Appendix A
Correspondence

Central Texas Clean Air Coalition

Bastrop County • Caldwell County • Hays County • Travis County • Williamson County
City of Austin • City of Bastrop • City of Elgin • City of Lockhart • City of Luling
City of Round Rock • City of San Marcos

December 20, 2006

Richard E. Green
Regional Administrator
U.S. EPA Region 6
1445 Ross Avenue
Dallas, Texas 75202-2733

Subject: <u>8-hour Ozone Flex Program Letter of Intent</u>

Dear Administrator Greene;

On behalf of the Central Texas Clean Air Coalition (CAC), I would like to thank EPA for its approval of the 8-hour Ozone Flex Program and for its release of program guidance. The Austin/Round Rock (A/RR) MSA has a long-standing commitment to air quality and is grateful for the opportunity to participate in this timely new program.

The A/RR MSA currently monitors attainment of the 8-hour ozone standard. We believe that the region's attainment status is due, in large part, to the emission reductions achieved under the MSA's Early Action Compact and 1-hour Ozone Flex Plan.

Please consider this letter our notice of intent to participate in the 8-hour Ozone Flex Program. We anticipate a plan that includes, at minimum, the emission reduction measures implemented under our Early Action Compact and 1-hour Ozone Flex Plan. We will consider additional measures as we develop and finalize our plan.

Thank you for this opportunity. We are look forward to our continued partnership in securing the clean, healthy air that is the birthright of every American.

With best regards,

Will Wynn
Mayor, City of Austin
Chair, Central Texas Clean Air Coalition

The CTCAC is supported by the Early Action Compact Task Force and by staff of the
Capital Area Council of Governments (CAPCOG)
Air Quality Planning Division
PO Box 17848, Austin, TX 78760

Capital Area Council of Governments
PO Box 17848, Austin, TX 78760
512.916.6000 ~ Fax 512.916.6001
www.capcog.org

October 2, 2007

Mr. Steve Spaw
Director, Monitoring Operations Division
Texas Commission on Environmental Quality
P.O. Box 13 087
Austin, TX 78701

Dear Mr. Spaw,

The Central Texas Clean Air Coalition (CAC) is a bi-partisan organization of elected officials from the five-county Austin metro region, including officials representing the five counties and the seven most populous cities in those counties. As Mayor of Austin, I serve as current chairman of the CAC.

The CAC and its member governments have worked over the past several years to implement measures intended to maintain the area's compliance with the federal ozone standard. While we have been successful in achieving emission reductions, we believe the region will continue to be challenged in meeting the ozone standard, especially if the EPA proposed new standards are adopted. We have therefore expressed our intent to submit an 8-hour O3 Flex plan to keep existing measures in place while considering additional proactive steps than can reasonably be taken to protect the health of our citizens. One of the additional steps recently considered and supported by a vote of the CAC is to ask TCEQ to implement an ozone watch and warning system similar to the ones in Dallas and San Antonio. I am hopeful that this request will meet with the TCEQ's favorable approval, and that such a system, based on regional monitoring and meteorological data can be implemented by the next ozone season.

We look forward to our continued work with the TCEQ on safeguarding our air resources, and want to offer our thanks to your staff in particular for all the assistance they have provided to improve our regional air quality monitoring initiatives.

Regards,

Will Wynn
Chairman
Central Texas Clean Air Coalition

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

July 3, 2007

The Honorable Will Wynn, Chair
Central Texas Clean Air Coalition
P. O. Box 17848
Austin, Texas 78760

Dear Mayor Wynn and Members of the Central Texas Clean Air Coalition:

I'm writing in response to the letter that the Central Texas Clean Air Coalition provided to the Texas Commission on Environmental Quality (TCEQ) on April 17, 2007, in which six requests were made of the agency regarding the development of an Eight-Hour Ozone Flex Program. Following are the requests and the agency's responses.

1) Will the existing Early Action Compact (EAC) State Implementation Plan (SIP) measures remain in place for the duration of the Eight-Hour Ozone Flex Program (a five-year term with renewal options)?

The Austin-Round Rock EAC State Implementation Plan (SIP) adopted on November17, 2004, by the Commission includes a commitment to maintain controls through 2012. The EAC plan was required to have "a component to address emissions growth at least five years beyond December 31, 2007, ensuring the area will remain in attainment of the eight-hour standard during that period." The TCEQ does not have any plans to discontinue the state's measures - two-speed idle (TSI) and onboard diagnostic (OBD) based vehicle Inspection and Maintenance (I/M) program in Travis and Williamson Counties; Low-Income Vehicle Repair Assistance Program (LIRAP) in Travis and Williamson Counties; portable fuel container statewide requirements; Stage 1 Vapor Recovery requirements; solvent using processes; and cutback asphalt restrictions. In regards to participation in the Texas Emission Reduction Plan (TERP), the TCEQ has met the two tons per day commitment agreed upon in the EAC. However, if grants are available in the Austin-Round Rock area in the future, we encourage prospective participants in the Austin-Round Rock area to apply.

Idling restrictions on heavy-duty diesel vehicles (14,000 pounds or more) are also a component of the EAC. However, the Memorandum of Agreement (MOA) with the TCEQ and local entities expires January 2, 2008. If the local area wishes to continue this program, the MOA will need to be renewed by all parties.

2) Can we get an updated list of state and federal measures in place or expected to be in place during the Eight-Hour Ozone Flex Program MOA timeframe?

A list of current state and federal initiatives in place in the Central Texas area is enclosed. We cannot predict what the commission or the federal government may require in the future. You are encouraged to participate in future development of state-level control strategies.

3) Will the TCEQ be able to commit a specified amount of Texas Emission Reduction Plan (TERP) money to the Austin-Round Rock region?

   TERP money distribution is determined by the Commissioners, and I cannot predict where future funding will be allocated. Legislative changes from the 80th session will also require revisions to the TERP rules which may affect where TERP funding will be dedicated in the future. Therefore, a commitment to a specified level of TERP funding cannot be made at this time for the Eight-Hour Ozone Flex Program.

4) If the region reaches a trigger that requires inclusion of a contingency measure in the SIP, can the TCEQ ensure that the SIP revision will be accomplished within 24 months?

   The current commission cannot commit to future rulemaking for a future commission. Therefore, the commission cannot commit to future rulemaking for an enhanced inspection and maintenance program or requiring Texas Low Emission Diesel (TxLED). However, the commission will assess the situation and determine the appropriate strategy with the local area.

5) Can the TCEQ accommodate the propose timeline?

   The TCEQ is prepared to meet the proposed timeline for the Eight-Hour Ozone Flex Program. However, agency approval is only one element of the timeline and it will be imperative for the local organizations, as well as the EPA to maintain their timeline commitments for the Eight-Hour Ozone Flex Program MOA to go to agenda in March 2008.

6) Does the TCEQ have additional ideas for measures that it would like our region to consider?

   At this time, the agency does not have any additional ideas for implementation under the Eight-Hour Ozone Flex Program that you have proposed. Staff will continue to work with your organization and make any new information available.

The TCEQ commends the Central Texas Clean Air Coalition's continuing efforts to maintain clean air in Central Texas. The area continues to take every opportunity to maintain its attainment status. The TCEQ supports your efforts in developing the Eight-Hour Ozone Flex Program with the revisions provided. If you have any questions or need any assistance, please feel free to contact Susana M. Hildebrand, P.E., at 512/239-4699.

Sincerely,

Glenn Shankle, Executive Director
Texas Commission on Environmental Quality

Enclosure

Federal and State Control Measures Applicable in the Central Texas Area

Federal Measures	Descriptions
Federal Area/Non-Road Measures	EPA has implemented a series of strategies for area and non-road sources. Some of these include the gas engine rule and marine recreational engine standards.
Federal On-Road Measures	EPA has implemented a series of strategies for on-road vehicles. Tier 1 and Tier 2 vehicle standards, low- sulfur diesel standards, National Low Emission Vehicle standards, and reformulated gasoline.
State Measures	**Descriptions**
California Gasoline Engines	California standards for non-road gasoline engines 25 horsepower or larger.
Gas-Fired Heaters and Small Boilers	Rule limiting nitrogen oxide (NO_X) emissions from these small-scale residential and industrial sources.
Texas Low Emission Diesel – TxLED	Requires all diesel for both on-road and non-road use to have a lower aromatic content and a higher cetane number.
Texas Emission Reduction Plan – TERP	TERP provides grant funds for heavy-duty diesel engine replacement/retrofit. Replaces construction restrictions and Tier 2 and Tier 3 accelerated purchases.
Portable Fuel Containers Rule	Establishes new design "no-spill" criteria requirements for portable fuel containers sold, offered for sale, manufactured, and/or distributed in Texas.
Inspection and Maintenance – I/M	I/M requires the regular inspection of vehicles 2–24 years old in Travis and Williamson Counties. Vehicles must be inspected through Department of Public Safety–certified inspection stations for emissions of nitrogen oxide (NO_X), volatile organic compounds (VOCs) and carbon monoxide (CO).
Low-Income Vehicle Repair Assistance Program – LIRAP	Low-Income Vehicle Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program (LIRAP) in Travis and Williamson Counties
Low Reid Vapor Pressure Gasoline – Low RVP	Low RVP gasoline is fuel that is refined to have a lower evaporation rate and lower volatility than conventional gasoline. It also reduces the evaporative emissions generated during vehicle refueling and therefore decreases the emissions of volatile organic compounds (VOCs) and other ozone-forming emissions.

Stage I Vapor Recovery for stations with greater than or equal to 25,000 gallon per month output	Stage I vapor recovery is a control strategy to capture gasoline vapors that are released when gasoline is delivered to a storage tank. The vapors are returned to the tank truck as the storage tank is being filled with fuel, rather than released to the ambient air.
Solvent Using Processes – Degreasing	Volatile organic compound (VOC) control strategy for solvent-cleaning operations in batch-loaded cold cleaners, open-top vapor degreasers, conveyorized degreasers, and air-tight and airless cleaning systems.
Cutback Asphalt Restrictions	Volatile organic compound (VOC) solvents used in conventional cutback asphalt for the paving of roadways, driveways, or parking lots is restricted to no more than 7.0 percent of the total annual volume averaged over a two-year period. This applies to asphalt used by or specified by any state, municipal, or county agency that uses or specifies the type of asphalt application from April 16 – September 15.
Idling Restrictions on Heavy-Duty Vehicle Engines	Limits heavy-duty motor vehicle idling to five consecutive minutes from April through October within the political jurisdiction of any local government that has signed a memorandum of agreement with the commission to delegate enforcement to a local enforcement agency.

