2014 Colorado Oil and Gas Drill Rig Field Study

Model Evaluation Database

Colorado Field Study Workgroup

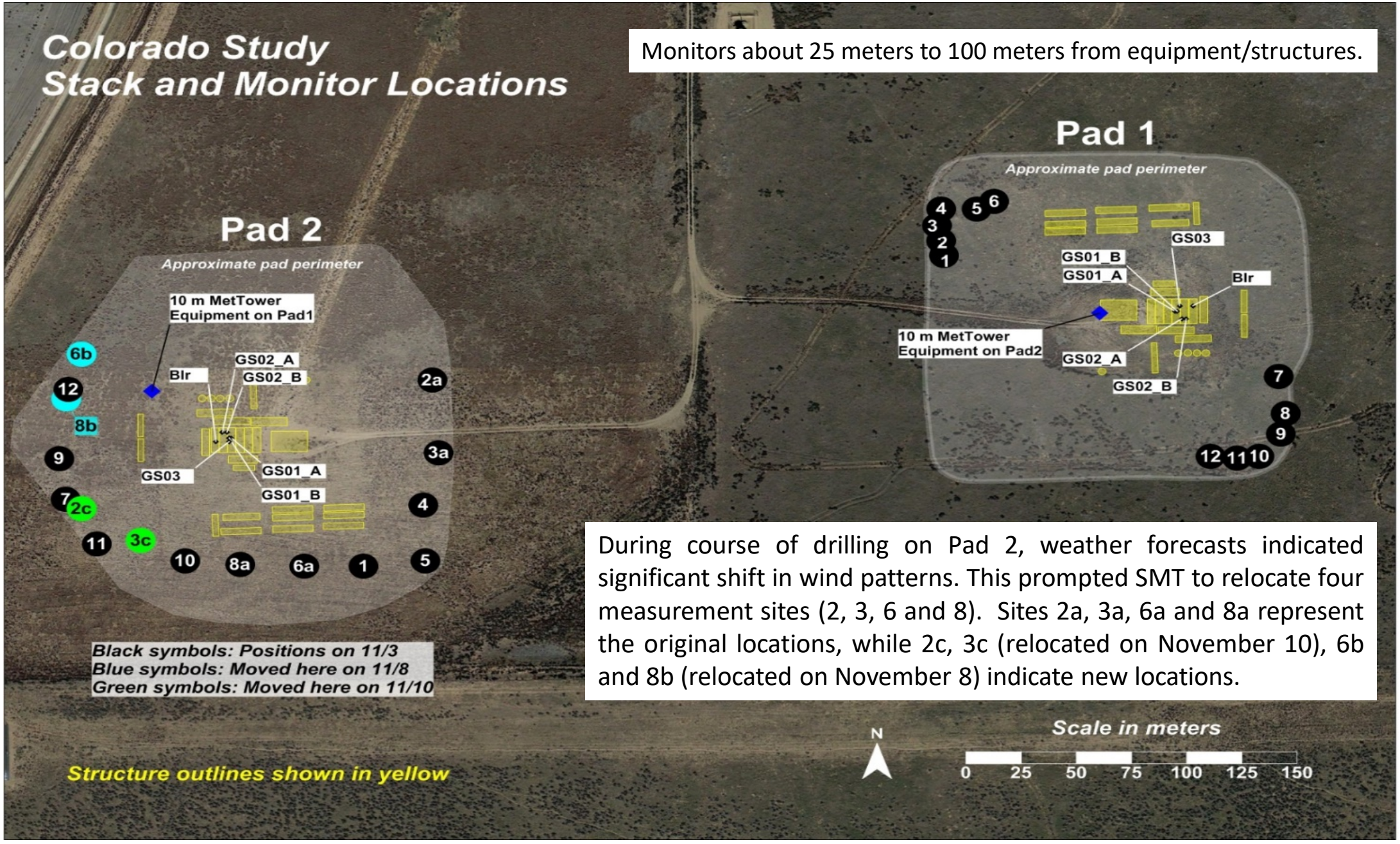
ERM, API, AECOM, Earth Systems Sciences, Bunyak Consulting (under contract with WESTAR), WESTAR-WRAP, City and County of Denver, EPA, and BLM

