Fw: Oster scoping
Jeffrey Oliveira to: Marti Fisher 08/02/2010 04:03 PM

----- Forwarded by Jeffrey Oliveira/Planning/COSLO on 08/02/2010 04:03 PM -----

From: "Susan Harvey" <ifsusan@tcsn.net>
To: "Jeff Oliveira" <joliveira@co.slo.ca.us>
Cc: "'John Nall'" <jnall@co.slo.ca.us>, "'M. Jencks'" <mjencks@jenckscolaw.com>
Date: 07/30/2010 11:42 AM
Subject: Oster scoping

Jeff – Please find attached North County Watch comments on the Oster Las Pilitas scoping process. Also attached are 6 document attachments.

Thank you,

Susan Harvey,
North County Watch

coal tar based sealants.pdf Coal tar asphalt sealants polluting homes, lowering IQs.doc ehp0113-a00456 pavement.pdf
Parking lots create sticky pollution problem.pdf PAHs Underfoot.doc Estrada and El Camino.pdf Scoping comments july 30, 2010.pdf

North County Watch

San Luis Obispo County
Department of Planning and Building
San Luis Obispo, California 93406

Sent Via email to Jeff Oliveira joliveira@co.slo.ca.us

Re: Scoping Comments on Oster Las Pilitas Quarry

July 30, 2010

Dear Mr. Oliveira,

Thank you for the opportunity to comment on the Oster Quarry scoping. Please add my name to the notification list for this project.

Asphalt Recycling

The project description includes the recycling of asphalt and concrete. If Footnote 6 of Table 2-2 was not clear enough, the Planning Commission and Board of Supervisors affirmed that asphalt and concrete recycling are not permitted on rural lands or ag zoned lands. The Project Description needs to be revised and remove the reference to asphalt and concrete recycling in order to comply with local and state law before any further action is taken on the project. *Neighbors in Support of Appropriate Land Use v. the County of Tuolumne* 5th Appellate Court 2007 *states*:

> Section 65852 is the third step in a three-step logical sequence that has been in place since 1953. ...Section 65850 sets forth types of zoning regulations cities and counties may impose, including restrictions on the uses of buildings and land. Section 65851 states that, for purposes of zoning regulations, cities and counties may divide land into zones. Section 65852 provides that the regulations contemplated by section 65850 must be uniform within each of the zones contemplated by section 65851, but may differ from zone to zone.
>
> The general meaning of this sequence is not difficult to understand: Cities and counties may create rules and they may create zones; the rules should be the same for each parcel within a zone but may be different for parcels in different zones. Our Supreme Court aptly has explained the fundamental reason for having a scheme of this nature. It did so in the context of a dispute over a variance, but the same principle applies here:

"A zoning scheme, after all, is similar in some respects to a contract; each party foregoes rights to use its land as it wishes in return for the assurance that the use of neighboring property will be similarly restricted, the rationale being that such mutual restriction can enhance total community welfare. [Citations.] If the interest of these parties in preventing unjustified variance awards for neighboring land is not sufficiently protected, the consequence will be subversion of the critical reciprocity upon which zoning regulation rests." (*Topanga Assn. for a Scenic Community v. County of Los Angeles* (1974) 11 Cal.3d 506, 517-518.)

If a zoning scheme is like a contract, the uniformity requirement is like an enforcement clause, allowing parties to the contract to challenge burdens unfairly imposed on them or benefits unfairly conferred on others. According to a leading treatise, section 65852 "is intended to prevent unreasonable discrimination against or benefit to particular properties within a given zone." (4 Manaster & Selmi, Cal. Environmental Law and Land Use, *supra*, Zoning, § 60.70, p. 60-114.3 (rel. 45-9/06).)

By creating an ad hoc exception to benefit one parcel in this case—an exception that was not a rezoning or other amendment of the ordinance, not a conditional use permit in conformance with the ordinance, and not a proper variance—the county allowed this "contract" to be broken. If the county had, for instance, rezoned the property, it would be declaring that the Petersons' property appropriately *belonged* in a different zone and was subject to all the rules and limitations applicable to the other parcels in the new zone. Others similarly situated could argue, at future rezonings, that their parcels also belong in a different zone. If the county had altered the zoning ordinance to allow commercial uses like the ones here at issue as conditional uses within the agricultural zone, it would necessarily have given other owners in the zone the opportunity to apply for conditional use permits allowing those uses. Instead, the county simply let one parcel and owner off the hook. In light of the key role played by the requirement of uniformity in a zoning scheme, the parcel's neighbors had a right to expect that this would not happen.

Local zoning power is broad since it issues directly from the broad police power detailed in the California Constitution and not from the narrower provisions of the planning and zoning law. The foundations of zoning would be undermined, however, if local governments could grant favored treatment to some owners on a purely ad hoc basis. Cities and counties unquestionably have the power to rezone and their decisions to do so are entitled to great deference; but rezoning, even of the smallest parcels, still necessarily respects the principle of uniformity. This is because a rezoning places a parcel within a general category of parcels (those in the new zone), all of which are subject to the same zoning regulations. The county's action in this case, by contrast, placed the Petersons' land in a class by itself.

North County Watch requests that you remove the asphalt and concrete recycling component of the project in order to act within the confines of state and local law. Should the EIR process move forward with the current project description, the following Hazardous Materials issues must be studied.

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Hazardous Materials

The environmental document needs to differentiate the percentage of production and sales that are anticipated for on-site DG product and, if it were to be permitted, recycled product. The Initial Study

states that asphalt to be recycled will be free of oil. That will be impossible – asphalt is a roadway surface; it will have oil on it. The impact of asphalt fines, toxins and compounds such as PAH on the environment and in dust will have to be studied. (Please see five attached articles.)

The Initial Study explicitly states that there will be no storage of fuel on site. How will equipment be fueled? How will fuel be transported to the site?
The Initial Study statement on page 19 presents a major inconsistency in the document that must be resolved:

> On-site servicing and fueling of vehicles shall be accomplished with the use of the following best management practices:
> 1. Servicing and fueling shall take place only in designated fueling areas outside of on-site drainages. P 19

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Traffic and Transportation

On-site sales impacts need to be considered in the environmental analysis. What percentage of sales will be on-site? Are all sales intended to be on-site? Are the 208 truck trips predicated on 40 tons per truck load? Sales that generate hauls less than 40 tons per trip, generate more traffic.
The environmental document needs to consider the cumulative effects of traffic generated by the approved Santa Margarita Ranch Ag Cluster. The SMR Ag Cluster generated extensive requirements for improvements to the Highway 101/Highway 58 interchange.

