AERMOD Implementation Workgroup
NO_2 & SO_2 modeling

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AERMOD Implementation Workgroup NO_2 & SO_2 focus

- Understand and inform users of permit modeling issues with the new 1-hour NO_2 and SO_2 NAAQS
- Model example sources of NO_2 and SO_2 using existing and newly issued guidance
- Co-chaired by Erik Snyder (R6) and James Thurman (OAQPS)
- Comprised of members from states and territories, local agencies, EPA regional offices, and OAQPS

Stages of AIWG

- Stage I – Compile information, generate "Generic" facilities and conduct single facility modeling for June 2011 Regional Modelers Workshop (Completed)
- Stage II – Continue AIWG process, looking at source groupings for culpability, cumulative, adding background (different tier approach), evaluate guidance issues and sensitivity, etc. (Ongoing)

General Methodologies

- Started with a list of approximately 12 typical facilities that require air modeling. Expanded based on workgroup input.
- Requested input of example facilities from workgroup members. Collected 1-7 example facilities.
- To counter potential concerns about modeling actual facilities, we created generic facilities.
- EPA R6 reviewed and created generic facilities. Created base scenarios and alternative combinations of stack height changes and emission rate/control level changes to create multiple scenarios for each facility type.
  - Base scenarios represent facilities as currently configured or configured for permit modeling (emissions and release parameters)
- State modelers generally modeled facilities that were of interest to them in their respective states or regions.
- Modeled with 5 years of meteorological data and building downwash

Caveats

- Modeling is not cumulative. Other sources would need to be included for a regulatory analysis. Cumulative modeling scenarios are limited to a few background sources, full analysis would include more sources.
- Modeling values do not include background monitoring values. These would also need to be included in analyses for regulatory purposes.
- Modeling conducted to inform, some model set-ups may not be acceptable in a regulatory analysis without technical support.
- Modeling of generic plants are based on actual facilities but some adjustments have been made. Some stack height changes, but a more detailed analysis of height and exit velocity would need to be done. A generic boundary was chosen and actual non-ambient air area may be larger or smaller.
- Modeling conducted to inform, not replicate an actual plant. Plant boundaries, stack parameters, downwash, etc; still needs to be evaluated on a specific basis.

Summary of NO_2 results

Facility	Base emissions (tpy)	Maximum NAAQS (μg/m³) (ppb)	Sensitivity test & emissions (tpy)	Maximum NAAQS (μg/m³) (ppb)	Comments
Steel mill	711	318 (169)-OLM 300 (160)-PVMRM < 1% receptors violate	65 m stack ht on units > 1g/s. Emissions 711 tpy	128 (68) – OLM* 250(133) – PVMRM (1 receptor exceeds)	OLM passes; PVMRM still exceeds.
Ethanol plant	1180	1289 (685)-NO2/NOX 0.5; 5 % receptors violate	NO2/NOx 0.5 with controls & increased stack height on one unit (170 tpy)	1289 (685)-NO2/NOX 0.5; 5 % receptors violate	Exceedances < 1 km from source.
Materials recycler	70	401 (214) – NO2/NOX 0.2; < 1% receptors violate;	Stack height increase (> 25 m)	17 (9)	violations < 500 m for base case
Natural gas turbine (NY)	450	145 (77)	Increase stack height with controls (390 tpy)	122 (65)	No downwash, NO2/NOX ratio of 0.05
Natural gas turbine (MS)	450	16 (8)	Increase stack height with controls (390 tpy)	11 (6)	Difference between NY and MS due to ozone, meteorology, and terrain
Coal EGU	1870	234 (125); < 1 % receptors violate	Stack increase with higher exit velocity & controls (610)	234 (125); < 1 % receptors violate	Violations out to 2 km.
Biomass facility	240	22 (11)	Stack height increase and no controls (1220)	45 (24)	Urban source; NO2/NOX ratio of 0.1 using OLM; Sensitivity to PVMRM

Summary of NO_2 results

Facility	Base emissions (tpy)	Maximum NAAQS ($\mu g/m^3$) (ppb)	Sensitivity test & emissions (tpy)	Maximum NAAQS ($\mu g/m^3$) (ppb)	Comments
Natural gas processing plant	Uncontrolled (3190)	1440 (766) 60% of receptors violate	Increase stack height and lower emissions (330)	85 (45)	0.25 ISR
Refinery	8770	189 (100)	Increase stack height and lower emissions; (5200 tpy)	171 (91)	Flat; PVMRM
NG compressors	Uncontrolled (4069)	1674 (890); 21% receptors violate; Violations <= 7 km	Increase stack height and lower emissions (626 tpy)	43 (23)	
Cement kiln	Base (7170)	44 (24)	Controls (2180)	8 (4)	0.25 ISR
Landfill gas turbine	Base (80)	29 (15)	Increase stack height	4 (2)	0.1 ISR
Fuel oil turbine	Less controls (2230)	484 (257); 1% receptors exceed; violations out to 1.7 km	Increase stack height & lower emissions (1190)	337 (179); <1% receptors exceed; violations out to 1.2 km	PVMRM 0.1 ISR; results sensitive to OLM and O3 data.

Summary of SO_2 results

Facility	Base emissions (tpy)	Maximum NAAQS (μg/m³) (ppb)	Sensitivity test & emissions (tpy)	Maximum NAAQS (μg/m³) (ppb)	Comments
Ethanol plant	890	296 (113); 1 receptor violates	65 m stack ht and controls on one unit. Emissions 195 tpy	296 (113)); 1 receptor violates	Violations occur at 50 m fence line; stack height changes and controls had little effect on max DV; 300 m fence line – no exceedances
Coal EGU (OAQPS)	Uncontrolled & stack ht = 65 m (10713)	905 (346); < 1% receptors violate; exceedances out to 8 km.	Stack increase with higher exit velocity & controls (2074)	33 (13)	Rural; relatively flat terrain.
Coal EGU (OK)	4959	48 (18)	Stack increase with higher exit velocity & controls (2074)	28 (11)	Rural; relatively flat terrain. OK results more sensitive to changes
Refinery	4020	272 (104); < 1% receptors violate; violations b/w 10 and 11 km	Stack height increase (822)	36(14)	Rural source with terrain; Sensitivity to urban/rural and flat/elevated terrain
Cement Kiln	3129	34 (13)	Controls added (348)	4 (2)	Rural; relatively flat terrain
Pulp & paper	3403	924 (353); 28% receptors violate; Exeedances out to 4 km	Stack height increase & controls (1630)	212 (81); < 1% receptors violate; violations < 1 km	

Summary of SO_2 results

Facility	Base emissions (tpy)	Maximum NAAQS (μg/m³) (ppb)	Sensitivity test & emissions (tpy)	Maximum NAAQS (μg/m³) (ppb)	Comments
Landfill gas turbine	45	17 (7)	Stack height increase (45)	2 (0.8)	
Fuel oil turbine	417	257 (98); < 1% receptors violate; violations between 0.5- 1km	Stack height increase (417)	178 (68)	Complex terrain;
Flare	6083	324 (124); <1% receptors violate	65 m stack height & controls (626)	9 (4)	Complex terrain; Violation approx 6 -7 km from source

More details about all sources can be found in draft summary document:
http://www.epa.gov/ttn/scram/10thmodconf/review_material/AIWG_Summary.pdf

Single Source Examples

Ethanol plant parameters
Modelers: Dawn Froning (MO), Jen Krzak (IA)

- Evaluated scenarios with 4 different meteorological data sets
- 4 scenarios
  - Scenario 1: Base (1184 tpy)
  - Scenario 2: 65 m stack height for C0004 (1184 tpy)
  - Scenario 3: 65 m stack height for C0004 and additional controls (381 tpy)
  - Scenario 4: 65 m stack height for C0004 and more stringent controls (172 tpy)
  - Volume Source unchanged (C0005)
- C0001 & C0002 are flares, C0003 is an emergency fire pump and C0004 is regenerative thermal oxidizer and boiler stack

		Baseline					S2	S3		S4	
srcid	stype	NO_2	stackht	Temp	Vel.	Diam	stackht	NO_2	stackht	NO_2	stackht
C0001	POINT	0.1	11	800	7	0.8	11	0.1	11	0.1	11
C0002	POINT	0.01	11	800	5	0.6	11	0.01	11	0.01	11
C0003	POINT	1.2	2	700	64	0.1	2	1.2	2	1.2	2
C0004	POINT	32	43	440	22	3	65	9	65	3	65