OVERVIEW: 2014 Colorado Field Study

- **Drill Rig 1-hour Nitrogen Dioxide (NO_2) Collaborative Monitoring Study (2014 Colorado Field Study):**
  - Bureau Land Management (BLM) initiated the project to improve information about drill rig impacts for National Environmental Policy Act (NEPA) assessments.
  - Co-Sponsors: BLM and the American Petroleum Institute (API).
  - Supporting Groups: Western States Air Resource Council (WESTAR) provided project oversight and was advised by a Study Management Team (SMT) with representation from BLM, API, EPA, and Wyoming Department of Environmental Quality – Air Quality Division (WDEQ-AQD).
  - A Petroleum Company located in Colorado provided access to the test sites and logistical support to the contractor measurement teams.
- **Objectives:**
  - Measure drill rig diesel generator emissions and associated ambient air concentrations near drill rigs.
  - Collect data to evaluate EPA's dispersion air quality model (AERMOD) ability to effectively characterize air quality impacts resulting from drill rig operations and associated emissions.
  - Use data and results of model evaluation to determine:
    - Whether improvements to AERMOD may be needed to more accurately represent these sources; and
    - How NEPA decisions could account for uncertainty associated with these sources.

OVERVIEW: 2014 Colorado Field Study

- **Time Period:** October 10, 2014 to November 16, 2014.
- **Study Sites:** Two adjacent well pad sites in Denver-Julesburg Basin near Platteville, Colorado.
  - Three oil and gas wells drilled near center of each pad. Each well took six to ten days to drill.
- **Equipment (same equipment used at each well pad):**
  - Drill rig powered by two diesel fired Caterpillar 3512B generators (Genset 01 and Genset 02) and one diesel fired Caterpillar C27 generator (Genset 03). Diesel engines rated and verified as EPA Tier 2 engines.
  - Exhaust from Gensets 01 and 02 split between two separate stacks each (1-2 meters apart), while Genset 03 exhaust routed to single stack. Emissions measured from five stacks associated with three diesel generators.
  - Boiler used during cold weather.
  - Other smaller potential sources of NOx included diesel generators for night-time lighting, front-end loader, forklift, portable flare, and gasoline and diesel on-road vehicles. Emissions not explicitly accounted in datasets.
- **Datasets Collected from 2014 Colorado Field Study (5-minute and 1-hour averaging periods):**
  - Nitric Oxide (NO), NOx, and NO_2 stack concentrations monitored from 3 diesel engines that powered drilling rig.
  - Carbon Dioxide (CO_2), Ozone (O_3), temperature, and pressure of engine exhaust monitored to obtain exhaust flow rates and to calculate mass emissions of NO_x and NO_2.
  - Ambient concentrations of NO_x and NO_2 monitored at 12 sites located upwind, downwind, crosswind to drill rig.
  - Ambient levels of O_3 monitored at one upwind and one downwind site. Ozone is important because pollutant regulates conversion of NO emissions to NO_2 through ozone titration.
  - Wind speed and direction, temperature, humidity, rainfall monitored from 10-m tower to understand dispersion of emissions.


Colorado Study
Stack and Monitor Locations
Monitors about 25 meters to 100 meters from equipment/structures.
Pad 1
Approximate pad perimeter
4
5
6
3
2
1
GS03
GS01_B
GS01_A
Blr
10 m MetTower
Equipment on Pad2
GS02_A
GS02_B
7
8
9
12
11
10
Pad 2
Approximate pad perimeter
10 m MetTower
Equipment on Pad1
6b
12
Blr
GS02_A
GS02_B
2a
8b
9
3a
GS03
GS01_A
GS01_B
7
2c
4
11
3c
10
8a
6a
1
5
Black symbols: Positions on 11/3
Blue symbols: Moved here on 11/8
Green symbols: Moved here on 11/10
During course of drilling on Pad 2, weather forecasts indicated significant shift in wind patterns. This prompted SMT to relocate four measurement sites (2, 3, 6 and 8). Sites 2a, 3a, 6a and 8a represent the original locations, while 2c, 3c (relocated on November 10), 6b and 8b (relocated on November 8) indicate new locations.
N
Scale in meters
0
25
50
75
100
125
150
Structure outlines shown in yellow