Appendix B
Emission Reduction Measures

DRAFT Appendix B

Local Government 8-Hour O3 Flex Program Emission Reduction Measures

Emission Reduction Measure	City of Austin	Travis County	City of Round Rock *	Williamson County	City of San Marcos *	Hays County *	City of Bastrop *	City of Elgin *	Bastrop County *	City of Lockhart *	City of Luling *	Caldwell County *
Access Management							X	X		X		
Airport Clean Air Plan, includes:												
• ABIA Airside Incentives have infrastructure in place at airport for use by airside tenants	X											
• Alternative fuels for shuttle buses	X											
• Alternative fuels available for Aviation Fleet landside users.	X											
• ABIA alternative fuel infrastructure available at airport for landside users	X											
Alternative Commute Infrastructure	X						X	X				
Alternative Fuel Vehicles	X	X	X									
Business Evaluation of Fleet Useage, Including Operations and Right Sizing		X	X	X								
Cleaner Diesel		X	X	X		X	X	X	X			
Commute Solutions Programs, may include	X									X		
• Compressed Work Week	X	X	X						X		X	
• Flexible Work Schedule	X	X	X									
• Carpool or Alternative Transportation Program, may include incentive	X	X										
• Transit Pass Subsidized by Employer	X											
• Teleworking (full time)	X											
• Teleworking (part time)	X		X									
Contractor provisions for high ozone days	X											
Direct Deposit	X	X	X	X	X	X	X		X	X		X
Drive-Through Facilities on Ozone Action Days		X								X		
e-Government and/or Available Locations	X	X	X	X	X	X						
Electric utility investments in energy demand management programs	X											
Environmental dispatch of power plants	X											

Emission Reduction Measure	City of Austin	Travis County	City of Round Rock *	Williamson County	City of San Marcos *	Hays County *	City of Bastrop *	City of Elgin *	Bastrop County *	City of Lockhart *	City of Luling *	Caldwell County *
Expedited permitting for mixed use, transit oriented or in-fill development							X	X				
Fueling of Vehicles in the Evening	X	X	X	X		X			X	X	X	X
Landscaping voluntary start at noon on high ozone days (education program)										X		
Low Emission Vehicles	X	X	X	X						X		X
Low VOC Asphalt		X	X									
Low VOC Roadway Striping Material	X	X	X	X		X	X	X		X		
Open Burning Restrictions			X				X	X				
Ozone Action Day Program, includes:	X	X	X	X	X	X	X	X	X	X	X	X
• Employee Education Program	X	X	X	X	X	X	X	X	X	X	X	X
• Public Education Program	X	X	X	X	X	X	X	X	X	X	X	X
• Ozone Action Day Notification Program	X	X	X	X	X	X	X	X	X	X	X	X
• Ozone Action Day Response Program	X	X	X	X		X						X
Resource Conservation	X	X	X	X	X	X					X	
Shaded Parking	X	X										
Shift the electric load profile	X											
Texas Low Emission Diesel (TxLED) Equivalent for Fleets	X	X										
Transit-Oriented Development	X											
Transportation Emission Reduction Measures (TERMs)	X	X	X		X		X	X				
Tree Planting	X	X	X	X	X	X	X	X		X		
Urban Heat Island/Cool Cities Program	X											
Vehicle Maintenance	X	X	X	X	X	X			X			X

* Denotes local government EAC commitments continued for the 8-hour O3 Flex Program, contingent on local government confirmation.

Appendix B DRAFT
8-Hour O3 Flex Program Participating Agency Emission Reduction Measures

Emission Reduction Measure	Capital Metro	CAMPO	TxDOT Headquarters*	TxDOT Austin*	TCEQ	CAPCOG	LCRA	CTRMA
Transportation Emission Reduction Measures (TERMs)	X			X				
Access Management				X				
Low VOC Striping Material	X			X				X
Tree Planting				X			X	X
Commute Alternatives, including:								
• Compressed Work Week	X	X		X	X			
• Flexible Work Schedule	X	X		X	X	X		
• Carpool or Alternative Transportation, may include incentives	X				X		X	
• Employer Subsidized Transit	X	X						
• Teleworking (full time)								
• Teleworking (part time)		X		X	X			
• Bicycle and Pedestrian Facilities							X	
Direct Deposit	X	X		X	X	X	X	X
e-Government and/or Available Locations	X	X			X	X		
Fueling of Vehicles in the Evening	X			X				X
Resource Conservation	X	X		X	X	X	X	X

Emission Reduction Measure	Capital Metro	CAMPO	TxDOT Headquarters*	TxDOT Austin*	TCEQ	CAPCOG	LCRA	CTRMA
Ozone Action Day Education Program, includes:								
Employee Education Program	X	X		X	X	X	X	X
Public Education Program	X	X		X	X			X
Ozone Action Day Notification Program	X	X		X	X	X	X	X
Ozone Action Day Response Program								
Alternative Fuel Vehicles	X			X	X			
Right Sizing	X							
5-minute Limit on Diesel Idling	X						X	
Cleaner Diesel	X		X				X	
Vehicle Maintenance	X				X		X	
Vapor Recovery on Pumps	X							
Low VOC Asphalt	X							
Low-Emission Vehicles	X		X		X		X	
TERP (Texas Emission Reduction Program)	X		X					
Transit-Oriented Development	X							X
Shaded Parking					X			X

* Denotes agency EAC commitments continued for the 8-hour O3 Flex Program, contingent on agency confirmation.

Appendix C
TERP

Aplicant	Area	Aproved Amount	Total Projected NOx Reduction	Tons per Day NOx Reduced	Projected cost per ton	Category	Description
Capital Excavation Company	Austin	$ 130,911	11.20	0.007	$ 11,687	Non-Road	PURCHASE (1) MOTOR GRADER AND LEASE (4) EXCAVATORS
Jimmy Evans Company, Ltd	Austin	$ 42,361	3.57	0.003	$ 11,857	Non-Road	PURCHASE (1) WHEEL LOADER, (1)MOTOR GRADER
Del Webb Corporation	Austin	$ 14,450	1.85	0.002	$ 7,807	Non-Road	LEASE (1) WHEEL LOADER
Capital Metropolitan Transportation Authority	Austin	$ 92,181	24.79	0.099	$ 3,718	On-Road	TXLED
JC Evans Construction Holding, Inc. (dba JC Evans)	Austin	$ 47,278	3.99	0.003	$ 11,837	Non-Road	Lease 2 Non-Road Graders
K & K Enterprises	Austin	$ 17,480	2.50	0.002	$ 7,000	Non-Road	REPLACEMENT OF 1 JOHN DEERE 655C TRACK LOADER
B & B Truck Tractor & Parts	Austin	$ 13,045	1.86	0.001	$ 7,000	On-Road	REPLACEMENT OF 1 KENWORTH T300
Texas Landfill Management, LLC	Austin	$ 160,625	23.01	0.018	$ 6,979	Non-Road	REPLACEMENT OF 1 SCRAPER AND 1 COMPACTOR
Texas Lehigh Cement Company, LP	Austin	$ 57,407	8.66	0.007	$ 6,626	Non-Road	REPOWER OF 1 LOADER
Texas Lehigh Cement Company, LP	Austin	$ 455,254	95.63	0.055	$ 4,761	Non-Road	REPLACEMENT OF 3 TRUCKS
BFI Waste Systems Of North America, Inc.	Austin	$ 204,000	29.19	0.023	$ 6,989	Non-Road	REPOWER OF 9 DOZERS AND SCRAPERS
Dean Word Company, Ltd.	Austin	$ 331,000	47.42	0.027	$ 6,981	Non-Road	REPLACEMENTS OF 6 DOZERS AND GRADERS
Texas Landfill Management, LLC	Austin	$ 36,398	7.35	0.006	$ 4,955	Non-Road	DOZER
Elgin Butler Brick Company	Austin	$ 65,380	9.34	0.007	$ 7,004	Non-Road	REPLACEMENT OF VOLVO L150E AND DRESSER 520B
Centex Materials, LLC	Austin	$ 141,411	17.79	0.014	$ 7,949	Non-Road	REPOWER OF 2 LOADERS AND 1 DOZER
Yarrington Road Materials LP	Austin	$ 98,000	14.00	0.008	$ 6,998	Non-Road	REPLACEMENT OF 2 LOADERS
Austin Engineering Company, Inc.	Austin	$ 9,310	1.33	0.001	$ 7,023	Non-Road	REPLACEMENT OF 1 CAT 930
KBJ Partnership	Austin	$ 48,826	6.98	0.005	$ 7,000	Non-Road	REPLACEMENT OF 1 EXCAVATOR
KBJ Partnership	Austin	$ 6,000	2.25	0.002	$ 2,665	Non-Road	REPLACEMENT OF 1 BACKHOE LOADER
K & K Enterprises	Austin	$ 21,394	3.06	0.002	$ 7,000	Non-Road	REPLACEMENT OF 1 CAT 953C
Cunningham Constructors & Associates, Inc.	Austin	$ 22,878	3.27	0.002	$ 7,000	Non-Road	REPLACEMENT OF 1 KOMATSU PC200LC-7
K & K Enterprises	Austin	$ 24,001	3.43	0.003	$ 7,000	Non-Road	REPLACEMENT OF 1 CAT 225B
Centex Materials, LLC	Austin	$ 22,533	3.22	0.003	$ 7,000	Non-Road	REPLACEMENT OF 1 MICHIGAN 75E WHEEL LOADER
Texas Lehigh Cement Company, LP	Austin	$ 96,670	13.81	0.011	$ 7,000	Non-Road	REPLACEMENT OF 1 SHUTTLEWAGON RAIL CAR MOVER
Dean Word Company, Ltd.	Austin	$ 396,000	56.62	0.032	$ 6,994	Non-Road	REPLACEMENT & REPOWER OF 10 EXCAVATORS
Schroeder Construction Company, Ltd	Austin	$ 38,805	4.65	0.004	$ 8,341	Non-Road	REPLACEMENT OF 2 EXCAVATORS
Ella Contracting' Inc.	Austin	$ 112,381	16.05	0.013	$ 7,000	Non-Road	REPLACEMENT OF 4 DOZERS
Odeen Hibbs Trucking Company	Austin	$ 292,740	41.83	0.033	$ 6,998	On-Road	REPLACEMENT OF 8 TRUCKS
Texas Aggregates, LP	Austin	$ 463,000	66.21	0.053	$ 6,993	Non-Road	REPLACEMENT OF 1 DRAGLINE, 2 TRUCKS AND 1 BACKHOE
ID/Guerra L.P.	Austin	$ 30,407	4.37	0.002	$ 6,966	Non-Road	REPLACEMENT OF 1 EXCAVATOR
Aguado Stone, Inc.	Austin	$ 49,377	7.05	0.006	$ 7,000	Non-Road	REPLACEMENT OF 1 KOMATSU WA250 WHEEL LOADER
Haegelin Construction Company, Ltd	Austin	$ 81,970	10.86	0.009	$ 7,550	Non-Road	REPLACEMENT OF 3 EXCAVATORS
Austin White Lime Company	Austin	$ 594,096	84.87	0.049	$ 7,000	Non-Road	Replace 1 Non-Road Bore/Drill Rig, 2 Non-Road Forklifts, 2 Non-Road Off-Highway Trucks, 2 Non-Road Rubber Tire Loaders
Austin White Lime Company	Austin	$ 112,104	16.84	0.013	$ 6,657	Non-Road	REPOWER OF 2 HAUL TRUCKS
Cemex Construction Materials, LP	Austin	$ 149,730	21.42	0.012	$ 6,990	On-Road	REPLACEMENT OF 11 INTERNATIONAL 5600I CEMENT MIXERS
Shumaker Enterprises, Inc.	Austin	$ 45,913	6.56	0.005	$ 7,000	Non-Road	REPLACEMENT OF 1 KOMATSU PC 400-5 EXCAVATOR
Shumaker Enterprises, Inc.	Austin	$ 208,950	29.87	0.017	$ 6,995	Non-Road	REPLACEMENT OF 2 LOADERS
Schroeder Construction Company, Ltd	Austin	$ 28,431	4.06	0.002	$ 7,000	Non-Road	REPLACEMENT OF 1 KOMATSU PC200LC-6 EXCAVATOR
Black Sheep Independ Dba Denvers Towing	Austin	$ 7,366	1.05	0.001	$ 7,000	On-Road	REPLACEMENT OF 1 FORD F350 TRUCK
S & M Business, Inc. Dba Austin Land Service	Austin	$ 71,924	10.27	0.006	$ 7,000	Non-Road	REPLACEMENT OF 1 LOADER
Weisman Equipment Company, Ltd.	Austin	$ 10,272	1.47	0.001	$ 7,000	Non-Road	REPOWER OF 1 LOADER
Weisman Equipment Company, Ltd.	Austin	$ 92,540	13.22	0.008	$ 6,999	Non-Road	REPLACEMENT OF 3 GRADERS
Weisman Equipment Company, Ltd.	Austin	$ 81,694	11.75	0.006	$ 6,954	Non-Road	REPLACEMENT OF 12 PAVER, LOADERS, DOZERS
Cashway Building Materials	Austin	$ 7,490	2.16	0.001	$ 3,468	Non-Road	Replace 1 Non-Road Forklift
Capitol Beverage	Austin	$ 7,900	1.58	0.001	$ 5,000	Non-Road	Replace 1 Non-Road Forklift
Capitol Beverage	Austin	$ 12,670	2.54	0.002	$ 4,988	Non-Road	Replace 1 Non-Road Forklift
Capitol Beverage	Austin	$ 7,490	1.50	0.001	$ 4,993	Non-Road	Replace 1 Non-Road Forklift
Capitol Beverage	Austin	$ 12,960	2.59	0.002	$ 5,004	Non-Road	Replace 1 Non-Road Forklift
Capitol Beverage	Austin	$ 6,730	1.79	0.001	$ 3,760	Non-Road	Replace 1 Non-Road Forklift
Stark's Welding	Austin	$ 4,750	0.95	0.001	$ 5,000	Non-Road	Replace 1 Non-Road Forklift
Taylor Compress	Austin	$ 8,290	1.66	0.001	$ 4,994	Non-Road	Replace 1 Non-Road Forklift
Taylor Compress	Austin	$ 3,010	0.60	0.000	$ 4,992	Non-Road	Replace 1 Non-Road Forklift
Southeastern Freight Lines, Inc.	Austin	$ 10,590	2.12	0.002	$ 4,996	Non-Road	Replace 1 Non-Road Forklift
Southeastern Freight Lines, Inc.	Austin	$ 6,620	1.33	0.001	$ 4,992	Non-Road	Replace 1 Non-Road Forklift
Texas Lehigh Cement Company, LP	Austin	$ 259,185	41.72	0.024	$ 6,212	Non-Road	Replace one 1989 CAT Rubber Tire Loader with a 2005 CAT Rubber Tire Loader
BFI Waste Services of Texas, LP	Austin	$ 60,778	13.51	0.008	$ 4,500	On-Road	Replace 6 On-road Trucks
City of Austin	Austin	$ 205,000	29.30	0.017	$ 6,996	On-Road	Slow Fill & Fast Fill CNG Refuling Station For City Refuse Trucks, Replace 6 On-Road Trucks