The environmental document needs to assess the safety impacts of 208 truck trips (in a 10 hour day that equals one truck every 3 minutes) at the intersection Highway 58 and El Camino Real. Please see attached photos. Presumably, a 65 foot long truck could be straddling the Entrada/El Camino Rail Road grade crossing every 3 minutes.

We believe the following assumption in the Initial Study is flawed and that a left turn lane will need to accommodate more than one 65 foot truck:

> Due to the relatively low volume of project trips, low background traffic on Calf Canyon Highway, and acceptable levels of service, a separate left-turn lane is not necessary for acceptable operation of the project driveway.

The cumulative impacts of the expansion of the Hanson Quarry need to be assessed.

Geology

The proposed project anticipates a working slope of 1.5 to 1 which is very steep. For purposes of requirements of SMARA regulation 2772 (3)[1], fault assessment needs to be comprehensive.
The project site is 2.5 from the town of Santa Margarita and closer than that to the approved Santa Margarita Ag cluster on Pozo Road. The SMR Ag cluster stated:

> Thirty-four active and potentially active earthquake producing faults lie within 100 miles of the center of the Santa Margarita Ranch property. Individual earthquakes as large as Magnitude 7.9 have occurred within this distance. Fault rupture of the ground surface is possible on any of these faults with a large enough earthquake and secondary effects such as ground settlement, liquefaction and landsliding can occur. P4.6-1

The project Initial Study states:

> Steep slope faces are likely to be created during the mining process, resulting in a potential for damage to mining equipment and injury or death to workers if the steep slopes along actively mined faces are unstable and fail. However, implementation of OSHA regulations related to mine safety, Title 8, Chapter 4 Division of Industrial Safety, Subchapter 17 Mine Safety Orders, which include regulation regarding ground control (Article 12) and safety of workers near the free face would minimize the potential that workers could be injured or killed by ground failures such as rock fall or landslides. P 18

Although the project will not be residential development, the environmental review needs to examine the same potential earth quake hazards that the EIR for the SMR Ag Cluster addressed including the Nacimiento Fault zone, the Rinconada Fault zone, the San Andreas Fault Zone, the Huasna/Oceanic Fault zone, Los Osos Fault, the Hosgri Fault.

The Initial Study cites the Chicago Grade EIR and the Santa Ysabel MND yet overlooks the SMR Ag Cluster EIR as a reference.

Land Use

We take issue of the description of the project as "semi-industrial use" for purposes of land use designations. This is inaccurate and misleading. This project is an industrial use.

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[1] 2772 (3) The designed steepness and proposed treatment of the mined lands' final slopes shall take into consideration the physical properties of the slope material, its probable maximum water content, landscaping requirements, and other factors. In all cases, reclamation plans shall specify slope angles flatter than the critical gradient for the type of material involved. Whenever final slopes approach the critical gradient for the type of material involved, regulatory agencies shall require an engineering analysis of the slope stability. Special emphasis on slope stability and design shall be necessary when public safety or adjacent property may be affected.

Air Quality

Statements such as the following have no basis for consideration in an environmental document.

> Existing and proposed development within the County of San Luis Obispo require materials such as DG and granitic rock to facilitate construction activities within the County. Existing patterns associated with the delivery of construction materials often require transport from outside the immediate area of the project sites. These truck trips often require longer transport distances and hence additional air quality impacts associated with on-going development activities within the County and surrounding areas. As such, impacts related to vehicle / equipment emissions and dust generation are considered potentially significant impacts.
>
> ...These emissions would be lower than those attributable to using aggregate material from a more distant source, which would cause substantially higher transportation fuel use. As a result, the GHG emissions caused by aggregate mine operation would be less than significant. P 9

In fact, the project area has more than sufficient options for procurement of aggregate at the Hanson and Rocky Canyon Quarry. There is no evidence or supporting studies that deal with "existing patterns associated with the delivery of construction materials...." as a basis for extravagant claims that the project under consideration will reduce the importation of aggregate. Nor is there any mechanism to impose restrictions on procurements or transportation of aggregate material such that it should be considered a suitable off-set for Green House gasses that will be generated by the new project. The how or where aggregate materials might be procured is irrelevant as an offset for GHG generation from a new project.

Noise

The Initial Study states that the closest residence to the project is 1,699 feet away. The mitigation requirements for Noise in the Biorn Diani EIR (April, 2008) for a project that used crushing equipment identified residences at the same general distance as the Oster project. Extensive mitigation options were prescribed due to the complexity involved with modeling the magnitude, location, operating hours and frequency of the numerous noise sources proposed (vehicles, mobile equipment, stationary equipment). We suggest that the Biorn EIR be consulted. Similarly, the impacts generated by the SMR Ag Cluster identified Noise as a Class 1 impact. The noise generated by the 208 truck trips through town needs to be studied. Baseline is the current condition. The Initial Study seems flawed in its assessment that "The added truck traffic in Santa Margarita increases noise levels but the changes are not substantial...." There is no indication whether the Noise Study was completed under assumptions of the original flawed traffic study that greatly underestimated the truck traffic.

The Noise impact of 208 one-way truck trips at the school should be assessed.

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Cumulative Impacts

The Cumulative Impact of the expansion of the Hanson Quarry should be analyzed. The Hanson Quarry is reported to have a 100 year supply of aggregate available. It is a vested mine. It will expand.

Alternatives

Both the expansion of the Hanson Quarry and the Rocky Canyon Quarry are legitimate alternatives that should be studied as environmentally superior alternatives.

Water

A water supply assessment (WSA) will be required for this project. *Center for Biological Diversity* v. *County of San Bernardino* 2010 Cal.App. 4th found that a composting facility that used as little as one and a half acre feet a year of water required a water supply assessment pursuant to Water Code section 10910-10915 and CEQA.

Thank you for your consideration of our comments.

Susan Harvey

CC: John Nall
Michael Jencks

Attachments:
Entrada and El Camino
Coal Tar Based Sealants
Coal Tar Asphalt Sealants Polluting Homes
Parking lots create sticky pollution problem
Paving Paradise - Ehp 0113
PAHs Underfoot

North County Watch P.O. Box 455 Templeton, CA 93465

Parking lots create sticky pollution problem

Suburbia, beware. Vast stretches of parking lots in the U.S. are coated with toxic coal tar that is slowly crumbling into dust. Coal-tar-based sealants, which give the lots an ebony finish, produce dust containing 100 to 1000 times higher PAH levels than unsealed lots, according to new research published in *ES&T* (DOI 10.1021/es802119h). Many PAHs are carcinogenic and harm aquatic life, and runoff from the lots could be a major source of urban water contamination, the scientists report.

