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

EPA- 454/B-15-003

July 2015

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

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Analysis Division
Air Quality Modeling Group
Research Triangle Park, North Carolina

Preface

This document provides the results and interpretation of AERMOD simulations for typical PSD sources. The focus of the analysis is to determine the impact of a range of source types on pollutant concentrations in the near and far field.

Contents

Preface 4
Contents 5
Tables 6
Figures 7
1. Introduction 8
2. Background 8
3.0 Approach to evaluating near-source and long-range impacts 10
3.1 Source Types and Characteristics 10
3.2 Modeling Assessment of Various Facility Types 11
4. Summary of results 14
4.1 NO2 and SO2 screening 14
4.2 Refined analyses for NO2 and SO2 17
4.3 Refined analyses for PM10 and PM25 20
5. Conclusions 21
6. Additional information 21
References 22
Appendix A 23
Plots from NO2 and SO2 screening analysis 23
Appendix B 34
Plots from NO2 and SO2 refined analysis 34
Appendix C 47
Plots from PM refined analysis 47

Tables

Table 1 - Significant Impact Levels (SILs) for Criteria Pollutant by Class 1, 2, and 3 Areas. 9
Table 2 - PSD Increment for Criteria Pollutants by Class 1, 2, and 3 Areas. 10
Table 3 - Summary of Modeling Scenarios by Source Type from AERMOD Implementation Workgroup (AIWG) 11
Table 4 - Results for Phase 1 screening modeling for NO2 and SO2 by Facility type[5] 15
Table 5 - Results for Phase 1 screening modeling for NO2 and SO2 by Facility type, continued 16
Table 6 - Summary of NO2 and SO2 emissions for the coal EGU facility 17
Table 7 - Results from the Phase 2 refined analysis for NO2 18
Table 8 - Results from the Phase 2 refined analysis for SO2 19
Table 9 - Summary of 2011 NEI emission data used in refined modeling analysis 20

Figures

Figure 1 – Location of receptors for screening and refined runs. 13
Figure 2 - Results from the screening analysis for the asphalt plant. 24
Figure 3 - Results from the screening analysis for the biomass plant 25
Figure 4 - Results from the screening analysis for the cement kiln 26
Figure 5 - Results from the screening analysis for the coal EGU 27
Figure 6 - Results from the screening analysis for the ethanol plant 28
Figure 7 - Results from the screening analysis for the flare 29
Figure 8 - Results from the screening analysis for the fuel oil turbine 30
Figure 9 - Results from the screening analysis for the landfill gas turbine 31
Figure 10 - Results from the screening analysis for the natural gas compressor station 32
Figure 11 - Results from the screening analysis for the pulp and paper plant 33
Figure 12 - Refined NO2 and SO2 results, ASX, max and design values, 1-hr NAAQS 35
Figure 13 - Refined NO2 and SO2 results, DHT, max and design values, 1-hr NAAQS 36
Figure 14 - Refined NO2 and SO2 results, OAK, max and design values, 1-hr NAAQS 37
Figure 15 - Refined NO2 and SO2 results, SMQ, max and design values, 1-hr NAAQS 38
Figure 16 - Refined SO2 results, ASX, 3 & 24-hr increment 39
Figure 17 - Refined SO2 results, DHT, 3 & 24-hr increment 40
Figure 18 - Refined SO2 results, OAK, 3 & 24-hr increment 41
Figure 19 - Refined SO2 results, SMQ, 3 & 24-hr increment 42
Figure 20 - Refined NO2 & SO2 results, ASX, annual NAAQS 43
Figure 21 - Refined NO2 & SO2 results, DHT, annual NAAQS 44
Figure 22 - Refined NO2 & SO2 results, OAK, annual NAAQS 45
Figure 23 - Refined NO2 & SO2 results, SMQ, annual NAAQS 46
Figure 24 - Refined PM25 results, ASX, 24-hr annual increment 48
Figure 25 - Refined PM25 results, DHT, 24-hr annual increment 49
Figure 26 - Refined PM25 results, OAK, 24-hr annual increment 50
Figure 27- Refined PM25 results, SMQ, 24-hr annual increment 51
Figure 28 - Refined PM25 results, ASX, 24-hr NAAQS 52
Figure 29 - Refined PM25 results, DHT, 24-hr NAAQS 53
Figure 30 - Refined PM25 results, OAK, 24-hr NAAQS 54
Figure 31 - Refined PM25 results, SMQ, 24-hr NAAQS 55

1. Introduction

For long-range transport (LRT) applications of distances of more than 50 km from a source, the proposed revisions to EPA's *Guideline on Air Quality Models* (published as Appendix W to 40 CFR Part 51) include recommendations of a screening approach for addressing PSD increment and removal of CALPUFF as an EPA preferred model for such applications. While there is no proposed replacement refined model =for LRT applications under Appendix W, the information provided in this report indicates that the need for LTR assessments for NAAQS and PSD increment violations for inert pollutants is rare thereby mitigating the necessity for a preferred model for regulatory LRT assessments. This document provides technical details of an EPA modeling assessment that supports this proposed change, including summarizing the model scenarios and approach used to determine the impact of a range of source types on pollutant concentrations in the near and far field.

2. Background

The permitting process for the Preventions of Significant Deterioration Program (PSD) 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 multi-step process. As described in Section 9 of the proposed version of Appendix W, this two-stage process entails:

1. Conduct a single-source impact analysis where only the new or modifying source is considered in the analysis. The new or modifying source will model its own emissions to determine the appropriate impacts for each applicable pollutant and each averaging time. The predicted impacts from the single source are compared to the Significant Impact Level (SIL) for each averaging time and pollutant.
    a. If all single source impacts are less than the SIL, then the new or modifying source is generally not expected to cause or contribute to a violation of a NAAQS or PSD increment and the compliance demonstration is considered complete.
    b. If the single source impacts are greater than the SIL anywhere, then there is a chance that the source will cause or contribute to a violation of a NAAQS or PSD increment and then a cumulative impact analysis should be undertaken.
2. The cumulative impact analysis takes into account all sources affecting the air quality in an area including the project source impact and consideration of background, which includes contributions from natural, nearby, and unknown sources. The cumulative modeling demonstrations for NAAQS and PSD increment are different:
    a. For a NAAQS compliance demonstration, the emissions from the new or modifying source must be added to the background concentrations and the resulting "design concentration(s)" are compared to the specific NAAQS to determine compliance. When modeled violations are evident, the contribution from the new or modifying source to the modeled violations can be compared to the SIL to determine if the source is causing or contributing to the modeled violation(s).
    b. For a PSD increment compliance demonstration, the total increase in concentrations from all permitted sources is compared to the 'baseline' concentration. The total increase in concentrations is not allowed to be greater than the applicable PSD increment.

As indicated above, the SIL is used as demonstration tool to determine the culpability of a new or modifying source to any NAAQS or PSD increment violations. Table 1 shows the SIL levels for PM2.5, PM10, SO2, NO2, and CO, while Table 2 shows the PSD increment levels of fine particulate matter (PM2.5), coarse particulate matter (PM10), sulfur dioxide (SO2), and nitrogen dioxide (NO2). In 1996, a rulemaking was proposed with Class I specific SILs for NO2 (annual: 0.1 ug/m3), SO2 (annual: 0.1 ug/m3, 24-hr: 0.2 ug/m3, 3-hr 1.0 ug/m3) and PM10 (annual: 0.2 ug/m3, 24-hr: 0.3 ug/m3) (U. S. EPA, 1996). While this rule never went final, such that these Class I SILs have never been promulgated, it is our understanding that they have been used in practice by some states and regions for a screening analysis to eliminate the need for increment analysis are longer transport distances.

Pollutant	Class 1	Class 2	Class 3	Source
Fine Particulate Matter ($PM_{2.5}$)				
Annual mean	0.06[1]	0.3	0.3	40 CFR 51.165 (b)(2)
24-hr maximum	0.07	1.2	1.2	
Particulate Matter (PM_{10})				
Annual arithmetic mean	*	1	*	40 CFR 52.21 (k)(2)
24-hr maximum	*	5	*	
Carbon Monoxide (CO):				
8-hr maximum	*	500	*	40 CFR 51.165 (b)(2)
1-hr maximum	*	2000	*	
Sulfur Dioxide (SO_2)				
Annual mean	*	1	*	40 CFR 51.165 (b)(2)
24-hr maximum	*	5	*	
3-hr maximum	*	25	*	
1-hr maximum	*	3 ppb (~7.8 ug/m3)	*	(U. S. EPA, 2010b)
Nitrogen Dioxide (NO_2):				
Annual mean	*	1	*	40 CFR 51.165 (b)(2)
1-hr maximum	*	4 ppb (~7.5 ug/m3)	*	(U. S. EPA, 2010a)

Table 1 - Significant Impact Levels (SILs) for Criteria Pollutant by Class 1, 2, and 3 Areas.

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 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 is 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 overly conservative in the far-field. Thus, when long range transport (LRT) is expected to be important (i.e., impacts beyond the nominal distance of 50 km),

[1] The annual and 24-hr Class I SILs were remanded and vacated by request from the EPA in January 22, 2013. These values are currently under review and the EPA is developing a proposed rule to update the PM25 SILs. See the PM25 modeling guidance for more discussion on this issue (U. S. EPA, 2014).

an alternative model is necessary for assessing impacts for those distances with the current Appendix W recommending the use of the CALPUFF modeling system (U. S. EPA, 2003). Section 6.2.3 of the current version of Appendix W, published in 2005, 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).

Pollutant	Class 1	Class 2	Class 3
Fine Particulate Matter ($PM_{2.5}$)			
Annual mean	1	4	8
24-hr maximum	2	9	18
Particulate Matter (PM_{10})			
Annual arithmetic mean	4	17	34
24-hr maximum	8	30	60
Sulfur Dioxide (SO_2)			
Annual mean	2	20	40
24-hr maximum	5	91	182
3-hr maximum	25	512	700
Nitrogen Dioxide (NO_2):			
Annual mean	2.5	25	50
1-hr maximum	NA	NA	NA

Table 2 - PSD Increment for Criteria Pollutants by Class 1, 2, and 3 Areas.

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

In order to assess the nature of long range transport aspects of a PSD compliance demonstration, a variety of facility types were modeled across several inert criteria pollutants for 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 NO2 and SO2 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 NO2 (U. S. EPA, 2010a) and SO2 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 stack height, addition of controls, and modifications of facility boundaries reflecting changes in ambient air. Also for NO2 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) NO2/SO2	Stack heights (m)[2]
Asphalt plant	188/13.2	6, 3,0. 3
Biomass	244/174	55, 9, 9
Cement kiln	7140/3129	160, 160, 90[3], 90[1]
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, 253, 253, 253, 25[1], 6[1], 6[1], 6[1]
Landfill gas turbine	80/45	13,13,13,10
NG compressor	90/0.01	11, 11, 11, 11, 53
Pulp & paper plant	9657/3403	30, 30 ,29, 85, 85, 72, 72, 76, 8, 67, 67

3.2 Modeling Assessment of Various Facility Types

The goal of this modeling assessment is to determine what types of facilities may have significant impacts, as defined as modeled concentrations above the SIL, at distances greater than 50 km from the source. There are fundamentally 4 parameters that affect this result: 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 maximum impacts from a facility. These two aspects of a modeling 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

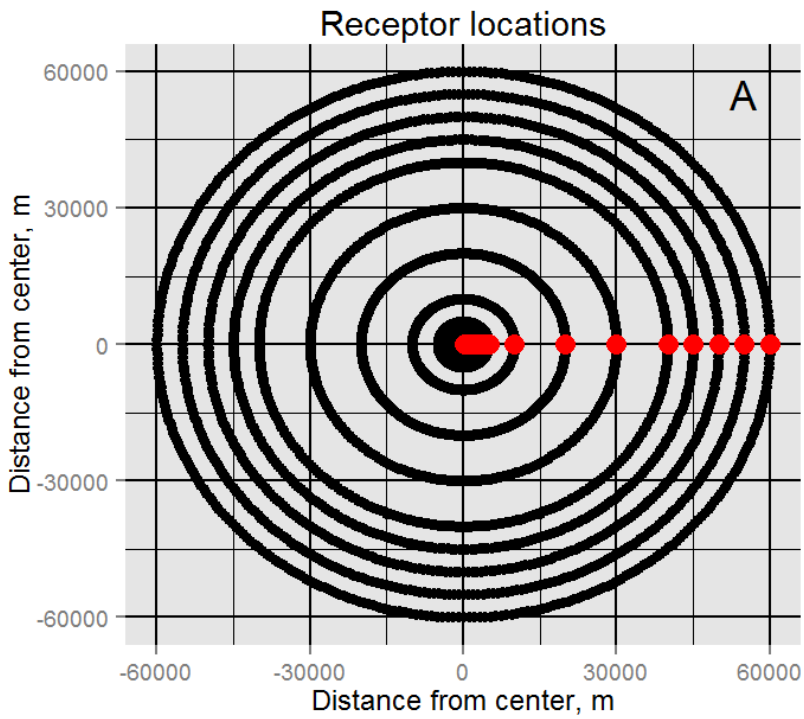
[2] Primary stacks for NO2, for SO2, for both

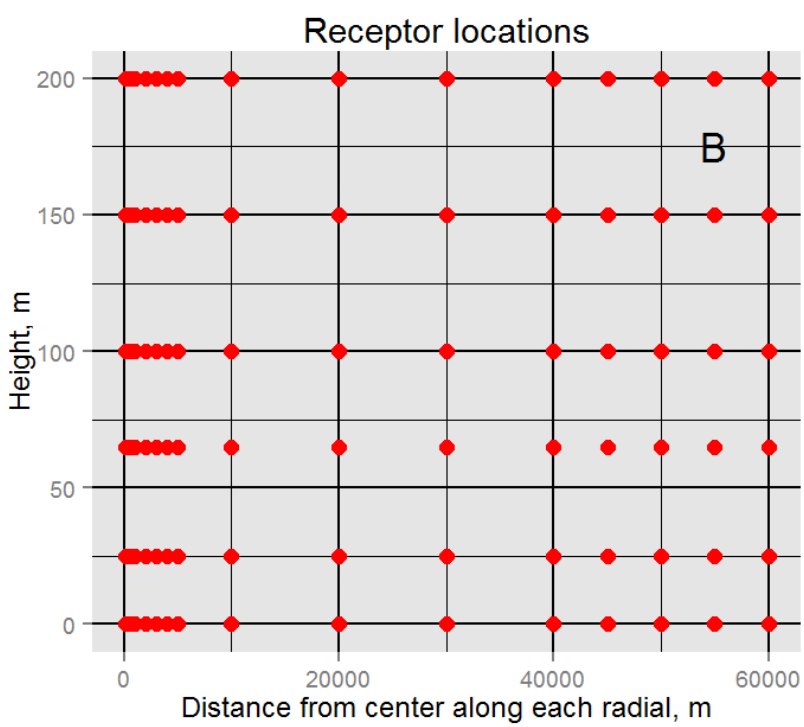
[3] NO2 only, no SO2 emissions at this stack height.

enough. Thus, it is essential to have emissions that reflect reality with respect to the facility type, which makes the AIWG modeling scenarios ideal for this evaluation.

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 three-phased analysis of was used here:

1. 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 across 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 and highly unstable conditions, which would give the highest concentrations for elevated release, with 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, which generally could not occur regardless of the wind direction. For these model simulations, receptors were placed at distances ranging from 100 m to 60 km. Multiple receptor heights were used in order to evaluate the potential presence of terrain downwind, with receptor heights including 0, 25, 65, 100, 150, and 200 m (Figure 1). Due to the plume centerline option being used, only a single receptor at each distance and height was required. Thus, the results from this initial phase represent an extremely conservative estimate of plume impacts. If the results from a facility showed impacts less than the SIL under this initial phase, then it is not expected for it to have impacts greater than the SIL for a refined single-source analysis.
2. The second phase of more refined modeling was pursued for those facilities whose predicted impacts from the first phase were above the SIL at 50 km. For this phase, AERMOD's CO SCREEN option was not used and several sets of actual meteorology were used instead of screening meteorology. One set of the actual meteorology selected was known to cause higher concentrations in surface releases, while one was known to cause higher concentrations with elevated releases. Additional meteorological data sets were used to provide more complete and robust findings. 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. For this second phase, we calculated 1-hour, 3-hour, 24-hour and annual concentrations to compare to the SILs for various averaging periods.
3. The third phase was pursued if results from the second phase still indicated impacts above the SIL at 50 km, wherein the facilities were evaluated against the relevant NAAQS for each averaging period. If the facility's impact was above the NAAQS in the near field, then the emissions were scaled down such that the source's impact satisfied the NAAQS in the near-field and its impacts at 50 km and beyond were evaluated and compared to the SIL for the appropriate averaging periods. This phase was based off the modeling in phase 2 by linearly scaling concentrations rather than scaling emissions and rerunning model simulations.





4.

Figure 1 – Location of receptors for screening and refined runs.[4]

[4] 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.

The AIWG scenarios included NO2 and SO2 emissions only, with NO2 using full conversion. However, PSD increments exist for CO, PM10, and PM2.5. Since CO air quality levels and emissions are currently so low, this pollutant is rarely an issue in PSD permitting and therefore were not evaluated in this assessment. However, PM10 and PM2.5 are necessary to include in this assessment and evaluated along with NO2 and SO2. 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 for PM emissions, based on the NO2 and SO2 emissions for a particular facility type. Additional details on this analysis are provided in the next section.

4. Summary of results

4.1 NO2 and SO2 screening

The first phase of screening analysis was conducted for NO2 and SO2 only. The results are summarized in Table 4 and Table 5 and in multiple figures are provided in Appendix A. For these screening runs, the maximum concentration for both NO2 and SO2 at each receptor was recorded. In addition, the 8th high 1-hour concentration for NO2 and the 4th high 1-hour concentration for SO2 were also recorded at each receptor. The 8th and 4th high 1-hour concentrations are the concentrations typically used for determining compliance in a refined cumulative modeling analysis. While results are conservative given the plume centerline concentrations calculated in the screening analysis, they give some sense of the distribution of the highest concentrations and provide valuable perspective on the maximum concentrations.

Several of the facility impacts were below their respective 1-hour SILs at the 50 km distance. The flare was below the SIL for NO2 and the asphalt plant and biomass burning plant were below the SIL for SO2. The landfill gas turbine and natural gas (NG) compressor were below the SIL at 50 km for both NO2 and SO2. Several other facilities were very close to the SIL at 50 km or had some receptors above and some below the SIL, depending on the receptor height. Only the NG compressor was compliant with any NAAQS, which has negligible SO2 emissions. While several facilities were close to the NAAQS, most were orders of magnitude higher than the NAAQS for both the highest concentration and the associated ranks concentration.

