# Technical Support Document (TSD) for AERMOD-Based Assessments of Long-Range Transport Impacts for Primary Pollutants

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# Technical Support Document (TSD) for AERMOD-Based Assessments of Long-Range Transport Impacts for Primary Pollutants

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# Preface

This document provides the results and interpretation of AERMOD screening and refined model simulations to estimate the pollutant concentration impacts in the near-field (i.e., less than 50km from source) and far-field (i.e., greater than 50km from source) for a wide range of source types for the purposes of informing the 2016 revisions to EPA's Guideline on Air Quality Models (published as Appendix W to 40 CFR Part 51). This document is not intended to demonstrate methods to assess facility impacts for NAAQS or PSD increment nor is it intended to provide any guidance on the usage of screening for long-range transport or any other regulatory analyses.

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# 1. Introduction

For long-range transport (LRT) applications at distances of more than 50 km from a source, the final revisions to EPA's *Guideline on Air Quality Models* (published as Appendix W to 40 CFR Part 51) include recommendations for a screening approach for addressing the NAAQS and Prevention of Significant Deterioration (PSD) increment and removal of CALPUFF as an EPA preferred model for such applications. In supporting these final revisions, the purpose of the modeling assessment detailed in this document is to demonstrate what types of facilities may have significant impacts for NAAQS or PSD increment at distances greater than 50 km from the source. While EPA has not determined a replacement refined model for LRT applications under the revised *Guideline*, the information provided in this report indicates that the need for LTR assessments for NAAQS and PSD increment violations for inert pollutants is limited, thereby mitigating the necessity for a preferred regulatory model for LRT assessments. This document provides technical details of the modeling assessment, including summarizing the model scenarios and approach used to determine the air quality impact of a range of source types on pollutant concentrations in the near-field (*i.e.*, within 50 km) and far-field (beyond 50 km).

# 2. Background

The permitting process for the PSD program requires that a new or modifying source demonstrate that the additional emissions will not cause or contribute to a violation of the NAAQS or PSD increment. The traditional approach for demonstrating compliance is a two-stage approach, as recommended in section 9.2.3 of the *Guideline*, and has been applied in the PSD program for more than 25 years. Under this two-stage approach, permitting authorities have issued PSD permits based on a demonstration that the air quality impacts of a proposed source are below levels of impact considered to be significant. In this document, significant impact levels (SILs) are used for illustrative purposes as a demonstration tool to determine the culpability of a new or modifying source to any NAAQS or PSD increment violations. In this context, a modeled ambient impact from a proposed new or modified source that is determined to be less than the applicable SIL is generally considered not to "cause or contribute" to any modeled violations of the relevant NAAQS or PSD increment.

Table 1 shows the SIL levels for NAAQS by criteria pollutant (i.e., $PM_{2.5}$, $PM_{10}$, $SO_2$, $NO_2$, and CO), while Table 2 shows the PSD increment levels and associated SIL levels of $PM_{2.5}$, $PM_{10}$, $SO_2$, and $NO_2$. In 1996, a rulemaking was proposed with Class I specific SILs for $NO_2$, $SO_2$, and $PM_{10}$ (U. S. EPA, 1996). Please note that these SILs for Class I PSD increments have never been promulgated; however, the values shown in Table 2 have been used in practice under the PSD program over the past 20 years.

For most PSD compliance demonstrations, the near-source impacts (*e.g.*, those occurring within 50 km of the new or modifying source) are the controlling factor in successfully meeting Clean Air Act (CAA) requirements. For the inert criteria pollutants, these near-source impacts are assessed with the EPA's preferred dispersion model, AERMOD (Cimorelli, et al, 2005). Due to variations in meteorology that are expected to occur beyond 50 km and the time required for a plume to travel this distance, steady-state plume models like AERMOD are expected to be conservative in the far-field. Thus, when LRT is expected to be important (*i.e.*, impacts beyond the nominal distance of 50 km), an alternative model is necessary for assessing impacts for those distances with the previous *Guideline* recommending the use of the CALPUFF modeling system (U. S. EPA, 2003). Section 6.2.3 of the 2005 version of the *Guideline* discusses the regulatory needs for LRT impact assessments. The focus in section 6.2.3 is the need to protect Class I areas and, in particular, Class I PSD increments are identified as the most stringent regulatory benchmarks in the PSD program. While refined LRT modeling could also be needed for NAAQS, it is uncommon that a facility can demonstrate compliance for a NAAQS and not also comply with applicable PSD increment(s).

**Table 1 - Significant Impact Levels (SILs) for NAAQS by Criteria Pollutant.**

| Pollutant | Class I | Class II | Class III | Source |
|---|---|---|---|---|
| **Fine Particulate Matter ($PM_{2.5}$)** | | | | |
| Annual mean | * | 0.2 (0.3)[1] ug/m$^3$ | * | 40 CFR 51.165 (b)(2) (U.S. EPA, 2016) |
| 24-hour maximum | * | 1.2 ug/m$^3$ | * | |
| **Particulate Matter ($PM_{10}$)** | | | | |
| Annual arithmetic mean | * | 1 ug/m$^3$ | * | 40 CFR 51.165(b)(2) |
| 24-hour maximum | * | 5 ug/m$^3$ | * | |
| **Carbon Monoxide (CO)** | | | | |
| 8-hour maximum | * | 500 ug/m$^3$ | * | 40 CFR 51.165(b)(2) |
| 1-hour maximum | * | 2000 ug/m$^3$ | * | |
| **Sulfur Dioxide ($SO_2$)** | | | | |
| Annual mean | * | 1 ug/m$^3$ | * | 40 CFR 51.165(b)(2) |
| 24-hour maximum | * | 5 ug/m$^3$ | * | |
| 3-hour maximum | * | 25 ug/m$^3$ | * | |
| 1-hour maximum | * | 3 ppb (~7.8 ug/m$^3$) | * | (U. S. EPA, 2010b) |
| **Nitrogen Dioxide ($NO_2$):** | | | | |
| Annual mean | * | 1 ug/m$^3$ | * | 40 CFR 51.165(b)(2) |
| 1-hour maximum | * | 4 ppb (~7.5 ug/m$^3$) | * | (U. S. EPA, 2010a) |

On August 1, 2016 the EPA released draft guidance with new PM2.5 SILs based on a new technical analysis (U.S. EPA, 2016). The draft guidance recommended the most conservative values from either 51.165 and the new technical analysis, which is 0.2 ug/m3 for the annual standard and 1.2 ug/m3 for the 24-hour standard.

**Table 2 - PSD Increment[2] and associated SILs for Criteria Pollutants by Class I, Class II, and Class III Areas.**

| Pollutant | Class I | Class II | Class III | Source |
|---|---|---|---|---|
| **Fine Particulate Matter ($PM_{2.5}$)** | | | | |
| Annual mean ug/m$^3$ | 1 (0.05) | 4 (0.2) | 8 (0.2) | (U.S. EPA, 2016)[3] |
| 24-hour maximum ug/m$^3$ | 2 (0.27) | 9 (1.2) | 18 (1.2) | (U.S. EPA, 2016) |
| **Particulate Matter ($PM_{10}$)** | | | | |
| Annual mean ug/m$^3$ | 4 (0.2) | 17 (1) | 34 (1) | 61 FR 38338 (July, 23 1996)[4] |
| 24-hour maximum ug/m$^3$ | 8 (0.3) | 30 (5) | 60 (5) | 61 FR 38338 (July, 23 1996) |
| **Sulfur Dioxide ($SO_2$)** | | | | |
| Annual mean ug/m$^3$ | 2 (0.1) | 20 (1) | 40 (1) | 61 FR 38338 (July, 23 1996) |
| 24-hour maximum ug/m$^3$ | 5 (0.2) | 91 (5) | 182 (5) | 61 FR 38338 (July, 23 1996) |
| 3-hour maximum ug/m$^3$ | 25 (1) | 512 (25) | 700 (25) | 61 FR 38338 (July, 23 1996) |
| 1-hour maximum | NA | NA | NA | |
| **Nitrogen Dioxide ($NO_2$)** | | | | |
| Annual mean ug/m$^3$ | 2.5 (0.1) | 25 (1) | 50 (1) | 61 FR 38338 (July, 23 1996) |
| 1-hour maximum | NA | NA | NA | |

[2] PSD Increments for all pollutants listed here are set in 40 CFR 52.21 (c).

[3] The draft EPA guidance includes new PM2.5 SILs for PSD increment. The prior PM2.5 SILs for PSD increment from the 2010 rule were vacated. See (U.S. EPA, 2016) for more information.

[4] The EPA published an NPRM in 1996 that included adding SILs for PSD increment for $SO_2$, $PM_{10}$, and NO2 to the CFR. This proposed rule was never went finalized. However, the proposed SILs for PSD increment have been used by states and industry permit applicants for PSD increment in the absence of any other guidance or rulemaking. These proposed SILs are thus used here in this analysis as a benchmark for the facility impacts.

# 3.0 Approach to evaluating near-source and long-range impacts

In order to assess the nature of LRT aspects of a PSD compliance demonstration, inert criteria pollutant emissions from a wide variety of facility types were modeled across a range of meteorology conditions to improve our understanding of the source impacts in the near-field (*i.e.*, within 50 km) and far-field (beyond 50 km).

## 3.1 Source Types and Characteristics

Table 3 provides a summary of the source types that were included in a modeling study conducted by EPA state agencies under the AERMOD Implementation Workgroup (AIWG). In 2011, EPA re-instituted the AIWG with a focus on the new 1-hour $NO_2$ and $SO_2$ NAAQS. The purpose of the workgroup was to provide insights into challenges being brought forward by stakeholders regarding modeling as part of compliance demonstrations for the new standards (Snyder & Thurman, 2012). The workgroup focused on modeling of "real world" examples utilizing existing and newly formed guidance for the $NO_2$ (U. S. EPA, 2010a) and $SO_2$ NAAQS (U. S. EPA, 2010b). The AIWG workgroup was composed of EPA staff from the Regional offices and the Office of Air Quality Planning and Standards (OAQPS) as well as modelers from state, territorial, and local air quality agencies. The workgroup compiled a list of source types or facilities that were of interest to various state and local agencies.

For each modeled facility, emissions and source characteristics were based on actual facilities from past permitting experiences but were modified to be generic facilities. AIWG participants conducted several modeling scenarios across multiple regions of the country that reflected changes in stack height, addition of controls, and modifications of facility boundaries reflecting changes in ambient air. Also for $NO_2$ sources, the modeling scenarios involved comparing the use of available Tier 3 methods under Appendix W: Plume Volume Molar Ratio Method (PVMRM) and Ozone Limiting Method (OLM). For complete details of the AIWG modeling study and results, the full report is available at:

http://www.epa.gov/ttn/scram/10thmodconf/review_material/AIWG_Summary.pdf

and

http://www.epa.gov/ttn/scram/10thmodconf/review_material/AIWG_Summary_v2.pdf.

**Table 3 - Summary of Modeling Scenarios by Source Type from AERMOD Implementation Workgroup (AIWG)**

| Facility | Base emission (tpy)[5] $NO_2/SO_2$ | Stack heights (m)[6,7] |
|---|---|---|
| Asphalt plant | 188/13.2 | 6, 3, 0.3 |
| Biomass | 244/174 | 55, 9, 9 |
| Cement kiln | 7140/3129 | 160, 160, 90[8], 908 |
| Coal EGU | 1863/4959 | 150, 100, 6, 5, 5 |
| Ethanol plant | 1180/890 | 11, 11, 2, 43, 25 |
| Flare | 104/6083 | 25 |
| Fuel oil turbine | 1184/417 | 25, 25, 25, 258, 258, 258, 258, 68, 68, 68 |
| Landfill gas turbine | 80/45 | 13,13,13,10 |
| NG compressor | 90/0.01 | 11, 11, 11, 11, 58 |
| Pulp & paper plant | 9657/3403 | 30, 30 ,29, 85, 85, 72, 72, 76, 8, 67, 67 |

## 3.2 Modeling Assessment Overview

The goal of this modeling assessment is to determine what types of facilities may have significant impacts in terms of NAAQS and PSD increment, as defined in this analysis as modeled concentrations above the applicable SIL, at distances greater than 50 km from the source. There are fundamentally four aspects that affect source impacts: 1) the source configuration (*e.g.*, stack height), 2) the emission rate, 3) the meteorology in the geographic area, and 4) the terrain in the geographic area. The source configurations and meteorology are closely tied when determining air quality impacts from a facility. These two aspects of a compliance demonstration under PSD are more constrained than the possible range of emissions. Any facility, whatever source configuration and meteorology, can have significant impacts at any distance if the emissions are high enough. Thus, it is essential to have emissions that reflect all possible realities with respect to the facility type, which makes the AIWG modeling scenarios ideal for this evaluation.

[5] The analysis is based on annual emissions, which is what was available from the original AIWG databases. However, annual emissions may not fully represent impacts for NAAQS or PSD increment from short term emissions that can be evaluated separately for some facilities.

[6] Primary stacks for $NO_2$ are colored blue, for $SO_2$ are colored red, for both are colored purple

[7] Since the facilities were modeled in flat terrain, the stack heights here are a combination of the stack height and the stack elevation.

[8] $NO_2$ only, no $SO_2$ emissions at this stack height.

Each original AIWG scenario was evaluated with a limited number of meteorological scenarios, which generally originated in the vicinity of the physical location of the facility that the scenario was based upon. However, to expand the usefulness of these scenarios for the purposes of this assessment and to more efficiently evaluate maximum potential impacts, a two-phased analysis was used here:

1. Screening modeling for NAAQS: The first phase consists of a screening analysis using worst-case meteorology generated by MAKEMET and AERMOD's SCREEN option (which calculates only plume-centerline concentrations). The results from this screening analysis generate the potential maximum 1-hour concentration from a particular source type in the near-field and at or about the 50km distance. Since the screening analysis only generates 1-hour concentrations, we limited this screening analysis to the 1-hour NAAQS for $NO_2$ and $SO_2$ . To provide a more appropriate basis in assessing the significance of source impacts in the far-field, we assessed the source impacts at the 50km distance assuming NAAQS compliance in the near-field (i.e., scaling factors developed that reflect adjusting predicted near-field concentrations to comply with NAAQS). As such, source types with predicted impacts notably above the applicable NAAQS SIL at 50 km from this phase were considered for further analysis in the second phase.
2. Refined modeling for NAAQS and PSD Increment: The second phase consisted of a refined analysis based on 5-years of meteorology from 4 regionally varying NWS stations and AERMOD version 14134. For this second phase, the 1-hour, 3-hour, 24-hour and annual concentrations were computed for comparison to the appropriate SILs under more realistic modeling scenarios. Similar to the screening modeling, predicted impacts at the 50km distance were assessed assuming NAAQS compliance in the near-field. Since the screening analysis indicated that only facilities with tall stacks might comply in the near-field and still have significant impacts at 50 km, the refined analysis focused on a single tall-stack facility (*i.e*., coal EGU) that serves as a representative example of these source types.

The original AIWG scenarios included $NO_2$ and $SO_2$ emissions only, with $NO_2$ using full conversion. However, PSD increments exist for CO, $PM_{10}$, and $PM_{2.5}$. Since CO air quality levels and emissions are currently so low, this pollutant is rarely an issue in PSD permitting and therefore was not evaluated in this assessment. However, $PM_{10}$ and $PM_{2.5}$ were necessary to include in this assessment and were evaluated along with $NO_2$ and $SO_2$. Since PM emissions were not included in the original AIWG scenarios, an analysis of the EPA's 2011 National Emissions Inventory (NEI, http://www.epa.gov/ttn/chief/net/2011inventory.html) was conducted to determine scaling factors to generate PM emissions based on the $NO_2$ and $SO_2$ emissions for a particular facility type.

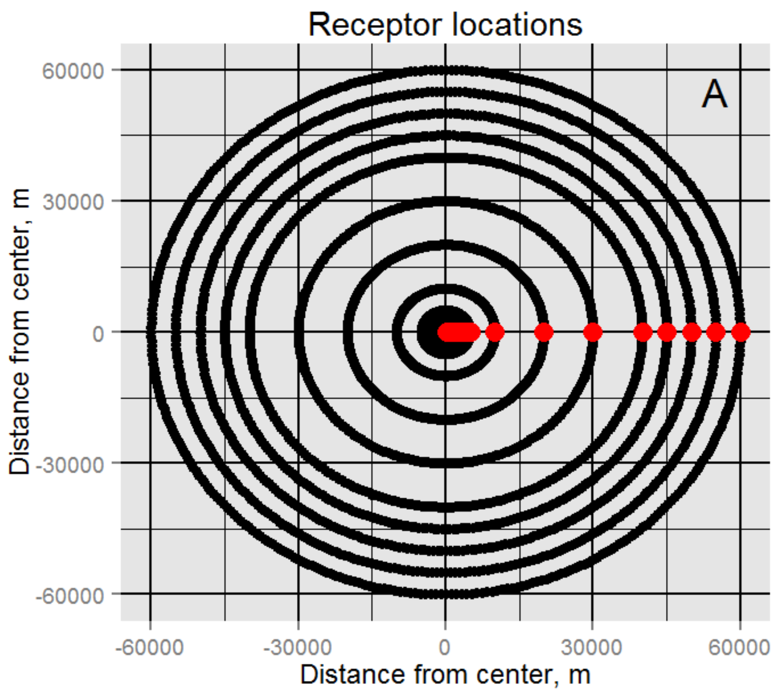
# 4. Summary of results

## 4.1 Phase 1: $NO_2$ and $SO_2$ NAAQS screening

In the first phase, screening meteorology, generated by the MAKEMET tool included in AERSCREEN (U. S. EPA, 2011), was used to evaluate a source's maximum 1-hour concentration impacts that could occur from these "worst-case" meteorological datasets. The screening meteorology includes conditions ranging from low wind/high stability cases, which would give highest concentrations for near-surface releases, to high wind/highly unstable conditions, which would give the highest concentrations for elevated releases (tall stacks). In addition to using screening meteorology, this initial phase used the SCREEN option in AERMOD, which determines plume centerline concentrations, regardless of the wind direction and source/receptor spatial relationships. When using this option with multiple sources in a single AERMOD run, the estimated concentrations are biased to be higher because each receptor will see the plume centerline from each source, regardless of the wind direction. For these model simulations, receptors were placed at distances ranging from 100 m to 60 km. Figure 1 illustrates the multiple receptor heights that were used to evaluate the potential presence of terrain downwind, with receptor heights including 0, 25, 65, 100, 150, and 200 m. Due to the plume centerline option being used, only a single receptor at each distance and height was required. The results from this initial phase represent an extremely conservative estimate of plume impacts. For $NO_2$, full conversion was used, *i.e.*, the emissions were 100% $NO_2$, and the half-life option in AERMOD was not used for $SO_2$.

The screening analysis was conducted for $NO_2$ and $SO_2$ only. The results are summarized in Table 4 and in Figures 2 through 11 in Appendix A. For these screening runs, we estimated the maximum concentration for both $NO_2$ and $SO_2$ at each receptor. In addition, the $8^{th}$ high 1-hour concentration for $NO_2$ and the $4^{th}$ high 1-hour concentration for $SO_2$ were estimated at each receptor. The $8^{th}$ and $4^{th}$ high 1-hour concentrations are the concentration metrics typically used for determining compliance in a PSD demonstration. While the $8^{th}$ and $4^{th}$ high results are conservative (due to the plume centerline concentrations calculated in the screening analysis mentioned earlier), these metrics give some sense of the distribution of the highest concentrations and provide valuable perspective on the maximum concentrations.

As shown in Table 4, several of the facilities have predicted impacts below the respective 1-hour NAAQS SILs for both $NO_2$ and $SO_2$ at the 50 km distance. The landfill gas turbine and natural gas (NG) compressor were below the NAAQS SIL at 50 km for both $NO_2$ and $SO_2$. The flare was below the NAAQS SIL for $NO_2$ and the asphalt plant and biomass burning plant were below the NAAQS SIL for $SO_2$. Several other facilities were very close to the NAAQS SIL at 50 km or had some receptors above and some below the SIL, depending on the receptor height. When the conservative nature of the screening modeling is taken into account, it is apparent that the predicted impacts that are slightly above the NAAQS SIL in the screening analysis (*e.g.*, the asphalt and biomass plant have impacts just above the SIL at 50 km) can be expected to be below the NAAQS SIL under a refined modeling analysis with representative meteorological inputs. That said, there are still some source types that have impacts at the 50 km distance well above the NAAQS SILs, including the cement kiln, coal EGU, ethanol plant, flare, fuel oil turbine, and pulp and paper plant.



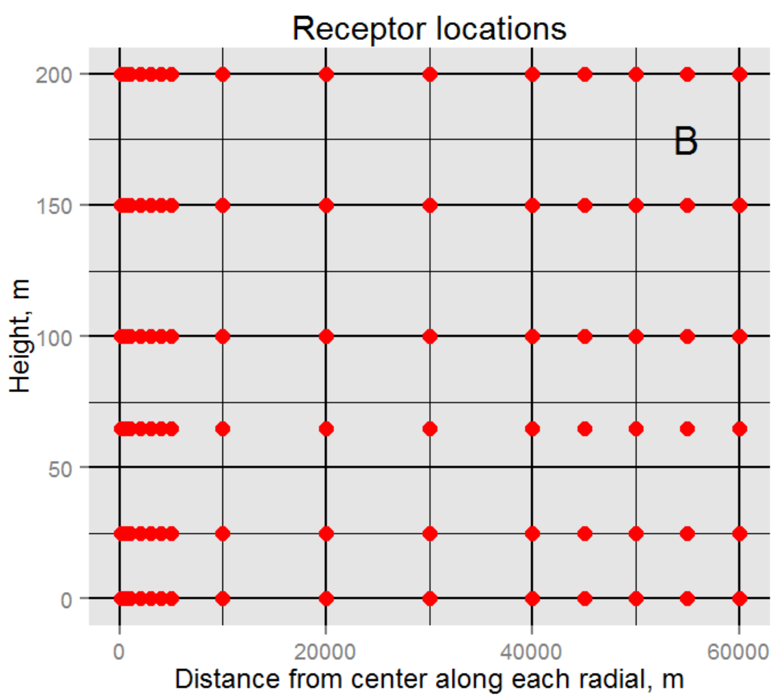




**Figure 1 – Location of receptors for screening and refined runs.**[9]

[9] Panel A shows the x and y locations, with refined receptors colored in black and screening receptors in red. Panel B shows the x and z locations for all receptors along any x/y radial.

While the results of the source impacts at 50 km compared to the appropriate SILs shown in Table 4 are insightful, these screening modeling results do not reflect the fact that a PSD compliance demonstration necessitates demonstrating compliance with the NAAQS in the near-field. Thus, it is reasonable to assume that NAAQS compliance in the near field would need to be met before considering the source impacts at 50 km and comparing to the applicable SIL for NAAQS and/or PSD increments, particularly if the concentrations in the near field are orders of magnitude above the NAAQS (*i.e.*, the NAAQS is the controlling standard). While the screening results are not equivalent to a NAAQS demonstration (which would calculate 8th and 4th high values for $NO_2$ and SO2, respectively, averaged over 5 years of modeling with actual meteorology), the results for many of the facilities suggest that the sources would need to reduce their emissions such that near-field compliance is achieved. Thus, the results in Table 5 present the 'scaled-back' results in that the predicted near-field concentrations have been used to estimate adjustments required to meet the NAAQS, and the resulting adjustment factors were used to then "scale back" the predicted 50km source impacts to yield estimates that reflect near-field NAAQS compliance. The adjustments are made according to the following equation:

**Equation 1**

$$Scaled\ 50\ km\ impact = Original\ 50\ km\ impact * (\frac{NAAQS}{(Representative\ near\ field\ impact)})$$

Table 5 shows estimates of the 'scaled-back' source impact at 50 km based on meeting the NAAQS in the near-field. The representative near-field impact is determined as the average of the 8th and 4th high results for $NO_2$ and $SO_2$, respectively, across the six receptor heights from the screening results (See Appendix Table A.1, see next paragraph for more discussion on this selection). The 50 km scaled impact is the maximum impact at 50 km (as opposed to the 8th or 4th high) from all receptor heights scaled back such that the representative near-field concentration meets the NAAQS. That is, the highest 50 km impact from Table 4 has been reduced by a factor necessary for the percentile results to meet the NAAQS. For example, for the fuel oil turbine, the representative near-field concentration from the screening analysis for $NO_2$ (the average of the $8^{th}$ maximum 1-hour averages shown in Appendix Table A.1) was 639.4 ppb, while the standard is 100 ppb and the maximum impact at 50 km was 12.5 ppb (Table 4). Even without considering background levels or contributions from nearby sources, the emissions would need to be reduced by a factor of 6 to satisfy a NAAQS compliance demonstration (i.e., the 639.4 ppb impact would need to be less than or equal to 100 ppb, equating to roughly a reduction factor of 6). This reduction would also apply to the impact at 50 km, resulting in an impact of 1.4 ppb at 50 km, which is well below the SIL of 4 ppb. When the 50 km impacts are scaled-back from these facilities to meet the NAAQS in the near field, the predicted impacts from all the facilities at 50 km fall below the applicable 1-hour SILs for the $NO_2$ and $SO_2$ NAAQS.

