New Jersey Volkswagen Settlement
Project Proposal

First Student, Inc.

December 20, 2018

Table of Contents

First Student

Caring for students today, tomorrow, together.

600 Vine Street; Suite 1400, Cincinnati, OH 45402

December 20, 2018

New Jersey Department of Environmental Protection (NJ DEP)
Division of Air Quality
Mail code 401-02E
Trenton, NJ 08625-0420

Dear NJ DEP:

First Student is the leading school transportation solutions provider in North America, moving more passengers per day than all U.S. airlines combined by leveraging best practices, technologies and processes to deliver quality transportation solutions. First Student serves the student population in New Jersey with 1,359 buses (116 customers serviced out of 17 locations) across the state, and we take the health of New Jersey's student population very seriously by setting the highest standards for pursuing environmentally sustainable and safety initiatives for our fleet. In fact, First Student is the only industry recipient of the coveted 2009 Green Cross for Safety medal by the National Safety Council. First Student was also awarded the 2013-2014 Occupational Excellence Award by the National Safety Council.

First Student's employees (40,000 plus nationwide and 1,477 New Jersey employees) are committed to supporting the communities we serve both collectively and individually through a wide range of charitable giving and volunteering activities at both the local and corporate levels. The following are some examples of the ways First Student is engaging with communities:

Employee Fundraising
- Children's Miracle Network
- Making Strides against Breast Cancer
- American Cancer Society
- Guardian Angel Network

Donations Supporting Youth & Education
- Flying Pig Marathon - Cincinnati
- After-School Program – Branford Board of Education, Conn.
- Safety Education Program – Normandy Collaborative, Mo.

- "Stamp out Hunger" – Three Rivers Food Bank, Ore.
- Breast Cancer Coalition - Mass.
- Autism All-Star Team – Knights of Columbus, Ill.
- Special Olympics – Plainfield Police Department, Ill.
- Holiday Food Drive – King City, Ont.

As you can see, First Student's connection to the local community is strong, and underscores our commitment to student health and safety by reducing diesel emissions. Diesel-fueled buses emit diesel particulate matter (PM), toxic air contaminants that adversely affect human health, including proper lung development in children. Research published in the Journal of the Air & Waste Management Association has concluded that, "A high percentage of school buses in California and elsewhere are powered by diesel engines and commuting children may be exposed to high concentrations of exhaust particles and gases during their commutes, at school bus stops, or at loading/unloading zones." Please see attached appendices for more information.

Funding school bus replacements not only reduces diesel PM, but also reduces NOx, which is the focus of the VW Mitigation Trust.

For this project, First Student plans on replacing 143 eligible 2004 and 2005 diesel buses with the same number of new diesel replacement vehicles (please see the attached fleet info listing), resulting in cleaner and healthier conditions for both the students and the New Jersey neighborhoods in which these buses operate. Awarding the VW Mitigation Trust grants to First Student will incentivize us to modernize our fleet faster than normal budgets will allow, and will serve as a long-term beneficial investment for the State of New Jersey's efforts to reduce harmful diesel emissions. Please feel free to reach out to me directly should you have any questions regarding this proposal.

Thanks for your consideration,

Brian Beechem
Sr. Director
600 Vine Street, Suite 1400, Cincinnati, Ohio 45202
Office: 513.419.3218
Mobile: 513.256.0351
brian.beechem@firstgroup.com
www.firstgroupamerica.com

CAMDEN COUNTY EDUCATIONAL SERVICES COMMISSION
225 WHITE HORSE AVENUE
CLEMENTON, NEW JERSEY 08021-3916

December 6, 2018

New Jersey Department of Environmental Protection (NJDEP)
Division of Air Quality
Mail code 401-02E
Trenton, NJ 08625-0420

Dear New Jersey Department of Environmental Protection:

It is our pleasure write this letter in support of the application submitted by First Student, Inc ("First Student") for the New Jersey Volkswagen grant program, as part of the Volkswagen Environmental Mitigation Trust settlement.

First Student is a preferred school transportation solutions provider for the Camden County Educational Services Commission, a transportation consolidator for districts in Camden City, Camden County and surrounding counties, proudly serving over 50 districts, with over 15,000 students and 500 routes. First Student takes the health and safety of our students very seriously by continuously pursuing environmentally sustainable initiatives for their fleet, and we have formed a trusted relationship with First Student because of their overall commitment to that effort.

Diesel-fueled buses emit diesel particulate matter (PM), toxic air contaminants that adversely affect human health, including proper lung development in children. Several studies of diesel PM and children's exposure to air pollution on school buses and has found that the school bus itself is a major source of diesel PM exposure for children riding the bus. Funding school bus replacements not only reduces diesel PM, but also reduces NOx, which is the focus of the VW Mitigation Trust.

We fully support the efforts of First Student as they seek New Jersey VW grant funding to help support the reduction in diesel emissions in Camden County. We believe that awarding the grant to First Student will incentivize them to modernize their fleet faster than normal budgets will allow and will serve as a long-term beneficial investment for New Jersey's efforts to reduce harmful diesel emissions. With fewer diesel emissions, our students won't be forced to breathe toxic pollutants that aggravate or increase incidents of respiratory illness, asthma, or other health problems.

Sincerely,

Daniel Del Vecchio

Daniel Del Vecchio
Superintendent

State of New Jersey

[illegible]

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

CATHERINE R. McCABE
Commissioner

PROJECT SOLICITATION

OVERALL GOAL

The State of New Jersey, as a beneficiary of the Trust established pursuant to the national Volkswagen settlement, intends to use its allocation from the mitigation trust to efficiently implement projects that reduce oxides of nitrogen (NOx) emissions in a cost effective and technically feasible manner. The implemented projects must meet the criteria of the Consent Decree. New Jersey is issuing this solicitation for project ideas to ensure a broad range of project ideas are considered.

Submissions must contain all the information outlined in the "Project Proposals" section of this document.

ELIGIBLE PROJECTS

[illegible]

Source Category	Emission Reduction Strategy	Allowed Expenditure Amount
1. Class 8 local freight trucks & port drayage trucks	[illegible]	[illegible] [illegible]
2. Class 4-8 school bus, shuttle bus or transit bus	[illegible]	[illegible]
3. Freight switching locomotives	[illegible]	[illegible]
4. Ferries/Tugs	[illegible]	[illegible]
5. Oceangoing vessels	[illegible]	[illegible]

6. Class 4-7 local freight trucks	[illegible]	[illegible]
7. Airport ground support equipment	[illegible]	[illegible]
8. Forklifts and Port Cargo Handling Equipment	[illegible]	[illegible]
9. Electric vehicle charging stations or hydrogen fueling stations for light duty vehicles only		[illegible] *government owned* [illegible] [illegible] *non-government owned* [illegible] [illegible] [illegible]

PROJECT PROPOSALS (Open with Adobe Reader)

Electronic submittals are preferred and should be sent to VWComments@dep.nj.gov however paper submittals will also be accepted and should be sent to:

[illegible]

[illegible]

To enter information electronically use Adobe Reader

CONTACT INFORMATION

[illegible]	First Student, Inc.
[illegible]	600 Vine Street, Suite 1400
[illegible]	Cincinnati, Ohio 45202-2474
[illegible]	Brian Beechem
[illegible]	Sr. Director
[illegible]	(513) 419-3218
[illegible]	brian.beechem@firstgroup.com

PROJECT NAME	New Jersey VW School Bus Replacement

PROJECT CATEGORY OR CATEGORIES [illegible]

1 ☐ 2 ☑ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐

PROJECT PRIORITY [illegible] 1 [illegible] 1 [illegible]

[illegible]

PROJECT BUDGET $ 13,048,641.32

[illegible]

The estimate for this proposal is $13,182,026 for 143 vehicles to be initially funded from internal First Student funds. The proposed cost share would be 60% for the 2004 buses and 50% for the 2005 buses, resulting in a grant request of $5,912,950.75

PROJECT DESCRIPTION ([illegible]

[illegible] Multiple locations - See enclosed map

[illegible] 1,228,386

[illegible] 15 years for the replacement buses

[illegible] 143

[illegible]

[illegible] 13.29 [illegible]

[illegible] EPA Diesel Emissions Calculator

[illegible] 1.20 [illegible]

[illegible] EPA Diesel Emissions Calculator

[illegible]

Yes, this project will benefit several communities / demographic groups. Where: 1) Over 10% have asthma. 2) Low Income - family income is below the area median income 3) 20% of the pop. is over 65 (Seniors) 4) There are large populations with people of color. Please see attached demographic info.

[illegible]

N/A

[illegible]

The cost effectiveness for this project will be $3,143 per ton reduced per year for NOx emissions and $34,956 per ton per year for PM 2.5 emissions. Per the EPA calculator, this project proposal will result in the elimination of over 13.291 short tons of NOx annually (60.449 tons lifetime) and 1.195 short tons of PM 2.5 emissions annually (5.427 tons lifetime).

[illegible]

The project timeline:

1) First Student anticipates ordering the replacement buses no later than March 2019
2) Replacement bus delivery - expected August/September 2019
3) The old buses will then be scrapped within 30-60 days after replacement per program guidelines

[illegible]

First Student owns, operates and maintains over 42,000 yellow school buses in the US and Canada. In New Jersey, First Student operates 1,352 buses in 18 districts, and our replacement fleets are all delivered in large groups, very rarely a single delivery. We have many years of experience with the technical training, maintenance capabilities, safety training and fueling capacity to implement a large delivery of vehicles to the districts we serve across New Jersey.

[illegible]

N/A

[illegible]

N/A

[illegible]

The 143 replacement vehicles in this proposal are slated to serve multiple school districts, including: Bridgewater/Raritan (12), Andover (3), Delran (5), Englewood (12), Bergen - Passaic (5), Lafayette Terminal (22), Brunswick (21), Butler (1), Lawnside (10), East Orange (6), Berlin (3), Chatham (1), Neptune City (3), English Town (3), Lincoln Park (5) Warren (24), Riverview (6).

Two additional pages have been provided as supplemental space to answer any of the questions above.

Please see the enclosed supplemental attachments and appendices.

2

First Student, Inc.
New Jersey Volkswagen Mitigation Project Proposal

New Jersey VW Proposal
Applicant: First Student

Existing Vehicle										Replacement Vehicle						Grant Request		
VIN	Location	Make	Model	Model Year	Vehicle Class	Vehicle Type	Annual Mileage	Annual Idling Hours	Annual Fuel Usage (Gallons)	Replacement Model Year	Replacement Make	Replacement Model	Replacement Fuel Type	Replacement MPG (if known)	Replacement Cost	Reimbursement %	Applicant Cost Share $	Grant Request $
4DRBRABP34A965025	10563 Bridgewater/Raritan	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	11,550	137.65	1,777	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABPX4A965006	10563 Bridgewater/Raritan	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,800	137.65	2,431	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD45CN38953	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,139	137.65	1,868	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD25CN38952	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,241	137.65	1,576	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD05CN38951	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,326	137.65	1,896	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDDX5CN38942	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,728	137.65	1,650	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD85CN38941	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,954	137.65	1,993	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDDX5CN38939	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,507	137.65	1,924	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD65CN38937	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	11,105	137.65	1,708	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD25CN05529	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,484	137.65	2,228	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD05CN05528	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,036	137.65	1,852	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD95CN05527	10563 Bridgewater/Raritan	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,096	137.65	1,861	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBRABP64A965021	11232 Andover	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	6,943	40.91	1,068	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAWDD05CN52035	11232 Andover	FREIGHTLINER	FS 65 Chassis	2005	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	24,130	40.91	3,712	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAWDD95CN52034	11232 Andover	FREIGHTLINER	FS 65 Chassis	2005	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	14,397	40.91	2,215	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDDX5CN05536	11240 Delran	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	8,825	102.22	1,358	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD85CN05535	11240 Delran	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	7,853	102.22	1,208	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD65CN05534	11240 Delran	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	6,080	102.22	935	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD45CN05533	11240 Delran	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	8,694	102.22	1,338	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD25CN05532	11240 Delran	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	6,904	102.22	1,062	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBRABP44A965017	11309 Englewood	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,920	308.80	1,680	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP54A965012	11309 Englewood	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,571	308.80	2,088	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP34A961203	11309 Englewood	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,927	308.80	1,681	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP64A961213	11309 Englewood	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,290	308.80	2,352	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDDX5CN08792	11309 Englewood	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,625	308.80	2,558	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD75CN05526	11309 Englewood	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,615	308.80	2,402	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD55CN05525	11309 Englewood	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	19,812	308.80	3,048	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD34CM60308	11309 Englewood	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	20,685	308.80	3,182	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD14CM60307	11309 Englewood	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	19,197	308.80	2,953	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD04CM34670	11309 Englewood	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	19,234	308.80	2,959	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD44CM34669	11309 Englewood	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,348	308.80	2,207	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD74CM34665	11309 Englewood	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	18,112	308.80	2,787	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD14CM34676	11310 Bergen - Passaic	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,219	237.50	1,880	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDDX4CM34675	11310 Bergen - Passaic	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	17,354	237.50	2,670	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD84CM34674	11310 Bergen - Passaic	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,142	237.50	2,330	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD64CM34673	11310 Bergen - Passaic	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	17,709	237.50	2,725	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD24CM34671	11310 Bergen - Passaic	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	17,720	237.50	2,726	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDC05CU30935	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	21,161	57.04	3,256	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDCX5CM98160	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,883	57.04	2,290	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXAK64CL84098	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	19,937	57.04	3,067	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBUAAP65B979481	11501 Lafayette Terminal	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,326	57.04	2,512	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP65B979478	11501 Lafayette Terminal	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	89,895	57.04	13,830	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP45B979477	11501 Lafayette Terminal	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,923	57.04	2,450	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAWDD45CN52037	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	17,428	57.04	2,681	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAWDD55CN52032	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	14,778	57.04	2,273	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAWDD24CM57281	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2004	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	13,015	57.04	2,002	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRAAP84B963153	11501 Lafayette Terminal	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	20,183	57.04	3,105	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRAAP64B963152	11501 Lafayette Terminal	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	18,884	57.04	2,905	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRAAP44B963151	11501 Lafayette Terminal	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	19,029	57.04	2,928	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRAAP64B963149	11501 Lafayette Terminal	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	17,871	57.04	2,749	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD05CN38948	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,555	57.04	2,239	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD95CN38947	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,830	57.04	2,282	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD75CN38946	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,878	57.04	2,597	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD55CN38945	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	18,823	57.04	2,896	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD35CN05524	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	17,813	57.04	2,740	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD85CN05521	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	17,783	57.04	2,736	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDDX5CN05519	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	18,968	57.04	2,918	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXALX4CM34414	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	8,553	57.04	1,316	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXAL84CM34413	11501 Lafayette Terminal	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	9,612	57.04	1,479	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP44A965020	11741 Brunswick	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,259	108.03	2,040	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP64A965018	11741 Brunswick	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,135	108.03	2,175	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP34A965008	11741 Brunswick	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,553	108.03	2,393	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBUAFP05B983325	11741 Brunswick	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,693	108.03	2,414	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAFP75B983323	11741 Brunswick	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,444	108.03	2,376	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP75B983345	11741 Brunswick	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	18,030	108.03	2,774	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP65B983336	11741 Brunswick	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,609	108.03	2,555	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP65B983343	11741 Brunswick	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,344	108.03	2,053	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP65B983353	11741 Brunswick	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,703	108.03	2,570	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP85B983354	11741 Brunswick	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,748	108.03	2,423	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAPX5B983355	11741 Brunswick	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,485	108.03	2,382	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD35CN38958	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,556	108.03	2,239	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDDX5CN38956	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,095	108.03	2,015	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD85CN38955	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,099	108.03	2,323	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD65CN38954	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,925	108.03	1,989	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD25CN38949	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,593	108.03	2,091	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD15CN38943	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,811	108.03	2,125	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD85CN38938	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,437	108.03	2,067	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD45CN38936	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,350	108.03	2,208	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62

First Student, Inc.
New Jersey Volkswagen Mitigation Project Proposal

New Jersey VW Proposal																		
Applicant: First Student																		
Existing Vehicle										Replacement Vehicle						Grant Request		
VIN	Location	Make	Model	Model Year	Vehicle Class	Vehicle Type	Annual Mileage	Annual Idling Hours	Annual Fuel Usage (Gallons)	Replacement Model Year	Replacement Make	Replacement Model	Replacement Fuel Type	Replacement MPG (if known)	Replacement Cost	Reimbursement %	Applicant Cost Share $	Grant Request $
4UZAAXDD35CN38930	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,946	108.03	1,992	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXAL24CM34410	11741 Brunswick	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,342	108.03	1,591	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD95CN05530	11839 Butler	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	9,986	206.98	1,536	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBRABP14A964987	11840 Lawnside	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,995	114.67	2,153	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP44A965096	11840 Lawnside	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,123	114.67	1,865	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP84A965084	11840 Lawnside	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,584	114.67	1,628	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP84A961200	11840 Lawnside	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,433	114.67	1,913	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD35CN38944	11840 Lawnside	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,179	114.67	2,335	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD55CN05542	11840 Lawnside	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	18,560	114.67	2,855	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD35CN05541	11840 Lawnside	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,139	114.67	2,175	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD55CN05539	11840 Lawnside	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,320	114.67	2,357	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD35CN05538	11840 Lawnside	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	21,996	114.67	3,384	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD15CN05537	11840 Lawnside	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	20,181	114.67	3,105	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBRABP74A965013	12625 East Orange (Star Shu	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,003	162.58	2,308	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP14A965010	12625 East Orange (Star Shu	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,383	162.58	2,213	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP14A965007	12625 East Orange (Star Shu	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	11,551	162.58	1,777	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP14A961202	12625 East Orange (Star Shu	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,308	162.58	1,586	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABM04B958369	12625 East Orange (Star Shu	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	7,656	162.58	1,178	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABM94B958368	12625 East Orange (Star Shu	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,782	162.58	2,428	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP74A965027	20023 Berlin	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,726	86.11	2,112	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP84A965022	20023 Berlin	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	11,195	86.11	1,722	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP44A961212	20023 Berlin	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,987	86.11	1,998	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP94A965014	20029 Chatham	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,998	69.42	2,154	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP94A965093	20560 Neptune City	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,443	118.04	2,068	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP14A965086	20560 Neptune City	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,570	118.04	1,626	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP14A961197	20560 Neptune City	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,674	118.04	1,642	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP04A965015	20562 Englishtown	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,822	97.66	2,588	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP34A965011	20562 Englishtown	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,894	97.66	2,291	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP54A965009	20562 Englishtown	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,598	97.66	2,246	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD55CN38931	20565 Lincoln Park	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,941	212.72	1,683	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD05CN05531	20565 Lincoln Park	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,835	212.72	1,667	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXAL44CM34411	20565 Lincoln Park	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,225	212.72	1,573	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXAL64CM34412	20565 Lincoln Park	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	9,544	212.72	1,468	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXAL64CM34409	20565 Lincoln Park	FREIGHTLINER	FS 65 Chassis	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	10,169	212.72	1,564	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP54A965088	20567 Warren	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	20,494	65.97	3,153	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBUAFP95B983324	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,027	65.97	2,466	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAFP05B983129	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,560	65.97	2,548	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAFP95B983128	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	18,748	65.97	2,884	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAFP75B983127	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,204	65.97	2,185	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBRABMG4A966823	20567 Warren	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	17,042	65.97	2,622	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABM44A966822	20567 Warren	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,203	65.97	2,339	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABM24A966821	20567 Warren	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,368	65.97	2,364	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBUAAP45B979480	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,977	65.97	2,458	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP85B979479	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,924	65.97	2,450	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP25B979476	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,208	65.97	2,493	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP05B979475	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,317	65.97	2,049	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAAP95B979474	20567 Warren	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,438	65.97	2,529	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAWDD25CN52036	20567 Warren	FREIGHTLINER	FS 65 Chassis	2005	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	10,443	65.97	1,607	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAWDD75CN52033	20567 Warren	FREIGHTLINER	FS 65 Chassis	2005	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	10,813	65.97	1,663	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAWCT74CL83591	20567 Warren	FREIGHTLINER	FS 65 Chassis	2004	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	19,513	65.97	3,002	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAWCT94CL83592	20567 Warren	FREIGHTLINER	FS 65 Chassis	2004	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	15,721	65.97	2,419	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAWCT64CL83579	20567 Warren	FREIGHTLINER	FS 65 Chassis	2004	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	18,304	65.97	2,816	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAWDD64CM57283	20567 Warren	FREIGHTLINER	FS 65 Chassis	2004	Class 6: 19,501 - 26,000 lb (8,845 - 11,794 kg)	Type C	12,098	65.97	1,861	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRAAP24B963150	20567 Warren	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	12,435	65.97	1,913	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4UZAAXDD95CN38933	20567 Warren	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,932	65.97	2,143	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD75CN38932	20567 Warren	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,823	65.97	2,127	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDD15CN05540	20567 Warren	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,342	65.97	2,360	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4UZAAXDDX5CN05522	20567 Warren	FREIGHTLINER	FS 65 Chassis	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,270	65.97	2,503	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBUAFN45A977662	20592 New Jersey Body Shop	IC	PB105	2005	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	21,273	68.92	3,273	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	50%	$ 45,624.62	$ 45,624.62
4DRBRABP94A965028	20628 Riverview	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,468	27.60	2,072	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP54A965026	20628 Riverview	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	20,067	27.60	3,087	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP14A965024	20628 Riverview	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	15,560	27.60	2,394	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABPX4A965023	20628 Riverview	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	16,927	27.60	2,604	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP84A965019	20628 Riverview	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	13,571	27.60	2,088	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
4DRBRABP24A965016	20628 Riverview	INTERNATIONAL	3000IC	2004	Class 7: 26,001 - 33,000 lb (11,794 - 14,969 kg)	Type C	14,340	27.60	2,206	2020	International	CE	Diesel	Approx 7.5 mpg	$ 91,249.24	40%	$ 54,749.54	$ 36,499.70
																Totals	$ 7,135,690.57	**$ 5,912,950.75**
																No of Buses	143	$ 13,048,641.32

First Student | Click Here for Latest Version | **International** | First Canada

Vehicle Quote Request

Request Date	November 20, 2018	Request #	20819
			*Request # assigned by Vehicle Procurement
Request Received Date	November 20, 2018		
Bus Purchase Priority	Replacement	Request Type	Location Specific
Requestor Name	Colin Michael	Loc ID	11840
Requestor Phone	(856) 546-8131	Region	400
Location Name	Lawnside	AGM	Colin Michael
Contract Name	Colin Michael	SVP	D. Armitt

Expected Inservice Date	June 15, 2020	School Start Date	August 15, 2020
Location Manager	Colin D. Michael	Phone	(856) 546-8131
Delivery Street Address 1	270 Gloucester Pike		
City	Lawnside	Province/State	NJ
Country	USA	Postal Code	08045-1150

Model Type	Type C Conventional	Province/State Specification	NJ
Intended Purpose	Yellow School Bus		

**Choose WC configuration

Quantity Required	1	# of Seated Passengers	54		# of Wheelchairs	-
Fuel Specification	Type C Diesel	Track Seating	None		Seat W/C Positions?	No
		Integrated Child Seats (ICS)	First two rows		Lift Position	None
Brake Specification	Hydraulic	# of ICS seats	10			

First Student Standard and Climate Package Options for the Model/State you selected are listed for your reference.
These options will automatically be included in the supplier pricing to be subsequently provided.

First Student Standard Options for Specified Model — Type C Conventional Hydraulic

- Child CheckMate/TheftMate
- Zonar (Factory Installed)
- Two-way Radio/Antenna Pre-Wire
- Camera Pre-Wire (4 Locations)
- Extra Auxiliary Fan
- Driver's Dome Light
- Remote Heated Mirrors
- Extended Left Mirror Bracket (for greater visibility)
- Front & Rear Mud Flaps
- Front License Plate Mounting Bracket
- High-Back Student Seating
- Three-Piece Rubber Flooring
- Yellow Nosed Step Treads (If Available)
- Yellow Textured Hand Rails
- Mechanical Suspension Driver's Seat
- Electric Entrance Door
- Entrance Door Interlock
- Synthetic Rear Axle Lube
- Synthetic Front Seals & Bearings
- Dual Tire Valve Stems
- Performance Friction Brake Rotors
- Brake Dust Shields
- Upgraded Undercoating (Edge-Guard/Underguard)
- Stainless Steel Exhaust & Brake Lines
- ABS-Full Vehicle Wheel Control (4-Channel)
- LED Stop/Tail/ Liscense/Marker Lights
- LED Side Directional Lights
- LED Warning Lights
- LED Interior Lights
- Body Disconnect
- 3-Switch with Entrance Door Override
- Backing Alarm
- Crossing Arm & Magnet
- Orange Driver's Seat Belt
- Maximum Allowable Window Tint

Climate Package Options for Specified State — Package 4

- Block Heater
- High Output Water Pump
- Plywood Floors
- Stepwell Heater
- 1 50K BTU & 1 84K BTU Heaters
- Insulated Roof and Wall Bows
- 3-760 Batteries
- 270 AMP Alternator
- Winter Cold Front
- On/Off Viscous Fan
- Stainless Steel Brake Lines
- Stainless Steel Stepwell
- Snow Tires
- Performance Friction Brake Rotors (Hydraulic only)

Other specifications - Please ONLY list specifications required but not identified above.

Acoustical Ceiling	Yes	Drop Chains	No	Tinted Windows	Yes
Total Number of Hatches	Two	Mid-ship Heater	Yes	Tow Hooks	Yes
Air Conditioning	Yes	Plywood Floors	Yes	Under-storage *(Type C& D Only)*	No
Air Suspension *(Type C & D Only)*	Yes	Camera Pre-wire Hookup	Rear-($61 upcharge)	White Roof	Yes
AM/FM Radio w/ PA	Yes	Seat Belts	Lap Belts	Fuel Fired Heater	No
Coaxial Cable	Yes	Strobe Light	Yes		

Additional information- Please explain any options required not previously identified above as well as specifics relating to seat belts, etc.