Martin A. Hernandez	Austin	$	114,408	13.83	0.008	$	8,272 On-Road	Replacement of 1989 Peterbilt with 2005 Peterbilt
Capital Metropolitan Transportation Authority	Austin	$	428,852	85.80	0.049	$	4,998 On-Road	Re-power 36 Urban Busses
Joe L Cook	Austin	$	70,263	8.27	0.007	$	8,500 On-Road	Replacement Of 1982 Ford With 2005 Peterbuilt
Louis Vasquez Gutierrez	Austin	$	105,961	12.47	0.007	$	8,500 On-Road	Replacement Of 1990 Frieghtliner With 2006 Frieghtliner
Kathleen S. Bush	Austin	$	128,843	16.44	0.009	$	7,836 On-Road	Replacement Of 1989 International With 2005 International
Rocking C Trucking	Austin	$	46,974	5.53	0.003	$	8,500 On-Road	Replacement Of 1993 Frieghtliner With 2004 Kenworth
Houshang Ostadian	Austin	$	82,635	9.72	0.006	$	8,500 On-Road	Replacement Of 1981 International With 2005 Freightliner
Blair Trucking, Inc.	Austin	$	100,370	14.34	0.011	$	7,000 On-Road	Replace 3 Trucks
K B J Partnership	Austin	$	30,805	4.47	0.004	$	6,894 Non-Road	Replace One Wheel Loader
Dean Allen Sauer	Austin	$	68,500	12.59	0.008	$	5,442 On-Road	Replacement Of 1989 Peterbilt With 2002 Peterbilt
Jackson Trucking	Austin	$	89,000	18.84	0.015	$	4,724 On-Road	Replace 1 On-road Truck
Ray McEachern	Austin	$	99,000	24.66	0.020	$	4,015 On-Road	Replace 7 On-road Trucks
K & K Enterprises	Austin	$	42,403	6.15	0.005	$	6,894 Non-Road	Replace 3 Wheel Loaders
Austin Engineering Company, Inc.	Austin	$	23,833	3.46	0.003	$	6,894 Non-Road	Replace 1 Wheel Loader
Leonardo Avila	Austin	$	34,015	9.60	0.006	$	3,543 On-Road	Replacement Of 1988 Kentworth With 1999 Flt
Robert Juarez	Austin	$	96,779	11.39	0.009	$	8,500 On-Road	Replacement Of 1989 Freightliner With 2005 Mack
Hays Consolidated Independent School District	Austin	$	79,345	11.33	0.006	$	7,000 On-Road	Replace 11 School Busses (Verification Forms Are Signed By Authorized Official Of The Application; Certification Forms Have See Attached)
Austin Bridge & Road, LP	Austin	$	71,122	14.42	0.012	$	4,931 Non-Road	Replace 1 Cold Milling Machine
Eugene R Kinde, Dba Minn Tex Transportation	Austin	$	94,438	15.83	0.009	$	5,967 On-Road	Replacement Of 1987 Kenworth With 2004 Peterbilt
Charles Dirk Talbot	Austin	$	108,277	12.74	0.007	$	8,500 On-Road	Replace 1 On-Road Truck
Coors of Austin, LP	Austin	$	73,783	10.54	0.006	$	7,000 On-Road	Replace 10 Trucks
Trans Global Solutions, Inc.	Austin	$	1,090,000	206.78	0.109	$	5,271 Locomotive	Retro-fit Of 5 Switcher Locomotives
Juan R. Berberena	Austin	$	51,386	8.53	0.005	$	6,026 On-Road	Replace 1 Truck
Ester Marshall dba Marshall Trucking	Austin	$	95,200	12.97	0.007	$	7,342 On-Road	Replace 1 On Road Truck
Robert M. Sullivan, Jr.	Austin	$	84,758	12.49	0.007	$	6,784 On-Road	Replace 1 On Road Truck
Pablo Jaimes Martinez	Austin	$	67,200	9.45	0.005	$	7,112 On-Road	Replace 1 On Road Truck
Oscar L. Barnes	Austin	$	103,200	14.55	0.008	$	7,092 On-Road	Replace 1 On Road Truck
Eladio Jaimes	Austin	$	67,148	8.64	0.007	$	7,768 On-Road	Replace 1 On Road Truck
TXI Operations, LP (Austin Green S & G)	Austin	$	45,700	12.37	0.007	$	3,694 Non-Road	Repower 2 Non Road Truck Engines
Edward Rogers	Austin	$	103,200	12.96	0.007	$	7,965 On-Road	Replace 1 On Road Truck
La Fuente Trucking	Austin	$	82,275	18.51	0.011	$	4,445 On-Road	Replace 1 On Road Truck
Moises Rosales	Austin	$	104,598	17.52	0.010	$	5,972 On-Road	Replace 1 Dump Truck
Arnold T. Sanchez	Austin	$	62,833	12.58	0.007	$	4,997 On-Road	Replace 1 Truck
J.D. Abrams, LP	Austin	$	8,748	2.45	0.002	$	3,577 Non-Road	Repower 1 Crane Engine
Darral G. Henderson	Austin	$	91,558	16.90	0.014	$	5,418 On-Road	Replace 1 Truck
Jose F. Solorzano	Austin	$	95,597	12.09	0.007	$	7,909 On-Road	Replace 1 Truck
Liberty Excavation	Austin	$	102,185	22.87	0.013	$	4,469 On-Road	Replace 1 Haul Truck And 1 Dump Truck
Jose B. Pedroza	Austin	$	80,091	16.17	0.009	$	4,954 On-Road	Replace 1 Truck
Carlos Garcia	Austin	$	77,000	14.44	0.008	$	5,333 On-Road	Replace 1 Truck
M & M Trucking (Henry Medel)	Austin	$	69,000	12.93	0.007	$	5,335 On-Road	Replace 1 Truck
M & M Trucking (Henry Medel)	Austin	$	69,000	13.10	0.007	$	5,266 On-Road	Replace 1 Truck
Edwin Clay Polasek	Austin	$	89,786	17.03	0.010	$	5,271 On-Road	Replace 1 Truck
Edwin Clay Polasek	Austin	$	89,786	17.32	0.010	$	5,183 On-Road	Replace 1 Truck
Thomas P. Strazza	Austin	$	80,000	15.24	0.009	$	5,248 On-Road	Replace 1 Truck
Alfonso Orocio	Austin	$	62,000	12.64	0.007	$	4,906 On-Road	Replace 1 Truck
Feliciano Mendoza	Austin	$	63,000	12.03	0.007	$	5,236 On-Road	Replace 1 Truck
Roy Paredes Trucking	Austin	$	70,000	13.47	0.008	$	5,195 On-Road	Replace 1 Truck
Ramiro Hernandez	Austin	$	69,062	14.44	0.008	$	4,784 On-Road	Replace 1 Truck
Sergio Nino	Austin	$	81,000	16.56	0.009	$	4,891 On-Road	Replace 1 Truck
Capital Metropolitan Transportation Authority	Austin	$	357,234	72.90	0.042	$	4,900 On-Road	Re-Power 34 Buses
Capital Metropolitan Transportation Authority	Austin	$	209,204	42.69	0.024	$	4,900 On-Road	Re-Power 28 Busses
Sammie J. Kellough	Austin	$	148,000	27.94	0.016	$	5,297 On-Road	Replace 2 Trucks
Raymond Vallejo, Jr.	Austin	$	73,000	14.01	0.008	$	5,210 On-Road	Replace 1 Truck
Wright Distributing Company	Austin	$	67,500	13.45	0.008	$	5,019 On-Road	Replace 4 Delivery Trucks
Bobby D. Alba	Austin	$	80,000	17.11	0.010	$	4,677 On-Road	Replace 1 Truck
Bobby D. Alba	Austin	$	90,000	16.89	0.010	$	5,330 On-Road	Replace 1 Truck
Bobby D. Alba	Austin	$	90,000	17.40	0.010	$	5,173 On-Road	Replace 1 Truck
Bobby D. Alba	Austin	$	90,000	17.11	0.010	$	5,261 On-Road	Replace 1 Truck
Adam Melendrez	Austin	$	80,949	15.29	0.009	$	5,296 On-Road	Replace 1 Truck
Dirk McCune Trucking	Austin	$	172,728	32.46	0.022	$	5,321 On-Road	Replace 3 Trucks
Leon Kellough, Jr.	Austin	$	72,000	13.47	0.008	$	5,344 On-Road	Replace 1 Dump Truck
Juan DeAnda, Jr.	Austin	$	69,000	13.34	0.008	$	5,173 On-Road	Replace 1 Truck
Babette's Trucking	Austin	$	73,650	20.41	0.012	$	3,608 On-Road	Replace 1 Truck
Isidoro A. Martinez	Austin	$	77,000	14.56	0.008	$	5,289 On-Road	Replace 1 Dump Truck
Gloria Crowder	Austin	$	74,000	17.58	0.010	$	4,208 On-Road	Replace 1 Truck
Isidoro A. Martinez	Austin	$	77,000	14.86	0.008	$	5,181 On-Road	Replace 1 Dump Truck
Miguel Negrete	Austin	$	76,000	17.96	0.010	$	4,231 On-Road	Replace 1 Truck
Tex Mix Partners, Ltd. (dba Tex Mix Concrete)	Austin	$	15,250	3.47	0.002	$	4,400 On-Road	Replace 1 Truck
R.T.I. Hot Mix, Ltd.	Austin	$	105,649	22.31	0.016	$	4,734 Non-Road	Repower 1 Off-HighwayTruck and 1 Eagle Portable Rock Plant
Schwab Excavation, Inc.	Austin	$	386,718	75.49	0.043	$	5,123 On-Road	Replace 3 on-road tractors and 1 non-road grader
I Bar Enterprises, Ltd.	Austin	$	69,492	18.34	0.010	$	3,789 On-Road	Replace 1 Truck
Centex Materials, LLC	Austin	$	1,683,000	348.00	0.199	$	4,836 Non-Road	Replace 5 Off-Highway Trucks, Replace 4 Wheel Loaders
V&G Luna Construction, LLC (dba L&L Construction)	Austin	$	68,995	12.74	0.007	$	5,416 On-Road	Replace 1 Truck