		NO_2	ht	σy	σz
C0005	VOL	0.625	25	2	16

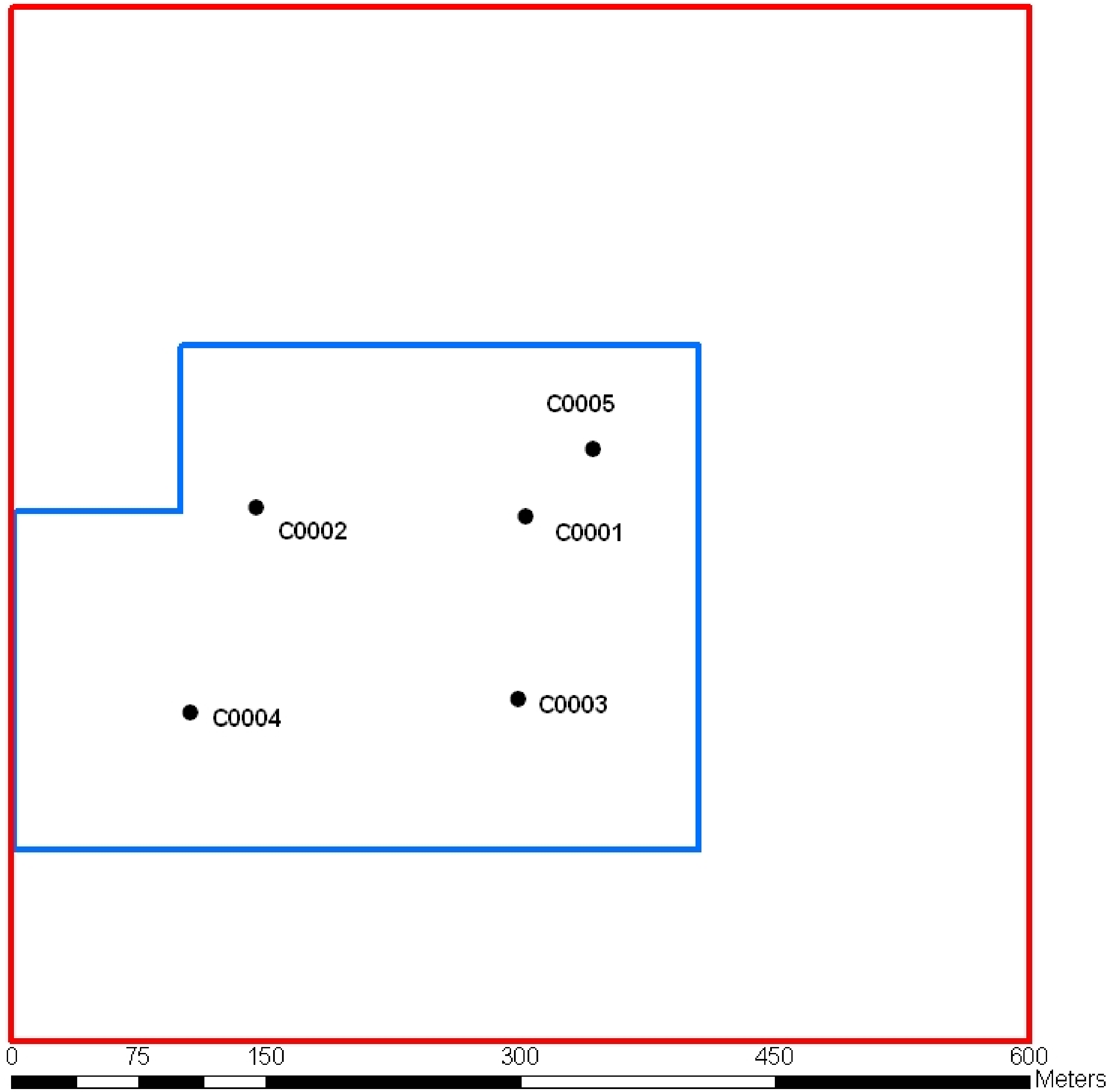
Volume source

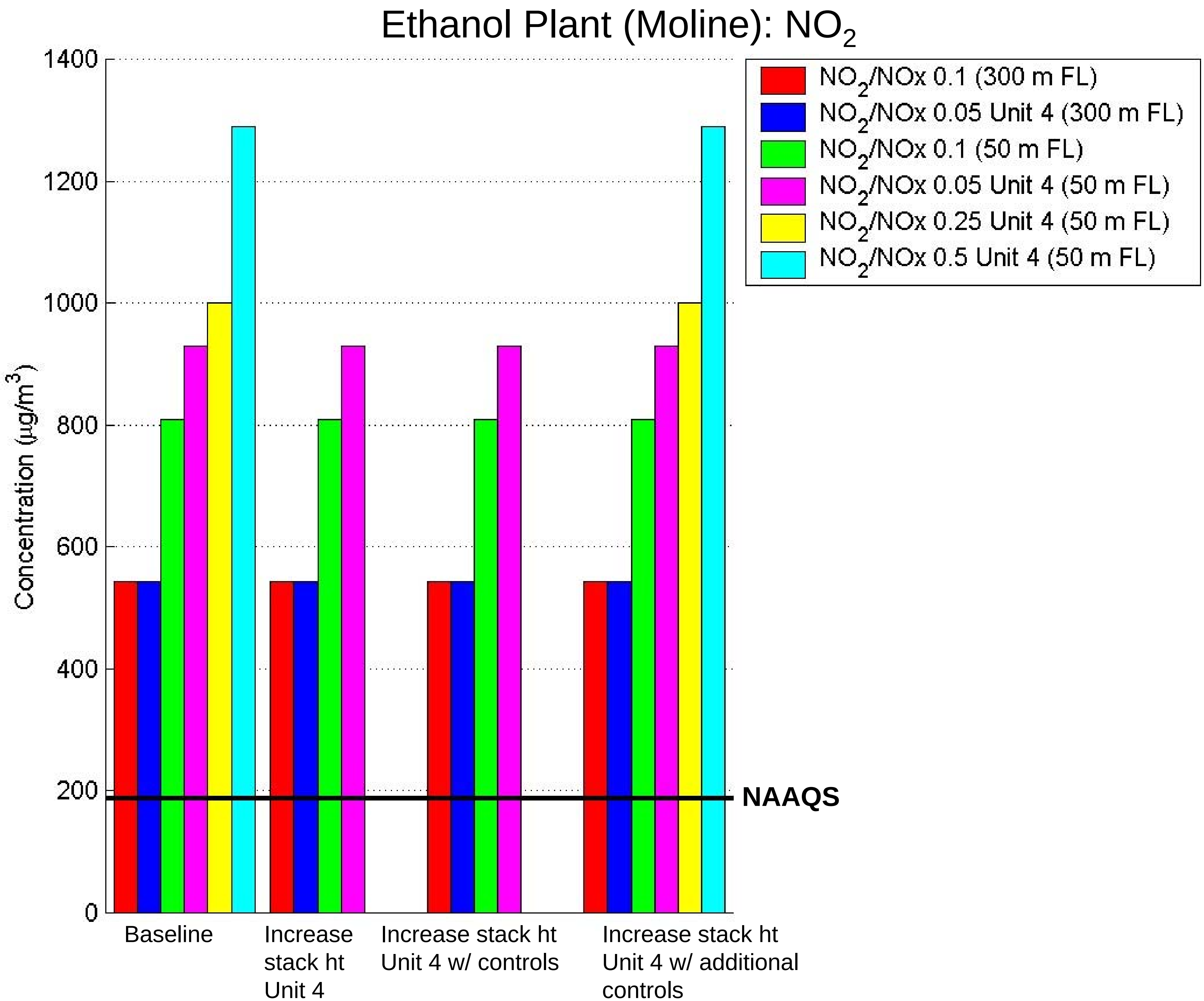
* Emission rates in g/s

Ethanol plant

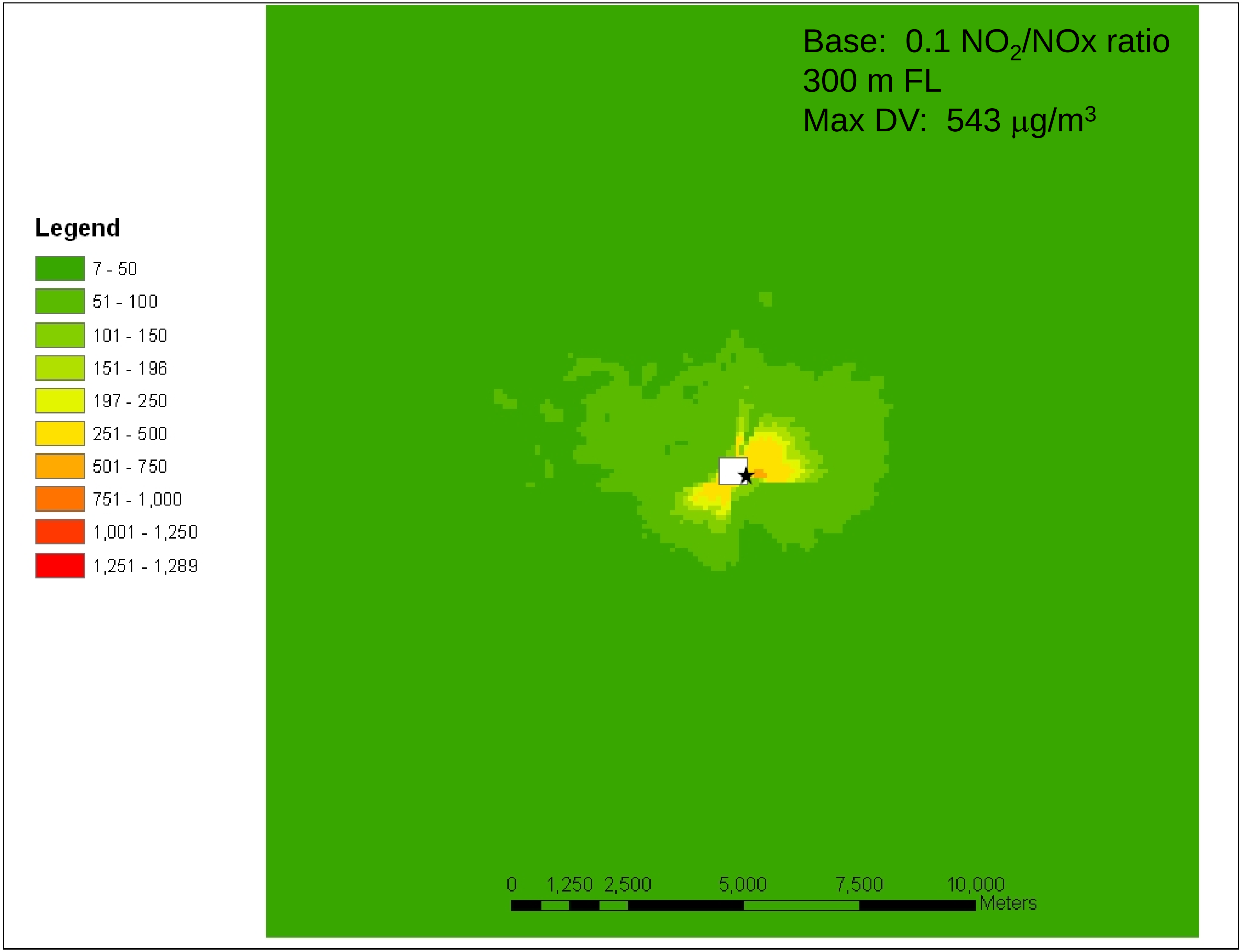
- Also modeled sensitivity to:
  - Distance to ambient air (300 m vs. 50 m)
  - NO_2/NO_x in stack ratios (NO2STACK)
    - 0.1 all sources
    - 0.05 for C0004, 0.1 for all others
    - 0.25 all sources

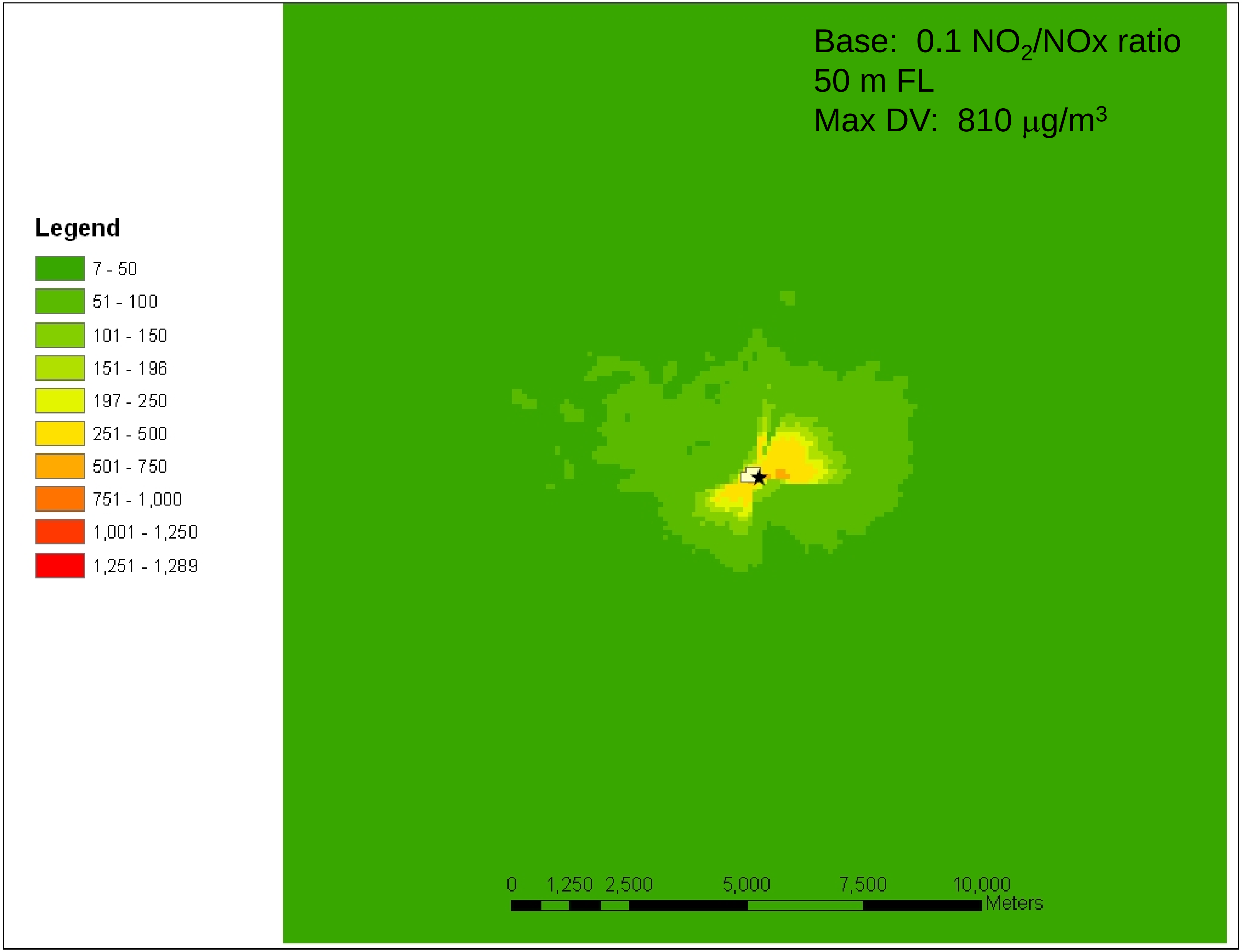
Ethanol plant sources with 50 m fence line (blue) and 300 m fence line (red)