The focus of the evaluation here is to determine if source impacts are above the SILs at 50 km. However, as noted in Table 4 and Table 5, most of the facilities are fairly close to the applicable SILs at 50 km but well above the NAAQS in the near field. While the analysis of the SILs at 50 km is largely within the context of the PSD increment, an analysis of PSD increment would be completed in conjunction with an analysis of NAAQS. 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, particularly if the concentrations in the near field are orders of magnitude above the NAAQS (i.e.., the NAAQS is the controlling standard). When the emissions from these facilities are scaled back to meet the NAAQS in the near field, the impacts from most of the facilities at 50 km fall well below the applicable SILs. For example, for the fuel oil turbine, the equivalent of the design value from the screening runs for NO2 (the 8th maximum 1-hr average) was 1115 ppb (not shown), while the standard is 100 ppb and the maximum impact at 50 km was 12.5 ppb. The emissions would need to be reduced by a factor of 11 to pass a NAAQS demonstration. This reduction would also apply to the impact at 50 km, resulting in an

Table 4 - Results for Phase 1 screening modeling for NO2 and SO2 by Facility type[5]

Facility	Receptor Elevation	NO2 NAAQS (impacts in ppb)		SO2 NAAQS (impacts in ppb)	
		Maximum 1-hour impact	Impact at 50 km (SIL 4 ppb)	Maximum 1-hour impact	Impact at 50 km (SIL 3 ppb)
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

Table 5 - Results for Phase 1 screening modeling for NO2 and SO2 by Facility type, continued[5]

Facility	Receptor Elevation	NO2 NAAQS (impacts in ppb)		SO2 NAAQS (impacts in ppb)	
		Maximum 1-hour impact	Impact at 50 km (SIL 4 ppb)	Maximum 1-hour impact	Impact at 50 km (SIL 3 ppb)
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	303.0	26.7	452.9	11.3
	25	290.6	26.8	603.3	11.3
	65	815.1	26.8	3438.1	18.0
	100	9733.0	43.7	2718.0	12.0
	150	10313.8	85.8	2542.2	21.8
	200	8546.9	65.6	2235.4	18.4

[5] The screening runs have several layers of conservatism built into them. Firstly, the screening meteorology is designed to pick the meteorology that will result in the worst case concentrations for any facility configuration. Secondly, plume centerline concentrations have been calculated, giving the highest concentration possible from along a cross section of a plume. Thirdly, the plume centerline concentrations are occurring for each source simultaneously. While there is some physical possibility of the worse-case met occurring and directing a plume such that a receptor is along the plume centerline, the third case is generally not possible.

impact of 1.4 ppb at 50 km, which is well below the SIL of 4 ppb. The pattern that emerges from this adjustment to emissions indicates that facilities with emissions from the taller stacks (e.g., the cement kiln and the coal EGU) are the only ones that still have some impacts above the applicable SIL at 50 km. Facilities with the lower release points have their maximum impacts in close proximity to the fence line so their impacts at 50 km are much lower after the adjustment to meet the NAAQS. 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. Of course, this pattern is significantly influenced by including receptors that are close to stack height. When looking at only the elevated receptors, the emissions scaling necessitated to bring the elevated receptors to NAAQS levels replicates the pattern of maximum near field impacts for facilities with lower release heights.

The findings from the screening results is that most types of facilities in most terrain will have their maximum impacts relatively close to the source. When the emissions from these facilities are adjusted to meet the NAAQS, the far-field impacts are unequivocally less than the SIL such that no assessment of LRT would be necessary. While terrain is a complicating factor, the results also show that the only facility type that could pass a NAAQS assessment in the near-field but still have impacts above the applicable SIL at distances of 50 km or greater are those with very tall stacks.

4.2 Refined analyses for NO2 and SO2

Based on the findings from the initial screening analysis, the second phase of refined modeling, which uses 5 years of actual meteorology and computes NAAQS and increment appropriate modeled design values, focuses solely on those facility types with tall stacks. Both the coal EGU and the cement kiln fit this profile, but we focused only on the coal EGU because its SO2 emissions were concentrated at the tallest stack and its NO2 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 NO2 and SO2.

Table 6 - Summary of NO2 and SO2 emissions for the coal EGU facility

Stack height (m)	150[6]	100	6	5	5
NO2 emissions (tpy)	1564	174	104	10.4	10.4
SO2 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-year average), NAAQS specific design value (5-year average of 98th percentile and 99th percentile daily 1-

[6] The 150 m stack is above GEP height, but was modeled at this height anyway.

hour maximum concentrations), annual average (5-year average of each annual average), and 24-hour and 3-hour increment levels (highest first and second values) for SO2. 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).

Table 7 - Results from the Phase 2 refined analysis for NO2

Met scenario	Receptor Elevation	Maximum 1-hr impact (ppb, 1st high)		98th percentile 1-hr impact (ppb, 8th high)	
		All receptors	50 km (SIL 4 ppb)	All receptors	50 km (SIL 4 ppb)
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
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
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
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

Plots summarizing the refined modeling analysis for NO2 and SO2 are presented in Appendix B and the results are summarized in Table 7 and Table 8. The most striking difference from the screening and refined analysis is the decrease in the maximum 1-hour values. For NO2, 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 SO2, the maximum concentrations decrease even

Table 8 - Results from the Phase 2 refined analysis for SO2

Met scenario	Receptor Elevation	Maximum 1-hr impact (ppb, 1st high)		99th percentile 1-hr impact (ppb, 4th high)	
		All receptors	50 km (SIL 4 ppb)	All receptors	50 km (SIL 4 ppb)
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
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
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
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

further from 4388 ppb to 454 ppb. For NO2, the maximum 1-hour concentrations at 50 km from the refined modeling (with unscaled emissions) are now well below the 1-hour SIL at X to Y. However, the SO2 concentrations are still above the SIL at 50 km with the unscaled emissions, ranging from F to G. If the SO2 emissions are scaled such that the near-field results meet the NAAQS, then the impact at 50 km are below the 1-hour SIL at W to V. However, the maximum impacts in the near-field for SO2 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, realistically, a facility with a 150 m stack with large emissions is not likely to be built in the immediate vicinity of terrain near or above stack height, as the facility would not be able to pass a 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 would pass the NAAQS in the near-field, but be above the 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 indeed have significant impacts at 50 km or greater and need an LRT assessment. For the other averaging times, the maximum concentrations or estimated increment contributions are well below the SILs and increments at 50 km, even with the unscaled emissions. If emissions were scaled to pass the 1-hour NAAQS, then the concentrations at 50 km for the other averaging periods would be even farther below the benchmarks being considered here. In general, these results show that the longer the averaging period, the less likely that there will be significant impacts at distances of 50 km and greater.

4.3 Refined analyses for PM10 and PM25

Since the AIWG facilities did not include PM10 or PM2.5 emissions, we derived these emissions by scaling from the emission rates for SO2 and NO2 based on emission ratios of these pollutants for EGUs listed in the NEI. The ratios of PM10 and PM2.5 emissions to NOx emissions for all EGUs with NOx emissions greater than 40 tons were calculated. Similarly, emission ratios were computed for EGUs with SO2 emissions greater than 40 tons. PM emissions were significantly lower than NOx and SO2 emissions. The results are summarized in Table 7. On average, the PM10 emissions were about 22% of NOx and SO2 emissions, while PM2.5 emissions were around 19% of NOx and SO2 emissions. The facilities with the greatest PM10 and PM2.5 emission ratios resulted in PM10 and PM2.5 being 50% of NOx and 38% of SO2. Given how close PM10 and PM2.5 emission ratios were, this assessment focused on PM2.5 emissions only, as the PM2.5 standard are more stringent than the PM10 standards. Since both PM10 and PM25 would be modeled as inter pollutants, the model would treat each pollutant equally with respect to dispersion, so modeling both PM10 and PM25 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.

Table 9 - Summary of 2011 NEI emission data used in refined modeling analysis

NOx ratios					
PM10 max	PM10 min	PM10 mean	PM25 max	PM25 min	PM25 mean
8.0%	49.4%	22.9%	4.8%	49.2%	19.5%
SO2 ratios					
PM10 max	PM10 min	PM10 mean	PM25 max	PM25 min	PM25 mean
3.1%	37.7%	22.6%	2.7%	37.6%	18.7%

Plots summarizing the refined modeling analyses for PM2.5 are presented in Appendix C. The results from the annual average are well below the annual SILs at 50 km. For the 24-hour concentrations, it is difficult to draw specific conclusions from the results, given the uncertainty in the applicable SIL. The maximum concentrations are certainly well below the increment and below some of the 24-hr Class I SILs that are available. For the NO2-scaled emissions, the NAAQS near-field concentrations are slightly above the NAAQS (16 ug/m3) and right at the lowest PM25 SIL option. The SO2-scaled emissions have slightly higher maximum impacts (20 ug/m3) but are in between the two lowest PM25 SIL options. For the NO2 case, when emissions are scaled down to meet the NAAQS, the 50 km impacts become solidly below the SIL, while the SO2 50 km impacts are still higher than the lowest PM25 SIL option.

5. Conclusions

The results from this analysis indicate that for most facility types, if the facility can confirm compliance with the short-term standards in the near-field, then there are not likely to be significant impacts at 50 km. Thus, for most facilities that show compliance in the near-field, no evaluation of LRT would be needed. 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 NO2, SO2 and PM25 SILs. These types of facilities have their maximum impact much farther from the facility than most, which means a higher emissions rate would be acceptable. The results also indicate that terrain features can be important for these types of facilities, as elevated terrain, near stack height, can see higher plume impacts much closer to the source. When this occurs, the compliance with the short-term standard may be sufficient to decrease long-range impacts and eliminate the potential need for an LRT assessment. Conversely, elevated receptors in the far-field can increase the need for LRT assessments, as these receptors would experience impacts closer to the plume centerline. Given the GEP restrictions on stack heights, there are not likely to be many facilities with stacks tall enough to pass the near-field NAAQS requirement while still having significant impacts at 50 km.

6. Additional information

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

Chris Owen, PhD
Office of Air Quality Planning and Standards, U. S. EPA
109 T.W. Alexander Dr.
RTP, NC 27711
919-541-5312
owen.chris@epa.gov

References

Cimorelli, et al. (2005). AERMOD: A Dispersion Model for Industrial Source Applications. Part I: General Model Formulation and Boundary Layer Characterization. *J. App. Meterol*, 682-693.

Snyder, E., & Thurman, J. (2012). AERMOD Implementation Workgroup NO2 & SO2 modeling. *10th Conference on Air Quality Modeling.* U. S. EPA, RTP, NC.

U. S. EPA. (1996). 40 CFR Parts 51 and 52: Prevention of Significant Deterioration (PSD) and Nonattainment New Source Review (NSR). *FR, Vol. 61, No. 142, July 23, 1996*, 38249 - 38344.

U. S. EPA. (2003). Guideline on Air Quality Models. *40 CFR Part 51 Appendix W (68 FR 18440)*.

U. S. EPA. (2010a, June 29). *Guidance Concerning the Implementation of the 1-hour NO2 NAAQS for the Prevention of Significant Deterioration Program.*

U. S. EPA. (2010b, August 23). *Guidance Concerning the Implementation of the 1-hour SO2 NAAQS for the Prevention of Significant Deterioation Program.*

U. S. EPA. (2011, March). AERSCREEN User's Guide. pp. EPA-454/B-11-001.

U. S. EPA. (2014, May). *Addendm to User's Guide for the AERMOD Meteorological Preprocessor (AERMET), EPA document number EPA-454/B-03-002.* Retrieved from RTP, NC.

U. S. EPA. (2014). Guidance for PM2.s Permit Modeling, EPA report number EPA-454/B-14-001. *RTP, NC*, May.

Appendix A

Plots from NO2 and SO2 screening analysis

For all figures in this section, the NO2 SIL is shown in blue and the SO2 SIL is shown in red.

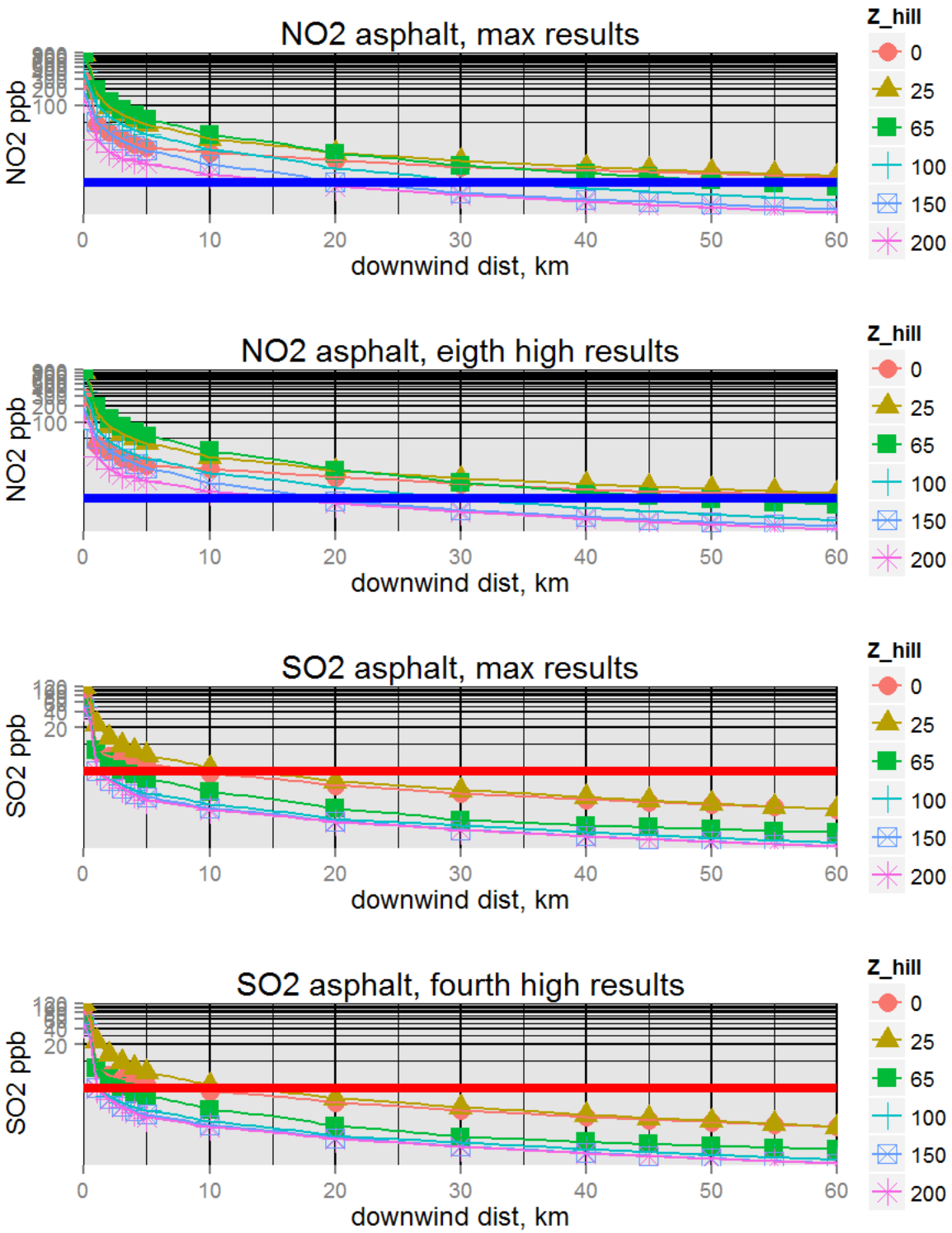


Figure 2 - Results from the screening analysis for the asphalt plant.

