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# The Indiana Enhanced I/M Program
# 0.5% On Road Testing 2009

Prepared for:

## Indiana Department of Environmental Management

December 2011

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# Acknowledgements

The author wishes to acknowledge the support and input given by a number of individuals and organizations. Particular thanks are extended to the following contributors:

The Indiana Department of Environmental Management for funding and sponsoring this study and for their active support and contributions.

ESP Indiana Program Operations and the ESP Remote Sensing team.

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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 |
| BAR | California Bureau of Automotive Repair |
| BMV | Bureau of Motor Vehicles |
| CCM | Corner Cube Mirror |
| Clean Screening | The process of using RSD to identify vehicles with low emissions to exempt them from the required emission inspection at an inspection station |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| Cutpoint | An emissions level used to classify vehicles as having met an emissions inspection requirement |
| Decile | A group containing one-tenth of the entries in a value ordered set |
| Enhanced I/M | A set of more rigorous vehicle I/M Program inspection requirements defined by the U.S. EPA usually involving IM240 testing |
| ESP | Environmental Systems Products |
| Evaporative Emitters | Vehicles releasing gaseous or liquid hydrocarbons from the fuel tank or fuel system |
| Excess Emissions | Vehicle emissions exceeding an I/M cutpoint |
| FTP | Federal Test Procedure |
| g/mi | Grams per mile, the units of measurement for FTP and IM240 tests |
| GVWR | Gross Vehicle Weight Rating |
| HC | Hydrocarbons |
| HDDV | Heavy-duty diesel vehicle |
| High-Emitter Identification | The on-road identification of vehicles with high emission levels |
| I/M | Inspection and Maintenance Program |
| IDEM | Indiana Department of Environmental Management |

| | |
|---|---|
| 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 simulating real world driving conditions |
| IM93 Test | A loaded-mode transient tailpipe emission test conducted when the vehicle is driven through a 93-second cycle on a dynamometer up to three times. The 93 seconds are the same as the first 93 seconds of the IM240 test. |
| IR | Infrared; electromagnetic radiation with a wavelength longer than that of visible light |
| KW/t | Kilowatts per metric ton, the units of measurement for vehicle specific power |
| LDDV | Light-duty diesel vehicle |
| LDGV | Light-duty gasoline-powered vehicle |
| LDGT | Light-duty gasoline-powered truck |
| NO | Nitric oxide also known as nitrogen monoxide |
| $NO_2$ | Nitrogen dioxide |
| $NO_X$ | Oxides of nitrogen, usually measured as nitric oxide (NO) |
| OBDII | On Board Diagnostic system to detect emissions related problems required on all 1996 and newer light–duty vehicles |
| OREMS | On-Road Emissions Monitoring System, a protocol and associated performance standards for remote sensing vehicle emissions testing developed by the California BAR since 1995 |
| Positive Power | An operating mode where the engine is generating power to drive the wheels |
| Repairable Emissions | The emission reductions 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 |
| SDM | Source Detector Module, an RSD component that measures emissions |
| Tag Edit | The transcription of vehicle license plates or tags from images to text |
| TSI | Two-Speed Idle test |
| U.S. EPA | United States Environmental Protection Agency |

| | |
|---|---|
| UV | Ultraviolet; electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays |
| UV Smoke | An RSD measurement of particulate matter using UV light |
| VIN | Vehicle Identification Number |
| VMT | Vehicle Miles Traveled |
| VSP | Vehicle Specific Power; estimated engine power divided by the mass of the vehicle |
| VTR | Vehicle Test Record |

# 1 SUMMARY

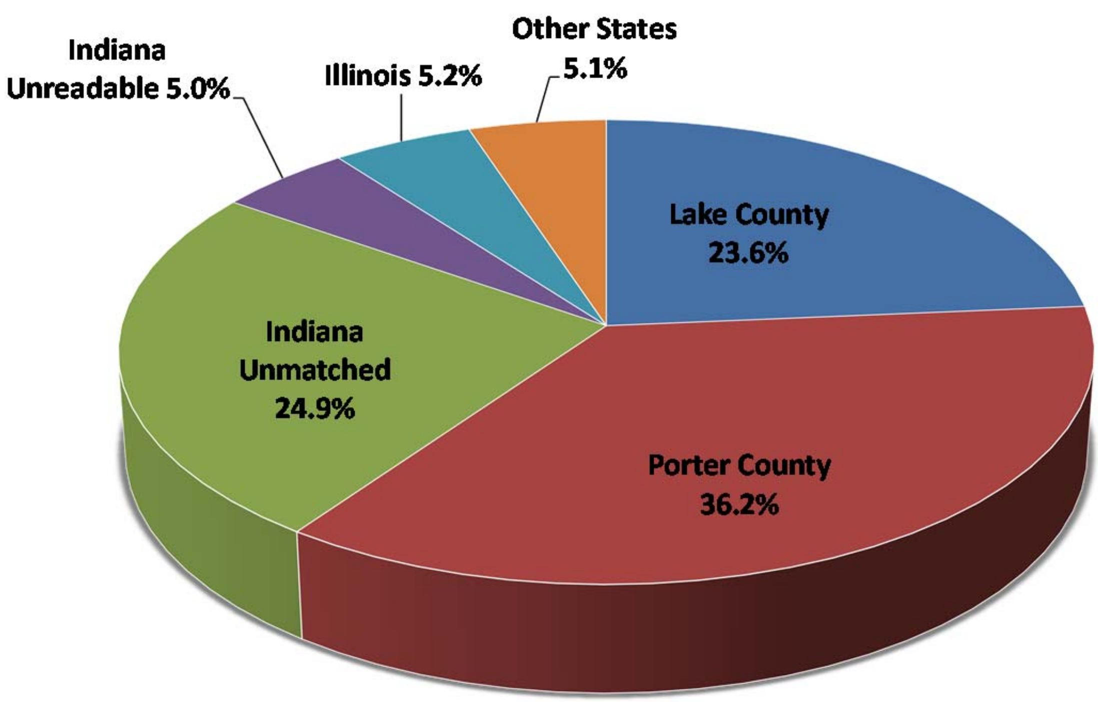
The Northern Indiana Inspection and Maintenance (I/M) Program contract between the Indiana Department of Environmental Management (IDEM) and Environmental Systems Products Inc. (ESP) requires on-road testing of 1% of the subject vehicles every two years. This report covers on-road testing performed in 2009 in the Northern Indiana I/M area comprising Lake and and Porter counties. A remote sensing device (RSD) was used at roadside locations to measure emissions of passing vehicles and capture images of the vehicle plates. The vehicle plates were matched to registration records to obtain information about the type, age and weight class of the vehicle measured.

ESP collected 31,844 valid on-road vehicle emissions measurements from eight roadside locations from April through August 2009. License plates were decoded for 27,931 of the vehicles measured and 16,709 of these were matched to vehicle registrations in Lake and Porter County.

<u>**Survey Results**</u>

The chart below shows the registered jurisdiction of the vehicles measured in the nonattainment region. Of the 27,931 vehicles measured with readable plates, 59.8% were registered in the two counties, 24.9% were Indiana plates not identified as registered in Lake and Porter counties and 15.3% were from other states.

***Figure 1-1: Registration Jurisdictions of Vehicles Measured in Lake and Porter Counties***



**On-road Vehicle Emissions**

The average emissions of vehicles registered in the jurisdictions are shown in Table 1-1. Average emission rates of all vehicles measured on-road in the two counties, regardless of where they were registered, were 0.11 % carbon monoxide (CO) 16 ppm hydrocarbon (HC) hexane and 174 ppm oxides of nitrogen (NOx).

Vehicles identified as registered in Lake and Porter counties had lower emissions than other Indiana plates. Emissions of vehicles from other states were mostly within the range of those registered in Lake and Porter counties. The age and type of the vehicles traveling from other states is unknown.

**Table 1-1 Fleet Emissions by Registered I/M Area**

| Jurisdiction | N | CO | HC | NOx | Smoke | VSP |
|---|---|---|---|---|---|---|
| Lake County | 6,602 | 0.11 | 17 | 166 | 0.013 | 13.2 |
| Porter County | 10,107 | 0.09 | 10 | 145 | 0.014 | 14.7 |
| Indiana Unmatched | 6,952 | 0.16 | 25 | 228 | 0.021 | 14.1 |
| Indiana Unreadable | 1,394 | 0.10 | 13 | 172 | 0.013 | 14.0 |
| Illinois | 1,454 | 0.12 | 16 | 172 | 0.016 | 13.6 |
| Other States | 1,420 | 0.11 | 15 | 161 | 0.016 | 14.3 |
| Total | 27,929 | 0.11 | 16 | 174 | 0.016 | 14.1 |

Figure 1-2 shows average emissions by age for passenger vehicles and light-duty trucks. Vertical lines with bars indicate 95% confidence intervals of the average values. RSD UV Smoke is a measurement of particulate emissions (PM). For diesel smoke, an RSD UV smoke value of one corresponds to one gram of particulate per 100 grams of combusted fuel. For gasoline vehicles the relationship between the RSD UV smoke value and particulate mass is less well defined and depends on the type of smoke, e.g. black carbon smoke, blue oil smoke or white coolant smoke, and is the subject of ongoing research.

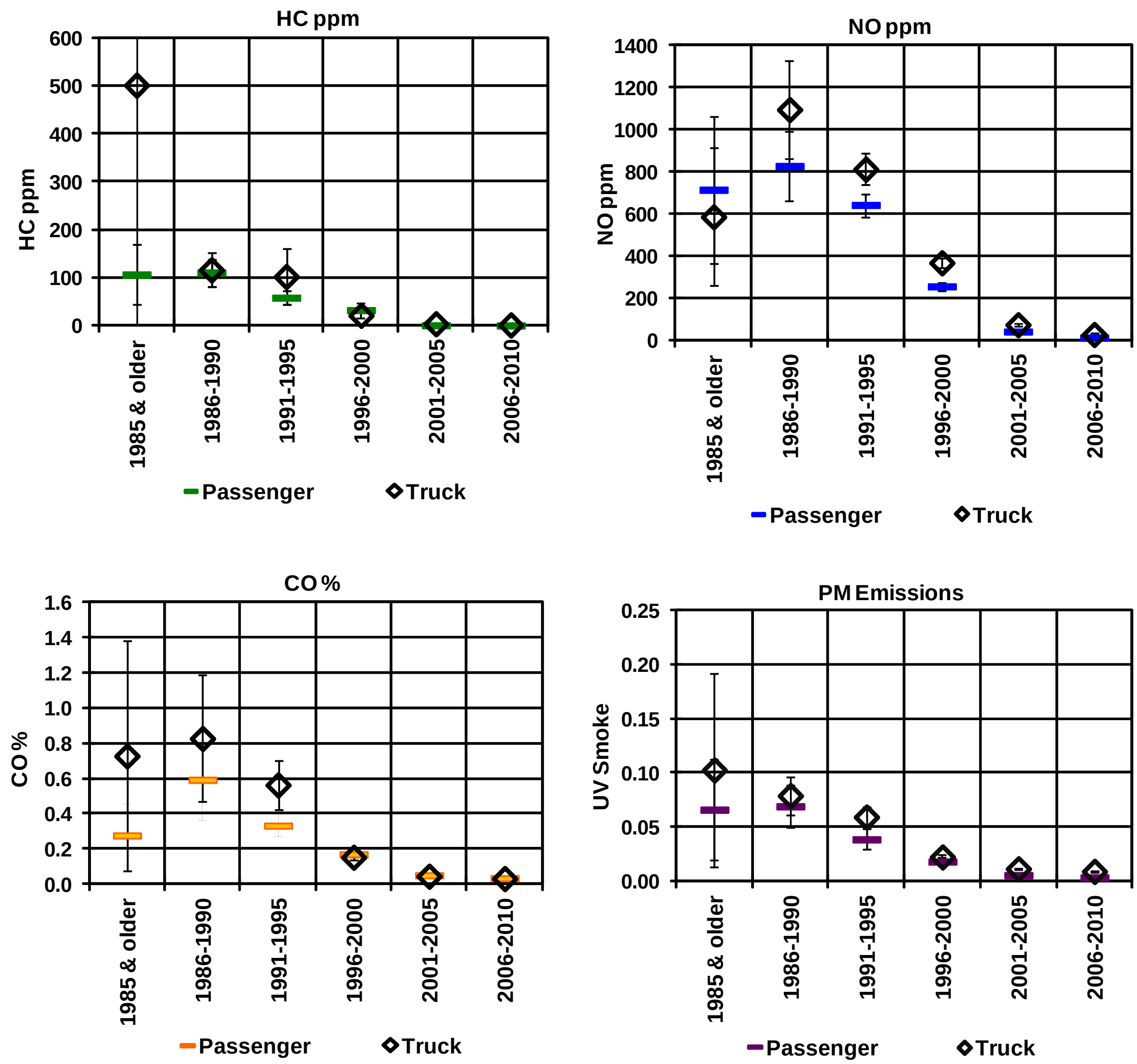
Emissions of 1996 and newer models are much lower than those of older models. The vast majority of 2001 and newer models had very low emissions. Older model trucks had higher average emissions than passenger vehicles of all pollutants. Light-duty trucks also have lower fuel economy and greater exhaust volume resulting in a larger mass of emissions.

**Compliance with the I/M Program**

Inspection records from January 2007 through December 2009 were examined to determine the last inspection for the vehicles measured on-road. Inspections were confirmed for 95.5% of 1981-2005 passenger models and 94.5% of trucks with a gross vehicle weight rating (GVWR) of up to 6000 lbs.

Confirmed inspection rates were higher for odd model year vehicles than for even model year vehicles. It is possible that more even model-year vehicles were inspected than were confirmed and that the overall compliance rate is higher than 95%.

*Figure 1-2: Emissions by Vehicle Type and Model Year*




## High-Emitters

Gasoline powered vehicles had a highly skewed emissions distribution with a small percentage of high-emitters contributing a substantial portion of total light-duty vehicle emissions.

ESP identified high emitters using criteria used in similar on-road surveys conducted in Maryland. The criteria required at least two measurements to confirm a vehicle as being a high emitter. Sixty vehicles, 2.3% of vehicles with two or more measurements, exceeded the cutpoints on both of their last two measurements for the same pollutant. The sixty vehicles had average emissions that were 22 times higher for HC and 9 times higher for CO and NOx than the average emissions of all vehicles with two measurements.

Forty-five percent of high emitters were 1995 and older models and 42% were 1996-1999 models.

**Recommendations**

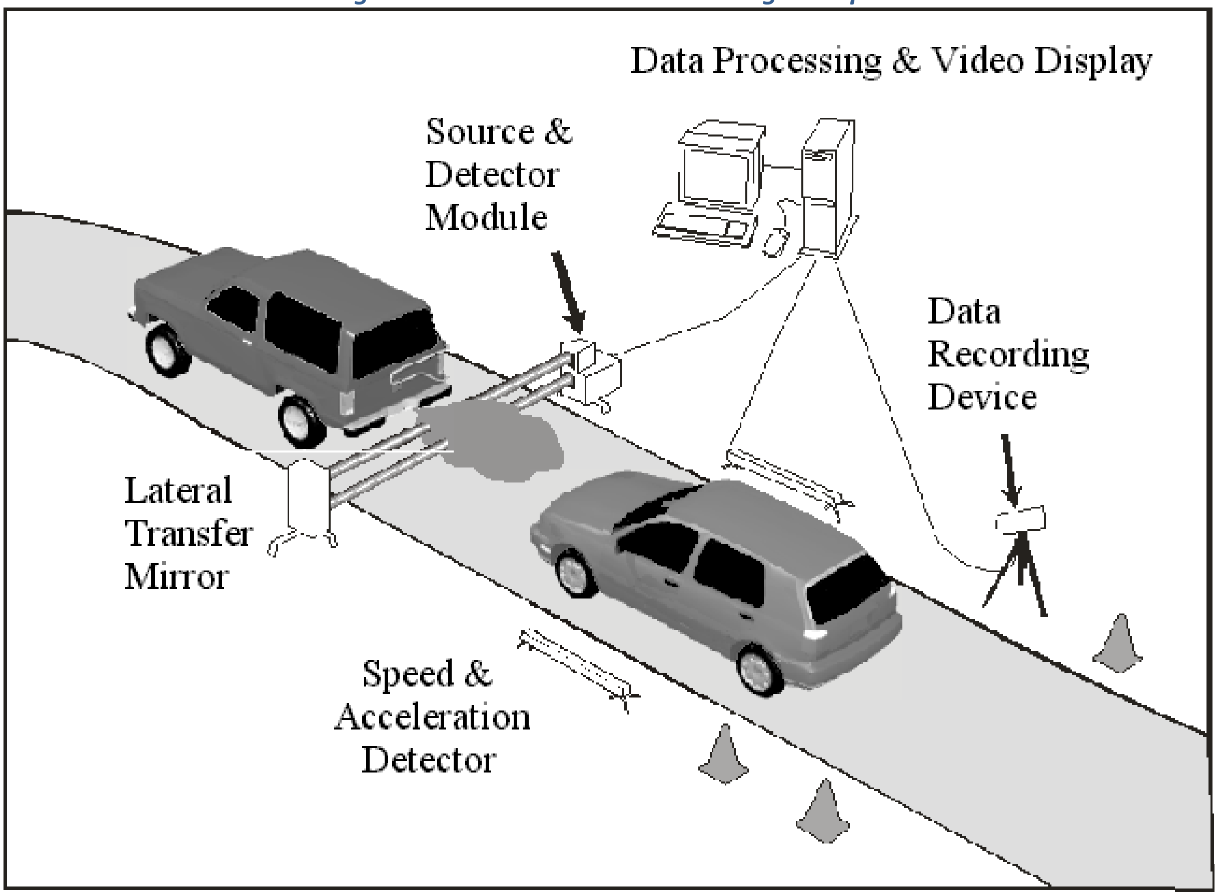
- A comprehensive on-road emissions measurement program could be a valuable supplement to the current I/M Program by:
    - Identifying on-road evaporative emitters, some of which will not be identified by OBD-II;
    - Identifying high-emitters not captured by the I/M Program, or failing between tests;
    - Monitoring on-road vehicles for compliance;
    - Providing feedback on the effectiveness of the Program and repairs;
    - Examining the impact of OBD-II readiness exemptions and other I/M Program design decisions and options, e.g. the inclusion or exclusion of additional models.
- Consider dual testing (IM93 and OBD-II) for 1996 to 1999 model year vehicles given the numbers of high-emitters for these models. California currently dual tests OBD-II models and will continue to dual test 1996-1999 models after legislation[1] to allow OBD-II only testing of 2000 and newer models becomes effective in 2013. The legislation also allows for dual-testing of 2000 and newer models with emission problems that may not be adequately detected by the vehicle's OBD-II system.
- Consider raising the GVWR limit on vehicles tested from 9000lbs to 10,000lbs or 14,000lbs. These heavier trucks have higher mass emissions and delivery trucks and shuttles have high vehicle miles traveled (VMT).
- Consider emissions testing for light-duty diesel powered vehicles. Light-duty diesel vehicles, although fewer in number, have particulate and NOx emissions that are many times higher than gasoline vehicle emissions.
- Consider implementing a clean screen pilot to reduce the I/M burden on owners of well maintained vehicles and develop a wealth of on-road measurements that provide better focus on high emitters.

# 2 EQUIPMENT AND SITES

## 2.1 Equipment Description

The remote sensing device (RSD) survey used the ESP's RSD4000 testing system. The RSD4000 detects vehicle emissions when a vehicle 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, $CO_2$, NO 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 complement 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 RSD4000 includes the following features:

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

## 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 (NO) 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, $CO_2$ and NO, 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 of the 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 $CO_2$ and NO, 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 Audits (drive-by audits)

Every month during the course of data collection, an audit truck was utilized to audit the RSD4000 systems.