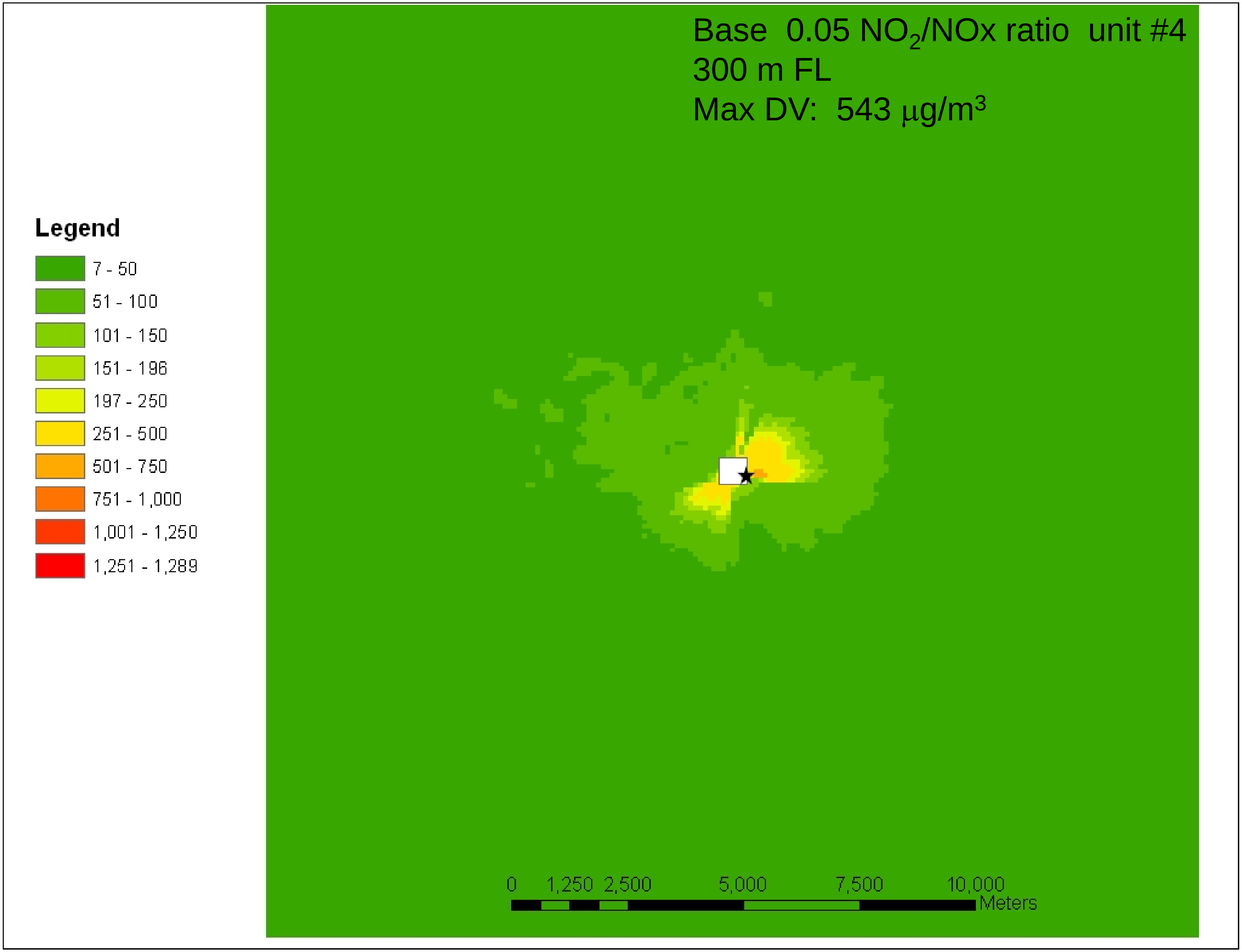


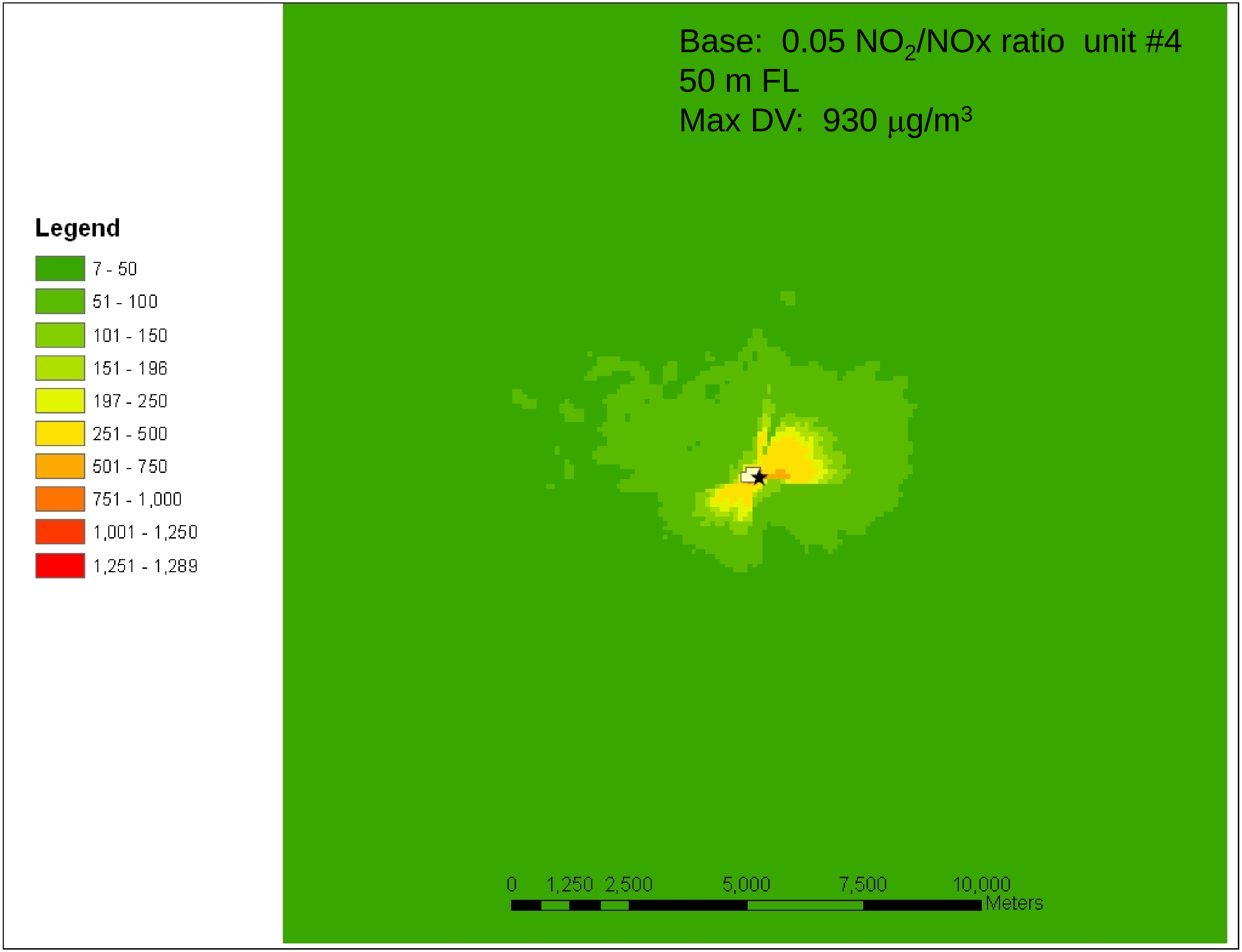
Ethanol Plant (Moline): NO2
1400
1200
1000
800
600
400
200
0
Concentration (μg/m3)
NO2/NOx 0.1 (300 m FL)
NO2/NOx 0.05 Unit 4 (300 m FL)
NO2/NOx 0.1 (50 m FL)
NO2/NOx 0.05 Unit 4 (50 m FL)
NO2/NOx 0.25 Unit 4 (50 m FL)
NO2/NOx 0.5 Unit 4 (50 m FL)
NAAQS
Baseline
Increase stack ht Unit 4
Increase stack ht Unit 4 w/ controls
Increase stack ht Unit 4 w/ additional controls


Base: 0.1 NO_2/NOx ratio
300 m FL
Max DV: 543 μg/m^3
Legend
7 - 50
51 - 100
101 - 150
151 - 196
197 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,289
0
1,250
2,500
5,000
7,500
10,000
Meters

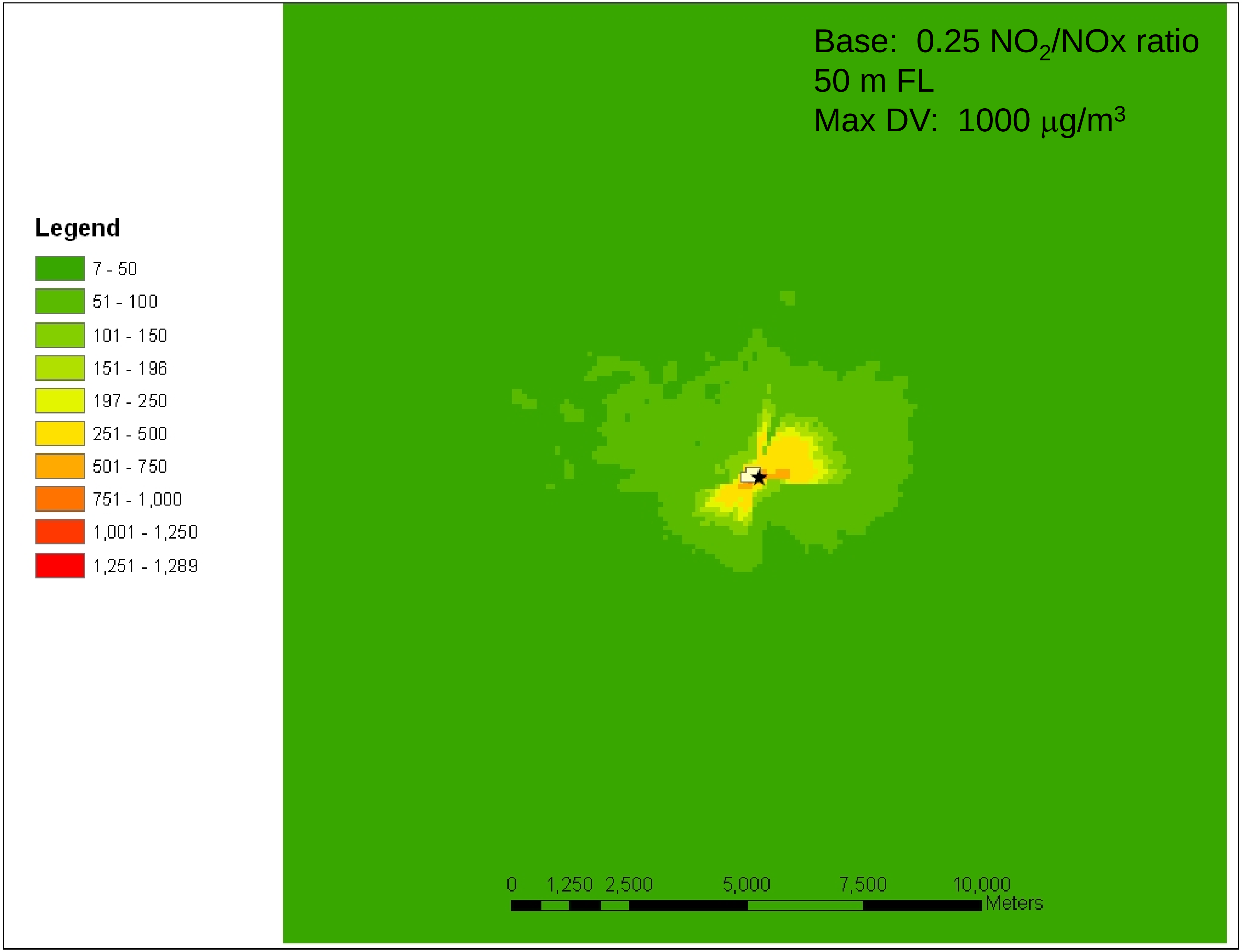


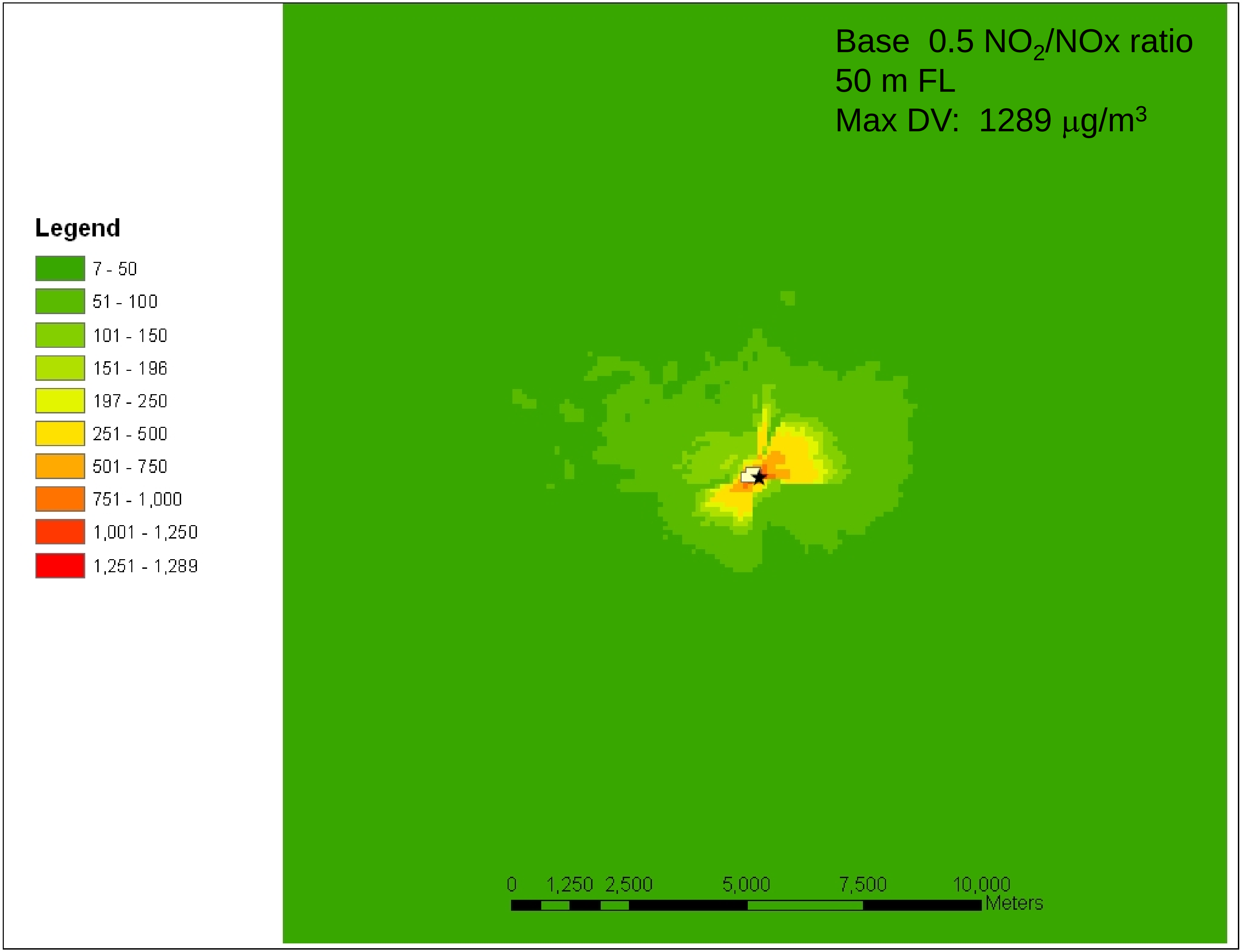
Base: 0.1 NO_2/NOx ratio
50 m FL
Max DV: 810 $\mu g/m^3$
Legend
7 - 50
51 - 100
101 - 150
151 - 196
197 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,289
0 1,250 2,500 5,000 7,500 10,000
Meters


Base 0.05 NO_2/NOx ratio unit #4
300 m FL
Max DV: 543 μg/m^3
Legend
7 - 50
51 - 100
101 - 150
151 - 196
197 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,289
0 1,250 2,500 5,000 7,500 10,000
Meters



Base: 0.05 NO_2/NOx ratio unit #4
50 m FL
Max DV: 930 $\mu g/m^3$
Legend
7 - 50
51 - 100
101 - 150
151 - 196
197 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,289
0 1,250 2,500 5,000 7,500 10,000
Meters


Base: 0.25 NO_2/NOx ratio
50 m FL
Max DV: 1000 μg/m³
Legend
7 - 50
51 - 100
101 - 150
151 - 196
197 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,289
0
1,250
2,500
5,000
7,500
10,000
Meters



Base 0.5 NO_2/NOx ratio
50 m FL
Max DV: 1289 $\mu g/m^3$
Legend
7 - 50
51 - 100
101 - 150
151 - 196
197 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,289
0
1,250
2,500
5,000
7,500
10,000
Meters

Ethanol plant findings

- Results are sensitive to distance to ambient air and initial NO_2/NO_x instack ratio
- Maximum design values do not change based on changing stack height or applying controls to stack of interest
  - Appear to be driven by C0003 (emergency fire pump)
- Problematic emissions may not always be due to stacks thought to be causing the problem.

Coal fired EGU

- Modelers: James Thurman (OAQPS) and Eric Milligan (OK)
- Six scenarios modeled
  - Baseline (4959 tpy)
  - Stack height increase (4959 tpy)
  - Controls (2074 tpy)
  - Stack height increase with controls (2074 tpy)
  - Further stack height increase with controls (2074 tpy)
  - Second stack height increase with controls and higher exit velocity (2074 tpy)
  - OAQPS modeled with 65 m stack height
  - OAQPS also modeled with uncontrolled emissions (10713 tpy)
  - OAQPS modeled with Charleston, SC meteorological data; Oklahoma with Springfield, MO.
- EGU based on a proposed EGU with controls already in place

EGU parameters

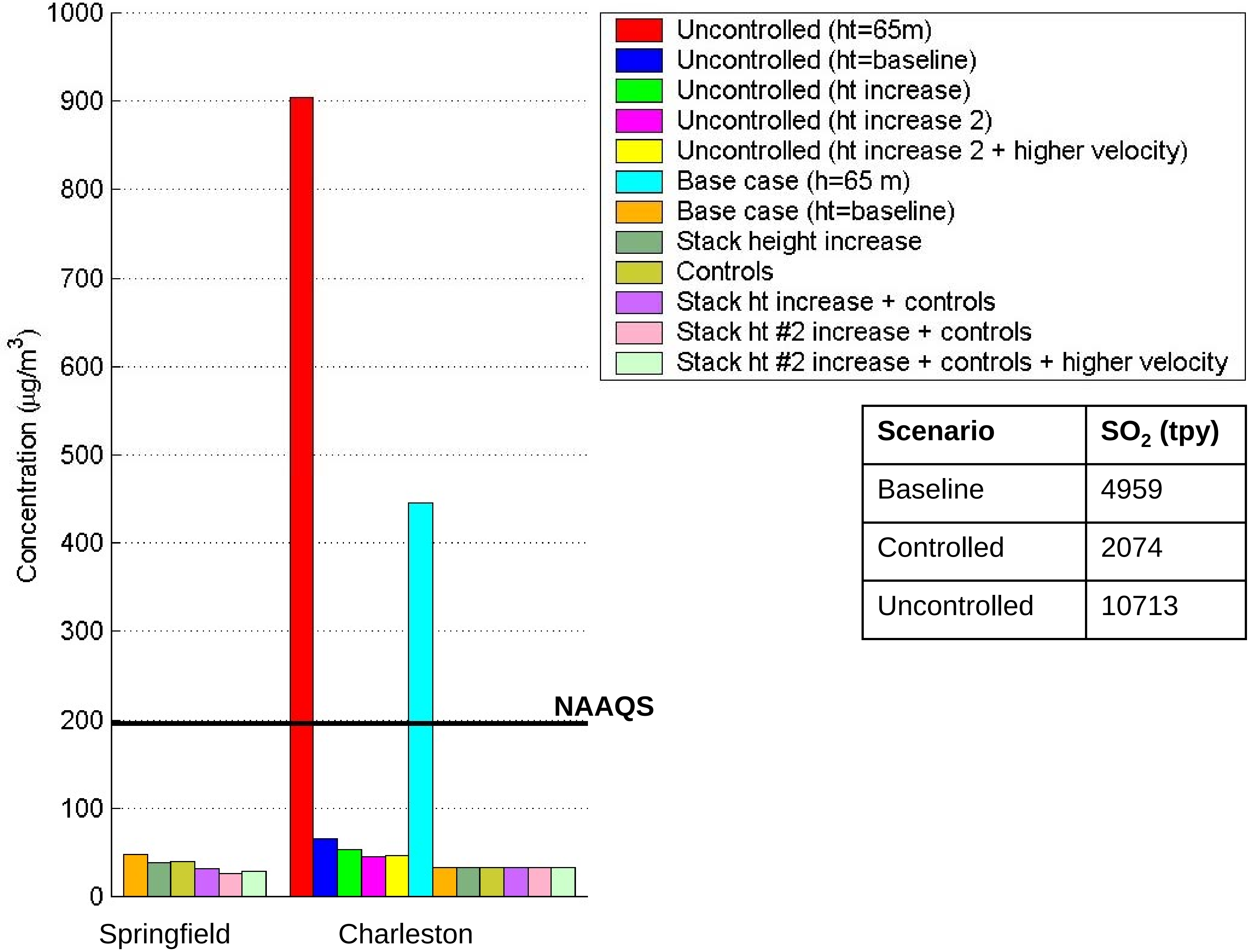
Baseline							SC 2	SC3	SC4		SC5		SC6	
srcid	stype	SO2	stackht	temp	Vel	Diam	stackht	SO2	stackht	SO2	stackht	SO2	Vel.	Diam
C0001	POINT	140	150	350	25	7	200	57	200	57	250	57	30	6
C0002	POINT	2.5	100	600	20	2	140	2.5	140	2.5	140	2.5	30	1.5
C0003	POINT	0.125	6	700	45	0.3	6	0.125	6	0.125	6	0.125	45	0.3
C0004	POINT	0.02	5	700	45	0.15	5	0.02	5	0.02	5	0.02	45	0.15
C0005	POINT	0.01	5	700	45	0.15	5	0.01	5	0.01	5	0.01	45	0.15

