State of New Jersey
Department of Environmental Protection

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

CATHERINE R. MCCABE
Commissioner

PROJECT PROPOSAL

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.

NJDEP anticipates primarily funding pilot electrification projects, including the replacement of heavy-duty vehicles/engines such as buses, trucks, and non-road equipment in urban areas disproportionately impacted by diesel emissions, as well as electric vehicle charging/fueling infrastructure installation in strategic locations across the state.

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

ELIGIBLE PROJECTS

A general summary is below. Click here for comprehensive list and associated definitions.

Source Category	Emission Reduction Strategy	Allowed Expenditure Amount
1. Class 8 local freight trucks & port drayage trucks	Repower and replacement	Up to 40% for repower with diesel or alternative fuel or up to 75% (up to 100% if government owned) for repower with electric. Electric charging infrastructure costs are an eligible expense. Up to 25% for replacement with diesel or alternative fuel or up to 75% (up to 100% if government owned) for electric replacement. Electric charging infrastructure costs are an eligible expense.
2. Class 4-8 school bus, shuttle bus or transit bus	Repower and replacement	Same as row 1
3. Freight switching locomotives	Repower and replacement	Same as row 1
4. Ferries/Tugs	Repower	Same as row 1
5. Oceangoing vessels	Shorepower	Up to 25% for shore side infrastructure if non-government owned (up to 100% if government owned)

Source Category	Emission Reduction Strategy	Allowed Expenditure Amount
6. Class 4-7 local freight trucks	Repower and replacement	Same as row 1.
7. Airport ground support equipment	Repower and replacement	Up to 75% to repower or replace with electric (100% if government owned). Electric charging infrastructure costs are an eligible expense.
8. Forklifts and Port Cargo Handling Equipment	Repower and replacement	Up to 75% to repower or replace with electric (100% if government owned). Electric charging infrastructure costs are an eligible expense.
9. Electric vehicle charging stations or hydrogen fueling stations for light duty vehicles only		Up to 100% to purchase, install and maintain infrastructure if available to public at *government owned* property. Up to 80% to purchase, install and maintain infrastructure if available to public at *non-government owned* property. Up to 60% to purchase, install and maintain infrastructure at a workplace or multi-unit dwelling that is not available to the general public. Up to 33% to purchase, install and maintain infrastructure for publicly available hydrogen dispensing that is high volume or 25% for lower volume.

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:

NJDEP
Division of Air Quality
Mail code 401-02E
Trenton, NJ 08625-0420
Attn: VW Settlement

All proposals must contain the following information; incomplete applications will not be considered. If your project is selected, you may be contacted for additional detailed information. Send questions to VWComments@dep.nj.gov

To enter information electronically, use Adobe Reader

CONTACT INFORMATION

Applicant Name	Student Transportation of America, Inc.
Applicant Address	3349 Route 138 - Building A, Suite C
City, State, Zip Code	Wall, New Jersey 07719-9671
Contact Person	Dana Jean Morris
Title/Position	Director of Taxation
Phone	732-280-4200
E-mail	djmorris@ridesta.com
Owner Name	Student Transportation of America, Inc.
Owner Address	3349 Route 138 - Building A, Suite C
City, State, Zip Code	Wall, New Jersey 07719-9671
Contact Person	Dana Jean Morris
Title/Position	Director of Taxation
Phone	732-280-4200
E-mail	djmorris@ridesta.com

PROJECT NAME	School Bus Replacement

PROJECT CATEGORY OR CATEGORIES (choose from 1-9 in "Eligible Projects" section above)

1 ☐ **2** ■ **3** ☐ **4** ☐ **5** ☐ **6** ☐ **7** ☐ **8** ☐ **9** ☐

PROJECT PRIORITY Priority # 1 of 1 proposals
If submitting more than one proposal, what is the sponsor's priority of this proposal?

NOTE FOR CATEGORY 9 PROPOSALS

If your proposal is for Category 9 (Light Duty Zero Emission Vehicle Supply Equipment), follow these instructions:

Electric Vehicle stations: Do not complete this form. Instead, go to *It Pay$ to Plug In* – NJDEP's Electric Vehicle Charging Grants Program, and apply for a Charging Grant. Volkswagen funds for charging stations will be administered through *It Pay$ to Plug In*.

Hydrogen fuel cell vehicle supply equipment: Complete all of the questions on this form.

PROJECT BUDGET
Provide total estimated project budget, include source, amount of cost share, and administrative costs if applicable:
$1,320,000.00
Grant Request: $1,320,000 (100%) (Please note this does not include charging infrastructure which an estimate would be provided upon request)

PROJECT DESCRIPTION (Briefly describe the project by completing the following questions) See below.
Geographic area where emissions reductions will occur? Trenton
Estimated size of population benefitting from the emission reductions? 84,964
Estimated useful life of the project? 15 years
Number of engines/vehicles/vessels/equipment included in the project? 4
DEP will be modeling emission benefits for all projects. Please provide the necessary information below: See attached Fleet Spreadsheet Model Year Horsepower Annual hours of use Annual amount of fuel used
Will the project benefit one or more communities that are disproportionately impacted by air pollution? If so, please describe? Student Transportation of America, Inc. ("STA") has a large presence throughout the state of New Jersey, with a concentration of 2006 model year diesel buses in the Trenton area.
Only shovel ready projects will be considered. Please list project partners. STA currently has a long-standing contract to provide school bus services for Trenton Area Public School District
Estimated timeframe for implementation? Include a project timeline that identifies start and end dates, as well as the timeline for key milestones. -Within 3 months of award: Reach procurement contracts with school bus suppliers. -Within 6 months of award: Begin implementation of school buses. -Within 12-14 months of award: Complete implementation of school buses and associated infrastructure.
Demonstrated success in implementing similar projects? See Supplemental Pages

If your proposed project involves alternative fuels, provide a demonstration of current or future plans to provide adequate refueling infrastructure. Due to an existing partnership with the NJ DEP, Student Transportation is in the process of updating infrastructure needed for five new electric buses that is set to be complete by June 2021. These infrastructure upgrades will allow the companies to scale their electric bus presence in Trenton at a lower refueling infrastructure cost per unit basis in the future.
Has your organization been approved to receive and expend any other grant funds related to this project? If so, please provide details. Not applicable.
Please provide any additional information that supports this project. See Supplemental Pages

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

Supplemental Page 1

Will the project benefit one or more communities that are disproportionately impacted by air pollution?

STA serves a diverse student body nationally, who's health is negatively impacted by breathing in the diesel particulate matter emitted from these current school buses. More than 25 million American children commute to school via school bus, and they are exposed to toxic air from school buses. The project would involve replacing 4 diesel buses in Trenton. This project is exceptionally important considering STA's New Jersey headquarters.

Electric school buses are an emerging technology that STA has started to implement in their fleet. STA sees no better state to partner with than their headquartered state. STA would like this to serve as a continued success story that could provide positive media attention that New Jersey is choosing to take the most aggressive measures to protect their population by partnering with companies on electrification projects that totally eliminate these harmful emissions.

The Trenton site in Mercer County is the most disproportionately impacted by air pollution (according to the American Lung Association's 2018 State of the Air Report), as they are the worst county in the state in terms of air quality. In 2018 alone, Mercer County experienced 22 "orange alert" days because of bad air quality, in which the air quality is considered unhealthy for children, active adults, and anyone with asthma or other respiratory ailments.

Recent research conducted at the Environmental Protection Agency's (EPA) National Center for Environmental Assessment analyzed the racial and economic profiles of certain communities to decipher a causal relationship with exposure to health-threatening air pollution. The discovery was that race and poverty are correlated to exposure to poor air quality, as those living in poverty experience a 1.35 times higher burden than did the overall population.