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 shown below:

| | HC (ppm) | CO | $CO_2$ | NO (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 Overview of 0.5% Sample

### 2.3.1 Sample Design Criteria

The objective is to obtain the 0.5% sample from sites that will be generally representative of vehicles operating in the I/M program areas.

As shown in Figure 2-2: Site Locations, eight sites were used to collect RSD data. The intent was to collect tests on a random sample that is representative of all the on-road vehicle traffic. Measurements are distributed geographically with no one area receiving an undue amount of testing.

### 2.3.2 Description of Sample Site Characteristics

Site selection is critical to obtaining RSD measurements that are representative of vehicle operation. Recommended site attributes include:

- Absence of cold start vehicle operating conditions;
- Sites where vehicles will generally be accelerating or driving at a steady speed uphill to avoid the highly variable tailpipe emissions that can occur under deceleration;
- Absence of enrichment due to high load conditions;
- Single lane operation;
- High volume traffic;
- Unobtrusive citing of the remote sensing equipment;
- Stability in the traffic mix from one year to the next; and
- Adequate median space for safe operation of the RSD equipment

## 2.4 Sites selected for studies

Table 2-1 lists the site locations selected for the 0.5% sample. All the sites selected are on-ramps or exit loops that provide the required physical characteristics of an appropriate RSD site. Sites were pre-qualified for:

- Single lane operation with space for the RSD equipment to be deployed without disrupting traffic flow
- Geographically dispersed throughout the I/M area;

- A satisfactory percentage of valid readings; and
- An adequate traffic volume.

### 2.4.1 Sites Used

Table 2-1 shows the survey sites used and the number of days of on-road data collection.

Figure 2-2 displays the distribution of the sites.

Detailed descriptions of the sites with pictures and layouts are in Appendix A

**Table 2-1: Sites Used**

| Site Code | Location | City | County | Degrees of Grade | Valid RSD in Desired VSP Range |
|---|---|---|---|---|---|
| IN03 | 61st Ave West to I-65 North | Merrilville | Lake | 0.37 | 644 |
| IN05 | IN 2 to IN 49 South | Valparaiso | Porter | 0.57 | 7,396 |
| IN16 | US 30 to IN 49 North | Valparaiso | Porter | 0.20 | 5,922 |
| IN2-49N | IN 2 to IN 49 North | Valparaiso | Porter | 1.20 | 6,985 |
| IN30 | US 231 to I-65 North | Crown Point | Lake | 1.20 | 6,326 |
| IN6165 | E 61st Ave East to I-65 North | Hobart | Lake | 0.20 | 363 |
| INBURR | Burr St to I-80 / I-94 East | Gary | Lake | 0.23 | 3,951 |
| S61ST | E 61st Ave East to I-65 South | Merrilville | Lake | 0.60 | 257 |
| | | | | | 31,844 |

*Figure 2-2: Site Locations*

## 2.5 Data Screening

The RSD system applies checks to determine the validity of emissions measurements. These include determining if a sufficient exhaust plume was measured. The general criteria for an RSD system 'valid' measurement include:

- The system was active and calibrated;
- A valid exhaust gas measurement was recorded;
- A valid speed and acceleration was recorded; and
- A readable plate was recorded and transcribed.

Particular applications can require further screening. ESP applied the following additional screening checks to the RSD measurements to ensure the data used were representative of the vehicle emissions:

- Screening for Vehicle Specific Power (VSP) range; and
- Screening of hourly observations to check for cold starts.

The exhaust plume validations and the additional screening procedures are described in the following paragraphs.

### 2.5.1 Valid 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 $CO_2$ 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 $CO_2$ 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-duty 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

[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%.

Engine load is a function of the vehicle speed and acceleration, the slope of the site, vehicle mass, aerodynamic drag, rolling resistance, and transmission losses. The effects of these forces can be aggregated into a single parameter called VSP, which was the topic of a presentation at the Ninth Coordinating Research Council (CRC) On-road Vehicle Emissions Workshop[2.] The CRC E-23 Project[34] further developed the concept of vehicle specific power. In 2002, EPA adopted the use of VSP as a parameter for predicting vehicle emissions in the recently adopted Motor Vehicle Emissions Simulator (MOVES) emissions inventory model that replaces Mobile6[5].

Studies have found vehicle emissions to be 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. Therefore ESP requires that vehicle emission observations be made when VSP is positive and sites are selected to measure vehicles when they are typically operating with moderate engine load. For CO high-emitter identification, upper limits are placed on VSP depending on the model year.

### 2.5.3 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 (Table 2.3). The percent of vehicles up to 5 years old that exceed 150 ppm HC tend to be higher during periods of near freezing temperatures. All hours with twenty or more measurements had less than 5% of new models with emissions greater than 150 ppm HC. Table 2-4 shows that temperatures were never close to freezing. Temperatures also never exceeded $100^{o}$F, which can lead to high evaporative emissions.

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

| Day | Unit | Site | 06:00 & earlier | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17-Apr-09 | __06064605 | IN03 | | | | | | | | | | | |
| 18-Apr-09 | __06064605 | IN03 | | | | | | | 0% | | | | |
| 23-Apr-09 | __06064605 | INBURR | | | | | | | | | | | |
| 24-Apr-09 | __06064605 | INBURR | | | | | | | 0% | | | | |
| 4-May-09 | __06064605 | INBURR | | | | | | | 0% | | | | |
| 5-May-09 | __06064605 | INBURR | | | 0% | | | | | | | 0% | |
| 6-May-09 | __06064605 | INBURR | | | | | | | | | | | |
| 7-May-09 | __06064605 | INBURR | | | | | | | | | | 0% | |
| 8-May-09 | __06064605 | INBURR | | | | 0% | | | 0% | 0% | 0% | 0% | |
| 11-May-09 | __06064605 | IN03 | | | | | | | | | | | |
| 14-May-09 | __06064605 | S61ST | | | | | | | | | | | |
| 19-May-09 | __06064605 | INBurr | | | | | | | | | | | |
| 20-May-09 | __06064605 | IN6165 | | | | | | | | | | | |
| 12-Jun-09 | __06064605 | IN30 | | | | | 0% | 0% | 0% | | 0% | 0% | |
| 15-Jun-09 | __06064605 | IN30 | | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 2% | 0% | |
| 16-Jun-09 | __06064605 | IN30 | | 0% | 0% | | 0% | 0% | 0% | 0% | | | |
| 23-Jun-09 | __06064605 | IN30 | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | |
| 24-Jun-09 | __06064605 | IN16 | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | |
| 25-Jun-09 | __06064605 | IN16 | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | |
| 26-Jun-09 | __06064605 | IN16 | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | |
| 29-Jun-09 | __06064605 | IN16 | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | | |
| 30-Jun-09 | __06064605 | IN2-49N | | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | |
| 2-Jul-09 | __06064605 | IN2-49N | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | | |
| 9-Jul-09 | __06064605 | IN2-49N | | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | | |
| 13-Jul-09 | __06064605 | IN05 | | 0% | | 0% | 0% | 0% | 0% | 0% | 0% | | |
| 14-Jul-09 | __06064605 | IN05 | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | | |
| 15-Jul-09 | __06064605 | IN05 | | | | | | 0% | 0% | 0% | | | |
| 16-Jul-09 | __06064605 | IN05 | | | | | | | 0% | 0% | | | |
| 17-Jul-09 | __06064605 | IN05 | | | | | | | 0% | 0% | | | |
| 21-Jul-09 | __06064605 | IN05 | | | 0% | 0% | 0% | | 0% | 0% | 0% | | |
| 24-Jul-09 | __06064605 | IN05 | | | 0% | 0% | | 0% | 0% | 0% | | | |
| 27-Jul-09 | __06064605 | IN05 | | | 0% | | | | 0% | 0% | | | |
| 3-Aug-09 | __06064605 | IN2-49N | | | | | 0% | 0% | 0% | 0% | | | |
| 4-Aug-09 | __06064605 | IN2-49N | | 3% | | 0% | 0% | 0% | 0% | 0% | | | |
| 5-Aug-09 | __06064605 | IN2-49N | | 0% | 0% | 0% | 0% | | | | | | |
| 6-Aug-09 | __06064605 | IN2-49N | | | | | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

**Table 2-4: Average Hourly Temperature Fahrenheit**

| Day | Unit | Site | 06:00 & earlier | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17-Apr-09 | __06064605 | IN03 | | | | | | | 68 | | | | |
| 18-Apr-09 | __06064605 | IN03 | | | | | | 71 | 75 | 78 | | | |
| 23-Apr-09 | __06064605 | INBURR | | | | | | 64 | 67 | 70 | | | |
| 24-Apr-09 | __06064605 | INBURR | | | | | | 81 | 84 | 88 | | | |
| 4-May-09 | __06064605 | INBURR | | | | | 70 | 72 | 76 | 77 | | | |
| 5-May-09 | __06064605 | INBURR | | 61 | 64 | 68 | 71 | 75 | 78 | 76 | 72 | 70 | 70 |
| 6-May-09 | __06064605 | INBURR | | 60 | 61 | | | | | | | | |
| 7-May-09 | __06064605 | INBURR | | | 67 | 68 | 72 | 76 | 79 | 80 | 82 | 83 | 82 |
| 8-May-09 | __06064605 | INBURR | | | 66 | 67 | 69 | 69 | 73 | 76 | 78 | 79 | 81 |
| 11-May-09 | __06064605 | IN03 | | | | | 60 | 65 | 69 | 70 | 74 | 74 | 77 |
| 14-May-09 | __06064605 | S61ST | | | | | | 77 | 77 | 76 | 74 | 74 | |
| 19-May-09 | __06064605 | INBurr | | | | | | 77 | 78 | 82 | 84 | | |
| 20-May-09 | __06064605 | IN6165 | | | | | | 83 | 84 | 89 | 91 | 91 | |
| 12-Jun-09 | __06064605 | IN30 | | | | | 85 | 83 | 88 | 89 | 86 | 82 | |
| 15-Jun-09 | __06064605 | IN30 | | 74 | 80 | 83 | 87 | 88 | 87 | 89 | 87 | 86 | |
| 16-Jun-09 | __06064605 | IN30 | | 68 | 69 | | 76 | 75 | 75 | 75 | | | |
| 23-Jun-09 | __06064605 | IN30 | 78 | 82 | 88 | 93 | 98 | 103 | 103 | 99 | 100 | 97 | |
| 24-Jun-09 | __06064605 | IN16 | | 78 | 82 | 88 | 91 | 95 | 98 | 94 | 86 | 86 | |
| 25-Jun-09 | __06064605 | IN16 | | 78 | 81 | 84 | 89 | 91 | 93 | 97 | 100 | 100 | |
| 26-Jun-09 | __06064605 | IN16 | 77 | 77 | 79 | 81 | 84 | 86 | 89 | 90 | 90 | 90 | |
| 29-Jun-09 | __06064605 | IN16 | 66 | 68 | 71 | 74 | 76 | 78 | 80 | 80 | 78 | 79 | |
| 30-Jun-09 | __06064605 | IN2-49N | 65 | 64 | 66 | 68 | 68 | 74 | 74 | 69 | 67 | 69 | |
| 2-Jul-09 | __06064605 | IN2-49N | | 64 | 65 | 68 | 70 | 74 | 77 | 79 | 81 | | |
| 9-Jul-09 | __06064605 | IN2-49N | | 69 | 72 | 75 | 79 | 84 | 89 | 91 | 94 | | |
| 13-Jul-09 | __06064605 | IN05 | 69 | 75 | 83 | 86 | 90 | 90 | 89 | 86 | 83 | | |
| 14-Jul-09 | __06064605 | IN05 | | 71 | 77 | 80 | 77 | 82 | 85 | 85 | 83 | | |
| 15-Jul-09 | __06064605 | IN05 | | | | | | 81 | 81 | 85 | | | |
| 16-Jul-09 | __06064605 | IN05 | | | | | | 87 | 89 | 89 | | | |
| 17-Jul-09 | __06064605 | IN05 | | | | | | 75 | 77 | 74 | | | |
| 21-Jul-09 | __06064605 | IN05 | 76 | 76 | 84 | 86 | 86 | 88 | 87 | 85 | 84 | 82 | |
| 24-Jul-09 | __06064605 | IN05 | 74 | 82 | 88 | 89 | | 94 | 90 | 89 | | | |
| 27-Jul-09 | __06064605 | IN05 | 77 | 86 | 88 | 92 | | 93 | 92 | 89 | 89 | | |
| 3-Aug-09 | __06064605 | IN2-49N | | | | 74 | 77 | 77 | 79 | 84 | | | |
| 4-Aug-09 | __06064605 | IN2-49N | | 74 | 77 | 82 | 84 | 84 | 84 | 85 | | | |
| 5-Aug-09 | __06064605 | IN2-49N | 65 | 68 | 72 | 76 | 79 | | | | | | |
| 6-Aug-09 | __06064605 | IN2-49N | | | | 73 | 76 | 79 | 82 | 84 | 88 | 89 | 91 |

### 2.5.4 Screening of Day-to-Day Variations in Emission Values

Each day's emission measurements of 2005 and newer model year vehicles were ordered by value and divided into ten groups or deciles each containing an equal number of the ordered measurements. Day-to-day decile emission values were compared for 2005 and newer vehicles. Only a small percentage of these newer vehicles are expected to have high emissions. We expect, therefore, their intermediate decile emission values should not vary significantly from day-to-day, from site-to-site or between RSD units. In Figure 2-3, the daily HC decile values of measurements are plotted side-by-side. The right hand legend indicates the color of each decile number. This comparison revealed median values for 2005 and newer model year vehicles that ranged day-to-day from –14.4 ppm to -0.2 ppm. Although these variations are well within the HC specification of the RSD units they are significant compared to average fleet emissions for newer vehicles.

The most likely explanation is that this represents the limits of accuracy in the daily instrument set-up although it is unusual that the median would be negative on all days. For HC, an adjusted set of values was created by direct addition or subtraction of a daily offset that would set the daily median values to zero. We believe this is appropriate since the median I/M test result for new models is normally zero or very close to zero. The results of the correction are shown in Figure 2-4 and analyses shown later in this report used the adjusted HC values.

Day-to-day decile CO, NO and UV smoke values for 2005 and newer model year vehicles are shown in Figures 2-5 to 2-7. Median values for CO, NOx and smoke were +0.009% to +0.019%, -2 to +20 ppm and -.002 to +0.01 respectively. These negative and positive values are very small and adjustments were not applied to these pollutants.

