This report discusses the analysis and comparison of Nitrogen Dioxide data from for two automatic urban and rural network (AURN) ambient air monitoring stations for the year 2016 and 2017.

Site Description

The kerbside AURN chosen is Camden Kerbside (UKA00259) in Camden Borough, London. Background AURN chosen is London Haringey Park South (UKA00568) in Haringey Borough, London. Henceforth, Camden Kerbside and London Haringey Park South are referred to as kerbside site and background site respectively. Data used in the report is from DEFRA, (2017). Chosen sites are located apart by a distance of 5.66 km as shown in Fig-1.

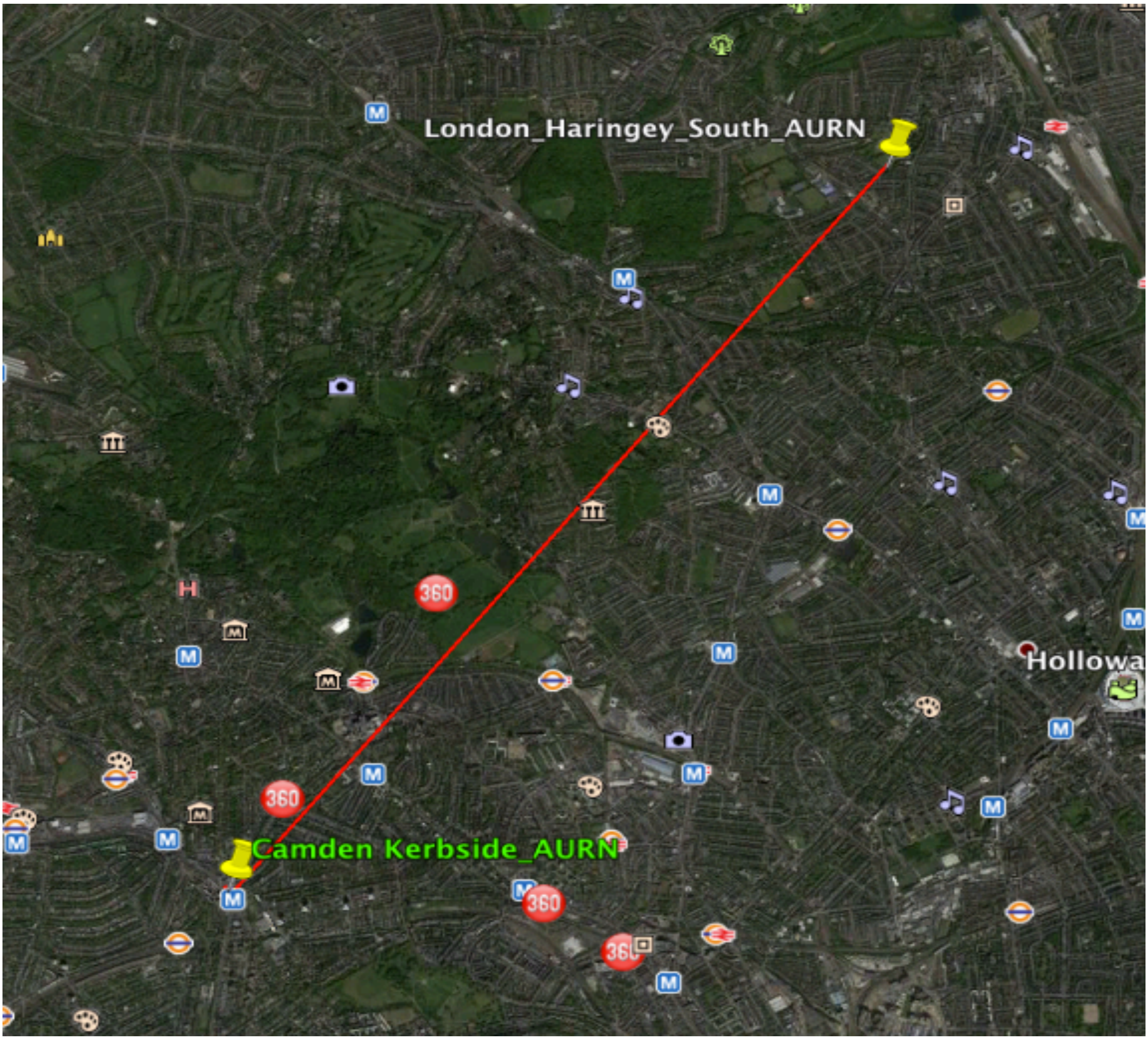


Fig-1 Distance between background and kerbside site (GoogleEarth, 2018)

Kerbside Site

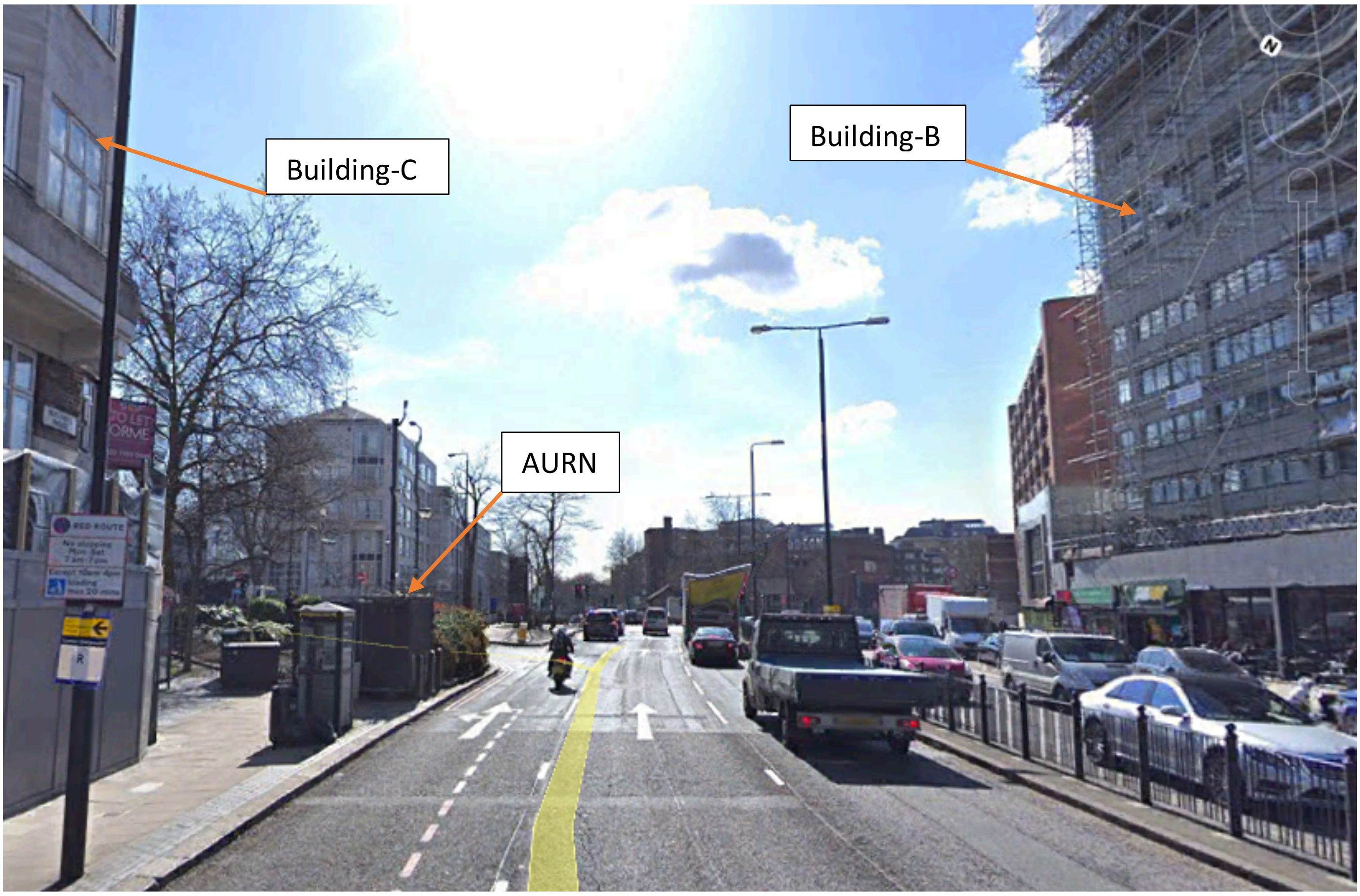


Fig-2 Kerbside AURN location (GoogleEarth, 2018)

The grid reference for Kerbside site is Latitude 51°32'39.24"N and Longitude 0°10'30.80"W (DEFRA, 2018b). The pollutants measured by AURN are Nitric Oxide, Nitrogen Dioxide (NO_2), Nitrogen Oxides as Nitrogen Dioxide, Particulate Matter (PM_{10}), Non-Volatile PM_{10}, Volatile PM_{10}, $PM_{2.5}$, Non-volatile $PM_{2.5}$, Volatile $PM_{2.5}$. The Chemiluminescence sampler is used for NO_2 measurement. The site was commissioned on 16th May 1996.

