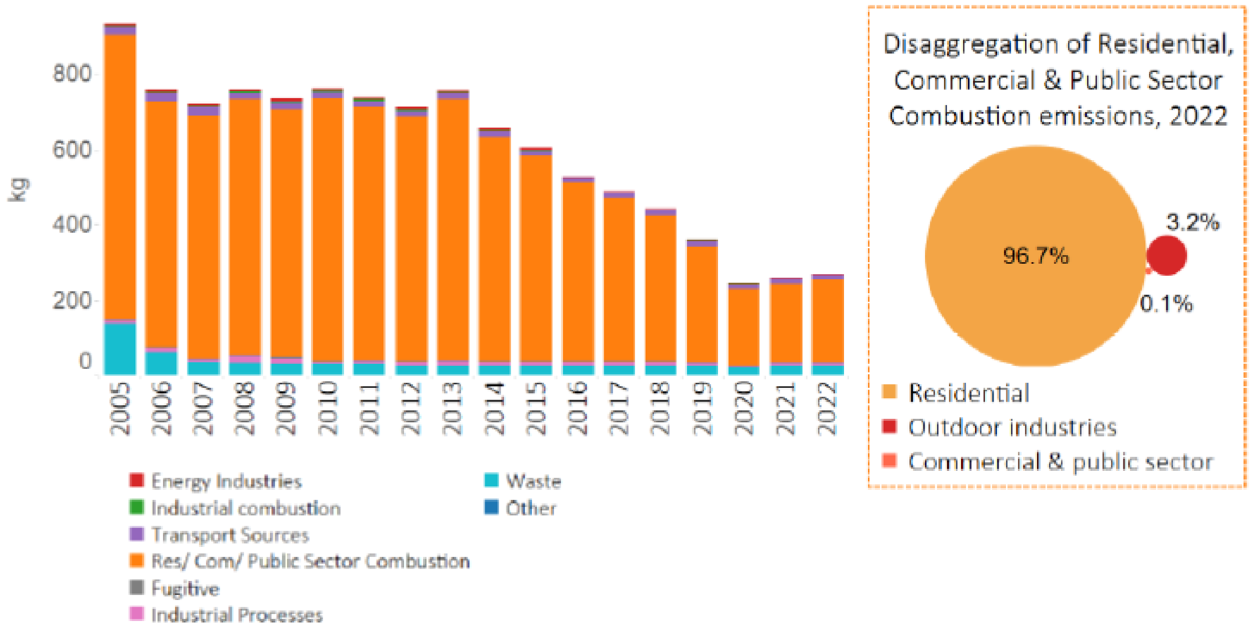


*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

## Scotland benzene (a) Pyrene (B(a)P) Inventory by NFR Sector 2005 – 2022

Figure A4.3 provides a summary of Benzene (a) Pyrene (BaP) emission estimates for Scotland by category.