54 passenger, NJ spec school bus. Front and rear AC. Upgraded undercoating, PFC brakes, upgraded stariwell and upgraded brake lines. 100 gallon fuel tank.

Below to be completed by supplier:

Vehicle Price Breakdown:

Quote Number:	2749	Chassis Type:	
Quote Request Date:	November 20, 2018	Quote Received Date:	
Supplier:	International		

Quantity Quoted	Actual Capacity - Ambulatory	Actual Capacity - Wheelchair	Bus Passenger Size (Size required, i.e. 54 pax size)	Quoted Currency (USD $ or CAD $)	Approx. Chassis Cost (Type A only)
1	54	0	66	USD	

Base/Federal Cost	State/Province Upgrade Cost	Additional Options Cost	Lift Option Cost	Freight Cost	Total Cost Per Unit	Extended Cost
$ 68,537.56	$ 3,768.15	$ 17,643.53		$ 1,300.00	$ 91,249.24	$ 91,249.24

INTEGRATED CE S BUS

Sales Proposal For:

FS 1 20819-2749 NJ 54 CE

Presented By:

INT'L TRK & ENGINE CORP

Code	Description
PB10500	Base Chassis, Model INTEGRATED CE S BUS with 254.00 Wheelbase, N/A CA, and 143.00 Axle to Frame.
1570	TOW HOOK, FRONT (2) Frame Mounted
1CAC	FRAME RAILS High Strength Low Alloy Steel (50,000 PSI Yield); 10.125" x 3.062" x 0.312" (257.2mm x 77.8mm x 8.0mm); 480.1" (12195mm) Maximum OAL Includes : CHASSIS PAINT Chassis Painted Prior to Body Mounting : FRAME RAILS All holes Laser Aligned and Machine Punched, Powder Coated Prior to Full Assembly, Assembled in Fixture using "Grade 8" Bolts : FRAME REINFORCEMENT, SPECIAL 3.30" x 1.80" x 0.312" x 31.50" Inverted "L" in Front Shock Absorber Mounting Area
1LMW	CROSSING GATE, FRONT Electric, Yellow Blade, Bumper Mounted Includes : CONTROL ASSEMBLY Solid State, Located Rear of Front Bumper, Heater not Required : CROSSING GATE, FRONT Matches Contour of Bumper
1LTU	BUMPER, FRONT Full Width, Aerodynamic, Heavy Duty, Steel, Naviflex Spray on Coating
1SAM	CROSSMEMBER, REAR, AF (2)
1WHU	WHEELBASE RANGE 254" (645cm) Only
1WRP	TOW HOOK, REAR (2) Mounted on Lower Rail Flange
2ASH	AXLE, FRONT NON-DRIVING {Meritor MFS-10-122A} I-Beam Type, 10,000-lb Capacity Includes : AXLE, FRONT SQUARING to Plus or Minus .015 Inch, using a Special Fixture to Assure Parallelism of Springs Notes : The following features should be considered when calculating Front GAWR: Front Axles; Front Suspension; Brake System; Brakes, Front Air Cam; Wheels; Tires.
3ADB	SUSPENSION, FRONT, SPRING Parabolic Taper Leaf, Shackle Type, 10,000-lb Capacity, with Shock Absorbers Includes : SPRING PINS Bolt and Nut Type : SPRING PINS Rubber Bushings, Maintenance-Free Notes : The following features should be considered when calculating Front GAWR: Front Axles; Front Suspension; Brake System; Brakes, Front Air Cam; Wheels; Tires.
4100	BRAKE SYSTEM, HYDRAULIC {Wabco} Split System, with Automatic Adjustment and Four Channel ABS
4GBJ	BRAKE, PARKING {Bosch} DSSA Type, 12" x 3"; for Hydraulic Brake Chassis; Foot Operated in Cab; Differential Mounted Includes : BRAKE, PARKING Foot Activated Parking Brake
4JNP	BRAKES, FRONT, HYDRAULIC DISC Quadraulic; Four 70mm Diameter Pistons
4JNU	TRACTION CONTROL, HYDRAULIC Automatic; Hydraulic Brake System
4NNL	BRAKES, REAR, HYDRAULIC DISC Quadraulic; Four 70mm Diameter Pistons
4SPN	AIR COMPRESSOR {Cummins} 18.7 CFM Capacity, with Tank for Air Source on Hydraulic Chassis, with Air Pressure Gauge, Low Pressure Alarm and Wiring

Code	Description
4WGT	PARKING BRAKE INTERLOCK Parking Brake Cannot be Released until Ignition Switch is in the "ON" Position and the Service Brake Pedal is Applied, Use with Hydraulic Brake Chassis Only
4WXP	GVWR LIMITATION FOR BUS with Hydraulic Brakes, Limited to 29,800-lbs Maximum to meet FMVSS 105 Requirements, for Conventional Bus
5AAA	STEERING COLUMN Stationary
5CAL	STEERING WHEEL 2-Spoke, 18" Dia., Black
5PRR	STEERING GEAR {TRW (Ross) TAS66} Power
7BLA	EXHAUST SYSTEM Single, Horizontal Aftertreatment Device, Frame Mounted Under Right Rail, for Long Horizontal Tail Pipe Includes : NOTE: The Horizontal Tailpipe Includes a Temperature Control Device
7WBK	TAIL PIPE Long Horizontal, Exits Right Side Through Bumper
8000	ELECTRICAL SYSTEM 12-Volt, Standard Equipment Includes : FUSES, ELECTRICAL SAE Blade-Type : HAZARD SWITCH Push On/Push Off, Located on Top of Steering Column Cover : HEADLIGHT DIMMER SWITCH Integral with Turn Signal Lever : MISCELLANEOUS FEATURES Modular, Loom Protected, Grommets in all Applicable Body Openings, Assembled in Computer Assisted Fixture which Verifies Continuity and Correct Assembly Prior to Installation : PARKING LIGHT Integral with Front Turn Signal and Rear Tail Light : STARTER SWITCH Electric, Key Operated : TURN SIGNAL FLASHER : TURN SIGNAL SWITCH Self-Cancelling with Lane Change Feature : TURN SIGNALS, FRONT Includes Reflectors; Flush Mounted : WINDSHIELD WIPER SWITCH 2-Speed with Wash and Intermittent Feature (5 Pre-Set Delays), Integral with Turn Signal Lever : WIRING, CHASSIS Color Coded and Continuously Numbered
8GXK	ALTERNATOR {Leece-Neville BLP4006HN} Brushless, 12 Volt 325 Amp. Capacity, Pad Mount, with Remote Sense
8NBX	BATTERY SYSTEM {JCI} Maintenance-Free (3) 12-Volt 2850CCA Total
8RPG	TELEMATICS SYSTEM {ZONAR SYSTEMS V3} Installation Package, Less System; Includes Power Connector, J1939 Datalink Connector, Stop Arm and Entrance Door Inputs, Located Inside Dash Center Panel for Customer Installed Zonar V3 Module
8TTK	BATTERY BOX Steel, with Sliding Tray, 25.25" Wide, for Standard Batteries, Mounted Left Side Behind Front Axle Perpendicular to Frame Rail
8TUT	COLLISION MITIGATION SYSTEM Omit
8VAZ	HORN, ELECTRIC (2) Trumpet Style, Mounted on Top of Mega-Bracket
8WPB	HEADLIGHTS Halogen; Composite Aero Design for Two Light System; Includes Daytime Running Lights
8WTK	STARTING MOTOR {Delco Remy 38MT Type 300} 12 Volt; less Thermal Over-Crank Protection
8WWJ	INDICATOR, LOW COOLANT LEVEL with Audible Alarm
8WXB	HEADLIGHT WARNING BUZZER Sounds When Head Light Switch is on and Ignition Switch is in "Off" Position
9AAE	LOGOS EXTERIOR, ENGINE Badges
9WAB	HOOD TILT ASSIST {EASY TILT} Mechanical
9WAY	FRONT END Tilting, Fiberglass, with Three Piece Construction

Code	Description
	Includes : AIR INTAKE SYSTEM Integrated Pre-Cleaning System to Enhance Air Filter Life : GRILLE Removable; Fiberglass Painted Hood Color : SPLASH SHIELD Integral with Front End Assembly
10020	CHASSIS PAINT Full Chassis
10060	PAINT SCHEMATIC, PT-1 Single Color, Design 100
	Includes : PAINT SCHEMATIC ID LETTERS "NB"
10788	PAINT TYPE Urethane, One or Two Colors, Other than Imron or International.
10AAY	OVER THE AIR PROGRAMMING {Navistar} for Cummins Engines
10XAK	PROMOTIONAL PACKAGE 7 Year Unlimited Miles/km Warranty, Limited Time Program for Allison 2000 Series Transmission on School and Commercial Buses (Supplied directly through Allison)
11001	CLUTCH Omit Item (Clutch & Control)
12703	ANTI-FREEZE Red, Extended Life Coolant; To -40 Degrees F/ -40 Degrees C, Freeze Protection
12EJJ	ENGINE, DIESEL {Cummins B6.7 220} EPA 2017, 220HP @ 2400 RPM, 520 lb-ft Torque @ 1600 RPM, 2600 RPM Governed Speed, 220 Peak HP (Max), School Bus Only
	Includes : FUEL FILTER Included with Cummins B6.7 Engines Engine Mounted : FUEL/WATER SEPARATOR Fuel/Water Separator; Heated; with Water-in-Fuel Sensor. Engine Mounted
12TJA	FAN DRIVE {Warner Electric FC-550} Electronically Activated and Controlled
12UGN	THROTTLE, HAND CONTROL Electronic
	Notes : Cruise Control Switches Mounted on Steering Wheel are Non-Illuminated.
12UYE	RADIATOR Aluminum; 2-Row, Cross Flow, Over Under System, 717 SqIn Louvered, with 313 SqIn Charge Air Cooler. with In-Tank Transmission Cooler
	Includes : DEAERATION SYSTEM with Surge Tank : HOSE CLAMPS, RADIATOR HOSES Gates Shrink Band Type; Thermoplastic Coolant Hose Clamps : RADIATOR HOSES Premium, Rubber
12VBR	AIR CLEANER with Service Protection Element
	Includes : GAUGE, AIR CLEANER RESTRICTION Air Cleaner Mounted
12VGY	FEDERAL EMISSIONS {Cummins B6.7} EPA, OBD and GHG Certified for Calendar Year 2019
12VWH	GOVERNOR Electronic Road Speed Type; for Electronic Engines and Bus Models; with 55 MPH Default
12VYV	IDLE MANAGEMENT SYSTEM Ramp Engine Speed with Air Condition On, in Neutral and Parking Brake Set, Accommodation Package
12WSY	BLOCK HEATER, ENGINE {Phillips} 120 Volt/750 Watt, for Cummins ISB/B6.7 Engines
12WZD	EMISSION COMPLIANCE Engine Shutdown System Exempt Vehicles, Complies with California Clean Air Regulations
13ARV	TRANSMISSION, AUTOMATIC {Allison 2500 PTS} 5th Generation Controls, Wide Ratio, 6-Speed with Double Overdrive, Less PTO Provision, Less Retarder, with 33,000-lb GVW and GCW Max, School Bus
	Includes

Code	**Description**
	: OIL FILTER, TRANSMISSION Mounted on Transmission : TRANSMISSION OIL PAN Magnet in Oil Pan
13WLN	TRANSMISSION OIL Synthetic; 20 thru 28 Pints
13XBA	SHIFT CONTROL PARAMETERS Allison 1000 or 2000 Series Transmissions, 5th Generation Controls, with DynActive and Dynamic Shift Sensing (FuelSense 2.0 Basic)
14AGG	AXLE, REAR, SINGLE {Dana Spicer 21060S} Single Reduction, 21,000-lb Capacity, 190 Wheel Ends . Gear Ratio: 5.57 Includes : REAR AXLE DRAIN PLUG (1) Magnetic, For Single Rear Axle Notes : The following features should be considered when calculating Rear GAWR: Rear Axles; Rear Suspension; Brake System; Brakes, Rear Air Cam; Brake Shoes, Rear; Special Rating, GAWR; Wheels; Tires. : When Specifying Axle Ratio, Check Performance Guidelines and TCAPE for Startability and Performance
14TBS	SUSPENSION, REAR, AIR, SINGLE {International IROS} 21,000-lb Capacity, 9.25" Ride Height, with Shock Absorbers Notes : The following features should be considered when calculating Rear GAWR: Rear Axles; Rear Suspension; Brake System; Brakes, Rear Air Cam; Brake Shoes, Rear; Special Rating, GAWR; Wheels; Tires.
14WMN	AXLE, REAR, LUBE {EmGard FE-75W-90} Synthetic Oil; 1 thru 29.99 Pints
15SHU	FUEL TANK Top Draw, Steel, Rectangular, 100 US Gal (379L), Includes Protective Cage, with Fuel Filler Assembly and Vent Hosing, Mounted Between Frame Rails and Behind Rear Axle Notes : Requires 254" WB Minimum
15WDT	DEF TANK 12 U.S. Gal. 45.4L Capacity, Frame Mounted Outside Right Rail, Behind 0 Bow
16010	COWL Flat Back
16HBA	GAUGE CLUSTER English with English Electronic Speedometer Includes : GAUGE CLUSTER (5) Engine Oil Pressure (Electronic), Water Temperature (Electronic), Fuel (Electronic), Tachometer (Electronic), Voltmeter : ODOMETER DISPLAY, Miles, Trip Miles, Engine Hours, Trip Hours, Fault Code Readout : WARNING SYSTEM Low Fuel, Low Oil Pressure, High Engine Coolant Temp, and Low Battery Voltage (Visual and Audible)
16HKT	IP CLUSTER DISPLAY On Board Diagnostics Display of Fault Codes in Gauge Cluster
16HLJ	GAUGE, DEF FLUID LEVEL
27DUW	WHEELS, FRONT {Accuride 51408} DISC; 22.5x8.25 Rims, Powder Coat Steel, 2-Hand Hole, 10-Stud, 285.75mm BC, Hub-Piloted, Flanged Nut, with Steel Hubs
28DUW	WHEELS, REAR {Accuride 51408} DUAL DISC; 22.5x8.25 Rims, Powder Coat Steel, 2-Hand Hole, 10-Stud, 285.75mm BC, Hub-Piloted, Flanged Nut, with Steel Hubs
29580	WHEEL SEALS, FRONT {International} Oil-Lubricated Wheel Bearings
29ACD	TIRE VALVE CAP Flo-Thru Design
29WLK	WHEEL BEARING, FRONT, LUBE {EmGard FE-75W-90} Synthetic Oil
47AGC	BODY, BUS Conventional; 78" Headroom, 31'2" Body Length, +9 Section Front and Rear, 66 Passenger, 254 WB

Code	Description
47AJC	BODY TAG, METAL Capacity to Include the Total Number of Passengers
47ALP	INTERLOCK, STARTER with Key Switch, Electric Entrance Door with Vandal Locks, Outward Opening
47APR	HEADLINER, BODY Conventional; 25'11"-34'11" Body Length, Perforated Full Length with Sound Insulation Full Length
47APX	FASTENERS, HEADLINER Screws
47ARH	BOWS, ROOF 14 ga., One Piece Construction
	Includes : BOWS, ROOF Positioned Floor Line to Floor Line, Threaded Through Roof Strainers and Drip Rail
47ARP	LIGHT BARS Plastic
47ATB	SKIRT, BODY Conventional, 20", 16ga., 31'2", 31'11", 32'8", 33'5", 34'2", 34'11", Body Length
	Includes : SKIRT, BODY Extra Smooth Steel Supported by Floor Gussets
47AUR	TIE DOWNS, BODY Grade 8 Bolts, Every Body Section
	Includes : TIE DOWNS, BODY with Formed Tab that Fits into Floor Structure to Prevent Turning
47AXT	RUB RAILS, BODY (4) Conventional; Steel, 31'2", 31'11", 32'8", 33'5", 34'2", 34'11", Body Length, Includes Snow Rail
	Includes : RUB RAILS Full Length, Primer Coated (Both Sides), Attached to Body without Cuts or Splices
47AYB	BODY, REAR Includes Emergency Door
	Includes : DOOR, REAR EMERGENCY with Concealed Hinges : HEADER BUMPER Padded, Mounted Over Rear Door; Upholstered to Match Passenger Seat Color
47AZE	SIDE SHEET, BODY, EXTERIOR Conventional, 16ga., Smooth, 31'2", 31'11", 32'8", 33'5", 34'2", 34'11", Body Length
47AZL	FLOOR, BODY with Wheel Wells
47BAR	SUPPORTS, REAR BUMPER Bolted to Frame
47BBH	LINING, SIDE INTERIOR, LOWER Embossed Steel, Clear Coated
47BDA	FLOOR, COATING , Chemguard Metal Coating, Applied to Main Floor and Intermediate Sills
47BEX	SEALER Water-proof Sealer on all Floor Covering Seams
47BKK	LETTERS, SCHOOL BUS FRONT/REAR Decal; "SCHOOL BUS"; with 8" Black Reflective Letters, 3M Fluorescent Diamond Grade, Yellow On Front and Rear Cap
47BLD	STEP, FRONT ENTRANCE DOOR 27 1/4" Depth; 14ga Steel, Formed Treads, Naviflex Finish
47BLK	BODY CERTIFICATION TAG Mylar Label, Located Above Driver Window, with Actual Tire Load Rating
47DAE	FASTENERS, REAR DOOR Lag Screws, Rear Door To Body
47DAJ	COVER, REAR DOOR INSIDE HANDLE Partial Coverage
47DDE	HANDLE, ASSIST, ENTRANCE DOOR Outside Entrance
47DDH	HOLD BACK, REAR DOOR Stationary, No Cables, with Plastic Cover
47DDU	LATCH, REAR DOOR One Point Slide Bar, Cam Operated, with One Inch Stroke

Code	Description
47DEY	HANDLE, EXTERIOR, REAR Emergency Door; Yellow
47DNB	DOOR, ENTRANCE, FRONT Electric, Outward Opening, with Split Pane Glass
	Includes : DOOR, ENTRANCE, FRONT Aluminum Frame with Pin Style Hinges, Ball Bearing Assisted, Interchangeable Top and Bottom Glass Vandal Lock : LOCK, VANDAL, ENTRANCE DOOR With Key Switch
47DNR	SWITCH, LOCATION Left of Driver; Includes Master Flasher, Amber Flasher, and 3 Position Door Control with Red Override
47DRW	RELEASE, ENTRANCE DR EXTERIOR Manual Door Control Right Front Electric Entrance Door
47DXZ	PAINT, RUB RAIL Flange to Flange, Including Top Flange of Window Line Rub Rail
47EBM	HOLD DOWN, BATTERY For (2) Standard Size Batteries
47EWS	LOCK, VANDAL, ENTRANCE DOOR , Electric Close Only with Toggle Switch
47KDY	MONITOR, POST TRIP INSPECTION {Child Check Mate EP-2 PLUS} Wiring Only for Child Theft-Mate System, Activated by Warning Lights, with Disable Alarm at Rear of Bus, with Brake Input and Dome Light Activation, with Speaker and Motion Sensor
47LAT	NOISE REDUCTION, ROOF BOW Conventional; Insulation, 31'2", 31'11", 32'8", 33'5", 34'2", 34'11", Body Lengths
47LAU	INSULATION, ROOF AND SIDES 1.50", All Models
47MBA	UNDERCOAT, BODY Fire Resistant, Water Based, TT-C-730 Spec
	Includes : UNDERCOATING Performed Before and After Mounting on Chassis
47MBM	BUMPER, REAR Painted; 12" High, 3/16" Thick, with 6.5" Hole for Exhaust
47MKM	LETTERS, BATTERY COMPARTMENT (01) Decal; "Battery"; 1" Black Letters, Centered on Standard Battery Box
47MNV	ARROW, RR DOOR, OUTSIDE Decal; Black .75" Stroke, Indicating Handle Direction
47MSA	STRIPING, PERIMETER, REAR Emergency Door; Reflective, Yellow
47MTY	WIRING DIAGRAM Schematic, Electrical
	Includes : ACCESS PANEL for Wiring Diagram Schematic Located on Body Exterior; Below Driver Window
47MVA	LETTERS, HEADER Decal; "WATCH YOUR STEP", 1" Black, Above Windshield
47MVC	LETTERS, STEPWELL Decal, "WATCH YOUR STEP", 2.5" Black, Behind Door on Step Riser
47NAB	PAINT COLOR, RUB RAILS 0001 Canyon Black
47NBG	LETTERS, DOOR, REAR Decals; "EMERGENCY DOOR", 2" Red Reflective Letters Inside and Outside
47NGW	SEAL, RUB RAILS Top Edge, All Rails
47NJA	PAINT COLOR, BODY EXTERIOR 4421 School Bus Yellow
47NJM	PAINT FLASHER BACKGRD 0001 Canyon Black
47NJS	PAINT COLOR, BUMPER Rear; 0001 Canyon Black
47NKE	PAINT COLOR, ROOF 9219 Winter White, (Does Not Include Lift Door) Beginning 5" Above Drip Rail, Rounded Corners
47NKM	PAINT COLOR, BODY INTERIOR 9384 Spring White

Code	Description
47NKZ	LETTERS, FUEL I.D. Decal; "DIESEL FUEL", 2" Black, Adjacent to Fuel Filler Door
47NMG	OPERATING INSTR, REAR Decal, Inside Rear Emergency Door
47NNA	LETTERS, E/E WINDOW, LEFT (01) Decal Set, "EMERGENCY EXIT", Black Inside and Outside
47NNY	LETTERS, E/E WINDOW, RIGHT (01) Decal Set, "EMERGENCY EXIT", Black, Inside and Outside
47NRN	STRIPING, E/E WINDOW, LEFT (01) Perimeter, Reflexite V82
47NRT	STRIPING, E/E WINDOW, RIGHT (01) Perimeter, Reflexite V82
47NTE	LOGO, ROOF LINE Decal; Wing and Shield, First Body Section, Above Driver Window and Entrance Door Over Driver Window and Entrance Door
47NTY	PAINT HOOD AND FENDER To Match Body Exterior
47PBZ	HANDLE, ASSIST Windshield Side Mounted, Left and Right, Body Color
47PGN	BODY RATING TAG Mylar Label; for the State of New Jersey, Located Above Driver Window
47PLX	LETTERS, DEF, I.D. Decal; "DEF ONLY", 1" Black, on DEF Filler Door
47SUB	SUB FLOOR, PLYWOOD Conventional; B-B Marine Grade, with Sealed Edges, 5/8", 5 Ply, for 31'2",31'11", 32'8", 33'5", 34'2", 34'11", Body Length
48ACN	SEAT BELT, DRIVER, COLOR with Blaze Orange Seat Belt Webbing
48ANT	WINDOW, DRIVER Laminated, Clear
48APL	WINDOW, STOPS 12" Opening, Only with 78" Headroom
48ARS	WINDOW, SASH (18) 27" Sections, 9"x 23" Opening
48AST	WINDOW, SASH +9 SECTIONS (4) 9" x 32 1/4" Opening
48BAG	WINDOW, E/E, LEFT (01) Vertical Hinge
48BJA	COLOR, WINDOW FRAME, PASS Passenger Window, Natural Aluminum Finish
48BKN	WINDOW, E/E, RIGHT (01) Vertical Hinge
48BUB	WINDOW, PASSENGER, TINT Conventional; 28% LIght, Tempered Glass, 78" Headroom, with 34'11", 31'2", 31'11", 32'8", 33'5", 34'2" Body Lengths
48CGR	HEATER, WATER PUMP (High Output, Booster Pump) Electrically Operated, Metal Housing; Non-Self Priming
48CGT	FOOTMAN LOOP, SEAT BELT Retaining Loop for Seat Belt
48CXB	AIR CONDITIONER, BODY IC Air, 120,000 BTU, Evaporators, Condensers & Compressors, with Dual 13 CID Compressors, Front & Rear Flush Mounted Evaporators, Skirt Mounted Condensers, EC4.0 Control System
48GHC	HEATER, DRIVER 90,000 BTU, with Defroster and without Rear Heat Duct Includes : AIR FILTER : HEATER HOSES Premium : HOSE CLAMPS, HEATER HOSE Mubea Constant Tension Clamps
48GHK	HAND RAIL, ENTRANCE DOOR, FWD Textured Yellow; Curved
48PAM	WINDSHIELD 3 Flat Pieces, 73% Light, with Band
48PAV	WHEEL POCKET COVER Plastic, ABS
48PAW	AISLE POSITION for 45" Left and 30" Right (15" aisle)
48PBB	FLOOR COVERING, COLOR Black

