
# Lawnmower Emissions – PEMS Pilot Testing and Upcoming Surveillance Program

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# Outline

- Background and Objectives
- Equipment
- Preparation and Data Collection
- Results
- Conclusions
- Next Steps

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# Background

- PEMS are widely applied for on-road vehicles and off-road diesel equipment
- Current PEMS may not be applicable for small off-road engines (SORE) as it requires a complex set-up
- Emissions of reactive organic gases (ROG) and oxides of nitrogen (NOx) from SORE becomes increasing important
- SORE emissions have a direct health impact to the local communities and the lawn and garden workers

# Objectives

- Evaluate the technical challenges associated with PEMS measurement of SORE
- Compare real-world emissions vs. emission standards
- Compare real-world emissions vs. SORE2020 emission factor
- Understand the operating cycle for lawn mower (idling, stop-and-go)

# Equipment

- 2005 new Honda walk-behind lawn mower

  4.4 hp (4-stroke and carbureted)

- PEMS and auxiliary units

  AVL 493 Gaseous PEMS (1065 PEMS with NDUV analyzer for NOx and NDIR analyzer for CO and $CO_2$)

  AVL heated FID for measuring THC (part of the AVL 493 gaseous PEMS)

  AVL PM PEMS with Micro soot sensor and gravimetric filter methods

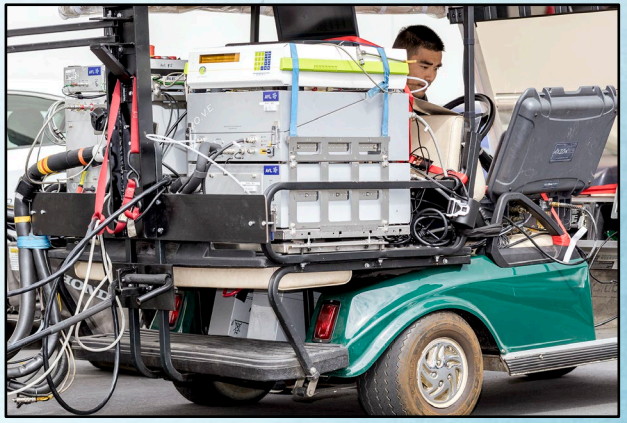
  Eco Physics PEMS (CLA analyzer for NOx)

  ECM sensor for NOx

  ECM sensor for $CO_2$ and CO

  AVL PLUtron (Fuel mass flow meter with $CO_2$ measurement)

  RPM meter

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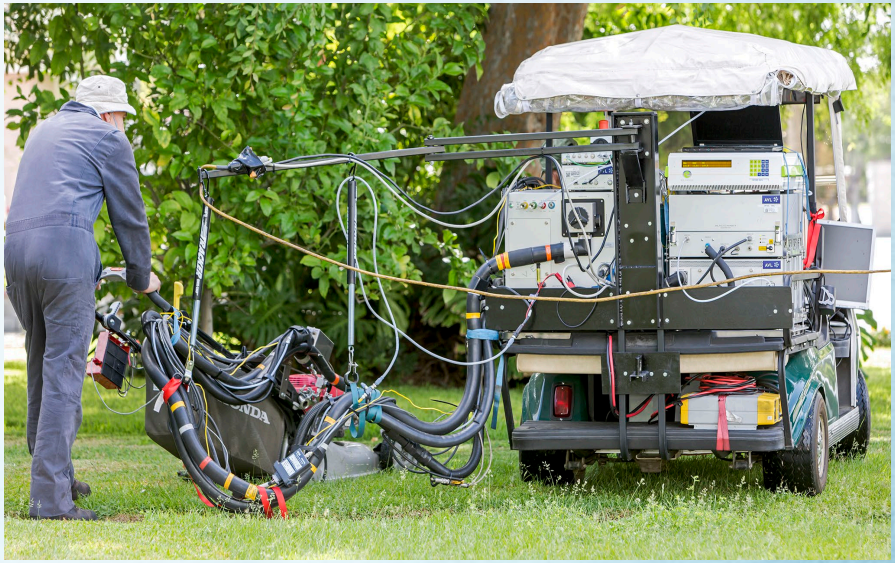
# Preparation