By replacing 4 diesel buses with 4 new all-electric buses will reduce emissions by 1.93 short tons of NOx over the life of the project. This will provide safer and healthier conditions for students and the local communities in which these buses operate. Replacing buses in Trenton aligns with STA's commitment to communities they serve and also aligns with New Jersey's plan to decrease emissions greatly in areas that are disproportionately affected by harmful high emittance diesel vehicles.

Trenton fits the mold of a community that is disproportionately burdened, as 27.3% live below the poverty level, and 60% of the population is a minority. A scientific study conducted by Paul Mohai, Byoung-Suk Kweon, Sangyun Lee, and Kerry Ard in 2011 (Volume 30, No. 5 of Health Affairs) highlighted the link between air pollution and poor student health and academic performance, therefore this should be a cause for immediate concern. As a result of the above findings, this project would be serving the communities and people of New Jersey that need it most.

STA, Headquartered in New Jersey, seeks opportunities to create a healthier environment and continue its commitment to the students served, the STA employees, and the community of its home state. STA is cognizant that continuous improvement in operations will have a direct impact on the health of the brightest asset of the future for New Jersey, the children.

Demonstrated success in implementing similar projects?

STA has taken aggressive measures to modernize their fleet in recent years, as STA prioritizes the health of its employees and children in the communities which it serves. STA enforces stringent anti-idling policies in New Jersey. This would be the second time partnering with New Jersey and implementing a diesel to electric bus project. STA has decades of experience with vehicle replacements and is actively working with New Jersey and other states on awarded projects through the Volkswagen Mitigation Trust program.

STA has a fleet of over 15,000 vehicles and routinely replaces school buses every year. The Company has also previously applied for Federal DERA funds for other projects, and is actively working with New Jersey and other states on implementing projects from Volkswagen Mitigation Trust Fund awards.

STA has partnered with New Jersey in previous rounds of funding through the Volkswagen Mitigation Funding. STA has demonstrated exceptional responsibility and communication throughout the project and continues to exemplify success. By funding 4 all-electric buses in Trenton it will allow STA and New Jersey to benefit from economies of scale. While most applicants will have to build out infrastructure to be able to house, charge, maintain and run all-electric buses efficiently, STA will not have the burden of building new infrastructure. STA currently has the storage facility as well as the needed power supply to operate all-electric buses. STA will be able to obtain the additional chargers needed, creating an efficient time frame from purchase to operation since STA does not have limited infrastructure to operate new all-electric buses. This will also decrease unforeseen circumstances involving the applicability and cost of upgrading electric supply needed for all-electric buses.

Fleet Information Spreadsheet

See Attached

Existing Vehicle																	Replacement Vehicle				DEQ Tool Information					
Vehicle Number	VIN	Location	Make	Model	Model Year	Total Mileage	Fuel Type	Fuel Gallons Used	Owned Since	Years in Operation	Annual Mileage	Annual Fuel Usage (Gallons)	Horsepower	Engine	Engine Model Year	Gallons Consumed(7.5 mpg)	Replacement Model Year	Replacement Fuel Type	Replacement Cost	Funding Request	Annual NOx reductions	Annual PM2.5 Reductions	Total Cost Effectiveness (NOx)	Lifetime NOx Reduction (% Reduced)	Lifetime PM 2.5 Reduction (% Reduced)	Total Cost Effectiveness (PM 2.5)
1	4UZABPDDX7CW15096	Trenton	Freightliner	Thomas C2	2007	167200	Diesel	22293	2007	14	11943	1592.38	210	CAT C7	2006	1592.38	2021	Electric	$ 330,000	$ 330,000	0.083	0.007	$ 664,010	$ 0.497	$ 0.041	$ 7,977,417
2	4UZABPDD27CW15089	Trenton	Freightliner	Thomas C2	2007	180746	Diesel	24099	2007	14	12910	1721.39	210	CAT C7	2006	1721.39	2021	Electric	$ 330,000	$ 330,000	0.089	0.007	$ 617,312	$ 0.535	$ 0.044	$ 7,470,285
3	4UZABPDD17CW15097	Trenton	Freightliner	Thomas C2	2007	142257	Diesel	18968	2007	14	10161	1354.83	210	CAT C7	2006	1354.83	2021	Electric	$ 330,000	$ 330,000	0.071	0.006	$ 771,543	$ 0.428	$ 0.036	$ 9,118,115
4	4UZABPDD97CW15090	Trenton	Freightliner	Thomas C2	2007	158182	Diesel	21091	2007	14	11299	1506.50	210	CAT C7	2006	1506.50	2021	Electric	$ 330,000	$ 330,000	0.079	0.007	$ 699,229	$ 0.472	$ 0.039	$ 8,355,162
																		Totals:	**$ 1,320,000**	**$ 1,320,000**	**0.322**	**0.027**	**$ 683,230**	**1.93**	**0.16**	**$ 8,250,000**
																					$4,099,379	**$48,888,889**				

Anti-Idling Policy

See Attached

Student Transportation of America

Anti-Idling Program Training

Why are we here?

- Excessive idling of school buses is harmful to the environment and public health, is against STA policy, and is against the law

- The USEPA & State of New Jersey regulate the idling of school buses & will impose penalties for violations

The Law

In New Jersey, buses may **NOT** idle for more than three (3) consecutive minutes if the vehicle is not in motion.

Exceptions

- For up to fifteen (15) consecutive minutes when engine has been stopped for three (3) or more hours and the ambient temperature is below 25°F
- For up to fifteen (15) minutes in a sixty (60) minute period when discharging or picking up passengers
- When required to operate a wheel chair lift or other auxiliary equipment
- Traffic conditions
- While being repaired or serviced

STA Policy

STA's policy is consistent with the State of New Jersey & Federal requirements. You are required to comply with STA's policy and the State and Federal restrictions.

Supporting Research

See Attached

AJPH
A PUBLICATION OF THE AMERICAN PUBLIC HEALTH ASSOCIATION

Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status

Ihab Mikati BS, **Adam F. Benson** MSPH, **Thomas J. Luben** PhD, MSPH, **Jason D. Sacks** MPH, and **Jennifer Richmond-Bryant** PhD

[+] Author affiliations, information, and correspondence details

Accepted: December 16, 2017 Published Online: March 07, 2018

Objectives. To quantify nationwide disparities in the location of particulate matter (PM)-emitting facilities by the characteristics of the surrounding residential population and to illustrate various spatial scales at which to consider such disparities.

Methods. We assigned facilities emitting PM in the 2011 National Emissions Inventory to nearby block groups across the 2009 to 2013 American Community Survey population. We calculated the burden from these emissions for racial/ethnic groups and by poverty status. We quantified disparities nationally and for each state and county in the country.

Results. For PM of 2.5 micrometers in diameter or less, those in poverty had 1.35 times higher burden than did the overall population, and non-Whites had 1.28 times higher burden. Blacks, specifically, had 1.54 times higher burden than did the overall population. These patterns were relatively unaffected by sensitivity analyses, and disparities held not only nationally but within most states and counties as well.

Conclusions. Disparities in burden from PM-emitting facilities exist at multiple geographic scales. Disparities for Blacks are more pronounced than are disparities on the basis of poverty status. Strictly socioeconomic considerations may be insufficient to reduce PM burdens equitably across populations.

ARTICLE CITATION

Ihab Mikati, Adam F. Benson, Thomas J. Luben, Jason D. Sacks, Jennifer Richmond-Bryant, “Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status”, *American Journal of Public Health* 108, no. 4 (April 1, 2018): pp. 480-485.

