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Virginia Remote Sensing Device 2009 Report

Prepared for:

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Glossary of Terms and Abbreviations

ADT	Average Daily Traffic
ASM	Acceleration Simulation Mode
Basic I/M	A set of vehicle I/M program inspection requirements defined by the U.S. EPA that may be used in areas not required to implement an Enhanced I/M program; the inspection procedure usually involves idle testing
Clean Screening	The process of identifying vehicles with low emissions that are then exempt from emission inspection at an inspection station
CO	Carbon monoxide
CO2	Carbon dioxide
Cutpoint	An emissions level used to classify vehicles as having met an emissions inspection requirement
Enhanced I/M	A set of more rigorous vehicle I/M program inspection requirements defined by the U.S. EPA that usually involves IM240 testing
EPA	United States Environmental Protection Agency
Excess Emissions	Vehicle emissions that exceed an I/M cutpoint
FTP	Federal Test Procedure
g/mi	Grams per mile, the units of measurement for FTP and IM240 tests
GIT	Georgia Institute of Technology
GVWR	Gross Vehicle Weight Rating
HC	Hydrocarbons
High Emitter Identification	The on-road identification of vehicles with high emission levels
I/M	Inspection and maintenance program
Idle Test	A tailpipe emission test conducted when the vehicle is idling and the transmission is not engaged
IM240 Test	A loaded-mode transient tailpipe emission test conducted when the vehicle is driven for up to 240 seconds on a dynamometer, following a specific speed trace that simulates real world driving conditions
KW/t	Kilowatts per metric ton, the units of measurement for vehicle specific power
LDGV	Light-duty Gasoline-powered Vehicle

LDGT	Light-duty Gasoline-powered Truck
NO_X	Oxides of nitrogen, usually measured as nitric oxide (NO)
OBDII	On board diagnostic system to detect emissions related problems that is required on all 1996 and newer light–duty vehicles
Repairable Emissions	The emission reductions that can be obtained by repairing a vehicle. The amount of repairable emissions is equal to or greater than the amount of excess emissions
RSD	Remote Sensing Device
VIN	Vehicle Identification Number
VDR	Vehicle On-road Record
VMT	Vehicle Miles Traveled
VSP	Vehicle Specific Power; estimated engine power divided by the mass of the vehicle
VTR	Vehicle Test Record

1 Introduction

The 1990 Federal Clean Air Act Amendments require that I/M Programs be implemented in urbanized areas exceeding the National Ambient Air Quality Standards for ozone and/or carbon monoxide (CO). The Federal Clean Air Act requires implementation of an enhanced I/M Program in the census-defined Washington DC Metropolitan Statistical Area (MSA). In Virginia, this area includes the cities of Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park, and the counties of Arlington, Fairfax, Prince William, Loudoun, and Stafford.

DEQ currently operates a decentralized enhanced I/M program in the Northern Virginia area consisting of approximately 490 independently operated inspection stations. All gasoline fueled vehicles less than 25 years old and up to 10,000 pounds gross vehicle weight rating (GVWR) are required to pass an emissions test or receive a waiver biennially before their motor vehicle license plates can be renewed. Currently, vehicles of model year 1981 and newer, and up to 8,500 lbs. GVWR are required to receive a two-mode Acceleration Simulation Mode (ASM-2) test if they are able to be tested on a single axle dynamometer. Other vehicles receive a two-speed idle (TSI) test. In addition, vehicles that do not receive and OBD test must pass a gas cap pressure test, a visual inspection of applicable emissions control equipment components, and a pre- and post-inspection check for visible emissions. DEQ implemented a new testing procedure, the on board diagnostic (OBD) test, for certain vehicles in 2004. Vehicles receiving an OBD test receive a gas cap test and visual catalyst check.

In 2004, DEQ contracted with ESP to collect emissions data using remote sensing devices (RSD) in an area designated as the Northern Virginia Enhanced Inspection and Maintenance (I/M) Program area and in a non-I/M area. RSD is used to enhance the effectiveness of the existing I/M program as follows:

Objectives:

- Identify high emitting vehicles within the I/M area that may have received inadequate repairs or undergone catastrophic emission control system failures, thus requiring repairs in between normal inspection cycles.
- Identify high emitting vehicles within the I/M area that may have evaporative system failures or liquid fuel leaks;
- Identify high emitting vehicles that are registered in Virginia, but outside the Northern Virginia I/M area and that operate primarily within the program area. These vehicles must be brought into compliance with I/M standards.
- Identify very clean vehicles within the I/M area that have much lower than average emissions, potentially postponing their next regularly scheduled biennial emissions inspection test. This process is referred to as "clean screening".
- Identify vehicles that are registered outside Virginia, but operate primarily within the program area and are high emitters. These vehicles are referred to authorities in the states in which they are registered concerning compliance with I/M standards.

ESP was contracted to implement remote sensing device (RSD) emissions data collection in the area designated as the Northern Virginia Enhanced Inspection and Maintenance (I/M) Program area.

The program commenced operation in October 2004, was extended in 2006 and has continued since.

Earlier reports covered data collected in 2005 and 2006. This report covers the data collection during calendar years 2007-9 and the observed on-road fleet emissions.

In 2007, data was collected in the Northern Virginia I/M area and in the non-I/M areas of Fredericksburg, Richmond and Tidewater. In 2008 and 2009, the data collection activity was focused on the I/M area.

Two significant program changes were made in 2009:

1) The cutpoints and tables used to identify high emitters were updated to reflect changes over time in the on-road fleet and to improve identification rates;
2) Algorithms and techniques to identify high evaporative emitters were added towards the end of 2009.

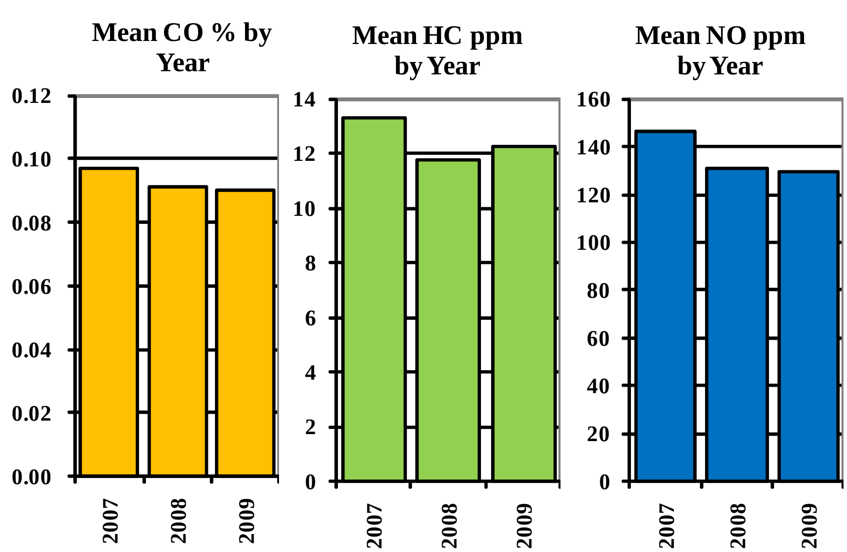
1.1 Findings and Conclusions

Following are the key findings and conclusions drawn from this analysis:

1.1.1 On Road Emissions

- The program met its data collection goals. In the three calendar years 2007 to 2009, an average of 410,000 vehicle measurements were made annually. An average 292,000 unique vehicles were measured covering 15% of the Northern Virginia I/M fleet.
- The average age of on-road vehicles increased by 0.7 years from 2007 to 2009 as a result of the recession. Two-thirds of the increase occurred between 2008 and 2009. Mean emissions decreased between 2007 and 2008, continuing a multi-year trend of reductions in average light vehicle emissions. In 2009, however, average emissions were very similar to those in 2008 as shown in Figure 1-1

Figure 1-1 Northern Virginia On-road Emissions



- The vehicle fleet in the I/M area was newer than the fleet in the non-I/M areas with the exception of Tidewater. In 2007, when compared on an age adjusted basis,

vehicles registered in the northern I/M area had lower HC, CO, NO and particulate emissions than vehicles registered in non-I/M areas.

1.2 High Emitters

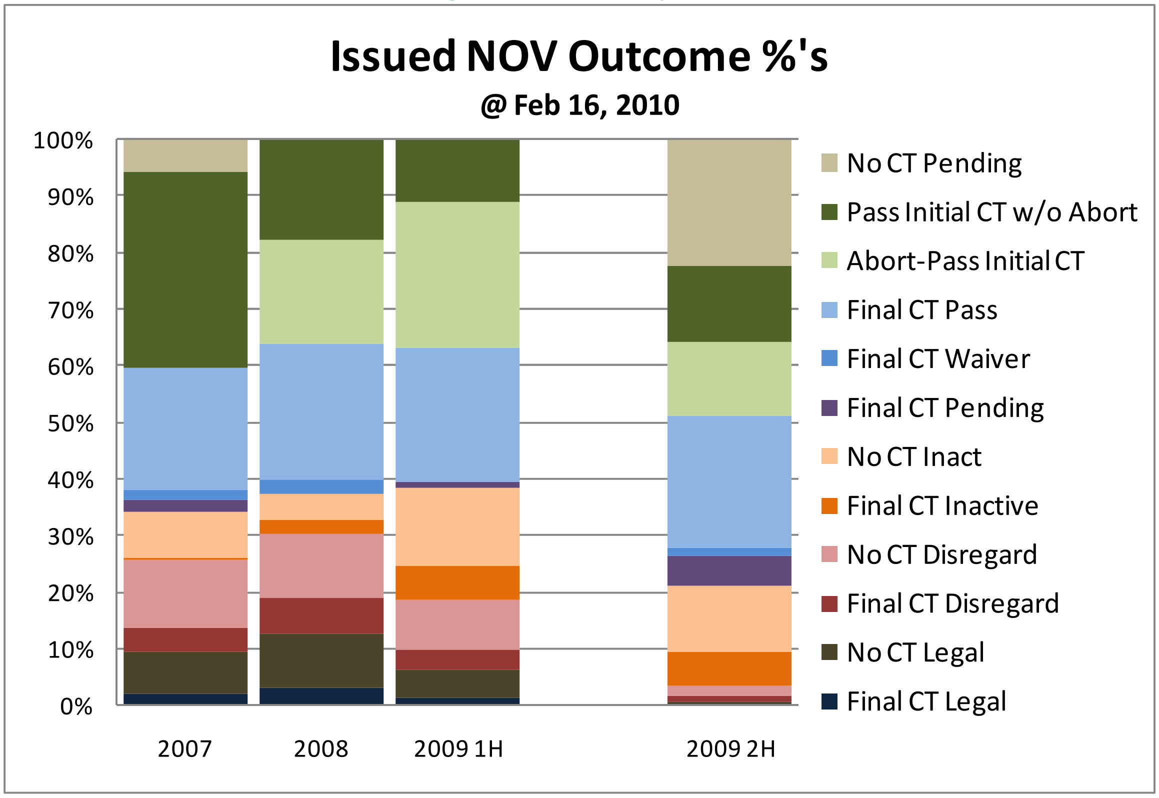
- The program successfully identified high emitters. 191 notices of violation were issued in 2007, 158 in 2008, 87 in the first half of 2009 and 198 in the second half of 2009.
- Vehicle owners issued a Notice of Violation were generally responsive to the program. The outcomes for vehicles issued a notice were:
  - 13%-18% passed a confirmatory test without an abort. These vehicles were either false positives or were repaired before the confirmatory test. The air quality benefit from these vehicles is unknown.
  - 17%-18% passed a confirmatory test with a preceding abort. The presence of an aborted test often indicates a vehicle was headed towards failing the test. The air quality benefits from these vehicles may be similar to those from vehicles that initially failed and were repaired to pass.
  - 24%-30% of vehicles were sold or retired. This is a positive outcome for air quality. If vehicles were sold within the area they will be repaired before resale, if retired, there is a permanent benefit from eliminating the high emitter from the highway.
  - 24%-27% passed a final test or completed the I/M requirements , including 2-3% obtaining waiver. These vehicles have been repaired.
  - 9%-12% were referred to legal for civil fine collection.

Figure 1-2 shows these results in more detail by period. Results for the 2009 second half year include pending actions for vehicles that are still in process.

- The fraction of vehicles measured that were identified as high emitters approximately tripled following the change in selection criteria and a somewhat smaller percentage of these were issued NOVs. For vehicles issued NOVs that obtained a confirmatory test, the percentage of vehicles passing the confirmatory test without an aborted test was reduced following the change in the selection criteria. This is interpreted to be a positive result.
- ESP examined the percentages of 1995 & older models and 1996 & newer models that passed an initial confirmatory test without an abort. 28% of the older models passed compared to 18% of 1996 & newer models. The percentages suggest that the high emitter selection criteria are working at least as well for the newer OBD vehicles as for the older models.
- Average RSD emissions of selected high emitters appeared to be independent of the confirmatory test result. This suggests that selection criteria emission cutpoints

could be further tightened without negatively impacting the fraction of vehicles passing the confirmatory test. It also appears the fraction of high emitters issued NOVs could be increased without affecting negatively affecting results.

Figure 1-2 NOV Response



The following section describes the collection program. The analysis of data collected is presented in Section 3.0. I/M and non-I/M emissions are discussed in section 4. Section 5 describes the high emitters identified and their status.

1.3 Program Performance Monitoring

ESP reviewed the use of RSD to assist in program performance monitoring. RSD were used in combination with program inspection results to:

- Illustrate feedback on the effectiveness of the inspection program and repairs;
- Examine the impact of readiness exemptions.

In establishing the OBD I/M rule, EPA allowed certain readiness exemptions that most I/M state programs have implemented. Readiness exemption rules permit vehicles to pass the I/M test when some of their OBD system monitors are not set ready, i.e. the OBD system has not received sufficient information to determine that all emissions control systems are functioning as designed.

On-road RSD measurements of emissions were used to evaluate the impact of readiness exemptions on the effectiveness of OBD I/M inspection. On-road emissions of vehicles measured before and after initial OBD inspections were compared to the state of the OBD system readiness. The findings from this analysis were:

- Vehicles with OBD systems that were ‘Not Ready’ had higher average emissions than the general OBD fleet;
- Lower emissions measured after the OBD test than before indicate repair benefits for vehicles that failed the OBD test;
- For vehicles that passed the OBD test with OBD systems ‘Not Ready’, emissions measured after the OBD test were the same as emissions measured before the OBD test indicating few, if any, repairs had been performed on these vehicles.

Readiness exemptions appear to be reducing the effectiveness of the OBD I/M inspection by allowing higher emitting vehicles to pass an initial inspection when the OBD system is not ready. Further investigation is required to quantify the impact.

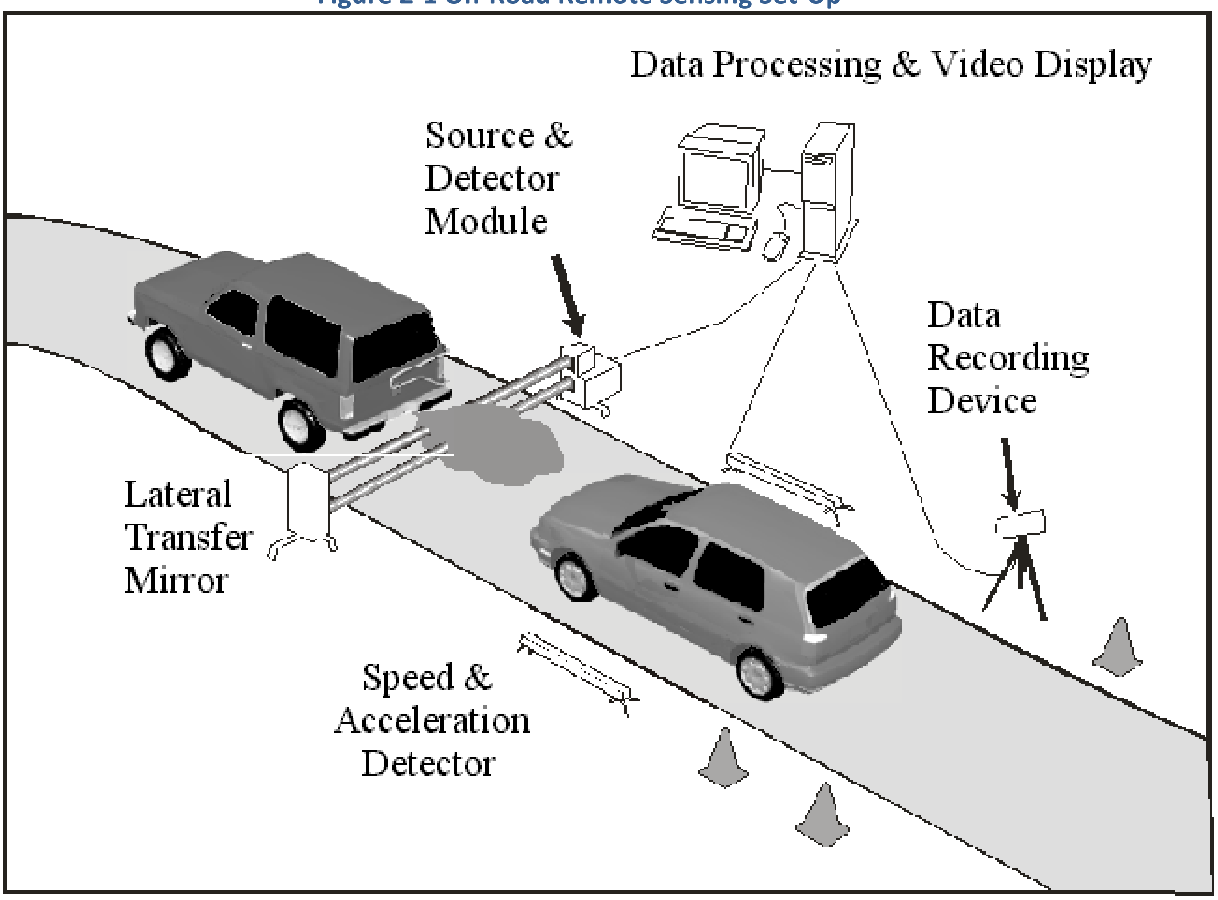
2 EQUIPMENT AND SITES

2.1 Equipment Description

The Virginia RSD program uses the newest addition to ESP's line of products, the RSD4000. The RSD4000 is based on the same underlying technology as the predecessor RSD3000 but has completely re-engineered electronics to improve sensitivity. It is a more durable, easily operable, deployable and portable system that significantly improves operator and program effectiveness through greater capture rates of more accurate vehicle emissions readings.

The RSD4000 detects vehicle emissions when a car drives through an invisible light beam the system projects across a roadway. Figure 2-1 illustrates the remote sensing equipment set-up. The process of measuring emissions remotely begins when the RSD4000 Source & Detector Module (SDM) sends an infrared (IR) and ultraviolet (UV) light beam across a single lane of road to a Corner Cube Mirror (CCM). The mirror reflects the beam back across the street (creating a dual beam path) into a series of detectors in the SDM.

Figure 2-1 On-Road Remote Sensing Set-Up



Fuel specific concentrations of HC, CO, CO2, NOx and smoke are measured in vehicle exhaust plumes based on their absorption of IR/UV light in the dual beam path. During this process, the data-recording device captures an image of the rear of the vehicle, while the Speed & Acceleration Detector measures the speed of each vehicle.

The RSD units are housed in fully outfitted cargo-style vans. These vans are equipped with heating/cooling, a generator, and adequate storage for all components. The vans carry a full compliment of road safety equipment and tools for making small repairs. The vans are equipped with additional lighting for testing during pre-dawn and post dusk hours. The new RSD4000 includes the following improvements over the RSD3000:

1) A longer beam range for safer, more versatile deployment
2) Wider, more stable platform resulting in less operational vibration
3) Simple and easy setup with laser alignment aids
4) Alignment platforms to facilitate a fast and secure alignment result
5) Continuous automatic CO2 for background compensation minimizes the need for field calibration. (Only one or two calibrations are generally required during a full day of data collection.)
6) Fourth generation real-time measurement validation
7) Signal sensitivity and accuracy that significantly exceed 2002 California BAR certification standards
8) Fewer degrees of freedom in alignment resulting in improved optical stability and less noise for increased productivity, yielding more valid records.
9) A Windows operating system for ease of operation and true multi-tasking
10) A fuel specific smoke measurement using a UV wavelength that senses the fine particles invisible to traditional visible light opacity meters
11) Rugged assemblies requiring less maintenance and resulting in less downtime

2.2 Equipment QA/QC Audits:

2.2.1 Factory Testing and Certification

When an RSD system is built at the Tucson Technology Center, it undergoes several steps to ensure accuracy. First, the source detector module is bench calibrated. It is then audited using several blends of gas. When the system is fully calibrated and assembled, it is tested again in the parking lot using an audit truck. The unit tests are based on the BAR OREMS specification.

An audit truck is a modified vehicle that uses a long exhaust stack to redirect the vehicle engine exhaust upwards and away from the roadway. Audit gases of known concentrations are dispensed through a simulated tailpipe routed to the rear of the audit truck. When the truck is driven past a roadside remote sensing SDM/CCM set of modules, the system measures the pollutant concentrations in the dispensed test gas instead of the vehicle engine exhaust.

The remote sensing unit is setup in a parking lot to avoid interference from other traffic. The auditor drives the audit truck through the remote sensing system 40 times for each gas blend during acceptance testing. ESP detector accuracy, including speed and acceleration, will

meet the detector accuracy tolerances shown below for at least 97.5% (39/40) runs for each gas. Six different audit gas blends are used to verify the unit accuracy over a range of pollutant concentrations.

2.2.2 Detector Accuracy:

The carbon monoxide (CO%) reading will be within ± 10% of the Certified Gas Sample, or an absolute value of ± 0.25% CO (whichever is greater), for a gas range less than or equal to 3.00% CO. Negative values shall be included and will not be rounded to zero. The CO% reading will be within ± 15% of the Certified Gas Sample for a gas range greater than 3.00% CO. Negative values will be included and will not be rounded to zero.

The hydrocarbon reading (recorded in ppm propane) will be within ± 15% of the Certified Gas Sample, or an absolute value of ± 250 ppm HC, (whichever is greater). Negative values will be included and will not be rounded to zero.

The nitric oxide reading (ppm) will be within ± 15% of the Certified Gas Sample, or an absolute value of ± 250 ppm NO, (whichever is greater). Negative values shall be included and will not be rounded to zero.

2.2.3 Speed and Acceleration Accuracy:

The vehicle speed measurement will be accurately recorded within ± 1.0 mile per hour.

The vehicle acceleration measurement will be accurately recorded within ± 0.5 mile per hour / second.

2.2.4 Daily Set-Up and Calibration

Every scheduled work day, the operator drives to an existing or new test site. The operator's first duty is to provide a safe work area for themselves and passing motorists. The next step is to set up the source detector module and allow the electronic components within to warm up for a minimum of 30 minutes. Following the set up and alignment of the other components, the SDM is aligned and ready for Calibration.

An automated calibration utilizing a mechanized gas cell within the SDM is a method of testing the equipment without the need to drive an audit truck past the unit. During a gap in the passing traffic, a test gas within a sealed cell, with a known blend of HC, CO, CO2 and NOx, is maneuvered into the optical path of the remote sensing beam. If necessary, the instrument set-up is adjusted so that the pollutant values measured by the unit, match the known concentrations of pollutants in the test gas blend.

Calibration for the RSD4000 occurs once at the beginning day and at mid-day if conditions warrant.

2.2.5 Equipment Audits

After each daily calibration, the Operator is required to perform an audit to verify an optimal calibration. A puff audit is a method of testing the equipment without the need to

drive an audit truck past the unit. During a gap in the passing traffic, a test gas with a known blend of HC, CO CO2 and NOx, is puffed into the optical path of the remote sensing beam. If the audit passes a predetermined pass/fail tolerance, the operator is allowed to begin testing vehicles. If not, the operator is required to realign and recalibrate the system until it passes the audit process.

Audits for the RSD4000 occur every hour (2 hour maximum before system lockout occurs), twice when a calibration is performed (once before to earmark data and once after to begin testing) and once at the end of the test collection period to earmark the data.

2.2.6 Quarterly Audits (drive-by audits)

Every three months during the course of data collection, an Audit Truck is utilized to audit all RSD4000 systems being used in Virginia.

The audit truck is outfitted with a gas cylinder rack that holds 4 compressed gas cylinders. Each gas cylinder is equipped with a high flow regulator, a high flow solenoid and a Tygon hose, which is adapted to a simulated tailpipe. Inside the truck cab, the audit truck operator has the ability to switch power from solenoid to solenoid to select the appropriate audit gas cylinder for drive-by audits. A traffic cone is placed 60-70 feet preceding the test site. This is used as a mark to begin the flow of gas to ensure there is an adequate plume of audit gas as the truck passes the RSD4000. The typical gas blends used in the audits are show below:

	HC (ppm)	**CO**	**CO2**	**NO_X (ppm)**
Blend # 1	500	0.5%	14.70%	3000
Blend # 2	3000	1.00%	14.38%	2000
Blend #3	2000	2.75%	13.10%	500
Blend #4	6000	5.00%	11.55%	250

In addition to the equipment, the operator is also audited for following procedures: site setup, calibration, camera alignment, traffic safety and documentation.

2.3 Site Selection Criteria

Evaluation of sites used in the previous study and the selection of new sites was performed during the work plan preparation. Site selection goals included developing a network of sites covering:

- The I/M Cities of Alexandria, Fairfax, Falls Church, Manassas and Manassas Park, and the counties of Arlington, Fairfax, Loudon, Prince William and Stafford.
- Non-I/M area sites in Fredericksburg, Richmond and Tidewater regions to serve as a suitable reference.

The sites should:

- Provide a representative sampling of the I/M area fleet over the 12-month collection period.
- Provide a representative sampling of the out-of-area fleet observed in the I/M area.
- Maximize valid records without compromising geographic coverage and data quality.
- Allow for multiple observations of vehicles when sites are repeated.
- Yield a measurement distribution roughly similar to the vehicle population.

The site visit strategy was to visit most sites two to four times during the data collection phase This provides a good balance of general fleet coverage as well as a significant number of vehicles with multiple measurements that have been used to assess the effectiveness of alternative high emitter and low emitter identification protocols.

2.4 Site Locations

2.4.1 Site Selection Activity

Two "two-man" teams canvassed the I/M and non-I/M areas. The teams visited the productive sites used in the 1996 and 2002 studies and identified new sites in the area.

The teams logged traffic information, site locations, and site configurations using GPS units, laser rangefinders, digital cameras, and traffic counters. The information was entered into an Access database through an ESP interface utility (developed by GIT) known as Analyzer, which enables immediate electronic filing of all pertinent information.

2.4.2 Sites Used

Table 2-1 shows the annual number of survey sites used and the number of days of on-road data collection. In 2007, some data were collected in Fredericksburg, Richmond and Tidewater in addition to the northern Virginia enhanced I/M area.

Table 2-1: Number of Sites Used

Sites Used			
Region	**2007**	**2008**	**2009**
Northern enhanced I/M	72	93	85
Fredericksburg	3	0	0
Richmond	1	0	0
Tidewater	2	0	0
Sites used	78	93	85
RSD Survey Days			
Region	**2007**	**2008**	**2009**
Northern enhanced I/M	186	184	189
Fredericksburg	6	0	0
Richmond	2	0	0
Tidewater	3	0	0
Total Days	197	184	189

Figures 2-2 through 2-5 display the distribution of the sites in Northern Virginia, Fredericksburg, Richmond and Tidewater.

Figure 2-2 Site Locations in Northern Virginia

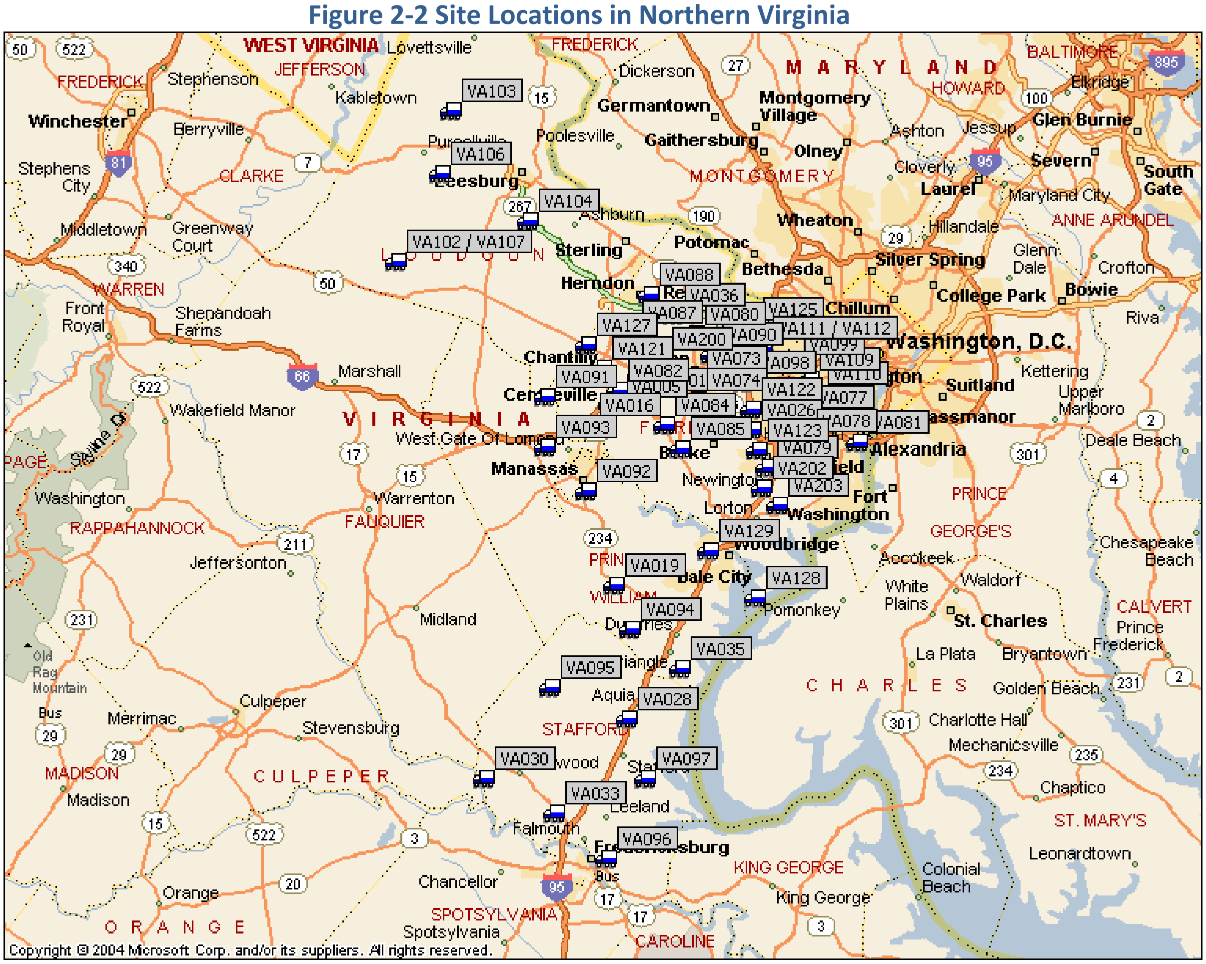


Figure 2-3 Site Locations in Fredericksburg

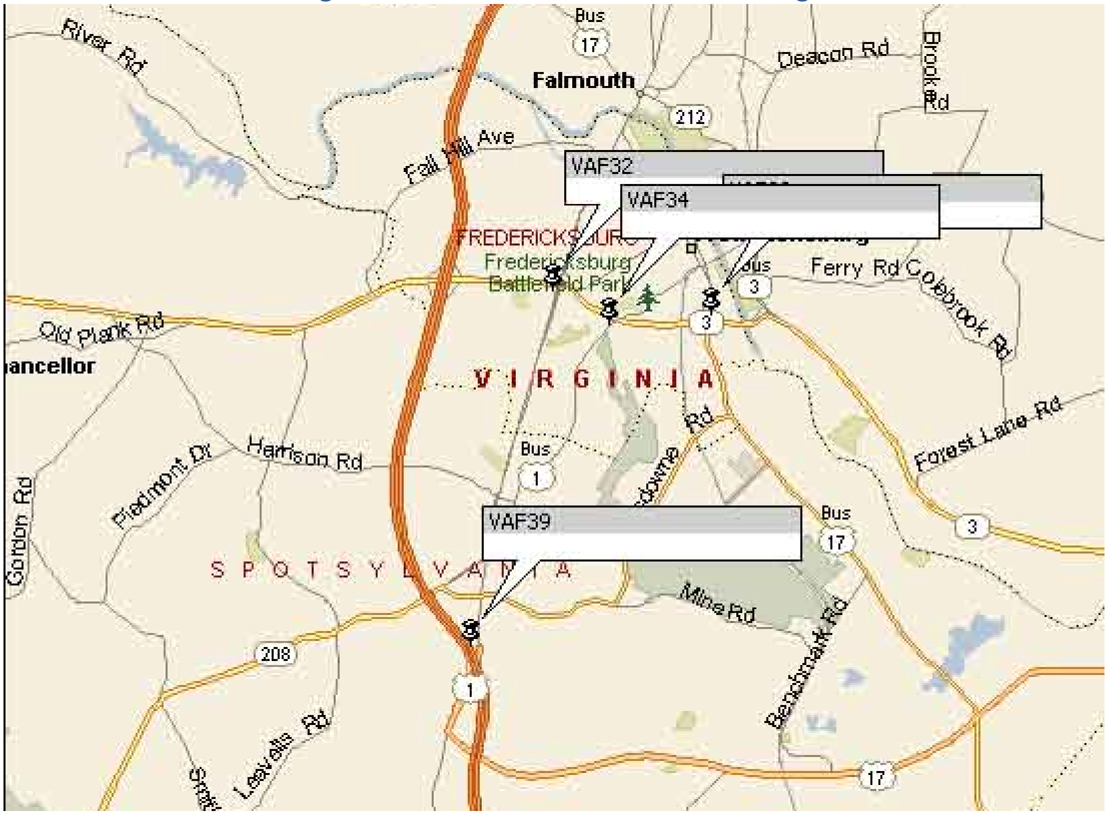


Figure 2-4 Site Locations in the Richmond Area

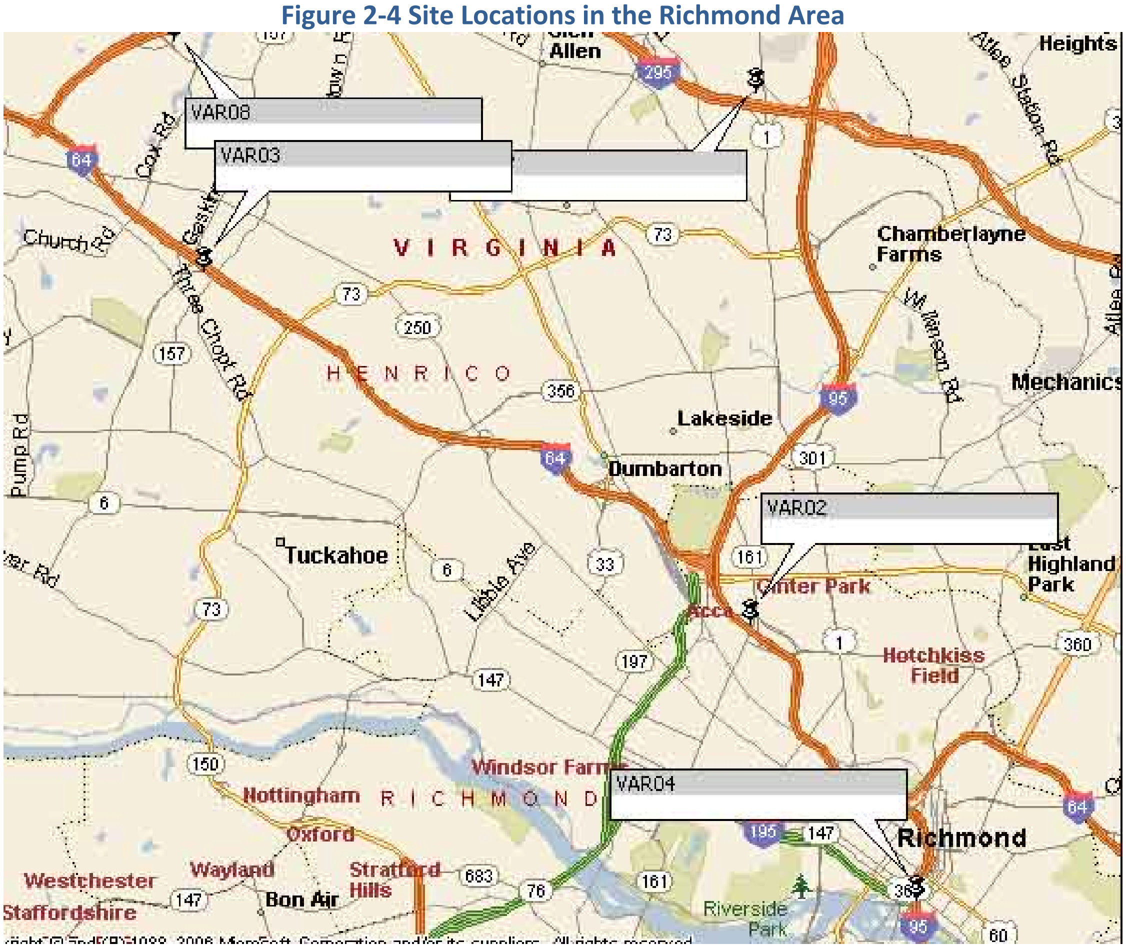


Figure 2-5 Site Locations in Tidewater

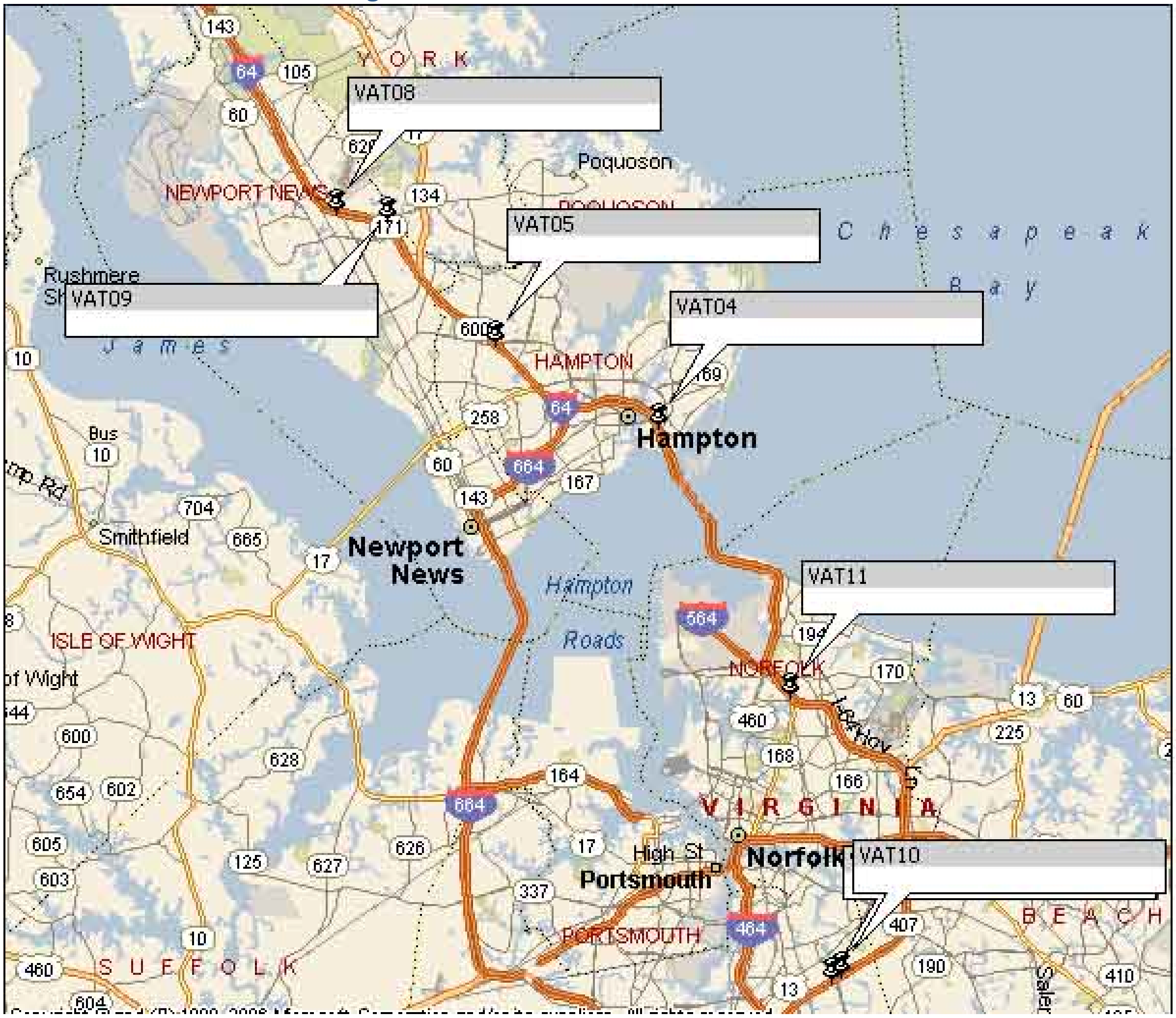


Table 2-2 lists the set of site locations visited during the study, the road grade in degrees, the number of days the site was used and the total active hours of data collection excluding any set-up and takedown time.