The AURN is located at the intersection of Finchley road and College Crescent road, nearest road is at distance of 1.5m (London Borough of Camden, 2018). The total motor vehicle counts on link length of 2.5km with traffic counter at Adelaide junction was 46,421 for 2016 and 49061 for 2017 (DFT, 2018). Within a 50m radius of the AURN site, there are three bus stops and one point with vehicle idle. The bus stops Finchley road college crescent (Stop B), College Crescent (Stop F) and College crescent (Stop G) are shown as a red, blue and yellow line from AURN site respectively in fig-3. The distance of Stop B, Stop F and Stop G from AURN is 40.3, 31.7 and 38.3 meters respectively. Further, there is a U-turn point at a distance of 20.4 meters from AURN site (shown in pink line) where vehicles would usually stop before making the turn and will be idling. The AURN in close vicinity to all these points apart from regular traffic flow is at a desirable position for measuring air quality. Camden borough is a smoke control zone which controls on the type of fuel (Eg: wood for the domestic heating) which can be used for domestic and commercial purpose (London Borough of Camden, 2018).

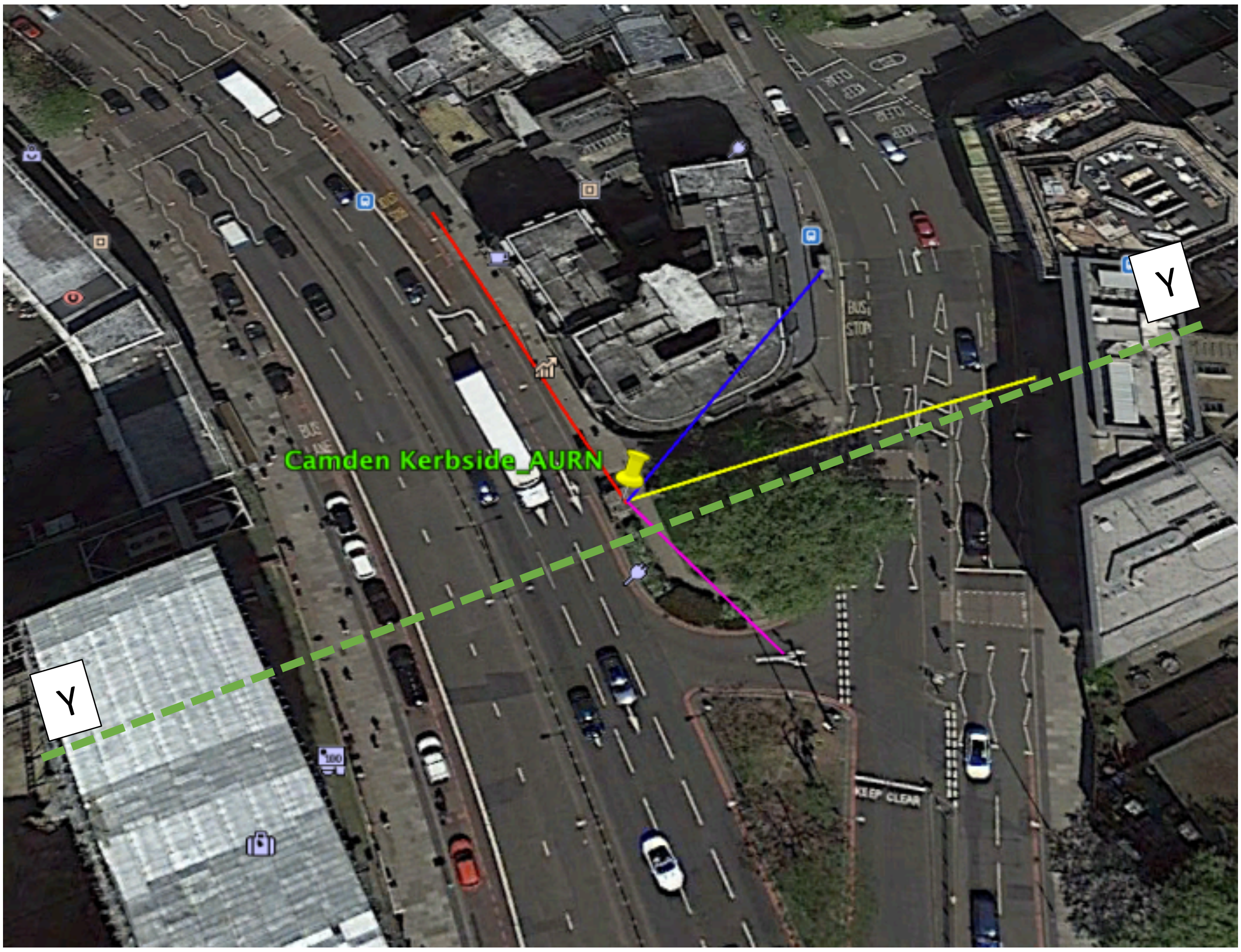


Fig-3 Bus stop and idling point location in AURN vicinity (GoogleEarth, 2018)

Further, prevailing wind direction for most of the year in the UK is westwardly (Lapworth and McGregor, 2008) and basic dispersion is shown in Fix-4. Based on the different aspect ratio (H/W) and position of AURN near or within the street canyon can affect readings as pollution wind flow pattern within canyon changes (Yazid et al., 2014). Also, there is a possibility of corner eddies formation because of building-C. AURN being on primary Vortex side of building-C in the background might affect the readings fresh winds comes and hits the building and AURN without mixing with pollutants (Gromke and Ruck, 2007). Also, Gromke and Ruck,(2007) have shown the presence of tree crowns can result in increased concentration as air exchange is hindered. Fig-2 indicates building-A is under construction and thus AURN position is representative based on when it was deployed needs to be assessed during future checks.

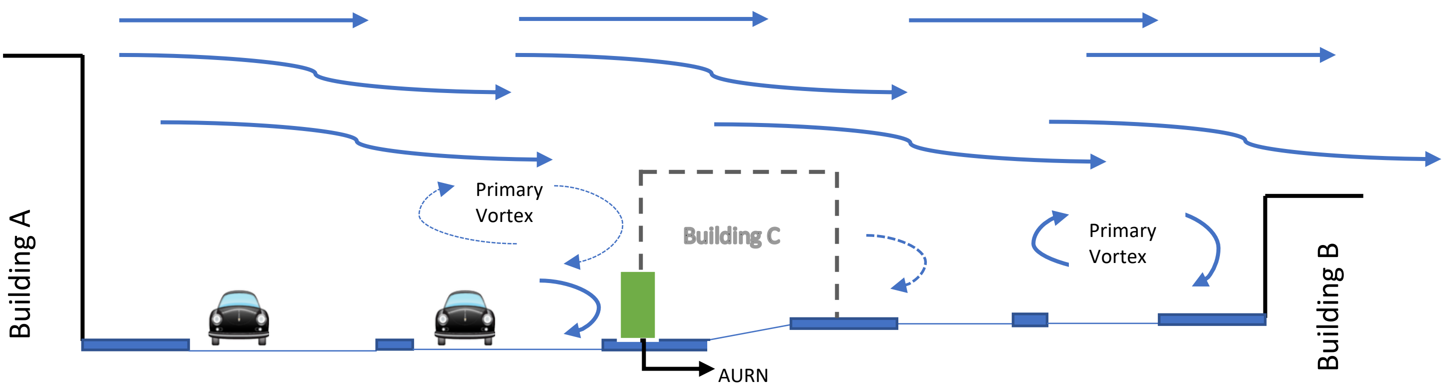


Fig-4 Wind profile around AURN at section line YY from fig-3 (dotted line indicates things behind AURN)

Background Site

Fig-5 Background site AURN (GoogleEarth, 2018)

The grid reference for background site is Latitude 51°35'2.64"N and Longitude 0° 7'31.53"W (DEFRA, 2018c). Pollutants measured by AURN are Ozone, Nitric Oxide, Nitrogen dioxide and Nitrogen oxides as nitrogen dioxides. The analysers used for NO_2 Measurement is Chemiluminescent analysers (DEFRA, 2007). The site was commissioned on 26th Oct 2012.