DOI: 10.2105/AJPH.2017.304297

PMID: 29470121

American Journal of Public Health®
800 I Street NW, Washington, DC 20001-3710
202-777-2742

Print ISSN: 0090-0036 | Electronic ISSN: 1541-0048

By Paul Mohai, Byoung-Suk Kweon, Sangyun Lee, and Kerry Ard

DOI: 10.1377/hlthaff.2011.0077
HEALTH AFFAIRS 30,
NO. 5 (2011): 852–862

Air Pollution Around Schools Is Linked To Poorer Student Health And Academic Performance

Paul Mohai (pmohai@umich.edu) is a professor in the School of Natural Resources and Environment and a faculty associate at the Institute for Social Research, both at the University of Michigan, in Ann Arbor.

Byoung-Suk Kweon is a research investigator at the Institute for Social Research and an adjunct assistant professor in the School of Natural Resources and Environment, University of Michigan.

Sangyun Lee is a postdoctoral research fellow in the School of Natural Resources and Environment, University of Michigan.

Kerry Ard is a graduate student in sociology and environmental policy at the University of Michigan.

ABSTRACT **Exposing children to environmental pollutants during important times of physiological development can lead to long-lasting health problems, dysfunction, and disease. The location of children's schools can increase their exposure. We examined the extent of air pollution from industrial sources around public schools in Michigan to find out whether air pollution jeopardizes children's health and academic success. We found that schools located in areas with the highest air pollution levels had the lowest attendance rates—a potential indicator of poor health—and the highest proportions of students who failed to meet state educational testing standards. Michigan and many other states currently do not require officials considering a site for a new school to analyze its environmental quality. Our results show that such requirements are needed. For schools already in existence, we recommend that their environmental quality should be investigated and improved if necessary.**

There are more than fifty-three million schoolchildren and more than 135,000 public and private schools in the United States.[1] Are these schools safe and healthy places for children to grow, play, and learn? Or are we exposing children to unhealthy pollution?

Children are known to be more vulnerable than adults to the effects of pollution. Exposure to environmental pollutants during important times of physiological development can lead to long-lasting health problems, dysfunction, and disease.[2] Children's lung functioning is not yet fully developed.[3–5] Compared to adults, they breathe in greater levels of polluted air relative to their weight and spend more time outside when air pollution levels are the highest.[5] And because of differences in metabolism, mouthing behavior—such as the tendency to put their hands and objects in their mouths—and respiratory rates, children are often exposed to higher levels of lead, arsenic, pesticides, and other pollutants.[4] Moreover, children have little or no choice about where they live or go to school.

Childhood is a critical period for brain formation. Researchers have shown that children exposed to air pollution perform worse on cognitive functioning tests[6] and have impaired neurological function[7–9] and lower IQ scores[10] compared with other children. Also, children exposed to high levels of nitrogen dioxide—a common air pollutant generated by the burning of fossil fuels—have been found to have "decreases of 6.71, 7.37 and 8.61 points in quantitative, working memory and gross motor areas, respectively."[11]

Similarly, children with high levels of exposure to nitrogen dioxide and particles 10 micrometers or less in the air—a standard used by the Environmental Protection Agency (EPA) to measure air quality—perform significantly worse on neurobehavioral tests, even after confounding variables are controlled for.[6] In one example of this kind of test, to measure line discrimination, the subject is instructed to hit the space bar on a computer keyboard within a second after seeing a long line, when being presented with long and short lines. And children with high levels of estimated exposure to black carbon—tiny particles released into the air by diesel exhaust, for example—have a decreased ability to perform well on both verbal and nonverbal intelligence and memory assessments, such as the Kaufman Brief Intelligence Test and the Wide Range Assessment of Memory and Learning.[10]

A large and growing body of evidence shows that pollution burdens fall disproportionately on low-income and racial or ethnic minority communities.[12–15] There is little evidence of disproportionate pollution burdens on children in these groups. However, a recent study by Manuel Pastor and his colleagues[16] found that California students in these categories were disproportionately exposed to high levels of respiratory risks from outdoor air pollution. Furthermore, the authors found that such exposure was associated with lower performance on standardized tests, even after controlling for important confounding variables such as school size, suburban—as opposed to urban or rural—location, and demographics of the student body.

The risks of air pollution around public schools were highlighted in a series of articles in *USA Today*.[17] The series provided estimates of air pollution from industrial sources for more than 125,000 schools in the United States, using data from the EPA. Schools were ranked based on the estimated pollution burdens around them. The *USA Today* analysis prompted the EPA to conduct a study of its own, and it selected sixty-four schools nationwide (two were in Michigan, where we conducted our study) for air quality monitoring, the results of which have been posted online by the agency.[18] However, neither *USA Today* nor the EPA examined the links between air pollution, health, and academic performance. Nor did they examine demographic disparities related to pollution burdens around schools.

School siting policies should protect children from their vulnerability to environmental pollution. However, many states do not have any school siting policies.[19] According to a 2006 survey, only fourteen states prohibit or severely restrict school districts from siting schools on or near sources of pollution or hazards that might pose a risk to children's health.[20] Twenty-one states have policies suggesting that officials "avoid" siting schools on or near specified man-made or natural environmental hazards, or "consider" those hazards when selecting school sites.

In November 2010 the EPA released a draft of voluntary school siting guidelines.[1] The draft guidelines recommend an initial assessment of air quality around a potential school site using existing data, such as the agency's air quality monitoring data or data from its National Air Toxics Assessment.[21] Although the guidelines do not propose maintaining minimum distances between schools and highways, factories, airports, rail lines, or other potential environmental hazards, they do recommend mitigating the effects of such hazards by using noise barriers, vegetation, or buildings. The agency says that "the guidelines are intended to assist communities and community members in making the best possible school siting decisions."[1] However, one critic has expressed concern that the voluntary guidelines might not be strong enough and could be ignored by many school districts.[22]

Children's health and well-being are viewed by many as top priorities in American society, but links between air pollution and children's school performance and health have received little attention and are not well understood. Our study started with three questions: Do public schools tend to be located in areas of less or more air pollution, compared to average or median levels for the state, the metropolitan area, and the school district? Are disparities in pollution burdens related to the demographic characteristics of the student body? And are levels of air pollution linked to student performance and health?

Study Data And Methods

We examined air pollution concentrations from industrial sources within one, two, and three kilometers of the 3,660 public elementary, middle, junior high, or high schools in Michigan. We based our estimates of air pollution deposition from industrial sources on the EPA's Risk-Screening Environmental Indicator geographic microdata.[23] The data set is modeled from emissions data in the EPA's Toxic Release Inventory to estimate pollution burdens in cells on a one-kilometer grid covering most of the continental United States (see "Data and Methods" in the online Appendix for a more detailed discussion).[24]

As a school performance measure, we used the 2007 Michigan Educational Assessment Program scores, a standardized test that all third to ninth graders in Michigan public schools are required to take.[25] More specifically, we used the percentage of students not meeting the state standards for English and math because, unlike other subjects, English and math are consistently tested from third to eighth grades (see "Data and Methods" in the online Appendix for a more detailed discussion).[24]

We downloaded information about school

demographics from the website of Michigan's Center for Educational Performance and Information.[26] This information included the number of students in each school, school expenditures, the racial and ethnic makeup of the school, and the number of students eligible for the free lunch program. We obtained address information and attendance rates for the schools from the Michigan Department of Education. We used ArcView geographic information system software, version 3.3, to digitally map the locations of the 3,660 schools.

We overlaid the school locations with the EPA's geographic microdata and estimated the total air pollution concentrations within one, two, and three kilometers of each school. Because these distances produce circular areas, and the EPA microdata pollution estimates are available only for one-kilometer squares, we used so-called areal apportionment to estimate pollution concentrations within the circular areas around the schools. That is, we determined the percentage of the area of a circle located within a microdata grid cell and multiplied this percentage by the pollution value for the cell. After the pollution estimates for all grid cells intersected by the circle were weighted by their respective percentages, we summed these weighted values over all of the grid cells to produce pollution estimates for the circular areas.

