NO_2/SO_2 AIWG: Analysis of intermittent emissions & cumulative analyses

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2012 Regional/State/Local Modelers Workshop

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AIWG summary

1. Started Spring 2011 with focus on single source modeling of NO_2 and SO_2 facilities of most interest to states
2. Initial report out at 2011 Regional/State/Local Modelers Workshop in Atlanta
3. Post-workshop QA of results and development of cumulative scenarios in fall 2011
4. Additional report out at 10th Modeling Conference in March 2012
5. Single source modeling draft summary and results available on SCRAM
   - Contains full set of charts/maps for each modeled source

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

Cumulative Analyses

- AIWG created eight hypothetical case studies based on the single source examples
  - Three facilities per study with eight scenarios
    - Two modeling scenarios per facility
- States also provided actual cases
- Caveats: No background concentration added on some scenarios, limited cumulative analysis. Modeling conducted to inform, some model set-ups may not be acceptable in a regulatory analysis without technical support.

Cumulative analyses: case studies

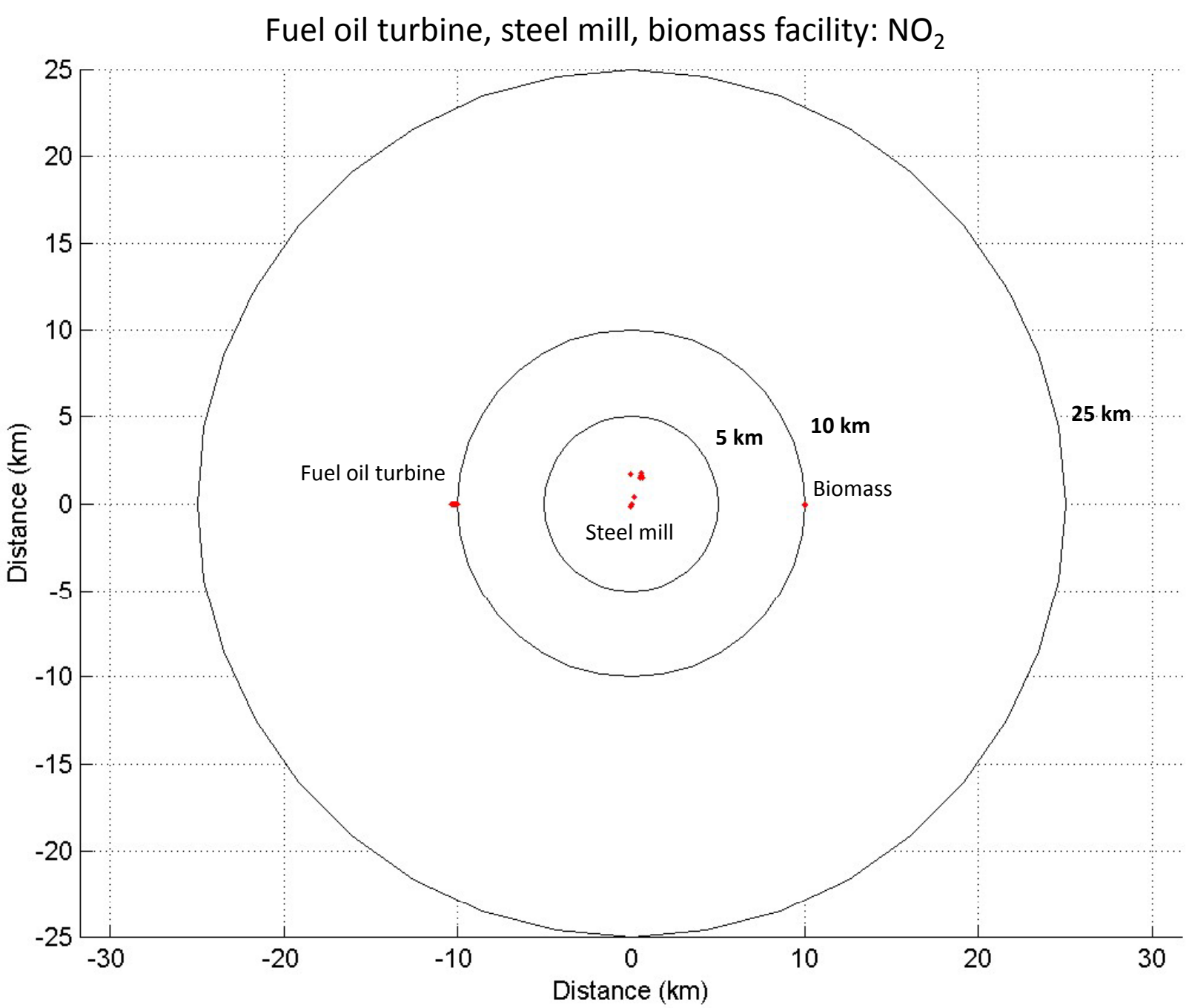
Pollutant(s)	Facility 1	Facility 2	Facility 3
NO_2	Natural gas turbine	Materials recycler	Fuel oil turbine
NO_2	Steel Mill	Biomass facility	Fuel oil turbine
NO_2	Ethanol plant	Natural gas processing facility	Refinery
NO_2, SO_2	Coal EGU	Cement kiln	Refinery
SO_2	Coal EGU	Cement kiln	Pulp & paper
SO_2	Flare	Landfill gas turbine	Pulp & paper
SO_2	Ethanol plant	Fuel oil turbine	Asphalt plant

Steel mill, fuel oil turbine, and biomass facility (NO_2)

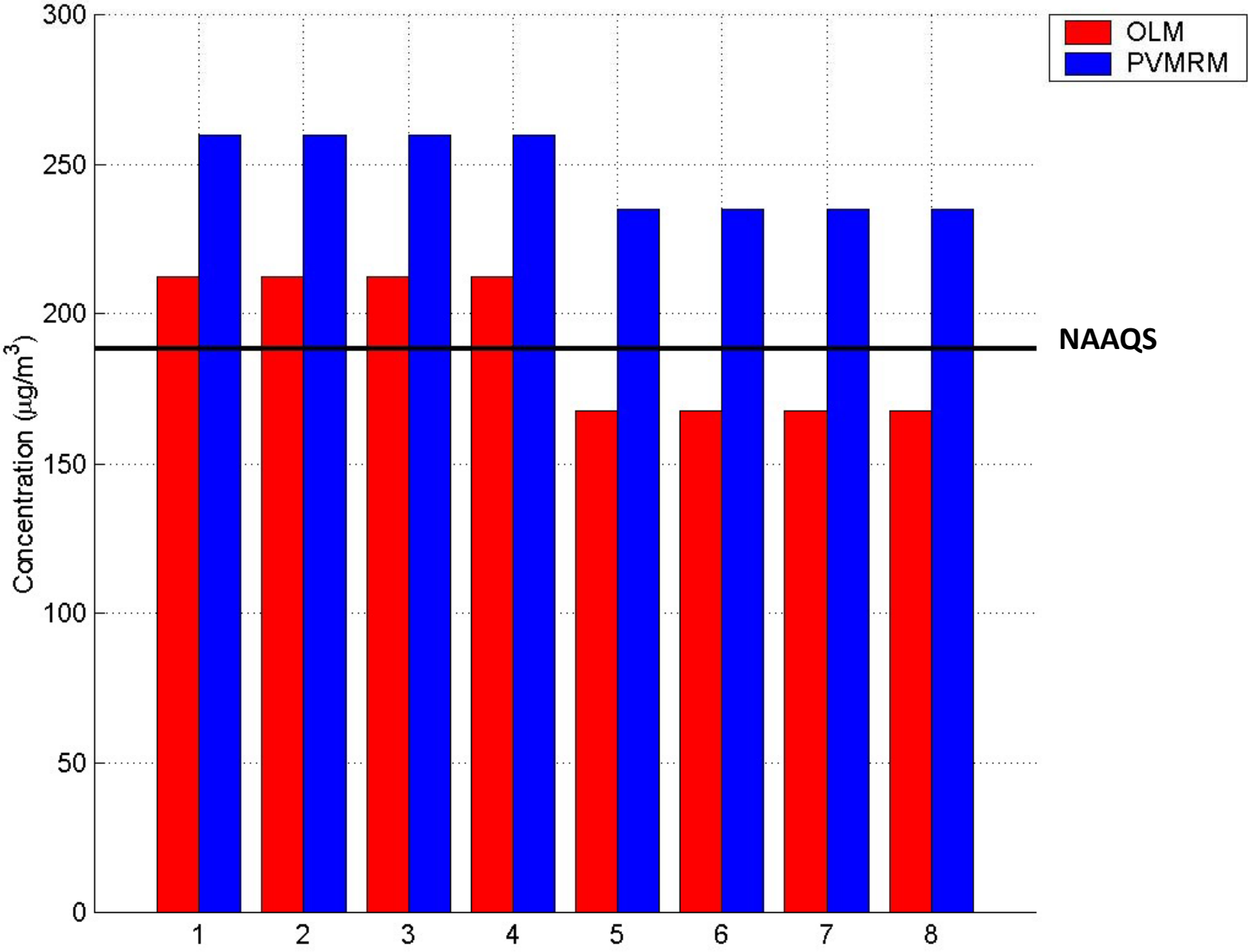
- Modeler: Doris Jung (CO)
- Modeled with OLM and PVMRM
- Emissions
  - Steel Mill: 711 tpy
  - Fuel oil turbine: 1,190 tpy
  - Biomass facility: 240 tpy

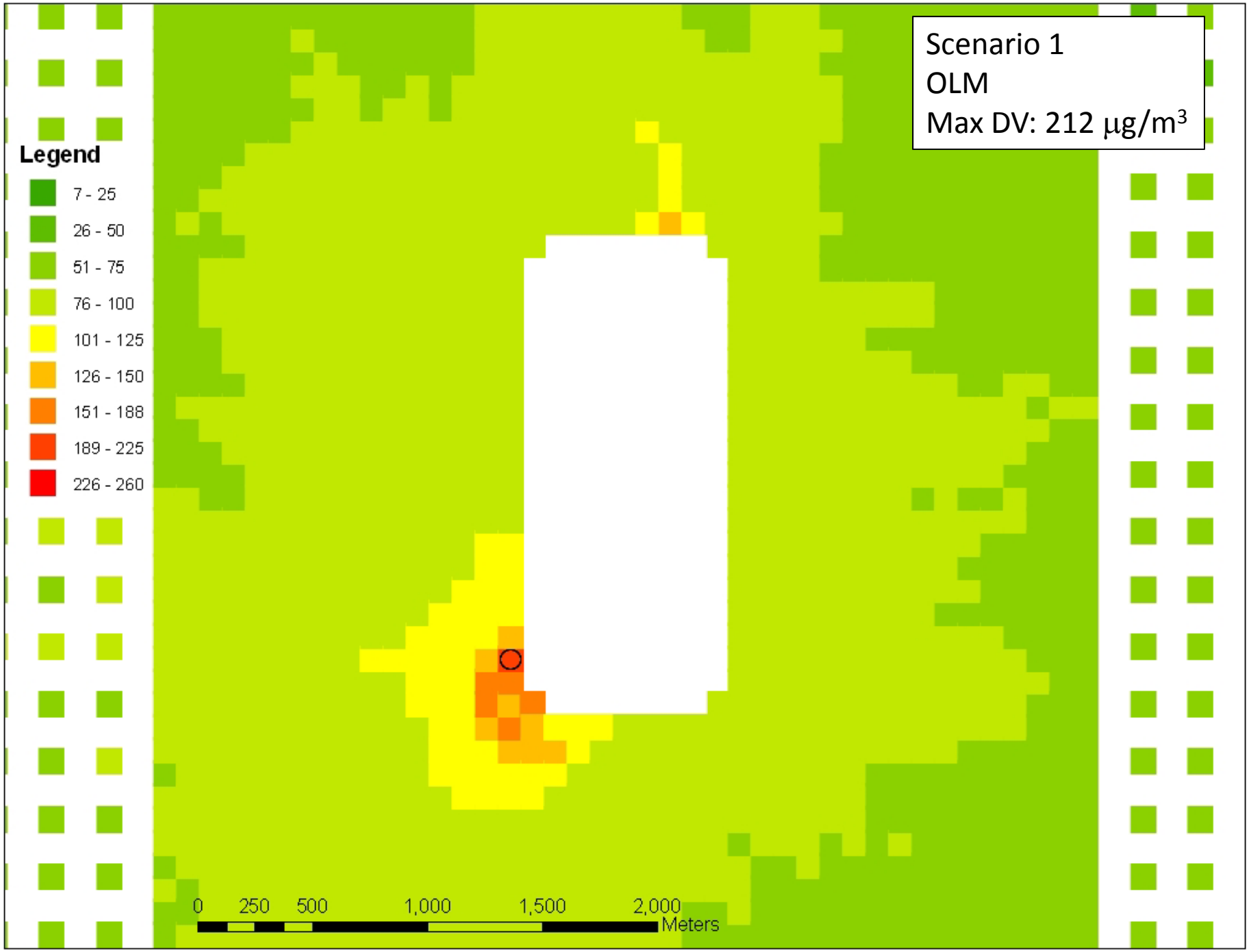
Modeling Scenarios

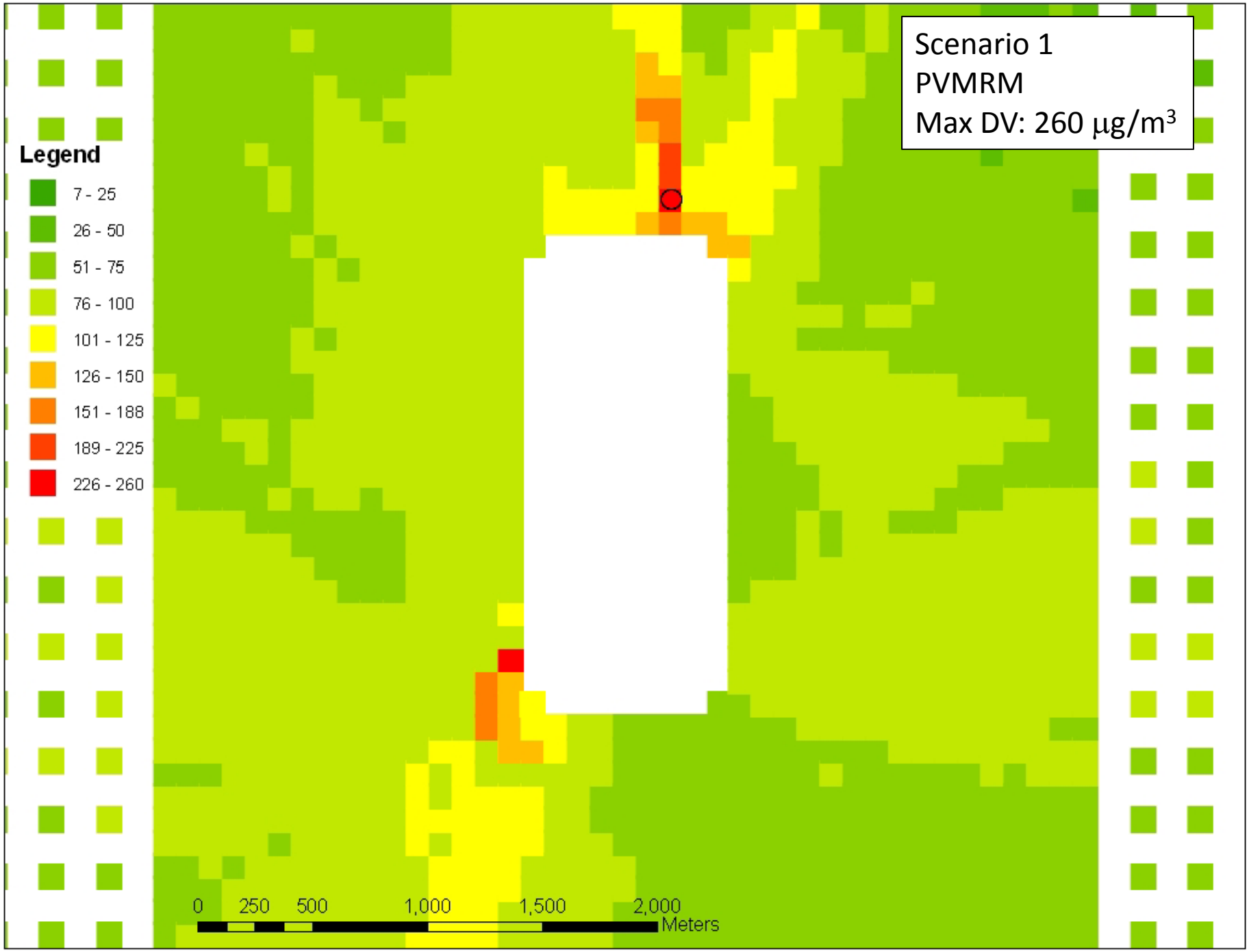
Modeling scenario	Steel mill	Fuel oil turbine	Biomass facility
1	Baseline	Baseline	Baseline
2	Baseline	Baseline	Increased stack height
3	Baseline	Increased stack height	Baseline
4	Baseline	Increased stack height	Increased stack height
5	Increased stack height to 45 m for stacks > 1 g/s	Baseline	Baseline
6	Increased stack height to 45 m for stacks > 1 g/s	Baseline	Increased stack height
7	Increased stack height to 45 m for stacks > 1 g/s	Increased stack height	Baseline
8	Increased stack height to 45 m for stacks > 1 g/s	Increased stack height	Increased stack height