*Figure 2-3: Daily HC Deciles*

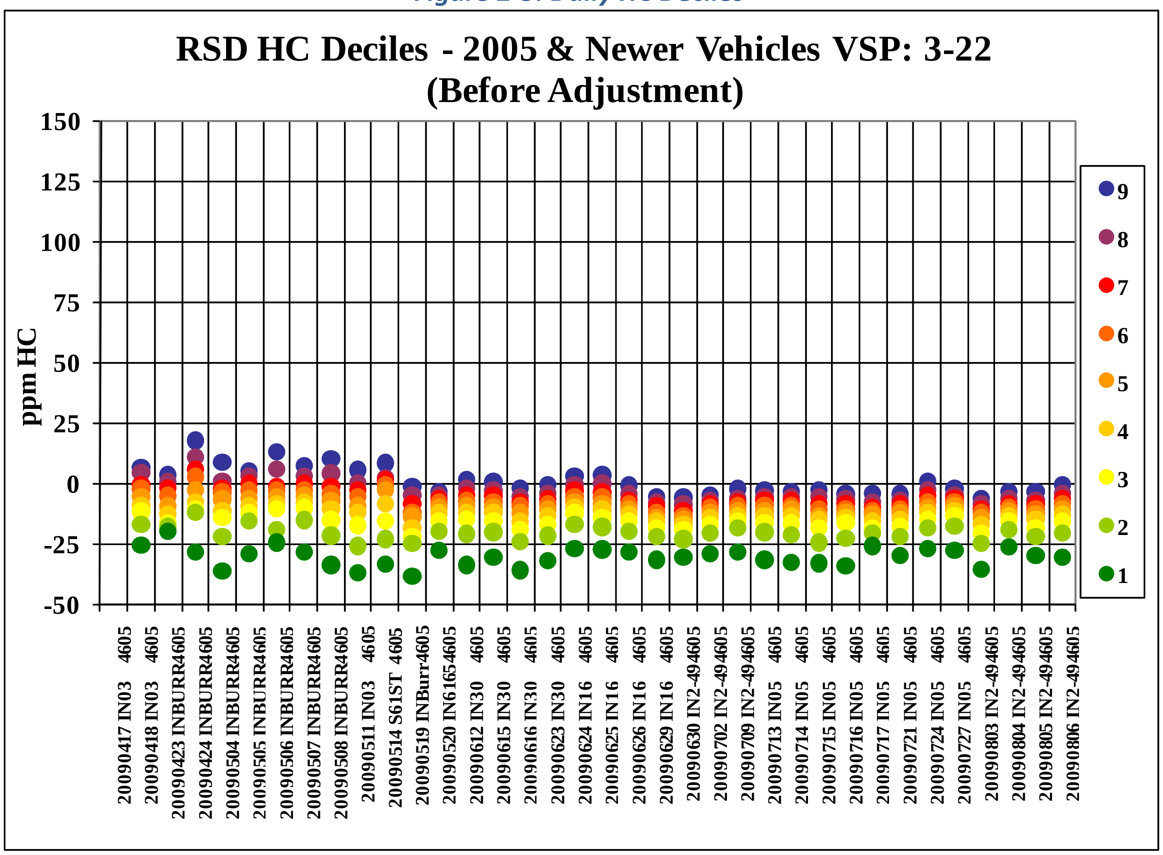


*Figure 2-4: Daily HC Deciles – After Adjustment*

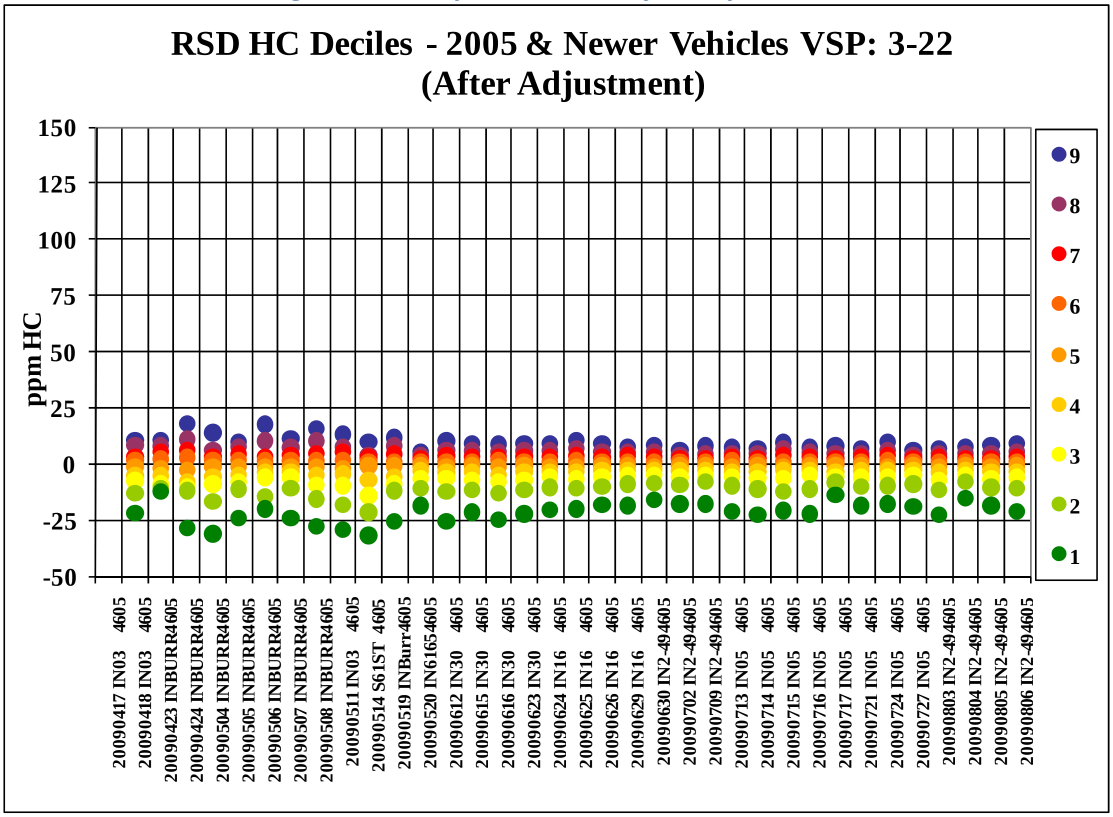



*Figure 2-5: Daily CO Deciles*

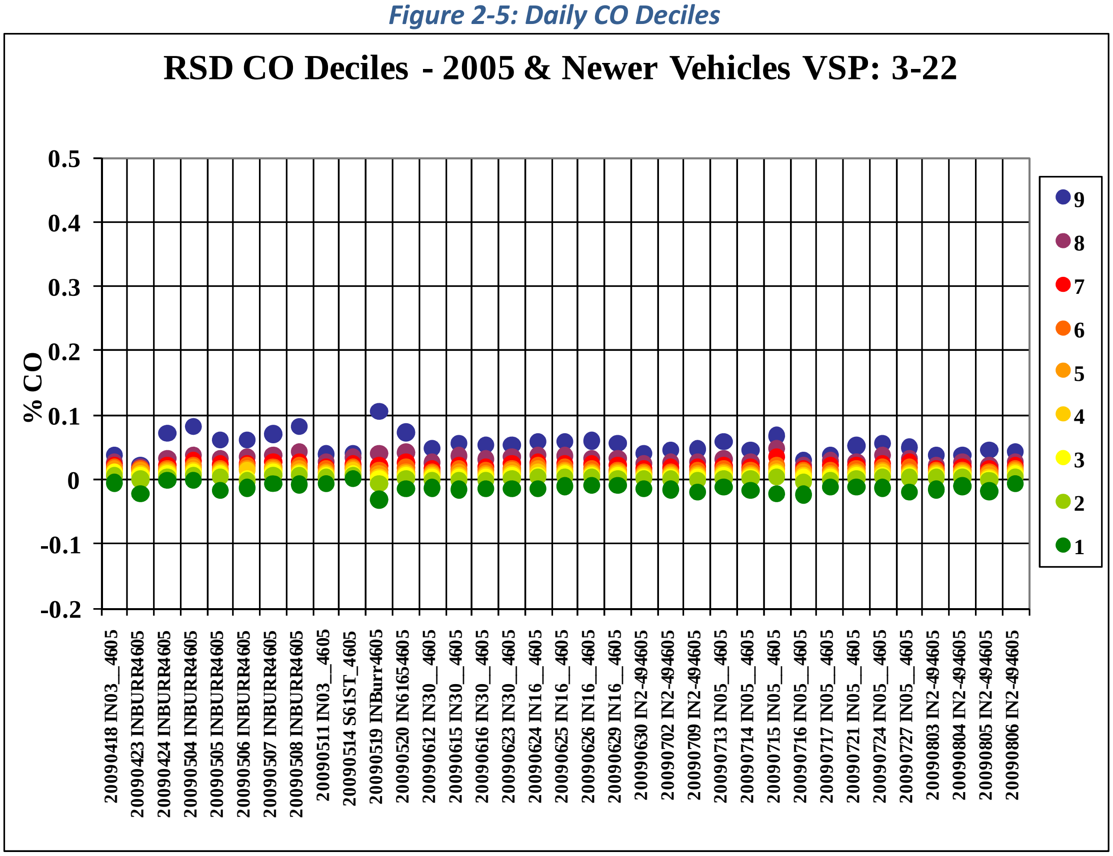


*Figure 2-6: Daily NO Deciles*

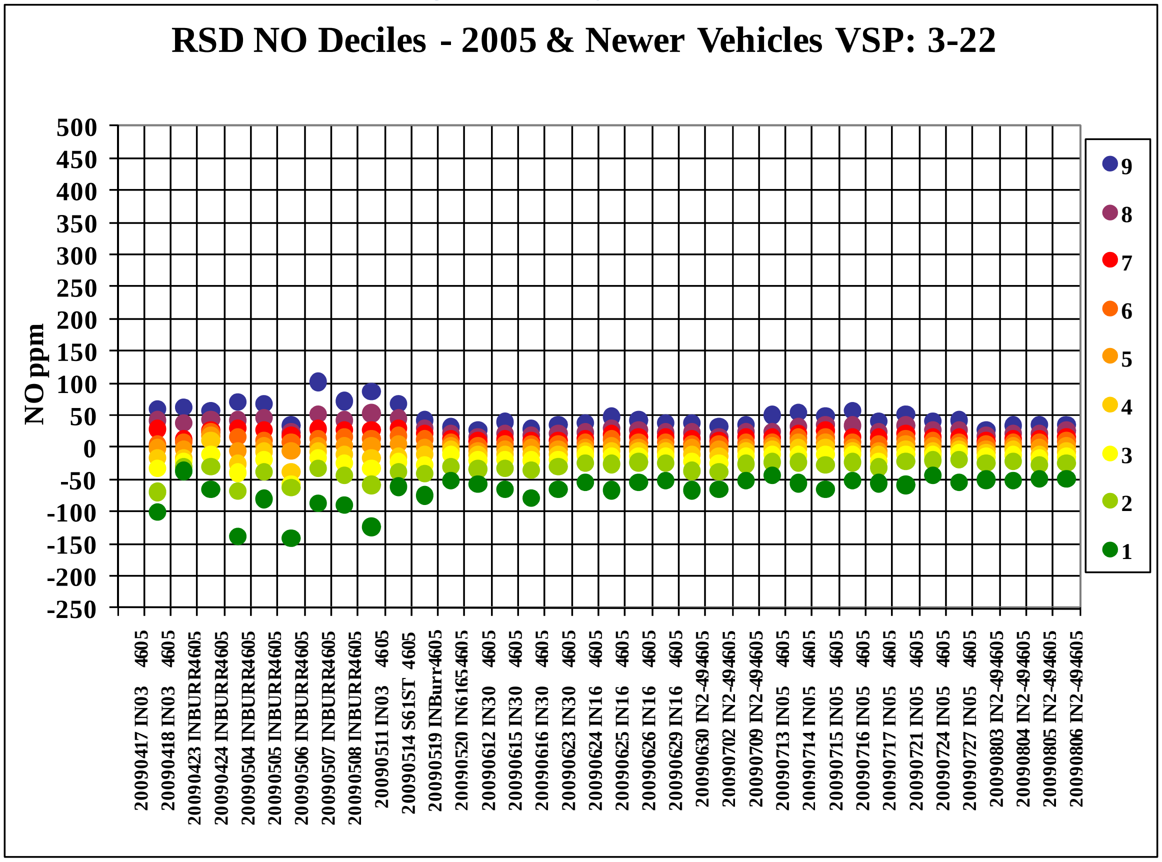
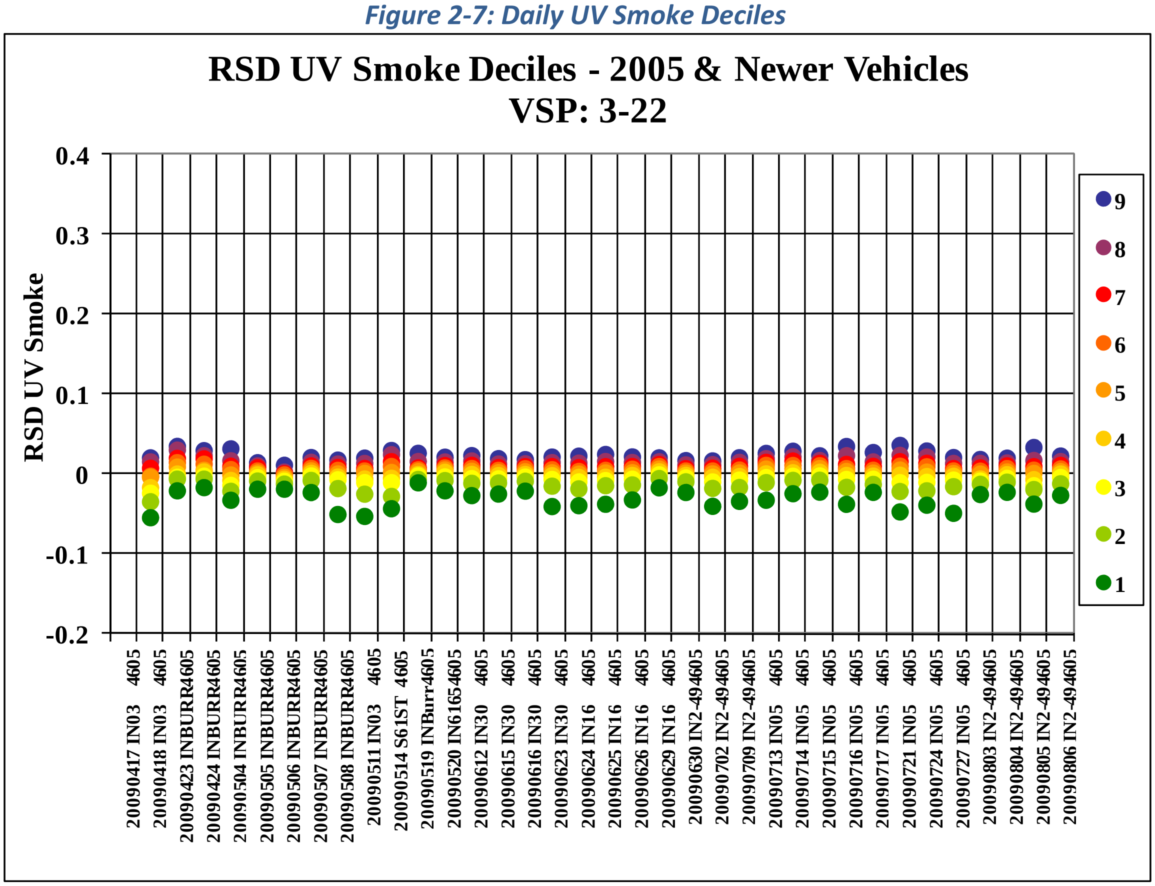



*Figure 2-7: Daily UV Smoke Deciles*



## 2.6 Sources of Data and Description of Elements

Data used in the analyses in this report come from two primary sources, the RSD on-road measurements and the Bureau of Motor Vehicles (BMV) registrations database.

In the following description of data elements, key fields that are used to access other tables are shown in **bold**.

### 2.6.1 RSD Measurements

For each vehicle the following information is collected:

- **Vehicle Plate or tag;**
- Date and Time;
- **Site Reference;**
- HC, CO, $CO_2$, NO and UV Smoke emissions; and
- Speed and acceleration.

### 2.6.2 RSD Sites

For each site the following information is collected:

- **Site Reference;**
- Description of location; and
- Slope of site in degrees;

### 2.6.3 Vehicle Registration Data

Data from the RSD is matched to the vehicle registrations data provided by BMV. Using the vehicle plate identified by RSD, the registration file is accessed to determine the vehicle identification number (VIN) and additional information about the vehicle such as model year and county in which it is registered. In order to obtain an accurate match, the plate number, a two-letter plate type and the registration year are required. BMV uses a series of plate types and the same plate number can be issued to more than one plate type. For this survey, plates were used only if they were not used for more than one plate type. This eliminated about 10% of potential matches. In addition, 2009 registration data were available only for Lake and Porter counties. Some data were obtained for vehicle plates registered to other counties but only on a limited subset of the plates observed.

Another limitation is that vehicle plates do not always remain with the same vehicle. Upon purchase of a new or used vehicle, an owner may transfer the same plate from the old vehicle to the new vehicle. In this situation, data processing delays can result in incorrect identification of some vehicles measured by RSD unless BMV transaction dates are included in the data, which was not the case for this survey.

### 2.6.4 NO vs. NOx

The vast majority of nitric oxides emitted from the vehicle tailpipe are in the form of NO. The NO is later oxidized to $NO_2$ and other oxides of nitrogen, which are collectively referred to as NOx. The RSD unit measures NO and typically we report NO values.

To convert from NO to NOx, a factor of 1.03 is applied. In Section 5, where individual vehicles are compared to standards for determination of high emitters, the NO values are converted to NOx and adjusted for humidity as described below. Charts and tables in Section 5 report NOx values.

### 2.6.5 NOx and Humidity

Higher humidity reduces vehicle NOx emissions. When vehicles are inspected in the I/M program, humidity correction factors are applied to adjust NOx measurements to values that would have been achieved when the water vapor content is 75 grains per lb. For temperatures above 75 degrees Fahrenheit (ºF):

Correction factor = e^(.004977*(H-75) - .004447*(T-75))

For temperatures below 75 ºF:

Correction factor = 1/(1.0 - .0047*(H - 75.0))

Where:

H = absolute humidity in grains of water/lb dry air

T = Temperature (ºF)

Both of the correction factors are capped at a value of 2.19.

Correction factors were calculated using weather information recorded by the weather station attached to the RSD van. Water vapor grains per lb were determined using the temperature, relative humidity and barometric pressure:

Saturated Vapor Pressure = (-4.14438 x $10^{-3}$ + 5.76645 x $10^{-3}$ x [Temp ºF] - 6.32788 x $10^{-5}$ x [Temp ºF]$^2$ + 2.12294 x $10^{-6}$ x [Temp ºF]$^3$ - 7.85415 x $10^{-9}$ x [Temp ºF]$^4$ + 6.55263*$10^{-11}$ x [Temp ºF]$^5$ )*25.4

Grains per lb = (43.478 x [Relative Humidity] x [Saturated Vapor Pressure]) / (([Barometric pressure Hg mm])-([Saturated Vapor Pressure]*[Relative Humidity]/100))

The vehicle NOx emissions reported in Section 5 have been adjusted for humidity.

# 3 VEHICLE EMISSION DATA COLLECTED

## 3.1 RSD Sample Quantity

### 3.1.1 Data Collection Summary

The number of light-duty vehicles registered in the Northern I/M area (Lake and Porter counties) is approximately 450,000. The requirement of a 1% sample of subject vehicles therefore requires 4,500 measurements.

In total, 31,844 RSD measurements were made from April 17$^{th}$ through August 6$^{th}$ 2009. These statistics include duplicate instances of the same vehicle where the vehicle has been measured by RSD more than once. Data were collected from eight sites.

**Table 3-1: Remote Sensing Measurements Summary**

| Item | Quantity | % |
|---|---|---|
| RSD valid HC, CO, NOx, Speed & Acceleration | | |
| and in desired operating mode (VSP) | 31,844 | |
| Additional screening: | | |
| NOx values less than -250 ppm | 2 | 0.0% |
| Valid and in desired VSP range after screening | 31,846 | |
| Valid with readable plate or state | 27,929 | 87.7% |
| Of which: | | |
| Indiana plate read | 23,663 | 84.7% |
| Indina plate unreadable | 1,394 | 5.0% |
| Out of State License Plate | 2,874 | 10.3% |
| Of which: | | |
| Matched to BMV Lake/Porter Registrations | 16,709 | 70.6% |

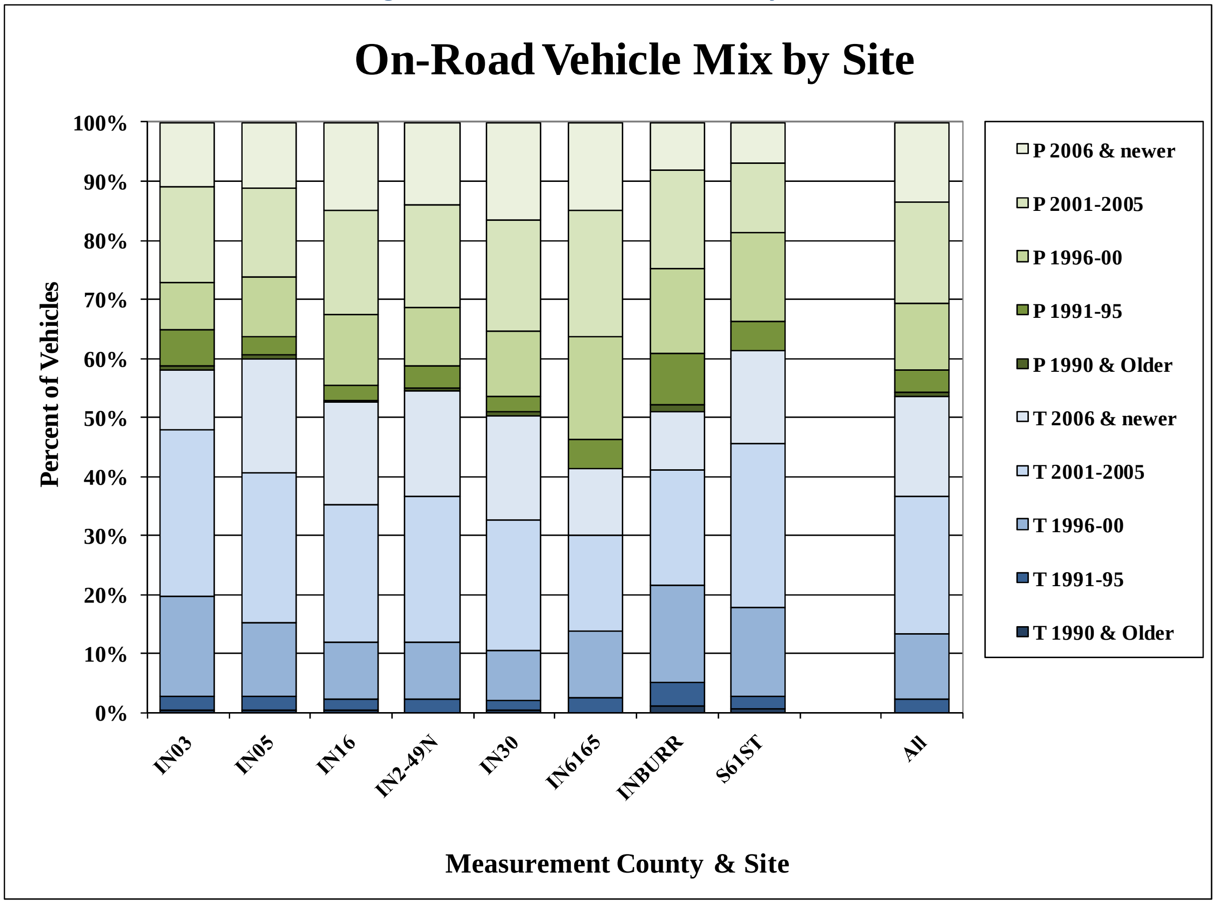
### 3.1.2 Vehicle Composition

Vehicle type was identified from the VIN for matched plates. These were determined to be:

- Passenger vehicles 46%
- Trucks 54%

Vehicles were then divided into five model year ranges to determine if the mix of vehicles by type and model year was consistent among sites. Figure 3-1: On-road Vehicle Mix by Site shows differences in the proportion of passenger vehicles and the age of vehicles.

*Figure 3-1: On-road Vehicle Mix by Site*



### 3.2 On-road Fleet Emission Distribution

The following four charts show the emission percentiles for HC, CO, NO and UV Smoke for all Indiana plate vehicles measured in the 5 to 22 kilowatts per metric ton (kW/t) range. Pollutant values are shown on the left y-axis.