OVERVIEW: Colorado Field Study Workgroup

- **Purpose:** Evaluate datasets collected from 2014 Colorado Field Study and develop Model Evaluation Database.
- **Workgroup Kick-Off Meeting:** January 2016
- **Participants:** EPA (Lead), BLM, ERM, API, AECOM, Earth Systems Sciences (ESS), Bunyak Consulting (under contract with WESTAR), WESTAR-WRAP, City and County of Denver.
- **Delays:** Changes in structure of workgroups, changes in contractor support, and length of review process.
- **Workgroup Phases:**
  - **Measurement Datasets (Released in August 2015):** Amec Foster Wheeler (contractor) developed original datasets that contained all measurement data collected from 2014 Colorado Field Study. Datasets were subjected to comprehensive quality control/quality assurance (QC/QA) procedures.
  - **2014 Colorado Model Evaluation Database (Released in August 2020):** Developed database containing datasets that are model-ready for EPA's air quality dispersion model and model evaluation studies. Effort included reviewing datasets for missing and questionable data points and applying analytical techniques to fill in missing or correct questionable data points to have continuous and comprehensive datasets for model evaluation studies.
  - **2014 Colorado Model Evaluation Report (Current Phase):** Conduct sensitivity studies with AERMOD (EPA's air quality model) to understand the model's ability to predict air quality impacts from drill rig operations.

OVERVIEW: 2014 Colorado Model Evaluation Database

- **Background:** It is important to have measurement datasets that are not missing data points for model simulations. Further, measurement data cannot be used "as-is" or directly input into model simulations. As a result, the Workgroup identified data points reported as missing or appeared to be outliers and filled those data points using various analytical techniques. The Workgroup also re-structured the datasets into acceptable formats for model simulations.

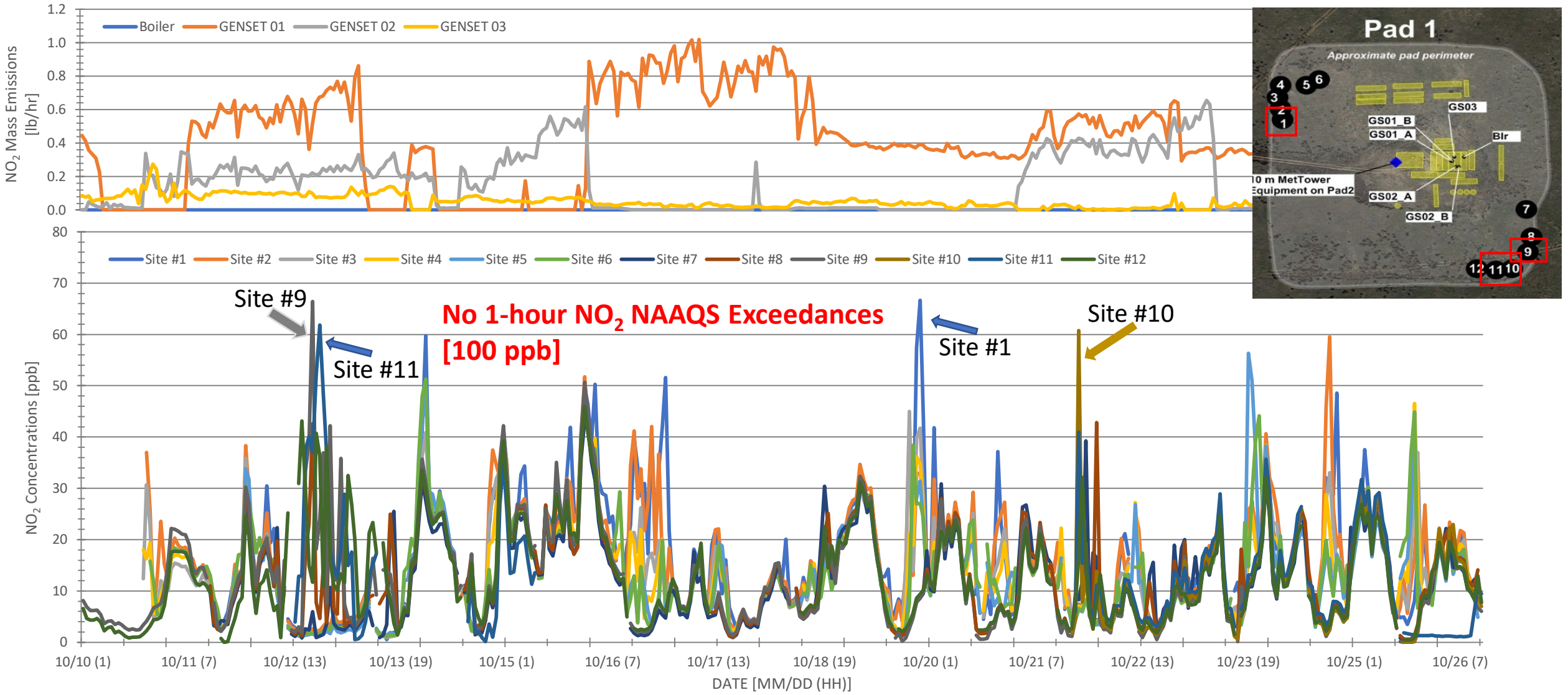
- **Analytical Techniques:** Interpolation, substitution, and corrections. Techniques only applied to hourly datasets and primarily implemented for the NO_x emissions. No modifications were applied to 5-minute datasets.
  - **Emissions Datasets:** Characteristics of NO_x stack concentrations, temperature, and delta-p measurements over time and inter-relationships between measurements examined to fill missing data points.
  - **Meteorological Dataset:** Interpolation of pressure and temperature for data points missing on November 10th and 16th and substitution of missing temperature data points collected on Pad 2 with NWS data on November 3rd.
  - **Ambient NOx and NO_2 Datasets:** No missing data points filled, only data points on November 3rd (hour 12) were invalidated in datasets.
  - **Ozone Datasets:** Missing data points of two ambient monitoring sites were filled with data collected from monitor located in Greeley (20 km north of sites). Site 1 and Site 12 were about 50% and 70% complete, respectively.