We determined the pollution concentrations at varying distances to see how robust the results of our analyses would be. We found that the results obtained at the varying distances were very consistent with each other. Because of space limitations, we thus report only the results of our analyses using the distance of two kilometers from the schools. This distance (approximately 1.2 miles) also serves as a proxy for the area that children are required to walk to school in most states—as opposed to being eligible for school buses—which exposes them to the pollution in this area.

Study Results

Exhibit 1 displays the 155,140 grid cells in Michigan sorted into deciles based on their estimated total air pollution concentration. The green areas have the lowest concentrations, while the red areas have the highest. Although the EPA's microdata are not designed to provide thresholds of health risk, they can be used to assess relative risk. Thus, people living in the areas with the lowest concentrations are at lower potential risk, compared to people in areas with the highest concentrations, of diseases associated with air pollution.

As Exhibit 1 indicates, although several places in Michigan's Upper Peninsula fall in the tenth, or most polluted, decile, most of the cells in this decile are in the lower part of Michigan, where the state's population is also concentrated. Exhibit 1 also indicates the locations of the public schools in Michigan for which Michigan Educational Assessment Program English and math scores are available. Because high schools do not consistently test for English and math, only elementary and middle schools are included. We provide a more detailed discussion about the links between pollution levels and performance on the standardized tests below.

LINKS BETWEEN SCHOOL LOCATIONS AND AIR POLLUTION In our analyses we first addressed the question of whether schools tend to be located in the less or more polluted areas of a particular region. Because more than 33 percent (1,221) of all public schools in Michigan are in the Detroit metropolitan area (Macomb, Oakland, and Wayne Counties), we began by comparing the median pollution levels around the schools in the metropolitan area with the median pollution levels in the metropolitan area as a whole (Exhibit 2).

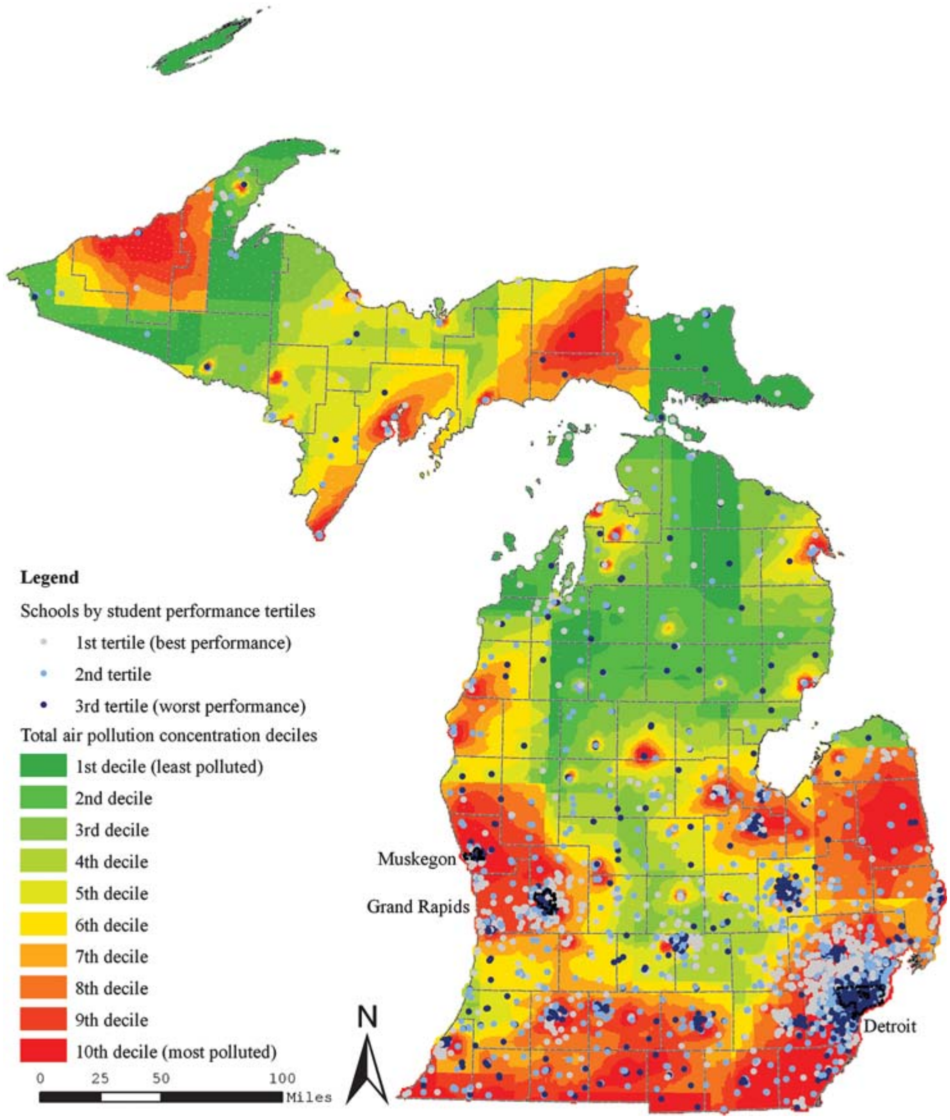
We found that the median air pollution concentrations of the areas within two kilometers of the schools in the metropolitan area were greater than the concentrations in the one-kilometer squares in the metropolitan area as a whole for every year from 1999 to 2006. Likewise, the median air pollution concentrations of the areas within two kilometers of the schools in the City of Detroit were higher than the concentrations in the one-kilometer squares in the city for the entire period.

Next we examined the distribution of all 3,660 schools in the state. We found that 62.5 percent of them were located in grid cells in the ninth and tenth deciles—the 20 percent of the cells with the greatest pollution from industrial sources (Exhibit 3). Almost half of the state's schools (48.4 percent) were in grid cells in the tenth decile. In addition, 67.3 percent of all schoolchildren in the state attended schools in the two most polluted deciles; more than half (53.0 percent) were in schools in the top decile.

We further found that the majority of schools in the two most polluted deciles were located in the more polluted parts of their respective school districts, thus further compounding the pollution burdens for students attending those schools. Specifically, 326 of the 514 schools in the ninth decile were in the more polluted parts of their school districts, as were 1,623 of the 1,773 schools in the tenth decile (Exhibit 3). Overall, 2,328 of the 3,660 public schools in Michigan, or 63.6 percent, were located in the

EXHIBIT 1

Deciles Of Total Air Pollution Concentrations From Industrial Sources In Michigan, With School Locations, By Student Performance Tertiles



SOURCE Authors' analysis of geographic microdata for 2006 from Note 23 in text. **NOTES** Only locations of elementary and middle schools are shown. Schools are sorted into three groups (tertiles) based on the percentage of students (grades 3–8 combined) who do not meet the Michigan Educational Assessment Program standards for English. The schools in the first tertile ("best performance") have the lowest percentage of students failing to meet the standards. For more details about the values of air pollution, see the Appendix (see Note 24 in text).

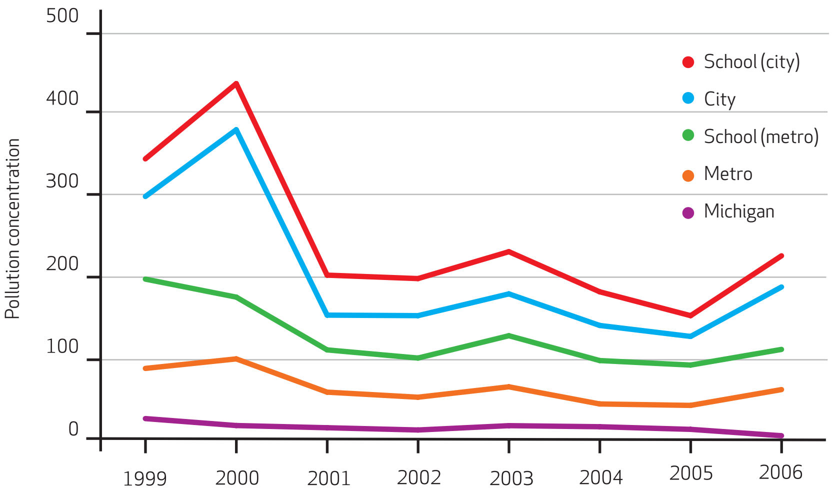
more polluted parts of their districts.