Upper black lines indicate the % of the pollutant (right y-axis) produced by a given % of vehicles (x-axis) when rank ordered from highest to lowest. This indicates 20% of vehicles account for 85% of CO, 90% of HC, 90% of NO and 70% of PM (UV Smoke) emissions.

The vast majority of vehicles have low emissions and contribute little to regional pollution. Ten-to-twenty percent of vehicles have much higher emissions and emit over 70-90% of the on-road light-duty vehicle emissions.

***Figure 3-2: CO Emissions Distribution***

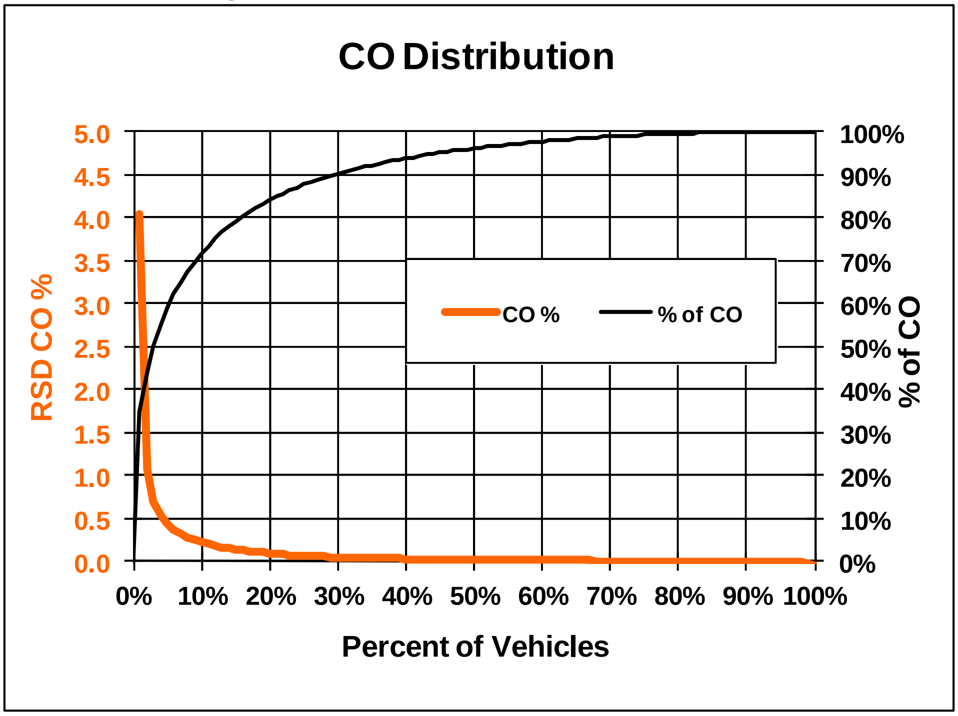


*Figure 3-3: HC Emissions Distribution*

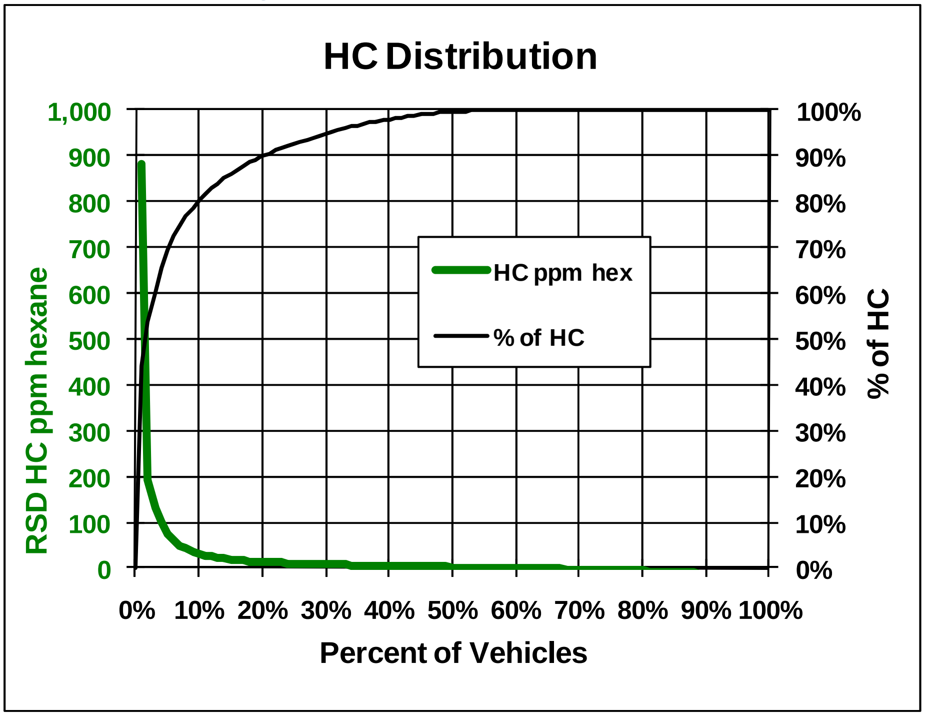



*Figure 3-4: NO Emissions Distribution*

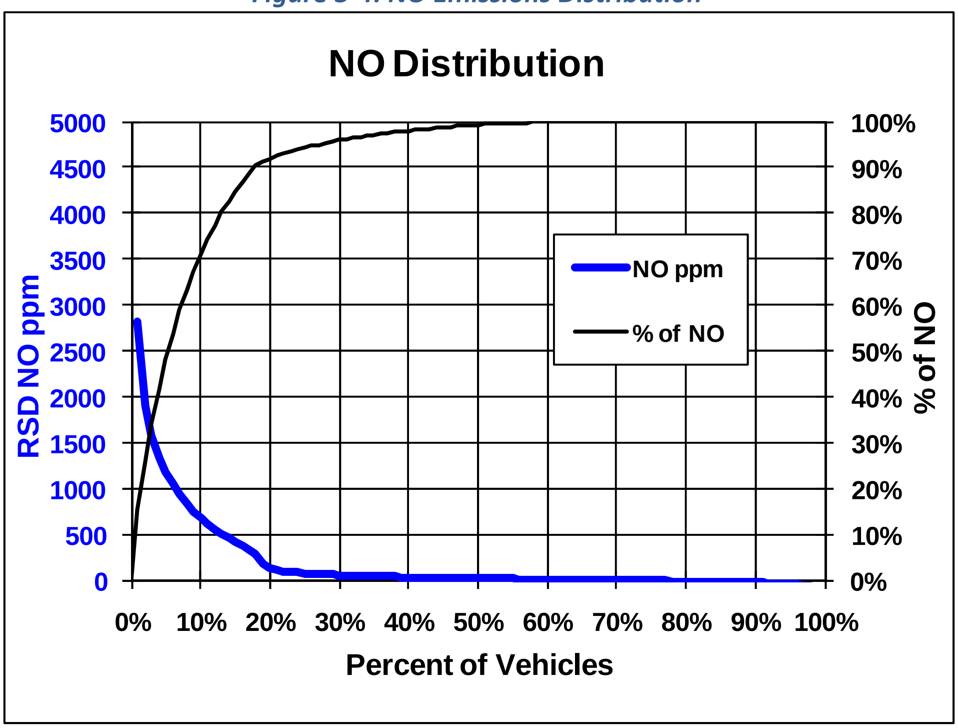
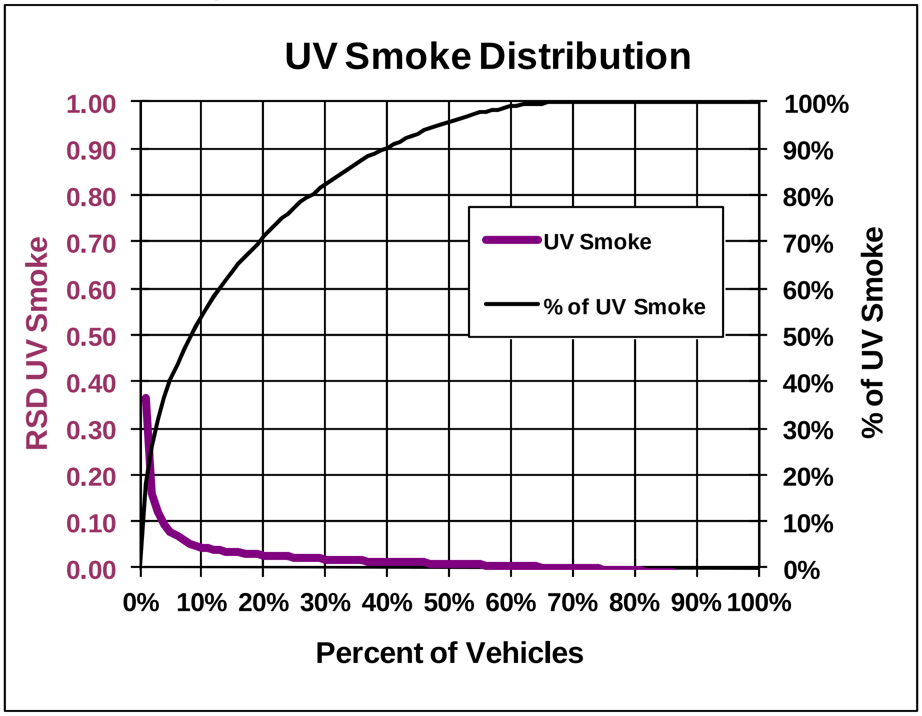


*Figure 3-5: UV Smoke Emissions Distribution*




## 3.3 Emissions by Registered Jurisdiction

In this section, emissions of vehicles registered in the different areas are compared (independent of where they were seen driving). Table 3-2 and Figures 3-7 to 3-10 show mean HC, CO, NO and Smoke measurements by jurisdiction. Data about the vehicles such as their type and model was only available for vehicles registered in Lake and Porter counties. Therefore, the results shown are for all vehicles from a jurisdiction and it is not known whether the vehicles from the different jurisdictions have a similar mix of vehicles by age and type. Thus one cannot draw many conclusions from the charts.

To assess whether the comparison of emission values may be affected by different vehicle operating conditions, the average vehicle specific power for each group is plotted in Figure 3-6. Average VSP is similar for all jurisdictions.

Vehicles known to be registered in Lake and Porter counties had lower HC and CO emissions than Indiana plates that were not matched to a Lake County or Porter County registration. Vehicles from other states had similar emissions. Illinois vehicles had higher CO and NOx than vehicles known to be registered in Lake and Porter counties.

Indiana plates that could not be read were mostly those that had two small letters one above the other in the first position on the plate. These small letters were often difficult to read and we understand this style of plate is being phased out as law enforcement officers also have difficulty reading them.

Most notable is that Indiana plated vehicles not identified as registered in Lake and Porter counties had over 30% higher average emissions across all pollutants, made up one quarter of the vehicles operating within Lake and Porter counties and emitted more than one third of the measured emissions. This merits additional investigation to verify that, for example, vehicle

owners moving into the region are properly registering their new address and that owners of vehicles failing I/M are not transferring their registration to other counties.

*Figure 3-6: Jurisdiction of Vehicles Measured*

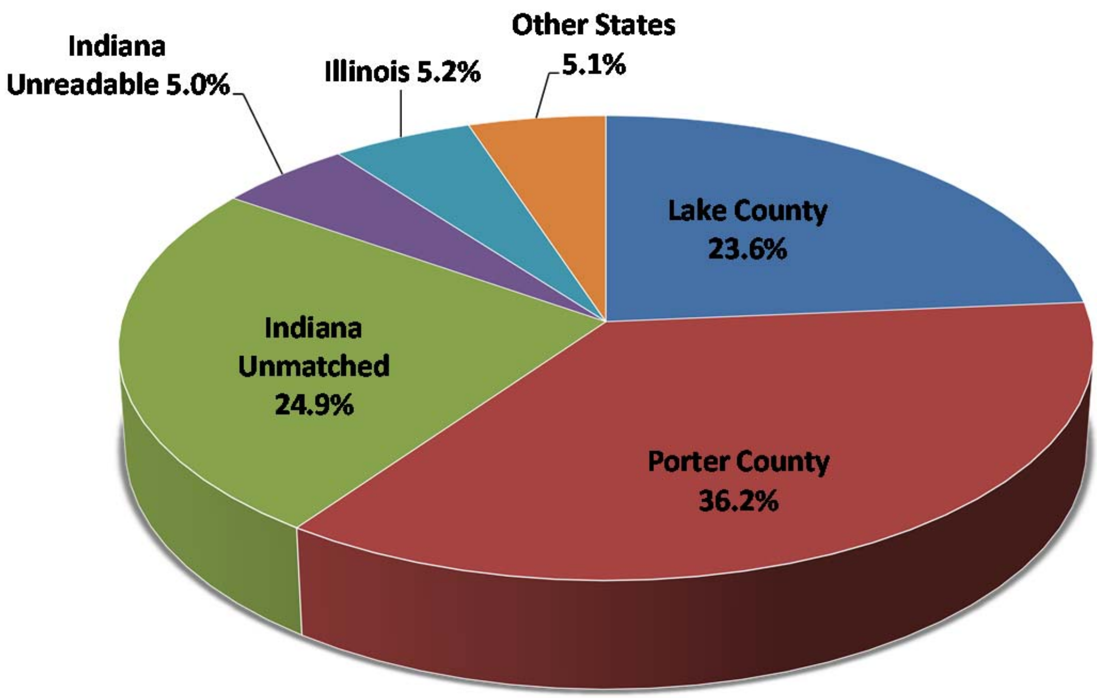



**Table 3-2: Emissions by Jurisdiction**

| Jurisdiction | N | CO | HC | NOx | Smoke | VSP |
|---|---|---|---|---|---|---|
| Lake County | 6,602 | 0.11 | 17 | 166 | 0.013 | 13.2 |
| Porter County | 10,107 | 0.09 | 10 | 145 | 0.014 | 14.7 |
| Indiana Unmatched | 6,952 | 0.16 | 25 | 228 | 0.021 | 14.1 |
| Indiana Unreadable | 1,394 | 0.10 | 13 | 172 | 0.013 | 14.0 |
| Illinois | 1,454 | 0.12 | 16 | 172 | 0.016 | 13.6 |
| Other States | 1,420 | 0.11 | 15 | 161 | 0.016 | 14.3 |
| Total | 27,929 | 0.11 | 16 | 174 | 0.016 | 14.1 |