Code	Description
48PHN	UPHOLSTERY, PASS SEATS, TYPE Prevaill, 42 oz.; for (21-22) Seats
48PJR	FLOOR COVERING, TRIM Aluminum
48PJZ	FLOOR COVERING, TYPE {Koroseal} All Body Lengths
48PKR	FAN, DEFOG LEFT CENTER 6.50" Diameter, Black, Mounted Left of Center Post, 2-Speed Switch in Panel
48PMC	HEATER, PASS, LT MIDSHIP 1ST 50,000 BTU
	Includes : AIR FILTER
48PMJ	HEATER, PASS, LT REAR 84,500 BTU
	Includes : AIR FILTER
48PMS	HEATER, STEPWELL 50,000 BTU
	Includes : AIR FILTER
48PPM	HEATER CUT OFF, VALVE Ball, with Butterfly Handle
48PPS	ROOF VENT, FRONT Static
48PSH	SEAT, DRIVER {Magnum 200} Mechanical Suspension
	Includes : SEAT BELT, DRIVER Adjustable D-Loop Seat Belt, Single Locking Retractor
48PUT	NUTS, BELT MOUNTING Standard Nuts For Seat Belt Mounting
48PVB	UPHOLSTERY, DRIVER SEAT, STYLE Plain
48PVN	UPHOLSTERY, DRIVER SEAT, COLOR Drivers Seat, Gray
48PWD	UPHOLSTERY, PASS SEATS, COLOR Gray, for Seats, Barriers and Head Bumpers
48PWR	UPHOLSTERY, DRIVER SEAT, TYPE Prevail, 42 oz.
48PXP	UPHOLSTERY, BARRIER, TYPE (1-2) Prevaill, 42 oz.
48RAA	BARRIER, CRASH, AFT ENTRY DOOR 30", 1 Leg
48RAM	BARRIER, CRASH, AFT DRIVER 45", 1 Leg
48REP	PANEL, MODESTY, AFT OF DRIVER Mounted Under Barrier
48RET	PANEL, MODESTY, AFT ENTR DOOR Mounted Under Barrier
48RLX	CUSHION, SEAT 15" Depth
	Includes : WARRANTY Four Years
48RRA	UPHOLSTERY, SEAT, STITCHING Single
	Includes : WARRANTY Two Years
48SAX	SEAT,PASS,LT,30",2 LEG (01)
48SEM	SEAT,PASS,LT,45",2 LEG (08)
48SGK	SEAT,PASS,RT,30",2 LEG (09)
48UCP	ROOF HATCH, FRONT {Transpec 1975-028-121-03} with Outside Release, with English Decals

Code	Description
48UCR	ROOF HATCH, REAR {Transpec 1975-028-121-03} with Outside Release, with English Decals
48USV	SEAT BACK, PASSENGER High Back
48UYB	HAND RAIL, ENTRANCE DOOR, AFT Textured Yellow, 4" Above Step
48VLD	SEAT BELT, DUAL Non-Retractable, Maroon/Brown, 10 Seats
48VPJ	SEAT BELT, TRIPLE Non-Retractable, Maroon/Blue/Brown, 08 Sets
48VVU	STEP TREADS Pebble Yellow Nosing Only, with Non-Metal Backing, used with Formed Treaded Steps
48WML	SEAT,CHILD,RT,30",2 LEG {CE White} (2) Wall Mount with 3 Point Seat Belts
48YGC	SEAT,3PT,CHILD,LT,45",4 LEG {CE White} (02) High Back, Wall Mount, with 3 Point Seat Belts and Child Restraint System
49ABE	WIRING MOD, BACK UP LIGHTS (2) Lights Connected to Rear Emergency Door Switch
49AHV	LIGHT, STROBE, STOP SIGN, FRT In Lieu Of Flashing Lights Furnished with Stop Sign, Speciality
49AMB	WIRE, FEED 4 Gauge, Chassis To Body
	Notes : Terminals have heat shrink protection.
49AMD	SWITCH, DRIVER PANEL, TYPE Rocker
49AMJ	ALARM, BACKING {Ecco #575} 107 db
49AMR	CIRCUIT, PROTECTION Fuse, Electrical System
	Includes : ACCESS PANEL for Body and Chassis Fuses/Circuit Breakers Located on Body Exterior; Below Driver Window
49AMY	SWITCH, REAR DOOR BUZZER for Emergency Door
49ANH	SWITCH, MAGNETIC, DISCONNECT Master, Ignition Operated, All Body Circuits
49ANP	COAXIAL CABLE for 2-Way Radio
49AWT	SPEAKERS AND WIRING (4) Flush Mounted in Light Bar
49BCN	FLASHER SYSTEM (8) Warning Lights, 8-Lamp System, Electronic Relay Flasher, Non-Sequential Operation, Red Lights Activate with Door Open
49BCR	LIGHT, EXTERIOR, CHECK Automatically Activates Lights for Pre Trip Inspection
49BDL	MONITOR, LIGHT SYSTEM {Sound Off} with 16 LED or Incandescent Indicator Lights
49BJG	LIGHTS, DIRECTIONAL, SIDE (2) {Truck Lite 35001Y} Armor Type, Amber LED, 1 Each Side, First Section Aft Entrance Door
49BLM	WIRING, TWO WAY RADIO Power and Ground Connection Only; Connection in Flasher Plate Area with 20 Amp Fuse Protection
49BXR	LIGHT, STROBE, CONNECTION To Have Strobe Light Active When Pupil Warning Lights are Active
49BYT	LIGHTS, STOP (2) {Sound Off} and Tail; 7" Round LED, Red
49BYZ	LIGHTS, DIRECTIONAL, REAR (2) {Sound Off} LED, 7" Round Amber LED
49BZG	LIGHTS, BACK UP (2) {Sound Off} LED, 7" Round Clear
49BZU	RADIO, ENTERTAINMENT {Custom Radio} AM/FM Stereo/USB Input, Includes Antenna and Cable, with Public Address System

Code	Description
49DAG	LIGHT, INDIC, WARNING LIGHTS LED Type; Red and Amber
49DBR	HOOD, WARNING LAMP (4) Black, 8-Lamp System, One Hood Above Two Lights
49DDC	LIGHTS, CLUSTER {Truck Lite 07045A & 07045R} LED; Amber Front and Red Rear
49EGC	MIRROR, INSIDE 6" x 30", Clear Safety Glass, Metal Back, Round Corners
49EGM	MIRROR, CROSS VIEW, EXTERIOR Heated, Black, Rosco
	Includes : MIRROR MOUNT Attached to Body with Metal Backing Plates
49EJM	MIRROR, REAR VIEW, EXTERIOR {Rosco} Suspended, Breakaway, Motorized Head, Heated, Black
49EKT	STOP ARM, FRONT Electric, Metal Blade, 18" Octagon, Double Sided, 1/2" White Border, Hi Intensity Grade, Strobing LED Lights
49ENK	VISOR, INTERIOR, LEFT FRONT 6" x 30", Transparent, For Left Windshield
49ESC	LIGHTS, DOME, DRIVER {Sound Off} (1) Rectangular LED, Separate Switch, Mounted in Light Bar
49EUU	KIT, FIRST AID with Pencil and Small Paper Pad, New Jersey
49GBV	WINDSHIELD WIPERS (2) Cowl Mounted
	Includes : WINDSHIELD WIPERS CONTROL Single Motor, Overlapping Wipe Pattern
49GDG	PADDING COMPART ABOVE DRIVER Window; Safety Equipment, Vandal Equip Compartment with Cutout for dome light
49GDS	COMPARTMENT ABOVE DRIVER Left of the Driver
	Includes : COMPARTMENT ABOVE DRIVER Compartment Size: 39" x 10" x 10" : HINGES Piano Type
49GEM	SAFETY TRIANGLES Warning Reflectors, Mounted on Front of Drivers Barrier 6" Below Top of Modesty Shield
49GGE	FIRE EXTINGUISHER, DRIVER AREA 5 lb 2A-40BC Minimum with Flexible Hose and Metal Nozzle
49GHN	REFLECTORS, REAR (2) 3", Red, Adhesive Back
49GHR	REFLECTORS, SIDE, REAR (2) 3", Red, Adhesive Back
49GHV	REFLECTORS, SIDE, FRONT (2) 3", Amber; Adhesive Back, 1 Aft Drivers Window Left, 1 Aft Entrance Door Right
49GHX	REFLECTORS, SIDE, INTERMEDIATE (2) 3" Amber, 1 Each Side, Below The Third Rub Rail From the Top, Adhesive Back
49GKZ	FUEL FILLER DOOR with Non-Locking Latch
49GUB	CUTTER, SEAT BELT {TIE TECH Safecut} for Cutting Seat Belts
49GUK	FENDERS, RUBBER, REAR (2)
49GUX	MUD FLAPS, FRONT WHEELS (2) Rubber
49GVC	MUD FLAPS, REAR WHEELS (2) Rubber; Behind Rear Wheels
49GWW	WINDSHIELD WASHER Kit; 6 Quart Capacity, Bottle
	Includes : WINDSHIELD WASHER ELECTRICAL CONNECTIONS Sealed and Locking Type
49GWZ	INSPECTION PLATE Fuel Sending Unit 8" x 8" Aluminum Diamond Tread Mounted Flush with Floor Mat

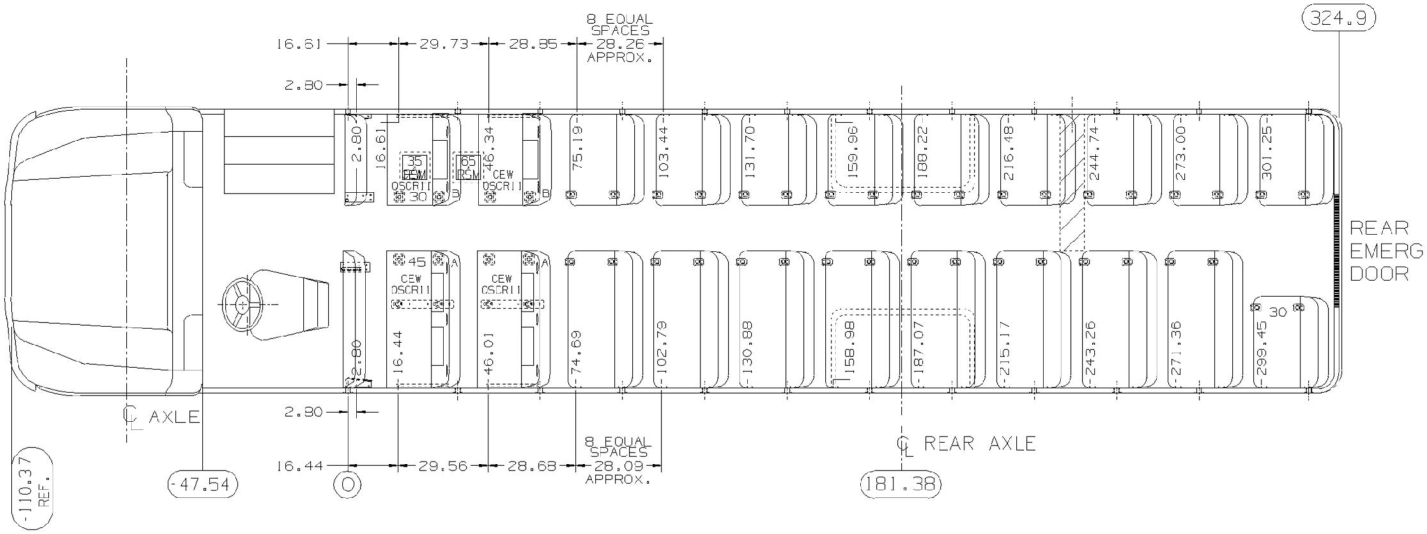
Code	Description
49GZT	FUEL FILLER PIPE Neck Cap and Vent Hosing for Use with Right Side Fill 100 Gal. Between the Rails Fuel Tanks
49HES	MIRROR, BRACE, EXTERIOR Telescoping for Breakaway Bracket
49JAC	DEF FILLER DOOR with Non-Locking Latch
49JBR	LIGHTS, DOME {Sound Off} (12) LED, Rectangular, Recessed Type, Mounted in Light Bar
49JBW	LIGHT, STEP {Sound Off} 4" Round LED, White, Wired to Clearance Lights, Operated by Entrance Door
49JBY	LIGHTS, MARKER, FRONT, REAR {Sound Off} (4) Total, Slimline Armored LED, (2) Amber Front and (2) Red Rear
49JCG	LIGHT, STROBE , LED, Specialty Man. Co. 845-3020, Low Profile, Double Flash, 3.60" High
49MZT	INSULATION, FUEL FILLER Rubber Isolator for Fuel Filler when Exhaust are on Same Side
49MZX	LATCH, COMPARTMENT Non Locking, for Overhead Storage Compartment
49NGG	LIGHTS, TAIL, LICENSE PLATE (2) {Sound Off} 4" Round LED, Red, Includes Stop & Light Window, Includes Mounting Gasket
49NGH	LIGHTS, WARNING (8) {Sound Off} (4) 7" Round Red Flashing LED and (4) 7" Round Amber Flashing LED, 2 Front, 2 Rear Each Color
49UBK	STATE OF OPERATION New Jersey
49ZNE	LIGHTS, MARKER, SIDE {Sound Off} Slimline Armored, LED, Intermediate, Centered; Required for Units 30 Foot or Longer
49ZNJ	WIRING, VIDEO SYSTEM {SEON TL4 DVR System} Pre-Wire Only; Mounting Location for (2) Front Cameras Above Driver, (1) Mid Mounted, Center Line of Roof, (1) Rear Camera, Camera Cables Not Included
50UAM	BODY PLAN, NON-SPECIAL NEEDS Conventional; 31' 02" Body Length, +9 Section Front & Rear, 54 Passenger, 254" WB, DX9352A000
7372139003	(4) TIRE, REAR 11R22.5 Load Range G M726ELA (BRIDGESTONE), 492 rev/mile, 75 MPH, Drive
7372139059	(2) TIRE, FRONT 11R22.5 Load Range G R268 ECOPIA (BRIDGESTONE), 501 rev/mile, 75 MPH, All-Position
OBD001	MISCELLANEOUS PERFORMANCE FRICTION BRAKE ROTORS
	Services Section:
40126	WARRANTY Standard for CE, RE, BE School Bus Models, Effective with Vehicles Built March 1, 2017 or Later, CTS-3304H
40PLB	SRV CONTRACT, EXT VEH COVERAGE {Navistar} To 36-Month/50,000 Miles (80,000 km), Covers 100% Parts and Labor; Includes Body; Excludes Extending Warranty for Engine, Transmission, Perforation or Corrosion of Cab/Cowl Structure and Paint
49GVN	WARRANTY 5-Year, Limited
	BSC QUOTE 661-171024-02 - INSTALL CHILD CHECK MATE EP2+ SYSTEM WITH MOTION SENSOR, SPEAKER, AND REAR DEACTIVATION SWITCH
	BSC QUOTE 661-171024-01 - INSTALL CUSTOMER SUPPLIED ZONAR V3 TRACKING MODULE WITH EVIR INSPECTION SYSTEM
	BSC QUOTE 661-171213-02 - INSTALL SEON TH4-HD-1Q3-500A-TH DVR, 500GB HARD DRIVE, 3 HD1Q CAMERAS, POWER HARNESS, EVENT/DIAGNOSTIC HARNESS

Code	Description
	CBC QUOTE 661-180301-01 ROSCO SAFE-T SCOPE 270 CAMERA SYSTEM with 7" Mor-Vision Ultra Bright Monitor in 6"x30" Mirror with lever lock
	CBC QUOTE 661-180525-02 BELMOR YELLOW WINTER FRONT

BODY PLAN

WHEELBASE 254"

PB10500, 31 FT. 2 IN., CAP 54, SEAT SIZE 45/30, SEAT SPACING VARIES



PURCHASED SEATS IN THIS UNIT ARE:
C.E. WHITE (3P) CHILD RESTRAINT

THIS UNIT CONFORMS TO APPLICABLE FMVSS

THIS DOCUMENT IS IN ACCORDANCE WITH ASME Y14.5M-1994 AS AMENDED BY THE INTERNATIONAL TRUCK DIVISION DIMENSIONING AND TOLERANCING ADDENDUM-2000.

50UAM/49000

REVISE ONLY ON UGRAF SYSTEM

INTERNATIONAL TRUCK AND ENGINE CORPORATION

INTERNATIONAL CONFIDENTIAL PROPRIETARY

REFERENCE	CSO-963
LINEAR MEASURE: mm ☐ in ☒	APPROX. MASS (WEIGHT) ROUGH PART FINISH PART
UNLESS SPECIFIED DIM TOLERANCES ARE: ONE PLACE (.X) ±1.5 mm ±.06 in; TWO PLACE (.XX) ±0.8 mm ±.03 in; THREE PLACE (.XXX) ±0.25 mm ±.010 in; ANGLES ±1°	THIRD ANGLE PROJECTION
NAME	BODY PLAN PB10500
CONTROL	E 50
VERSION	E
DRAWN	U020270
DATE	05APR18
SCALE	NONE
SIZE	4
PART NO.	DX9352A000
SHEET	01

Logged in as Joseph | logout | help
Note: Your session will time out after 30 minutes of inactivity.
For best results, do not use your browser's "back" arrow.

Emission Results and Health Benefits for Project: First Student New Jersey Proposal

Emission Results

Here are the combined results for all groups and upgrades entered for your project.[1]

Annual Results (short tons)[2]	NO_x	PM2.5	HC	CO	CO_2	Fuel[3]
Baseline for Upgraded Vehicles	14.834	1.220	1.999	7.368	3,732.9	331,811
Amount Reduced After Upgrades	13.291	1.195	1.827	6.720	878.3	78,075
Percent Reduced After Upgrades	89.6%	98.0%	91.4%	91.2%	23.5%	23.5%

Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles	67.466	5.538	9.083	33.486	16,996.3	1,510,784
Amount Reduced After Upgrades	60.449	5.427	8.302	30.539	3,999.0	355,468
Percent Reduced After Upgrades	89.6%	98.0%	91.4%	91.2%	23.5%	23.5%

Lifetime Cost Effectiveness ($/short ton reduced)						
Capital Cost Effectiveness[4] (unit & labor costs only)	$98,817	$1,100,585	$719,548	$195,601	$1,494	
Total Cost Effectiveness[4] (includes all project costs)	$98,817	$1,100,582	$719,547	$195,600	$1,494	

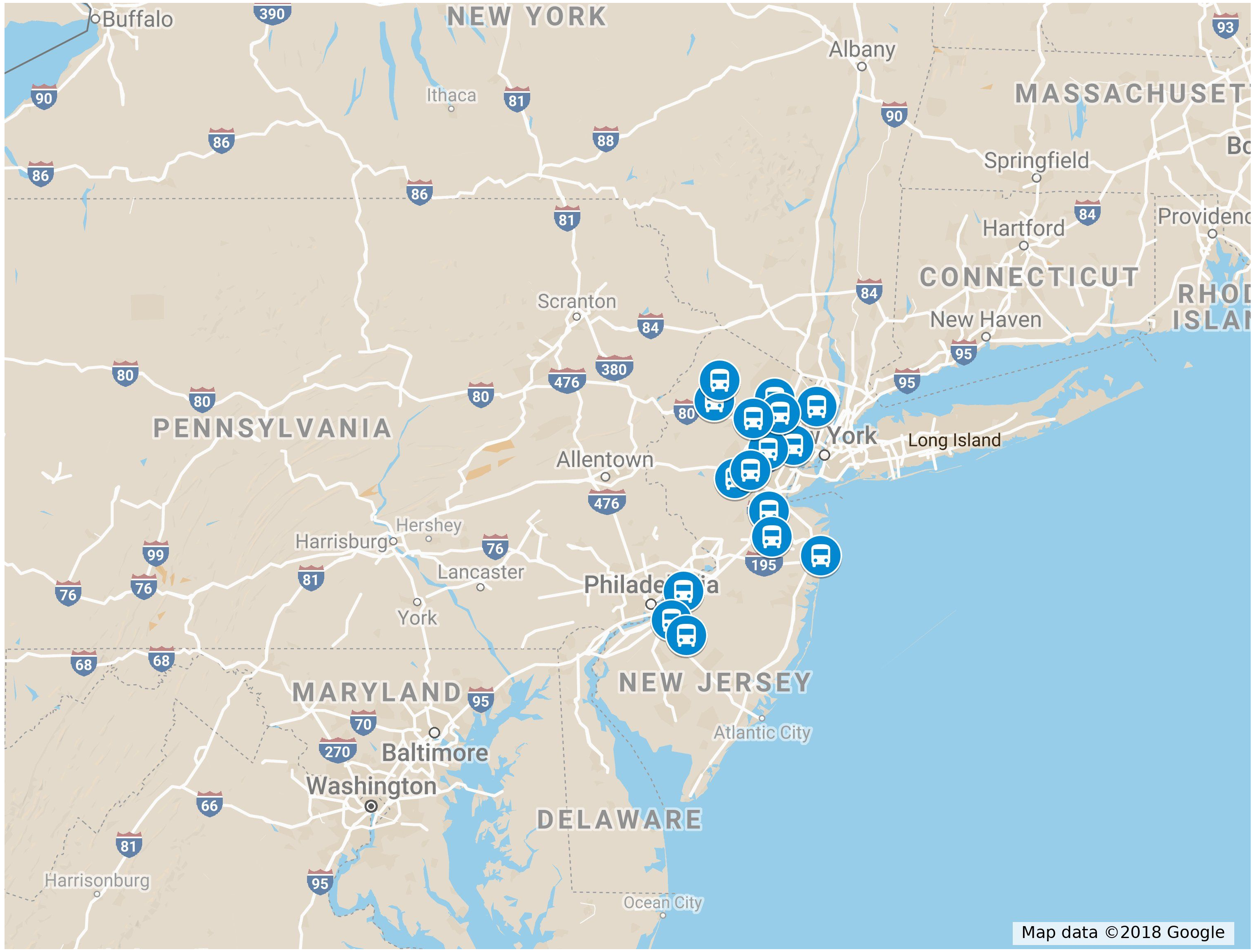
[1] Emissions from the electrical grid are not included in the results.
[2] 1 short ton = 2000 lbs.
[3] In gallons; fuels other than ULSD have been converted to ULSD-equivalent gallons.
[4] Cost effectiveness estimates include only the costs which you have entered.

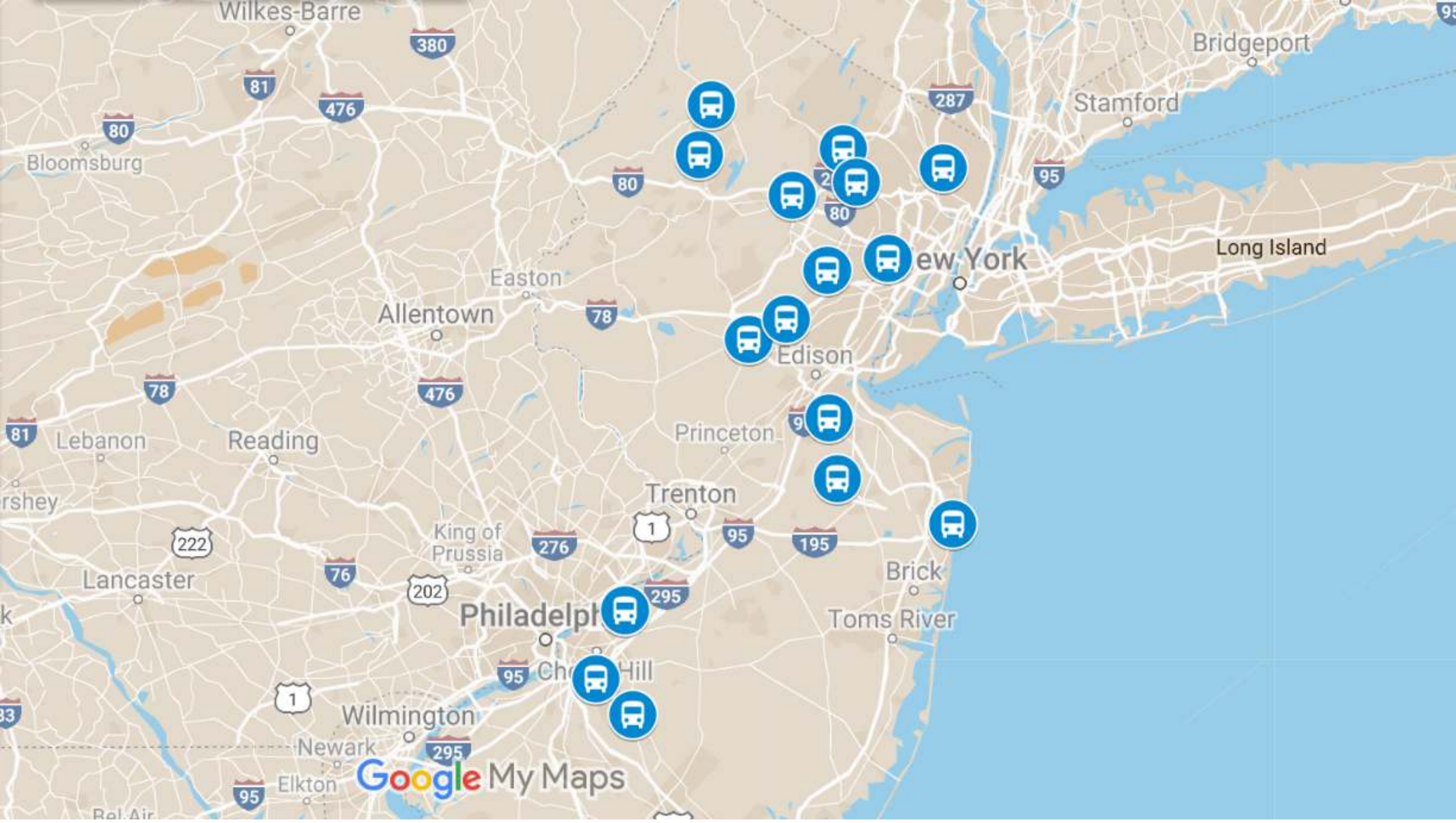
Remaining Life	**2005 NJ:** School Bus | School Buses	5 years
	2004 NJ: School Bus | School Buses	4 years

First Student NJ VW Replacement Locations

NJ VW Grant Locations

- Andover
- Bridgewater-raritan Reg
- Delran Township School District
- Englewood School District
- Bergen County Special Services School District
- First Student
- East Brunswick Schools Administration
- Butler High School
- Lawnside Borough
- East Orange School District
- Berlin
- Chatham
- Neptune City
- Englishtown
- Lincoln Park
- Warren
- Riverview Elementary School




Wilkes-Barre
380
81
476
80
Bloomsburg
Bridgeport
287
Stamford
95
Long Island
Easton
Allentown
78
Edison
476
81
Lebanon
Reading
Princeton
Trenton
King of
Prussia
222
276
1
95
195
Brick
Lancaster
76
202
295
Toms River
95
1
Wilmington
Newark
295
Elkton
95
Google My Maps

First Student

Caring for students today, tomorrow, together.