Table 2-2: Site Locations

Site	Location	Jurisdiction	I/M	Survey Days 2007	2008	2009
VA001	DEQ					1
VA005	Centerville - Rte 7100 North to I-66 East	FAIRFAX	Y	1	1	3
VA016	Centerville - US 29 South and North to I-66 East	FAIRFAX	Y	6	3	2
VA019	VA 638 (Neabesco Mills Road) South between I-95 and US 1	PRINCE WILLIAM	Y	4	2	1
VA026	Ravensworth - VA 620 East to I-495 South	FAIRFAX	Y	4	2	
VA028	I-95 South to VA 610 West	STAFFORD	Y	7	2	2
VA030	Garrisonville - VA 630 East and West to I-95 North	STAFFORD	Y	2	2	2
VA033	VA 17 South to I-95 South	STAFFORD	Y	4	5	
VA035	Prince William - VA 234 East and West to I-95 North	PRINCE WILLIAM	Y	8	2	6
VA036	Reston - VA 828 North and South to VA 267 East	FAIRFAX	Y	7	2	
VA057	Rose Hill - VA 633N, moving East from intersection with VA 611	FAIRFAX	Y	1	2	1
VA073	VA 123 South, 1/4 mile south of I-66 overpass	FAIRFAX CITY	Y	2		
VA074	Fairfax - I66 East to US 50 East	FAIRFAX CITY	Y	2		2
VA076	VA 244 East & West to VA 7 East	FAIRFAX	Y	3		3
VA077	I-395 S (exit 4) to VA 236 East (Duke Rd)	ALEXANDRIA	Y	2	2	2
VA078	VA 236 W (Duke Road) to I-395 N	ALEXANDRIA	Y	4	4	
VA079	Springfield - Franconia Rd (VA 644) West to I-95 North	FAIRFAX	Y	4	4	7
VA080	Wayside - VA 674 South moving East from Rte 5320	FAIRFAX	Y	3	2	3
VA082	Centerville - I-66 West to VA 28 South	FAIRFAX	Y	6	3	5
VA084	Brentwood - VA 620 East and West to Rte 7100 North	FAIRFAX	Y	1		
VA085	Brentwood - Rte 7100 South to VA 123 (Ox Road)	FAIRFAX	Y	1		
VA087	Franklin Farm - VA 608 West at insection with McLearen Rd	FAIRFAX	Y	1	2	2
VA088	Hernden - From Sunset Hills Rd East to Rte 7100 South	FAIRFAX	Y	1	2	2
VA090	Vienna - VA 673 North, just west from intersection with Church St.	FAIRFAX	Y	5	2	
VA091	Centerville - US 29 South/West to VA 28 South to Manassas	FAIRFAX	Y	1	2	2
VA092	Manassas - VA 234 Bus south in Manassas, south from VA 661	MANASSAS	Y	1		2
VA093	Manassas - VA 234 Bus North, just south of Virginia Armory	PRINCE WILLIAM	Y	1		2
VA095	Garrisonville - VA 610 W, between VA 648 and VA 643	STAFFORD	Y	2	4	2
VA096	Falmouth - VA 17 Bus N to I-95 S	STAFFORD	Y	2		2
VA097	Stafford - VA 630 W, 0.2mi west from intersection with US1	STAFFORD	Y	4		
VA098	Falls Church - VA 7 West (North) to I-66 West	FAIRFAX	Y	1	2	2
VA099	US 50 East to VA 7, at interesction with Seven Corners Place	FALLS CHURCH	Y	4	2	2
VA100	from US 15 (James Madison Hwy.) to I-66 East	PRINCE WILLIAM	Y	3	2	
VA102	Purcellville - Berlin Trke (VA 287) to VA 7 East	LOUDOUN	Y	3	2	4
VA103	VA 9 (Charles Town Pike) East, just East of VA 287 (Berlin Trpe)	LOUDOUN	Y	1	2	2
VA104	Leesburg - VA 7 East to US15 North	LOUDOUN	Y	1		2
VA105	from 7 Bus. (W. Market St.) West to VA 7 / VA 9 West	LOUDOUN	Y	3	2	1
VA106	Round Hill - Loudoun St. to VA 7 West	LOUDOUN	Y	1		1
VA109	Glencarlyn - N Carlin Springs Rd to US 50 West	ARLINGTON	Y	4	2	1
VA110	Glencarlyn - N Carlin Springs Rd to US 50 East	ARLINGTON	Y	3	2	1
VA111	VA 7 East to I-66 East	FAIRFAX	Y	3	2	
VA112	State Route 7 East to I-66 West	FAIRFAX	Y	1		2
VA113	VA 7 (Market St.) West to US 15 South	LOUDOUN	Y	3	1	2
VA114	from VA 267 West to US 15 Bypass / VA 7 East	LOUDON	Y	1	2	2
VA120	from N. George Mason Dr. South to N. Carlin Springs Rd. South	ARLINGTON	Y	3	2	2
VA121	Fair Lakes - US 50 West to Rte 7100 North	FAIRFAX	Y	6	1	1
VA122	Fair View Park - US 50 East to I-495 North	FAIRFAX	Y	5	2	
VA123	I-395 North to VA 648 West (Edsall Rd)	FAIRFAX	Y	1	2	1
VA124	VA 193 East (Georgetown Pike), just pass exit from I-495	FAIRFAX	Y	1		3
VA125	Tysons Corner - VA 267 East to I-495 South	FAIRFAX	Y	3	4	6
VA126	VA 120 (Glebe Rd) to I-395 North	FAIRFAX	Y	3	2	2
VA127	US 50 East to VA 28 South	FAIRFAX	Y	1	1	2
VA128	I-95 South to VA 123 North	PRINCE WILLIAM	Y	3	2	2
VA129	Dale City - From Horner Rd (VA 639) to I-95 South	PRINCE WILLIAM	Y	3	4	3
VA201	VA 7100 South to I-66 East	FAIRFAX	Y	3	2	2
VA202	Boudinot Dr. to I-95 South	FAIRFAX	Y	2	2	2
VA203	VA 7100 North to I-95 North	FAIRFAX	Y	4	2	5
VA204	VA 619 to I-95 South (Exit 150)	PRINCE WILLIAM	Y	1	1	2

Table 2-2: Site Locations continued

Site	Location	Jurisdiction	I/M	Survey Days 2007	2008	2009
VA205	VA 8900 East/West to i-95 South (Exit 136)	STAFFORD	Y	1	1	2
VA206	Russell St. to I-95 North	PRINCE WILLIAM	Y	1		2
VA207	Russell St. to I-95 South	PRINCE WILLIAM	Y	1	1	2
VA208	from Lorton Rd (VA642) to I-95 South	FAIRFAX	Y	1	1	2
VA209	from VA 123 South to I-95 North	PRINCE WILLIAM	Y	3	3	
VA210	from I-66 East to VA 7100 North	FAIRFAX	Y	3	2	1
VA211	VA 611 (Telegraph Rd.) South before Beulah St.	FAIRFAX	Y	3	4	4
VA212	Pohick Rd. (VA 641) North, a 1/4 mile past Magic Leaf Rd.	FAIRFAX	Y	1	2	2
VA213	Davis Ford Rd. South, just past Occaquan Oaks Ln.	PRINCE WILLIAM	Y	1	2	
VA214	Twinbrook Rd. North, just past Commonwealth Blvd.	FAIRFAX	Y	1	4	4
VA215	Walney Rd. East, between Walney Park Dr. and Walney Way	FAIRFAX	Y	1	3	1
VA216	from US 17 South (Warrenton Rd) to I-95 North	STAFFORD	Y		3	2
VA217	from I-66 East to VA 28 (Sully Rd) North	FAIRFAX	Y		1	1
VA218	from Ox Rd. to VA 7100 South	FAIRFAX	Y		1	
VA219	Sugarland Rd South btwn Landerset Dr and Drainsville Rd (VA 228)	FAIRFAX	Y		2	3
VA220	US 15 North, just pass Graduation Dr.	PRINCE WILLIAM	Y	2	2	
VA221	US 15 North, just pass Battlefiel Dr.	LOUDOUN	Y	2		
VA222	VA 7 West to US 15 North	LOUDOUN	Y	2	2	2
VA223	I-66 East to VA 7100 South	FAIRFAX	Y		3	2
VA224	VA 28 East to VA 234 North (Prince William Parkway)	PRINCE WILLIAM	Y		2	2
VA225	VA 28 East to VA 234 North (PrinceWilliamParkway)end of ramp	PRINCE WILLIAM	Y		1	2
VA226	VA 28 West to VA 234 North (Prince William Parkway)	PRINCE WILLIAM	Y		1	2
VA227	from VA 7 East to VA 7100 South	FAIRFAX	Y	2	3	2
VA228	VA 7 West (Leesburg Bypass) to VA 276 East (to Wash.)	LOUDOUN	Y		1	
VA229	VA 7 (King St.) to I-395 South	ALEXANDRIA	Y		3	2
VA230	from I-95 North to VA 7100 (Fairfax County Pkwy) South	FAIRFAX	Y		1	1
VA231	from Va 611 (Telegraph Rd) South (West) to Va 7100 North	FAIRFAX	Y		1	
VA232	from VA 224 to Seminary Rd.	FAIRFAX	Y		1	2
VA233	from VA 123 (Ox Rd.) North to VA 7100 North	FAIRFAX	Y		1	2
VA234	from VA 7100 North to I-66 West	FAIRFAX	Y		3	2
VA235	from I-66 East to VA 123 South	FAIRFAX	Y		2	
VA236	from I-66 West to VA 7100 South	FAIRFAX	Y		2	3
VA237	from I-66 West to VA 243 (Nutley St.) South	FAIRFAX	Y		2	3
VA238	from I-66 East to VA 243 (Nutley St.) North	FAIRFAX	Y		1	1
VA239	Loisdale Rd. South, pass Lois Dr.	FAIRFAX	Y		1	2
VA240	from VA 644 West to I-95 South	FAIRFAX	Y		1	
VA241	from I-395 North to VA 7 West	ARLINGTON	Y		2	1
VA242	from VA 120 South/East (Glebe Rd.) to I-395 South	ARLINGTON	Y		1	2
VA243	from I-395 South to VA 7 West	ARLINGTON	Y		1	2
VA244	from I-495 West / I-95 South to VA 644 East	FAIRFAX	Y		2	3
VA245	from VA 617 to VA 7900 / VA 7100 West	FAIRFAX	Y		1	2
VA246	from VA 7900 / VA 7100 North to Rolling Rd.	FAIRFAX	Y		1	2
VA247	from Rolling Rd. North to VA 7100 / VA 7900 North	FAIRFAX	Y			2
VA248	VA 665 (Fox Mill Rd.) South, just pass Helmont Dr.	FAIRFAX	Y		1	2
VA249	Hilltop Rd. West at Old Lee Hwy	FAIRFAX	Y		1	
VA251	VA 620 West to VA 7100 North	FAIRFAX	Y		2	2
VA252	I-495 North to VA 620 (Braddock Rd.) West	FAIRFAX	Y		2	
VA253	from US 29 to I-66 West	ARLINGTON	Y		3	2
VA254	from North Scott St to I-66 West	ARLINGTON	Y		2	3
VA255	from North Fairfax Dr (VA 237) West to I-66 West	ARLINGTON	Y		1	
VA256	from I-495 North to I-66 East	FAIRFAX	Y		1	
VA257	from I-66 West to Nutley St (VA 243) North	FAIRFAX	Y		1	1
VAF30	from I-95 North to VA 3 East	FREDERICKSBURG	N	2		
VAF34	US 1 Bus. South (Lafayette Blvd.), pass Alum Springs Rd (was VA134)	FREDERICKSBURG	N	3		
VAF39	from US 1 North / South to I-95 North (was VA139)	FREDERICKSBURG	N	1		
VAR06	Robin Hood Rd (Boulevard Road North) to I-95 South (and I-64 East)	HENRICO	N	2		
VAT06	VA 258 North / South toI-64	HAMPTON	N	1		
VAT10	I-64 East to Greenbrier Pkwy South	CHESAPEAKE	N	2		
Total				197	184	189

2.5 Data Screening

ESP applied the following screening checks to the RSD measurements to ensure the data used for vehicle evaluation are reasonable and consistent:

- Screening of exhaust plumes
- Screening for Vehicle Specific Power (VSP) range
- Screening of high and low values
- Screening of day-to-day median emissions values
- Screening of hourly observations to check for cold starts;

These screening procedures are described in the following paragraphs.

2.5.1 Screening of Exhaust Plumes

The RSD4000 unit takes many measurements of each exhaust plume in the one half second after each vehicle passes the equipment.

The basic gas record validity criteria applied are:

- A gas record is valid if there are at least 5 plume measurements where the sum of the amount of CO2 and CO gas exceed 10%-cm[i]; or

- A gas record is valid if there are at least 5 plume measurements where the sum of the amount of CO2 and CO gas exceed 5%-cm and the background gas values are very stable (not changing faster than a specified rate) at the time the front of the vehicle breaks the measurement beam.

2.5.2 Vehicle Specific Power (VSP)

VSP provides an estimate of the relative power output of the vehicle based upon speed, acceleration and slope at the site and for light vehicles is defined by the following equation:

VSP = 4.364*sin(Grade in Deg/57.3)*Speed + 0.22*Speed*Accel + 0.0657*Speed + 0.000027*Speed*Speed*Speed

Previous studies have found that vehicle emissions are more stable and more representative of the average in-use emissions of a vehicle when the engine is under a light to moderate load such as occurs when cruising above 30 mph, during non-aggressive acceleration, or driving up inclines. In day-to-day use, a majority of fuel is consumed in light to moderate engine load. DEQ therefore required that vehicle emissions observations be made when VSP is between 3 and 22 kW/t.

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[i] The unit of measurement 10%-cm is a measurement of the amount of a gas in the optical path. In this case, if all the molecules of the gas in the path were collected together into just one centimeter of the path then the concentration of the gas in the one-centimeter would be 10%.

2.5.3 Screening of High and Low Values

Measurements were screened for the presence of physically impossible high values or low values. The limits are:

CO <-0.5% or >20%

HC <-250ppm or >50,000ppm

NO <-500ppm or >20,000ppm

Smoke < -0.2 or >1000 units

2.5.4 Screening of Hourly Observations

ESP is concerned about vehicles operating in cold start mode or under conditions when exhaust plumes condense to steam. Vehicles measured under these conditions could appear to have high HC emissions without any emission system problems. To investigate this possibility, ESP tabulated for each site and hour the percentage of vehicles up to 5 years old that exceeded 150 ppm HC. The percent of vehicles up to 5 years old that exceed 150 ppm HC tend to be higher during periods of near freezing temperatures. As an example, the hourly percentage of measurements exceeding 150 ppm HC in January 2007 are shown in the Figure 2-3. The corresponding average temperatures are shown in Figure 2-4. The Figures confirm the presence of a greater percentage of high HC values when temperatures were below 35^{o}F. Relative humidity is also a factor. To mitigate this problem, the 53,980 measurements (4% of the total) made during hours when more than 5% of vehicles up to 5 years old exceeded 150 ppm HC were excluded from the emissions reported in section 3 and subsequent sections.

Table 2-3 Percentage of New Model Measurements Exceeding 150 ppm HC

Day	Site	Unit	06 & earlier	07	08	09	10	11	12	13	14	15	16	17	18 & later
2-Jan-07	4616	VAF39	0%	1%	0%	1%	0%	0%	0%	0%	0%	1%	0%	0%	#N/A
3-Jan-07	4616	VA095	5%	9%	4%	0%	3%	0%	2%	1%	0%	0%	0%	0%	0%
4-Jan-07	4616	VA076	0%	1%	3%	7%	0%	0%	#N/A	#N/A	0%	#N/A	4%	0%	#N/A
5-Jan-07	4616	VA099	0%	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
9-Jan-07	4615	VA033	2%	1%	0%	1%	0%	0%	0%	1%	0%	2%	1%	2%	#N/A
10-Jan-07	4615	VA122	2%	2%	2%	2%	2%	1%	1%	0%	0%	0%	3%	3%	#N/A
11-Jan-07	4615	VA122	11%	13%	5%	2%	4%	2%	1%	1%	1%	1%	0%	1%	#N/A
12-Jan-07	4615	VA035	0%	#N/A	#N/A	#N/A	#N/A	0%	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
16-Jan-07	4618	VA121	0%	0%	0%	0%	0%	0%	0%	0%	#N/A	#N/A	#N/A	#N/A	#N/A
17-Jan-07	4618	VA033	4%	3%	4%	4%	3%	5%	0%	1%	2%	1%	2%	3%	#N/A
18-Jan-07	4618	VA121	0%	0%	0%	1%	0%	0%	2%	0%	1%	0%	0%	#N/A	#N/A
19-Jan-07	4616	VA035	7%	4%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	#N/A
23-Jan-07	4616	VA035	3%	4%	4%	3%	0%	2%	2%	0%	2%	3%	2%	1%	#N/A
24-Jan-07	4616	VA035	2%	2%	4%	11%	4%	4%	1%	1%	0%	#N/A	#N/A	#N/A	#N/A
25-Jan-07	4616	VA082	0%	0%	1%	1%	0%	0%	0%	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
26-Jan-07	4616	VA082	7%	14%	13%	10%	8%	13%	8%	5%	8%	3%	0%	0%	#N/A
29-Jan-07	4616	VAT06	0%	0%	5%	4%	5%	0%	7%	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
30-Jan-07	4616	VA036	12%	7%	6%	6%	18%	19%	8%	7%	10%	14%	12%	7%	#N/A
31-Jan-07	4616	VA036	18%	22%	17%	14%	8%	7%	4%	10%	5%	9%	4%	5%	#N/A

Table 2-4 Average Hourly Temperature

Day	Site	Unit	06 & earlier	07	08	09	10	11	12	13	14	15	16	17	18 & later
2-Jan-07	4616	VAF39	42	43	47	55	65	70	73	75	74	75	64	59	57
3-Jan-07	4616	VA095	33	35	37	46	62	69	73	75	77	75	68	62	60
4-Jan-07	4616	VA076	50	50	51	54	56	60	62	63	66	68	67	65	63
5-Jan-07	4616	VA099	60	60	60	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
9-Jan-07	4615	VA033	37	38	40	46	53	55	55	55	54	53	53	53	53
10-Jan-07	4615	VA122	39	40	44	50	55	58	59	61	59	59	55	49	48
11-Jan-07	4615	VA122	30	31	35	45	54	57	59	60	59	56	54	51	50
12-Jan-07	4615	VA035	45	#N/A	#N/A	#N/A	52	53	53	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
16-Jan-07	4618	VA121	59	59	58	57	57	55	54	54	55	#N/A	#N/A	#N/A	#N/A
17-Jan-07	4618	VA033	31	31	34	46	52	53	53	50	47	46	44	42	42
18-Jan-07	4618	VA121	30	33	35	36	37	38	41	43	43	42	42	42	#N/A
19-Jan-07	4616	VA035	39	39	41	43	51	58	59	61	61	61	55	55	#N/A
23-Jan-07	4616	VA035	49	51	53	54	57	59	58	57	59	58	59	51	45
24-Jan-07	4616	VA035	40	44	47	47	50	53	51	52	54	#N/A	#N/A	#N/A	#N/A
25-Jan-07	4616	VA082	37	38	40	43	44	44	44	44	#N/A	#N/A	#N/A	#N/A	#N/A
26-Jan-07	4616	VA082	21	22	26	36	38	38	39	41	43	44	43	43	#N/A
29-Jan-07	4616	VAT06	27	29	31	32	33	34	36	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
30-Jan-07	4616	VA036	27	30	33	37	43	45	47	48	50	52	50	47	45
31-Jan-07	4616	VA036	24	25	26	27	28	30	33	35	36	37	38	38	38

2.5.5 Screening of Variations in Emissions Values

For each calendar quarter, ESP rank ordered the emissions measurements of vehicle models up to five years old from best to worst and divided the results into ten groups each containing 10% of the results. Most of these newer vehicles should have low emissions that fall within a narrow range of emissions concentrations for each pollutant. The results for the cleanest 90% of vehicles were plotted by quarter and RSD unit in Figures 2-6 through 2-9.

HC results were generally well banded with median emissions (between decile groups 5 and 6) close to zero. However, some small differences were evident and these can be significant when compared to fleet average emissions. Therefore, an adjusted set of values was calculated. For HC, CO and smoke, offsets were applied to each days results so that the median values of vehicles less than five years old would be zero. Emissions for most of these new vehicles are expected to be close to zero and this adjustment corrects any small biases in the daily RSD data. For NO offsets were calculated by determining median values of vehicles less than five years old for the whole dataset and applying a small offset to each days results so that the median values of vehicles less than five years old would match the average median for all days of 5ppm NO. The different treatment for NO is because the RSD NO channel is not adjusted for background NO and is not subject to daily set-up bias. Also, slight deterioration in NOx emissions has been noted even for new models and new model median NO is not expected to be zero. Adjustments changed enhanced area 2007-2009 annual averages by up to +/-0.025% CO, +/- 5.0ppm HC, +/- 1.0ppm NO and +/-0.012 RSD Smoke Factor. The adjustments were downward for HC, CO and smoke and in general reduced differences between the annual averages from year-to-year.

The differences between the results were small but the use of adjusted values has resulted in slightly lower average emissions for the newest vehicles and slightly smaller standard deviations from mean values. We believe this indicates the adjusted values are more accurate and have therefore presented the data using the adjusted values.

Figure 2-6: RSD Unit HC Deciles for Models Up to Five Years Old

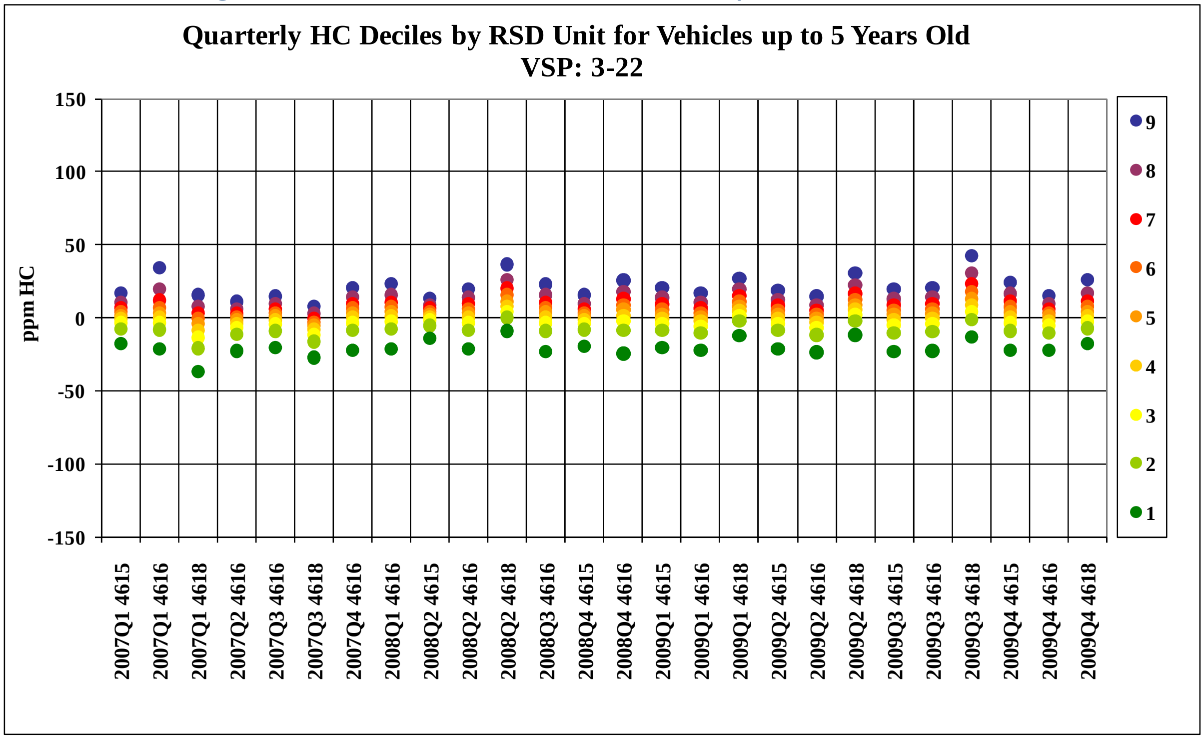


Figure 2-7: RSD Unit Median CO for Models Up to Five Years Old

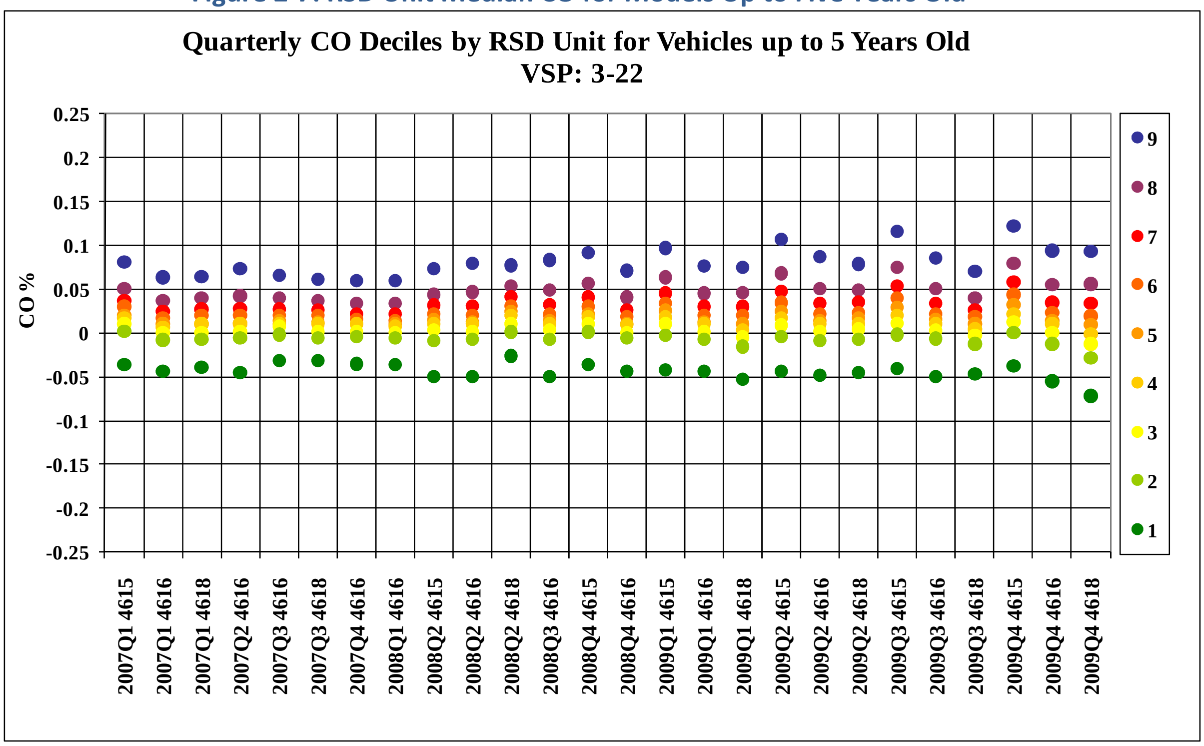


Figure 2-8: RSD Unit Median NO for Models Up to Five Years Old

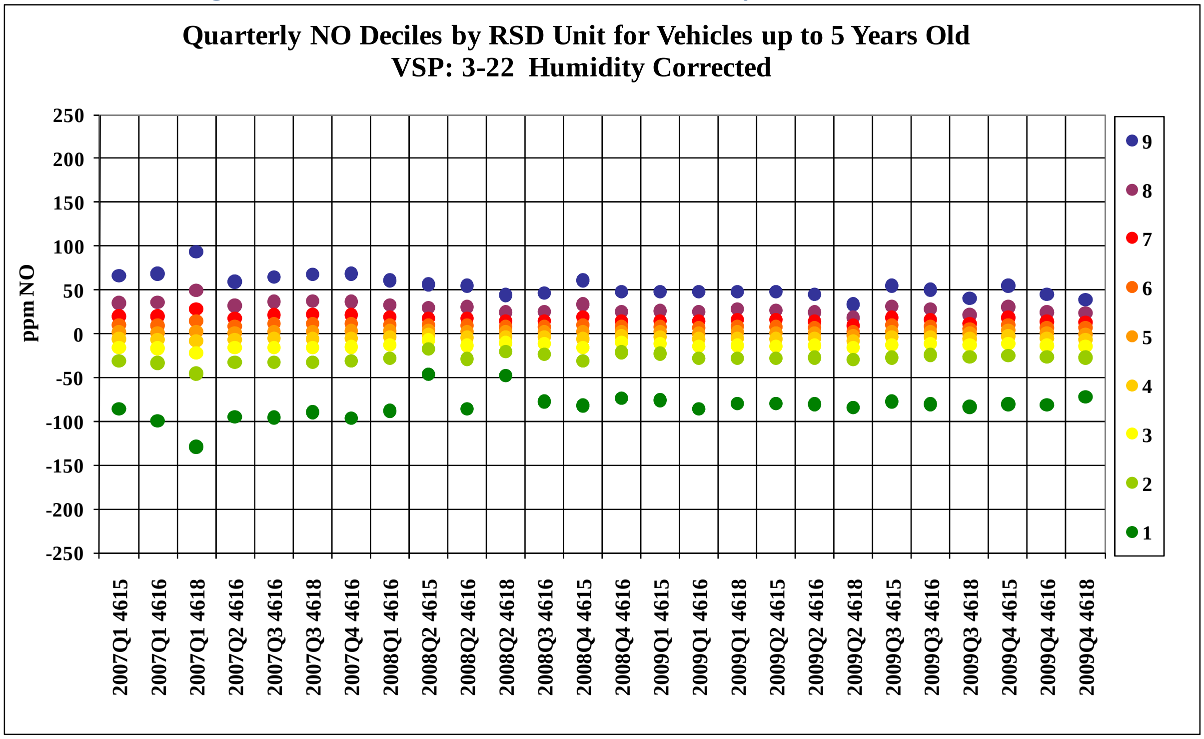
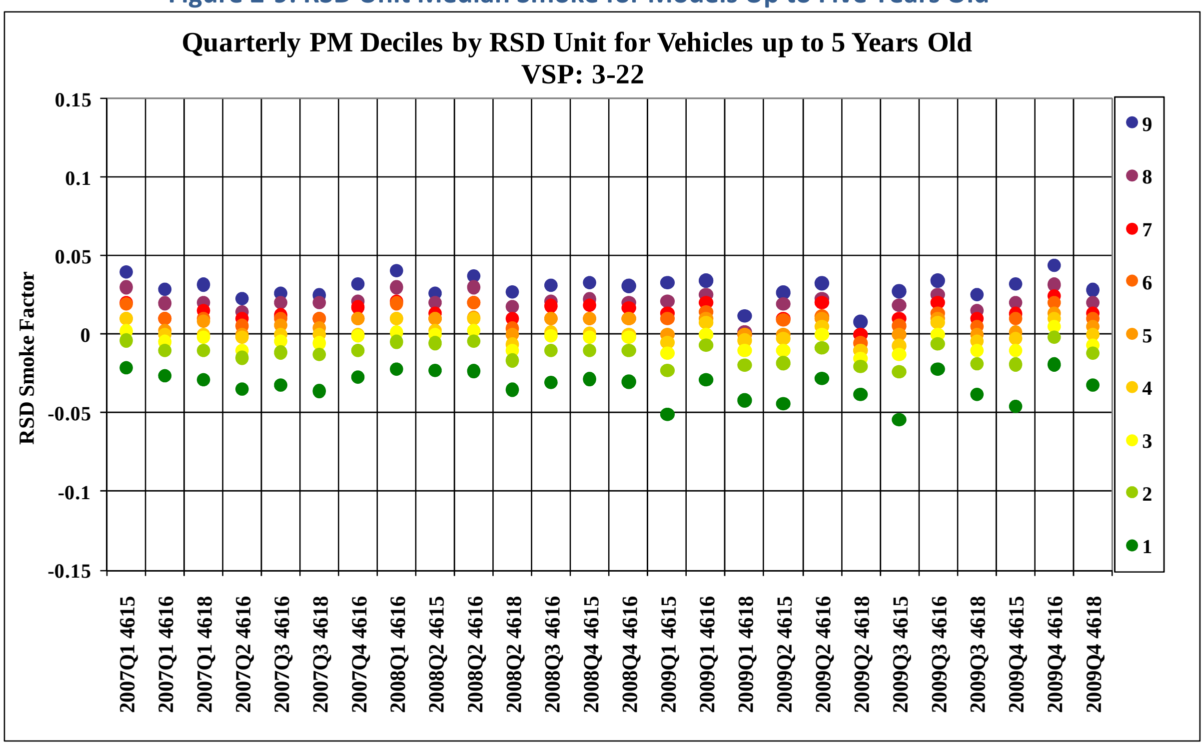


Figure 2-9: RSD Unit Median Smoke for Models Up to Five Years Old



3 ANALYSIS OF DATA COLLECTED

3.1 Statistics and RSD Coverage

3.1.1 Overall Program Statistics

Table 3-1: Remote Sensing Records with VA License Plate by Region

Valid RSD Records Collected w VA Plate				
Region	**2007**	**2008**	**2009**	**Total**
Northern enhanced I/M	408,316	440,471	348,652	1,197,439
Fredericksburg	15,207	-	-	15,207
Richmond	5,075	-	-	5,075
Tidewater	13,820	-	-	13,820
Total Records	442,418	440,471	348,652	1,231,541

Table 3-2: Remote Sensing Records with VA License Plate by Quarter and Unit

Valid RSD Records Collected w VA Plate					
YR	**QTR**	**4615**	**4616**	**4618**	**Total**
2007	**1**	28,587	63,084	7,143	98,814
2007	**2**		111,145		111,145
2007	**3**		107,301	23,649	130,950
2007	**4**		101,509		101,509
2008	**1**		68,736		68,736
2008	**2**	4,499	131,871	4,874	141,244
2008	**3**		142,043		142,043
2008	**4**	27,743	60,705		88,448
2009	**1**	34,839	58,605	6,538	99,982
2009	**2**	24,832	67,987	2,629	95,448
2009	**3**	51,188	18,063	5,206	74,457
2009	**4**	32,855	40,512	5,398	78,765
Total		204,543	971,561	55,437	1,231,541

Table 3-3 reports the number of vehicles with one, two, three, four and five or more measurements within each year.

Table 3-2: Multiple Measurements

Vehicles with Multiple Measurements within Each Calendar Year			
	2007	**2008**	**2009**
Unique VINs	307,961	313,133	256,342
VINs with 1 measurement	227,347	230,703	197,384
VINs with 2 measurements	54,667	57,970	41,911
VINs with 3 measurements	17,103	16,966	11,423
VINs with 4 measurements	5,579	5,069	3,713
VINs with 5 or more measurements	3,265	2,425	1,911
VINs with 2 or more measurements	80,614	82,430	58,958
% of Unique Vins	26%	26%	23%

3.1.2 Remote Sensing Coverage by Jurisdiction

The fractions of registered vehicles measured in four regions in calendar years 2007 to 2009 are summarized in Tables 3-3 to 3-5 respectively. The Northern I/M jurisdictions and other jurisdictions for which a significant number of vehicles were measured in 2007 are shown.

In Table 3-3, 2007 measurements are compared to 2008 registrations. Fourteen percent of diesel and gasoline vehicles were measured in Northern Virginia. In this region, Alexandria, Arlington and Loudoun had the lowest percentages of vehicles measured and Stafford the highest. Nine percent of vehicles from Fauquier and Fredericksburg were measured and one percent from Richmond and Tidewater.

In 2008 and 2009, 16% and 13% of gasoline vehicles were measured in the Northern area respectively. With growth temporarily halted, the numbers of registrations were almost the same in 2008 and 2009. Collection in other areas was discontinued to focus efforts on identifying high emitters in the Northern Enhanced I/M area. Some vehicles registered in Richmond and Tidewater were observed in the north.