The sealants first drew attention in Austin, Texas, when city workers discovered high PAH levels in sediments near Barton Springs, a popular swimming spot and home to an endangered salamander species. Scientists from the U.S. Geological Survey (USGS) first reported in *ES&T* in 2005 that runoff from Austin parking lots sealed with coal tar contained 65 times more PAHs than runoff from unsealed lots. Since then, Austin and Dane County, Wisc., home to the city of Madison, have banned coal-tar sealants. Now the USGS team, led by research hydrologist Peter Van Metre, has compared lots sealed with coal tar and with asphalt in nine U.S. cities.

Pavement sealants, used to prevent cracks from freezing and thawing, are most often used on parking lots rather than roads and are ground into dust as vehicles drive over them. In the new study, researchers compared PAHs in dust from sealed and unsealed parking lots. Dust from sealed lots in the central and eastern U.S. contained an average of 2200 milligrams per kilogram (mg/kg) of 12 PAHs, compared with 27 mg/kg in unsealed lots. "There is evidence, at least qualitatively, that where coal tar is in use in urban settings it's the major source [of PAHs to streams]," Van Metre says.

Coal tar is the most common sealant east of the Continental Divide, the study shows, whereas low-PAH asphalt sealants dominate in the West. This pattern is consistent with industry information and corresponds with the availability of coal tar, which is a byproduct of steel manufacturing.

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Coal-tar sealants are sprayed onto parking lots and driveways to give the surface a new appearance and protect underlying asphalt.

Other sources of PAHs, such as exhaust particles, tire-wear residue, and motor oil, could not account for the high levels found on and near coal-tar-sealed parking lots, Van Metre says. "Even if the soil was made completely of tire rubber or motor oil, it wouldn't reach these PAH levels," he says. No one knows how much coal-tar sealant is used nationally, but according to industry estimates, about 600,000 gallons of sealant, or about 1 gallon per person, are applied annually in the Austin area alone.

"America is doing the worst possible thing by putting down a material with extremely high PAH levels on the surface, where it flakes off and wears down," says Craig Depree, an environmental chemist at the National Institute of Water and Atmospheric Research (New Zealand). Depree has matched the chemical fingerprint of PAHs in New Zealand streams to coal tar in older roads repaved with asphalt.

"There's no regulation of how much [coal-tar sealant] is used or the PAH content of sealants," adds Tom Ennis, environmental resource manager for Austin's Watershed Protection and Development Review Department. Ennis's research group recommended the Austin ban after finding biological effects such as altered growth, survival, and development in amphibians exposed to sediment containing coal-tar sealant.

PAHs are not the only pollutants that wash off pavement. "The dominant hydrology of urban areas is storm water," says Alison Watts of the University of New Hampshire (UNH) Stormwater Center. Storm water sends large pulses of runoff, loaded with various contaminants, into streams. The research center is now continuously monitoring runoff water quality from three parking lots—unsealed as well as coal-tar- and asphalt-sealed.

Van Metre, Watts, and environmental scientist Mateo Scoggins of Austin's watershed department have briefed the U.S. EPA and lawmakers on their results. The EPA's maximum soil screening level for one PAH, benzo[*a*]pyrene, is 0.09 mg/kg, 5300 times lower than the level in dust from coal-tar-sealed driveways sampled in suburban Chicago. However, EPA's stormwater program, which could help control non-point-source pollution from parking lots, was recently criticized as ineffective in a report by the National Research Council. Because the sealants are used on some playgrounds and driveways, Van Metre says, the human-health effects of coal-tar dust should be studied further.

—ERIKA ENGELHAUPT

10.1021/es803118b
Published on Web 11/19/2008

PAHs Underfoot: Contaminated Dust from Coal-Tar Sealcoated Pavement is Widespread in the United States

Peter C. Van Metre*, Barbara J. Mahler and Jennifer T. Wilson
U.S. Geological Survey, Austin, Texas
Environ. Sci. Technol., 2009, *43* (1), pp 20-25
DOI: 10.1021/es802119h
Publication Date (Web): November 19, 2008

* Corresponding author e-mail: pcvanmet@usgs.gov.

Abstract

We reported in 2005 that runoff from parking lots treated with coal-tar-based sealcoat was a major source of polycyclic aromatic hydrocarbons (PAHs) to streams in Austin, Texas. Here we present new data from nine U.S. cities that show nationwide patterns in concentrations of PAHs associated with sealcoat. Dust was swept from parking lots in six cities in the central and eastern U.S., where coal-tar-based sealcoat dominates use, and three cities in the western U.S., where asphalt-based sealcoat dominates use. For six central and eastern cities, median ΣPAH concentrations in dust from sealcoated and unsealcoated pavement are 2200 and 27 mg/kg, respectively. For three western cities, median ΣPAH concentrations in dust from sealcoated and unsealcoated pavement are similar and very low (2.1 and 0.8 mg/kg, respectively). Lakes in the central and eastern cities where pavement was sampled have bottom sediments with higher PAH concentrations than do those in the western cities relative to degree of urbanization. Bottom-sediment PAH assemblages are similar to those of sealcoated pavement dust regionally, implicating coal-tar-based sealcoat as a PAH source to the central and eastern lakes. Concentrations of benzo[*a*]pyrene in dust from coal-tar sealcoated pavement and adjacent soils greatly exceed generic soil screening levels, suggesting that research on human-health risk is warranted.

Introduction

Contamination of urban aquatic sediments by PAHs, which represent the largest class of suspected carcinogens (1), has been increasing in the United States during the last 20–40 years (2, 3). PAHs in the environment largely are a product of the incomplete combustion of petroleum, oil, coal, and wood (4). Sources in the urban environment include industrial emissions and wastes (5); home heating with fuel oil, wood, and coal; power plants (6); vehicles (7, 8); and pavement sealants, also known as sealcoat (9). In a study of PAH sources in Austin, Texas, particles in runoff from parking lots treated with coal-tar-based sealcoat had a mean total PAH concentration of 3500 mg/kg, 65 times greater than that in particles from concrete and asphalt parking lots that were not sealcoated (9). On the basis of comparison with suspended sediment concentrations, loads, and chemical assemblages in streams, the study concluded that sealcoat was a major source of PAHs to streams in the four watersheds studied. Recent studies have documented adverse biological effects in some Austin streams receiving runoff from coal-tar sealcoated lots (10), and demonstrated altered survival, growth, and development in a model amphibian species (*Xenopus laevis*) exposed to sediment spiked with coal-tar-based sealcoat (11).