**A4.3 Time Series of Scotland's B(a)P Emissions 2005-2022**

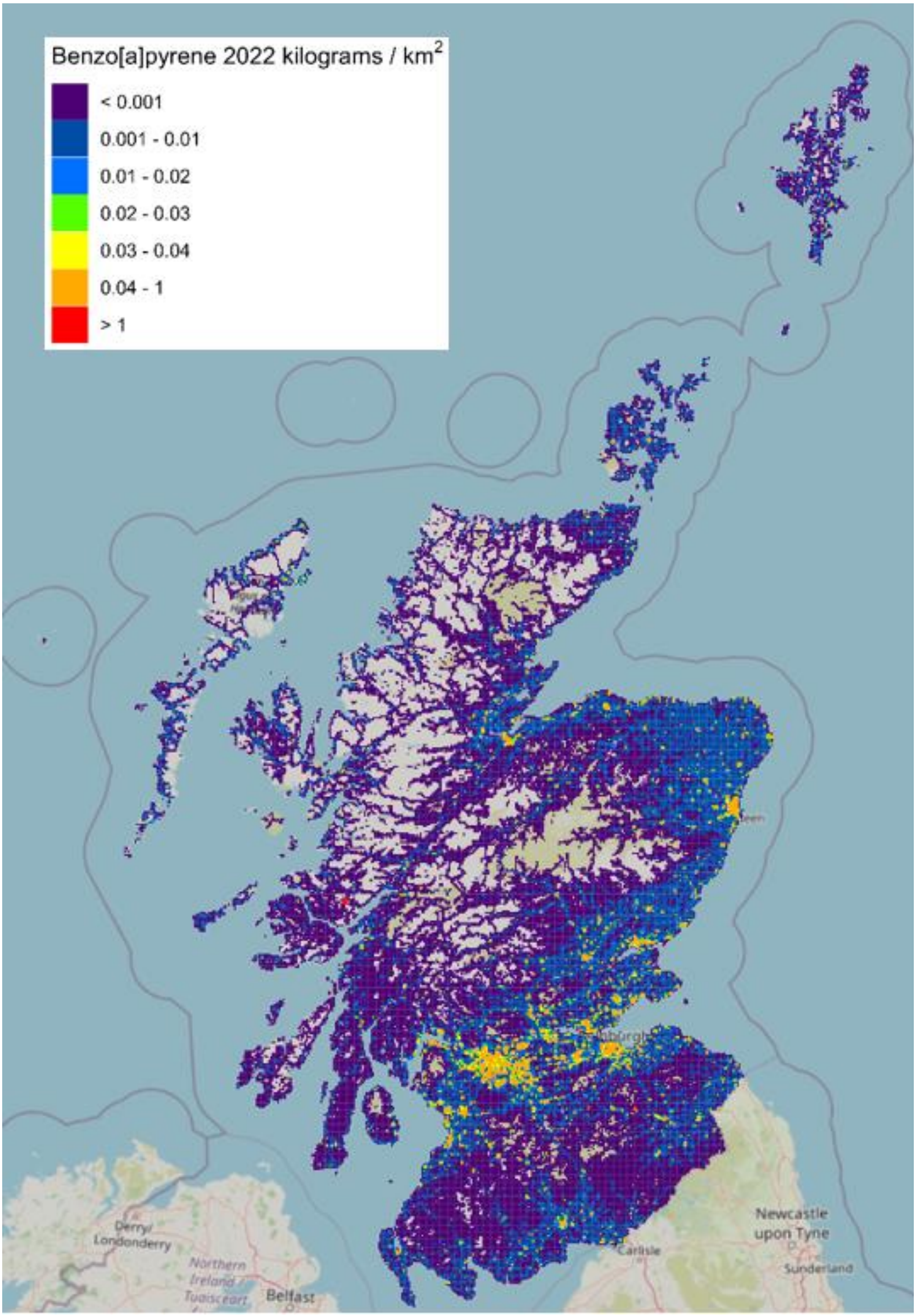



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of benzo(a)pyrene in Scotland were estimated to be 270 kg in 2022, representing 4% of the UK total for benzo(a)pyrene. Emissions have decreased 71% since 2005, primarily driven by a reduction in agricultural waste burning. Emissions from residential combustion account for 79% of the B[a]P emissions from Scotland in 2022, with domestic wood and coal combustion accounting for a significant proportion of the sector.

Figure A4.4 shows a map of Scotland's B(a)P emissions in 2022.