600 Vine Street; Suite 1400
Cincinnati, OH 45202

December 11, 2018

NJ Department of Environmental Protection (NJ DEP)
Division of Air Quality
Mail code 401-02E
Trenton, NJ 08625-0420

RE: Verified Funding Commitment Letter – VW Settlement

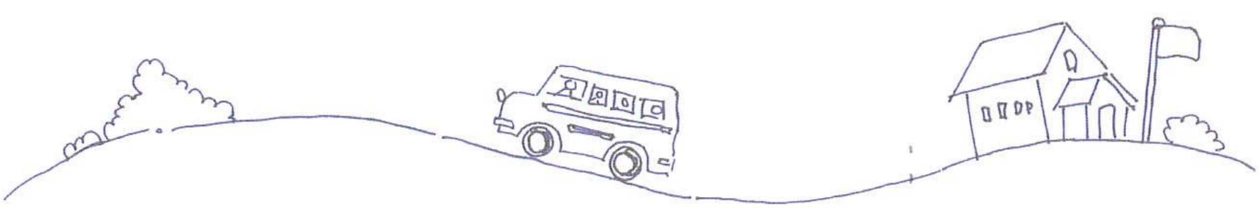
Dear NJ DEP:

I , Brian Beechem, an "Authorized Representative" of First Student, Inc., do hereby attest that First Student, Inc. has available Cash Funds in an amount that is sufficient to fund the entire project being proposed in this Diesel Emission Mitigation Program Proposal, such project estimated to cost $13,048,641.32. I further attest that these Cash Funds on deposit are free of any liens or encumbrances. Said Cash Funds are immediately available and freely transferable.

Authorized Representative: ____________________

Authorized Representative Name (printed): Brian Beechem

Date of Signature: 12/11/2018



New Jersey Demographic info
All info based on 2011-2015 Census data - Policy Map.com

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Average	Total
City/School District	Bridgewater/Raritan	Andover	Delran	Englewood	Bergen County - Passaic	Lafayette	Brunswick	Butler	Lawnside	East Orange	Berlin	Chatham	Neptune City	English Town	Warren	Riverview		
Census Tract qualification (Severely Distressed)	Not Eligible	Not Eligible	Not Eligible	Eligible	Not Eligible	Not Eligible	Not Eligible	Not Eligible	Not Eligible	Severely Distressed	Not Eligible	Not Eligible	Not Eligible	Not Eligible	Severely Distressed	Not Eligible		
Percent of People in Poverty	3.55%	2.90%	12.60%	16.00%	4.20%	2.20%	6.80%	8.20%	15.90%	15.00%	14.00%	2.50%	4.50%	2.80%	25.80%	4.90%	8.87%	N/A
Tract Income as % of AMI (Area Median Income)	163.48%	137.11%	82.18%	70.67%	106.28%	184.83%	103.45%	101.92%	82.49%	48.31%	80.71%	244.62%	100.28%	168.01%	82.55%	130.42%	117.96%	N/A
Population	44,464	5,978	16,623	29,112	948,406	2,538	57,073	7,774	2,926	65,378	7,606	8,928	4,708	1,943	16,029	8,900	76,774	1,228,386
Median Family Income	$144,412	$97,028	$72,596	$62,432	$93,889	$182,337	$68,092	$70,964	$72,868	$42,676	$54,940	$216,089	$88,583	$148,417	$42,750	$112,781	$98,178	N/A
Area Median Income	$88,336	$66,390	$88,338	$88,343	$88,341	$98,651	$65,821	$69,627	$88,336	$88,338	$68,071	$88,337	$88,336	$88,338	$51,787	$86,475	$81,367	N/A
Percent Population under 18	23.57%	29.91%	21.05%	21.78%	32.97%	24.51%	22.26%	18.94%	17.92%	22.62%	22.95%	30.45%	18.41%	23.40%	22.04%	26.17%	23.68%	N/A
Percent Population over 65	15.25%	11.79%	13.38%	15.34%	8.32%	19.46%	15.34%	20.70%	23.47%	13.46%	19.04%	13.47%	21.47%	15.77%	20.27%	8.00%	15.91%	N/A
Percent of Adults Reporting to Have Asthma	7.97%	8.61%	8.51%	8.60%	8.44%	7.86%	9.20%	9.41%	9.81%	10.84%	10.43%	8.05%	9.15%	8.30%	9.54%	9.18%	8.99%	N/A
Percent of People of Color (Asian/Pacific Islander, Black, Hispanic, two or more races)	31.12%	7.41%	6.77%	54.40%	43.03%	18.43%	5.38%	4.22%	94.17%	96.85%	3.67%	13.24%	40.65%	12.54%	39.22%	7.88%	29.94%	N/A
Percent of People with Chronic Obstructive Pulmonary Disease	5.98%	6.20%	6.37%	5.96%	6.04%	5.35%	8.29%	8.46%	6.51%	7.19%	8.80%	5.96%	6.92%	6.44%	11.19%	5.43%	6.94%	N/A

*Source – Policymap.com

ORIGINAL ARTICLE

Adopting Clean Fuels and Technologies on School Buses

Pollution and Health Impacts in Children

Sara D. Adar[1], Jennifer D'Souza[1], Lianne Sheppard[2,3], Joel D. Kaufman[2,4,5], Teal S. Hallstrand[4], Mark E. Davey[6], James R. Sullivan[2], Jordan Jahnke[7], Jane Koenig[2], Timothy V. Larson[2,8], and L. J. Sally Liu[2,6†]

[1]Department of Epidemiology, University of Michigan, Ann Arbor, Michigan; [2]Department of Environmental and Occupational Health Sciences, [3]Department of Biostatistics, [4]Department of Medicine, and [5]Department of Epidemiology, University of Washington, Seattle, Washington; [6]Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland; [7]Department of Biostatistics, University of Michigan, Ann Arbor, Michigan; and [8]Department of Civil and Environmental Engineering, University of Washington, Seattle, Washington

Abstract

Rationale: More than 25 million American children breathe polluted air on diesel school buses. Emission reduction policies exist, but the health impacts to individual children have not been evaluated.

Methods: Using a natural experiment, we characterized the exposures and health of 275 school bus riders before, during, and after the adoption of clean technologies and fuels between 2005 and 2009. Air pollution was measured during 597 trips on 188 school buses. Repeated measures of exhaled nitric oxide (FE_{NO}), lung function (FEV_1, FVC), and absenteeism were also collected monthly (1,768 visits). Mixed-effects models longitudinally related the adoption of diesel oxidation catalysts (DOCs), closed crankcase ventilation systems (CCVs), ultralow-sulfur diesel (ULSD), or biodiesel with exposures and health.

Measurements and Main Results: Fine and ultrafine particle concentrations were 10–50% lower on buses using ULSD, DOCs, and/or CCVs. ULSD adoption was also associated with reduced FE_{NO} (−16% [95% confidence interval (CI), −21 to −10%]), greater changes in FVC and FEV_1 (0.02 [95% CI, 0.003 to 0.05] and 0.01 [95% CI, −0.006 to 0.03] L/yr, respectively), and lower absenteeism (−8% [95% CI, −16.0 to −0.7%]), with stronger associations among patients with asthma. DOCs, and to a lesser extent CCVs, also were associated with improved FE_{NO}, FVC growth, and absenteeism, but these findings were primarily restricted to patients with persistent asthma and were often sensitive to control for ULSD. No health benefits were noted for biodiesel. Extrapolating to the U.S. population, changed fuel/technologies likely reduced absenteeism by more than 14 million/yr.

Conclusions: National and local diesel policies appear to have reduced children's exposures and improved health.

Keywords: particulate matter; air pollution; asthma; absenteeism; lung function

Traffic-related air pollution may adversely affect children's respiratory health (1–11). Little is known, however, about the health effects of commuting to school, especially aboard diesel-powered school buses. As more than 25 million American children commute via school bus (12) and experience elevated pollution levels on these buses (13–19), commuting is a major contributor to children's exposures to traffic-related air pollutants (14, 20–22).

To limit exposures to diesel exhaust and to protect health, the U.S. Environmental Protection Agency (USEPA) created a voluntary retrofit initiative to help states install clean air technologies on vehicles. Clean air technologies such as

(Received in original form October 29, 2014; accepted in final form April 9, 2015)

†Deceased.

Supported by the NIEHS (#1R01ES12657-01A1), the Washington Department of Ecology, and the University of Washington Center for Ecogenetics and Environmental Health (NIEHS, P30ES007033).

Author Contributions: S.D.A., L.S., J.D.K., T.S.H., M.E.D., J.K., and L.J.S.L. were involved in the study design of this project. S.D.A., T.S.H., M.E.D., J.R.S., and L.J.S.L. were involved in data collection. S.D.A., J.D'S., L.S., and J.J. were involved in data analysis. S.D.A., L.S., J.D.K., T.S.H., J.K., L.J.S.L., and T.V.L. were involved in data interpretation. S.D.A. wrote the first draft of the manuscript with feedback from all authors but L.J.S.L., who died before completion of the manuscript.

Correspondence and requests for reprints should be addressed to Sara D. Adar, Sc.D., Department of Epidemiology, University of Michigan, 1415 Washington Heights, SPHII-5539, Ann Arbor, MI 48109. E-mail: sadar@umich.edu

This article has an online supplement, which is accessible from this issue's table of contents at www.atsjournals.org

Am J Respir Crit Care Med Vol 191, Iss 12, pp 1413–1421, Jun 15, 2015

Originally Published in Press as DOI: 10.1164/rccm.201410-1924OC on April 13, 2015
Internet address: www.atsjournals.org

At a Glance Commentary

Scientific Knowledge on the Subject: Exposures to traffic-related air pollution at home and school have been repeatedly linked to adverse respiratory health in children. Children also experience elevated pollution levels on diesel-powered school buses, yet little is known about the resultant health effects or the level of protection offered by clean air technologies and fuels on school buses.

What This Study Adds to the Field: The findings from this natural experiment suggest that when children ride buses with clean air technologies and/or fuels, they experience lower exposures to air pollution, less pulmonary inflammation, more rapid lung growth over time, and reduced absenteeism than when they are on buses without these technologies and fuels. These improvements were often strongest among children with asthma, suggesting that cleaner buses may be especially important to protecting the health of our most vulnerable students. Given that more than 25 million American children commute to school each day via school bus, these findings have clear policy implications for protecting the health of school children.

diesel oxidation catalysts (DOCs) and crankcase ventilation systems (CCVs) are used to reduce tailpipe and engine emissions, respectively. These technologies, which can be adopted on older buses and are commonly installed on newer buses, are estimated to reduce particulate emissions and onboard concentrations by 20 to 50% (23–28). The USEPA also required that refineries produce ultralow-sulfur diesel (ULSD) starting in 2006 under the Highway Diesel Fuel Sulfur Control Requirements. ULSD and biodiesel are projected to reduce particle generation by approximately 10–30% and to enhance the operation of clean air technologies (23, 29). Although these initiatives have been estimated to prevent approximately 20,000 hospitalizations and 3.3 million days of lost productivity (30), no study has directly assessed the health impacts of these policies on individual children.

We investigated the impacts of clean air technologies and fuels on air pollution levels in school buses and on pulmonary health in a cohort of elementary school children. Associations were explored using a natural experiment in which we monitored in-bus air pollution concentrations and markers of health before, during, and after the staggered adoption of clean air technologies and fuels. Early results of this study have been previously reported as abstracts (31–33), and one published article (16).

Methods

Population and Design

We sampled 307 school bus riders (6–12 yr) attending a public elementary school in the Seattle and Tahoma, Washington, school districts (*see* Figure E1 in the online supplement). Children were monitored monthly (2005–2009) while the Puget Sound Clean Air Agency (PSCAA) incentivized clean air technology installation and a fuel change occurred under USEPA rules. Children were unaware of the technology and fuel of their buses, resulting in a blinded natural experiment with the collection of exposure and health measurements before, during, and after the staggered implementation of interventions. Children with asthma were preferentially recruited for power and as a sensitive subpopulation (34). Children in smoking households, on buses with fewer than 50 seats, taking oral corticosteroids, or missing information were excluded, resulting in a sample of 275. All protocols were approved by our institutional review board and written guardian consent and child assent were obtained.

Bus Characteristics

Children's buses were identified on the basis of information from the district transportation departments and later confirmed by school administrators and study technicians. When children rode more than one bus, we used their primary bus for our analyses. Bus characteristics, including age, mileage, technologies, and fuels, were compiled from the PSCAA, school transportation departments, and annual inspection. Adoption of clean air technologies and fuels was also tracked continuously with a focus on DOCs, CCVs, ULSD, and a biodiesel mixture (approximately 20%). Although we had also been interested in diesel particulate filters (DPFs), these were used only temporarily on five buses, so we had insufficient information for our models.

Air Pollution

We collected measurements inside 188 buses ("in cabin") during 597 regular commutes greater than 10 minutes. Fine ($PM_{2.5}$) and ultrafine (UFP) particulate matter were measured with a *p*DR-1200 equipped with a cyclone preseparator (Thermo Scientific, Waltham, MA) and P-TRAK 8525 (TSI, Shoreview, MN), respectively. A PAS2000CE (EcoChem Analytics, League City, TX) was also used to capture particle-bound polycyclic aromatic hydrocarbons (pb-PAHs) as well as the black carbon content of the particles. During most trips, pollution was also measured inside a gasoline hybrid electric car traveling before the bus with open windows ("on road"). Differences between the bus and road reflect the pollution from the bus itself ("self-pollution") as has been validated by chemical tracer research (35). Ambient pollution measurements were also obtained from the PSCAA.

Pulmonary Health

Lung function and exhaled nitric oxide ($F_{E_{NO}}$) were measured monthly at school by technicians unaware of the children's bus characteristics. Measurements were collected at fixed times on school day mornings and afternoons, in accordance with standard procedures (36). $F_{E_{NO}}$ and room nitric oxide were collected with an offline collection kit (Sievers, Boulder, CO). Children exhaled into 1.5-liter aluminized Mylar balloons at a constant pressure of 12 cm H_2O to prevent contamination by nasal nitric oxide and to normalize expiratory flow rates. $F_{E_{NO}}$ samples were collected in triplicate and analyzed within 4 hours with an NOA 280i (Sievers), using the median value for our analysis. FEV_1 and FVC were measured with a MicroDL spirometer (Micro Medical, Lewiston, ME). Self-reported absenteeism in the previous month was supplemented with technician-collected records on absenteeism on the day of health testing.

General health, including asthma symptoms and recent illness, was ascertained by technician-administered questionnaires. Asthma status was assessed annually by doctor diagnosis or symptoms of wheezing or whistling in chest, wheezing after exercise, or a dry cough at night over the previous year based on validated questions from the International Study of Asthma and Allergies in Childhood (ISAAC) survey (37). Asthma severity was defined as persistent asthma (on controller medication), intermittent asthma (not on controller medication), and nonasthmatic.

Covariates

Self-reported demographics (race, sex, parental education) and medical history were collected at an annual health screening. Height and weight were obtained during monthly examinations, concurrent with collection of pulmonary health endpoints. Meteorology (relative humidity and temperature) and flu prevalence data were obtained from the University of Washington Atmospheric Sciences Department and the U.S. Influenza-Like Illness Surveillance Network, respectively. School and home locations were classified as near a major roadway, using ArcGIS (ESRI, Redlands, CA), if they were within 100 m of an interstate or U.S. highway or within 50 m of a state or county highway.

Statistical Analysis

Descriptive statistics were generated using repeated-measures analysis of variance models. Exploratory analyses then compared pollution and health between buses that never or always had certain technologies/fuels as well as within buses before and after a switch. Pollutant and Fe_{NO} levels were log-transformed due to right-skewed distributions and investigated using multivariable mixed-effects models to account for correlation between repeated measures. Two-stage growth models with random intercepts and slopes were used for spirometry measures (38, 39). Risk differences for being absent within the past month were modeled with a mixed-effects log binomial regression. In-bus pollution models adjusted for ambient $PM_{2.5}$, weather (wind speed, temperature, relative humidity), bus characteristics (manufacturer, mileage, year, engine position, make, and model, bus base), and trip covariates (stops, duration, window usage, time of day, on-road pollution events). Health models were adjusted for age, race, sex, asthma, temperature, relative humidity, ambient $PM_{2.5}$, district flu prevalence, and seasonality. For Fe_{NO} and spirometry, height, weight, and cold/flu were also included. School air nitric oxide and day of week were included in Fe_{NO} models. Nonlinear relationships were assessed in R version 3.02 (www.r-project.org) and modeled with splines (flu prevalence) whereas other analyses used SAS version 9.3 (SAS Institute, Cary, NC). Models were run first with individual technologies and fuels and then with all technologies and fuels to separate the independent associations with pollutants and health. We further explored the impacts of DOC, CCV, and biodiesel among buses after the national switch to ULSD to assess the added benefit of nonrequired clean air interventions.

We tested for effect modification by asthma status and confirmed the robustness of our results to control for parental education, school/home roadway proximity, district, and additional time trends. We also explored sensitivity to classifying asthma on the basis of doctor diagnosis, restricting to children riding the same bus at least 75% of the time, control for or exclusion of buses with a DPF, and using fixed-effects models. Finally, we estimated preventable absences if all American school bus riders exclusively rode buses with clean air technologies and fuels. These calculations assumed that 54.6% of 54,876,000 school children ride buses (12), that 9.3% of these children have asthma (40), and that, of the children with asthma, 25% have persistent asthma (41).

Results

Study Participants

A total of 275 bus riders provided 3,223 observations with an average of 6 (range, 1–19) repeat visits over 4 years. These children were predominantly white and from college-educated families (Table 1). The mean age was 9.5 years. More than half (54%) were asthmatic, and the majority (85%) were not taking controller medication. Higher Fe_{NO} levels, more frequent absenteeism, and lower baseline lung function were observed among children with asthma compared with healthy children.

Buses Serving Study Population

During our 4-year study the adoption of clean air technologies and fuels increased over time (Figure 1). Across all buses serving our study population, approximately half had DOCs and ULSD and 35% had CCVs in the first year whereas greater than 90% had these technologies and fuels in the final year. This resulted in the majority of students always riding buses with DOCs (69%) and ULSD (81%) and fewer always riding buses with CCV (34%) and biodiesel (7%). Between 15 and 37% of students rode buses with and without clean air technologies and/or fuels, allowing for within-subject comparisons (Table 1 and Table E1). In general, there was little correlation between the various technologies and fuels, with the exception of DOC and ULSD, which had a correlation of approximately 0.5.

Measured Pollution Levels on Monitored Buses

Among the 597 trips on 188 buses with air pollution monitoring, the average mileage was 65,100 (SD, 58,700) and bus body year was 2002 (SD, 5) (Table 2). The average trip had a duration of 40 minutes (SD, 17 min) with 27 riders (SD, 14). Mean (±SD) in-cabin $PM_{2.5}$ concentrations (20 ± 18 $\mu g/m^3$) were approximately three times higher than ambient levels (7 ± 5 $\mu g/m^3$) and 1.5 times higher than roadway levels (13 ± 12 $\mu g/m^3$). Mean in-cabin UFP levels (21 ± 12 thousand/cm^3) were lower than on the surrounding roadways (29 ± 20 thousand/cm^3). Average pb-PAH concentrations were also lower inside bus cabins (101 ± 70 ng/m^3) than on surrounding roadways (125 ± 88 ng/m^3).

In multivariable models, we found strong evidence of lower in-cabin $PM_{2.5}$ concentrations with clean air technology use but weaker evidence for fuel types (Figure 2). DOCs and CCVs were associated with 26% (95% CI, −42 to −6%) and 40% (95% CI, −48 to −30%) lower in-cabin $PM_{2.5}$ concentrations, respectively. In contrast, UFPs were lowest with DOCs (−43%; 95% CI, −53 to −31%) and ULSD (−47%; 95% CI, −58 to −34%) with weaker reductions for CCVs and no associations with biodiesel. For pb-PAH concentrations, there were consistent increases with DOCs, CCVs, and ULSD. Only biodiesel was associated with lower in-cabin pb-PAH concentrations (−40%; 95% CI, −49 to −28%). Findings were similar for self-pollution concentrations and models adjusted for other technologies and fuels (results not shown).

Exhaled Nitric Oxide

Strong and statistically significant associations were identified between Fe_{NO} and ULSD use in fully adjusted models (Figure 3). Among the whole cohort, ULSD was associated with 16% (95% CI, −21 to −10%) lower Fe_{NO} levels. These

Table 1. Characteristics of Bus-Riding Elementary School Children Monitored between 2005 and 2009 during the Adoption of Clean Air Technologies and Fuels

	All	No Asthma	Intermittent Asthma	Persistent Asthma
Number of children	275 (100%)	126 (46%)	126 (46%)	23 (8%)
Number of samples	3,223 (100%)	1,590 (49%)	1,326 (41%)	307 (10%)
Baseline age, yr				
6–8	90 (33%)	34 (27%)	47 (37%)	9 (39%)
9–10	127 (46%)	65 (52%)	52 (41%)	10 (43%)
11–12	58 (21%)	27 (21%)	27 (21%)	4 (17%)
Female	124 (45%)	57 (45%)	58 (46%)	9 (39%)
Race				
Asian	25 (9%)	11 (9%)	13 (10%)	1 (4%)
Black	23 (8%)	4 (3%)	18 (14%)	1 (4%)
Other	19 (7%)	5 (4%)	9 (7%)	5 (22%)
White	203 (74%)	105 (83%)	83 (66%)	15 (65%)
Parental education				
College	33 (12%)	8 (6%)	22 (17%)	3 (13%)
Some college	35 (13%)	16 (13%)	16 (13%)	3 (13%)
College	88 (32%)	45 (36%)	32 (25%)	11 (48%)
College	105 (38%)	54 (43%)	45 (36%)	6 (26%)
School district				
Tahoma	89 (32%)	39 (31%)	39 (31%)	11 (48%)
Seattle	186 (68%)	87 (69%)	87 (69%)	12 (52%)
Height, m	1.4 (0.1)	1.4 (0.1)	1.4 (0.1)	1.4 (0.2)
Weight, kg	35.2 (11.0)	34.2 (9.1)	36.2 (12.1)	34.6 (14.1)
Outcomes				
$F_{E_{NO}}$, ppb	12.1 (1.9)	10.0 (1.6)	14.2 (2.0)	14.3 (2.3)
FEV_1, L				
Baseline	1.73 (0.4)	1.78 (0.36)	1.69 (0.42)	1.67 (0.47)
Δ per year	0.13 (0.49)	0.15 (0.4)	0.14 (0.51)	0.01 (0.77)
FVC, L				
Baseline	2.09 (0.48)	2.13 (0.45)	2.06 (0.49)	2.09 (0.54)
Δ per year	0.17 (0.54)	0.2 (0.38)	0.2 (0.57)	−0.06 (0.94)
MMEF, cl/s				
Baseline	167.0 (56.1)	176.2 (52.5)	160.5 (58.2)	152.3 (58.2)
Δ per year	14.5 (121.1)	14.4 (113.5)	14.8 (125.7)	12.9 (141.4)
Missed school days per month	0.35 (0.25)	0.32 (0.25)	0.35 (0.26)	0.40 (0.24)
Interventions				
DOC				
Never	36 (13%)	19 (15%)	15 (15%)	2 (9%)
Sometimes	48 (17%)	23 (18%)	18 (18%)	7 (30%)
Always	191 (69%)	84 (67%)	93 (67%)	14 (61%)
CCV				
Never	81 (29%)	37 (29%)	36 (29%)	8 (35%)
Sometimes	101 (37%)	52 (41%)	41 (33%)	8 (35%)
Always	93 (34%)	37 (29%)	49 (39%)	7 (30%)
ULSD				
Never	13 (5%)	8 (6%)	5 (4%)	0 (0%)
Sometimes	40 (15%)	18 (14%)	15 (12%)	7 (30%)
Always	222 (81%)	100 (79%)	106 (84%)	16 (70%)
Biodiesel				
Never	183 (67%)	90 (71%)	77 (61%)	16 (70%)
Sometimes	72 (26%)	32 (25%)	38 (30%)	2 (9%)
Always	20 (7%)	4 (3%)	11 (9%)	5 (22%)

Definition of abbreviations: CCV = crankcase ventilation system; DOC = diesel oxidation catalyst; $F_{E_{NO}}$ = fraction of exhaled nitric oxide; MMEF = maximal midexpiratory flow; ULSD = ultralow-sulfur diesel.
Data are given as n (%) or mean (SD).

associations were strongest among children with asthma: 31% (95% CI, −39 to −21%), 20% (95% CI, −28 to −12%), and 6% (95% CI, −14 to 2%) lower levels among children with persistent asthma, intermittent asthma, and no asthma, respectively. These associations were robust to control for other technologies and fuels (results not shown).