Centex Materials, LLC	Austin	$	747,000	143.42	0.082	$	5,209	On-Road	Replace 18 Cement Trucks
Texas Aggregates, LP	Austin	$	399,894	83.02	0.047	$	4,817	Non-Road	Replace 1 Dragline & 2 Off Highway Truck
Douglas R. Wiggins, Jr.	Austin	$	84,000	17.96	0.010	$	4,676	On-Road	Replace 1 Truck
Trans Global Solutions, Inc.	Austin	$	896,000	199.13	0.078	$	4,500	Locomotive	Retrofit/Add-On 4 Switchers
GH Contracting, Inc.	Austin	$	24,016	4.80	0.003	$	5,000	Non-Road	Replace 1 Excavator
McKinney Drilling Company	Austin	$	1,303,535	275.67	0.158	$	4,729	Non-Road	Repower 1 Haul Truck, Replace 6 Compressors, Repower 11 Cranes, Repower 20 Drilling Rigs, Repower 1 Water Truck, Repower 1 Pump, Repower 1 Welder
Leander Independent School District	Austin	$	19,466	6.47	0.004	$	3,010	On-Road	Replace 5 School Busses
BPM Leasing, LLC	Austin	$	48,808	8.87	0.005	$	5,500	On-Road	Replace haul truck
BPM Leasing, LLC	Austin	$	49,443	8.99	0.005	$	5,500	On-Road	Replace haul truck
Bedrock Stone & Design, Inc.	Austin	$	49,443	8.99	0.005	$	5,500	On-Road	Replace flatbed truck
Blair Trucking, Inc.	Austin	$	76,513	13.91	0.008	$	5,500	On-Road	Replace haul truck
Genaro Guerrero	Austin	$	50,712	9.22	0.005	$	5,500	On-Road	Replace dump truck
Daniel Briseno	Austin	$	50,289	9.14	0.005	$	5,500	On-Road	Replace dump truck
Ray Crain Trucking	Austin	$	74,119	13.48	0.008	$	5,500	On-Road	Replace haul truck
Ray Crain Trucking	Austin	$	73,820	13.42	0.008	$	5,500	On-Road	Replace haul truck
Ray Crain Trucking	Austin	$	73,820	13.42	0.008	$	5,500	On-Road	Replace haul truck
Ray Crain Trucking	Austin	$	77,410	14.07	0.008	$	5,500	On-Road	Replace haul truck
Ray Crain Trucking	Austin	$	74,119	13.48	0.008	$	5,500	On-Road	Replace haul truck
P.C.W. Construction, Inc.	Austin	$	55,854	10.16	0.006	$	5,500	On-Road	Replace dump truck
P.C.W. Construction, Inc.	Austin	$	55,220	10.04	0.006	$	5,500	On-Road	Replace dump truck
Hence W. Irby, Jr.	Austin	$	70,766	13.42	0.008	$	5,272	On-Road	Replace haul truck
Jose J. Cancino (dba Estrella Trucking Co., Inc.)	Austin	$	19,639	3.57	0.002	$	5,500	On-Road	Replace dump truck
Alberto Carrillo	Austin	$	49,443	8.99	0.005	$	5,500	On-Road	Replace dump truck
Vera's Trucking	Austin	$	73,521	13.37	0.008	$	5,500	On-Road	Replace haul truck
William Marshal Copeland	Austin	$	73,521	13.37	0.008	$	5,500	On-Road	Replace dump truck
Poldrack Grain & Cattle	Austin	$	58,379	11.41	0.007	$	5,117	On-Road	Replace haul truck
James R. Brown	Austin	$	76,513	13.91	0.008	$	5,500	On-Road	Replace haul truck
Eduardo Bustillos	Austin	$	76,513	13.91	0.008	$	5,500	On-Road	Replace dump truck
Felix P. Loza	Austin	$	55,576	10.10	0.006	$	5,500	On-Road	Replace dump truck
Greg D. Werchan	Austin	$	50,289	9.14	0.005	$	5,500	On-Road	Replace dump truck
Simon P. Macias	Austin	$	53,672	9.76	0.006	$	5,500	On-Road	Replace haul truck
Balli Trucking, Inc.	Austin	$	73,820	13.42	0.008	$	5,500	On-Road	Replace haul truck
David Fenske	Austin	$	73,521	13.37	0.008	$	5,500	On-Road	Replace haul truck
Don Farmer	Austin	$	79,504	14.46	0.008	$	5,500	On-Road	Replace haul truck
H & H Foradory Construction, Inc.	Austin	$	73,521	13.37	0.008	$	5,500	On-Road	Replace haul truck
TOTAL/AVERAGE		**$**	**20,332,917**	**3684.30**	**2.26**	**$**	**5,934**	**# of PROJECTS**	**165**

Appendix D
TERMS

DRAFT Appendix D Primary Terms

Traffic Signal Improvements

SPONSORING AGENCY	PROJECT NAME	PROJECT DESCRIPTION	PROJECT LOCATION	IMPLEMENTATION. DATE	# SIGNALIZED INTERSECTIONS
City of Austin	Signal Synchronization	* Annual synchronizations include an average of 250 signals, within 30 to 35 signalized segments or segment groups.	Various	2008	250
City of Austin	Signal Synchronization	* Annual synchronizations include an average of 250 signals, within 30 to 35 signalized segments or segment groups.	Various	2009	250
City of Round Rock	Signal Improvement	Install New Traffic Signals	Various	2008	3
TxDOT	Signal improvements	Install New Traffic Signals	Various	2008	3

Intersection Improvements

SPONSORING AGENCY	PROJECT NAME	PROJECT DESCRIPTION	PROJECT LOCATION	IMPLEMENTATION. DATE	# INTERSECTIONS
City of Round Rock	Sam Bass Rd.	Construct new thru lane	At IH 35 SB frontage	2008	1
City of Round Rock	Sam Bass Rd.	Construct RT Lane and 2 LT lanes	At Chisolm Trail	2008	1
TxDOT	FM 973	Construct continuous LT lane	From SH 71 to Pearce Ln.	2008	2
TxDOT	IH 35	Frontage Road Improvements & Turn Arounds	At RM 620 to S of McNeil	2008	1
TxDOT	US 183	Construct Grade Separation Structure	@ FM 672 in Caldwell County	2008	1
TxDOT	IH 35	Construct Turn Arounds	At SH 29 in Williamson County	2008	1

Bicycle and Pedestrian Projects

SPONSORING AGENCY	PROJECT NAME	PROJECT DESCRIPTION	PROJECT LOCATION	IMPLEMENTATION. DATE	PROJECT LENGTH (miles)
City of Round Rock	CR 122/Red Bud Lane	Construct sidewalks	From US 79 to Gattis School Rd.	2008	1.44

Intelligent Transportation System (ITS)

SPONSORING AGENCY	PROJECT NAME	PROJECT DESCRIPTION	PROJECT LOCATION	IMPLEMENTATION. DATE	PROJECT LENGTH (miles)
TxDOT	US 290	Install Conduit and Detection and Freeway Transportation Mgmt. System	From SPRR To US 183	2009	2.7
TxDOT	US 183	Complete Conduit and Detection and Freeway Transportation Mgmt System	From Lakeline Blvd to Travis County line	2009	4.5

Appendix E
TTI Study

Emissions Comparison Between Dirt Roads and Paved Roads Using Portable Emissions Measurement Systems

By

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Capital Area Council of Governments

Contract No. R08-4/05-TTI-01

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EXECUTIVE SUMMARY

The overall goal of this study was to determine the possible increase in vehicular emissions as a result of traveling on a dirt road versus a paved road. The approach followed in the study was to use portable emissions measurement system (PEMS) equipment onboard two light-duty vehicles (2000 Ford Explorer and 1998 For F150) that have extensive dirt road mileage and to perform several tests on a dirt road and a paved road while the vehicles were equipped with both dirty and clean air filters. A consistent drive cycle was used and emissions were collected on a second-by-second basis. A distance measurement instrument (DMI) with special driver assistance software was used to enable the driver to follow a consistent drive cycle. Comparisons were made between the emissions of vehicles with dirty and clean air filters and vehicles driving on the paved and dirt roads, while controlling for the vehicle type and drive cycle. The study concluded the following:

- The dirt road resulted in higher emissions than the paved road for all the pollutants tested.
- Emissions from the older Ford F-150 were consistently higher than those from the newer Ford Explorer for all pollutants.
- The dirty air filter resulted in higher NOx and CO_2 emissions than the clean air filter for all the scenarios and vehicles tested.
- The dirty air filter resulted in lower VOC emissions for all the scenarios and vehicles tested (due to the “open loop effect” from high engine loads placed by the selected drive cycle).
- In 16 of the 20 scenarios, the dirty air filter resulted in higher emissions than the clean air filter for CO and PM (the four counter intuitive CO and PM results are due to measurement error).
- Fuel consumption appears to be higher with a dirty air filter than with a clean air filter and higher on a dirt road than on a paved road, particularly for older vehicles (based on CO_2 emissions).

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

Rural counties and cities across the U.S. typically have large percentages of dirt roads as compared to more urbanized counties and cities (*1*). In addition to the well documented safety concerns related to dirt roads (propensity for potholes, reduced visibility due to dust, reduced traction, and reduced geometric standards), there has been recent discussion to also consider the air quality aspects related to dirt roads. Dirt roads generate fugitive dust due to traffic. This dust contains a broad range of particulates including fine particulate matter (PM). In addition to concerns about dust, there are questions concerning the possible negative impacts of dirt roads on tailpipe emissions of vehicles extensively using such roads (*2*).

Caldwell County, which is located south of Austin, Texas is an example of a county that is not only concerned about the PM emissions due to the dust caused by its dirt roads, but also the possible negative impact that these dirt roads have on the tailpipe emissions of the vehicles that use them on a regular basis. To examine these concerns, the Capital Area Council of Government (CAPCOG) commissioned the Texas Transportation Institute (TTI) to analyze the possible negative impacts of dirt roads on tailpipe emissions from light-duty gasoline vehicles.

The overall approach followed in the study was to use portable emissions measurement system (PEMS) equipment onboard two light-duty vehicles that have extensive dirt road mileage and to perform several tests on a dirt road and a paved road while the vehicles were equipped with both dirty and clean air filters. A consistent drive cycle was used and emissions were collected on a second-by-second basis. A distance measurement instrument (DMI) with special driver assistance software was used to enable the driver to follow a consistent drive cycle. Comparisons could be made between the emissions of vehicles with dirty and clean air filters and vehicles driving on the paved and dirt roads, while controlling for the vehicle type and drive cycle.

The paper is divided into the following five sections. The first section contains the introductory remarks. The second section describes the approach used in this study. The third section describes the results of the study. The fourth section contains the concluding remarks and the fifth section contains recommendations for future research in this area.

APPROACH

The following sections provide a more detailed description of the various components of this study.

Test Sites

This study was conducted in Caldwell County where the city of Lockhart is the county seat. Lockhart has a population of approximately 12,500 and is located approximately 25 miles south of Austin, Texas. This county has 360 lane miles of paved roads and 506 lane miles of dirt roads (*3*). The relatively high percentage of dirt roads (almost 60%) is typical of rural Texas. For testing purposes, the study team selected a two-mile stretch of a typical dirt road (FM 179) and a two-mile stretch of typical paved road (FM1185). Care was taken to select test sections that were fairly level and straight with very little traffic. The dirt road is covered with pit run gravel, which has a fine dust that is distributed into the air under traffic conditions.