"Dry Run" at ARB Parking Lot



Practice Run at a local residence

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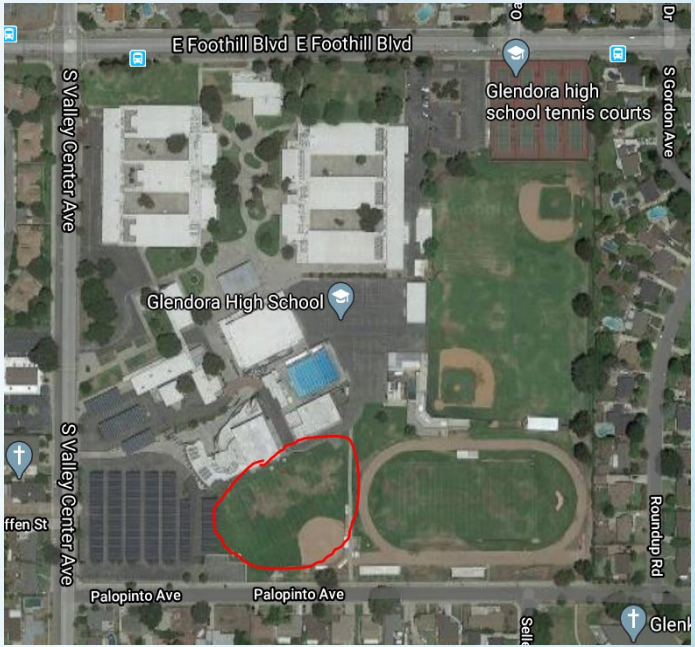
# Testing at Glendora High School




- Field testing lasted about one hour
- Includes idling time, stop and go
- Generator used for power supply