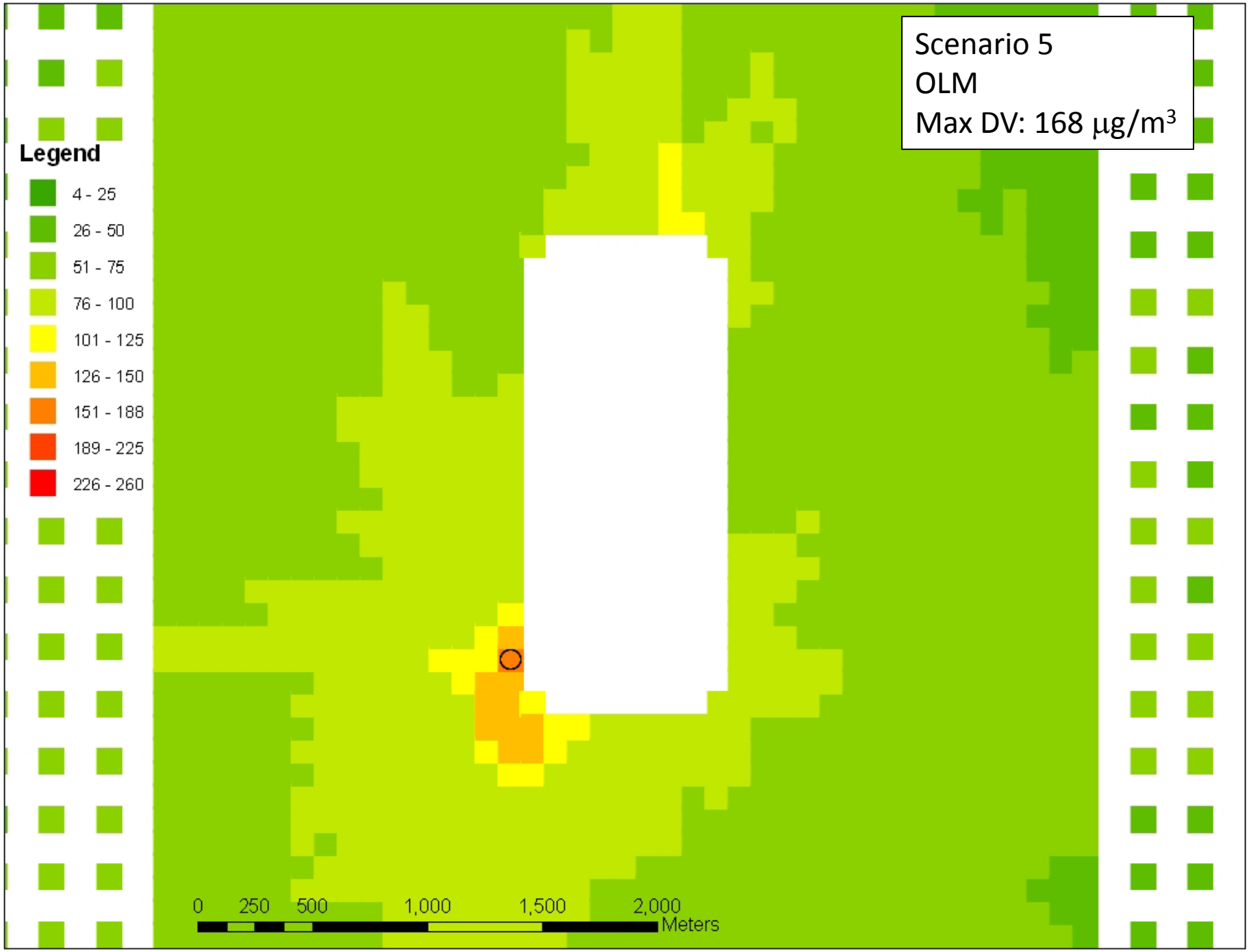

Fuel oil turbine, steel mill, biomass facility: NO2
Distance (km)
Distance (km)
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-20
-10
0
10
20
30
5 km
10 km
25 km
Fuel oil turbine
Biomass
Steel mill

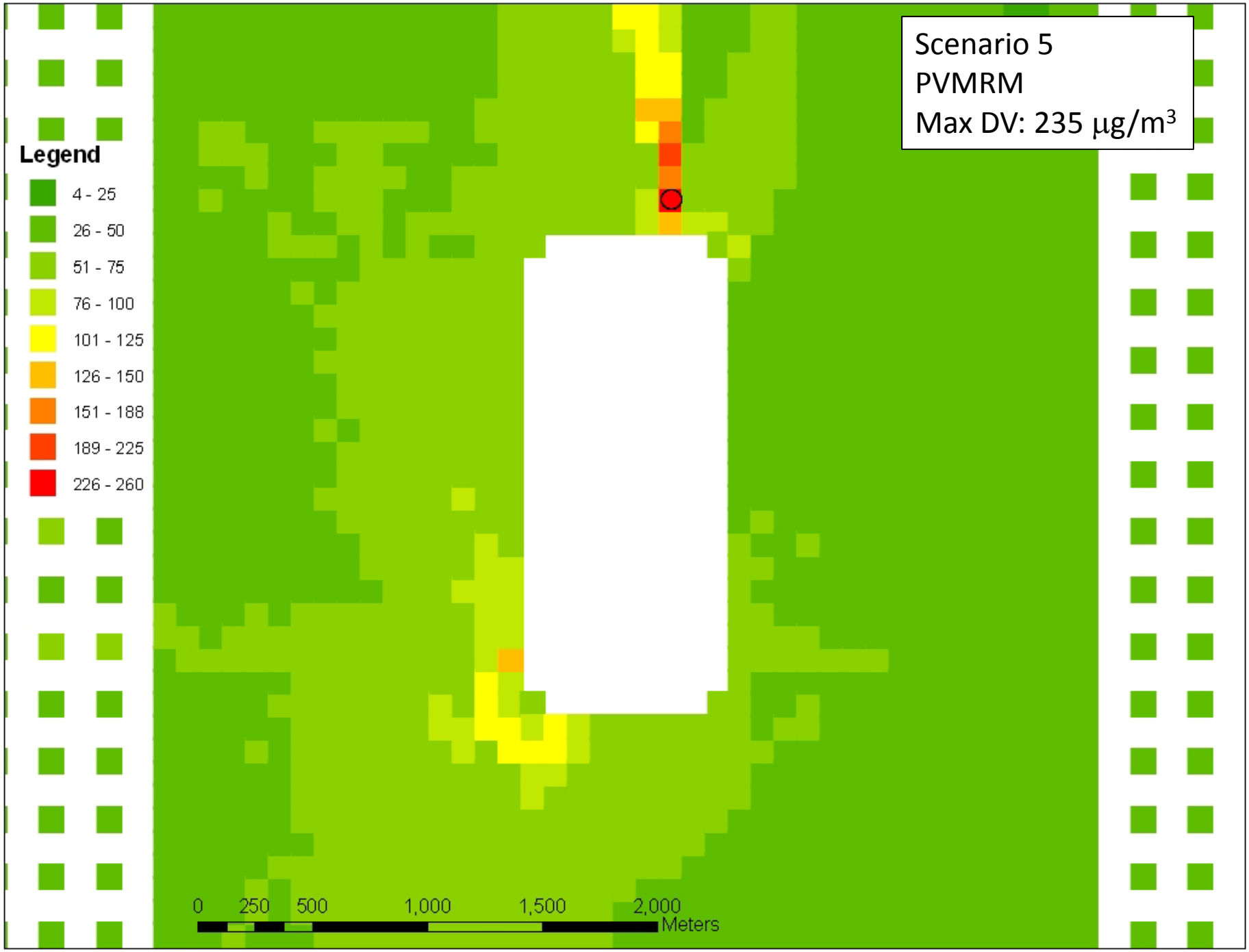
Maximum design values




Scenario 1
OLM
Max DV: 212 µg/m3
Legend
7 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 188
189 - 225
226 - 260
0
250
500
1,000
1,500
2,000
Meters


Scenario 1
PVMRM
Max DV: 260 µg/m3
Legend
7 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 188
189 - 225
226 - 260
0
250
500
1,000
1,500
2,000
Meters


Scenario 5
OLM
Max DV: 168 µg/m3
Legend
4 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 188
189 - 225
226 - 260
0
250
500
1,000
1,500
2,000
Meters


Scenario 5
PVMRM
Max DV: 235 µg/m3
Legend
4 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 188
189 - 225
226 - 260
0
250
500
1,000
1,500
2,000
Meters

Findings

- Use of PVMRM leads to higher maximum DV versus OLM
- All design values drop once steel mill stack heights increase
- Source that is giving maximum shifted between source on the SW corner for OLM and Northern edge for PVMRM. May investigate further

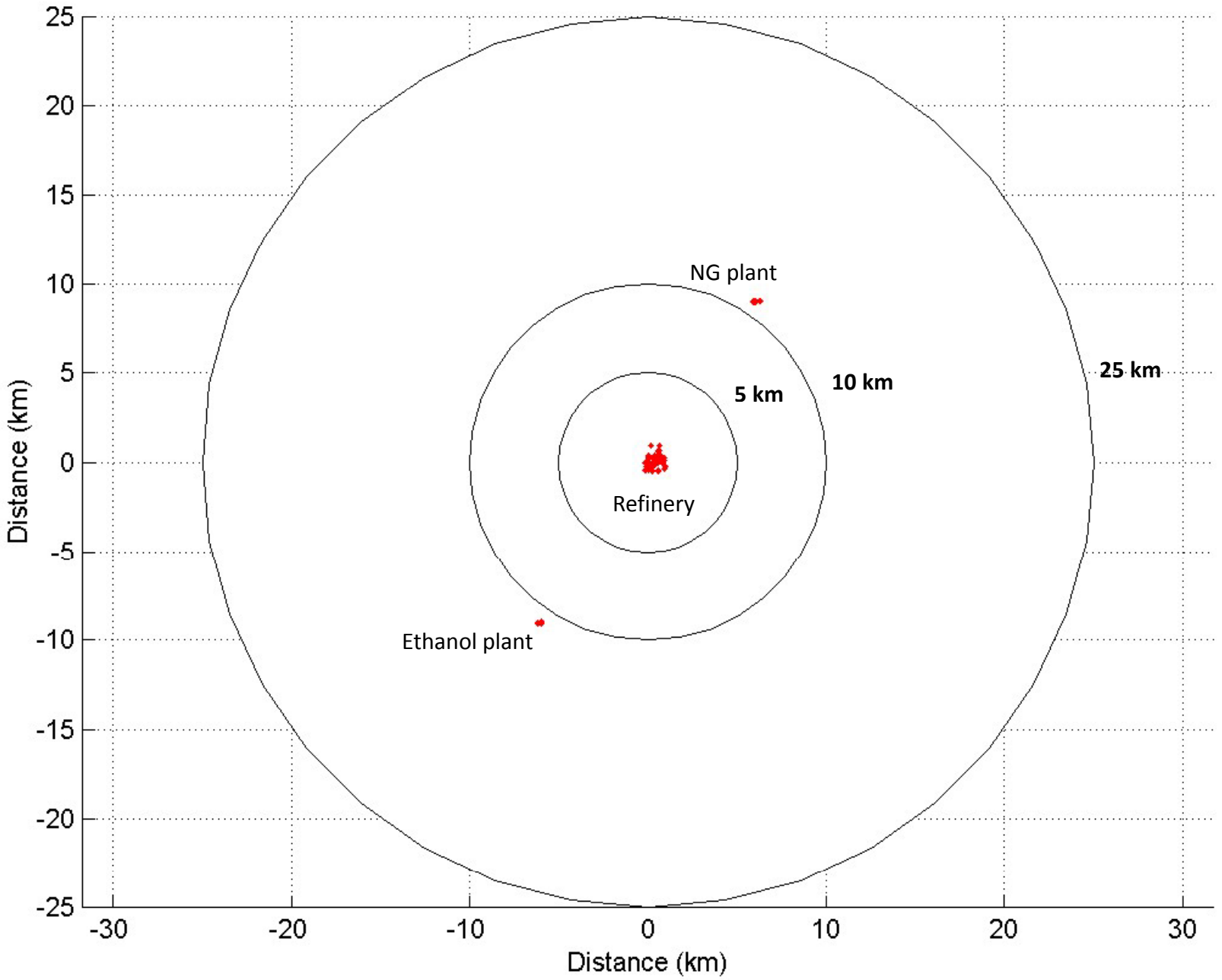
Ethanol plant, refinery, natural gas plant (NO_2)

- Modeler: Jennifer Krzak (IA)
- Comparisons between two different surface stations and two 5-year periods
  - Moline, Waterloo; 2000-2004, 2005-2009
- Receptor grid centered on ethanol plant
- Background of 71.5 $\mu g/m^3$ for Moline runs
- Emissions
  - Ethanol plant: 1,180 tpy
  - Refinery: 8,770 tpy
  - Natural gas plant: 330 tpy