AURN located in the Priory park as shown in the figure-5 which is surrounded by a residential area. The roads represented from background site via red, green and pink are at a distance of 46.4m, 110m, and 143m respectively in fig-6. There are no bus stops within 50 m radius. There are no high-rise buildings in a surrounding which could result in street canyon or traffic-related turbulence effect. There are no sources of pollutants nearby apart from moving traffic, assuming fuel used in domestic and commercial purpose is controlled. Thus, AURN serves as a good site to measure the background.

Fig-6 Nearest roads from AURN (GoogleEarth, 2018)

Based on GoogleEarth,(2018) the white unit in fig-5 on the background site seems to be the air conditioner. The fan of evaporator on top of AURN can affect the surrounding air sucked in via AURN inlet pipe (Tate, 2018). Fig-5 and 6 show that there are trees surrounding the AURN. Trees can remove air pollutants by intercepting them which can either get absorbed or resuspended by falling of leaf or rain (DEFRA, 2010). As part of QA/QC check it involves checking if the site is still representative for its purpose and thus it can be assumed the net effect from trees is minimal, but air condition unit needs repositioning.

Statistical Analysis

Parameters	UK Standard	Kerbside Site		Background Site	
		2016	2017	2016	2017
Annual Mean ($\mu g.m^{-3}$)	40	65.8	52.7	25.6	24.3
Data collection rate (%)	90	99.5	92.5	98.5	99.7
Minimum ($\mu g.m^{-3}$)	NA	4.4	3.1	0.59	1.0
Maximum ($\mu g.m^{-3}$)	NA	385.3	204.6	108.9	110.7
Standard Deviation ($\mu g.m^{-3}$)	NA	36.6	28.3	17.6	16.9
No of times 1 hour mean limit value (200 $\mu g.m^{-3}$) exceeded	18 times per year	37	1	0	0
Annual mean value (40 $\mu g.m^{-3}$) exceeded?	Yes/No	Yes	Yes	No	No

Table-1 Statistical Analysis of NO_2 concentration of Kerbside and Background site for Year 2016 and 2017 (DEFRA, 2018a)