AIR POLLUTION AND SCHOOL DEMOGRAPHICS The demographics of the schools' student bodies followed a similar pattern. We found that 44.4 percent of all white schoolchildren in the state attended schools located in grid cells in the 10th (most polluted) decile, but 81.5 percent of all African American schoolchildren and 62.1 percent of all Hispanic schoolchildren did so. In those schools, 62.2 percent of all students were enrolled in the free lunch program, our chief socioeconomic indicator (Exhibit 3).

AIR POLLUTION, HEALTH, AND ACADEMIC PERFORMANCE Are air pollution burdens around schools linked to student health and performance? Although we cannot conclusively establish cause and effect linkages from our macro-level analysis, we can nevertheless examine associations and rule out obvious confounding variables, such as school demographics, school expenditures, and locations (suburban versus urban or rural) of schools.[16] And we can deter-

EXHIBIT 2

Median Total Air Pollution Concentrations Within Two Kilometers Of Schools And In Larger Areas, 1999–2006



SOURCE Authors' analysis of geographic microdata for 1999–2006 from Note 23 in text. **NOTES** Metro is the Detroit metropolitan area. City is the City of Detroit. Schools (metro) is areas within two kilometers of schools in the Detroit metropolitan area. Schools (city) is areas within two kilometers of schools in the City of Detroit. Median air pollution concentration values for Michigan, the Detroit metropolitan area, and the City of Detroit are for the one-kilometer squares in the respective areas. Median air pollution concentration values for schools in the Detroit metropolitan area and the City of Detroit are for the circular areas within two kilometers of the schools in those locations.

mine how robust the associations are, and whether they warrant concern.

▸ **CHEMICALS IN THE AIR:** We found that 95 percent of the estimated total air pollution concentrations around the schools came from twelve chemicals: diisocyanates, manganese, sulfuric acid, nickel, chlorine, chromium, trimethylbenzene, hydrochloric acid, molybdenum trioxide, lead, cobalt, and glycol ethers. The chemicals are listed in order, with diisocyanates contributing the most to pollution, and glycol ethers the least. These chemicals come from a variety of sources, including the motor vehicle, steel, and chemical industries; power plants; the manufacturers of rubber and plastic products; and the manufacturers of wood products. The chemicals are suspected of producing a wide variety of health effects, including increased risk of respiratory, cardiovascular, developmental, and neurological disorders, as well as cancer.[27]

Some of the chemicals, such as lead and manganese, may have direct effects on brain functioning and hence children's ability to perform well in school.[28] However, chemicals that have other health effects, including carcinogens and those that increase the risk of respiratory disorders, may also result in absences from school and otherwise impair students' ability to perform well.

▸ **SCHOOL ATTENDANCE RATES:** Because direct measures of health at the level of the individual school are not available in Michigan, we used school attendance rates as a proxy for health outcomes. We found that attendance rates were lower in schools with greater concentrations of pollution around them. This relationship was not linear, so we sorted the schools into quintiles based on the total estimated air pollution concentration within two kilometers. Although attendance rates did not vary appreciably for schools in the first three quintiles, we found statistically significant decreases in these rates for schools in the fourth and fifth quintiles. This was true even after we controlled for confounding variables, such as the rural, suburban, or urban location of the school; average expenditure per student; size of the student body; student-teacher ratio; and percentage of students enrolled in the free lunch program (see Appendix Exhibit 1).[24]

▸ **STUDENT PERFORMANCE IN ENGLISH AND MATH:** Our next step was to determine whether a relationship existed between pollution levels around the schools and the percentage of students who failed to meet the Michigan Educational Assessment Program standards for English and math. We first examined the overall pattern between pollution levels around the schools and the percentages of students failing to meet the state standards. As with attendance rates, we found that this relationship was not linear, so again we looked at quintiles of schools based on the total estimated air pollution concentration within two kilometers.

We first examined performance on the English tests. For each grade level for the schools in each quintile of pollution, we determined the average percentage of students who failed to meet the standards. As Exhibit 4 shows, there was no appreciable difference in the average percentages of students failing to meet the standards for English among the schools in the first, second, and third quintiles. However, there were distinct increases in these percentages for schools in the fourth and fifth quintiles. This was true for every grade level. We next examined performance on the math tests and obtained nearly identical results (Exhibit 5).

We investigated whether these patterns were statistically significant and whether they persisted after we controlled for school attendance rates and school locations, expenditures, and demographics. We used ordinary least squares regression, with the percentages of students in a school failing to meet the state standards in English and in math as the dependent variables and dummy variables representing each of the five quintiles of air pollution concentration around the schools as the independent variables.

EXHIBIT 3

School Demographics By Deciles Of Total Air Pollution Concentrations

	Schools[a]	Students: All[a]	White[a]	African American[a]	Hispanic[a]	In free lunch program[a]	Proportion of schools with higher concentrations than their districts[b]
DECILE 1							
Number	65	16,754	13,228	170	129	5,732	0/65
Percent	1.78	1.03	1.14	0.05	0.17	1.19	0.00
DECILE 2							
Number	78	23,118	21,793	193	405	7,043	8/78
Percent	2.13	1.42	1.88	0.06	0.53	1.46	10.26
DECILE 3							
Number	95	32,269	30,354	337	537	9,441	11/95
Percent	2.60	1.98	2.61	0.10	0.71	1.96	11.58
DECILE 4							
Number	147	50,165	46,124	1,173	1,370	11,666	26/147
Percent	4.02	3.08	3.97	0.36	1.81	2.43	17.69
DECILE 5							
Number	182	71,208	63,349	2,074	3,274	15,978	35/182
Percent	4.97	4.37	5.45	0.64	4.32	3.32	19.23
DECILE 6							
Number	233	100,045	89,117	4,064	3,921	21,319	95/233
Percent	6.37	6.14	7.67	1.26	5.18	4.43	40.77
DECILE 7							
Number	268	109,229	87,444	14,545	3,946	28,470	84/268
Percent	7.32	6.70	7.53	4.51	5.21	5.92	31.34
DECILE 8							
Number	305	129,906	113,023	8,315	4,700	30,525	120/305
Percent	8.33	7.97	9.73	2.58	6.21	6.35	39.34
DECILE 9							
Number	514	233,399	181,574	28,641	10,413	51,645	326/514
Percent	14.04	14.32	15.63	8.89	13.75	10.74	63.42
DECILE 10							
Number	1,773	863,629	515,839	262,685	47,046	298,984	1,623/1,773
Percent	48.44	52.99	44.40	81.53	62.11	62.18	91.54
TOTAL							
Number	3,660	1,629,722	1,161,845	322,197	75,741	480,803	2,328/3,660 (63.60%)

SOURCE Authors' analysis of geographic microdata for 2006 from Note 23 in text and school demographic data for 2007 from Note 25 in text. [a]Percentage of the total in the respective column. [b]Percentage of the total number of schools in the decile (row).