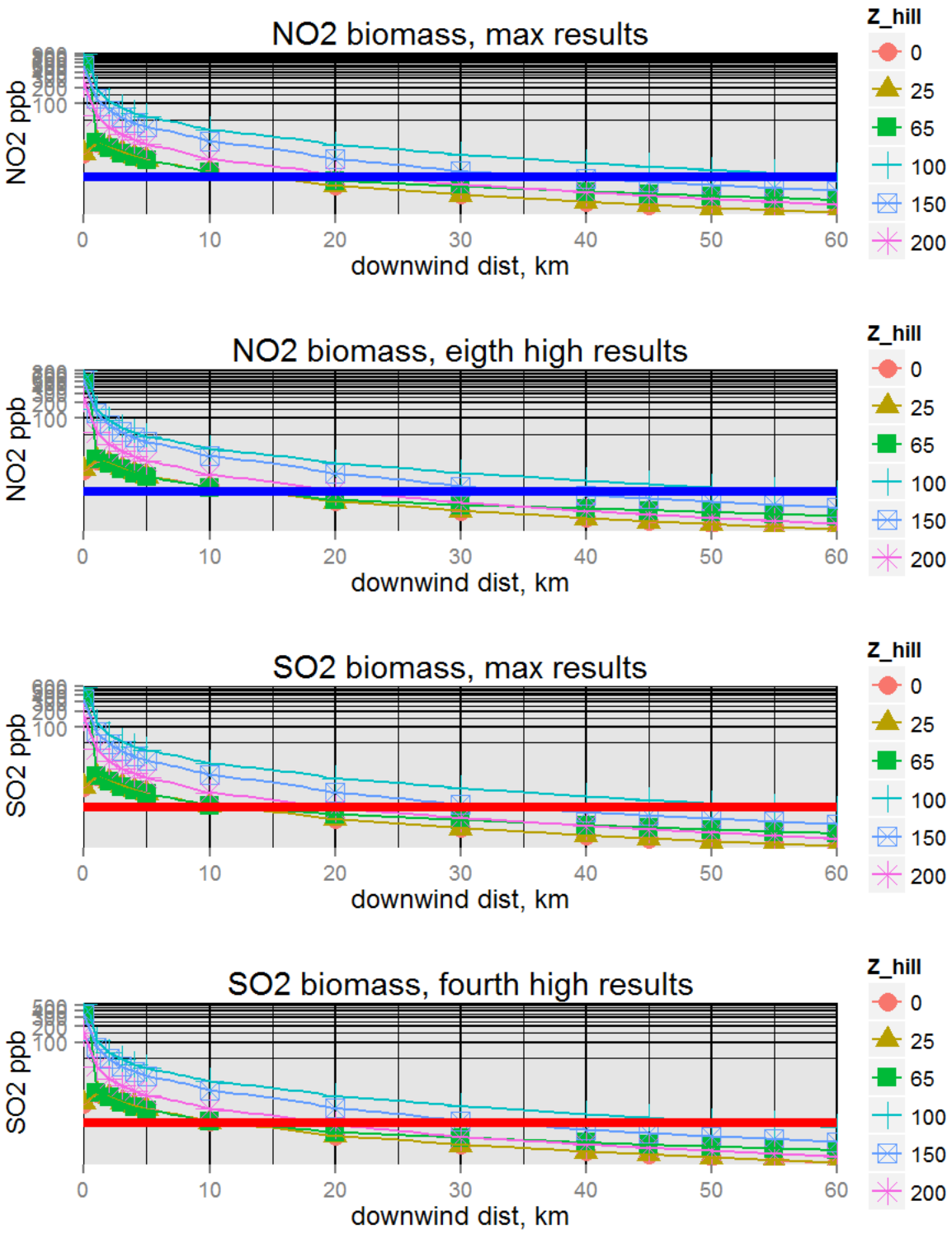


Figure 3 - Results from the screening analysis for the biomass plant

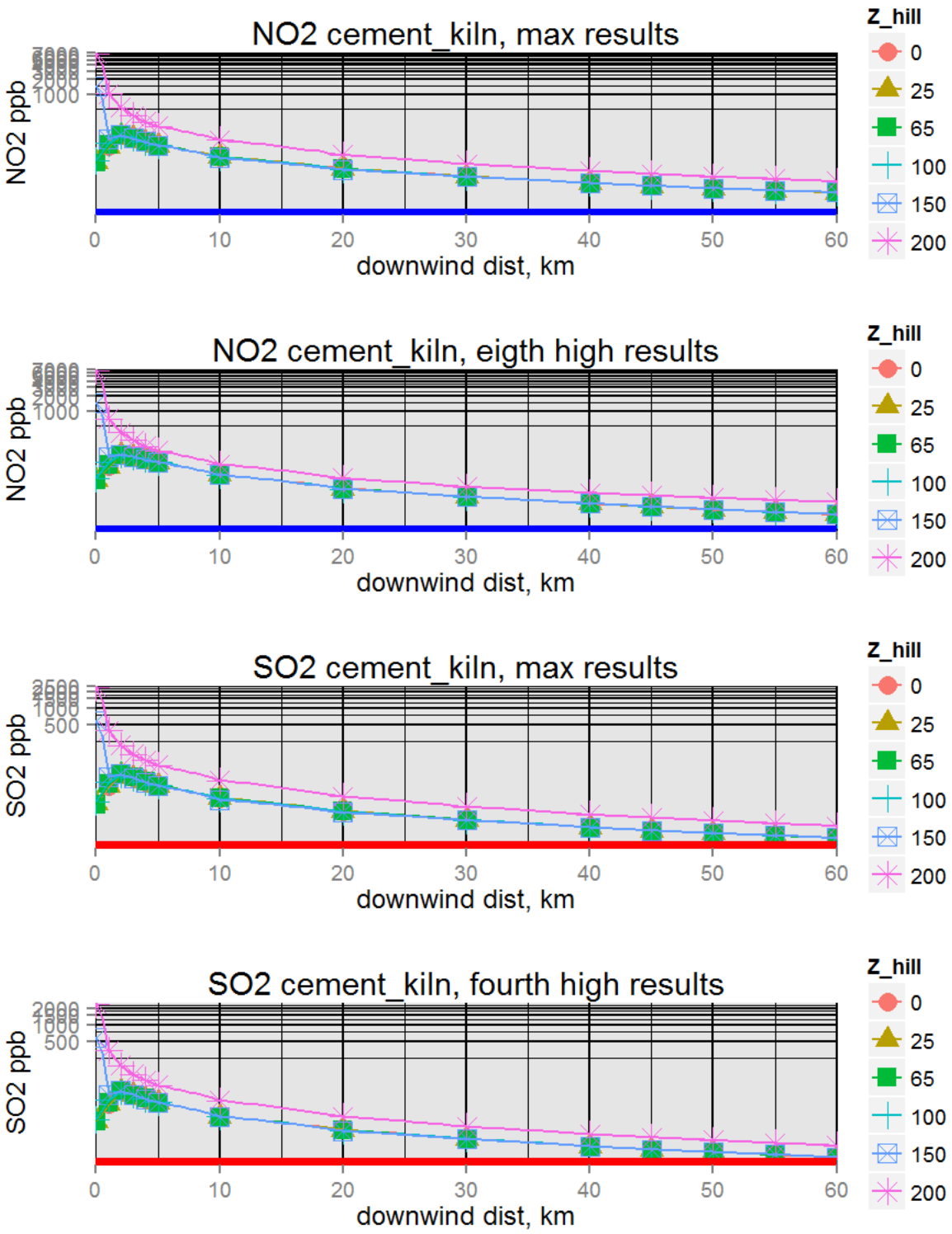


Figure 4 - Results from the screening analysis for the cement kiln

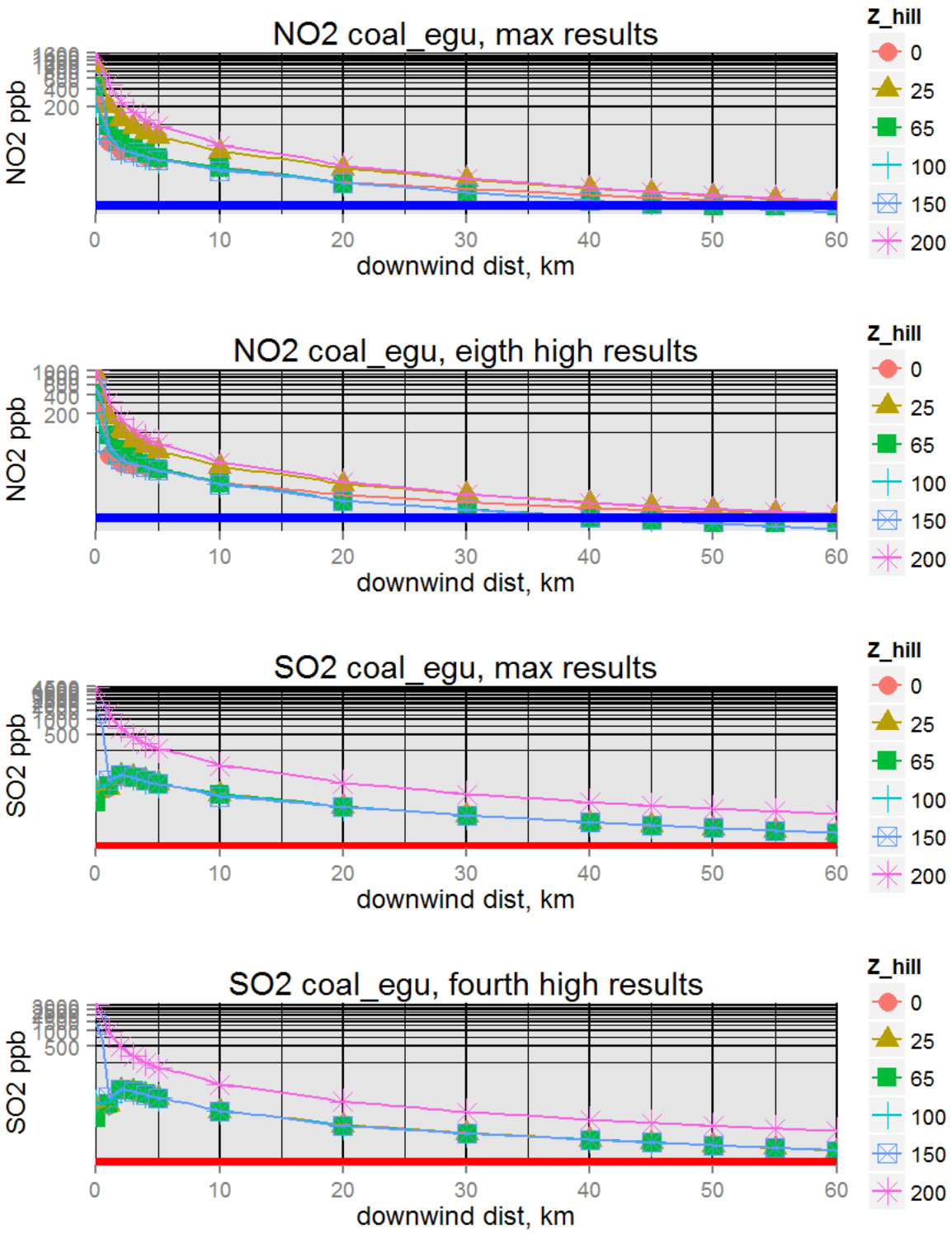


Figure 5 - Results from the screening analysis for the coal EGU

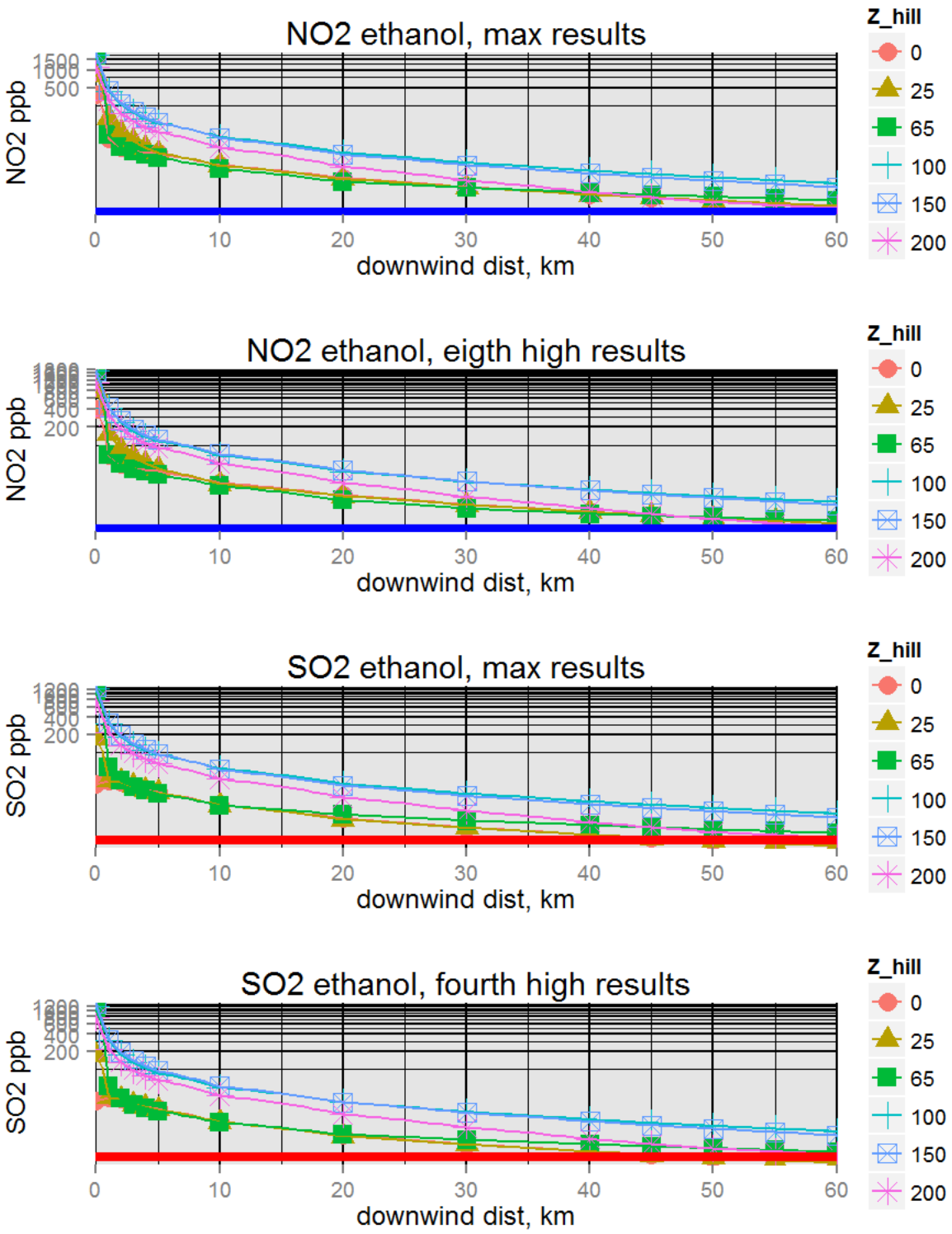


Figure 6 - Results from the screening analysis for the ethanol plant

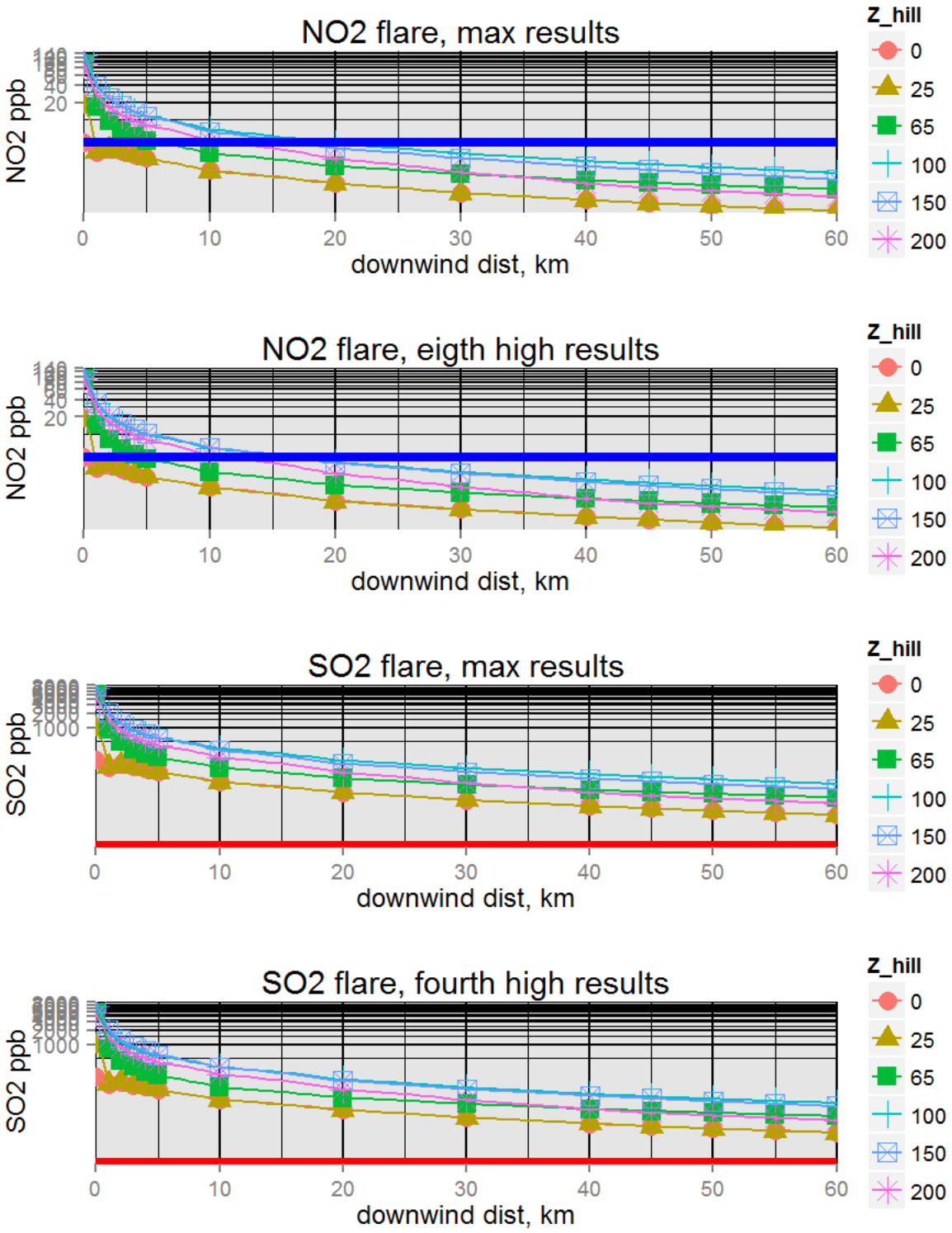


Figure 7 - Results from the screening analysis for the flare

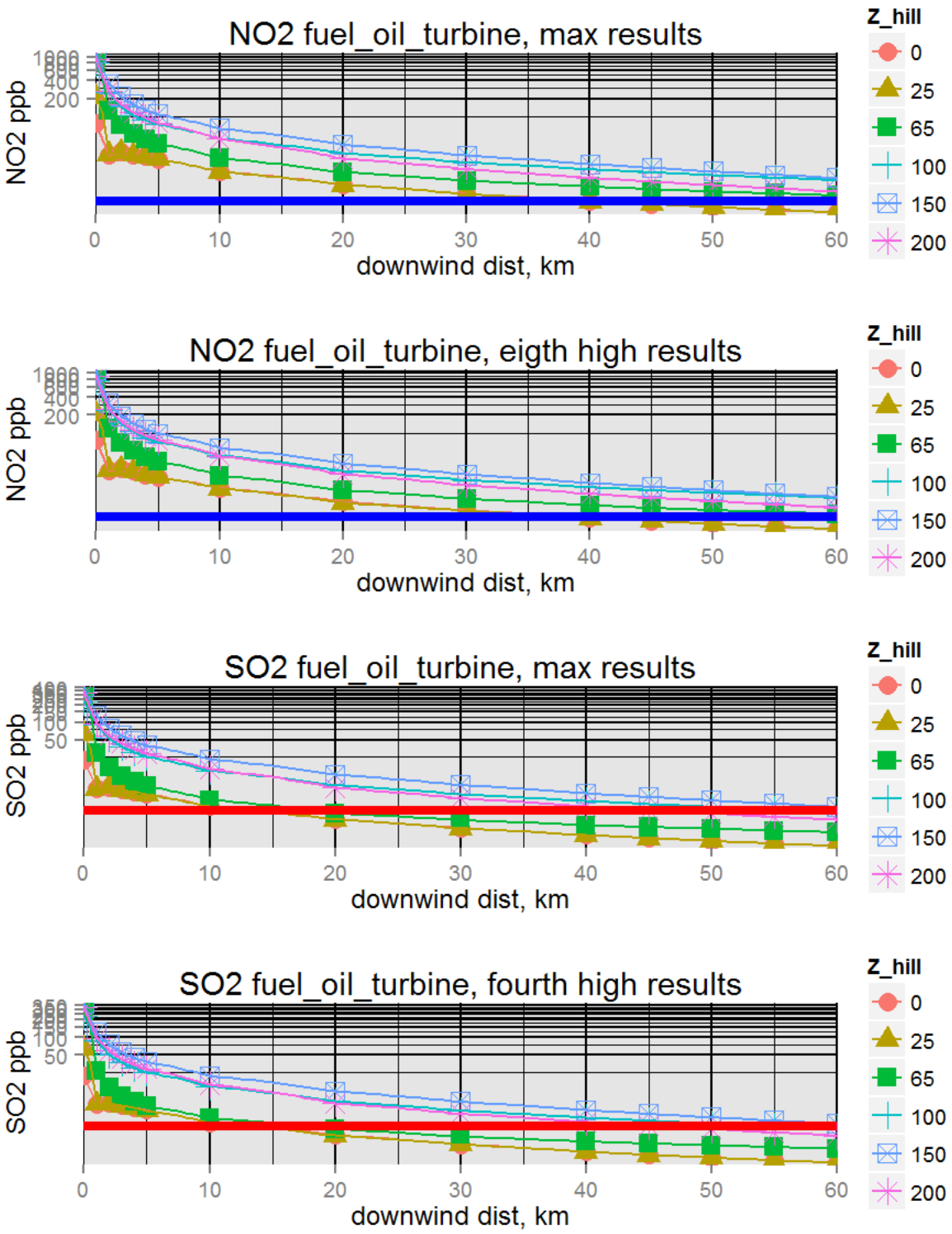