While this analysis is insightful, the nature of the screening modeling, with multiple levels of receptors at each distance, can make the results somewhat difficult to interpret, particularly when determining which near-field concentration is indeed "representative". The receptor grid was designed to reflect a variety of terrain possibilities, but certain combinations of receptors can also result in virtual terrain that is unrealistic. Thus, it is not an easy choice to select a near-field receptor to use in determining the near-field NAAQS compliance scaling discussed above. For example, the asphalt plant, which has the majority of the $NO_2$ emissions at 31 m, has the smallest impacts at the receptors with an elevation of 200 m. This is reasonable, as the plume from a 31 m stack has the farthest to travel to a 200 m receptor from the potential receptor heights. However, if a hypothetical domain had terrain that had the facility at an elevation of 0 m with a stack of 31 m (as we modeled here) and some downwind receptor at a 200 m elevation, then this domain would out of necessity need to have receptor elevations between 0 m and 200 m. Thus, there should be receptors at intermediate elevations in between the source and the 200 m receptor that would see higher concentrations than the concentration at the 200 m receptor. Therefore, the concentration from the 200 m receptors is not representative as the domain-wide controlling concentration. However, the concentrations from the receptors at 65 m, which are close to the stack height, may not be representative either. This is because the maximum impacts at these receptor heights occur immediately at the fence line, which implies a terrain in which the facility fence line is located immediately adjacent to the base of some sort of cliff, such that the ground-level receptors are at an elevation of 65 m above the facility (which has a base elevation of 0 m). This is unlikely and thus the maximum impact from the 65 m receptors may not be representative either. This unlikely “cliff” scenario is exaggerated even more with taller stack facilities. For example, the coal EGU has its $NO_2$ emissions distributed between a 120 m and 172 m stack, with the maximum impacts occurring at the 200 m receptors. Again, these maximum impacts would be at fence line receptors, implying a significant terrain feature of 200 m immediately at the fence line of the facility. Conversely, it is unlikely that the terrain over the entire domain of almost 40,000 square km is flat (*i.e.*, all elevations are only 0 m) or that there is a plateau, such that all receptors are at an elevation of 25 m over the entire domain. Ultimately, no single concentration from Appendix Table A.1 can be considered representative of the near-field impacts from a variety of potential terrain arrangements. Thus, the average of the $4^{th}$ high and $8^{th}$ high near-field concentrations were chosen as the “representative” near-field concentration.

In general, when complex terrain, such as the cliffs and plateaus discussed above, is not a major factor in the compliance demonstration, the expectation is that most receptor elevations are not significantly different from the baseline elevation of the facility. In such cases, facilities with the lower release points (shorter stacks) have their maximum impacts in close proximity to the source such that their impacts at 50 km are much lower after the adjustment to meet the NAAQS. Conversely, facilities with emissions concentrated at tall stacks do not see their maximum impacts until much farther downwind because the plumes need more time to impact the surface (or for the terrain to raise to the plume centerline). As a result, the impacts at 50 km are not reduced as much as they are with short stacks when the NAAQS compliance is taken into account. As the discussion of receptor heights and near-field impacts highlights, the considerations of stack heights and receptor elevations are an important consideration in determining what kind of facilities can potentially have significant impacts at 50 km. Based on these considerations and the adjustments to reflect near-field NAAQS compliance indicates that facilities with emissions from the taller stacks are most likely to still have some impacts above the applicable SIL at 50 km.

**Table 4 - Phase 1 Screening Modeling Results for $NO_2$ and $SO_2$ by Facility type: Maximum Impact Results**

| Facility | Receptor Elevation | $NO_2$ NAAQS (impacts in ppb) | | $SO_2$ NAAQS (impacts in ppb) | |
|---|---|---|---|---|---|
| | | Maximum 1-hour impact | Impact at 50 km (SIL 4 ppb)[10] | Maximum 1-hour impact | Impact at 50 km (SIL 3 ppb)[10] |
| Asphalt plant | 0 | 291.0 | 5.7 | 96.1 | 0.7 |
| | 25 | 856.8 | 6.2 | 115.4 | 0.7 |
| | 65 | 884.7 | 4.4 | 50.0 | 0.2 |
| | 100 | 408.3 | 2.3 | 49.7 | 0.2 |
| | 150 | 181.1 | 1.6 | 49.3 | 0.1 |
| | 200 | 129.8 | 1.4 | 49.0 | 0.1 |
| Biomass | 0 | 17.5 | 1.0 | 11.2 | 0.7 |
| | 25 | 17.7 | 1.0 | 11.3 | 0.7 |
| | 65 | 548.5 | 1.7 | 351.4 | 1.1 |
| | 100 | 899.4 | 5.5 | 576.2 | 3.5 |
| | 150 | 534.6 | 2.8 | 342.5 | 1.8 |
| | 200 | 243.7 | 1.5 | 156.1 | 1.0 |
| Cement kiln | 0 | 148.7 | 12.6 | 60.8 | 5.2 |
| | 25 | 149.1 | 12.7 | 61.0 | 5.2 |
| | 65 | 150.4 | 12.7 | 61.5 | 5.2 |
| | 100 | 152.2 | 12.7 | 62.2 | 5.2 |
| | 150 | 1468.9 | 12.7 | 567.6 | 5.2 |
| | 200 | 6771.0 | 21.7 | 2397.5 | 8.8 |
| Coal EGU | 0 | 232.8 | 5.0 | 74.8 | 6.9 |
| | 25 | 970.7 | 6.0 | 74.9 | 6.9 |
| | 65 | 434.3 | 3.8 | 75.8 | 6.9 |
| | 100 | 222.1 | 3.8 | 77.3 | 6.9 |
| | 150 | 517.2 | 3.8 | 1328.8 | 6.9 |
| | 200 | 1572.6 | 6.1 | 4388.2 | 16.7 |
| Ethanol plant | 0 | 391.4 | 6.4 | 32.2 | 3.0 |
| | 25 | 811.9 | 6.4 | 175.6 | 3.0 |
| | 65 | 1735.2 | 7.4 | 1091.4 | 4.7 |
| | 100 | 1746.1 | 15.6 | 1223.5 | 11.0 |
| | 150 | 1871.6 | 13.7 | 1311.5 | 9.6 |
| | 200 | 1109.3 | 6.0 | 777.3 | 4.2 |

[10] SILs used in the analysis are described in Section 2 above.

**Table 4 - Phase 1 Screening Modeling Results for $NO_2$ and $SO_2$ by Facility type: Maximum Impact Results (continued)**

| Facility | Receptor Elevation | $NO_2$ NAAQS (impacts in ppb) | | $SO_2$ NAAQS (impacts in ppb) | |
|---|---|---|---|---|---|
| | | Maximum 1-hour impact | Impact at 50 km (SIL 4 ppb)[10] | Maximum 1-hour impact | Impact at 50 km (SIL 3 ppb) [10] |
| Flare | 0 | 4.0 | 0.3 | 207.2 | 16.4 |
| | 25 | 17.2 | 0.3 | 897.8 | 16.4 |
| | 65 | 95.8 | 0.7 | 5014.2 | 37.7 |
| | 100 | 132.3 | 1.5 | 6924.3 | 77.3 |
| | 150 | 150.8 | 1.2 | 7888.0 | 60.9 |
| | 200 | 90.2 | 0.6 | 4718.9 | 29.9 |
| Fuel oil turbine | 0 | 78.3 | 3.2 | 22.0 | 0.9 |
| | 25 | 212.4 | 3.2 | 64.1 | 0.9 |
| | 65 | 770.3 | 5.8 | 275.6 | 1.4 |
| | 100 | 808.5 | 10.8 | 231.8 | 3.5 |
| | 150 | 1126.0 | 12.5 | 403.9 | 4.5 |
| | 200 | 907.9 | 7.4 | 325.1 | 2.7 |
| Landfill gas turbine | 0 | 28.1 | 1.0 | 13.0 | 0.4 |
| | 25 | 110.5 | 1.1 | 65.7 | 0.5 |
| | 65 | 230.5 | 1.9 | 136.9 | 1.0 |
| | 100 | 174.0 | 1.1 | 104.0 | 0.6 |
| | 150 | 75.5 | 0.5 | 45.1 | 0.3 |
| | 200 | 42.4 | 0.4 | 25.3 | 0.2 |
| NG compressor | 0 | 92.6 | 3.2 | 0.0 | 0.0 |
| | 25 | 835.8 | 3.7 | 0.1 | 0.0 |
| | 65 | 351.9 | 1.8 | 0.1 | 0.0 |
| | 100 | 181.9 | 1.2 | 0.0 | 0.0 |
| | 150 | 59.9 | 1.0 | 0.0 | 0.0 |
| | 200 | 43.1 | 1.0 | 0.0 | 0.0 |
| Pulp & paper plant | 0 | 5204.6 | 116.6 | 3586.2 | 39.4 |
| | 25 | 8493.1 | 117.5 | 21095.9 | 38.3 |
| | 65 | 192356.4 | 338.7 | 39363.7 | 88.0 |
| | 100 | 13176.6 | 87.8 | 4807.2 | 30.1 |
| | 150 | 3499.5 | 59.0 | 2034.3 | 19.8 |
| | 200 | 2681.9 | 59.0 | 1697.4 | 19.2 |

**Table 5 - Phase 1 screening modeling results for $NO_2$ and $SO_2$ by Facility type: Maximum Impact Results at 50 km scaled to Reflect Near-Field NAAQS Compliance**

| Facility | | $NO_2$ NAAQS NAAQS: 100 SIL: 4 (ppb) | $SO_2$ NAAQS NAAQS: 75 SIL: 3 (ppb) |
|---|---|---|---|
| **Asphalt plant** | Representative near-field impact (unscaled)[11] | 445.7 | *68.2*[12] |
| | 50 km scaled impact[13] | 1.4 | *0.7* |
| **Biomass plant** | Representative near-field impact (unscaled) | 351.4 | 231.1 |
| | 50 km scaled impact | 1.6 | 1.5 |
| **Cement kiln** | Representative near-field impact (unscaled) | 1452.3 | 531.6 |
| | 50 km scaled impact | 1.5 | 1.6 |
| **Coal EGU** | Representative near-field impact (unscaled) | 545.9 | 812.1 |
| | 50 km scaled impact | 1.1 | 2.1 |
| **Ethanol plant** | Representative near-field impact (unscaled) | 1238.9 | 765.5 |
| | 50 km scaled impact | 1.3 | 1.4 |
| **Flare** | Representative near-field impact (unscaled) | 76.7 | 4201.6 |
| | 50 km scaled impact | *1.5* | 1.8 |
| **Fuel oil turbine** | Representative near-field impact (unscaled) | 639.4 | 214.8 |
| | 50 km scaled impact | 1.9 | 2.1 |
| **Landfill gas turbine** | Representative near-field impact (unscaled) | 104.1 | *62.9* |
| | 50 km scaled impact | 1.8 | *1.0* |
| **NG compressor** | Representative near-field impact (unscaled) | 253.4 | *0.0* |
| | 50 km scaled impact | 1.5 | *0.0* |
| **Pulp & paper plant** | Representative near-field impact (unscaled) | 36836.8 | 11993.1 |
| | 50 km scaled impact | 0.9 | 0.6 |

[11] The representative near-field impact is calculated as the average of the “Maximum 1-hour impact” shown in Appendix Table A.1 across each receptor elevation.

[12] For several facilities, the representative near-field impact is below the level of the NAAQS. In these cases (highlighted in red), the 50 km impact is not scaled as described in the next footnote. Instead, the original result from Table 4 is taken directly for Table 5.

[13] The 50 km scaled impact is calculated as the maximum of the “Impact at 50 km” values in Table 4 across each receptor elevation multiplied by the ratio of the level of the NAAQS to the representative near-field impact shown in this table. See Equation 1.

## 4.2 Phase 2: Refined analyses for $NO_2$ and $SO_2$

The second phase of the analysis focused on characterizing impacts from tall stack sources using a more refined approach to determine modeled source-level impacts. For this phase, AERMOD version 14134 was used with representative meteorological inputs from several sets of NWS stations across the nation (described further below). A variety of meteorological data sets were used to provide more complete and robust findings that better represent source impacts across the nation. Since the plume centerline concentrations were not calculated in this phase, a polar receptor grid was used with 1-degree radial spacing through 360 degrees. Receptor distances and heights matched those from Phase 1 screening analysis as shown in Figure 1. For this second phase, 1-hour, 3-hour, 24-hour and annual concentrations were calculated to compare to the SILs for various averaging periods.

This refined modeling approach will generate less conservative estimates of the impacts at 50 km from the various facilities relative to the screening analysis that indicated the potential for source impacts above the SIL at 50 km. As discussed above, when NAAQS compliance is considered, it appears that only facilities with tall stacks have the potential to show compliance in the near-field assessment for the NAAQS and still have impacts at 50 km near the SIL. The coal EGU and the cement kiln had the tallest stacks with the cement kiln emissions mainly at the 160 m stacks, while the coal EGU emissions are mainly at the 150 and 100 m stacks. While the screening analysis indicated that the pulp and paper facility had the highest near-field and 50 km impacts, the tallest stacks at this facility were roughly half the height of the primary stacks at the cement kiln and coal EDU. Therefore, we focused only on the coal EGU because its $SO_2$ emissions were concentrated at the tallest stack while its $NO_2$ emissions were distributed to the two tallest stacks (150 m and 100 m stack heights), thereby providing the most insightful test case for refined modeling. Table 6 shows the specific emissions for each stack at the coal EGU scenario for $NO_2$ and $SO_2$.

**Table 6 - Summary of $NO_2$ and $SO_2$ emissions for the coal EGU facility**

| Stack height (m) | 175[14] | 120 | 51 | 50 | 50 |
|---|---|---|---|---|---|
| $NO_2$ emissions (tpy) | 1564 | 174 | 104 | 10.4 | 10.4 |
| $SO_2$ emissions (tpy) | 4867 | 87 | 4.3 | .7 | .3 |

For the refined modeling analysis, we used four meteorological datasets consisting of 5 years of meteorological data from 2006 to 2010, reflecting National Weather Service (NWS) stations located at JFK airport in Ashland, WI (ASX), Somerset airport in Somerville, NJ (SMQ), Dalhart airport in Dalhart, TX (DHT), and Oakland airport in Oakland, CA (OAK). These datasets were selected based on prior usage of a large set of meteorological datasets regularly used by the EPA and are known to represent a range of meteorological conditions. These data sets also provide spatial variability in the refined modeling analyses. The airports are all ASOS sites, with 1-minute observations processed through AERMINUTE and AERMET using the beta u* adjustment option (U. S. EPA, 2014). The maximum 1-hour concentration (5-

[14] The 150 m stack is above GEP height, but was modeled at this height for illustrative purposes.

year average), NAAQS specific design value (5-year average of 98th percentile and 99th percentile daily 1-hour maximum concentrations), annual average (5-year average of each annual average), and 24-hour and 3-hour PSD increment levels (highest first and second values) for $SO_2$. As noted above, a polar grid was used with 1-degree separation and 360 degrees (receptor distances and heights matched those used in the screening analysis).

### *4.2.1 1-hour NAAQS Results*

Plots summarizing the refined modeling analysis for $NO_2$ and $SO_2$ are presented in Appendix B and the results are summarized in Tables 7 and 8 for each 1-hour NAAQS. The most striking difference from the screening and refined analysis is the decrease in the maximum 1-hour values for both pollutants. For $NO_2$, the maximum from the screening (with unscaled emissions) was 1572 ppb, while the maximum from the refined runs was around 546 ppb (again, with unscaled emissions). For $SO_2$, the maximum concentrations decrease even further from 4388 ppb to 454 ppb. For $NO_2$, the maximum 1-hour concentrations at 50 km from the refined modeling (with unscaled emissions) are now well below the 1-hour NAAQS SIL at 50 km. However, the $SO_2$ concentrations are still above the SIL at 50 km with the unscaled emissions. If the $SO_2$ emissions are scaled such that the near-field results meet the NAAQS, then the impact at 50 km are below the 1-hour NAAQS SIL. However, the maximum impacts in the near-field for $SO_2$ are driven by results at the 150 and 200 m receptors, *i.e.*, elevated receptors reflective of terrain features in vicinity of the facility. The elevated receptors were included to evaluate the potential impacts of terrain on the modeling results. However, it is not likely that a large emitting facility with a 150 m stack would be built in the immediate vicinity of terrain near or above stack height because the facility would likely have issues providing a successful NAAQS compliance demonstration. Thus, it is somewhat unrealistic to consider these elevated receptors at the closest distances. If these elevated receptors are not considered in the near-field, then the EGU source type would satisfy the NAAQS compliance demonstration in the near-field, but be above the NAAQS SIL in the far-field. Thus, the near-field concentrations would not indicate a NAAQS violation because there would be no receptors near stack height and that a source of this type could possibly have significant impacts at 50 km or greater and need an LRT assessment.

Table 7 – Phase 2 Refine Modeling Results for $NO_2$ by NWS Station

| Met station | Receptor Elevation | Maximum 1-hour impact (ppb, 1st high) | | 98th percentile 1-hour impact (ppb, 8th high) | |
|---|---|---|---|---|---|
| | | All receptors | 50 km (SIL 4 ppb) | All receptors | 50 km (SIL 4 ppb) |
| Ashland, WI (ASX) | 0 | 546.81 | 1.50 | 366.15 | 0.94 |
| | 25 | 505.18 | 1.66 | 344.43 | 1.04 |
| | 65 | 373.36 | 1.34 | 270.46 | 0.97 |
| | 100 | 301.35 | 1.27 | 217.27 | 0.85 |
| | 150 | 311.18 | 1.39 | 217.01 | 0.99 |
| | 200 | 286.22 | 1.60 | 191.64 | 1.15 |
| Dalhart, TX DHT | 0 | 357.80 | 1.38 | 235.82 | 0.75 |
| | 25 | 340.30 | 1.45 | 210.89 | 0.76 |
| | 65 | 269.71 | 1.32 | 129.94 | 0.77 |
| | 100 | 216.93 | 1.28 | 118.30 | 0.73 |
| | 150 | 199.68 | 1.35 | 128.86 | 0.80 |
| | 200 | 239.83 | 1.50 | 127.65 | 0.96 |
| Oakland, CA OAK | 0 | 417.98 | 1.62 | 318.30 | 1.16 |
| | 25 | 397.27 | 1.75 | 302.32 | 1.17 |
| | 65 | 312.91 | 1.53 | 239.16 | 1.15 |
| | 100 | 250.09 | 1.52 | 191.94 | 1.12 |
| | 150 | 245.54 | 1.56 | 146.20 | 1.14 |
| | 200 | 212.50 | 1.91 | 138.62 | 1.19 |
| Somerville, NJ SMQ | 0 | 443.30 | 1.15 | 344.51 | 0.72 |
| | 25 | 425.08 | 1.22 | 370.58 | 0.81 |
| | 65 | 302.98 | 1.20 | 227.72 | 0.81 |
| | 100 | 243.67 | 1.09 | 183.29 | 0.72 |
| | 150 | 253.43 | 1.19 | 189.48 | 0.94 |
| | 200 | 250.14 | 1.32 | 184.82 | 1.08 |

Table 8 - Phase 2 Refine Modeling Results for $SO_2$ by NWS Station

| Met scenario | Receptor Elevation | Maximum 1-hour impact (ppb, 1st high) | | 99th percentile 1-hour impact (ppb, 4th high) | |
|---|---|---|---|---|---|
| | | All receptors | 50 km (SIL 3 ppb) | All receptors | 50 km (SIL 3 ppb) |
| Ashland, WI (ASX) | 0 | 23.65 | 2.58 | 14.22 | 1.98 |
| | 25 | 23.69 | 2.57 | 14.31 | 1.97 |
| | 65 | 24.08 | 2.57 | 14.68 | 1.96 |
| | 100 | 34.60 | 2.56 | 24.57 | 1.95 |
| | 150 | 68.70 | 2.56 | 57.76 | 1.95 |
| | 200 | 262.24 | 3.20 | 200.78 | 2.47 |
| Dalhart, TX DHT | 0 | 23.39 | 2.47 | 12.04 | 1.81 |
| | 25 | 23.60 | 2.46 | 12.07 | 1.80 |
| | 65 | 23.97 | 2.46 | 12.40 | 1.78 |
| | 100 | 49.53 | 2.46 | 42.82 | 1.77 |
| | 150 | 87.43 | 2.46 | 53.61 | 1.76 |
| | 200 | 652.11 | 3.15 | 454.48 | 2.28 |
| Oakland, CA OAK | 0 | 28.98 | 3.01 | 21.36 | 2.65 |
| | 25 | 29.01 | 2.99 | 21.52 | 2.64 |
| | 65 | 29.23 | 2.97 | 21.75 | 2.63 |
| | 100 | 43.59 | 2.96 | 28.06 | 2.63 |
| | 150 | 82.33 | 2.95 | 67.46 | 2.62 |
| | 200 | 394.67 | 4.04 | 329.24 | 2.97 |
| Somerville, NJ SMQ | 0 | 25.57 | 2.08 | 16.24 | 1.63 |
| | 25 | 25.63 | 2.07 | 16.35 | 1.63 |
| | 65 | 25.75 | 2.06 | 16.47 | 1.62 |
| | 100 | 34.85 | 2.05 | 24.03 | 1.62 |
| | 150 | 49.22 | 2.04 | 38.58 | 1.62 |
| | 200 | 177.58 | 2.40 | 139.80 | 2.12 |

*4.2.2 3-hour, 24-hour, and annual PSD increment results*

For the NO2 and SO2 PSD increment analysis, the results from the refined analysis presented in Section 4.2.1 have been used to scale down the impacts in the 3-hour and 24-hour $SO_2$ PSD increment and the annual $NO_2$ and SO2 PSD increment calculations. The scaling factors are given in Table 9. As shown in Table 10 for the 3-hour and 24-hour $SO_2$ PSD increment, the scaled down impacts at 50 km are below the Class II PSD increment SILs and slightly above the respective Class I PSD increment SILs for three of the four meteorological data sets (Section B.2). However as shown in Table 10 for the annual $NO_2$ and SO2 PSD increment, the source impacts at 50 km are well below both Class I and Class II PSD increment SILs for all cases (Section B.3). In general, these results show that the longer the averaging period, the less likely that there will be significant source impacts at distances of 50 km and greater.

**Table 9 - Scaling factors from NAAQS refined analysis for use in PSD increment refined analysis**

| Meteorological dataset | $NO_2$ scaling factors | $SO_2$ scaling factors |
|---|---|---|
| **ASX** | 0.27 | 0.37 |
| **DHT** | 0.42 | 0.17 |
| **OAK** | 0.31 | 0.23 |
| **SMQ** | 0.27 | 0.54 |

**Table 10 - Phase 2 refined modeling results for $NO_2$ and $SO_2$ PSD increments by NWS station**

| | | ASX | | DHT | | OAK | | SMQ | |
|---|---|---|---|---|---|---|---|---|---|
| | Elev. | Max domain | 50 km | Max domain | 50 km | Max domain | 50 km | Max domain | 50 km |
| | | PSD Increment SILs: C1 - 1; C2 - 25 (ug/m3) | | | | | | | |
| 3-hr SO2 H1H | 100 | 25.1 | 1.11 | 8.0 | 0.55 | 10.2 | 1.23 | 26.3 | 1.77 |
| | 150 | 51.0 | 1.11 | 34.8 | 0.56 | 42.1 | 1.22 | 50.1 | 1.77 |
| | 200 | 223.6 | 1.32 | 214.9 | 0.90 | 193.2 | 1.20 | 221.1 | 1.79 |
| 3-hr SO2 H2H | 100 | 15.4 | 1.05 | 6.6 | 0.50 | 9.6 | 1.07 | 21.6 | 1.71 |
| | 150 | 43.9 | 1.05 | 27.0 | 0.50 | 40.6 | 1.07 | 46.6 | 1.70 |
| | 200 | 199.4 | 1.21 | 200.5 | 0.69 | 169.6 | 1.07 | 210.9 | 1.77 |
| | | PSD Increment SILs: C1 - 0.2; C2 - 5 (ug/m3) | | | | | | | |
| 24-hr SO2 H1H | 100 | 5.0 | 0.24 | 2.4 | 0.10 | 3.1 | 0.35 | 8.5 | 0.54 |
| | 150 | 23.6 | 0.27 | 12.2 | 0.10 | 16.7 | 0.35 | 22.6 | 0.53 |
| | 200 | 120.8 | 0.34 | 79.3 | 0.13 | 76.3 | 0.35 | 158.4 | 0.53 |
| 24-hr SO2 H2H | 100 | 4.7 | 0.24 | 2.3 | 0.09 | 2.9 | 0.33 | 8.0 | 0.42 |
| | 150 | 17.2 | 0.25 | 8.5 | 0.10 | 15.1 | 0.33 | 20.2 | 0.43 |
| | 200 | 101.8 | 0.29 | 73.2 | 0.13 | 60.4 | 0.33 | 108.7 | 0.52 |
| | | PSD Increment SILs: C1 - 0.1; C2 - 1 (ug/m3) | | | | | | | |
| Annual NO2 | 100 | 4.1 | 0.01 | 1.3 | 0.00 | 3.5 | 0.02 | 8.7 | 0.02 |
| | 150 | 4.0 | 0.01 | 1.2 | 0.00 | 3.7 | 0.02 | 8.2 | 0.02 |
| | 200 | 4.6 | 0.01 | 1.5 | 0.00 | 4.6 | 0.02 | 7.7 | 0.02 |
| Annual SO2 | 100 | 0.4 | 0.02 | 0.7 | 0.01 | 0.7 | 0.07 | 0.6 | 0.02 |
| | 150 | 0.9 | 0.02 | 2.2 | 0.02 | 2.2 | 0.07 | 1.4 | 0.03 |
| | 200 | 4.3 | 0.03 | 10.3 | 0.02 | 9.5 | 0.07 | 3.9 | 0.03 |

## 4.3 Phase 2: Refined analyses for $PM_{10}$ and $PM_{2.5}$

Since the AIWG facilities did not include $PM_{10}$ or $PM_{2.5}$ emissions, we derived these emissions by scaling from the emission rates for $SO_2$ and $NO_2$ based on emission ratios of these pollutants for EGUs listed in the NEI. The ratios of $PM_{10}$ and $PM_{2.5}$ emissions to $NO_X$ emissions for all EGUs with $NO_X$ emissions greater than 40 tons were calculated. Similarly, emission ratios were computed for EGUs with $SO_2$ emissions greater than 40 tons. PM emissions were significantly lower than $NO_X$ and $SO_2$ emissions. The emissions data used in the refined modeling analysis are summarized in Table 11. On average, the $PM_{10}$ emissions were about 22% of $NO_X$ and $SO_2$ emissions, while $PM_{2.5}$ emissions were around 19% of $NO_X$ and $SO_2$ emissions. The facilities with the greatest $PM_{10}$ and $PM_{2.5}$ emission ratios resulted in $PM_{10}$ and $PM_{2.5}$ being 50% of $NO_X$ and 38% of $SO_2$. Given how close $PM_{10}$ and $PM_{2.5}$ emission ratios were, this assessment focused on $PM_{2.5}$ emissions only, as the $PM_{2.5}$ standard are more stringent than the $PM_{10}$ standards. Since both $PM_{10}$ and $PM_{2.5}$ would be modeled as inert pollutants, the model would treat each pollutant equally with respect to dispersion, so modeling both $PM_{10}$ and $PM_{2.5}$ with the approximately the same emission rates would result in roughly the same modeled concentrations. The average emission ratios (20%) were used to scale the PM emissions for the PM analysis, based on the original $NO_2$ and $SO_2$ emissions presented in Section 3.1.