For children with persistent asthma, lower $F_{E_{NO}}$ levels were observed for children riding buses with DOCs (−12%; 95% CI, −23 to −0.4%) or CCVs (−14%; 95% CI, −24 to −4%) compared with buses without these technologies. Associations with CCVs, but not DOCs, were robust to control for other technologies and fuels but they were not

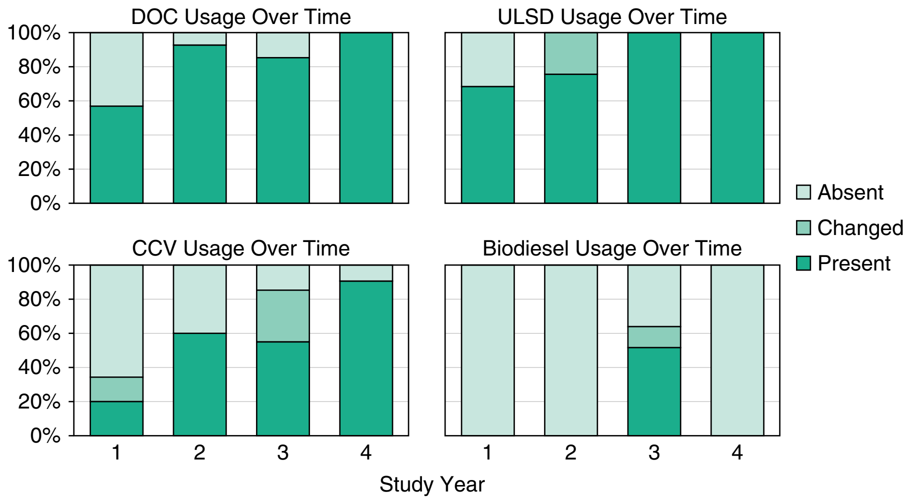


Figure 1. Clean air technologies and fuels over the 4-year study (defined as absent all year, changed during the year, or present all year). CCV = crankcase ventilation system; DOC = diesel oxidation catalyst; ULSD = ultralow-sulfur diesel.

found among other children. Biodiesel was unassociated with $F_{E_{NO}}$.

Pulmonary Function

Among all children, rates of change were 0.17 L/yr for FVC and 0.13 L/yr for FEV_1. After control for other factors, we observed 0.02 (95% CI, 0.003–0.05) and 0.02 (95% CI, 0.001–0.04) L/yr faster rates of change in FVC among children riding buses with ULSD and DOCs, respectively (Figure 4). These associations with FVC were generally robust to control for other technologies and fuels as well as stratification by school year among children without asthma (results not shown). Suggestive increases in FEV_1 over time were also found among all children for ULSD (0.01 L/yr; 95% CI, −0.006 to 0.03) and DOC (0.01 L/yr; 95% CI, −0.008 to 0.03) use, due primarily to associations with children without asthma and those with mild asthma. Lower changes in FEV_1 were observed with DOCs, ULSD, and biodiesel among those with persistent asthma. Although these associations were generally robust to control for multiple interventions, they had wide confidence intervals and could not be distinguished from no association.

Table 2. Characteristics of Monitored School Buses and Trips

	All Buses		Buses That Switched Technologies/Fuels	
	Buses	Trips	Buses	Trips
n	188	597	62	292
Clean air technologies*				
Diesel oxidative catalyst	165 (88%)	510 (85%)	18 (29%)	93 (32%)
Crankcase ventilation	134 (71%)	376 (63%)	36 (58%)	177 (61%)
Diesel particulate filter	5 (3%)	10 (2%)	0 (0%)	0 (0%)
Clean air fuels*				
Ultralow-sulfur diesel	183 (97%)	549 (92%)	18 (29%)	93 (32%)
Biodiesel	59 (31%)	152 (25%)	28 (45%)	138 (47%)
Mileage, in thousands	65.7 (57.4)	65.1 (58.7)	70.1 (54.5)	71.3 (58.9)
Body year	2002 (5.2)	2002 (5.0)	2002 (4.7)	2002 (4.7)
Seating capacity	72 (4.4)	72 (4.5)	73 (4.0)	73 (4.1)
Opacity, %	4 (7.3)	5 (9.8)	5 (7.9)	5 (9.6)

Data are given as n (%) or mean (SD).
*Bus results reported if bus ever had the technology or fuel. Trip data reflect the conditions during the monitoring event.

Absenteeism

Children missed an average of 3.1 school days over 9 months (2.9 for children without asthma, 3.6 for children with persistent asthma). Among all children, there was an 8% (95% CI, −16 to −1%) lower risk of being absent in the previous month when riding a bus with ULSD as compared with other buses (Figure 5). Similar findings were observed for DOC use: a 6% (95% CI, −11 to −0.2%) reduction in the risk of absenteeism over the past month. These associations were largest among children with asthma, especially those receiving controller therapy. Although associations with ULSD were robust to control for other technologies and fuels, associations with DOCs were diminished by control for ULSD (results not shown). On the basis of these findings, we estimate that the switch to ULSD resulted in 14 million fewer absences per year across the United States.

Sensitivity of Results

Associations between clean air technologies and fuels with each of the health endpoints were qualitatively robust to further adjustment for parental education, school/home proximity to major roads, district, and additional time trends. Our findings were also insensitive to use of doctor-diagnosed asthma, restricting to children riding the same bus at least 75% of the time, excluding or controlling for buses with a DPF, and modeling using fixed effects. Restriction to only those buses using ULSD suggested independent improvements with DOCs for absenteeism among children with severe asthma and changes in FVC over time, although little change was observed with FEV_1 or $F_{E_{NO}}$ after this restriction (results not shown).

Discussion

In this natural experiment, we documented lower in-vehicle exposures and improved pulmonary health of children with the adoption of clean air technologies and fuels on school buses. $PM_{2.5}$ concentrations were 25–40% lower on buses with DOCs and CCVs, and UFP levels were 40–50% lower on buses with DOCs and ULSD. In health analyses, we found that ULSD was most consistently associated with beneficial effects with evidence of less pulmonary inflammation, faster lung growth, and lower risks of school absenteeism. These

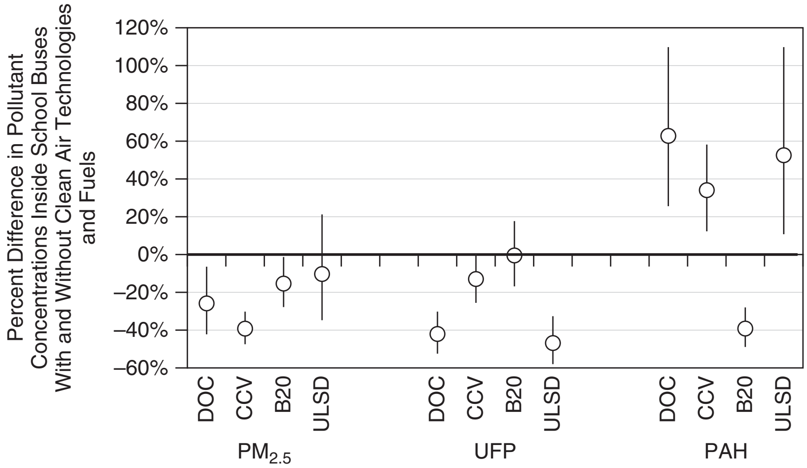


Figure 2. Associations of clean air technologies and fuels with air pollution concentrations inside school buses after control for ambient weather and pollutants, bus characteristics, and trip features. Models were adjusted for ambient wind speed, temperature, relative humidity, ambient $PM_{2.5}$, noted pollution events, trip duration, number of stops, open windows, time of day, bus base, year bus was built, mileage, engine make and model, body make, and random intercept for each bus. These contrasts include data from different buses and those that switched technologies. B20 = biodiesel; CCV = crankcase ventilation system; DOC = diesel oxidative catalyst; PAH = polycyclic aromatic hydrocarbons; $PM_{2.5}$ = fine particulate matter, ≤2.5-μm diameter; UFP = ultrafine particulate matter; ULSD = ultralow-sulfur diesel.

results were robust to control for other technologies and fuels and were often largest among children with asthma, especially those with persistent asthma. DOCs, and to a lesser extent CCVs, also were associated with better health, but these findings were primarily restricted to those with persistent asthma and were often sensitive to control for ULSD. Overall, we found that adopting certain clean air technologies and fuels reduced in-vehicle particulate exposures and likely improved respiratory health.

To our knowledge, no prior studies have examined the individual-level health impacts of clean air technologies and fuels, although one school district–level analysis suggested that a school bus emission reduction program was associated with decreased incidence of bronchitis, asthma, and pneumonia (42). Our findings suggest that the benefits of school bus emission reductions are also experienced at the child level. We identified sizeable improvements in absenteeism for children riding buses with ULSD that are comparable to 50–70% of the reductions observed for children living in nonsmoking homes as compared with homes with smokers (43). With 25 million children riding buses to school (12), we estimate that switching to ULSD resulted in 14 million fewer absences per year in the United States. Such reductions in absenteeism may translate to improved grades and health for the students (15, 16) as well as less missed work and lost productivity for their caregivers. Although results were strongest with ULSD, we also found evidence of reduced absenteeism among children with severe asthma and increased FVC over time with DOC usage even when restricted to buses using ULSD. This suggests that there may be additional benefit to clean air technologies independent of any changes in fuel.

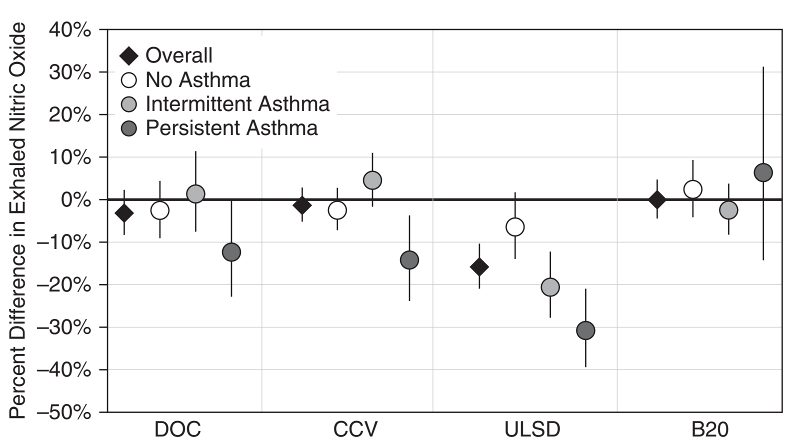


Figure 3. Adjusted associations (percent difference, 95% confidence interval) between levels of exhaled nitric oxide and clean air technologies and fuels among all students and by asthma status. Models were adjusted for age, sex, race/ethnicity, height, asthma status, ambient temperature, relative humidity, fine particulate matter (≤2.5-μm diameter), room nitric oxide, district flu prevalence, individual report of a cold or flu, within–school year time trend, time of day, and random subject effect. B20 = biodiesel; CCV = crankcase ventilation system; DOC = diesel oxidative catalyst; ULSD = ultralow-sulfur diesel.

Clean air technologies and fuels were not only associated with health benefits but also with reductions in on-board pollution. Both DOC and CCVs showed significant reductions in $PM_{2.5}$ and UFPs. This is generally consistent with previous in-vehicle studies, which found reductions of 25–60% for $PM_{2.5}$ and 5–70% for UFPs (17, 25, 27, 28). Reductions in UFPs, and to a lesser extent $PM_{2.5}$, with ULSD are also consistent with an earlier in-cabin study using ULSD in combination with DPF (17). Interestingly, our findings of comparatively larger reductions in $PM_{2.5}$ with CCVs and larger reductions in UFPs with DOCs are supported by previous research demonstrating that in-cabin $PM_{2.5}$ concentrations are primarily due to crankcase emissions and that UFPs primarily originate from the tailpipe (35, 44). Although we have previously demonstrated distinct patterning of pb-PAHs from $PM_{2.5}$ and UFPs in school buses (45), the observed increase in pb-PAHs with DOCs, CCVs, and ULSD is unexpected given that past research has generally shown reductions with clean air technologies and fuels (17, 46–48). Unfortunately, we have little explanation for these findings. One hypothesis is that a shift in the distribution of PAHs between the gaseous and particle phase may have led to measurement artifact because enhanced

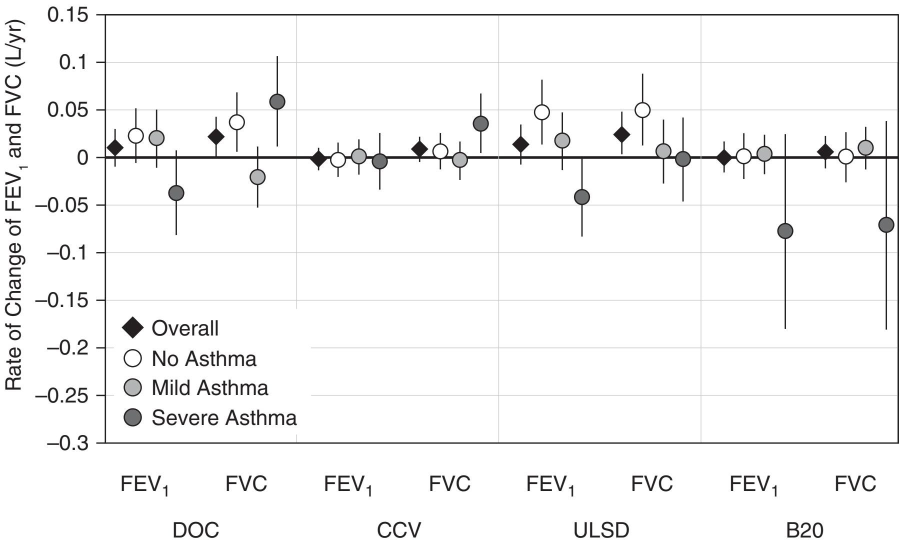


Figure 4. Adjusted associations (percent difference, 95% confidence interval) between rate of change in lung function over time and clean air technologies and fuels among all students and by asthma status. Models were adjusted for age, sex, race/ethnicity, height, weight, asthma status, ambient temperature, relative humidity, fine particulate matter (≤2.5-μm diameter), district flu prevalence, individual report of a cold or flu, within–school year time trend, and random subject effect. B20 = biodiesel; CCV = crankcase ventilation system; DOC = diesel oxidative catalyst; ULSD = ultralow-sulfur diesel.

nitro-PAH formation and nucleation can occur with clean air technologies (46, 49, 50).

The finding that ULSD and DOCs were most strongly and consistently associated with health suggests that UFPs may be a critical exposure on school buses. This is not surprising because UFPs are hypothesized to be especially toxic because of their high deposition in the lower airways, large surface areas to absorb chemicals/free radicals, lower removal by alveolar macrophages, and ability to initiate inflammation (51). Associations with $\mathrm{FE_{NO}}$, a marker of cytokine activity in the airways and alveoli (52), also suggest that lowered inflammation is a likely mechanism through which decreased exposures may lead to improved health. Furthermore, our finding of greater health improvements among children with asthma is also consistent with UFPs because airway narrowing increases the deposition efficiency of UFP in the lungs (53).

The cohesiveness of our findings across several endpoints further supports the hypothesized benefits of clean air technologies and fuels on respiratory health. Our results are consistent with controlled exposure studies in animals and humans, which have reported increased inflammation after the inhalation of diesel exhaust (54–58). Given that ULSD, DOCs, and CCVs were associated with lower particulate concentrations, our results are further supported by population-based studies of children that have linked higher particulate concentrations with higher $\mathrm{FE_{NO}}$ (59, 60), slower lung growth (61, 62), asthma exacerbation (63), and school absenteeism (61, 64–66). Although all of our results were on the same order of magnitude as past research, our lung growth findings were somewhat larger than expected (61, 64–67). This may be partially attributable to the young age of this population or the high asthma prevalence because some, although not all, research has reported enhanced associations among this group (34).

This study has numerous strengths including its large size and repeated, individual-level health and in-vehicle air pollution measurements surrounding the adoption of clean air technologies and fuels. It is not, however, without limitations. One key limitation is the possibility for residual confounding by time because some technologies/fuels, like ULSD, were used only in the later years of the study. If our statistical models inadequately captured any temporal trends in health, then we could incorrectly attribute some of the observed changes in health to the bus technologies/fuels. Sensitivity analyses indicated that this was unlikely for $\mathrm{FE_{NO}}$ and absenteeism as our models were robust to additional adjustment for time and there were no significant time trends among children who rode buses that did not change technologies or fuels. In contrast, FVC is more closely linked to time in this population. We allowed for different growth curves by age and age-adjusted height after accounting for differences between the sexes, ages, and asthma status. Within this age range, linear trends are expected and observed. If, however, accelerated growth due to puberty occurred among a small fraction of children, then the true associations with lung growth could be overestimated. Another limitation is that our absenteeism information was not verified by school records. Any misclassification would not likely be differential, however, because children were unaware of their bus characteristics. In addition, we supplemented self-reported absenteeism data with technician-recorded absenteeism of children during their monthly examinations to account for the inherent problem that absent children cannot report their absenteeism. Finally, although we

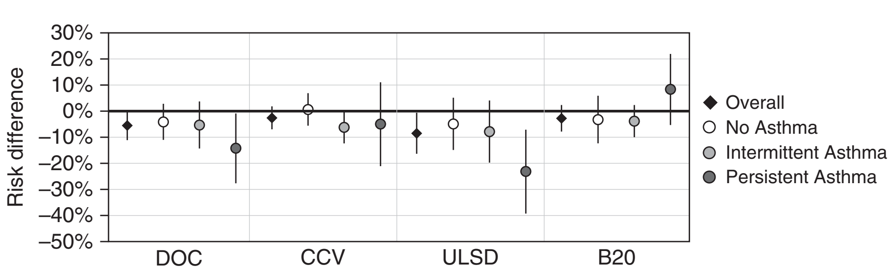


Figure 5. Adjusted associations (risk difference, 95% confidence interval) for any absenteeism in the past month as a function of clean air technologies and fuels among all students and by asthma status. Models were adjusted for age, sex, race/ethnicity, asthma status, ambient temperature, relative humidity, fine particulate matter (≤2.5-μm diameter), district flu prevalence, within–school year time trend, and random subject effect. B20 = biodiesel; CCV = crankcase ventilation system; DOC = diesel oxidative catalyst; ULSD = ultralow-sulfur diesel.

a priori anticipated that children with asthma would be more sensitive to exposures, we cannot exclude the possibility that our findings of enhanced associations among those with persistent asthma were due to chance given the small sample size (23 children, 307 samples).

In summary, we used a natural experiment to examine associations between clear air technologies and fuels in school buses and children's health. Our results show that the national switch to ULSD fuel may have had a measureable positive public health impact on children riding diesel school buses. This benefit was likely especially important for children with asthma. Our results further suggest that children with asthma may also have benefited from the nationwide voluntary school bus retrofit initiative and the adoption of DOCs and CCVs. Although the exact results varied by outcome, ULSD and DOCs were most consistently associated with both reduced pollutant concentrations and improved health, suggesting a role for UFPs in the health effects of diesel-powered school buses. ■

Author disclosures are available with the text of this article at www.atsjournals.org.

Acknowledgment: This work would not have been possible without the efforts of René Irish, Erin Corwine, Nichole Real, Tim Gould, Alex Ineichen, and the Diesel Bus Monitoring Team. The authors are thankful for the advice and support of Dr. Jim Krieger (Seattle-King County Department of Public Health), Michael Boyer and David Adler (Department of Ecology), Bridget Anderson, Michelle Zaleski, Doug Sander, and Bruce Zahradnik (Tahoma Schools), Jill Lewis (Seattle Schools), Stacy Roberts, Robert Cook, and David Oylear (First Student), and Michael Montgomery (Curtis Transportation). The authors are also extremely grateful for collaborations with Joellen Lewtas (University of Washington), David Anderson (Seattle Schools Transportation Department), and Paul Carr and John Anderson (PSCAA Diesel Solution Program). The authors also thank the Seattle and Tahoma principals, teachers, and students whose daily support made this study possible.

References

1. Brunekreef B, Janssen NA, de Hartog J, Harssema H, Knape M, van Vliet P. Air pollution from truck traffic and lung function in children living near motorways. *Epidemiology* 1997;8:298–303.
2. Gauderman WJ, Avol E, Lurmann F, Kuenzli N, Gilliland F, Peters J, McConnell R. Childhood asthma and exposure to traffic and nitrogen dioxide. *Epidemiology* 2005;16:737–743.
3. Gordian ME, Haneuse S, Wakefield J. An investigation of the association between traffic exposure and the diagnosis of asthma in children. *J Expo Sci Environ Epidemiol* 2006;16:49–55.
4. McConnell R, Berhane K, Yao L, Jerrett M, Lurmann F, Gilliland F, Künzli N, Gauderman J, Avol E, Thomas D, *et al*. Traffic, susceptibility, and childhood asthma. *Environ Health Perspect* 2006;114:766–772.
5. van Vliet P, Knape M, de Hartog J, Janssen N, Harssema H, Brunekreef B. Motor vehicle exhaust and chronic respiratory symptoms in children living near freeways. *Environ Res* 1997;74:122–132.
6. Brauer M, Hoek G, Smit HA, de Jongste JC, Gerritsen J, Postma DS, Kerkhof M, Brunekreef B. Air pollution and development of asthma, allergy and infections in a birth cohort. *Eur Respir J* 2007;29:879–888.
7. English P, Neutra R, Scalf R, Sullivan M, Waller L, Zhu L. Examining associations between childhood asthma and traffic flow using a geographic information system. *Environ Health Perspect* 1999;107:761–767.
8. Janssen NAH, Brunekreef B, van Vliet P, Aarts F, Meliefste K, Harssema H, Fischer P. The relationship between air pollution from heavy traffic and allergic sensitization, bronchial hyperresponsiveness, and respiratory symptoms in Dutch schoolchildren. *Environ Health Perspect* 2003;111:1512–1518.
9. Morgenstern V, Zutavern A, Cyrys J, Brockow I, Gehring U, Koletzko S, Bauer CP, Reinhardt D, Wichmann HE, Heinrich J. Respiratory health and individual estimated exposure to traffic-related air pollutants in a cohort of young children. *Occup Environ Med* 2007;64:8–16.
10. Ryan PH, LeMasters G, Biagini J, Bernstein D, Grinshpun SA, Shukla R, Wilson K, Villareal M, Burkle J, Lockey J. Is it traffic type, volume, or distance? Wheezing in infants living near truck and bus traffic. *J Allergy Clin Immunol* 2005;116:279–284.
11. Weinmayr G, Romeo E, De Sario M, Weiland SK, Forastiere F. Short-term effects of PM_{10} and NO_2 on respiratory health among children with asthma or asthma-like symptoms: a systematic review and meta-analysis. *Environ Health Perspect* 2010;118:449–457.
12. Snyder TD, Dillow SA. Digest of education statistics 2010 [NCES 2011-015]. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education; 2011.
13. Environmental and Human Health, Inc. Children's exposure to diesel exhaust on school buses. North Haven, CT: EHHI; 2002.
14. Behrentz E, Sabin LD, Winer AM, Fitz DR, Pankratz DV, Colome SD, Fruin SA. Relative importance of school bus-related microenvironments to children's pollutant exposure. *J Air Waste Manag Assoc* 2005;55:1418–1430.
15. Solomon GM, Campbell TR, Ruderman Feuer G, Masters J, Samkian A, Kavita AP. No breathing in the aisles: diesel exhaust inside school buses. New York: National Resources Defense Council and Coalition for Clean Air; 2001.
16. Adar SD, Davey M, Sullivan JR, Compher M, Szpiro A, Liu LJS. Predicting airborne particle levels aboard Washington State school buses. *Atmos Environ (1994)* 2008;42:7590–7599.
17. Hill LB, Zimmerman NJ, Gooch J. A multi-city investigation of the effectiveness of retrofit emissions controls in reducing exposures to particulate matter in school buses. Boston, MA: Clean Air Task Force; 2005.
18. Fitz DR, Winer AM, Colome SD, Behrentz E, Sabin LD, Lee SJ. Characterizing the range of children's pollutant exposure during school bus commutes: final report prepared for the California Air Resources Board. Sacramento, CA: California Air Resources Board; 2003.
19. Sabin LD, Behrentz E, Winer AM, Jeong S, Fitz DR, Pankratz DV, Colome SD, Fruin SA. Characterizing the range of children's air pollutant exposure during school bus commutes. *J Expo Anal Environ Epidemiol* 2005;15:377–387.
20. Wu CF, Delfino RJ, Floro JN, Quintana PJE, Samimi BS, Kleinman MT, Allen RW, Liu LJS. Exposure assessment and modeling of particulate matter for asthmatic children using personal nephelometers. *Atmos Environ* 2005;39:3457–3469.
21. Sabin LD, Kozawa K, Behrentz E, Winer AM, Fitz DR, Pankratz DV, Colome SD, Fruin SA. Analysis of real-time variables affecting children's exposure to diesel-related pollutants during school bus commutes in Los Angeles. *Atmos Environ* 2005;39:5243–5254.
22. Rea AW, Zufall MJ, Williams RW, Sheldon L, Howard-Reed C. The influence of human activity patterns on personal PM exposure: a comparative analysis of filter-based and continuous particle measurements. *J Air Waste Manag Assoc* 2001;51:1271–1279.
23. Neeft JPA, Makkee M, Moulijn JA. Diesel particulate emission control. *Fuel Process Technol* 1996;47:1–69.
24. Hammond D, Jones S, Lalor M. In-vehicle measurement of ultrafine particles on compressed natural gas, conventional diesel, and oxidation-catalyst diesel heavy-duty transit buses. *Environ Monit Assess* 2007;125:239–246.
25. Trenbath K, Hannigan MP, Milford JB. Evaluation of retrofit crankcase ventilation controls and diesel oxidation catalysts for reducing air pollution in school buses. *Atmos Environ* 2009;43:5916–5922.
26. Westphal GA, Krahl J, Munack A, Ruschel Y, Schröder O, Hallier E, Brüning T, Bünger J. Mutagenicity of diesel engine exhaust is eliminated in the gas phase by an oxidation catalyst but only slightly reduced in the particle phase. *Environ Sci Technol* 2012;46:6417–6424.
27. Rim D, Siegel J, Spinhirne J, Webb A, McDonald-Buller E. Characteristics of cabin air quality in school buses in central Texas. *Atmos Environ* 2008;42:6453–6464.