Data Presentation

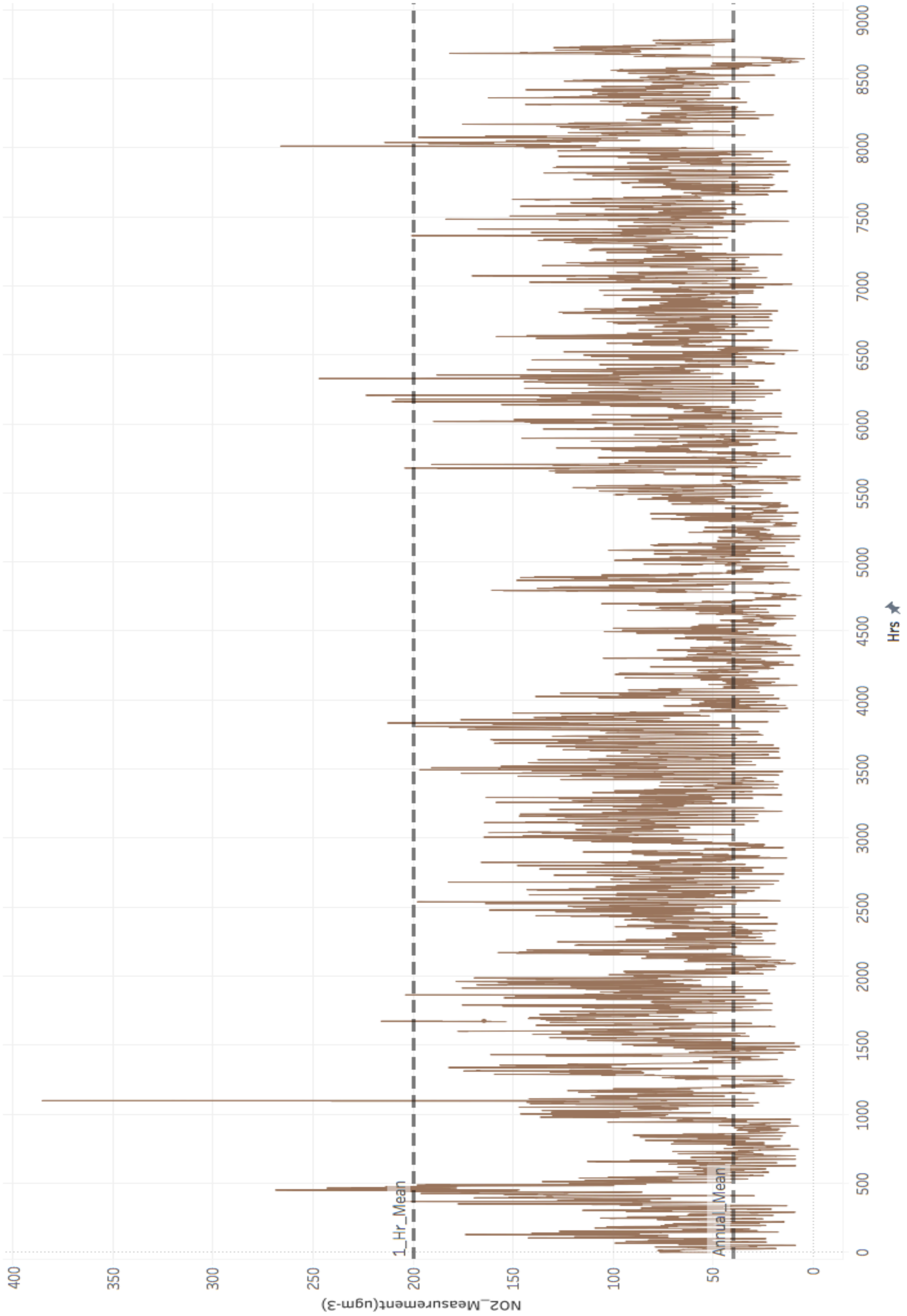


Fig-7 Time series plot for kerbside site 2016

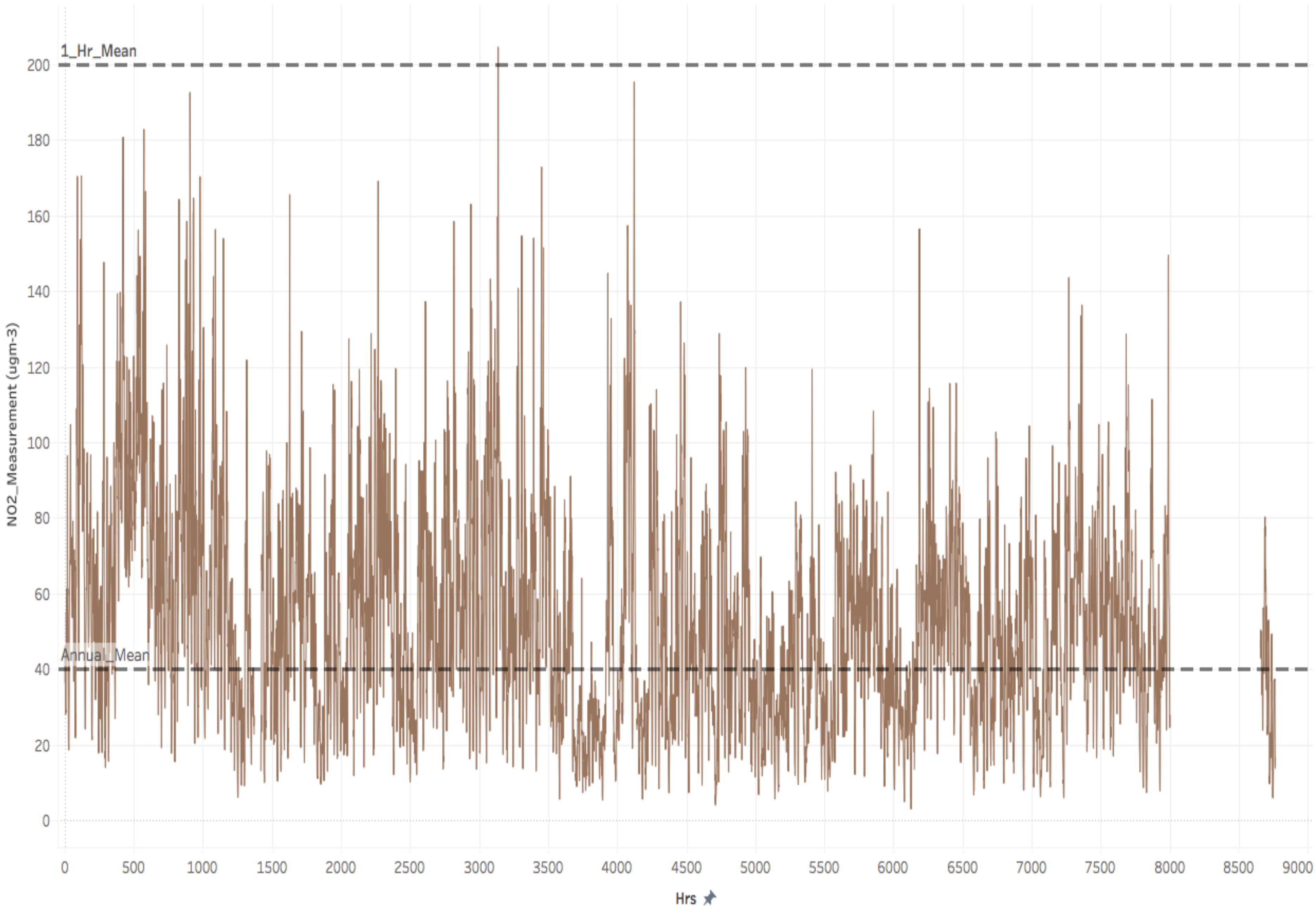


Fig-8 Time series plot for kerbside site 2017

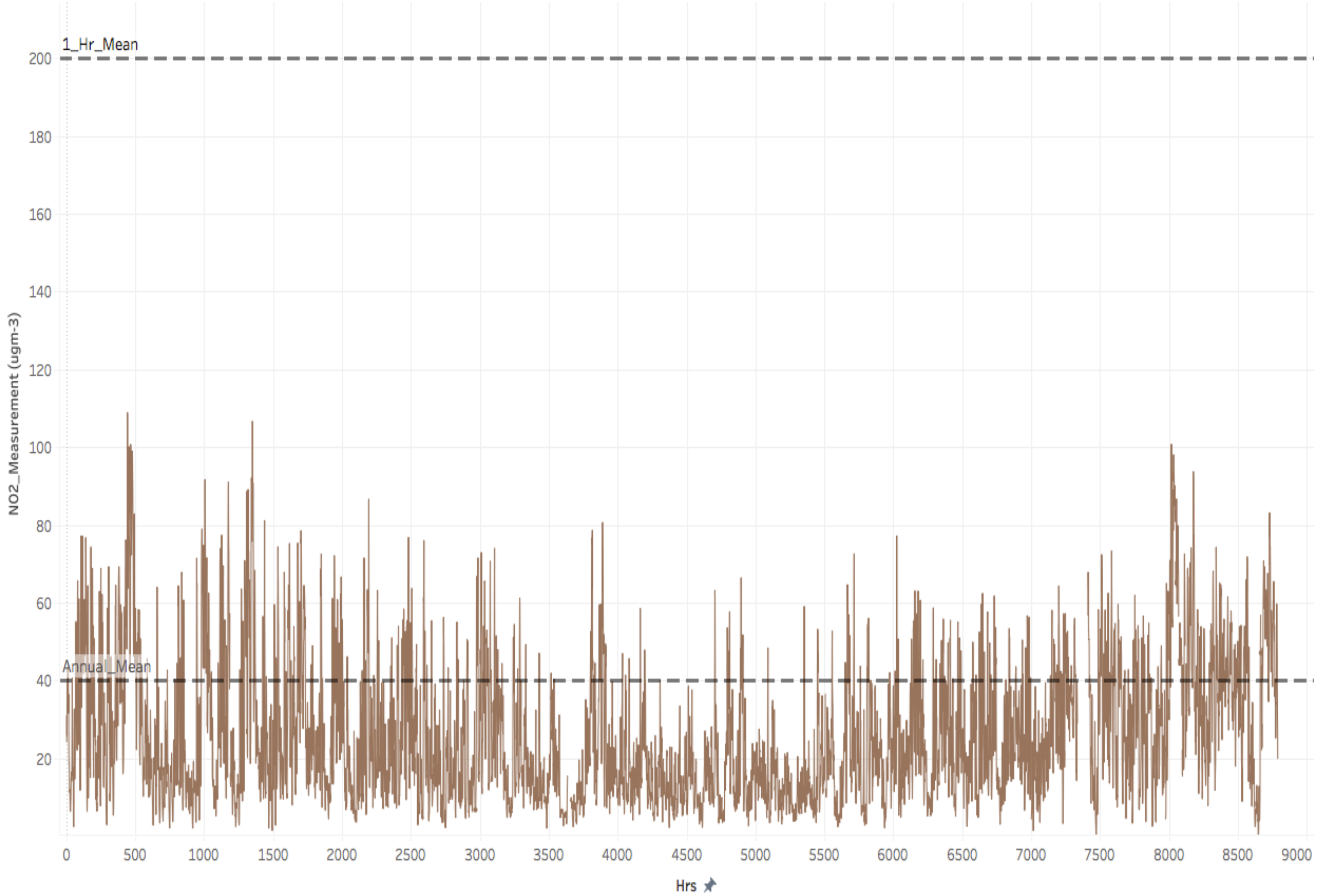


Fig-9 Time series plot for background site 2016

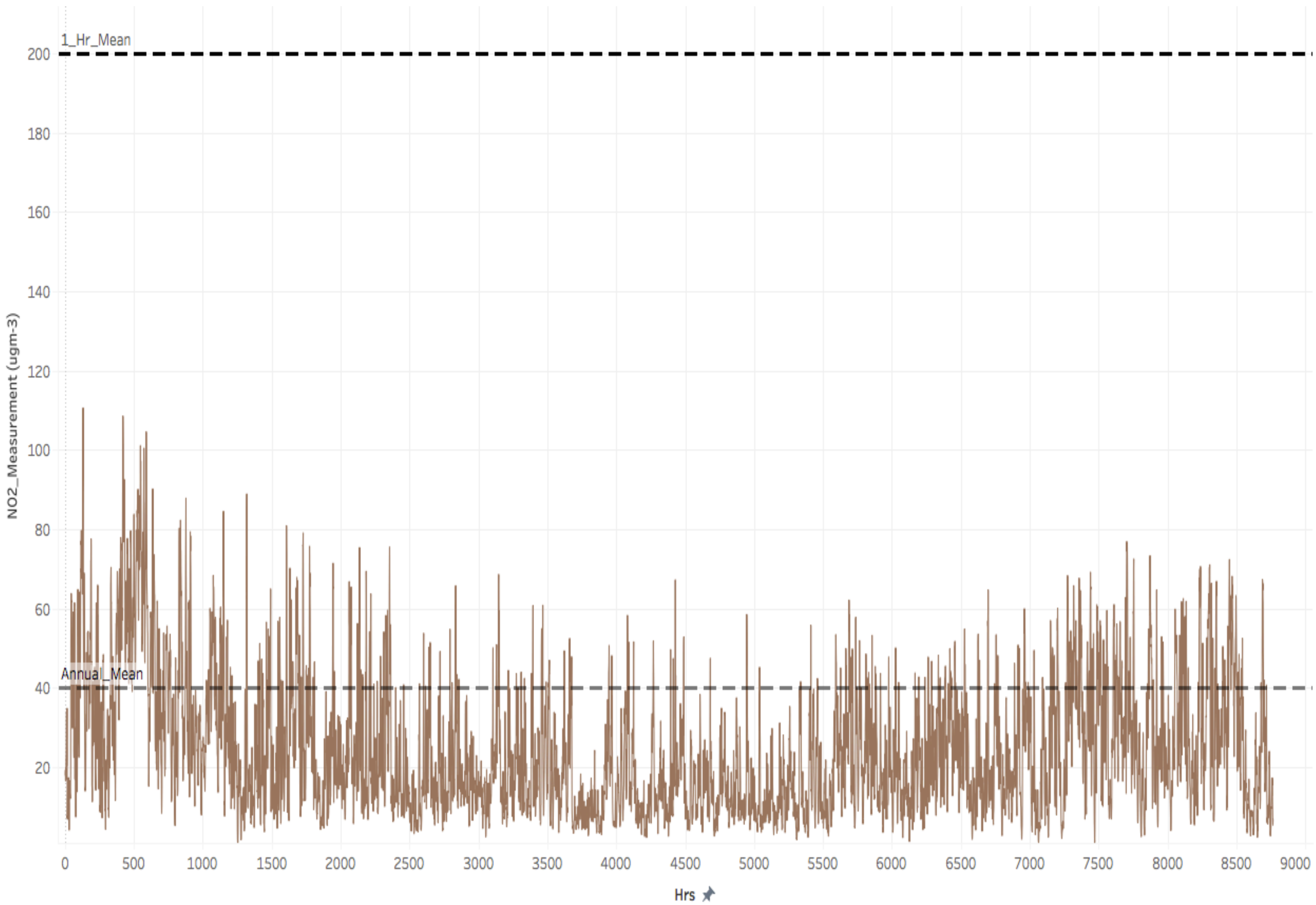


Fig-10 Time series plot for background site 2017

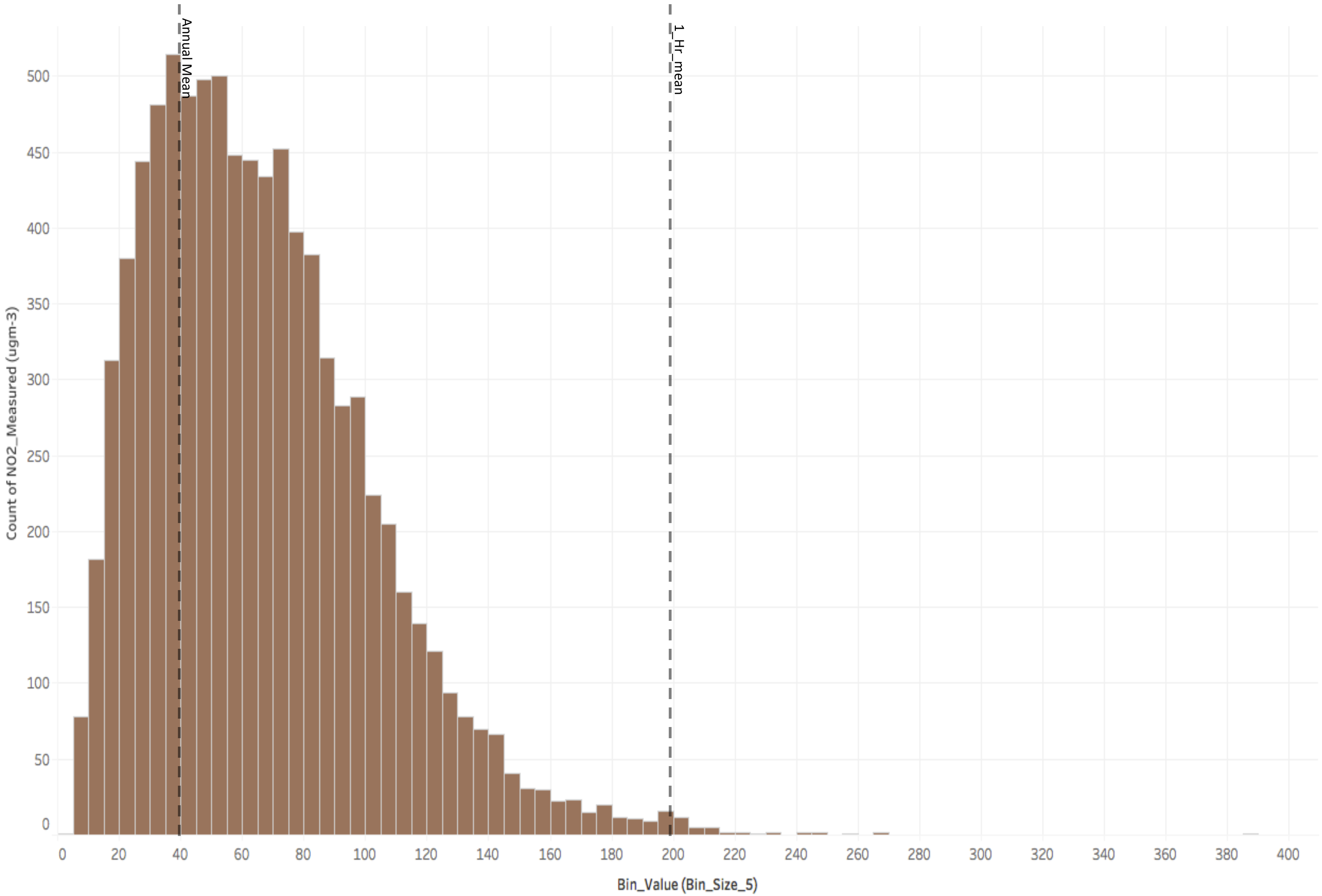


Fig-11 Histogram for kerbside 2016

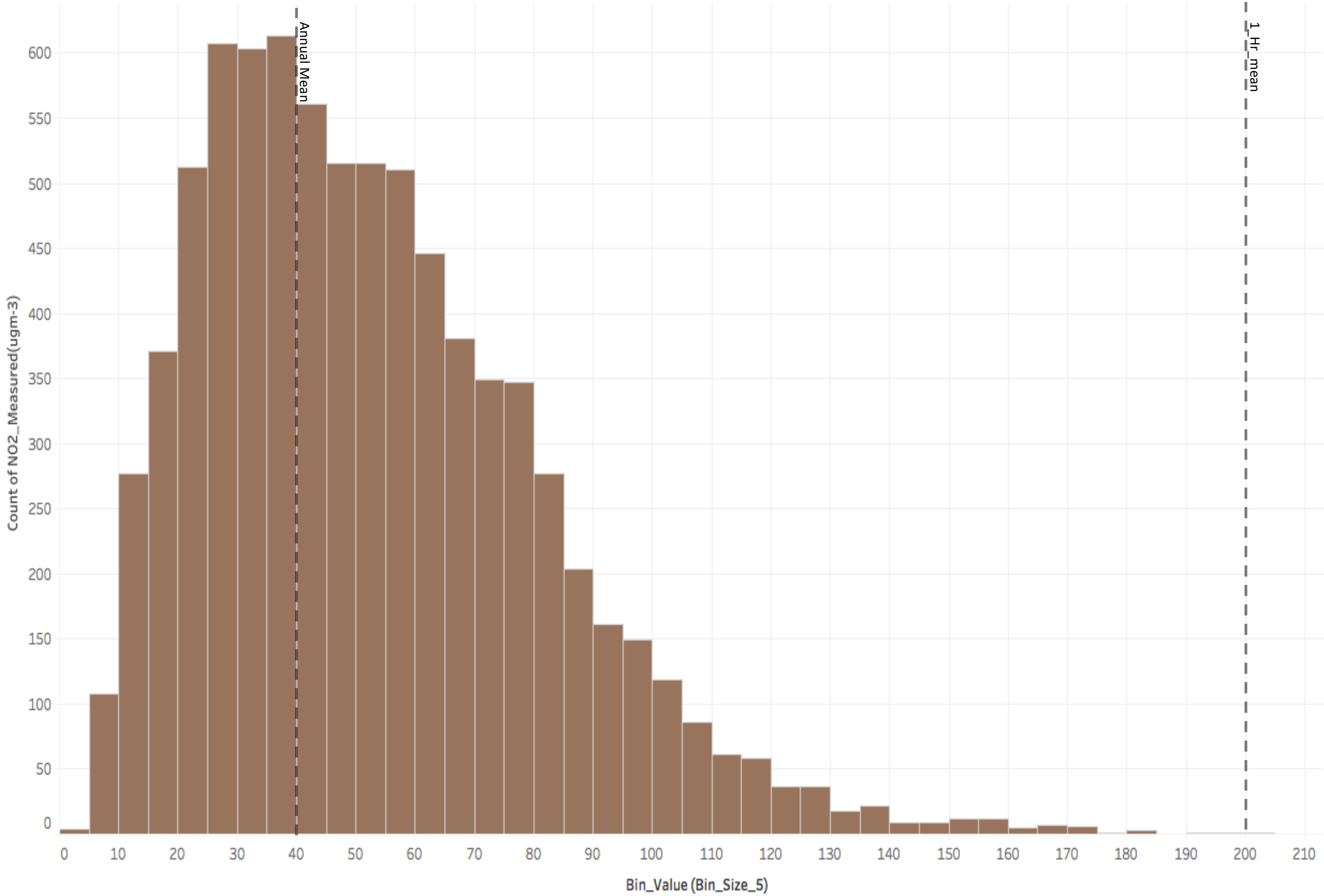


Fig-12 Histogram for kerbside site 2017

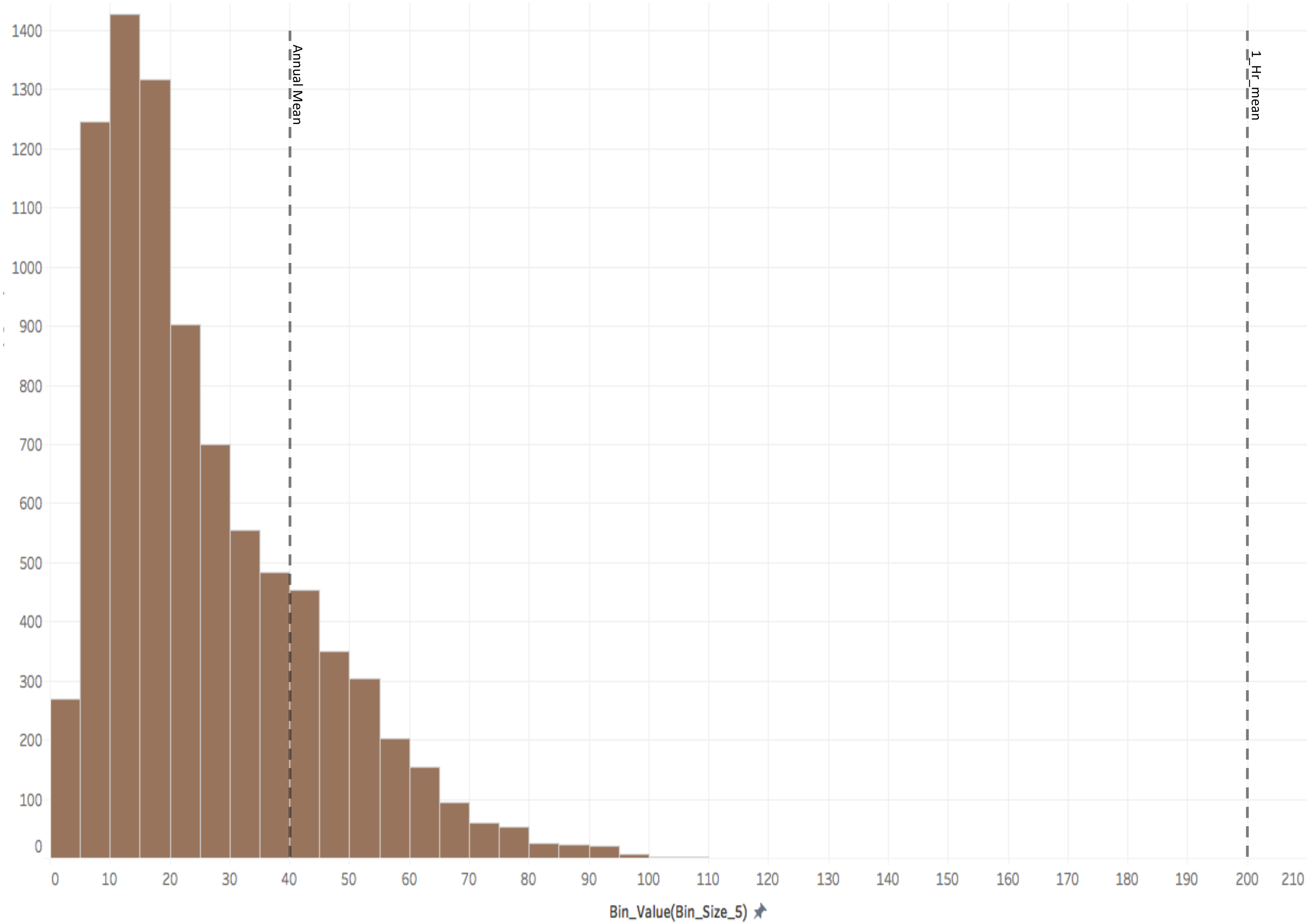


Fig-13 Histogram for background site 2016

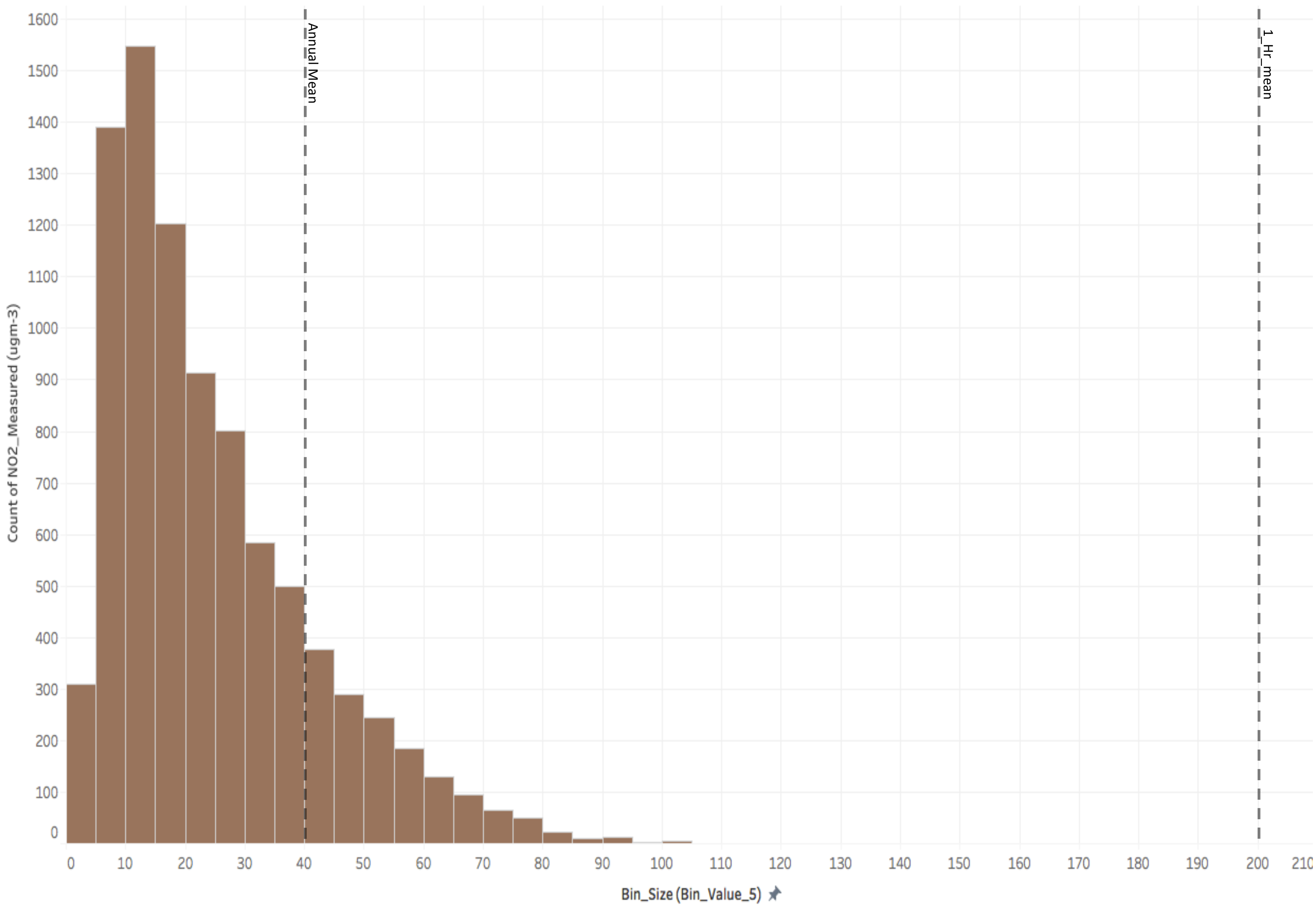


Fig-14 Histogram for background site 2017

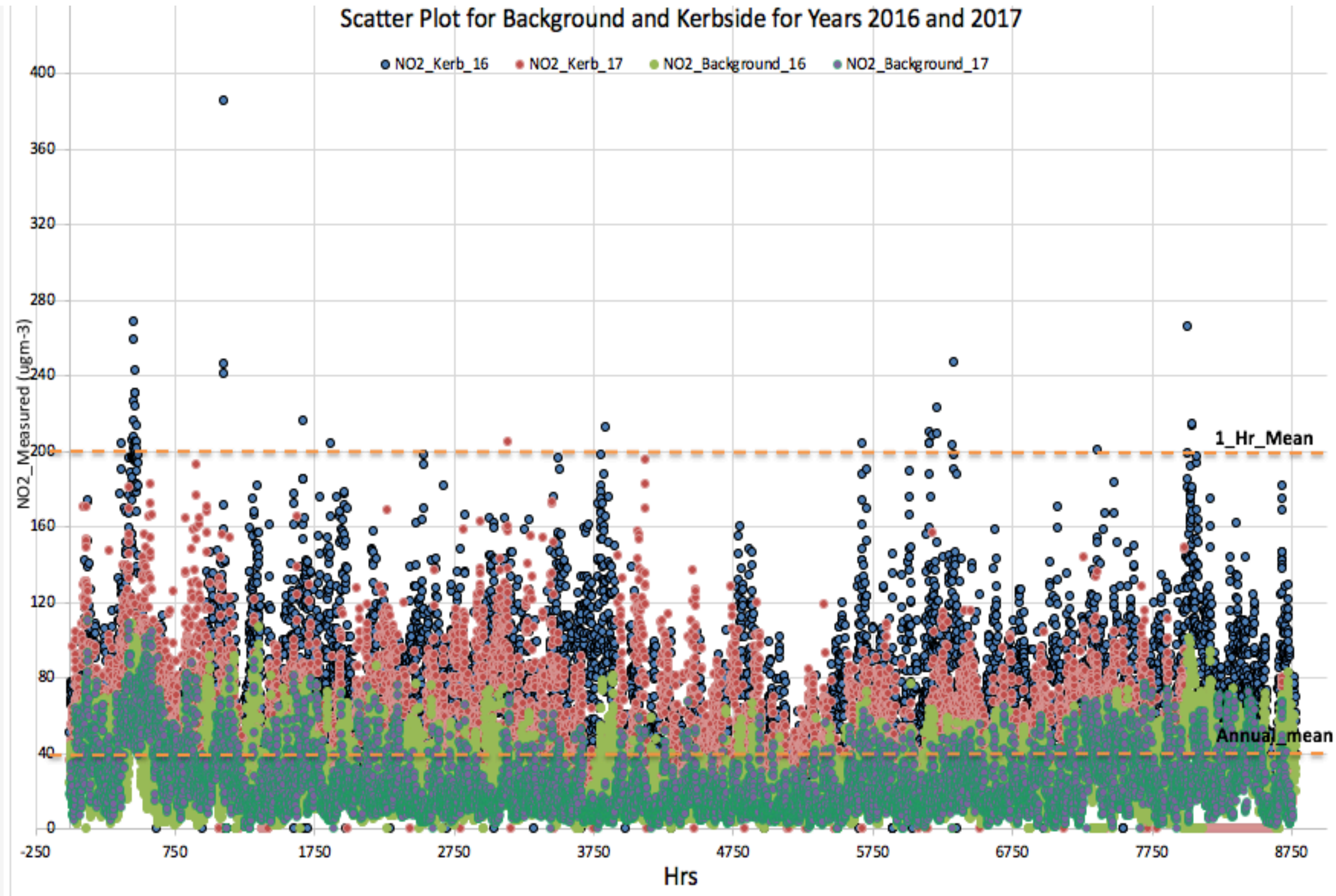


Fig-15 Scatter Plot for year 2016 and 2017

Data Quality Control

The purpose of Quality assurance/Quality Controls (QA/QC) is to ensure that data is genuinely representative of ambient conditions, accurate and precise to meet monitoring objectives, comparable and reproducible, consistent over time, yearly data capture rate above 90% and meet data quality objectives, methodology guidance as per EU directive for relevant pollutants and measurement techniques and site location is representative of its classification (Eaton, 2016). Operation manual for the AURN is produced and provided to all Local Site Operators (LSO), which is key to harmonise field procedures and improve quality of data produced by monitoring equipment with accurate calibration and optimised operation.

The AURN undergoes daily automatic analyser checks to provide information on the routine performance of the analyser and any long-term drifts, usually at midnight (Clark et al., 2012). To check the zero response zero air (free from any pollutants) is used to check instruments response. To check the span NO_2 response which instrument can measure near to the maximum that instrument can measure (Clark et al., 2012).

