MOBILE6 Validation Studies

Presented by

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ENVIRON International Corporation

EPA Mobile Source Present and Future Models Workshop

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Presentation Overview

- Purpose
- Tunnel study comparisons (completed)
- Work in progress
  - Ambient ratio analyses
  - Heavy-duty diesel vehicle emissions analyses
  - Remote sensing data comparisons

Purpose

- To conduct top-down assessments of MOBILE6 emission factors using “real-world” data
- To use available data on vehicle emissions collected in a controlled manner such that the vehicle sources are well-characterized and can be attributed to a test fleet that can be reasonably duplicated using MOBILE6.

Tunnel Study Comparisons

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Tunnel Study Comparisons: Purpose

- Use emission factors data from existing tunnel studies to determine MOBILE6 model performance under set conditions
- Compare to previous MOBILE versions' performance under the same conditions to determine the effects of model updates

Approach

- Compare fleet-average, light-duty (LD), and heavy-duty (HD) emission factors
- Select tunnels based upon availability of data, applicability of US Federal emission factors, and to facilitate modeling of a range of operating parameters
- Where LD or HD emission factors were not specifically derived in the original study, a regression of fleet-average emission factors and fleet mix was used to extract vehicle class-specific factors

Approach (continued)

- Experimental runs were modeled as a period (hour) of the day using hourly temperatures to make full use of the model's air conditioning effects module (i.e., sunlight amount)
- Refueling, diurnal, and start emissions were excluded (i.e., it was assumed that all vehicles are in hot stabilized mode)

Issues/Caveats

- Effects of grades are NOT modeled by MOBILE6
- Heavy-duty diesel NOx defeat device operation difficult to determine (implicitly assumed in MOBILE6 for applicable model years)

Tunnel Descriptions

Tunnel	Location	Length (m)	Fleet
Fort McHenry	Baltimore, MD	2174	Highway
Tuscarora Mountain	Pennsylvania Turnpike, PA	1623	Highway
Callahan Connector	Boston, MA	1545	Urban
Caldecott	S.F. Bay Area, CA	1100-1149	Highway

Tunnel Data Utilized

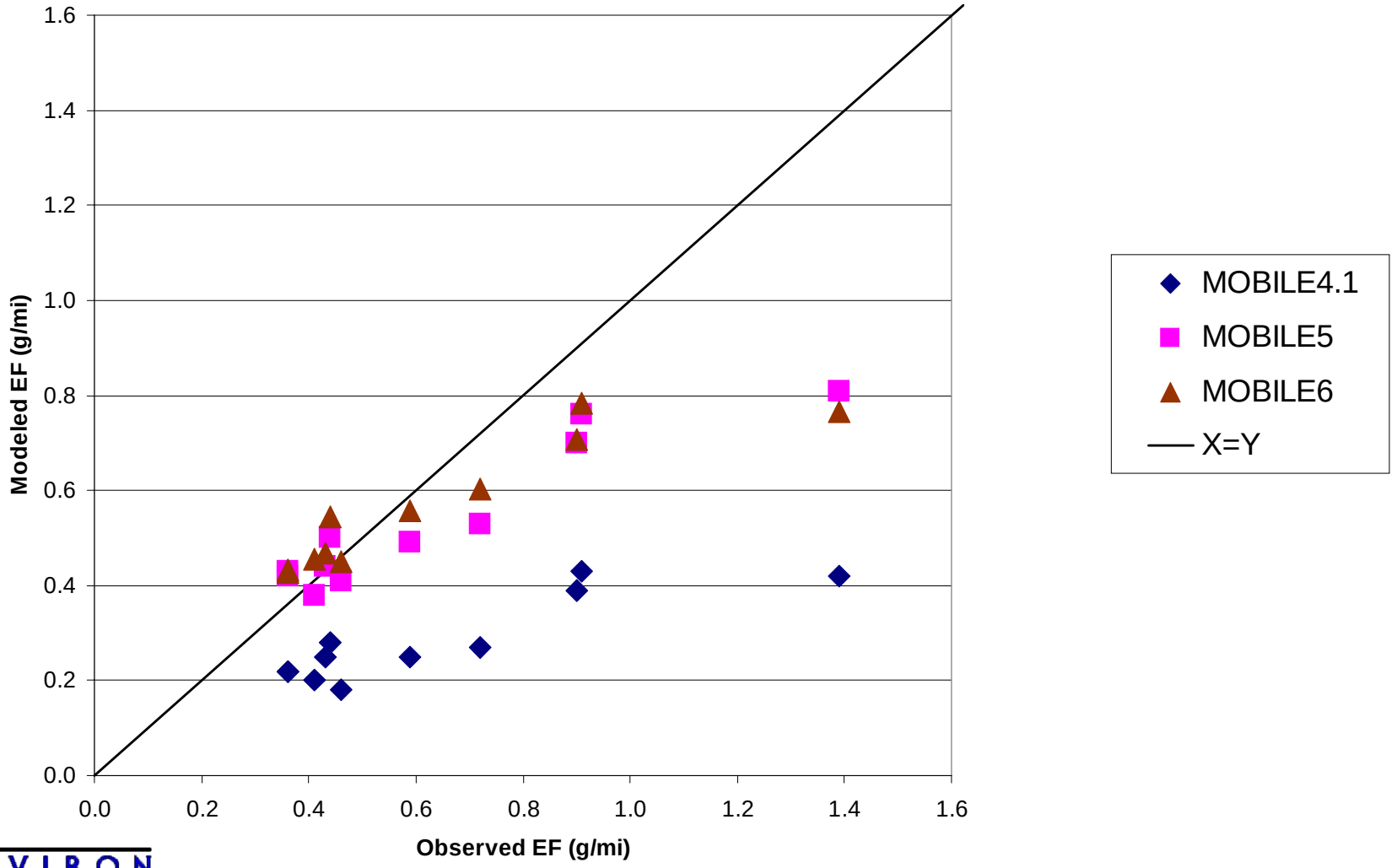
Tunnel	Year of Study	Fleet-Avg	LD	HD
Fort McHenry	1992(s)	X	x	x
Tuscarora	1992(s), 1999(s)	x	x	x
Callahan	1995(s)	x		
Caldecott*	1997(s)			x

(s) marks summer season

* comparison with CA data requires adjustment to model outputs to account for differences in certification standards

Fleet Average Results – Fort McHenry NMHC

Comparison of Observed to Modeled Fleet Average NMHC Emission Factors at Fort McHenry (1992), Bore 3



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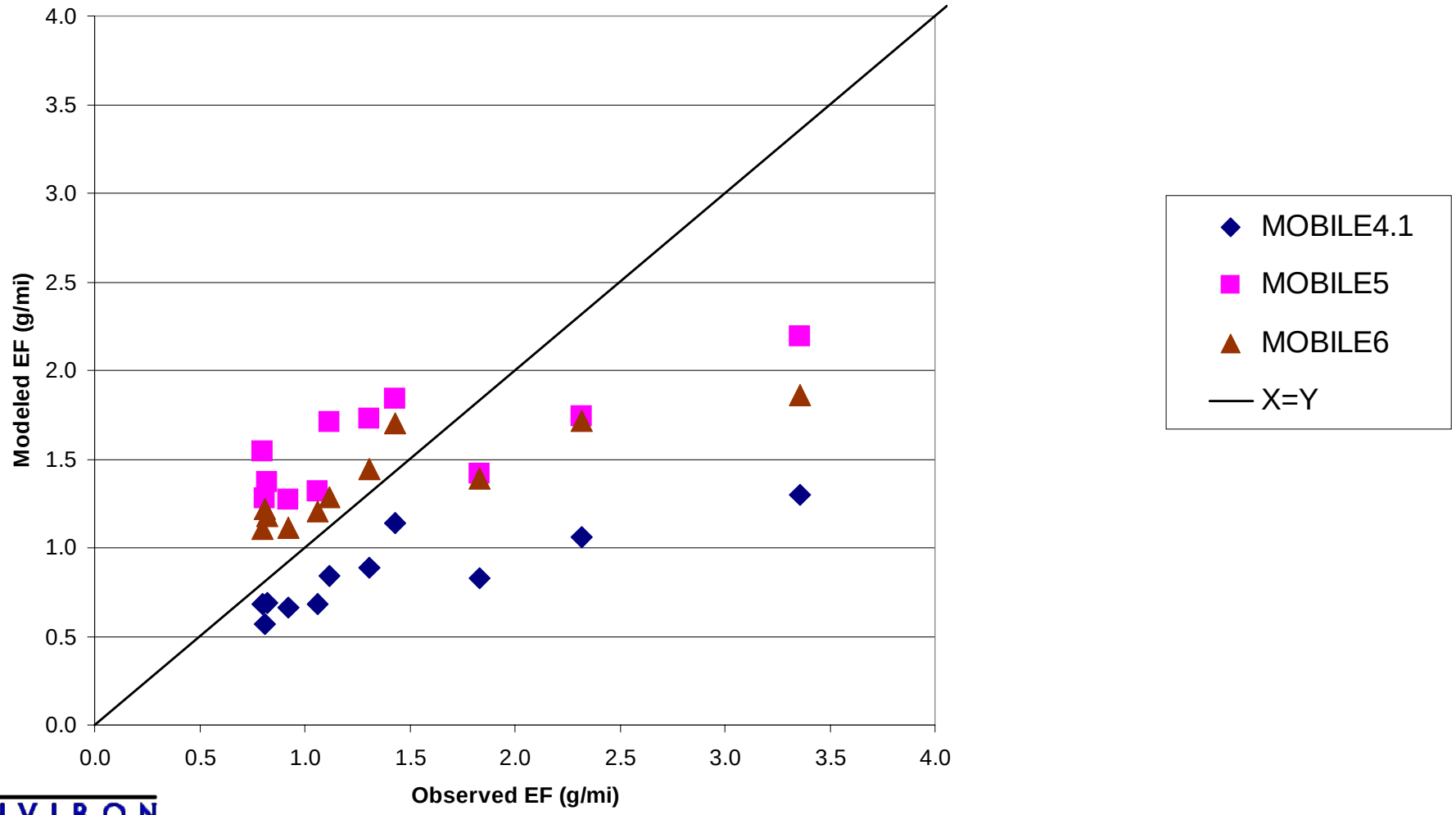