**Figure A4.4 Map of B(a)P Emissions in Scotland, 2022**

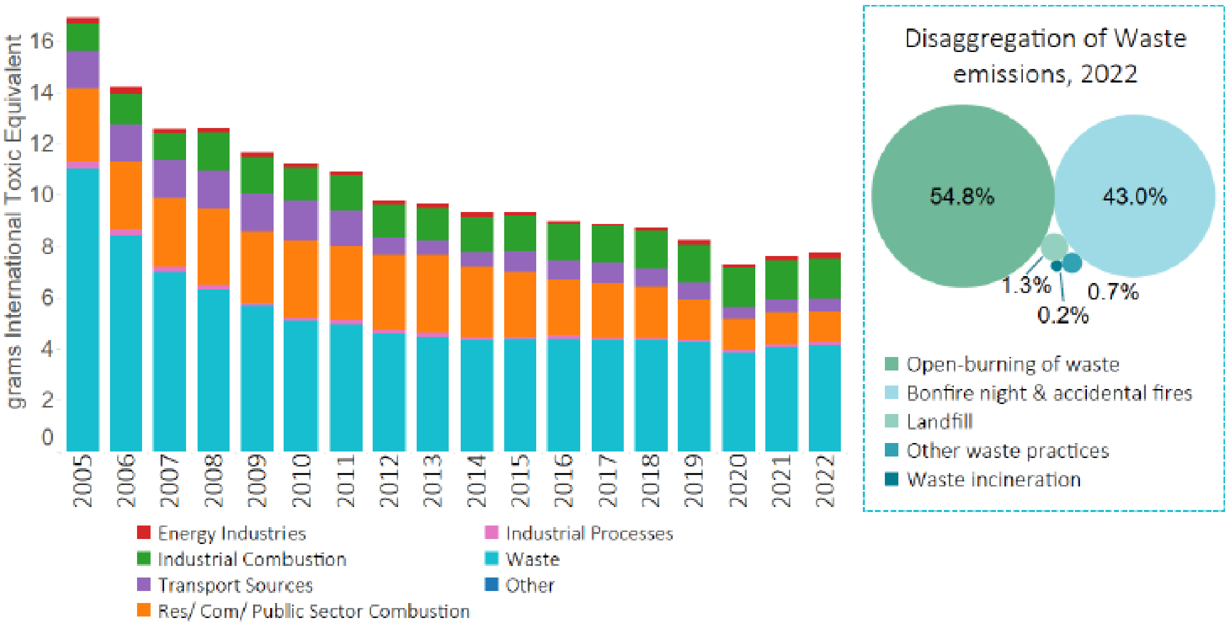



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

# Scotland Dioxins Inventory by NFR Sector 2005 – 2022

Figure A4.5 provides a summary of Dioxins emission estimates for Scotland by category.