Most sealcoat products have either a refined-coal-tar or asphalt (crude oil) base. The coal-tar varieties typically are 15–35% coal tar, a known carcinogen with extremely high concentrations of PAHs (12). The City of Austin reported a median concentration of the sum of 16 PAHs (dry weight basis) for coal-tar-based sealcoat products of more than 50,000 mg/kg and a median for asphalt-based sealcoat products of about 50 mg/kg (13). A recent informal survey on the Internet (June 5, 2008) located sealcoat applicators in all 50 U.S. states and Canada (see Supporting Information for Internet sites accessed). Although national use is not reported, the sealcoat industry estimates that in the State of Texas 225 million L of refined coal-tar-based sealcoat are applied annually ((10) and references therein), and the New York Academy of Sciences reported estimated annual use of coal-tar-based sealcoat in the New York harbor watershed of approximately 5.3 million L (14). Anecdotal reports (e.g., Web sites, blogs, commercial availability, comments by industry representatives) indicate that coal-tar-based sealcoat dominates use east of the Continental

Divide (central and eastern U.S) and asphalt-based sealcoat dominates use west of the Continental Divide (western U.S.).

High concentrations of PAHs in particles washed from coal-tar sealcoated parking lots in Austin raise two questions. First, are similarly high PAH concentrations associated with sealcoated pavement in other U.S. cities? Second, does use of coal-tar-based sealcoat lead to contamination of aquatic sediments? To answer these questions, the U.S. Geological Survey (USGS) collected dust from sealcoated and unsealcoated pavement in Austin and eight other U.S. cities; samples were collected in the watersheds of lakes sampled by the USGS National Water-Quality Assessment (NAWQA) Program (Figure 1). The primary objectives were to characterize concentrations of PAHs in dust from sealcoated and unsealcoated pavement at the national scale and to evaluate PAH concentrations in lake sediments in the context of regional differences in sealcoat use. An additional objective of the study was to investigate potential off-site transport of PAHs by transport modes other than runoff. To address this objective at a reconnaissance level, samples of soil and street dust were collected near sealcoated and unsealcoated parking lots in Lake in the Hills, Illinois, a suburb of Chicago.

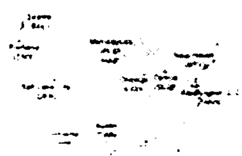

Figure 1. Cities where samples of pavement dust and other pavement-related solids were collected. Abbreviations (e.g., DEK) identify each watershed where dust and/or scrapings samples and lake-sediment cores were collected (Table 1).

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Materials and Methods

Methods, quality-control results, and full data for the dust and pavement-related solids described in this paper are presented in ref 15 and briefly summarized here. Cities in this study are those where lake sediment cores were sampled by the NAWQA Program in 2004–2007 (seven cities) or previously (Lake Anne, Reston, VA, 1996; Town Lake, Austin, 1998). The design and methods for the NAWQA lakes study are presented in ref 16 and analytical methods are presented in 16 or are the same as described here and in ref 15 for dust samples. Parking lots chosen for dust sampling serve multifamily residential housing, schools, office parks, or retail businesses; none serve industrial facilities. Two residential driveways also were sampled. In five cities composite samples of dust from three parking lots of the same surface type (sealcoated or not sealcoated) were analyzed, and in four cities samples from individual lots were analyzed (Table 1). Individual lots were sampled in some cities to better understand variation in PAH concentrations among sealcoated pavements in the same area. In Austin, dust samples were collected from six individual lots, two of which were known to be sealcoated with coal-tar-based sealcoat and four with asphalt-based sealcoat. In Lake of the Hills, in addition to samples from individual parking lots, dust samples from two sealcoated driveways, dust from (unsealcoated) roads adjacent to sealcoated and unsealcoated pavement, and soil adjacent to sealcoated and unsealcoated pavement also were collected and analyzed (15).

Table 1. Number of Dust Samples Collected by City and Lake Watershed

city and state	suburb, if applicable	lake watershed	NAWQA lake ID	no. of samples from sealcoatedpavement	no. of samples from unseal-coated pavement
Seattle, WA	Mountlake Terrace	Lake Ballinger	BAL	9	1
Portland, OR	Beaverton	Tanasbrook Ponds	TNB	2	1
Salt Lake City, UT		Decker Lake	DEK	1[a]	1[a]

city and state	suburb, if applicable	lake watershed	NAWQA lake ID	no. of samples from sealcoatedpavement	no. of samples from unseal-coated pavement
Minneapolis, MN	Brooklyn Center	Palmer Lake	PLM	1[a]	1[a]
Minneapolis, MN		Lake Harriet	HAR	1[a]	1[a]
Chicago, IL	Lake in the Hills	Lake in the Hills	LKH	7	2
Detroit, MI	Commerce	S. Commerce Lake	SCM	1[a]	1[a]
New Haven, CT		Lake Whitney	WTY	1[a]	1[a]
Washington, DC	Reston, VA	Lake Anne	ANN	1[a]	
Austin, TX		Town Lake	TWN	6	

a

Sample is a composite of dust from three parking lots of the same type in the lake watershed indicated.

Dust samples from driveways and parking lots were collected by sweeping areas of several square meters using a soft, clean, nylon brush and a clean plastic dustpan (Figure S1, Supporting Information). Areas sampled generally were in drive lanes; areas with oil staining or heavy accumulations of sediment, such as near curbs, were avoided. Brushes and dustpans were discarded after collection of each sample analyzed. Dust samples were sieved using a 0.5-mm stainless steel mesh to remove coarse sand, gravel, and debris. Details of street dust and soil sampling are presented in ref 15. Samples were placed in clean glass jars and shipped chilled to the USGS National Water Quality Laboratory for analysis.

Samples were analyzed for PAHs using pressurized liquid extraction and gas chromatography/mass spectrometry (GC/MS) (17), with modifications for some samples as described in 15 and references therein. Quality control consisted of analysis of surrogate compounds added to each environmental sample and analysis of spiked samples and blank samples concurrent with analysis of each set of environmental samples. Quality-control data are presented in ref 15. Total PAH (ΣPAH) is defined here as the sum of concentrations of 12 parent PAHs: naphthalene, acenaphthylene, acenaphthene, 9H-fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*a*]pyrene, and dibenzo[*a,h*]anthracene. These are the PAHs used in the consensus-based sediment-quality-guideline probable effect concentration (PEC) (18, 19), with the exception of 2-methylnaphthalene, which was not quantified in this study. ΣPAH as reported here treats nondetections as zero values.