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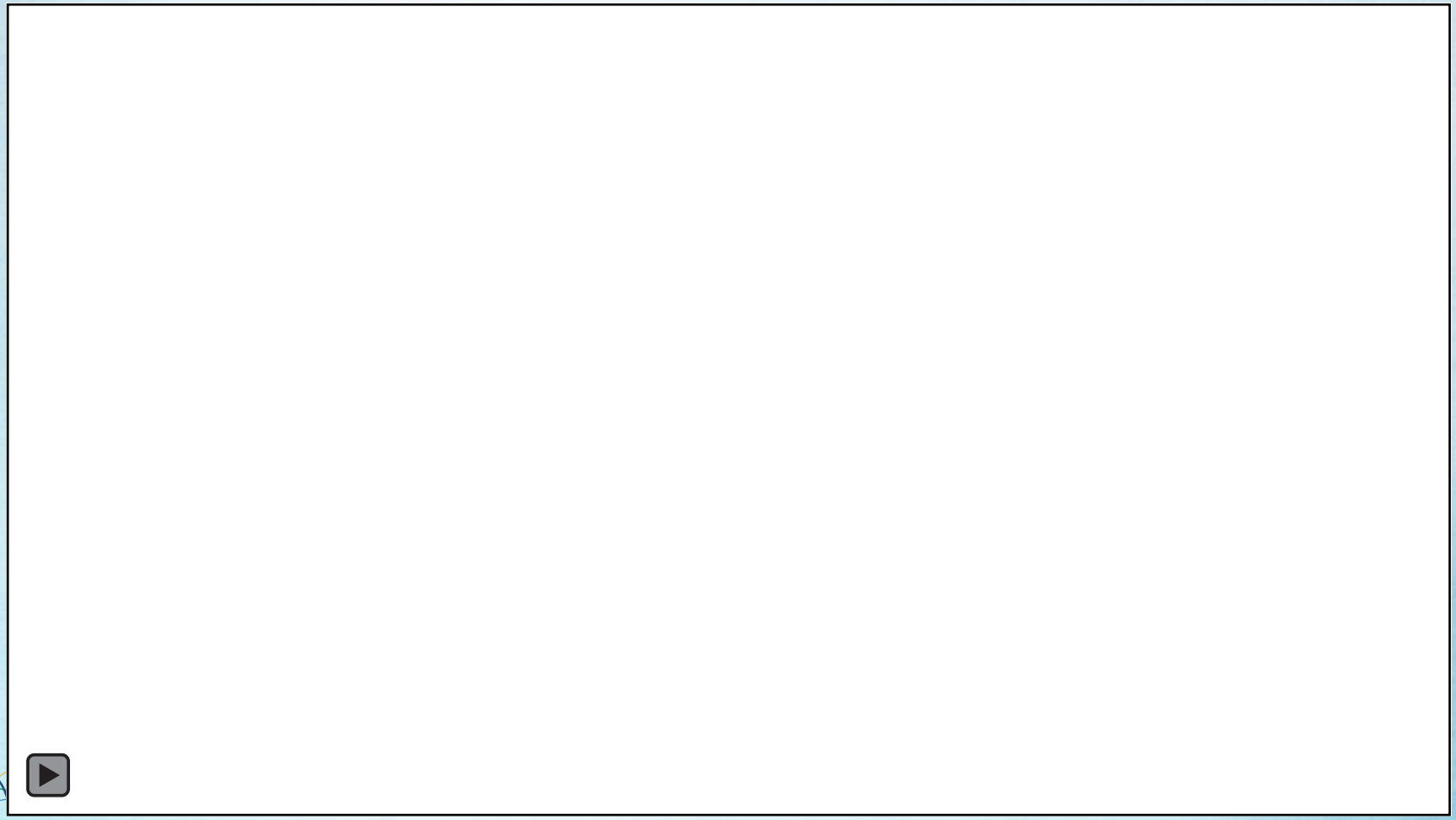
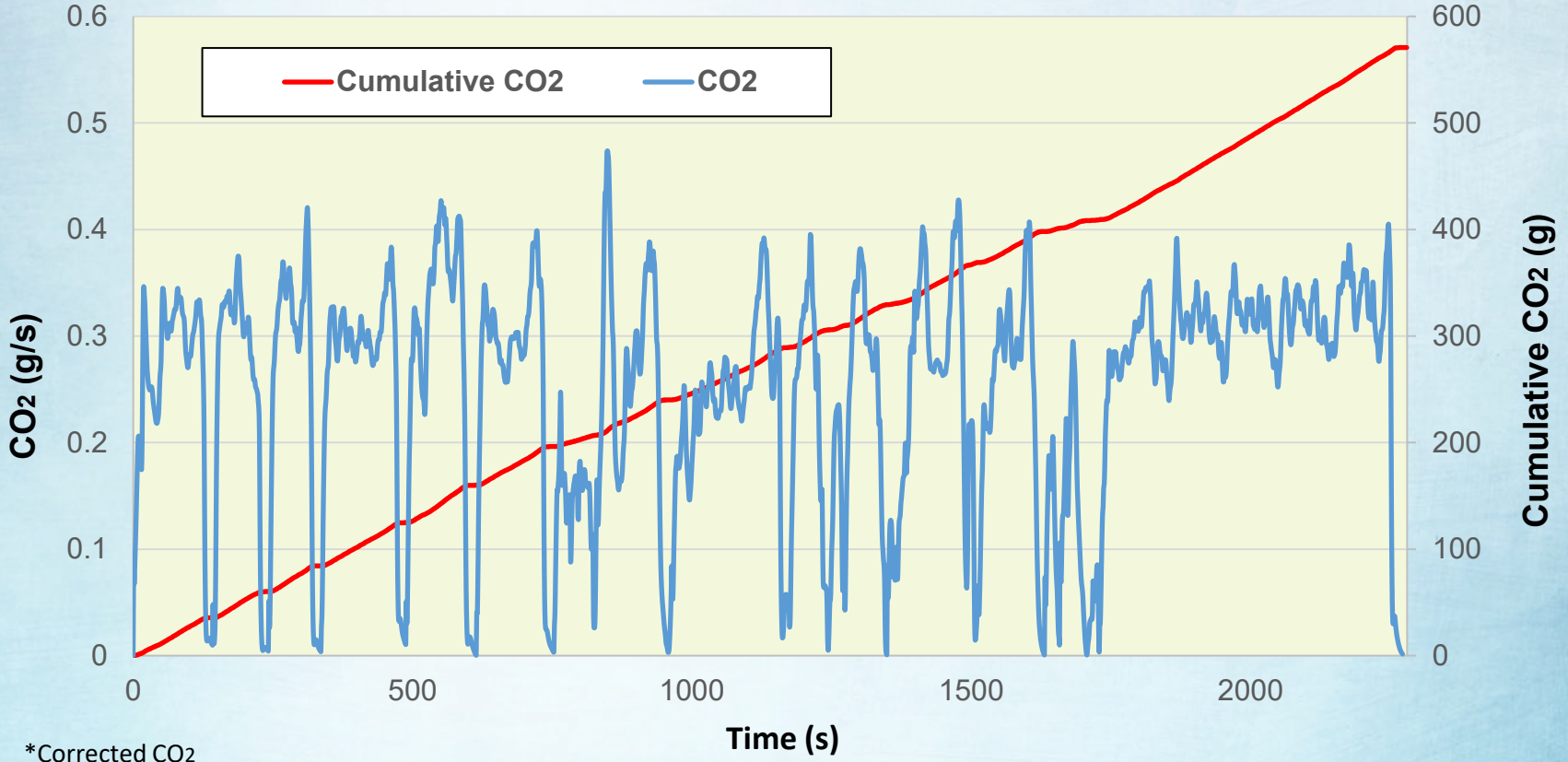
# Real-World Measurements Video Clip