We found that air pollution concentrations are statistically significant predictors of student performance, even after controlling for confounding variables. The results of this analysis are presented in the Appendix.[24]

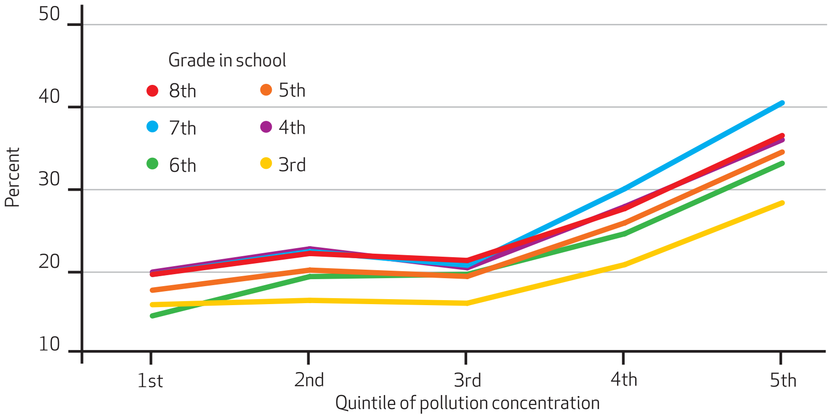
ROBUSTNESS OF FINDINGS Space limitations do not allow us to display the results here, but we found nearly identical patterns when we analyzed the 2005 National Air Toxic Assessment data.[21] This data set includes air pollution estimates from multiple sources. In addition to the major industrial sources in the EPA's Risk-Screening Environmental Indicator microdata—which refer to square kilometers rather than entire census tracts, and which were thus more suitable for our purposes—the National Air Toxic Assessments include minor industrial sources and on-road mobile sources, such as cars, trucks, and buses, as well as nonroad mobile sources, such as airplanes, tractors, and lawn mowers. We also found very similar patterns when we analyzed actual distances from schools to major industrial facilities and major highways.

Conclusions And Policy Implications

Our findings show that schools in Michigan were disproportionately located in places with high levels of air pollution from industrial sources, whether the basis of comparison was the median level for the state or the school's metropolitan area or school district. Fewer than half of the

EXHIBIT 4

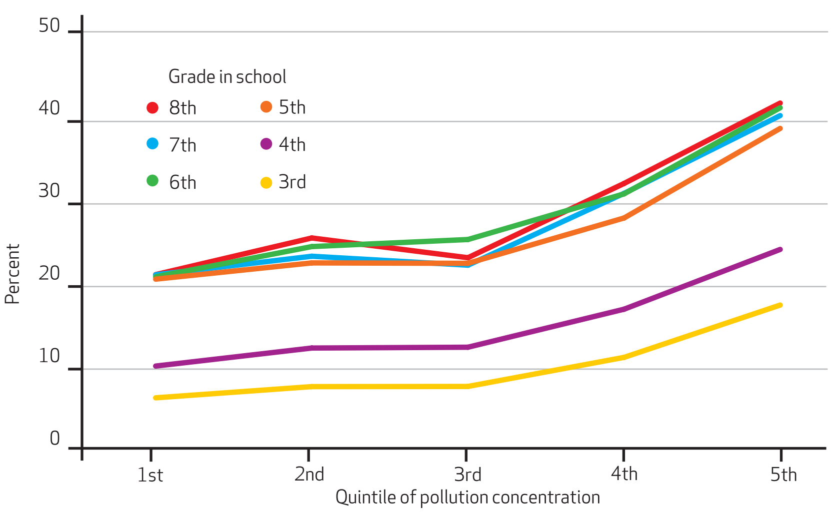
Average Percentage Of Students Not Meeting Michigan Educational Assessment Program Standards In English, By Quintile Of Total Air Pollution Concentration



SOURCE Authors' analysis of geographic microdata for 2006 from Note 23 in text and Michigan Educational Assessment Program scores for 2007 from Note 25 in text. **NOTE** For each quintile, the average percent of students not meeting the test-score standard is based on the average percentage across all schools in the quintile.

EXHIBIT 5

Average Percentage Of Students Not Meeting Michigan Educational Assessment Program Standards In Math, By Quintile Of Total Air Pollution Concentration



SOURCE Authors' analysis of geographic microdata for 2006 from Note 23 in text and Michigan Educational Assessment Program scores for 2007 from Note 25 in text. **NOTE** For each quintile, the average percent of students not meeting the test-score standard is based on the average percentage across all schools in the quintile.

white students in the state (44 percent)—but substantial majorities of African American students (82 percent), Hispanic students (62 percent), and students enrolled in the free lunch program (62 percent)—attended schools in the most polluted (by industrial sources) 10 percent of the state.

Furthermore, schools located in areas with the highest pollution levels also had the lowest attendance rates (a potential indicator of poor health) and the highest proportions of students failing to meet the state's educational testing standards. These associations remained statistically significant even when we controlled for important confounding variables such as schools' locations (urban, suburban, or rural), spending per student, and school socioeconomic characteristics. Because of the lack of available data, we could not control for all possible confounding variables. Future studies should include variables such as parental education levels; language and cultural differences; and crowding, natural versus artificial light, and ventilation in the classroom, which might influence children's school performance as well.

What explains these patterns, and what should be done about them? Because little attention to date has been given to the environmental quality of where schools are located, it is difficult to pinpoint all of the possible causes of the patterns we found. The large amount of land that a school requires and the costs of land acquisition probably mean that officials searching for new school locations focus on areas where property values are low, which may be near polluting industrial facilities, major highways, and other potentially hazardous sites.[29]

A recent survey of Michigan school superintendents verified the fact that land availability and cost are a major consideration in school siting decisions. When the superintendents were asked to rank various considerations in school boards' decisions about where to locate new schools, the two most important considerations were the availability of land and whether the school district already owned the land.[30]

Half of the states, including Michigan, do not require any evaluation of the environmental quality of areas under consideration as sites for new schools, nor do they prohibit siting new industrial facilities and highways near existing schools. This makes it likely that new schools will be built in undesirable locations to keep the cost of land acquisition down.

Our findings underscore the need to expand the concept of environmental justice to include children as a vulnerable population. They are required to attend school and have little or no say in where they live or go to school, which makes them particularly dependent on governmental policies to protect them from harm. Moreover, as our findings show, children of color are disproportionately at risk.

There is a need for proactive school policies that will protect children from exposure to unhealthy levels of air pollution and other environmental hazards. To achieve that goal, we make four policy recommendations, which we discuss in turn: site analysis, minimum distance requirements, environmental mitigation, and multilevel cooperation.

ANALYZE POTENTIAL SCHOOL SITES Our first policy recommendation is that potential school sites be thoroughly analyzed. The analysis should include testing the quality of the soil, water, and air; inventorying nearby sources of pollution, such as highways, industrial facilities, power plants, and airports; investigating previous and current uses of the land; and studying the local climate—that is, characteristics such as usual wind direction and wind tunnels—topography, and other physical aspects of the site.

The quality of the environment around existing schools should also be evaluated, and steps taken to address unsafe conditions.

REQUIRE MINIMUM DISTANCES BETWEEN SCHOOLS AND POLLUTION SOURCES Second, policies need to be enacted that insist on a minimum distance between sources of pollution and school locations. The locations of existing schools need to be taken into account when considering new highways, industrial facilities, and other potential sources of contamination. Currently, only seven states (California, Florida, Indiana, Kentucky, Mississippi, Utah, and West Virginia) prohibit locating schools near sources of pollution such as factories, plants, stables, mills, and stockyards. Six of the seven states do not mandate any specific distance. Only Indiana specifies a minimum distance: 500 feet from a school to a source of pollution, a distance too small to completely protect children from environmental hazards. Even though no previous research indicates what is a safe distance, pollution levels generally decrease with greater distance from the sources of the pollution.[31,32]

ADOPT POLICIES TO REDUCE EXPOSURE Third, environmental mitigation policies should be adopted, to reduce children's potential exposure to pollution. It may be particularly important to implement mitigation approaches in urban settings where land is scarce, and where sites for schools away from sources of pollution are difficult to find. California and Florida allow schools to be built on previously polluted sites if the pollution has been cleaned up and removed, and children attending the school will not be exposed to contaminants.