*Figure 3-7: RSD HC Emissions by Jurisdiction*

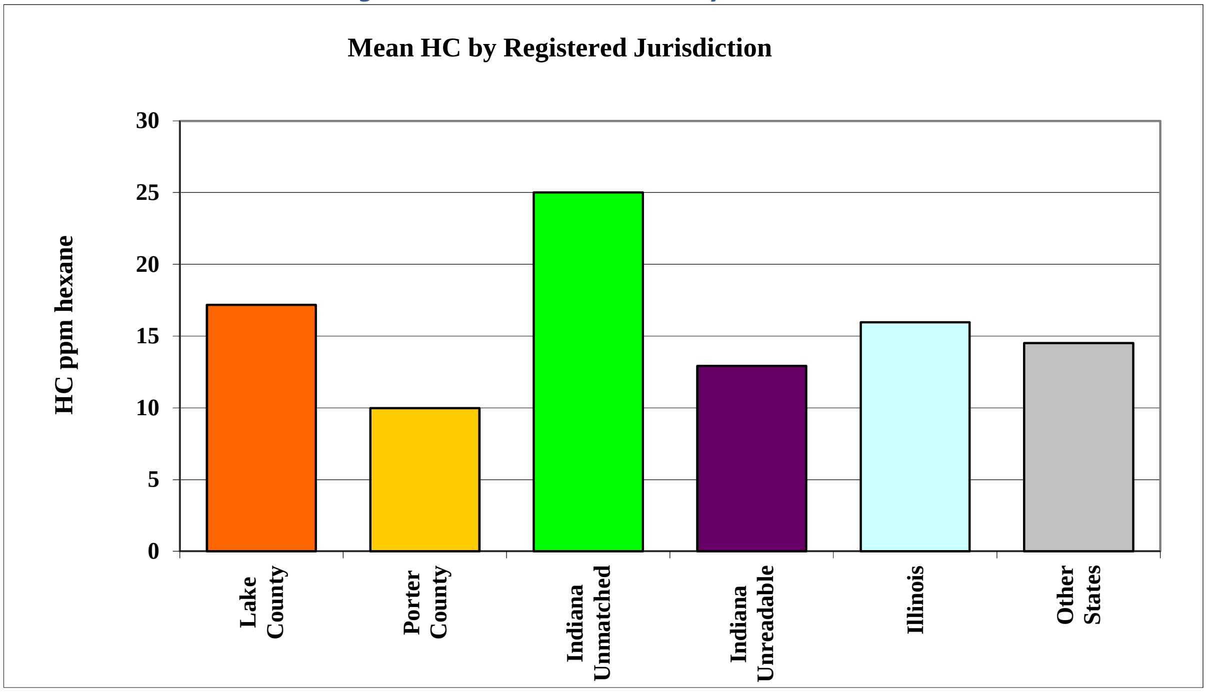



*Figure 3-8: RSD CO Emissions by Jurisdiction*

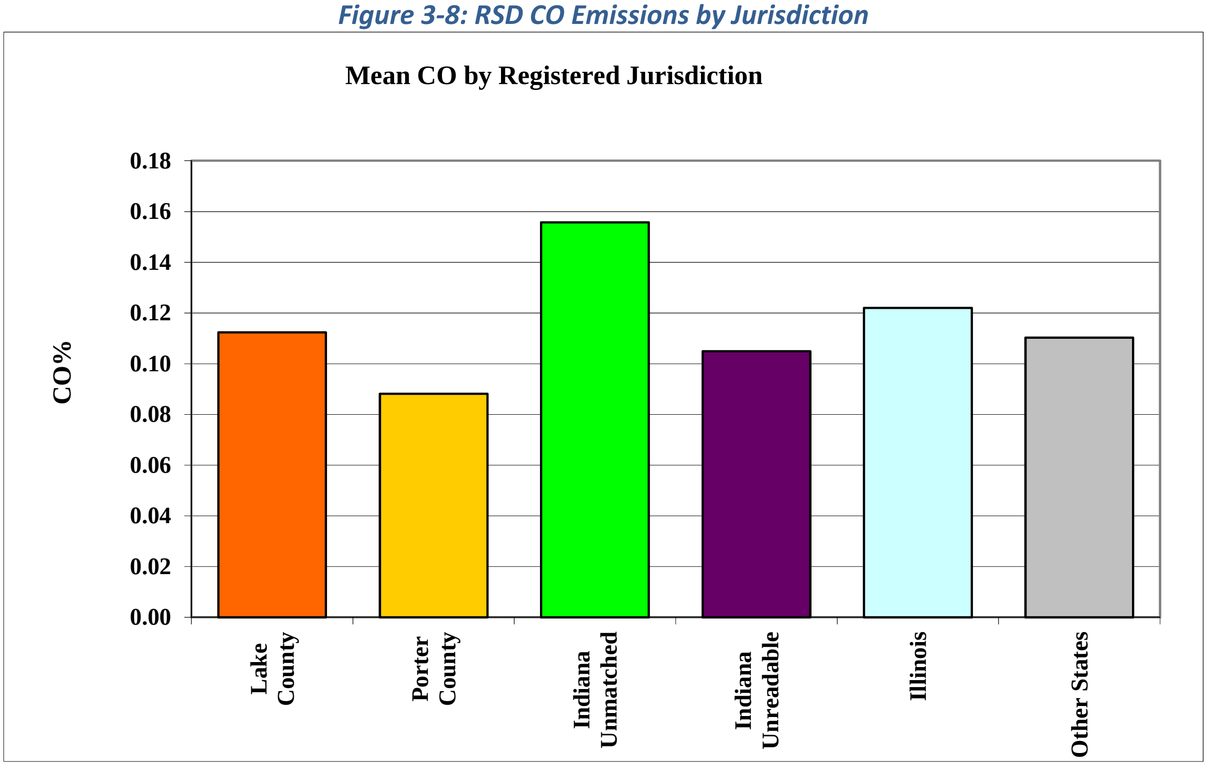


*Figure 3-9: RSD NOx Emissions by Jurisdiction*

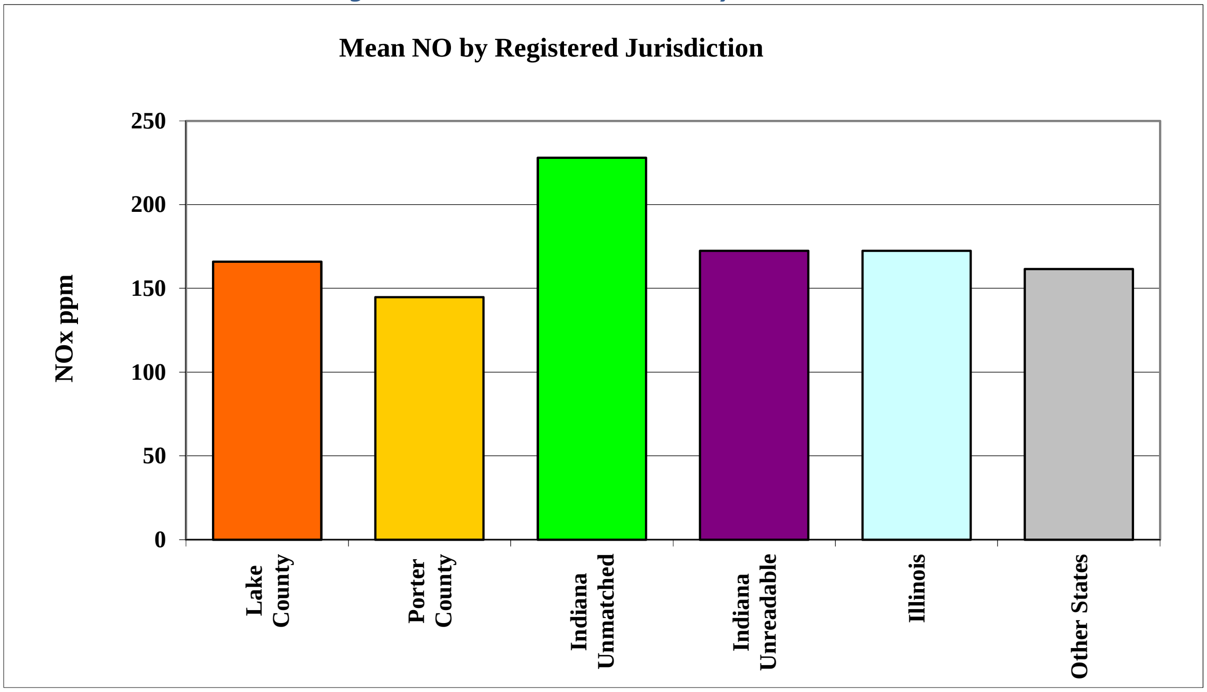



*Figure 3-10: RSD UV Smoke Emissions by Jurisdiction*

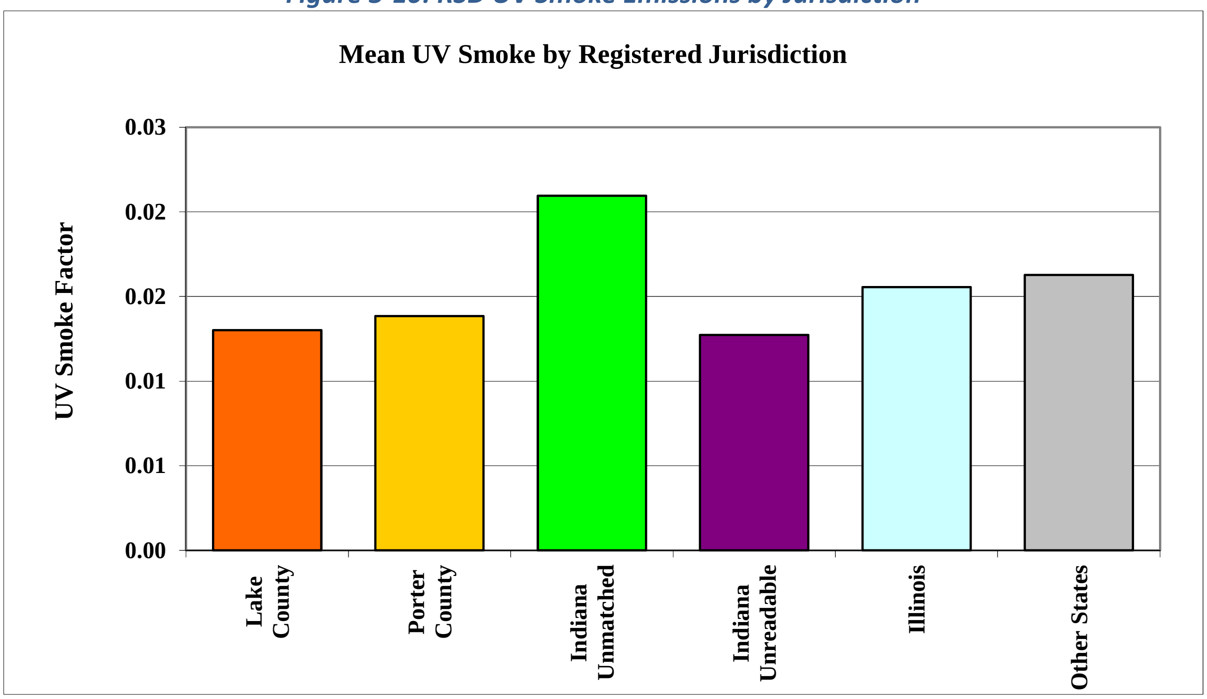
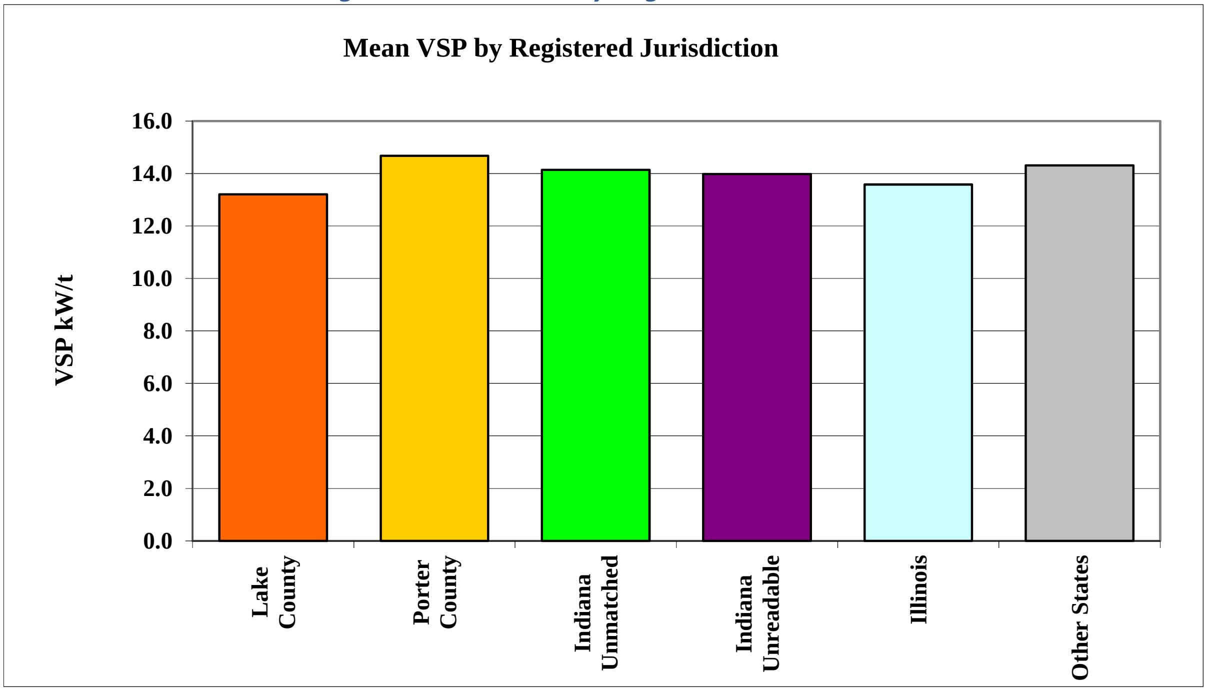


*Figure 3-11: RSD VSP by Registered Jurisdiction*



## 3.4 Emissions by Type and Model Year

Emissions for different models by 5-year bins are shown in Figure 3-12 for passenger vehicles and light-duty trucks.

The difference in average emissions between the oldest and newest models is extreme. 1985 and older models had the highest emissions. 1986-1995 models were many times dirtier than newer models. Even 1996-2000 models had emissions several times those of 2006-2010 models. Older model trucks had higher emissions than passenger vehicles.

*Figure 3-12: Emissions by Vehicle Type and Model Year*

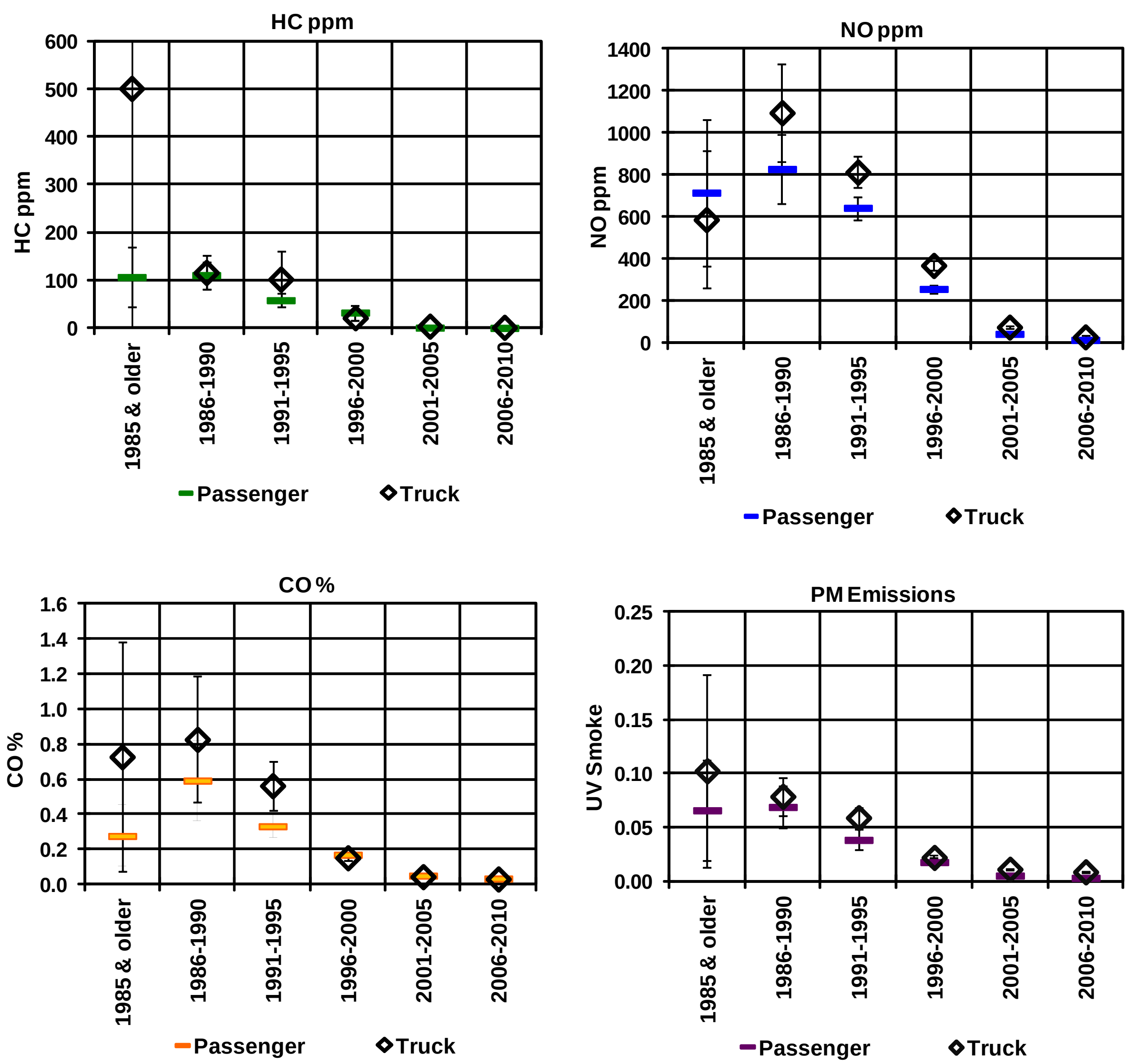


Figure 3-13 compares average emissions of passenger vehicles in Lake and Porter counties. Older models in Porter County may have higher HC and NOx emissions. A larger on-road sample is required to confirm the differences are statistically significant.

*Figure 3-13: Lake and Porter Counties Passenger Vehicle Emissions*

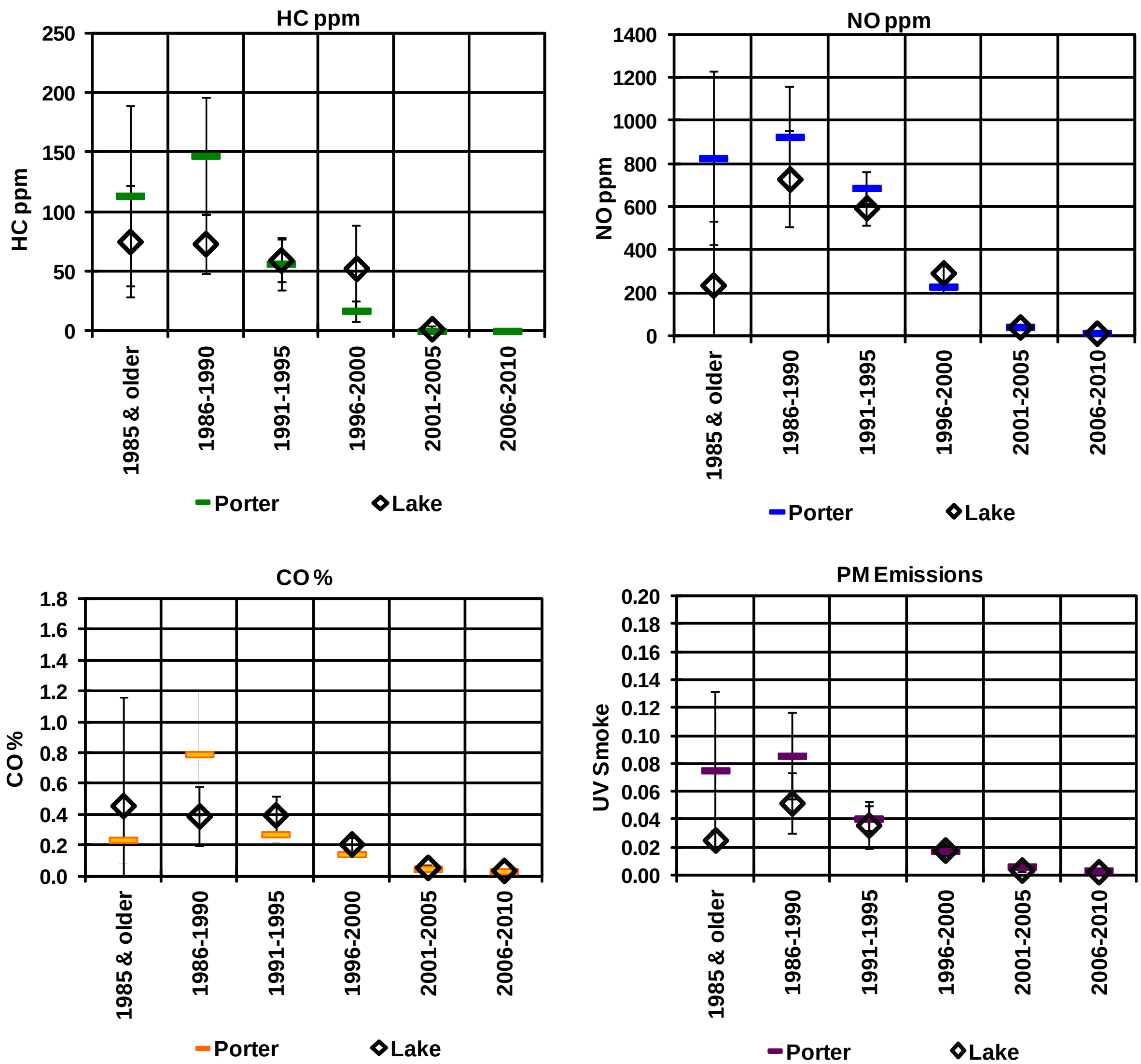
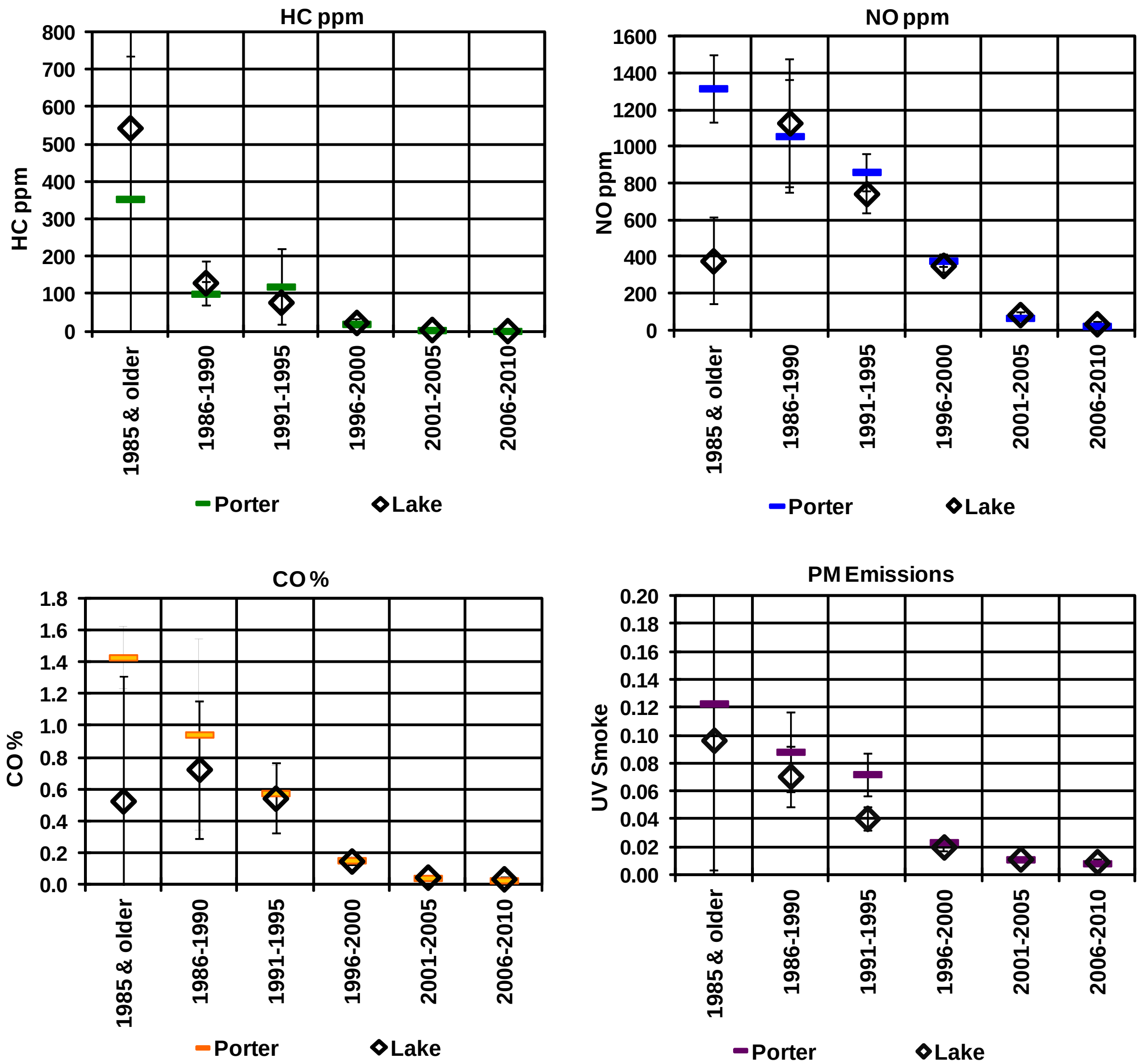


Figure 3-14 compares average emissions of light-duty trucks in Lake and Porter counties. Differences in emissions in the two counties are smaller than for passenger vehicles. Note the truck chart scales span a wider range than the passenger vehicle charts for HC and NO.