C0001 is a 780 MW (gross) boiler, C0002 is an auxiliary boiler, C0003 is an emergency diesel generator and C0004 & C0005 are fire pumps

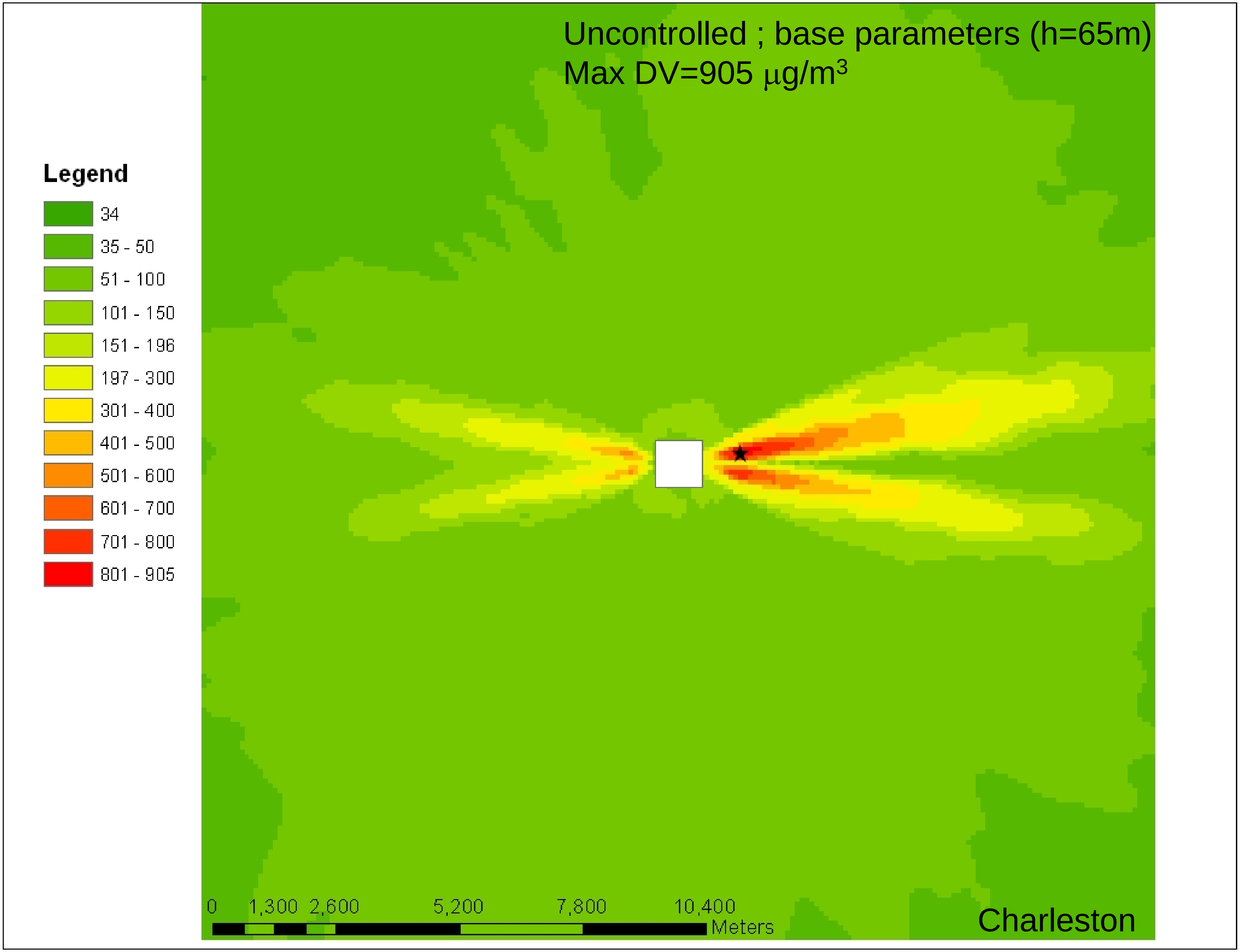
*Uncontrolled emissions for C0001 = 290 g/s
OK controlled emissions for C0001 = 112 g/s