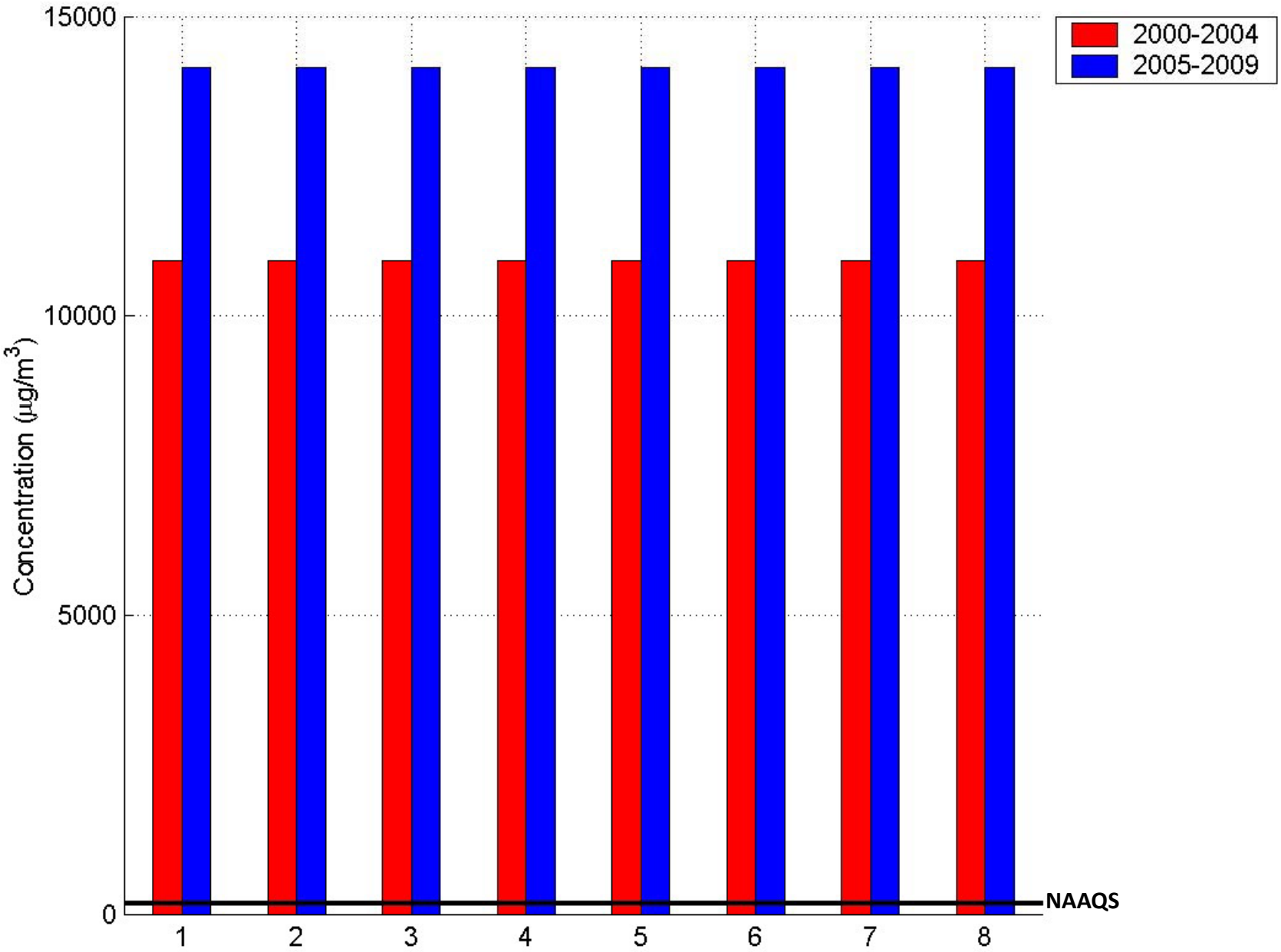
Modeling Scenarios

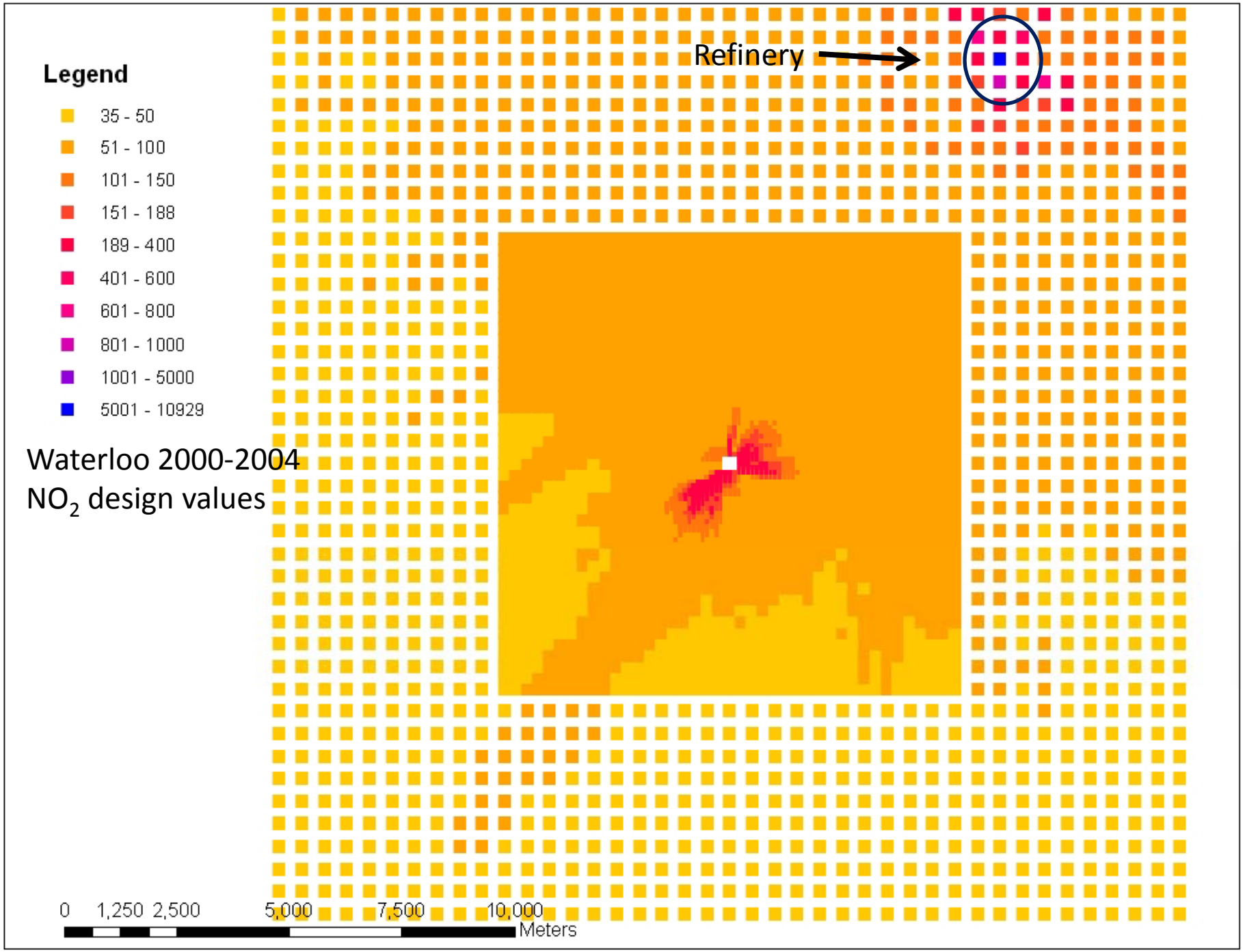
Modeling scenario	Ethanol plant	Refinery	Natural gas plant
1	Baseline	Baseline	Baseline
2	Baseline	Baseline	Increased stack height
3	Baseline	Increased stack height	Baseline
4	Baseline	Increased stack height	Increased stack height
5	Increased stack height for ETH0004	Baseline	Baseline
6	Increased stack height for ETH0004	Baseline	Increased stack height
7	Increased stack height for ETH0004	Increased stack height	Baseline
8	Increased stack height for ETH0004	Increased stack height	Increased stack height

Ethanol plant, refinery, natural gas processing plant: NO_2

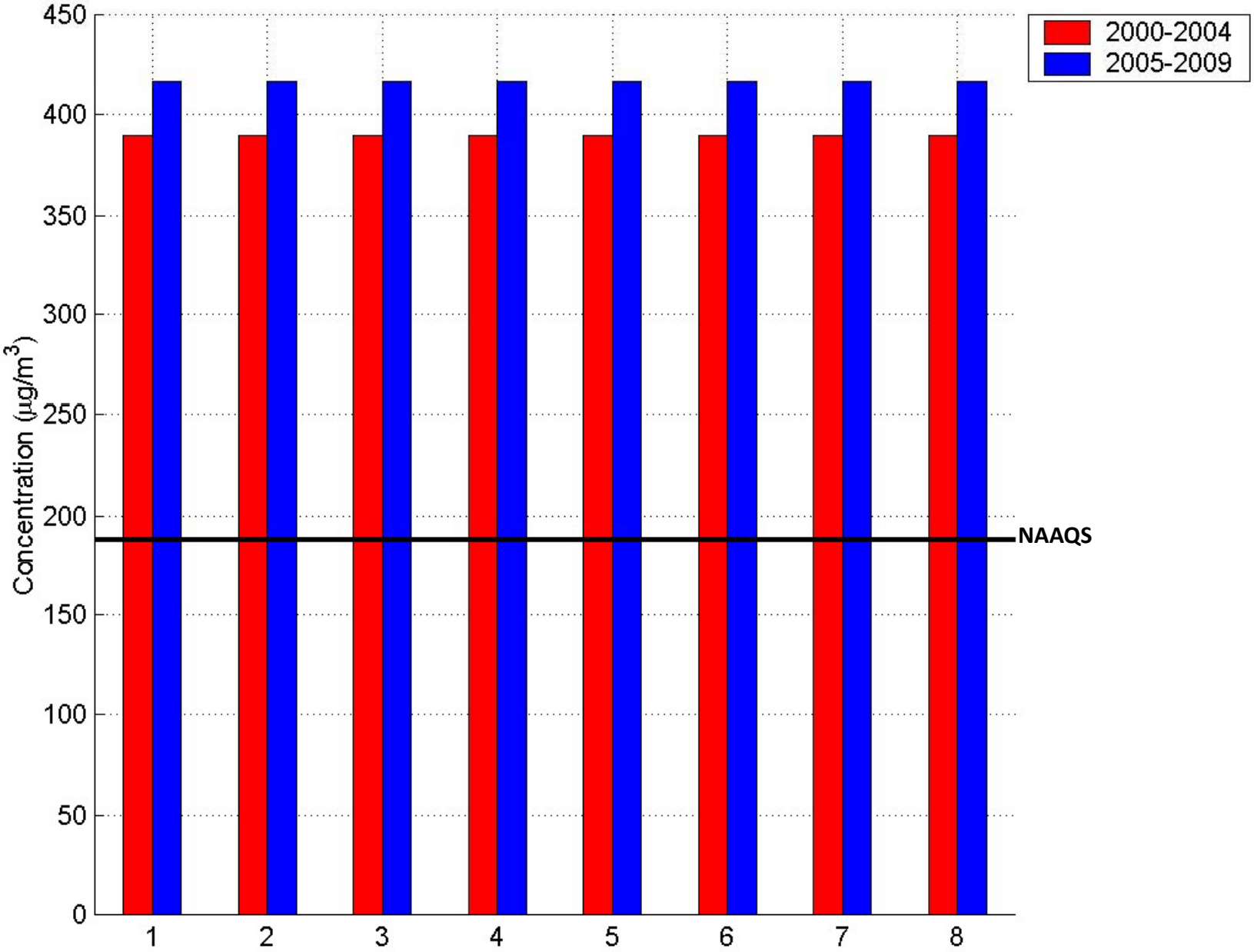


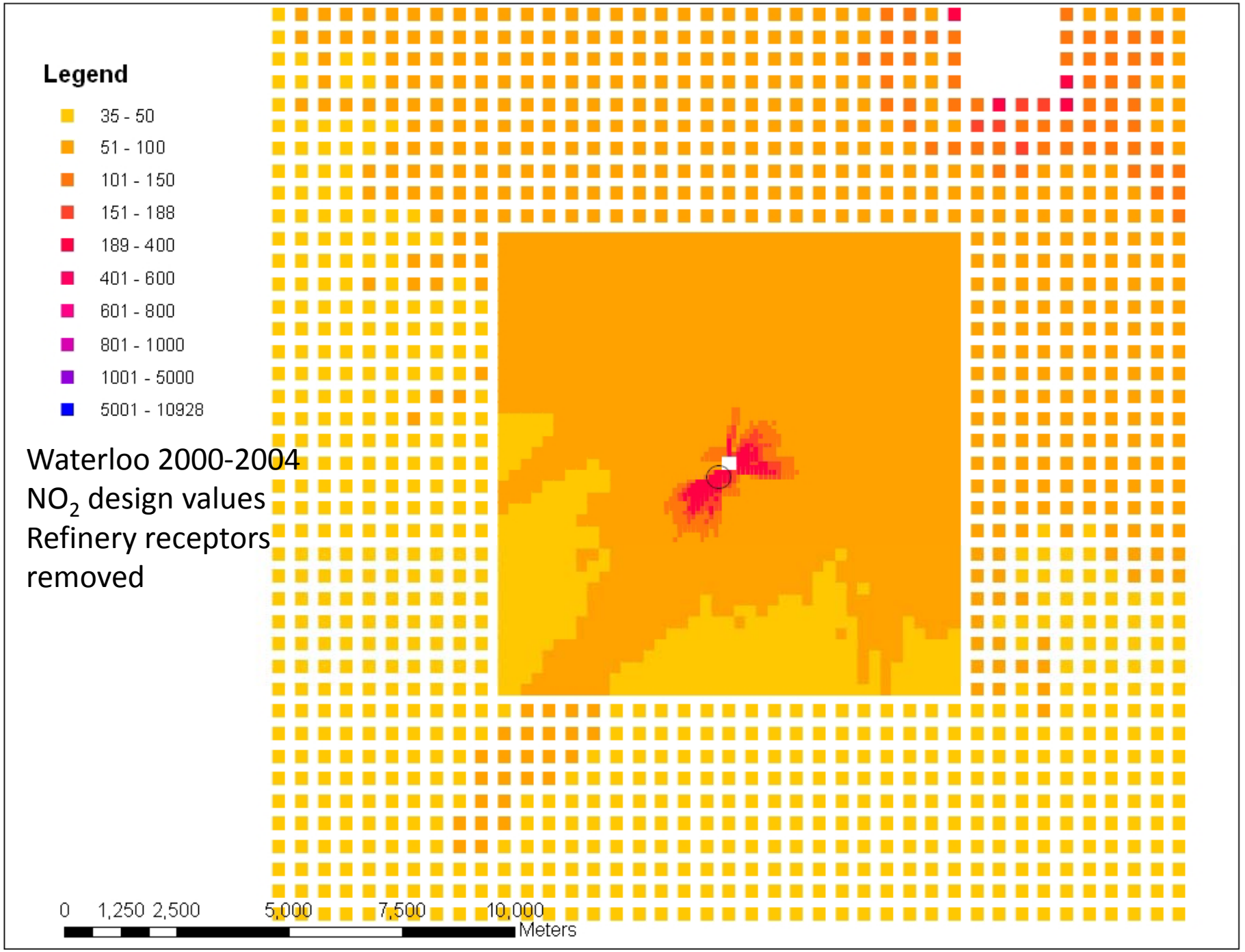
Waterloo maximum NO_2 design values



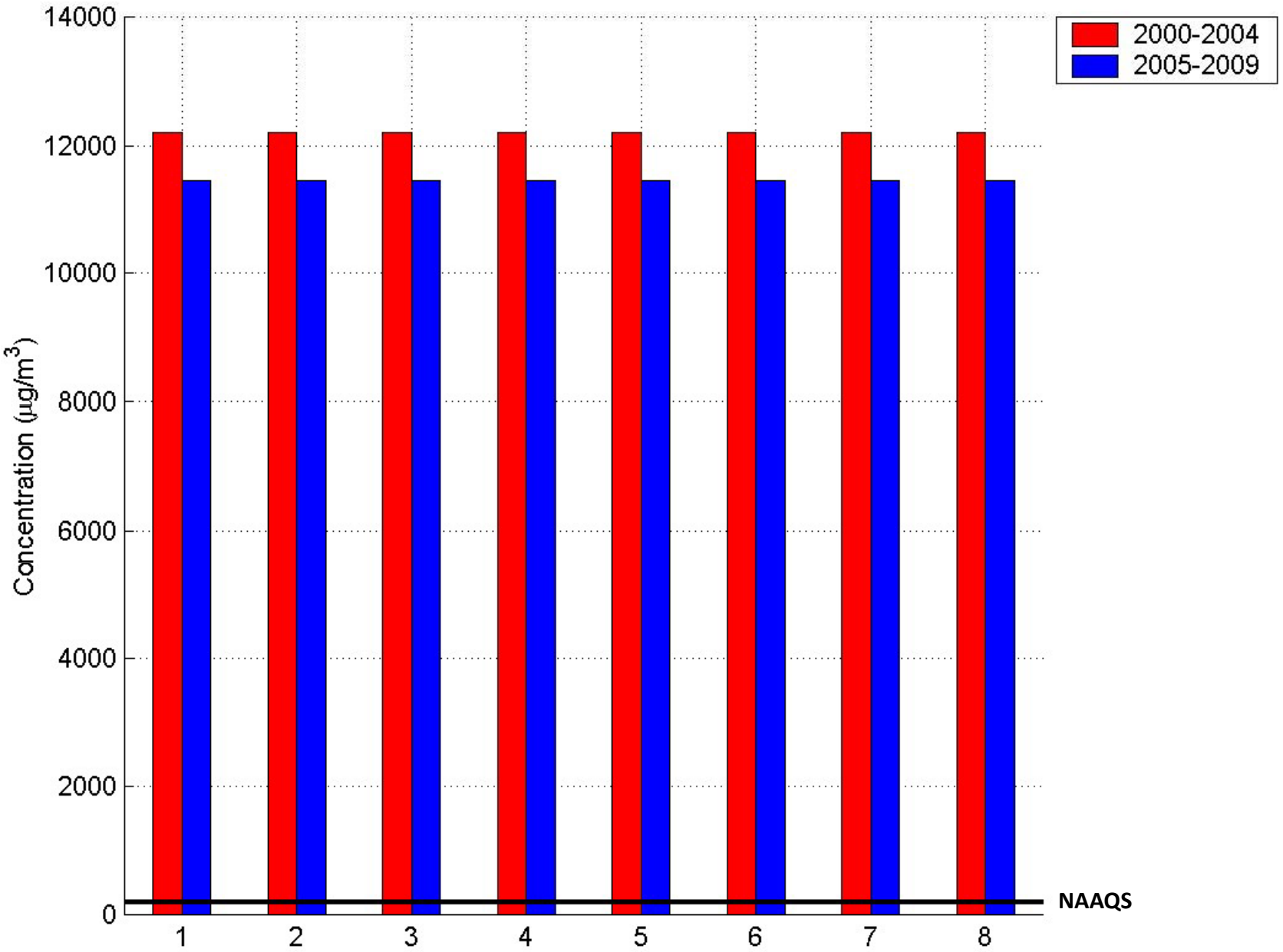

Legend
35 - 50
51 - 100
101 - 150
151 - 188
189 - 400
401 - 600
601 - 800
801 - 1000
1001 - 5000
5001 - 10929
Refinery
Waterloo 2000-2004
NO_2 design values
0 1,250 2,500 5,000 7,500 10,000
Meters