Figure 8 - Results from the screening analysis for the fuel oil turbine

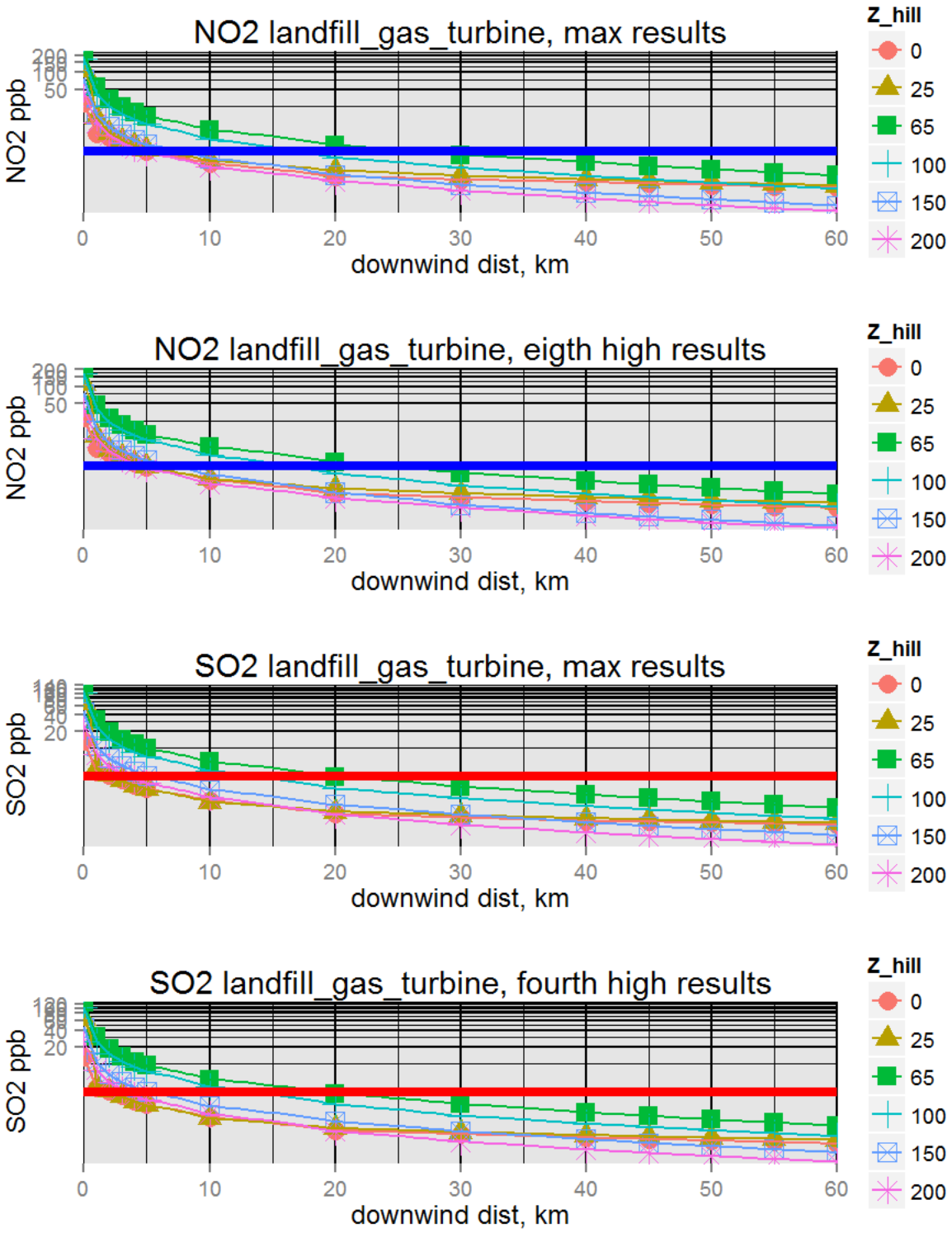


Figure 9 - Results from the screening analysis for the landfill gas turbine

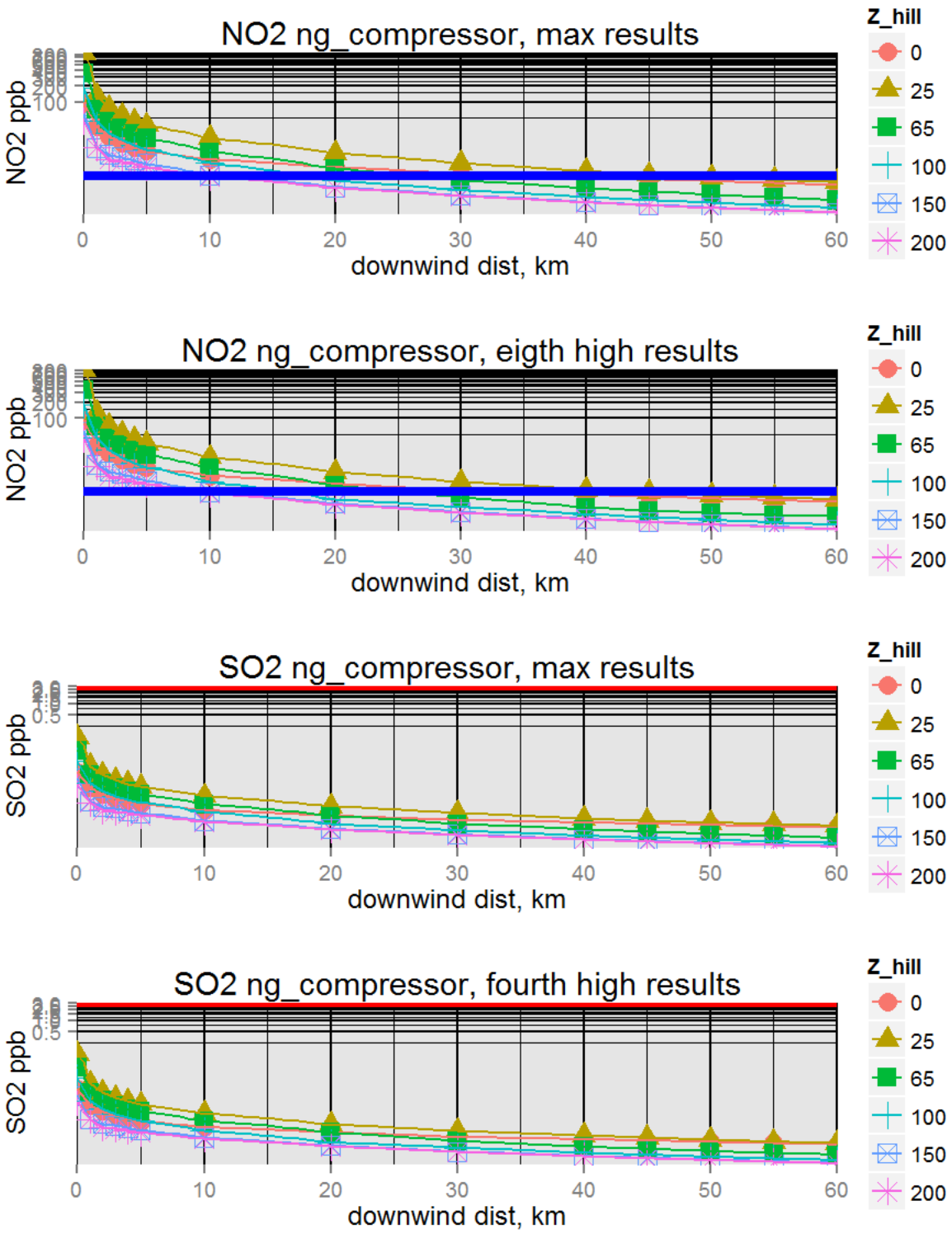


Figure 10 - Results from the screening analysis for the natural gas compressor station

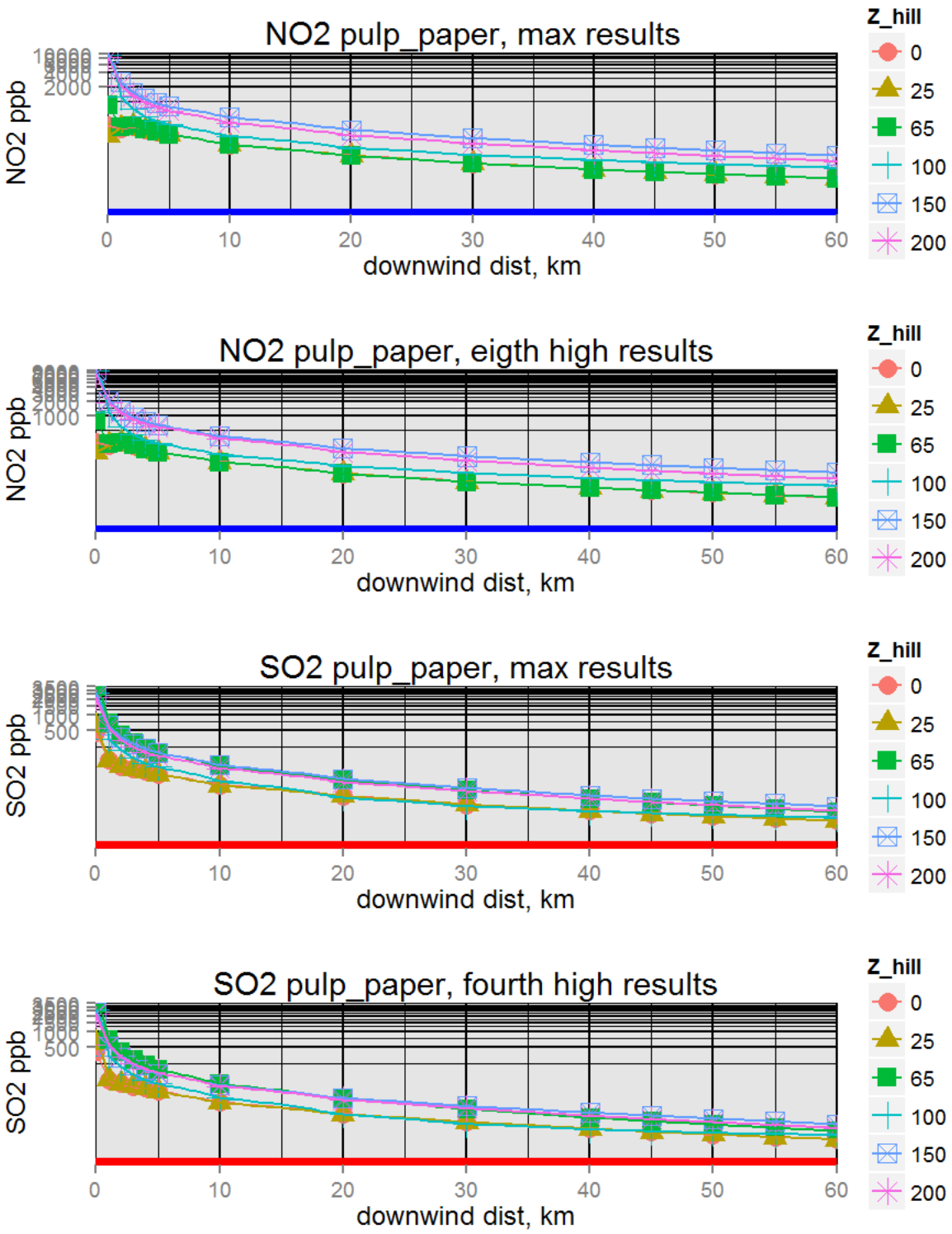


Figure 11 - Results from the screening analysis for the pulp and paper plant

Appendix B

Plots from NO2 and SO2 refined analysis

For all figures in this section, the NO2 SIL is shown in blue and the SO2 SIL is shown in red.