Table 3-3: Unique VINs Measured in 2007

	Unique Vehicles Successfully Measured by Registered Jurisdiction 2007		Light Vehicles Registered in Jurisdiction 2008		% Measured	
	Diesel	Gas & Other	Diesel	Gas & Other	Diesel	Gas & Other
Northern Virginia:						
ALEXANDRIA	75	12,351	742	124,685	10%	10%
ARLINGTON	68	11,026	968	130,748	7%	8%
FAIRFAX COUNTY	844	103,219	7,412	782,069	11%	13%
FAIRFAX CITY	28	2,354	168	19,996	17%	12%
FALLS CHURCH	9	1,471	95	13,037	9%	11%
LOUDOUN	413	23,035	3,418	221,230	12%	10%
MANASSAS PARK	44	1,667	162	9,344	27%	18%
MANASSAS	71	3,791	358	28,352	20%	13%
PRINCE WILLIAM	699	54,250	3,998	274,588	17%	20%
STAFFORD	441	21,173	1,649	92,673	27%	23%
Subtotal	2,692	234,337	18,970	1,696,722	14%	14%
Fauquier & Fredericksburg:						
CAROLINE	28	1,414	459	26,316	6%	5%
FAUQUIER	190	4,825	1,962	62,397	10%	8%
FREDERICKSBURG	41	1,984	333	19,017	12%	10%
KING GEORGE	30	851	404	20,921	7%	4%
SPOTSYLVANIA	198	11,430	1,608	103,155	12%	11%
Subtotal	487	20,504	4,766	231,806	10%	9%
Richmond Area:						
CHESTERFIELD	31	1,533	2,983	269,439	1%	1%
HANOVER	24	628	1,876	94,964	1%	1%
HENRICO	51	2,091	2,369	247,055	2%	1%
RICHMOND CITY	166	1,599	2,111	141,328	8%	1%
Subtotal	272	5,851	9,339	752,786	3%	1%
Tidewater Area:						
CHESAPEAKE	42	3,776	2,824	175,061	1%	2%
HAMPTON	4	656	1,424	107,428	0%	1%
NEWPORT NEWS	2	716	1,196	145,086	0%	0%
NORFOLK	18	2,120	1,231	164,466	1%	1%
PORTSMOUTH	3	286	754	69,714	0%	0%
VIRGINIA BEACH	38	4,720	3,992	340,877	1%	1%
Subtotal	107	12,274	11,421	1,002,632	1%	1%
Total	3,112	254,446	40,063	3,471,157	8%	7%

Table 3-4: Unique VINs Measured in 2008

	Unique Vehicles Successfully Measured by Registered Jurisdiction 2008		Light Vehicles Registered in Jurisdiction 2008		% Measured	
	Diesel	Gas & Other	Diesel	Gas & Other	Diesel	Gas & Other
Northern Virginia:						
ALEXANDRIA	66	15,297	742	124,685	9%	12%
ARLINGTON	80	14,607	968	130,748	8%	11%
FAIRFAX COUNTY	911	127,613	7,412	782,069	12%	16%
FAIRFAX CITY	16	2,707	168	19,996	10%	14%
FALLS CHURCH	12	1,657	95	13,037	13%	13%
LOUDOUN	433	30,254	3,418	221,230	13%	14%
MANASSAS PARK	33	1,540	162	9,344	20%	16%
MANASSAS	52	3,703	358	28,352	15%	13%
PRINCE WILLIAM	541	53,321	3,998	274,588	14%	19%
STAFFORD	292	17,585	1,649	92,673	18%	19%
Subtotal	2,436	268,284	18,970	1,696,722	13%	16%
Fauquier & Fredericksburg:						
CAROLINE	14	948	459	26,316	3%	4%
FAUQUIER	192	5,557	1,962	62,397	10%	9%
FREDERICKSBURG	15	1,317	333	19,017	5%	7%
KING GEORGE	15	479	404	20,921	4%	2%
SPOTSYLVANIA	92	7,200	1,608	103,155	6%	7%
Subtotal	328	15,501	4,766	231,806	7%	7%
Richmond Area:						
CHESTERFIELD	8	798	2,983	269,439	0%	0%
HANOVER	5	404	1,876	94,964	0%	0%
HENRICO	12	864	2,369	247,055	1%	0%
RICHMOND CITY	124	649	2,111	141,328	6%	0%
Subtotal	149	2,715	9,339	752,786	2%	0%
Tidewater Area:						
CHESAPEAKE	5	279	2,824	175,061	0%	0%
HAMPTON	1	189	1,424	107,428	0%	0%
NEWPORT NEWS	2	325	1,196	145,086	0%	0%
NORFOLK	2	429	1,231	164,466	0%	0%
PORTSMOUTH	-	70	754	69,714	0%	0%
VIRGINIA BEACH	6	701	3,992	340,877	0%	0%
Subtotal	16	1,993	11,421	1,002,632	0%	0%
Total	2,616	274,309	40,063	3,471,157	7%	8%

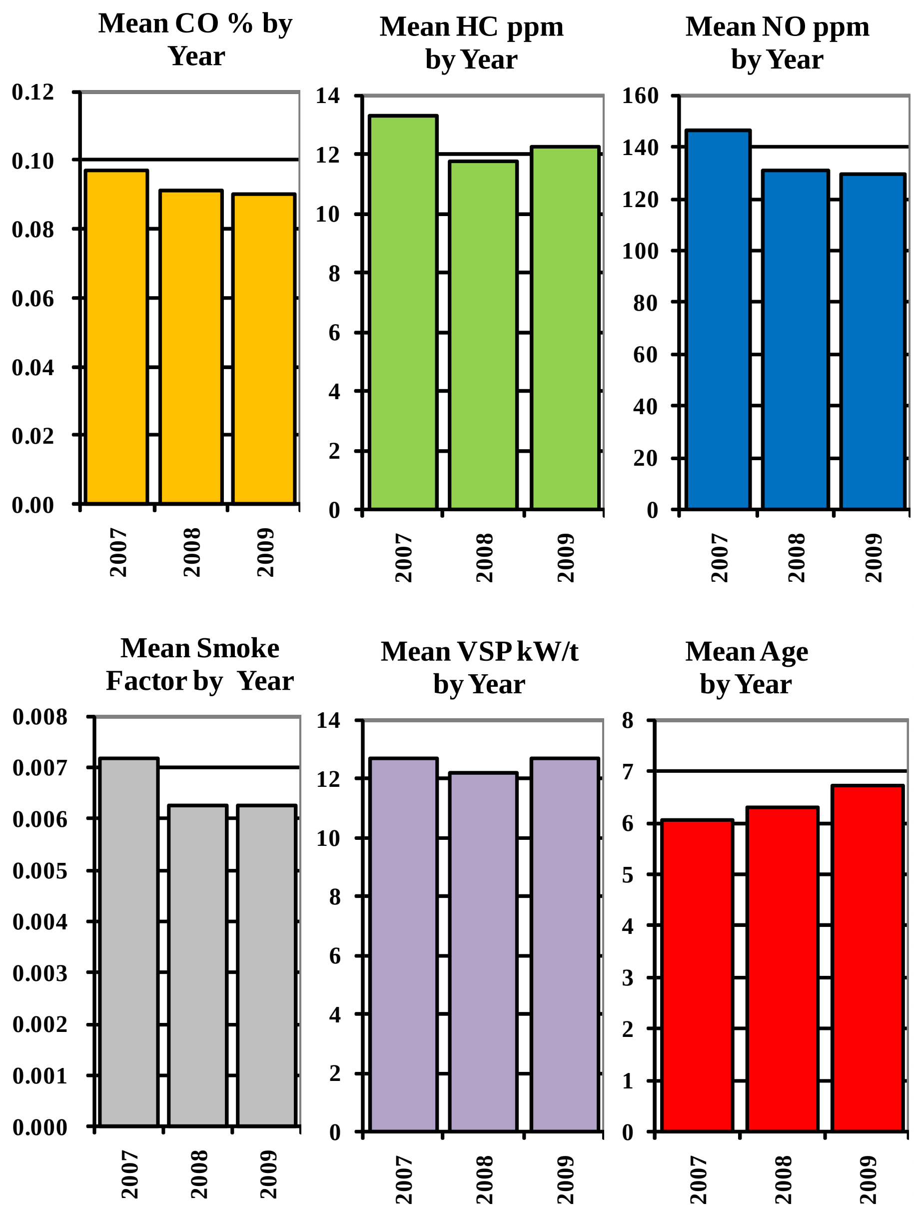
Table 3-5: Unique VINs Measured in 2009

	Unique Vehicles Successfully Measured by Registered Jurisdiction 2009		Light Vehicles Registered in Jurisdiction 2009		% Measured	
	Diesel	Gas & Other	Diesel	Gas & Other	Diesel	Gas & Other
Northern Virginia:						
ALEXANDRIA	50	11,284	778	116,890	6%	10%
ARLINGTON	60	10,130	984	130,555	6%	8%
FAIRFAX COUNTY	791	107,454	7,511	781,424	11%	14%
FAIRFAX CITY	15	2,006	165	20,459	9%	10%
FALLS CHURCH	9	1,579	96	13,447	9%	12%
LOUDOUN	413	28,594	3,435	224,595	12%	13%
MANASSAS PARK	28	1,731	156	9,510	18%	18%
MANASSAS	58	4,007	335	28,233	17%	14%
PRINCE WILLIAM	454	45,071	3,989	278,386	11%	16%
STAFFORD	155	10,148	1,613	93,149	10%	11%
Subtotal	2,033	222,004	19,062	1,696,648	11%	13%
Fauquier & Fredericksburg:						
CAROLINE	9	409	450	25,976	2%	2%
FAUQUIER	128	3,581	1,983	61,971	6%	6%
FREDERICKSBURG	8	760	342	18,992	2%	4%
KING GEORGE	2	334	409	21,048	0%	2%
SPOTSYLVANIA	46	3,712	1,577	102,804	3%	4%
Subtotal	193	8,796	4,761	230,791	4%	4%
Richmond Area:						
CHESTERFIELD	8	519	3,059	267,426	0%	0%
HANOVER	4	253	1,905	94,455	0%	0%
HENRICO	8	607	2,357	245,474	0%	0%
RICHMOND CITY	97	421	1,946	140,240	5%	0%
Subtotal	117	1,800	9,267	747,595	1%	0%
Tidewater Area:						
CHESAPEAKE	3	206	2,906	174,883	0%	0%
HAMPTON	5	138	1,482	106,092	0%	0%
NEWPORT NEWS	1	247	1,206	142,752	0%	0%
NORFOLK	-	275	1,234	159,078	0%	0%
PORTSMOUTH	-	68	731	67,978	0%	0%
VIRGINIA BEACH	3	444	4,091	337,236	0%	0%
Subtotal	12	1,378	11,650	988,019	0%	0%
Total	2,170	225,942	40,321	3,451,254	5%	7%

3.2 Enhanced I/M Area Vehicle Fleet Emission Rates

Figure 3-1 shows the average annual emissions of vehicles registered in the Northern Enhanced I/M area, the average measured VSP and the average measured vehicle age. Age was calculated as the date of observation minus the model year. Thus, for example, if observations were made uniformly during 2007 then 2006 models would have a calculated average age of 1.5 years[i].

Figure 3-1: Mean Emissions, VSP and Age 2007-2009



[i] This is an overestimate of age of the on-road vehicles. More accurately, if the sales cycle of 2006 models was effectively Q4 2005-Q3, 2006 then the average age of a 2006 model observed in 2007 would be 1.25 years. On the other hand, newer vehicles tend to be driven more miles each year and are therefore more likely to be measured as part of the on-road emissions survey than older vehicles. Therefore, the average age of active registered vehicles is older than the average age of observed vehicles.

Average emissions generally declined from 2007 to 2009 with most of the decrease occurring between 2007 and 2008. There was a 0.5 ppm increase in HC emissions in 2009 over 2008. Notably, the reductions occurred even though the average age of the vehicles measured from 2007 to 2009 increased – presumably a result of the 2008 and 2009 economic recession that dramatically slowed new vehicle sales.

3.2.1 Emission Rates by Residence of Registration

In Figures 3-2 to 3-7 the Northern Virginia I/M area results are shown by Jurisdiction, where the jurisdiction codes correspond to Alexandria, Arlington, Fairfax City, Fairfax County, Falls Church, Loudoun, Manassas Park, Manassas, Prince William and Stafford.

Manassas Park and Manassas had older fleets and larger increases in observed vehicle age. Vehicles from these jurisdictions also showed small increases or smaller decreases in HC and CO. Reductions in NOx between 2007 and 2009 were observed in all jurisdictions but in Fairfax and Stafford NOx emissions were higher in 2009 than in 2008. These may have been influenced by the higher average specific power of observations in these jurisdictions in 2009 compared to 2008 (Figure 3-7).

Figure 3-2: Mean Observed Age 2007-2009 by Jurisdiction

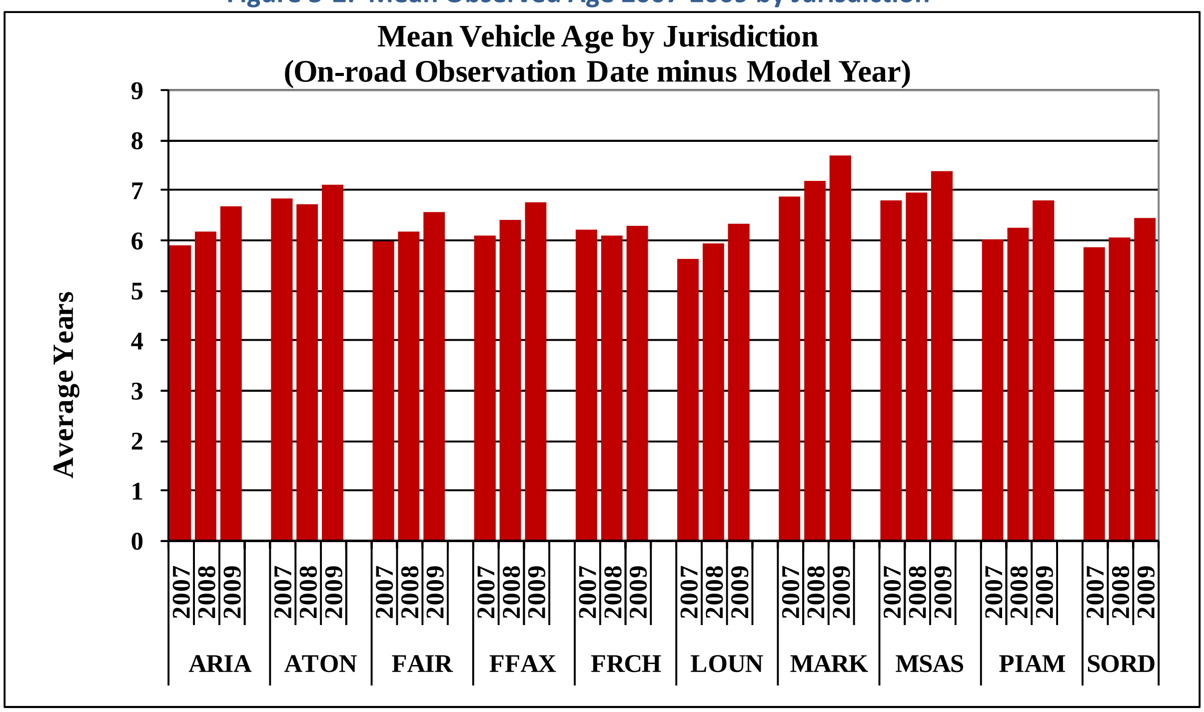


Figure 3-3: Mean CO 2007-2009 by Jurisdiction

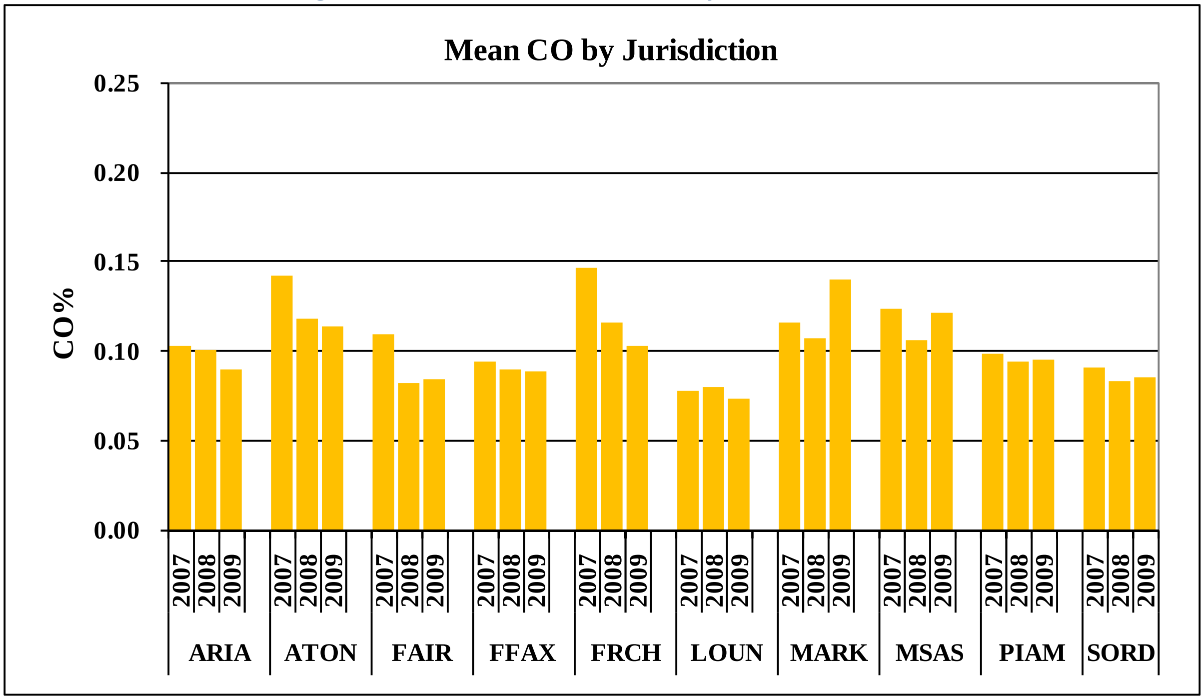


Figure 3-4: Mean HC in 2007-2009 by Jurisdiction

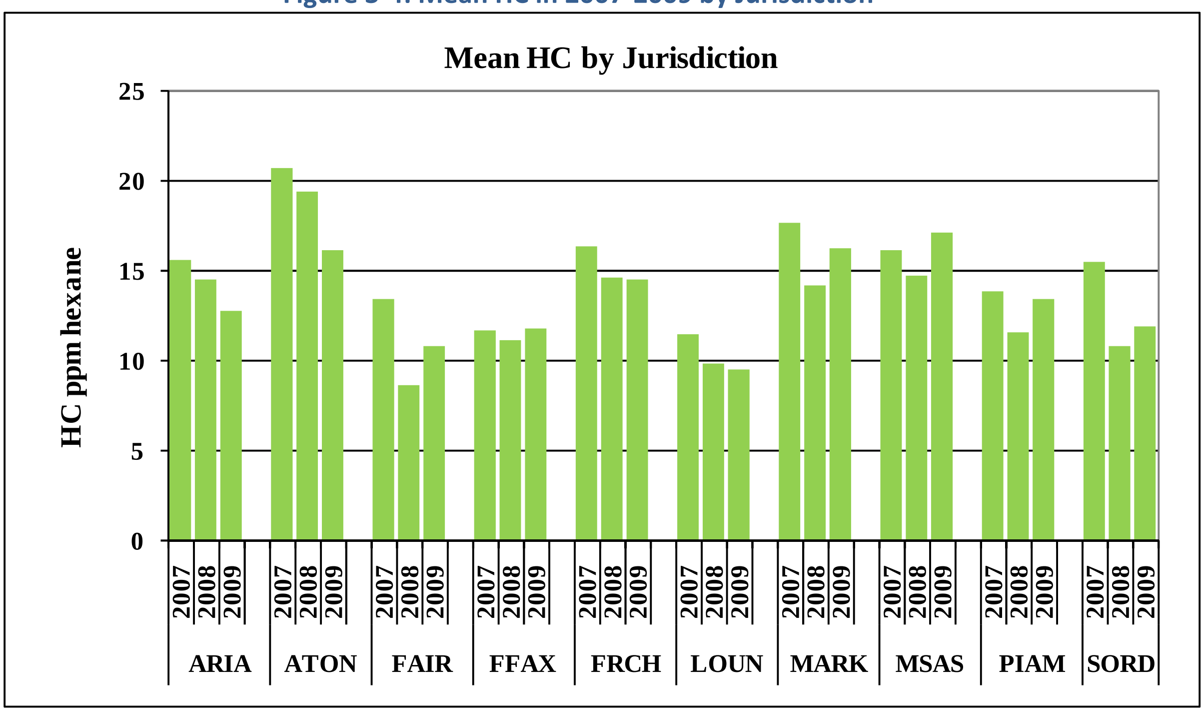


Figure 3-5: Mean NO in 2007-2009 by Jurisdiction

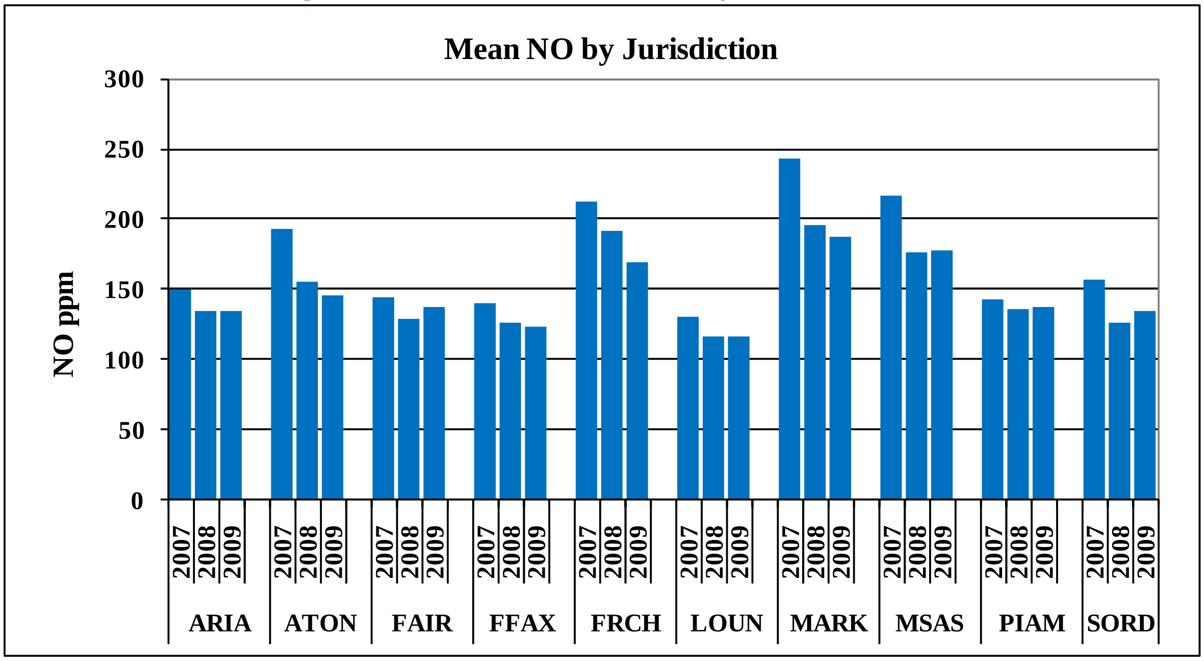


Figure 3-6: Average Smoke in 2007-2009 by Jurisdiction

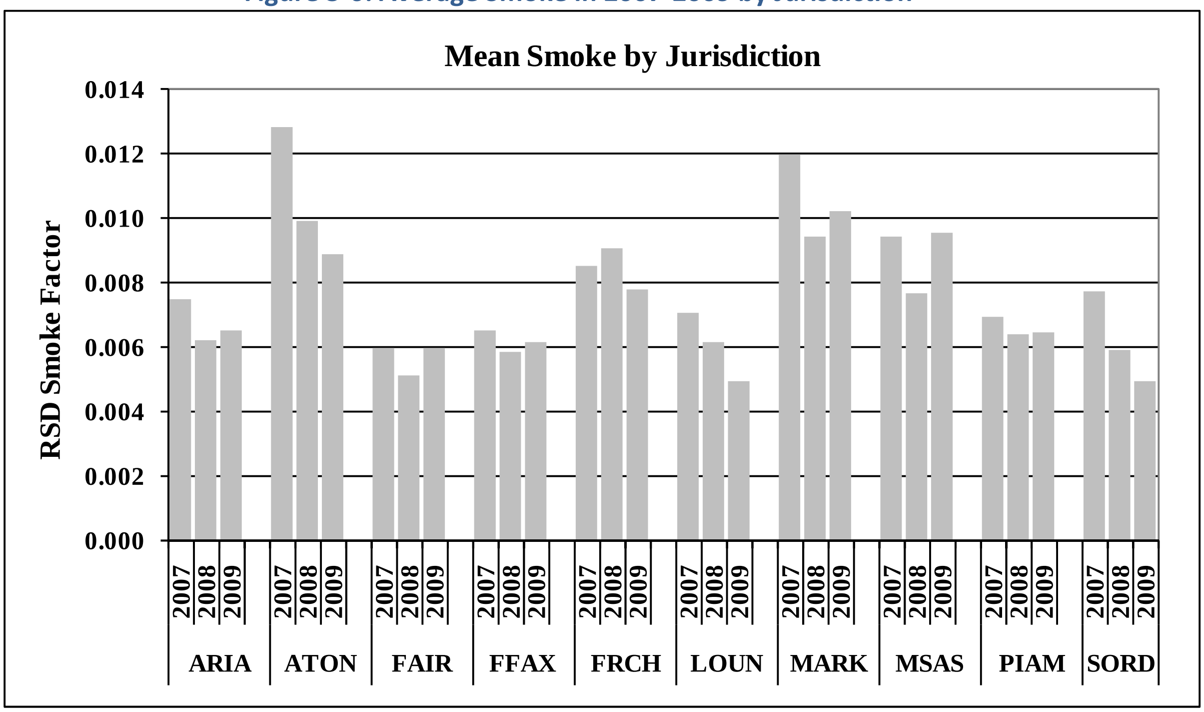
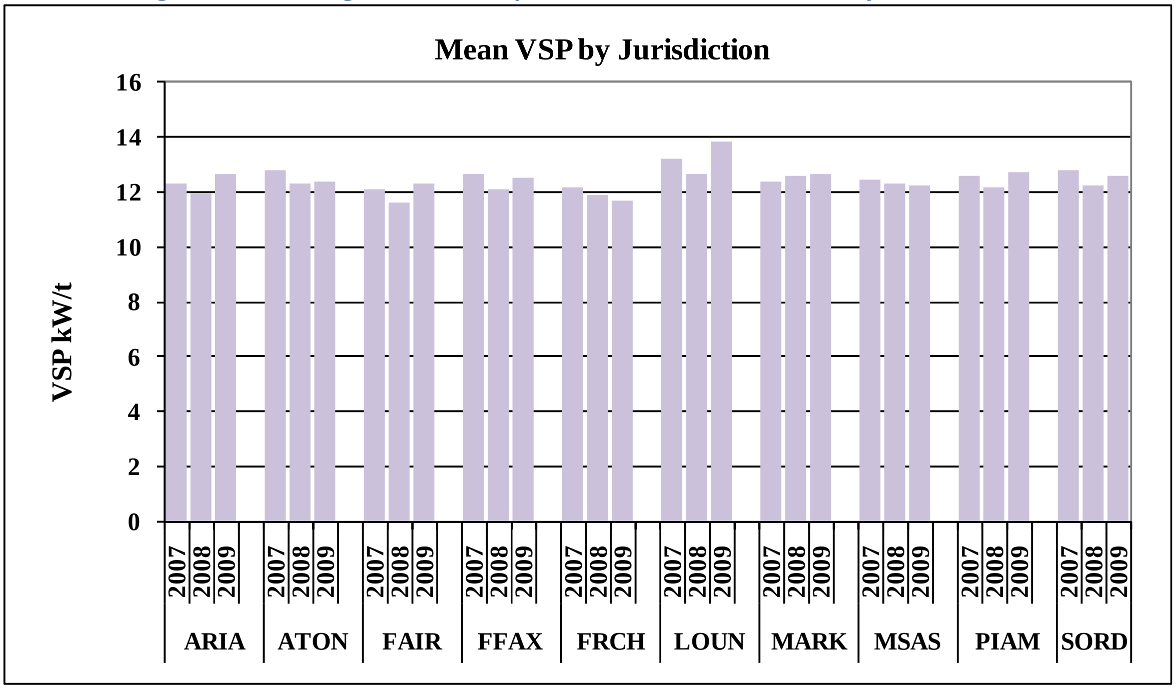


Figure 3-7: Average Observed Specific Power in 2007-2009 by Jurisdiction



3.3 2007 to 2009 Enhanced Area Emissions

Emissions for different model year ranges are shown in Figures 3-8 to 3-11. Each set of three bars shows the emissions in 2007, 2008 and 2009. Small increases in mean emissions are evident for 1991 and newer models. This is expected as there will be some unpreventable deterioration as vehicles age.

Results for 1996 and newer vehicles are shown in more detail in Figures 3-12 to 3-15. This series of chart shows consistent deterioration for all except the newest two or three model years.