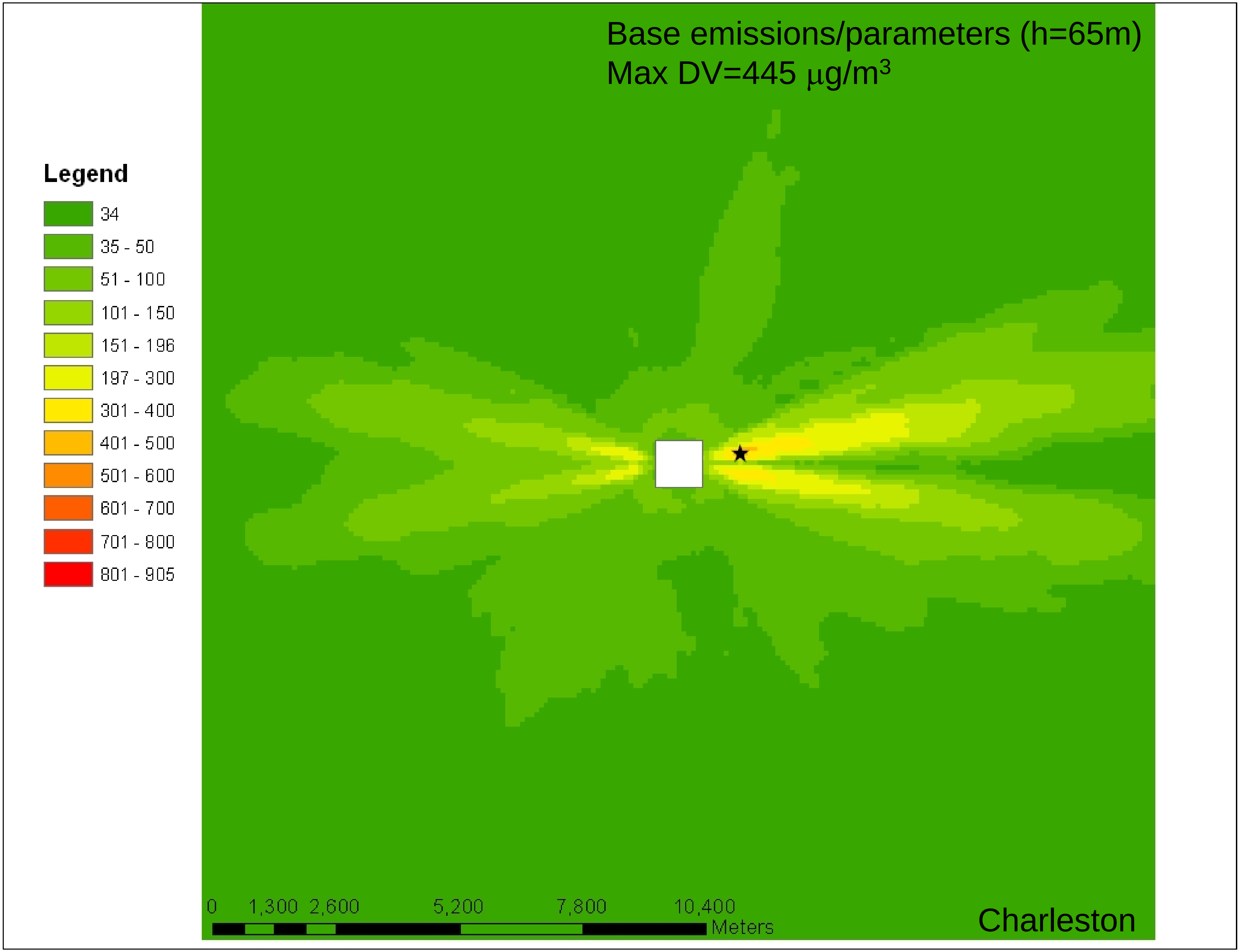
* Emission rates in g/s

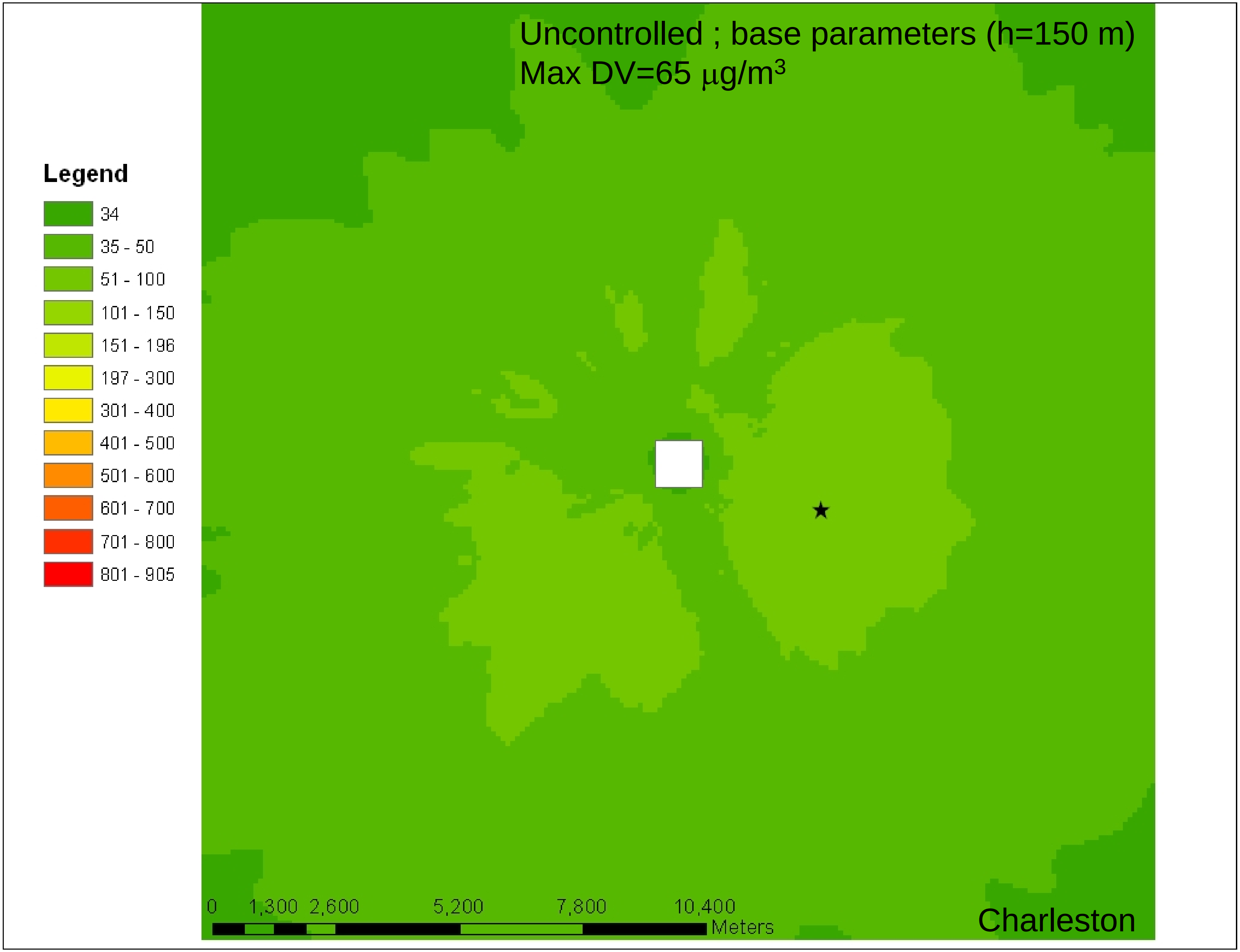
Coal EGU: SO_2

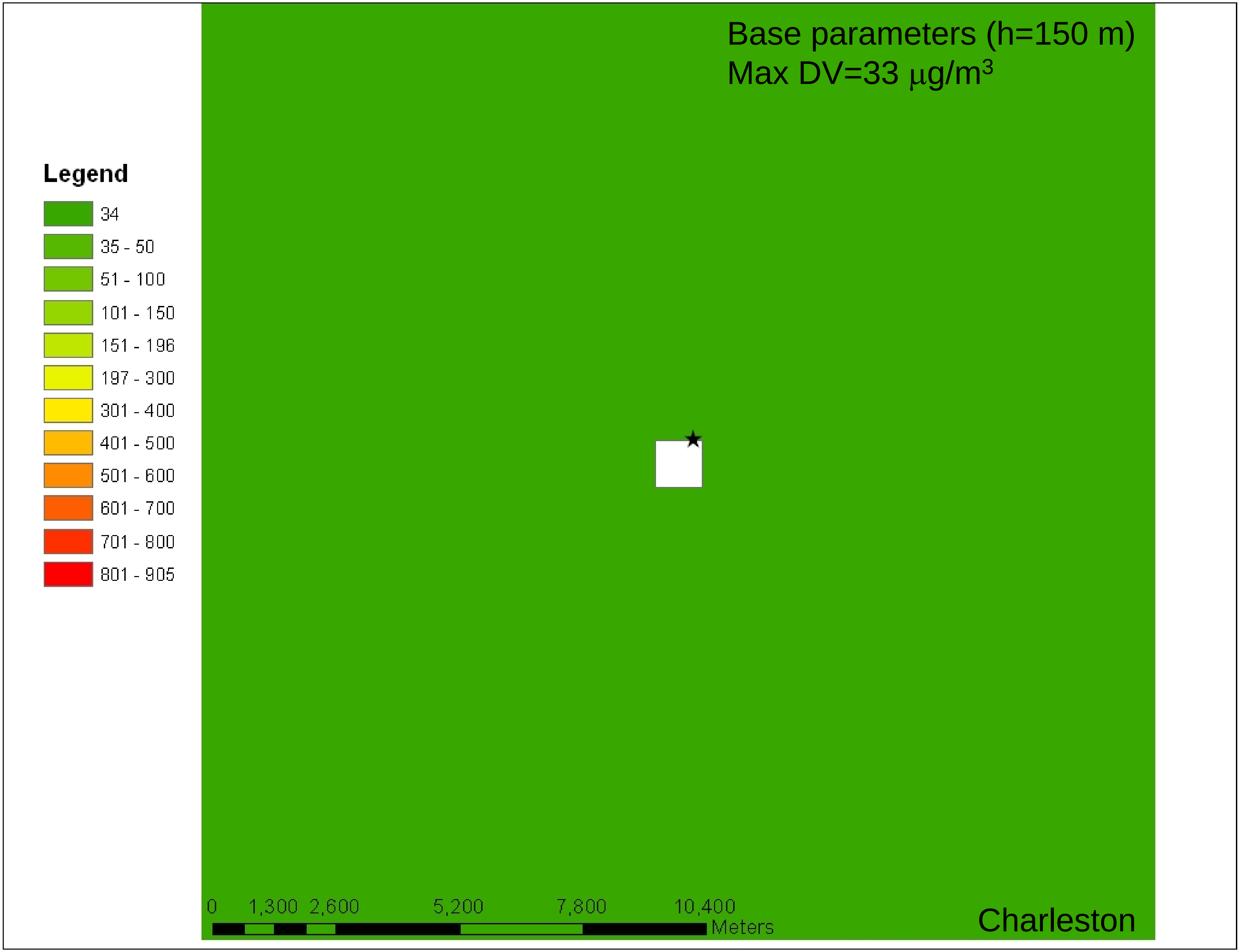


Scenario	SO_2 (tpy)
Baseline	4959
Controlled	2074
Uncontrolled	10713


Uncontrolled ; base parameters (h=65m)
Max DV=905 μg/m3
Legend
34
35 - 50
51 - 100
101 - 150
151 - 196
197 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 905
0 1,300 2,600 5,200 7,800 10,400
Meters
Charleston


Base emissions/parameters (h=65m)
Max DV=445 µg/m³
Legend
34
35 - 50
51 - 100
101 - 150
151 - 196
197 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 905
0 1,300 2,600 5,200 7,800 10,400
Meters
Charleston


Uncontrolled ; base parameters (h=150 m)
Max DV=65 μg/m3
Legend
34
35 - 50
51 - 100
101 - 150
151 - 196
197 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 905
0 1,300 2,600 5,200 7,800 10,400
Meters
Charleston


Base parameters (h=150 m)
Max DV=33 µg/m3
Legend
34
35 - 50
51 - 100
101 - 150
151 - 196
197 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 905
0 1,300 2,600 5,200 7,800 10,400
Meters
Charleston

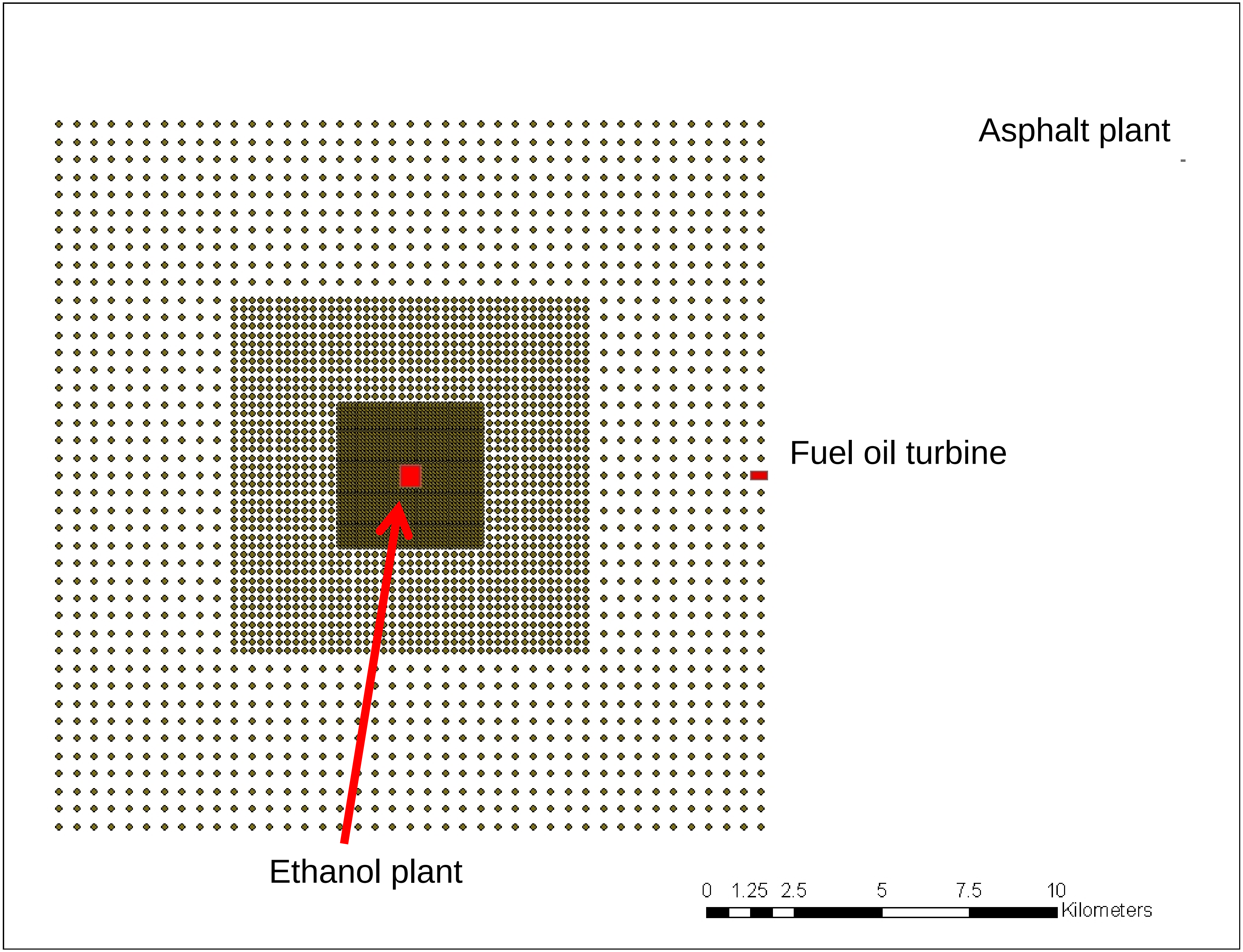
EGU findings

- No NAAQS exceedances unless stack heights changed to 65 m.
  - For base and controlled cases, maximum DV driven by diesel emergency generator (C0003)
  - For uncontrolled cases and all 65 stack height cases, maximum DV driven by 780 MW boiler (C0001)
- Springfield case more sensitive to changes in stacks than Charleston case
  - Combination of meteorology/terrain?
- Results not indicative of all EGUs (especially older ones)

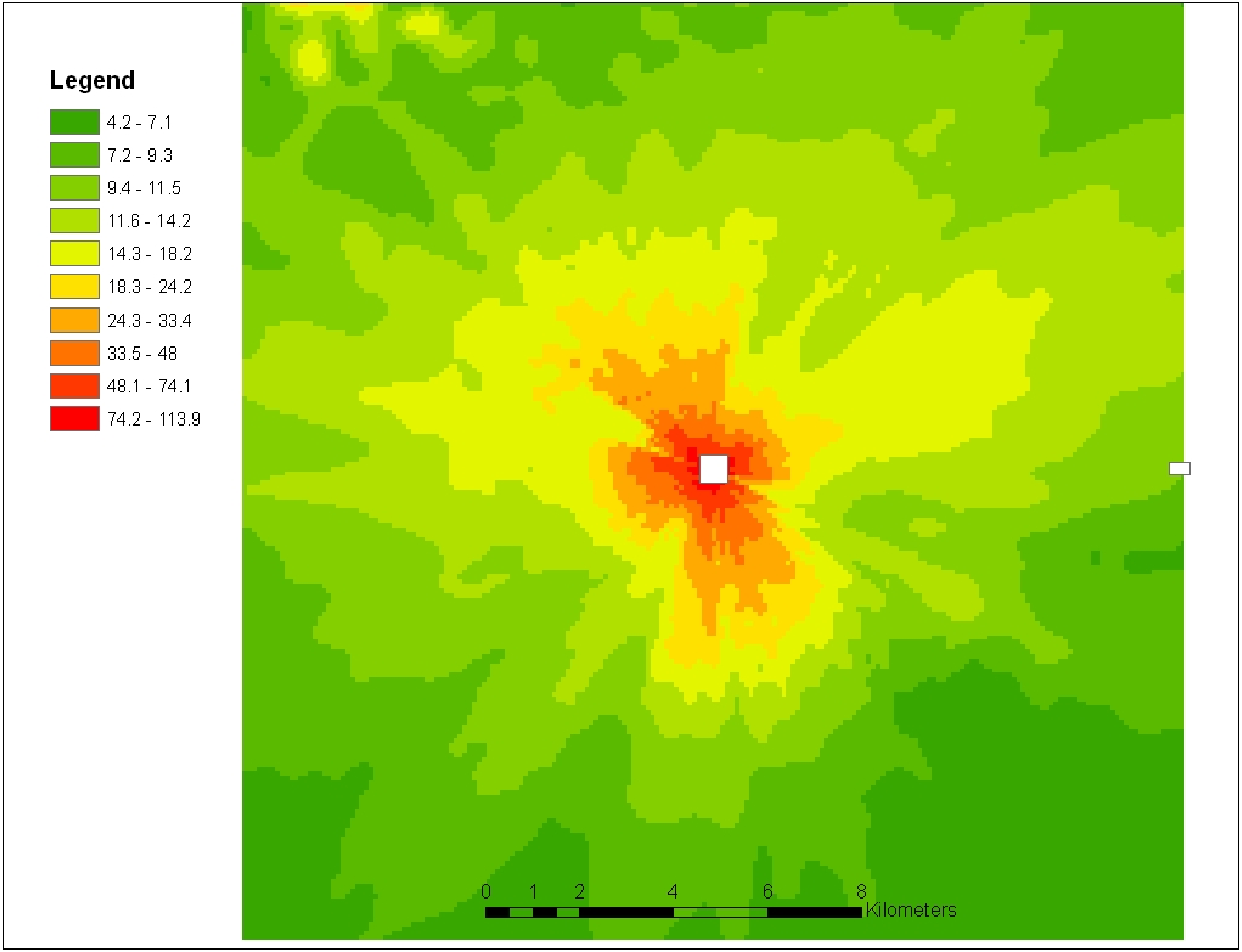
Cumulative scenarios

- SO_2: Ethanol plant, fuel oil turbine, and asphalt plant (AIWG facilities)
  - No NAAQS exceedances
- NO_2: Multiple facilities in a PSD scenario centered on ceiling tile manufacturer in MN.
  - One receptor exceeded NAAQS but was located on facility property.
- NO_2: Natural gas compressors

Cumulative scenario 1
Ethanol plant, fuel oil turbine, and asphalt plant



Asphalt plant
Fuel oil turbine
Ethanol plant
0 1.25 2.5 5 7.5 10
Kilometers

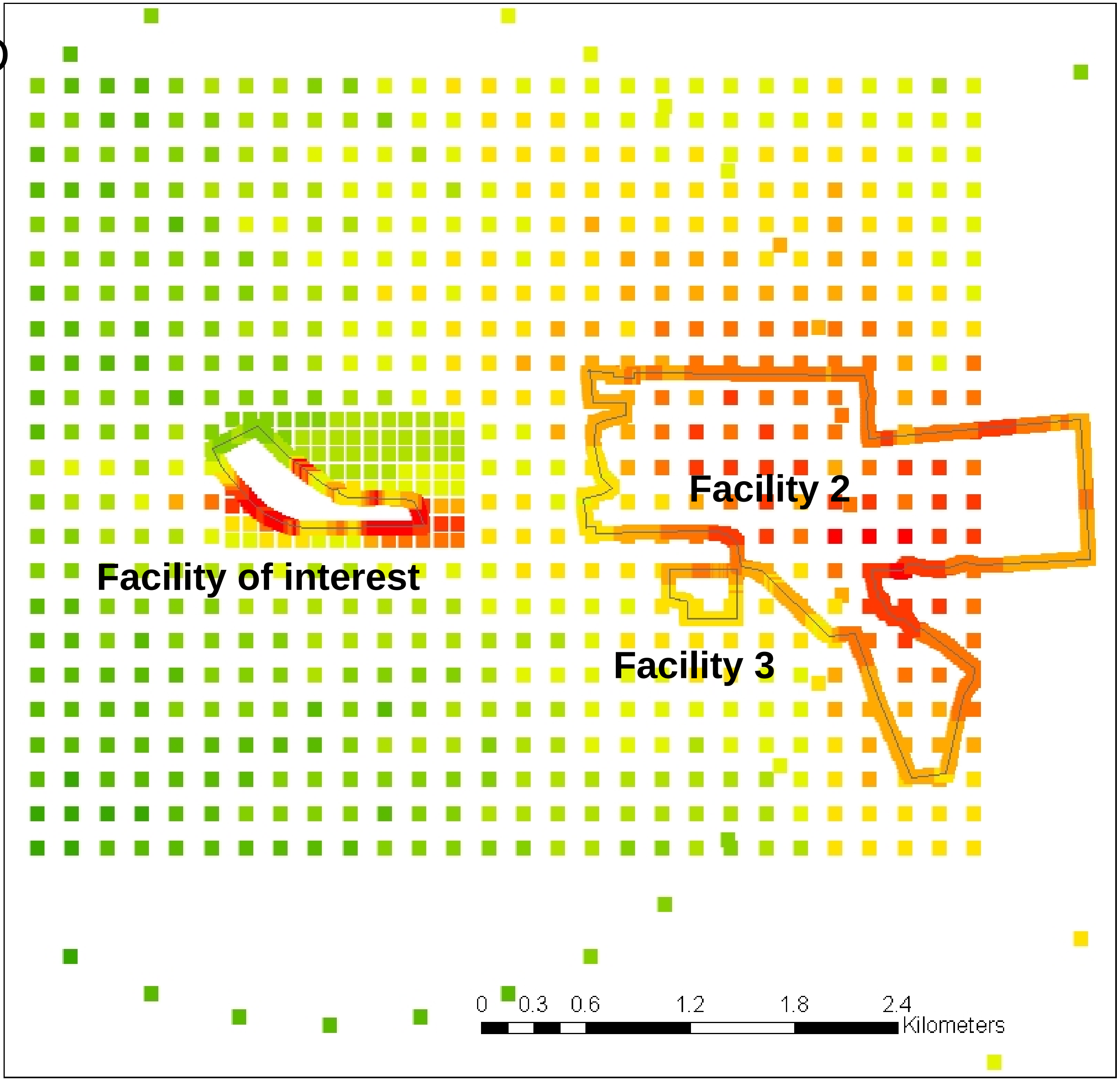

Legend
4.2 - 7.1
7.2 - 9.3
9.4 - 11.5
11.6 - 14.2
14.3 - 18.2
18.3 - 24.2
24.3 - 33.4
33.5 - 48
48.1 - 74.1
74.2 - 113.9
0 1 2 4 6 8
Kilometers