Network inter-calibration and site audits are undertaken to check and evaluate a wide range of analyser key functions and on-site calibration standard against common such as independent audit gas cylinders transported to each site in the network to assess performance of measurement systems (Eaton, 2016). The audit result provides vital information for data ratification. For example, if a fault such as poor converter efficiencies for NO_x analyser is noted and data is scaled correctly or deleted as per guidelines. This is done every 6 months for every site and every analyser in the network which provides detailed and quantified information on overall network performance. The outliers that are identified based on accepted criteria undergo rigorous checks to determine the cause and if any corrective action is required (Eaton, 2016). For example, ±10% of the network average for NO_x, CO and SO_2 analysers (Eaton, 2016).

Data validation is performed to refine data scaling based on all the calibration and audit data available, and to identify and correct or remove anomalous data due to the instrument, sampling faults, where data fall outside the uncertainties or limits of detection against accepted specification for reporting. Data validation is followed by more thorough checking at three-month intervals to ensure that the data are reliable and consistent and is known as data ratification (DEFRA, 2017).

Data Interpretation

Kerbside site did not meet the annual mean for both the years 2016 and 2017. It exceeded the hourly limit 37 times in 2016 and 1 time in 2017. However, data collected in 2017 was less by 7% compared to 2016 and needs caution. Variance for kerbside site reduced from 380.9 $\mu g.m^{-3}$ to 201.5 $\mu g.m^{-3}$ from 2016 to 2017 respectively, as during 2017 concentration values did not breach 385.3 μg.m-3 mark. Thus, the histogram for 2017 is more positively skewed in comparison to 2016.