**A4.5 Time Series of Scotland's Dioxins Emissions 2005-2022**

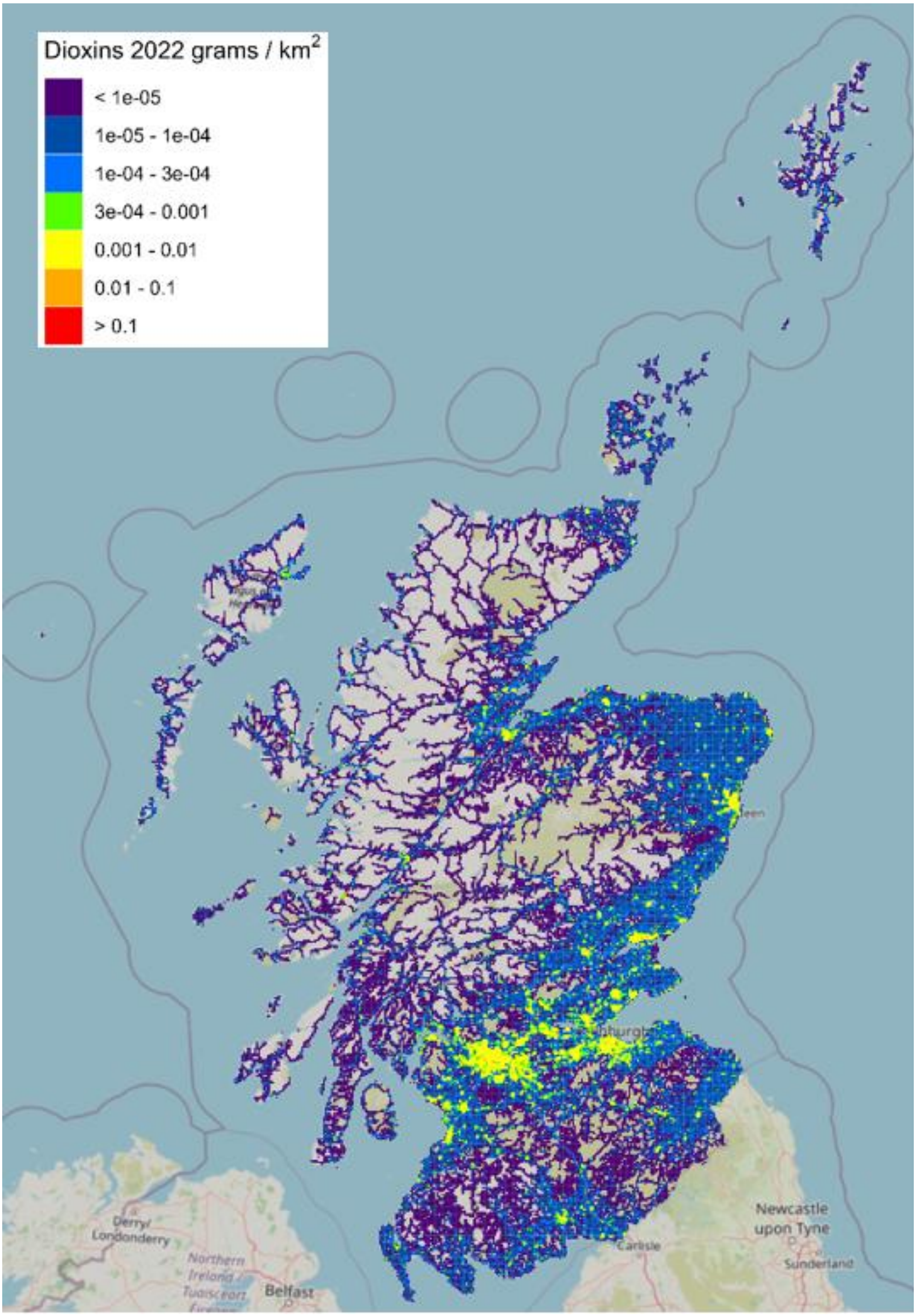



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of dioxins in Scotland were estimated to be 7.7 g international toxic equivalents in Scotland in 2022, representing 6% of the UK total for dioxins. Emissions have declined by 54% since 2005, mainly driven by a reduction in emissions from the waste sector. The decline in dioxin emissions since 2005 tracks the trend of a reduction in coal use in power stations, and the introduction of more stringent regulatory controls and the promotion of alternative waste disposal and recycling streams to reduce small-scale open waste burning of household and garden waste.

Figure A4.6 shows a map of Scotland's Dioxin emissions in 2022.

**Figure A4.6 Map of Dioxin Emissions in Scotland, 2022**

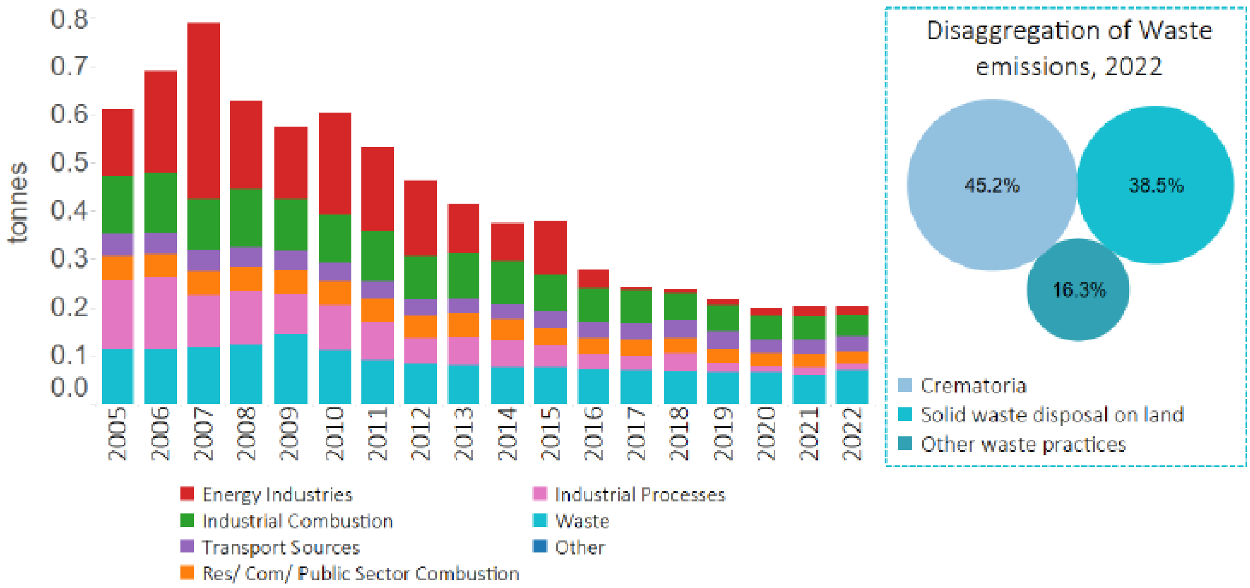



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

# Scotland Mercury (hg) Inventory by NFR Sector 2005 – 2022

Figure A4.7 provides a summary of Mercury (Hg) emission estimates for Scotland by category.