- **Number of Data Points:** A total of 912 hours reported in original datasets. Following the data review process, final datasets include 723 hours.

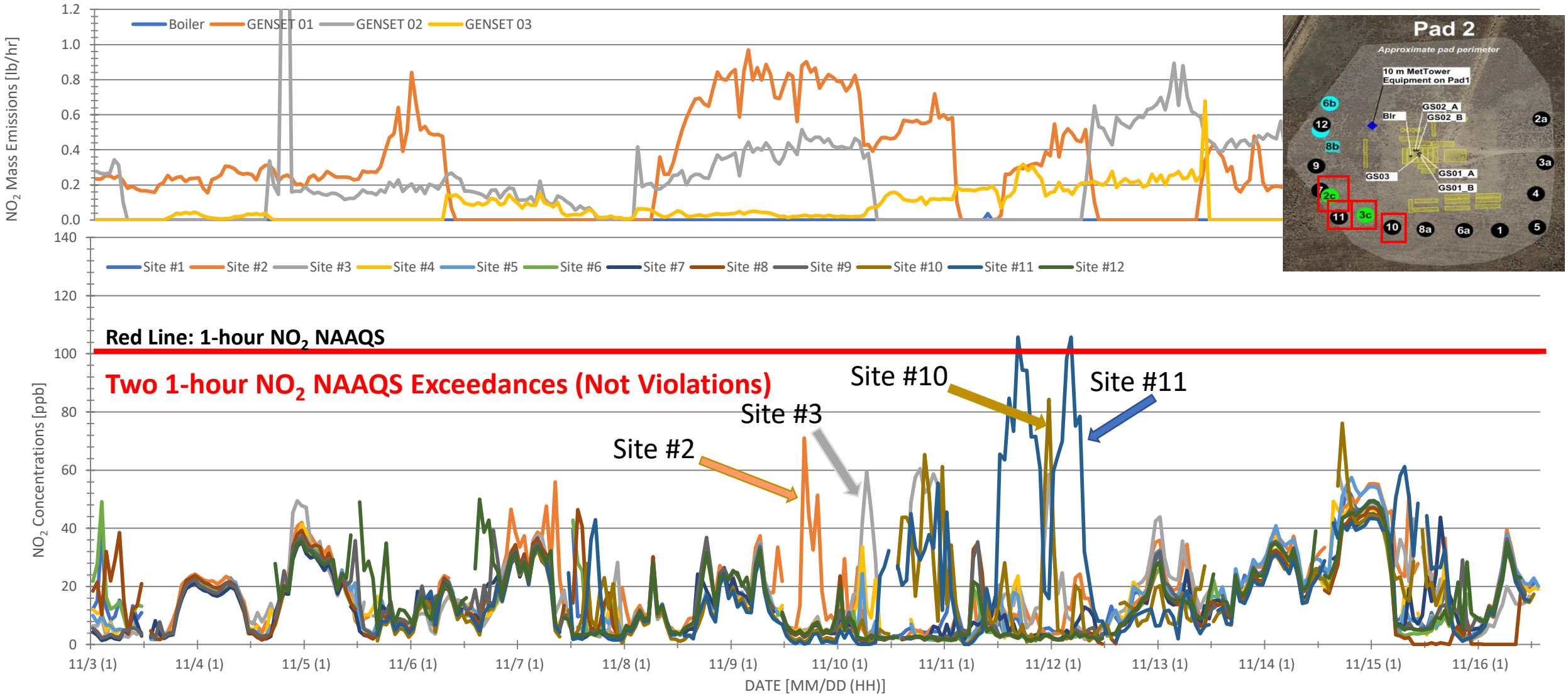
OVERVIEW: 2014 Colorado Model Evaluation Database