28. Zhang Q, Zhu Y. Performance of school bus retrofit systems: ultrafine particles and other vehicular pollutants. *Environ Sci Technol* 2011; 45:6475–6482.
29. Stanislaus A, Marafi A, Rana MS. Recent advances in the science and technology of ultra low sulfur diesel (ULSD) production. *Catal Today* 2010;153:1–68.
30. U.S. Environmental Protection Agency (EPA). Report to Congress: highlights of the diesel emissions reduction program. Washington DC: EPA; 2009.
31. Adar SD, Hallstrand TS, Kaufman JD, Liu LS. Changes in pulmonary function in childhood are associated with exposures to traffic from school bus exhaust and residential proximity to roadways [abstract]. *Am J Respir Crit Care Med* 2009;179:A4737.
32. Sally Liu LJ. Modeling children's exposures to diesel exhaust from commuting by diesel school buses before and after engine [abstract]. *Epidemiology* 2006;17:S36.
33. Liu L, Adar SD, Hallstrand T. Respiratory effects of exposures to diesel exhaust among children bus riders before and after the diesel bus engine retrofit [abstract]. *Epidemiology* 2008;19:S300.
34. Sacks JD, Stanek LW, Luben TJ, Johns DO, Buckley BJ, Brown JS, Ross M. Particulate matter-induced health effects: who is susceptible? *Environ Health Perspect* 2011;119:446–454.
35. Liu LJS, Phuleria HC, Webber W, Davey M, Lawson DR, Ireson RG, Zielinska B, Ondov JM, Weaver CS, Lapin CA, *et al*. Quantification of self pollution from two diesel school buses using three independent methods. *Atmos Environ (1994)* 2010;44:3422–3431.
36. American Thoracic Society; European Respiratory Society. ATS/ERS recommendations for standardized procedures for the online and offline measurement of exhaled lower respiratory nitric oxide and nasal nitric oxide, 2005. *Am J Respir Crit Care Med* 2005;171: 912–930.
37. Jenkins MA, Clarke JR, Carlin JB, Robertson CF, Hopper JL, Dalton MF, Holst DP, Choi K, Giles GG. Validation of questionnaire and bronchial hyperresponsiveness against respiratory physician assessment in the diagnosis of asthma. *Int J Epidemiol* 1996;25: 609–616.
38. Wypij D, Pugh M, Ware JH. Modeling pulmonary function growth with regression splines. *Stat Sin* 1993;3:329–350.
39. Berhane K, Gauderman WJ, Stram DO, Thomas DC. Statistical issues in studies of the long-term effects of air pollution: the Southern California Children's Health Study. *Stat Sci* 2004;19:414–434.
40. Bloom B, Jones LI, Freeman G. Summary health statistics for U.S. children: National Health Interview Survey, 2012. *Vital Health Stat 10* 2013;258:1–81.
41. Peters SP, Ferguson G, Deniz Y, Reisner C. Uncontrolled asthma: a review of the prevalence, disease burden and options for treatment. *Respir Med* 2006;100:1139–1151.
42. Beatty TK, Shimshack JP. School buses, diesel emissions, and respiratory health. *J Health Econ* 2011;30:987–999.
43. Levy DE, Winickoff JP, Rigotti NA. School absenteeism among children living with smokers. *Pediatrics* 2011;128:650–656.
44. Ireson RG, Easter MD, Lakin ML, Ondov JM, Clark NN, Wright DB. Estimation of diesel particulate matter concentrations in a school bus using a fuel-based tracer—a sensitive and specific method for quantifying vehicle contributions. *Transport Res Record* 2004;1880: 21–28.
45. Larson T, Zielinska B, Ireson R, Liu LS. Source apportionement of $PM_{2.5}$ inside two school buses using partial least squares regression discriminant analysis with chemical mass balance. *Atmos Pollut Res* 2011;2:144–150.
46. Hesterberg TW, Long CM, Sax SN, Lapin CA, McClellan RO, Bunn WB, Valberg PA. Particulate matter in new technology diesel exhaust (NTDE) is quantitatively and qualitatively very different from that found in traditional diesel exhaust (TDE). *J Air Waste Manag Assoc* 2011;61:894–913.
47. Tang S, Frank BP, Lanni T, Rideout G, Meyer N, Beregszaszy C. Unregulated emissions from a heavy-duty diesel engine with various fuels and emission control systems. *Environ Sci Technol* 2007;41:5037–5043.
48. Laroo CA, Schenk CR, Sanchez LJ, McDonald J. Emissions of PCDD/Fs, PCBs, and PAHs from a modern diesel engine equipped with catalyzed emission control systems. *Environ Sci Technol* 2011;45: 6420–6428.
49. Zhao H, Ge Y, Zhang T, Zhang J, Tan J, Zhang H. Unregulated emissions from diesel engine with particulate filter using Fe-based fuel borne catalyst. *J Environ Sci (China)* 2014;26:2027–2033.
50. Heeb NV, Schmid P, Kohler M, Gujer E, Zennegg M, Wenger D, Wichser A, Ulrich A, Gfeller U, Honegger P, *et al*. Impact of low- and high-oxidation diesel particulate filters on genotoxic exhaust constituents. *Environ Sci Technol* 2010;44:1078–1084.
51. Ibald-Mulli A, Wichmann H-E, Kreyling W, Peters A. Epidemiological evidence on health effects of ultrafine particles. *J Aerosol Med* 2002; 15:189–201.
52. Barnes PJ, Dweik RA, Gelb AF, Gibson PG, George SC, Grasemann H, Pavord ID, Ratjen F, Silkoff PE, Taylor DR, *et al*. Exhaled nitric oxide in pulmonary diseases: a comprehensive review. *Chest* 2010;138: 682–692.
53. Anderson PJ, Wilson JD, Hiller FC. Respiratory tract deposition of ultrafine particles in subjects with obstructive or restrictive lung disease. *Chest* 1990;97:1115–1120.
54. Lim HB, Ichinose T, Miyabara Y, Takano H, Kumagai Y, Shimojyo N, Devalia JL, Sagai M. Involvement of superoxide and nitric oxide on airway inflammation and hyperresponsiveness induced by diesel exhaust particles in mice. *Free Radic Biol Med* 1998;25:635–644.
55. Steerenberg PA, Nierkens S, Fischer PH, van Loveren H, Opperhuizen A, Vos JG, van Amsterdam JG. Traffic-related air pollution affects peak expiratory flow, exhaled nitric oxide, and inflammatory nasal markers. *Arch Environ Health* 2001;56:167–174.
56. van Amsterdam JG, Hollander A, Snelder JD, Fischer PH, van Loveren H, Vos JG, Opperhuizen A, Steerenberg PA. The effect of air pollution on exhaled nitric oxide of atopic and nonatopic subjects. *Nitric Oxide* 1999;3:492–495.
57. Steerenberg PA, Bischoff EW, de Klerk A, Verlaan AP, Jongbloets LM, van Loveren H, Opperhuizen A, Zomer G, Heisterkamp SH, Hady M, *et al*. Acute effect of air pollution on respiratory complaints, exhaled NO and biomarkers in nasal lavages of allergic children during the pollen season. *Int Arch Allergy Immunol* 2003;131:127–137.
58. Pourazar J, Mudway IS, Samet JM, Helleday R, Blomberg A, Wilson SJ, Frew AJ, Kelly FJ, Sandström T. Diesel exhaust activates redox-sensitive transcription factors and kinases in human airways. *Am J Physiol Lung Cell Mol Physiol* 2005;289:L724–L730.
59. Koenig JQ, Jansen K, Mar TF, Lumley T, Kaufman J, Trenga CA, Sullivan J, Liu LJ, Shapiro GG, Larson TV. Measurement of offline exhaled nitric oxide in a study of community exposure to air pollution. *Environ Health Perspect* 2003;111:1625–1629.
60. Fischer PH, Steerenberg PA, Snelder JD, van Loveren H, van Amsterdam JGC. Association between exhaled nitric oxide, ambient air pollution and respiratory health in school children. *Int Arch Occup Environ Health* 2002;75:348–353.
61. Rojas-Martinez R, Perez-Padilla R, Olaiz-Fernandez G, Mendoza-Alvarado L, Moreno-Macias H, Fortoul T, McDonnell W, Loomis D, Romieu I. Lung function growth in children with long-term exposure to air pollutants in Mexico City. *Am J Respir Crit Care Med* 2007;176:377–384.
62. Gauderman WJ, Avol E, Gilliland F, Vora H, Thomas D, Berhane K, McConnell R, Kuenzli N, Lurmann F, Rappaport E, *et al*. The effect of air pollution on lung development from 10 to 18 years of age. *N Engl J Med* 2004;351:1057–1067.
63. Evans KA, Halterman JS, Hopke PK, Fagnano M, Rich DQ. Increased ultrafine particles and carbon monoxide concentrations are associated with asthma exacerbation among urban children. *Environ Res* 2014;129:11–19.
64. Gilliland FD, Berhane K, Rappaport EB, Thomas DC, Avol E, Gauderman WJ, London SJ, Margolis HG, McConnell R, Islam KT, *et al*. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. *Epidemiology* 2001;12:43–54.
65. Park H, Lee B, Ha EH, Lee JT, Kim H, Hong YC. Association of air pollution with school absenteeism due to illness. *Arch Pediatr Adolesc Med* 2002;156:1235–1239.
66. Avol EL, Gauderman WJ, Tan SM, London SJ, Peters JM. Respiratory effects of relocating to areas of differing air pollution levels. *Am J Respir Crit Care Med* 2001;164:2067–2072.
67. Wang X, Wypij D, Gold DR, Speizer FE, Ware JH, Ferris BG Jr, Dockery DW. A longitudinal study of the effects of parental smoking on pulmonary function in children 6-18 years. *Am J Respir Crit Care Med* 1994;149:1420–1425.

Journal of the Air & Waste Management Association

ISSN: 1096-2247 (Print) 2162-2906 (Online) Journal homepage: http://www.tandfonline.com/loi/uawm20

Relative Importance of School Bus-Related Microenvironments to Children's Pollutant Exposure

Eduardo Behrentz , Lisa D. Sabin , Arthur M. Winer , Dennis R. Fitz , David V. Pankratz , Steven D. Colome & Scott A. Fruin

TECHNICAL PAPER

ISSN 1047-3289 *J. Air & Waste Manage. Assoc.* **55**:1418–1430

Relative Importance of School Bus-Related Microenvironments to Children's Pollutant Exposure

Eduardo Behrentz, Lisa D. Sabin, and Arthur M. Winer
Environmental Science and Engineering Program, School of Public Health, University of California, Los Angeles, CA

Dennis R. Fitz and David V. Pankratz
College of Engineering, Center for Environmental Research and Technology, University of California, Riverside, CA

Steven D. Colome
Integrated Environmental Sciences, Irvine, CA

Scott A. Fruin
California Air Resources Board, Research Division, Sacramento, CA

ABSTRACT
Real-time concentrations of black carbon, particle-bound polycyclic aromatic hydrocarbons, nitrogen dioxide, and fine particulate counts, as well as integrated and real-time fine particulate matter ($PM_{2.5}$) mass concentrations were measured inside school buses during long commutes on Los Angeles Unified School District bus routes, at bus stops along the routes, at the bus loading/unloading zone in front of the selected school, and at nearby urban "background" sites. Across all of the pollutants, mean concentrations during bus commutes were higher than in any other microenvironment. Mean exposures (mean concentration times time spent in a particular microenvironment) in bus commutes were between 50 and 200 times greater than those for the loading/unloading microenvironment, and 20–40 times higher than those for the bus stops, depending on the pollutant. Although the analyzed school bus commutes represented only 10% of a child's day, on average they contributed one-third of a child's 24-hr overall black carbon exposure during a school day. For species closely related to vehicle exhaust, the within-cabin exposures were generally dominated by the effect of surrounding traffic when windows were open and by the bus's own exhaust when windows were closed. Low-emitting buses generally exhibited high concentrations only when traveling behind a diesel vehicle, whereas high-emitting buses exhibited high concentrations both when following other diesel vehicles and when idling without another diesel vehicle in front of the bus. To reduce school bus commute exposures, we recommend minimizing commute times, avoiding caravanning with other school buses, using the cleanest buses for the longest bus routes, maintaining conventional diesel buses to eliminate visible emissions, and transitioning to cleaner fuels and advanced particulate control technologies as soon as possible.

IMPLICATIONS

A high percentage of school buses in California and elsewhere are powered by diesel engines and commuting children may be exposed to high concentrations of exhaust particles and gases during their commutes, at school bus stops, or at loading/unloading zones. This research showed bus commutes were much more important than bus stops or loading/unloading zones for children's exposure because more time was spent commuting and concentrations were higher in bus cabins. Self-pollution and the type of vehicle being followed were the main drivers for within-cabin exposure during bus commutes; however, the effect of these factors was influenced by window position, pollutant type, and other variables. Based on our findings we make recommendations for reducing children's overall bus commute-related exposures.

INTRODUCTION
Out of the 6 million school children in California, 1 million are transported by public school buses, and ~70% of the 26,000 school buses operating in California are powered by diesel engines.[1,2] Because of their high-volumetric inhalation rates relative to body mass, narrower lung airways, immature immune systems, and rapid

growth, children are more susceptible than adults to the health effects of various air pollutants.[3–6]

A number of studies have reported increased personal exposure and risk associated with bus commutes and traffic congestion.[7–15] A recent study of in-vehicle concentrations, conducted in Sacramento and Los Angeles using a passenger vehicle as a chase car, found that proximity to diesel vehicles caused high concentrations of in-vehicle fine particles and black carbon (BC).[16] Moreover, children may be exposed to high concentrations of diesel particulate matter (DPM) and other associated vehicle emissions while waiting at school bus stops, riding on buses (particularly when buses are caravanning), or during the time they are assembled at a school for loading or unloading near buses that are idling.

However, to date, no comprehensive studies of children's exposure while traveling to and from school in general, and on diesel school buses in California in particular, have been published in the peer-reviewed literature. This is true despite the fact that roadways and sidewalks have been shown to have the highest outdoor concentrations for many air pollutants, and in-vehicle concentrations have been shown to be higher than those measured at fixed site monitors and in some cases higher than measured along roadways.[14–22]

The overall objective of this study was to characterize the relative importance of exposures experienced by children during time spent in three school bus-related microenvironments: school bus cabins, school bus stops, and the school loading/unloading zone.

In addition, we estimated the contribution of the most relevant of these microenvironments to overall 24-hr exposure.

METHODS

We measured the concentrations of BC, particle-bound polycyclic aromatic hydrocarbons (PB-PAHs), nitrogen dioxide (NO_2), fine particulate matter ($PM_{2.5}$), and fine particulate counts in the size range between 0.3 and 0.5 μm (PC) inside six school buses (at the rear of the cabin) to capture the dynamic behavior of vehicle-related pollutants and to determine the most important factors governing children's exposure associated with commuting on school buses.[23,24] A total of 22 morning and afternoon runs, in Spring 2002, were conducted in Los Angeles on two urban school bus routes. Although no children were on board during the measurements, the bus routes followed in-use time and route patterns of the Los Angeles Unified School District. We also conducted six measurement periods at two bus stops along the primary route, and three measurement periods in front of the school where the children congregated briefly after exiting or before boarding the buses. To simulate typical bus operation, windows were closed during morning runs and partially opened (every other window down 10–15 cm) during afternoon runs. Six different buses were used, including two older high-emitting diesel buses, two diesel buses more representative of current fleets, one particle trap-outfitted diesel bus, and one compressed natural gas (CNG) powered bus. Table 1 lists the buses selected for testing.

In addition, we recorded traffic conditions and other exposure-related events using a high-resolution video camera mounted at the front of the test bus. Using the videotaped record of an exposure run, which showed the view of the road in front of the test bus, we systematically identified the events and characteristics that occurred in the area surrounding the test bus (i.e., presence of any diesel-powered vehicle, exhaust location of the vehicle being followed, presence of visible emissions, level of traffic congestion, and roadway type). This information was later correlated with the pollutants' real-time concentration data.[23] We also metered a tracer gas into the buses' exhaust system to determine the degree of self-pollution (the fraction of a bus's own exhaust that can be found inside its cabin) for the tested buses.[25]

The purpose of collecting videotape records and self-pollution data was to establish the relative importance of two potential significant sources of children's exposure inside school buses: the bus's own exhaust and the exhaust from other nearby vehicles.

Another objective of this study was to identify a school with a diverse student population drawn from various parts of Los Angeles, which offered a broad range of travel distance, roadway type, and traffic congestion

Table 1. Characteristics of school buses selected for testing.

Bus Type[a]	Year	Make	Model	Rows	Engine	Mileage	Displacement (liters)
HE1	1975	Crown	Supercoach	15	Cummins 290	316,000	6
HE2	1985	Crown	Supercoach	15	Detroit Diesel 671	315,000	6
RE1	1993	Thomas	Saf-T-Liner	13	Cat 3116	177,000	6.6
RE2	1998	Thomas	Saf-T-Liner	14	Cummins 250 HP 8.3	111,000	8.3
TO	1998	Thomas	Saf-T-Liner	14	Cummins 250 HP 8.3	78,000	8.3
CNG	2002	Thomas	Saf-T-Liner	14	John Deere 8.1	1000	8.1

Notes: [a]HE1, HE2 = high-emitter diesel school buses; RE1, RE2 = representative diesel school buses; TO = particle-trap outfitted diesel school bus; CNG = compressed natural gas school bus.

scenarios associated with bus commutes. The schoolselected was the Brentwood Science Magnet School (BSMS) in West Los Angeles (Figure 1), a K-5 facility in the Los Angeles Unified School District. Nineteen bus routes from diverse areas of Los Angeles County served this magnet school with a total enrollment of 1,209 students in the 1999–2000 school year.

Characterization of Microenvironments

Three microenvironments were investigated: "bus commutes" refers to measurements made inside buses during travel on a typical route to or from the BSMS; "bus stops" refers to sampling at two of the stops along one of the selected routes; and "loading/unloading" zone refers to measurements made in front of the BSMS. In addition, we measured "background" concentrations with the test buses parked with the engine off and the windows fully opened at different locations around Los Angeles.

Bus Commutes. Two different in-use bus routes that traveled from south central Los Angeles to west Los Angeles were used: a primary urban route (U1) with significant driving time on freeways, used for most of the runs; and for comparison, a second urban route (U2) with no time on freeways (Figure 1). Route U1 involved a wide variety of traffic conditions and roadway types, ranging from single-lane residential streets with little or no traffic, to heavily congested, multi-lane freeways. Approximately 40% of this route traveled on two of the most heavily congested freeways in the United States (I-405 and I-10) during peak (morning) and near-peak (mid-afternoon) traffic periods. The vehicle mix on these freeways included a substantial percentage of medium and heavy-duty diesel vehicles, including school buses. In general, as documented by our videotapes, vehicle types ranged from predominantly newer passenger vehicles and light-duty trucks close to the BSMS, to a high proportion of older cars and transit and school buses in south central Los Angeles.

Measurements were made on Route U1 during 18 bus runs in April, May, and June 2002, consisting of 9 morning and 9 afternoon commutes. The original route was 27 miles long and required a total commute time of ~100 min. We used a shortened version of this route during our sampling, because the average commute time for all BSMS bus routes was significantly shorter (75 min). Each morning run started at ~6:30 a.m. at the farthest pick-up location (of the truncated route) and ended at ~7:40 a.m. at BSMS. During the afternoon runs, the bus left BSMS at ~3:05 p.m. and reached the final drop-off location at ~4:10 p.m. At each stop, the bus pulled up to the curb, opened the doors, and waited for 1 min before driving away, to simulate the conditions of children loading or unloading from the bus.

As mentioned above, Route U2 traveled only on surface streets and covered a different geographic area than Route U1. In the morning, this route started in Carson, south of the BSMS, and traveled north through industrial areas with a substantial percentage of heavy-duty diesel traffic (Figure 1). Four exposure runs were conducted on U2, two in the morning and two in the afternoon, in May 2002. The morning runs started at ~6:15 a.m. at the first stop in Carson and finished at ~7:30 a.m. at the final stop of the truncated route we used to keep the commute time not much longer than 1 hr. In the afternoon, we drove the route in reverse, leaving from the first stop at ~3:35 p.m. and arriving at the final bus stop on U2 at ~5:00 p.m.

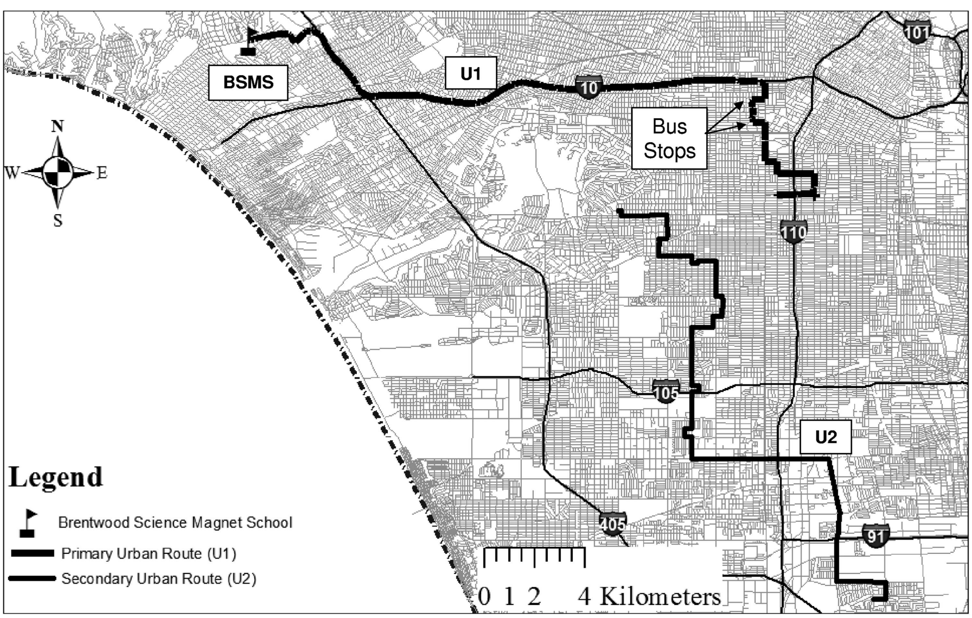


Figure 1. Location of BSMS, commute routes, and bus stops.

Bus Stops. These measurements were conducted at two bus stops along U1 (Figure 1). The first stop, in front of the Vermont Elementary School (on the northeast corner of 27th Street and Vermont Avenue) was characterized by increased traffic congestion during peak periods and served as a bus stop for several other school bus routes. Diesel school buses arrived to pick up or drop off children frequently during the period just before school started and after it let out. Measurements were conducted at this bus stop during two mornings and two afternoons in November 2001.

The second bus stop selected was the Weemes Elementary School (on 36th Place, three blocks west of Vermont Avenue) and was also characterized by increased traffic congestion during peak periods and also served as a bus stop for several other school bus routes. Measurements were made during one morning and afternoon in May 2002. The average time spent by a bus at these two stops was ~1 min, with the engine of the bus remaining on after the bus pulled up to the curb and children loaded/unloaded. Occasionally, a bus would idle at these stops for up to 5 min.

Each measurement period at the bus stops started at least 30 min before the arrival of the BSMS bus and continued for at least 30 min after the bus departed. Our fully instrumented bus was parked (engine off) next to the sidewalk on the street, and other buses and passenger vehicles pulled in front of or behind our instrumented bus to drop off/pick up children at the bus stops. Air samples from outside the bus, between the street and the sidewalk, were continuously drawn to the analyzers (located inside the cabin) through sampling lines that hung down from a window to a height of ~1.5 m.

Loading/Unloading Zone. Loading/unloading zone measurements were made during one morning and two afternoons in November 2001, using an instrumented van parked next to the sidewalk of the BSMS, in a portion of the staff parking lot, ~0.5 m from the sidewalk where children congregated briefly when leaving or boarding the buses. The sampling lines connected to the analyzers collected air from outside the van between the sidewalk and the street at a height of ~1.5 m.

Each morning 19 school buses typically arrived and parked one behind the other along the sidewalk in front of the school, between 7:40 a.m. and 8:00 a.m. to unload children. Generally, each bus turned off its engine as soon as it parked, in compliance with Los Angeles Unified School District regulations. Children quickly unloaded from the buses onto the sidewalk in front of the school, then walked as a group into the school. Buses arrived at different times, so often children were present on the sidewalk when another bus pulled up to the curb.

In the afternoon, buses arrived and parked along the sidewalk in front of the school, between 2:00 p.m. and 2:30 p.m. During our observations, each bus turned off its engine as soon as it parked. School ended at 2:45 p.m., and children quickly boarded the 19 buses. Typically, children were on the sidewalk no more than 5 min before they boarded.

Because the duration of our measurements in the loading/unloading zone was not long enough (40–70 min) for integrated mass sampling in the relatively clean air of west Los Angeles, we did not collect ambient $PM_{2.5}$ data during these sampling periods. In addition, we do not report PC data for this microenvironment, because the PC instrument used during loading/unlading measurements was different from the PC instrument used throughout the rest of the study. More details and discussion about this data set can be found elsewhere.[23]

Background Measurements. Because of the lack of noncriteria pollutant measurements at nearby air quality stations operated by the South Coast Air Quality Management District, and the desire to use the same instruments and methods used in the microenvironment measurements, we obtained our own ambient air background measurements for comparisons with the microenvironment data (with the exception of background $PM_{2.5}$ mass integrated data, again because of the relatively short sampling periods).