# Glendora High School (CO2)*




*Corrected $CO_2$

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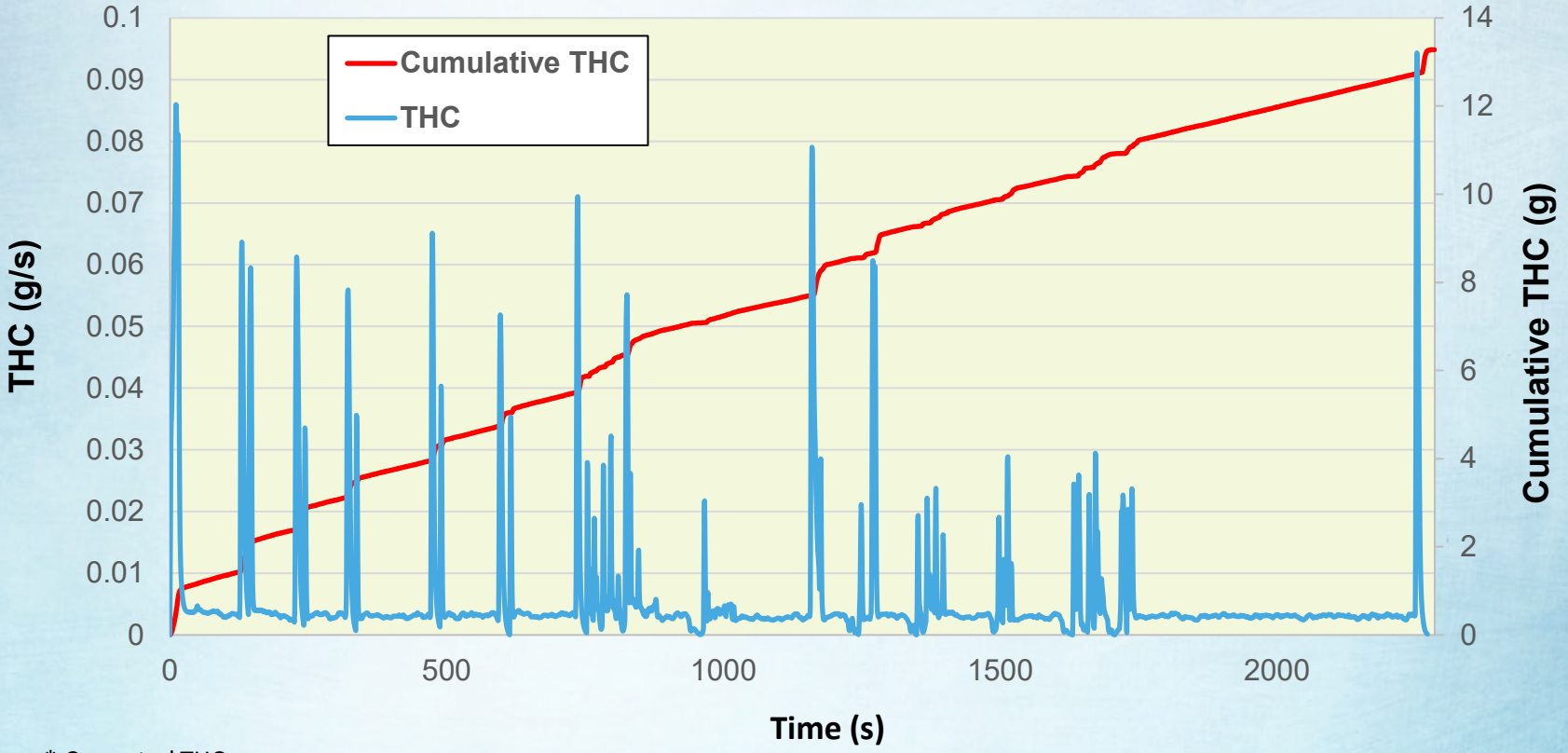
# Glendora High School (THC)*