**Table 11- - Summary of 2011 NEI emission data used in refined modeling analysis**

| $NO_x$ ratios | | | | | |
|---|---|---|---|---|---|
| **$PM_{10}$ max** | $PM_{10}$ min | $PM_{10}$ mean | $PM_{2.5}$ max | $PM_{2.5}$ min | $PM_{2.5}$ mean |
| 8.0% | 49.4% | 22.9% | 4.8% | 49.2% | 19.5% |
| **$SO_2$ ratios** | | | | | |
| **$PM_{10}$ max** | $PM_{10}$ min | $PM_{10}$ mean | $PM_{2.5}$ max | $PM_{2.5}$ min | $PM_{2.5}$ mean |
| 3.1% | 37.7% | 22.6% | 2.7% | 37.6% | 18.7% |

### *4.3.1 24-hour NAAQS results*

Plots summarizing the refined modeling analyses for $PM_{2.5}$ are presented in Appendix C, broken out by averaging time and form. The comparison against the $PM_{2.5}$ 24-hour NAAQS are presented in Section C.1. As shown in Table 12, the results for both the $SO_2$-scaled and $NO_2$-scaled emissions for all 4 meteorological data sets are generally below the 24-hour NAAQS SIL of 1.2 ug/m3 within the first 5 km from the source and are an order of magnitude below the SIL at 50 km.

**Table 12 – Phase 2 refined modeling results for 24-hour PM2.5 NAAQS by NWS station**

| | | ASX | | DHT | | OAK | | SMQ | |
|---|---|---|---|---|---|---|---|---|---|
| | **Elev.** | **Max domain** | **50 km** | **Max domain** | **50 km** | **Max domain** | **50 km** | **Max domain** | **50 km** |
| | | NAAQS SIL: 1.2 (ug/m3) | | | | | | | |
| **PM2.5 24-hr NAAQS $NO_2$-scaled, 8th high** | 100 | 10.7 | 0.03 | 7.4 | 0.02 | 11.5 | 0.07 | 13.5 | 0.04 |
| | 150 | 10.6 | 0.04 | 6.8 | 0.03 | 11.5 | 0.07 | 12.3 | 0.04 |
| | 200 | 10.7 | 0.04 | 9.0 | 0.03 | 14.8 | 0.07 | 12.4 | 0.05 |
| **PM2.5 24-hr NAAQS $SO_2$-scaled, 8th high** | 100 | 1.5 | 0.07 | 1.8 | 0.05 | 1.7 | 0.17 | 1.8 | 0.09 |
| | 150 | 4.5 | 0.08 | 5.5 | 0.06 | 5.5 | 0.17 | 3.9 | 0.09 |
| | 200 | 21.6 | 0.09 | 27.2 | 0.07 | 29.1 | 0.18 | 14.9 | 0.11 |

### *4.3.2 Annual NAAQS and PSD increment results*

The comparisons against the annual NAAQS (0.2 ug/m3) and PSD increment (0.05 ug/m3) SILs is presented in Section C.2. As shown in Table 13, similar to the 24-hour NAAQS results, the refined modeling results for all 4 meteorological data sets are generally below the annual NAAQS SIL within the first 10 km and are below the annual PSD increment SIL within the first 20 km. The modeled impacts are again an order of magnitude below both SILs at 50 km.

**Table 13 – Phase 2 refined modeling results for annual PM2.5 NAAQS and PSD increment by NWS station**

| | | ASX | | DHT | | OAK | | SMQ | |
|---|---|---|---|---|---|---|---|---|---|
| | **Elev.** | **Max domain** | **50 km** | **Max domain** | **50 km** | **Max domain** | **50 km** | **Max domain** | **50 km** |
| | | NAAQS SIL: 0.2 \| PSD Increment SILs C1 - 0.05; C2 - 0.2 (ug/m3) | | | | | | | |
| **PM2.5 annual $NO_2$-scaled** | 100 | 2.2 | 0.01 | 1.5 | 0.00 | 3.1 | 0.01 | 3.2 | 0.01 |
| | 150 | 2.2 | 0.01 | 1.4 | 0.00 | 3.2 | 0.01 | 3.0 | 0.01 |
| | 200 | 2.5 | 0.01 | 1.7 | 0.00 | 4.0 | 0.01 | 2.9 | 0.01 |
| **PM2.5 annual $SO_2$-scaled** | 100 | 0.3 | 0.01 | 0.4 | 0.01 | 0.5 | 0.04 | 0.5 | 0.02 |
| | 150 | 0.6 | 0.01 | 1.0 | 0.01 | 1.4 | 0.05 | 1.0 | 0.02 |
| | 200 | 3.2 | 0.02 | 4.9 | 0.01 | 6.2 | 0.05 | 2.9 | 0.02 |

### *4.3.2 24-hour PSD increment results*

The comparisons against the 24-hour PSD increment (0.27 ug/m3) SILs is presented in Section C.2. As shown in Table 14, unlike the results for the 24-hour NAAQS and the annual NAAQS and PSD increment, the refined modeling impacts are not clearly below the SIL at 50 km. For the $SO_2$-scaled results, the impacts at 50 km are slightly above the SIL in all cases, while the $NO_2$-scaled results are slightly below the SIL in all cases. The results from the 24-hour and annual NAAQS analysis did not as clearly indicate issues with NAAQS compliance in the near-field (the maximum 24-hour results were around 10-12 ug/m3, while the maximum annual results were around 3-4 ug/m3). Thus, there is no clear suggestion that the emissions would need to be reduced to meet the NAAQS in the near-field such that the 24-hour PSD increment impacts would be reduced. Nonetheless, the impacts are fairly close to the 24-hour PSD increment SILs without emissions adjustments.

**Table 14 – Phase 2 refined modeling results for 24-hour PM2.5 PSD increment by NWS station**

| | | ASX | | DHT | | OAK | | SMQ | |
|---|---|---|---|---|---|---|---|---|---|
| | **Elev.** | **Max domain** | **50 km** | **Max domain** | **50 km** | **Max domain** | **50 km** | **Max domain** | **50 km** |
| | | PSD Increment SILs: C1 - 0.27; C2 - 1.2 (ug/m3) | | | | | | | |
| **PM2.5 24-hr $NO_2$-scaled H1H** | 100 | 18.1 | 0.07 | 12.5 | 0.05 | 16.8 | 0.12 | 25.9 | 0.08 |
| | 150 | 19.3 | 0.07 | 12.3 | 0.06 | 16.7 | 0.12 | 27.9 | 0.09 |
| | 200 | 21.0 | 0.08 | 30.0 | 0.06 | 23.8 | 0.12 | 24.2 | 0.09 |
| **PM2.5 24-hr $SO_2$-scaled, H1H** | 100 | 2.7 | 0.13 | 2.8 | 0.11 | 2.7 | 0.30 | 3.1 | 0.20 |
| | 150 | 12.8 | 0.15 | 14.3 | 0.12 | 14.5 | 0.30 | 8.4 | 0.20 |
| | 200 | 65.3 | 0.18 | 93.3 | 0.15 | 66.3 | 0.31 | 58.7 | 0.20 |

## 5. Conclusions

While this analysis did not necessarily capture all occurances of possible Class I area increment concern, the results indicate that for most source types, if NAAQS compliance with the short-term standards can be demonstrated in the near-field, then there are not likely to be significant source impacts at 50 km. Thus, for most facilities that show compliance in the near-field, no evaluation of LRT would seem to be necessary for NAAQS. There are indications, however, that for a select class of facilities, mainly those that have very tall stacks (greater than 100 m), there is a possibility of having an impact that is significant with respect to the short-term $NO_2$, $SO_2$ and $PM_{2.5}$ PSD increment. These types of facilities may have their maximum impact much farther from the facility than most. The results also indicate that terrain features can be important for these types of facilities, as elevated terrain at or near stack height, can result in higher plume impacts much closer to the source. When this occurs, NAAQS compliance with the short-term standard may be sufficient to decrease long-range impacts and eliminate the potential need for an LRT assessment for NAAQS or PSD increment. Conversely, elevated receptors in the far-field can increase the need for LRT assessments, as these receptors may experience impacts closer to the plume centerline.

## 6. Additional information

Data for the analyses described in this TSD can be obtained by contacting:

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# References


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# Appendix A

## Plots and tables from the $NO_2$ and $SO_2$ NAAQS screening analysis

For all figures in this section, the $NO_2$ SIL is shown in blue and the $SO_2$ SIL is shown in red.

**Table A.1 - Phase 1 screening modeling results for NO2 and SO2 by Facility type: 8th and 4th high results from screening analysis**

| | | $NO_2$ 8th high (ppb) | | $SO_2$ 4th high (ppb) | |
|---|---|---|---|---|---|
| Facility | Receptor Elevation | Maximum domain wide impact | Impact at 50 km (SIL 4 ppb) | Maximum domain wide impact | Impact at 50 km (SIL 3 ppb) |
| Asphalt plant | 0 | 290.98 | 5.01 | 96.09 | 0.67 |
| | 25 | 834.55 | 5.86 | 115.35 | 0.70 |
| | 65 | 884.69 | 3.89 | 50.03 | 0.24 |
| | 100 | 355.51 | 2.00 | 49.72 | 0.16 |
| | 150 | 178.68 | 1.45 | 49.32 | 0.14 |
| | 200 | 129.77 | 1.30 | 48.96 | 0.14 |
| Biomass plant | 0 | 15.84 | 0.95 | 10.70 | 0.66 |
| | 25 | 15.96 | 0.95 | 10.79 | 0.66 |
| | 65 | 478.56 | 1.62 | 330.84 | 1.05 |
| | 100 | 826.66 | 4.76 | 538.14 | 3.18 |
| | 150 | 531.36 | 2.57 | 342.52 | 1.64 |
| | 200 | 239.94 | 1.26 | 153.73 | 0.87 |
| Cement kiln | 0 | 131.36 | 10.22 | 60.18 | 4.75 |
| | 25 | 132.24 | 10.25 | 60.42 | 4.75 |
| | 65 | 132.04 | 10.26 | 60.98 | 4.75 |
| | 100 | 132.31 | 10.27 | 61.85 | 4.75 |
| | 150 | 1468.85 | 10.28 | 567.58 | 4.75 |
| | 200 | 6716.97 | 17.61 | 2378.44 | 7.77 |
| Coal EGU | 0 | 232.76 | 4.96 | 74.15 | 6.50 |
| | 25 | 876.53 | 5.53 | 74.34 | 6.51 |
| | 65 | 425.18 | 3.33 | 75.22 | 6.52 |
| | 100 | 212.36 | 3.33 | 75.24 | 6.52 |
| | 150 | 517.19 | 3.32 | 1328.82 | 6.51 |
| | 200 | 1011.55 | 5.70 | 3244.59 | 15.27 |
| Ethanol Plant | 0 | 391.43 | 6.15 | 31.80 | 2.95 |
| | 25 | 789.49 | 6.13 | 174.55 | 2.95 |
| | 65 | 1735.24 | 6.26 | 1091.40 | 4.27 |
| | 100 | 1702.15 | 14.10 | 1206.21 | 10.40 |
| | 150 | 1706.04 | 13.23 | 1311.49 | 9.27 |
| | 200 | 1109.31 | 5.92 | 777.34 | 4.20 |

Table A.1 - Phase 1 screening modeling results for NO2 and SO2 by Facility type: 8th and 4th high results from screening analysis (continued)

| Facility | $NO_2$ 8th high (ppb) | | | $SO_2$ 4th high (ppb) | |
|---|---|---|---|---|---|
| | Receptor Elevation | Maximum domain wide impact | Impact at 50 km (SIL 4 ppb) | Maximum domain wide impact | Impact at 50 km (SIL 3 ppb) |
| Flare | 0 | 3.96 | 0.29 | 207.24 | 15.71 |
| | 25 | 17.16 | 0.29 | 897.76 | 15.72 |
| | 65 | 90.49 | 0.64 | 4962.82 | 34.24 |
| | 100 | 123.43 | 1.28 | 6534.81 | 67.90 |
| | 150 | 134.97 | 1.13 | 7888.02 | 60.57 |
| | 200 | 90.19 | 0.56 | 4718.89 | 29.92 |
| Fuel oil turbine | 0 | 78.29 | 3.03 | 22.03 | 0.85 |
| | 25 | 212.39 | 3.03 | 64.14 | 0.85 |
| | 65 | 770.30 | 5.15 | 275.63 | 1.39 |
| | 100 | 760.16 | 10.01 | 226.57 | 3.28 |
| | 150 | 1115.39 | 11.06 | 375.08 | 4.20 |
| | 200 | 899.59 | 7.29 | 325.10 | 2.63 |
| Landfill gas turbine | 0 | 28.07 | 0.85 | 13.04 | 0.40 |
| | 25 | 109.57 | 1.03 | 65.11 | 0.45 |
| | 65 | 202.29 | 1.69 | 125.04 | 0.96 |
| | 100 | 168.51 | 1.02 | 104.05 | 0.61 |
| | 150 | 74.95 | 0.47 | 44.81 | 0.31 |
| | 200 | 41.34 | 0.41 | 25.33 | 0.21 |
| NG compressor | 0 | 92.64 | 3.02 | 0.01 | 0.00 |
| | 25 | 804.09 | 3.51 | 0.12 | 0.00 |
| | 65 | 348.38 | 1.60 | 0.05 | 0.00 |
| | 100 | 179.34 | 1.18 | 0.03 | 0.00 |
| | 150 | 55.66 | 0.98 | 0.01 | 0.00 |
| | 200 | 40.27 | 0.96 | 0.01 | 0.00 |
| Pulp & paper plant | 0 | 279.81 | 23.97 | 423.68 | 10.58 |
| | 25 | 276.14 | 24.06 | 603.28 | 10.63 |
| | 65 | 815.05 | 24.12 | 3438.12 | 16.32 |
| | 100 | 9282.87 | 39.86 | 2624.44 | 11.39 |
| | 150 | 9242.13 | 80.56 | 2377.23 | 21.30 |
| | 200 | 7811.38 | 60.86 | 2235.38 | 18.24 |