Eighteen sets of background measurements were conducted with the test bus parked with the engine off and the windows fully opened to allow ambient air throughout the cabin. The duration of these measurements was as long as practical (from 10 min to 2 hr) and longer than the minimum time needed (except for $PM_{2.5}$) to establish stable and detectable background concentrations. Measurements were conducted at several locations in Los Angeles: close to the intersection of two congested streets and in proximity to the I-405 freeway (duration ~30 min); in a University of California, Los Angeles parking lot away from traffic (~2 hr); in front of the BSMS after morning commutes were completed or before afternoon commutes started (~15 min); and in front of several of the schools that served as bus stops on the routes used during our study, either before morning commutes started or after afternoon commutes were completed (10–25 min).

Measurement Methods

A Climet (Redlands, CA) Spectro 0.3 Optical Particle Counter, operating at a flow rate of 1.0 l min^{-1} was used for particulate count concentration measurements in 16 size bins from 0.3 to 10 μm. The size range between 0.3 and 0.5 μm was used for our data analysis, because the highest number concentrations were found in this size bin. This size range, as part of the accumulation mode, was expected to reflect particle mass from secondary particle formation, a significant source of $PM_{2.5}$ mass in the Los Angeles basin. Detecting a portion of the largest particles generated by diesel vehicles was also likely, because diesel vehicles produce more mass in the accumulation mode than gasoline-powered vehicles.[26,27]

BC concentrations were measured using a Magee Scientific Aethalometer (Berkeley, CA), which drew sample air through a 0.5-cm^2 spot on a quartz fiber filter tape. Infrared light at 880 nm was transmitted through the quartz tape and detected using photodetectors, with the response to the change in light transmittance reported as BC.

An EcoChem Model PAS 2000 analyzer (West Hills, CA) was used to measure the concentrations of particle-bound PAHs based on photoionization of only the PB-PAH absorbed on aerosols. The lower detection threshold of this method was close to 3 ng m^{-3} total PB-PAH.

Nitrogen dioxide concentrations were measured by gas chromatographic separation of NO_2 and peroxyacetyl nitrate, followed by reaction with luminol and detection of emitted photons.[28] We also collected data for NO (using a chemiluminescence technique); however, we only report NO_2 concentration data, because this pollutant is the one of more interest from a health effects perspective.

Filter samples for particulate matter were collected using custom sampling systems designed for portable use. The inlets were of the Harvard design, which have been shown to have effective cuts at 2.5 μm while sampling at 20 l min^{-1}.[29] The flow rates were controlled by a needle valve and measured with a rotameter and calibrated against a volumetric flow rate sensor. The samples were collected on 37-mm Gelman "Teflo" filters (Pall Corp., East Hills, NY) with a 2-μm pore size. A Cahn Model 34 microbalance (ThermoCahn, Madison, WI) was used to determine the weight of the filters to within ±2 μg before and after sampling. All of the filters were equilibrated at 23 °C and 40% relative humidity for at least 24 hr before weighing. Filters were weighed a minimum of three times before and after sample collection.

Real-time $PM_{2.5}$ measurements were made using a DustTrak Aerosol Monitor Model 8520 (TSI Inc., Shoreview, MN). In this instrument, an impactor is used to perform the necessary size cuts, and the PM concentration is determined by measuring the intensity of 90 ° scattering of light from a laser diode. The instrument sample flow rate was 1.7 l min^{-1}.

Using a mass flow controller, we metered sulfur hexafluoride (SF_6), into the bus's exhaust system from cylinders containing 0.5% and 1% SF_6. The injection probe extended ~15 cm into the bus's exhaust pipe (located in the right-hand side of the rear bumper in all of the tested buses and in the great majority of the school buses we observed during the field study) to provide reasonable mixing of the SF_6 without attempting to snake the probe around the bends in the exhaust system.[25]

The SF_6 concentrations were measured inside the bus cabins using an AeroVironment Model CTA 1000 analyzer (Monrovia, CA) based on electron capture detection after water and oxygen were removed from the sampled air. The instrument was developed for operation on a moving platform and had a sensitivity of ~10 ppt with a response time of 3 sec.

As noted earlier, an 8-mm high-resolution video camera was mounted at the front of the test buses to record traffic conditions and other exposure-related events occurring in front of and adjacent to the test bus during the measurement periods. All of the video camera records were digitized into MPEG format.

Additional details about measurement methods, data analysis, and quality control procedures are given elsewhere.[23–25]

RESULTS AND DISCUSSION

School Bus Commute-Related Microenvironments

The mean concentrations observed for each of five pollutants in each microenvironment are given in Table 2. Mean concentrations observed for the loading/unloading microenvironment in front of the BSMS were low compared with those for the bus commute, or the bus stops in south central Los Angeles, and comparable with the background values we measured in west Los Angeles.

Mean concentrations at the bus stop microenvironment (means from the two bus stops) were between 1.5 and 3 times higher than mean concentrations at the loading/unloading zone microenvironment, depending on the pollutant. The highest ratio was observed for PB-PAH, whereas the lowest ratios occurred for NO_2. These results are explained by the substantial difference in air quality, at street level, between west Los Angeles

Table 2. Mean pollutant concentrations in the three school bus commute-related microenvironments and background ambient air.

	Mean concentrations			
	Background[a]	Loading/ Unloading Zone	Bus Stops	Bus Commutes[b,c]
BC (μg m^{-3})	2 ± 0.1	2 ± 0.3	4 ± 0.4	3–19 (8)
PB-PAH (ng m^{-3})	27 ± 1.5	15 ± 0.3	44 ± 4.5	64–400 (134)
NO_2 (ppb)	49 ± 1.0	35 ± 0.2	54 ± 1.9	34–110 (73)
PC (count cm^{-3})[d]	83 ± 3.1	N/C	62 ± 1.8	77–236 (130)
$PM_{2.5}$ (μg m^{-3})[e]	20 ± 2.4e	N/C	25[f]	21–62 (43)

Notes: N/C = Concentration data were not collected; [a]These values were measured around Los Angeles with the bus parked, engine off, and with the windows fully open and represent urban ambient air background concentrations during the study; [b]The ranges are associated with the different bus types and window position (open and closed); [c]The values within parentheses are the means for all runs; [d]In 0.3–0.5 μm size range; [e]From published data for Los Angeles basin;[31] [f]Not enough data to establish a confidence interval.

(upwind of major freeways and close to the ocean) and south central Los Angeles (heavily impacted by a wide range of emission sources) and also by the influence of other school buses that were dropping or collecting children while we measured the concentrations at the bus stops.

Mean concentrations, across all runs, inside buses were between 2 and 9 times higher than those at the loading/unloading zone for the corresponding pollutant. Again, the highest ratio was observed for PB-PAH, whereas the lowest ratio was for NO_2. Mean concentrations inside buses were 1.5, 2, and 3 times higher than the mean concentrations at the bus stops for NO_2, BC, and PB-PAH, respectively. However, the highest individual commute concentrations inside bus cabins were factors up to 9 times (for PB-PAH) higher than the mean concentrations at bus stops. Mean concentrations inside buses were 1.5 and 2 times higher than the mean concentrations at bus stops for $PM_{2.5}$ and PC, respectively.

The mean in-cabin pollutant concentrations reported in Table 2 are consistent with previous comparable studies,[7,16,21] as shown in Figure 2. We did not include PB-PAH as part of these comparisons because of the limited exposure data available to date for this pollutant.

Comparison of Microenvironment Exposures

To provide a measure of the relative importance of a given microenvironment we calculated pollutant-specific mean exposures, defined as the mean concentration of a specific pollutant in a given microenvironment multiplied by the time spent by children in that microenvironment. These results are presented in Table 3.

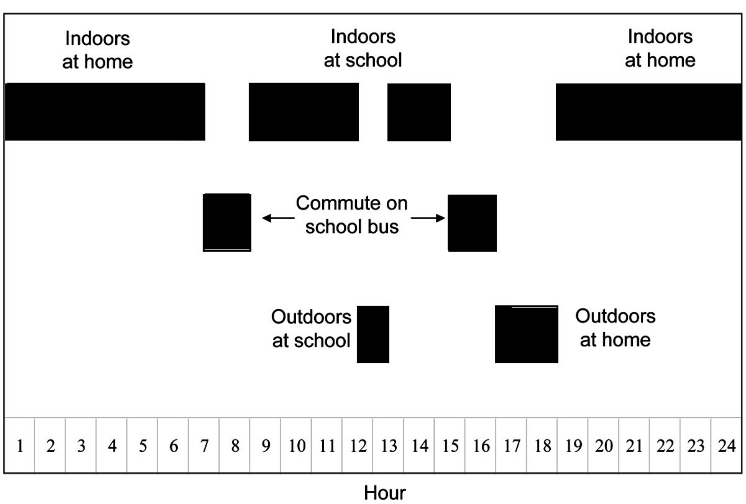


Figure 2. Time-activity pattern for a child on school day. Short periods (of several minutes) not reflected in this diagram include walking from home to the bus stop and from the bus stop to home, waiting at the bus stop, and loading and unloading the school bus.

Because our objective was to characterize the range of exposures experienced by children during school bus commutes, especially under high exposure conditions, mean exposures were estimated based on the travel time from the first bus stop to the school in the morning and the travel time from the school to the last bus stop in the afternoon, corresponding to the child with the maximum commute time. The times children spent at the loading/unloading zone and the bus stops were estimated from our observations in the field and are consistent with results from previous research.[30] In our study, the maximum time spent commuting on the bus was 15 and 25 times greater than the mean time spent at bus stops and the loading/unloading zone, respectively (Table 3).

Mean exposures for the bus stops were between 2.5 and 5 times higher than for the loading/unloading zone. The highest of these ratios was observed for PB-PAH, whereas the lowest was for NO_2. Across all pollutants the exposures during bus commutes were much higher than for the other two microenvironments. The mean exposures for the urban commutes that were part of this study were between 50 (NO_2) and 200 (PB-PAH) times higher than for the loading/unloading zone and between 20 (NO_2) and 40 (PB-PAH) times higher than for the bus stops. The mean exposures for the bus commutes for both PC and $PM_{2.5}$ were 30 times higher than for the bus stops.

These results indicate the loading/unloading zone was the least important microenvironment in terms of school bus-related exposure, both because children generally spent a short time on the sidewalk (5 min or less) before entering the school in the morning or boarding the buses in the afternoon and because bus drivers were required by school district policy to turn off their engines as soon as they arrived in the morning, before the children left the buses. Similarly, in the afternoon, drivers were instructed not to turn on their engines before all children were aboard the buses and the entire fleet was prepared to depart.

In contrast to the absence of idling buses at the BSMS loading/unloading zone, during our monitoring periods at both the Vermont Avenue School and the Weemes Elementary School bus stops, as many as half a dozen buses would pull up in front of the school and wait with the engine idling until children boarded. In several cases, buses were early and waited with their engines idling for several minutes, while children waiting for other buses stood nearby. Buses would then accelerate away from the curb, often releasing an exhaust cloud of black smoke (approximately one-third of the 19 diesel buses serving the BSMS emitted visible smoke on acceleration).

Table 3. Mean exposures for three school bus commute-related microenvironments.

	Mean Exposures[a]		
	Loading/ Unloading Zone	Bus Stops	Bus Commutes
BC (μg m^{-3} hr)	0.1	0.3	10
PB-PAH (ng m^{-3} hr)	0.8	4	170
NO_2 (ppb hr)	2	5	90
PC (counts cm^{-3} hr)[b]	N/A	5	160
$PM_{2.5}$ (μg m^{-3} hr)	N/A	2	55
Average time spent in this microenvironment (min)	3	5	75[c]

Notes: N/A = Not available; [a]Defined as the mean concentration of a specific pollutant in a given microenvironment multiplied by the time (hr) typically spent by children in that microenvironment; [b]In 0.3–0.5 μm size range; [c]Average commute time (one way) for BSMS bus routes.

Notwithstanding these results for the bus stop microenvironment, it is clear from our data that bus commutes, both because of the much longer exposure times and the more elevated pollutant concentrations, are by far the largest contributor to school bus-related exposure for a child's time-activity pattern associated with long duration school bus commutes.

Contribution of School Bus Commutes to Overall Daily Exposure

In addition to the microenvironment measurements, we estimated the approximate contribution of the bus-commute microenvironment to a typical BSMS student's overall 24-hr exposure during a school day. We performed these calculations only for BC, $PM_{2.5}$, and NO_2, because microenvironment data for these pollutants were readily available, whereas microenvironmental concentration data for PB-PAH and PC were difficult to obtain. However, because PB-PAH and PC concentrations inside school buses were highly correlated with those of BC and $PM_{2.5}$, respectively,[23,24] our results could be extrapolated for PB-PAH and PC concentrations.

Equation 1 was used to estimate the relative contribution of the school bus commute (SBC) microenvironment (R_{SBCj}) to the 24-hr overall exposure for a particular pollutant:

$$R_{SBCj} = \frac{C_{SBCj} \cdot T_{SBC}}{\Sigma_i (C_{ij} \cdot T_i)}, \tag{1}$$

where C_{SBCj} is the mean concentration (μg m^{-3}) of pollutant j during bus commutes, T_{SBC} is the average commute time for BSMS bus routes (hr), C_{ij} is the mean concentration of pollutant j in microenvironment i (μg m^{-3}), and T_i is the time spent (hr) in microenvironment i during a school day.

Figure 3 shows the time-activity pattern used for our calculations. The times shown spent in each microenvironment are consistent with previous research[5] and were deemed representative for a child who commutes on a school bus from south central Los Angeles to BSMS. In this case the child spends about one half of a school day (~12 hr) indoors at home, 2.5 hr commuting on a diesel school bus, approximately 7 hr inside school buildings, and the balance (2.5 hr) outdoors.

For BC and NO_2, the mean concentrations for the outdoors-at-school microenvironment were assumed to be the same as those measured at the loading/unloading zone. For the outdoors-at-home microenvironment, we assumed the mean BC and NO_2 concentrations to be the same as those measured during our background experiments. As mentioned before, we did not collect $PM_{2.5}$ data at the loading/unloading zone nor during our background measurements. Because for this pollutant, ambient air concentrations on the western side of the Los Angeles basin (where our bus study took place) exhibit a

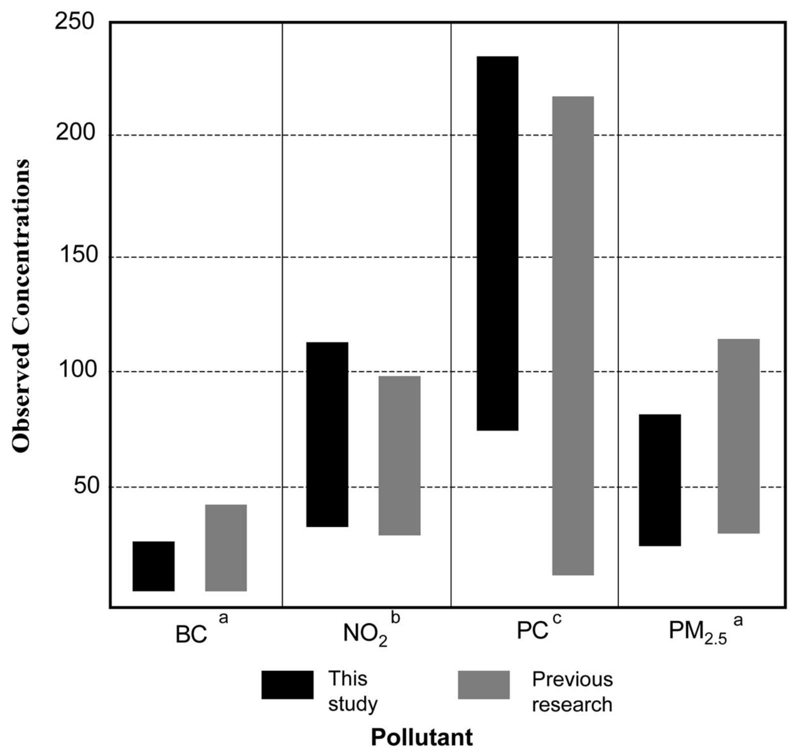


Figure 3. Ranges of concentrations observed in present and previous in-vehicle studies (commute averages). (a) Rodes et al., 1998 (μg m^{-3});[16] (b) Chan et al., 1993 (ppb);[7] and (c) Alm et al., 1999 (counts cm^{-3}).[21]

relatively low variability,[31] we used the same concentrations for both the outdoors-at-school and outdoors-at-home microenvironments. These concentrations were obtained from data recently published for this area.[31]

Infiltration of outdoor air into homes has been estimated to contribute 70% to the PM levels in naturally ventilated homes and 30% in air-conditioned homes,[32,33] and despite the strong effect of indoor sources such as smoking and cooking, the contribution of outdoor air to indoor PM levels remains significant.[33,34] Indoor exposure to BC is even more heavily influenced by outdoor concentrations.[35] Although housing characteristics, such as the presence of a gas range, are associated with indoor levels of NO_2, indoor NO_2 concentrations are significantly correlated with outdoor NO_2 concentrations.[33,36]

Based on these indoor/outdoor relationships, we estimated the mean concentrations for the indoor microenvironments (home and school) using published indoor/outdoor concentration (I:O) ratios in conjunction with our outdoor concentration data, rather than using average concentrations measured in comparable microenvironments during previous studies. According to recent research, typical BC I:O ratios are ~0.75 when no indoor sources are present.[35,37] Because we would not expect the presence of significant sources (e.g., smoking, cooking, and candle burning) in the school at times when children are in attendance, we used this value in combination with the mean concentration for the outdoors-at-school microenvironment to estimate the mean BC concentration for the school indoor microenvironment.

BC mean indoor concentrations could be up to two times higher when indoor sources are present compared with when no indoor sources are present.[35,37] We assumed activity involving BC sources for at least several hours while the child spends time indoors at home and, therefore, used an I:O ratio of 1.25 and the mean concentration for the outdoors-at-home microenvironment to estimate the mean BC concentration for the home indoor microenvironment.

Typical average I:O ratios for NO_2 for urban centers in southern California vary between 1.1 and 3.2 with a mean of 2.1 ± 1.7.[36,38] To estimate the mean concentration for the school indoor microenvironment we used the lowest of these values (1.1; i.e., no significant sources). For the home indoor microenvironment we used the mean I:O ratio of 2.1. To estimate $PM_{2.5}$ mean concentrations at home and inside the school, we used I:O ratios of 1.5 and 0.8, respectively, based on reported values[31,39,40] and similar considerations as above.

Table 4 summarizes our results for the contribution of school bus commutes to overall daily exposure by pollutant and microenvironment. This table shows that for BC, although the time spent in the school bus microenvironment only represents 10% of a child's day, on average the school bus commute contributes up to one-third to the overall 24-hr exposure of a child during a school day. These results are consistent with previous research in California, in which the in-vehicle contribution to overall DPM exposure was estimated to range between 30% and 55% of total DPM exposure on a statewide population basis[41] (taking into account the relatively high fraction of elemental carbon in DPM[27] and the strong association between elemental carbon and BC as measured with an Aethalometer).[42,43] In contrast, Table 4 also shows that for $PM_{2.5}$ the exposures in the different microenvironments were, on average, matched with the relative times spent in each one.

Finally, for all pollutants, while the outdoors microenvironment contributed only a small fraction (8% or less) to the 24-hr exposure, because of the small amount of time spent outdoors, the indoors-at-home microenvironment dominated the overall exposure (45–70% depending on the pollutant), although closely followed by the bus commute microenvironment in the case of BC.

Table 4. Contribution to overall exposures (24 hr) by pollutant and microenvironment.

		Mean Concentration			Exposure[a]			Contribution to Overall Exposure[b,c]		
Microenvironment	Time spent, hr (%)	BC ($\mu g\ m^{-3}$)	NO_2 (ppb)	$PM_{2.5}$ ($\mu g\ m^{-3}$)	BC ($\mu g\ m^{-3}$ hr)	NO_2 (ppb hr)	PM2.5 ($\mu g\ m^{-3}$ hr)	BC (%)	NO_2 (%)	$PM_{2.5}$ (%)
Indoors at home	12 (50)	3d	100[d]	30[d]	30	1200	360	45	70	55
Indoors at school	7 (30)	2d	35[d]	15[d]	10	260	110	15	15	20
Outdoor at home	1.2 (5)	2	50	20[e]	3	60	25	4	3	4
Outdoors at school	1.2 (5)	2	35	20[e]	3	45	25	4	2	4
Bus commutes	2.5 (10)	8	75	45	20	180	110	30	10	15
Total	24 (100)				65	1800	630			

Notes: All values rounded based on significant figures. [a]Mean concentration times time spent in each microenvironment; [b]From eq 1; [c]Totals do not add 100% because rounding errors through several steps of the calculations; [d]Estimated based on published I:O ratios[29–33] and outdoor concentrations measured during this study; [e]From published data for Los Angeles basin.[31]

Factors Affecting Commute Exposures

Bus commute exposure, the most important in terms of school bus use and also a significant contributor to overall exposure for pollutants such as BC, exhibited high variability under the conditions we studied. This variability is explained by the complex interactions of numerous factors that may affect pollutant concentrations inside the bus cabin, including window position, self-pollution, influence of surrounding traffic, route type, and bus type.

Window Position. Figures 4 and 5 show the differential effect of window position on the two types of pollutants considered in this study: species closely related to fresh diesel exhaust and not influenced by secondary formation (BC and PB-PAH) and species substantially affected by regional sources, secondary formation, and meteorological conditions ($PM_{2.5}$ and PC).[14,15] NO_2 is associated with fresh vehicle emissions and is also a secondary pollutant for which high background concentrations are possible. The dual characteristics of this pollutant demonstrate that our differentiation between "directly emitted" and "background" pollutants, although valid for the analyses presented here, must be approached with caution and may not work in all scenarios. The data presented in Figures 4 and 5 were collected during the same day (morning and afternoon) using the trap-outfitted bus on Route U1.

For BC (Figure 4), a directly emitted pollutant, the real-time concentrations with windows closed (morning) exhibit a relatively uniform pattern along the run with a slight upward trend that can be attributed to a combination of self-pollution (see below), accumulation because of limited ventilation, build-up of roadway concentrations, and the transition (during the morning commute) from relatively light residential street traffic near bus stop areas to heavy freeway traffic. No pronounced transient peaks are observed during this run with windows closed. For the same pollutant, the run with windows open (afternoon) exhibits a lower baseline (the mean concentration is about half the morning run mean concentration) with noticeable transient peaks that were correlated with the presence of diesel vehicles around the test bus.[23,24] These peak concentrations reach as high as 15 times the baseline concentrations.

For $PM_{2.5}$ (Figure 5), a background pollutant, the real-time concentrations (for the same runs as above) with windows closed are again relatively uniform. However, there is no upward trend for this case, which suggests that for background pollutants the effect of self-pollution is not as important for within-cabin exposure as for directly emitted pollutants. Similar to the case for BC (Figure 4), there are no significant transient peaks during this run, demonstrating that, as expected, the effect of surrounding traffic (see below) is not as important with windows closed compared with windows open. Figure 5 also shows that for $PM_{2.5}$ the run with windows open exhibits a slightly lower baseline (~25% less as opposed to ~75% less in the case of BC) with several transient peaks. However, in contrast to the observations for BC, these peak concentrations are only about twice as high as the baseline concentrations. These results demonstrate the effect of surrounding traffic is far more important for directly emitted pollutants than for background pollutants.

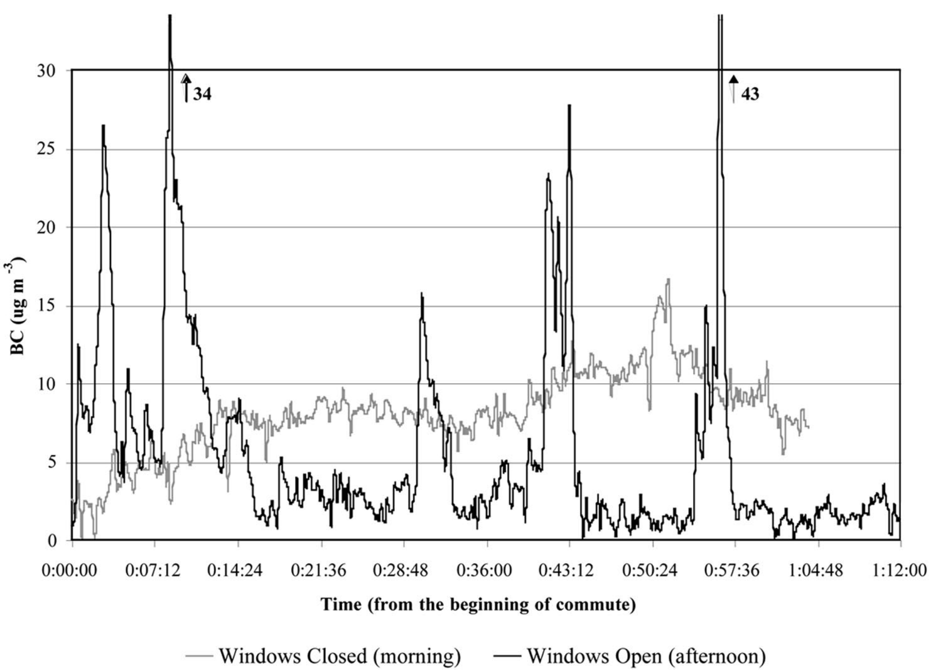


Figure 4. Real-time BC concentrations during a commute with windows open and a commute with windows closed. The great majority of the transient peaks observed for directly emitted pollutants during runs with windows open were correlated with events occurring around the test bus (e.g., following another diesel school bus).