Figure 3-8: Mean CO % in 2007-2009 by Model Year Range

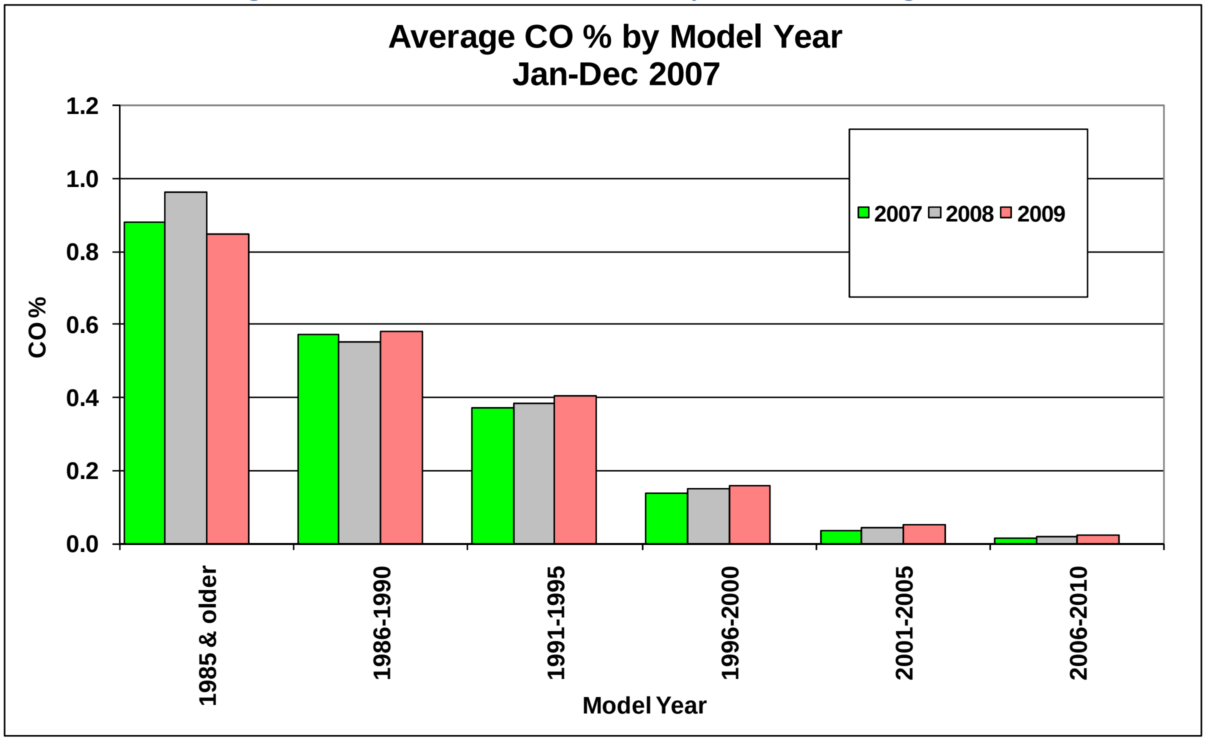


Figure 3-9: Mean HC ppm in 2007-2009 by Model Year Range

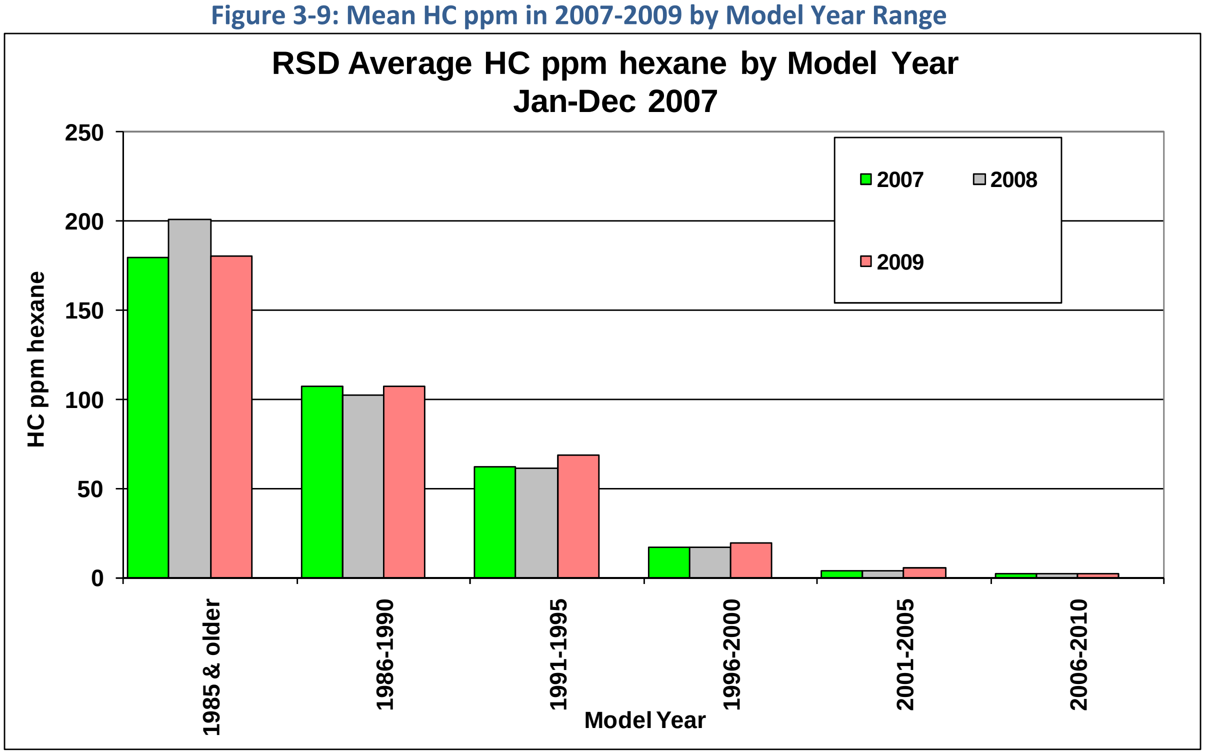


Figure 3-10: Mean NO ppm in 2007-2009 by Model Year Range

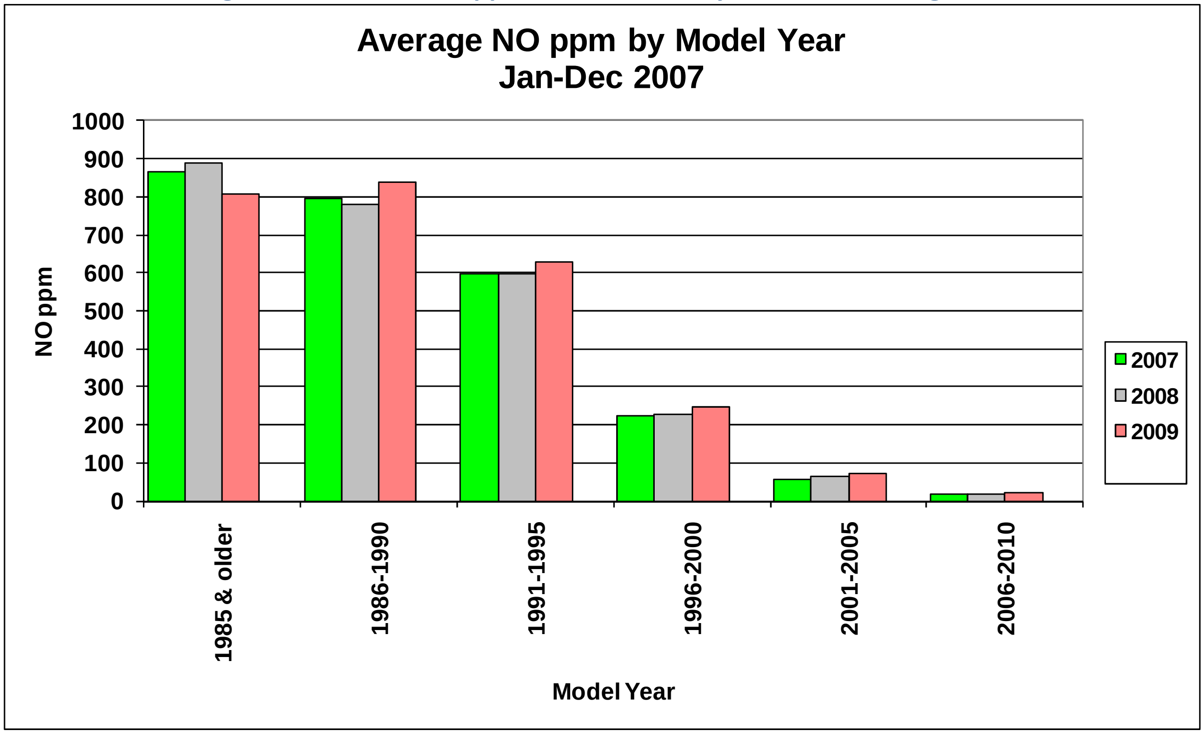


Figure 3-11: Mean UV Smoke in 2007-2009 by Model Year Range

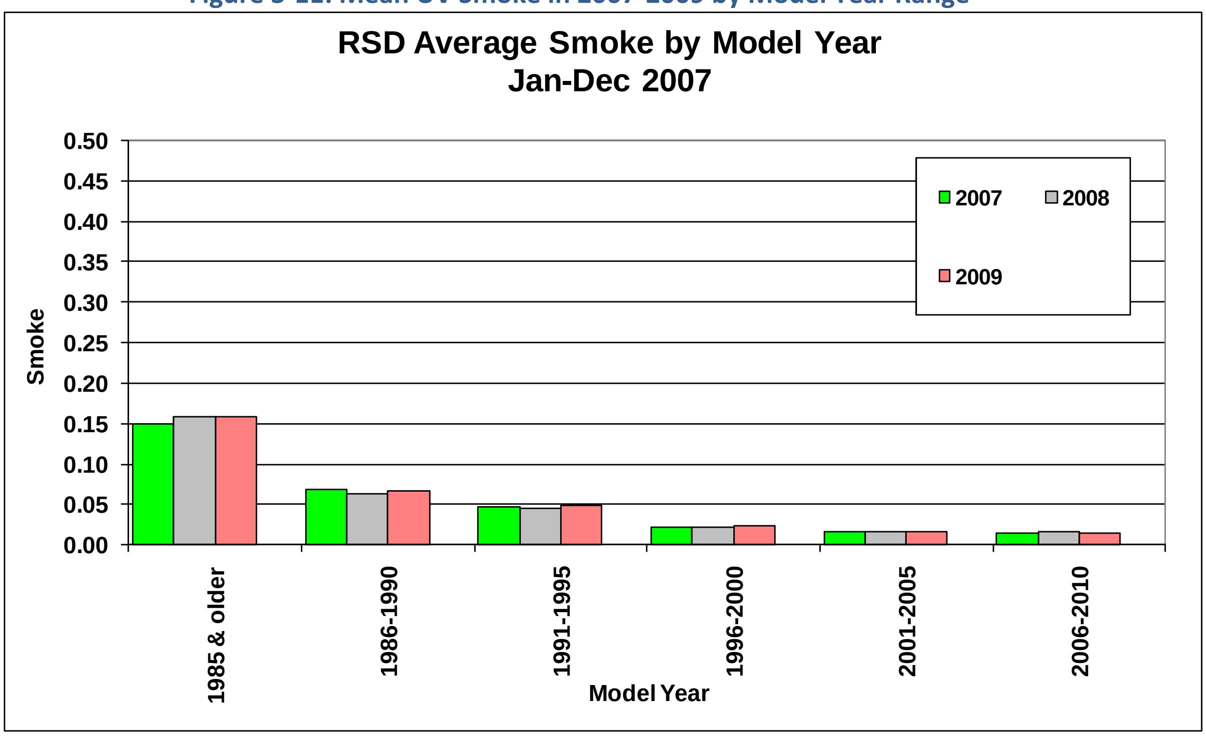


Figure 3-10: Mean CO% in 2007-2009 for 1996 and Newer Models

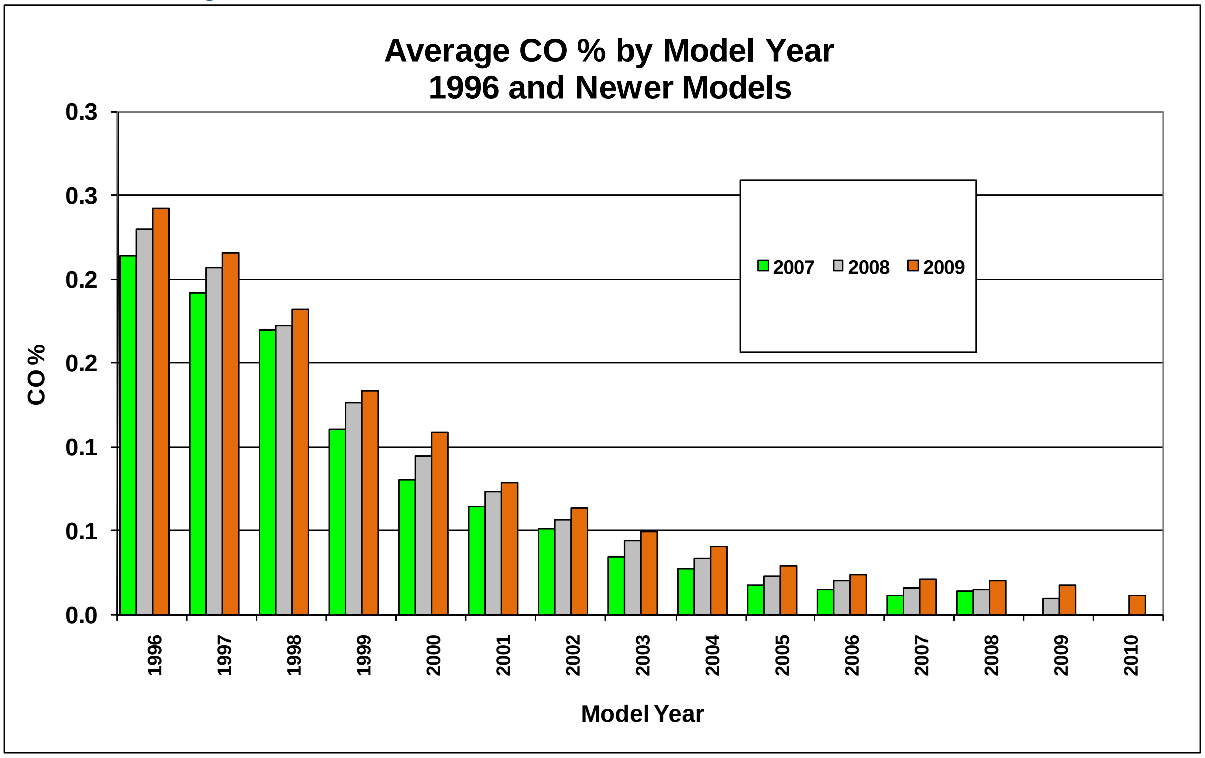


Figure 3-10: Mean HC ppm in 2007-2009 for 1996 and Newer Models

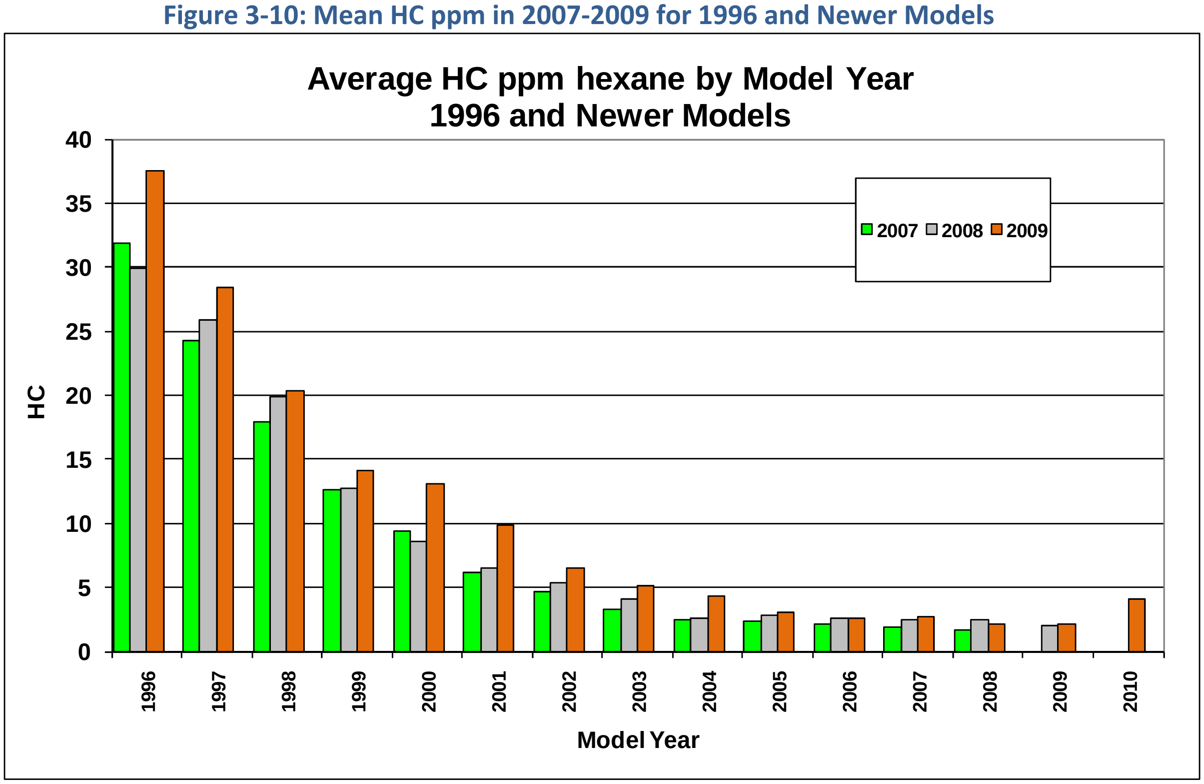


Figure 3-10: Mean NO ppm in 2007-2009 for 1996 and Newer Models

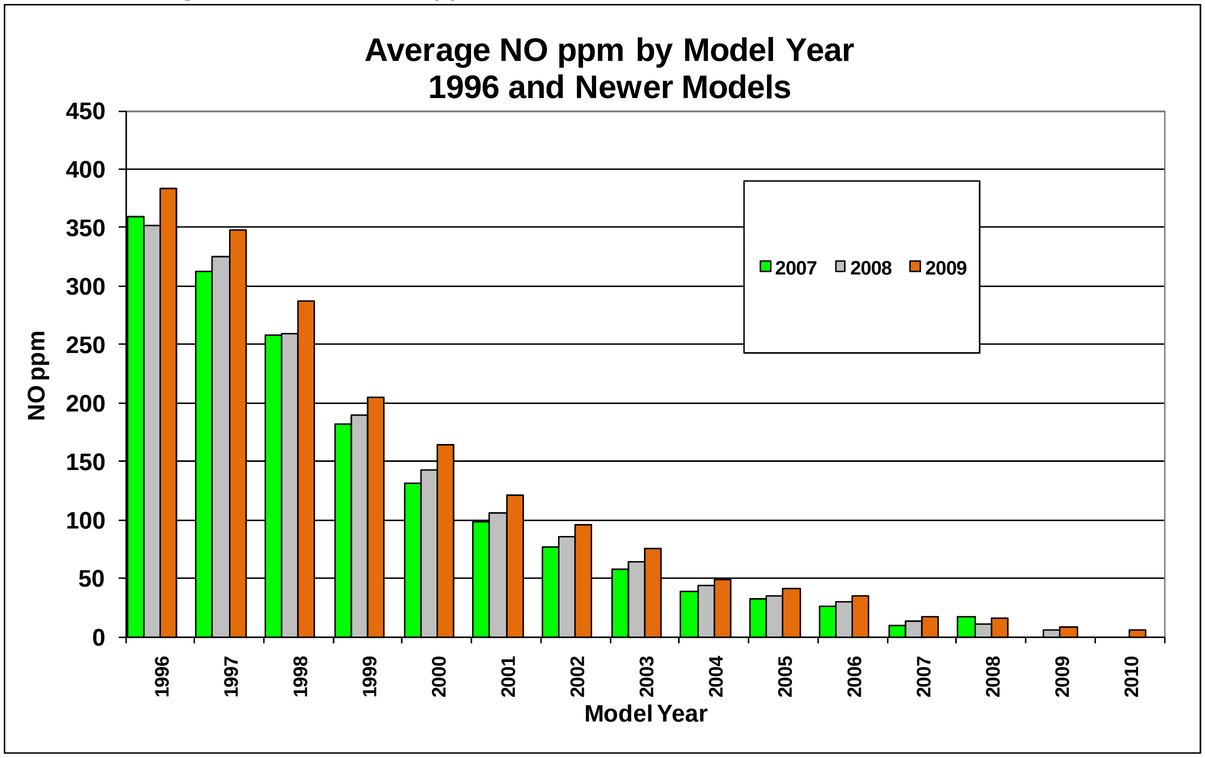
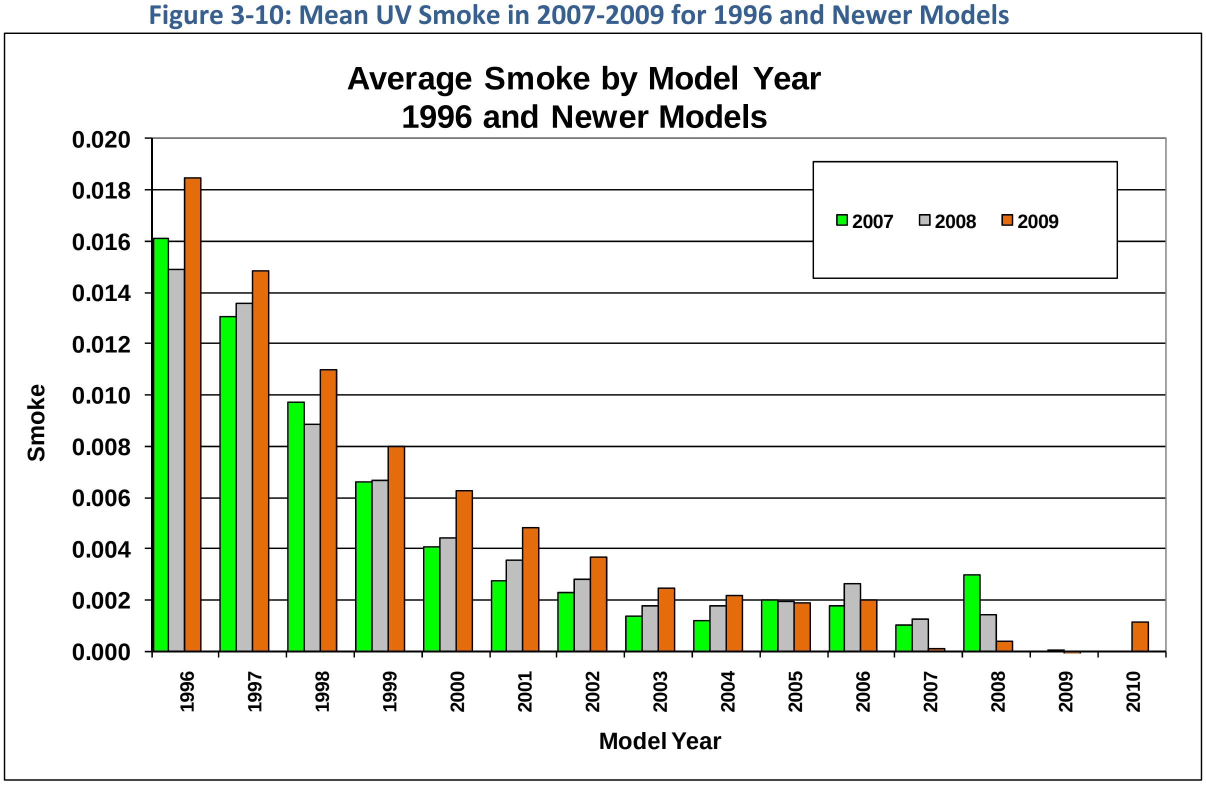


Figure 3-10: Mean UV Smoke in 2007-2009 for 1996 and Newer Models



4 I/M vs. Non-I/M Area Emissions

4.1 2007 Vehicle Fleet Emission Rates

4.2 I/M Registered vs. Non-I/M Registered Vehicles

Table 3-3 tabulated the measurements made in each area of the Commonwealth. In 2007, vehicles were measured in Fredericksburg, Richmond and Tidewater as well as in the Northern Enhanced I/M area. For 2007 measurements, ESP calculated average emission rates for observations of vehicles registered in the Northern Virginia I/M area and for the combined measurements made in the non-I/M areas.

Table 4-1 and Figures 4-1 through 4-7 show a comparison of 2007 emissions for the two groups. Two scenarios are presented:

- Registered vehicles, and
- Age adjusted.

The 'On-road Fleet' scenario reflects averages of observations of vehicles registered in each area. The 'Age Adjusted' scenario takes the average emissions by model year for the area and multiplies them by the combined model year fractions of the I/M and non-I/M areas. This is intended to eliminate reductions that occur solely because one area has more new vehicles than the other area. It could be argued the mere presence of an I/M program creates a shift to newer vehicles, so the adjustment may partially hide some I/M benefits.

The difference between the I/M and non-I/M registered fleets is 28% for CO, 48% for HC, 26% for NOx and 48% for smoke. The Age Adjusted differences between the I/M and non-I/M areas are lower at 14% for CO, 37% for HC, 14% for NOx and 36% for smoke.

Table 4-1 I/M and Non-I/M Average Emissions in 2007

In 2007	On-Road Fleet			Age Adjusted		
	I/M Reg'd	Non I/M Reg'd	I/M % Lower	I/M Reg'd	Non I/M Reg'd	I/M % Lower
CO %	0.09	0.13	28%	0.10	0.11	14%
HC ppm	13	26	48%	14	21	37%
NO ppm	148	201	26%	151	177	14%
UV Smoke	0.007	0.014	48%	0.007	0.011	36%

Figure 4-1: 2007 I/M vs. Non-I/M CO

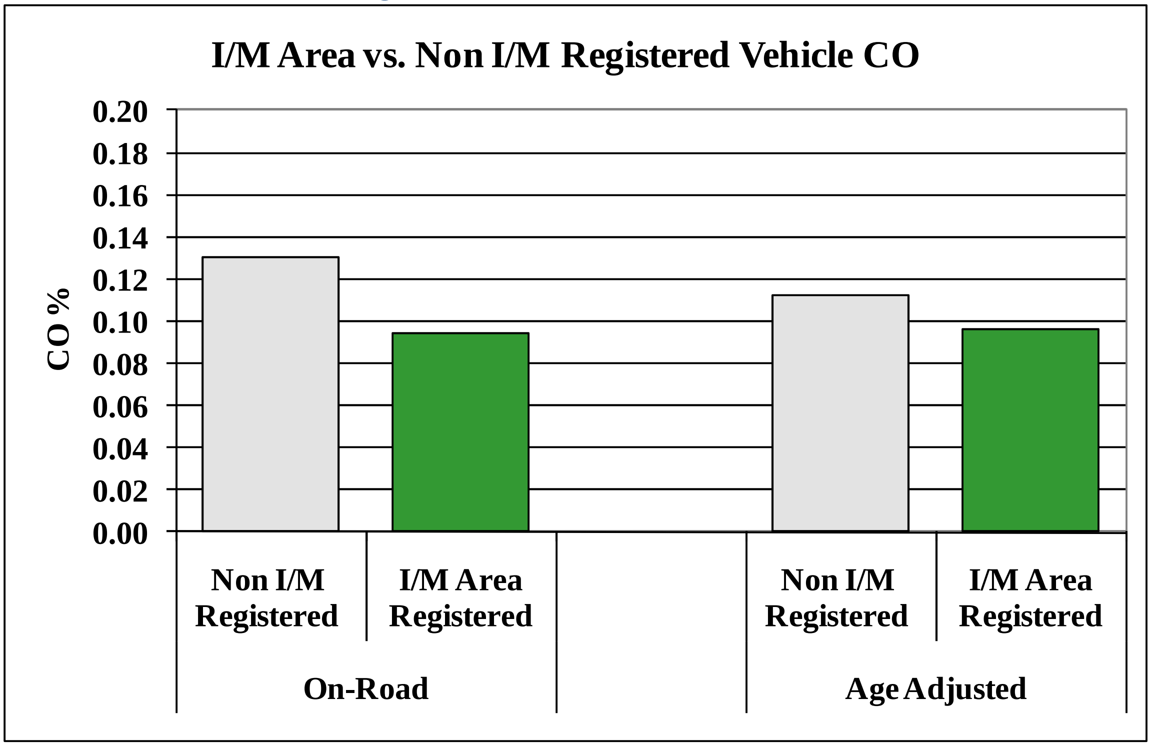


Figure 4-2: 2007 I/M vs. Non-I/M HC

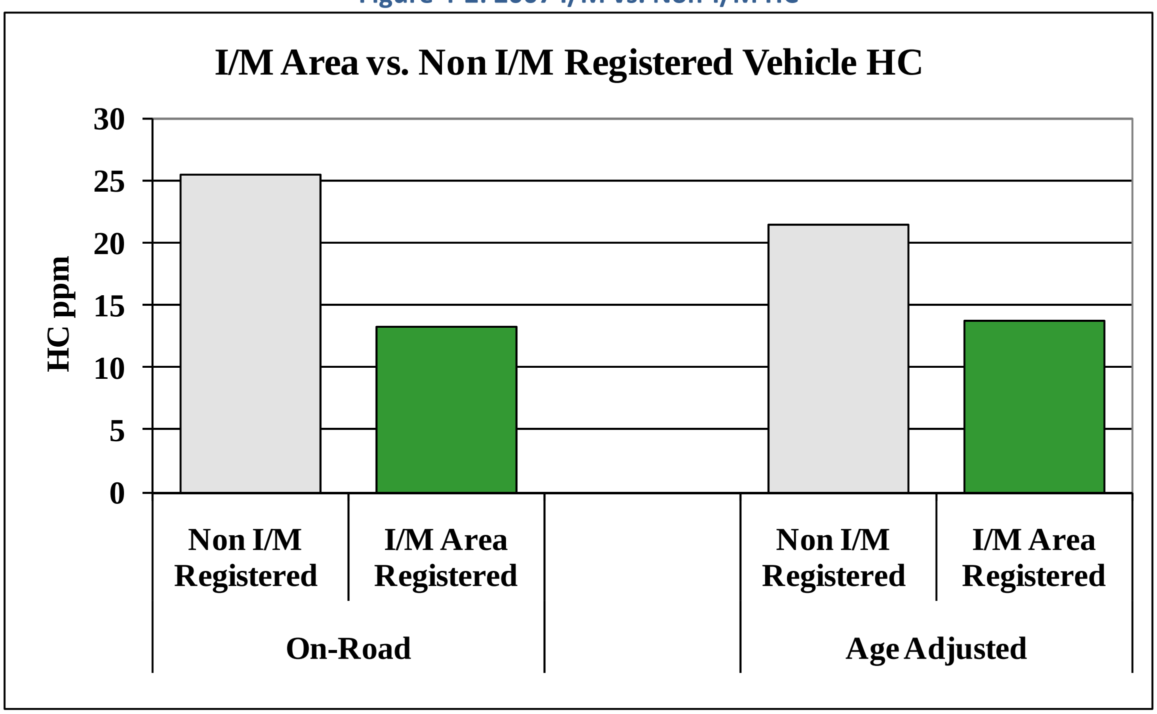


Figure 4-3: 2007 I/M vs. Non I/M NO

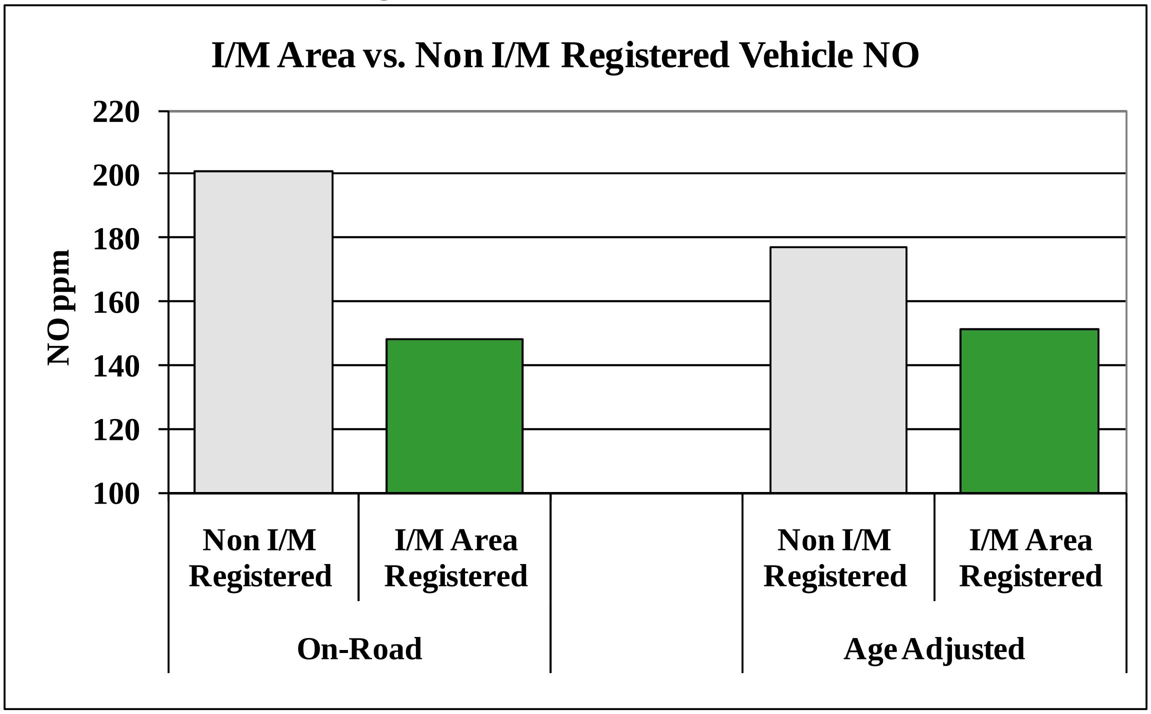
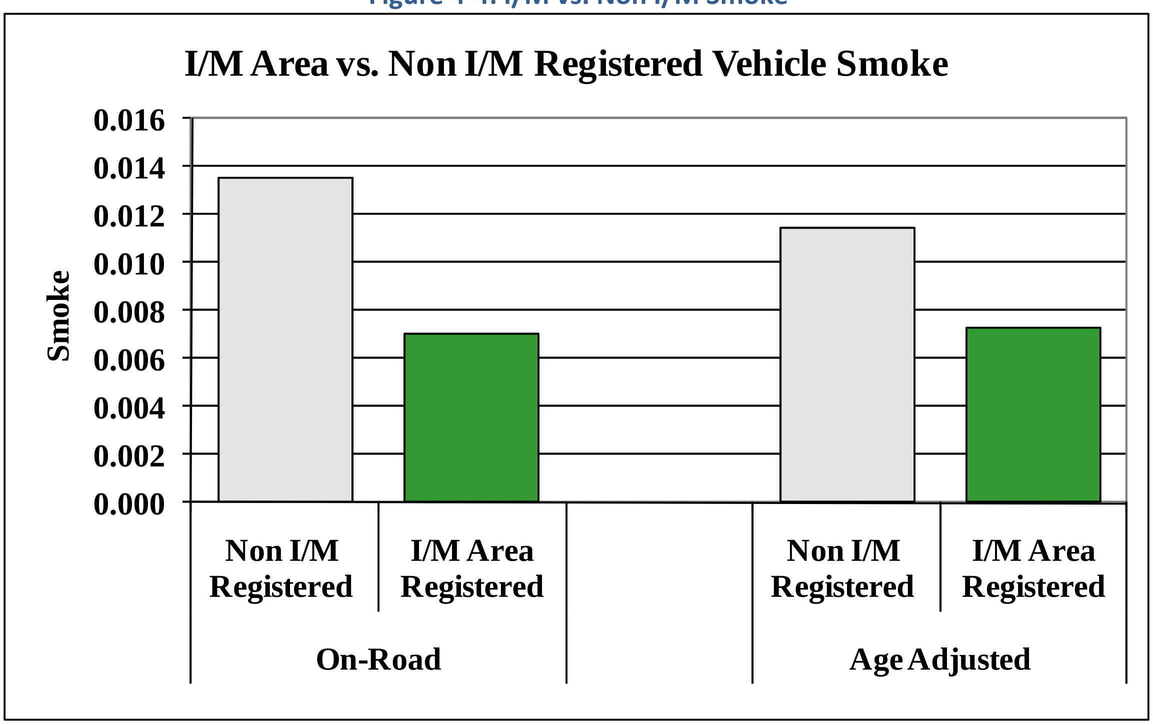


Figure 4-4: I/M vs. Non I/M Smoke



4.2.1 Summary of 2005-2007 I/M Registered vs. Non-I/M Registered Vehicles

Table 4-2 and Figures 4-5 to 4-9 compare I/M and non-I/M area emissions from 2005 through 2007. With the exception of smoke, the average light vehicle emissions have declined

from year-to-year. I/M area emissions have consistently been lower than the aggregate of non-I/M areas.

Table 4-2 Average Emissions from 2005 through 2007

Year	Region	CO %	HC ppm	NO ppm	UV Smoke
2007	Non I/M Registered	0.13	26	201	0.014
	I/M Area Registered	0.09	13	148	0.007
	I/M % lower	28%	48%	26%	48%
2006	Non I/M Registered	0.15	27	231	0.015
	I/M Area Registered	0.12	20	194	0.010
	I/M % lower	19%	28%	16%	31%
2005	Non I/M Registered	0.18	31	303	0.012
	I/M Area Registered	0.13	19	220	0.007
	I/M % lower	28%	38%	27%	41%

Figure 4-5: 2005-2007 I/M vs. Non I/M CO

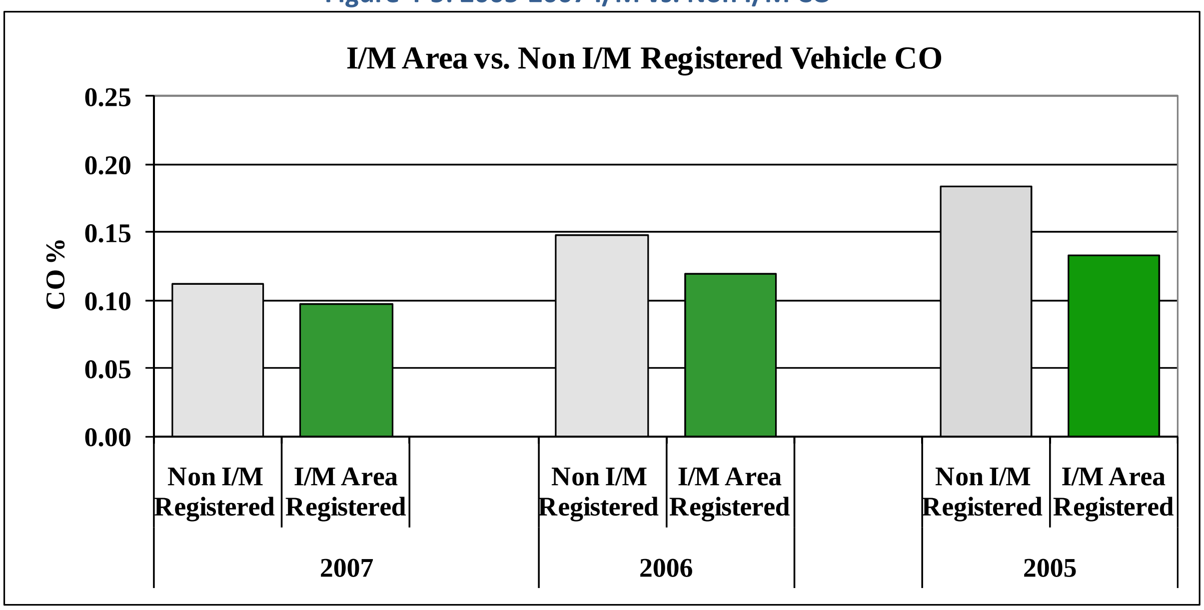


Figure 4-8: 2005-2007 I/M vs. Non I/M HC

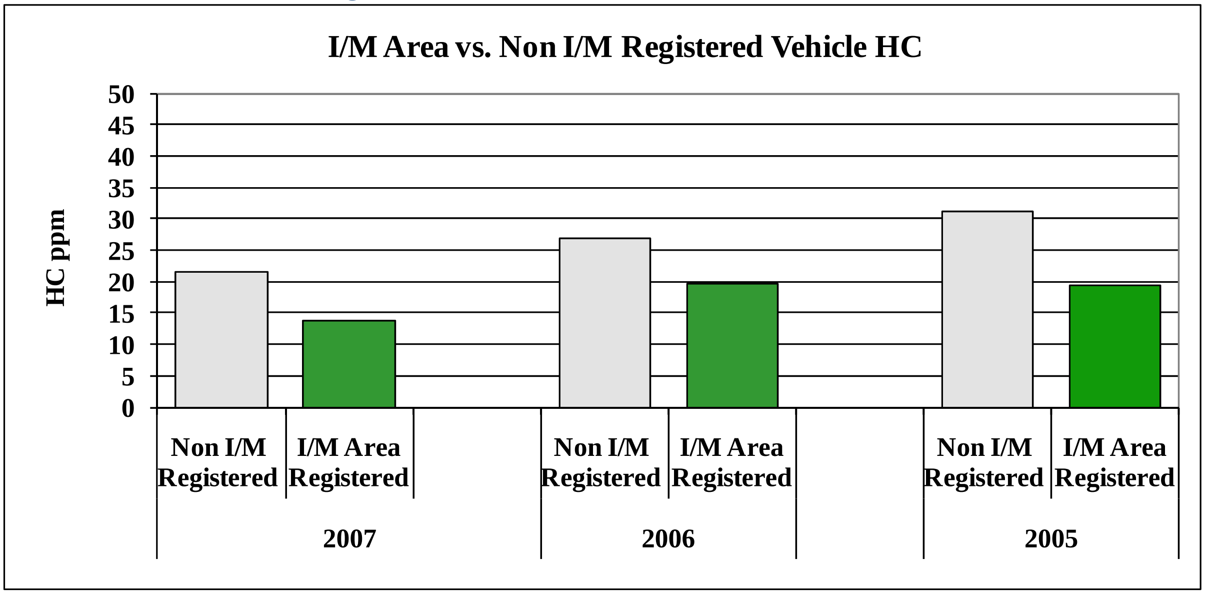


Figure 4-8: 2005-2007 I/M vs. Non I/M NO

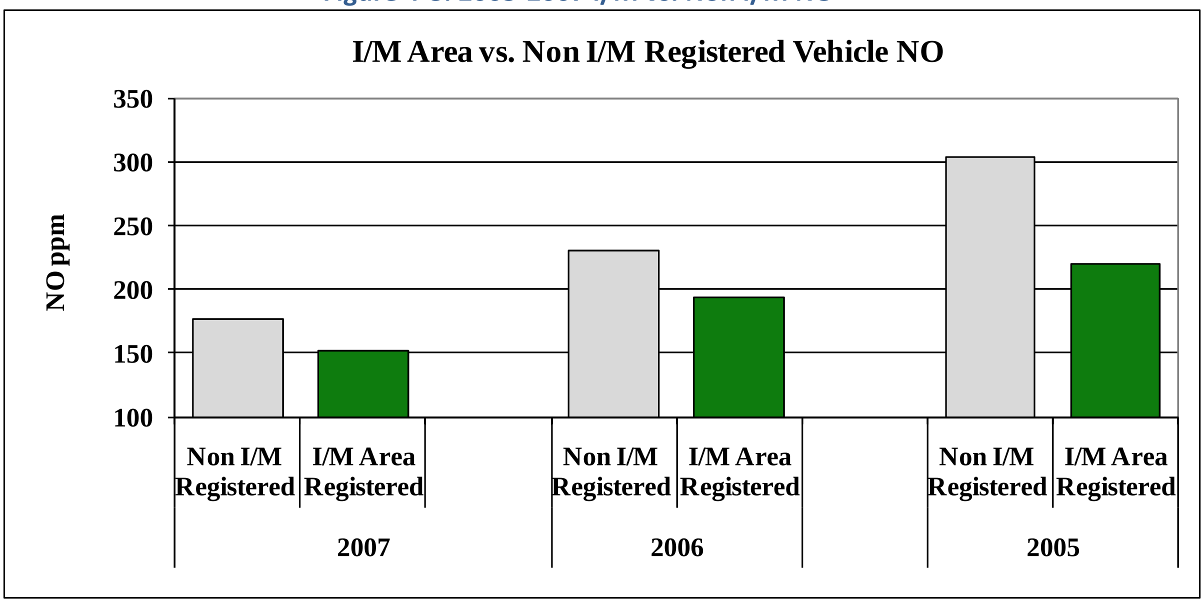
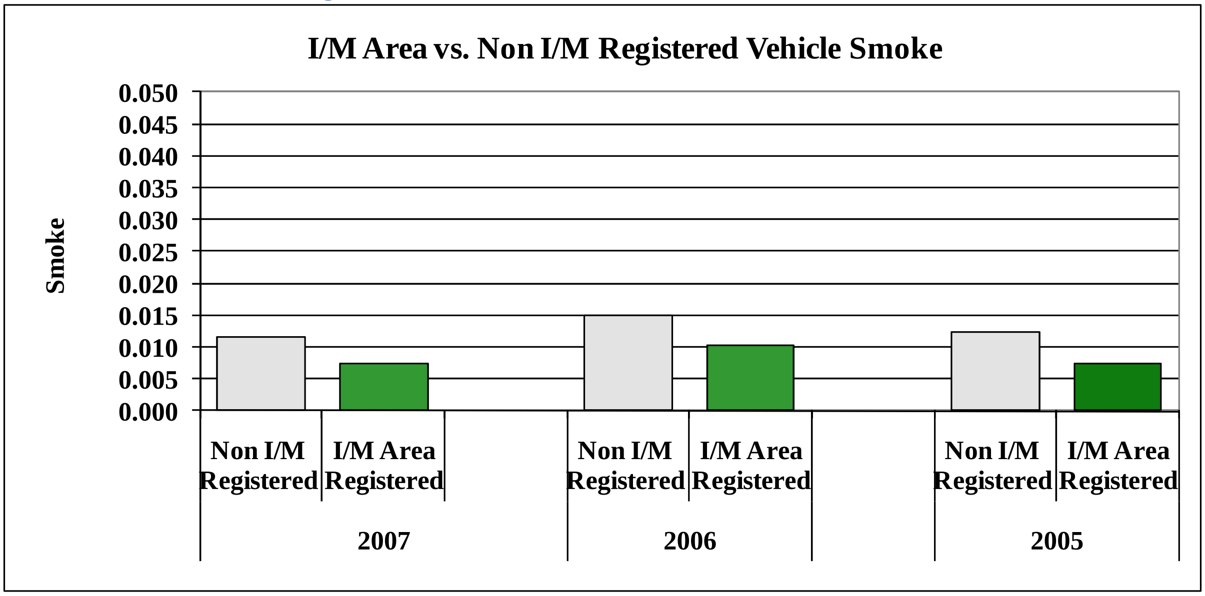


Figure 4-8: 2005-2007 I/M vs. Non I/M Smoke



4.2.2 I/M and Non-I/M Emissions Differences by Model Year in 2007

Figures 4-9 to 4-12 compares the differences in emissions levels for vehicles registered to non-I/M jurisdictions vs. those registered in I/M areas in 2007. A positive bar indicates the Northern Virginia Enhanced I/M area vehicles had lower emissions. As expected, the differences are smaller for newer models and greater for older models.

An exception is 1981 and older models. However, only 87 model year 1981 and older models were surveyed in the non-I/M area and 184 in the I/M area. Therefore the difference for the 1981 and older models may not be significant. In 2007, 1982 and older vehicles were not tested in the I/M program.

Figure 4-9: Model Year CO Differences in 2007

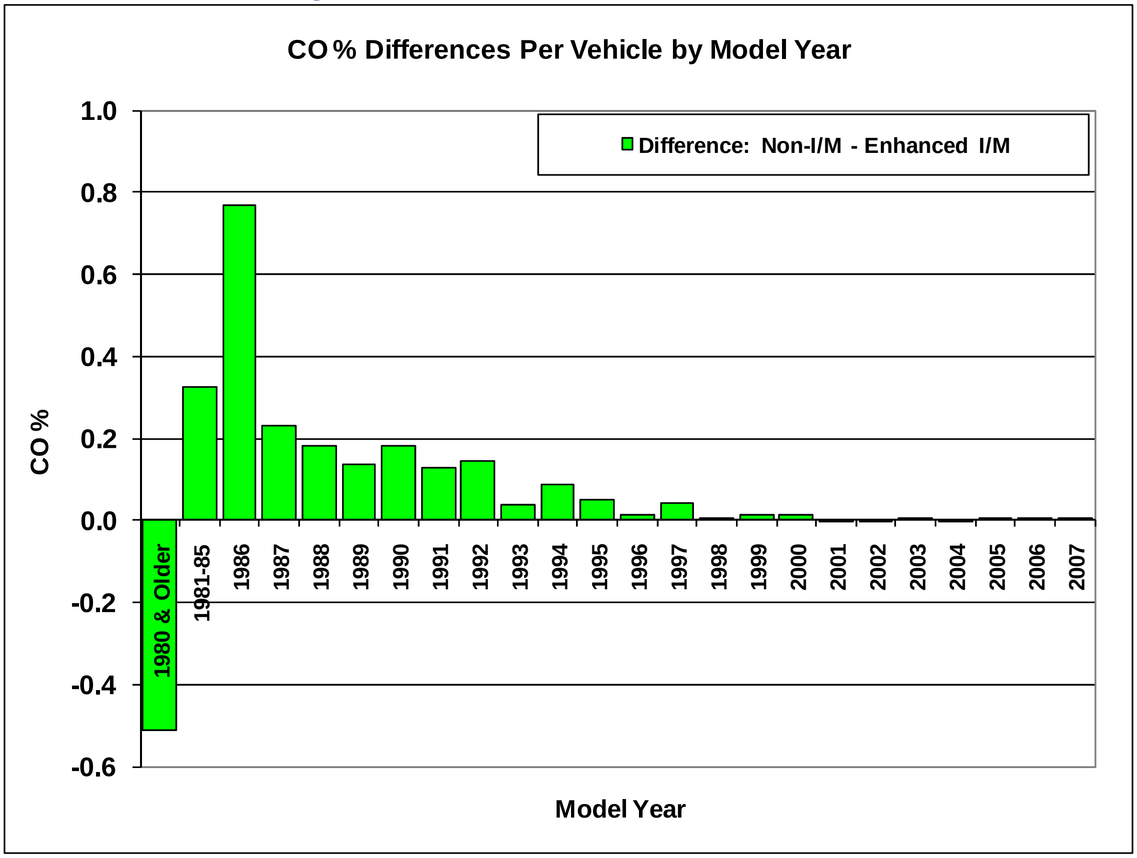


Figure 4-10: Model Year HC Differences in 2007

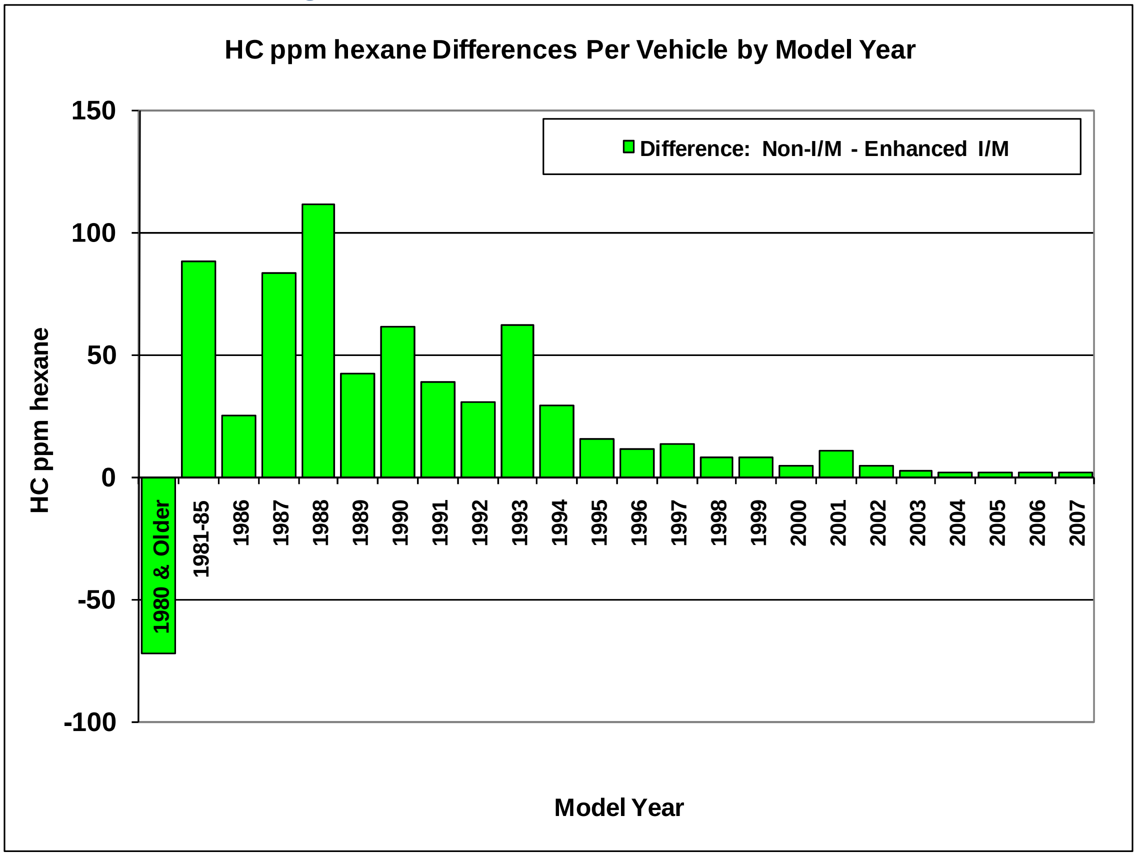


Figure 4-11: Model Year NO Differences in 2007

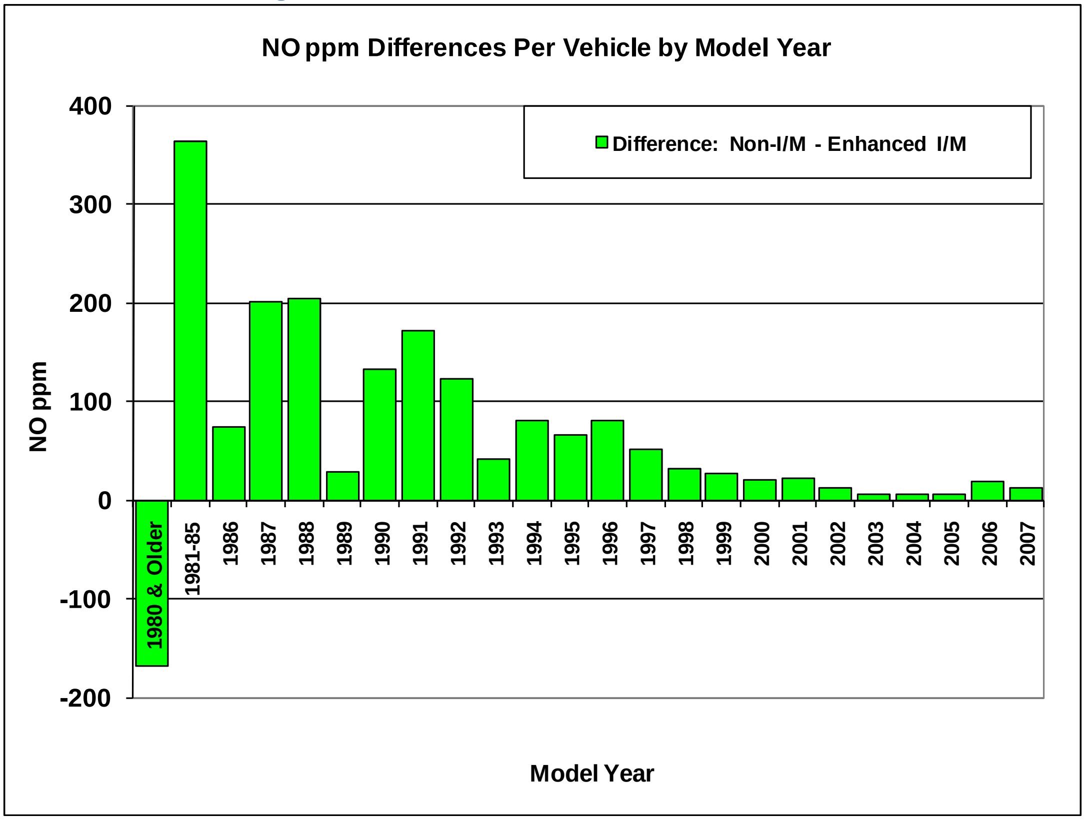
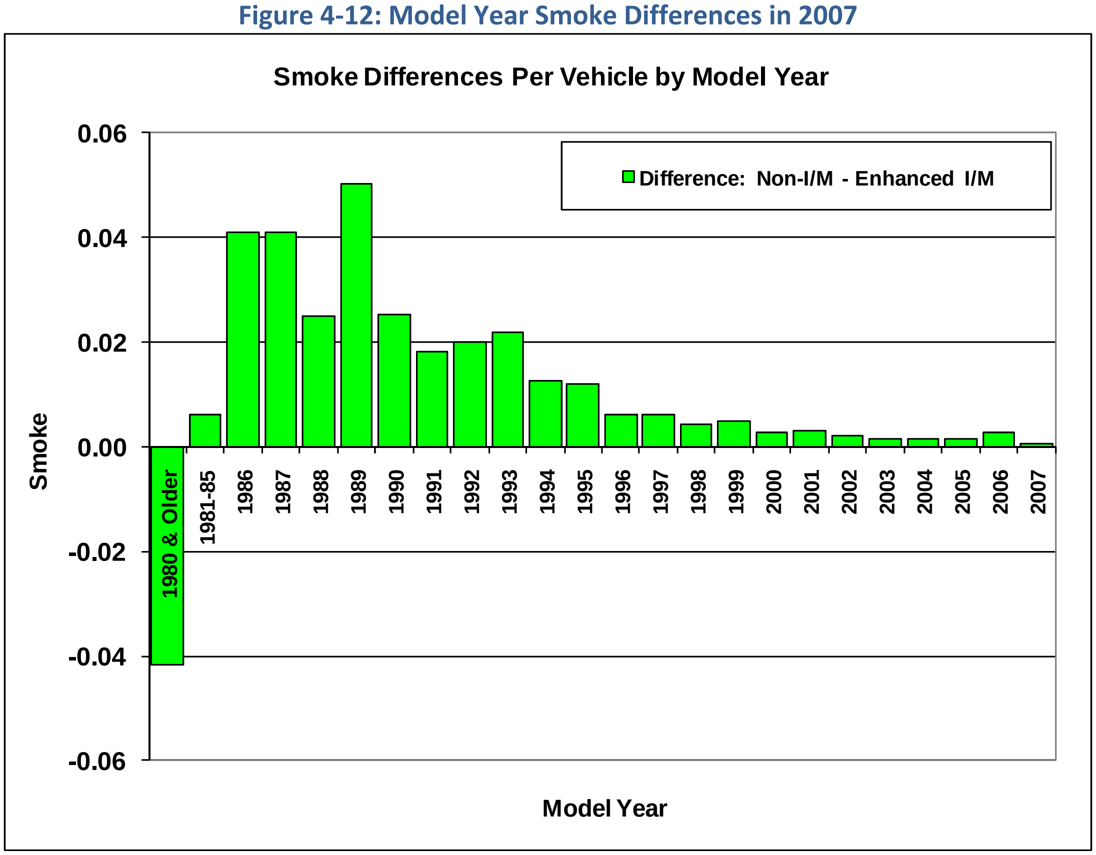


Figure 4-12: Model Year Smoke Differences in 2007



4.2.3 Emission Rates by Residence of Registration

For measurements made in 2007, ESP calculated average emission rates by region and jurisdiction of registrations. Results are summarized by region in Figure 4-13. Vehicles registered in the Northern Virginia Enhanced I/M jurisdictions and Tidewater had considerably lower emission rates than those registered in Fredericksburg and Richmond. Vehicles in the Northern Virginia Enhanced I/M and Tidewater were also younger (Figure 4-14).