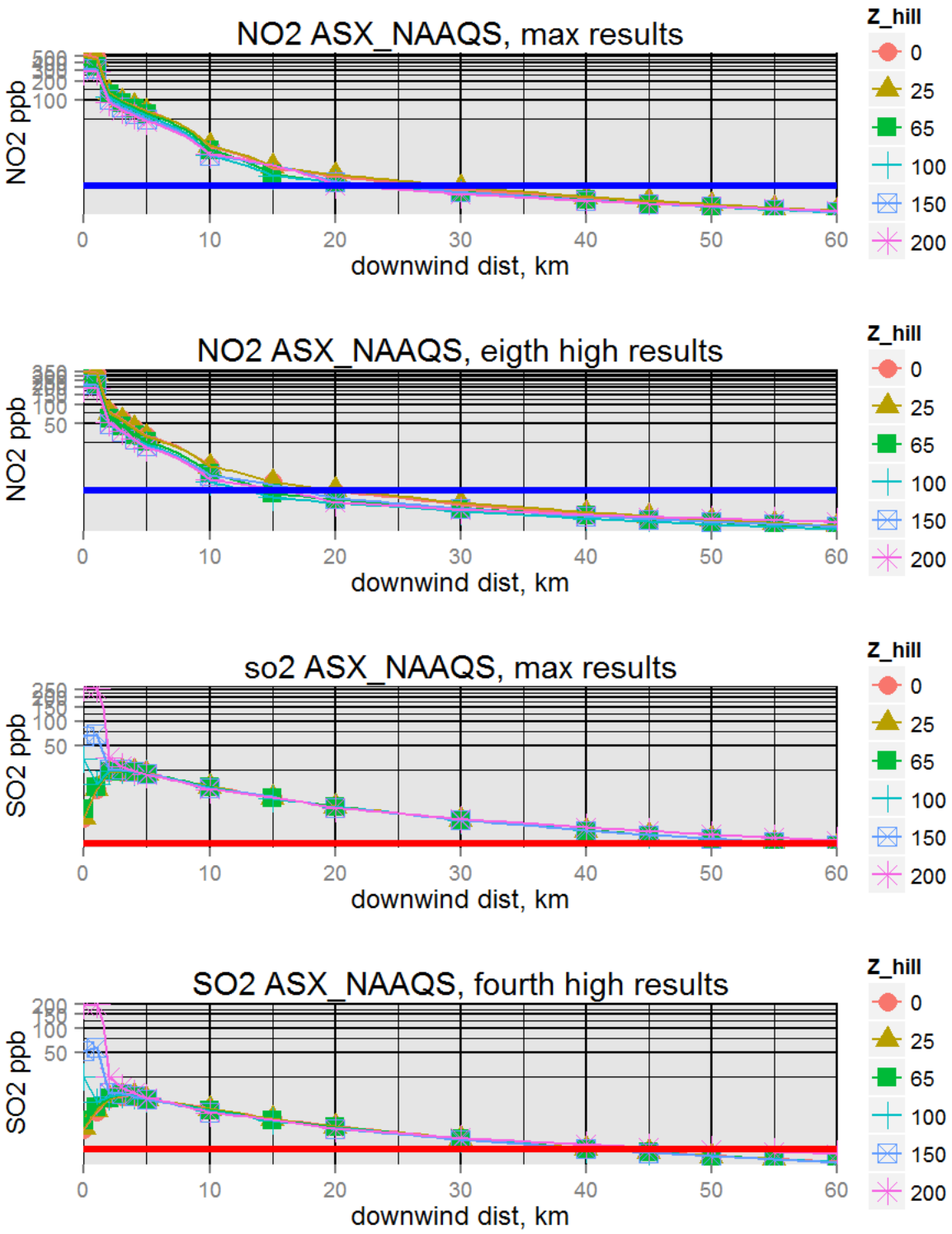


Figure 12 - Refined NO2 and SO2 results, ASX, max and design values, 1-hr NAAQS

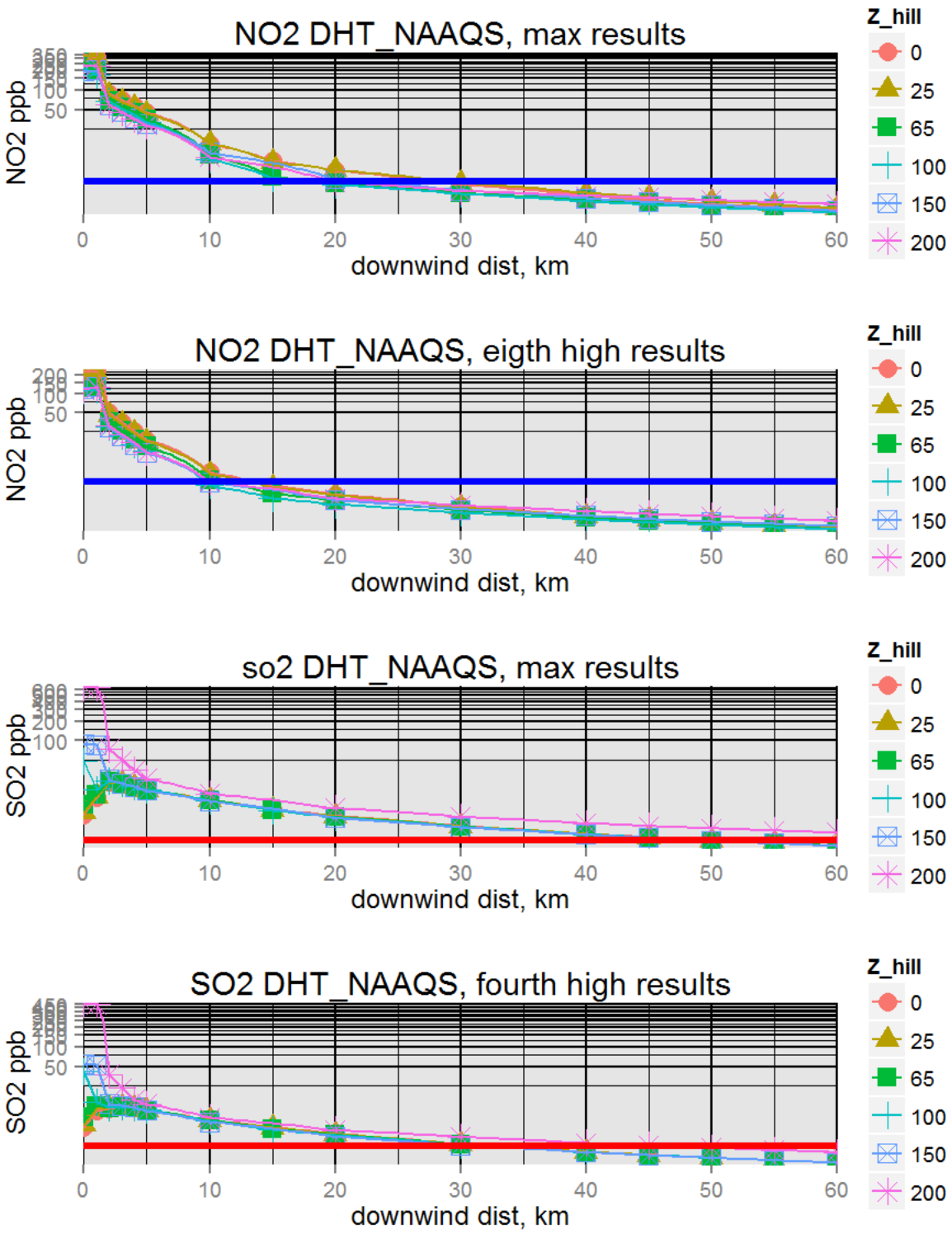


Figure 13 - Refined NO2 and SO2 results, DHT, max and design values, 1-hr NAAQS

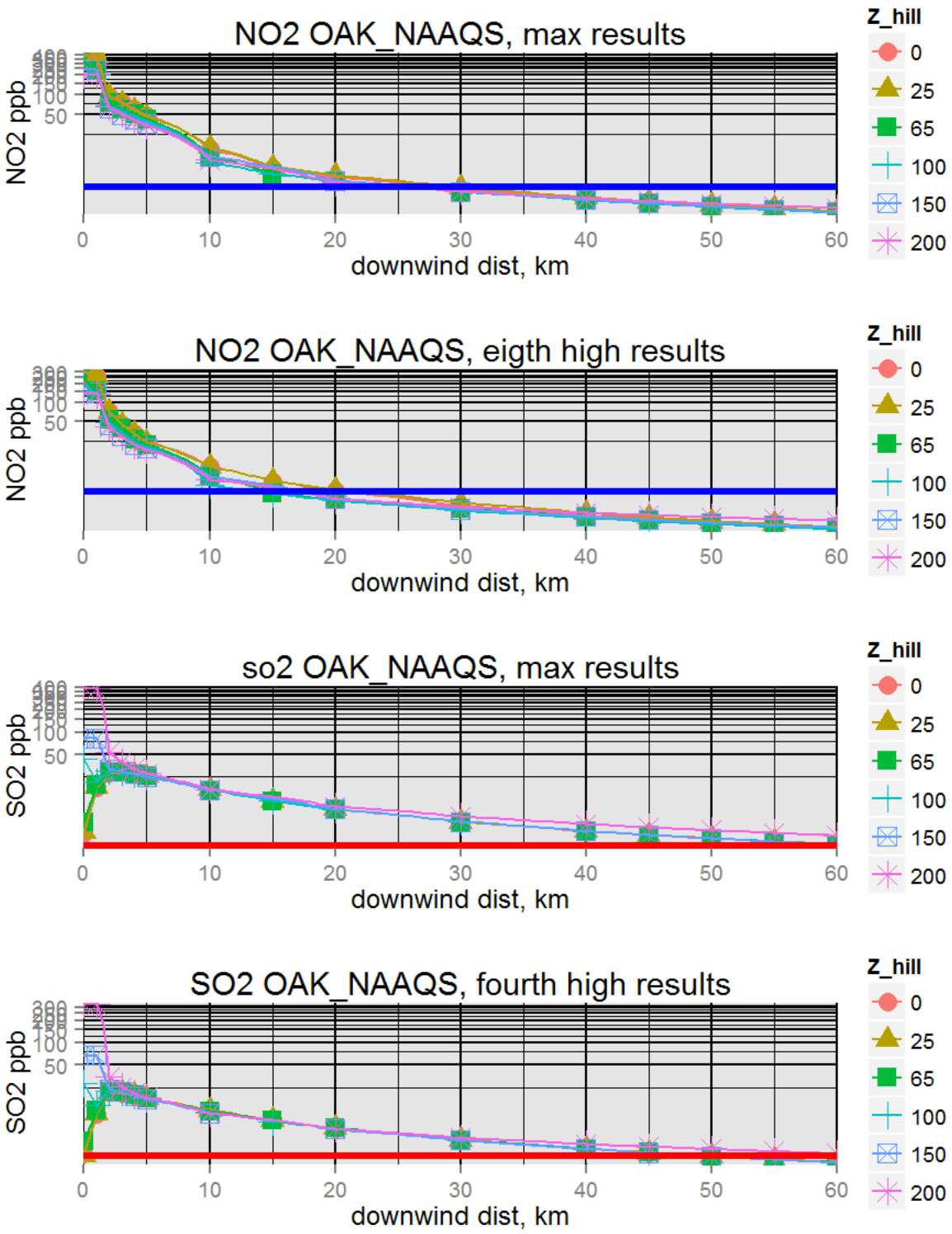


Figure 14 - Refined NO2 and SO2 results, OAK, max and design values, 1-hr NAAQS

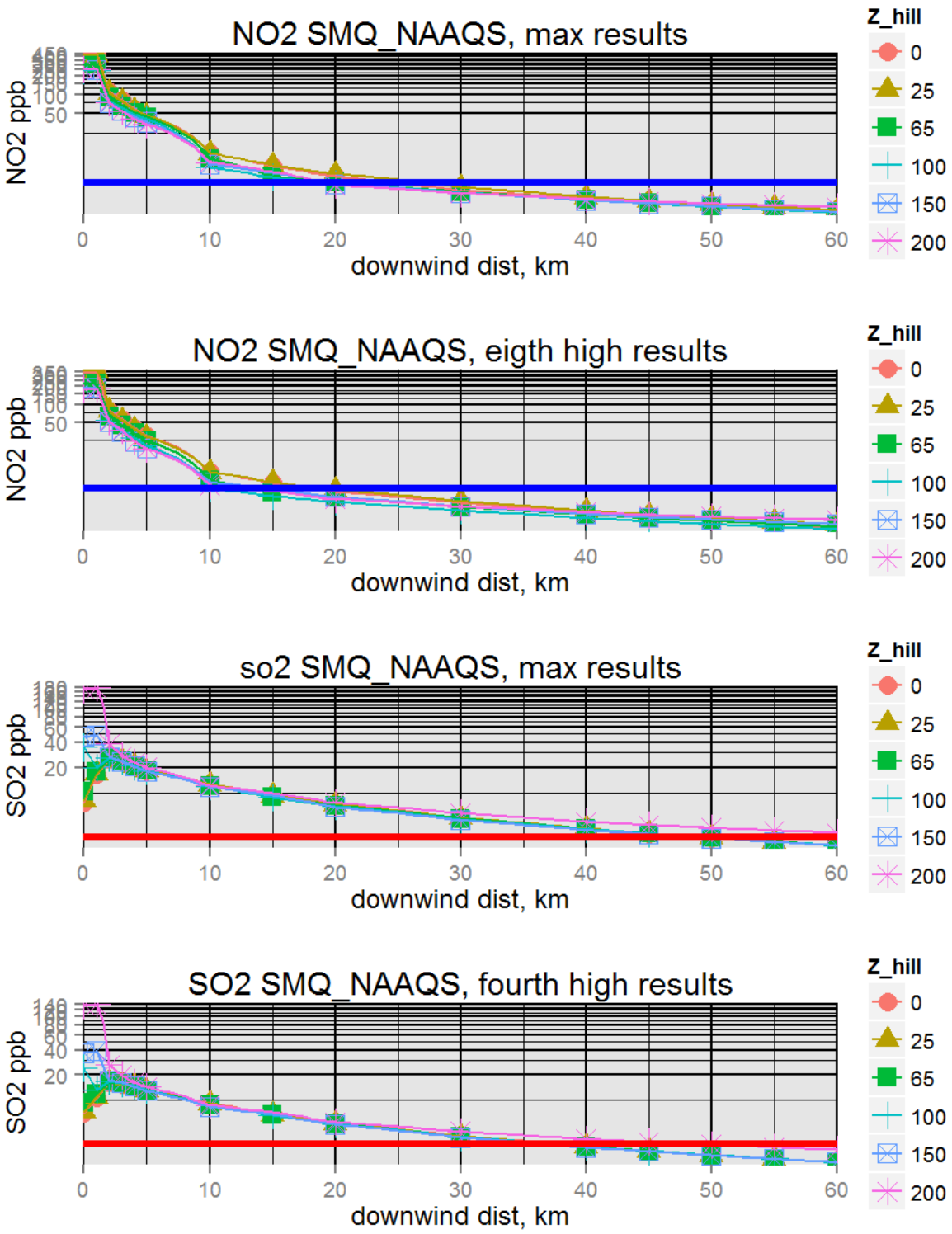


Figure 15 - Refined NO2 and SO2 results, SMQ, max and design values, 1-hr NAAQS

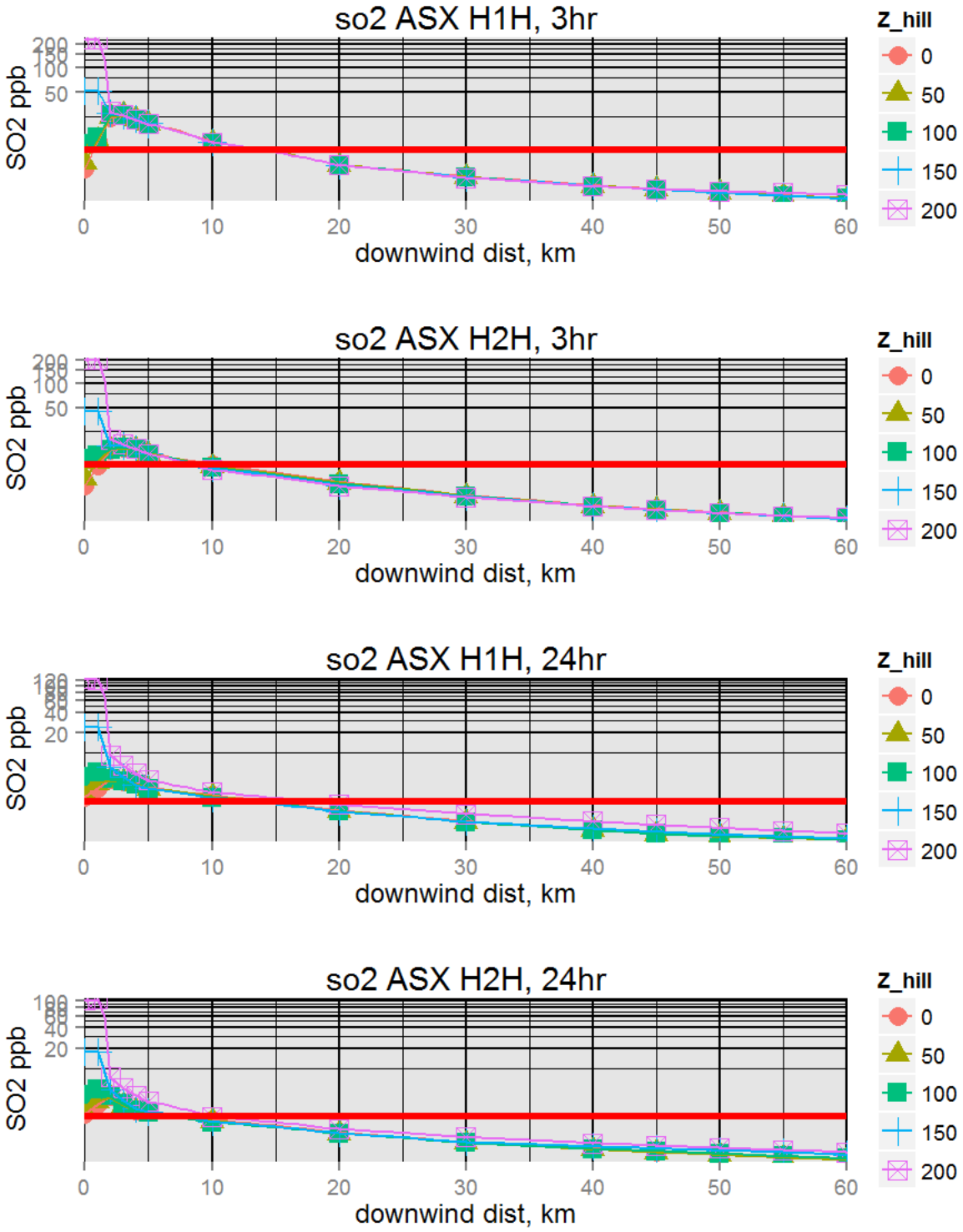


Figure 16 - Refined SO2 results, ASX, 3 & 24-hr increment

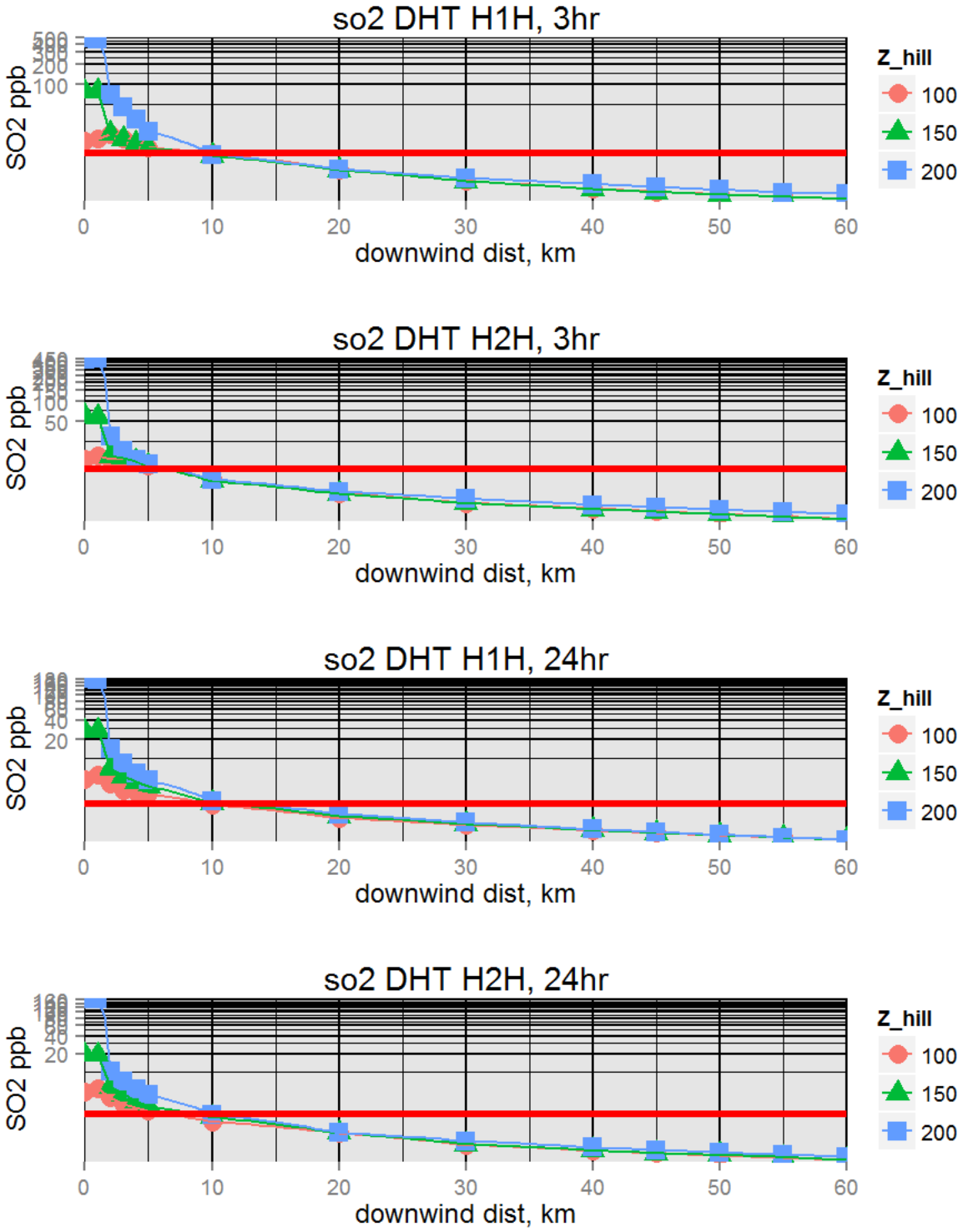


Figure 17 - Refined SO2 results, DHT, 3 & 24-hr increment

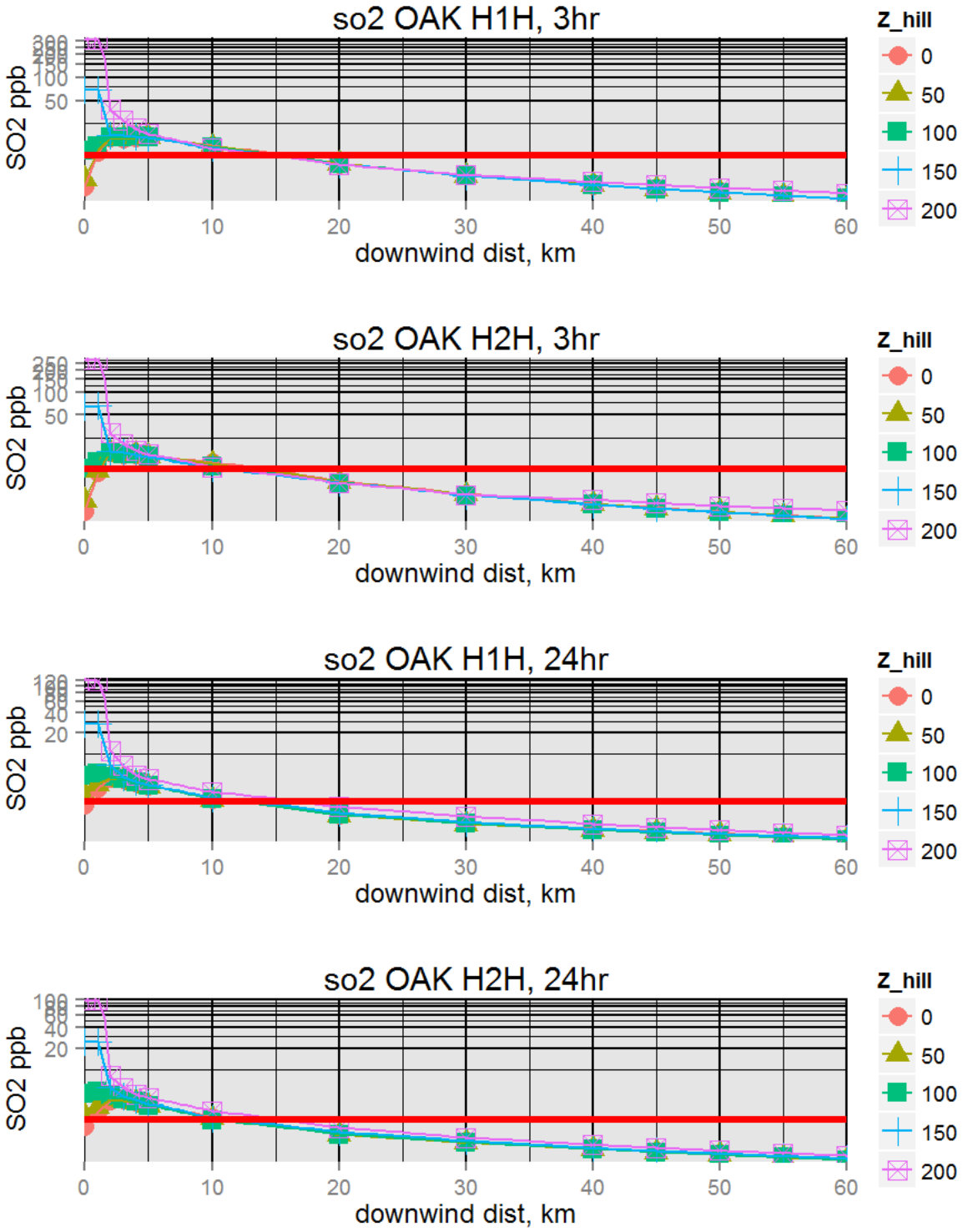


Figure 18 - Refined SO2 results, OAK, 3 & 24-hr increment

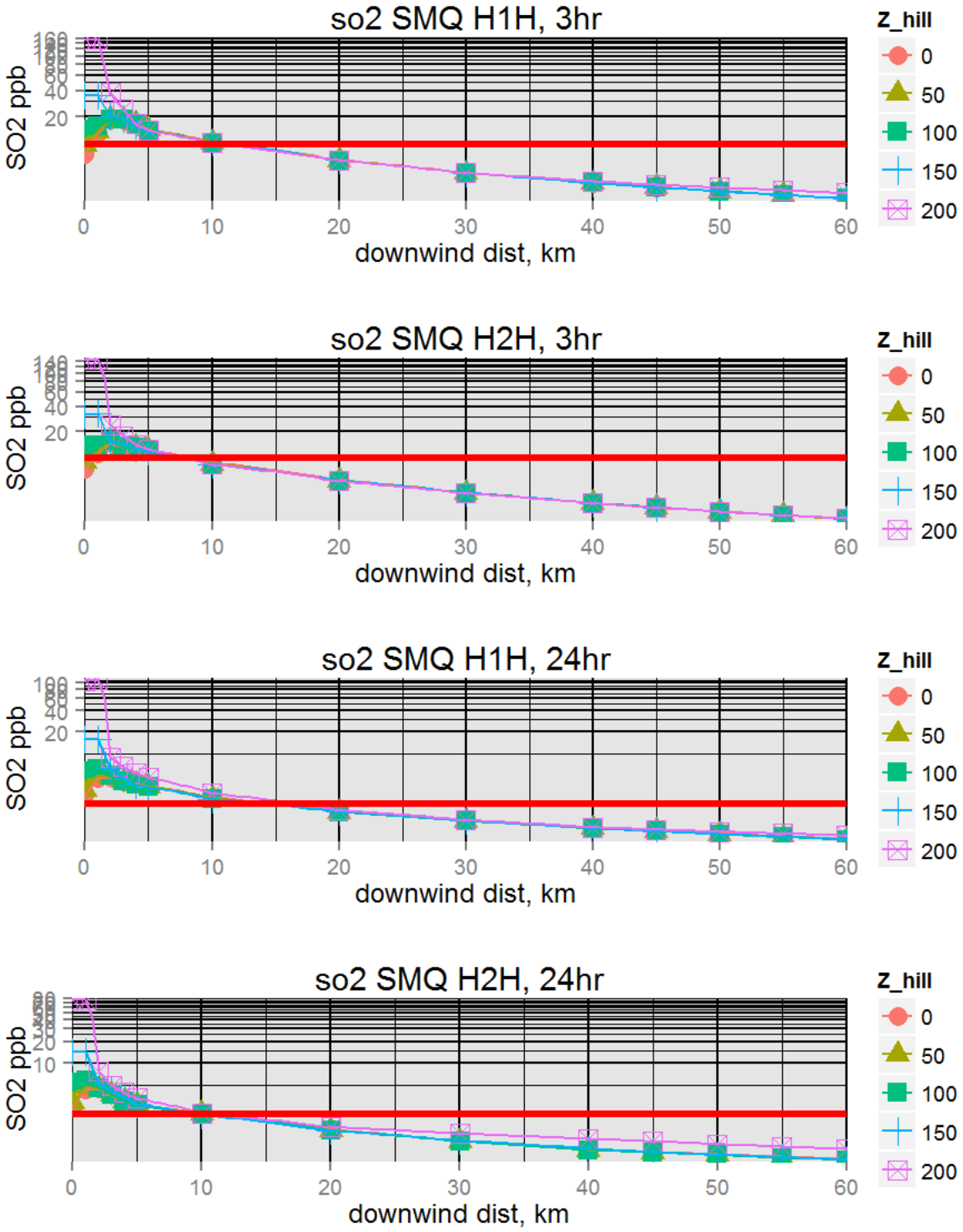