Background site meets the annual mean for both the years 2016 and 2017. It did not exceed hourly limit during the year 2016 and 2017. There are no significant changes between the years 2016 and 2017 as shown in table-1 with variance 108.3 $\mu g.m^{-3}$ for 2016 and 109.7 $\mu g.m^{-3}$ for 2017 and can be assumed background conditions remained similar during both the years.

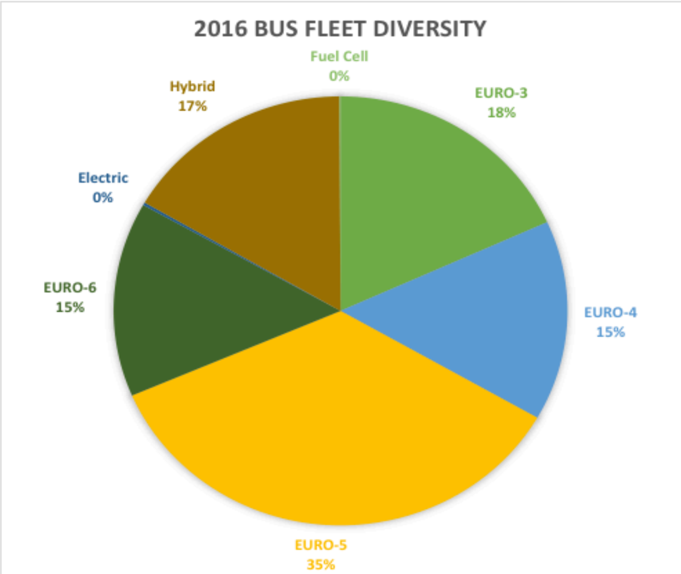
For kerbside AURN gaps in data collection of 6 hrs in week-3 of feb'16, week-1 2 hrs of Sep'16, 44 hrs of Feb'17 and 4 hrs in week-3 of Aug'17 can be due to 6-month QA/QC checks for AURN as per the spec. 27 days data in Dec'17 is not made available which could be due to the failure of equipment or deleted as per the guidelines of the ratification process. The duration mentioned are in line with quarterly report of on

AURN network (Eaton, 2016). For background AURN gap in data collection of 3 hrs in week-3 of Feb’16 and 76 hrs in week-1 of Nov’16 can be due to 6-month QA/QC checks.

Kerbside site, on 15 Feb 2016 shows NO_2 concentration at 385.6 mark. On 16th Feb’16 the NO_2 analyser was found to be at 13% measuring uncertainty against the standard of 10% (Eaton, 2016). Assuming data is ratified the possible reason for high value for the Monday of week-3 of Feb’16 cannot be explained except high vehicle use due to the tube strike uncertainty during the week based on web archive search (TFL, 2016b). Also, the NO2 concentration increase followed the traffic peak times pattern on Monday morning (8:00 AM 143.1 $\mu g.m^{-3}$ and 7:00 PM 385.3 $\mu g.m^{-3}$). However, there were no similar spikes for the rest of the days in the same week and makes it more difficult to conclude cause for the spike.