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Results

Concentrations of dust from pavement in the central and eastern U.S. contrast sharply with those in the western U.S. (Figure 2). For the six central and eastern U.S. cities, a region where coal-tar-based sealcoat is reported to dominate use, the median ΣPAH concentration (computed as the median of the median value for each city) in dust from sealcoated lots was 2200 mg/kg. In contrast, the median ΣPAH concentration in dust from unsealcoated lots (collected in four of the six central and eastern cities) was 27 mg/kg, a factor of about 80 lower. This considerable difference cannot be attributed to other sources of PAHs, such as fallout of industrial emissions, exhaust particles, tire-wear residue, or leaking motor oil, because PAHs from such sources are equally likely to occur on both unsealcoated and sealcoated lots. The ΣPAH concentrations reported here are consistent with ΣPAH concentrations in particles in runoff from coal-tar sealcoated and unsealcoated lots in Austin of 3500 and 54 mg/kg, respectively (9). Two of the dust samples collected in the central and eastern cities were from sealcoated driveways of single-family homes in suburban Chicago. ΣPAH concentrations in these samples (5800 and 9600 mg/kg) exceeded those in all of the parking lot dust samples.

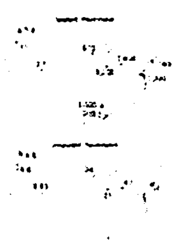

Figure 2. ΣPAH concentration (mg/kg) in samples of dust from sealcoated and unsealcoated pavement. Concentrations shown either are a median if multiple samples analyzed or the result for a composite sample from three pavements of the same type (see Table 1 for details). Two values are shown for Austin, TX: (a) median of two lots reportedly sealcoated with coal-tar-based sealcoat; (b) median of four lots reportedly sealcoated with asphalt-based sealcoat.

The results from the western cities tell a different story (Figure 2). Concentrations of ΣPAH from sealcoated and unsealcoated lots in the three western cities were low (13 mg/kg or less); the single exception in Seattle (one of nine sealcoated lots sampled in that city) of 850 mg/kg indicates use of coal-tar-based sealcoat on this lot. The low ΣPAH concentrations for most sealcoated lots in the western cities are consistent with reports that asphalt-based sealcoat use dominates in the western U.S.

There is substantial variability in ΣPAH concentrations in dust from sealcoated pavement within regions, with a range in concentrations in the central and eastern cities (median of each city with all lots included) of 345 to 3400 mg/kg and from 0 (nondetection of all compounds) to 5.9 mg/kg in western samples. Numerous factors likely affect variability within a region or even within a watershed, including sealcoat type, sealcoat age, climate, and parking lot characteristics such as slope and use. Nonetheless, concentrations in dust from central and eastern sealcoated pavement are significantly (Mann–Whitney U test, $p = 0.02$) and substantially (1000×) greater than concentrations in dust from western sealcoated pavement.

For the assessment of offsite transport of PAHs, soil and street dust were collected near sealcoated parking lots and driveways and near an unsealcoated parking lot in the watershed of Lake in the Hills. None of the streets was sealcoated. Concentrations of PAHs in soil and street dust near sealcoated pavement exceeded those near unsealcoated pavement by a factor of from 6.4 to 39 (street dust) and 2.3 to 14 (soil) (Table 2).

Table 2. ΣPAH Concentrations in Dust Swept from Pavement, in Dust Swept from Adjacent (Unsealcoated) Streets, and in Soil Adjacent to Pavement in Lake in the Hills

dust site	street dust, mg/kg	sealcoated pavement dust, mg/kg	soil, mg/kg
LKH 1		3,200	
LKH 2		2,800	
LKH 3		5,200	
LKH.PLS1	310	2,200	23
LKH.PLS4		3,200	140
LKH.PLS2	51	9,600	

dust site	street dust, mg/kg	sealcoated pavement dust, mg/kg	soil, mg/kg
LKH.PLS3	130	5,800	
unsealcoated pavement dust, mg/kg			
LKH 4		23	
LKH.PLU1	8.0	18	10

Discussion

At the national scale, one result stands out from the sampling of pavement dust: ΣPAH concentrations in dust from sealcoated pavement in the central and eastern U.S. cities greatly exceed those in dust from unsealcoated pavement in the same cities and from sealcoated and unsealcoated pavement (with a single exception) in the western U.S. cities (Figure 2). In the central and eastern cities, the median ΣPAH concentration in dust from sealcoated pavement exceeded that from unsealcoated parking lots by a factor of about 80. In contrast, ΣPAH concentrations in dust from sealcoated and unsealcoated pavement in the three western cities are similar and about 1000 times lower than in dust from sealcoated pavement in the central and eastern cities. The elevated PAH concentrations in dust from sealcoated pavement in all six central and eastern cities where samples were collected, in contrast to the western cities where asphalt-based sealcoat dominates use, indicate that PAH-contaminated dust associated coal-tar sealcoated pavement occurs across a large part of the United States. The 1000:1 east/west ratio is comparable to the ratio of ΣPAH concentrations in refined coal-tar-based sealcoat products to those in asphalt-based sealcoat products (median ΣPAH of more than 50,000 and 50 mg/kg, respectively (13)). Concentrations of PAHs in dust from sealcoated and unsealcoated pavement in all of the central and eastern U.S. cities sampled are consistent with concentrations reported from Austin (9).

Mahler et al. (9) reported that particles in runoff from parking lots with coal-tar-based sealcoat might account for the majority of stream PAH loads in the Texas watersheds sampled, raising the following question: Is use of coal-tar-based sealcoat affecting water quality at a national scale? We examine this by comparing PAH concentrations in lake sediment in the watersheds where dust samples were collected, relative to urban land use, and by comparing PAH assemblages of the lake sediments to those of the dust.

PAH data from the top sample (ranging from 1 to 5 cm thickness) of a sediment core are available for lakes in the 10 watersheds for which pavement dust PAH data are presented here (Supporting Information Table S1). PAH concentrations in lake sediment have been shown to correlate strongly to percent urban land use in the watershed at the national scale (3). The relation to land use is not as evident for PAH in these 10 lakes because of the sparser data set, but there is a clear separation between central and eastern lakes and western lakes, with higher PAH concentrations in the central and eastern U.S. for a given amount of urban land use (Figure 3). ΣPAH in sediment at the tops of cores from three of the seven lakes in the central and eastern cities exceed the PEC, the concentration above which adverse effects to benthic biota are expected (19). Elevated PAH concentrations and adverse effects on benthic communities downstream from runoff from coal-tar sealcoated parking lots have been reported for some Austin streams (10).

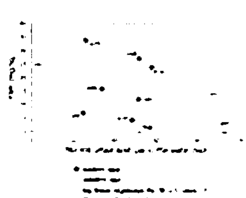

Figure 3. ΣPAH concentration at the tops (ranging from 1 to 5 cm depth) of lake sediment cores in watersheds where dust samples were collected, in relation to urban land use (2001 data) (30). Abbreviations for lakes are as shown in Figure 1 and in Table 1; PAH data are available in Supporting Information Table S-1. The dashed curve is a log-linear regression of ΣPAH versus percent urban land use for 38 lakes distributed across the U.S.