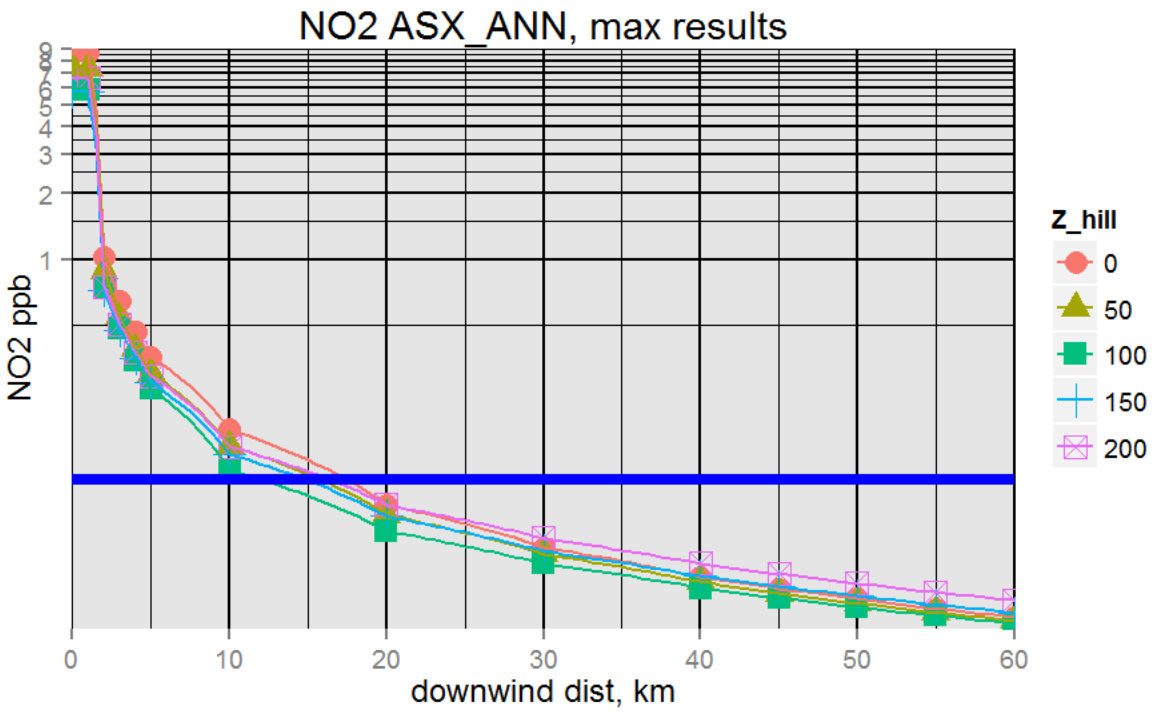


Figure 19 - Refined SO2 results, SMQ, 3 & 24-hr increment



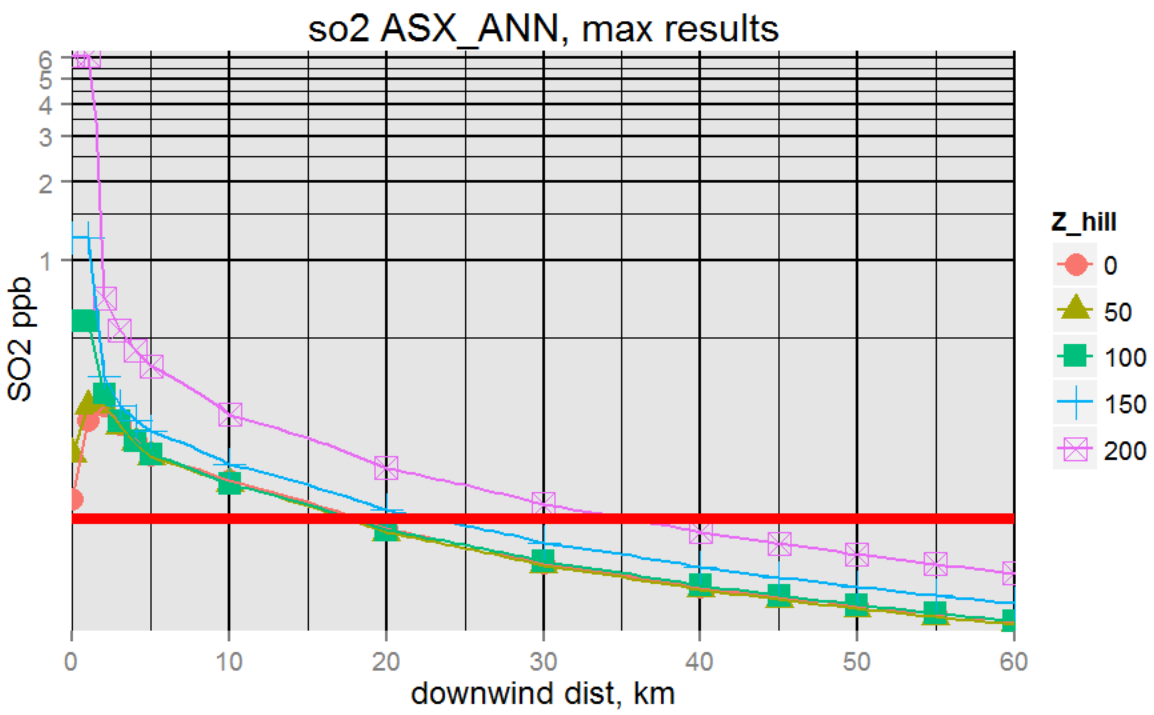


Figure 20 - Refined NO2 & SO2 results, ASX, annual NAAQS

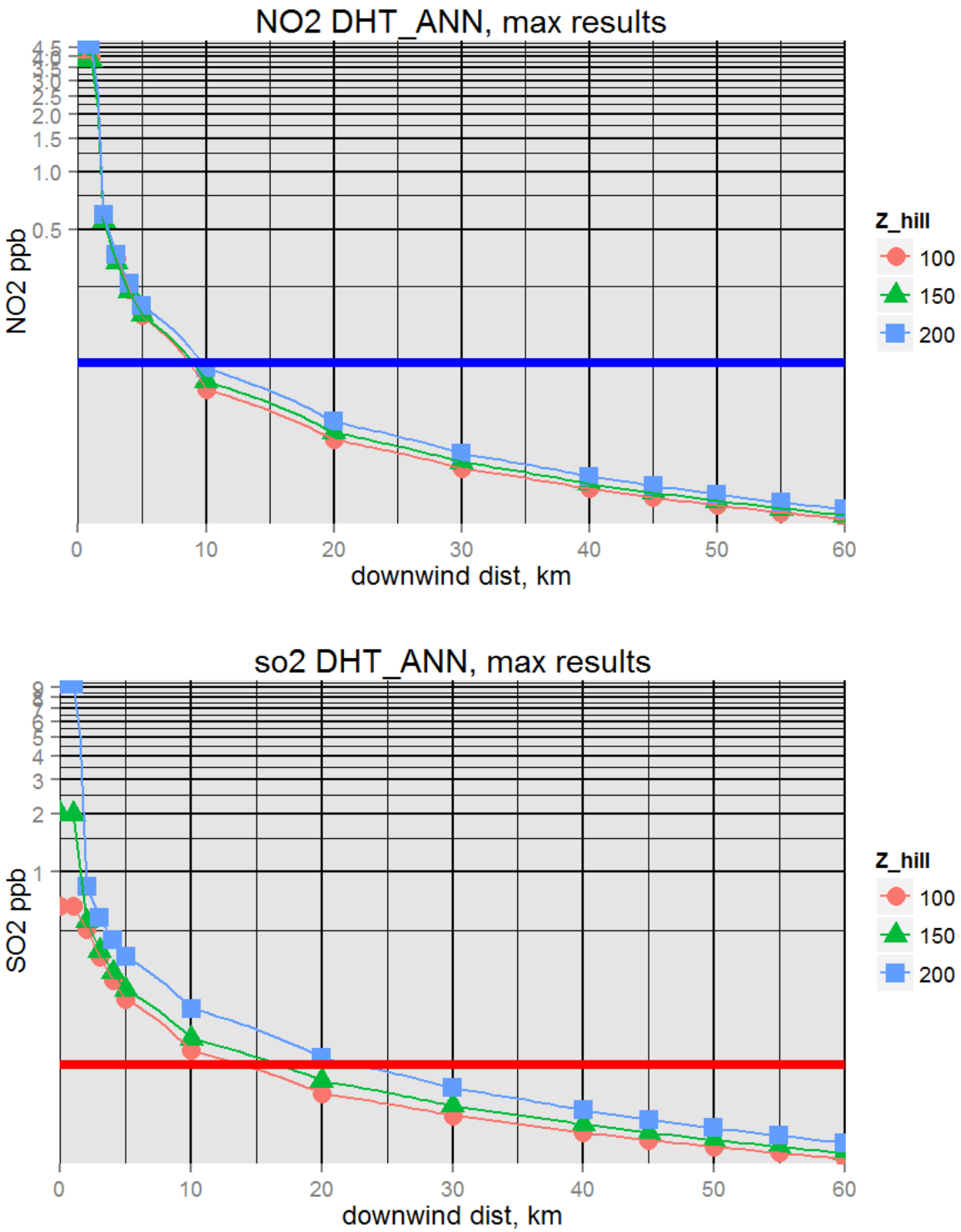
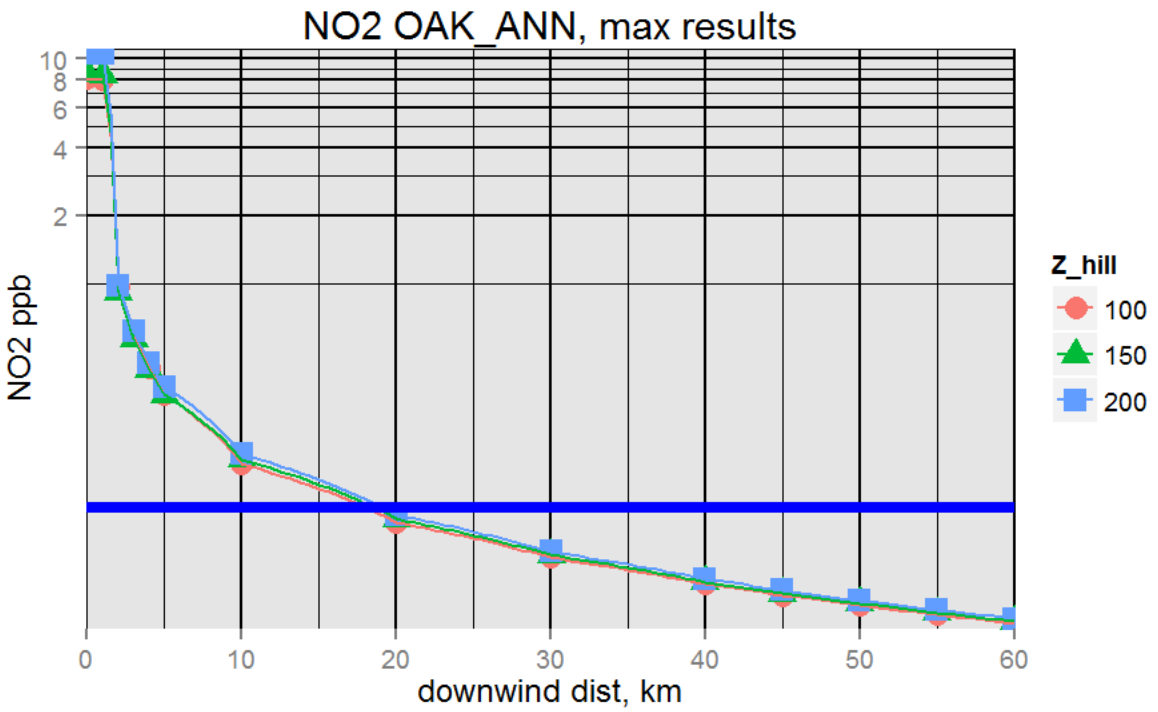


Figure 21 - Refined NO2 & SO2 results, DHT, annual NAAQS



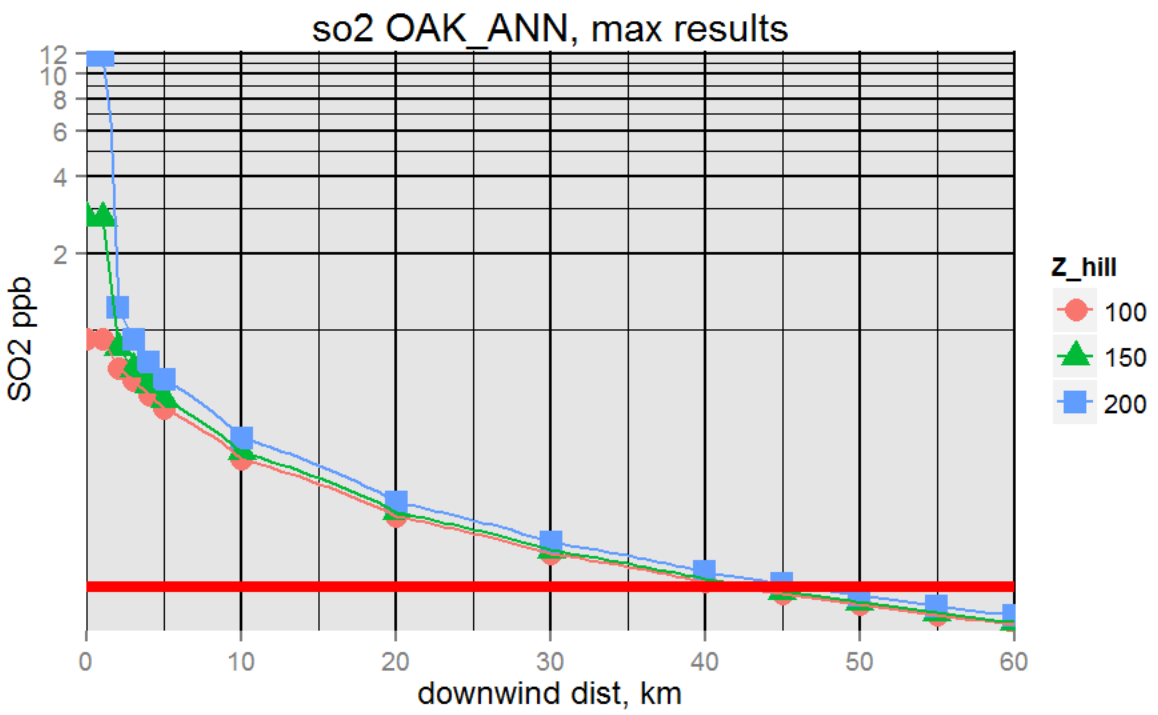
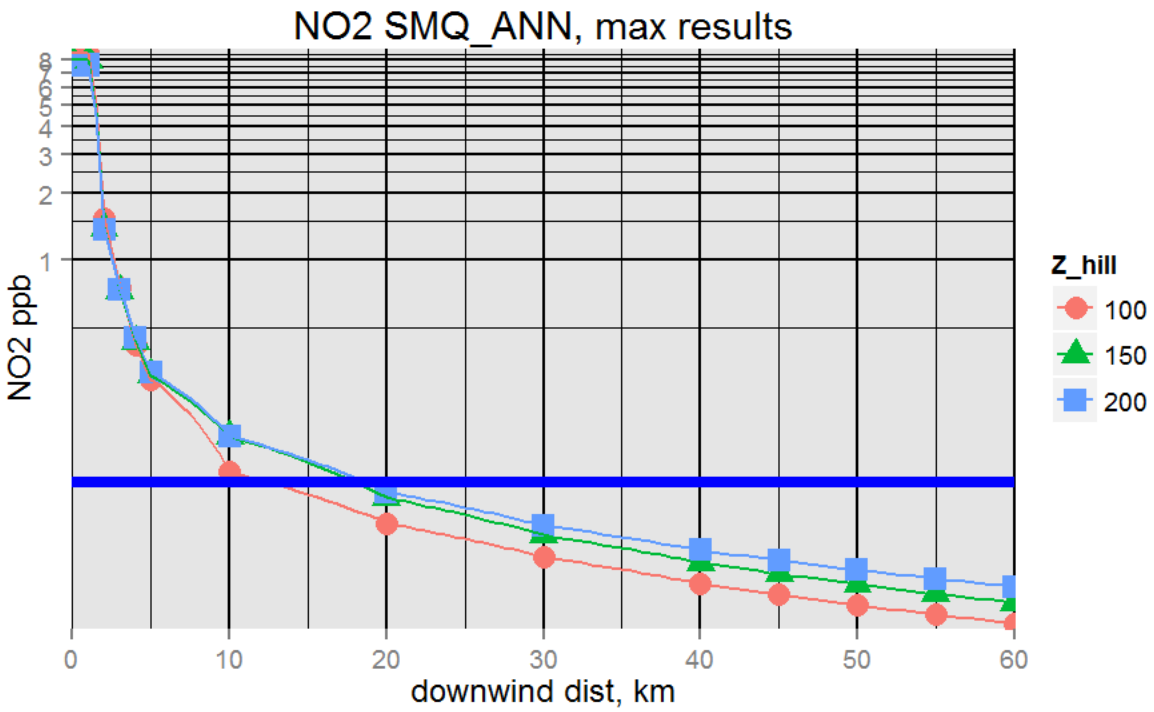


Figure 22 - Refined NO2 & SO2 results, OAK, annual NAAQS



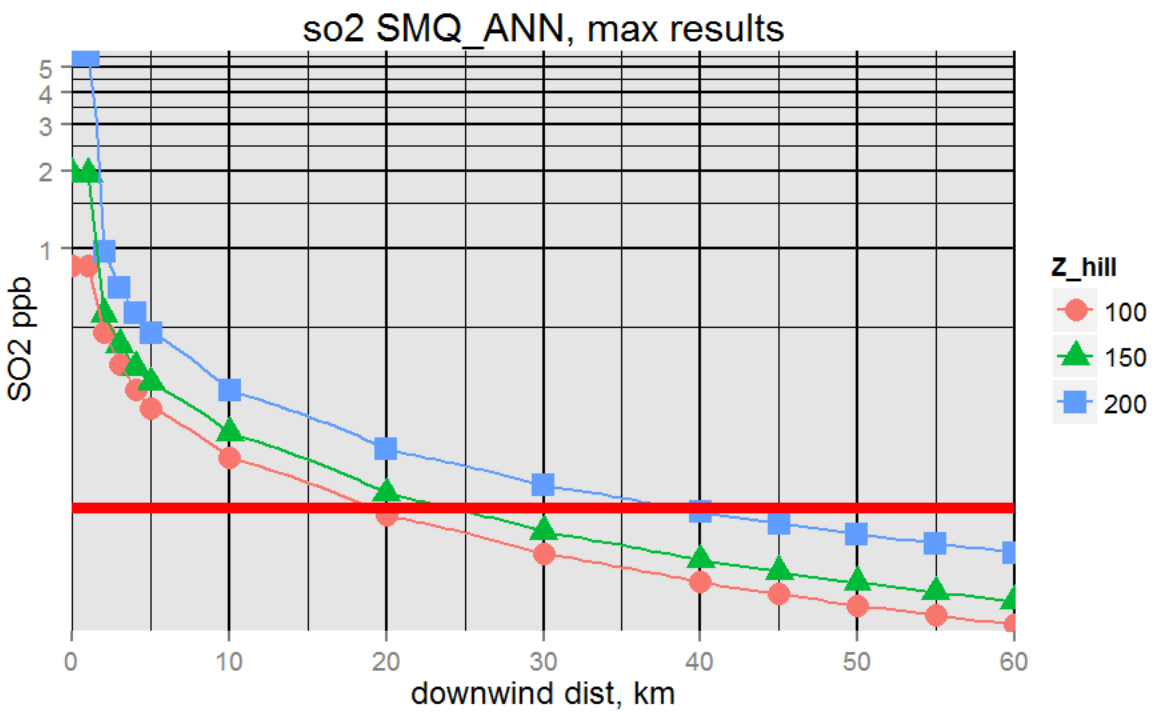


Figure 23 - Refined NO2 & SO2 results, SMQ, annual NAAQS

Appendix C

Plots from PM refined analysis

For all figures in this section, the PM25 increment is indicated on each plot. For the NO-scaled emissions, this is shown in blue and the SO2-scaled emissions are shown in red.