Improving indoor air quality and minimizing the infiltration of air pollution into school buildings are other mitigations that may reduce exposure to contaminants. The EPA created its voluntary Indoor Air Quality Tools for Schools Program[33] to improve indoor air quality for children. The program provides an action kit that describes best practices (such as painting with organic compounds that are not very volatile), industrial guidelines (cleaning carpets according to manufacturers' guidelines), sample policies (banning bus idling), and a sample management plan. Jerome Paulson and Claire Barnett recommend regulating indoor air quality for schools with standards that are "appropriate to children's higher respiration rate[, which] enhances vulnerability to toxins."[34]

These efforts should improve the current environmental conditions of schools, but they should not be used as a way to make up for poor school siting decisions.

ENSURE COOPERATION AMONG AGENCIES Finally, oversight and enforcement at the national, state, and local levels are needed to ensure better school environments. Until the EPA's recent draft voluntary school guidelines,[1] the federal government had little involvement in school siting policy. And although the guidelines address a wide range of issues, because the guidelines are voluntary, they may be ignored. Nevertheless, state and local agencies interested in creating healthier schools can benefit from the EPA's scientific knowledge, technical expertise, and environmental data.

State environmental agencies already cooperate with the EPA in regulating the redevelopment of brownfields—properties that contain or may contain some hazardous substance whose presence affects any future use of the properties. And brownfield redevelopment and school siting have been linked. Alison Cohen reports that because of the problem of land availability, brownfields are often considered as viable sites for schools.[35] However, building schools in previous brownfields requires great caution. The standards for cleaning brownfields up are not necessarily high enough; Michigan lowered its standards in 2000, for example.[36] Thus, state environmental agencies should develop stringent standards for cleaning up brownfields intended as school sites.

All relevant national, state, and local stakeholders—including school administrators and health officials, parents, teachers, industry and community leaders, public health professionals, environmental scientists, and educational policy makers—need to work together to develop policies that will ensure safe learning environments for schoolchildren. In states such as Michigan, school districts are mainly responsible for deciding where to build new schools.[30] However, previous cooperation between the EPA and state agencies demonstrates that different levels of government can work together on these issues. Indeed, they must, if we are to protect the health and enhance the learning environment of the nation's children. ■

A version of this paper was presented at the Institute of Medicine Roundtable on Environmental Health Sciences, Research, and Medicine, November 15, 2010, in Washington, D.C. The authors thank the Kresge Foundation for its generous support of this project.

NOTES

1 Environmental Protection Agency. School siting guidelines [Internet]. Washington (DC): EPA; 2010 Nov [cited 2011 Jan 2]. Available from: http://www.epa.gov/schools/siting/

2 Landrigan PJ, Trasande L, Thorpe LE, Gwynn C, Lioy PJ, D'Alton ME, et al. The national children's study: a 21-year prospective study of 100,000 American children. Pediatrics. 2006; 118(5):2173–86.

3 American Lung Association. Children's health [Internet]. Washington (DC): The Association; [cited 2011 Jan 2]. Available from: http://www.stateoftheair.org/2010/health-risks/health-risks-childrens.html

4 Bearer CF. How are children different from adults? Environ Health Perspect. 1995;103(Suppl 6):7–12.

5 Kleinman MT University of California, Irvine. The health effects of air pollution on children [Internet]. Diamond Bar (CA): South Coast Air Quality Management District; 2000 [cited 2011 Apr 7]. Available from: http://www.aqmd.gov/forstudents/health_effects_on_children.html

6 Wang S, Zhang J, Zeng X, Zeng Y, Wang S, Chen S. Association of traffic-related air pollution with children's neurobehavioral functions in Quanzhou, China. Environ Health Perspect. 2009;117(10): 1612–8.

7 Calderón-Garcidueñas L, Mora-Tiscareño A, Ontiveros E, Gómez-Garza G, Barragán-Mejía G, Broadway J, et al. Air pollution, cognitive deficits, and brain abnormalities: a pilot study with children and dogs. Brain Cogn. 2008;68(2): 117–27.

8 Calderón-Garcidueñas L, Franco-Lira M, Torres-Jardón R, Henriquez-Roldán C, Barragán-Mejía G, Valencia-Salazar G, et al. Pediatric respiratory and systemic effects of chronic air pollution exposure: nose, lung, heart, and brain pathology. Toxicol Pathol. 2007;35(1):154–62.

9 Sunyer J. The neurological effects of air pollution in children. Eur Respir J. 2008;32(3):535–7.

10 Suglia F, Gryparis A, Wright RO, Schwartz J, Wright RJ. Association of black carbon with cognition among children in a prospective birth cohort study. Am J Epidemiol. 2008; 167(3):280–6.

11 Freire C, Ramos R, Puertas R, Lopez-Espinosa MJ, Julvez J, Aguilera I, et al. Association of traffic-related air pollution with cognitive development in children. J Epidemiol Community Health. 2010;64(3):223.

12 Brulle RJ, Pellow DN. Environmental justice: human health and environmental inequalities. Annu Rev Public Health. 2006;27:103–24.

13 Bullard RD, Mohai P, Saha R, Wright B. Toxic wastes and race at twenty: 1987–2007 [Internet]. Cleveland (OH): United Church of Christ, Justice and Witness Ministries; 2007 Mar [cited 2011 Apr 7]. Available from: http://www.ucc.org/assets/pdfs/toxic20.pdf

14 Mohai P, Lanz P, Morenoff J, House JS, Mero RP. Racial and socioeconomic disparities in residential proximity to polluting industrial facilities: evidence from the Americans' Changing Lives Study. Am J Public Health. 2009;99(Suppl 3): S649–56.

15 Mohai P, Pellow DN, Roberts JT. Environmental justice. Annu Rev Environ Resour. 2009;34:405–30.

16 Pastor M, Morello-Frosch R, Sadd J. Breathless: pollution, schools, and environmental justice in California. Policy Stud J. 2006;34(3):337–62.

17 USA Today. The smokestack effect: toxic air and America's schools. USA Today [serial on the Internet]; 2009 [cited 2011 Apr 7]. Available from: http://content.usatoday.com/news/nation/environment/smokestack/index

18 Environmental Protection Agency. Assessing outdoor air near schools [Internet]. Washington (DC): EPA; [last updated 2010 Dec 20; cited 2011 Apr 7]. Available from: http://www.epa.gov/schoolair/

19 Neal DE. Healthy schools: a major front in the fight for environmental justice. Environ Law. 2008;38(2): 473–93.

20 Fishchbach S. Not in my schoolyard: avoiding environmental hazards at school through improved school site selection policies [Internet]. Providence (RI): Rhode Island Legal Services; 2006 Mar [cited 2011 Apr 7]. Available from: http://www.childproofing.org/school_siting_50_state.htm

21 Environmental Protection Agency. National Air Toxic Assessments [Internet]. Washington (DC): EPA; [last updated 2011 Mar 11; cited 2011 Apr 8]. Available from: http://www.epa.gov/ttn/atw/natamain

22 Weinhold B. Children's health: school siting; EPA says location matters. Environ Health Perspect. 2011;119(1):A19.

23 Environmental Protection Agency. Risk-screening environmental indicators (RSEI) [Internet]. Washington (DC): EPA; [last updated 2010 Aug 11; cited 2011 Apr 8]. Available from: http://www.epa.gov/opptintr/rsei/

24 To access the Appendix, click on the Appendix link in the box to the right of the article online.

25 Michigan Department of Education. MEAP: Michigan Educational Assessment Program [home page on the Internet]. Lansing (MI): The Department; [cited 2011 Apr 8]. Available from: http://www.michigan.gov/mde/0,1607,7-140-22709_31168—,00.html

26 Center for Educational Performance and Information. Student data and reports [Internet]. East Lansing (MI): The Center; [cited 2011 Apr 8]. Available from: http://www.michigan.gov/cepi/0,1607,7-113-21423_30451—,00.html

27 Scorecard. Chemical profiles [Internet]. Washington (DC): Scorecard; [cited 2011 Apr 18]. Available from: http://scorecard.goodguide.com/chemical-profiles/

28 Kim Y, Kim BN, Hong YC, Shin MS, Yoo HJ, Kim JW, et al. Co-exposure to environmental lead and manganese affects the intelligence of school-aged children. Neurotoxicology. 2009;30(4):564–71.