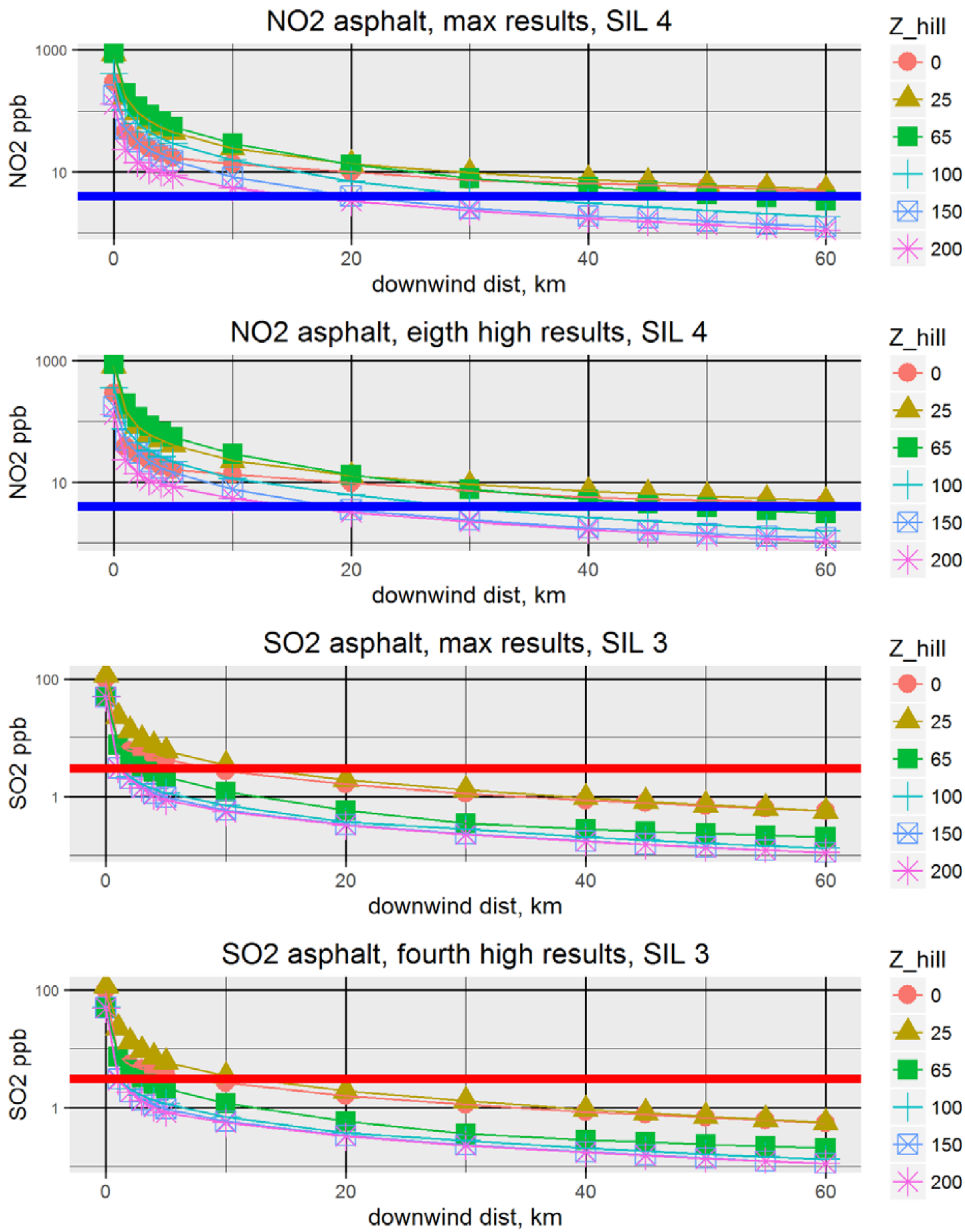



**Figure 2 - Results from the screening analysis for the asphalt plant.**

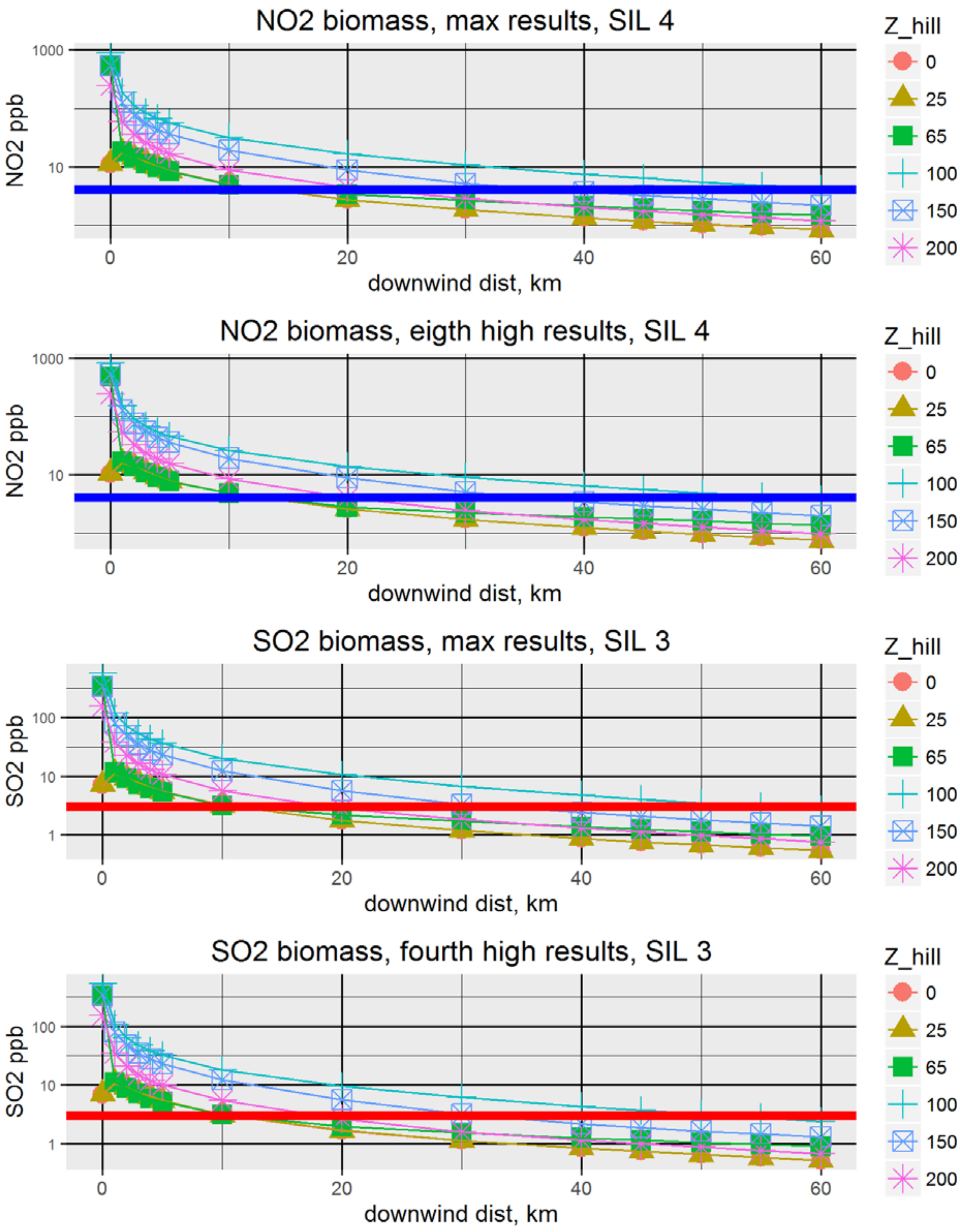



**Figure 3 - Results from the screening analysis for the biomass plant**

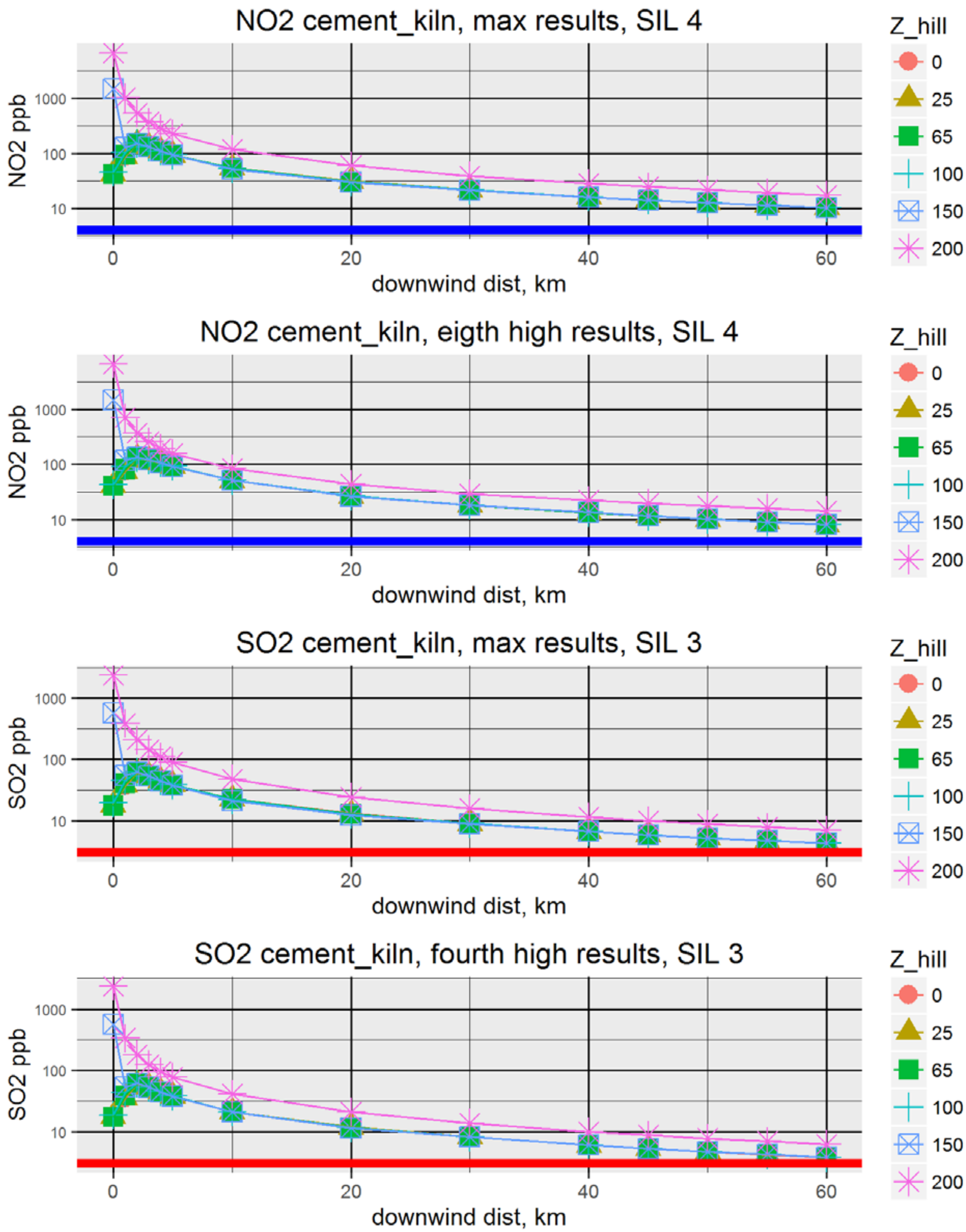



**Figure 4 - Results from the screening analysis for the cement kiln**

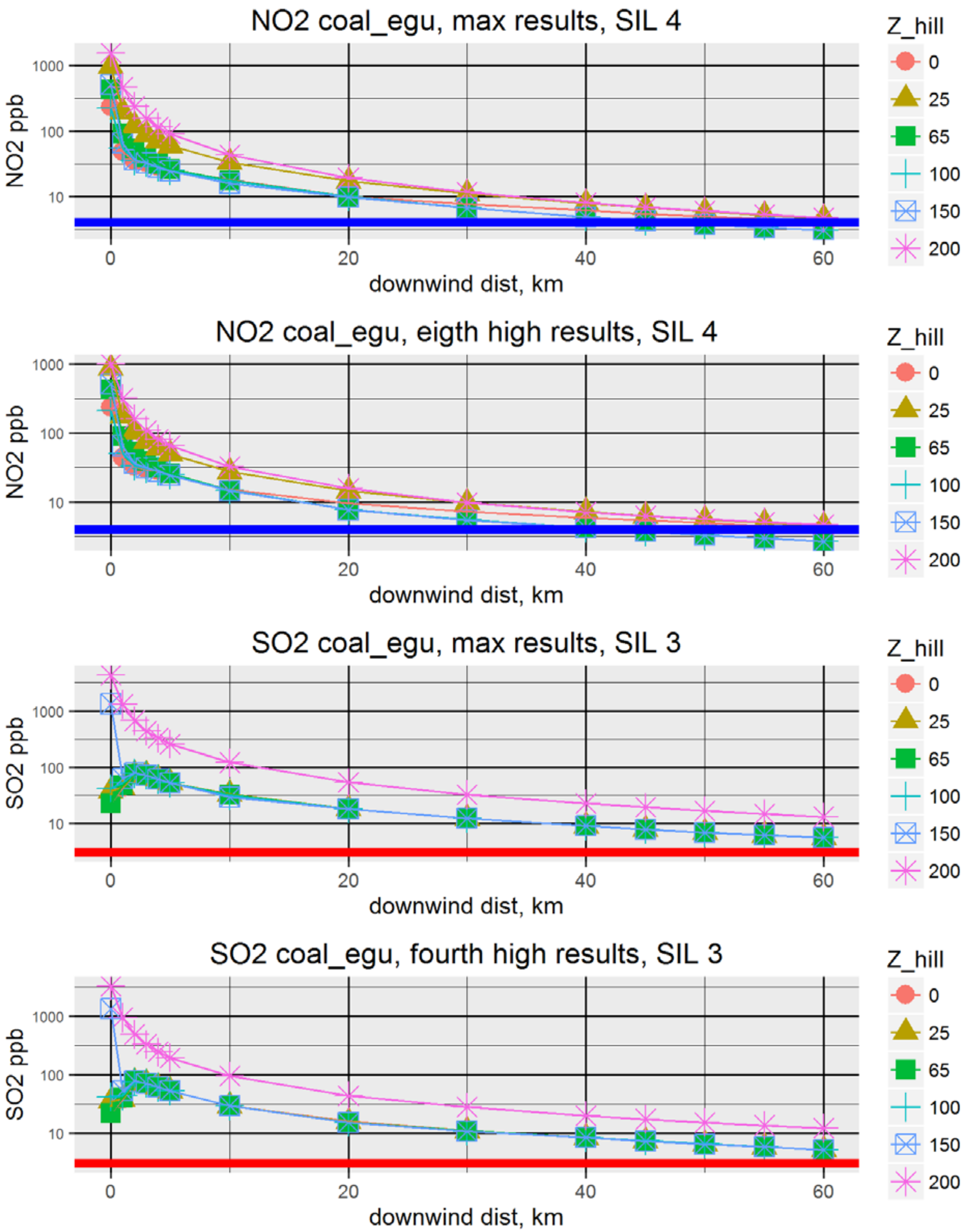



**Figure 5 - Results from the screening analysis for the coal EGU**

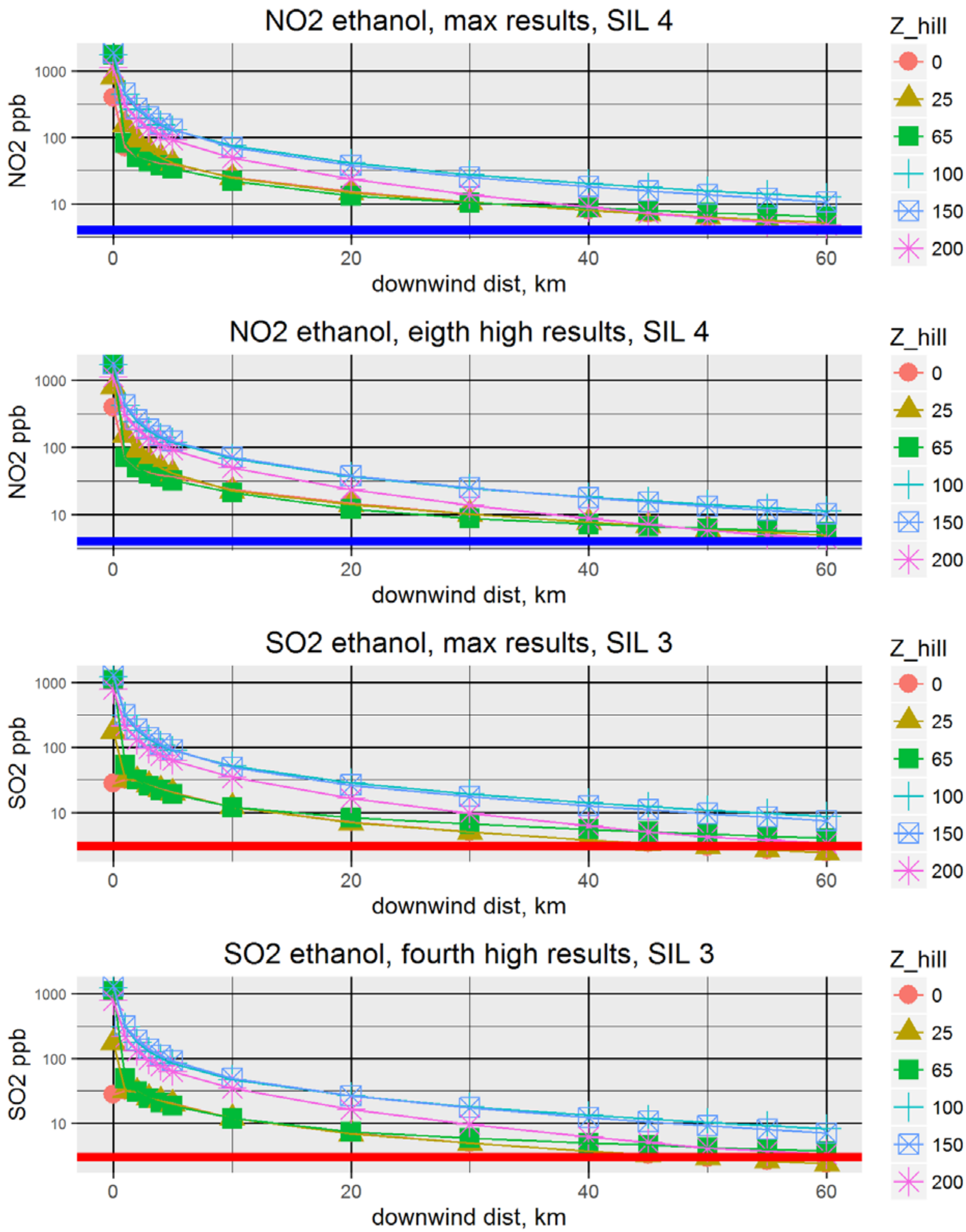



**Figure 6 - Results from the screening analysis for the ethanol plant**

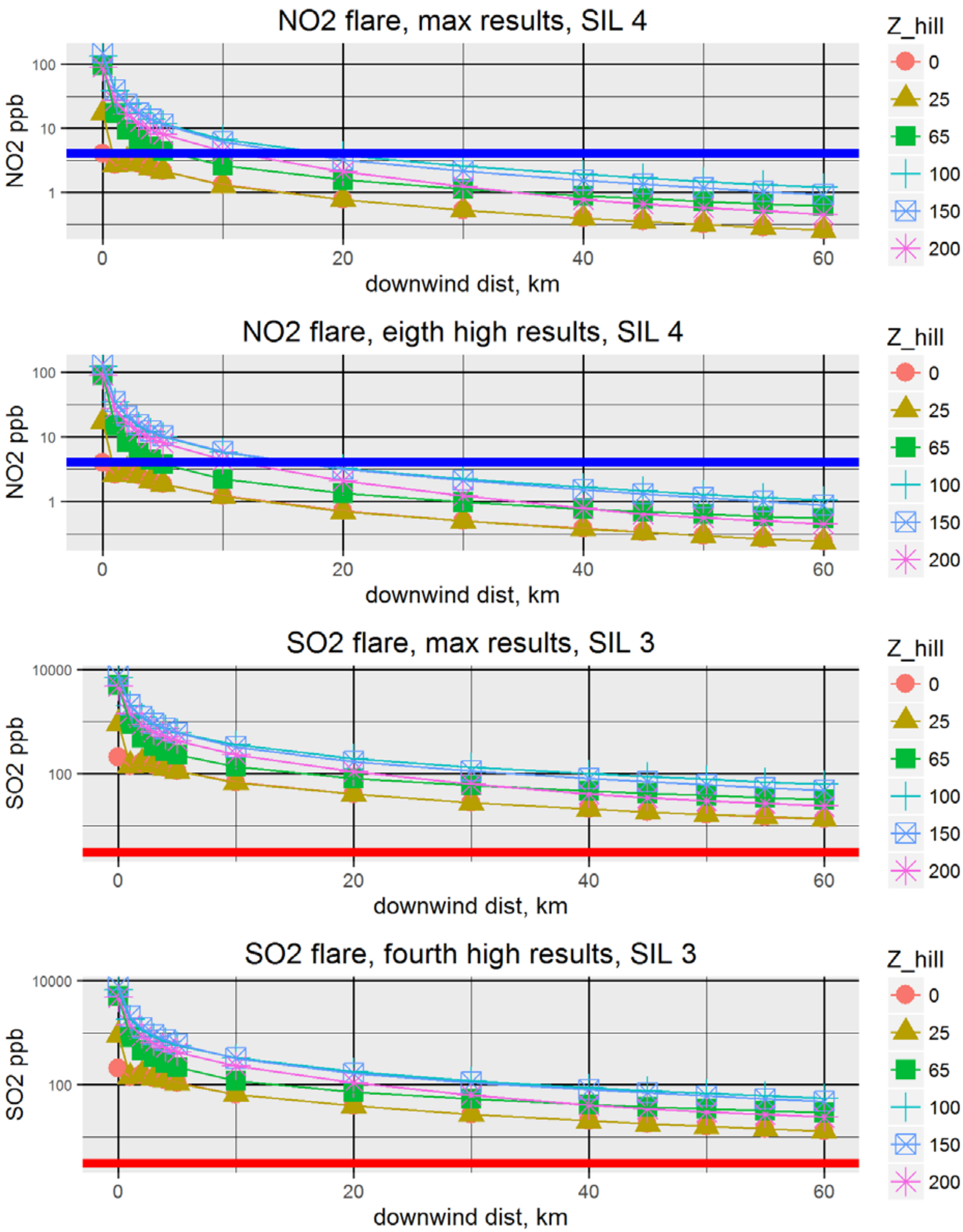



**Figure 7 - Results from the screening analysis for the flare**

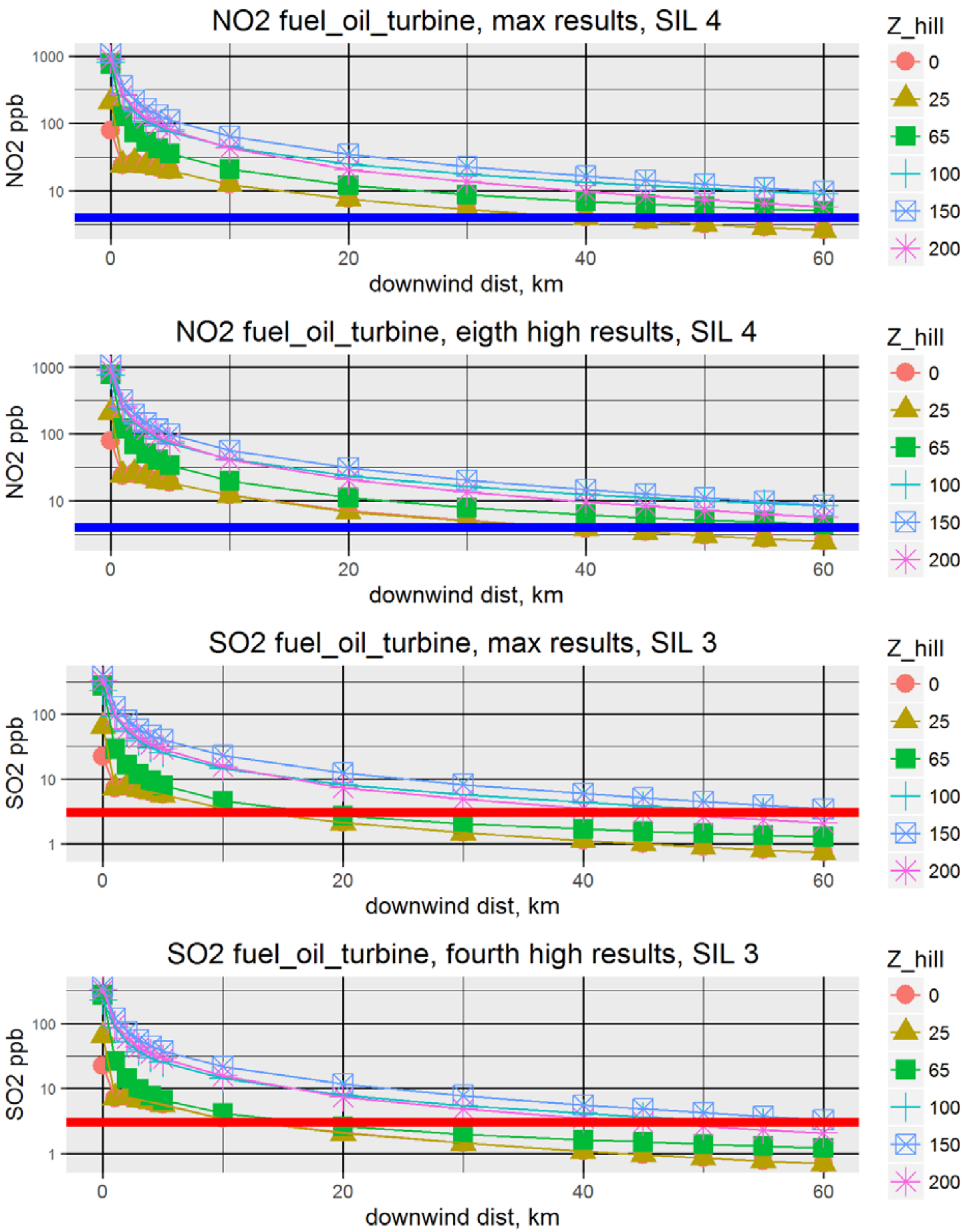



**Figure 8 - Results from the screening analysis for the fuel oil turbine**

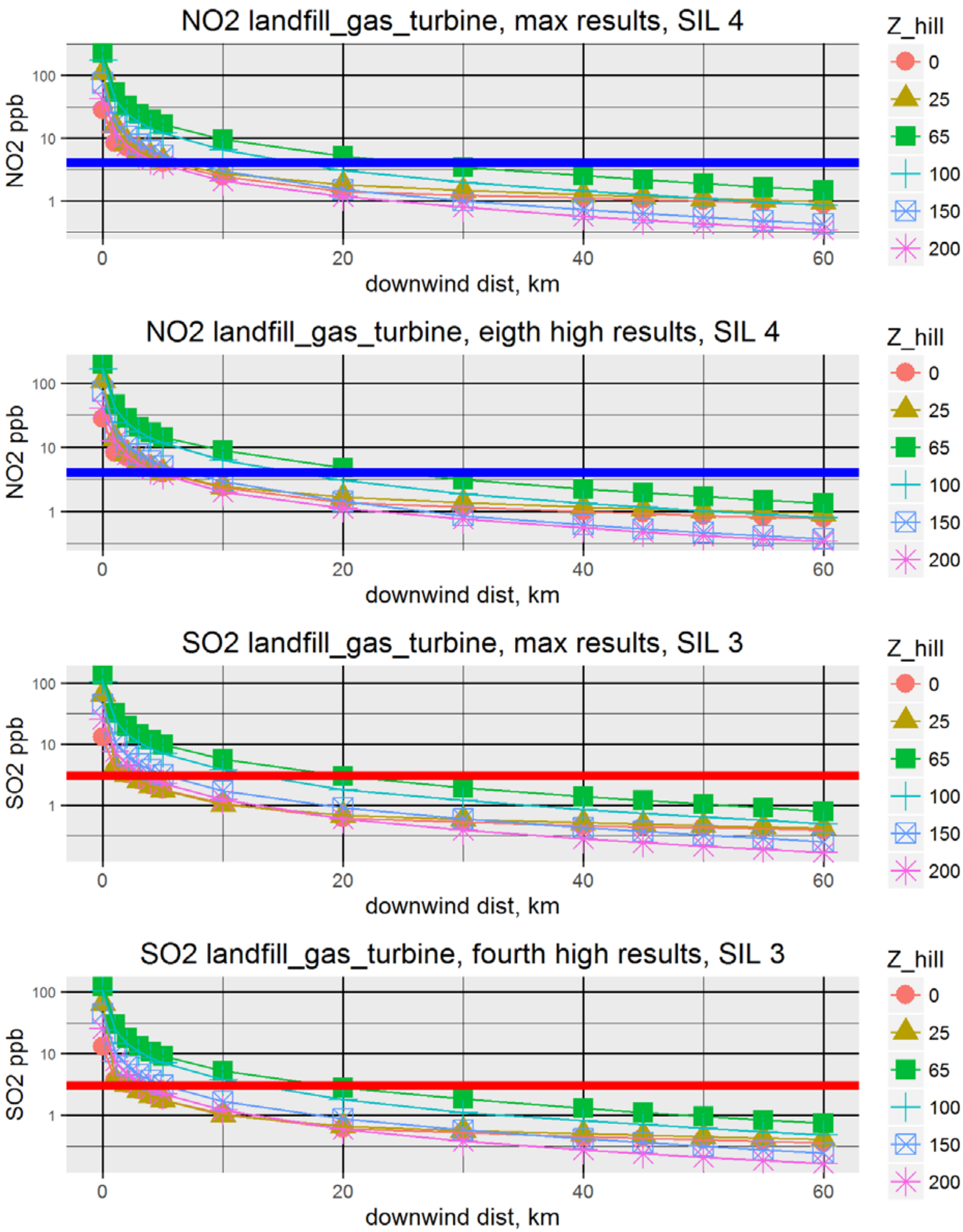



**Figure 9 - Results from the screening analysis for the landfill gas turbine**

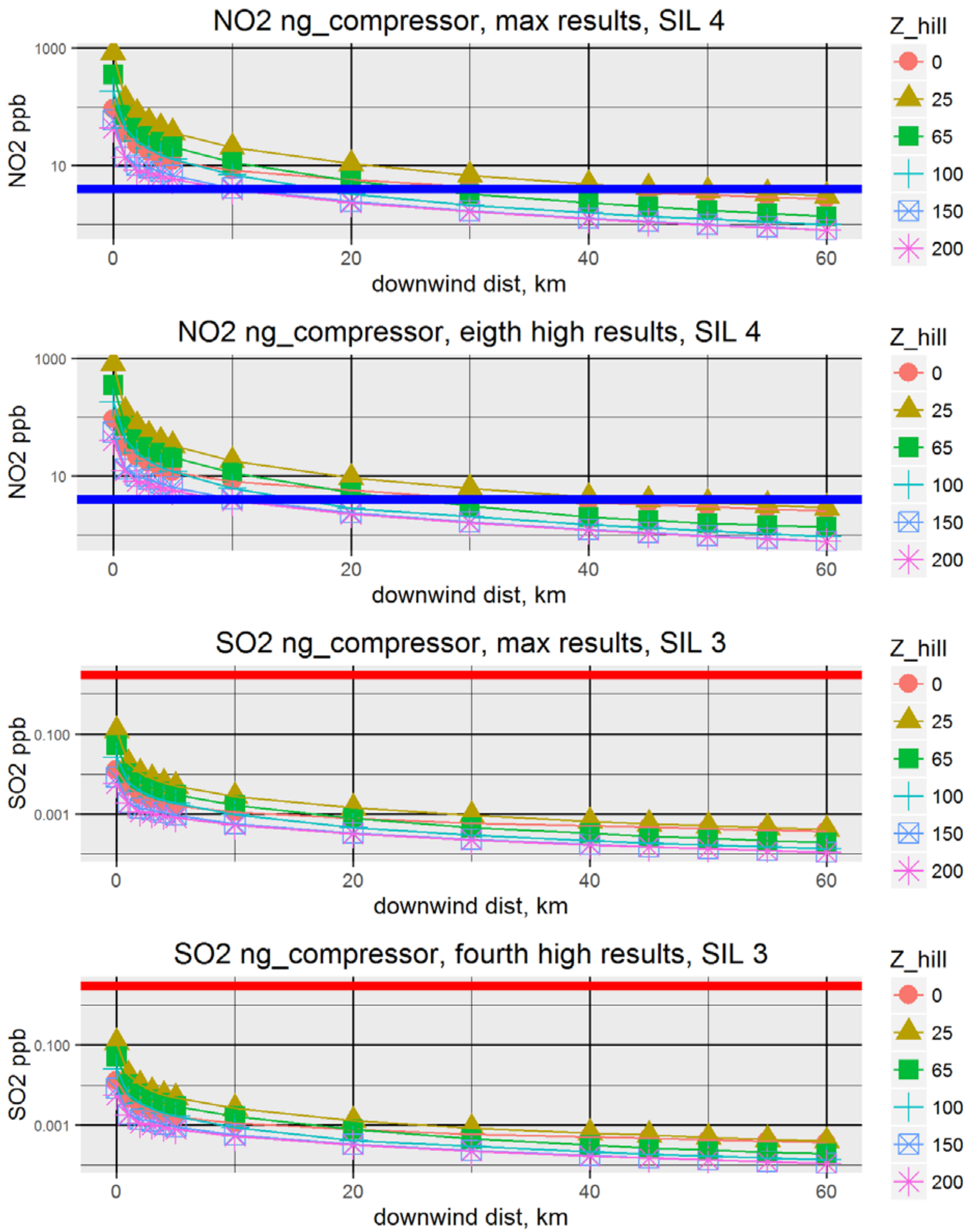



**Figure 10 - Results from the screening analysis for the natural gas compressor station**

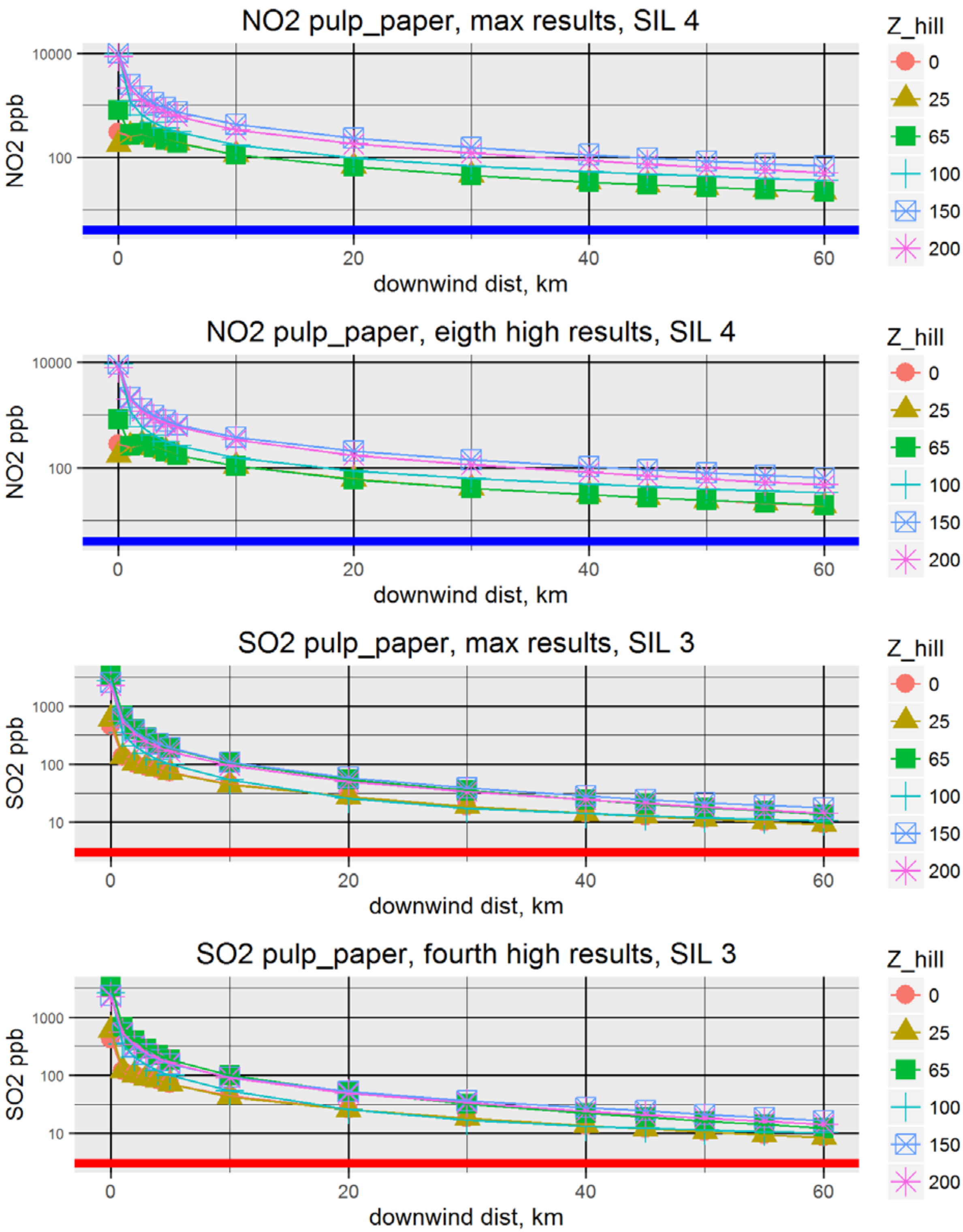



**Figure 11 - Results from the screening analysis for the pulp and paper plant**

# Appendix B

## Plots from $NO_2$ and $SO_2$ refined analysis

For all figures in this section, the $NO_2$ SIL is shown in blue and the $SO_2$ SIL is shown in red.