Waterloo maximum NO_2 design values: refinery receptors removed

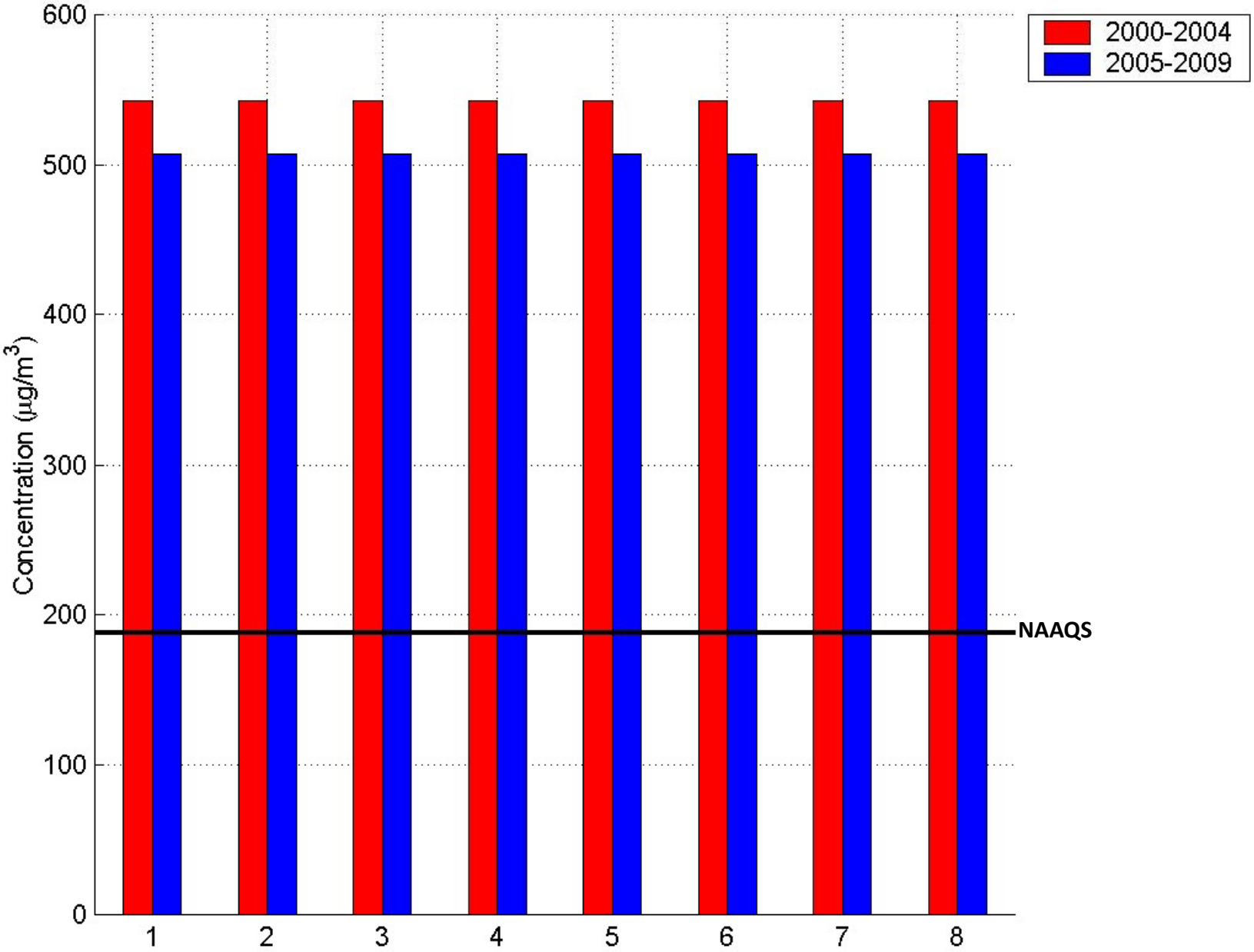



Legend
35 - 50
51 - 100
101 - 150
151 - 188
189 - 400
401 - 600
601 - 800
801 - 1000
1001 - 5000
5001 - 10928
Waterloo 2000-2004
NO_2 design values
Refinery receptors
removed
0 1,250 2,500 5,000 7,500 10,000
Meters

Moline maximum NO_2 design values



Moline maximum NO_2 design values: refinery receptors removed



Findings

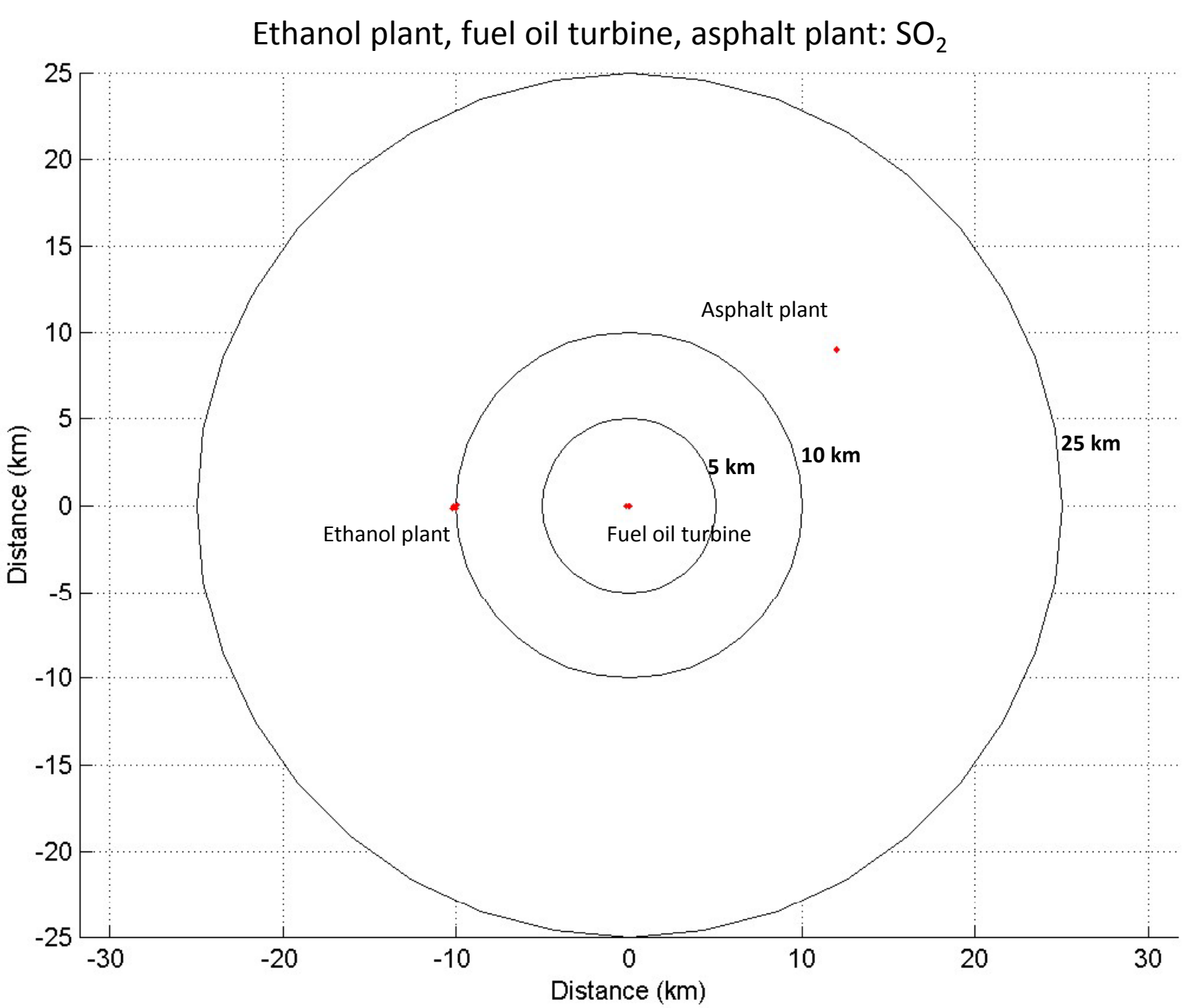
- Maximum design values driven by refinery
  - Overall maximum on refinery property
- Removing refinery on-property receptors results in lower design values
  - Still exceedances (driven by ethanol plant) but lower

Ethanol plant, fuel oil turbine, and asphalt plant (SO_2)

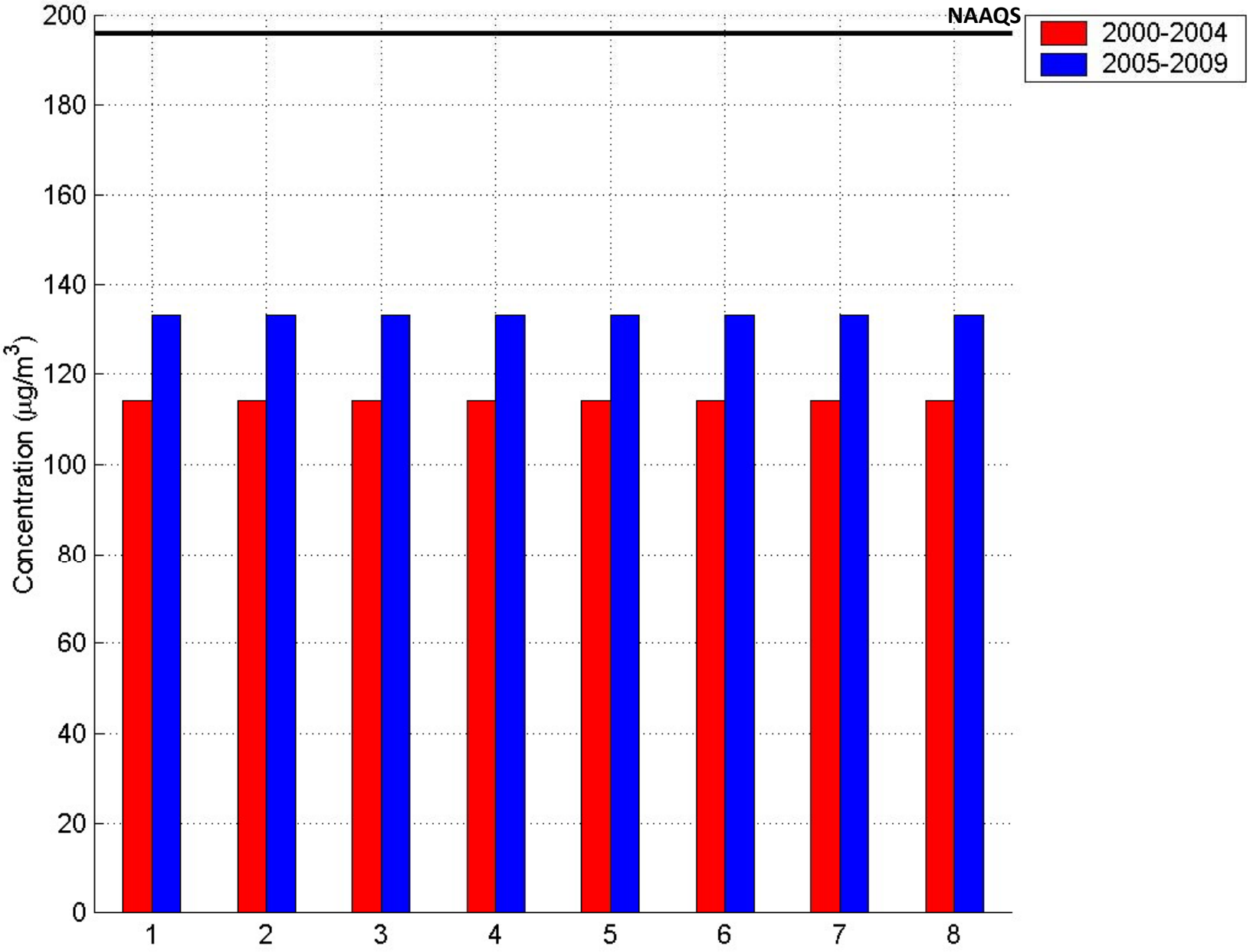
- Modeler: Jennifer Krzak (IA)
- Comparisons between two different surface stations and two 5-year periods
- Receptor grid centered on ethanol plant
- Emissions
  - Ethanol plant: 890 tpy
  - Fuel oil turbine: 417 tpy
  - Asphalt plant: 13 tpy

Modeling Scenarios

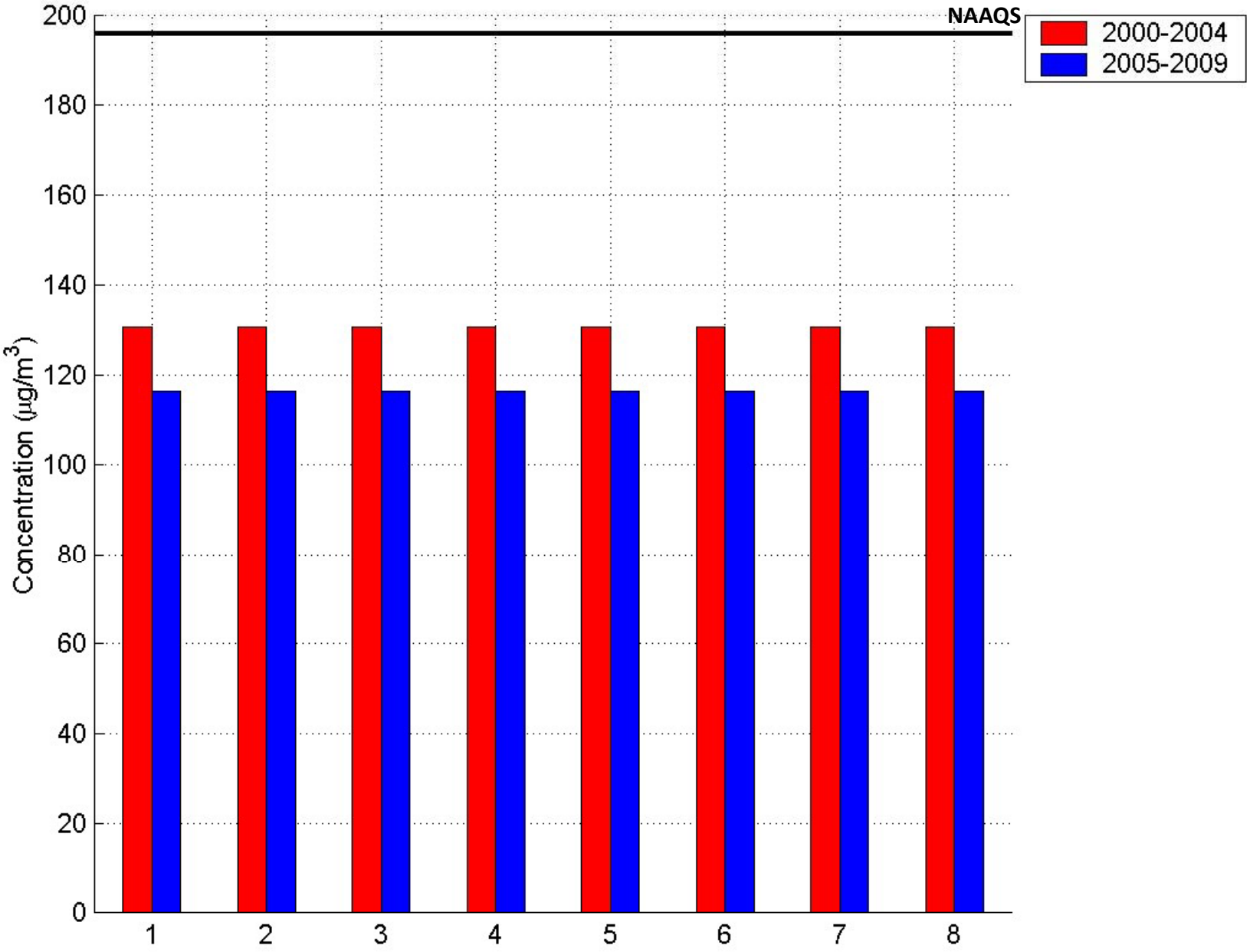
Modeling scenario	Ethanol plant	Fuel oil turbine	Asphalt plant
1	Baseline	Baseline	Baseline
2	Baseline	Baseline	Increased stack height
3	Baseline	Increased stack height	Baseline
4	Baseline	Increased stack height	Increased stack height
5	Increased stack height for ETH0004	Baseline	Baseline
6	Increased stack height for ETH0004	Baseline	Increased stack height
7	Increased stack height for ETH0004	Increased stack height	Baseline
8	Increased stack height for ETH0004	Increased stack height	Increased stack height