*Figure 3-14: Lake and Porter Counties Light-Duty Truck Emissions*




The relationship between UV Smoke Factor and mass for gasoline PM estimates is approximate. Gasoline particulates have different characteristics than diesel particulates and, as noted earlier, an accurate characterization of typical gasoline vehicle particulates and their mass correlation to RSD UV Smoke Factor is the subject of continuing research.

## 3.5 Emission Contributions by Type and Age

Table 3-3 shows the split between passenger vehicles and light-duty trucks in numbers and their estimated emissions contributions. Light-duty trucks were 53.8% of vehicles observed compared to 46.2% passenger vehicles.

Relative emission contributions in Table 3-3 were calculated using a simplified approach: emission contribution is proportional to the number of measurements times the emission levels. The number of RSD measurements of a class of vehicles has been demonstrated in studies[6] to be proportional to the VMT of the class, i.e. the greater the miles driven by a class of vehicle the more often its members are observed on-road. The mass of exhaust per mile is inversely proportional to fuel economy, i.e. better fuel economy equated to a smaller mass of exhaust emissions per mile. Mass emissions are consequently proportional to the average emission concentrations times the number of observations divided by fuel economy. This allows the relative share or contribution of emissions produced by different classes of vehicles to be calculated.

Average fuel economies of 23 mpg for passenger vehicles and 17 mpg for light-duty trucks were used in the calculations. This is reasonable if fuel economy is similar across all age groups (fuel economy has changed little since the early 1980's). More accurate estimates could be obtained by determining and applying the individual fuel economy for each vehicle.

Using the simple approach described above, light-duty trucks are estimated to contribute 57.6%, 56.6%, 63.1% and 67.9% of the light-duty vehicle sector CO, HC, NO and PM (UV Smoke) emissions. It is assumed that UV Smoke is a reasonable measure of total particulate emissions.

**Table 3-3: Vehicles and Emission Contributions by Type and Age**

| | | Emission Contributions | | | |
|---|---|---|---|---|---|
| **Type** | **Vehicles** | **CO** | **HC** | **NO** | **PM** |
| Passenger | 46.2% | 42.4% | 43.4% | 36.9% | 32.1% |
| Truck | 53.8% | 57.6% | 56.6% | 63.1% | 67.9% |

Within passenger vehicles, Table 3-4 shows that 1986-1995 models were 9.4% of measurements contributing 43.2% of HC and 35.5% of NO. In contrast, 2006-2010 models were 29% of measurements contributing only 0.9% of HC and 25.4% of NO.

The lower section of Table 3-4 shows the light-duty trucks measured were predominantly 2001 and newer models (74.15%) contributing 16.2% of light-duty truck HC and 49.8% of light-duty truck NO.

*Figure 3-15: Passenger and Light-Duty Truck Emission Contributions*

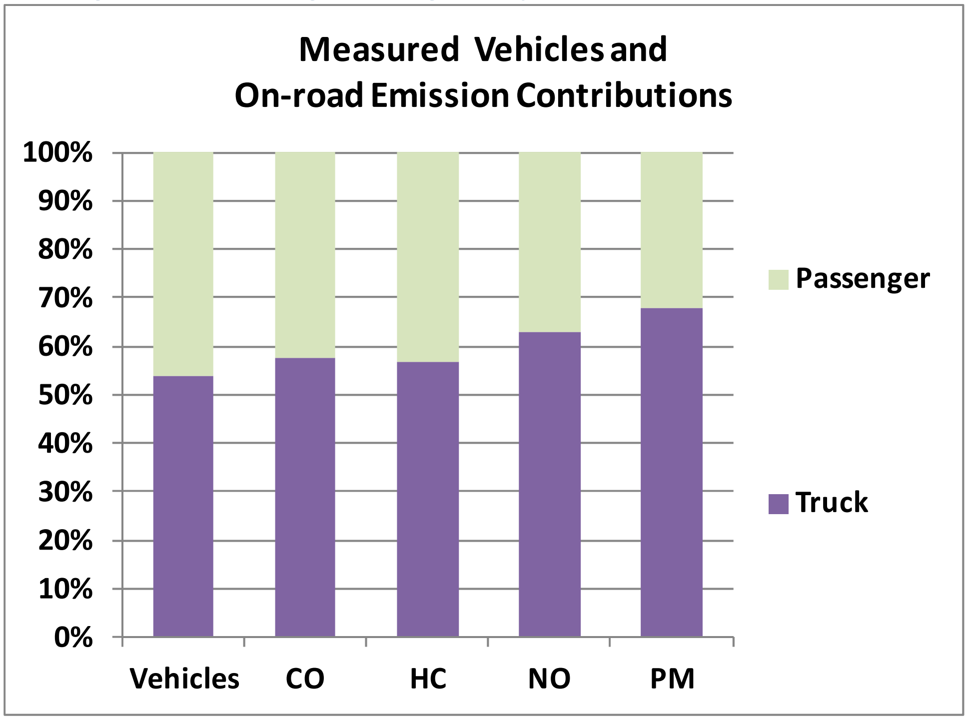



**Table 3-4: Vehicles and Emission Contributions by Age**

| | | Passenger Vehicle Emission Contributions | | | |
|---|---|---|---|---|---|
| Model Years | Vehicles | CO | HC | NO | PM |
| 1985 & Older | 0.2% | 0.5% | 1.5% | 1.0% | 1.2% |
| 1986-1990 | 1.3% | 7.4% | 10.1% | 7.4% | 8.0% |
| 1991-1995 | 8.1% | 25.7% | 33.1% | 35.9% | 27.5% |
| 1996-2000 | 24.2% | 39.0% | 54.3% | 42.4% | 37.9% |
| 2001-2005 | 37.2% | 18.0% | 0.9% | 10.6% | 17.4% |
| 2006-2010 | 29.0% | 9.4% | 0.0% | 2.6% | 8.0% |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | | | | |
| | | Light Truck Emission Contributions | | | |
| Model Years | Vehicles | CO | HC | NO | PM |
| 1985 & Older | 0.1% | 0.8% | 4.2% | 0.4% | 0.7% |
| 1986-1990 | 0.7% | 6.4% | 6.9% | 4.9% | 3.6% |
| 1991-1995 | 4.2% | 26.0% | 36.1% | 21.5% | 16.2% |
| 1996-2000 | 20.5% | 34.4% | 36.6% | 47.6% | 29.7% |
| 2001-2005 | 43.2% | 21.5% | 13.2% | 20.2% | 31.9% |
| 2006-2010 | 31.3% | 10.9% | 3.0% | 5.4% | 17.9% |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

Figures 3-16 and 3-17 further illustrate the split of vehicles and contributions within the passenger vehicle and light-duty truck sectors.

*Figure 3-16: Passenger Vehicle Emission Contributions by Age*

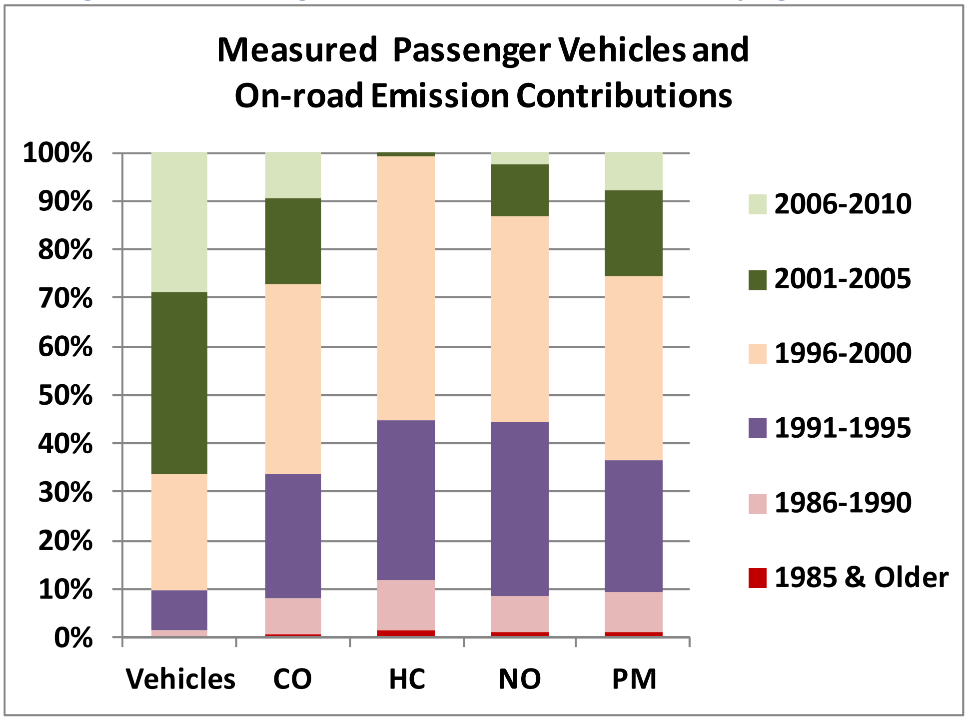
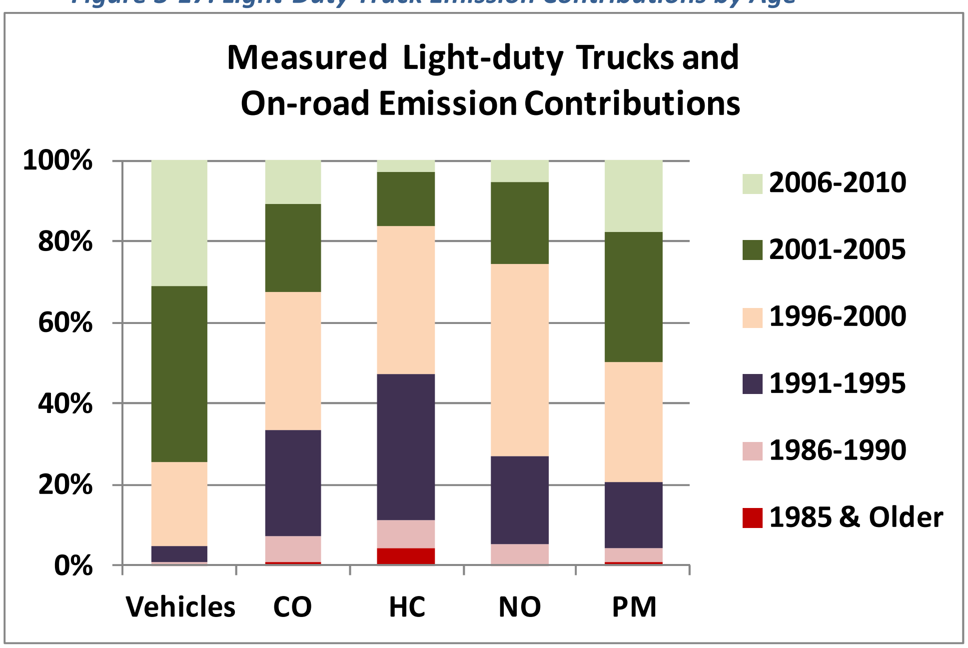



*Figure 3-17: Light-Duty Truck Emission Contributions by Age*



## 4 I/M STATUS OF ON-ROAD VEHICLES

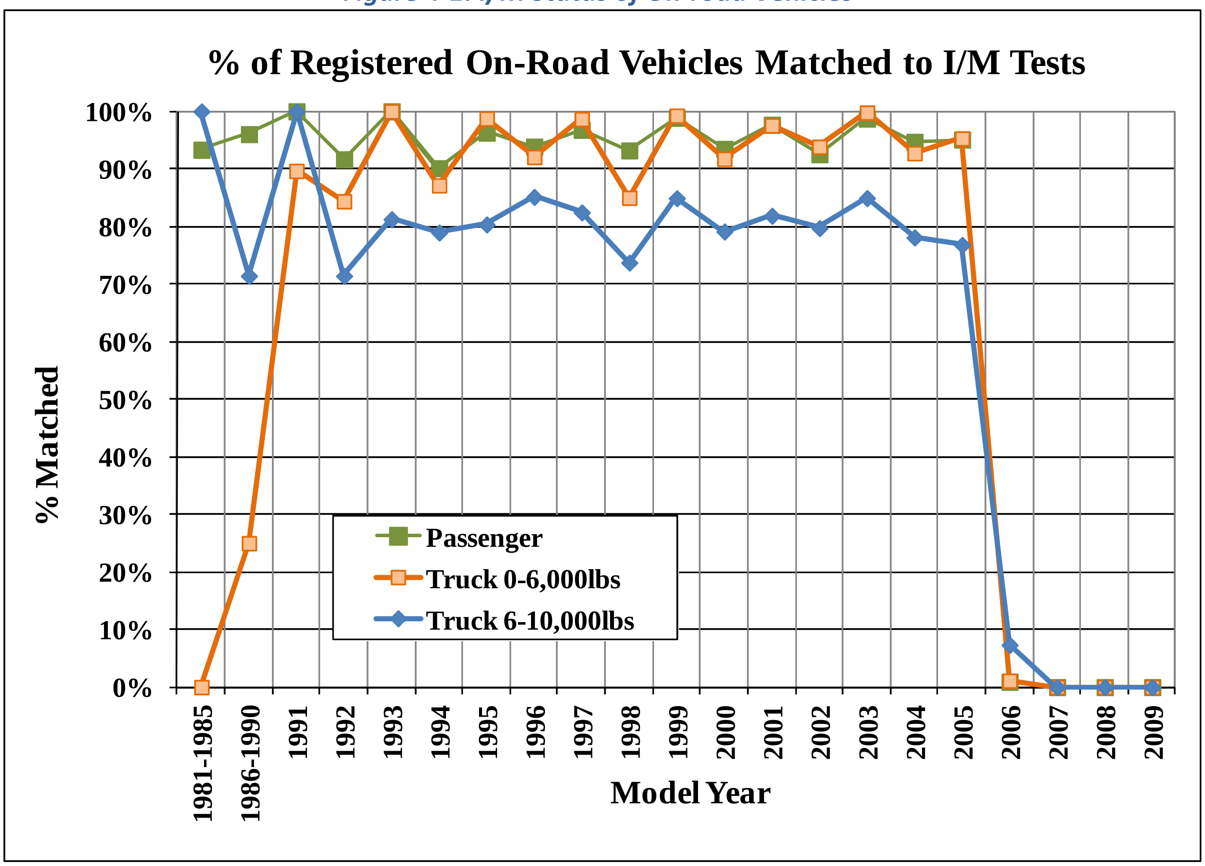
ESP compared on-road emissions to the previous I/M inspection result for gasoline and diesel powered vehicles registered within the two counties. I/M records from 2007-2009 were analyzed to extract the date and the result of the last I/M test.

Figure 4-1: I/M Status of On-road Vehicles summarizes the status of vehicles observed on-road by model year. Vehicles as old as 1976 models were subject to inspection but the oldest model vehicles identified as being registered to Lake or Porter counties were 1981 models.

Because of the four-year new model exemption, 2006 and newer models were not required to have obtained an emissions inspection at the time the data were reviewed.

The upper orange and green lines show that 95.5% of 1981-2005 passenger models and 94.5% of trucks 6000 lbs GVWR or less had obtained at least one inspection between 1/1/2007 and 12/31/2009. The equivalent rate for trucks between 6000 and 10,000lbs GVWR and greater was 80.3%. Some of these are exempt from testing as the upper weight limit on the inspection requirement is 9000lbs. In addition, diesel vehicles are exempt.

*Figure 4-1: I/M Status of On-road Vehicles*




There is an obvious biennial pattern in the results showing the rate of matched tests was higher for odd model year vehicles. Odd model-year vehicles were covered by two of the years of test data reviewed for matched inspections (2007 & 2009), which may account for the higher

percentage. But this does not explain why matching tests were not found among 2008 tests for about 10% of the even model-year vehicles. This result will be reexamined in the 2011 survey.

Figure 4-2: I/M Status of On-road Vehicles by County shows on-road vehicles with test matched records by county for the 1976-2005 models by fuel, type (P-passenger, T-truck) and truck weight class (1 or 2). A few diesel powered vehicles had inspection records although they were exempt. Figure 4-3 confirms that inspection rates were similar in the two counties. There was some difference for the 6,000 to 10,000lb GVWR truck category. In Lake County 85% of 6,000-10,000lb GVWR trucks were inspected vs. 82% in Porter County.