* Corrected THC

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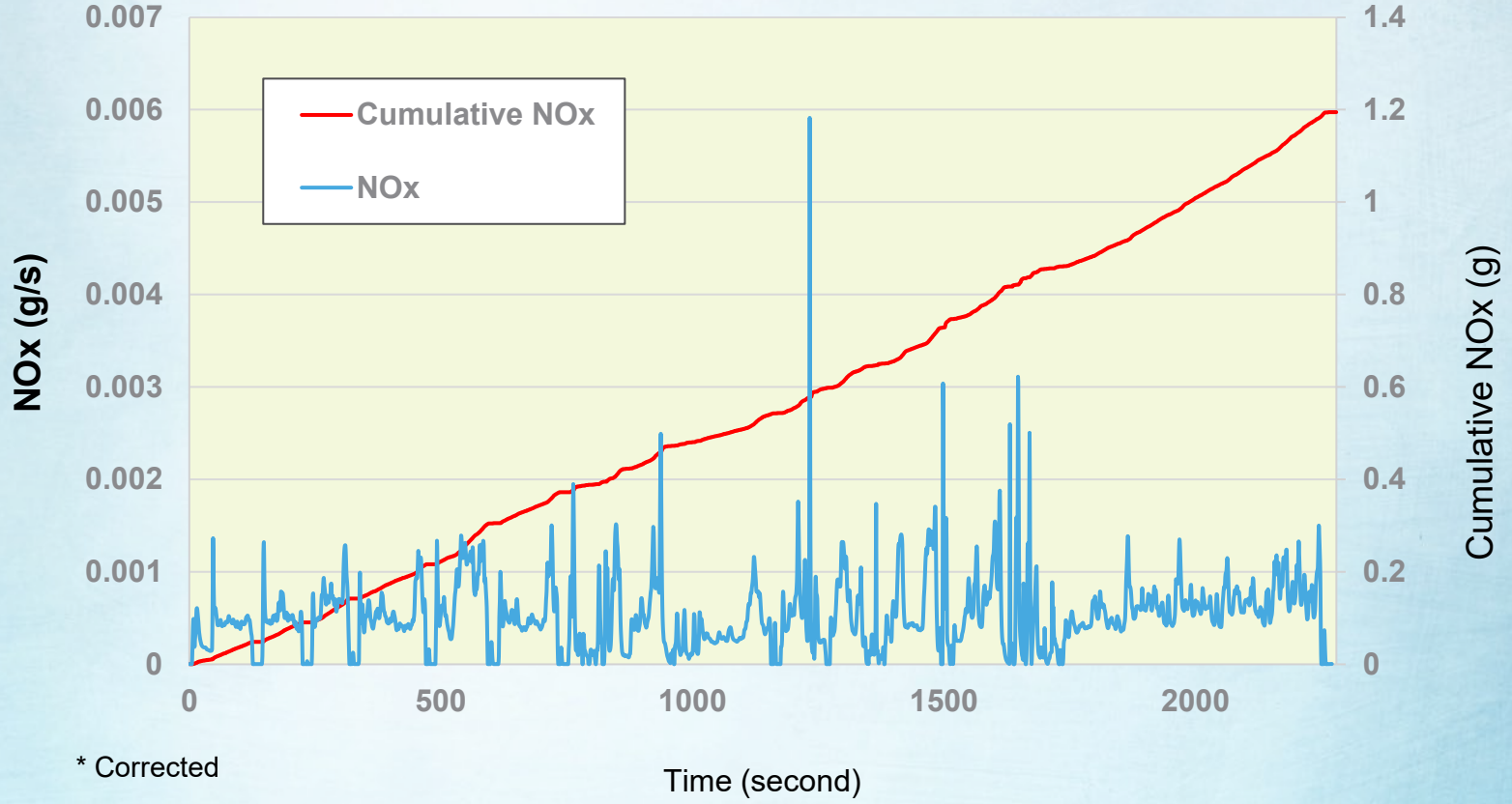
# Glendora High School (NOx)*