Ethanol plant, fuel oil turbine, asphalt plant: SO_2
Asphalt plant
5 km
10 km
25 km
Ethanol plant
Fuel oil turbine
Distance (km)
Distance (km)
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-20
-10
0
10
20
30

Moline maximum SO_2 design values



Waterloo maximum SO_2 design values



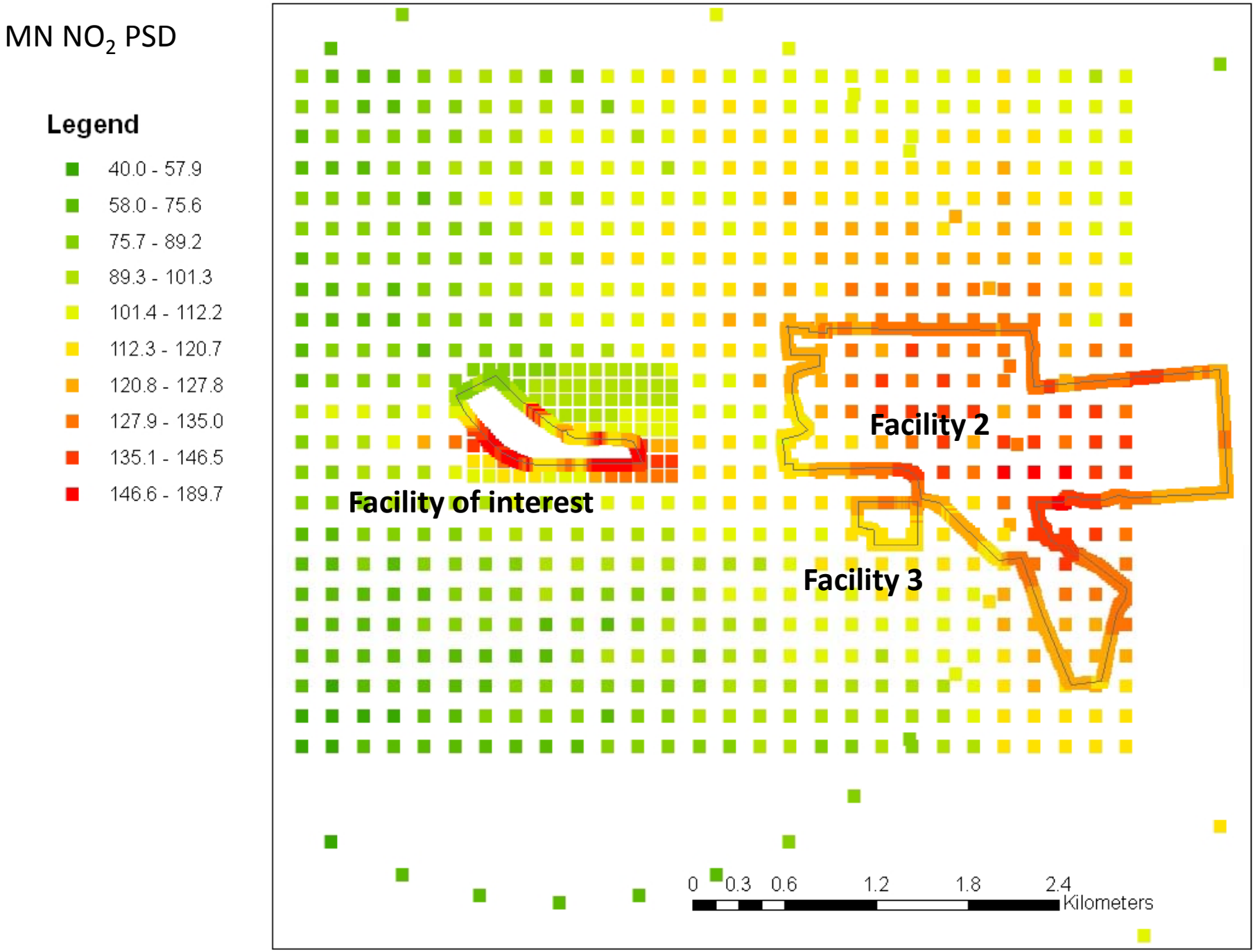
Findings

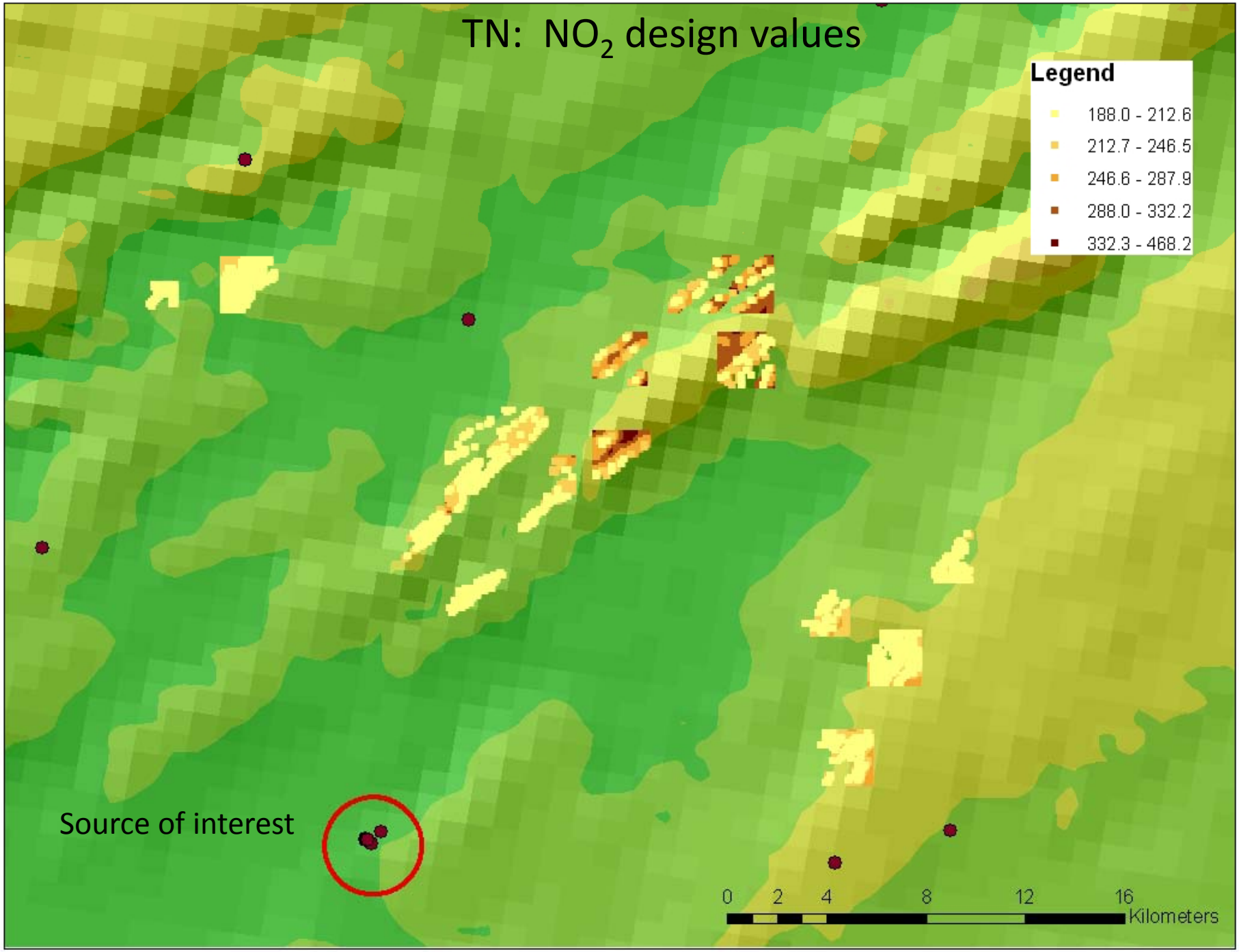
- No NAAQS exceedances
- Maximum design values driven by ethanol plant
- Control strategies have little effect
  - Other sources within facilities driving design values

Real World - Actual cumulative modeling

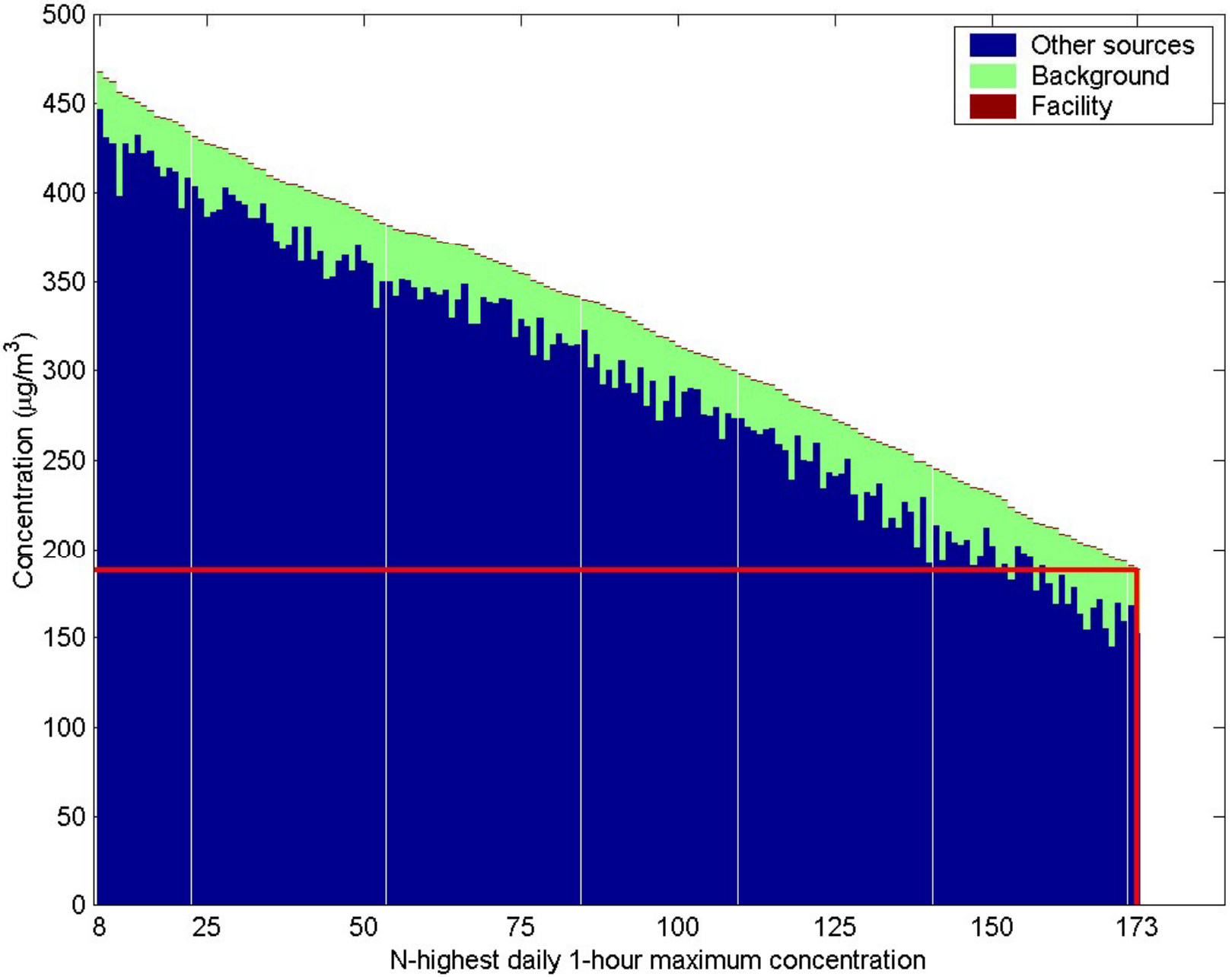
- MN: ceiling tile manufacturer
  - OLM
  - Hourly background
- TN: explosives component manufacturing
  - OLM
  - Hourly background
- WI: coal facility and biomass facility
  - Compared four meteorological sites and OLM vs. PVMRM
  - Compared urban vs. rural for one site
  - Regional background of 48.9 $\mu g/m^3$
- All cases are for NO_2

