Prepared for NZ Transport Agency Waka Kotahi

NO_X TO NO_2 TOOL: USER GUIDE

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REV	DATE	DETAILS
A	8 November 2024	To accompany NO_x to NO_2 Tool Version 1.01

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1 INTRODUCTION

Emissions from road traffic include nitrogen monoxide (NO) and nitrogen dioxide (NO_2), the NO within those emissions converts within the atmosphere to nitrogen dioxide (NO_2) in the presence of sunlight and ozone (O_3) and contributes to total ambient NO_2 concentrations nearby.

Dispersion modelling of transport emissions is therefore completed using NO_x emission rates, with the resulting predictions of NO_x contributions at receptor locations needing to be converted to NO_2 for comparison with relevant criteria and guideline values for NO_2.

These modelled transport emissions comprise a portion of the total atmospheric NO_2, yet the chemical balance between NO_x and NO_2 relates their respective totals including other sources, and monitored NO_2 represents total ambient concentrations of NO_2 including these other sources alongside the traffic contribution.

Therefore, the verification of models of NO_x dispersion from road-transport emissions requires conversion between NO_x and NO_2, considering their 'background' (i.e., non-transport) contributions.

A Tool has been developed on behalf of New Zealand Transport Agency (NZTA) Waka Kotahi, to enable conversion between annual-average concentrations of oxides of nitrogen (NO_x) and annual average nitrogen dioxide (NO_2), based on data from Regional Council monitoring sites in New Zealand, for use within the verification of road traffic dispersion modelling predictions against monitored values of NO_2, during the detailed assessment of operational road traffic emissions.

The developed Tool provides a method for conversion between modelled roadside NO_x and total NO_2 incorporating estimated background concentrations, to allow comparison with assessment criteria or with monitored concentrations of NO_2. It also enables conversion from monitored concentrations of NO_2 to NO_x, to estimate the total NO_x that would give rise to the observed NO_2. The total NO_x can be partitioned into background and road-transport components using the modelled NO_x. These quantities are used in the model verification process outlined within the accompanying guidance on dispersion model verification[1].

[1] WSP (2024) Model Verification Guidance for Detailed Assessment of Air Quality Impacts from Road Transport Projects. Prepared for NZ Transport Agency Waka Kotahi.

2 RELATIONSHIP BETWEEN NO_X AND NO_2

A relationship between NO_x and NO_2 was developed by NIWA[2], based on Regional Council monitoring data prior to 2016. This involved fitting a curve through the data, whose form is represented by Equation 1.

$$NO_2 = \frac{(A NO_x)}{1+(B NO_x)+(C NO_x^2)} \quad (1)$$

Concentrations are annual averages, in µg/m^3. The best-fit parameters were calculated as follows:

- A = 5.85 x 10^{-1}
- B = 6.37 x 10^{-3}
- C = 2.24 x 10^{-7}

WSP has reviewed this relationship using a range of Regional Council NO_x and NO_2 monitoring data for the years 2019 to 2023 and found the relationship developed by NIWA still holds, as expected.

However, the measured NO_X concentration is defined as the sum of concentrations of NO and NO_2. For dispersion modelling purposes, NO_x emissions usually include NO expressed as NO_2. WSP has therefore re-evaluated the relationship by fitting a curve with the same form as Equation 1, expressing NO_x as NO_2. The data points and new curve are shown in Figure 2-1.

[2] NIWA (2019) Review of NO_2/NO_X empirical conversion equations. NIWA Client Report 2019193AK, prepared for NZ Transport Agency Waka Kotahi, July 2019.