Cumulative scenario 2
PSD application for ceiling tile manufacturer

MN NO_2 PSD

Legend

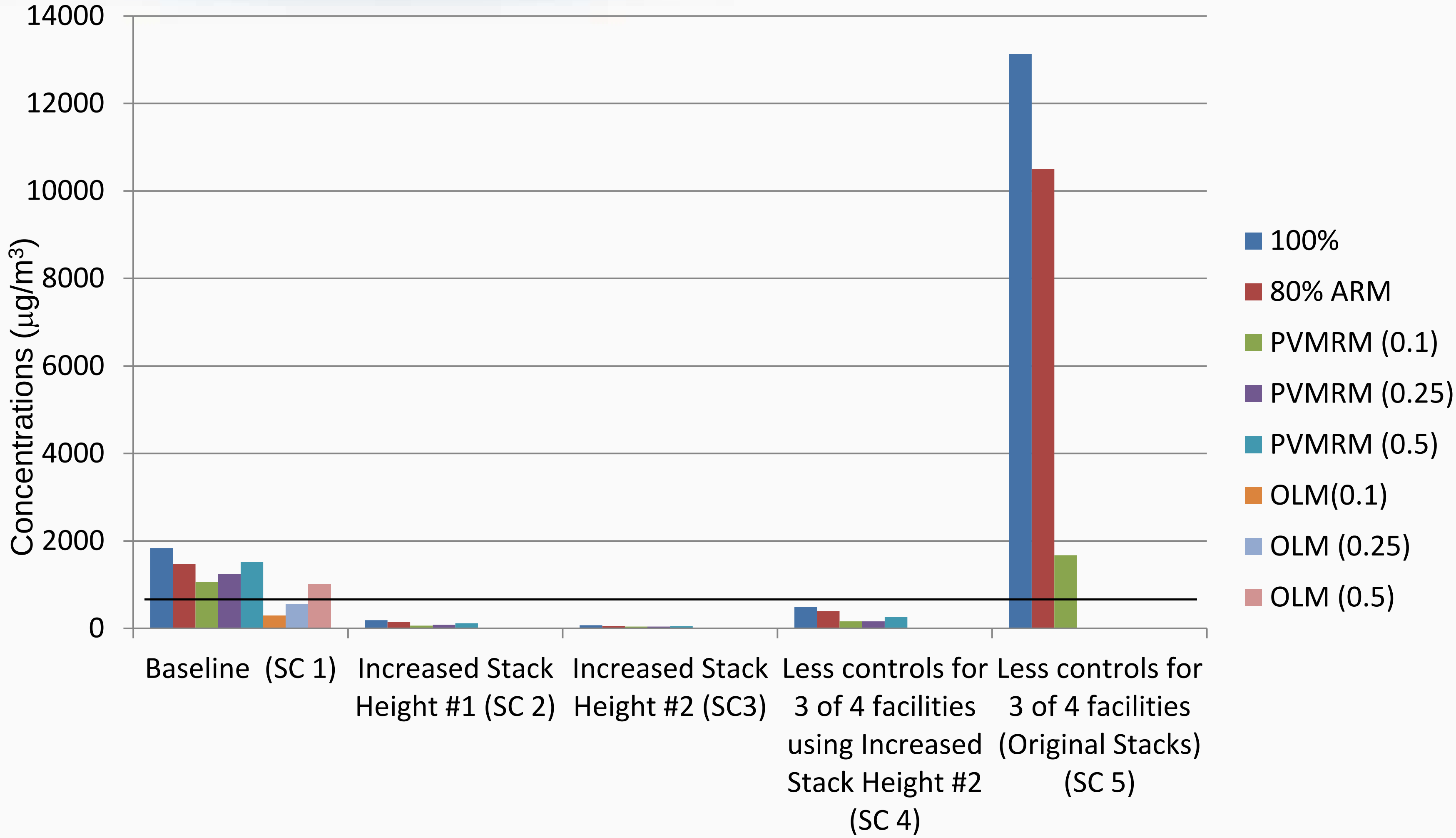
- 40.0 - 57.9
- 58.0 - 75.6
- 75.7 - 89.2
- 89.3 - 101.3
- 101.4 - 112.2
- 112.3 - 120.7
- 120.8 - 127.8
- 127.9 - 135.0
- 135.1 - 146.5
- 146.6 - 189.7



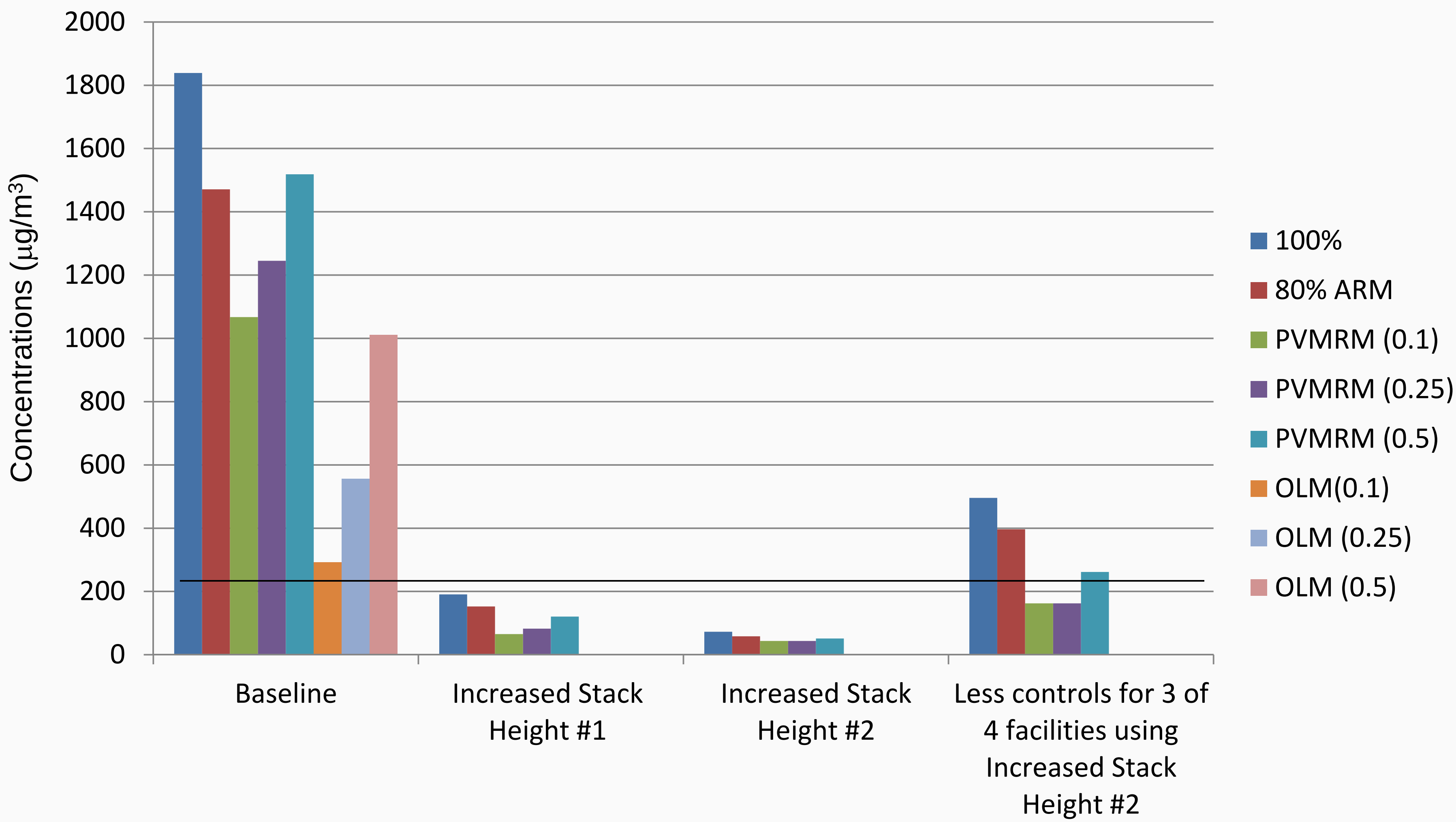
4 NG Compressor Stations Modeling Scenarios

- Modelers: Erik Snyder, Ashley Mohr, Chiu Foong, EPA Region 6
- Modeled 4 NG Compressor Stations where engines are well controlled. Most engines emission rates are 0.3-1.5 g/BHP-HR
- 4 scenarios
  - Scenario 1: Baseline (Approx. 28 tpy, 230 tpy, 165 tpy, 135 tpy)
  - Scenario 2: 17 m stack height or higher for all engines
  - Scenario 3: 35 m stack height or higher for all engines
  - Scenario 4: Scenario 3 with lesser controls for 3 of 4 facilities (6 g/BHP-HR)
- Modeled all 4 scenarios 100% and 80% conversion, with OLM and PVMRM with 0.1, 0.25, and 0.5 in-stack NO_2/NOx ratios (0.9 equilibrium ratio)
- Also modeled lesser controlled scenario using 100%, 80% and PVMRM (0.10 ISR & 0.90 EQ) and existing short stacks (SC 5)

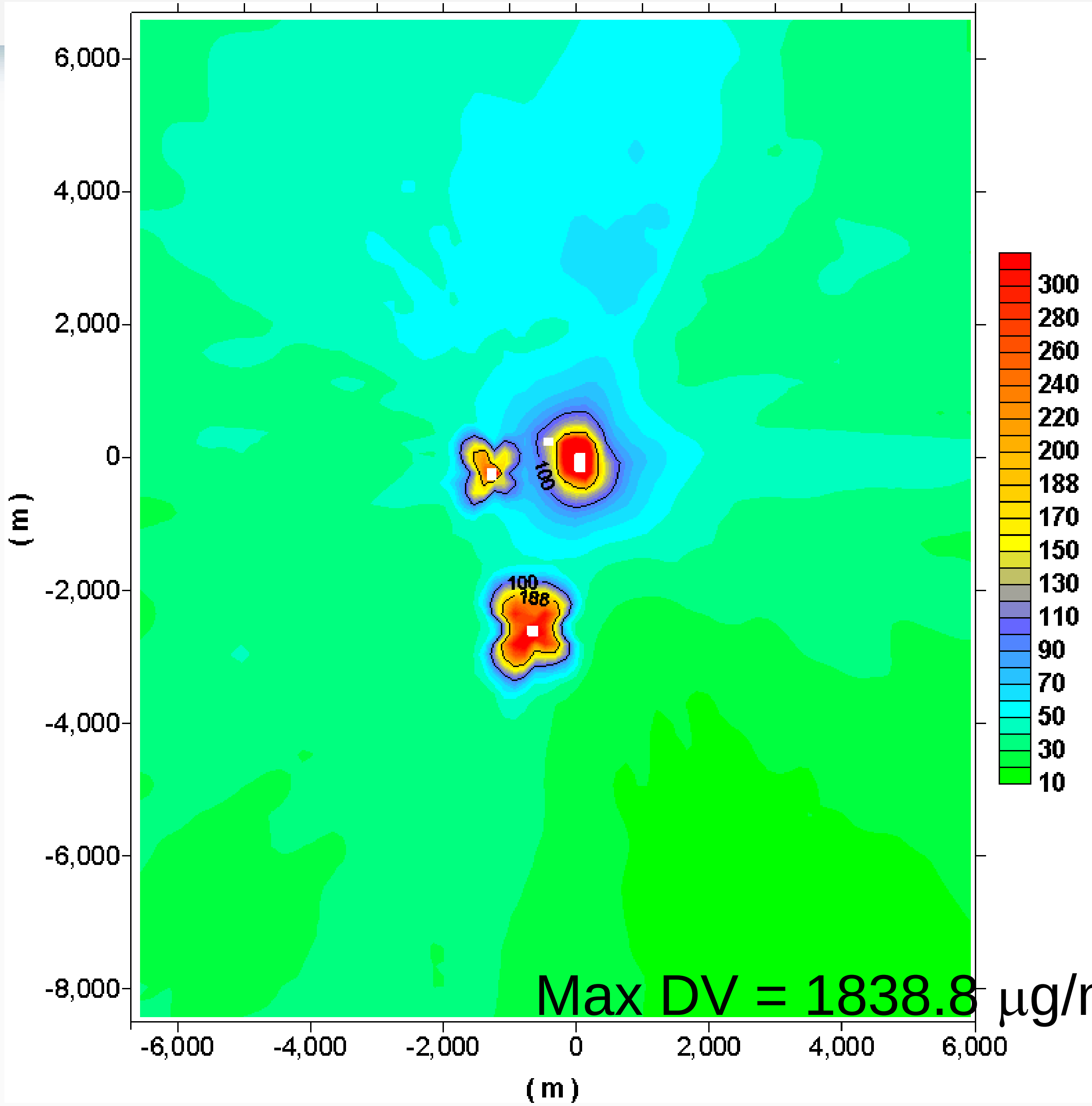
Natural gas compressors (cumulative): NO_2



Natural gas compressors (cumulative): NO_2 (without the large spike from SC5)