Self-Pollution. The amount of a bus's own exhaust that can be found inside its cabin varied significantly between buses and also depended on window position. For all of the buses tested, self-pollution (measured with the tracer gas experiments) was substantially higher with all of the windows closed compared with the windows partially open. Moreover, older buses showed a larger percentage of their own exhaust entering into the cabin compared with newer buses.[25]

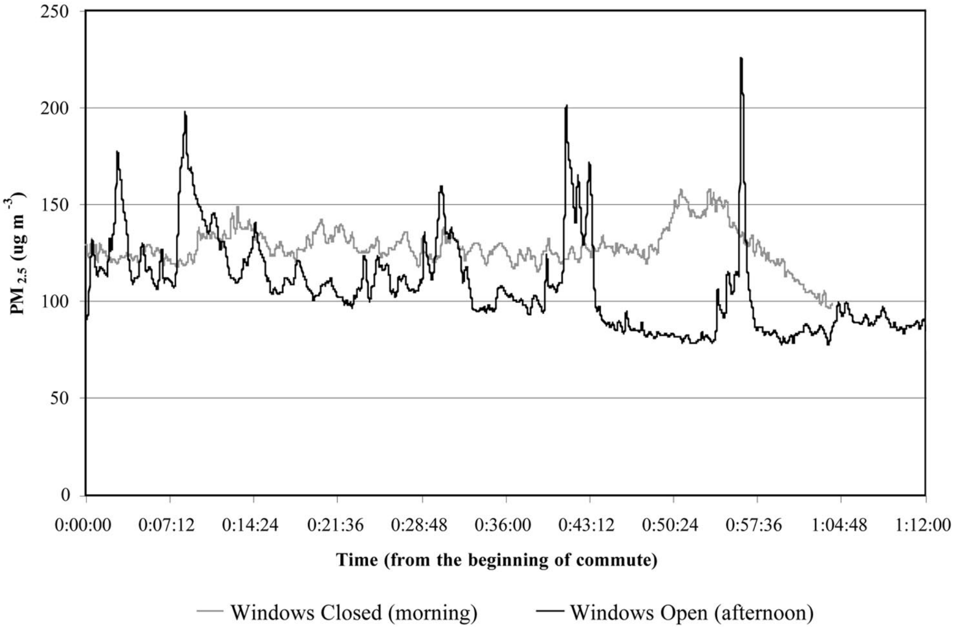


Figure 5. Real-time $PM_{2.5}$ concentrations during a commute with windows open and a commute with windows closed.

Different bus models and ages corresponded to different construction and cabin designs, and the results of our SF_6 tracer analyses suggested these differences may result in a wide range of pollutant exposures across bus types (see below). More detailed analyses about self-pollution in the tested buses are presented elsewhere.[25]

Influence of Surrounding Traffic. Using the videotapes collected during runs with windows open we were able to correlate the great majority of the transient peaks observed for BC and PB-PAH (see Figure 4) with events occurring around the test bus (e.g., following another diesel school bus).[24] For runs with windows open, we found BC and PB-PAH concentrations inside the test buses were highest when following a diesel school bus that emitted visible exhaust and lowest when following a gasoline vehicle or when no vehicles were in front of the test bus (no target).[23]

On average in the afternoon runs (windows open), another diesel vehicle was within three car lengths in front of or adjacent to our bus, during more than one-quarter of the commute, with diesel school buses responsible for >60% of these encounters. This high incidence of following other diesel school buses was in part because of caravanning behind other buses after leaving the BSMS.

The trap-outfitted diesel bus and CNG bus generally exhibited high peak concentrations only while traveling behind a diesel vehicle, whereas the conventional diesel buses exhibited high peaks both when following other diesel vehicles and while idling without another diesel vehicle in front of the bus. When following a smoky diesel school bus during runs with windows open, concentrations inside the cabin were on average 8 and 12 times higher for BC and PB-PAH, respectively, compared with following a gasoline vehicle or no target. When following a diesel school bus that was not emitting visible exhaust, BC and PB-PAH concentrations inside the test buses were on average 4 and 6 times higher, respectively, compared with following a gasoline vehicle or no target.[23]

Route Type. The overall mean concentrations of BC and PB-PAH (for commutes with windows open) were not significantly different between the two routes used in this study, although U1 spent ~40% of the time on the freeway, whereas U2 was entirely on surface streets. This is explained by the fact that characteristics that were similar between routes, such as encounters with other diesel vehicles (particularly diesel school buses), dominated the highest peak concentrations of BC and PB-PAH and resulted in comparable mean concentrations on both routes.

Bus Type. Table 5 provides a summary of the mean exposures inside buses during commutes on Route U1. For runs with windows closed, we observed the lowest exposure inside the CNG bus and the highest exposure inside the conventional diesel buses (for these analyses we pooled the high emitter and representative buses into one category). Compared with the CNG bus, exposures to BC and PB-PAH (with windows closed) were 3 times higher inside the trap-outfitted diesel bus, and 3 to 5 times higher inside the conventional diesel buses (high-emitting and representative). Results for the trap-outfitted bus were generally in between the conventional diesel buses and the CNG bus. However, exposure to diesel-related pollutants on-board our specific trap-outfitted bus appeared to be higher than expected, based on emission data reported for other trap-equipped diesel vehicles.[44]

As explained above, for commutes with windows open, the concentrations inside the buses were dominated by outside sources, thus reducing the influence of bus type on exposures in the bus commute microenvironment (see Table 5).

Table 5. Mean exposures during commutes (one way) by bus type.

	Windows Closed (Morning)			Windows Open (Afternoon)[a]		
	CNG Bus	Trap-Outfitted Diesel Bus	Conventional Diesel Buses	CNG Bus	Trap-Outfitted Diesel Bus	Conventional Diesel Buses
BC ($\mu g\ m^{-3}$ hr)	3	10	15	4	5	7
PB-PAH (ng m^{-3} hr)	80	250	270	150	130	110
NO_2 (ppb hr)	45	55	100	50	110	95

Notes: All values rounded based on significant figures. Includes bus commutes on U1 only. Values correspond to mean exposures: mean concentration times time spent commuting on school buses. One run using the CNG bus with windows open and one run using the CNG bus with windows closed; two runs with trap-outfitted bus (TO)/windows open and two runs with TO/windows closed; six runs with conventional diesel buses/windows open and six runs with conventional diesel buses/windows closed; The number of buses tested in each category included: one CNG bus; one particle trap-outfitted diesel bus; and four conventional diesel buses; [a]With windows open, concentrations inside the buses were dominated by outside sources, thus reducing the influence of the bus type.

For particulate counts (in the size range from 0.3 to 0.5 μm) and $PM_{2.5}$ mass, differences observed between bus types were not easily explained, because, as discussed earlier, these pollutants are subject to significant background influences. Similarly, these pollutants are less useful in determining the effect of the other variables studied here (self-pollution, surrounding traffic, and route type). More details about these results are given elsewhere.[23]

UNCERTAINTY AND REPRESENTATIVENESS

The uncertainty in our concentration measurements was determined by the precision of each of the analyzers used during the study. In most cases, the signal-to-noise ratios observed in our measurements were adequate and did not affect our conclusions. In addition, the baseline concentrations we observed were well above the limit of detection of all of the instruments the great majority of the time.

The uncertainty in our calculations of the contribution of the bus-commute microenvironment to a child's 24-hr exposure during a school day was dominated by the uncertainties related to each of our assumptions about the magnitude of pollutant I:O ratios (and the relative paucity of appropriate microenvironment measurement data). We estimate these individual uncertainties to be between 30% and 50%. However, because we used these data on a relative basis in a first-order approximation model, these uncertainties are not expected to affect our overall conclusions.

Concentration data for one of the bus stops and all of the bus commutes were collected during the spring season in the Los Angeles basin, with onshore flow conditions typical of the area and time of year. In general, we observed consistent conditions (low wind speeds, relatively clear skies, and a local temperature inversion) throughout the 8 weeks of the spring sampling period. Measurements at the second bus stop and at the loading/unloading zone were conducted during a winter period, when wind speeds and ventilation of the basin were more variable, and average pollutant concentrations were expected to be somewhat lower in the loading/unloading zone and bus stop microenvironments, especially for background pollutants.

However, given the relative unimportance of the loading/unloading zone microenvironment in terms of overall exposure, we considered it appropriate to compare all three of the microenvironments across the winter and spring seasons. Similarly, because conditions during the winter bus stop measurements were not greatly different from the spring bus stop measurement conditions, we considered it appropriate to pool the bus stop data and concluded that seasonal differences did not significantly affect our analyses or our conclusion that the bus stop microenvironment was also of minor importance compared with the bus commute microenvironment.

Because of resource constraints common to any vehicle-related field project, the present study was unable to test a full range of possible commutes, traffic and meteorological conditions, bus manufacturers, model years, school districts, or geographic locations in California. Our results are representative only to the extent that the commutes, buses, conditions, and areas we studied were similar to school bus conditions in other locations.

Notwithstanding the issues discussed above, the combination of small sample size, small number of runs, and relatively high variability of the results obtained for the different buses and experimental setups dominated the uncertainty during our project. Additional field studies could be conducted to broaden the range of conditions investigated, although substantial resources are required to conduct studies of this magnitude.

CONCLUSIONS

Measurements made on-board school buses in Los Angeles indicated higher exposures occurred during children's commutes than ambient air concentrations from central site monitors would indicate. These exposures resulted primarily from the commute itself and not from loading/unloading or waiting at bus stops.

The overall mean bus commute concentrations for vehicle-related pollutants, such as BC and PB-PAH, were ~2 to 3 times higher than mean concentrations at the bus stops. For the same set of pollutants, the highest mean concentrations for an individual (~1 hr) bus commute were factors of 5 to 9 times higher than the mean concentrations at bus stops. Exposures (mean concentrations times time spent) were highest for the urban bus commutes, between 20 and 40 times higher than at bus stops and between 50 and 200 times greater than for the loading/unloading zone microenvironment, depending on the specific pollutant.

Although the 24-hr exposure for a child during a school day is dominated by indoor microenvironments, for vehicle-related pollutants (BC and PB-PAH) the contribution of school bus commutes could be as high as one-third of overall 24-hr exposure.

For "directly emitted" pollutants, the dominant variable associated with high concentrations inside the bus cabin when the windows were open was the presence of another diesel vehicle in the proximity of our test bus. For the same set of pollutants, when windows were closed the dominant factor determining in-cabin exposure was the degree of self-pollution. These two factors were sufficiently important that although we used two urban routes with different characteristics, we did not observe significant differences between the mean concentrations for the two routes. For "background" pollutants (e.g., $PM_{2.5}$) window position and surrounding traffic were less important, because these pollutants are heavily influenced by other factors, including regional sources, meteorology, and secondary formation.

During commutes when the windows of the bus were closed, we found substantial differences in concentrations measured inside the bus cabin depending on the fuel type, after-treatment technology, and levels of self-pollution of the test bus, whereas the impact of outside sources was less important.

Our results demonstrate that the type of school bus a child rides on is not the only determinant of exposure and that conventional diesel school buses can have a double exposure impact on commuting children: first, the influence of the bus's own exhaust on concentrations inside the cabin and second, exposures to the exhaust from other nearby conventional diesel school buses.

This study involved long commutes, often in congested conditions and with significant self-pollution for several buses; therefore, our findings cannot be viewed as typical for all buses under all commute scenarios. Moreover, a relatively small proportion of children attend magnet schools, and children attending neighborhood schools generally have shorter commutes than those studied here.

Under the conditions we studied, effective ways to reduce on-board exposures during the commute itself include minimizing commute times, avoiding caravanning with other school buses, using the cleanest buses for the longest bus routes, maintaining school buses to minimize or eliminate visible exhaust, and phasing in alternative fuels and advanced particulate emissions control technologies.

ACKNOWLEDGMENTS

The contributions of the California Air Resources Board staff were greatly appreciated. The authors thank the staff of the Los Angeles Unified School District BSMS for their cooperation. They also thank Kurt Bumiller and Matt Smith, from College of Engineering—Center for Environmental Research and Technology, University of California, Riverside, as well as Seong Jeong Lee, Kenneth Wong, and Kathleen Kozawa from the Department of Environmental Health Sciences, University of California, Los Angeles, School of Public Health. The authors gratefully acknowledge support for this research by the Air Resources Board, Contract No. 00–322, as well as the South Coast Air Quality Management District and U.S. Environmental Protection Agency. The statements and conclusions in this document are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

REFERENCES

1. California Department of Education, Office of School Transportation. 2002 Student Transportation Information, available at http://www.cde.ca.gov/bus/fastfacts.pdf.
2. Horie, Y.; Tranby, C.; Sidawi, S. *On-Road Motor Vehicle Activity Data. Volume I - Bus Population and Activity Pattern*. ARB Final Report. California Air Resources Board, Research Division, Sacramento, CA, 1994.
3. Pope, A. Respiratory Disease Associated With Community Air Pollution and a Steel Mill, Utah Valley; *Am. J. Public Health* **1989**, *79,* 623-628.
4. Phillips, T.J.; Jenkins, P.L.; Mulberg, E.J. Children in California: Activity Patterns and Presence of Pollutant Sources. In *Proceedings of the 90th Annual Meeting of the A&WMA*, Air & Waste Management Association: Pittsburgh, PA 1991.
5. Wiley, J.A.; Robinson, J.P.; Cheng, Y.T.; Piazza, T.; Stork, L.; Plasden, K. *Study of Children's Activity Patterns*. Final Report. Contract No. A773–149. California Air Resources Board, Research Division: Sacramento, CA, 1991.
6. U.S. EPA. *Environmental Health Threats to Children*. EPA. 175-F-96–001. EPA Office of the Administrator: Washington, D.C., September 1996.
7. Chan, L.Y.; Wu, H.W.A. Study of Bus Commuter and Pedestrian Exposure to Traffic Air Pollution in Hong Kong; *Environment International* **1993**, *19,* 121-132.
8. Fernandez-Bermauntz, A.A.; Ashmore, M.R. Exposure of Commuters to Carbon Monoxide in Mexico City: I. Measurements of In-Vehicle Concentrations; *Atmos. Environ.* **1995**, *29,* 525-532.
9. Conceicao, E.Z.; Silva, M.C.; Viegas, D.X. Air Quality Inside the Passenger Compartment of a Bus; *J. Exposure Analysis and Environmental Epidemiology* **1997**, *7,* 521-534.
10. Wu, C.C.; Suarez, A.E.; Lin, Z.B.; Kidwell, C.B.; Borgoul, P.V.; Caffrey, P.F.; Ondov, J.M.; Sattler, B. Application of an IR Tracer to Determine Soot Exposure to Students Commuting to School on Baltimore Public Buses; *Atmos. Environ.* **1998**, *32,* 1911-1919.
11. Autrup, H.; Daneshvar, B.; Dragsted, L.O.; Gamborg, M.; Hansen, Å.M.; Loft, S.; Okkels, H.; Nielsen, F.; Nielsen, P.S.; Raffin, E.; Wallin, H.; Knudsen, L.E. Biomarkers for Exposure to Ambient air Pollution—Comparison of Carcinogenic-DNA Adduct Levels With Other Exposure Markers and Markers for Oxidative Stress; *Environ. Health Perspect.* **1999**, *107,* 233-238.
12. Adams, H.S.; Nieuwenhuijsen, M.J.; Colvile, R.N. Determinants of Fine Particle ($PM_{2.5}$) Personal Exposure Levels in Transport Microenvironments, London, UK; *Atmos. Environ.* **2001**, *35,* 4557-4566.

13. Wargo, J.; Brown, D.; Cullen, M.; Addiss, S.; Alderman, N. *Children's Exposure to Diesel Exhaust on School Buses*. Environmental and Human Health: North Haven, CT, 2002.
14. Zhu, Y.; Hinds, W.C.; Kim, S.; Sioutas, C. Concentration and Size Distribution of Ultrafine Particles Near a Major Highway; *J. Air & Waste Manage. Assoc.* **2002**, *52,* 1032-1042.
15. Zhu, Y.; Hinds, W.C.; Kim, S.; Shen, S.; Sioutas, C. Study of Ultrafine Particles Near a Major Highway With Heavy-Duty Diesel Traffic; *Atmos. Environ.* **2002**, *36,* 4323-4335.
16. Rodes, C.; Sheldon, L.; Whitaker, D.; Clayton, A.; Fitzgerald, K.; Flanagan, J. *Measuring Concentrations of Selected Air Pollutants Inside California Vehicles*. Final Report, Contract No. 95–339. California Air Resources Board, Research Division: Sacramento, CA, 1998.
17. Shikiya, D.C.; Liu, C.S.; Hahn, M.I.; Juarros, J.; Barcikowski, W. *In-Vehicle Air Toxics Characterization Study in the South Coast Air Basin.* Final Report. South Coast Air Quality Management District, El Monte, CA, 1989.
18. Ptak, T.J.; Fallon, S.L. Particulate Concentration in Automobile Passenger Compartments; *Part. Sci. Technol.* **1994**, *12,* 313-322.
19. Lawryk, N.J.; Weisel, C.P. Exposure to Volatile Organic Compounds in the Passenger Compartment of Automobiles During Periods of Normal and Malfunctioning Operation; *J. Exp. Anal. Environ. Epidemiol.* **1995**, *5,* 511-531.
20. Jo, W.K.; Park, K.H. Commuter Exposure to Volatile Organic Compounds Under Different Driving Conditions; *Atmos. Environ.* **1999**, *33,* 409-417.
21. Alm, S.; Jantunen, M.J.; Vartianen, M. Urban Commuter Exposure to Particle Matter and Carbon Monoxide Inside an Automobile; *J. Exp. Anal. Environ. Epidemiol.* **1999**, *9,* 237-244.
22. Solomon, G.M.; Campbell, T.R.; Feuer, G.R.; Masters, J.; Samkian, A.; Paul, K.A. *No Breathing in the Aisles: Diesel Exhaust Inside School Buses*. Natural Resources Defense Council and Coalition for Clean Air: New York, 2001.
23. Fitz D.R.; Winer, A.M.; Colome, S.D.; Behrentz, E.; Sabin, L.D.; Lee, S.J.; Wong, K.; Kozawa, K.; Pankratz, D.; Bumiller, K.; Gemmill, D.; Smith, M. *Characterizing the Range of Children's Pollutant Exposure during School Bus Commutes.* Final Report, Contract No. 00–322. California Air Resources Board, Research Division: Sacramento, CA, 2003.
24. Sabin, L.D.; Behrentz, E.; Winer, A.M.; Lee, S.J.; Fitz, D.R.; Pankratz, D.; Colome, S.D.; Fruin, S. Characterizing the Range of Children's Air Pollutant Exposure during School Bus Commutes; *J. Exp. Anal. Environ. Epidemiol.* **2004.** In Press.
25. Behrentz, E.; Fitz, D.R.; Pankratz, D.; Sabin, L.D.; Colome, S.D.; Fruin, S.; Winer, A.M. Measuring Self-Pollution in School Buses Using a Tracer Gas Technique; *Atmos. Environ.* **2004**, *38,* 3735-3746.
26. Kittelson, D.B. Engines and Nanoparticles: A Review; *J. Aerosol Sci.* **1998**, *29,* 575-588.
27. Kleeman, M.J.; Schauer, J.J.; Cass, G.R. Size and Composition Distribution of Fine Particulate Matter Emitted From Motor Vehicles; *Environ. Sci. Technol.* **2000**, *34,* 1132-1140.
28. Fitz, D.R.; Pankratz, D.V.; Bumiller, K.; Smith, M.R. *Measurement of NO_2 and PAN by Gas Chromatography with Luminol Detection.* AWMA Symposium on Air Quality Measurement. San Francisco, CA, November 13–15, 2002.
29. Turner, W.A.; Olson, B.A.; Allen, G.A. Calibration of Sharp Cut Impactors for Indoor and Outdoor Particle Sampling; *J. Air & Waste Manage. Assoc.* **2000**, *50,* 484-487.
30. Solomon, G.M.; Bailey, D.; Campbell, T.; Masters, J.; Slavin, E. *South Coast School Bus Idling Study, November Draft.* U.S. Environmental Protection Agency–Region 09, Office of Regional Administrator, Air Division: Washington, DC, 2002.
31. Meng, Q.Y.; Turpin, B.J.; Korn, L.; Weisel, C.P.; Morandi, M.T.; Colome, S.D.; Zhang, J.; Stock, T.H.; Spektor, D.M.; Winer, A.M.; Zhang, L.; Lee, J.H.; Giovanetti, R.; Cui, W.; Kwon, J.; Alimokhtari, S.; Shendell, D.; Jones, J.; Farrar, C.; Maberti, S. Influence of Ambient (Outdoor) Sources on Residential Indoor and Personal $PM_{2.5}$ Concentrations: Analyses of RIOPA Data. *J. Exp. Anal. Environ. Epidemiol.* **2005**, *15,* 17–28.
32. Dockery, D.W.; Spengler, J.D. Indoor-Outdoor Relationship of Respirable Sulfates and Particles; *Atmos. Environ.* **1981**, *15,* 335-343.
33. Monn, C. Exposure Assessment of Air Pollutants: a Review on Spatial Heterogeneity and Indoor/Outdoor/Personal Exposure to Suspended Particulate Matter, Nitrogen Dioxide and Ozone; *Atmos. Environ.* **2001**, *35,* 1-32.
34. Wallace, L.A. Indoor Particles: A Review; *J. Air & Waste Manage. Assoc.* **1996**, *46,* 98-127.
35. LaRosa, L.E.; Buckley, T.J.; Wallace, L.A. Real-Time and Outdoor Measurements of Black Carbon in an Occupied House: an Examination of Sources; *J. Air and Waste Manage. Assoc.* **2002**, *52,* 41-49.
36. Lee, K.; Xue, J.; Geyh, A.S.; Ozkaynak, H.; Leaderer, B.P.; Weschler, C.J.; Spengler, J.D. Nitrous Acid, Nitrogen Dioxide, and Ozone Concentrations in Residential Environments; *Environ. Health Perspect.* **2002**, *110,* 145-149.
37. Naumova, Y.; Offenberg, J.H.; Eisenreich, S.J.; Meng, Q.; Polidori, A.; Turpin, B.J.; Weisel, C.P.; Morandi, M.T.; Colome, S.D.; Stock, T.H.; Winer, A.M.; Alimonkhtari, S.; Kwon, J.; Maberti, S.; Shendell, D.; Jones, J.; Farrar, C. Gas/Particle Distribution of Polycyclic Aromatic Hydrocarbons in Coupled Outdoor/Indoor Atmospheres; *Atmos. Environ.* **2003**, *37,* 703-719.
38. Spengler, J.D.; Schwab, M.; Ryan, P.B.; Colome, S.; Wilson, A.L.; Billick, I.; Becker, E. Personal Exposure to Nitrogen Dioxide in the los Angeles Basin; *J. Air & Waste Manage. Assoc.* **1994**, *44,* 39-47.
39. Ferro, A.R.; Kopperud, R.J.; Hildemann, L.M. Elevated Personal Exposure to Particulate Matter From Human Activities in a Residence. *J. Exp. Anal. Environ. Epidemiol.* **2004**, *14,* S34-S40.
40. Williams, R.W.; Suggs, J.; Rea, A.W.; Leovic, K.; Vette, A.F.; Croghan, C.; Sheldon, L; Rodes, C.E.; Thornburg, J.; Ejire, A.; Herbst, M.; Sanders, W. The Research Triangle Park Particulate Matter Panel Study: pm Mass Concentration Relationships; *Atmos. Environ.* **2003**, *37,* 5349-5363.
41. Fruin, S.A.; Winer, A.M.; Rodes, C.E. Black Carbon Concentrations in California Vehicles and Estimation of In-Vehicle Diesel Exhaust Particulate Matter Exposures; *Atmos. Environ.* **2004**, *38,* 4123-4133.
42. Allen, G.A.; Lawrence, J.; Koutrakis, P. Field Validation of a Semi-Continuous Method for Aerosol Black Carbon (Aethalometer) and Temporal Patterns of Summertime Hourly Black Carbon Measurements in Southwestern PA; *Atmos. Environ.* **1999**, *33,* 817-823.
43. Babich, P.; Davey, M.; Allen, G.; Koutrakis, P. Method Comparisons for Particulate Nitrate, Elemental Carbon, and $PM_{2.5}$ Mass in Seven U.S. Cities; *J. Air & Waste Manage. Assoc.* **2000**, *50,* 1095-1105.
44. Johnson, T.V. Diesel Emission Control in Review. In *Diesel Exhaust Emissions Control: Developments in Regulation and Catalytic Systems*; Society of Automotive Engineers International: Warrendale, PA, 2001; SAE Technical Paper 2001–01-0184.

About the Authors

Eduardo Behrentz is an assistant professor in the Civil and Environmental Engineering Department at the University of los Andes, Bogotá, Columbia. Lisa D. Sabin has a doctoral degree from the Environmental Science and Engineering Program at the University of California Los Angeles School of Public Health. Arthur M. Winer is a professor in the Environmental Health Sciences Department and a core faculty member in the Environmental Science and Engineering Program at the University of California Los Angeles School of Public Health. David V. Pankratz is a senior development engineer, and Dennis R. Fitz is the manager of the atmospheric processes group at the Center for Environmental Research and Technology, University of California, Riverside. Steven D. Colome is head of Integrated Environmental Sciences. Scott A. Fruin is an air resources engineer in the Health and Exposure Assessment Branch at the California Air Resources Board's Research Division. Address correspondence to: Arthur M. Winer, University of California Los Angeles, School of Public Health, 650 Charles E. Young Drive, South # 61–295 CHS, Los Angeles, CA 90095; phone: +1-310-206-1278; fax: +1-310-206-3358; e-mail: amwiner@ucla.edu.