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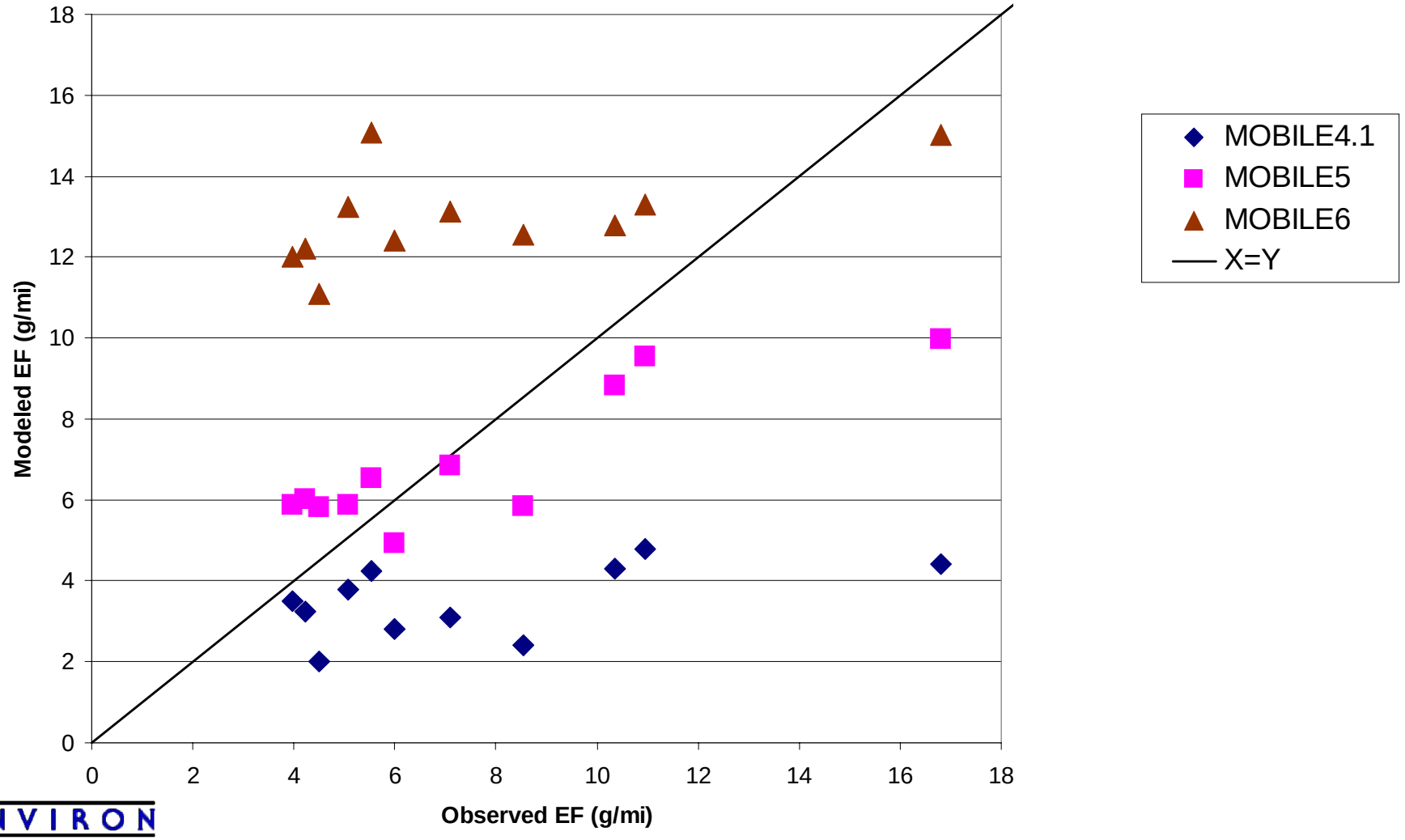
Fleet Average Results – Fort McHenry CO

Comparison of Observed to Modeled Fleet Average CO Emission Factors at Fort McHenry (1992), Bore 3



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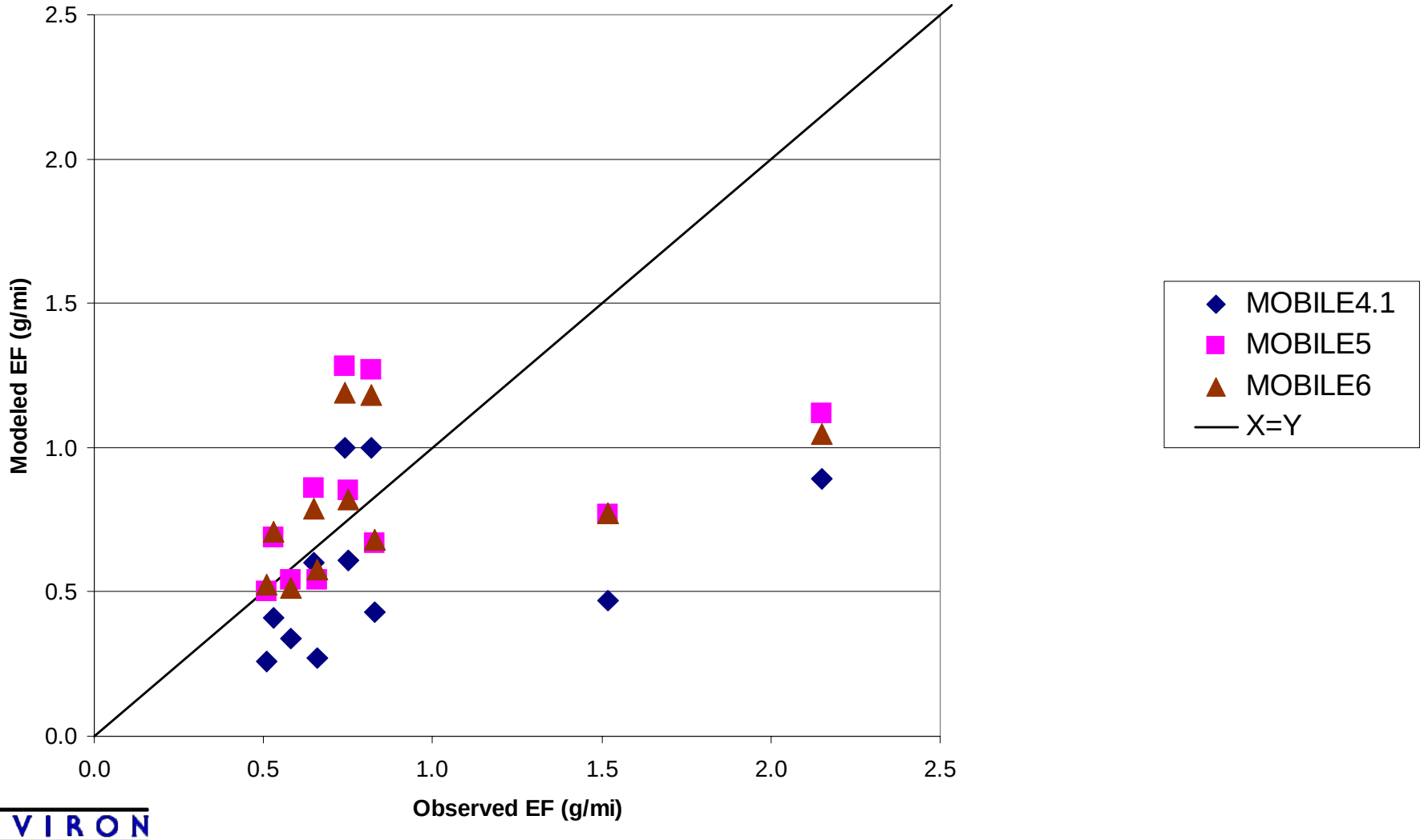
Fleet-Average Results – Fort McHenry NMHC

Comparison of Observed to Modeled Fleet Average NMHC Emission Factors at Fort McHenry (1992), Bore 4



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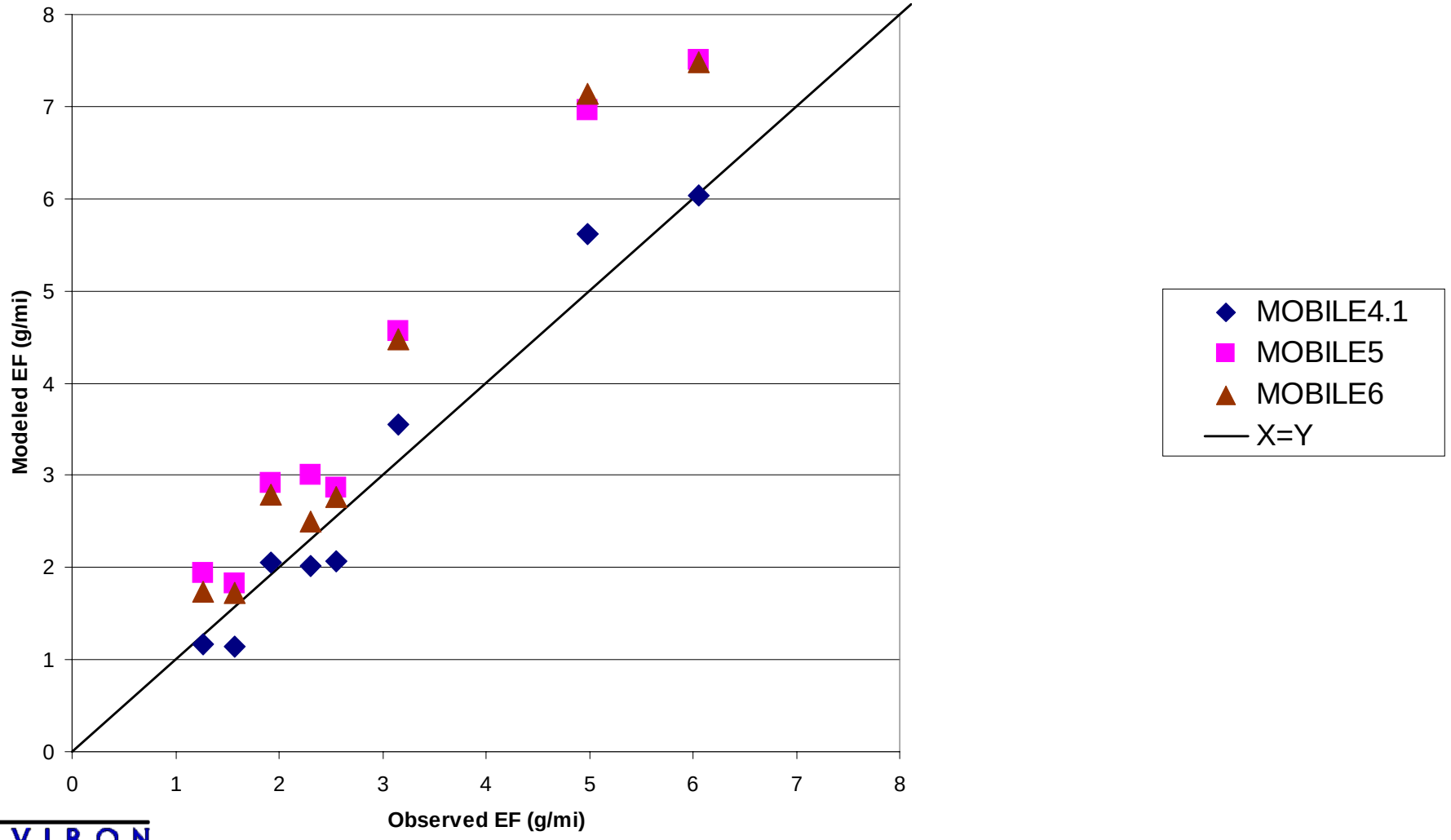