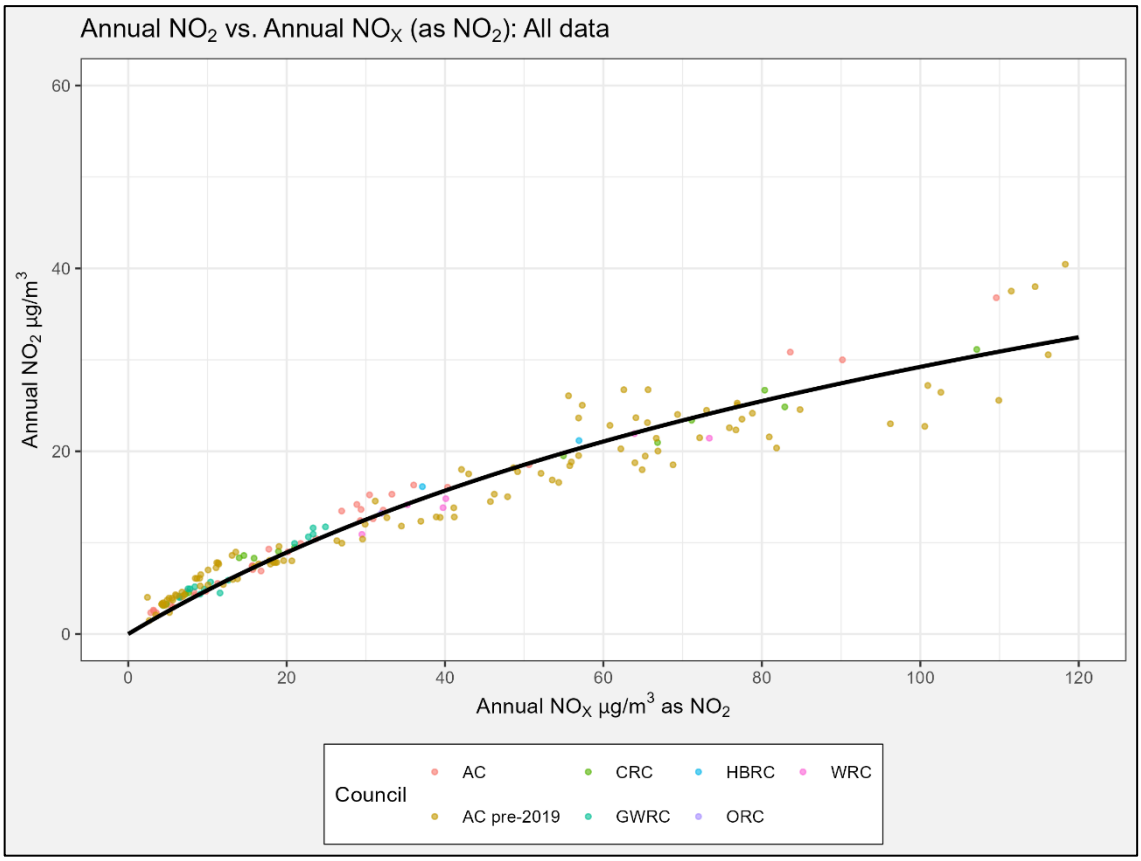


Figure 2-1: Annual-mean NO_2 plotted against annual-mean NO_x as NO_2.

The re-calculated NO_2/NO_x relationship is based on monitoring data from several Regional Councils *including* Auckland Council (AC), Greater Wellington Regional Council (GWRC), Waikato Regional Council (WRC), Canterbury Regional Council (CRC), Hawke's Bay Regional Council (HBRC) and Otago Regional Council (ORC). Pre-2019 AC data were supplied by NIWA.

The updated parameters for use in Equation 1 are as follows:

- A = 5.19×10^{-1}
- B = 8.28×10^{-3}
- C = -5.30×10^{-6}

The data presented in this section, and the workings of the conversion tool, are subject to the following assumptions:

- Both NO_x and NO_2 are expressed in micrograms per cubic meter (µg/m³).
- The relationship derived applies to total and background NO_x and NO_2 independently.
- The Tool converts from NO_x to NO_2 and from NO_2 to NO_x using the same best-fit curve.
- All quantities used in the conversion are annual averages.

3 USING THE NO_X TO NO_2 TOOL

This Tool allows the user to convert the modelled roadside NO_x concentration to total NO_2 concentration for the purpose of comparing the predicted NO_2 with the relevant annual-average guideline values, or with NO_2 monitoring data. It also allows for the conversion of the monitored total NO_2 to total NO_x concentration (partitioning between roadside and background components) to derive adjustment factors for the model verification procedure.