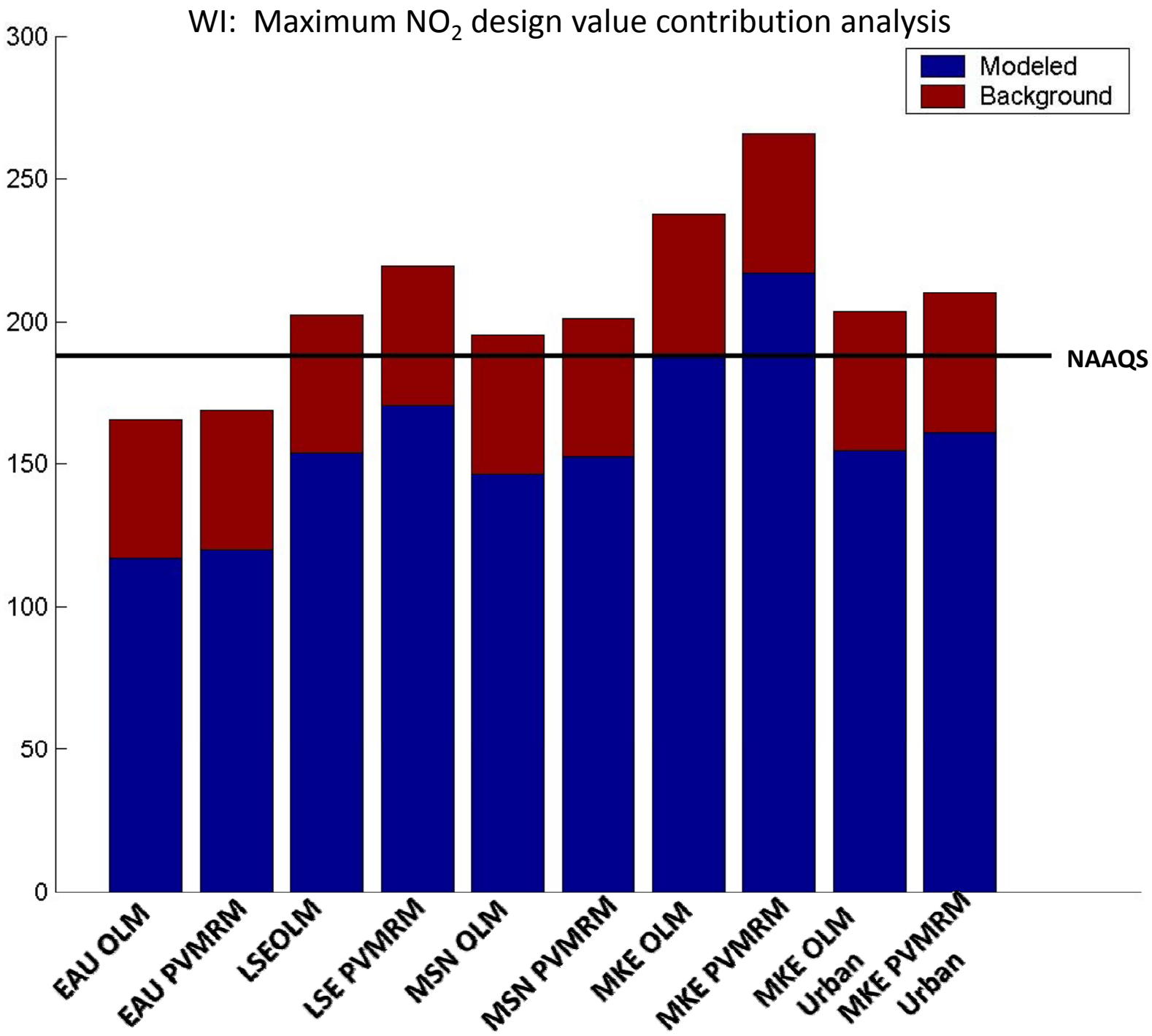
MN NO_2 PSD

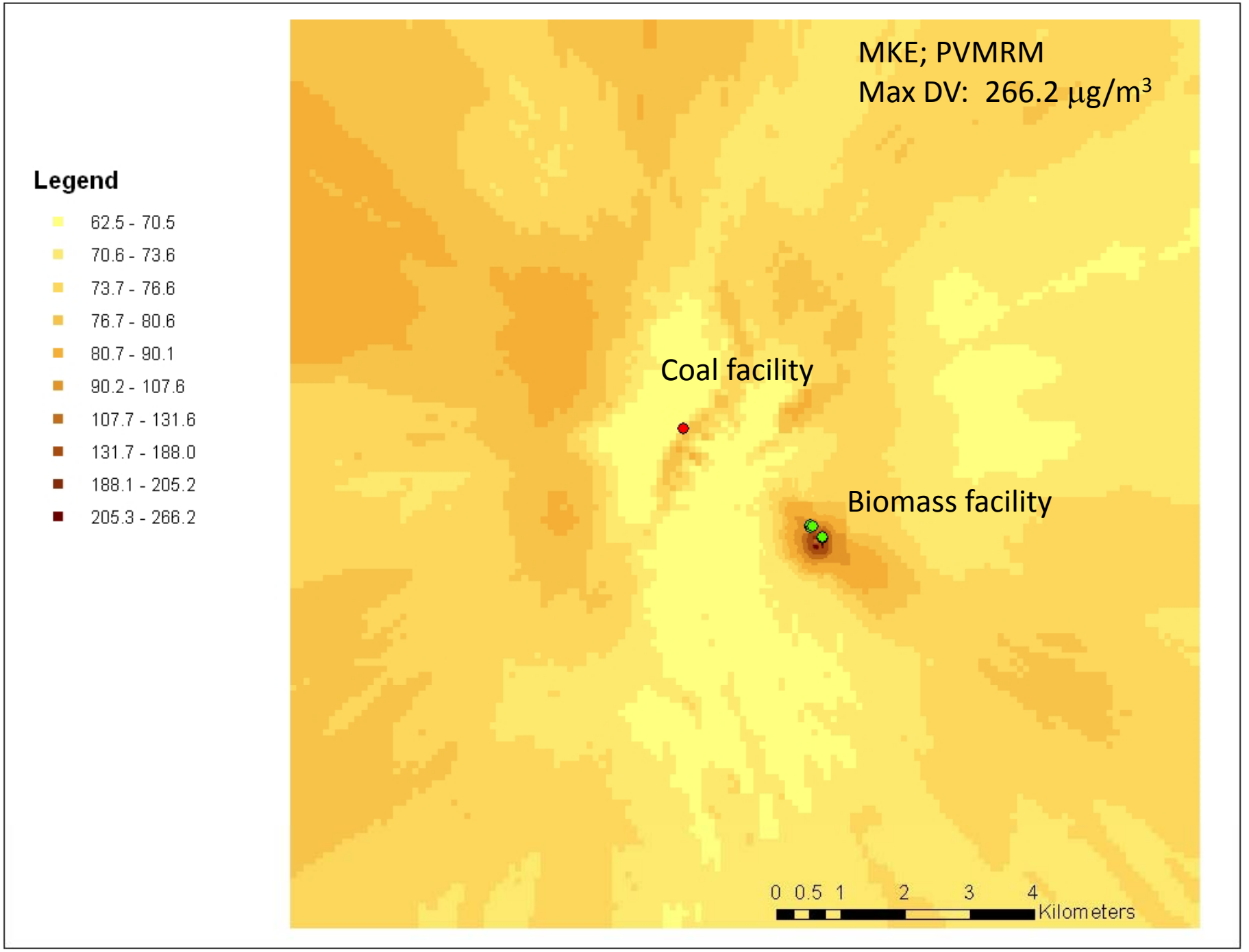

Legend
40.0 - 57.9
58.0 - 75.6
75.7 - 89.2
89.3 - 101.3
101.4 - 112.2
112.3 - 120.7
120.8 - 127.8
127.9 - 135.0
135.1 - 146.5
146.6 - 189.7
Facility of interest
Facility 2
Facility 3
0 0.3 0.6 1.2 1.8 2.4
Kilometers

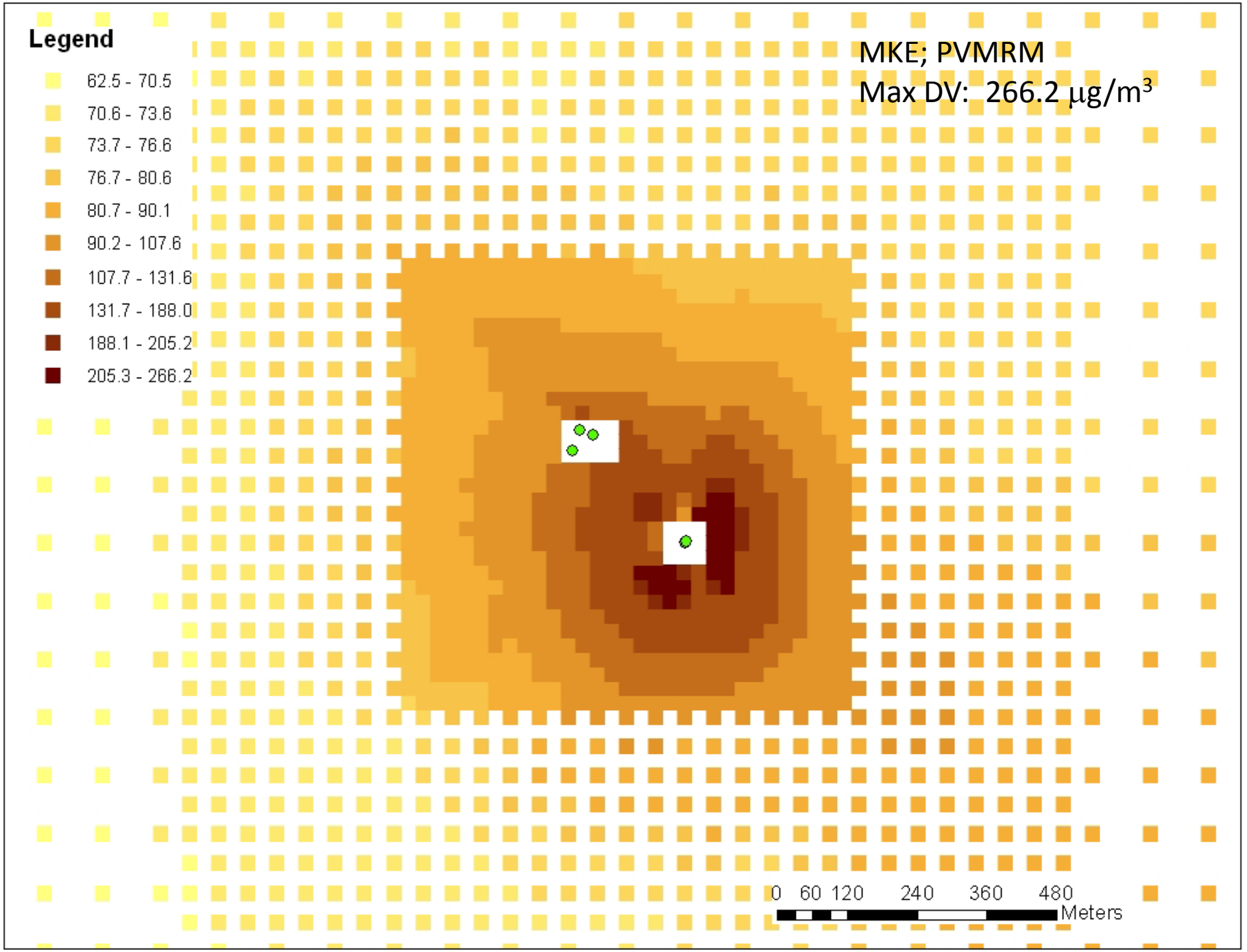

TN: NO_2 design values
Legend
188.0 - 212.6
212.7 - 246.5
246.6 - 287.9
288.0 - 332.2
332.3 - 468.2
Source of interest
0 2 4 8 12 16
Kilometers

TN: Maximum NO_2 design value contribution analysis




WI: Maximum NO2 design value contribution analysis
Modeled
Background
NAAQS
300
250
200
150
100
50
0
EAU OLM
EAU PVMRM
LSEOLM
LSE PVMRM
MSN OLM
MSN PVMRM
MKE OLM
MKE PVMRM
MKE OLM Urban
MKE PVMRM Urban


Legend
62.5 - 70.5
70.6 - 73.6
73.7 - 76.6
76.7 - 80.6
80.7 - 90.1
90.2 - 107.6
107.7 - 131.6
131.7 - 188.0
188.1 - 205.2
205.3 - 266.2
MKE; PVMRM
Max DV: 266.2 µg/m3
Coal facility
Biomass facility
0 0.5 1 2 3 4
Kilometers

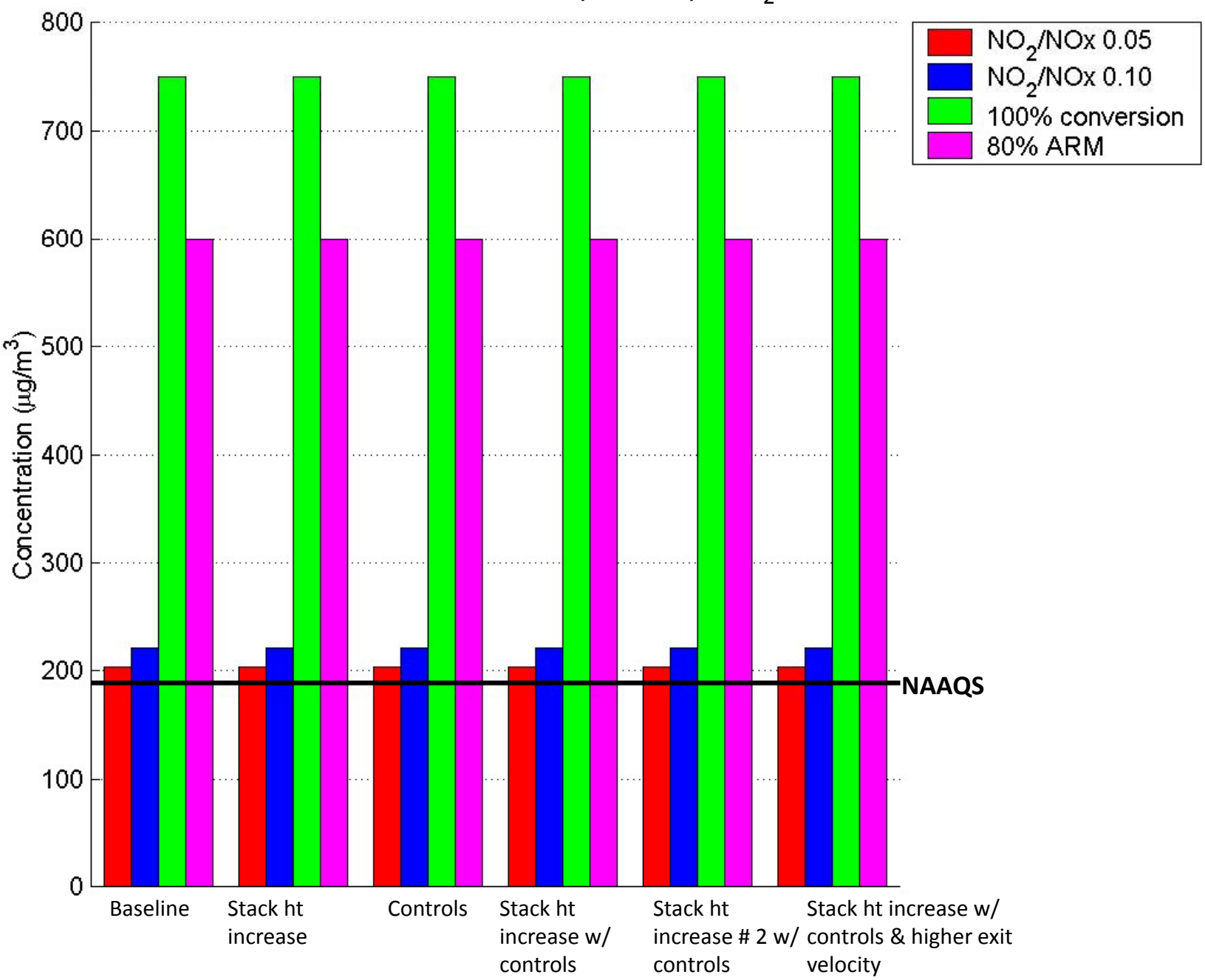

Legend
62.5 - 70.5
70.6 - 73.6
73.7 - 76.6
76.7 - 80.6
80.7 - 90.1
90.2 - 107.6
107.7 - 131.6
131.7 - 188.0
188.1 - 205.2
205.3 - 266.2
MKE; PVMRM
Max DV: 266.2 µg/m³
0 60 120 240 360 480
Meters

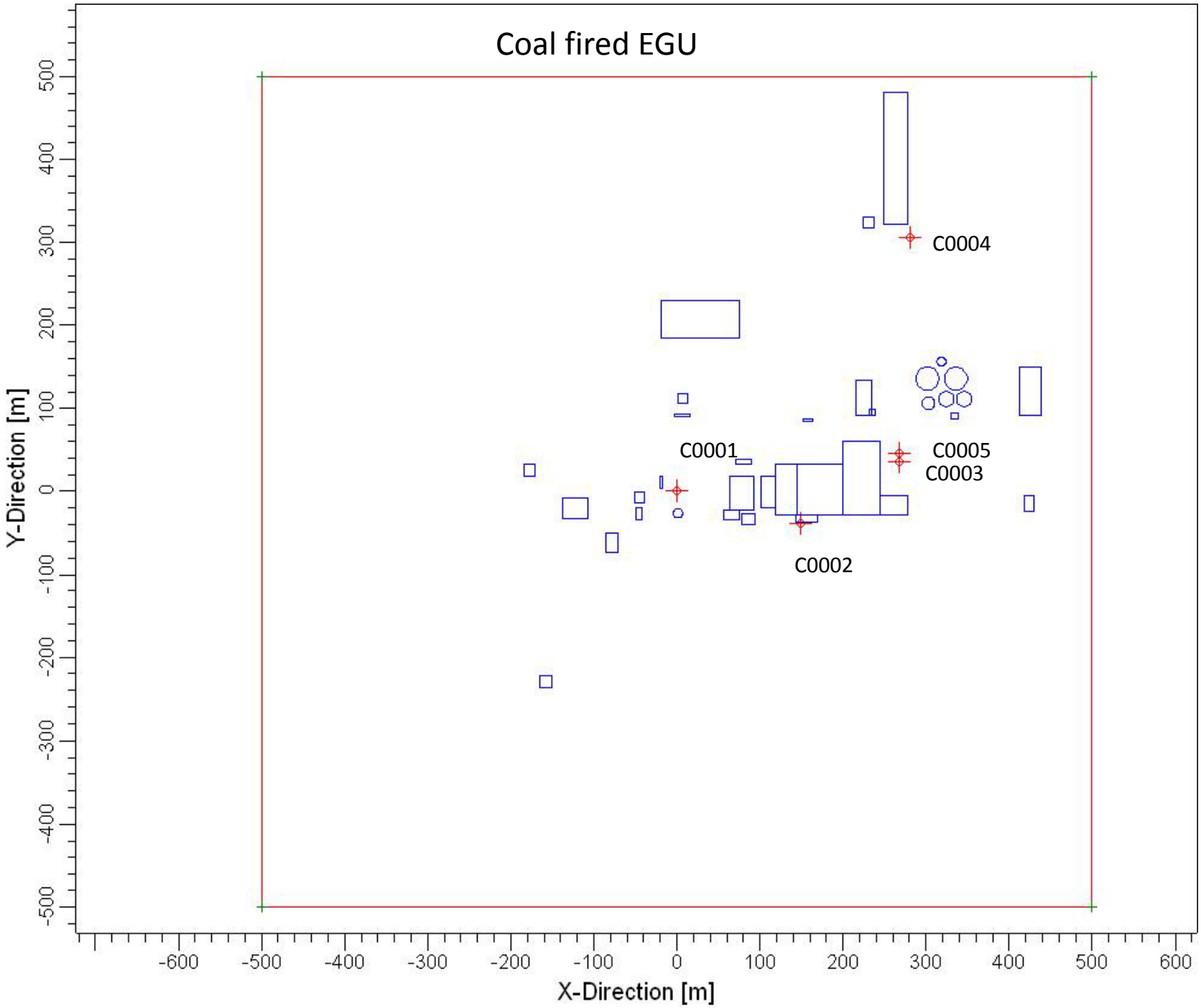
AIWG Scenarios - Intermittent emissions analyses