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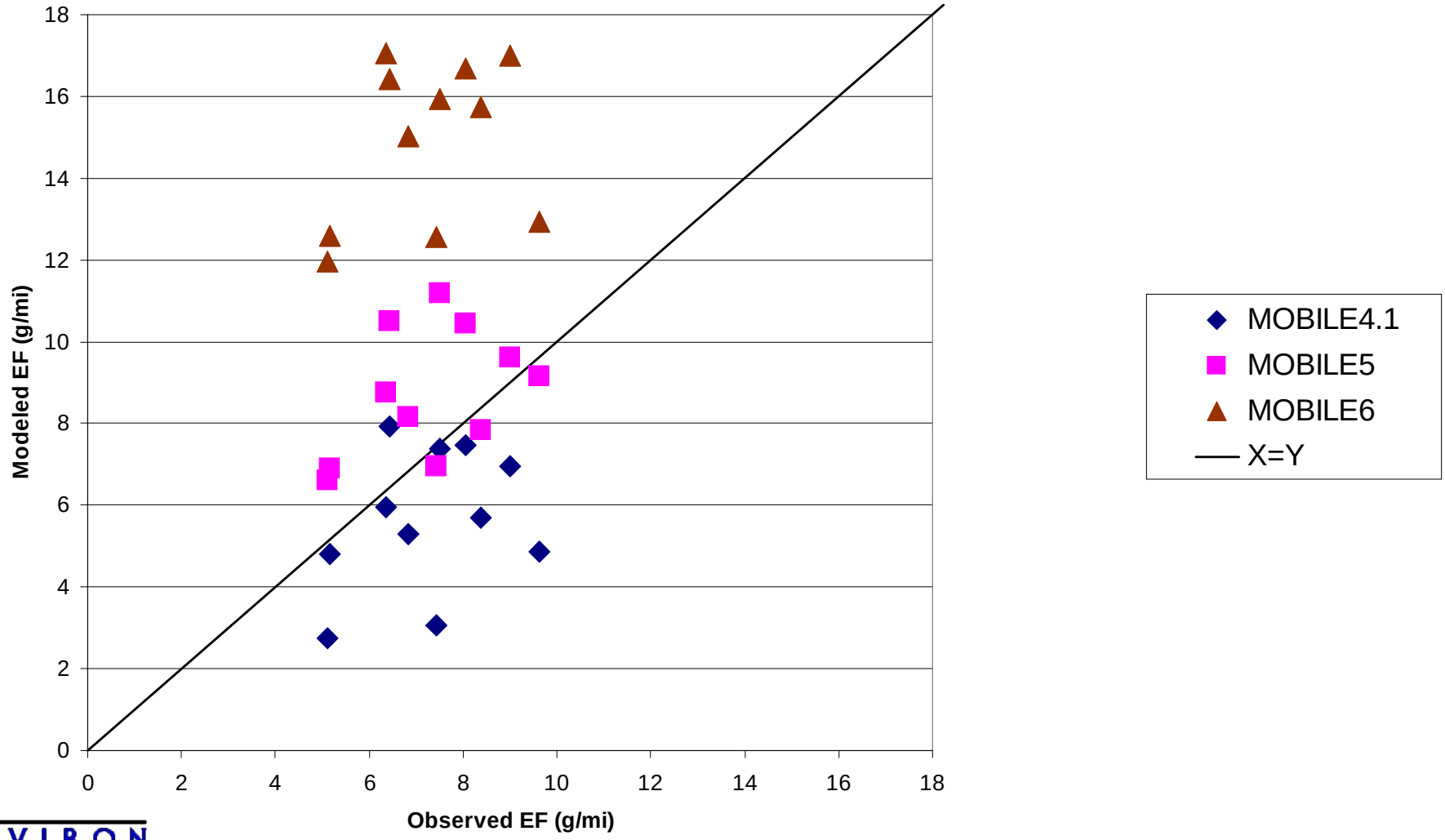

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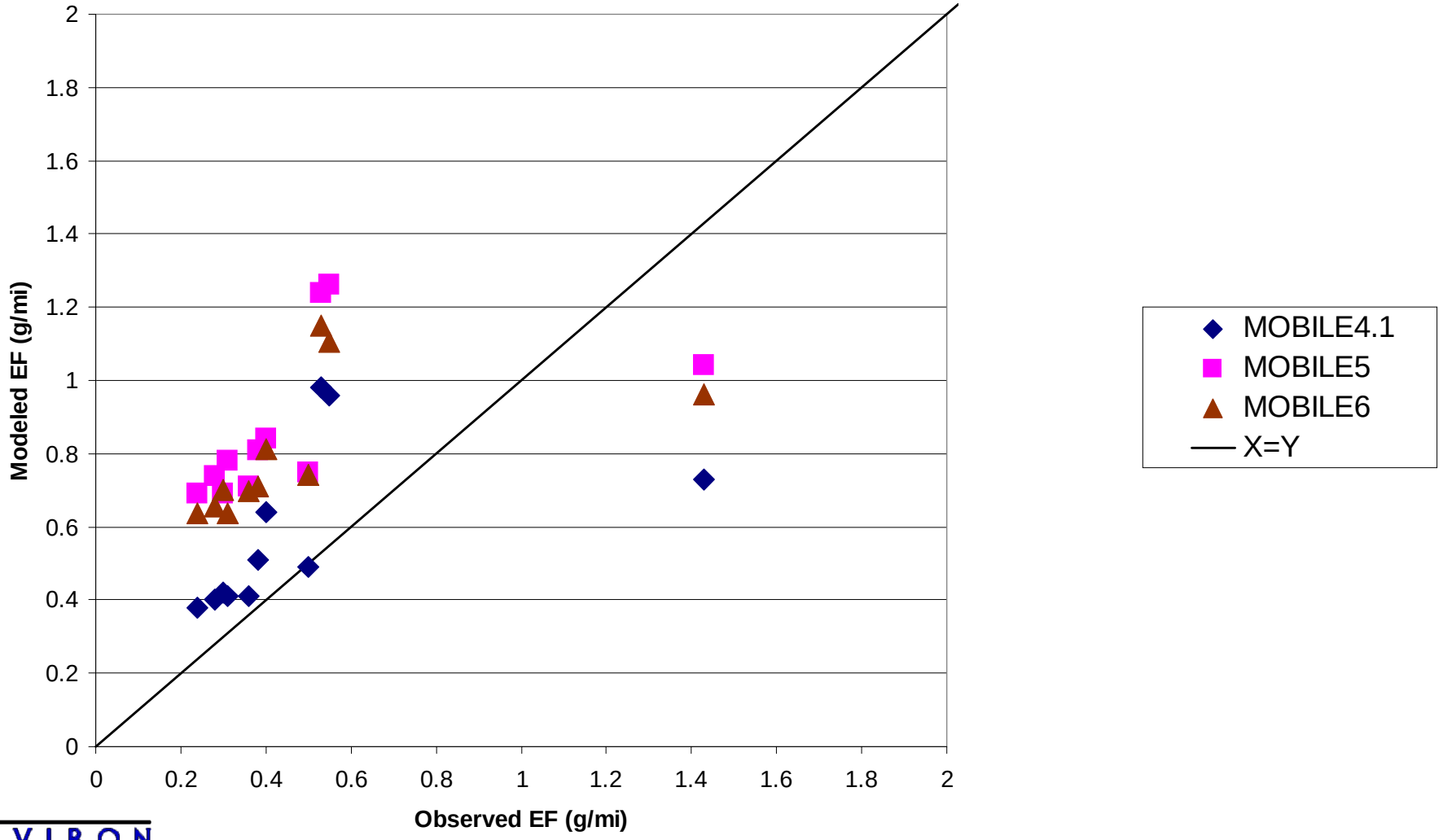
Fleet Average Results – Tuscarora NMHC

Comparison of Observed and Modeled Fleet Average NMHC Emission Factors at Tuscarora Mountain (1992)



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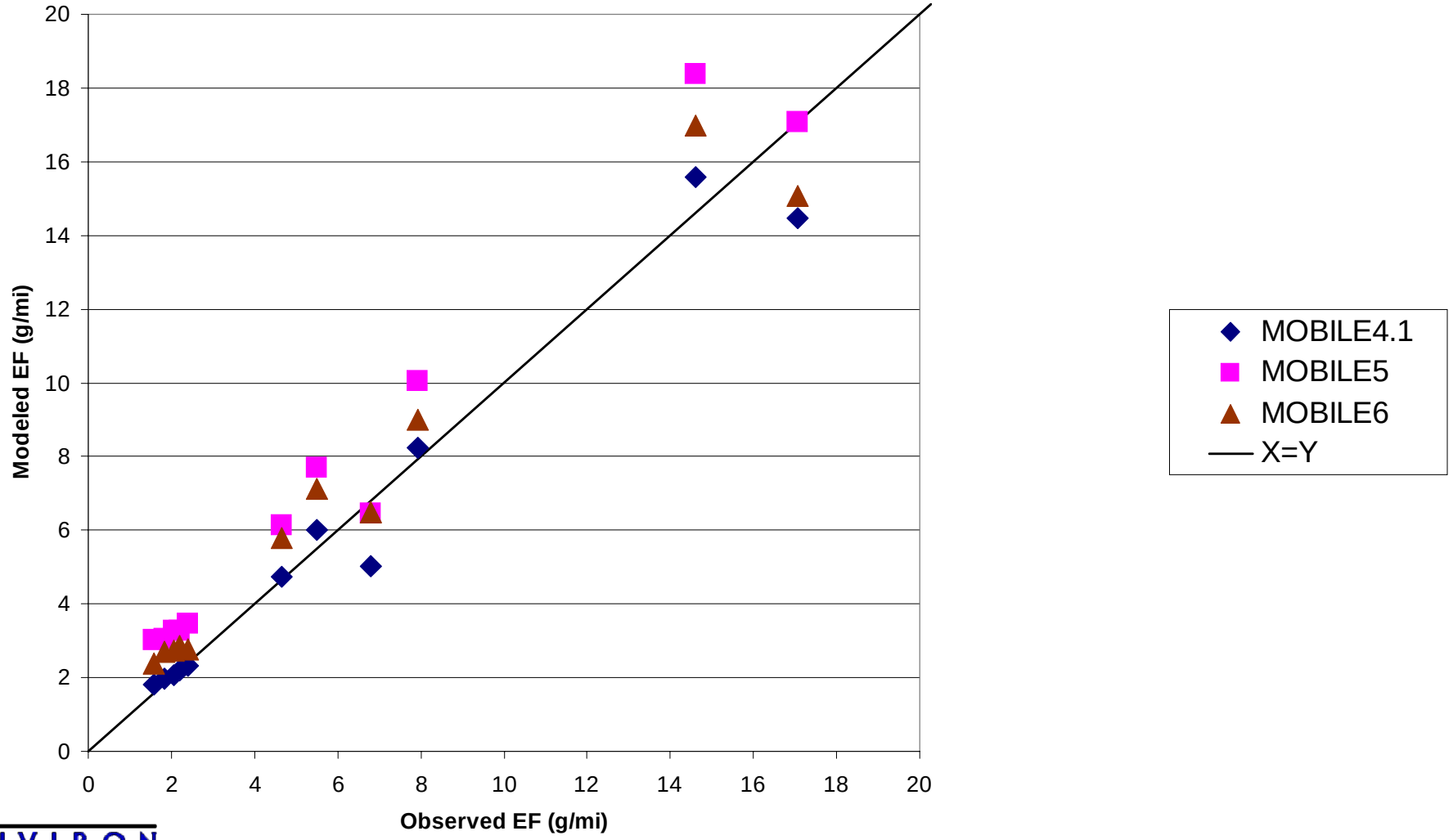