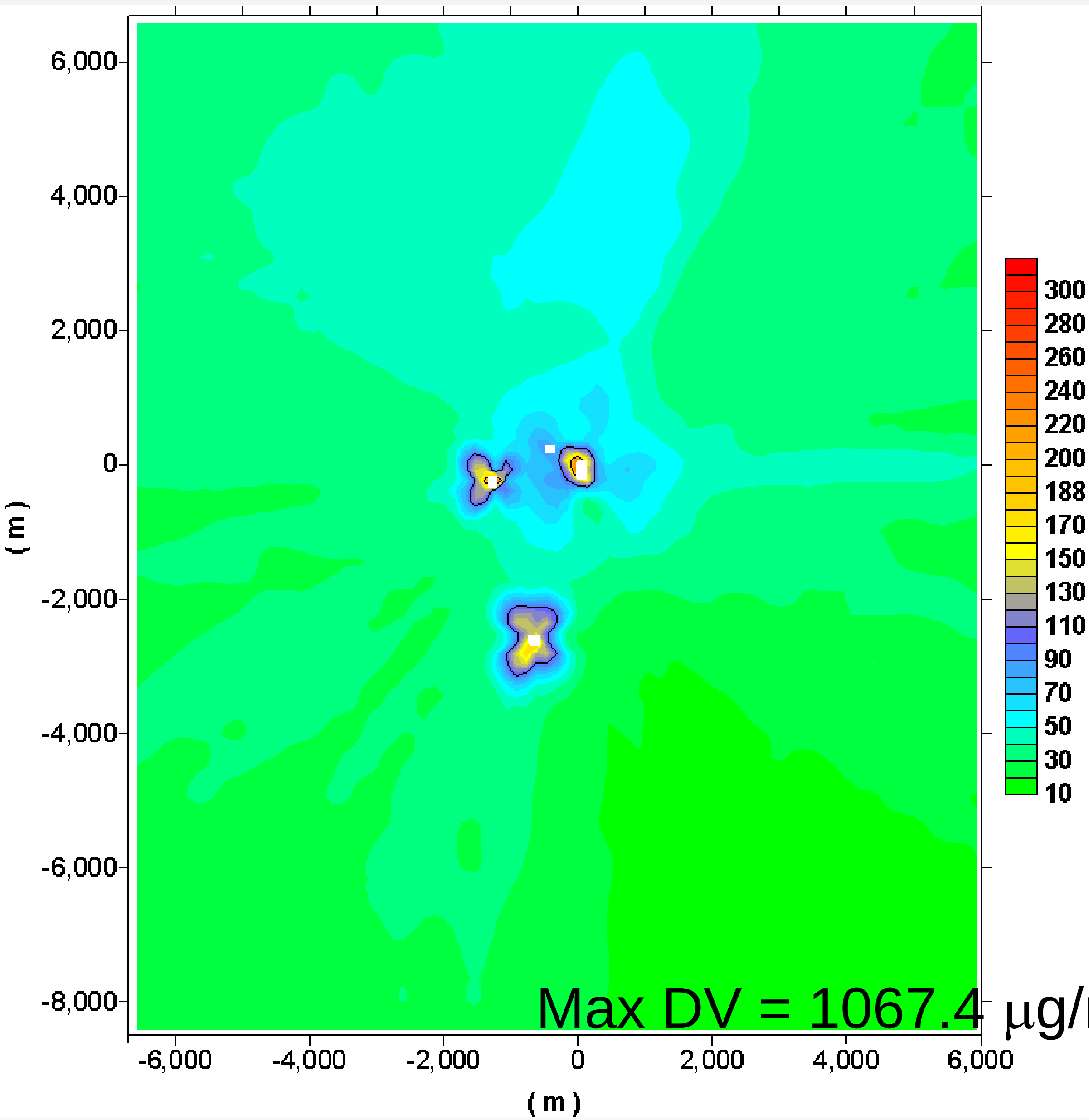


Scenario 1 – Cumulative NG CS (100%)



Max DV = 1838.8 $\mu g/m^3$

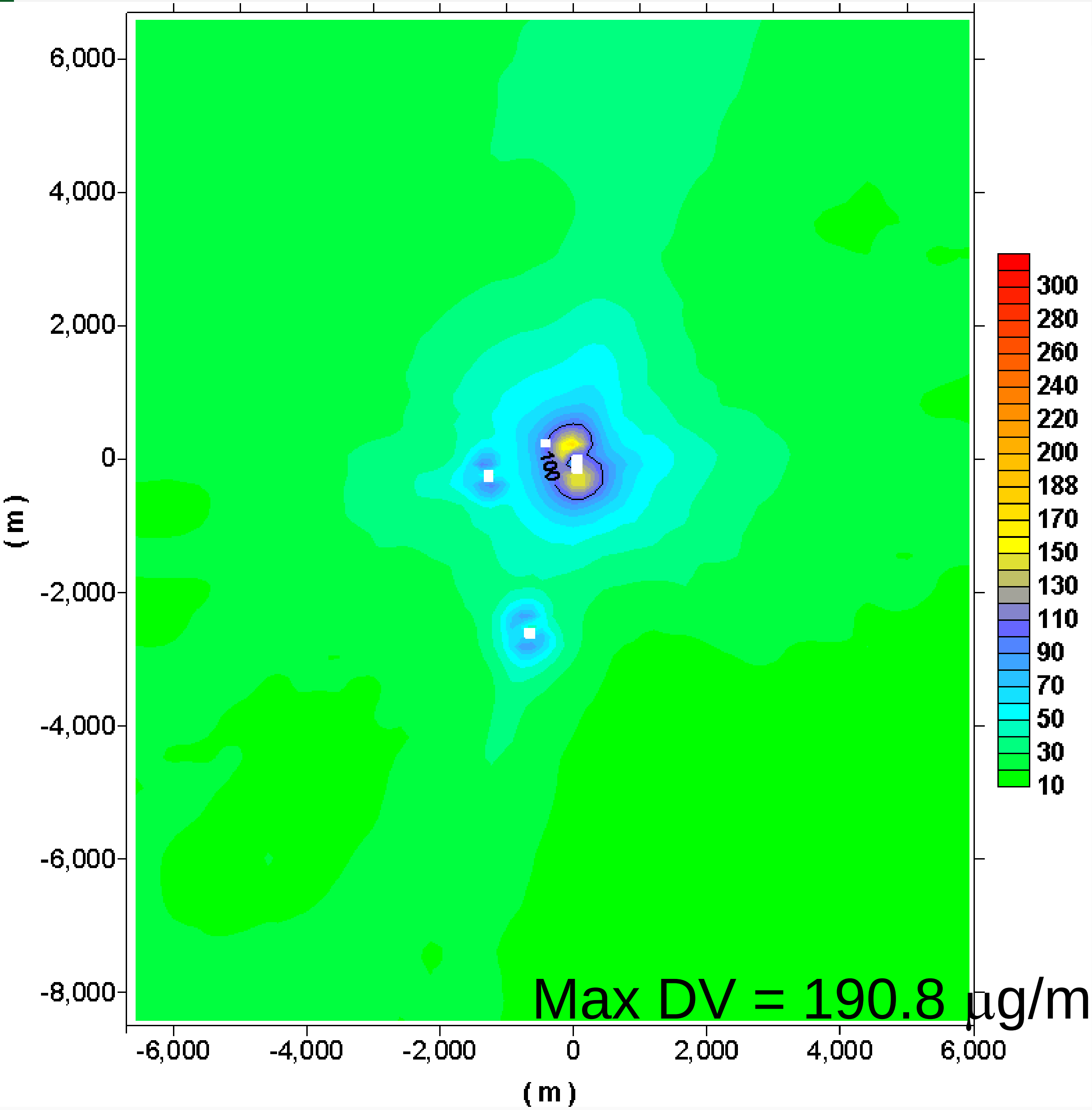
Scenario 1 – Cumulative NG CS



Max DV = 1067.4 µg/m^3

PVMRM
0.10 In
Stack Ratio
and 0.90
equilibrium

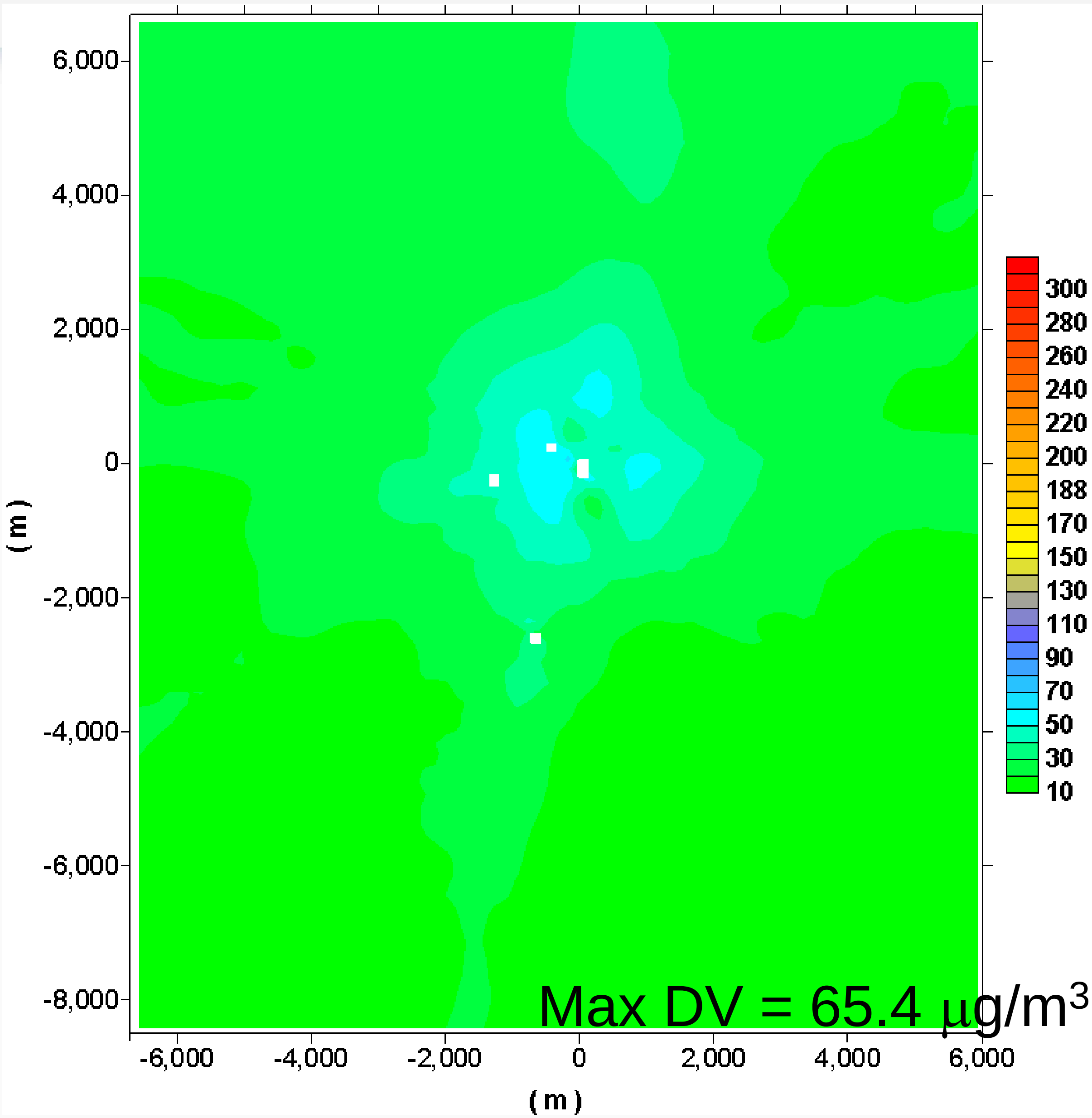
Scenario 2 – Cumulative NG CS



Max DV = 190.8 $\mu g/m^3$

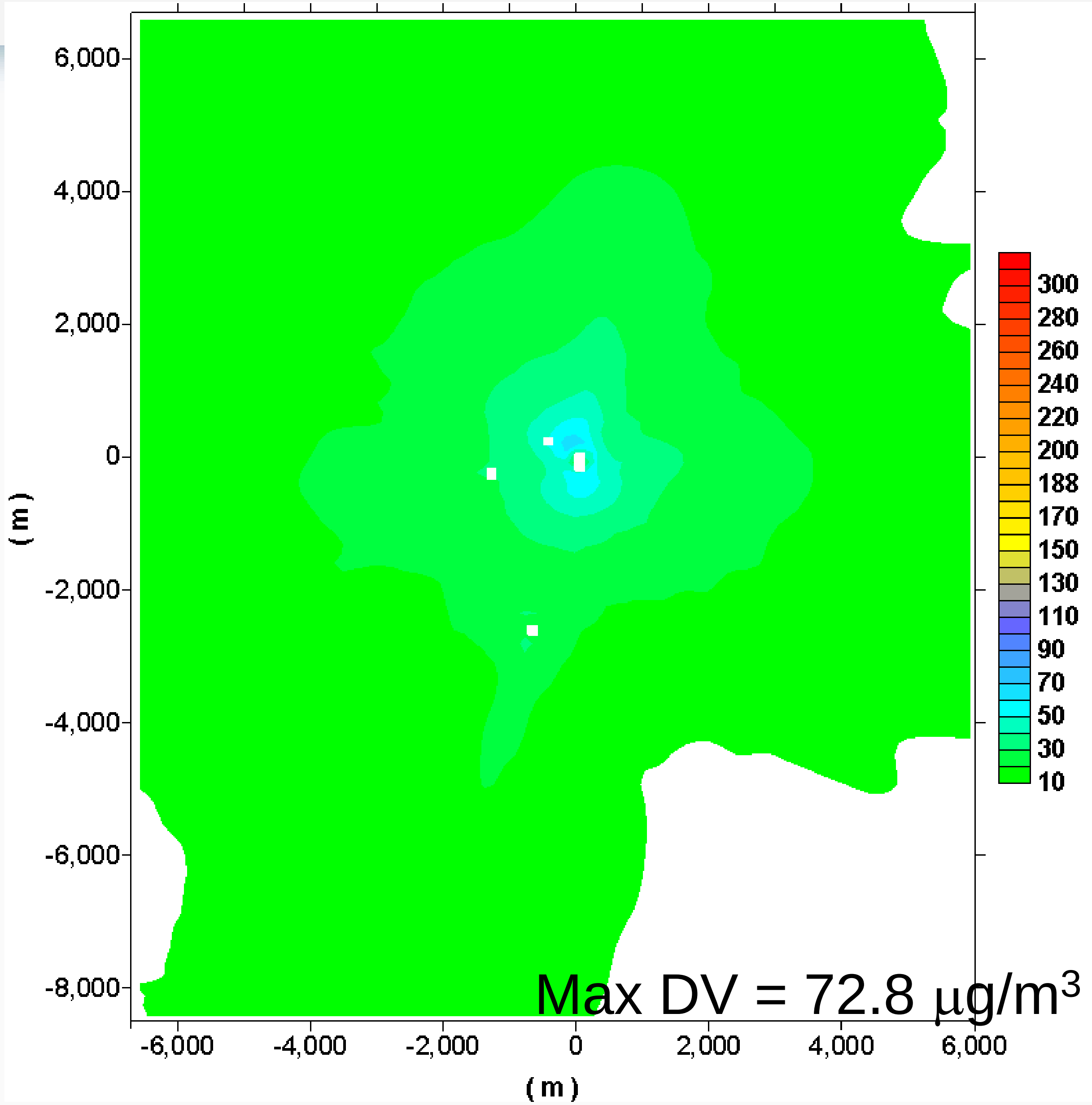
Increased Stacks to 17 m 100% Conversion