* Corrected

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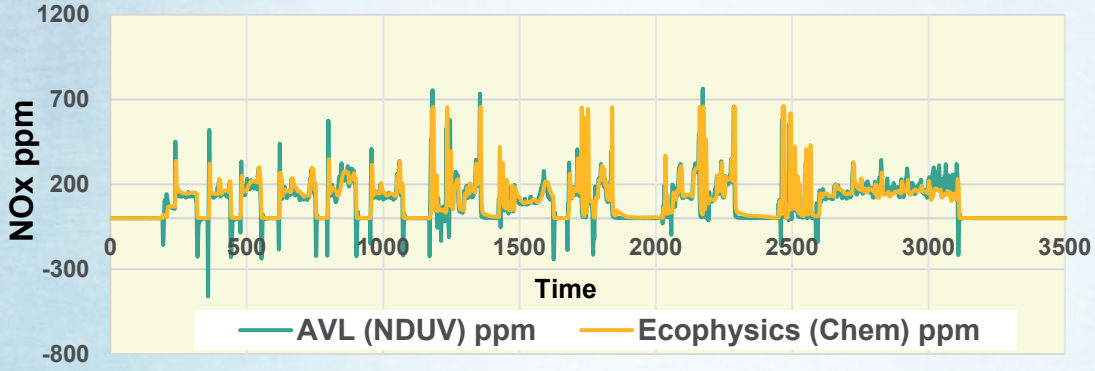
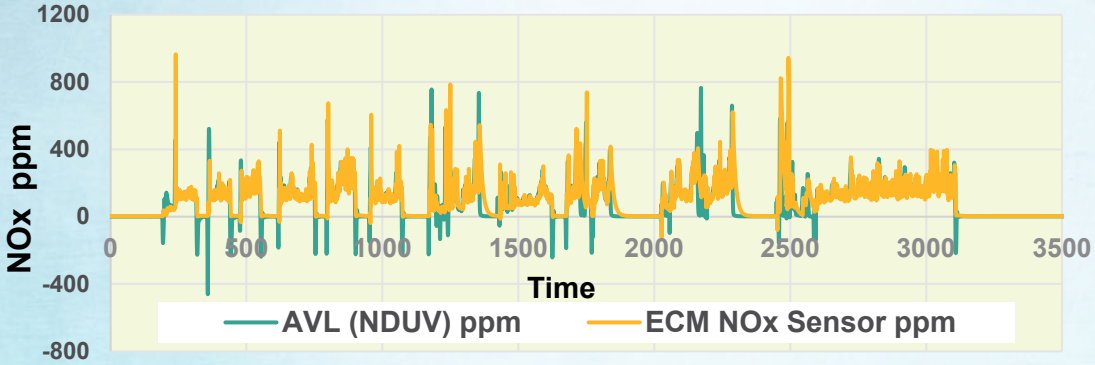
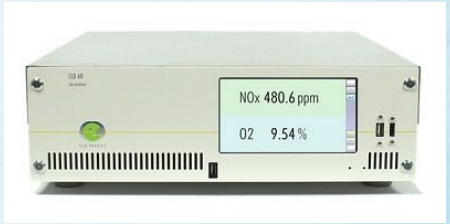
# Correlation of NOx Measurement