Test Vehicles

The study team used two light-duty gasoline vehicles with considerable mileage on the county's dirt roads as test vehicles. The first test vehicle was a 2000 model year Ford Explorer with 4.0L engine and 95,480 accumulated miles. This vehicle is used by the county as a 911 dispatch vehicle and is often driven on the dirt roads. The second test vehicle was a 1998 model year Ford F-150 pickup truck with a 4.6L engine and 130,523 accumulated miles. This vehicle is used by the county for transporting people and materials and is often driven on the dirt roads. The county's maintenance department performs the maintenance on these vehicles replacing the air filters on these vehicles every 3,000 miles. The county maintenance department indicated that at the time of the study both vehicles had accumulated approximately 3,000 miles on their current air filters. Figure 1 shows a picture of the test vehicles on the dirt road.

Test Dates

The testing was performed from Thursday, June 16 to Tuesday, June 21, 2005. These testing dates could be considered as typical summer days in central Texas. The conditions were mostly dry and sunny with temperatures in the mid 90 degrees Fahrenheit, resulting in very dusty driving conditions along the dirt road.

Drive Cycle

There are numerous drive cycles available that were developed for different purposes. The most famous drive cycle is the so-called Federal Test Procedure (FTP) that was established in the 1960s to represent urban driving behavior (*4*). Other examples of modern drive cycles are the Highway Fuel Economy Driving Schedule (HWFET), New York City Cycle (NYCC), and LA92 Dynamometer Driving Schedule, often called the Unified driving schedule (*5*). These drive cycles each have unique applications that are not necessarily consistent with the focus of this study. Specifically, the study team sought a drive cycle that would be representative of driving conditions on a rural dirt road and at the same time be simple enough to replicate easily.

The United Nations Economic Commission for Europe (UN/ECE) Part 1 and Part 2 drive cycles developed in Europe showed the most potential for achieving the criteria set for the ideal drive cycle (*5*). The study team used these drive cycles as a basis and developed a new rural dirt road drive cycle for this study. Figure 2 shows a graph of this drive cycle, which includes typical driving behaviors that can be expected on a rural dirt road including acceleration, deceleration, cruising, and idling. The drive cycle also is simple enough so that it can be replicated through actual driving conditions, especially considering that it only takes approximately six minutes to drive and covers a distance of 2.04 miles.

Test Equipment

Portable Emissions Measurement System

The PEMS unit used in this study was the OEM-2100 "Montana" system manufactured by Clean Air Technologies International, Inc. and is shown in Figure 3. The OEM-2100 system is comprised of a gas analyzer, a PM measurement system, an engine diagnostic scanner, a global positioning system (GPS), and an on-board computer. The gas analyzer measures the volume percentage of oxides of nitrogen (NOx), hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), and oxygen (O_2) in the vehicle exhaust. The PM measurement capability includes a laser light scattering detector and a sample conditioning system. The engine scanner is connected to the data link of electronically controlled vehicles, from which engine and vehicle data can be downloaded during vehicle operation (*6*). Intake airflow, exhaust flow, and mass emissions are estimated using a method reported by Vojtisek-Lom and Cobb (*7*).

DMI

A DMI was used to track the drive cycle of the test vehicles as they were driven on the test roads. A sensor of the electronic DMI is attached to a test vehicle's transmission where it receives consecutive pulses while the vehicle is in motion. A DMI typically can provide distances and instantaneous speeds up to every 0.5 seconds. This detailed travel time information can be downloaded automatically to a portable computer in an easy-to-use data format (*8*).

The study team used the RAC 200 DMI system from JAMAR, Inc. for this study. Ridge Engineering developed a custom-designed software program to enable the driver of a test vehicle to follow a pre-selected drive cycle. The driver assistance software was installed on a laptop computer and connected to the RAC 200. The laptop computer would display a graph and a table with the desired speeds for each second of the drive cycle. While the test vehicle is driven, the actual speeds would be shown in conjunction with the desired speeds on both graphical and tabular formats. A person seated in the passenger seat of the test vehicle can observe this output and provide verbal instructions to the driver about the correct acceleration, deceleration, speeds, and cruising to most accurately track the desired drive cycle. Figure 2 shows an example of the screen provided by the DMI and customized software as well as data where the drive cycle is being tracked during actual driving conditions.

A follower vehicle with a yellow flashing light on its roof was used to follow the test vehicle to ensure that it did not get rear ended by vehicles not expecting the fairly erratic driving of the test vehicle being driven according to the drive cycle.

Test Protocol

The study team developed a test protocol that would provide the best opportunity to test the emissions differences as a result of prolonged driving on dirt roads versus paved roads. The effect of dirt road driving was captured in two ways:

- the test vehicles were driven with air filters that had not been changed for approximately 3,000 miles as well as with brand new air filters; and
- the test vehicles were driven on both the paved and dirt test routes.

Each test scenario was driven four times and the emissions, engine, and speed data was collected on a second-by-second basis. The four test runs in each case were divided between two runs in each direction to reduce the possibility of directional bias. Figure 4 shows a flow diagram illustrating the test protocol used in this study. Each test scenario was repeated four times resulting in 32 test runs.

RESULTS

Drive Cycle

By using the DMI and the customized software described above, the driver was provided with continuous instructions from a passenger on how to most accurately follow the pre-selected drive cycle. Figure 5 shows a comparison between the pre-selected drive cycle with the actual speed profile superimposed on the pre-selected drive cycle. Figure 5 illustrates how, with the aid of the DMI and the customized software, the driver was able to follow the pre-selected drive cycle.

To determine the deviation between the desired and actual speeds over time, the mean absolute speed difference (MASD) metric was used. Equation 1 shows how the MASD metric was calculated.

$$MASD = \frac{1}{N} \sum_{i=1}^{n_i} \left[\left| V_{di} - V_{ai} \right| \right] \quad (1)$$

Where:

N = Total number of observations (number of seconds over time period);

V_{di} = Desired speed at time interval *I*; and

V_{ai} = Actual speed at time interval *i*.

It was found that the MASD ranged from 1.7 to 4 mph for the various runs with an average of approximately 2 mph. Considering that the average speed of the drive cycle is almost 20 miles per hour, it can be determined that the average driving error is approximately 10 percent, which is within reasonable bounds for a study of this nature.

Emissions

Accumulated Emissions

Emissions were collected under the various scenarios as outlined in Figure 4 using the PEMS equipment while the driver followed the pre-selected drive cycle. Pollutants of NOx, VOC, CO, PM, and CO_2 were collected with the PEMS equipment on a second-by-second basis. Table 1 shows the accumulated emissions results for the various scenarios. The sample mean of the four runs were taken and the standard deviations and coefficients of variations were calculated in each case. The coefficient of variation is defined as the standard deviation divided by the sample mean and is used as a metric to show the relative stability of the individual samples.

In Table 1, the coefficients of variations are, in almost all cases, less than one (standard deviations are less than the sample mean). This result shows some data stability even though the sample sizes were very small. The relative differences between the various scenarios can be compared by examining the sample means. However, a clearer picture can be obtained by examining Figures 6, 7, and 8. These figures show the comparison between the dirty air filter and the clean air filter as well as the dirt road and paved road for the two test vehicles and for all the pollutants tested. The CO_2 emissions are shown separately in Figure 8 because it is not a criteria pollutant. The following can be concluded from these figures.

<u>Overall Findings</u>

- The emissions of the older Ford F-150 are higher than that of the Ford Explorer for all the pollutants tested. This result is as expected because newer vehicles are subject to more stringent emissions standards.

- The dirt road resulted in higher emissions than the paved road for all the pollutants tested. This is due to the fact that there is less traction on a dirt road causing the vehicle's engine to work harder to follow the same drive cycle. Driving on the dirt road is also more difficult than on a paved road possibly causing more use of the breaks and the accelerator causing more strain on the engine. Finally, due to the lower geometric standards on dirt roads it is possible to have more grade changes on such roads even though they might not easily be noticeable.
- In 16 out of the 20 scenarios the dirty air filter resulted in higher emissions than the clean air filter.

<u>NOx Emissions</u>
Both the Explorer and the F-150 recorded higher NOx emissions with the dirty air filter versus the clean air filter on both the dirt road and paved road. Both vehicles had higher emissions on the dirt road than the paved road.

<u>VOC Emissions</u>
Both the Explorer and the F-150 had higher VOC emissions with the clean air filter versus the dirty air filter on the dirt road, whereas higher VOC emissions were recoded with the dirty air filter on the paved road. Both vehicles recorded higher emissions on the dirt road than on the paved road. The lack of a clear pattern and the slightly intuitive results with the VOC emissions can be attributed to the operation of the oxygen censors under different load conditions. The selected drive cycle requires acceleration to 50 mph in a short period of time, placing a very high load on the engine. Under these conditions, the oxygen censor is bypassed and the engine moves into the "open loop mode" where a large amount of fuel is provided for combustion to reach the required power levels (*9*). Under this open loop mode, the level of VOC emissions is very high and unpredictable, resulting in very inconsistent readings between the various scenarios.

<u>CO Emissions</u>
Both the Explorer and the F-150 recorded higher CO emissions with the dirty air filter on the paved road versus the clean air filter. In the dirt road scenario, the F-150 produced slightly higher CO emissions with the clean air filter than with the dirty air filter. The slightly higher CO emissions for the F-150 with the clean filter on the dirt road are possibly due to measurement errors. Both vehicles had higher emissions on the dirt road than the paved road.

<u>PM Emissions</u>
Both the Explorer and the F-150 recorded higher PM emissions with the dirty air filter versus the clean air filter on the dirt road. In the paved road scenario, the Explorer produced slightly higher PM emissions with the clean air filter than with the dirty air filter. The difference is again small, and it should be noted that gasoline-powered vehicles do not typically emit PM and the levels detected by the PEMS equipment are, therefore, extremely low resulting in the possibility of finding slightly counter intuitive results. Both vehicles produced higher emissions on the dirt road than the paved road.

CO_2 Emissions
Both the Explorer and the F-150 produced higher CO_2 emissions with the dirty air filter versus the clean air filter on both the paved road and on the dirt road. Both vehicles recorded higher emissions on the dirt road than the paved road. Research has shown that there is a very strong correlation between CO_2 emissions and fuel consumption (*10*). This result shows that the fuel consumption is higher with a dirty filter than with a clean filter and higher on a dirt road than on a paved road, particularly for older vehicles.

Emission Patterns

Dirty Air Filter versus Clean Air Filter
Figure 9 shows the NOx and VOC emissions rate comparisons between dirty and clean air filters on the dirt road, whereas Figure 10 shows the same comparison on the paved road. In addition to the emissions, these figures also show the mean speed profile driven by the test vehicles. In Figure 9, the emissions for NOx and VOC are generally higher when the dirty air filter is in place for both test vehicles. The VOC emissions difference is most prevalent on the Ford Explorer. Notably, the emissions generally track the speed profile, i.e., increase when the test vehicle accelerates and decrease when the test vehicle decelerates. Consistent driving therefore would result in lower total emissions.

Dirt Road versus Paved Road
Figure 11 shows the NOx and VOC emissions rate comparisons between dirt and paved roads using the dirty air filter, whereas Figure 12 shows the same comparison using the clean air filter. Figure 11 shows that the emissions for NOx and VOC are generally higher on the dirt road versus the paved road. The difference is again most prevalent for VOC emissions from the Explorer. The same trend is noticed in Figure 12 with the dirt road generally resulting in higher emissions.