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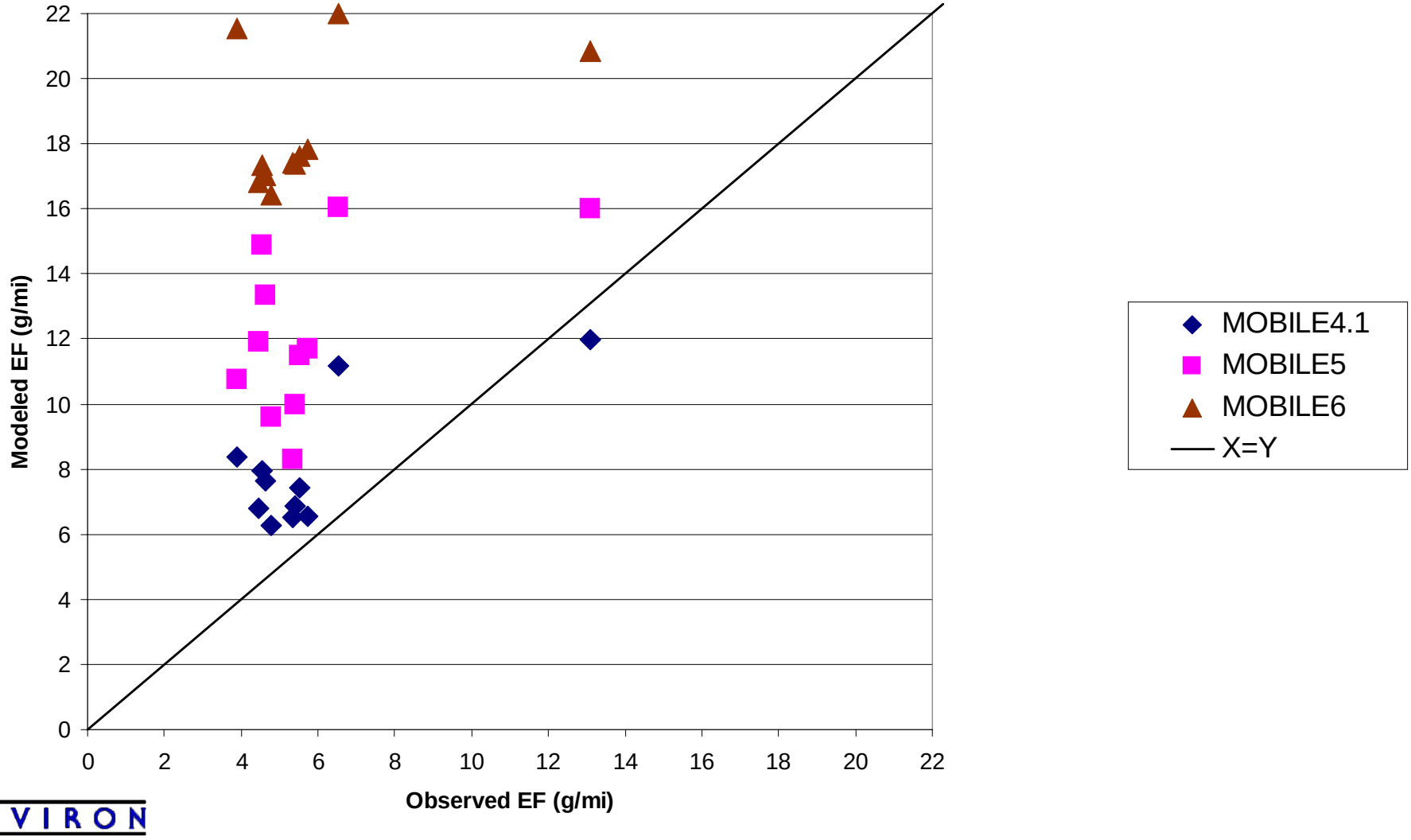

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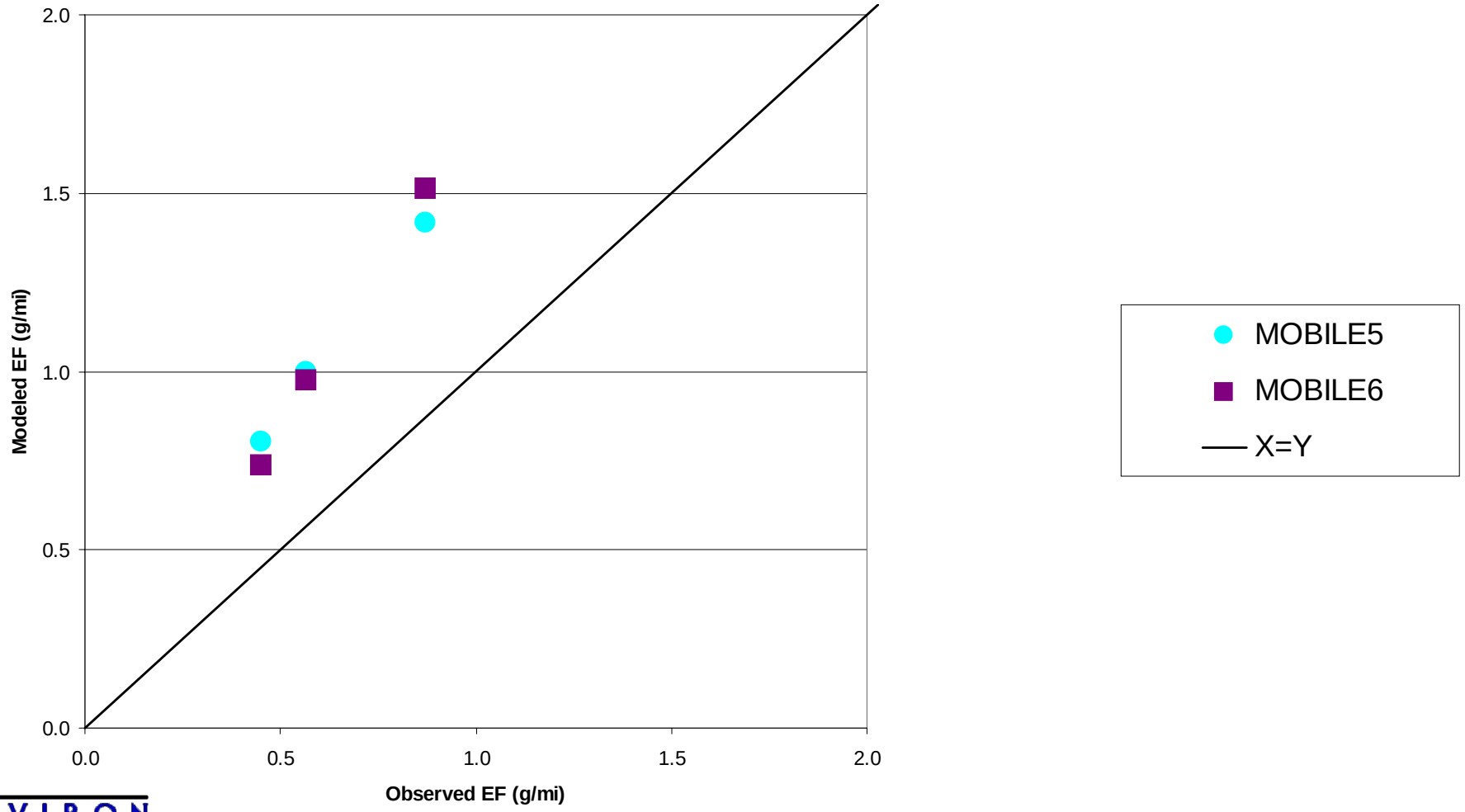
Fleet Average Results – Callahan NMHC

Comparison of Observed and Modeled Fleet Average NMHC Emission Factors at Callahan Tunnel (1995)



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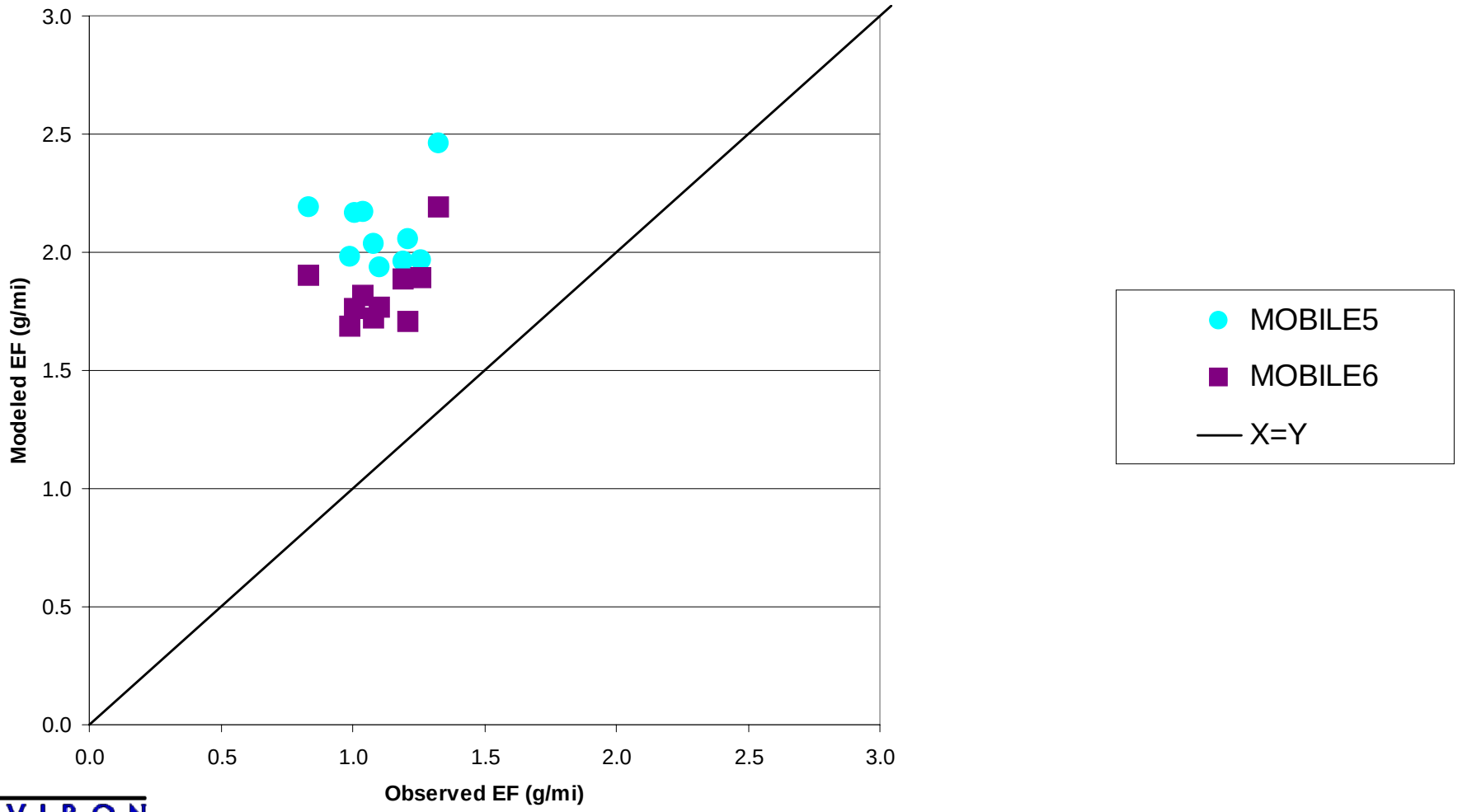