(3), recomputed using the 2001 land-use data (30). Probable Effect Concentration (PEC) (19) is indicated by the dashed line.

PAHs comprise a large group of compounds, and PAH assemblage often is used to infer PAH sources (20). Differences in PAH assemblages can be investigated by computing ratios of selected PAHs; two ratios that have been identified as indicators of coal tar as a PAH source are fluoranthene/pyrene (F:P) and benzo[*a*]pyrene/benzo[*e*]pyrene (A:E) (5, 21). These ratios were effective for distinguishing PAH from coal-tar-based sealcoat from other combustion PAH sources in Austin (9). A graph of F:P versus A:E shows similarity between dust and lake sediment regionally and difference between the two regions (Figure 4). Most central and eastern dust and lake samples plot near each other and near mean values for runoff particles from coal-tar sealcoated pavement in Austin (9), and closer to a coal-tar standard-reference material (SRM) (22) than do Western dust and lake samples. Western dust and lake samples plot separately from the central and eastern samples, away from the coal-tar SRM and closer to other urban PAH source materials (7, 23-25). The similarity of the PAH assemblages of lake sediment to those of dust within each region and to different PAH source materials is additional evidence that PAH loading to lakes in the central and eastern cities includes a substantial contribution from abraded coal-tar sealcoat. In contrast, in the watersheds of the western cities, where coal-tar sealcoat use is minimal and PAH concentrations relative to urban land use are lower, the contribution of other PAH sources to lake sediment is more evident.

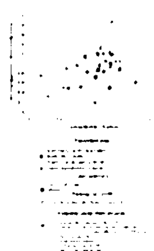

Figure 4. Comparison of source-indicator ratios of PAHs in dust samples, bottom sediment from lakes in the watersheds where dust was collected, and documented urban sources of PAHs. Dashed line indicates approximate separation between samples from central and eastern cities and those from western cities.

The elevated concentrations of PAHs in dust from sealcoated pavement in central and eastern cities cannot be attributed to urban sources of PAHs invoked in the past, such as used motor oil; burning of wood, coal, and oil; tire-wear particles; and vehicle exhaust (6-8). As all of these sources are expected to affect both sealcoated and unsealcoated pavement, they cannot explain the large difference (80×) in concentrations from sealcoated and unsealcoated pavements in the central and eastern cities. Furthermore, solely on the basis of concentration, these other urban PAH source materials cannot account for the high levels of PAHs in many of these dust samples because PAH concentrations in the dust samples exceed those in the reputed sources. Outside of coal tar and creosote (produced along with coal tar in the coking of coal), the urban source with the highest PAH concentration is used motor oil (about 600 mg/kg), followed by tire-wear particles (about 85–226 mg/kg) (26). Even in their pure form, undiluted by uncontaminated soil or other materials, these sources have PAH concentrations less than those measured in most dust samples swept from sealcoated pavement in the central and eastern cities (Figure 2). In essence, adding used motor oil or tire-wear particles to these dust samples would lower (dilute) the PAH concentrations. Scraping samples of coal-tar sealcoat from parking lots indicate that the dried and weathered product contains about 13,500 mg/kg PAH (median of samples from Austin (9) and Milwaukee (15), n = 10), and thus abraded sealcoat can account for the PAH concentrations in the dust samples even after substantial dilution by uncontaminated soil, sand, and organic debris.

Regional differences in PAH concentrations in dust from unsealcoated pavement and the results of the soil and street dust sampling from Lake in the Hills indicate offsite transport of PAHs from coal-tar sealcoated pavement. In addition to the east west difference in ΣPAH concentrations in dust from sealcoated pavement, there is an east west difference (Mann–Whitney U test, p = 0.03) in ΣPAH concentrations in dust from unsealcoated pavement (medians of 27 and 0.83 mg/kg, respectively). We hypothesize that this difference occurs because PAH-contaminated dust from coal-tar sealcoated parking lots is being transported to unsealcoated parking lots. Additionally several of the dust samples from unsealcoated pavement in the central and eastern cities have a PAH assemblage similar to that for dust samples from sealcoated pavement in the same region (15), consistent with offsite transport of PAHs from coal-tar sealcoated pavement. Higher PAH concentrations in soil and street dust samples collected near sealcoated pavement in Lake in the Hills relative to concentrations in those collected near unsealcoated pavement are direct evidence of this process (Table 2). There are many ways that dust can be transported offsite in addition to runoff, including wind, snow plows, and vehicles. Visual evidence of offsite transport includes observation of fine black flecks in gutters and on sidewalks adjacent to sealcoated pavement, and dark staining and fine black flecks on unsealcoated roads at the exits from some sealcoated parking lots (Supporting Information, Figure S2a and b).

The elevated concentrations of PAHs in dust swept from coal-tar sealcoated pavement raise the question of human-health risk, particularly as use of sealcoat is not confined to commercial parking lots but includes use on playgrounds and residential driveways (Supporting Information, Figure S2c and d). Two of the dust samples analyzed for this study were collected from sealcoated driveways of single-family residences in Lake in the Hills. ΣPAH concentrations in these samples (5800 and 9600 mg/kg) exceed those in all of the other dust samples collected for this study. Concentrations of benzo[*a*]pyrene, considered the most potent carcinogen in PAH mixtures (27), in these samples are 597 and 357 mg/kg; the median of 477 mg/kg is more than twice the median of 201 mg/kg (computed as the median of the median value for each city) in dust from sealcoated pavement for the six central and eastern cities. The median concentration of benzo[*a*]pyrene in the two driveway samples is 5300 times greater than the benzo[*a*]pyrene generic soil screening level (SSL) of 0.09 mg/kg used by the U.S. Environmental Protection Agency Superfund Program (28) and is 95 times greater than a less conservative benzo[*a*]pyrene soil guideline of 5 mg/kg proposed by Fitzgerald et al. (27). A summary of research on mutagenic hazards of settled house dust concluded there was "substantially elevated risk" corresponding to the 95th percentile or greater PAH content in the dust as summarized from 18 studies   the 95th percentile concentration of benzo[*a*]pyrene was 13.0 mg/kg (29). Although pavement dust is not soil or settled house dust, there are pathways for human exposure and ingestion of pavement dust, for example by playing basketball on a sealcoated driveway. Comparison of the results from this study to these guidelines and risk assessment suggests that research is warranted on human-health risks associated with exposure to pavement sealcoated with coal-tar-based sealant.

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Supporting Information

Internet links to sealcoat industry Web sites demonstrating the availability of these products throughout the U.S. and in Canada, photographs of sampling and of sealcoated pavement, and PAH data for lakes used in Figures 3 and 4. This material is available free of charge via the Internet at http://pubs.acs.org.