### *B.1 Comparisons against the 1-hour $NO_2$ and $SO_2$ NAAQS*

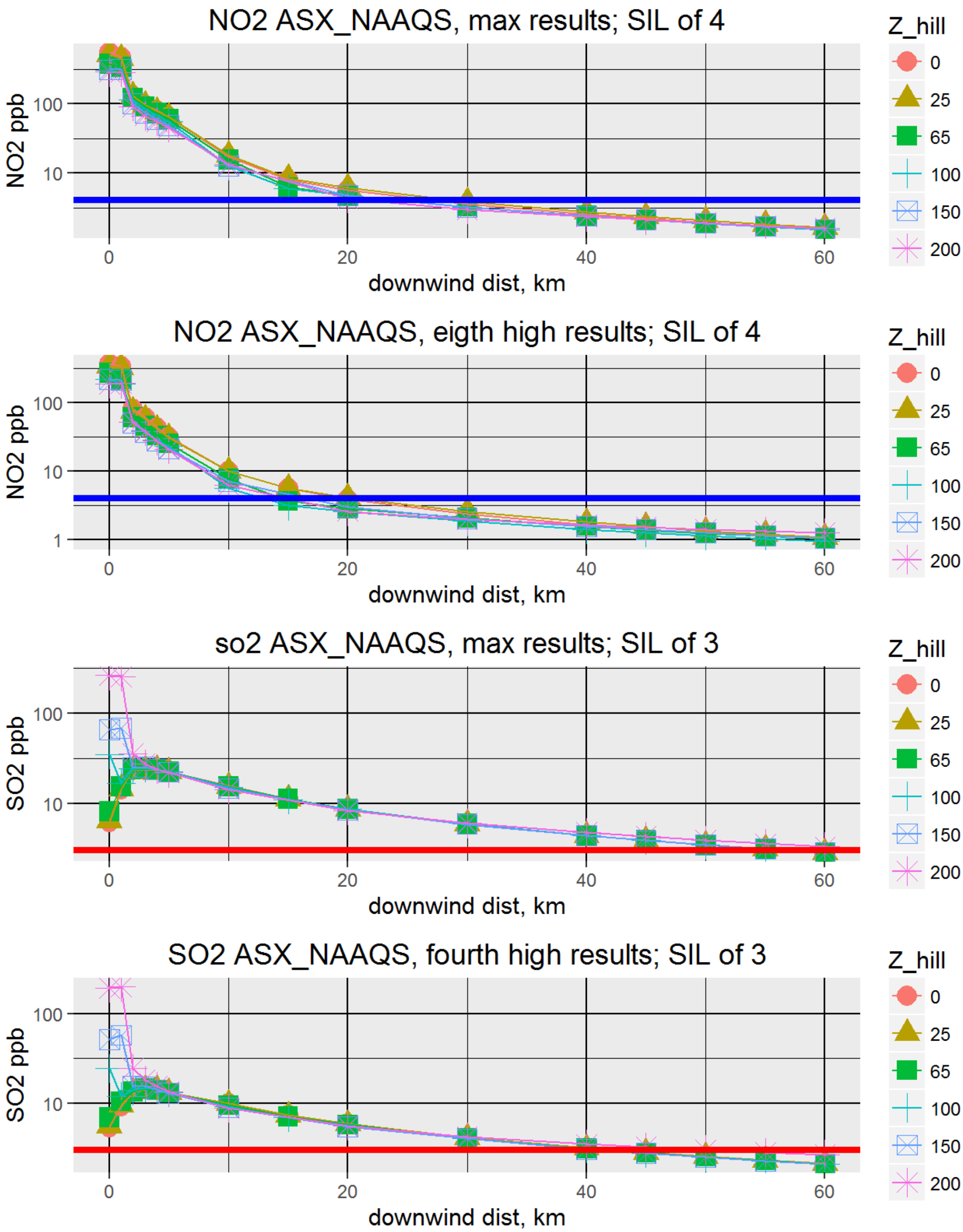



**Figure 12 - Refined $NO_2$ and $SO_2$ results, ASX, max and design values, 1-hour NAAQS**

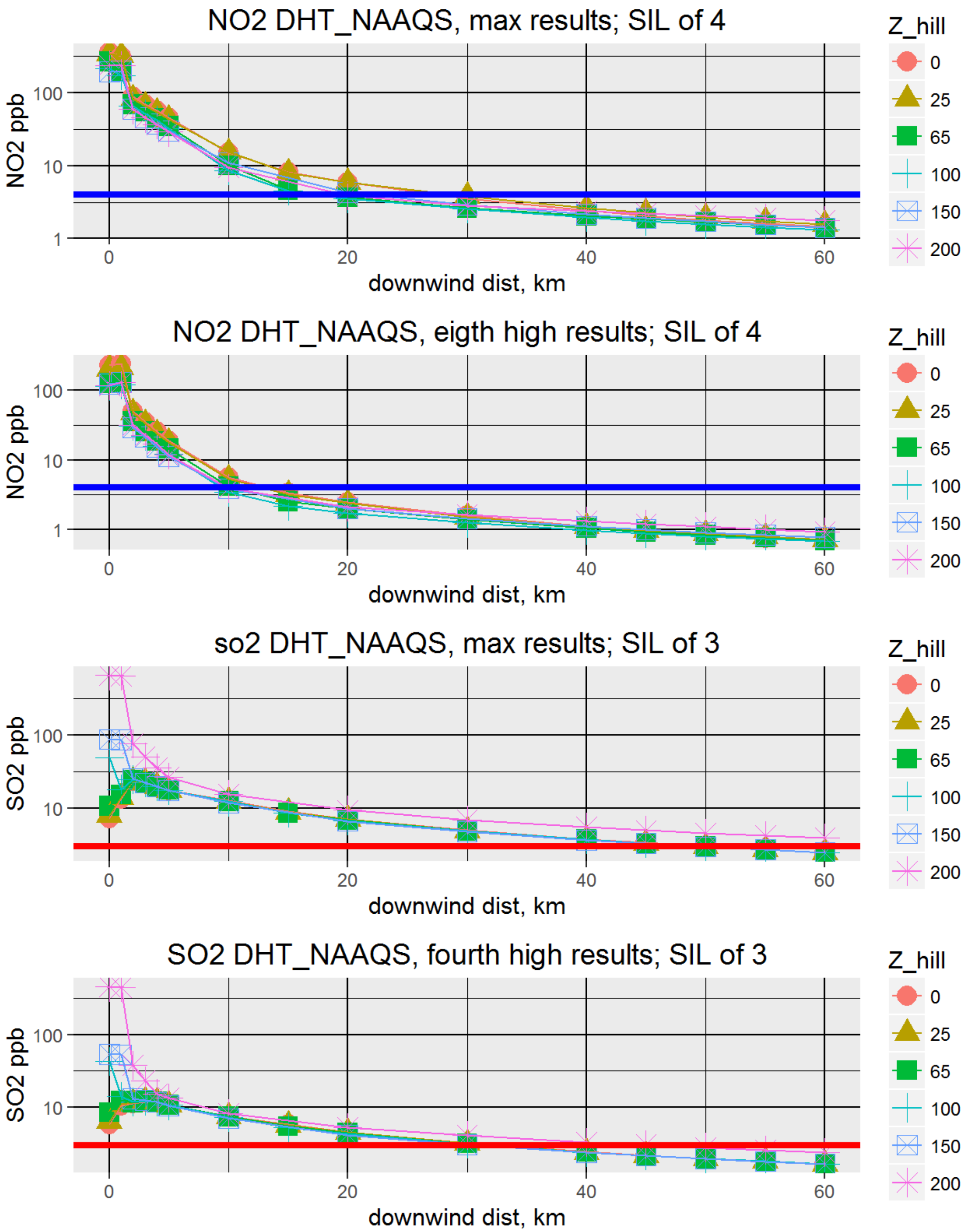



Figure 13 - Refined $NO_2$ and $SO_2$ results, DHT, max and design values, 1-hour NAAQS

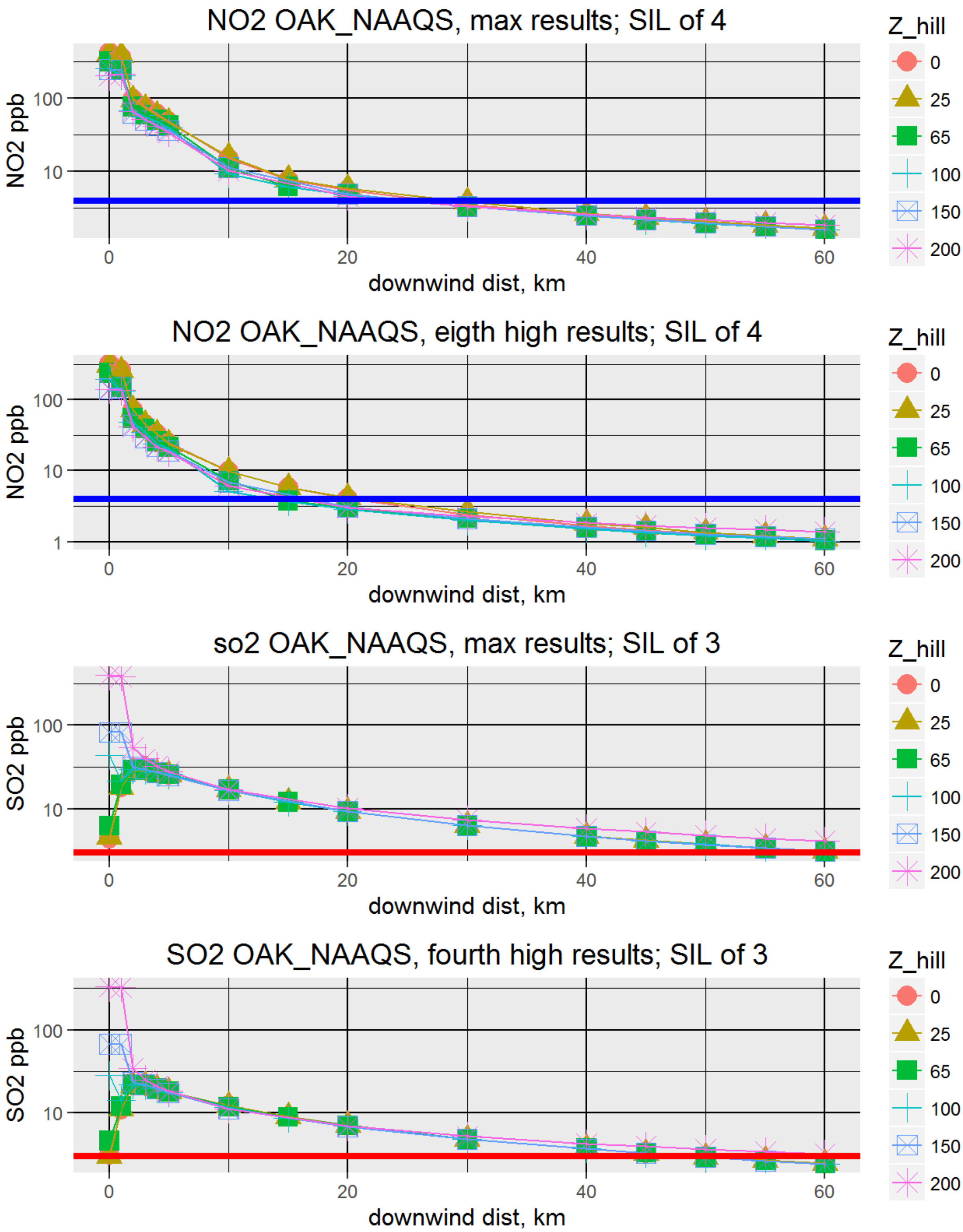



Figure 14 - Refined $NO_2$ and $SO_2$ results, OAK, max and design values, 1-hour NAAQS