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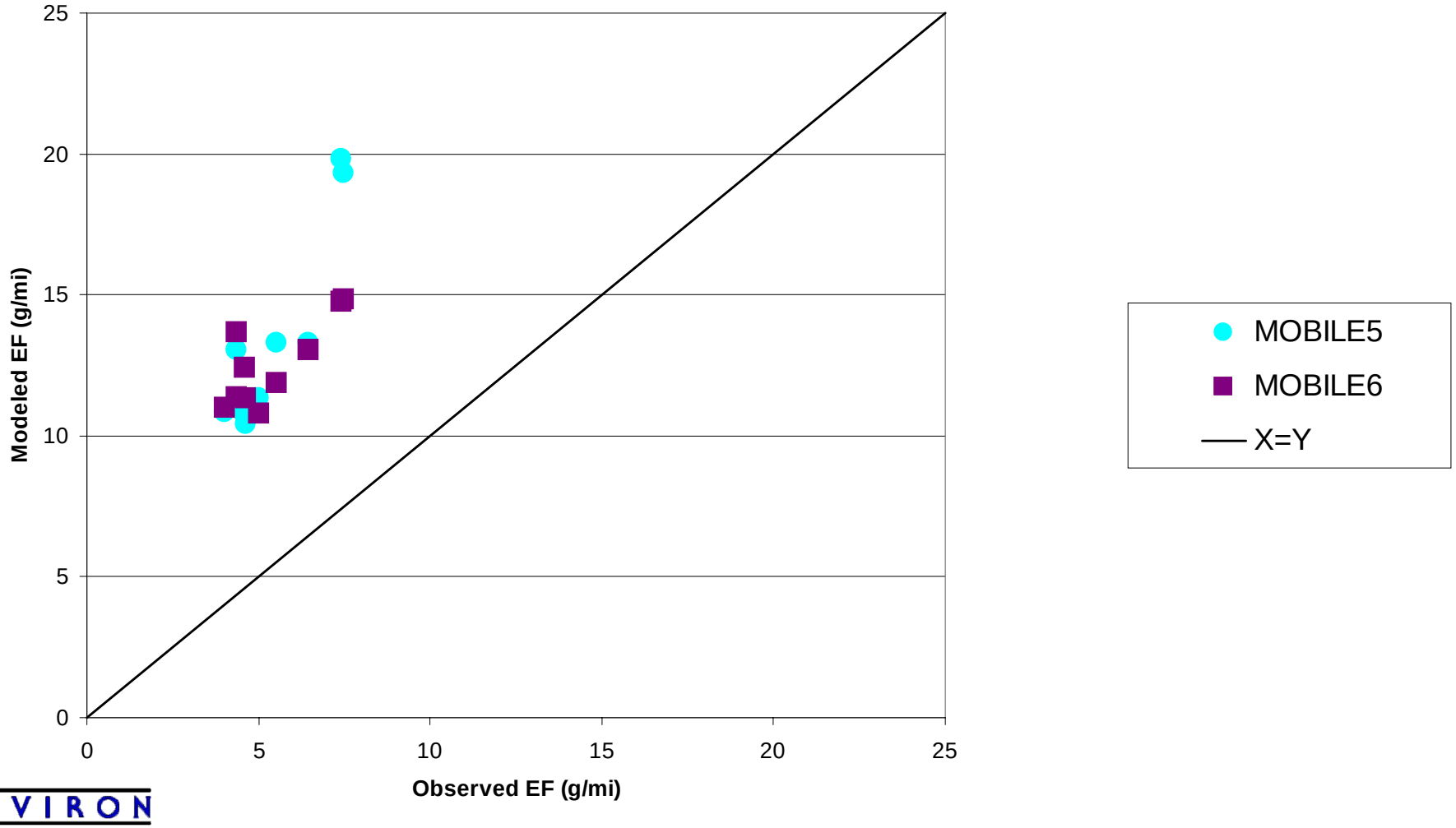

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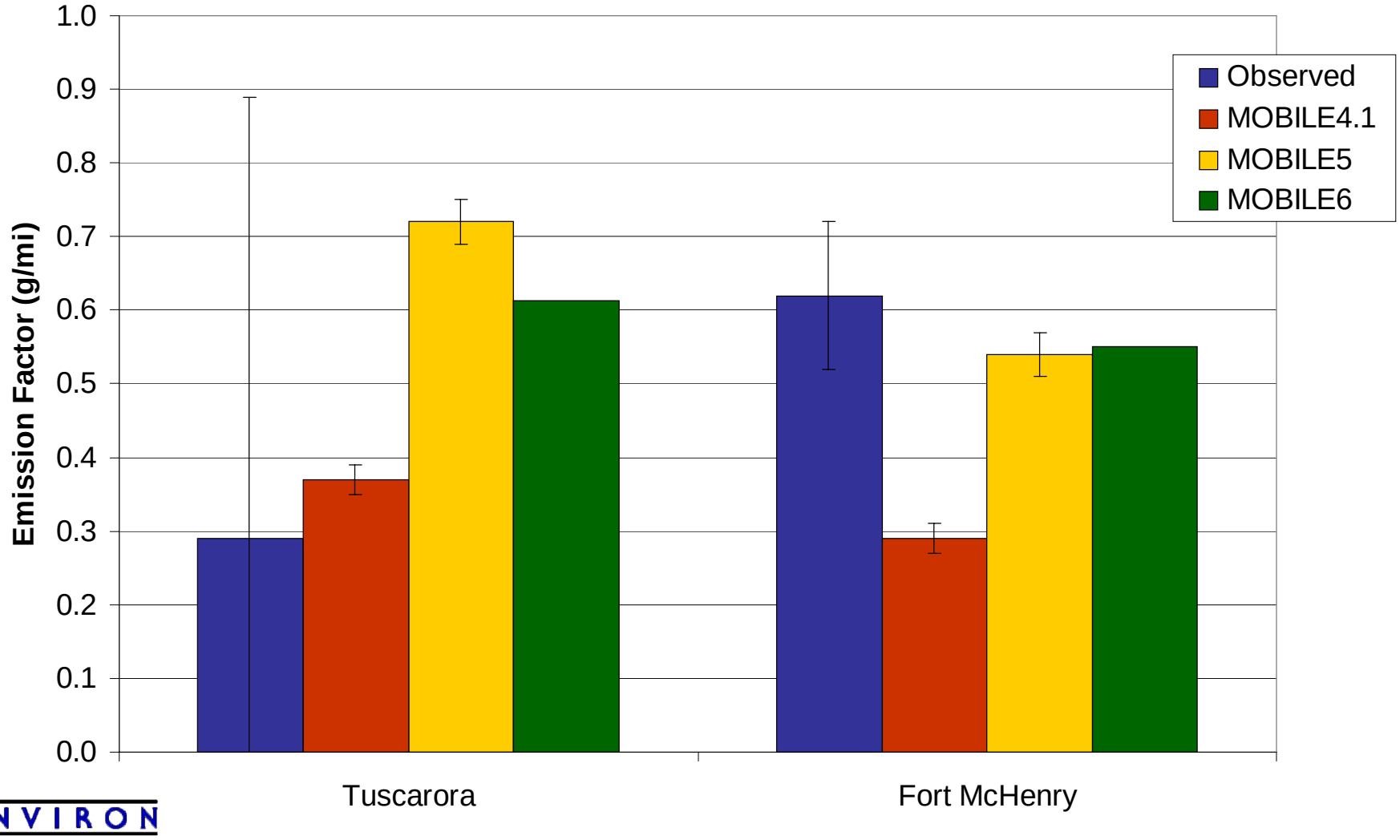
Light-Duty NMHC Emission Factors

Comparison of Observed and Modeled Light-duty NMHC Emission Factors at Fort McHenry and Tuscarora Mountain (both 1992)



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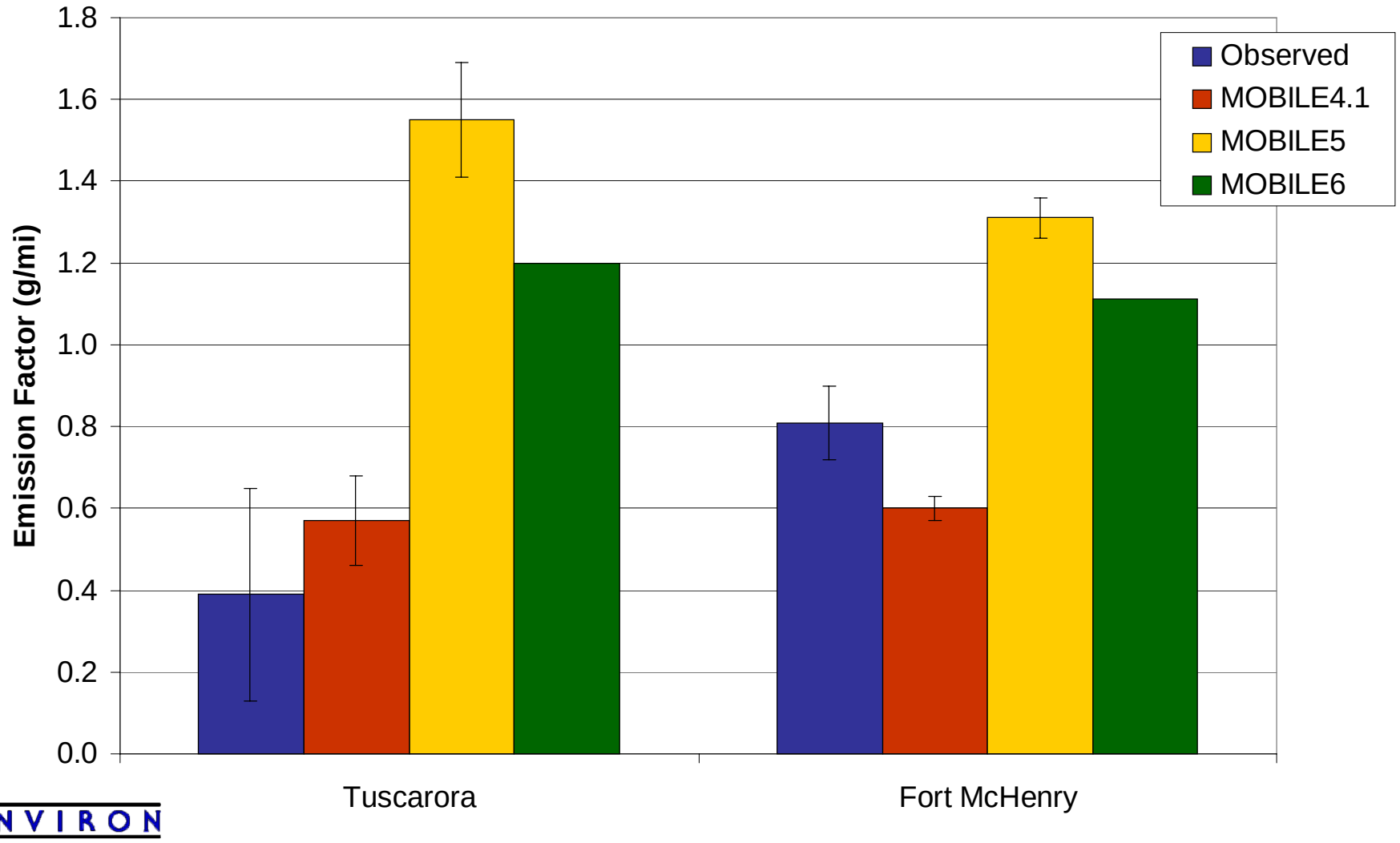