- **Final Work Product:** A Model Evaluation Database containing model-ready datasets for EPA's air quality dispersion model (AERMOD) and model evaluation studies.
- **Database Files:** Files, along with detailed descriptions of the calculations and associated graphical displays depicting the analytical techniques applied to the final datasets, included in the Database:
  - **Main Documentation:** Technical Support Document and README File.
  - **Original Datasets of the 2014 Colorado Field Study:** EXCEL Spreadsheets that contain all 5-minute and hourly data including emissions, meteorology, and monitoring.
  - **Supporting Documentation:** Reports that provide additional details regarding the 2014 Colorado Field Study.
  - **Primary Hourly Dataset of the 2014 Colorado Model Evaluation Database:** EXCEL spreadsheet that identifies all the calculations, substitutions, and interpolations carried out to develop database. Also contains readme, index, and glossary worksheets that provide further detail regarding the spreadsheet contents.
  - **Primary 5-Minute Dataset of the 2014 Colorado Model Evaluation Database:** EXCEL spreadsheet that contains a consolidated list of all 5-minute data developed from the original distribution files.
  - **Vendor Files:** Equipment Specification Sheets.
  - **Model Input Files:** AERMOD-Ready files to provide information on the physical layout of Pad 1 and Pad 2, including receptor locations, stack characteristics, and building/structure information, background concentrations, and meteorological files.