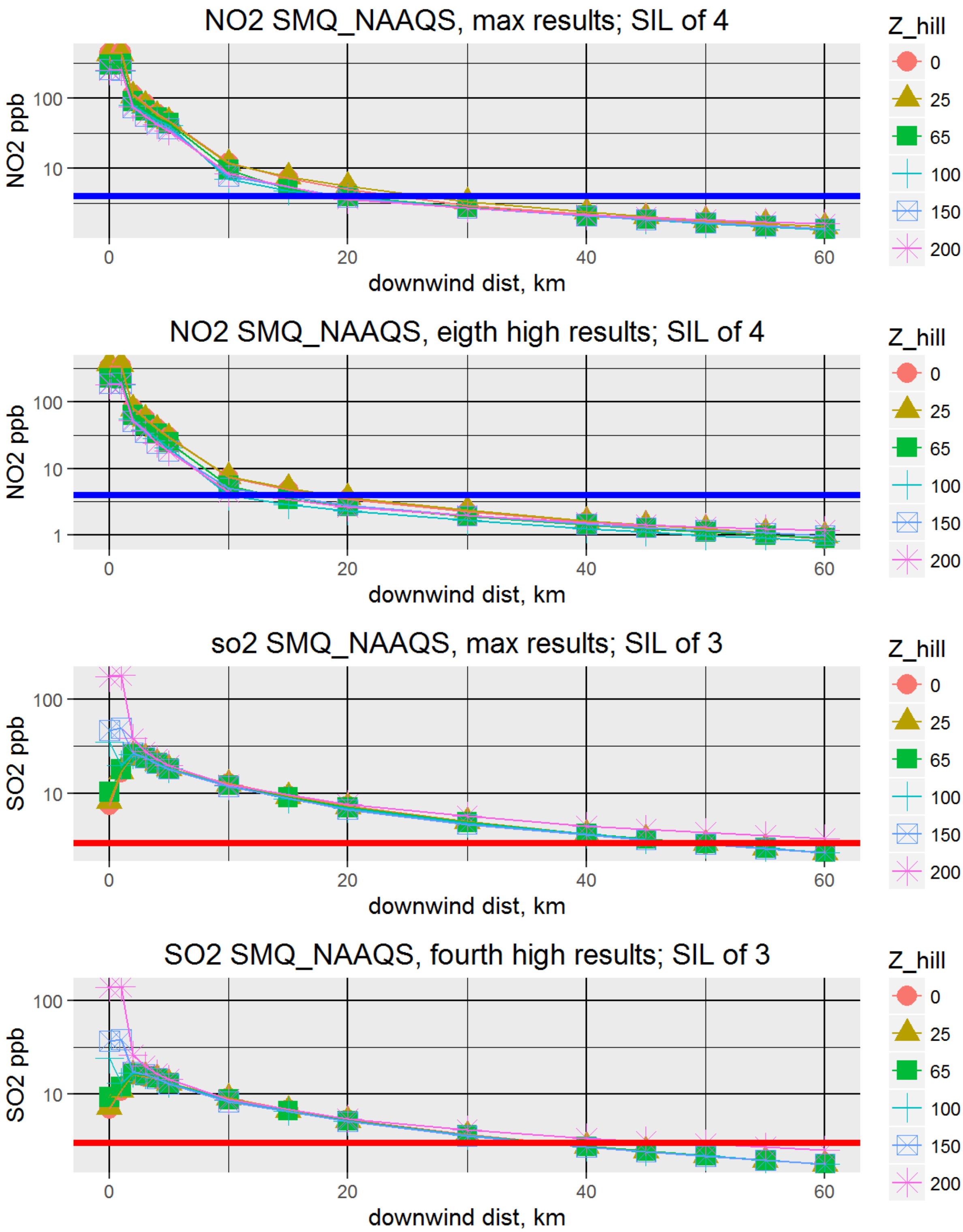



**Figure 15 - Refined $NO_2$ and $SO_2$ results, SMQ, max and design values, 1-hour NAAQS**

*B.2 Comparisons against the 3 and 24-hour $SO_2$ PSD increment*

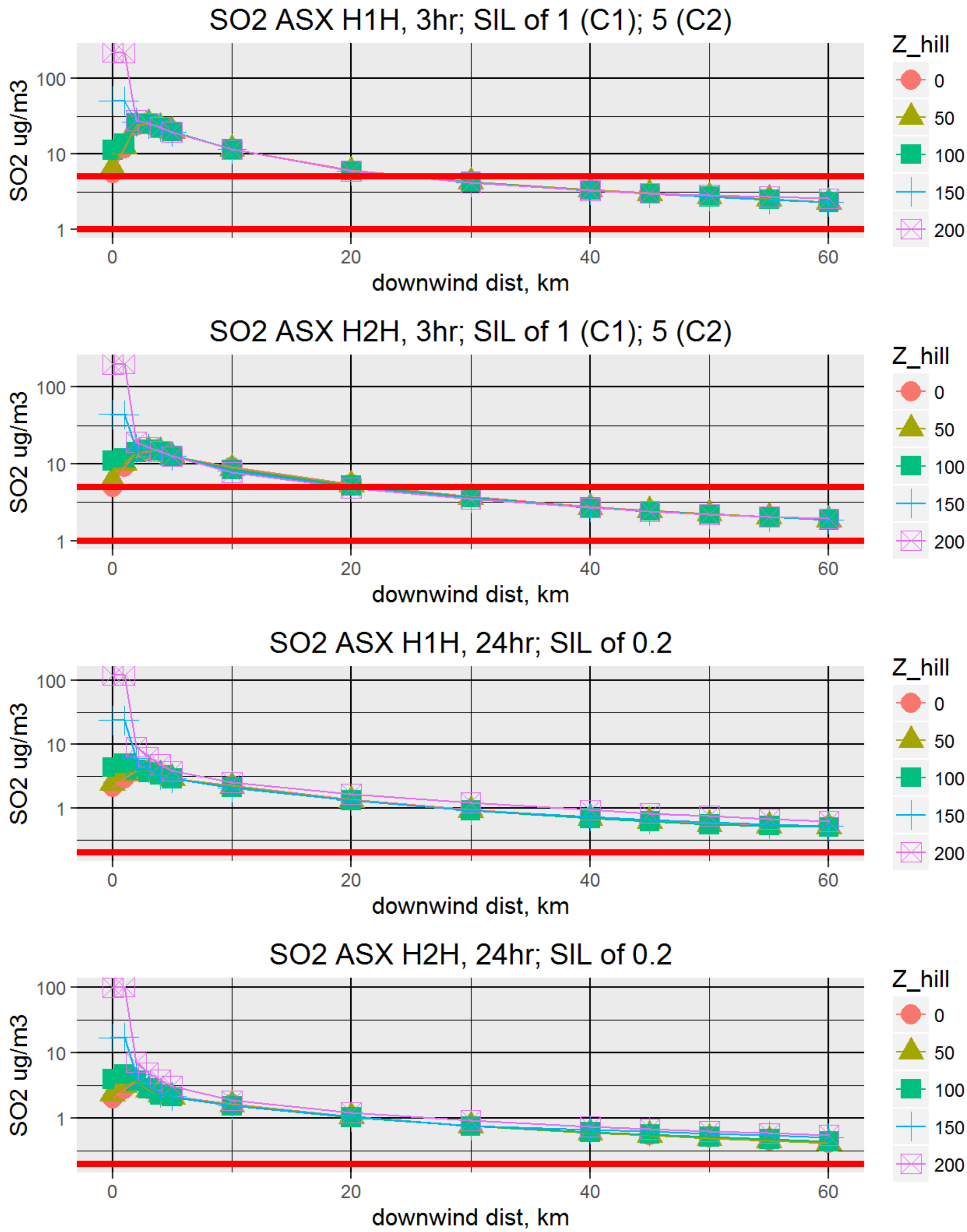



**Figure 16 - Refined $SO_2$ results, ASX, 3 & 24-hour PSD increment**

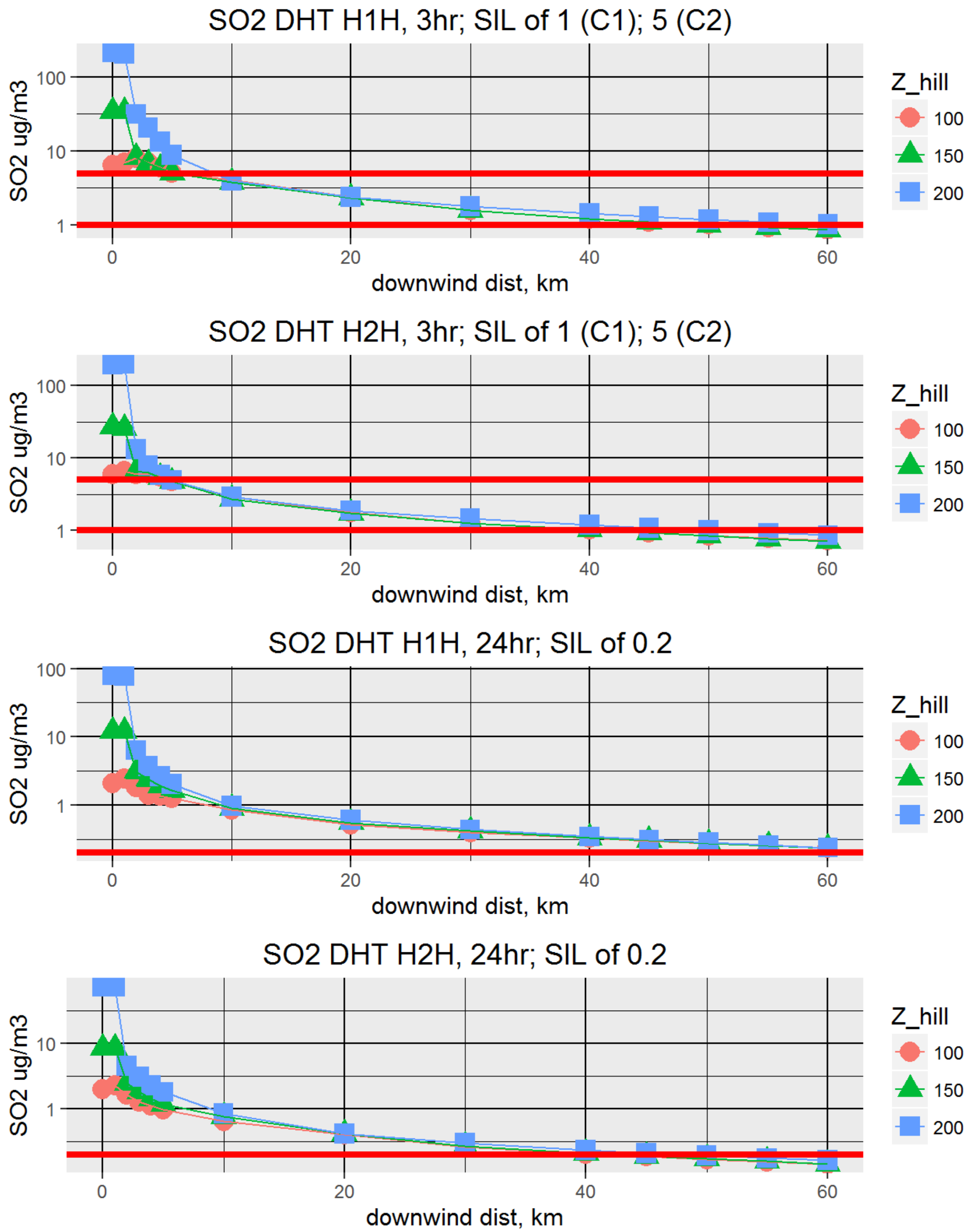



Figure 17 - Refined $SO_2$ results, DHT, 3 & 24-hour PSD increment

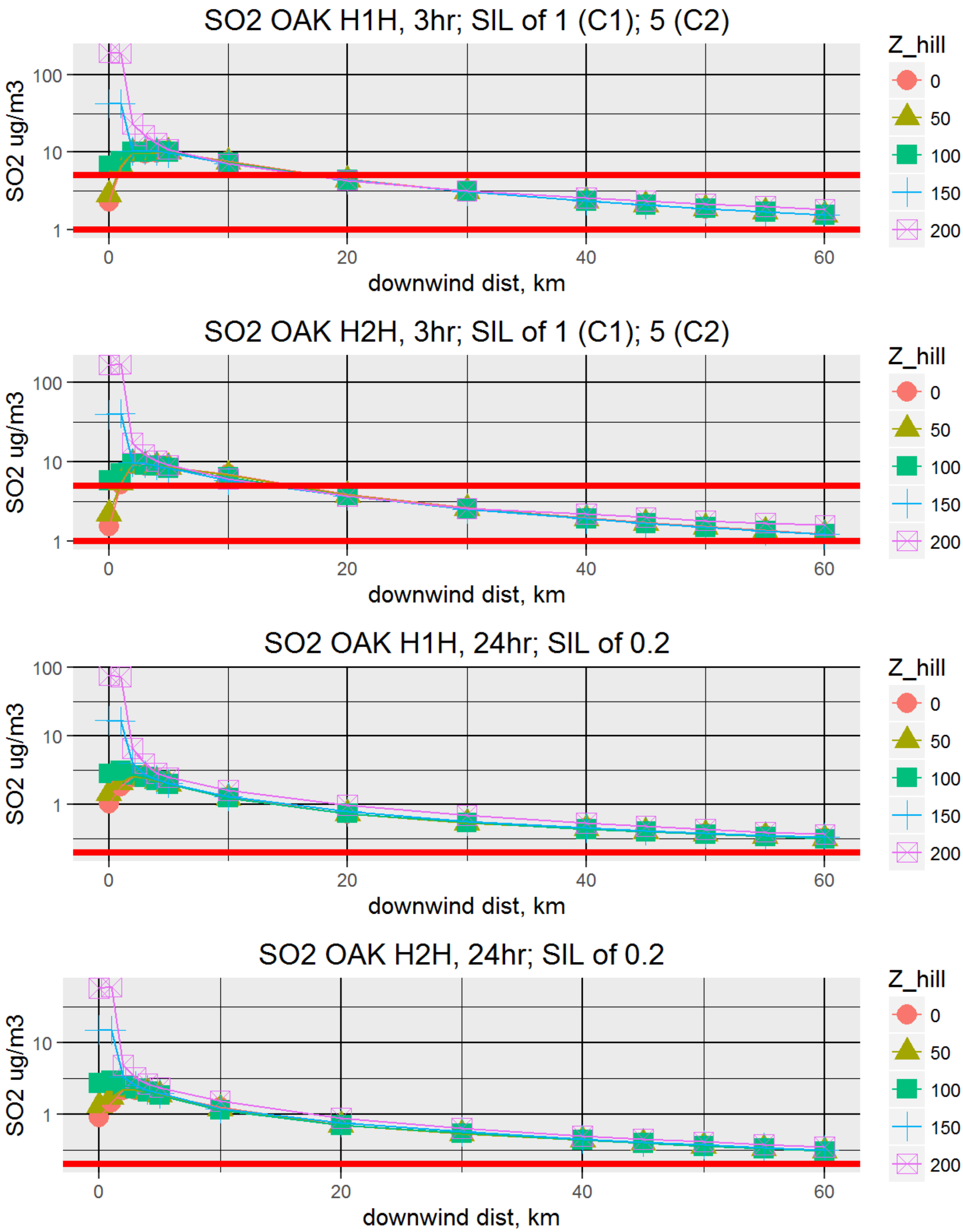



Figure 18 - Refined $SO_2$ results, OAK, 3 & 24-hour PSD increment

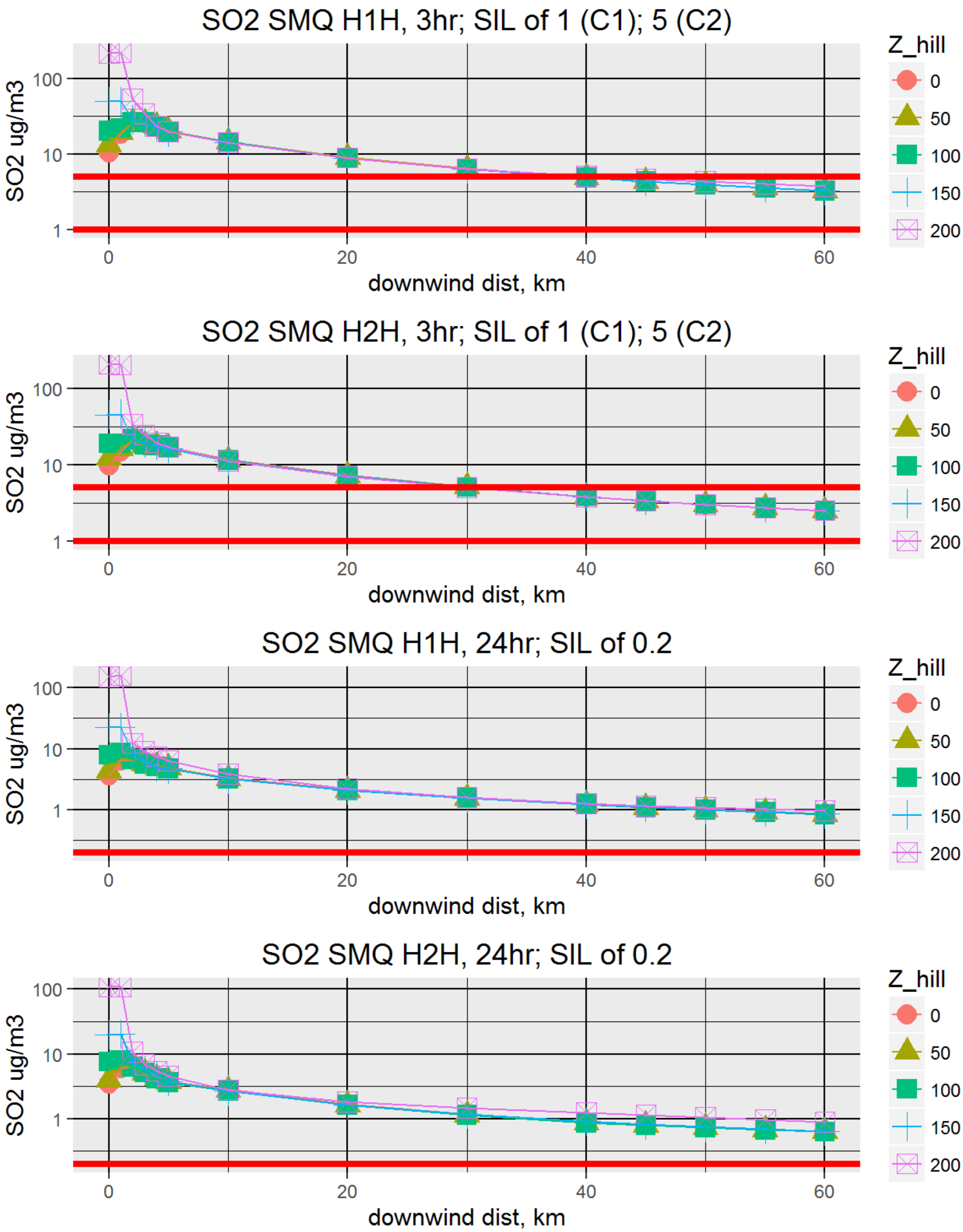



Figure 19 - Refined $SO_2$ results, SMQ, 3 & 24-hour PSD increment

*B.3 Comparisons against the annual $NO_2$ and $SO_2$ PSD increment*

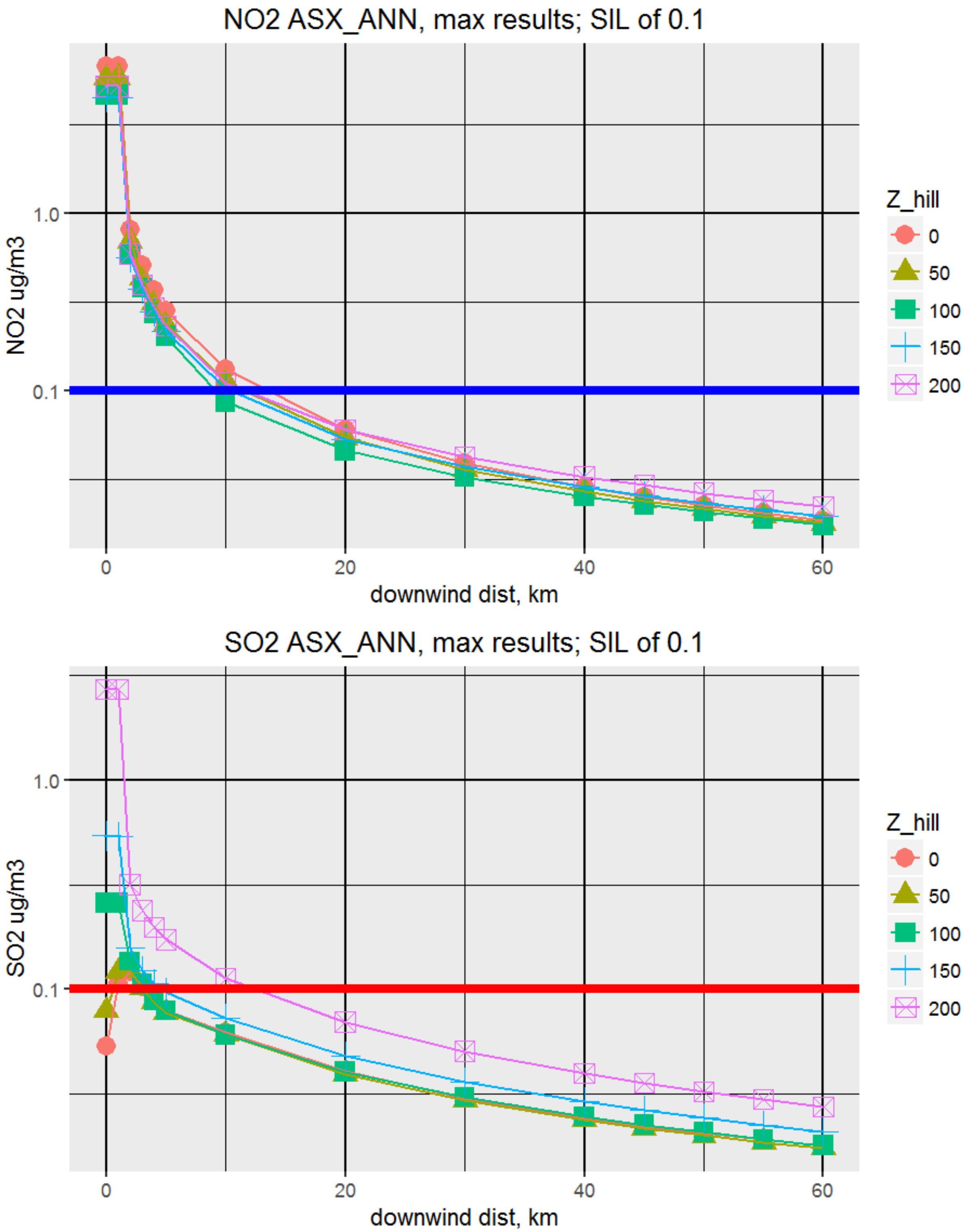



**Figure 20 - Refined $NO_2$ & $SO_2$ results, ASX, annual NAAQS**

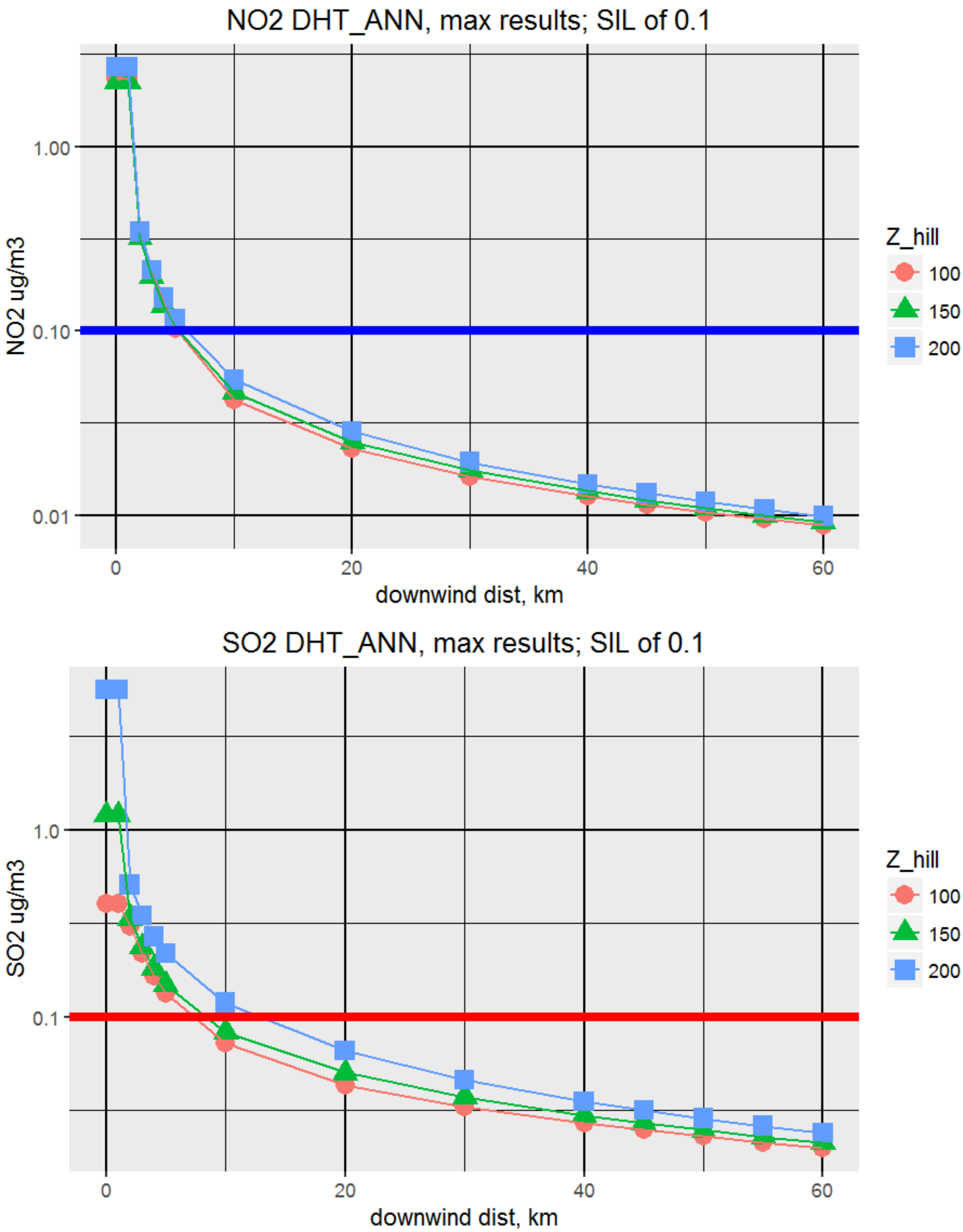



**Figure 21 - Refined $NO_2$ & $SO_2$ results, DHT, annual NAAQS**

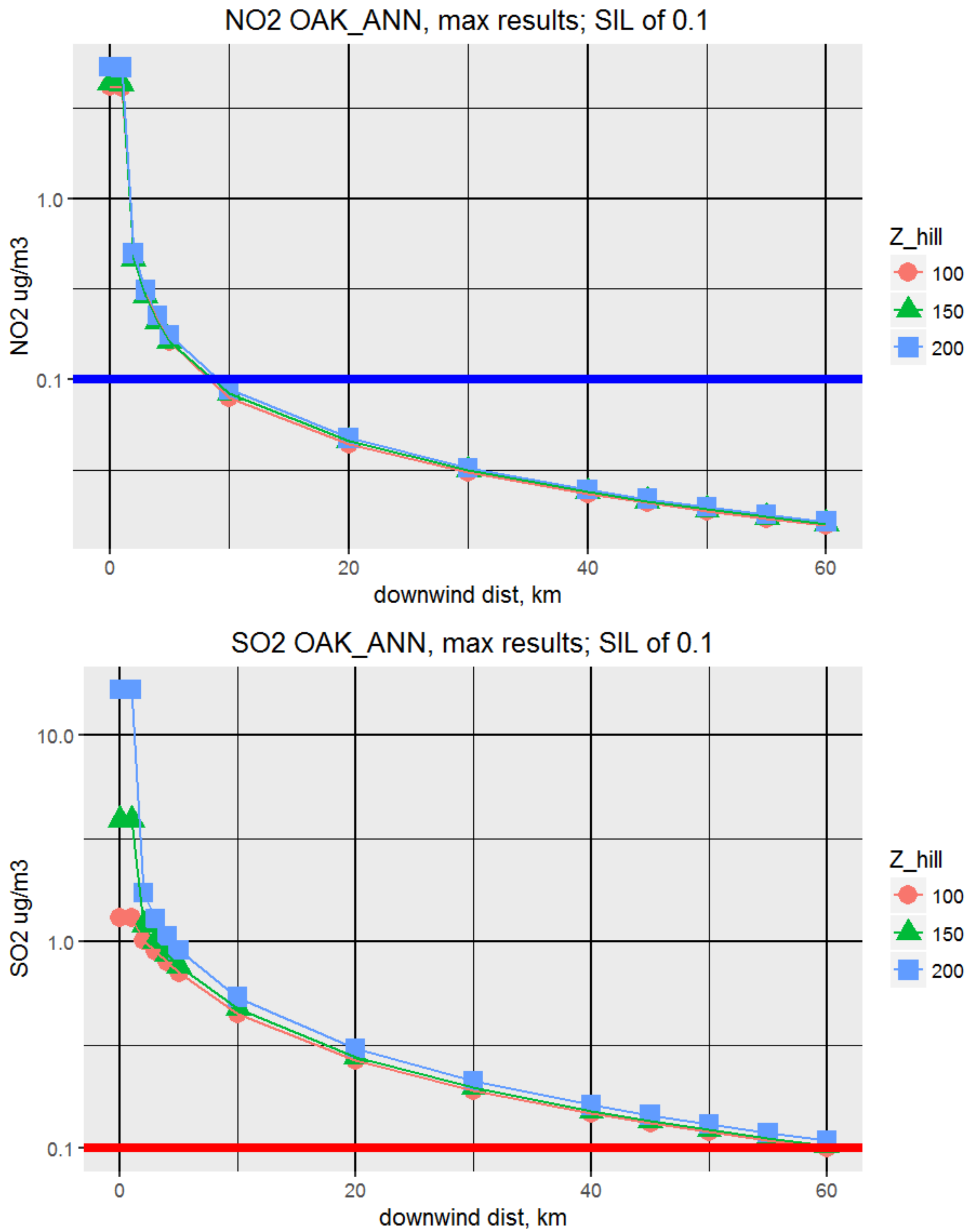



**Figure 22 - Refined $NO_2$ & $SO_2$ results, OAK, annual NAAQS**

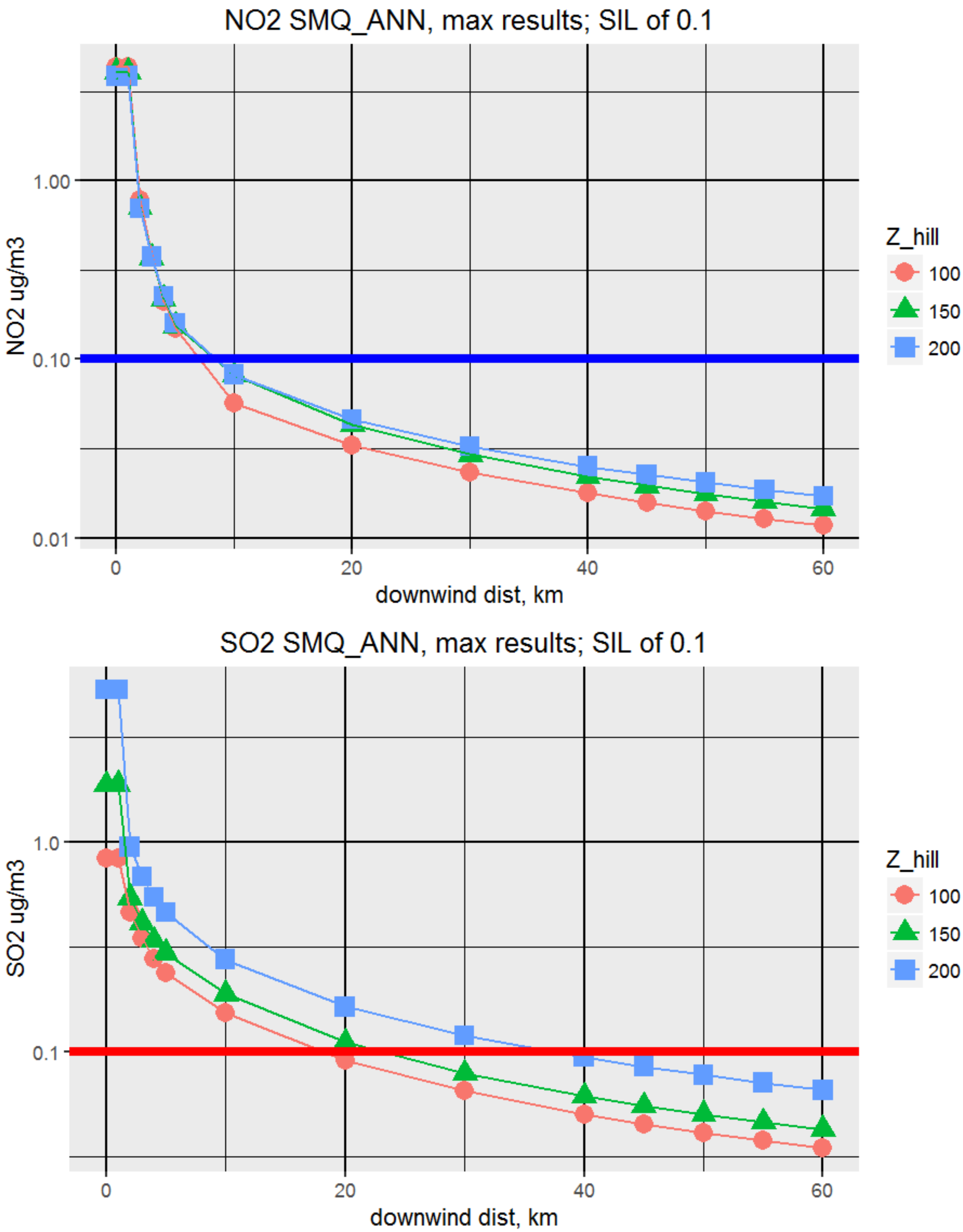



Figure 23 - Refined $NO_2$ & $SO_2$ results, SMQ, annual NAAQS

# Appendix C

## Plots from PM refined analysis

For all figures in this section, the $PM_{2.5}$ PSD increment is indicated on each plot. For the NO-scaled emissions, this is shown in blue and the $SO_2$-scaled emissions are shown in red.