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A novel photographic study was conducted on coal-tar-based sealcoated parking lots to estimate wear rate and PAH loading rates to the environment.

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Coal Tar-based Sealcoat

Environmental concerns

wq-strm4-12 • September 2009

If you decide to sealcoat your asphalt driveway this year, there are a few things you should know. Sealcoating makes old asphalt look new and protects its surface, but there are serious environmental concerns with its use.

Sealcoat comes in two basic varieties: coal tar-based and asphalt-based. The coal tar variety is more resilient, but it contains much higher levels of a class of chemicals called PAHs (polycyclic aromatic hydrocarbons) that harm fish, and with prolonged exposure, pose a risk of cancer in humans (see Figure 1).

Environmental problems

Coal tar is a waste material generated in the conversion of coal to coke. Manufacturers choose coal tar for sealcoat because of its resistance to petroleum products like gasoline and oil, which drip from cars and deteriorate asphalt surfaces. In time, sunlight and vehicle traffic wears down sealcoat and sealcoat flakes are washed away by rain or carried away by wind, contaminating stormwater ponds, streams and lakes with PAHs.

PAHs cause tumors in some fish, disrupts the reproduction of aquatic organisms, and causes some water-bottom species to avoid sediment altogether. Health risks to humans related to PAHs are based on the length of exposure to vapors or sediments contaminated with PAHs.

PAH Concentrations

Coal tar contains as much as 30 percent PAHs by weight. A study in Austin, Texas, compared the level of PAHs in water coming off parking lots without sealcoat to water coming off parking lots coated with asphalt- and coal-tar sealcoat (Figure 2).

Figure 1: Relative amounts of PAHs in sealcoat products

An Austin, Texas, study determined that sealcoat products based on coal tar contained up to 1,000 times more PAHs than asphalt-based products. Consider asphalt-based sealcoat if you choose to coat your driveway.

Figure 2: Concentrations of PAHs in runoff

Asphalt-based sealcoat runoff (B) can contain 10 times more PAHs than an uncoated driveway (A) and runoff from a coal-tar sealcoated driveway (C) may have concentrations of PAH 65 times higher than an uncoated driveway.

The study revealed that the asphalt-based sealcoat runoff contained 10 times more PAH than the uncoated parking lot and the coal-tar sealcoat runoff had concentrations of PAH that were 65 times higher than the uncoated lot.

Maintenance expenses

Besides the health effects and the danger to the environment, PAHs are making routine maintenance of stormwater ponds by cities and townships many, many times more expensive because sediment with high-enough concentrations of PAHs must be disposed of differently.

In Minnesota, when some cities removed sediment from their stormwater ponds as part of regular maintenance, they found elevated levels of PAHs. This discovery required them to find special disposal areas, costing them many thousands of dollars more.

Current regulation

Because of the environmental problems associated with PAHs, the City of Austin, Texas, Dane County, Wisconsin, and Washington D.C. have banned use of coal tar-based sealcoat in their jurisdictions (asphalt-based sealcoat may still be used).

Recent legislation passed in Minnesota bans the purchase of coal-tar sealcoat products by state agencies by July 1, 2010. Recently, two national home-improvement retailers, Lowe's and Home Depot, took coal tar-based sealcoat off their shelves. Check with your local unit of government to see if there are any restrictions.

Make the right choice

The best choice may be to not sealcoat your driveway at all. But if you do choose to sealcoat, study labels carefully to be sure to find an asphalt-based product. Lower concentrations of PAHs in waterways will prevent costly maintenance for your city and keep waterways safe for fish and other aquatic organisms.

If you have leftover material after sealing your driveway, you can re-use or recycle it at your community's household hazardous waste facility. To find your local facility,
visit: www.pca.state.mn.us/waste/hhw

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TWEET THIS

Coal tar asphalt sealants polluting homes, lowering IQs

January 6, 10:07 AM · Columbus Alternative Transportation Examiner · James Fellrath

http://www.flickr.com/photos/maleny_steve/ / CC BY-SA 2.0

A popular pavement sealant made of coal tar is disintegrating and making its way into house dust in many homes, according to a report from the Society of Environmental Toxicology and Chemistry (and via a Discovery Channel News article).

The dust is responsible for lowered IQs among the children in polluted homes, and may also be responsible for skin conditions and immune system problems (as has been proven among lab animals, though not yet for humans).

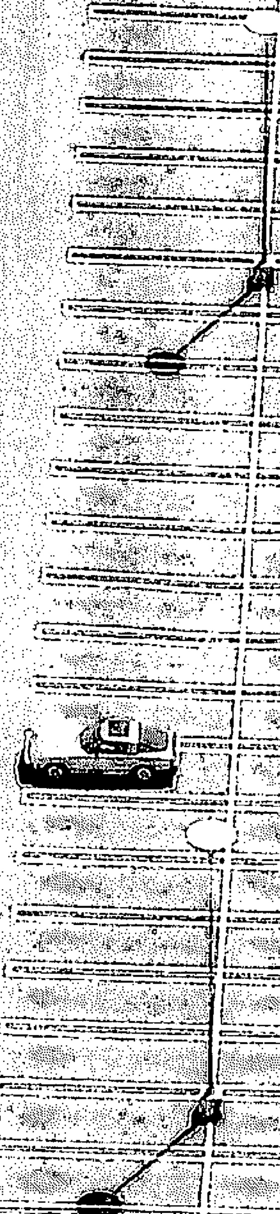
According to the article, polycyclic aromatic hydrocarbons, or PAHs, are a by-product of the coal tar sealant used to protect parking lots and roads and are used to create a uniform, black-colored covering. The coal tar sealants also contain 1000 times more PAHs than do regular asphalt-based sealants.

A study in Austin, TX in 2003 discovered high concentrations of PAHs in waterways downstream from surfaces covered with the coal tar sealants, and the study expanded to find them in normal house dust in apartments and homes near such surfaces, such as apartment complex parking lots.

The sealants are most commonly used in communities east of the continental divide. Austin and many other Texas cities have banned the use of coal tar sealants to protect people from their effects.

Companies such as B&C Blacktop and Shamrock Asphalt in Columbus use coal tar sealants, according to their websites.

For more info: Bike Commuting in Columbus



Paving Paradise

The Peril of Impervious Surfaces

Paved surfaces are quite possibly the most ubiquitous structures created by humans. In the United States alone, pavements and other impervious surfaces cover more than 43,000 square miles—an area nearly the size of Ohio—according to research published in the 15 June 2004 issue of *Eos*, the newsletter of the American Geophysical Union. Bruce Ferguson, director of the University of Georgia School of Environmental Design and author of the 2005 book *Porous Pavements*, says that a quarter of a million U.S. acres are either paved or repaved every year. Impervious surfaces can be concrete or asphalt, they can be roofs or parking lots, but they all have at least one thing in common—water runs off of them, not through them. And with that runoff comes a host of problems.