Near 500th hour (20th Jan’17 to 26th Jan’17) in 2017 pollution episode can be noted where NO_2 concentration increase can be seen in background and kerbside site. This was attributed to cold, calm and settled weather from high-pressure system (LondonAir, 2017). A similar increase in NO_2 concentration around 500th hour (20th Jan’16 to 21st Jan’16), near 8000th hour (29th Nov’16 to 6th Dec’16) during 2016 (LondonAir, 2016a). These episodes were noted across London and not only at the site’s local area that is being assessed in the report (LondonAir, 2016b). Further, it is important to note that weather has an impact on the dispersion of pollutants, such events are noted when emitted pollutants from various sources are not dispersed and thus reduction measures should target emission reduction (LondonAir, 2016b)

Since the background values have remained fairly constant from 2016 to 2017 we can interpret the air quality from NO2 perspective have improved in the area of Kerbside site AURN from measures taken in London and the Camden borough. Firstly, the number of new motor vehicles registered in the Camden borough remained constant by an uptake of 0.9% from 2016 to 2017. Secondly, from 2016 to 2017 the total HGV and total motor vehicle traffic count for the Camden borough reduced by 10.9% and increased by 0.4% respectively (DFT, 2018). Thirdly, bus fleet information from TFL, (2016a) and (2017) indicate a change in the diversity of emission standards as shown in fig-17. Also, vehicle fleet gets replaced from older EURO emission standard to new stricter EURO emission standards can have some contribution or could be a result of the reduction in HGV traffic reduction (Carslaw and Rhys-Tyler, 2013). Beginning March’2016 Camden council implemented diesel surcharge on its resident’s parking permits which has resulted in the decline in the uptake of residential diesel permits and market trader diesel permits by 7% and 25% respectively (London Borough of Camden, 2017; London Borough of Camden, 2018). Reduction in diesel vehicles which emit more NO_2 compared to petrol and hybrids could have contributed to the improvement (Carslaw et al., 2007).