*C.1 Comparisons against the PM2.5 24-hour NAAQS*

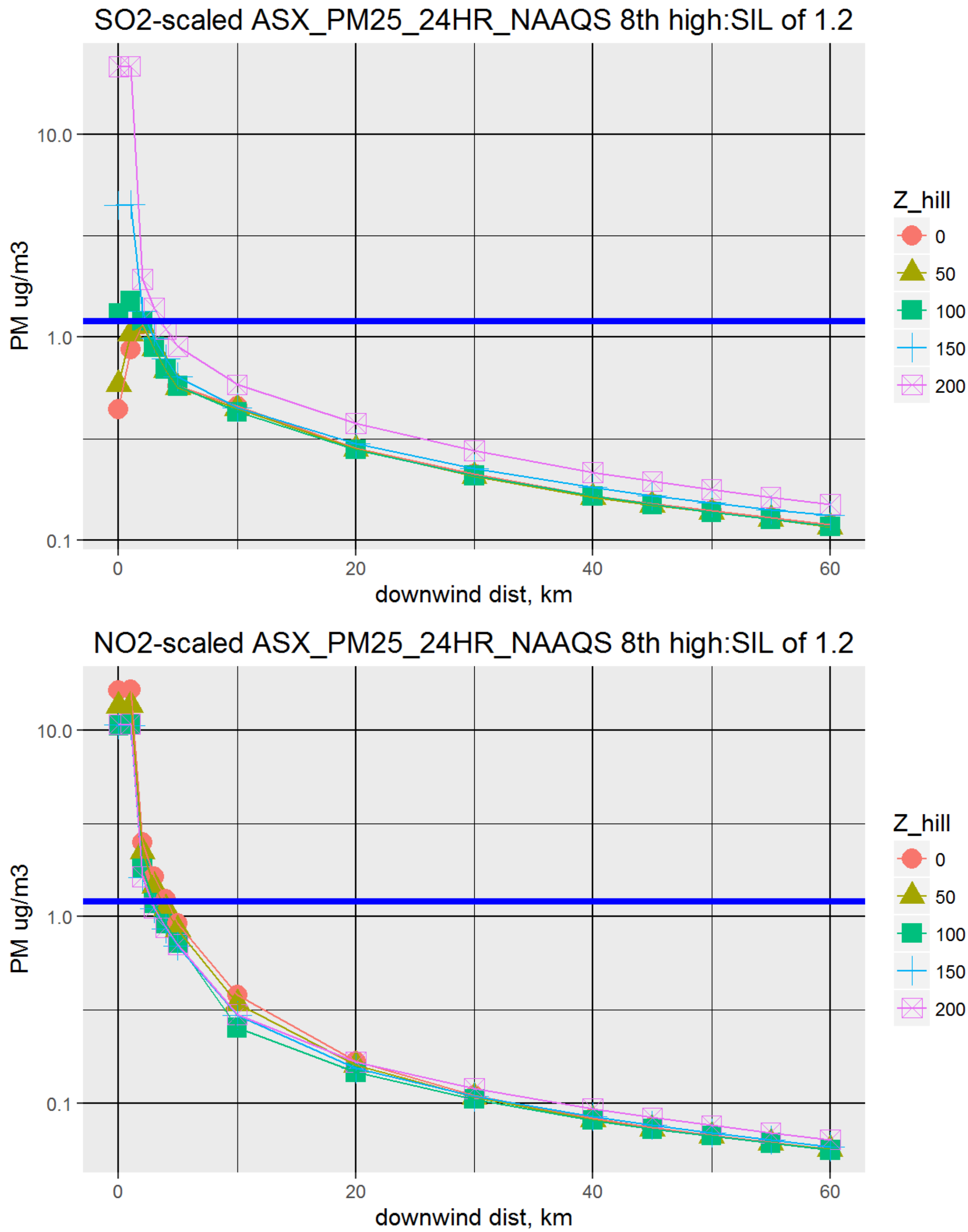



**Figure 24 - Refined $PM_{2.5}$ results, ASX, 24-hour NAAQS**

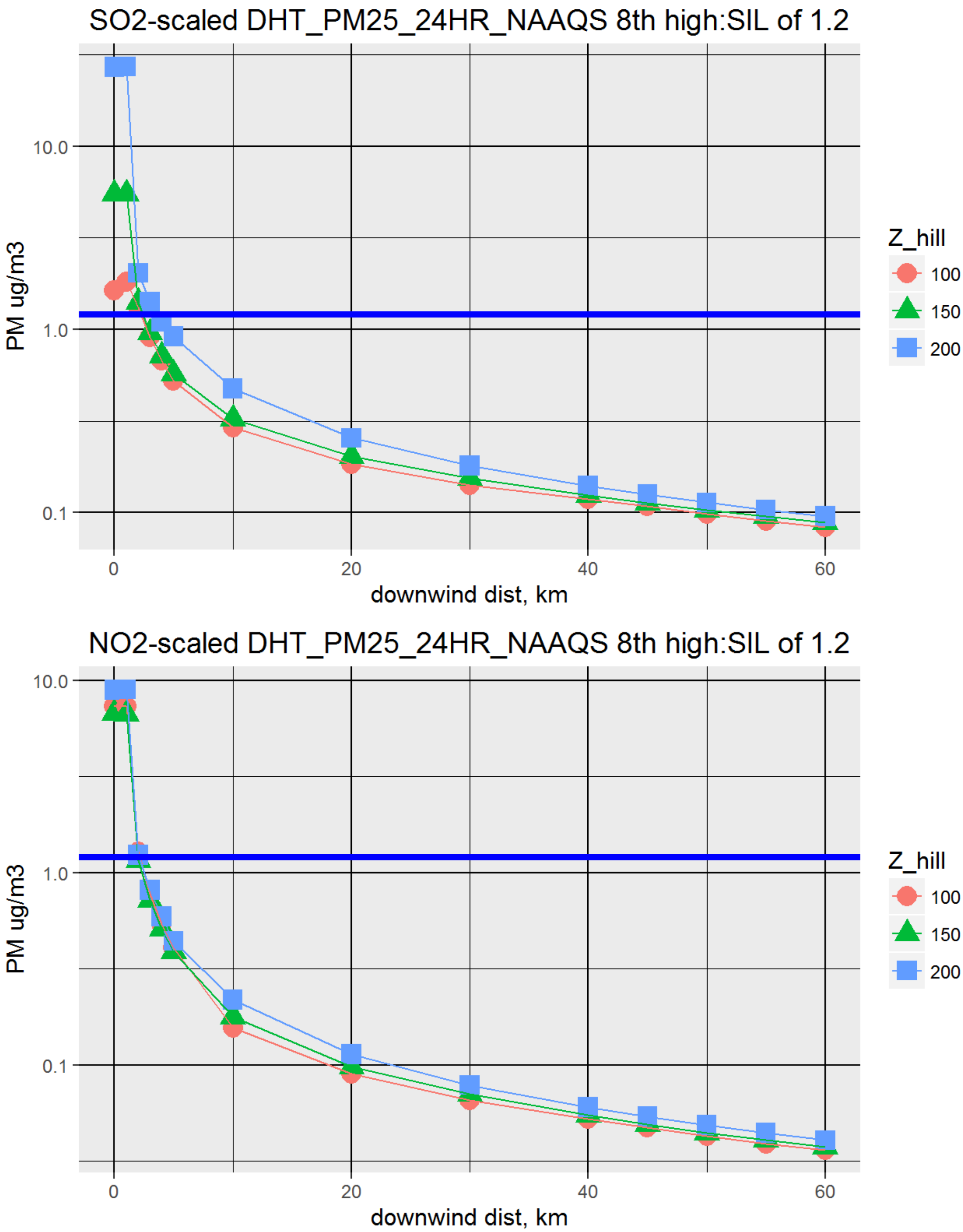
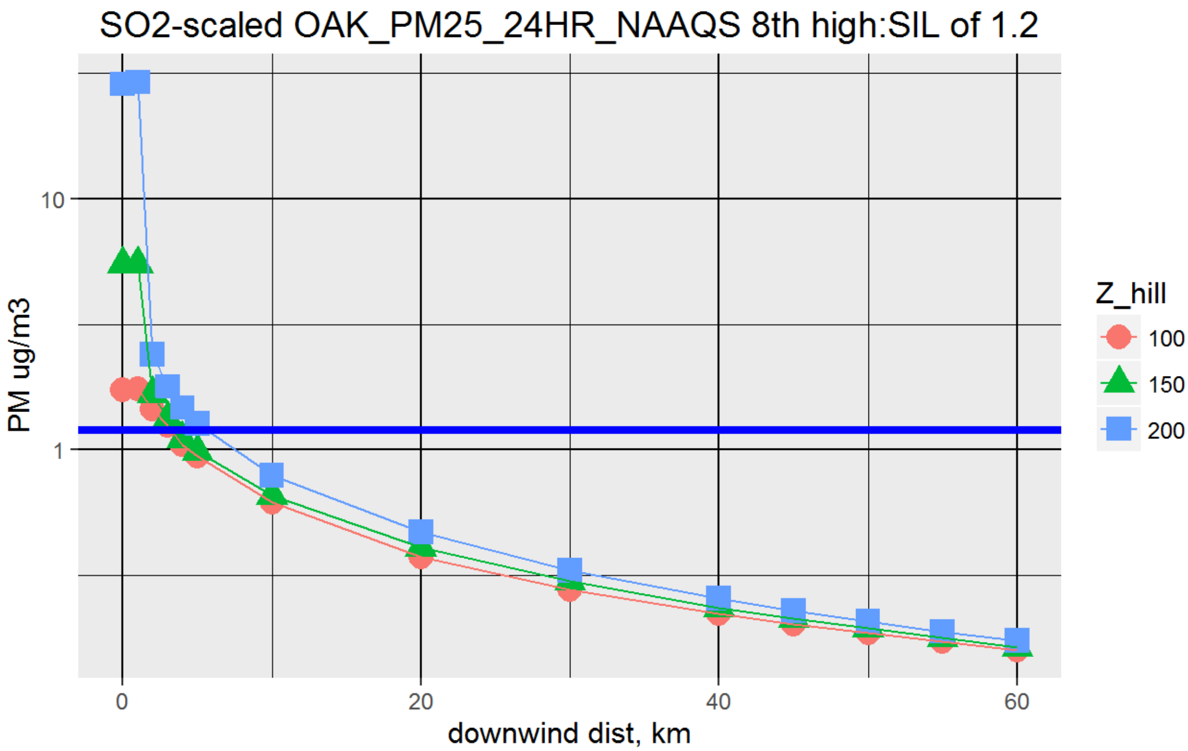



**Figure 25 - Refined $PM_{2.5}$ results, DHT, 24-hour NAAQS**



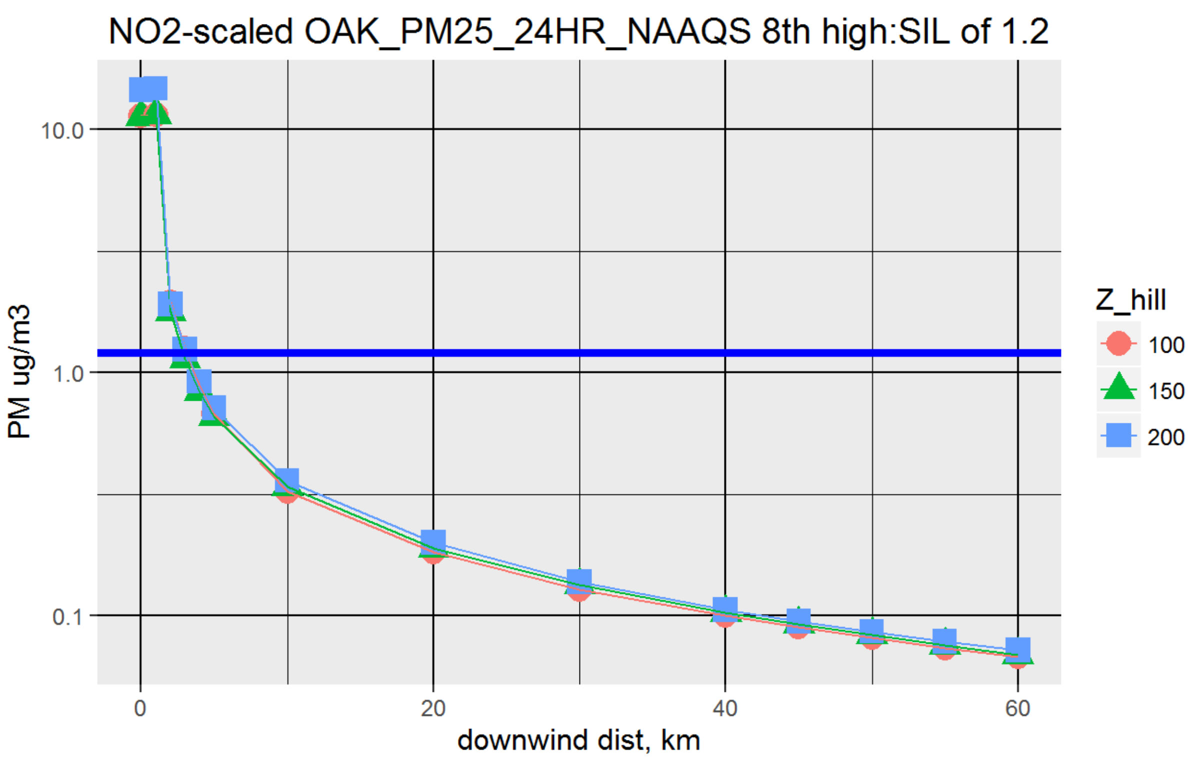




Figure 26 - Refined $PM_{2.5}$ results, OAK, 24-hour NAAQS

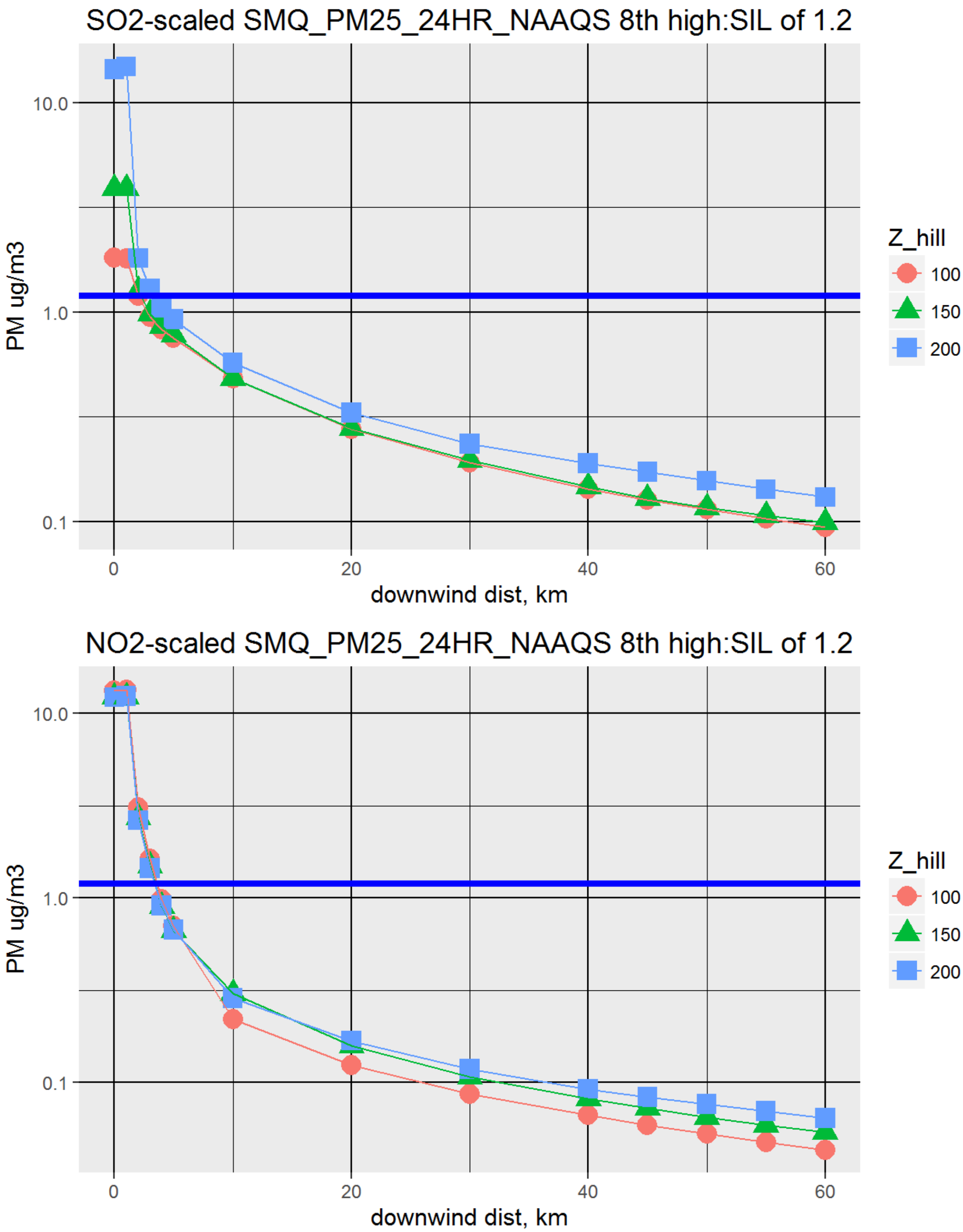
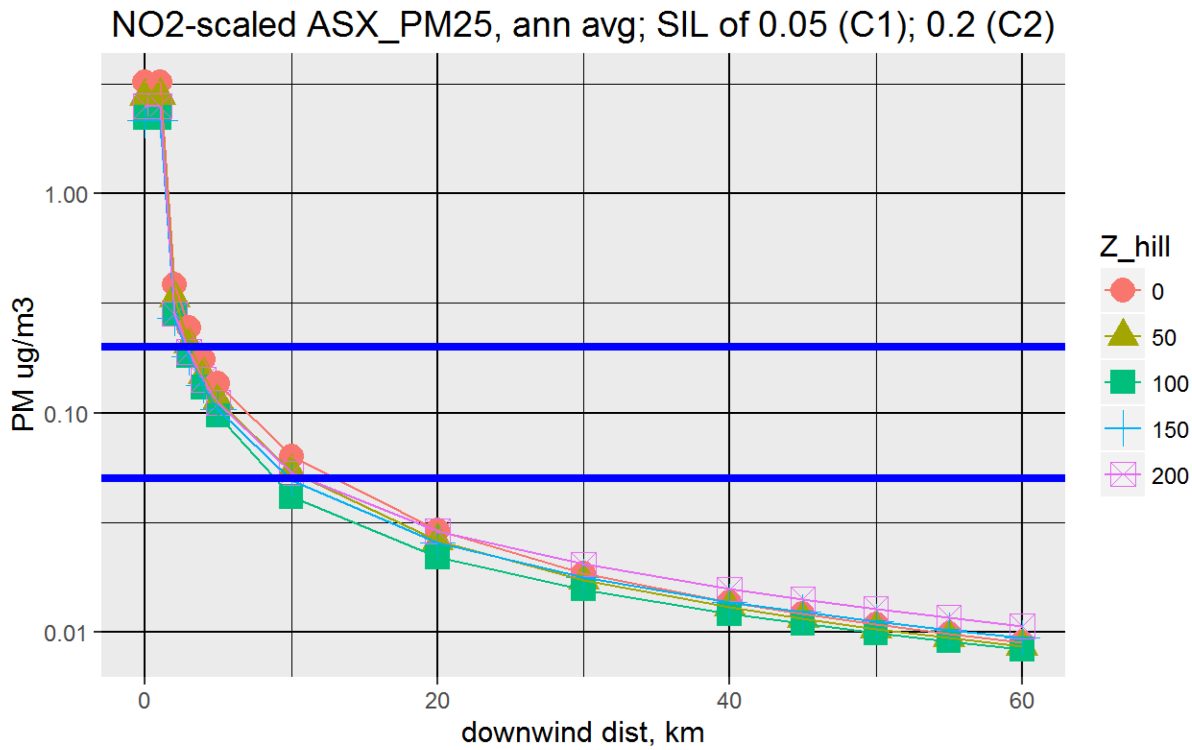



Figure 27 - Refined $PM_{2.5}$ results, SMQ, 24-hour NAAQS

*C.2 Comparisons against the annual PSD increment and NAAQS*



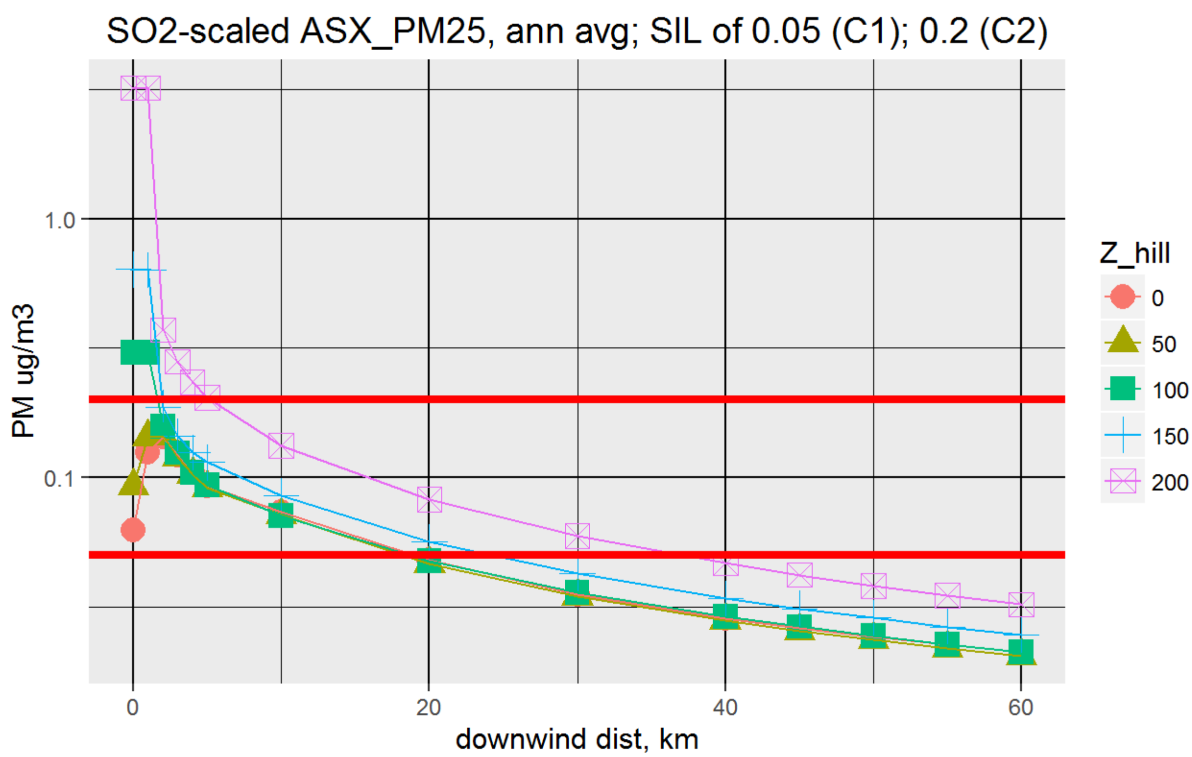
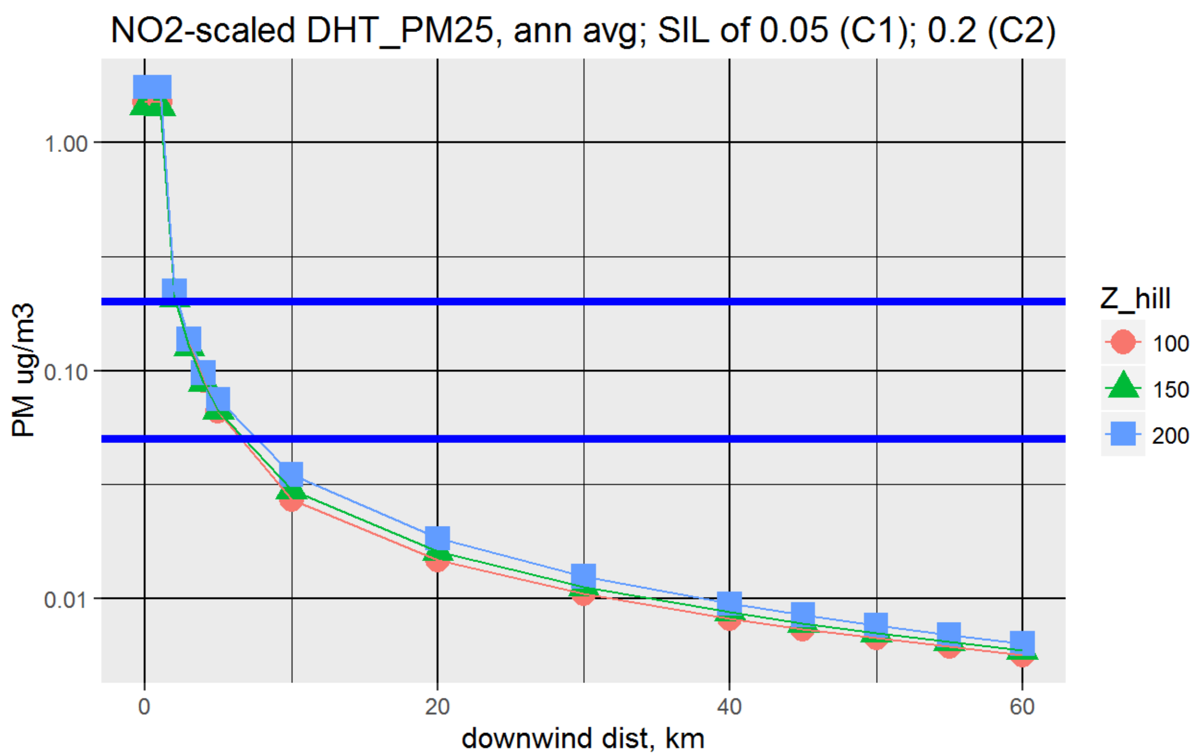