CONCLUSIONS

This study was one of the first of its kind and resulted in interesting findings in terms of the methodology as well as the results. The following could be concluded from this study.

- The dirt road resulted in higher emissions than the paved road for all the pollutants tested.
- The dirty air filter resulted in higher NOx and CO_2 emissions than the clean air filter for all the scenarios tested.
- The dirty air filter resulted in lower VOC emissions for all the scenarios tested (due to the “open loop effect” from high engine loads placed by the selected drive cycle).
- In 16 of the 20 scenarios, the dirty air filter resulted in higher emissions than the clean air filter for CO and PM (the four counter intuitive CO and PM results resulting from measurement error).
- The dirty air filters used in the testing have accumulated only 3,000 miles each, which could be lower than for air filters used in most vehicles traveling on dirt roads in Caldwell County. The observed effect of dirty air filters is therefore probably conservative (i.e., less than would occur in actual conditions).
- As expected, the emissions of the older Ford F-150 were consistently higher than that of the newer Ford Explorer for all pollutants.
- Based on the CO_2 emission results it could be inferred that the fuel consumption is higher with a dirty air filter than with a clean air filter and higher on a dirt road than on a paved road, particularly for older vehicles.

FUTURE RESEARCH

Following are ideas for future research in this area.

- A larger sample size (on the order of 10 to 15 runs per scenario) will ensure much greater stability and possibly statistical significance of the results.
- A broader range of vehicle types should be tested to assess the possible impact of different vehicle types.
- The possibility of using tape or other means to manually clog the air filter and thereby creating constant air filter flow between the tests should be considered.
- Other vehicle and engine parameters that might be impacted by driving on dirt roads should be investigated.
- The selected drive cycle should be simplified even further to make it easier to replicate in real driving conditions.
- The acceleration, deceleration, cruising, and idling sections of the simplified drive cycle should be isolated and analyzed separately to develop more accurate emissions profiles per driving mode.
- In addition to tailpipe emissions, the ambient air quality should also be monitored at the time of emissions testing.

ACKNOWLEDGEMENTS

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LIST OF TABLES AND FIGURES

TABLES

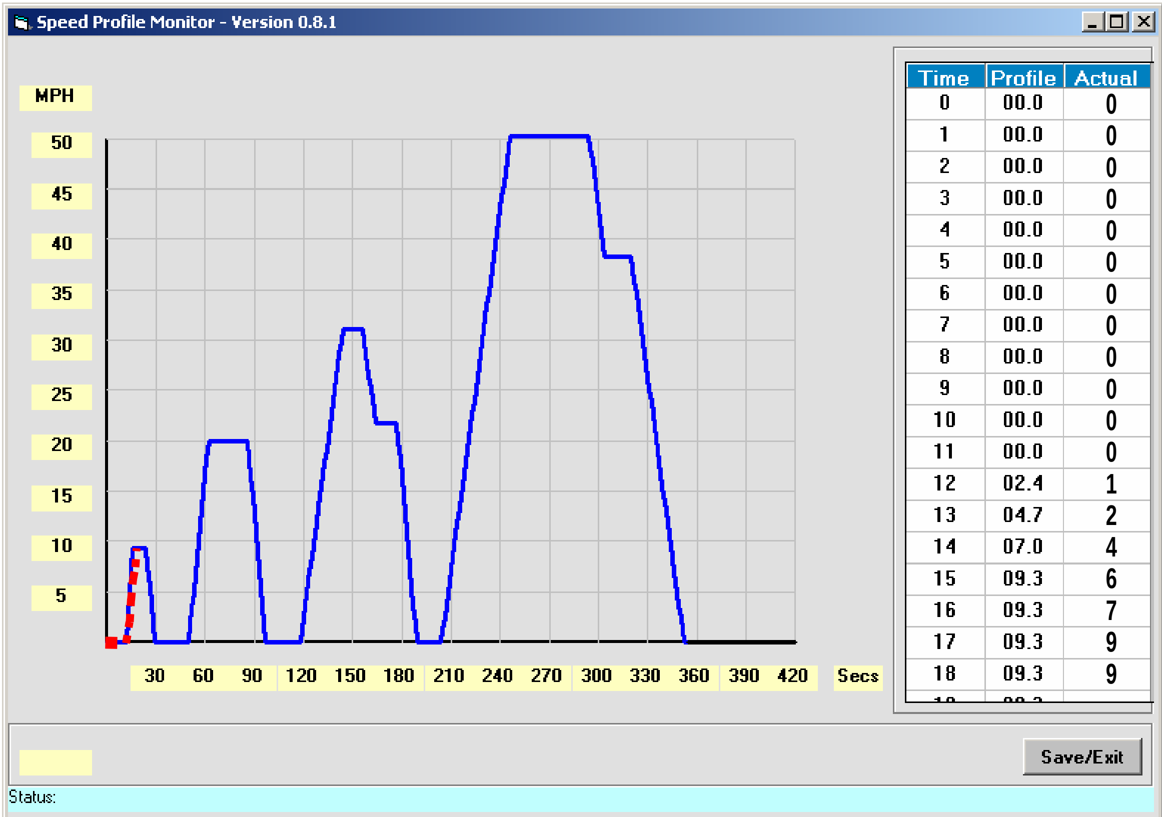
FIGURES

Table 1. Accumulated Emissions Results (grams).

Pollutant	Parameter	Ford Explorer				Ford F-150			
		Dirt Road		Paved Road		Dirt Road		Paved Road	
		Dirty Filter	Clean Filter	Dirty Filter	Clean Filter	Dirty Filter	Clean Filter	Dirty Filter	Clean Filter
NOx	Mean	709	443	345	219	1,991	1,359	1,576	1,050
	Stdev*	404	150	388	341	295	402	223	270
	CV**	0.6	0.3	1.1	1.6	0.1	0.3	0.1	0.3
VOC	Mean	115	173	120	118	241	275	313	142
	Stdev	45	100	54	54	182	170	115	73
	CV	0.5	0.4	0.5	0.5	0.8	0.6	0.4	0.5
CO	Mean	2,581	1,975	1,416	1,206	25,659	27,706	18,116	9,740
	Stdev	725	577	1,101	693	20,366	23,862	9,480	7,298
	CV	0.3	0.3	0.8	0.6	0.8	0.9	0.5	0.7
PM	Mean	0.6	0.3	0.3	0.4	3.2	2.2	1.1	0.9
	Stdev	0.2	0.2	0.4	0.1	3.1	1.8	0.9	0.4
	CV	0.4	0.8	1.2	0.2	1.0	0.8	0.8	0.4

* Standard Deviation
** Coefficient of Variation

Figure 1. Photo of Test Vehicles on Dirt Road.



Time	Profile	Actual
0	00.0	0
1	00.0	0
2	00.0	0
3	00.0	0
4	00.0	0
5	00.0	0
6	00.0	0
7	00.0	0
8	00.0	0
9	00.0	0
10	00.0	0
11	00.0	0
12	02.4	1
13	04.7	2
14	07.0	4
15	09.3	6
16	09.3	7
17	09.3	9
18	09.3	9

Figure 2. Screen Shot Created By the DMI and Customized Software.

Figure 3. Photos of PEMS Equipment Connected to Test Vehicle.

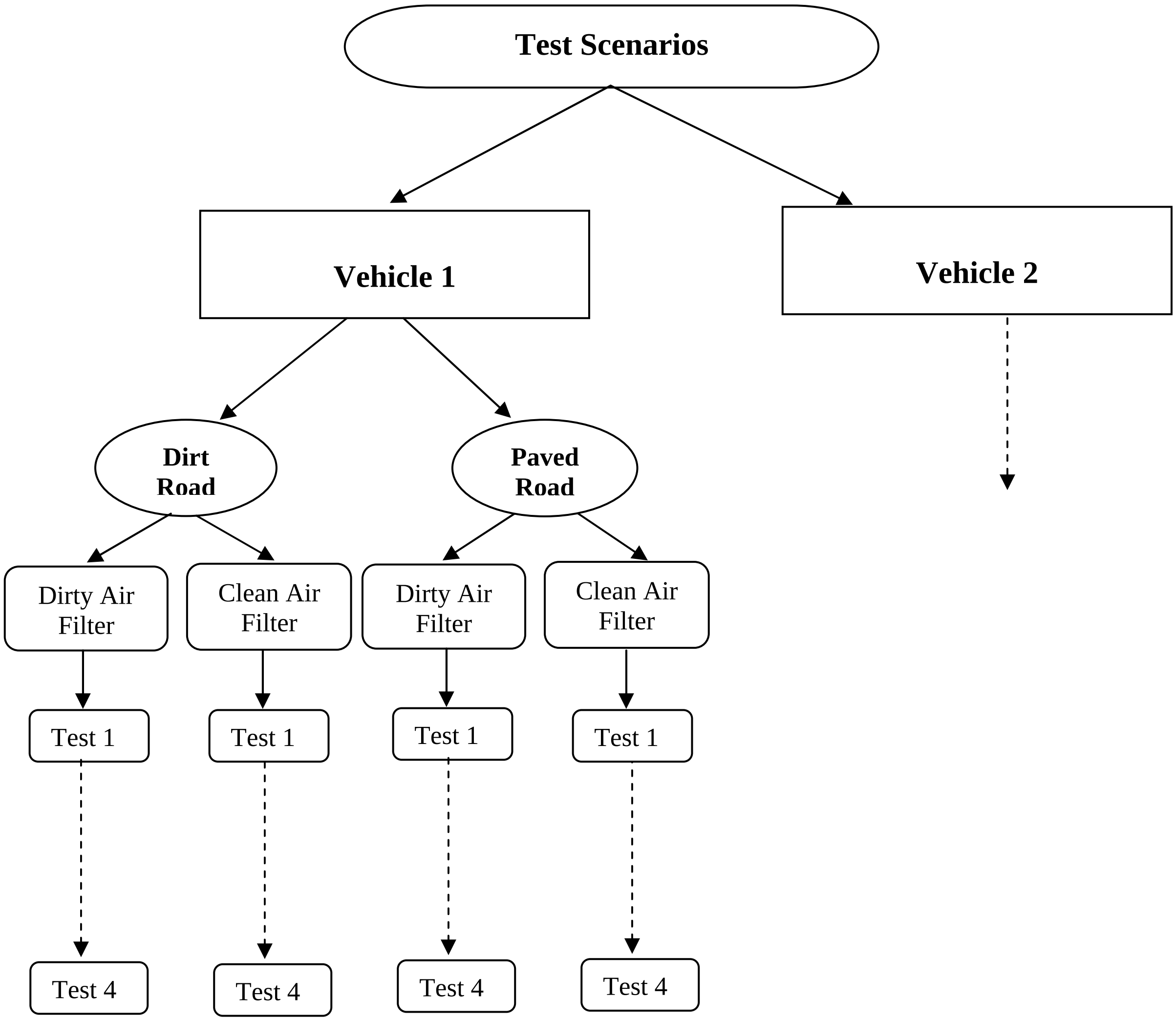


Figure 4. Flow Chart of the Test Protocol.