29 Such arguments have often been used to explain why poor people, including many people of color, live near polluting industrial facilities and hazardous waste sites.

30 Norton RK. Planning for school facilities: school board decision making and local coordination in Michigan. J Plann Educ Res. 2007;26(4): 478–96.

31 Korenstein S, Piazza B. An exposure assessment of PM10 from a major highway interchange: are children in nearby schools at risk? J Environ Health. 2002;65(2):9–17, 37.

32 Wu YC, Batterman SA. Proximity of schools in Detroit, Michigan to au-

tomobile and truck traffic. J Expo Sci Environ Epidemiol. 2006;16(5): 457–70.
33 Environmental Protection Agency. IAQ Tools for Schools Program [Internet]. Washington (DC): EPA; [cited 2011 Apr 8]. Available from: http://www.epa.gov/iaq/schools/
34 Paulson J, Barnett C. Who's in charge of children's environmental health at school? New Solut. 2010;20(1):18.
35 Cohen A. Achieving healthy school siting and planning policies: understanding shared concerns of environmental planners, public health professionals, and educators. New Solut. 2010;20(1):49–72.
36 Hula RC, Bromley-Trujillo R. Cleaning up the mess: redevelopment of urban brownfields. Econ Develop Quart. 2010;24(3): 276–87.

ABOUT THE AUTHORS: PAUL MOHAI, BYOUNG-SUK KWEON, SANGYUN LEE & KERRY ARD

Paul Mohai is a professor at the University of Michigan.

In their article in *Health Affairs* this month, Paul Mohai and coauthors recommend a checklist of considerations for use in the siting of schools to avoid exposing children to health-threatening pollution.

A professor in the School of Natural Resources and Environment at the University of Michigan, Mohai has long worked in the field of environmental justice. Yet he was surprised at the overwhelming number of Michigan schools that were near environmental hazards. The best explanation, he says, is that school systems often look for large parcels of land that are available cheaply—and land near industrial sites usually fits that bill. Unfortunately, he observes, at least twenty states "have no policy whatsoever in terms of taking into consideration environmental hazards when siting schools."

Mohai, who is also a faculty associate at the Institute for Social Research at the University of Michigan, was an early and major contributor to quantitative research examining the disproportionate environmental burdens in communities where residents are largely from racial or ethnic minority groups or of low income. His current research involves studies at the national level that examine the role environmental factors play in accounting for racial and socioeconomic disparities in health and student performance.

Mohai has a master of science degree in forest science and statistics from the State University of New York, Syracuse, and a doctorate in natural resource policy and sociology of natural resources from Pennsylvania State University.

Byoung-Suk Kweon is a research investigator at the University of Michigan.

Byoung-Suk Kweon is a research investigator at the Institute for Social Research and an adjunct assistant professor in the School of Natural Resources and Environment at the University of Michigan. For the past ten years, she has been conducting research on environmental risks around public schools and their consequences. She has a master's degree in landscape architecture from Cornell University and a doctorate in natural resources and environmental sciences from the University of Illinois, Urbana-Champaign.

Sangyun Lee is a postdoctoral research fellow at the University of Michigan.

Sangyun Lee is a postdoctoral research fellow in the School of Natural Resources and Environment at the University of Michigan. He has a master's degree in urban and environmental planning from the University of Virginia and a doctorate in environmental policy and behavior from the University of Michigan. His research interests include environmental justice, sustainable development, environmental policy and planning, and urban inequality.

Kerry Ard is a graduate student in sociology and environmental policy at the University of Michigan.

Kerry Ard is a doctoral student in sociology and environmental policy at the University of Michigan. The School of Natural Resources and Environment recently honored her with a Justin W. Leonard Award, which is given to students with superior academic credentials who are judged to have the greatest promise for leadership in the wise use of natural resources through the integration of natural and social sciences.

DEQ Calculations

See Attached

Emission Results and Health Benefits for Project: STA NJ 1

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/Engines	0.083	0.007	0.011	0.041	17.9	1,592
Amount Reduced After Upgrades	0.083	0.007	0.011	0.041	17.9	1,592
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles/Engines	0.497	0.041	0.068	0.248	107.5	9,552
Amount Reduced After Upgrades	0.497	0.041	0.068	0.248	107.5	9,552
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Lifetime Cost Effectiveness ($/short ton reduced)						
Capital Cost Effectiveness[4] (unit & labor costs only)	$664,010	$7,977,417	$4,884,056	$1,328,740	$3,071	
Total Cost Effectiveness[4] (includes all project costs)	$664,010	$7,977,417	$4,884,056	$1,328,740	$3,071	

[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

STA NJ 1: School Bus Vehicle Replacement - All-Electric	6 years

Emission Results and Health Benefits for Project: STA NJ 2

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/Engines	0.089	0.007	0.012	0.044	19.4	1,721
Amount Reduced After Upgrades	0.089	0.007	0.012	0.044	19.4	1,721
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles/Engines	0.535	0.044	0.072	0.266	116.2	10,326
Amount Reduced After Upgrades	0.535	0.044	0.072	0.266	116.2	10,326
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Lifetime Cost Effectiveness ($/short ton reduced)						
Capital Cost Effectiveness[4] (unit & labor costs only)	$617,321	$7,470,285	$4,563,938	$1,239,716	$2,841	
Total Cost Effectiveness[4] (includes all project costs)	$617,321	$7,470,285	$4,563,938	$1,239,716	$2,841	

[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

STA NJ 2: School Bus Vehicle Replacement - All-Electric	6 years

Emission Results and Health Benefits for Project: STA NJ 3

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/Engines	0.071	0.006	0.010	0.036	15.2	1,354
Amount Reduced After Upgrades	0.071	0.006	0.010	0.036	15.2	1,354
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles/Engines	0.428	0.036	0.059	0.215	91.4	8,124
Amount Reduced After Upgrades	0.428	0.036	0.059	0.215	91.4	8,124
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Lifetime Cost Effectiveness ($/short ton reduced)						
Capital Cost Effectiveness[4] (unit & labor costs only)	$771,543	$9,118,115	$5,609,061	$1,531,394	$3,611	
Total Cost Effectiveness[4] (includes all project costs)	$771,543	$9,118,115	$5,609,061	$1,531,394	$3,611	

[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

STA NJ 3: School Bus Vehicle Replacement - All-Electric	6 years

Emission Results and Health Benefits for Project: STA NJ 4

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/Engines	0.079	0.007	0.011	0.039	16.9	1,506
Amount Reduced After Upgrades	0.079	0.007	0.011	0.039	16.9	1,506
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles/Engines	0.472	0.039	0.064	0.236	101.7	9,036
Amount Reduced After Upgrades	0.472	0.039	0.064	0.236	101.7	9,036
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Lifetime Cost Effectiveness ($/short ton reduced)						
Capital Cost Effectiveness[4] (unit & labor costs only)	$699,229	$8,355,162	$5,123,379	$1,395,478	$3,246	
Total Cost Effectiveness[4] (includes all project costs)	$699,229	$8,355,162	$5,123,379	$1,395,478	$3,246	

[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

STA NJ 4: School Bus Vehicle Replacement - All-Electric	6 years