*Figure 4-2: I/M Status of On-road Vehicles by County*

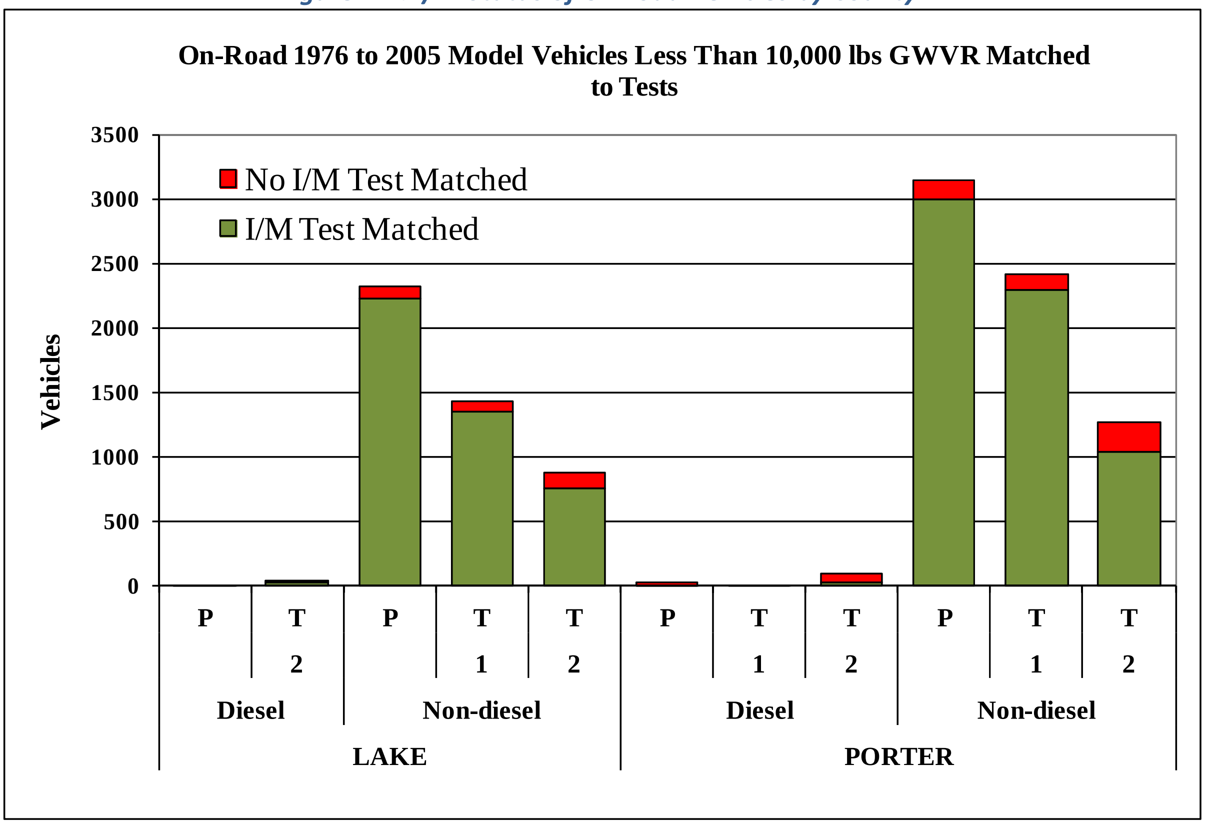
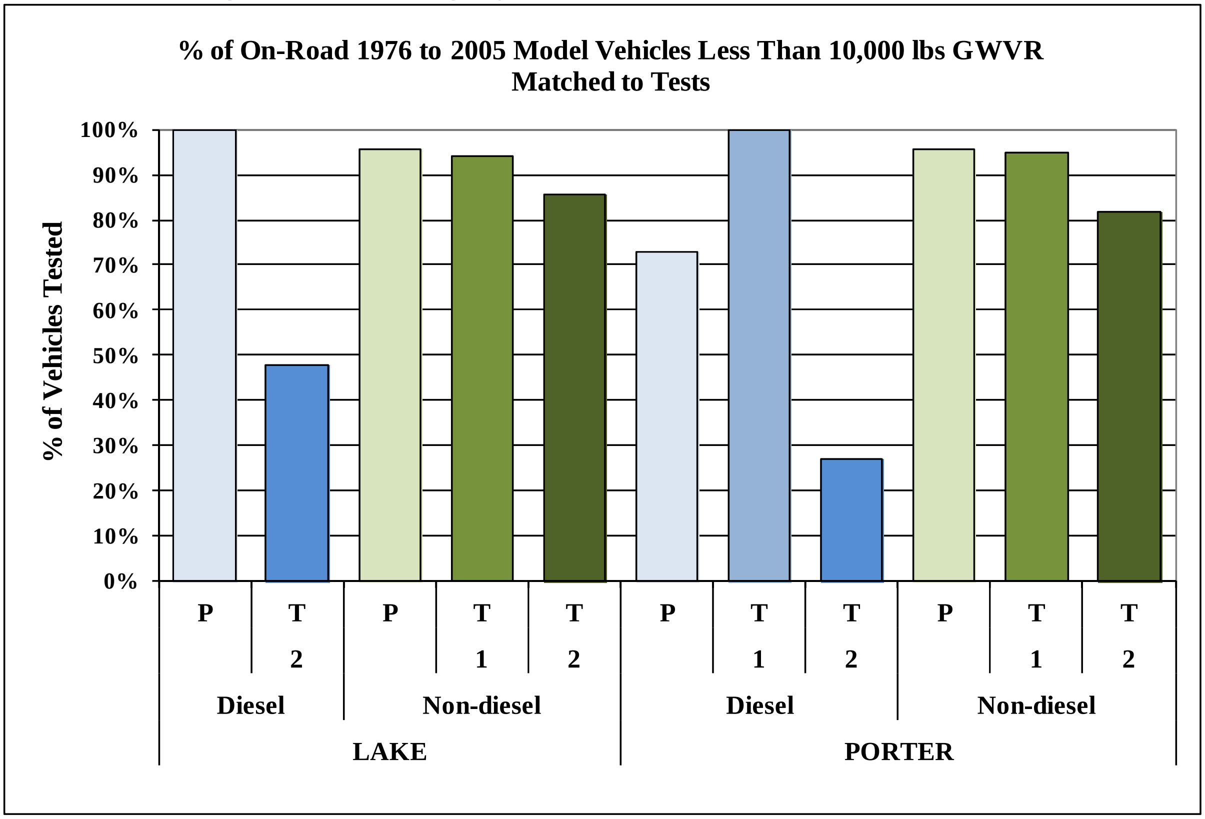


*Figure 4-3: Percentage of On-road Vehicles Matched to I/M Tests*



# 5 High Emitters

For this survey, high emitters were identified using cutpoints listed in Table 5-1, which have been used to identify high emitters in Maryland surveys. Vehicles were divided into three GVWR classes: 1) 0 to 6,000 lbs, 2) 6,001 to 10,000 lbs, and 3) over 10,000 lbs. The cutpoints for HC in this table are specified in ppm HC hexane, which is consistent with most I/M inspection equipment used to measure tailpipe concentrations. Remote sensing NOx emissions were corrected for humidity as described in Section 2 before being compared to the high emitter standards.

**Table 5-1: On-road High Emitter Cutpoints**

| | GVWR <= 6,000 lbs | | | GVWR 6,001-10,000 lbs | | | GVWR 10,001+ lbs | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | HC (ppm) | CO (%) | NOx (ppm) | HC (ppm) | CO (%) | NOx (ppm) | HC (ppm) | CO (%) | NOx (ppm) |
| 1977 | 700 | 7 | 2,718 | 700 | 7 | 2,557 | 700 | 7 | 5,000 |
| 1978 | 645 | 7 | 2,718 | 700 | 7 | 2,557 | 700 | 7 | 5,000 |
| 1979 | 600 | 6 | 2,718 | 700 | 7 | 2,045 | 700 | 7 | 5,000 |
| 1980 | 330 | 2.6 | 2,718 | 525 | 7 | 2,045 | 700 | 7 | 5,000 |
| 1981 | 330 | 1.8 | 2,718 | 375 | 4.5 | 2,045 | 700 | 7 | 5,000 |
| 1982 | 330 | 1.8 | 2,718 | 330 | 3.8 | 2,045 | 700 | 7 | 5,000 |
| 1983 | 330 | 1.8 | 2,718 | 330 | 2.3 | 2,045 | 700 | 5.3 | 5,000 |
| 1984 | 264 | 1.8 | 2,252 | 311 | 1.8 | 1,969 | 660 | 4.5 | 4,500 |
| 1985 | 264 | 1.8 | 2,252 | 292 | 1.8 | 1,969 | 660 | 4.5 | 4,500 |
| 1986 | 264 | 1.8 | 2,252 | 292 | 1.8 | 1,969 | 420 | 3.8 | 4,500 |
| 1987 | 264 | 1.8 | 2,252 | 187 | 1.8 | 1,969 | 330 | 1.8 | 4,500 |
| 1988 | 264 | 1.8 | 1,243 | 180 | 1.8 | 1,917 | 330 | 1.8 | 4,500 |
| 1989 | 264 | 1.8 | 1,243 | 180 | 1.8 | 1,917 | 330 | 1.8 | 4,500 |
| 1990 | 264 | 1.8 | 1,243 | 180 | 1.8 | 1,917 | 330 | 1.8 | 4,500 |
| 1991 | 208 | 1.8 | 1,087 | 168 | 1.8 | 1,457 | 330 | 1.8 | 4,000 |
| 1992 | 208 | 1.8 | 1,087 | 168 | 1.8 | 1,457 | 330 | 1.8 | 4,000 |
| 1993 | 208 | 1.8 | 1,087 | 168 | 1.8 | 1,457 | 330 | 1.8 | 4,000 |
| 1994 | 208 | 1.8 | 1,087 | 168 | 1.8 | 1,457 | 330 | 1.8 | 4,000 |
| 1995 | 208 | 1.8 | 1,087 | 168 | 1.8 | 1,457 | 330 | 1.8 | 4,000 |
| 1996+ | 100 | 1.0 | 893 | 168 | 1.0 | 1,457 | 330 | 1.8 | 3,600 |

In order to be considered a high emitter in Maryland, a vehicle was required to have 2 or more readings that exceed the standards for the same pollutant on different days. If the standard is exceeded by less than the tolerance of the RSD unit, a third measurement is required for confirmation.

Some 2,590 vehicles had two or more valid remote sensing measurements on different days within the normal VSP operating range of 3 to 22 kW/t. Sixty (2.3%) of these exceeded the cutpoints on both of their last two measurements for the same pollutant having average emissions that were 22 times higher for HC, and 9 times higher for CO and NOx than the average emissions of all vehicles with two measurements.

Forty-five percent of high emitters were 1995 and older models and 42% were 1996-1999 models.

Vehicles with out-of-state registrations were not considered in the high emitter analysis because their type and model year was unknown. Correct high emitter cutpoints cannot be selected without this information.

As summarized in Table 5-2, under the Maryland rules, 31 of the 60 suspected high emitters required additional confirmation by a third measurement. Those not requiring a third measurement are listed in Table 5- 3. Those requiring a third measurement are listed in Table 5-4.

**Table 5-2: High Emitter Summary**

| Pollutant Exceeded | High Emitter | Suspected | Total |
|---|---|---|---|
| HC only | 2 | 1 | 3 |
| CO only | 0 | 0 | 0 |
| NO only | 19 | 27 | 46 |
| HC & CO | 5 | 1 | 6 |
| HC & NOx | 2 | 2 | 4 |
| CO & NOx | 0 | 0 | 0 |
| All | 1 | 0 | 1 |
| Total | 29 | 31 | 60 |

Third measurements were available on 16 of the 31 suspected high emitters and these are listed in Table 5-5. Twelve were confirmed and four were not. Of the four not confirmed, one may have failed in the 40 days between the oldest measurement and the two most recent measurements, and two others had elevated emissions on their third measurement but did not exceed the standard.

## Table 5-3: High Emitters

| Year | Type | Make | Model | GVW Code | Fuel | Registration County | Date Last | Date Prev | HC Std | HC Last | HC Prev | CO Std | CO Last | CO Prev | NOx Std | NOx Last | NOx Prev |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High Emitters (Last two measurements both exceed the emissions standards for at least one pollutant by more than the RSD tolerance). | | | | | | | | | | | | | | | | | |
| 1988 | P | HOND | CIVIC CRX HF 1.5 LITRE | | G | POR | 13-Jul-09 | 30-Jun-09 | 264 | 286 | 521 | 1.8 | 6.6 | 5.4 | 1,243 | 496 | 548 |
| 1990 | T | CHEV | C1500 | 1 | G | POR | 14-Jul-09 | 25-Jun-09 | 264 | 120 | 18 | 1.8 | 0.1 | 0.1 | 1,243 | 1,997 | 2,359 |
| 1990 | P | CHEV | CORSICA LT | | G | LAK | 16-Jun-09 | 15-Jun-09 | 264 | 178 | 167 | 1.8 | 0.5 | 0.4 | 1,243 | 2,584 | 2,053 |
| 1991 | T | CHEV | ASTRO VAN | 1 | G | LAK | 19-May-09 | 05-May-09 | 208 | 209 | 325 | 1.8 | 7.8 | 5.6 | 1,087 | 178 | 87 |
| 1991 | T | PLYM | GRAND VOYAGER SE | 1 | G | POR | 05-Aug-09 | 04-Aug-09 | 208 | 90 | 587 | 1.8 | 0.3 | 0.4 | 1,087 | 2,093 | 3,778 |
| 1991 | P | CHRY | LEBARON | | G | POR | 29-Jun-09 | 26-Jun-09 | 208 | 176 | 78 | 1.8 | 0.6 | 0.2 | 1,087 | 2,156 | 2,391 |
| 1993 | T | DODG | DAKOTA | 1 | G | POR | 15-Jul-09 | 14-Jul-09 | 208 | 110 | 196 | 1.8 | 0.6 | 0.8 | 1,087 | 1,686 | 1,342 |
| 1993 | T | JEEP | CHEROKEE COUNTRY | 1 | G | POR | 27-Jul-09 | 21-Jul-09 | 208 | 60 | 59 | 1.8 | 0.4 | 0.5 | 1,087 | 1,938 | 2,053 |
| 1993 | P | BUIC | LESABRE CUSTOM/90T | | G | POR | 05-Aug-09 | 21-Jul-09 | 208 | (4) | (8) | 1.8 | 0.0 | 0.0 | 1,087 | 2,339 | 2,564 |
| 1994 | P | HOND | ACCORD EX | | G | POR | 06-Aug-09 | 03-Aug-09 | 208 | (8) | 7 | 1.8 | 0.3 | 0.3 | 1,087 | 1,574 | 1,448 |
| 1994 | P | OLDS | 88 ROYALE LS | | G | POR | 05-Aug-09 | 04-Aug-09 | 208 | 391 | 416 | 1.8 | 1.4 | 1.5 | 1,087 | 88 | 238 |
| 1994 | P | PONT | BONNEVILLE SE | | G | LAK | 19-May-09 | 14-May-09 | 208 | 3 | 5 | 1.8 | 0.0 | 0.0 | 1,087 | 4,192 | 4,749 |
| 1995 | T | JEEP | CHEROKEE SE | 1 | G | POR | 05-Aug-09 | 24-Jun-09 | 208 | 67 | 89 | 1.8 | 0.3 | 0.1 | 1,087 | 1,779 | 2,226 |
| 1995 | T | CHEV | K1500 | 2 | G | POR | 26-Jun-09 | 25-Jun-09 | 168 | 272 | 205 | 1.8 | 3.0 | 2.4 | 1,457 | 793 | 778 |
| 1996 | T | DODG | DAKOTA | 1 | G | POR | 24-Jul-09 | 21-Jul-09 | 100 | 96 | 34 | 1.0 | 0.4 | 0.6 | 893 | 2,055 | 1,946 |
| 1996 | T | DODG | RAM 1500 | 2 | G | POR | 21-Jul-09 | 13-Jul-09 | 168 | 1,725 | 2,021 | 1.0 | 1.2 | 4.0 | 1,457 | 1,011 | 654 |
| 1996 | P | PONT | BONNEVILLE SE | | G | LAK | 08-May-09 | 05-May-09 | 100 | 9,421 | 10,518 | 1.0 | 3.5 | 4.2 | 893 | 1,471 | 1,960 |
| 1997 | T | FORD | F250 | 2 | D | POR | 09-Jul-09 | 25-Jun-09 | 168 | 15 | (0) | 1.0 | 0.1 | (0.1) | 1,457 | 2,194 | 2,736 |
| 1997 | T | GMC | SAVANA G3500 | 2 | G | POR | 14-May-09 | 08-May-09 | 168 | 91 | 36 | 1.0 | 0.8 | 0.3 | 1,457 | 2,433 | 1,994 |
| 1997 | P | CHEV | CAVALIER/RS | | G | POR | 26-Jun-09 | 25-Jun-09 | 100 | 116 | 142 | 1.0 | 1.0 | 0.5 | 893 | 2,082 | 1,470 |
| 1997 | P | FORD | TAURUS GL | | G | POR | 16-Jun-09 | 15-Jun-09 | 100 | (28) | 11 | 1.0 | 0.1 | 0.1 | 893 | 1,396 | 1,155 |
| 1998 | T | CHEV | S10 | 1 | G | POR | 14-Jul-09 | 24-Jun-09 | 100 | 99 | 87 | 1.0 | 0.5 | 0.9 | 893 | 2,103 | 1,505 |
| 1998 | P | CHRY | SEBRING JX | | G | LAK | 08-May-09 | 04-May-09 | 100 | 126 | 128 | 1.0 | 0.5 | 0.7 | 893 | 1,544 | 1,444 |
| 1999 | T | CHEV | ASTRO VAN | 1 | G | LAK | 23-Jun-09 | 16-Jun-09 | 100 | 2,575 | 646 | 1.0 | 0.2 | 0.0 | 893 | 532 | 772 |
| 1999 | P | FORD | CONTOUR SE | | G | POR | 25-Jun-09 | 26-Oct-07 | 100 | 50 | 39 | 1.0 | 0.6 | 0.2 | 893 | 1,610 | 1,543 |
| 1999 | P | OLDS | CUTLASS GLS | | G | LAK | 07-May-09 | 23-Apr-09 | 100 | 411 | 330 | 1.0 | 6.2 | 6.6 | 893 | 245 | 409 |
| 2000 | T | GMC | SAFARI | 1 | G | LAK | 08-May-09 | 05-May-09 | 100 | 99 | 168 | 1.0 | 0.7 | 0.7 | 893 | 1,624 | 1,752 |
| 2000 | T | FORD | F250 SUPER DUTY | 2 | D | POR | 13-Jul-09 | 09-Jul-09 | 168 | 75 | 43 | 1.0 | 0.0 | 0.0 | 1,457 | 1,987 | 1,803 |
| 2000 | P | VOLK | JETTA GLS | | G | LAK | 23-Jun-09 | 16-Jun-09 | 100 | 38 | 25 | 1.0 | 0.2 | 0.3 | 893 | 1,472 | 1,219 |