3.1 NO_X TO NO_2 TAB

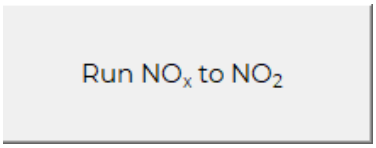
This tab within the Tool allows the user to derive total NO_2 concentrations from modelled roadside NO_x contributions, as follows:

1 Enter input data as follows:

- A list of receptors, defined by an ID and (optionally) their Eastings and Northings;
- The modelled contribution from transport to the NO_x GLC (Modelled Annual Road NO_x);
- The local background NO_2 concentration. In the absence of site-specific baseline data, estimates of background NO_2 concentration by Census Area Unit are available from NZTA[3].

2 Click the 'Run NO_x to NO_2' button to run the Tool, which will then evaluate the following:

- The local background concentration as NO_x (Annual Background NO_x);
- The NO_X concentration at each receptor (Annual Total NO_x);
- The total nitrogen dioxide concentration at the receptor (Annual Total NO_2);
- The incremental contribution to the nitrogen dioxide concentration from the road transport emissions (Annual Road NO_2).

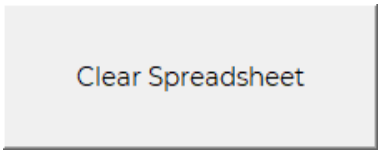


An example of inputs and output results is shown below:

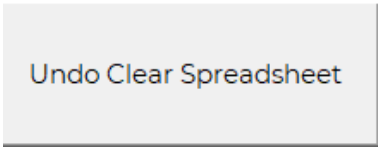
Receptor ID	Easting (m)	Northing (m)	Description	Comments	Modelled Annual Road NO_x (µg/m³)	Background NO_2 Concentration (µg/m³)	Annual Background NO_x (µg/m³)	Annual Total NO_x (µg/m³)	Annual Total NO_2 (µg/m³)	Annual Road NO_2 (µg/m³)
1	1748629.1	5427567.0			10.7	5.7	12.0	22.7	9.9	4.2

[3] NZ Transport Agency Waka Kotahi, Background air quality. Available from Background air quality | NZ Transport Agency Waka Kotahi (nzta.govt.nz)

3 Click on the ‘Clear Spreadsheet’ button to clear the spreadsheet to re-run the Tool for new model results.



4 Click on the 'Undo Clear Spreadsheet' button to restore previously cleared data (for example, if they were cleared by accident).



3.2 NO_2 TO NO_X TAB

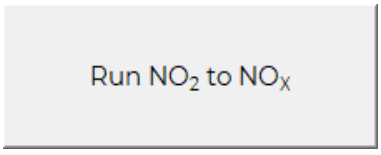
This tab within the Tool allows the user to derive the total NO_x concentration from monitored NO_2 contributions, and partition it into background and roadside contributions:

1 Enter input data as follows:

- A list of monitor locations, defined by an ID and (optionally) their Eastings and Northings;
- The monitored annual total NO_2 concentration;
- The local background NO_2 concentration.

2 Click the ‘Run NO_2 to NO_x’ button to run the Tool, which will then evaluate the following:

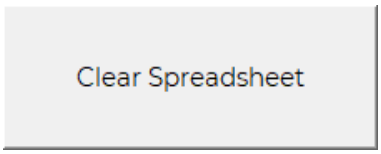
- The local background concentration converted to NO_x (Annual Background NO_x);
- The NOX concentration at the receptor (Annual Total NO_x);
- The incremental contribution to oxides of nitrogen concentrations from the road transport emissions (Annual Road NO_x).



An example of inputs and the output results is provided below:

Receptor ID	Easting (m)	Northing (m)	Description	Comments	Monitored Annual Total NO_2 ($\mu g/m^3$)	Background NO_2 Concentration ($\mu g/m^3$)	Annual Total NO_x ($\mu g/m^3$)	Annual Background NO_x ($\mu g/m^3$)	Annual Road NO_x ($\mu g/m^3$)
1	1748629.1	5427567			18.8	5.7	50.9	12.0	38.9

3 Click on the 'Clear Spreadsheet' button to clear the spreadsheet to re-run the Tool for new model results.



4 Click on the 'Undo Clear Spreadsheet' button to restore previously cleared data (for example, if they were cleared by accident).