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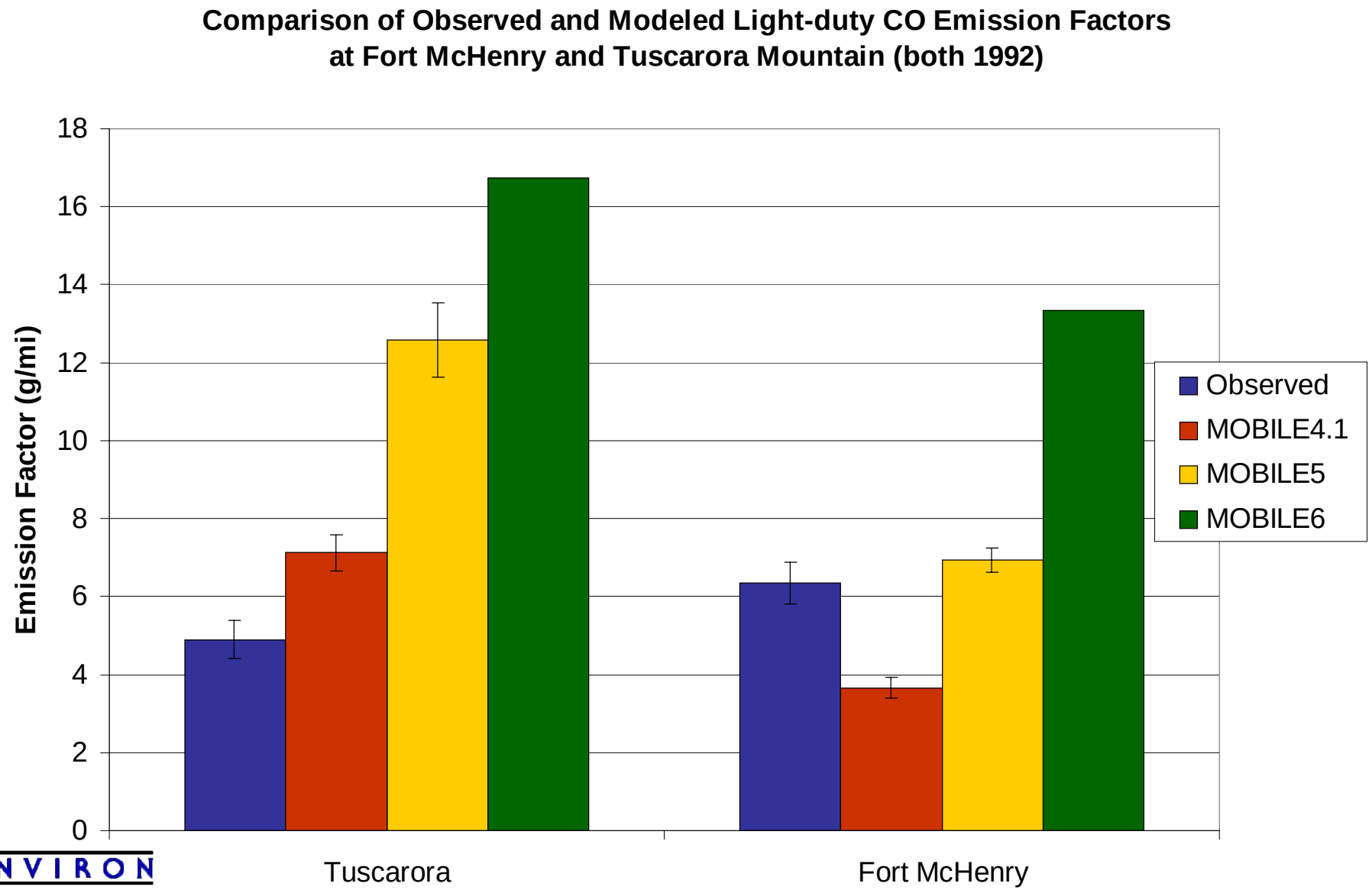
Light-Duty CO Emission Factors



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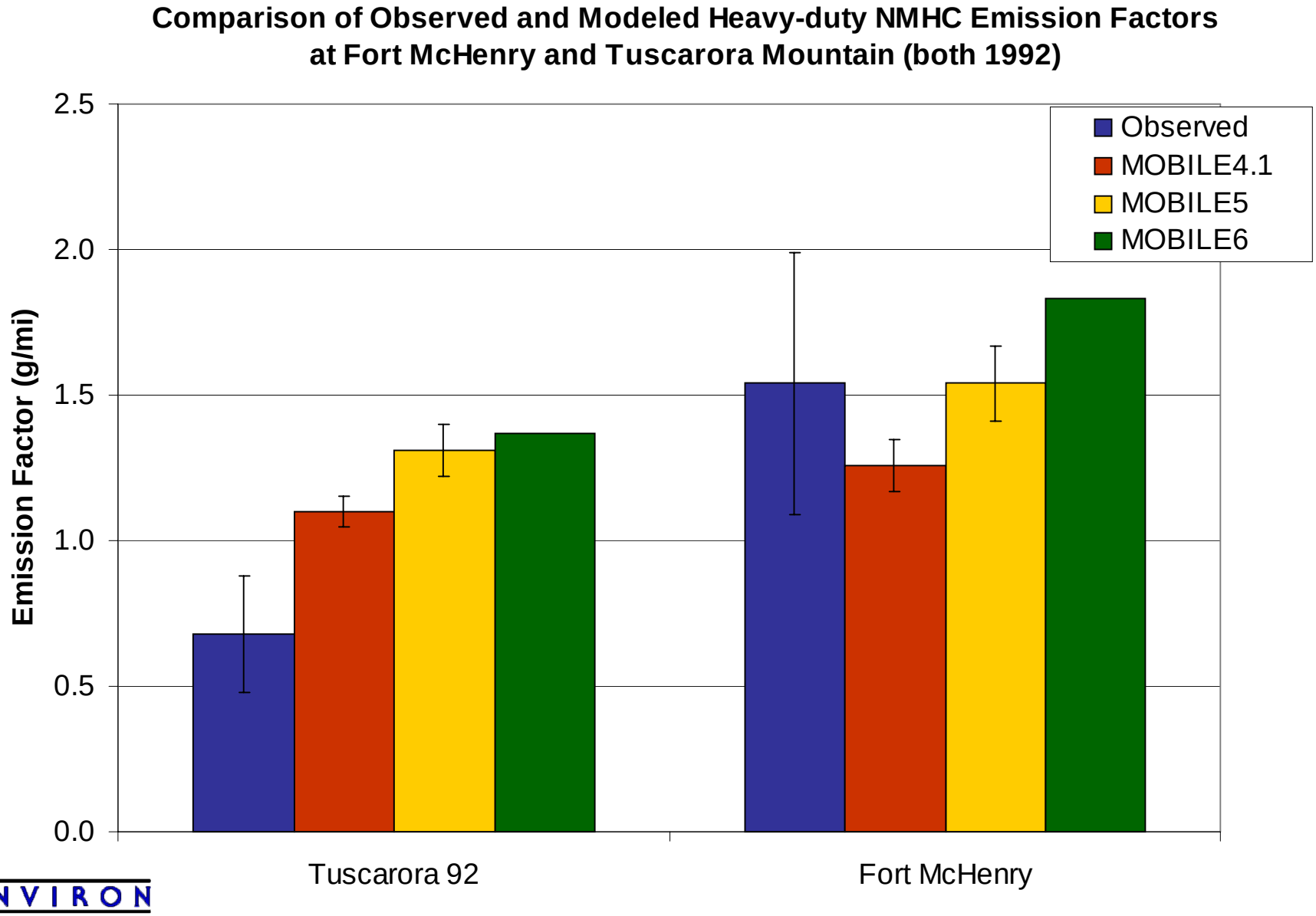
Heavy-Duty NMHC Emission Factors



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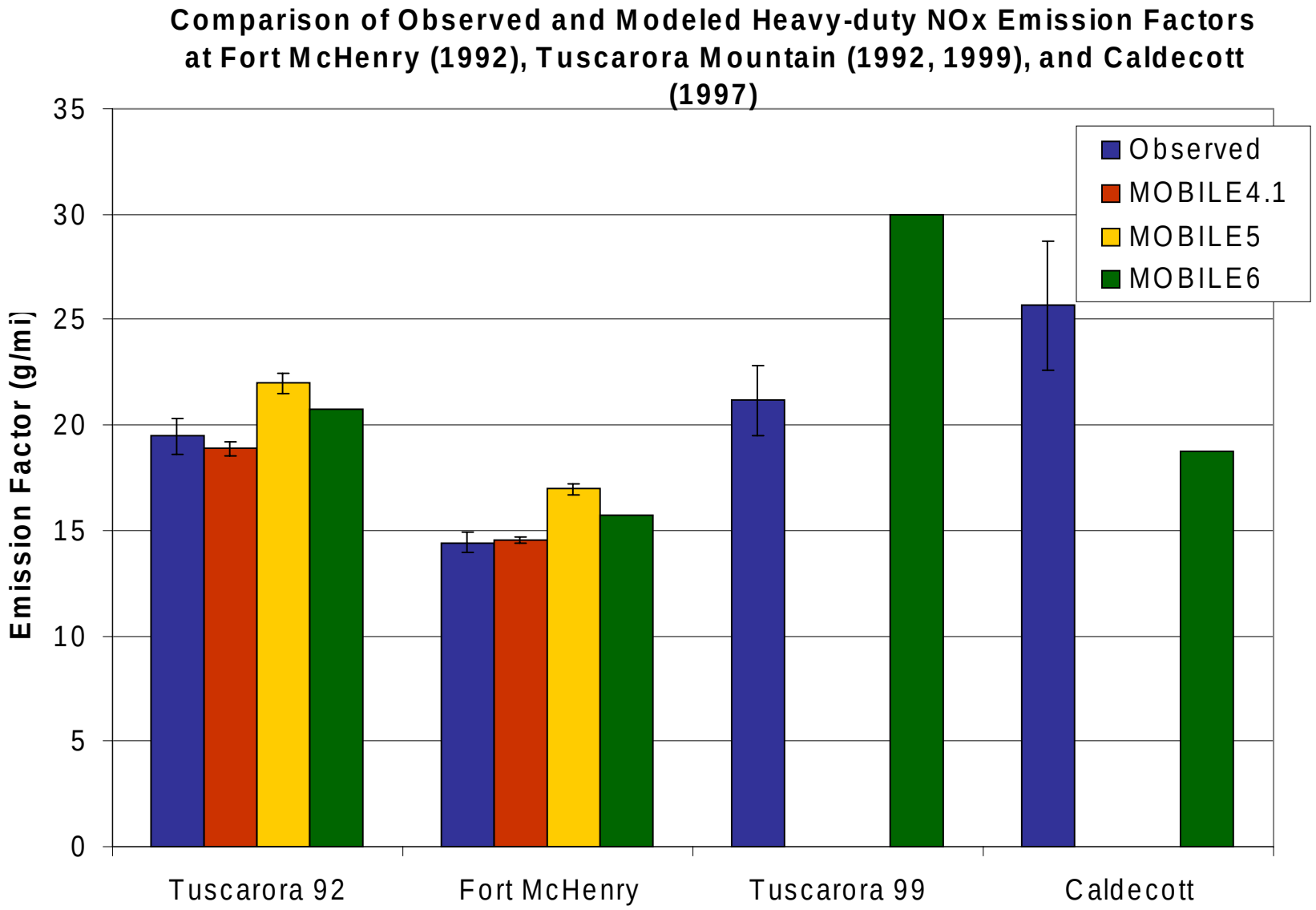