AVL Gas PEMS 493




ECOPHYSICS NOx Analyzer

ECM Sensor

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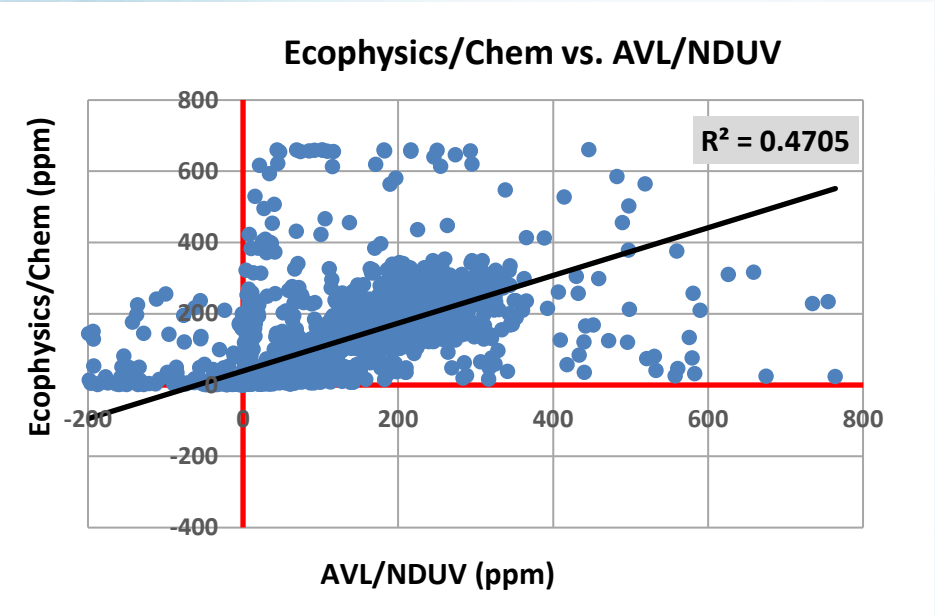
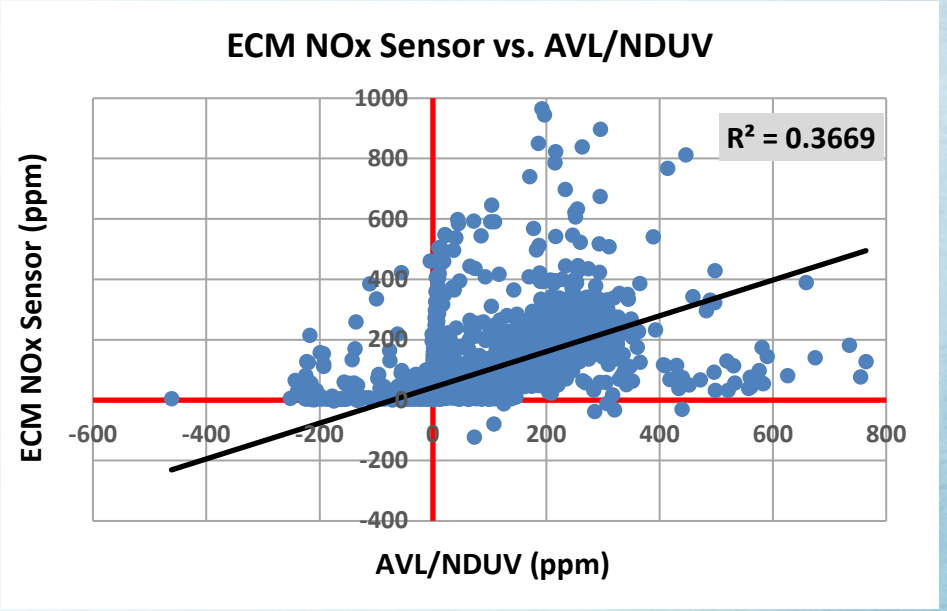
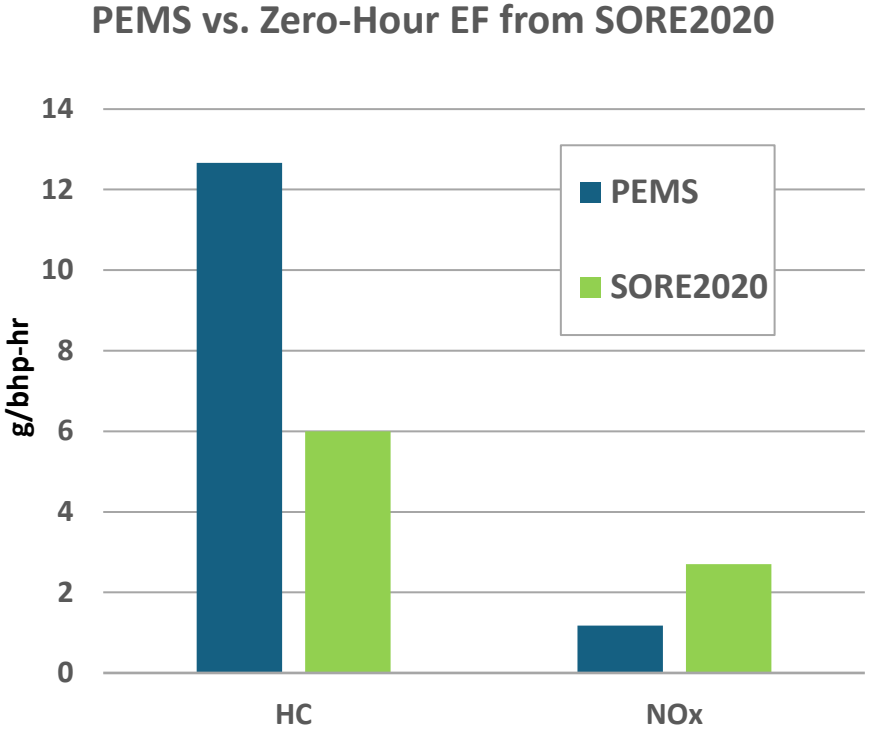
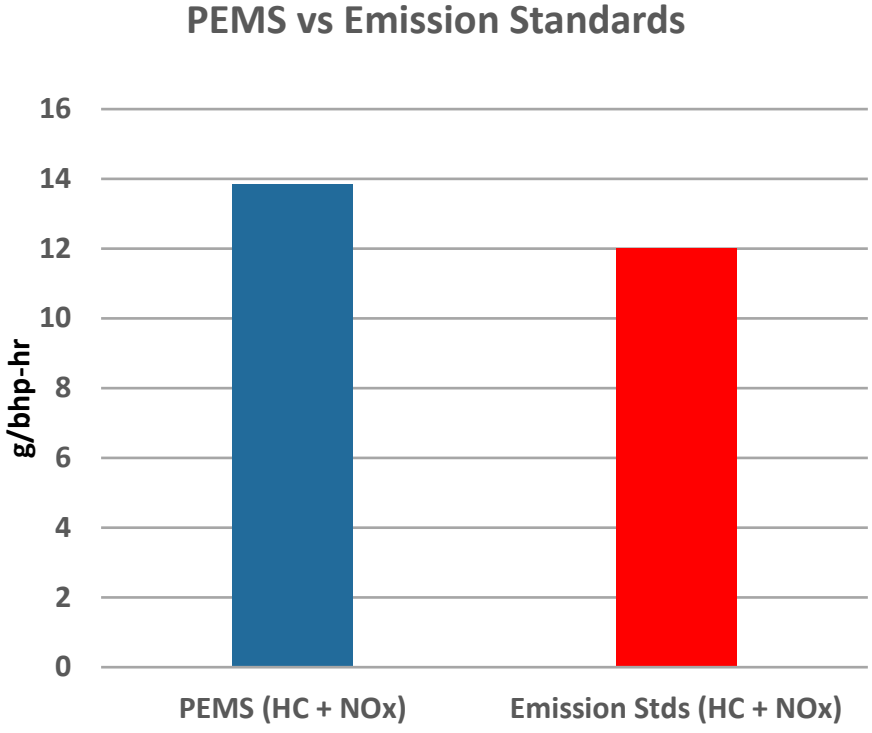
# Correlation of NOx Measurement (cont'd)



# Comparing PEMS Emissions vs. SORE2020 EF and Emission Standards



# Conclusions

- Based on a new 2005 lawn mower with 4.4 hp:
  - PM HC test data is 111% higher than the HC EF from SORE2020
  - PEMS NOx test data is 56% less than NOx EF from SORE2020
  - PEMS test data (HC +NOx) is about 15% higher than the emission standards
- The PEMS units, though producing reliable results, are bulky and cumbersome for small off-road equipment and reliable mini-PEMS is needed for future study
- Reasonable correlation in NOx reading from different measurement systems

# Upcoming Surveillance Program

- Develop an in-use surveillance test plan for in-use lawnmowers (n=16)
- Testing include:
  - Diurnal Test (SHED) - evaporative
  - Running Loss (SHED) - evaporative
  - Engine Dynamometer - exhaust
  - PEMS - exhaust
- May expand the in-use surveillance test plan for other off-road gasoline equipment (e.g., other lawn and garden equipment, recreational vehicles, and recreational marine vessels)

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# Acknowledgements


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- **ASD**
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