Average emissions are shown by jurisdiction in Figures 4-15 to 4-18 and Figure 4-19 shows the average VSP.

Figure 4-13: Mean Emissions, VSP and Age in 2007 by Region

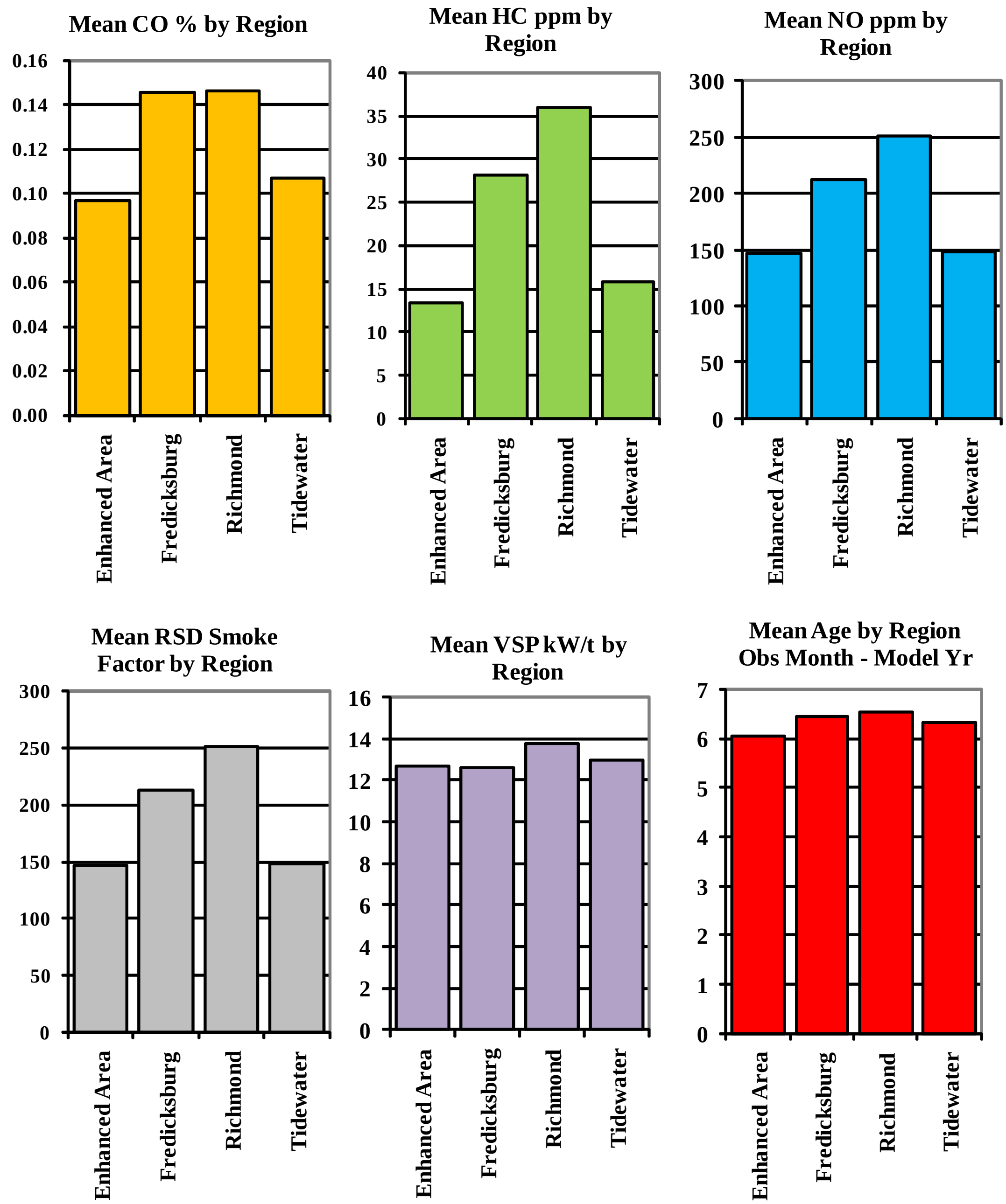


Figure 4-14: Mean Age in 2007 by Jurisdiction

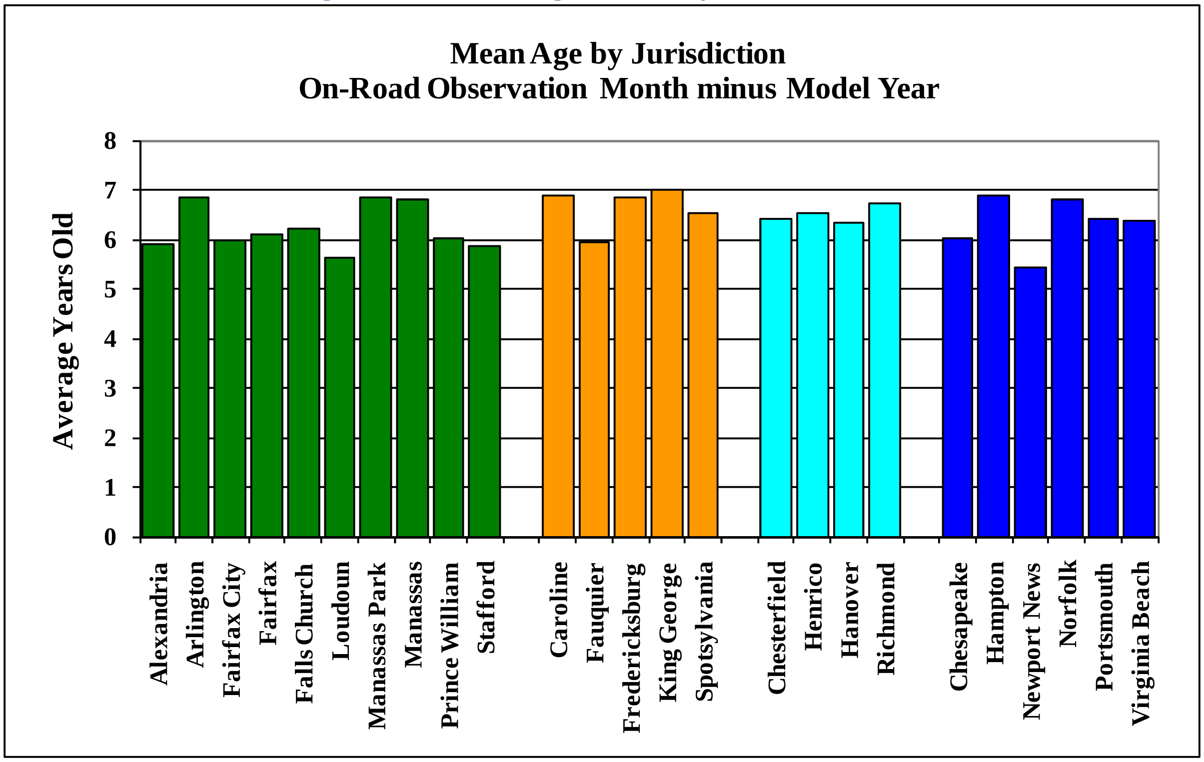


Figure 4-15: Mean CO in 2007 by Jurisdiction

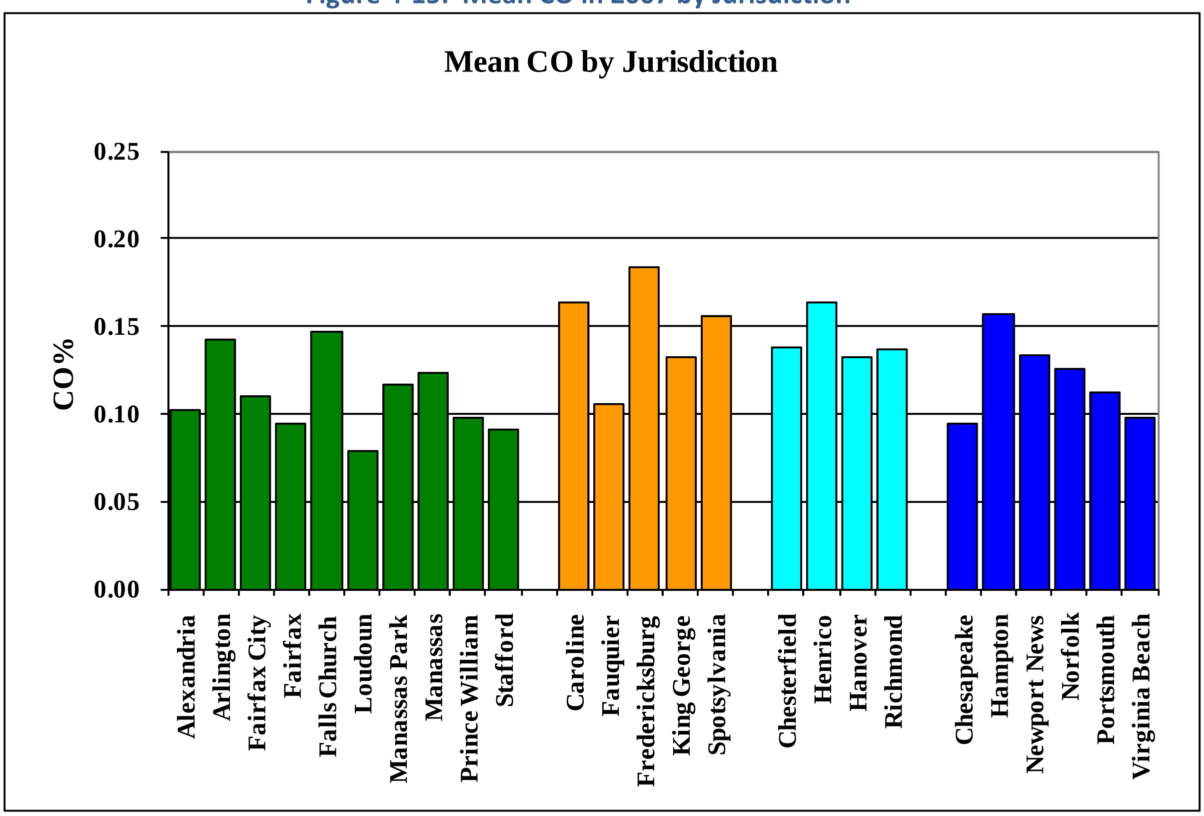


Figure 4-16: Mean HC in 2007 by Jurisdiction

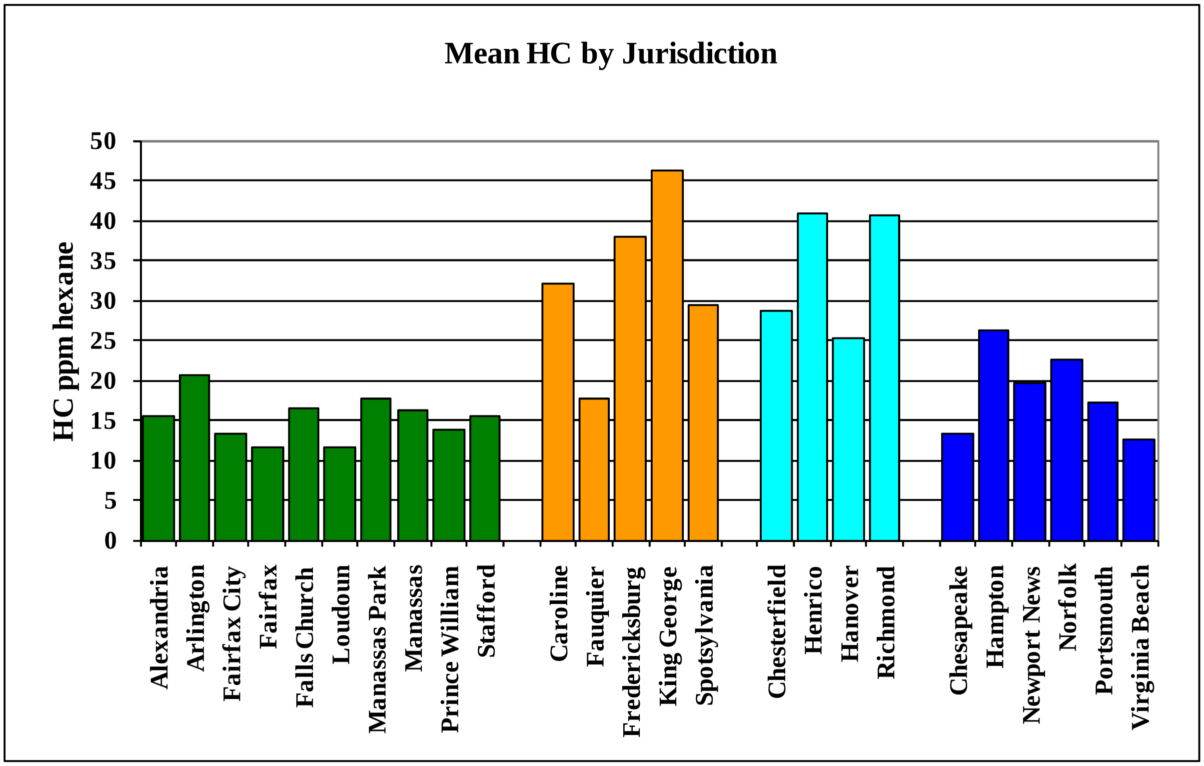


Figure 4-17: Mean NO in 2007 by Jurisdiction

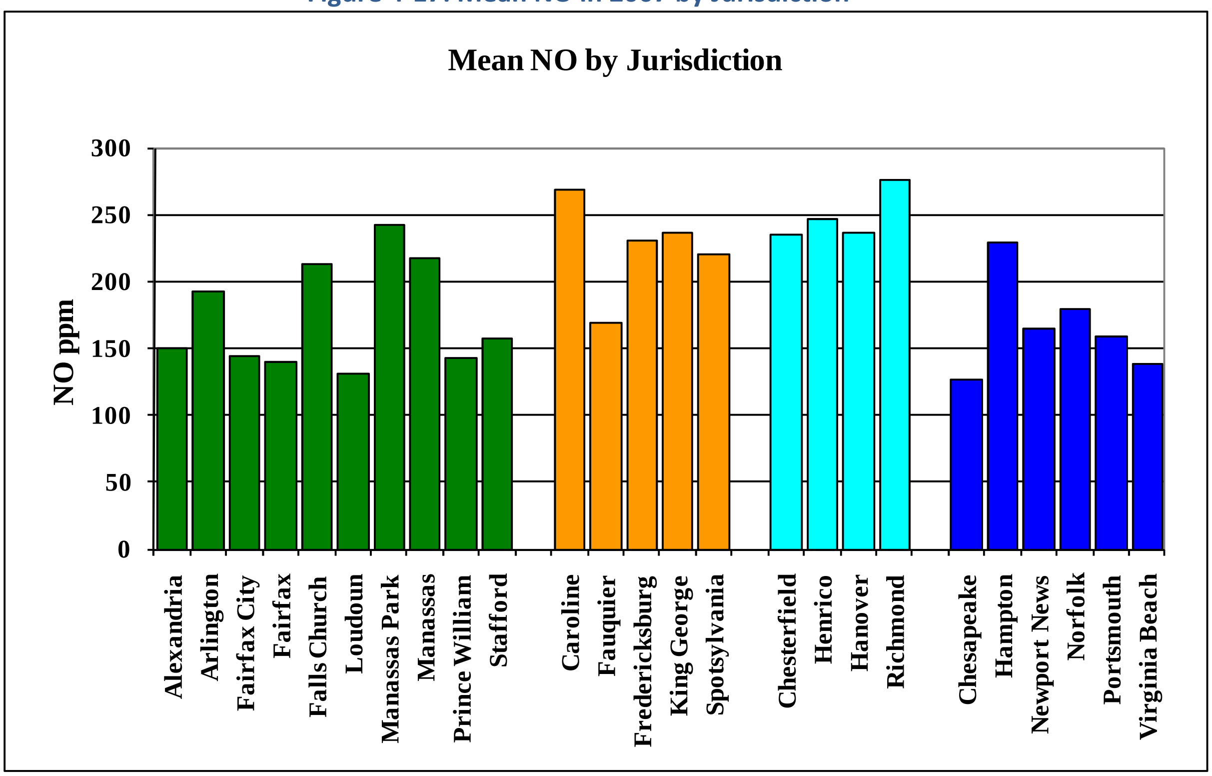


Figure 4-18: Smoke in 2007 by Jurisdiction

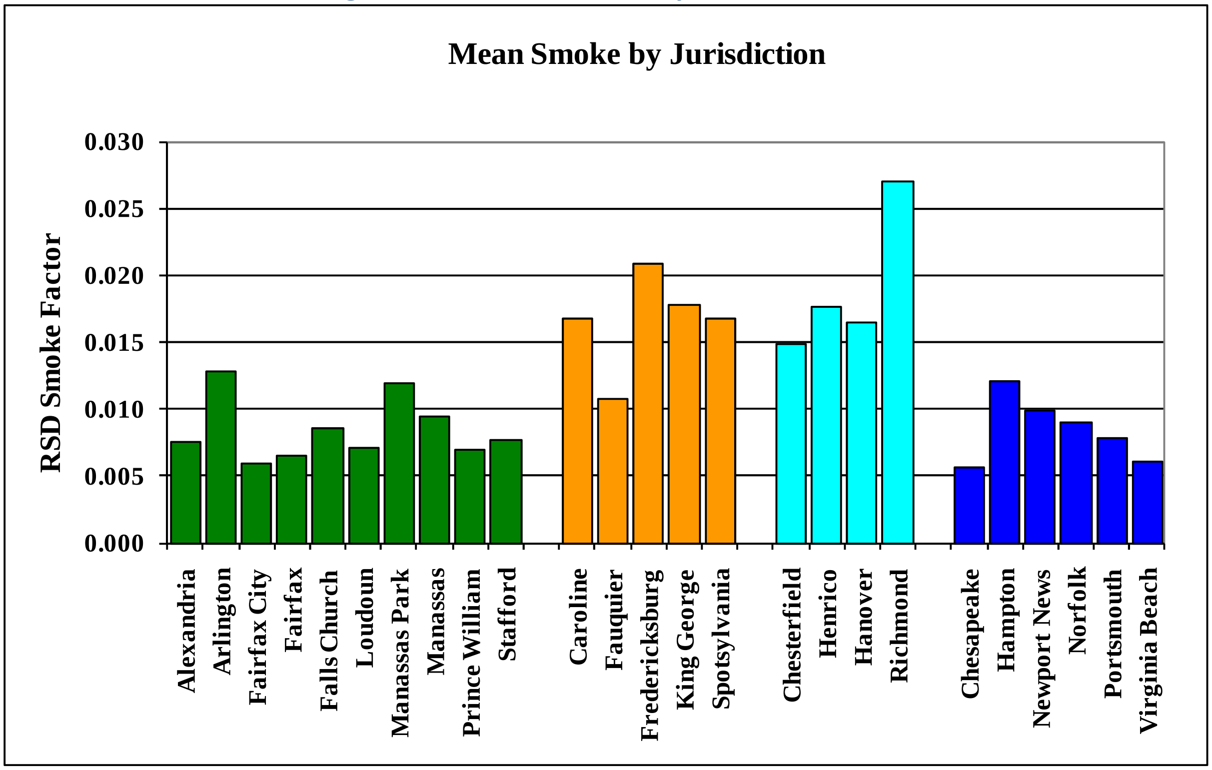
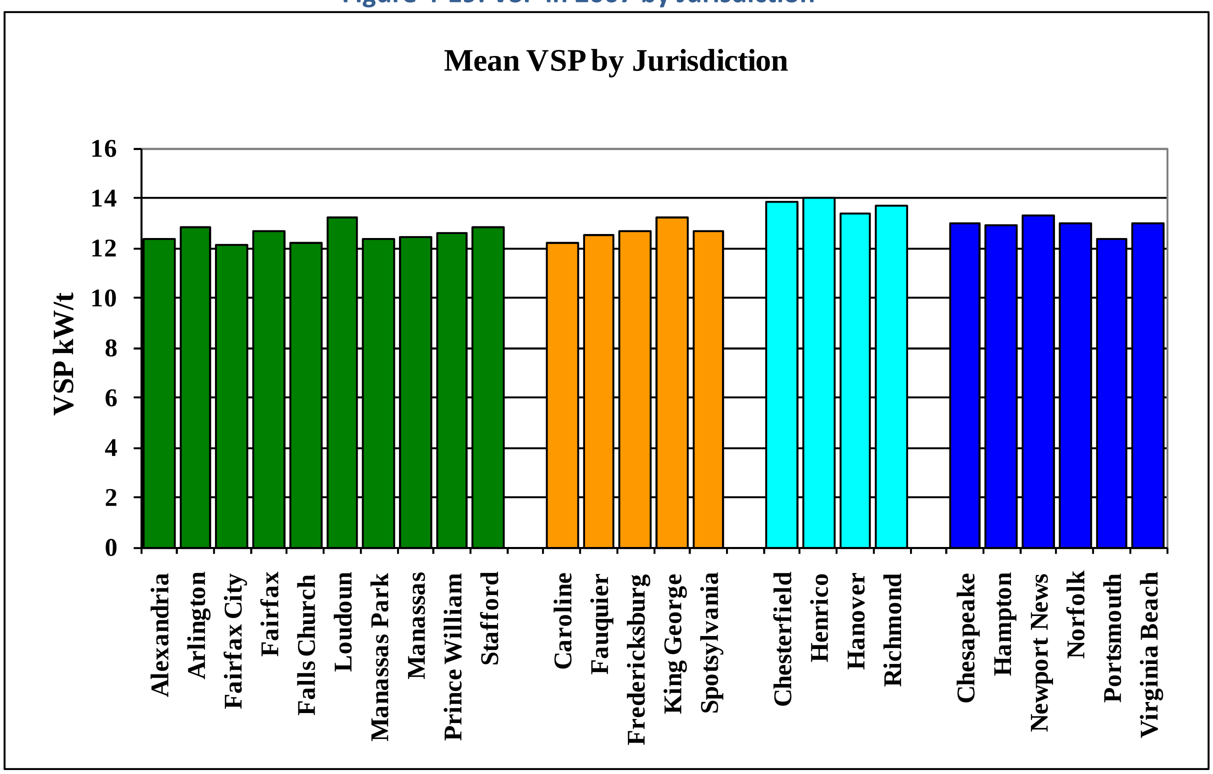


Figure 4-19: VSP in 2007 by Jurisdiction



4.2.4 2007 Emissions Rates by Area Models

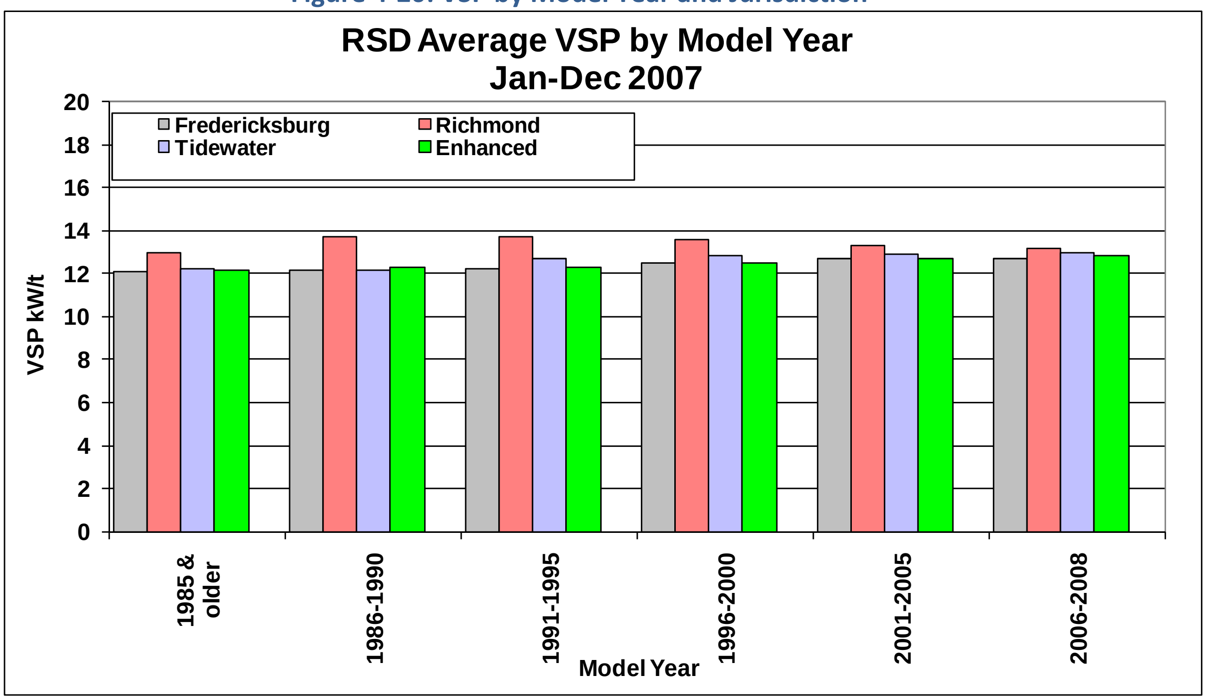
ESP compared emission rates in 2007 by model year group for vehicle measurements binned by the regions shown in Table 4-3. Enhanced refers to the jurisdictions within the Northern Virginia Enhanced I/M area. The VSP range was narrowed to 5-20kW/t.

Table 4-3: RSD Measurements with VSP 5-20kW/t

Model Year	Enhanced	Fredericks-burg	Richmond	Tidewater	Total
1985 & older	654	120	45	66	885
1986-1990	4,297	679	163	268	5,407
1991-1995	22,436	2,281	676	1,169	26,562
1996-2000	73,244	6,326	1,668	3,600	84,838
2001-2005	136,478	11,335	2,646	5,887	156,346
2006-2008	50,986	3,400	1,038	2,006	57,430
Total	288,095	24,141	6,236	12,996	331,468

Figure 4-20 compares the average VSP levels for each group. Emissions, especially NO emissions, are known to vary with VSP and Richmond measurements had an average VSP of 13.4 kw/t vs. 12.5-13 kw/t for other jurisdictions.

Figure 4-20: VSP by Model Year and Jurisdiction



Figures 4-21 to 4-24 show the emissions for each age range and region. Vehicles registered in the I/M area of Virginia have lower emission rates than those registered in non-I/M areas.. Despite being measured at similar VSP, Richmond and Fredericksburg vehicles have relatively higher emissions compared to I/M area vehicles.

Figure 4-21: CO by Model Year and Region

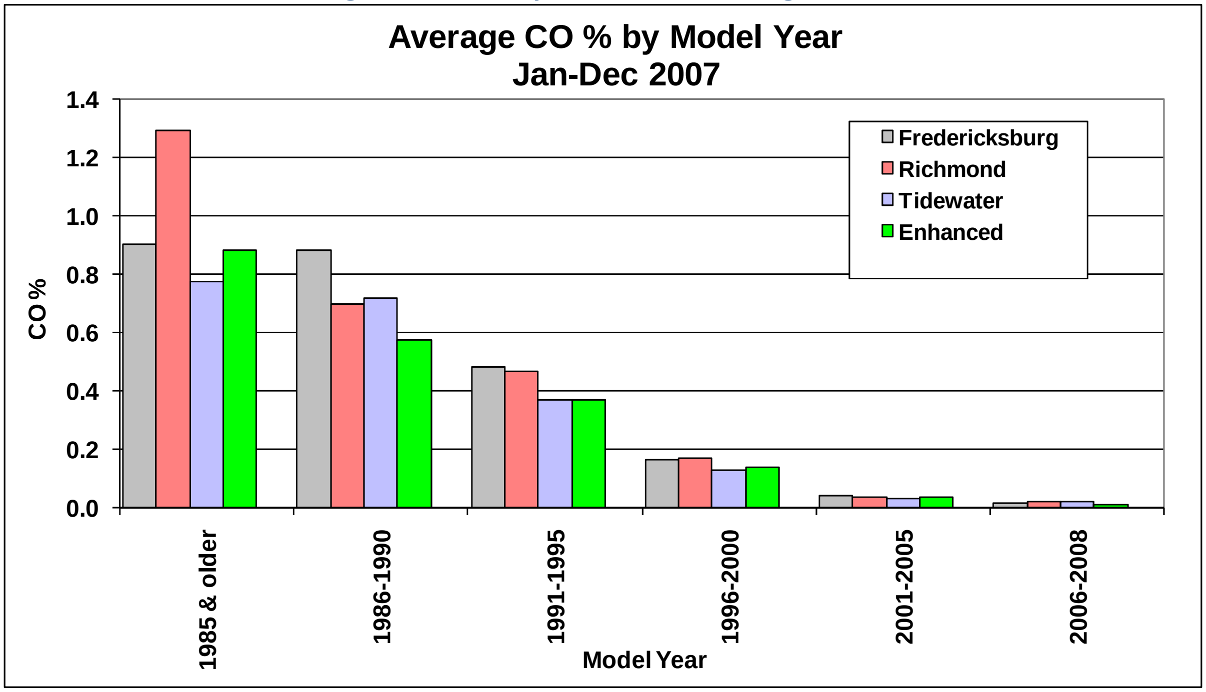


Figure 4-22: HC by Model Year and Jurisdiction

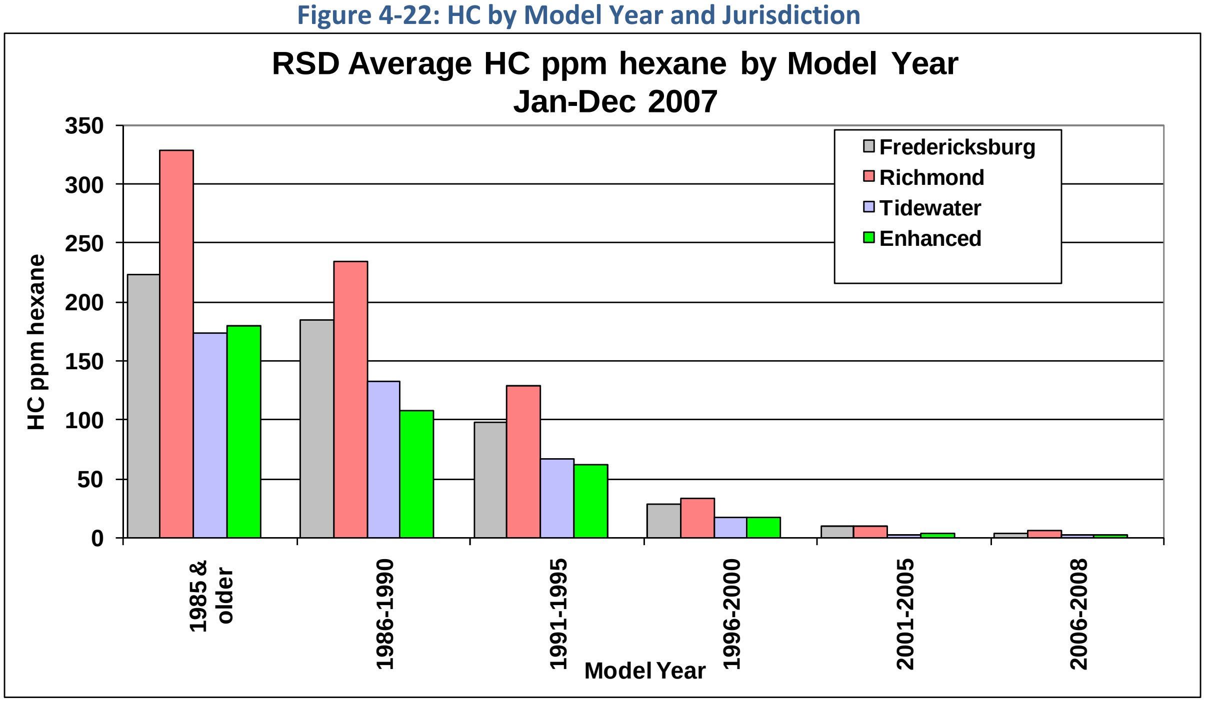


Figure 4-23: NOx by Model Year and Jurisdiction

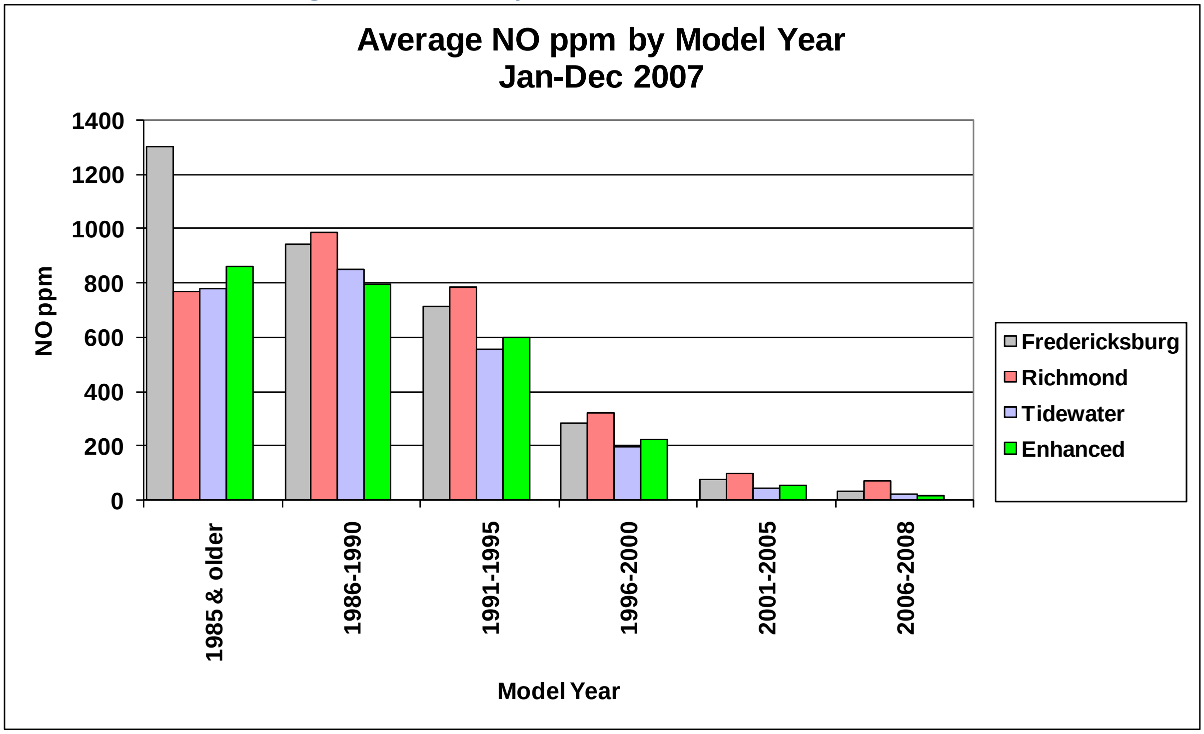
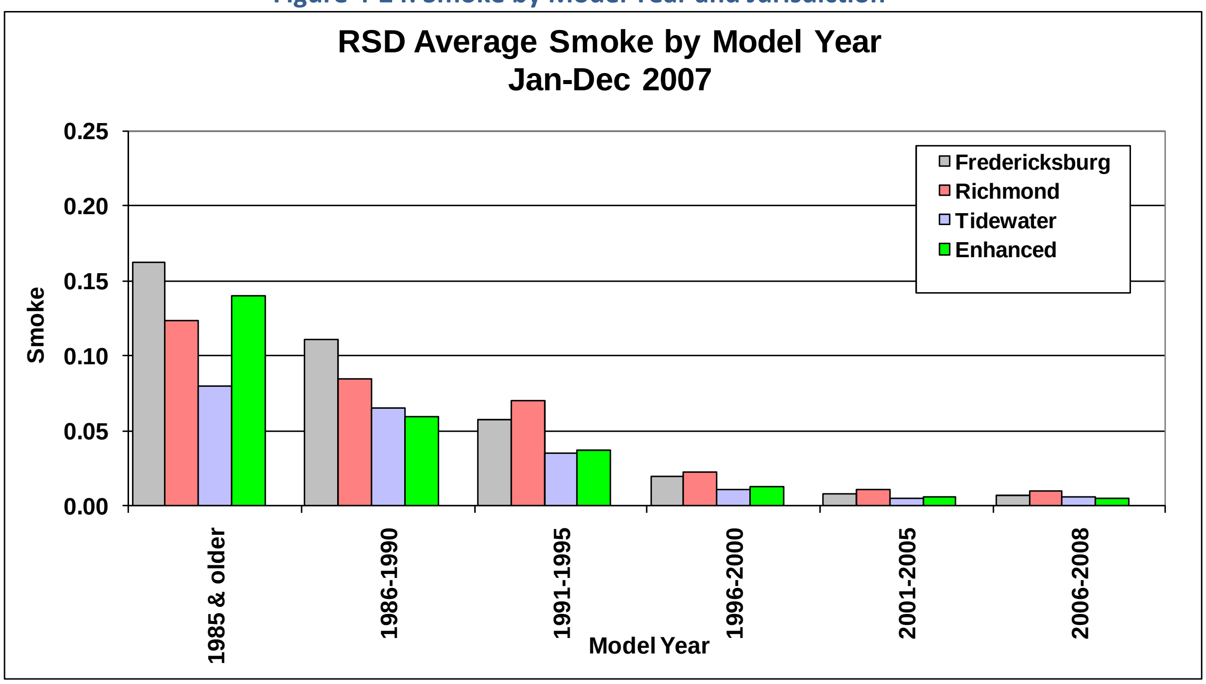


Figure 4-24: Smoke by Model Year and Jurisdiction



5 HIGH EMITTERS IDENTIFIED

5.1 Summary

The program successfully identified high emitters. Changes were made to the high emitter selection criteria and the number of high emitters identified and notices issues increased substantially. 191 notices of violation were issued in 2007, 158 notices in 2008, 87 notices in the first half of 2009 and 198 notices in the second half of 2009.