- March 1, 2011 NO2 memo discusses the emissions of intermittent type sources (emergency generators)
- Several of the single source modeling cases involved sources that could be intermittent in nature
  - Ethanol plant, Coal EGU, biomass facility
- Sensitivity runs for informational purposes only

Coal EGU: NO_2 intermittent emissions

- Coal fired EGU NO_2 maximum design values changed very little among scenarios
- Contribution analyses showed that C0003 (emergency diesel generator) and C0005 (diesel fire water booster pump) are the dominant contributors to maximum DV
  - C0003 and C0004 (fire water pump) were not to exceed 500 hours/year in proposed facility
  - C0003:
    - Emissions 3 g/s (104 tpy)
    - height=6 m
  - C0004:
    - Emissions 0.3 g/s (10 tpy)
    - Height=5 m
  - C0005:
    - Emissions 0.3 g/s (10 tpy)
    - Height=5 m

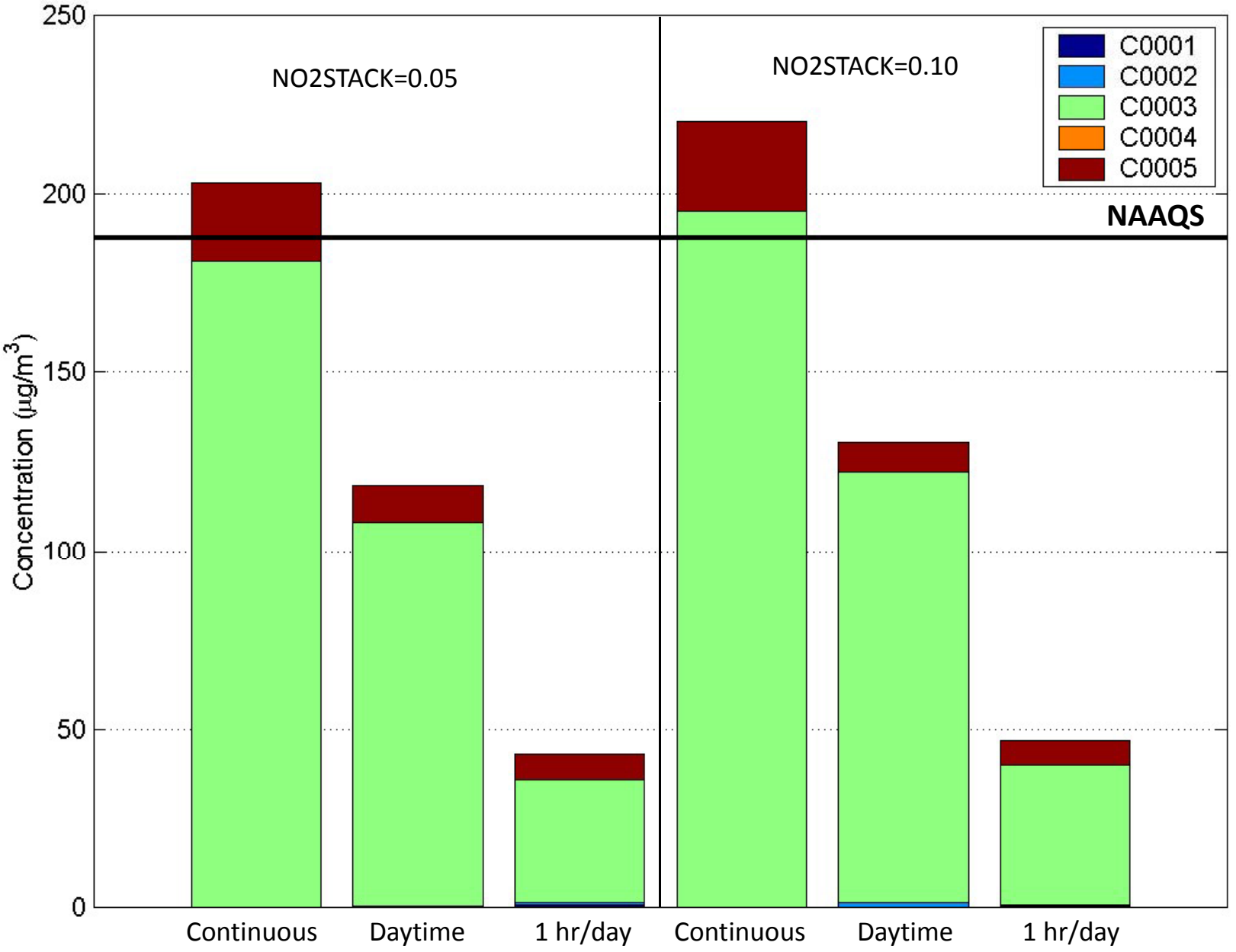

Coal EGU (OAQPS): NO2
NO2/NOx 0.05
NO2/NOx 0.10
100% conversion
80% ARM
Concentration (µg/m3)
800
700
600
500
400
300
200
100
0
NAAQS
Baseline
Stack ht increase
Controls
Stack ht increase w/ controls
Stack ht increase # 2 w/ controls
Stack ht increase w/ controls & higher exit velocity


Coal fired EGU
C0004
C0001
C0005
C0003
C0002
Y-Direction [m]
X-Direction [m]
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-500
-400
-300
-200
-100
0
100
200
300
400
500
600

Coal EGU: NO_2 intermittent emissions

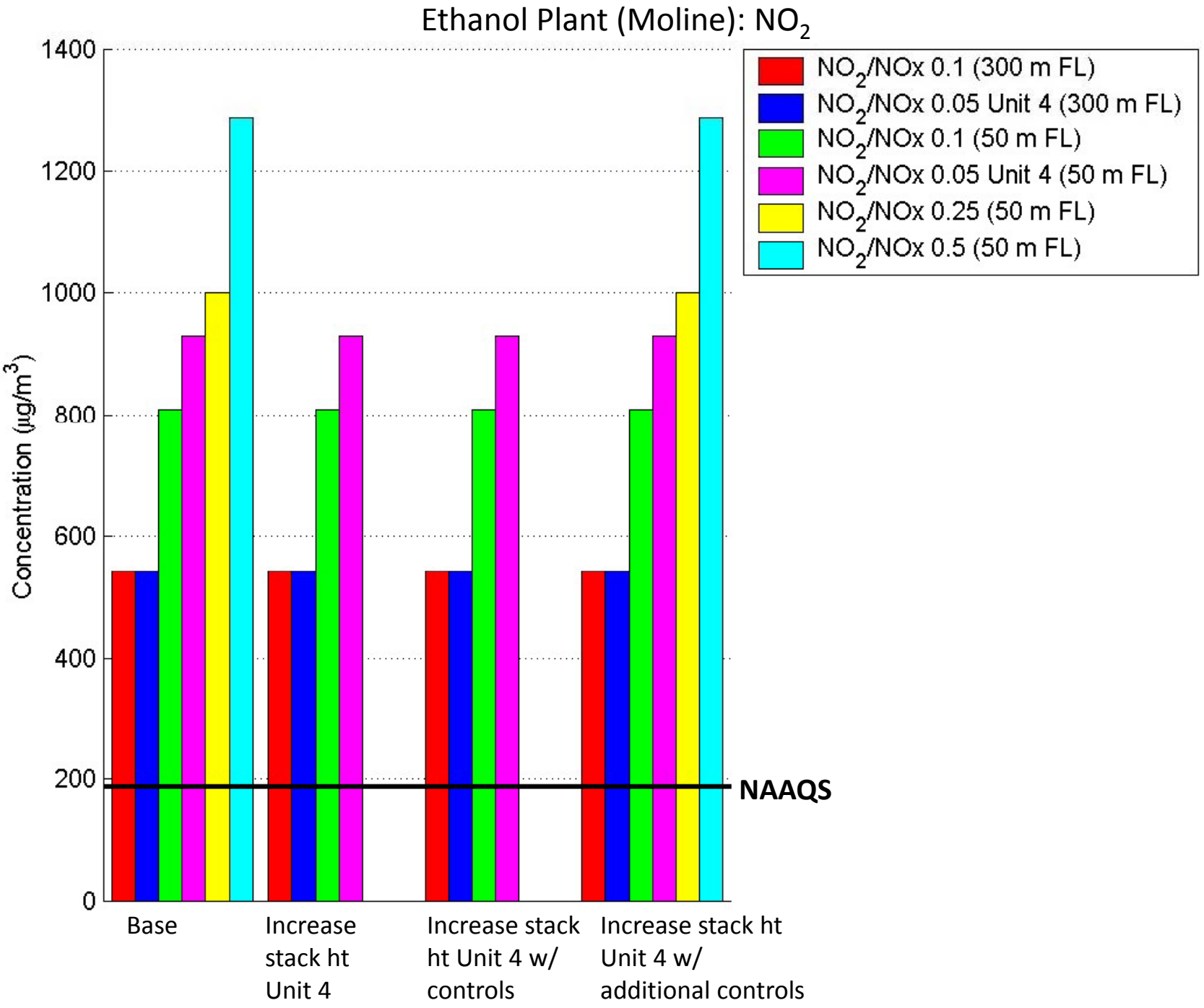
- Modeled sources C0003-C0005 with following emission limits
  - 1 hour/day (noon-1:00 PM)
  - 6:00 AM – 6:00 PM (daytime operations)
- Modeled with baseline stack parameters & emissions
  - Compared NO2STACK ratio of 0.05 and 0.1

Source contributions to maximum design values

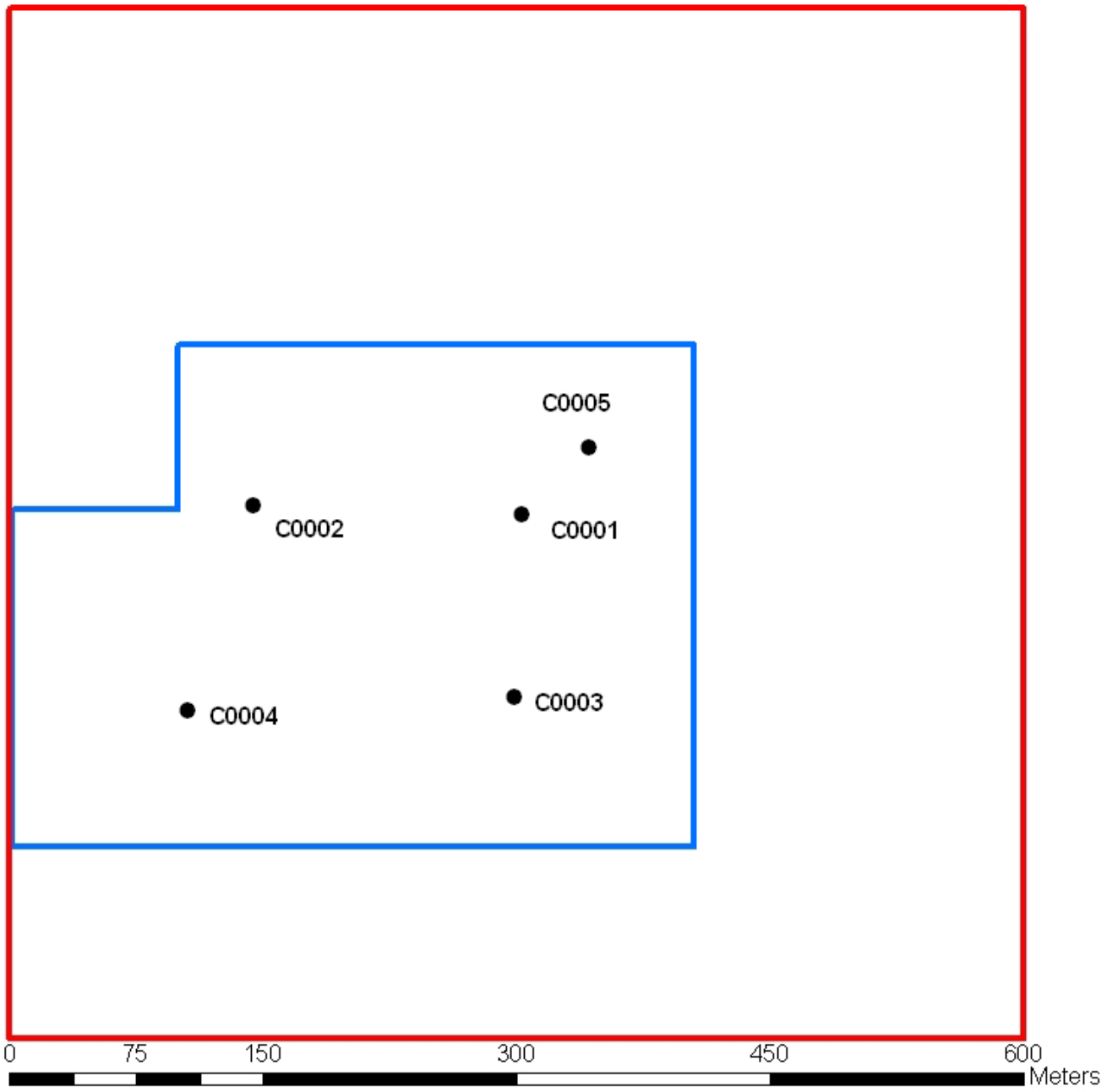


Ethanol plant: NO_2 intermittent emissions

- Ethanol plant maximum design values changed very little among scenarios
- Contribution analyses showed that C0003 (emergency diesel generator) is the dominant contributor to maximum DV
  - C0003 was not to exceed 500 hours/year in proposed facility
  - C0003 emissions 1.2 g/s, release height 2 m