**Figure 28 - Refined $PM_{2.5}$ results, ASX, annual PSD increment and NAAQS**



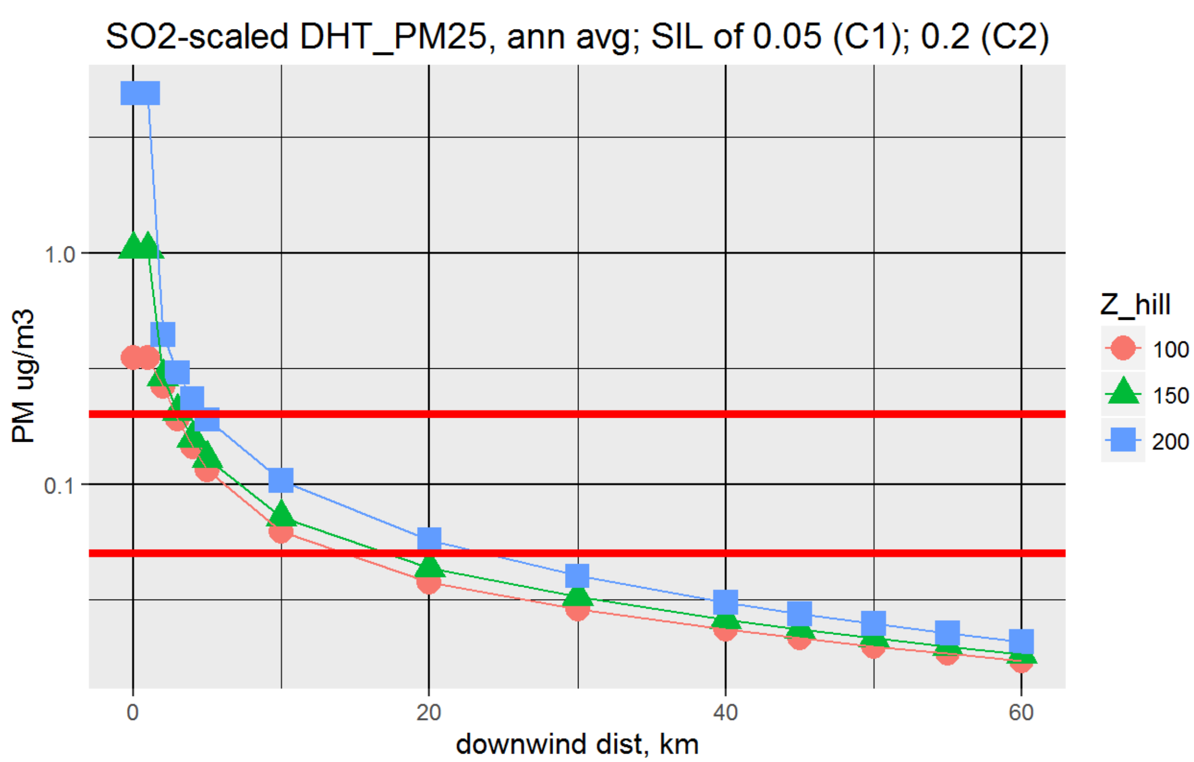




**Figure 29 - Refined $PM_{2.5}$ results, DHT, annual PSD increment and NAAQS**

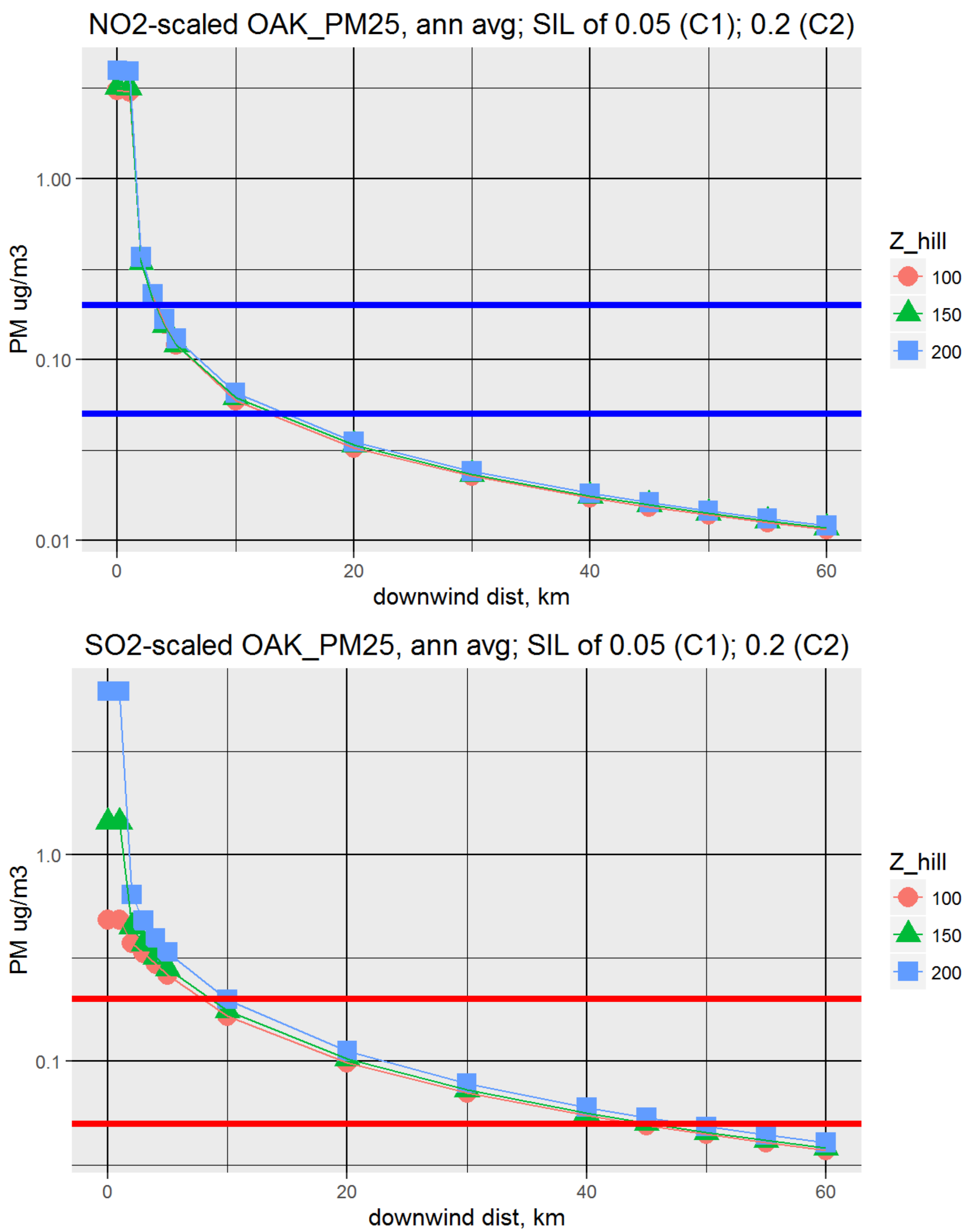



Figure 30 - Refined $PM_{2.5}$ results, OAK, annual PSD increment and NAAQS

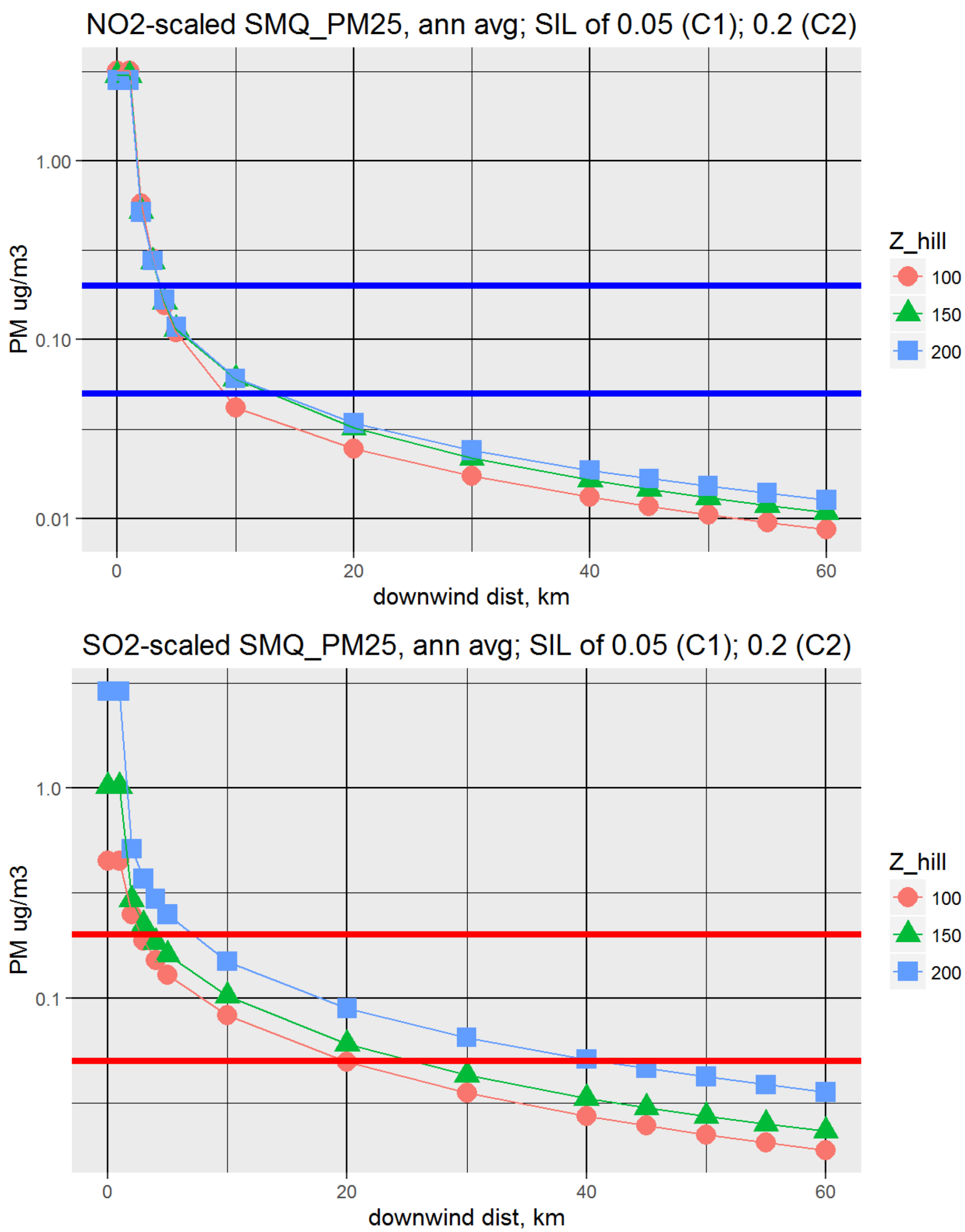
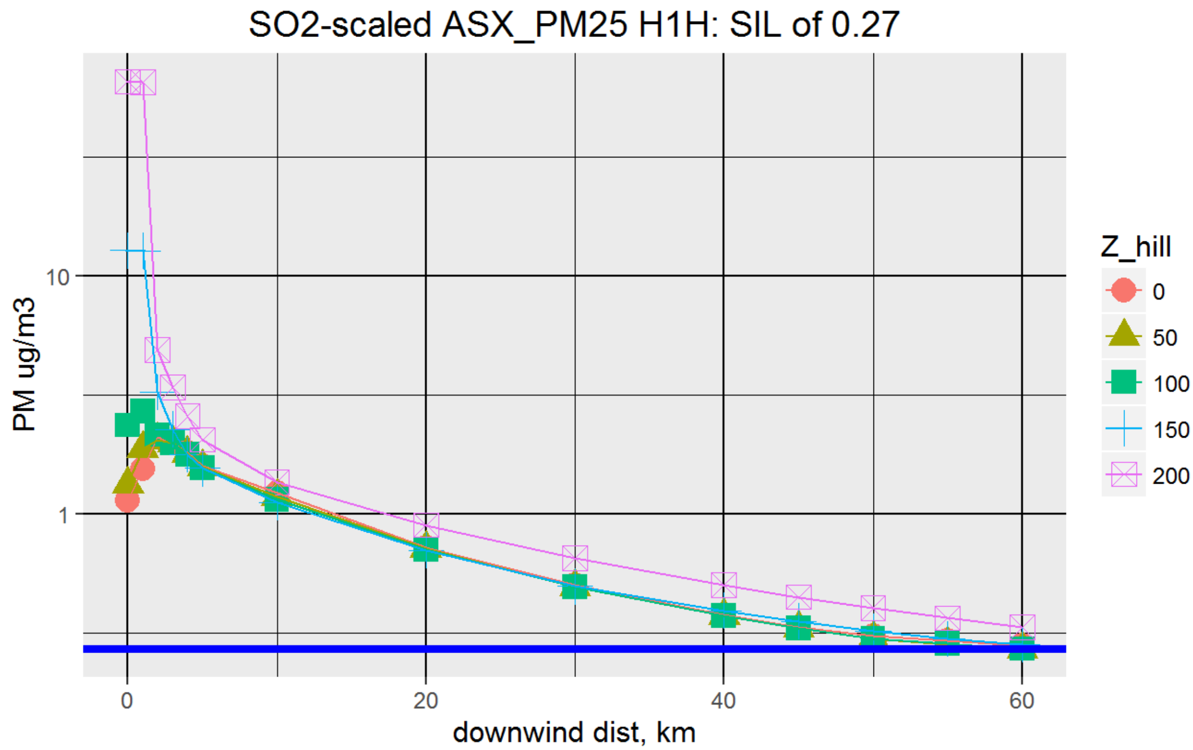



**Figure 31 - Refined $PM_{2.5}$ results, SMQ, annual PSD increment and NAAQS**

*C.3 Comparisons against the PM2.5 24-hour PSD increment*



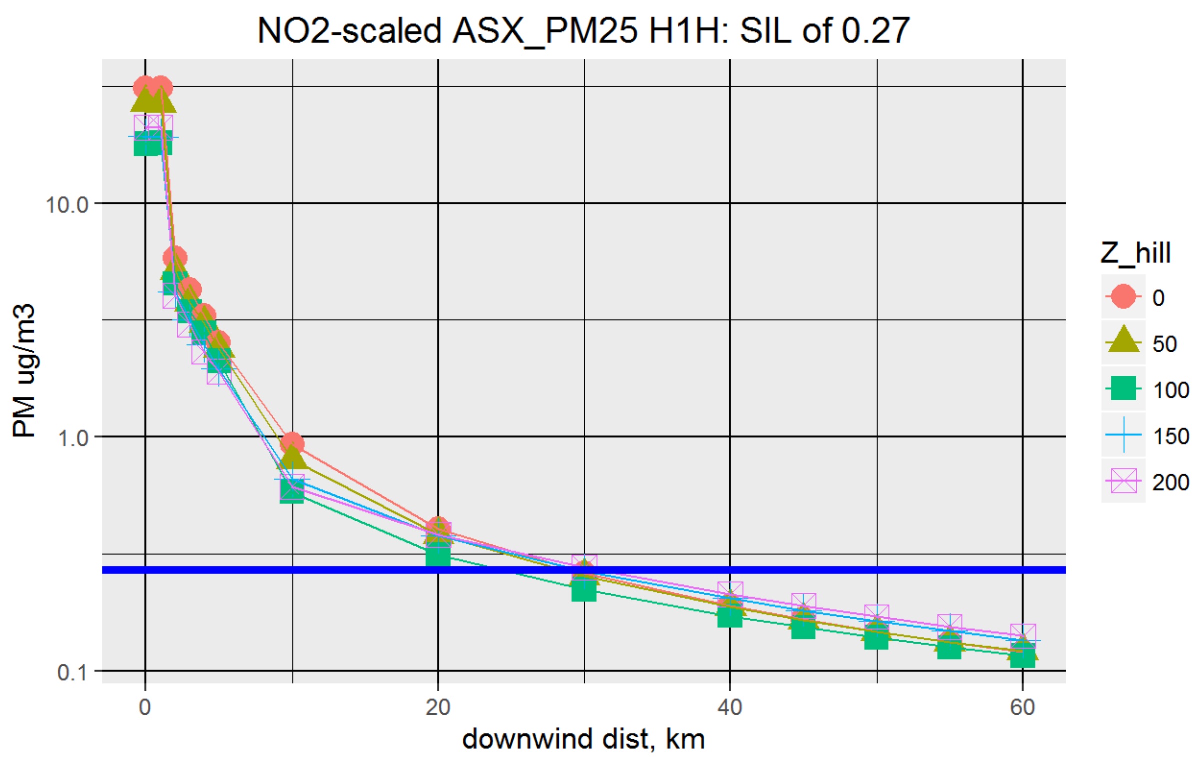




**Figure 32 - Refined $PM_{2.5}$ results, ASX, 24-hour PSD increment**

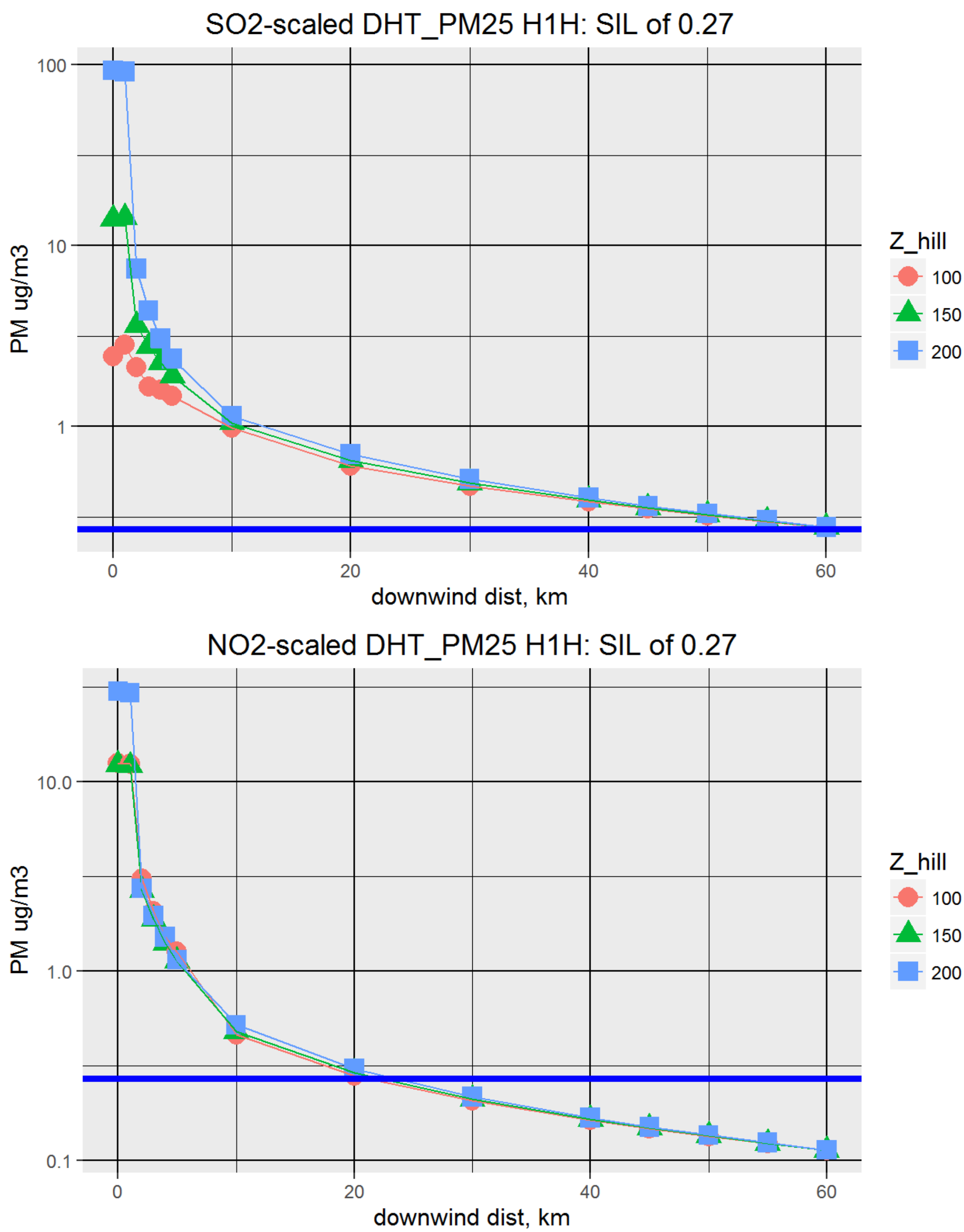



**Figure 33 - Refined $PM_{2.5}$ results, DHT, 24-hour PSD increment**

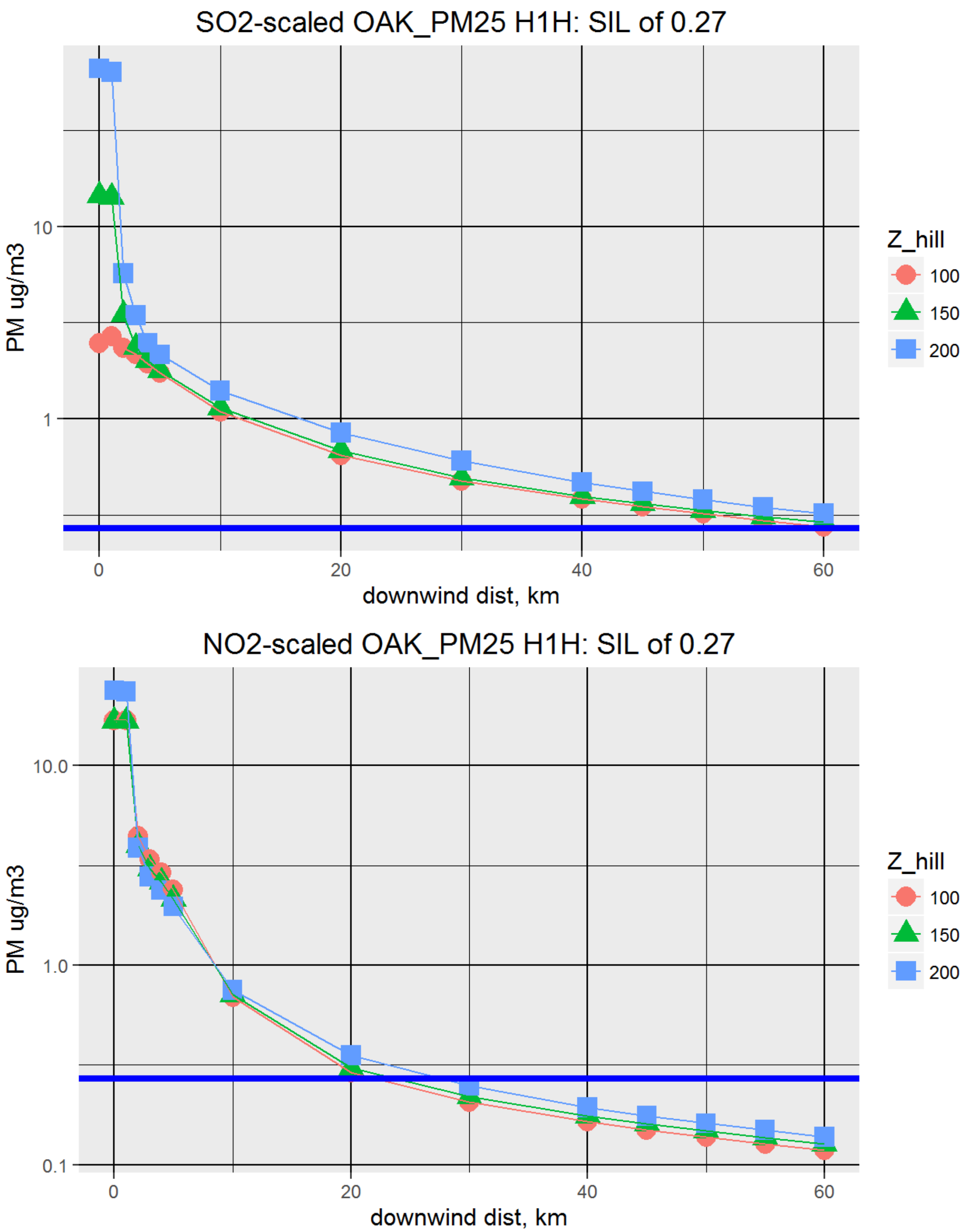



Figure 34 - Refined $PM_{2.5}$ results, OAK, 24-hour PSD increment

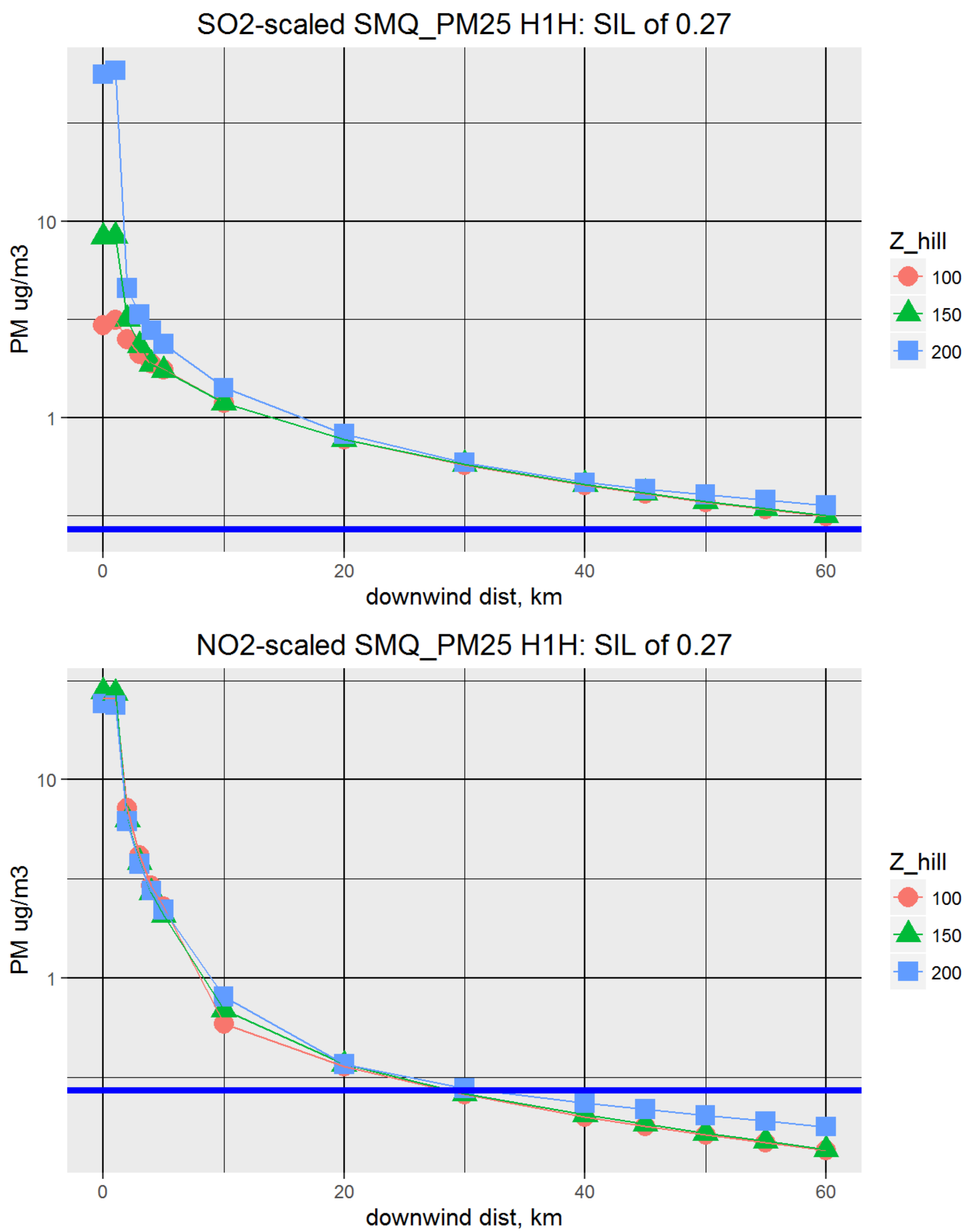



Figure 35 - Refined $PM_{2.5}$ results, SMQ, 24-hour PSD increment

| | | |
|---|---|---|
| United States Environmental Protection Agency | Office of Air Quality Planning and Standards<br>Air Quality Assessment Division<br>Research Triangle Park, NC | Publication No. EPA- 454/ B-16-007<br>December, 2016 |