Vehicle owners issued a Notice of Violation were generally responsive to the program. The outcomes for vehicles issued a notice were:

- 13%-18% passed a confirmatory test without an abort. These vehicles were either false positives or were repaired before the confirmatory test. The air quality benefit from these vehicles is unknown.

- 17%-18% passed a confirmatory test with a preceding abort. The presence of an aborted test often indicates a vehicle was headed towards failing the test. The air quality benefits from these vehicles may be similar to those from vehicles that initially failed and were repaired to pass.

- 24%-30% of vehicles were sold or retired. This is a positive outcome for air quality. If vehicles were sold within the area they will be repaired before resale, if retired, there is a permanent benefit from eliminating the high emitter from the highway.

- 24%-27% passed a final test or completed the I/M requirements , including 2-3% obtaining waiver. These vehicles have been repaired.

- 9%-12% were referred to legal for civil fine collection.

5.2 Identifying High Emitters

On-road RSD measurements of vehicle emissions within the Northern Enhanced I/M area were reported to the I/M program VID contractor, SGS-TestCom. Each month SGS-Testcom scanned the database and identified high emitting vehicles. High emitters were identified using two methods:

1) RSD-2: Two separate on-road observations of the vehicle both measured emissions were higher than RSD cutpoints, or

2) RSD-HEI: A single on-road observation of the vehicle measured emissions was higher than RSD cutpoints and the vehicle model was ranked in the top 25% of vehicles with the highest I/M failure rate.

RSD cutpoints were established by applying multipliers to ASM standards to allow a cushion for on-road variability in emissions. The process of determining if a vehicle was a high emitter followed this general path:

1) Find ASM or TSI cutpoints for the vehicle:
   a. ASM for trucks and for 1996 & newer passenger vehicles use ASM2525 Equivalent Test Weight (ETW) cutpoints from a look-up table:
      i. LDGT ETW is average of empty weight + GVWR
      ii. LDGV ETW is empty weight + 300 lbs.
   b. ASM for 1995 and older model passenger vehicles use ASM 2525 displacement cutpoints
      i. Look up the displacement coefficient value
      ii. Divide by engine displacement liters (except for HC 2525).
   c. For vehicles over 8500 lbs tested at idle use TSI cutpoints (VDEQ type H).

2) Multiply ASM/TSI cutpoints by RSD multiplier for the appropriate Test Type to obtain the RSD cutpoints.

3) If a single RSD measurement and exceeds RSD cutpoint, check if HEI value is 75 or higher.

4) If two RSD measurements, both must fail the RSD cutpoints and measurements must be within 120 days.

5.2.1 The HEI table

The HEI value as the percentile ranking of a vehicle group within all vehicles based on failure rate, i.e. HEI value for a group was equal to the sum of all vehicles in groups with an equal or lesser fail rate divided by the total number of vehicles in the fleet. The HEI table was updated annually base on the previous two-years I/M test results.

Initially HEI values were calculated separately for 1995 & older models and 1996 & newer models. Over time, the 1995 and older models became fewer in number, became older and their failure rates increased. The split in the HEI table, however, prevented more than 25% of these models from being considered for the RSD-HEI method.

5.2.2 July 2009 Modifications to the High Emitter Selection cutpoints and HEI tables

In mid 2009, the RSD cutpoint multipliers and the high emitter index were reviewed and updated. The HEI table update process was modified to calculate HEI values across the entire fleet – removing the split between 1995 & older and 1996 & newer models.

In addition, there were insufficient I/M tests of some older and rarer models to populate the HEI, which led to gaps in the table. Consequently, some models were not being evaluated for the hybrid method. Fall-back HEI tables were created to cover rarer older models without matching records in the primary HEI table. This was accomplished by using a less detailed model keys:

- The primary HEI table index: type, model year, make, cylinders and displacement.
- First fall-back HEI table index: type, model year, make and cylinders.
- Second fall-back HEI table index: type, model year.

The high emitter selection program was modified to search successively in the primary, first fall-back and second fall-back tables until an entry matching the vehicle was found.

RSD cutpoint multipliers were also reviewed and in some cases were reduced.

5.2.3 Issuance of Notice of Violations (NOVs)

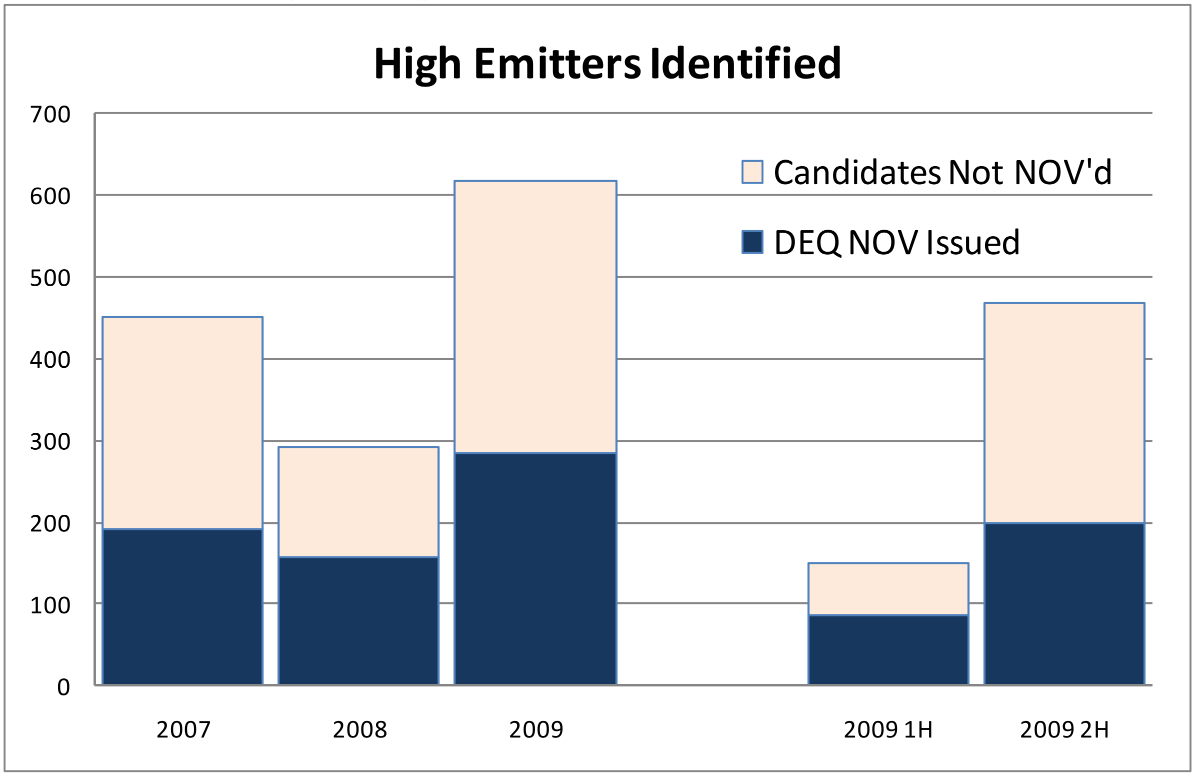
Following computer identification of a vehicle as a high emitter, candidates were individually checked and reviewed by DEQ to determine that all necessary data was obtained, the vehicle met the program rules and that no unusual circumstances existed, e.g. that the vehicle was not likely to have been in a cold start model by being measured very close to the owners home. Following a satisfactory review, vehicle owners were sent a Notice of Violation (NOV).

5.3 High Emitters Identified and Outcomes

Figure 5-1 summarizes the high emitter vehicles identified and the NOVs issued for 2007,8,9 and 1H & 2H 2009. The rate of high emitters identified in 2008 and the first half of 2009 declined as 1995 and older models became a smaller fraction of the fleet and, as noted above, at most one quarter were being considered for the RSD-HEI method.

From July 2009, the HEI values were calculated across the fleet as a whole. The rate of high emitter identifications approximately tripled in the second half of 2009 to about 1,000 vehicles per year. After DEQ review, NOVs were issued to just under half the identified candidates.

Figure 5-1 High Emitters Identified and NOVs Issued



Following receipt of an NOV, vehicle owners were required to obtain repairs and a confirmatory I/M test (CT) at a licensed inspection station. If a vehicle failed the initial confirmatory test the vehicle should be repaired until it passed a final confirmatory test.

Several outcomes were possible besides passing an initial or final confirmatory test:

1. No confirmatory test was obtained:
    a. Pending: The test was pending
    b. Legal: The case had been referred for legal action
    c. Disregard: The notice was moot, the vehicle had been sold or was no longer in operation.
    d. Inactive: The case was no longer active.
2. Pass initial confirmatory test: the vehicle passed its first confirmatory test attempt.
3. Final confirmatory test status:
    a. Pass: the vehicle passed after repair
    b. Waiver: the vehicle received a waiver after meeting the repair spending cap
    c. Pending: The final test was still pending
    d. Legal: The case was been referred for legal action
    e. Disregard: The notice was moot, the vehicle had been sold or was no longer in operation.

f. Inactive: The case was no longer active.

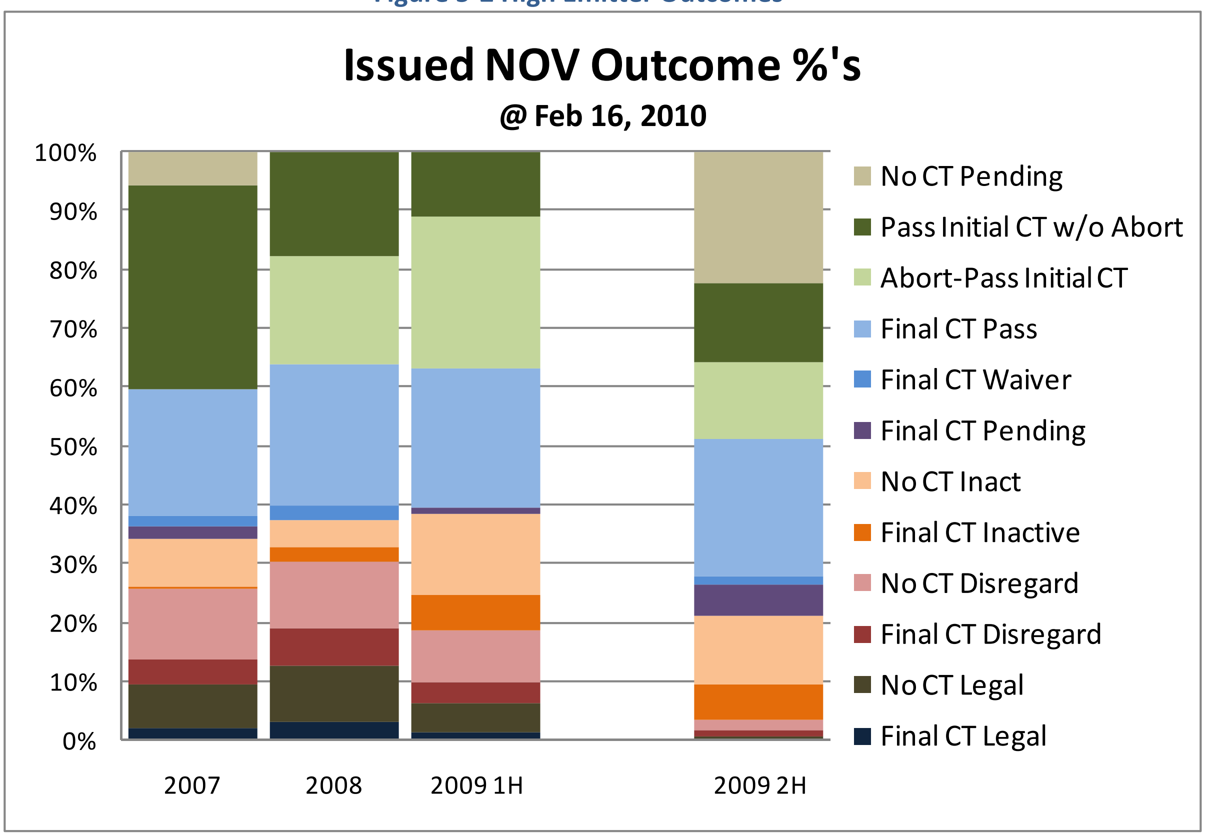
Figure 5-2 summarizes the status of vehicles issued NOVs. In 2008 and 2009, DEQ checked for the presence of an aborted test as part of the initial confirmatory test sequence. In figure 5-2 the fraction confirmatory tests with an aborted test element is identified separately.

An ASM test can be aborted if the vehicle drops out of the engine rpm window for the test. Inspectors can deliberately abort a test if a vehicle appears likely to fail, i.e. it has not passed within a relatively short time. This may be done to avoid charging the owner for multiple tests. The high incidence of aborted tests as part of the confirmatory test sequences suggests that many of the vehicles passing their 'initial' confirmatory test were repaired or tuned prior to passing the initial confirmatory test. In 2008, 18% of all NOV vehicles passed an initial confirmatory test without an abort. The rates in 2009 were 11% in the first half year and 14% in the second half.

In the second half of 2009, about 20% of vehicles had still to complete their confirmatory test and 4% had a final test pending. Over time, these vehicles will progress to another status.

The NOV vehicle status results indicate that at least 85% of identified high emitters were sold, retired, repaired or fined.

Figure 5-2 High Emitter Outcomes



Figures 5-3 to 5-6 show the distributions of candidates, NOVs issued and confirmatory test passes by model year. OBD-II vehicles were no more likely to pass the initial confirmatory test than older models.

Figure 5-3 2007 High Emitters

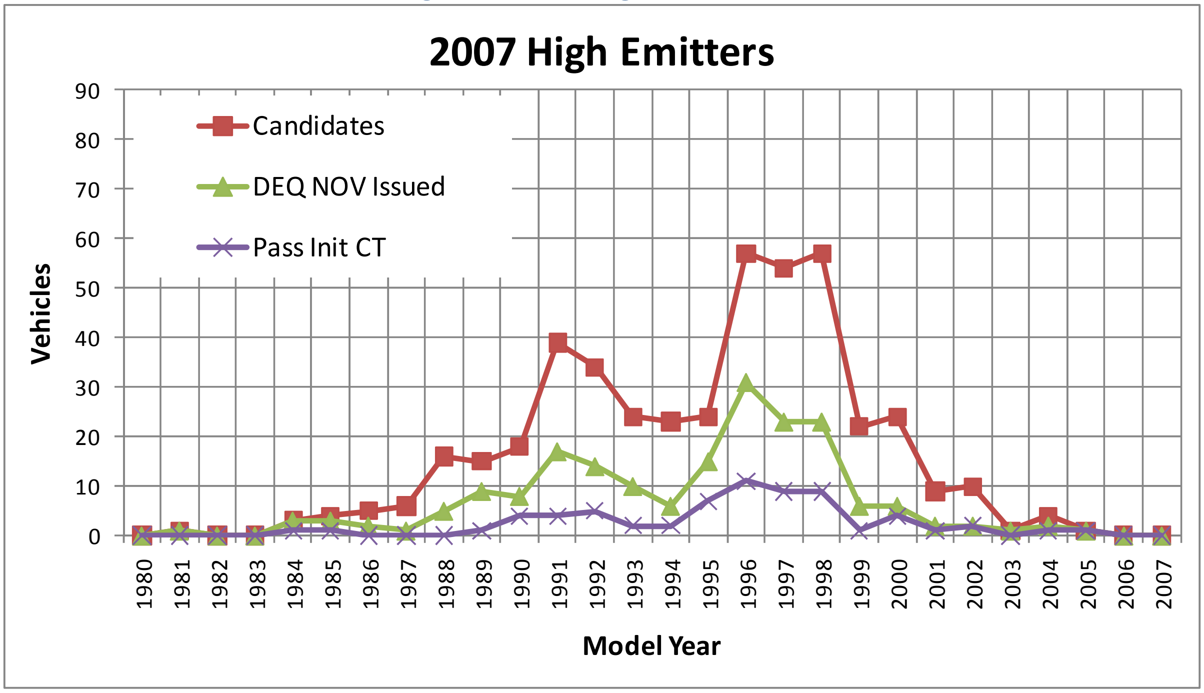


Figure 5-4 2008 High Emitters

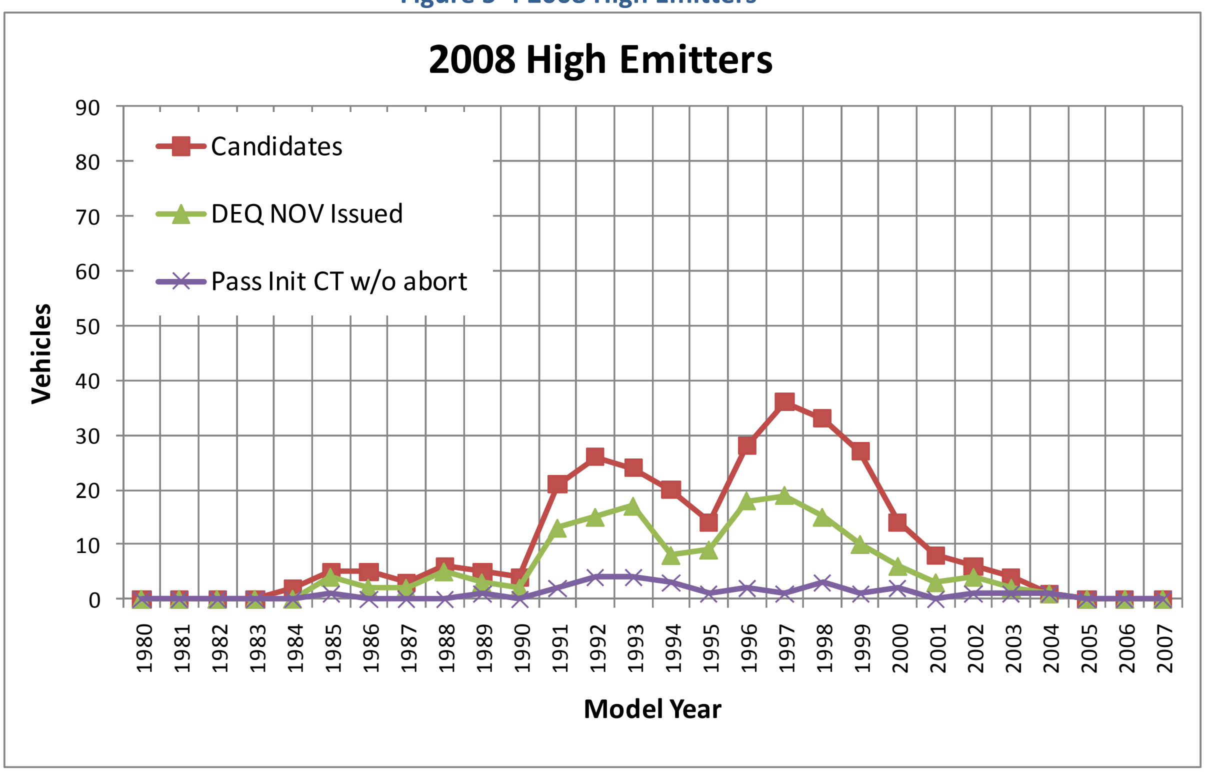


Figure 5-5 January-June 2009 High Emitters

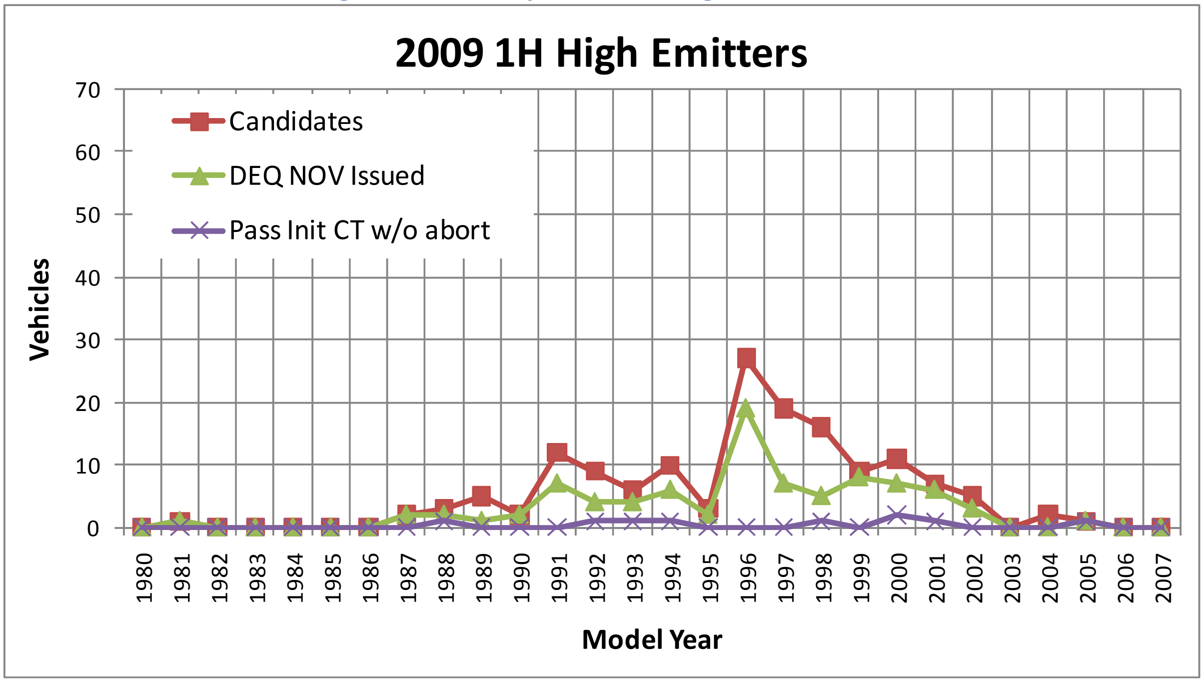
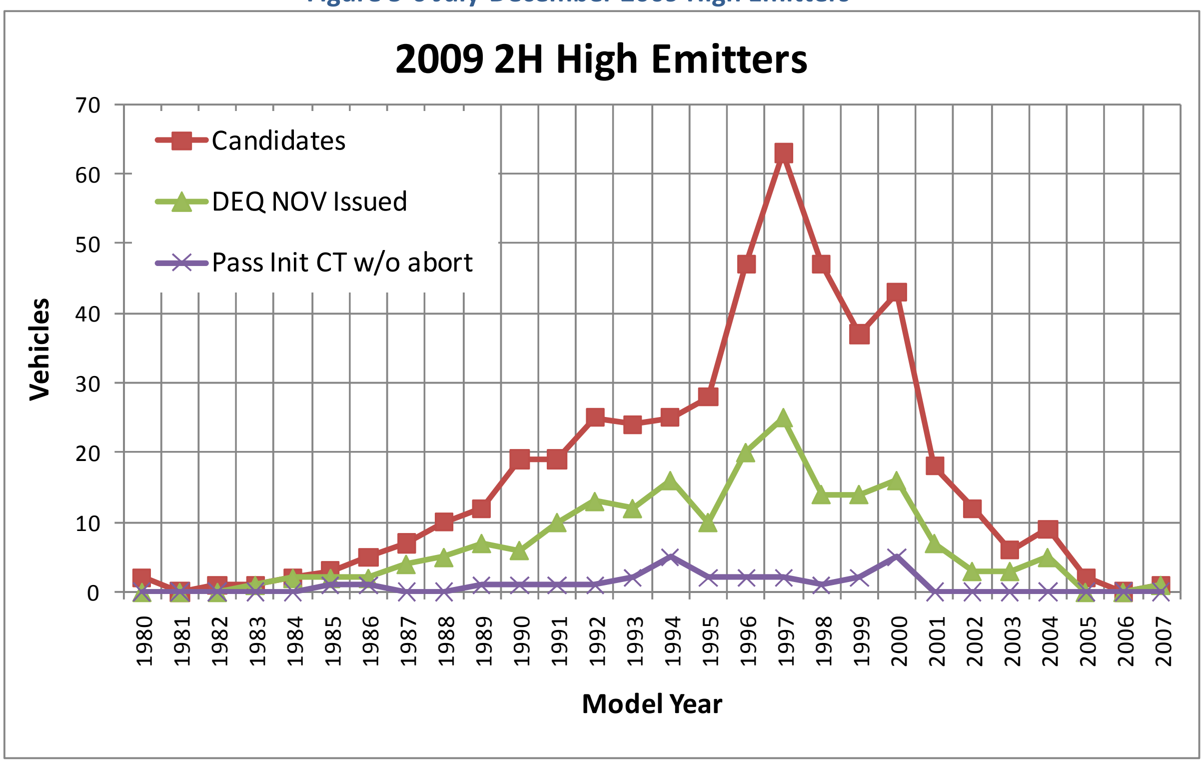


Figure 5-6 July-December 2009 High Emitters



5.4 High Emitters RSD Emissions by Pollutant

ESP examined the RSD average emissions of high emitting vehicles identified in 2008 and 2009 the results are presented in Tables 5-1 to 5-4.

- The upper section of each table shows the average RSD emissions of vehicles that were issued NOVs and of those that were not;
- The lower section of each table shows the average RSD emissions by initial confirmatory test result for vehicles responding to NOVs:
    - P-pass without an abort;
    - AP – pass with an abort
    - F – fail
    - Blank – no CT result

Results were calculated separately for two periods[i]:

- 2008 and the first half of 2009, and
- The second half of 2009 following the change in selection criteria.

Results were also calculated separately for 1996 and newer OBD-II models and the 1995 and older pre-OBD-II models.

Table 5-1 shows the results and emissions independent of which pollutant(s) were high. Tables 5-2 to 5-4 show results for vehicles that had at least one high RSD measurement for CO, HC and NO respectively.

5.4.1 High Emitters issued NOVs

NOVs were issued for 56% of the high emitters identified before the change in criteria and for 47% of those identified after the change in criteria.

By high CO, HC and NO respectively the percentages issued were:

- Before the change: 54%, 61% and 57%;
- After the change: 41%, 38% and 53%.

NOVs were issued for 56% of pre-OBD vehicles and 45% of OBD-II vehicles. By high CO, HC and NO respectively the percentages issued were:

- 1995 & older models: 51%, 61% and 66%
- 1996 & newer models: 44%, 37%, and 49%.

There were, therefore, a relatively fewer NOVs issued for OBD-II vehicles with high HC.

5.4.2 Confirmatory Test results of Vehicles Responding to NOVs

ESP examined the percentage of NOV vehicles that passed an initial confirmatory test without an abort before and after the change of selection criteria in mid-2009. A lower percentage of vehicles

[i] There is a slight timing difference between the tables. The high emitter vehicles were categorized according to the date they were selected. The NOV's were categorized according to the NOV issue date.

passing their initial confirmatory test without an abort may indicate better selection criteria. Before the change, 24% passed the test without an abort and after the change 22% passed the test without an abort.

By high CO, HC and NO respectively the percentages passing without an aborted test were:

- Before the change: 23%, 33% and 14%
- After the change: 21%, 28% and 21%.

The fraction of vehicles measured that were identified as high emitters approximately tripled following the change in selection criteria and a somewhat smaller percentage of these were issued NOVs. For vehicles issued NOVs that obtained a confirmatory test, the percentage of vehicles passing the confirmatory test without an aborted test was reduced following the change in the selection criteria. This is interpreted to be a positive result.

ESP examined the percentages of 1995 & older models and 1996 & newer models that passed an initial confirmatory test without an abort. 28% of the older models passed compared to 18% of 1996 & newer models.

By high CO, HC and NO respectively the percentages passing without an aborted test were:

- 1995 & older: 25%, 36% and 24%
- 1996 & newer: 20%, 23% and 18%.

The percentages suggest that the high emitter selection criteria are working at least as well for the newer OBD vehicles as for the older models.

5.4.3 Average RSD Emissions levels of Selected Vehicles

Tables 5-2 through 5-4 also show the RSD average emissions levels of vehicles according to their confirmatory test result. For vehicles with high CO, 1995 & older vehicles that passed under the older selection criteria had lower average CO than other groups. With the new selection criteria, CO emissions were higher for 1995 & older vehicles and slightly lower for 1996 & newer models. However the percentage of passing vehicles did not appear to be particularly sensitive to the CO levels.

For vehicles with high HC, average HC emissions were lower for newer models than with the new selection criteria. But, there was not a large difference in the average HC values between vehicles passing or failing the confirmatory test.

Average RSD NO emissions also appeared to be independent of the confirmatory test result and average NO was over 2200ppm for all groups.

This suggests that selection criteria emission cutpoints could be further tightened without negatively impacting the fraction of vehicles passing the confirmatory test. In addition, it seems likely the fraction of high emitters issued NOVs could also be increased.

Table 5-1 High Emissions of Any Pollutant

MY	Period	DEQ Action	Vehicles	Observations	Avg HE Index	RSD CO Highs	Avg RSD CO % of CO Highs	RSD HC Highs	Avg RSD HC ppm of HC Highs	RSD NO Highs	Avg RSD NO ppm of NO Highs
1995 & older	2008 & 1H 2009	Issued	82	114	83	55	5.14	60	1618	3	3149
1995 & older	2008 & 1H 2009	Not Issued	51	73	81	41	4.37	29	722	2	3534
Issued % / total		62%	133	187		96		89		5	
1995 & older	2H 2009	Issued	125	165	90	43	6.33	47	1642	65	2636
1995 & older	2H 2009	Not Issued	112	139	95	57	5.47	53	1154	31	2405
Issued % / total		53%	237	304		100		100		96	
1996 & Newer	2008 & 1H 2009	Issued	80	120	83	47	7.90	23	1901	31	3064
1996 & Newer	2008 & 1H 2009	Not Issued	76	100	85	39	6.10	19	1318	25	3126
Issued % / total		51%	156	220		86		42		56	
1996 & Newer	2H 2009	Issued	164	226	84	46	6.32	43	1726	119	2393
1996 & Newer	2H 2009	Not Issued	217	280	84	60	6.05	85	1051	121	1969
Issued % / total		43%	381	506		106		128		240	
Total		50%	907	1217		388		359		397	

MY	Period	Initial CT Result	Vehicles	Observations	Avg HE Index	RSD CO Highs	Avg RSD CO % of CO Highs	RSD HC Highs	Avg RSD HC ppm of HC Highs	RSD NO Highs	Avg RSD NO ppm of NO Highs
1995 & older	2008 & 1H 2009	P	16	22	80	10	3.60	15	1039	0	0
1995 & older	2008 & 1H 2009	AP	10	12	88	8	5.97	3	1305	0	0
1995 & older	2008 & 1H 2009	F	34	48	86	22	5.07	22	2438	3	3149
1995 & older	2008 & 1H 2009		18	26	83	12	5.30	17	1108	0	0
Total / Pass %		21%	78	108		52		57		3	
1995 & older	2H 2009	P	22	26	93	7	5.47	9	1705	9	2552
1995 & older	2H 2009	AP	8	14	81	3	9.30	5	1181	3	2777
1995 & older	2H 2009	F	45	53	92	17	5.46	10	1494	25	2554
1995 & older	2H 2009		48	69	89	14	7.51	22	1817	28	2734
Total / Pass %		18%	123	162		41		46		65	
1996 & Newer	2008 & 1H 2009	P	12	23	71	11	6.88	5	1482	3	2938
1996 & Newer	2008 & 1H 2009	AP	19	24	84	11	8.25	4	3105	8	3264
1996 & Newer	2008 & 1H 2009	F	25	42	83	15	9.13	9	1720	9	2920
1996 & Newer	2008 & 1H 2009		22	29	86	9	6.71	5	1341	10	3128
Total / Pass %		15%	78	118		46		23		30	
1996 & Newer	2H 2009	P	20	28	83	5	5.23	8	1113	16	2364
1996 & Newer	2H 2009	AP	39	51	81	8	6.20	17	1400	23	2627
1996 & Newer	2H 2009	F	59	83	85	20	7.01	11	1220	42	2244
1996 & Newer	2H 2009		46	64	83	13	5.73	7	3629	38	2430
Total / Pass %		12%	164	226		46		43		119	
Total		16%	443	614		185		169		217	

Table 5-2 One or More High RSD CO Measurements

MY	Period	DEQ Action	Vehicles	Observations	Avg HE Index	RSD CO Highs	Avg RSD CO % of CO Highs	RSD HC Highs	Avg RSD HC ppm of HC Highs	RSD NO Highs	Avg RSD NO ppm of NO Highs
1995 & older	2008 & 1H 2009	Issued	47	65	85	55	5.14	16	2100	2	3148
1995 & older	2008 & 1H 2009	Not Issued	34	48	80	41	4.37	11	675	1	3421
Issued % / total		58%	81	113		96		27		3	
1995 & older	2H 2009	Issued	36	49	87	43	6.33	7	2594	0	
1995 & older	2H 2009	Not Issued	47	60	94	57	5.47	16	920	0	
Issued % / total		43%	83	109		100		23		0	
1996 & Newer	2008 & 1H 2009	Issued	36	55	79	47	7.90	2	1294	0	
1996 & Newer	2008 & 1H 2009	Not Issued	36	47	85	39	6.10	1	520	0	
Issued % / total		50%	72	102		86		3		0	
1996 & Newer	2H 2009	Issued	35	49	81	46	6.32	4	1351	0	
1996 & Newer	2H 2009	Not Issued	54	64	86	60	6.05	21	794	2	2172
Issued % / total		39%	89	113		106		25		2	
Total		47%	325	437		388		78		5	

MY	Period	Initial CT Result	Vehicles	Observations	Avg HE Index	RSD CO Highs	Avg RSD CO % of CO Highs	RSD HC Highs	Avg RSD HC ppm of HC Highs	RSD NO Highs	Avg RSD NO ppm of NO Highs
1995 & older	2008 & 1H 2009	P	7	11	75	10	3.60	4	877	0	0
1995 & older	2008 & 1H 2009	AP	7	9	85	8	5.97	0	0	0	0
1995 & older	2008 & 1H 2009	F	19	29	85	22	5.07	6	3825	2	3148
1995 & older	2008 & 1H 2009		11	13	90	12	5.30	5	1123	0	0
Total / Pass %		16%	44	62		52		15		2	
1995 & older	2H 2009	P	7	9	90	7	5.47	1	518	0	0
1995 & older	2H 2009	AP	2	4	56	3	9.30	0	0	0	0
1995 & older	2H 2009	F	14	17	87	17	5.46	0	0	0	0
1995 & older	2H 2009		12	17	90	14	7.51	6	3009	0	0
Total / Pass %		20%	35	47		41		7		0	
1996 & Newer	2008 & 1H 2009	P	7	14	65	11	6.88	1	1189	0	0
1996 & Newer	2008 & 1H 2009	AP	9	12	81	11	8.25	1	1398	0	0
1996 & Newer	2008 & 1H 2009	F	11	17	78	15	9.13	0	0	0	0
1996 & Newer	2008 & 1H 2009		8	11	89	9	6.71	0	0	0	0
Total / Pass %		20%	35	54		46		2		0	
1996 & Newer	2H 2009	P	3	5	79	5	5.23	1	740	0	0
1996 & Newer	2H 2009	AP	6	8	83	8	6.20	1	611	0	0
1996 & Newer	2H 2009	F	15	21	82	20	7.01	1	919	0	0
1996 & Newer	2H 2009		11	15	78	13	5.73	1	3132	0	0
Total / Pass %		9%	35	49		46		4		0	
Total		16%	149	212		185		28		2	

Table 5-3 One or More High RSD HC Measurements

MY	Period	DEQ Action	Vehicles	Observations	Avg HE Index	RSD CO Highs	Avg RSD CO % of CO Highs	RSD HC Highs	Avg RSD HC ppm of HC Highs	RSD NO Highs	Avg RSD NO ppm of NO Highs
1995 & older	2008 & 1H 2009	Issued	49	69	81	17	5.14	60	1618	1	2875
1995 & older	2008 & 1H 2009	Not Issued	25	38	76	14	4.96	29	722	0	
Issued % / total		66%	74	107		31		89		1	
1995 & older	2H 2009	Issued	37	50	84	7	9.74	47	1642	2	1634
1995 & older	2H 2009	Not Issued	48	61	95	19	6.07	53	1154	1	1190
Issued % / total		44%	85	111		26		100		3	
1996 & Newer	2008 & 1H 2009	Issued	17	33	79	3	9.34	23	1901	1	2964
1996 & Newer	2008 & 1H 2009	Not Issued	18	23	85	1	6.49	19	1318	0	
Issued % / total		49%	35	56		4		42		1	
1996 & Newer	2H 2009	Issued	37	53	80	5	6.02	43	1726	4	2193
1996 & Newer	2H 2009	Not Issued	73	109	82	21	7.29	85	1051	6	1964
Issued % / total		34%	110	162		26		128		10	
Total		46%	304	436		87		359		15	

MY	Period	Initial CT Result	Vehicles	Observations	Avg HE Index	RSD CO Highs	Avg RSD CO % of CO Highs	RSD HC Highs	Avg RSD HC ppm of HC Highs	RSD NO Highs	Avg RSD NO ppm of NO Highs
1995 & older	2008 & 1H 2009	P	12	16	79	5	3.47	15	1039	0	0
1995 & older	2008 & 1H 2009	AP	3	3	95	0	0.00	3	1305	0	0
1995 & older	2008 & 1H 2009	F	20	27	83	6	6.09	22	2438	1	2875
1995 & older	2008 & 1H 2009		12	19	82	5	4.65	17	1108	0	0
Total / Pass %		26%	47	65		16		57		1	
1995 & older	2H 2009	P	8	9	90	1	4.67	9	1705	1	1593
1995 & older	2H 2009	AP	4	7	85	0	0.00	5	1181	0	0
1995 & older	2H 2009	F	8	10	84	0	0.00	10	1494	1	1675
1995 & older	2H 2009		16	23	79	6	10.76	22	1817	0	0
Total / Pass %		22%	36	49		7		46		2	
1996 & Newer	2008 & 1H 2009	P	4	7	66	2	8.02	5	1482	1	2964
1996 & Newer	2008 & 1H 2009	AP	4	5	88	1	10.67	4	3105	0	0
1996 & Newer	2008 & 1H 2009	F	5	14	87	0	0.00	9	1720	0	0
1996 & Newer	2008 & 1H 2009		4	7	73	0	0.00	5	1341	0	0
Total / Pass %		24%	17	33		3		23		1	
1996 & Newer	2H 2009	P	6	10	75	2	8.68	8	1113	1	1674
1996 & Newer	2H 2009	AP	14	20	76	1	8.12	17	1400	0	0
1996 & Newer	2H 2009	F	10	14	85	1	4.66	11	1220	2	1647
1996 & Newer	2H 2009		7	9	86	1	2.63	7	3629	1	3259
Total / Pass %		16%	37	53		5		43		4	
Total		22%	137	200		31		169		8	

Table 5-4 One or More High RSD NO Measurements

MY	Period	DEQ Action	Vehicles	Observations	Avg HE Index	RSD CO Highs	Avg RSD CO % of CO Highs	RSD HC Highs	Avg RSD HC ppm of HC Highs	RSD NO Highs	Avg RSD NO ppm of NO Highs
1995 & older	2008 & 1H 2009	Issued	3	6	88	3	3.46	1	16238	3	3149
1995 & older	2008 & 1H 2009	Not Issued	2	4	92	1	1.72	0		2	3534
Issued % / total		60%	5	10		4		1		5	
1995 & older	2H 2009	Issued	60	75	97	0		2	695	65	2636
1995 & older	2H 2009	Not Issued	31	39	96	0		2	323	31	2405
Issued % / total		66%	91	114		0		4		96	
1996 & Newer	2008 & 1H 2009	Issued	30	38	88	0		1	2010	31	3064
1996 & Newer	2008 & 1H 2009	Not Issued	23	31	85	0		0		25	3126
Issued % / total		57%	53	69		0		1		56	
1996 & Newer	2H 2009	Issued	99	135	85	0		3	5560	119	2393
1996 & Newer	2H 2009	Not Issued	111	136	84	1	2.45	5	1326	121	1969
Issued % / total		47%	210	271		1		8		240	
Total		53%	359	464		5		14		397	

MY	Period	Initial CT Result	Vehicles	Observations	Avg HE Index	RSD CO Highs	Avg RSD CO % of CO Highs	RSD HC Highs	Avg RSD HC ppm of HC Highs	RSD NO Highs	Avg RSD NO ppm of NO Highs
1995 & older	2008 & 1H 2009	P	0	0	0	0	0.00	0	0	0	0
1995 & older	2008 & 1H 2009	AP	0	0	0	0	0.00	0	0	0	0
1995 & older	2008 & 1H 2009	F	3	6	88	3	3.46	1	16238	3	3149
1995 & older	2008 & 1H 2009		0	0	0	0	0.00	0	0	0	0
Total / Pass %		0%	3	6		3		1		3	
1995 & older	2H 2009	P	9	10	98	0	0.00	1	410	9	2552
1995 & older	2H 2009	AP	2	3	97	0	0.00	0	0	3	2777
1995 & older	2H 2009	F	24	27	98	0	0.00	1	979	25	2554
1995 & older	2H 2009		25	35	94	0	0.00	0	0	28	2734
Total / Pass %		15%	60	75		0		2		65	
1996 & Newer	2008 & 1H 2009	P	3	6	87	0	0.00	1	2010	3	2938
1996 & Newer	2008 & 1H 2009	AP	7	9	86	0	0.00	0	0	8	3264
1996 & Newer	2008 & 1H 2009	F	9	11	87	0	0.00	0	0	9	2920
1996 & Newer	2008 & 1H 2009		10	11	90	0	0.00	0	0	10	3128
Total / Pass %		10%	29	37		0		1		30	
1996 & Newer	2H 2009	P	13	17	86	0	0.00	1	1475	16	2364
1996 & Newer	2H 2009	AP	20	24	84	0	0.00	0	0	23	2627
1996 & Newer	2H 2009	F	36	51	86	0	0.00	1	308	42	2244
1996 & Newer	2H 2009		30	43	84	0	0.00	1	14897	38	2430
Total / Pass %		13%	99	135		0		3		119	
Total		13%	191	253		3		7		217	

6 Using RSD for Program Performance Monitoring

6.1 ASM Inspection and Repair Effectiveness

Comparing on-road emissions to passing I/M test emissions can provide feedback on the effectiveness of the inspection program and repairs. Figures 6-1 to 6-3 show for different inspection stations the average ASM 2525 and the on-road RSD emissions of vehicles passing inspection. The on-road emissions were measured within 180 days following the pass at the station.