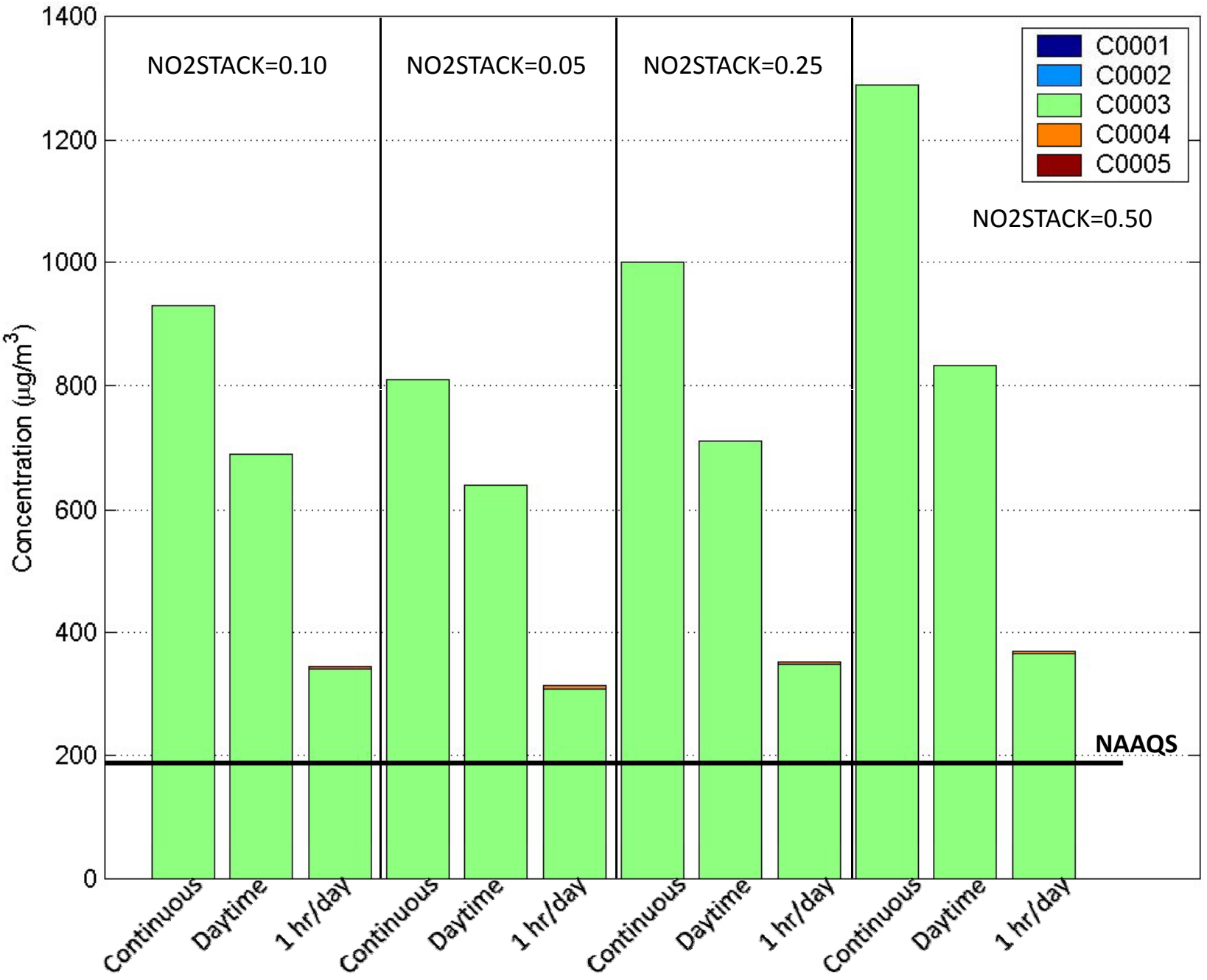

Ethanol Plant (Moline): NO2
NO2/NOx 0.1 (300 m FL)
NO2/NOx 0.05 Unit 4 (300 m FL)
NO2/NOx 0.1 (50 m FL)
NO2/NOx 0.05 Unit 4 (50 m FL)
NO2/NOx 0.25 (50 m FL)
NO2/NOx 0.5 (50 m FL)
Concentration (µg/m3)
1400
1200
1000
800
600
400
200
0
NAAQS
Base
Increase stack ht Unit 4
Increase stack ht Unit 4 w/ controls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

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

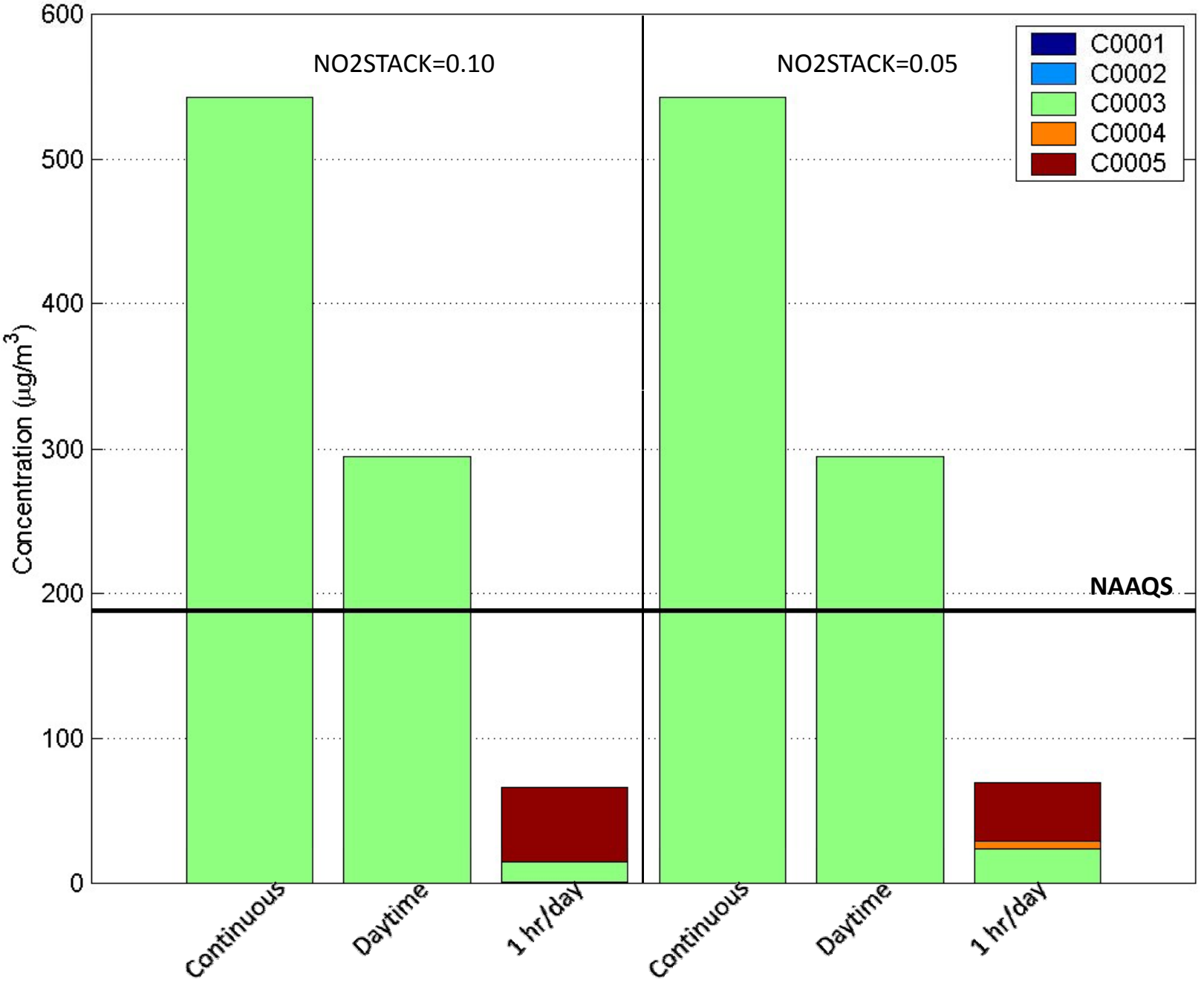


Ethanol plant: NO_2 intermittent emissions

- Modeled C0003 with following emission limits
  - 1 hour/day (noon-1:00 PM)
  - 6:00 AM – 6:00 PM (daytime operations)
- Modeled with baseline stack parameters & emissions
  - Compared NO2STACK ratio of 0.05, 0.1, 0.25, and 0.5
  - Fenceline 50 m and 300 m

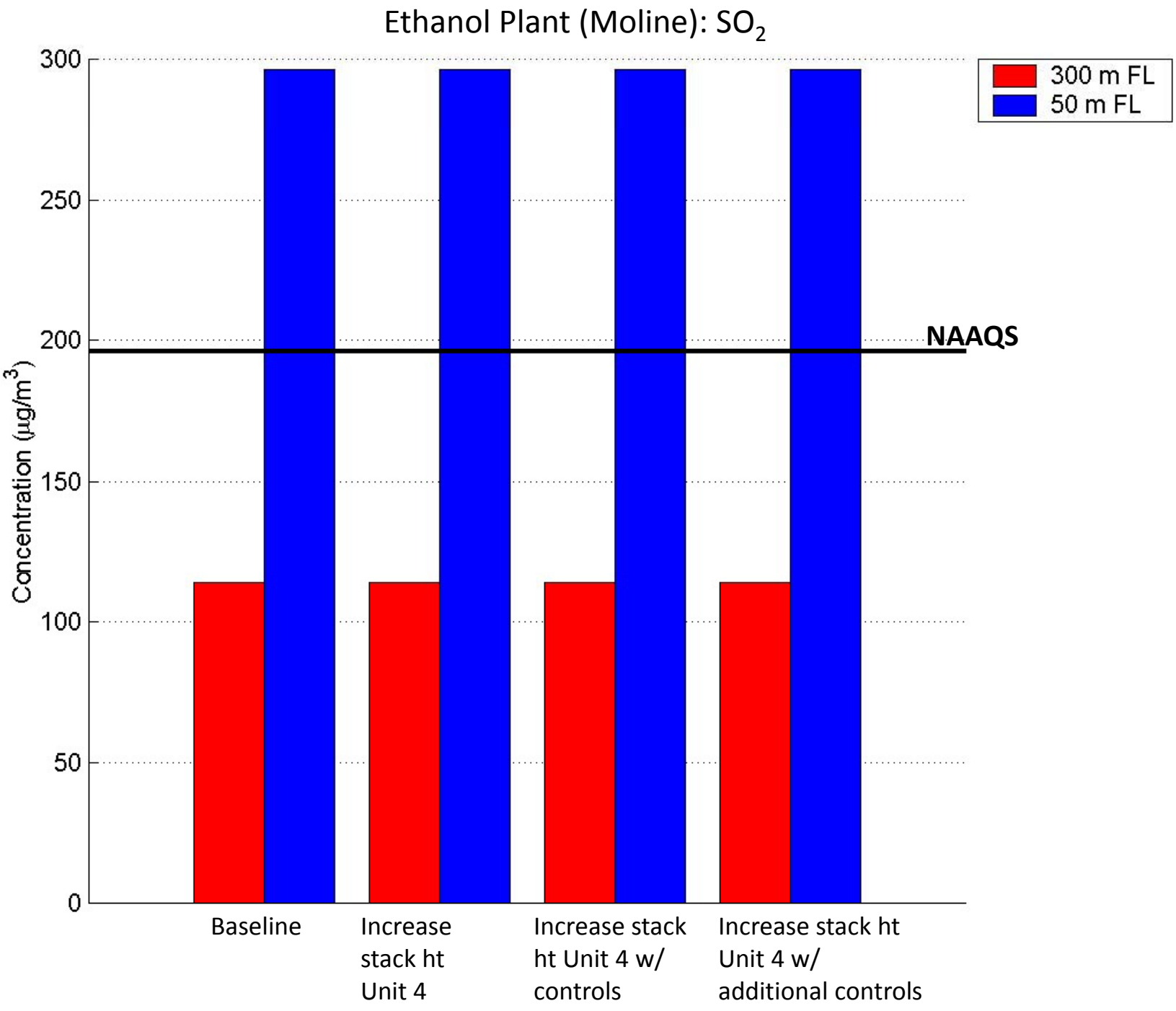

Source contributions to maximum design values (50 m FL)
NO2STACK=0.10
NO2STACK=0.05
NO2STACK=0.25
NO2STACK=0.50
C0001
C0002
C0003
C0004
C0005
NAAQS
Concentration (µg/m3)
1400
1200
1000
800
600
400
200
0
Continuous
Daytime
1 hr/day
Continuous
Daytime
1 hr/day
Continuous
Daytime
1 hr/day
Continuous
Daytime
1 hr/day

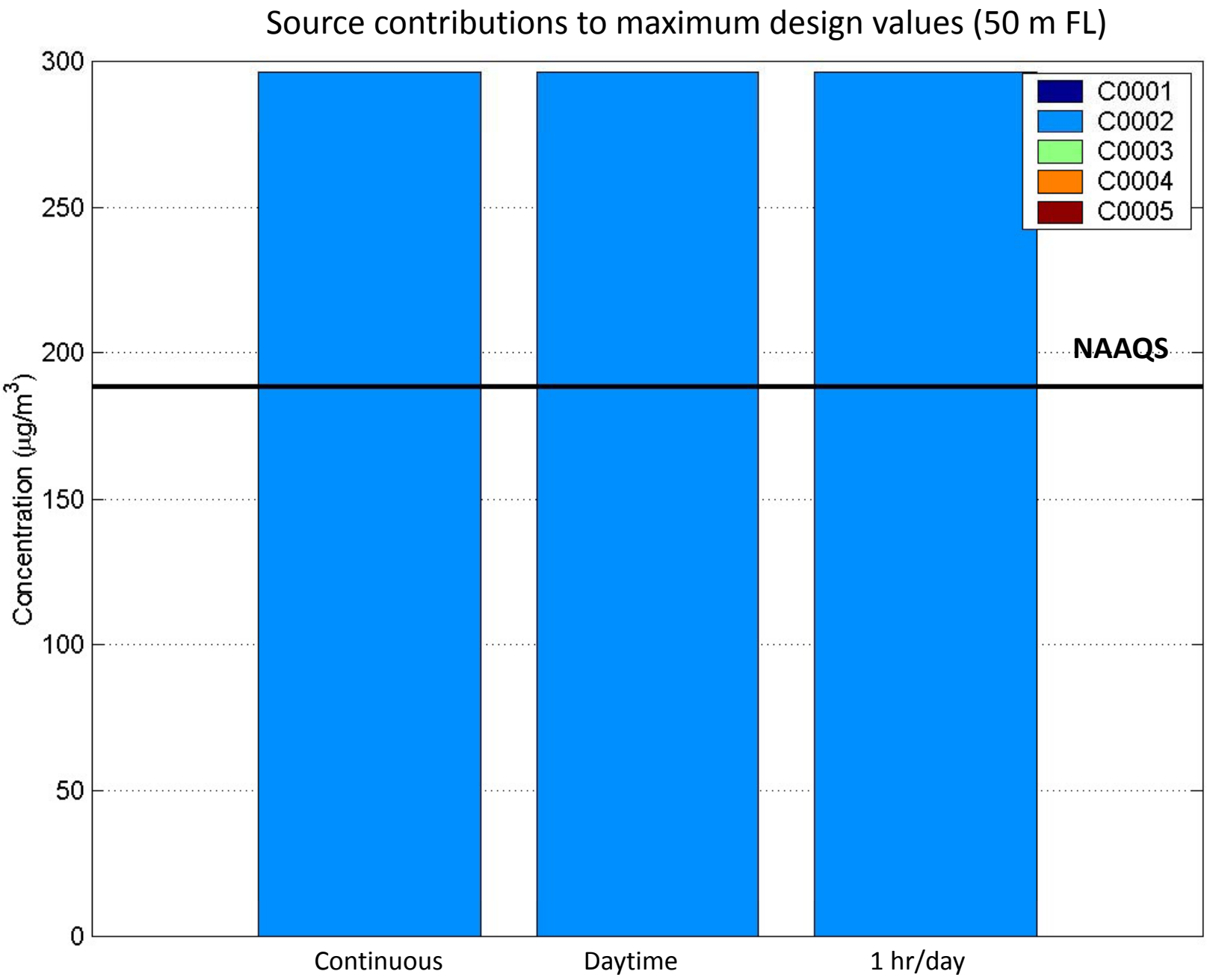
Source contributions to maximum design values (300 m FL)



Ethanol plant: SO_2

- Applied same methodology to SO2 for C0003
- C0003 SO2 emissions 0.1 g/s h=2 m


Ethanol Plant (Moline): SO_2
300 m FL
50 m FL
NAAQS
Concentration (µg/m^3)
300
250
200
150
100
50
0
Baseline
Increase stack ht Unit 4
Increase stack ht Unit 4 w/ controls
Increase stack ht Unit 4 w/ additional controls


Source contributions to maximum design values (50 m FL)
300
250
200
150
100
50
0
Concentration (µg/m3)
C0001
C0002
C0003
C0004
C0005
NAAQS
Continuous
Daytime
1 hr/day

Ethanol plant findings

- For NO_2, restricting C0003 emissions lowers maximum design values
- There are still exceedances at 50 m fenceline, increasing distance to 300 m lowers design values below NAAQS
- For SO_2, restricting C0003 at 50 m does not change maximum design values
  - C0001 driving max DV
  - C0003 SO_2 emissions much lower than C0003 NO_2 emissions
  - No NAAQS exceedances for SO_2 at 300 m fenceline, did not apply C0003 restrictions.

Intermittent emissions-summary

- In some cases, limiting intermittent type emissions to certain hours could mitigate such sources' contributions to NAAQS violations, especially where such sources could be driving design values

Acknowledgements

- We want to thank all the members of the Work Group for their time and efforts
- We hope this work proves beneficial and that members came away with information that will help in future applications

Next steps

- Continue AIWG process, looking at source groupings, cumulative, adding background (different tier approach), evaluate guidance issues and sensitivity, etc.
- Loop in more state experiences with permit modeling
- Finalize Draft AIWG report as needed.

Discussion/Input

- Would appreciate input on the types of sources that are a concern based on stakeholder initial investigations.
- Issues/items we should investigate?
- State modeling experiences?