## Table 5-4: High Emitters Requiring a Third Measurement

| Year | | Make | Body Style | | | Registration County | Date Last | Date Prev | HC Std | HC Last | HC Prev | CO Std | CO Last | CO Prev | NOx Std | NOx Last | NOx Prev |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A third reading is needed to verify high emitter status (The last two measurements exceed standard by less than the RSD tolerance). | | | | | | | | | | | | | | | | | |
| 1989 | P | HOND | CIVIC LX | | G | POR | 14-Jul-09 | 13-Jul-09 | 264 | 243 | 299 | 1.8 | 0.2 | 0.3 | 1,243 | 1,649 | 1,482 |
| 1990 | P | OLDS | DELTA 88 ROYALE BRO | | G | POR | 15-Jul-09 | 13-Jul-09 | 264 | 127 | 211 | 1.8 | 0.4 | 0.4 | 1,243 | 1,951 | 1,461 |
| 1991 | P | OLDS | 98 REGENCY ELITE | | G | POR | 06-Aug-09 | 04-Aug-09 | 208 | 8 | (2) | 1.8 | 0.2 | 0.2 | 1,087 | 1,387 | 1,318 |
| 1992 | P | MERC | TOPAZ GS | | G | LAK | 26-Jun-09 | 25-Jun-09 | 208 | 13 | 9 | 1.8 | 0.0 | 0.0 | 1,087 | 1,225 | 1,660 |
| 1993 | T | GEO | TRACKER | 1 | G | POR | 24-Jul-09 | 13-Jul-09 | 208 | 7 | 46 | 1.8 | 0.3 | 0.5 | 1,087 | 1,976 | 1,155 |
| 1993 | P | MAZD | PROTEGE DX | | G | POR | 06-Aug-09 | 05-Aug-09 | 208 | 65 | 122 | 1.8 | 0.2 | 0.3 | 1,087 | 1,806 | 1,178 |
| 1993 | P | MERC | TRACER | | G | POR | 02-Jul-09 | 30-Jun-09 | 208 | (15) | 2 | 1.8 | 0.1 | 0.1 | 1,087 | 1,392 | 1,255 |
| 1993 | P | NISS | SENTRA E/XE/SE | | G | LAK | 07-May-09 | 05-May-09 | 208 | 60 | 102 | 1.8 | 0.1 | 0.1 | 1,087 | 1,123 | 1,431 |
| 1994 | T | FORD | RANGER | 1 | G | POR | 06-Aug-09 | 14-Jul-09 | 208 | (10) | 8 | 1.8 | 0.5 | 0.0 | 1,087 | 1,147 | 2,712 |
| 1994 | P | HOND | ACCORD LX/EX | | G | LAK | 15-Jun-09 | 12-Jun-09 | 208 | (34) | (9) | 1.8 | 0.2 | 0.2 | 1,087 | 1,186 | 1,368 |
| 1995 | P | CADI | ELDORADO | | G | POR | 14-Jul-09 | 13-Jul-09 | 208 | 29 | 40 | 1.8 | 0.1 | 0.1 | 1,087 | 1,209 | 2,041 |
| 1995 | P | PONT | GRAND AM SE | | G | LAK | 23-Jun-09 | 12-Jun-09 | 208 | 87 | 104 | 1.8 | 0.5 | 0.5 | 1,087 | 1,967 | 1,198 |
| 1995 | P | SATU | SC2 | | G | POR | 04-Aug-09 | 30-Jun-09 | 208 | 6 | 85 | 1.8 | 0.0 | 0.4 | 1,087 | 1,137 | 1,650 |
| 1996 | P | BUIC | PARK AVENUE | | G | LAK | 19-May-09 | 07-May-09 | 100 | (6) | 11 | 1.0 | 0.1 | 0.4 | 893 | 897 | 1,023 |
| 1996 | P | BUIC | CENTURY SPECIAL/CU | | G | POR | 21-Jul-09 | 14-Jul-09 | 100 | 49 | 59 | 1.0 | 0.4 | 0.5 | 893 | 1,182 | 918 |
| 1996 | P | CHEV | LUMINA LS | | G | LAK | 09-Jul-09 | 02-Jul-09 | 100 | 71 | 70 | 1.0 | 0.3 | 0.4 | 893 | 915 | 1,094 |
| 1997 | T | FORD | F150 | 1 | G | LAK | 08-May-09 | 05-May-09 | 100 | 163 | 156 | 1.0 | 1.0 | 1.6 | 893 | 32 | (90) |
| 1997 | P | FORD | TAURUS GL | | G | LAK | 08-May-09 | 05-May-09 | 100 | 166 | 199 | 1.0 | 1.2 | 0.8 | 893 | 1,024 | 958 |
| 1997 | P | PLYM | BREEZE | | G | LAK | 19-May-09 | 05-May-09 | 100 | 136 | 113 | 1.0 | 0.7 | 0.4 | 893 | 450 | 438 |
| 1998 | T | FORD | RANGER | 1 | G | POR | 27-Jul-09 | 24-Jul-09 | 100 | 7 | 2 | 1.0 | 0.2 | 0.1 | 893 | 1,019 | 1,462 |
| 1998 | T | TOYO | 4RUNNER SR5 | 1 | G | LAK | 23-Jun-09 | 15-Jun-09 | 100 | (20) | 0 | 1.0 | (0.0) | 0.0 | 893 | 1,010 | 1,421 |
| 1998 | T | DODG | RAM VAN B1500 | 2 | G | LAK | 23-Jun-09 | 16-Jun-09 | 168 | 56 | 44 | 1.0 | 0.6 | 0.6 | 1,457 | 1,574 | 1,634 |
| 1998 | T | FORD | EXPEDITION | 2 | G | LAK | 05-Aug-09 | 04-Aug-09 | 168 | 9 | (6) | 1.0 | 0.1 | 0.1 | 1,457 | 1,633 | 1,510 |
| 1998 | P | VOLK | GOLF GL | | G | POR | 04-Aug-09 | 16-Jul-09 | 100 | 15 | (2) | 1.0 | 0.4 | 0.3 | 893 | 1,799 | 1,066 |
| 1999 | T | CHEV | ASTRO VAN | 1 | G | POR | 23-Jun-09 | 12-Jun-09 | 100 | 172 | 128 | 1.0 | 1.1 | 0.7 | 893 | 1,179 | 1,057 |
| 1999 | T | OLDS | SILHOUETTE | 1 | G | POR | 08-May-09 | 07-May-09 | 100 | (17) | 11 | 1.0 | 0.2 | 0.0 | 893 | 903 | 2,692 |
| 2000 | T | CHEV | BLAZER | 1 | G | POR | 03-Aug-09 | 09-Jul-09 | 100 | 6 | (18) | 1.0 | 0.0 | 0.1 | 893 | 894 | 1,117 |
| 2000 | T | FORD | RANGER | 1 | F | POR | 16-Jul-09 | 14-Jul-09 | 100 | (25) | (23) | 1.0 | 0.0 | 0.1 | 893 | 1,081 | 980 |
| 2001 | P | BUIC | REGAL LS | | G | LAK | 07-May-09 | 04-May-09 | 100 | 98 | 55 | 1.0 | 0.4 | 0.6 | 893 | 1,372 | 1,047 |
| 2001 | P | VOLK | NEW BEETLE GLS TDI | | D | POR | 27-Jul-09 | 13-Jul-09 | 100 | 17 | 50 | 1.0 | 0.3 | 1.2 | 893 | 969 | 951 |
| 2002 | T | CHEV | EXPRESS CUTAWAY G | 2 | G | LAK | 06-May-09 | 05-May-09 | 168 | 310 | 139 | 1.0 | 0.3 | 0.2 | 1,457 | 1,509 | 1,556 |

## Table 5-5: Suspected High Emitters With a Third Measurement

| | | | | Date | | | HC Values | | | | CO Values | | | | NOx Values | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Make | Body Style | Registration County | Last | Prev | 2nd Prev | Std | Last | Prev | 2nd Prev | Std | Last | Prev | 2nd Prev | Std | Last | Prev | 2nd Prev | Confirm |
| 1988 | HOND | CIVIC CRX HF 1.5 | POR | 13-Jul-09 | 30-Jun-09 | 26-Jun-09 | 264 | 286 | 521 | 321 | 1.80 | 6.6 | 5.4 | 0.8 | 1243 | 496 | 548 | 2,453 | Y |
| 1990 | CHEV | CORSICA LT | LAK | 16-Jun-09 | 15-Jun-09 | 12-Jun-09 | 264 | 178 | 167 | 261 | 1.80 | 0.5 | 0.4 | 0.5 | 1243 | 2,584 | 2,053 | 1,898 | Y |
| 1991 | CHRY | LEBARON | POR | 29-Jun-09 | 26-Jun-09 | 24-Jun-09 | 208 | 176 | 78 | 131 | 1.80 | 0.6 | 0.2 | 0.3 | 1087 | 2,156 | 2,391 | 3,259 | Y |
| 1991 | OLDS | 98 REGENCY ELI | POR | 06-Aug-09 | 04-Aug-09 | 03-Aug-09 | 208 | 8 | -2 | 7 | 1.80 | 0.2 | 0.2 | 0.3 | 1087 | 1,387 | 1,318 | 383 | |
| 1993 | BUIC | LESABRE CUSTC | POR | 05-Aug-09 | 21-Jul-09 | 09-Jul-09 | 208 | -4 | -8 | 6 | 1.80 | 0.0 | 0.0 | 0.0 | 1087 | 2,339 | 2,564 | 2,116 | Y |
| 1993 | MAZD | PROTEGE DX | POR | 06-Aug-09 | 05-Aug-09 | 04-Aug-09 | 208 | 65 | 122 | 67 | 1.80 | 0.2 | 0.3 | 0.3 | 1087 | 1,806 | 1,178 | 857 | |
| 1993 | JEEP | CHEROKEE COU | POR | 27-Jul-09 | 21-Jul-09 | 14-Jul-09 | 208 | 60 | 59 | 29 | 1.80 | 0.4 | 0.5 | 0.2 | 1087 | 1,938 | 2,053 | 1,694 | Y |
| 1994 | HOND | ACCORD EX | POR | 06-Aug-09 | 03-Aug-09 | 09-Jul-09 | 208 | -8 | 7 | 5 | 1.80 | 0.3 | 0.3 | 0.3 | 1087 | 1,574 | 1,448 | 1,456 | Y |
| 1994 | PONT | BONNEVILLE SE | LAK | 19-May-09 | 14-May-09 | 05-May-09 | 208 | 3 | 5 | -2 | 1.80 | 0.0 | 0.0 | 0.1 | 1087 | 4,192 | 4,749 | 1,198 | Y |
| 1994 | OLDS | 88 ROYALE LS | POR | 05-Aug-09 | 04-Aug-09 | 26-Jun-09 | 208 | 391 | 416 | -7 | 1.80 | 1.4 | 1.5 | 0.0 | 1087 | 88 | 238 | 9 | |
| 1996 | DODG | DAKOTA | POR | 24-Jul-09 | 21-Jul-09 | 13-Jul-09 | 100 | 96 | 34 | 107 | 1.00 | 0.4 | 0.6 | 0.6 | 893 | 2,055 | 1,946 | 2,372 | Y |
| 1997 | PLYM | BREEZE | LAK | 19-May-09 | 05-May-09 | 23-Apr-09 | 100 | 136 | 113 | 318 | 1.00 | 0.7 | 0.4 | 3.1 | 893 | 450 | 438 | 810 | Y |
| 1997 | GMC | SAVANA G3500 | POR | 14-May-09 | 08-May-09 | 07-May-09 | 168 | 91 | 36 | 32 | 1.00 | 0.8 | 0.3 | 0.4 | 1457 | 2,433 | 1,994 | 2,104 | Y |
| 1998 | CHRY | SEBRING JX | LAK | 08-May-09 | 04-May-09 | 23-Apr-09 | 100 | 126 | 128 | 1763 | 1.00 | 0.5 | 0.7 | 0.5 | 893 | 1,544 | 1,444 | 1,483 | Y |
| 1999 | OLDS | SILHOUETTE | POR | 08-May-09 | 07-May-09 | 05-May-09 | 100 | -17 | 11 | 19 | 1.00 | 0.2 | 0.0 | 0.1 | 893 | 903 | 2,692 | 1,597 | Y |
| 2000 | CHEV | BLAZER | POR | 03-Aug-09 | 09-Jul-09 | 02-Jul-09 | 100 | 6 | -18 | -6 | 1.00 | 0.0 | 0.1 | 0.0 | 893 | 894 | 1,117 | 99 | |

# 6 Clean Vehicles

The emissions distributions in Section 3 showed that the vast majority of vehicles are clean. Figures 6-1 and 6-2 show decile emissions within model years for HC and NO emissions. In the charts, the 1995 and older models were compressed into two groups because few vehicles were measured for each individual model year of these older models. The charts further illustrate that most of the newer model vehicles have very low emissions. Since, 1996 and newer OBD-II equipped vehicles inform their owners if faults are detected in emission control system components, owners of these models are generally aware of whether their vehicle needs service. Exceptions are faults such as fuel leaks that are not detected by OBD-II but register as high RSD HC emissions on-road.

The on-road measurements, in addition to identifying high-emitters, provides a way of reducing the I/M burden for owners that keep their vehicles well maintained and are responsive to the OBD-II check engine warnings. A Clean Screen program uses RSD measurements to exempt these vehicle owners from a station inspection and allows the funds that would otherwise be spent on station visits to be directed toward the on-road measurements, thereby allowing comprehensive on-road monitoring, and toward support of other emission reduction activities such as repair and scrap programs. The wealth of on-road measurements can be used to focus on the residual high exhaust and high evaporative emitters through notifications and repair/scrap assistance programs. The net result is more convenience for owners of clean vehicles and a stronger focus on the small percentage of high emitting vehicles.

*Figure 6-1: Decile HC Emissions*

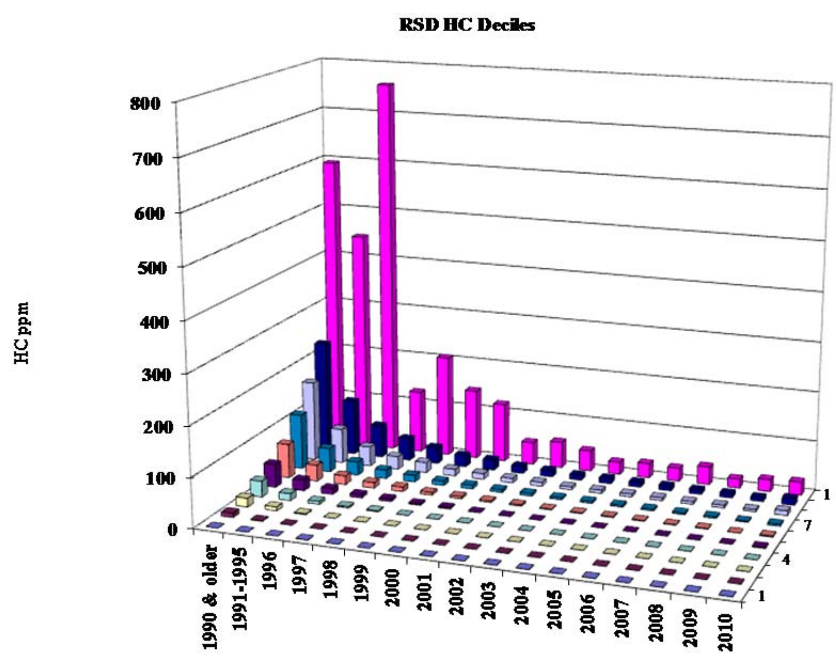
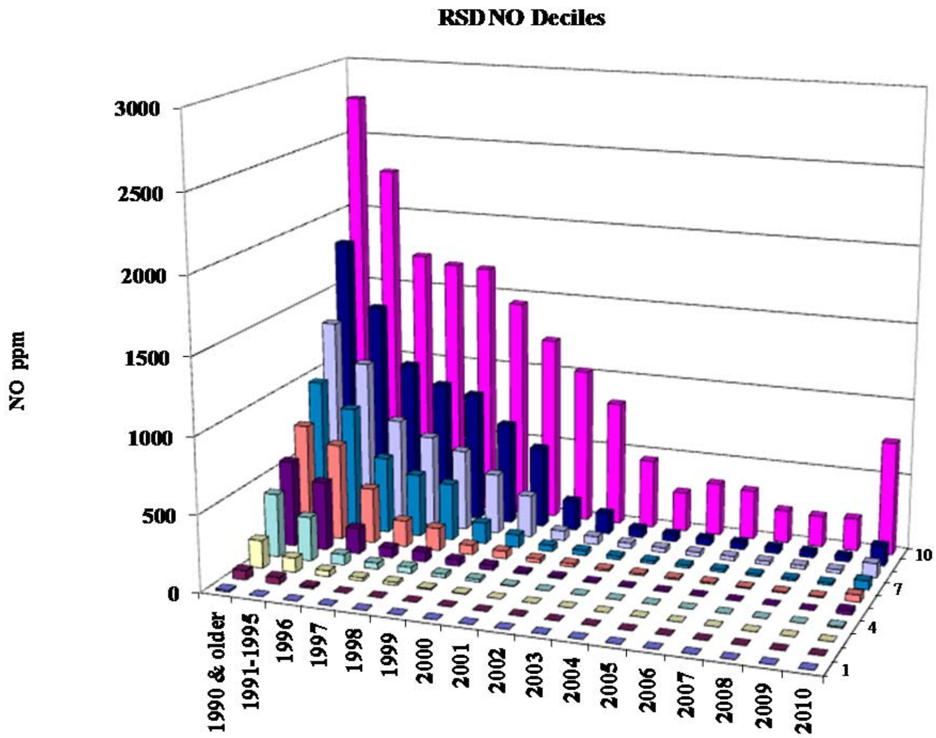


*Figure 6-2: Decile NO Emissions*

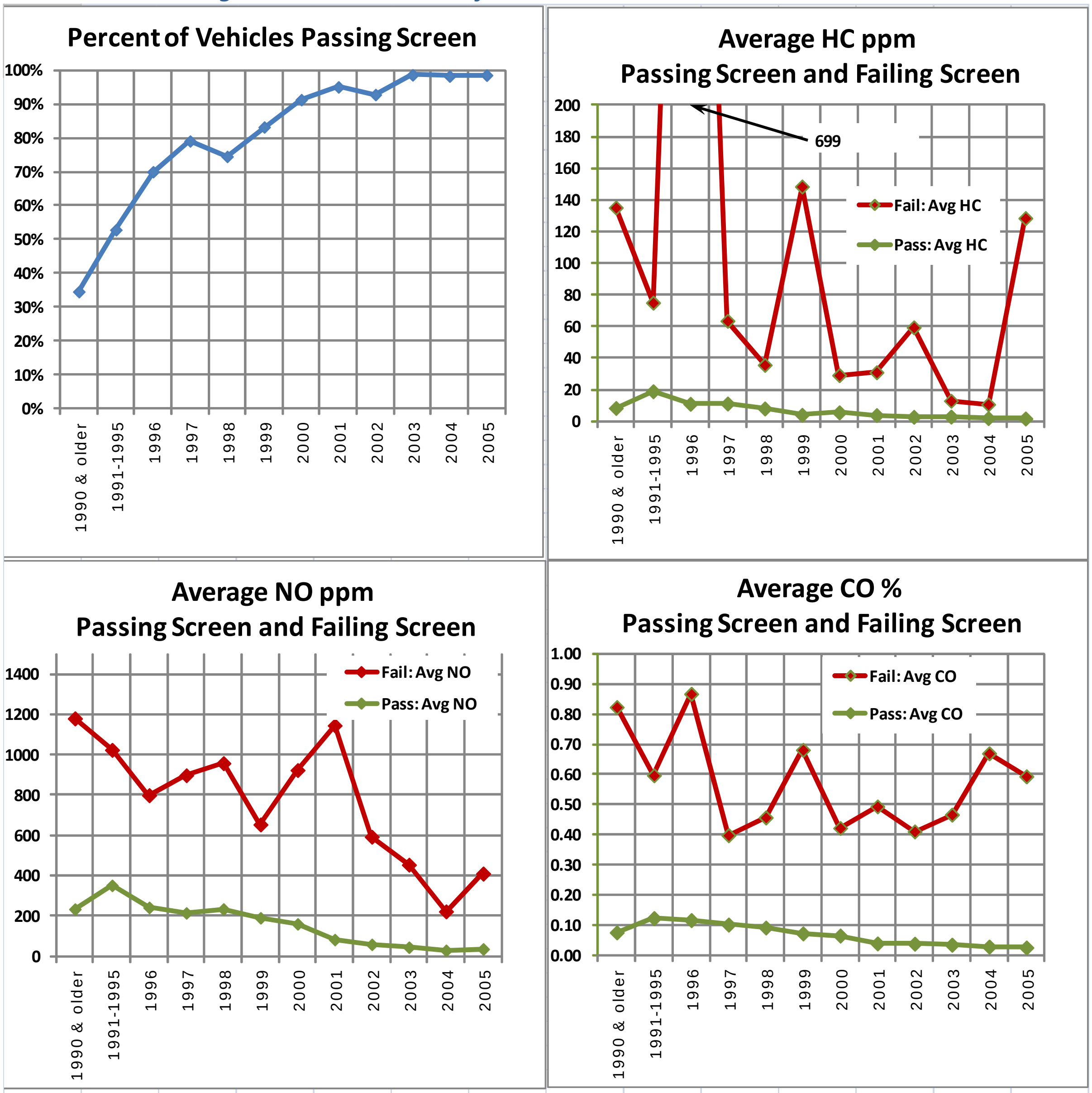



Colorado has been running a successful clean screen program in the Denver Metro Area (DMA) since 2003. Current Clean Screen criteria require vehicles to have two RSD measurements with emissions below 200 ppm HC, 0.5% CO and 1000 ppm NO. Vehicles may also pass with a single measurement if the historical fail rate for the model is low.

Figures 6-3 shows by model year the % of Indiana vehicles with two measurements that passed the Colorado criteria and the average emissions of those passing the screen vs. those failing the screen. The average emissions of those passing the screen were nearly all less than 15ppm HC, 250 ppm NOx and 0.1% CO. The vast majority of excess emissions identified by I/M remained in the vehicles failing the screen.

A pilot Clean Screen program was recently started in Tennessee and other air districts and state agencies have expressed interest. A pilot program is a good way for states to test effectiveness of a remote sensing clean screen.

***Figure 6-3: Screen Result for Vehicles with Two Measurements***



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