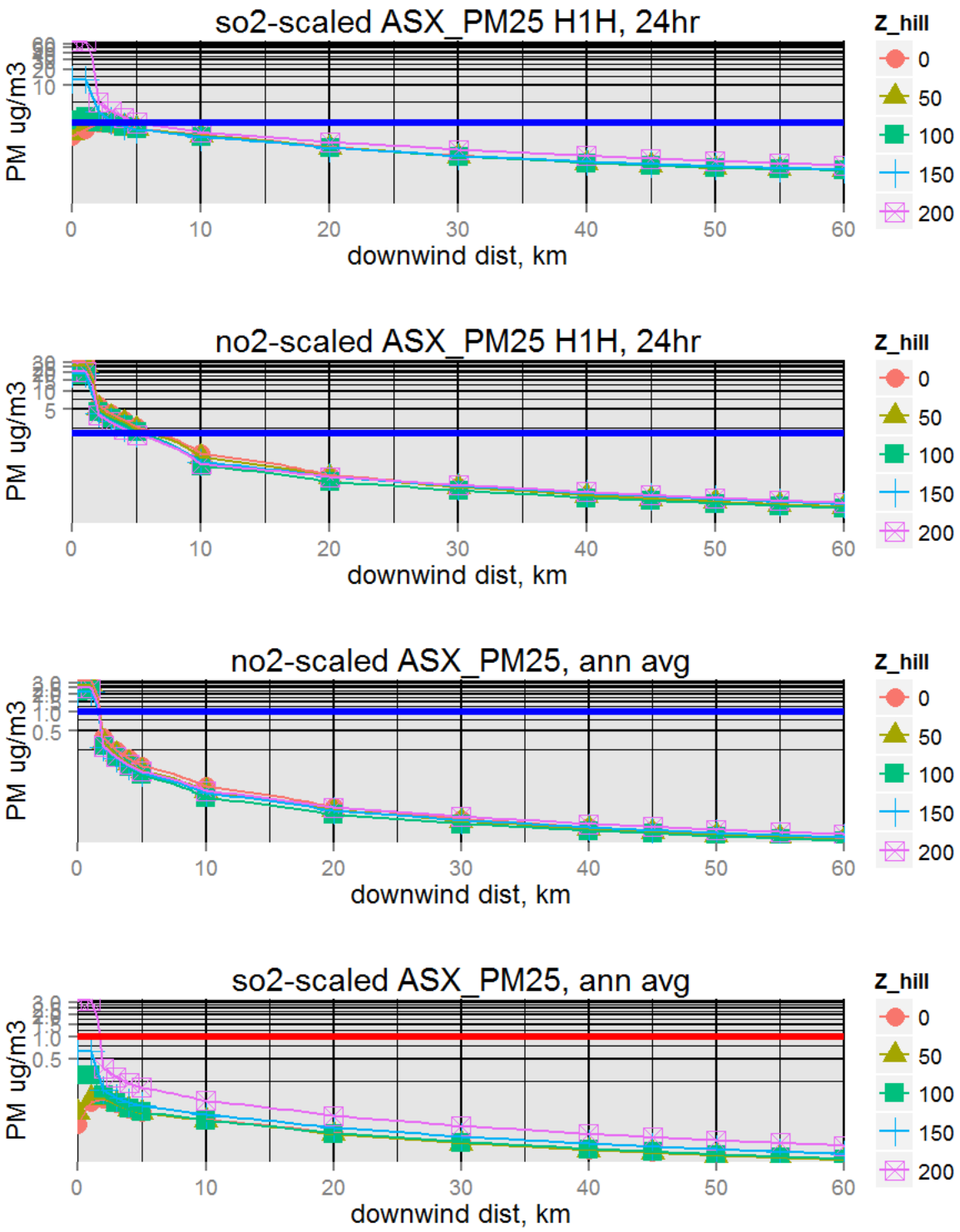


Figure 24 - Refined PM25 results, ASX, 24-hr annual increment

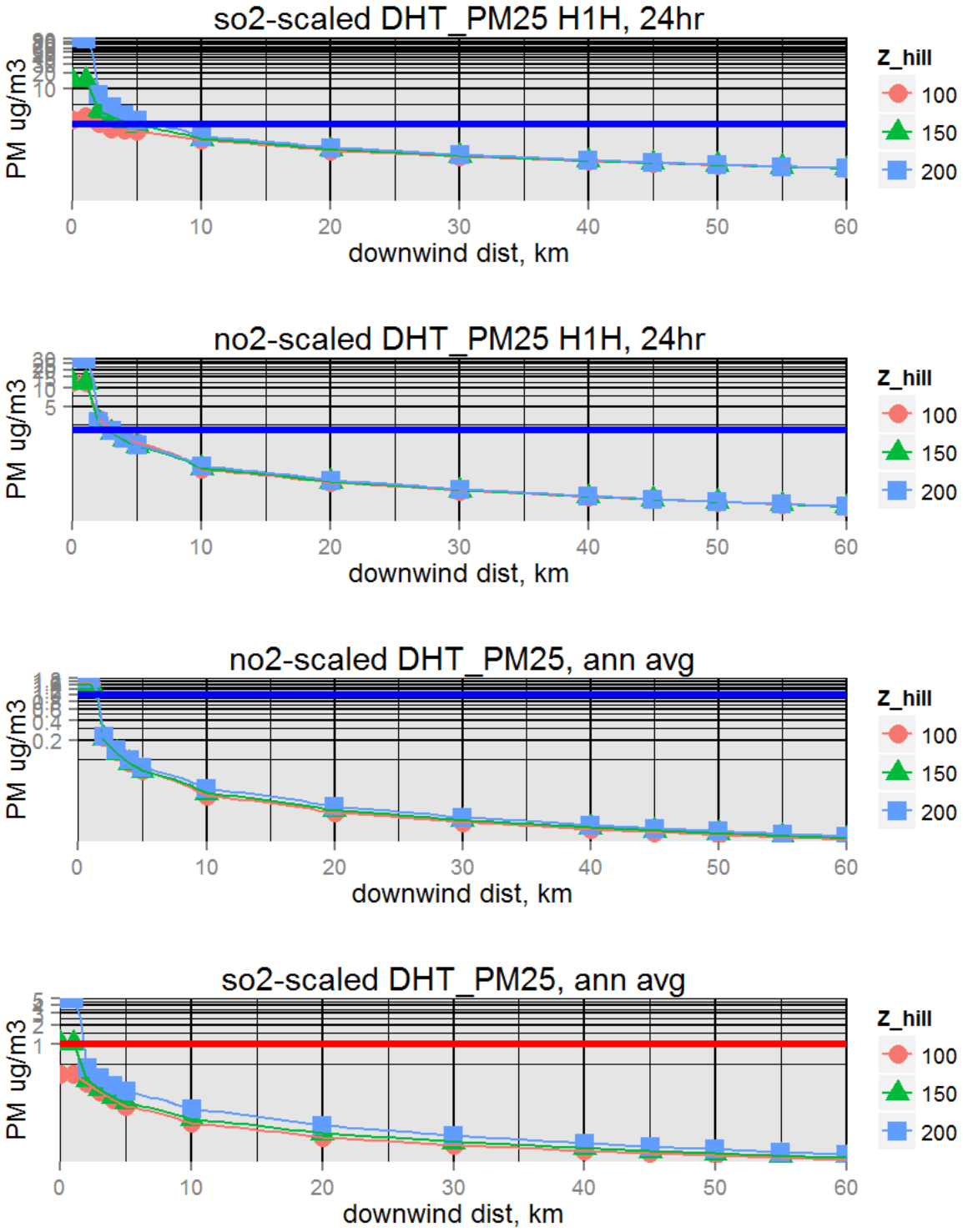


Figure 25 - Refined PM25 results, DHT, 24-hr annual increment

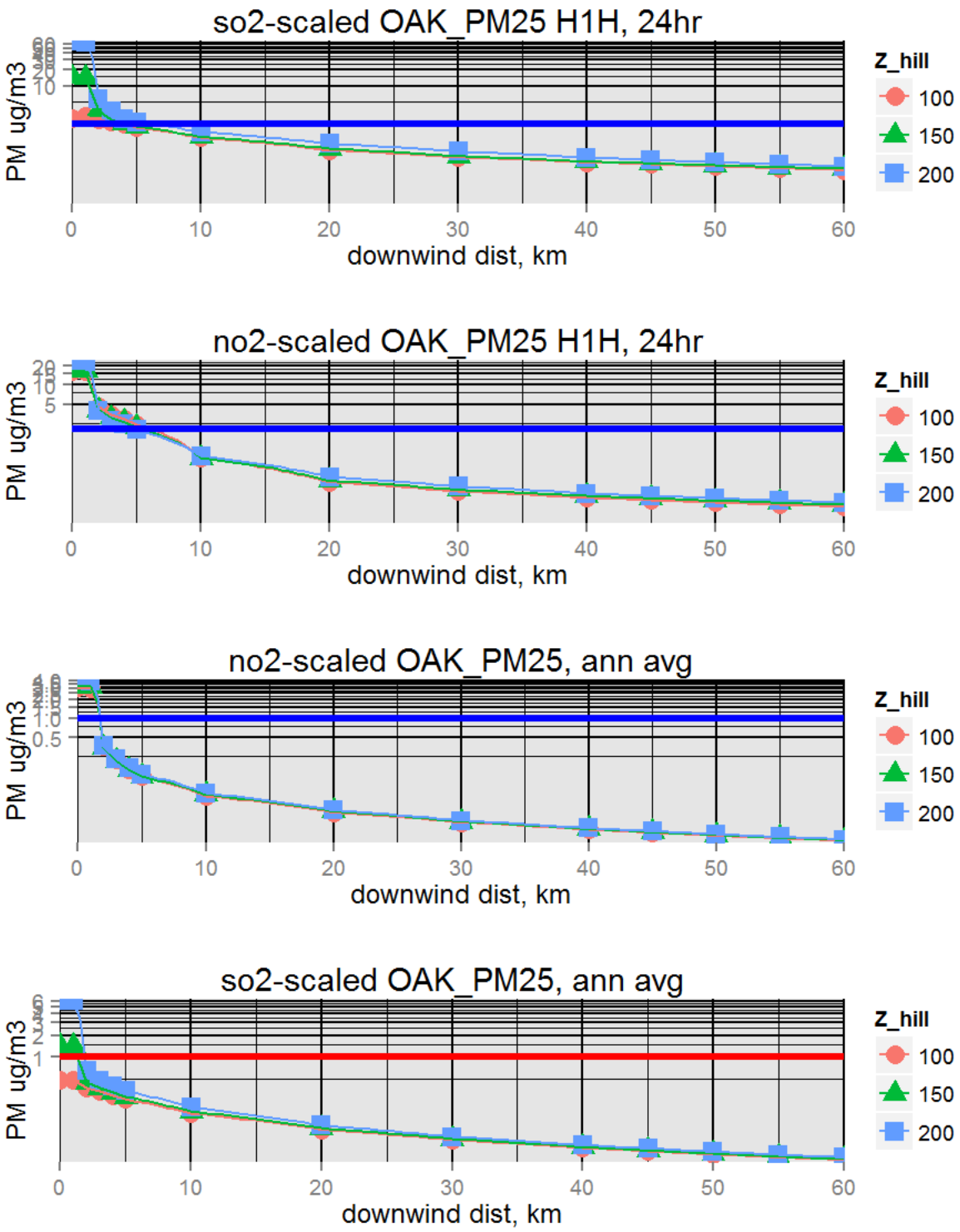


Figure 26 - Refined PM25 results, OAK, 24-hr annual increment

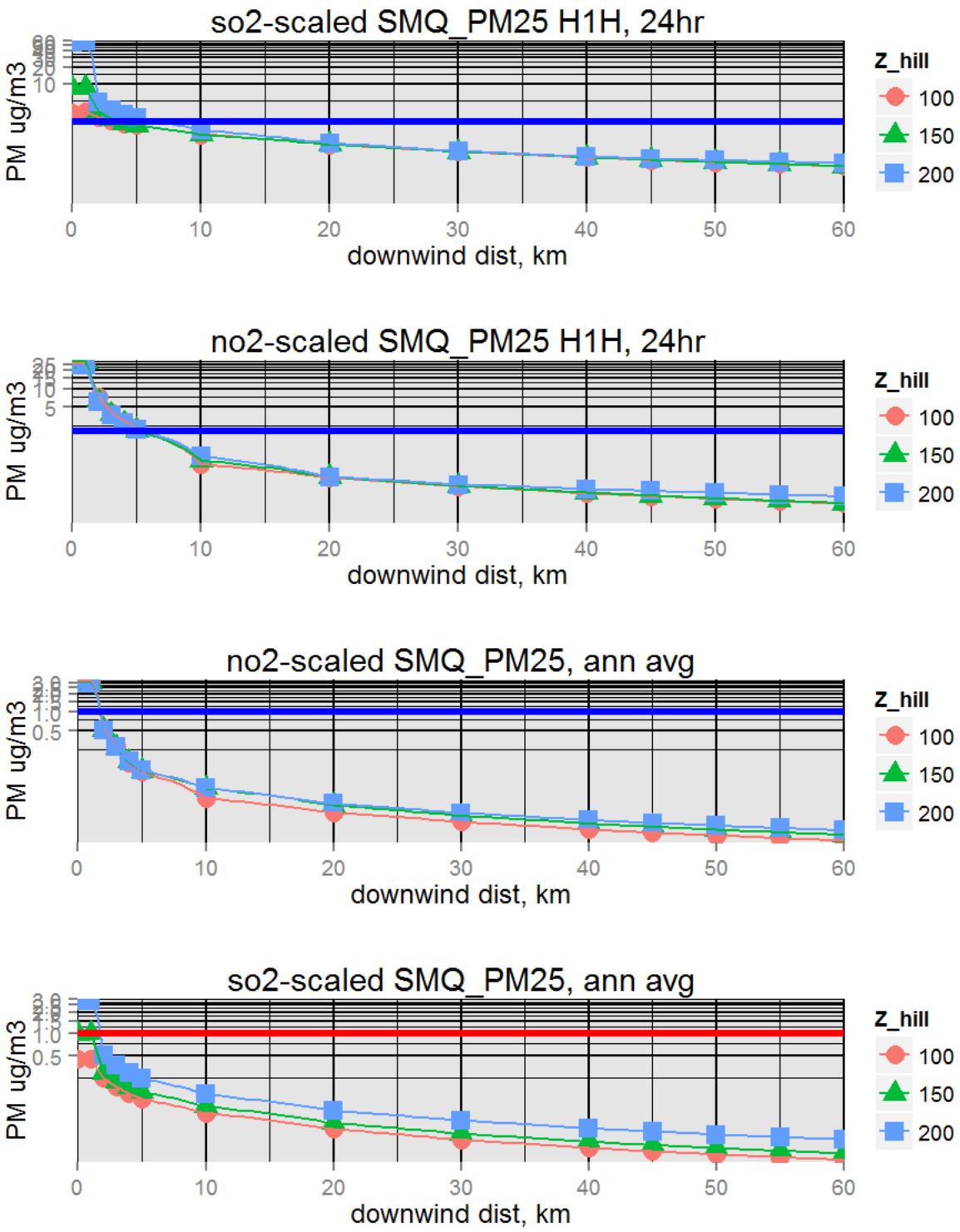
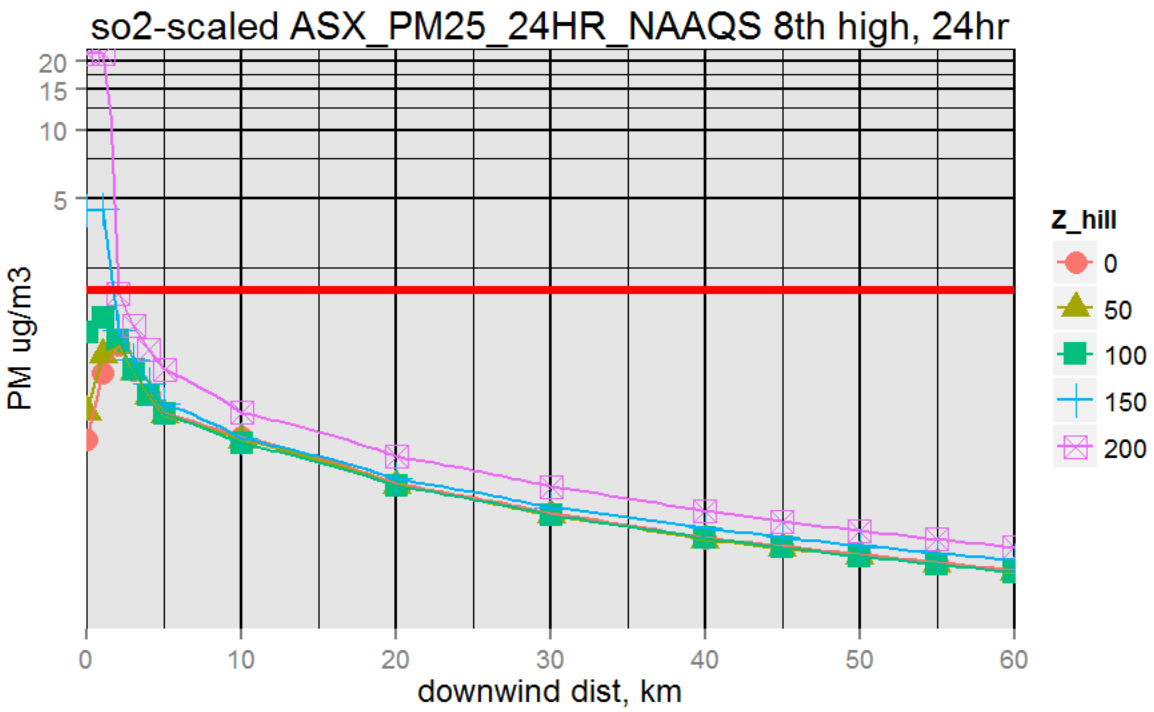