**A4.7 Time Series of Scotland's Mercury Emissions 2005-2022**

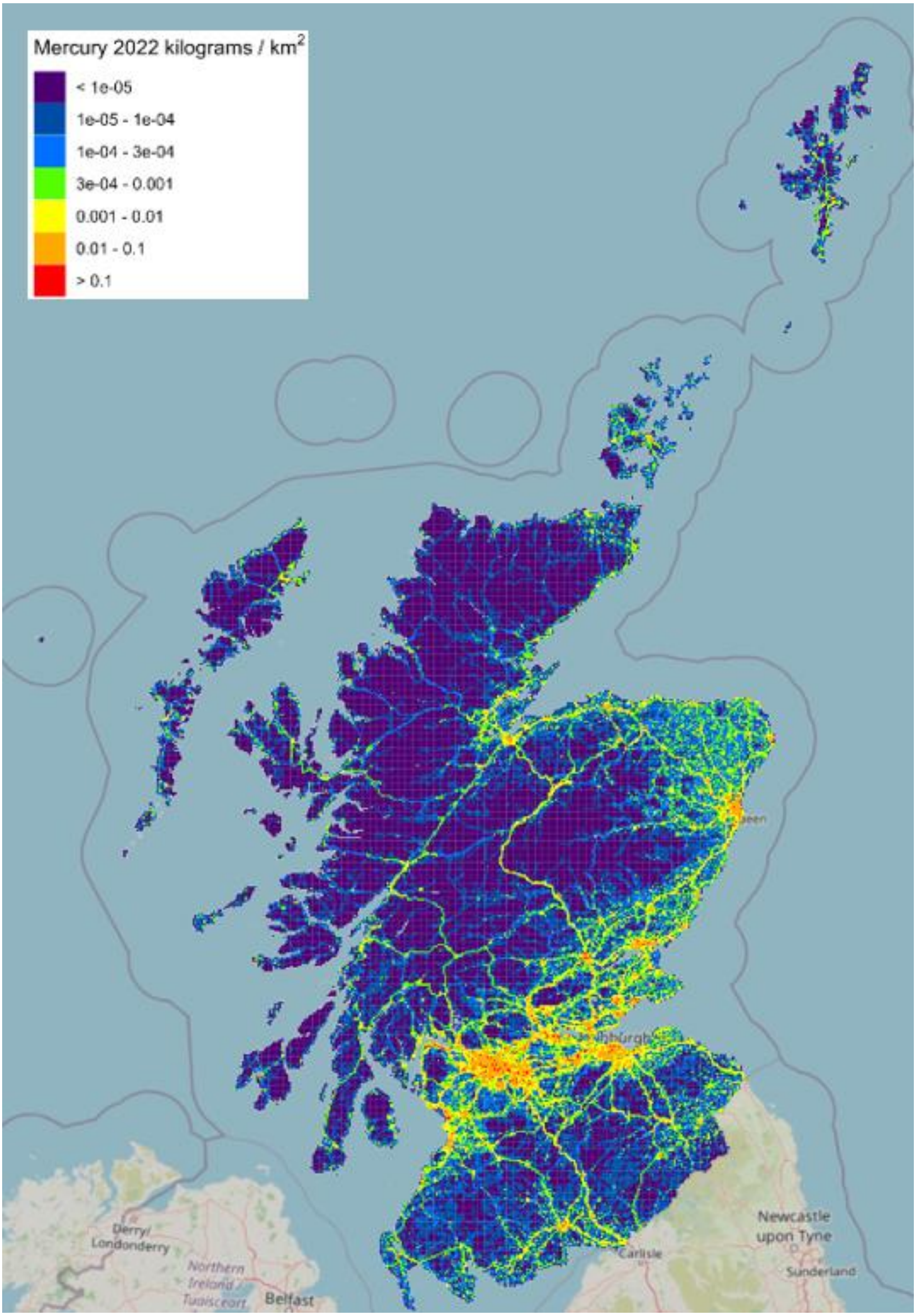



*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

Emissions of Hg in Scotland were estimated to be 0.20 t in 2022 and have declined by 67% since 2005. Emissions in Scotland account for 6% of the UK total in 2022 for Hg. This decline in emissions stems from changes to combustion in power and heat generation and chloralkali process emissions, with a 29% and 22% contribution to the overall Hg trend, respectively. The decline in emissions from power and heat generation is driven by the reduction in combustion of coal. As observed above, the emissions from energy industries have been negligible since 2017 since the cessation of coal used for energy generating purposes in Scotland. Since 2016, emissions from crematoria have been the largest source of emissions, representing 15% of the Scotland total Hg emissions in 2022.

Figure A4.8 shows a map of Scotland's Hg emissions in 2022.

**Figure A4.8 Map of Mercury Emissions in Scotland, 2022**




*Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 2005 – 2022*

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