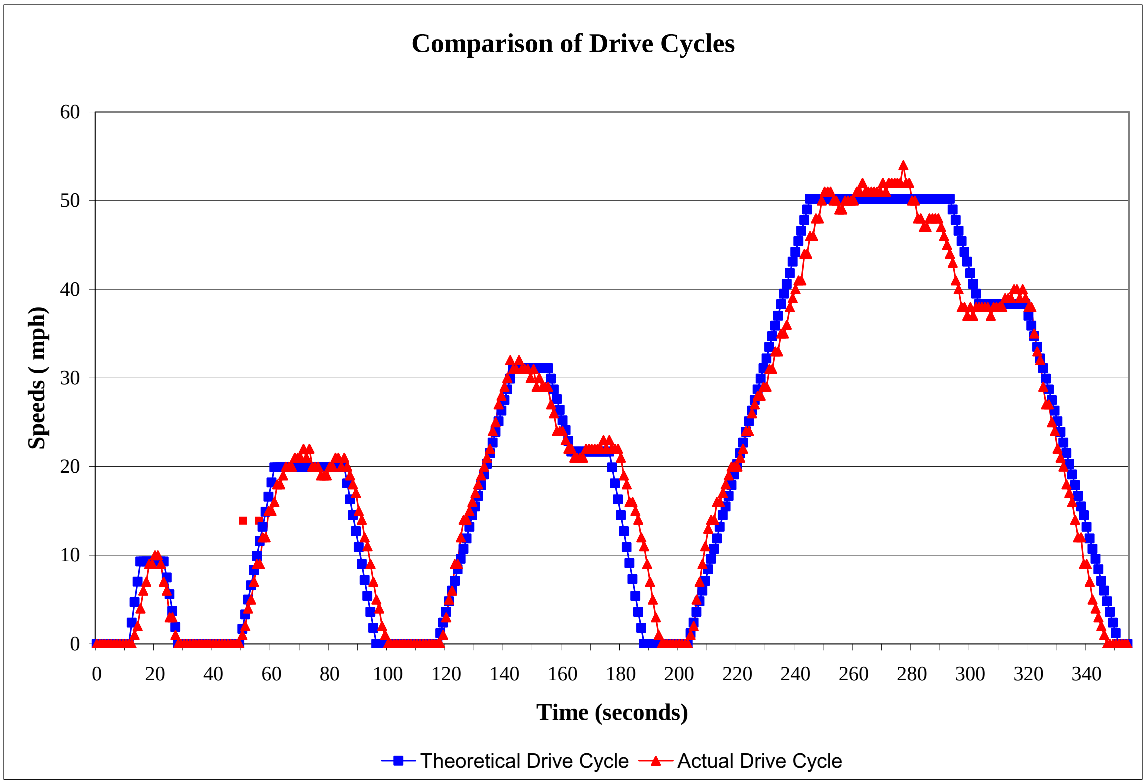


Figure 5. Comparison Between the Pre-Selected Drive Cycle and Actual Driving.

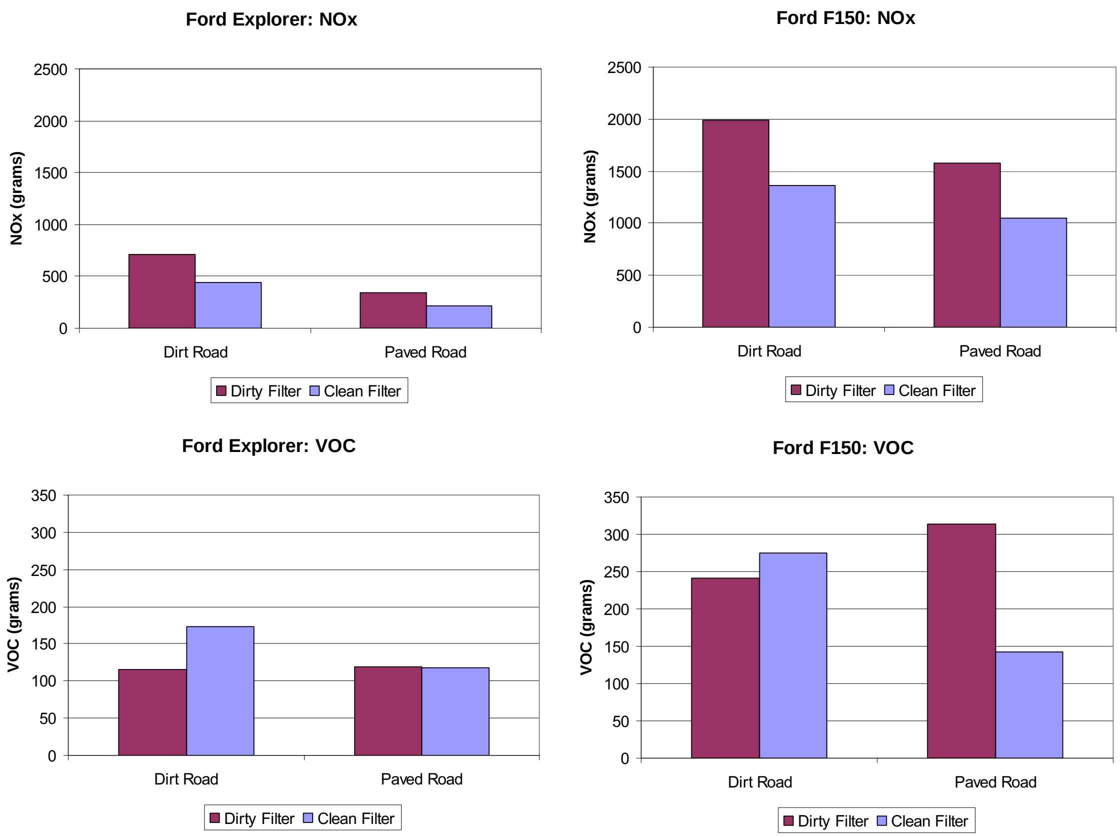


Figure 6. Comparisons of Mean Accumulated Emissions for NOx and VOC.

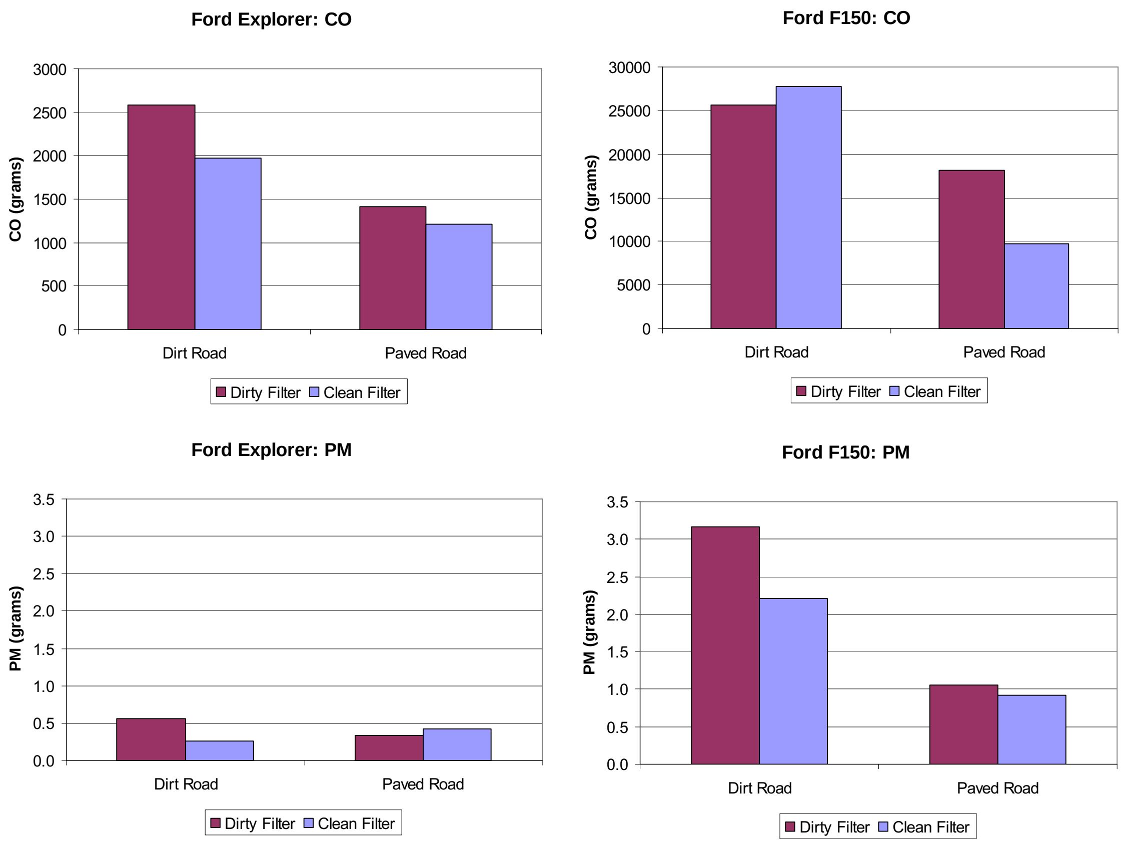


Figure 7. Comparisons of Mean Accumulated Emissions for CO and PM.

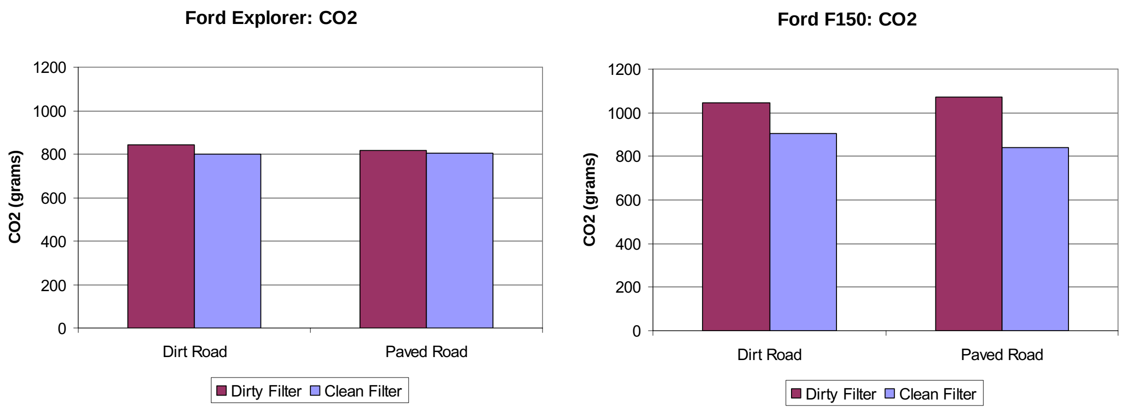


Figure 8. Comparisons of Mean Accumulated Emissions for CO_2.

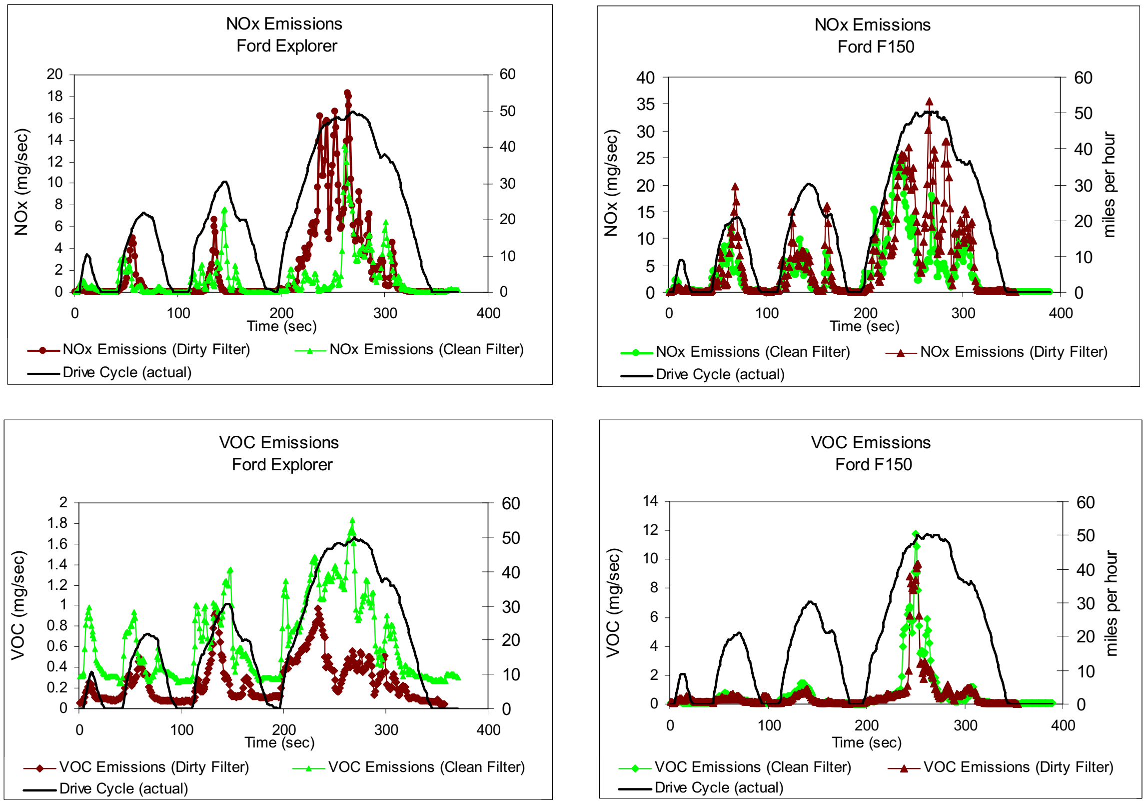


Figure 9. Emission Rate Comparisons between Dirty and Clean Air Filters on Dirt Road.