Figure 27 - Refined PM25 results, SMQ, 24-hr annual increment



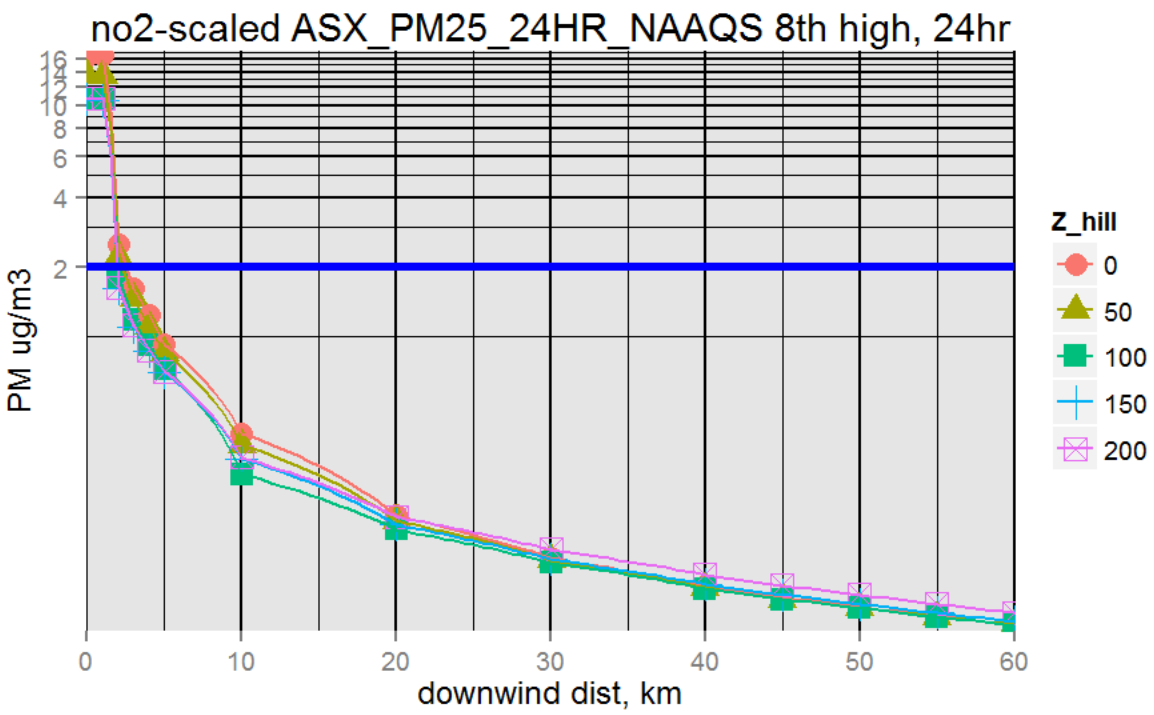
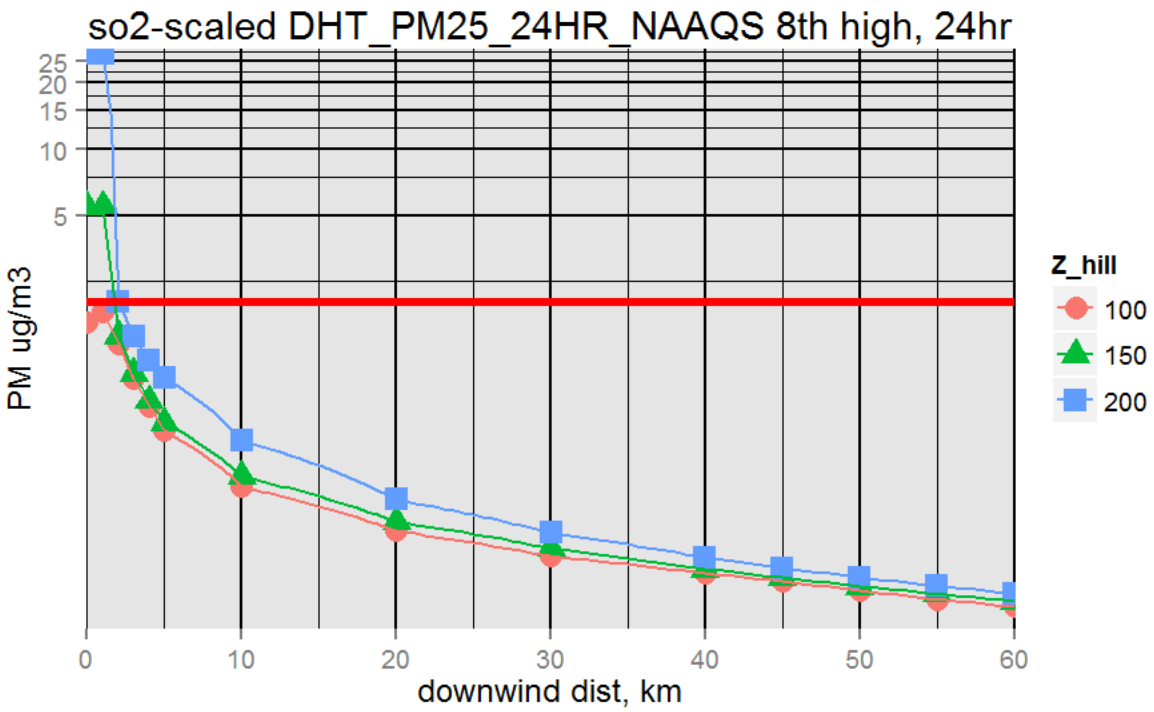


Figure 28 - Refined PM25 results, ASX, 24-hr NAAQS



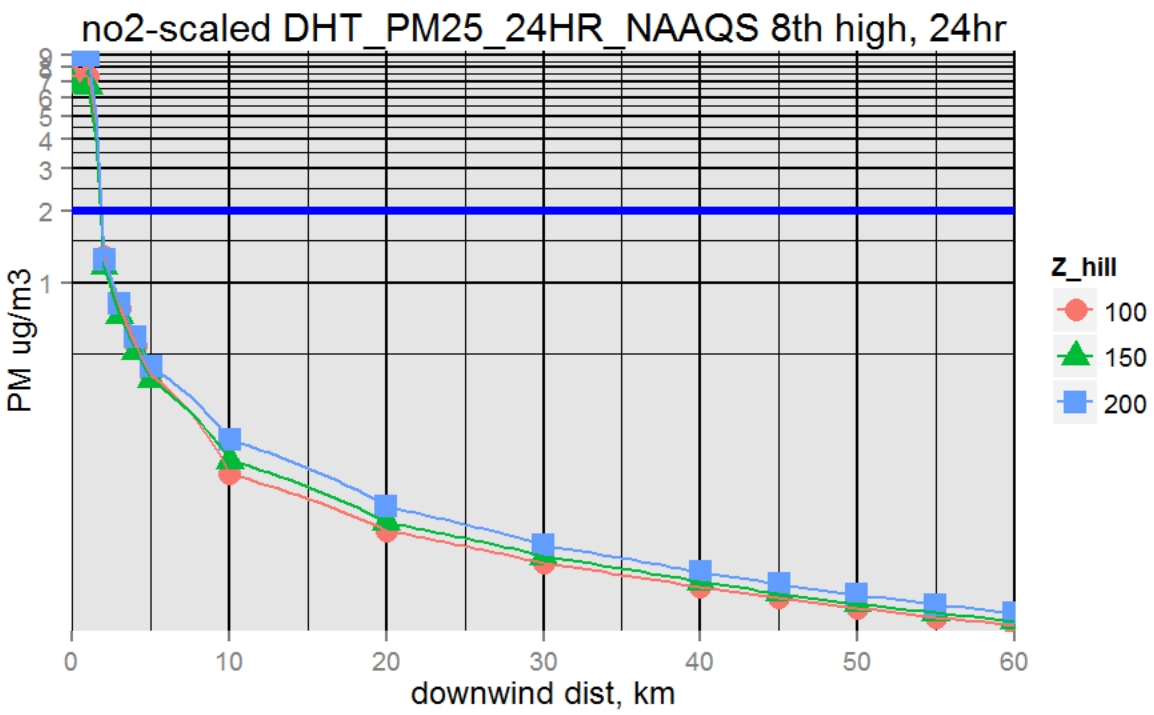
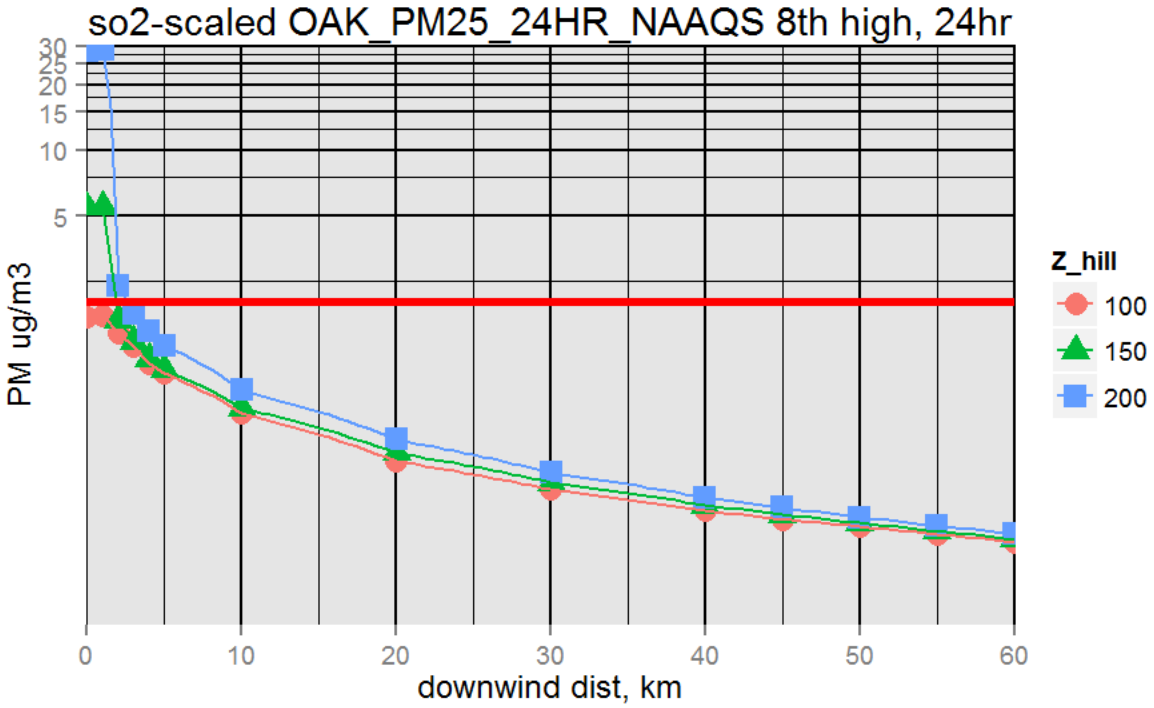


Figure 29 - Refined PM25 results, DHT, 24-hr NAAQS



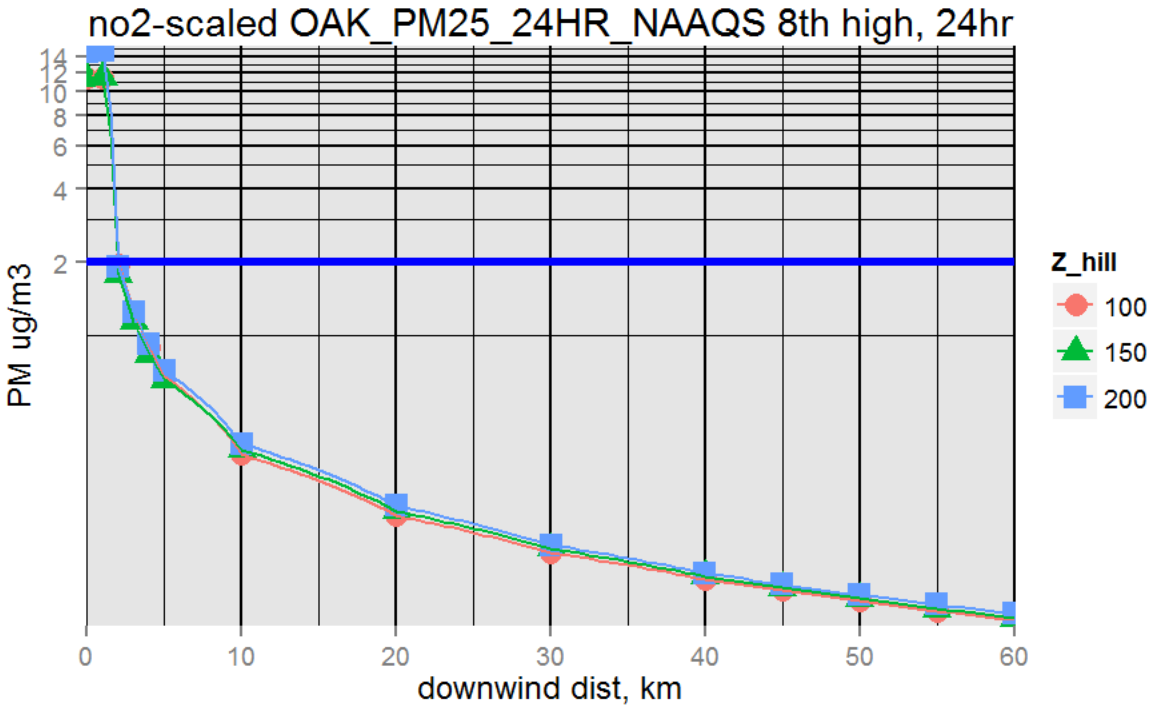
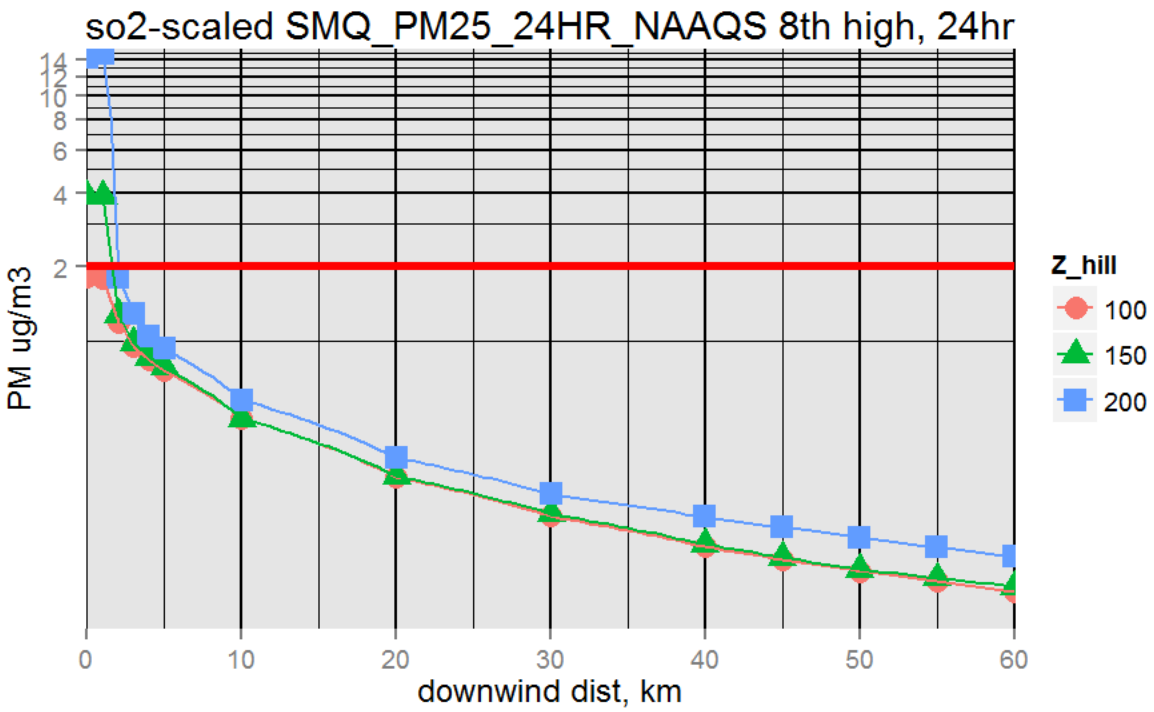


Figure 30 - Refined PM25 results, OAK, 24-hr NAAQS



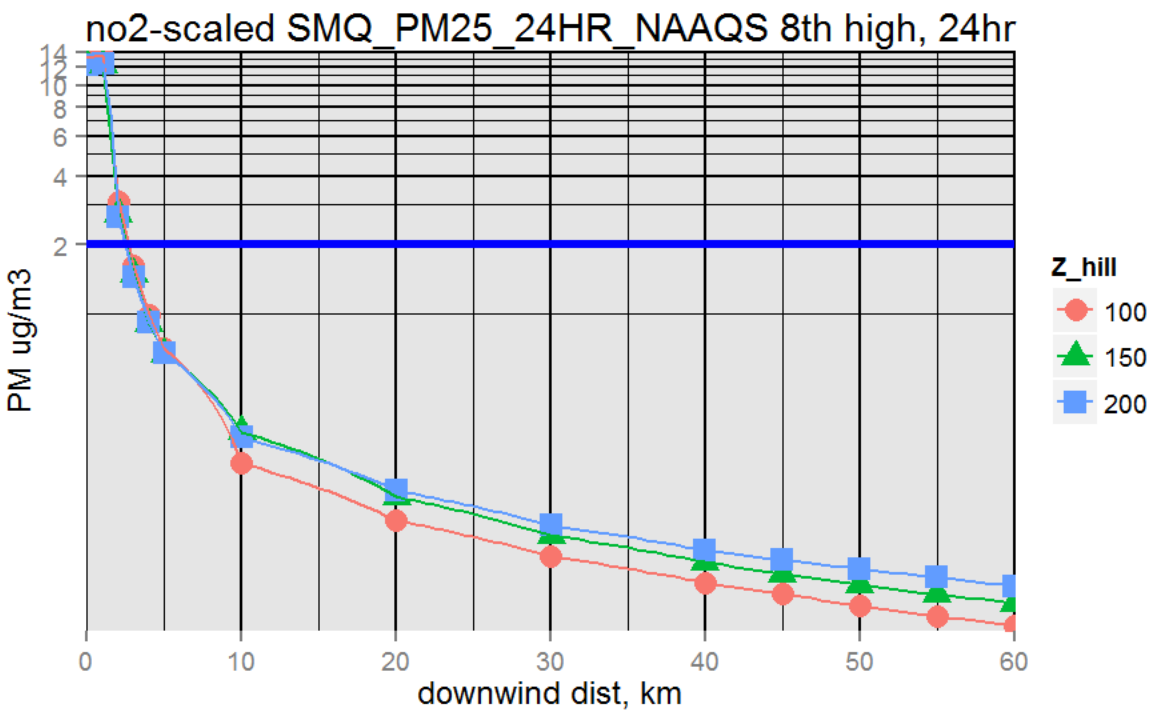


Figure 31 - Refined PM25 results, SMQ, 24-hr NAAQS

United States Environmental Protection Agency	Office of Air Quality Planning and Standards Air Quality Analysis Division Research Triangle Park, NC	Publication No. EPA- 454/B-15-003 [July, 2015]