The left side of each chart shows the average ASM and RSD emissions of all the vehicles measured at the stations and measured on-road. The average of the RSD emissions was twice the average of the ASM emissions for CO and similar to the average of ASM emissions for HC and NO.

Error bars indicate the 95% confidence intervals (standard error) of the means for the ASM and RSD emissions. The confidence intervals would become smaller with more results. At least 50, and typically between 50 and 100 vehicles tested at each of the stations shown, were surveyed on-road.

For stations where the ASM and RSD emissions are widely separated, the results can be investigated in more detail to determine the cause. For example, on-road emissions of vehicles tested by station XX93 were higher than the ASM emissions for all pollutants. Although the confidence intervals overlapped, this station is used an example for a more detailed look. Note that station XX82 also had differing emissions for HC but in that case the on-road emissions were lower than the ASM values.

Figures 6-4 and 6-5 compare the ASM and RSD emissions for individual vehicles. The results are ordered by the number of days after the ASM test that the on-road RSD measurement was made. For a number of vehicles, the on-road emissions were much higher than the ASM value.

At days 15, 17, 124, 173 and 179, two on-road measurements were made for the same vehicle. These are circled in green. The ASM results corresponding to each of the two on-road measurements have the same values and represent a single ASM test. In some cases the on-road value was similar to ASM and was obscured by the points marking the ASM results. For the vehicle measured on-road 179 days after the ASM test (right side of chart) both on-road measurements showed much higher HC and NO. These indicate the vehicle had become a high NO emitter within six months of passing the I/M test.

With additional on-road measurements, it is possible to develop better information about I/M program and vehicle performance using these types of analysis. Better performance measurement helps drive improvements in program design and effectiveness.

Figure 6-1 On-road and ASM HC Emissions of Vehicles Tested at Stations

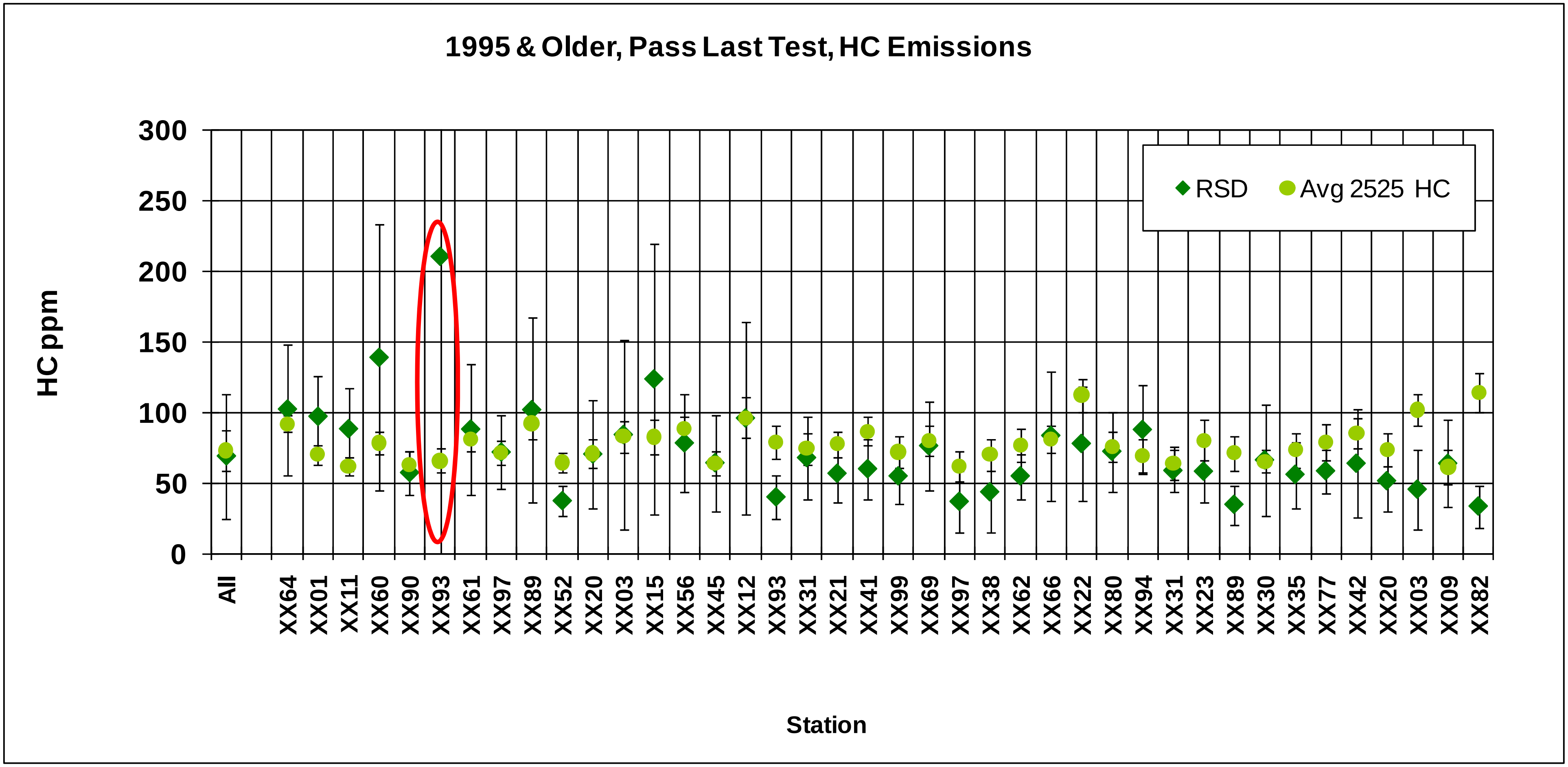


Figure 6-2 On-road and ASM CO Emissions of Vehicles Tested at Stations

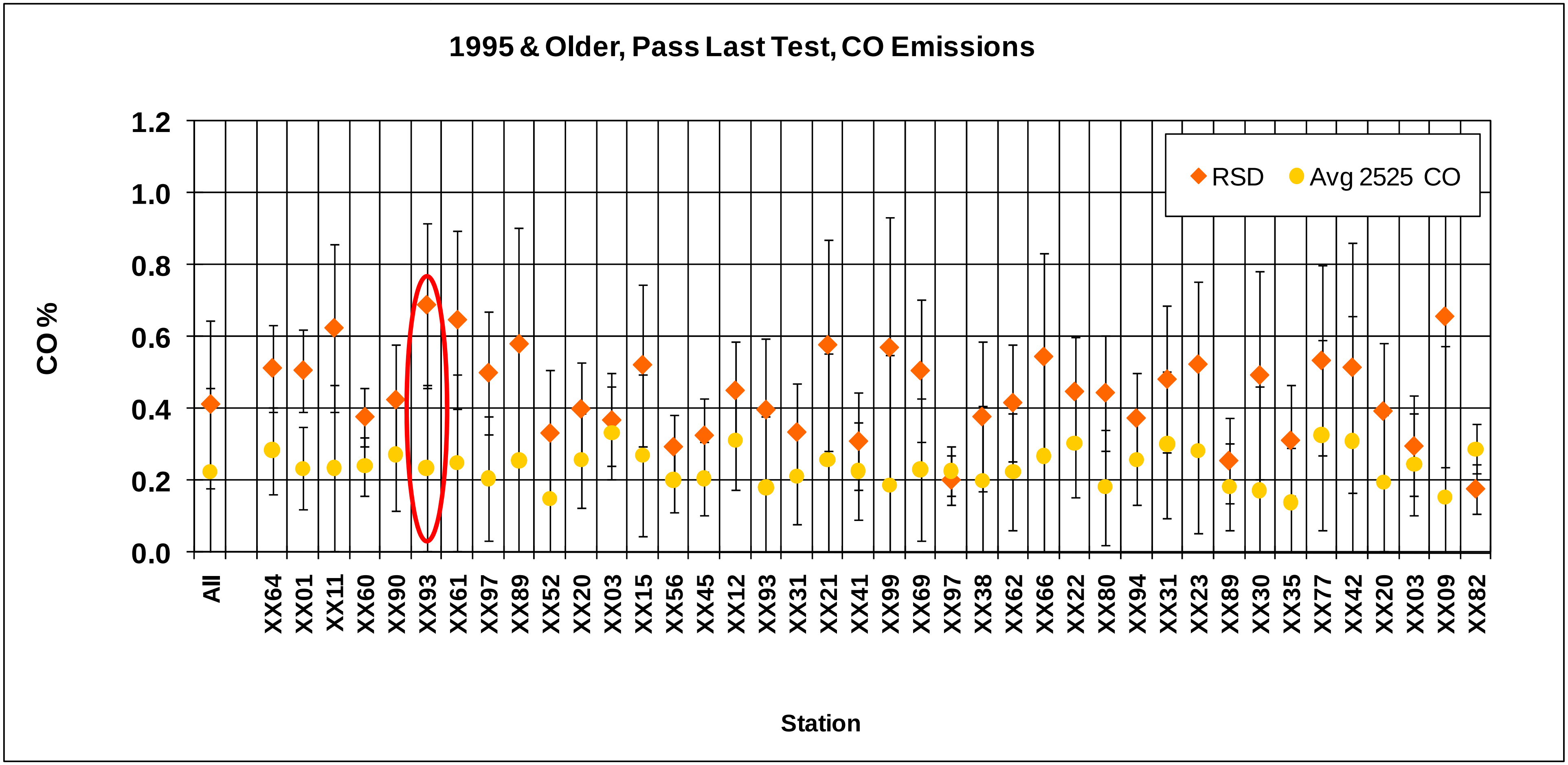


Figure 6-3 On-road and ASM NO Emissions of Vehicles Tested at Stations

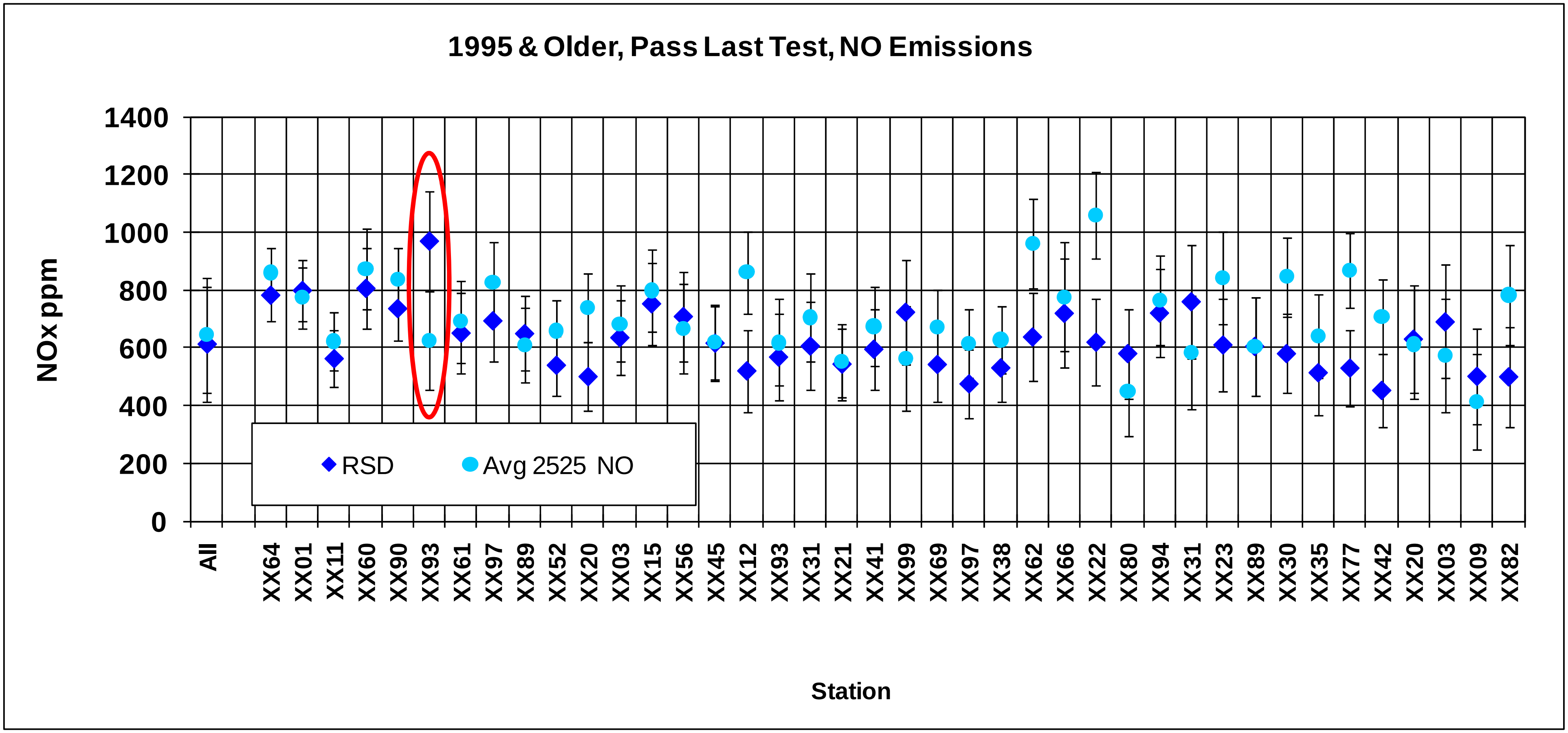


Figure 6-4 HC Measurements from Station XX93

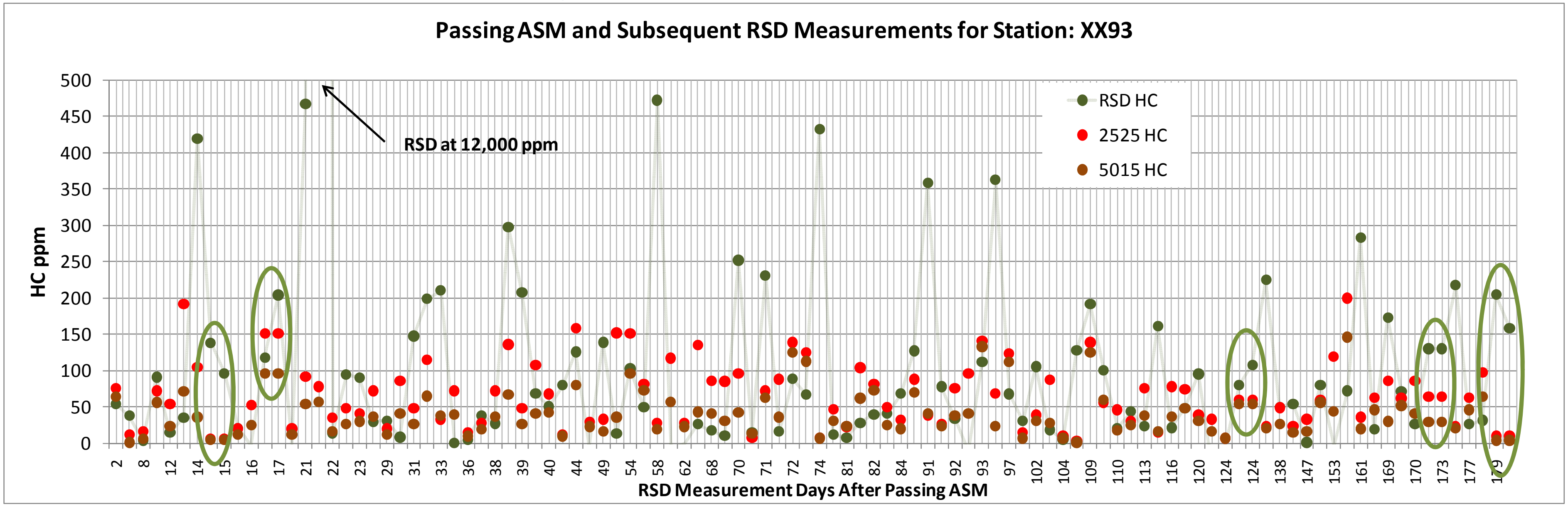
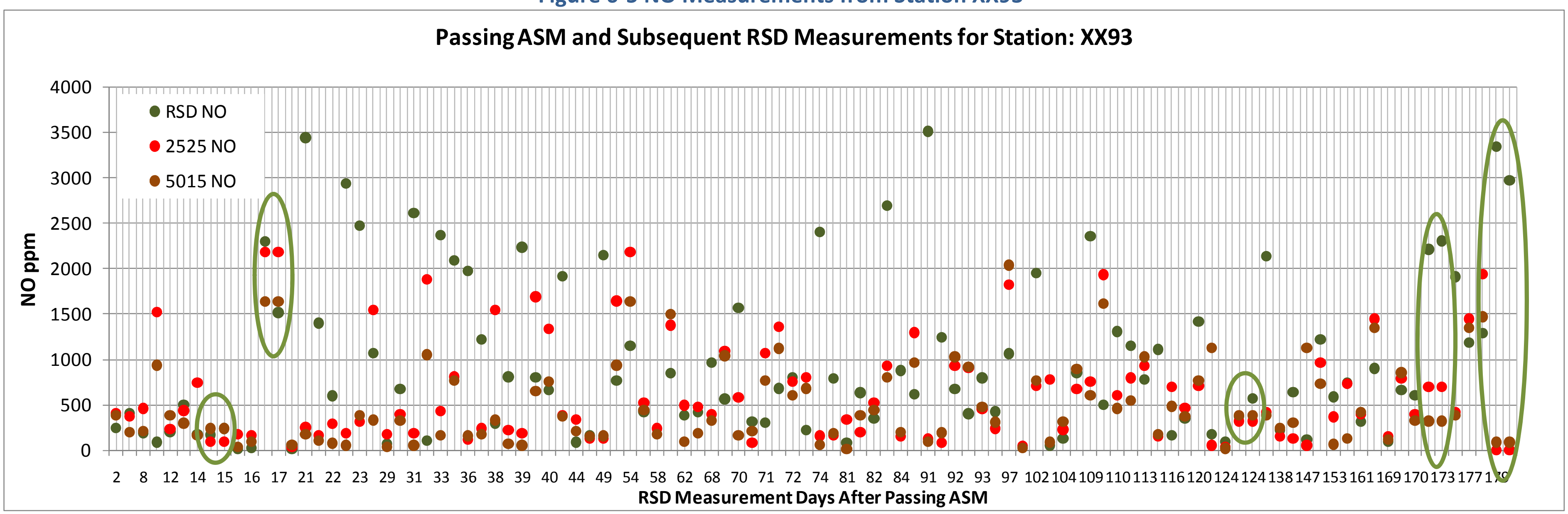


Figure 6-5 NO Measurements from Station XX93



6.2 OBD Readiness

In establishing the OBD I/M rule, EPA allowed certain readiness exemptions that most I/M programs have implemented. Readiness exemption rules permit vehicles to pass the I/M test when some of their OBD system monitors are not set ready, i.e. the OBD system has not received sufficient information to determine that all emissions control systems are functioning as designed.

On-road RSD measurements of emissions were used to evaluate the impact of readiness exemptions on the effectiveness of OBD I/M inspection. On-road emissions of vehicles measured before and after initial OBD inspections were compared to the state of the OBD system readiness.

Findings from this analysis include:

- Vehicles with OBD systems that were 'Not Ready' had higher average emissions than the general OBD fleet;
- Lower emissions measured after the OBD test than before indicate repair benefits for vehicles that failed the OBD test;
- For vehicles that passed the OBD test with OBD systems 'Not Ready' emissions measured after the OBD test were the same as emissions measured before the OBD test;

Readiness exemptions appear to be reducing the effectiveness of the OBD I/M inspection by allowing higher emitting vehicles to pass an initial inspection when the OBD system is not ready. Further investigation is required to quantify the impact.

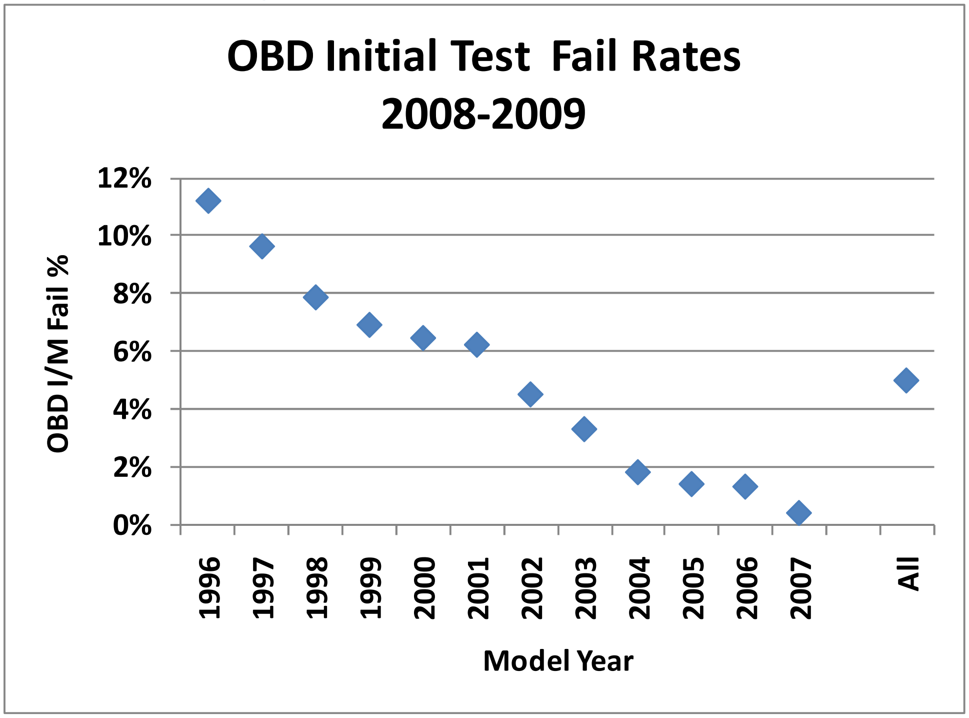
6.2.1 Frequency of OBD Systems being Not Ready

To determine which OBD monitors were most likely to be 'not ready' when vehicles took their I/M test, ESP reviewed the number of occurrences in 800,000 initial OBD tests performed in 2008 and 2009.

The overall OBD fail rate during the period was 5.0%. An additional 1.2% of vehicles had an OBD test result of 'N' which were vehicles over 8500 lbs that were not OBD-II compliant and reverted to the TSI test. Figure 6-6 shows the OBD I/M test fail rate by model year. Fail rates trended up with age from less than 1% for 2007 models to 11% for 1996 models. Since the malfunction indicator light (MIL) illuminates to alert owners when OBD-II systems detect a problem, it is expected that many owners of vehicles with illuminated MILs would have obtained repairs before having an inspection. Therefore, the initial test failure rates in Figure 6-6 are lower than the total failures and the true failure rate is unknown.

There appears to be a pause in the upward trend between 2001 and 2000 models. If the 2004 to 2001 model trend in fail rates had continued, the fail rates for 2000 to 1996 models would be higher. It is suspected the difference is due to two monitor readiness exemption allowed for model year 2000 and older vehicles.

Figure 6-6 OBD Initial OBD I/M Fail Rates



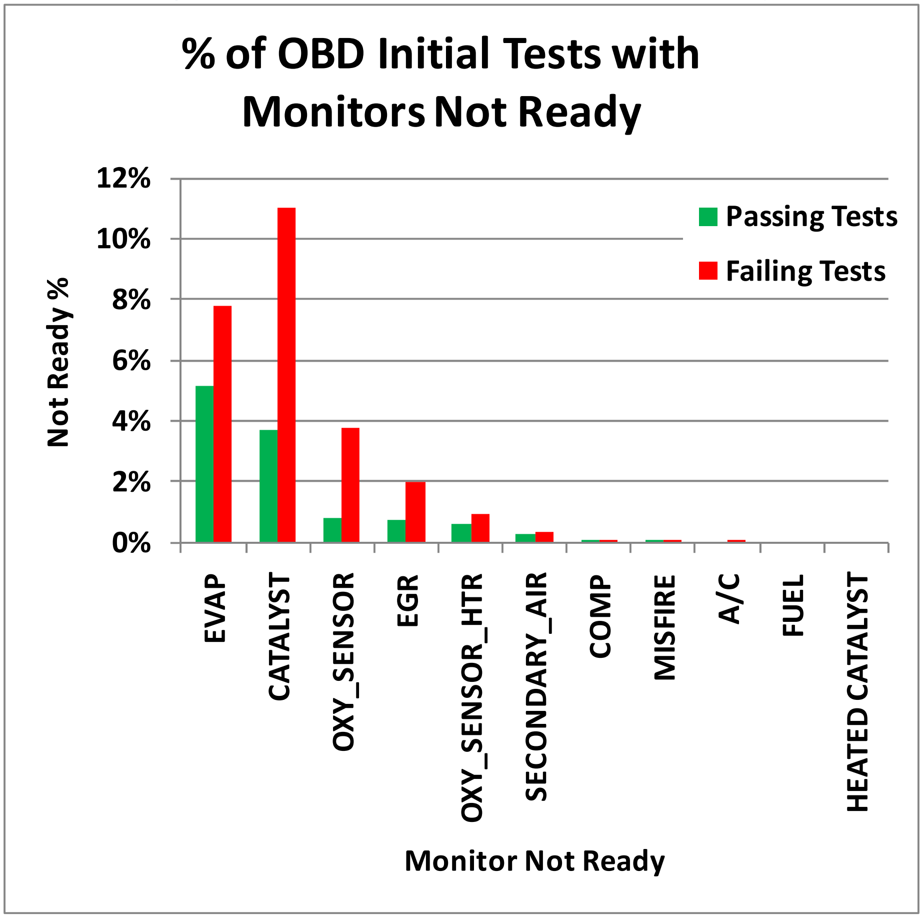
With a properly functioning vehicle that has been driven for a period of time the OBD system readiness monitors will typically all be set ready. Conditions that can result in monitors not being ready include: a new vehicle that has only been driven in cold weather, a recent reset of the OBD system and a recent disconnection of the battery.

Properly functioning vehicles that have been driven under normal conditions without any fault being indicated might be expected to have all readiness monitors set when inspected. In practice, significant numbers of vehicles do not have all monitors set, which raises the question of whether owners or garages are deliberately or accidentally resetting OBD systems before inspection. Figure 6-7 shows the rates of OBD monitors being unset in passing and failing OBD tests. Among vehicles that passed inspection, the rates of 'not ready' monitors were:

- Evaporative monitor 5.2%;
- Catalyst monitor 3.7%;
- Oxygen sensor monitor 0.7%;
- EGR monitor 0.7%
- Oxygen sensor heater monitor 0.6%

The rates for the evaporative and catalyst monitors are of the same order of magnitude as the five percent of vehicles that fail the OBD I/M inspection. Therefore, it is important to know the extent to which these unset monitors on passing vehicles reflect underlying faults as opposed to benign system resets.

Figure 6-7 OBD Initial OBD I/M Monitors Not Ready



The next sections examine the differences in on-road emissions by monitor status for the five system monitors most commonly not ready.

6.2.2 Evaporative Monitors

Figure 6-8 shows the 'not ready' rates of the evaporative monitor in passing and failing vehicles by model year. Note that 2001 and newer models were allowed only a single monitor not ready at the time of inspection. Older models were allowed two monitors not ready. Vehicles with more monitors not ready were rejected.

The 2007 models that failed inspection had a high rate of unset evaporative monitors. For very new vehicles it is not unusual for the evaporative monitor to be unset and this could have been the situation with vehicles purchased in late 2007 and tested in early 2008. If any of these models had another unset monitor they would be rejected from having the inspection. Aside from 2007 models, the not ready rates were not dramatically different for passing vehicles vs. failing vehicles. Rates were typically higher for older models. The lower rates observed for 1996 and 1997 models compared to 1998 are likely the result of the phase-in of evaporative system monitors. Not all 1996 and 1997 models were equipped with an evaporative system monitor.

Figure 6-8 Evaporative System Monitors Not Ready

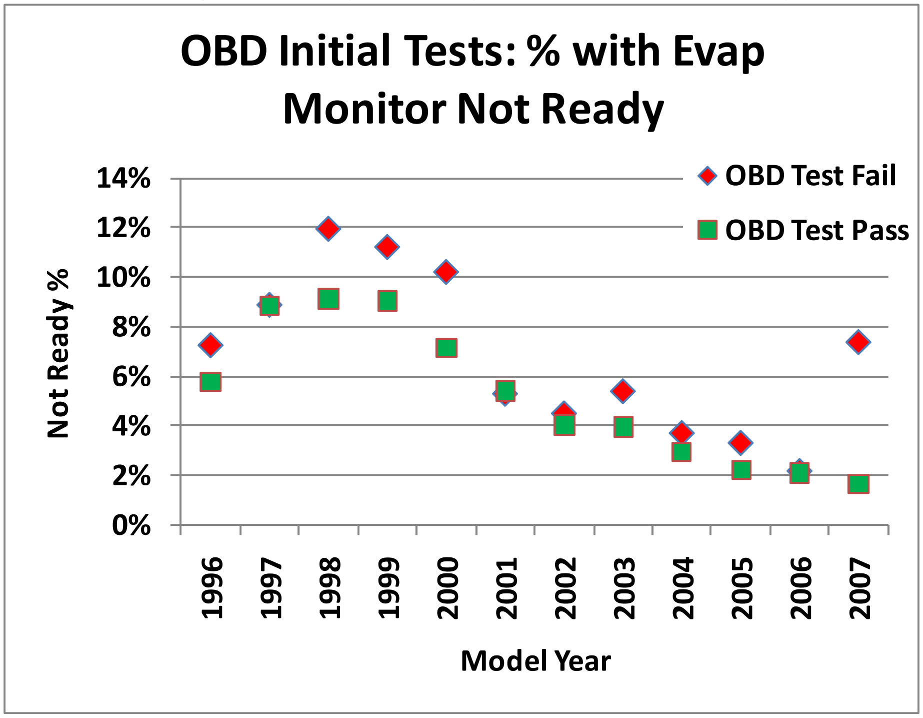


Figure 6-9 and Table 6-1 show the average on-road emissions of vehicles measured within 180 days before their initial inspection. The 5.2% of vehicles that passed inspection with evaporative monitors not ready had average HC emissions of 16ppm vs. 6ppm for vehicles that were ready and NO emissions of 206 ppm vs. 83 ppm. Further investigation is required to understand the causes of these emissions differences. They may be due in part because older models tend to have higher emissions and older models also had a higher incidence of evaporative monitors not ready. But, the reason for the evaporative monitors not being ready could be system resets related to OBD warnings about other components. Some of the higher HC emissions could be due to evaporative system leaks.

Another 5% of passing vehicles reported the evaporative monitor as unsupported. These are probably 1996 to 1998 models on which the evaporative monitor had not been phased in. This would also account, in part, for their even higher average HC and NO emissions of 25 ppm and 304 ppm respectively.

Vehicles that failed the OBD inspection with unsupported evaporative monitors and evaporative monitors not ready had the highest average HC emissions before the test.

Figure 6-10 and Table 6-2 show the average on-road emissions of vehicles measured within 180 days after their initial inspection. These are not the same individual vehicles as those measured before their OBD test but the two groups of vehicles are expected to behave similarly. The probability of on-road measurement before or after the OBD inspection was independent of OBD status.

Figure 6-9 On-road Emissions by Evaporative Monitor Status before OBD Test

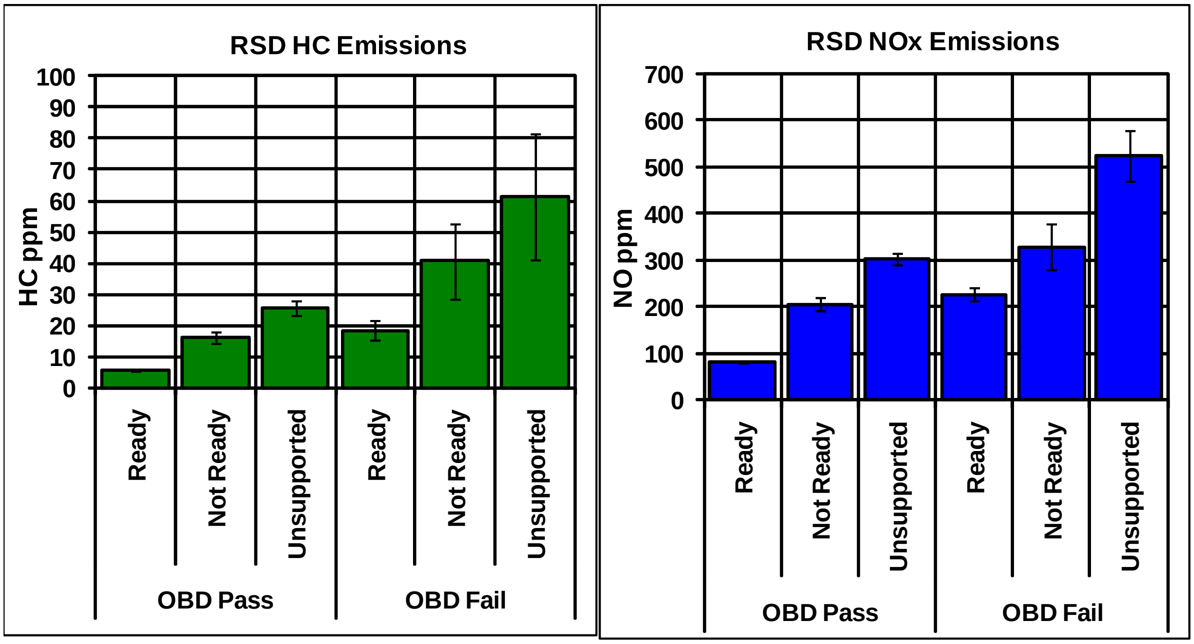
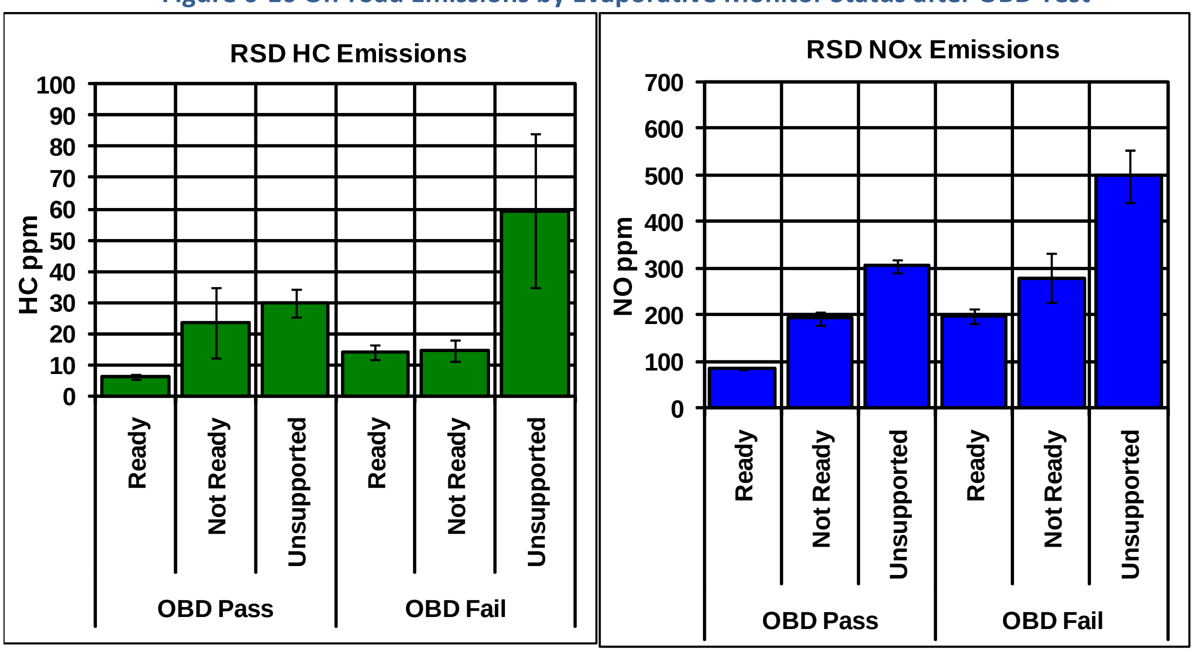


Figure 6-10 On-road Emissions by Evaporative Monitor Status after OBD Test



Vehicles that failed their OBD test had lower average HC and NO emissions when observed after the test than when observed before the test. The largest reductions were in the HC emissions of vehicles that failed the test with their evaporative monitor not ready. This indicates repairs reduced emissions from vehicles that failed their initial test. The exception was vehicles for which the evaporative monitor was reported as unsupported.