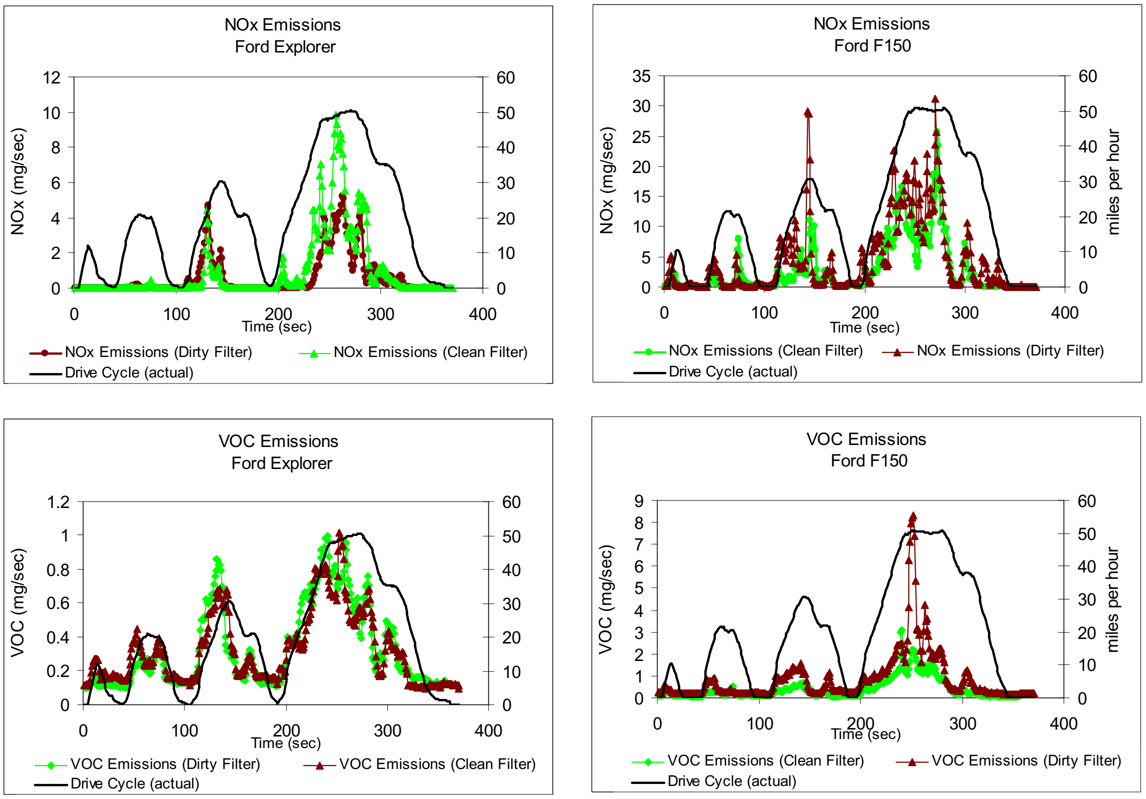


Figure 10. Emission Rate Comparisons between Dirty and Clean Air Filters on Paved Road.

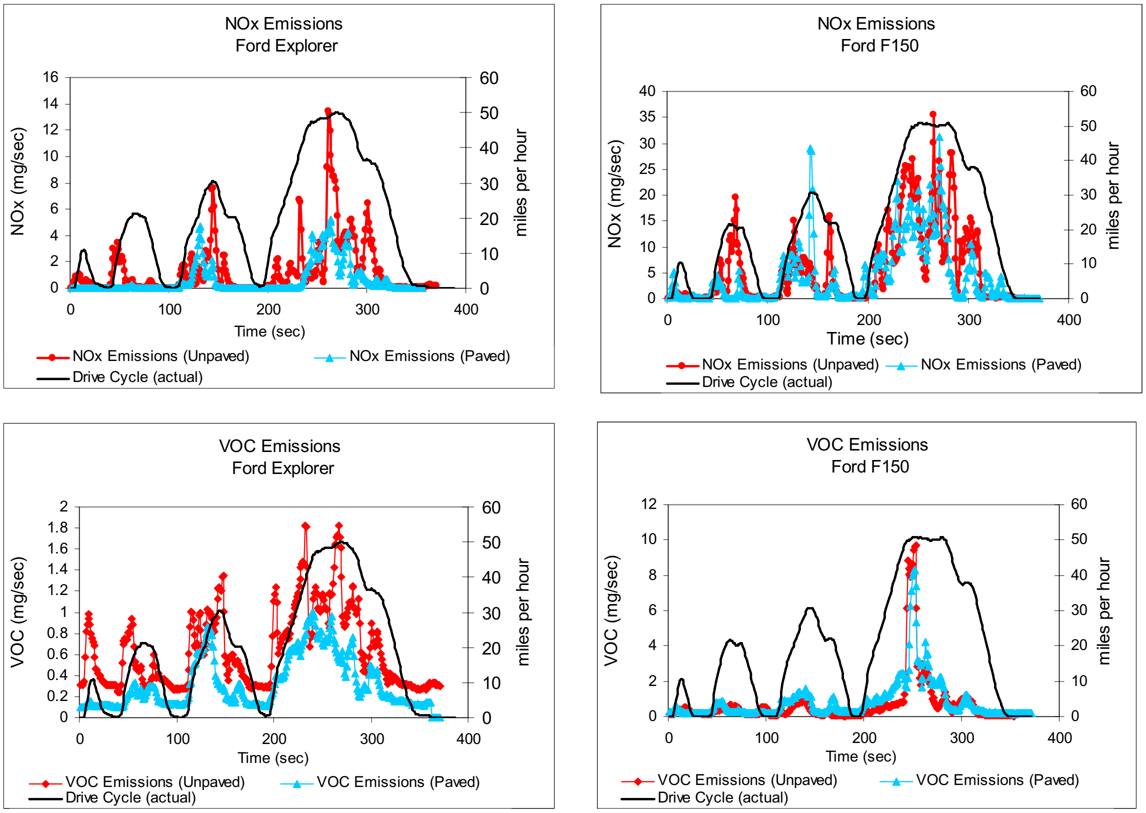


Figure 11. Emission Rate Comparisons between Dirt and Paved Road with Dirty Air Filters.

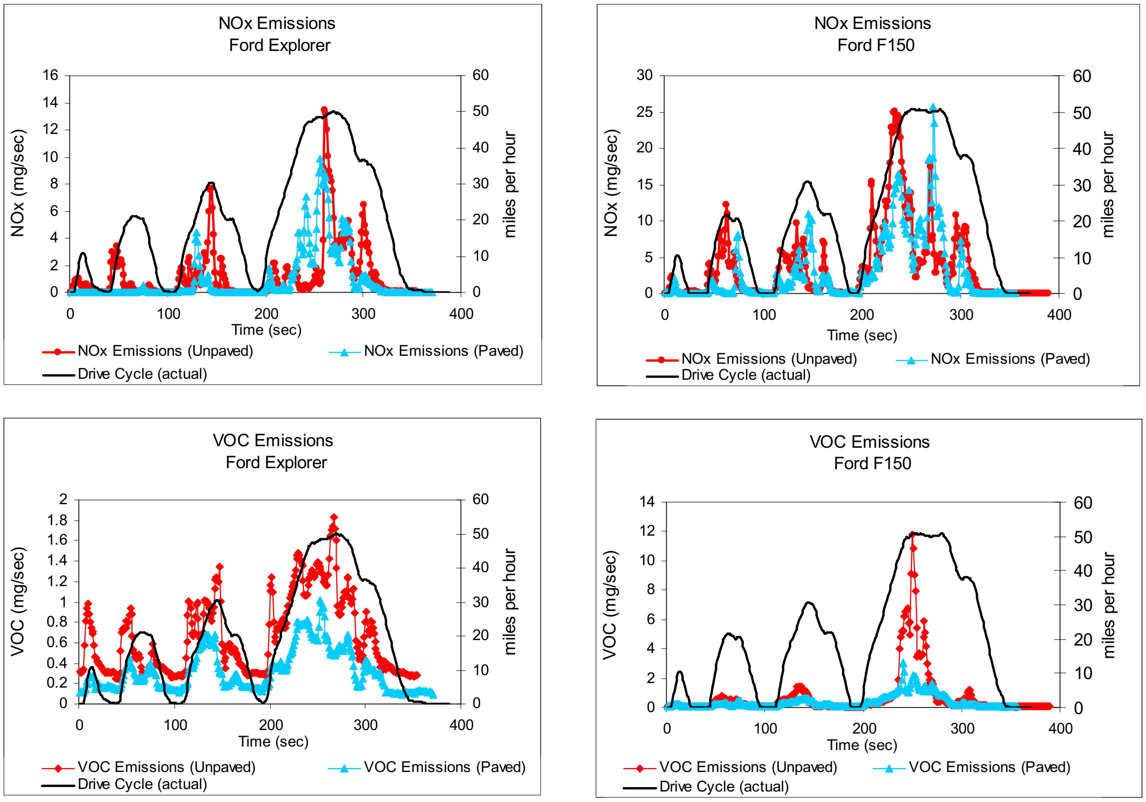


Figure 12. Emission Rate Comparisons between Dirt and Paved Road with Clean Air Filters.

Appendix F
Public Participation

8-Hour O3 Flex CAF News Ad Campaign Comments
October 25th, 2007

Travis County	**Dale Bulla**- -no idle zones at schools -install wind turbines and/or solar panels on school grounds -bio-diesel for buses -"walking days" encouraging students to walk to school -plant school gardens -outdoor butterfly garden
Travis County	**Colleen Brush-** -provide a tax incentive for reducing miles driven in a given time period, possibly annually
Travis County	**Marcus Fry-** -more right turn lanes on roadways
Travis County	**Robert Baker-** -incentives for pumping gas after dark -penalties on Ozone Action days i.e. higher gas prices, a surcharge -large incentives for alternative fuels/electric lawn equipment -signs at ALL drive through encouraging people to cut their engines
Hays County	**William Bentley-** -sky shielding of outdoor lighting
Travis County	**Dieter Grether-** -mandatory for all air ducts in both residential and commercial buildings be located inside conditioned space so as to not lose the temperatured air in transit to its location
Williamson County	**Brian Lilly-** -CART offer free/reduced fares on Ozone Action Days
Travis County	**Peter Shen-** -greatly enforce anti-idling
Travis County	**Pat Armstrong-** -focus on ways to evolve more people and companies into greener living and working practices -weekly newspaper spot dedicated to reader's ideas-possibly a contest, involve local schools as well as provide recognition/prize for winning ideas as well as additional commentary on how this winning idea will have an impact environmentally