Scenario 2 – Cumulative NG CS

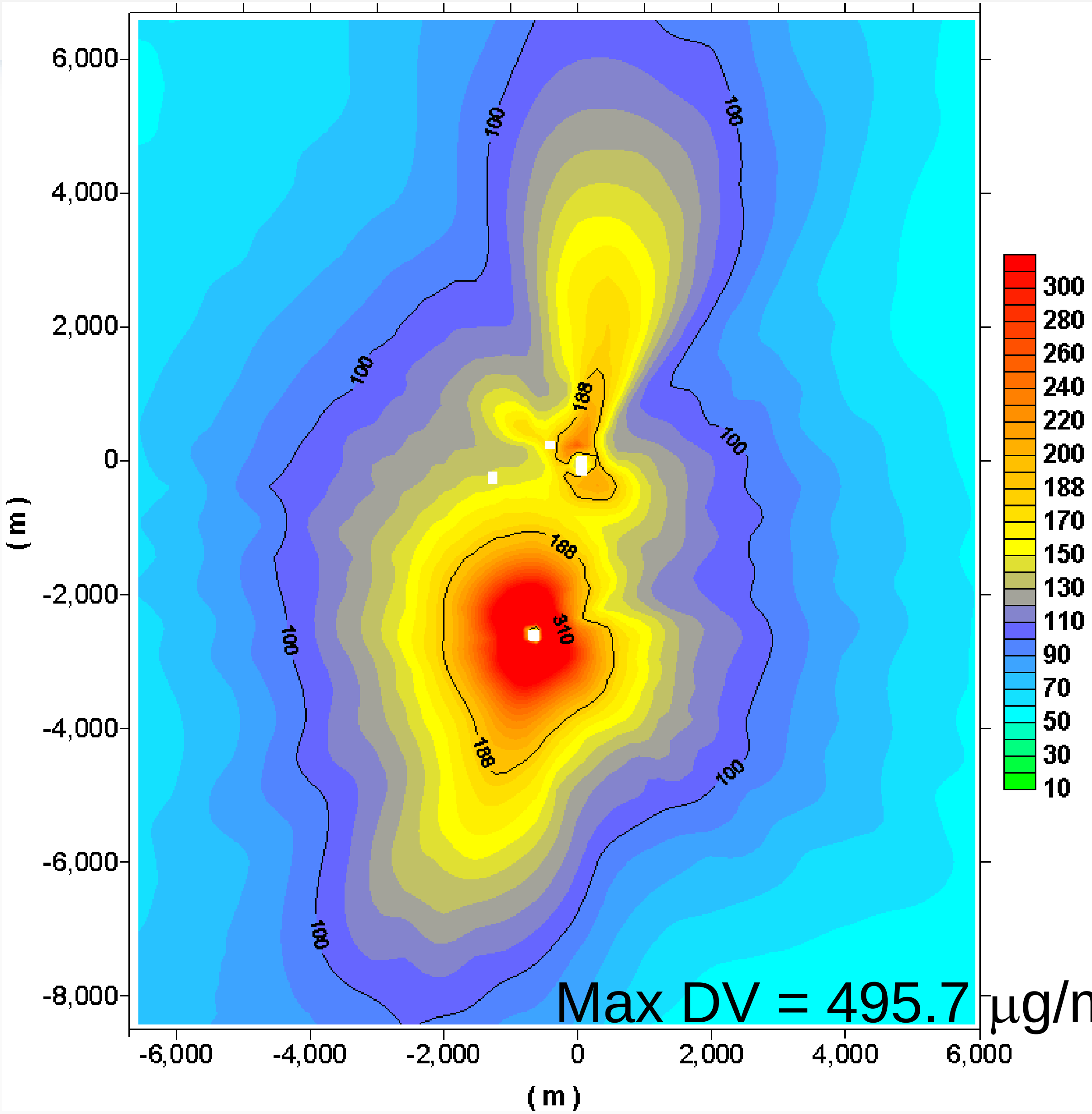


Increased Stacks to 17 m for engines with less controls PVMRM with 0.1 ISR

Scenario 3 – Cumulative NG CS (100%)



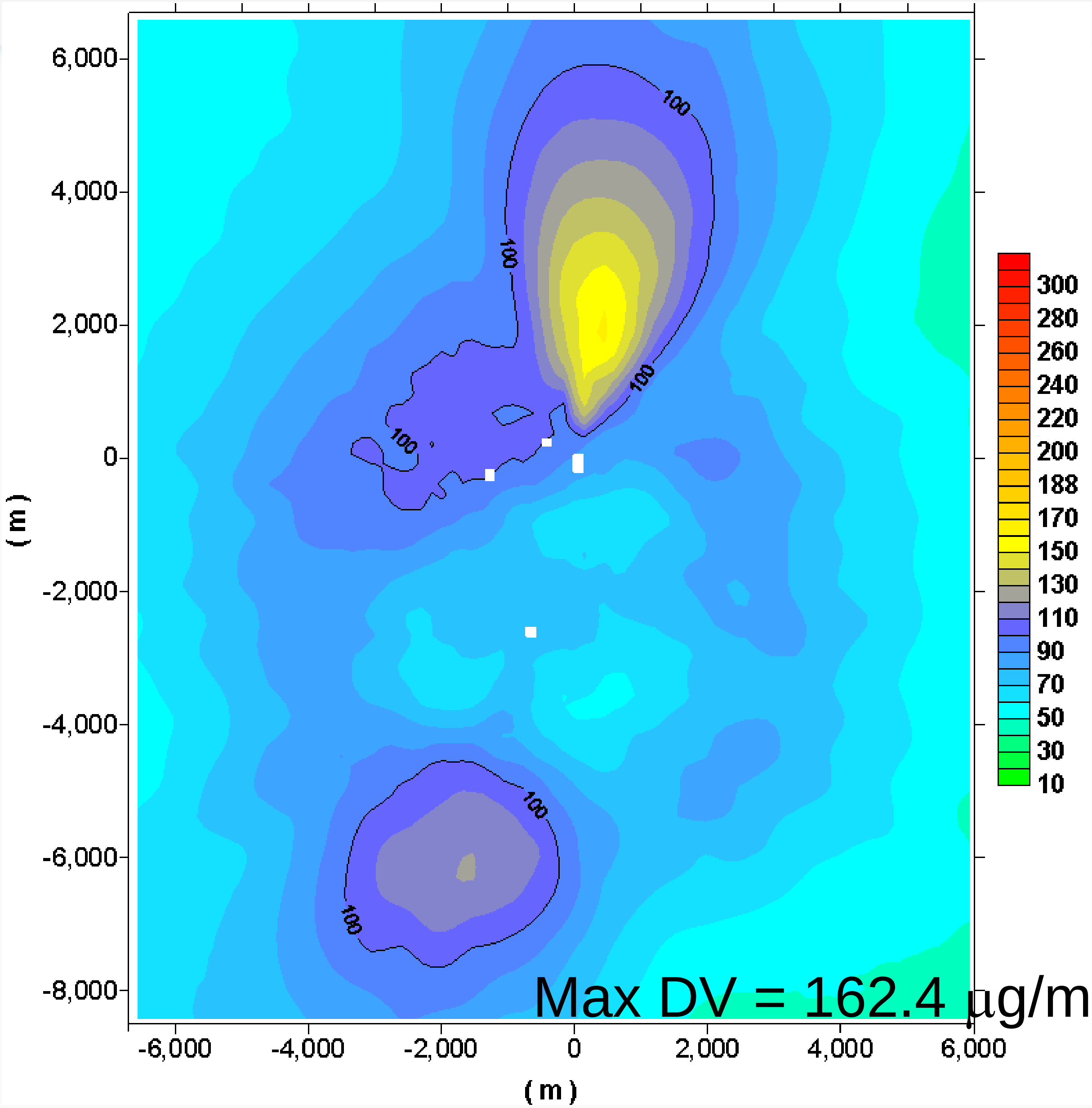
Scenario 4 – Cumulative NG CS (100%)



Max DV = 495.7 µg/m^3

Increased Stacks to 35 m for engines with less controls

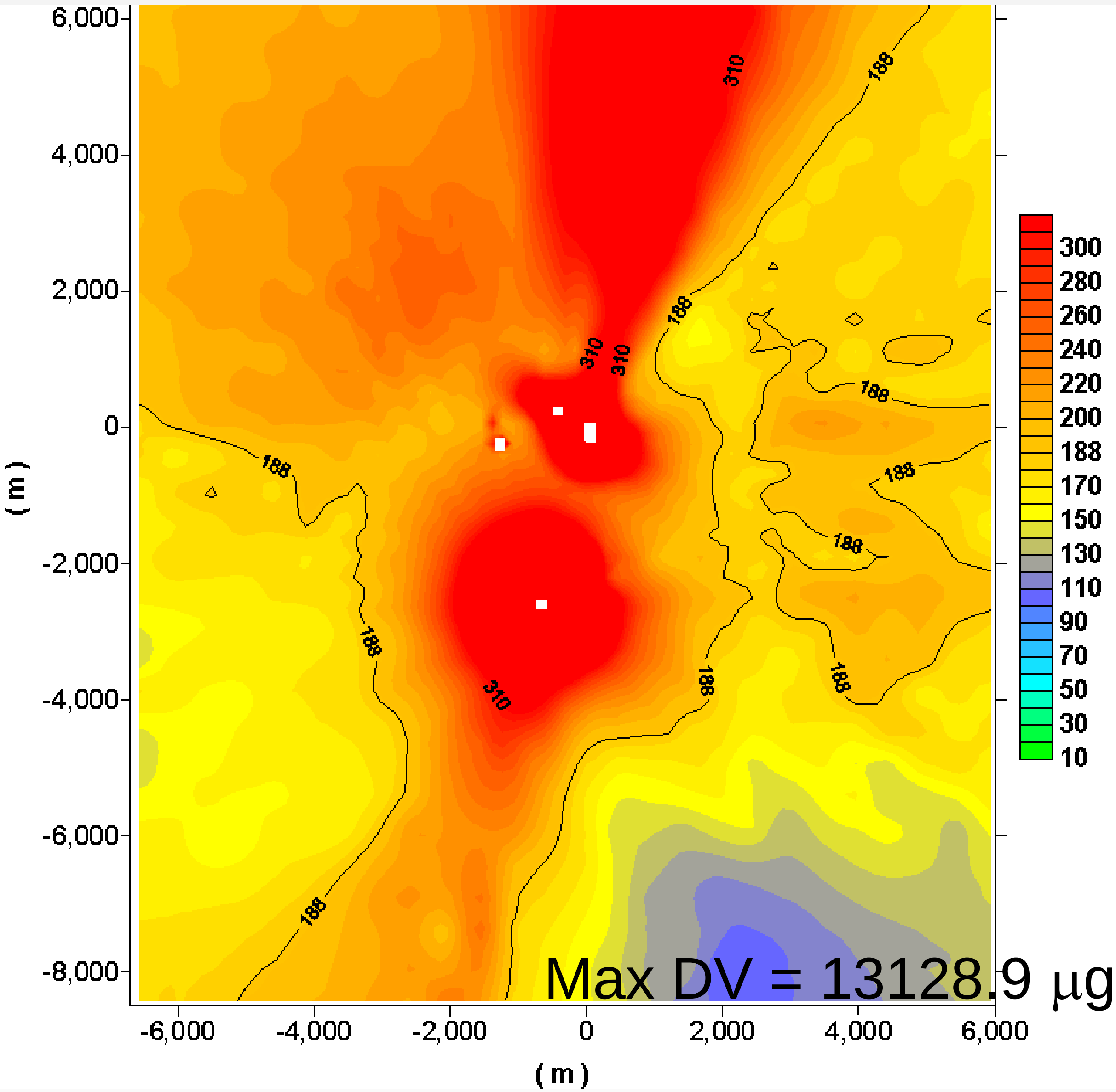
Scenario 4 – Cumulative NG CS



Max DV = 162.4 $\mu g/m^3$

Increased Stacks to 35 m for engines with less controls PVMRM with 0.1 ISR

Scenario 5 – Cumulative NG CS



Current short stacks and lesser controls on engines at 3 of the four facilities (100% Conversion) PVMRM reduced to 1673 ug/m3

Max DV = 13128.9 $\mu g/m^3$

Lessons learned

- Need to evaluate for controls and stack height increases within GEP.
- Low stacks and small property footprints are still a problem if not well controlled and may still require stack height increases in some cases
- In some cases, the stacks that drive design value are not the stacks of “interest”

Lessons learned

- Need to put forward early effort to compile facility information (short term emissions, down wash, facility non-ambient air lines, etc.)
  - Some states have started doing this, NEI and state inventory data does not usually give the detailed data needed for modeling.
    - Takes effort to pull permits and compile short-term emission limits. Some states have started/completed this task.
    - Emergency units are sometimes a problem for either standard. Restricting operations may be an option to resolve Emergency units impacts.

SO_2 Summary

- NAAQS violations not necessarily tied to emissions levels
  - Other variables at play
    - Source parameters, building downwash, terrain, meteorology, urban/rural classification, distance to ambient air
- Sources thought to be problematic may not be in all cases due to variables listed above
- Other sources may be problematic
- New SO_2 modeling may/is requiring additional controls but many permits are moving forward

NO_2 Summary

- As with SO_2, NAAQS violations not necessarily tied to emissions levels
  - Source parameters, building downwash, terrain, meteorology, urban/rural classification, distance to ambient air
- Obtaining NO_2/NOx in-stack ratios may be problematic, but may be necessary if background facilities are generating violations off property.
- NO_2 modeling can be sensitive to NO_2/NOx in-stack ratios, use of OLM vs. PVMRM, and ozone background data.
- Collection of NO_2/NOx in-stack ratios and populating a national database of ratios to aid in future modeling projects is important

Next steps

- Continue AIWG process, looking at source groupings, cumulative, adding background (different tier approach), evaluate guidance issues and sensitivity, etc.
- Loop in state experiences with permit modeling and initial maintenance modeling
- Present at 2012 R/S/L Modeling Workshop in April/May.
- Create report as needed.
  - http://www.epa.gov/ttn/scram/10thmodconf/review_material/AIWG_Summary.pdf
- Would appreciate input on the types of sources that are a concern based on stakeholder initial investigations.