For vehicles that passed their initial OBD test with the evaporative monitor not ready, the on-road emissions of those measured before the test were similar to the emissions of those measured after the test. This suggests few or no repairs took place for these vehicles as part of the test cycle. Passing vehicles with the evaporative monitor not ready had higher emissions whether observed before or after the test. The after inspection HC emissions of these vehicles were higher than the after inspection emissions of vehicles that failed the test with the

evaporative monitor not ready. This strongly suggests that some of the vehicle passing inspection with their evaporative monitor not ready had faults and would have benefited from repairs.

Table 6-1 On-road Emissions by Evaporative Monitor Status before the OBD Test

RSD Emissions within 180 days before OBD I/M Test						
Evap Monitor						
Test Result	**Evap Monitor**	**N**	**HC ppm**	**CO %**	**NO ppm**	**VSP**
OBD Pass	Ready	70,065	6	0.06	83	12.5
	Not Ready	3,872	16	0.15	206	12.0
	Unsupported	4,281	25	0.19	304	11.9
OBD Fail	Ready	3,653	18	0.18	226	12.3
	Not Ready	371	41	0.29	329	12.2
	Unsupported	430	61	0.37	524	11.7
Overall		**82,672**	**8**	**0.08**	**110**	**12.4**

Table 6-2 On-road Emissions by Evaporative Monitor Status after the OBD Test

RSD Emissions within 180 days after OBD I/M Test						
Evap Monitor						
Test Result	**Evap Monitor**	**N**	**HC ppm**	**CO %**	**NO ppm**	**VSP**
OBD Pass	Ready	58,682	6	0.06	86	12.4
	Not Ready	3,452	24	0.14	193	12.1
	Unsupported	3,820	30	0.20	305	12.0
OBD Fail	Ready	2,889	14	0.14	197	12.2
	Not Ready	289	15	0.22	279	11.9
	Unsupported	370	59	0.36	498	11.9
Overall		**69,502**	**9**	**0.08**	**111**	**12.4**

6.2.3 Catalyst Monitor

Figure 6-11 shows the not ready rates of the catalyst monitor in passing and failing vehicles by model year. As with the evaporative monitor, a high proportion of older models passing inspection had the catalyst monitor not ready. In this case the highest rates occurred in 1996 and 1997 models.

The high rates of catalyst monitors not being ready is cause for concern because the catalyst monitor is relatively easier to set than the evaporative monitor and because of the importance of the catalyst in reducing vehicle emissions. A catalyst monitor not ready without the MIL commanded on indicates either a recent reset of the OBD system or a pending fault condition.

Figure 6-12 and Table 6-3 show the average on-road emissions of vehicles measured within 180 days before their initial inspection. The 3.7% of vehicles that passed inspection with catalyst

monitors not ready had average HC emissions of 27ppm vs. 7ppm for vehicles that were ready and NO emissions of 350 ppm vs. 93 ppm.

A number of vehicle tests reported the catalyst monitor as unsupported. This number was small, however, compared to the number of tests reporting the catalyst monitor not ready.

Figure 6-13 and Table 6-4 show the average on-road emissions of vehicles measured within 180 days after their initial inspection. As in the case of the evaporative monitor:

- Vehicles with the catalyst monitor not ready had higher emission;
- For vehicles that failed inspection, emissions were lower after the OBD inspection than before inspection;
- For vehicles that passed inspection, emissions after inspection were similar to the emissions before inspection.

The number of vehicles passing the test without the catalyst monitor being ready (3.7%) is a large fraction in relation to the 5% of vehicles that failed the test. The unknown catalyst status of so many vehicles represents a potentially large gap in program effectiveness.

Figure 6-11 Catalyst Monitors Not Ready

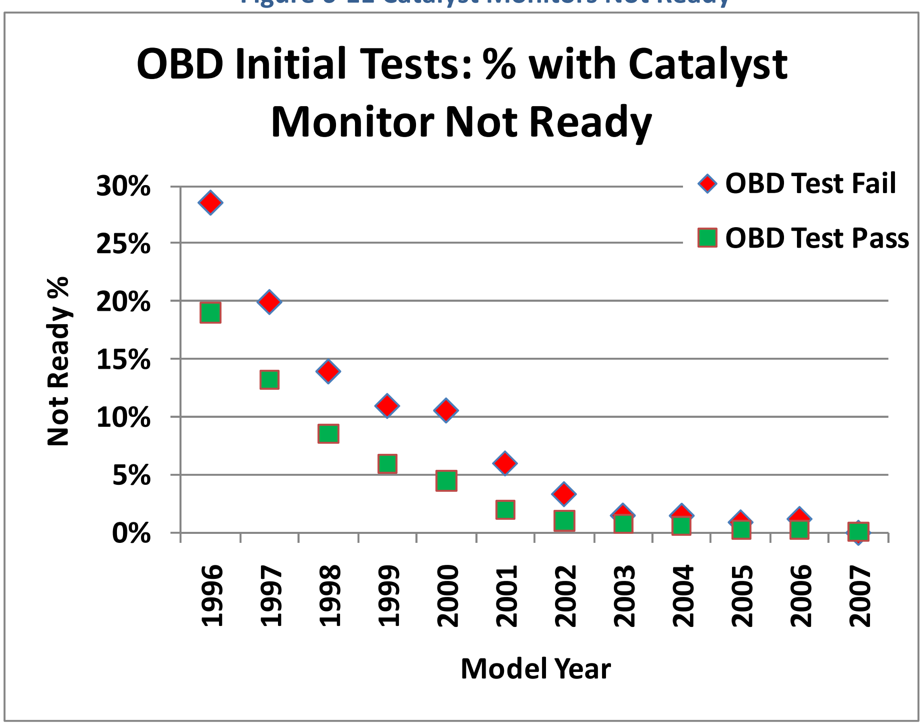


Figure 6-12 On-road Emissions by Catalyst Monitor Status before OBD Test

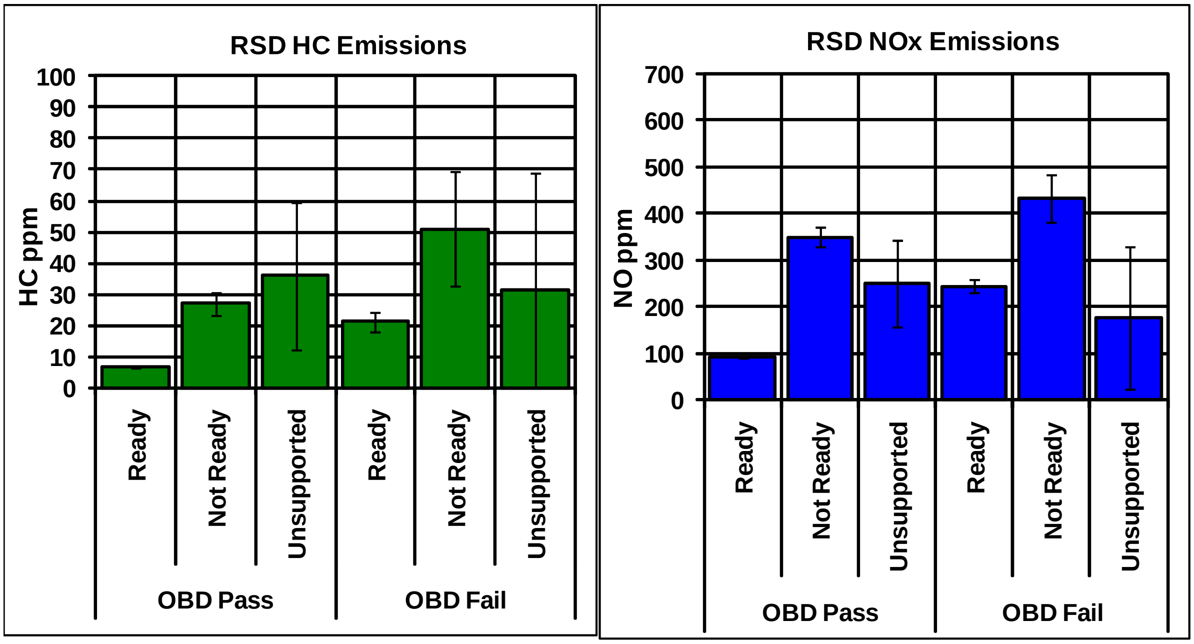


Figure 6-13 On-road Emissions by Catalyst Monitor Status after OBD Test

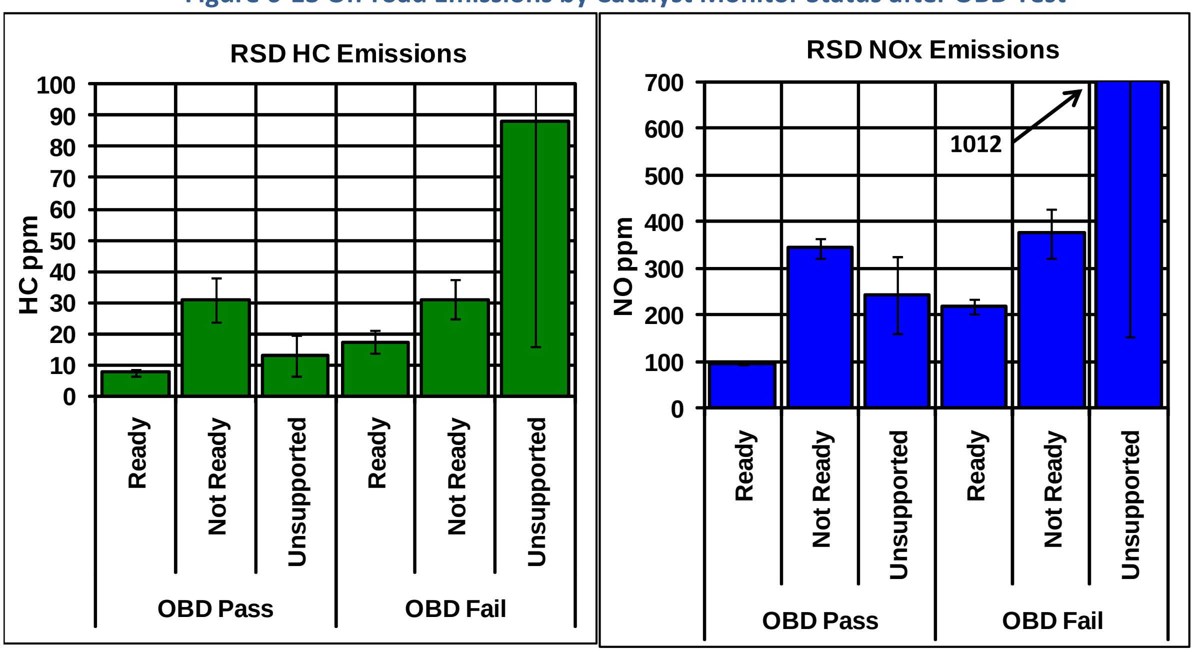


Table 6-3 On-road Emissions by Catalyst Monitor Status before OBD Test

RSD Emissions within 180 days before OBD I/M Test						
Catalyst Monitor Status						
Test Result	**Catalyst Mon**	**N**	**HC ppm**	**CO %**	**NO ppm**	**VSP**
OBD Pass	Ready	75,712	7	0.07	93	12.4
	Not Ready	2,394	27	0.24	350	12.2
	Unsupported	112	36	0.21	251	12.6
OBD Fail	Ready	3,981	21	0.19	244	12.2
	Not Ready	463	51	0.34	434	12.5
	Unsupported	10	32	0.06	177	8.9
Overall		**82,672**	**8**	**0.08**	**110**	**12.4**

Table 6-4 On-road Emissions by Catalyst Monitor Status after OBD Test

RSD Emissions within 180 days after OBD I/M Test						
Catalyst Monitor Status						
Test Result	**Catalyst Mon**	**N**	**HC ppm**	**CO %**	**NO ppm**	**VSP**
OBD Pass	Ready	63,684	8	0.07	96	12.4
	Not Ready	2,168	31	0.22	344	12.2
	Unsupported	102	13	0.08	243	13.0
OBD Fail	Ready	3,189	17	0.16	219	12.2
	Not Ready	354	31	0.23	375	12.1
	Unsupported	5	88	0.38	1012	9.9
Overall		**69,502**	**9**	**0.08**	**111**	**12.4**

6.2.4 Oxygen and Oxygen Sensor Heater Monitors

Figures 6-14 and 6-15 show the rates of vehicles with the oxygen sensor and oxygen sensor heater monitors not ready. As in previous sections, Figure 6-16 to 6-20 and Tables 6-5 to 6-8 show on-road emissions before and after the OBD test.

Vehicles that had monitors not ready had higher HC and higher NO emissions than ready vehicles both before and after the test. There were small differences in before and after emissions for passing vehicles. Emissions of HC and NO were generally lower after the test for failing vehicles.

Figure 6-14 Oxygen Sensor Monitors Not Ready

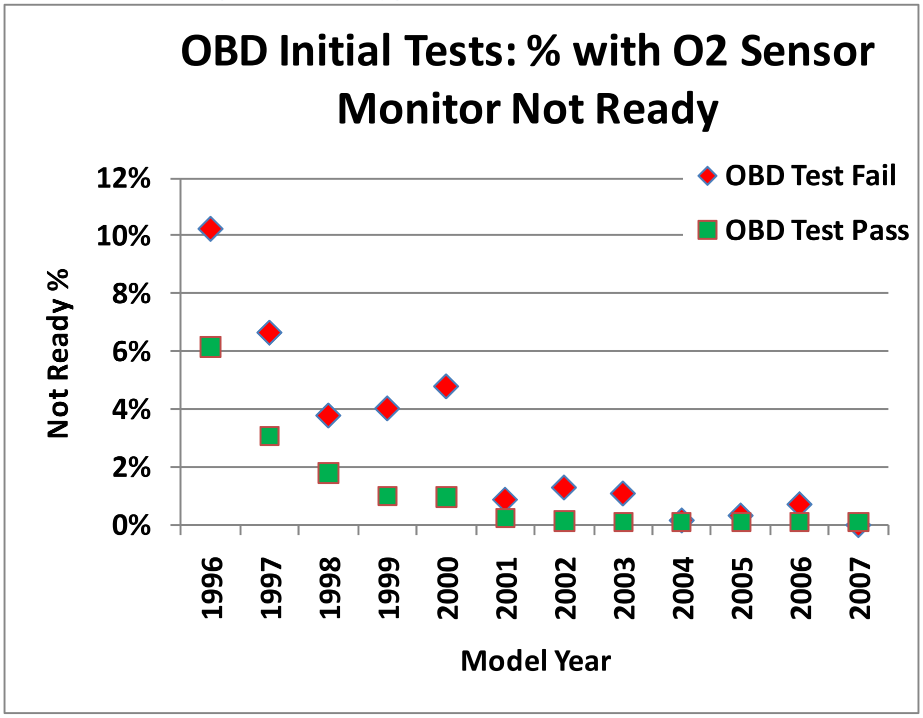


Figure 6-15 Oxygen Sensor Heater Monitors Not Ready

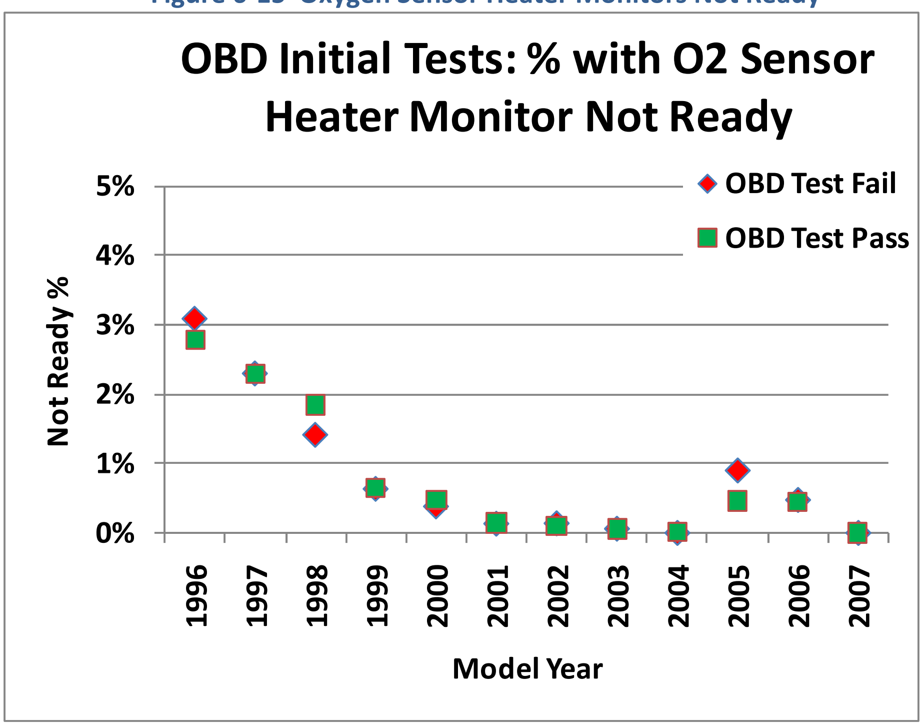


Figure 6-16 On-road Emissions by Oxygen Sensor Monitor Status before OBD Test

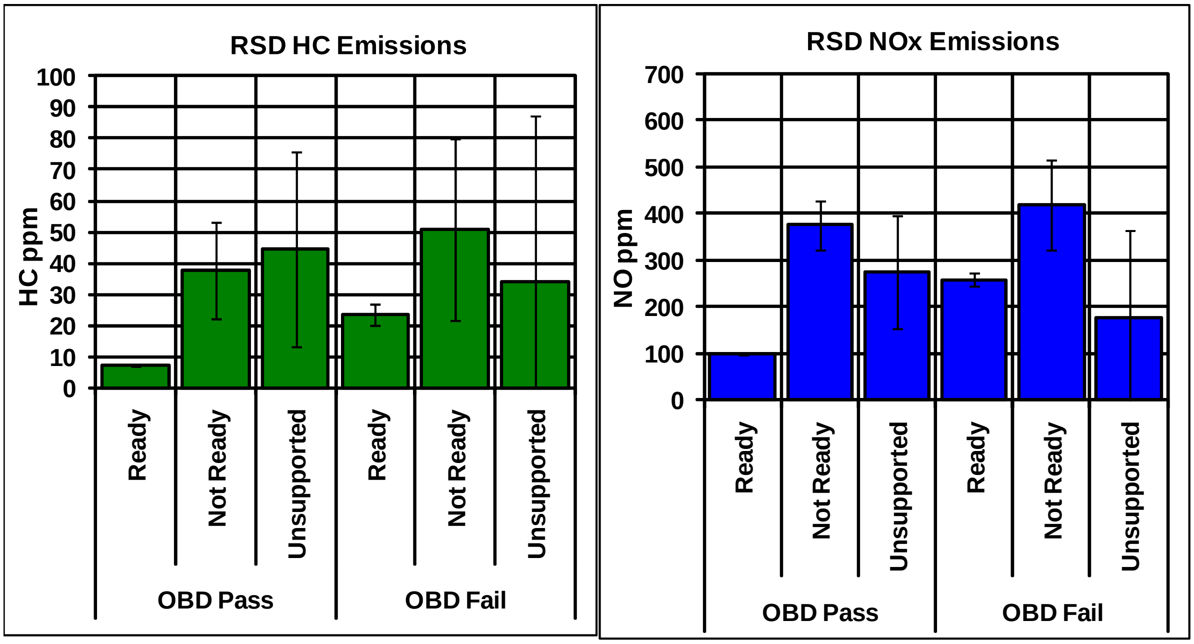


Figure 6-17 On-road Emissions by Oxygen Sensor Monitor Status after OBD Test

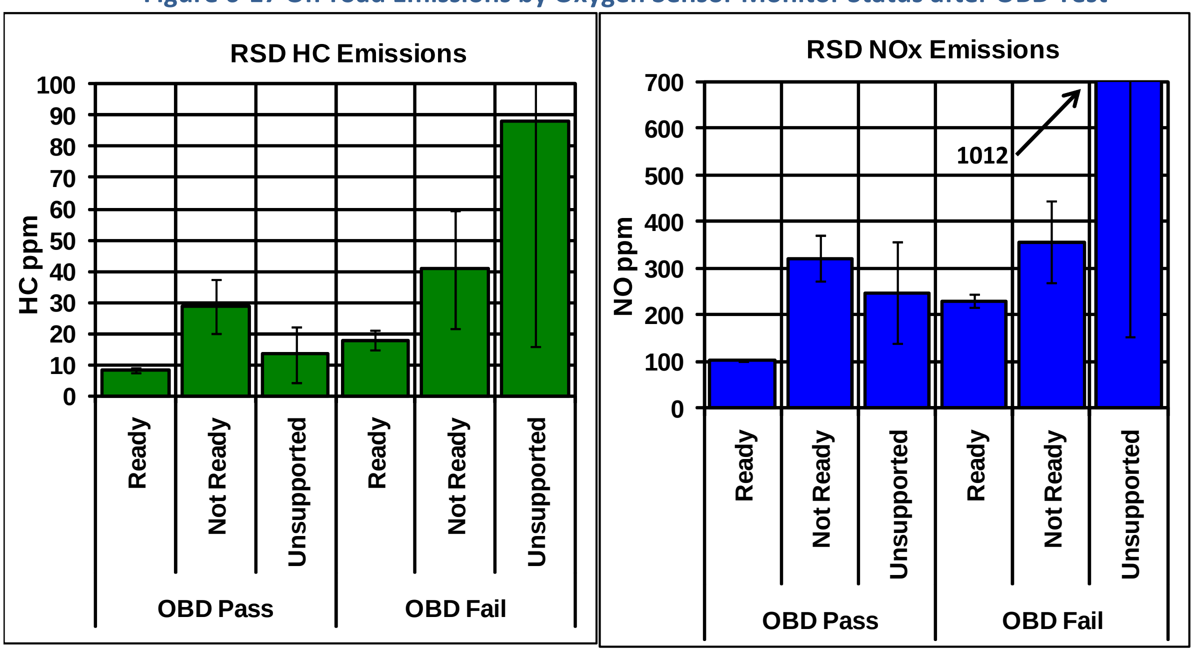


Table 6-5 On-road Emissions by Oxygen Sensor Monitor Status before OBD Test

RSD Emissions within 180 days before OBD I/M Test						
Oxygen Sensor Monitor						
Test Result	O2 Sensor	N	HC ppm	CO %	NO ppm	VSP
OBD Pass	Ready	77,725	7	0.07	99	12.4
	Not Ready	409	38	0.28	375	12.2
	Unsupported	84	45	0.27	276	12.0
OBD Fail	Ready	4,288	23	0.20	258	12.2
	Not Ready	159	51	0.41	419	12.5
	Unsupported	7	34	0.03	177	8.0
Overall		**82,672**	**8**	**0.08**	**110**	**12.4**

Table 6-6 On-road Emissions by Oxygen Sensor Monitor Status after OBD Test

RSD Emissions within 180 days after OBD I/M Test						
Oxygen Sensor Monitor						
Test Result	O2 Sensor	N	HC ppm	CO %	NO ppm	VSP
OBD Pass	Ready	65,467	8	0.07	103	12.4
	Not Ready	421	29	0.27	322	12.5
	Unsupported	66	13	0.07	247	12.6
OBD Fail	Ready	3,414	18	0.16	230	12.2
	Not Ready	129	41	0.42	357	12.3
	Unsupported	5	88	0.38	1012	9.9
Overall		**69,502**	**9**	**0.08**	**111**	**12.4**

Figure 6-18 On-road Emissions by Oxygen Sensor Heater Monitor Status before OBD Test

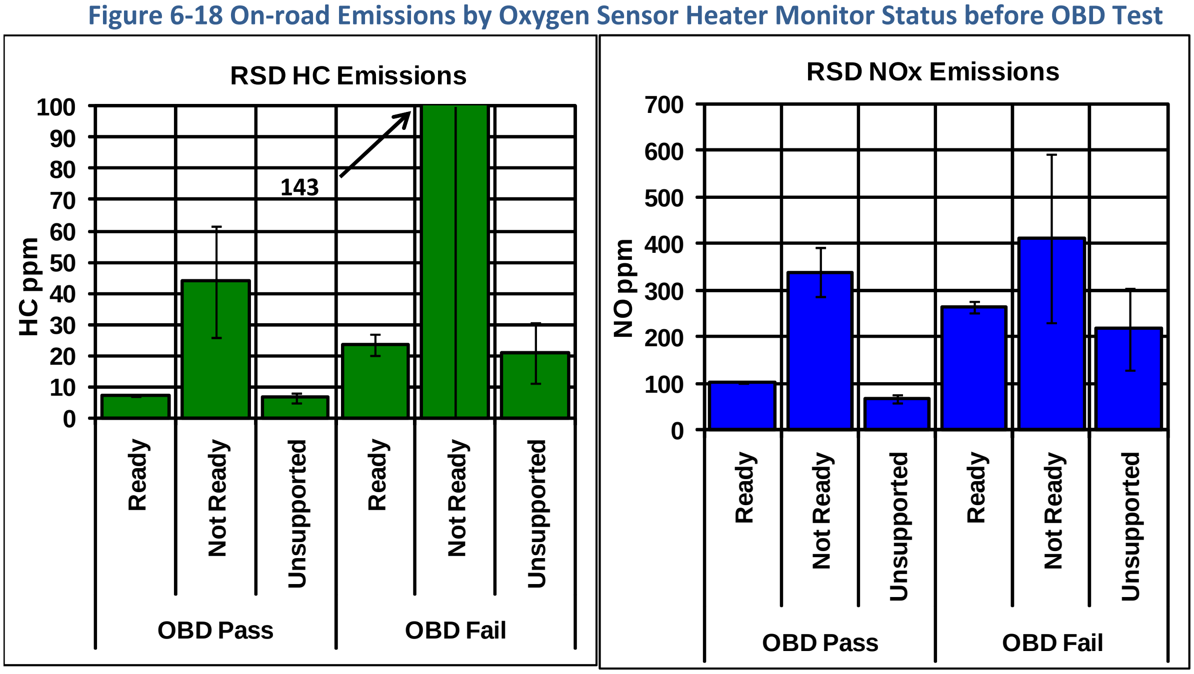


Figure 6-19 On-road Emissions by Oxygen Sensor Heater Monitor Status after OBD Test

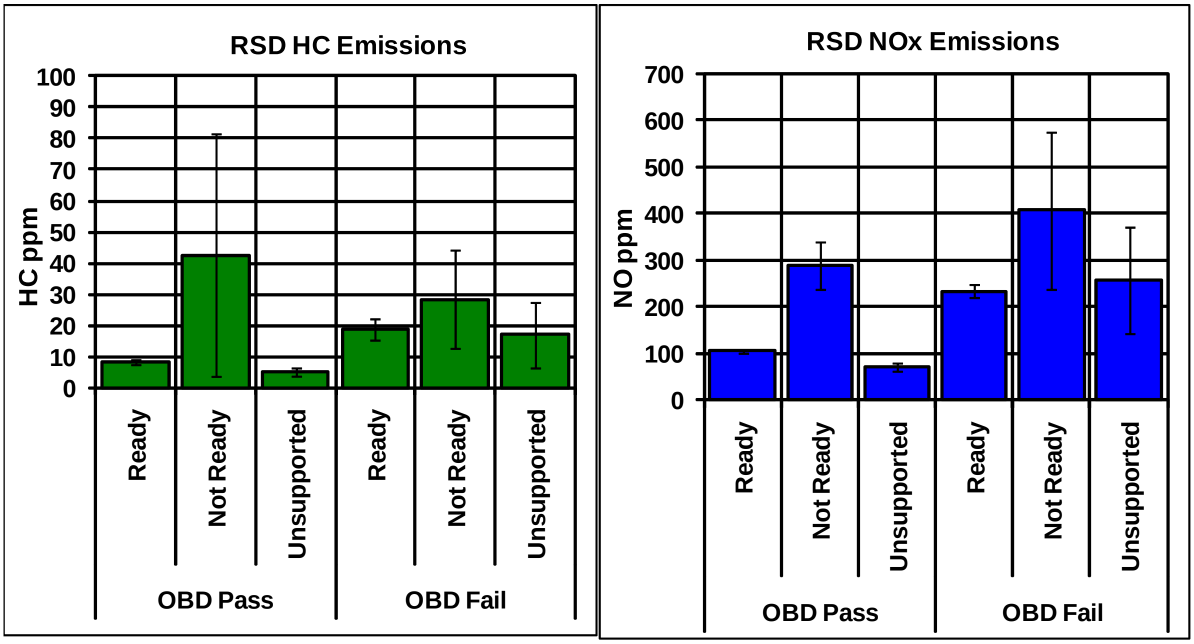


Table 6-7 On-road Emissions by Oxygen Sensor Heater Monitor Status before OBD

RSD Emissions within 180 days before OBD I/M Test						
Oxygen Sensor Heater Monitor						
Test Result	**O2 Sensor Htr**	**N**	**HC ppm**	**CO %**	**NO ppm**	**VSP**
OBD Pass	Ready	75,231	7	0.07	101	12.4
	Not Ready	327	44	0.18	339	12.1
	Unsupported	2,660	7	0.05	69	12.6
OBD Fail	Ready	4,324	24	0.20	264	12.2
	Not Ready	30	143	0.38	412	10.5
	Unsupported	100	21	0.19	217	12.1
Overall		**82,672**	**8**	**0.08**	**110**	**12.4**

Table 6-8 On-road Emissions by Oxygen Sensor Heater Monitor Status after OBD

RSD Emissions within 180 days after OBD I/M Test						
Oxygen Sensor Heater Monitor						
Test Result	**O2 Sensor Htr**	**N**	**HC ppm**	**CO %**	**NO ppm**	**VSP**
OBD Pass	Ready	63,588	8	0.08	105	12.4
	Not Ready	304	43	0.14	289	12.2
	Unsupported	2,062	5	0.05	70	12.4
OBD Fail	Ready	3,446	19	0.17	233	12.2
	Not Ready	28	28	0.17	407	11.4
	Unsupported	74	17	0.12	257	12.0
Overall		**69,502**	**9**	**0.08**	**111**	**12.4**

6.2.5 EGR Monitors

Figures 6-20 shows the rates of vehicles with the EGR monitor not ready. As in previous sections, Figures 6-21 and 6-22 and Tables 6-9 and 6-10 show on-road emissions before and after the OBD test. About half of the tests reported the EGR monitor as being unsupported and the numbers of tests reporting EGR as unsupported among failing tests were also significant.

The smaller number of EGR monitors not ready results in greater uncertainty in the average emissions values. Vehicles with EGR monitor not ready had higher emissions especially of NO. There were some HC and NO reductions among vehicles that failed OBD. For the few failing vehicles with EGR not ready, HC appears to have decreased while NOx increased. These results were not statistically significant. Additional data are required.

Figure 6-20 EGR Monitors Not Ready

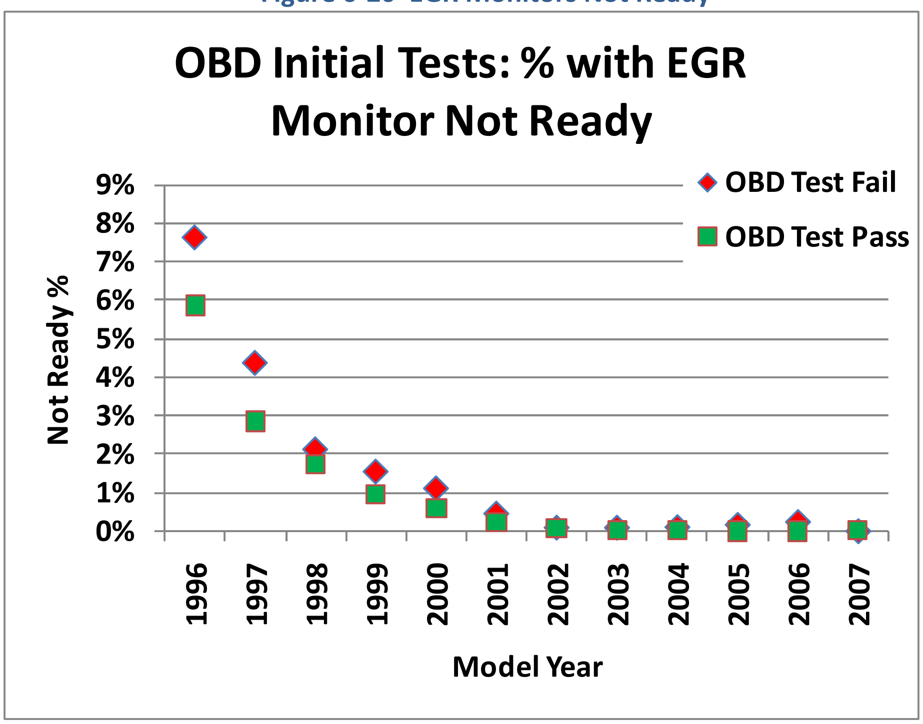


Figure 6-21 On-road Emissions by EGR Monitor Status before OBD Test

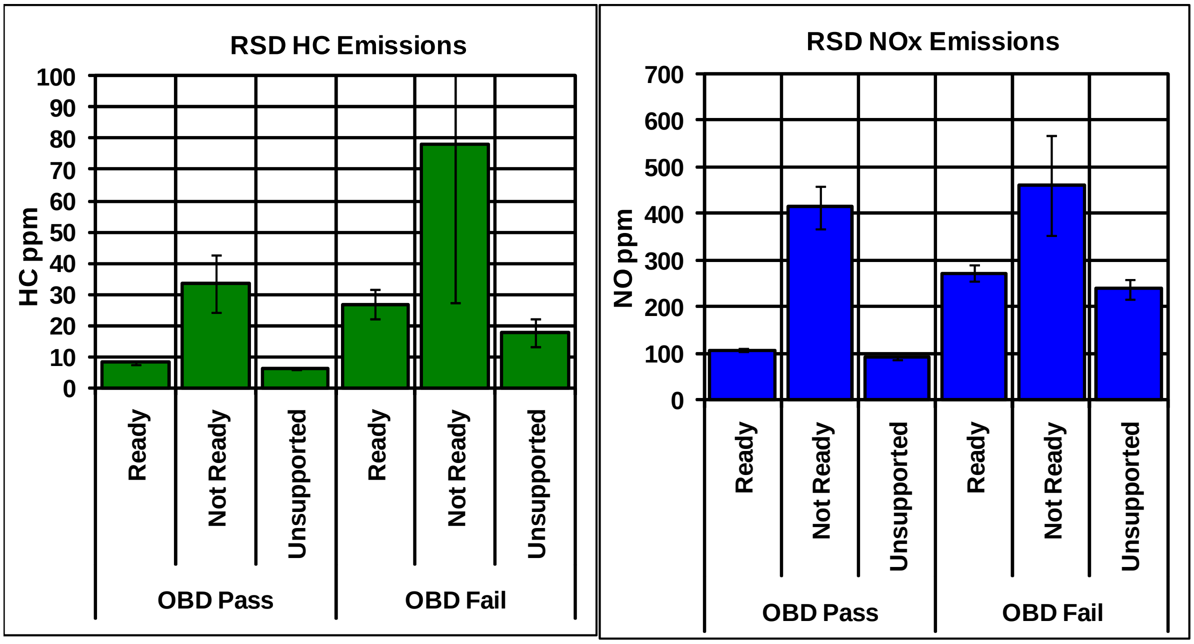


Figure 6-22 On-road Emissions by EGR Monitor Status after OBD Test

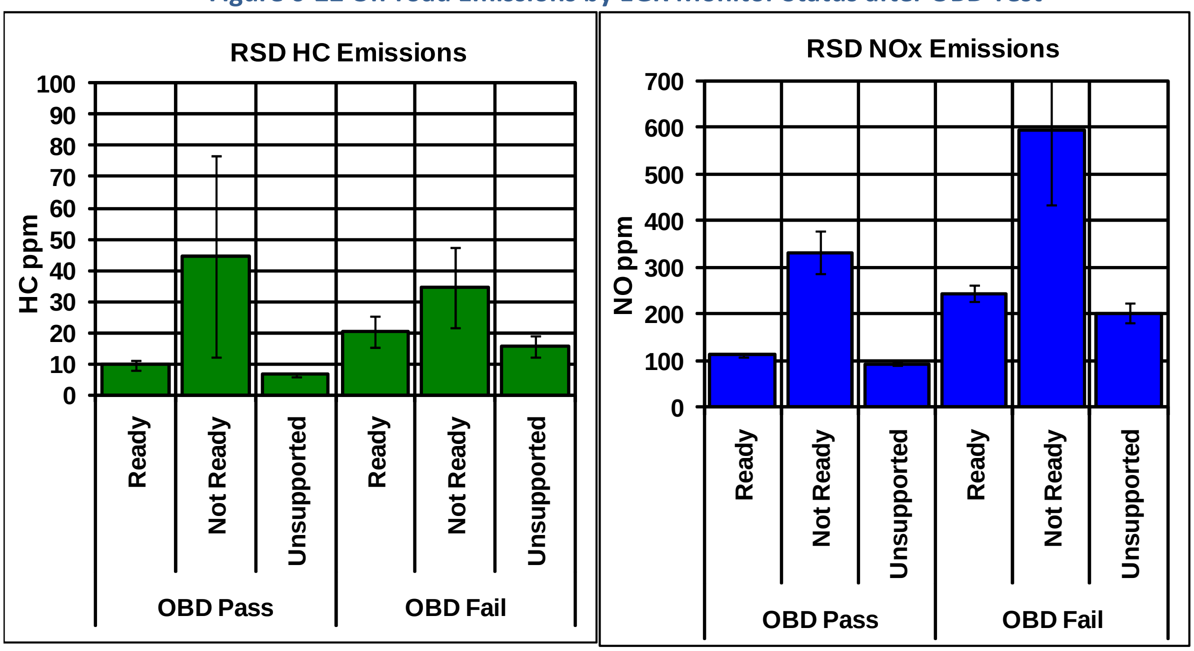


Table 6-9 On-road Emissions by EGR Monitor Status before OBD

RSD Emissions within 180 days before OBD I/M Test						
EGR Monitor						
Test Result	**EGR Monitor**	**N**	**HC ppm**	**CO %**	**NO ppm**	**VSP**
OBD Pass	Ready	39,801	8	0.07	108	12.3
	Not Ready	464	33	0.22	414	11.7
	Unsupported	37,953	6	0.07	90	12.5
OBD Fail	Ready	2,706	27	0.20	273	12.1
	Not Ready	87	78	0.45	461	11.8
	Unsupported	1,661	18	0.21	238	12.3
Overall		**82,672**	**8**	**0.08**	**110**	**12.4**

Table 6-10 On-road Emissions by EGR Monitor Status after OBD

RSD Emissions within 180 days after OBD I/M Test						
EGR Monitor						
Test Result	**EGR Monitor**	**N**	**HC ppm**	**CO %**	**NO ppm**	**VSP**
OBD Pass	Ready	33,862	10	0.08	112	12.3
	Not Ready	378	45	0.22	331	11.8
	Unsupported	31,714	6	0.07	93	12.5
OBD Fail	Ready	2,092	20	0.16	244	11.9
	Not Ready	77	35	0.21	594	11.7
	Unsupported	1,379	16	0.18	202	12.5
Overall		**69,502**	**9**	**0.08**	**111**	**12.4**