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Heavy-Duty CO Emission Factors

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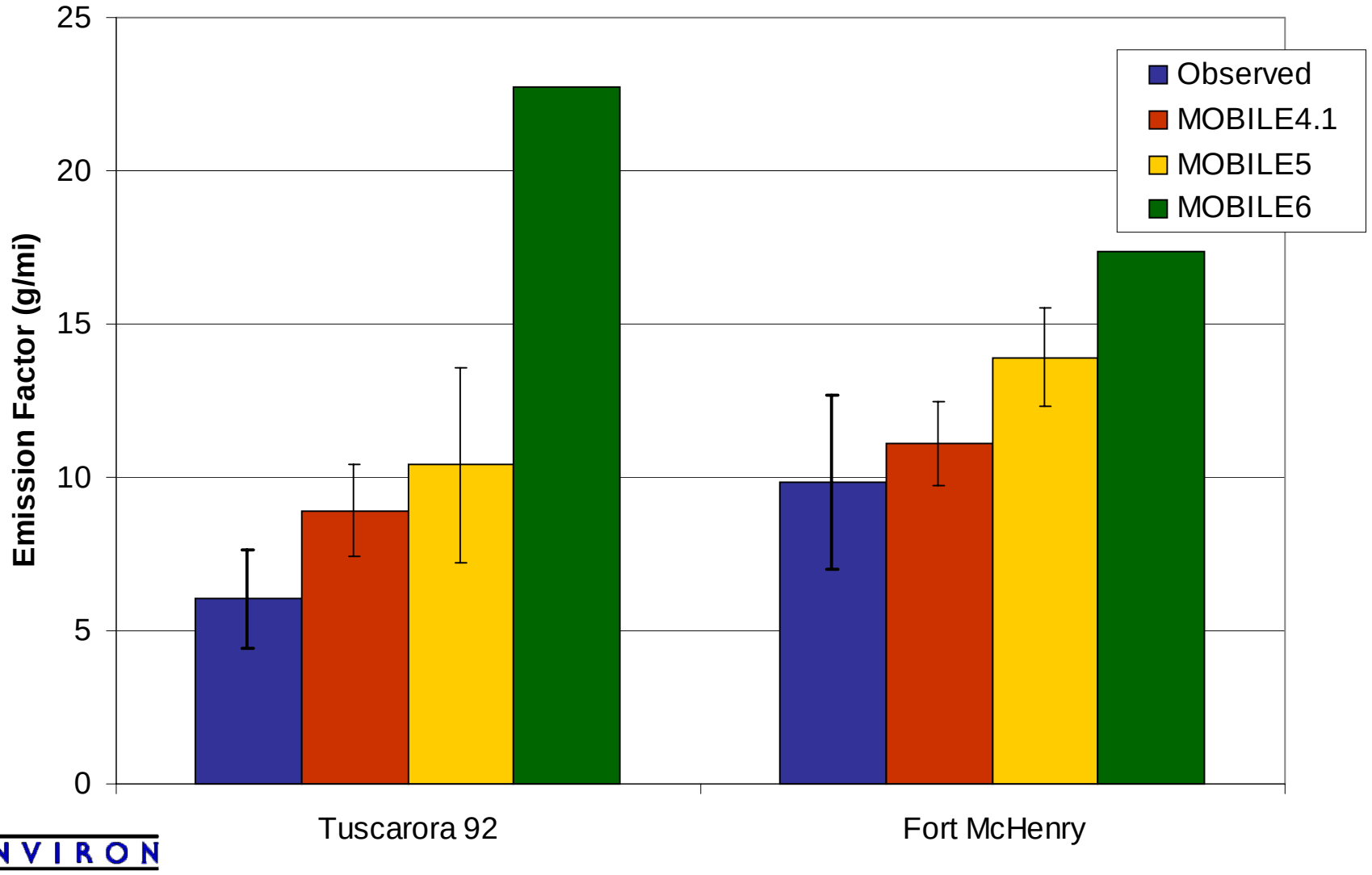

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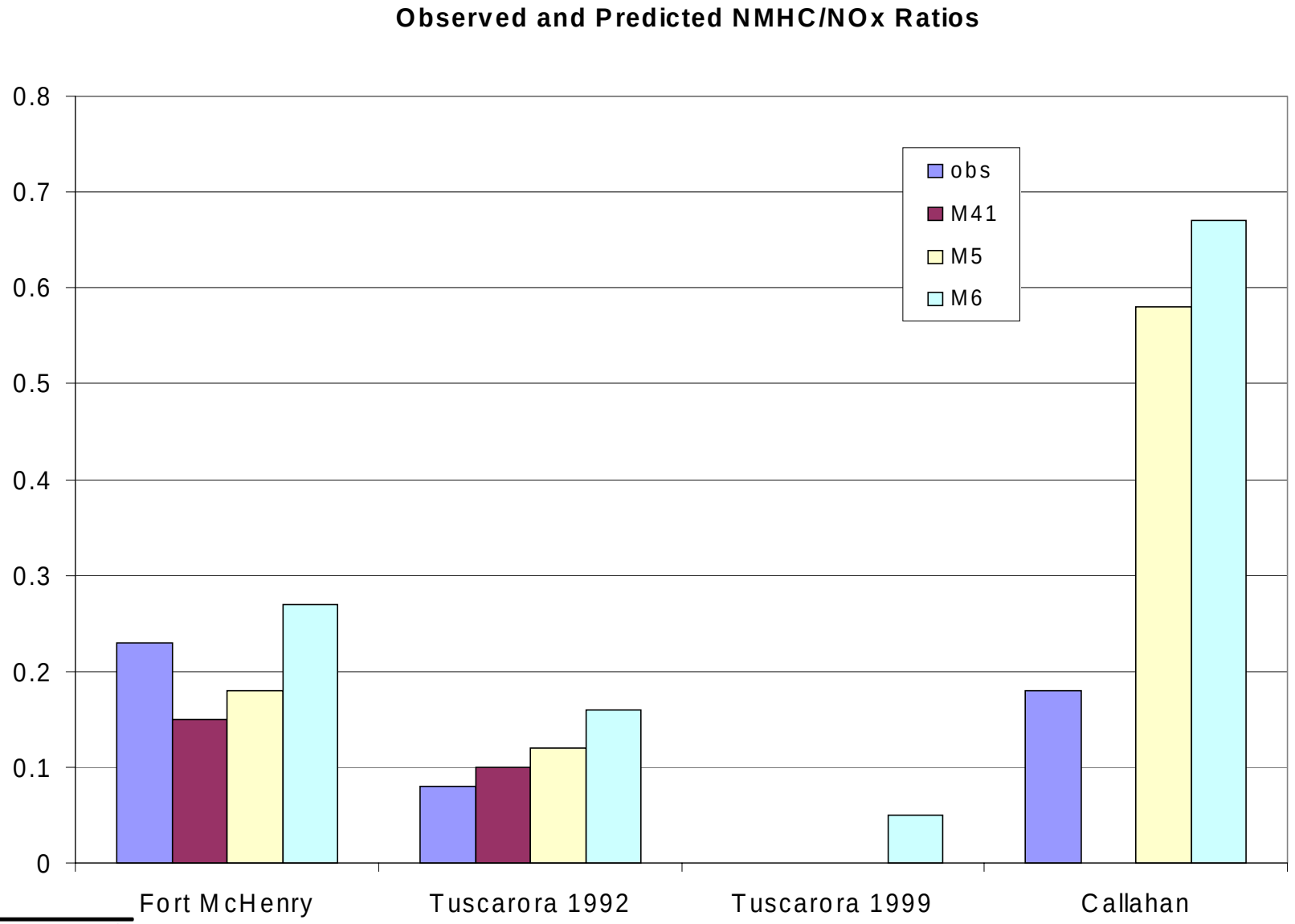
Comparison of NMHC/NOx Ratios



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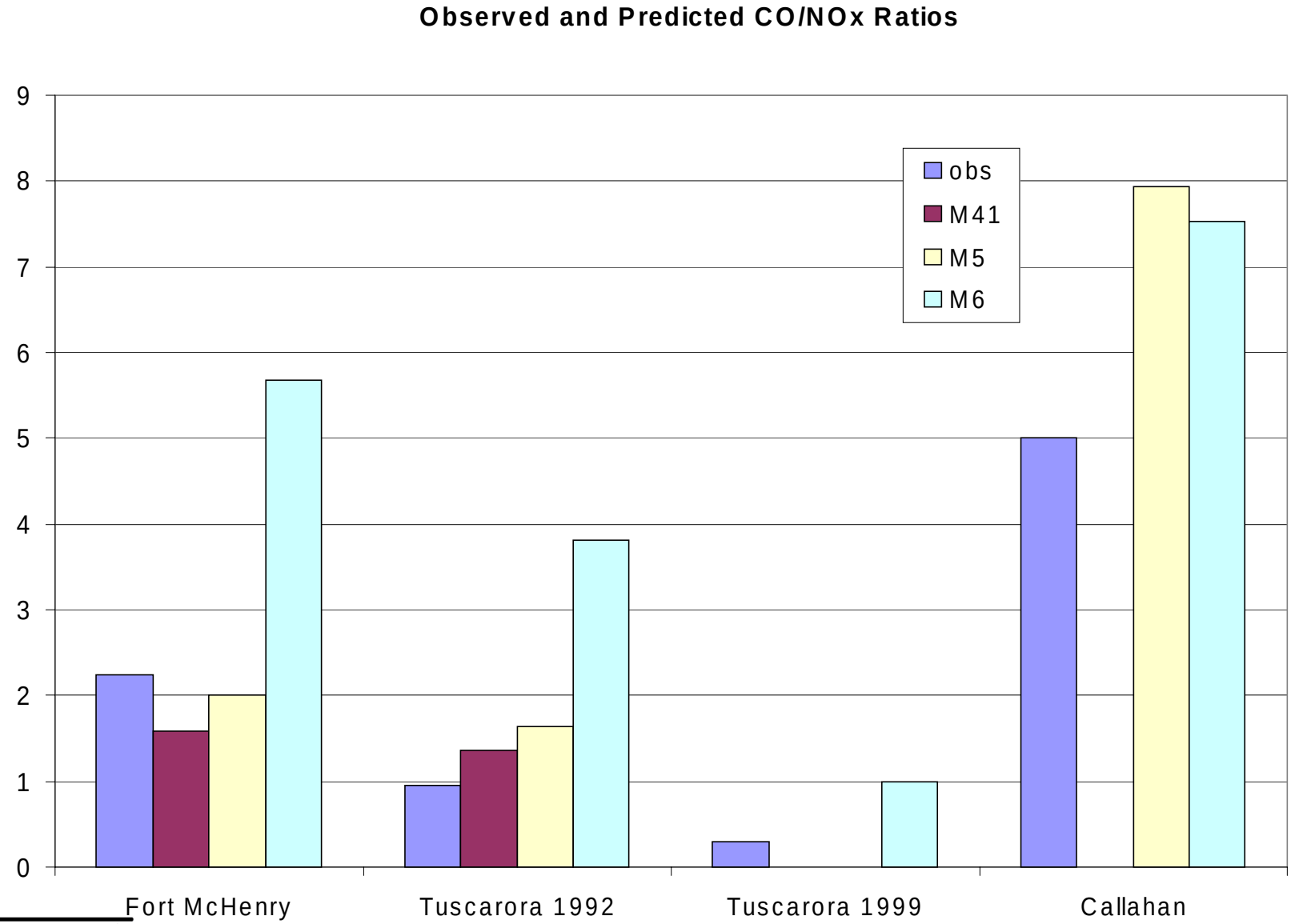
Comparison of CO/NOx Ratios