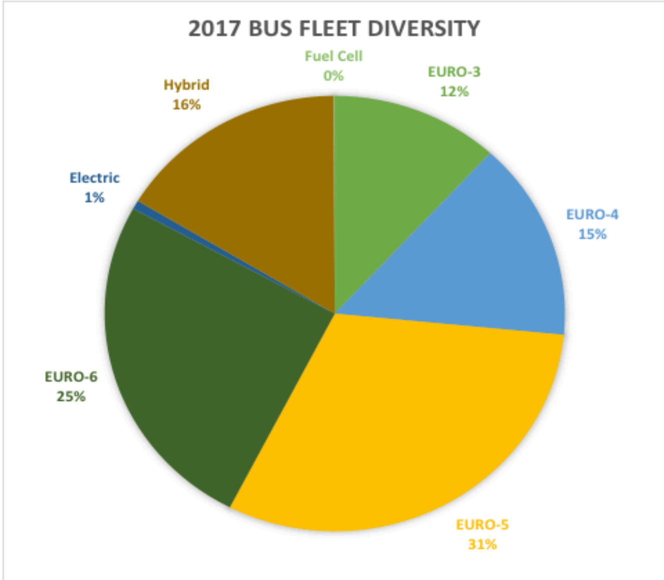


Fig-17 Emission standard diversity in London Bus fleet

With kerbside site, AURN close to three bus stops and a small change in a number of vehicles registered and reduction in traffic counts improvement in NO_2 standard performance can be attributed to improving emission standards (assuming real world are equal to certification test) of bus fleet and vehicles along with actions taken by Camden borough council. However, further empirical evidence and assessment with wider geographical scope are needed. As Carslaw and Rhys-Tyler, (2013) have shown there is no significant impact on NO_2 emissions with stricter EU standards based on 70,000 vehicles remote emission sensing for various model years.

References:

Carslaw, D.C., Beevers, S.D. and Bell, M.C. 2007. Risks of exceeding the hourly EU limit value for nitrogen dioxide resulting from increased road transport emissions of primary nitrogen dioxide. *Atmospheric Environment*. **41**(10), pp.2073–2082.

Carslaw, D.C. and Rhys-Tyler, G. 2013. New insights from comprehensive on-road measurements of NOx, NO2 and NH3 from vehicle emission remote sensing in London, UK. *Atmospheric Environment*. **81**, pp.339–347.

Clark, T., Eaton, S., Gray, S., Hector, D., Loader, A., Madle, A., Stacey, B., Stratton, S., Telfer, S. and Yardley, R. 2012. LSO_manual_2012_Part_A_Issue_1_final.pdf.

DEFRA 2018a. Air_Quality_Objectives_Update.pdf. [Accessed 16 December 2018]. Available from: https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf.

DEFRA 2007. Measurement methods and UK monitoring networks for NO2. [Accessed 3 December 2018]. Available from: https://uk-air.defra.gov.uk/assets/documents/reports/aqeg/chapter4.pdf.

DEFRA 2018b. Site information- Defra, UK. [Accessed 16 December 2018]. Available from: https://uk-air.defra.gov.uk/networks/site-info?site_id=CA1.

DEFRA 2018c. Site information- Defra, UK. [Accessed 16 December 2018]. Available from: https://uk-air.defra.gov.uk/networks/site-info?site_id=HG4.

DEFRA 2017. The Air Quality Data Validation and Ratification Process. [Accessed 16 December 2018]. Available from: https://uk-air.defra.gov.uk/assets/documents/Data_Validation_and_Ratification_Process_Apr_2017.pdf.

DEFRA 2010. What impact do trees have on air pollutant concentrations? - - Local Air Quality Management Support - Defra, UK. [Accessed 9 December 2018]. Available from: https://laqm.defra.gov.uk/laqm-faqs/faq105.html.

DFT 2018. Traffic counts - Transport statistics - Department for Transport. [Accessed 3 December 2018]. Available from: https://www.dft.gov.uk/traffic-counts/area.php?region=London&la=Camden.

Eaton, S. 2016. *QAQC Report for the Automatic Urban and Rural Network, January-March 2016* [Online]. United Kingdom: Ricardo Energy and Environment. Available from: https://uk-air.defra.gov.uk/assets/documents/reports/cat05/1608250956_AURN_QAQC_report_Q1_2016_Issue1.pdf.

GoogleEarth 2018. Overview. [Accessed 16 December 2018]. Available from: https://www.google.com/intl/en_uk/earth/.

Gromke, C. and Ruck, B. 2007. Influence of trees on the dispersion of pollutants in an urban street canyon—Experimental investigation of the flow and concentration field. *Atmospheric Environment*. **41**(16), pp.3287–3302.

Lapworth, A. and McGregor, J. 2008. Seasonal variation of the prevailing wind direction in Britain. *Weather*. **63**(12), pp.365–368.

London Borough of Camden 2017. *LB Camden Air Quality Annual Status Report for 2016* [Online]. Camden: London Borough of Camden. Available from: https://www.camden.gov.uk/ccm/cms-service/stream/asset/?asset_id=3694604&.

London Borough of Camden 2018. *London Borough of Camden Air Quality Annual Status Report for 2017* [Online]. Camden: London Borough of Camden. Available from: https://www.camden.gov.uk/ccm/cms-service/stream/asset/?asset_id=3735283&.

LondonAir 2016a. LAQN Pollution Episode. [Accessed 5 December 2018]. Available from: https://www.londonair.org.uk/london/asp/publicepisodes.asp?region=0&site=&postcode=&la_id=&level=All&bulletindate=17%2F01%2F2017&MapType=Google&zoom=&lat=51.4750&lon=-0.119824&VenueCode=&bulletin=explanation&episodeID=PM10PM25NO2MidJan2016&pageID=page1&cm-djitdk-djitdk=.

LondonAir 2016b. London Air Quality Network :: Welcome to the London Air Quality Network » Statistics Maps. [Accessed 16 December 2018]. Available from: https://www.londonair.org.uk/london/asp/publicepisodes.asp?region=0&site=&postcode=&la_id=&level=All&bulletindate=22%2F11%2F2018&MapType=Google&zoom=&lat=51.4750&lon=-0.119824&VenueCode=&bulletin=explanation&episodeID=PM10andNO2endNov&pageID=page1&cm-djitdk-djitdk=.

LondonAir 2017. 'Very High' pollution episode summary for 20th - 26th January 2017 from Kings College London. [Accessed 5 December 2018]. Available from: https://www.londonair.org.uk/london/asp/publicepisodes.asp?region=0&site=&postcode=&la_id=&level=All&bulletindate=17%2F01%2F2017&MapType=Google&zoom=&lat=51.4750&lon=-

0.119824&VenueCode=&bulletin=explanation&episodeID=PM10middleJanuary2017&pageID=page1&cm-djitdk-djitdk=.

Tate J. 2018. Air quality site selection. [Lecture Notes]. TRAN5032 Transport Data Collection and Analysis. University of Leeds.

TFL 2017. *fleet-audit-30-june-2017-final.pdf* [Online]. London: Transport for London. [Accessed 3 December 2018]. Available from: http://content.tfl.gov.uk/fleet-audit-30-june-2017-final.pdf.

TFL 2016a. *fleet-audit-30-september-2016-final.pdf* [Online]. London: Transport for London. [Accessed 3 December 2018]. Available from: http://content.tfl.gov.uk/fleet-audit-30-september-2016-final.pdf.

TFL 2016b. Tube strike travel advice for customers and road users. *Transport for London*. [Online]. [Accessed 16 December 2018]. Available from: https://tfl.gov.uk/info-for/media/press-releases/2016/february/-tube-strike-travel-advice-for-customers-and-road-users.

Yazid, A.W.M., Sidik, N.A.C., Salim, S.M. and Saqr, K.M. 2014. A review on the flow structure and pollutant dispersion in urban street canyons for urban planning strategies. *SIMULATION*. **90**(8), pp.892–916.