PAD 1: Timeseries of NO_2 Concentrations

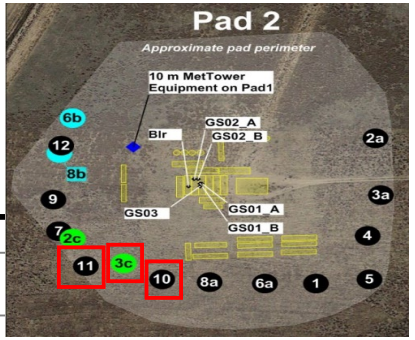


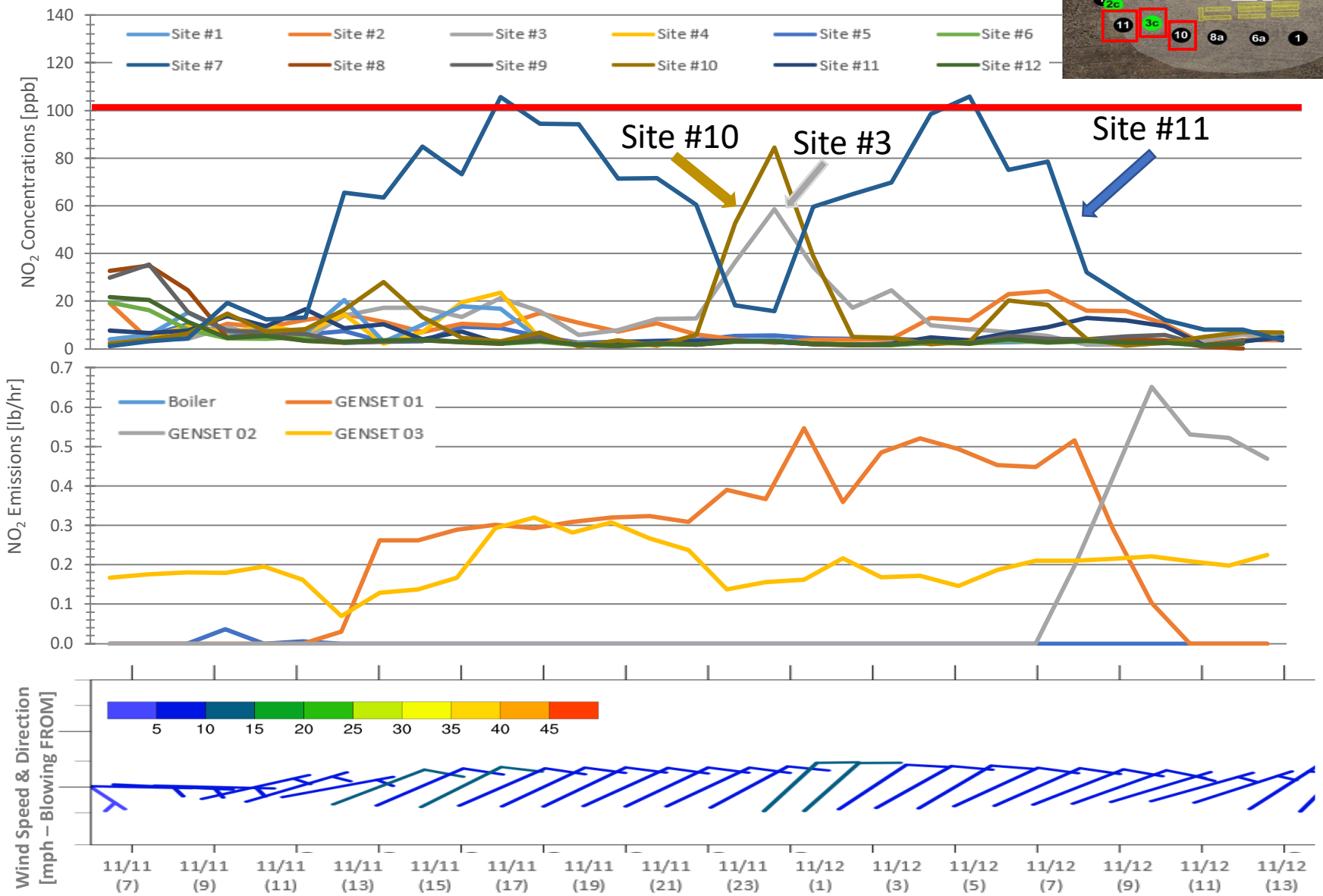
PAD 2: Timeseries of NO_2 Concentrations



PAD 2: Elevated NO_2 Episode (11/11 to 11/12)

PAD 2 - Parameter	Average Entire Period	Maximum Entire Period
BR - NO_2 ER [lb/hr]	0	0
GS 01 - NO_2 ER [lb/hr]	0.3	1.0
GS 02 - NO_2 ER [lb/hr]	0.2	2.5
GS 03 - NO_2 ER [lb/hr]	0.1	0.7
NO_2 Site #1 [ppb]	14.8	53.5
NO_2 Site #2 [ppb]	18.2	71.1
NO_2 Site #3 [ppb]	18.1	60.5
NO_2 Site #4 [ppb]	14.6	49.3
NO_2 Site #5 [ppb]	15.0	57.4
NO_2 Site #6 [ppb]	13.5	49.2
NO_2 Site #7 [ppb]	13.4	44.9
NO_2 Site #8 [ppb]	13.2	47.0
NO_2 Site #9 [ppb]	14.5	49.0
NO_2 Site #10 [ppb]	15.6	84.3
NO_2 Site #11 [ppb]	20.7	105.8
NO_2 Site #12 [ppb]	15.6	50.0
Ozone [ppb]	23.8	50
Wind Speed [mph]	7.2	33.3





Next Steps:

- **2014 Colorado Model Evaluation Database Package:**
  - Published on EPA's SCRAM Website at: https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod

- **Workgroup Phases:**
  - **Measurement Datasets (Released in August 2015):** Amec Foster Wheeler (contractor) developed original datasets that contained all measurement data collected from 2014 Colorado Field Study. Datasets were subjected to comprehensive quality control/quality assurance (QC/QA) procedures.
  - **2014 Colorado Model Evaluation Database (Released in August 2020):** Developed database containing datasets that are model-ready for EPA's air quality dispersion model and model evaluation studies. Effort included reviewing datasets for missing and questionable data points and applying analytical techniques to fill in missing or correct questionable data points to have continuous and comprehensive datasets for model evaluation studies.
  - **2014 Colorado Model Evaluation Report (Current Phase):** Conduct sensitivity studies with AERMOD (EPA's air quality model) to understand the model's ability to predict air quality impacts from drill rig operations based on the **dispersion of total NOx concentrations, downwash, and chemistry of NOx to NO_2 conversion**. Publish report that summarizes evaluation.