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Tunnel Study Comparisons Discussion

Factors updated in MOBILE6 include:

1. Off-cycle driving and air conditioning
2. Sulfur on catalysts
3. HD excess NOx (only on MY 1988-2000)
4. Newer technologies' deterioration

Nation-wide, these changes produce fleet-average increases (relative to MOBILE5) of approximately:

Year	CO	NO_X	VOC
1992	60%	25%	50%
1995	50%	25%	45%

Source: EPA presentation on MOBILE5/MOBILE6 at NAMVECC, 2001.

Discussion (continued)

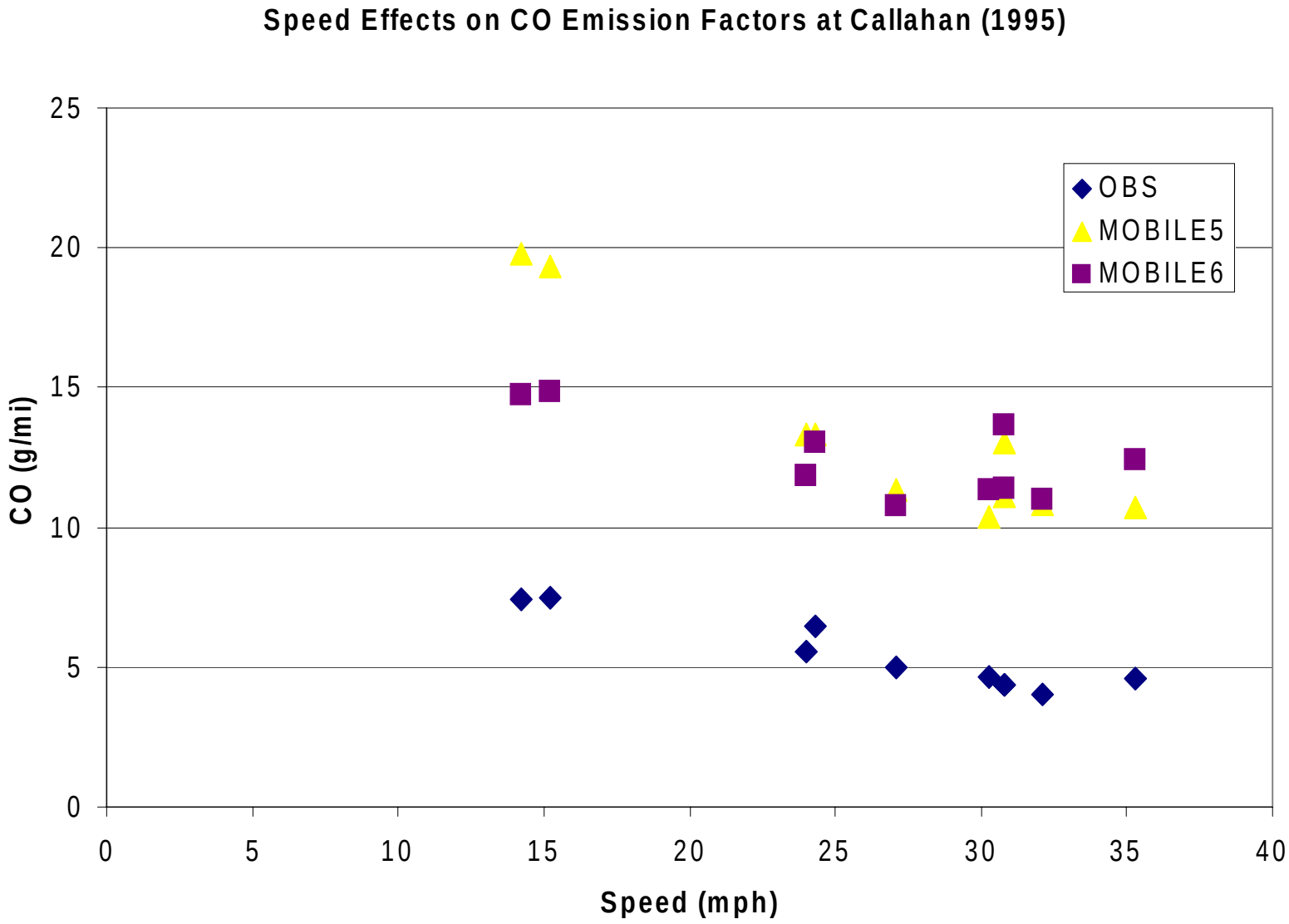
- Updated speed corrections can have significant impacts and the effects' directions depend upon the speed and pollutant.
- Approximate effects for the speeds observed in the tunnels (MOBILE6 relative to MOBILE5) for LD vehicles:

Tunnel	Avg. Spd.	CO	NO_X	VOC
Ft. McHenry	48 mph	+100%	-25%	+40%
Tusc. Mt.	58 mph	+100%	-40%	+15%
Callahan	26 mph	+20%	-15%	+15%

Discussion (continued)

- MOBILE6 NOx fleet average predictions are somewhat lower than MOBILE5 results, and are relatively close to the observed data.
- Small differences between MOBILE6 and MOBILE5 NMHC. MOBILE6 tends to over-predict when the observed emission factors are small and under-predict when they are large. High emitters during one of the Tuscarora runs may influence the results.
- MOBILE6 CO results are much higher than both observed and MOBILE5 values for Ft. McHenry and Tuscarora Mt. However, they are slightly lower (than MOBILE5) for the Callahan Tunnel. This is partially due to the lower humidity at Ft. McHenry and Tuscarora which decreases A/C usage.

CO Emission Factor Comparisons by Speed – Callahan



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Work in Progress

- **Ambient ratio analyses**
- Heavy-duty diesel vehicle emissions analyses
- Remote sensing data comparisons

Reconciliation of MOBILE6 Inventories with Ambient Data

- Obtain/develop gridded, speciated, temporally allocated inventory using MOBILE6 emission factors for on-road mobile
- Compare inventory NMHC/NOx and CO/NOx ratios with ambient ratios
- Focus on times/locations with maximum on-road mobile source contributions

Why Use Ambient/Inventory Reconciliation to Evaluate MOBILE 6?

- Evaluates emissions over a broader spectrum of vehicle types and operating modes than other evaluation methods
- Evaluates MOBILE results as actually used for development of photochemical modeling inventories
- Can be applied to any location with suitable ambient monitoring data

Ambient/Inventory Reconciliation – Caveats

- Confounding influences of area and point sources
- Typically limited to summer morning commute which implies emphasis on cold starts, less A/C usage, generally lower HDD activity
- Relies heavily on proper spatial allocation of emissions
- Limited to evaluation of emission ratios (NMHC/NOx, CO/NOx)
- Does not distinguish between accuracy of emission factors and activity levels

Current Reconciliation Studies

- Houston: August, 2000 inventory (sponsored by TCEQ)
- Lake Michigan, Northeast, Mid-Atlantic 1999 inventories (sponsored by CRC and LADCO)

Houston Reconciliation Analysis

- TCEQ August, 2000 ozone modeling inventory (MOBILE 6 runs from TTI)
- Hourly speciated NMHC plus NOx, CO and wind direction data at six sites
- Examined various upwind sectors with different on-road mobile contributions
- Draft report currently being reviewed by TCEQ

CRC E-64 Reconciliation Analysis

- Final approach being reviewed:
  - Recommendation to use NEI 99 inventory and associated MOBILE 6 inputs
  - Apply diurnal factors from Chicago Area Transit Study
  - Hourly speciated ambient data from PAMS
  - Focus on Lake Michigan, also look at Northeast and Mid-Atlantic sites

Heavy-Duty Chassis Data Comparison

- Compare chassis data with MOBILE6 estimates
- Match test cycle data with MOBILE6 estimate by appropriate facility type and average speed
- Account for differences in
  - Test Cycles
    - Heavy and Medium HD Trucks (UDDS, WVU, CSHVR-WVU cycles)
    - Transit Bus (CBD, others)
    - Garbage Truck (NY cycle)
    - Light HD Trucks (Light-duty FTP, US06 and other LD speed cycles)
  - Gross Vehicle Weight Rating (and curb weight)
  - Model year
  - Odometer

Heavy-Duty Chassis Data Sources

- WVU (Funded studies; DOE, ARB, NYDEC, CRC, etc., etc.)
- CE-CERT (Primarily LHDV)
- CIFER (High Altitude; NFRAQS and EPA programs)
- SwRI (EPA studies)
- Environment Canada

Diesel Fuel-Based Emissions Modeling

MOBILE6/VMT vs. Fuel Consumption

- Compare fuel consumption based emission rates (g/gallon) implied in MOBILE6 with published accounts
- Compare a State-wide emissions inventory generated with MOBILE6 and VMT data, and fuel consumption based emissions estimates

Remote Sensing Data Comparisons

- Purpose
  - To compare the *relative* contributions of emissions from high emitting vehicles from remote sensing data to MOBILE6 predictions
  - To assess whether MOBILE6 underestimates high emitter contribution
- High emitter contribution in MOBILE6
  - Is estimated in basic emission rates (BERs)
  - Is reduced by modeled I/M benefits
  - Can be calculated by model year
- Compare both non-I/M and I/M RSD data

Acknowledgements

- Coordinating Research Council
- EPA Office of Transportation and Air Quality
- Lake Michigan Air Directors Consortium (LADCO)
- Texas Commission on Environmental Quality

- Alan Gertler, Desert Research Institute
- Rob Harley, UC Berkeley

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