Globally, it is a little more difficult to judge the square mileage of impervious surfaces. "We can extrapolate from the United States to a degree," says Ferguson, "but there are too many variables to judge accurately." The United States has a lot of automobiles, and compared to many other countries, Americans tend to build more (and wider) roads, more (and bigger) parking lots, more (and more expansive) shopping centers, and larger houses (with accompanying larger roofs). He says, "The United States might be on a par with Europe, but we'd be very different from India, for example, or any country where large numbers of the populace live in smaller, scattered villages, mostly without paved roads, parking lots, and the like."

According to the nonprofit Center for Watershed Protection, as much as 65% of the total impervious cover over America's landscape consists of streets, parking lots, and driveways—what center staff refer to as "habitat for cars." Says Roger Bannerman, a researcher with the State of Wisconsin Department of Natural Resources: "You see some truly insane things in this country. I've seen subdivisions with streets that are thirty to forty feet wide. That's as wide as a two-lane highway. Most developers are going back to a twenty-five- to twenty-eight-foot width, but you can still see these huge streets."

Upon these automotive habitats fall a variety of substances, and thereby hangs the rest of the tale. Impervious surfaces collect particulate matter from the atmosphere, nitrogen oxides from car exhaust, rubber particles from tires, debris from brake systems, phosphates from residential and agricultural fertilizers, and dozens of other pollutants. "On a parking lot, for example, we have demonstrated buildups of hydrocarbons, bacterial contamination, metals from wearing brake linings, and spilled antifreeze," says Ferguson.

On a road of open-graded aggregate (stone), much of that material would seep down into the pavement and soil, and the community of microorganisms living there would begin a rapid breakdown process. But pollutants can't penetrate an impervious surface, and the rapid flow of rainwater off of impervious surfaces means these pollutants end up in the water. "So then," says Ferguson, "not only do you have too much water, all moving too fast, you have polluted water that kills fish and makes water unfit for drinking or recreation."

When Water Has Nowhere to Go

Areas across the country are being impacted by the growth in coverage by impervious surfaces. In Maryland, for example, when watershed imperviousness exceeds 25%, only hardier reptiles and amphibians can thrive, while more pollution-sensitive species are eliminated, according to a 1999 Maryland Department of Natural Resources report titled *From the Mountains to the Sea*. Watershed imperviousness exceeding 15% results in streams that are impossible to rate "good," states the report, and even 2% imperviousness can affect pollution-sensitive brook trout.

The 1.1-million-acre Chesapeake Bay watershed, one of the most diverse and delicate ecosystems in the world, is now being impacted by the 400,000 acres of impervious surfaces in Maryland. The Great Lakes, the streams and rivers of the Pacific Northwest, the Everglades of Florida—all are being impacted in one or more ways by runoff from streets, parking lots, and rooftops.

Bannerman has spent the last 30 years studying stream flow and the effect of urbanization on watersheds, including the depletion of groundwater reserves. "Not allowing the rainfall to infiltrate back into the aquifer is a very serious issue," he says. "If that happens, you lose the base flow [the portion of water derived from underground sources] for streams, and you lose the wetlands fed by springs. It's a complete disruption of the hydrologic cycle."

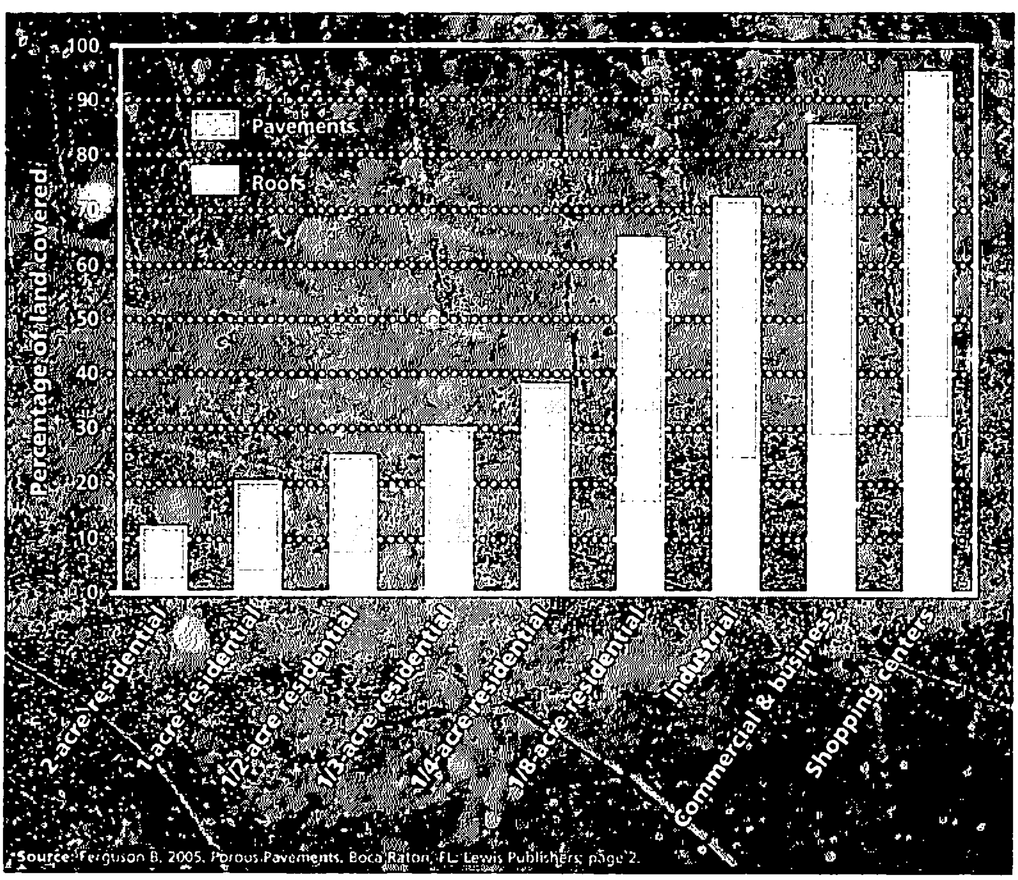
Bannerman cites the example of Lake Wingra, a 1.3-square-kilometer lake in Madison. "A hundred years ago," he says, "this lake was fed by around thirty-five separate springs. But today, because the lake is now almost entirely surrounded by urban areas, there are only four streams feeding the lake. Local organizations have gotten active in trying to restore the lake's water quality, but it's not the same lake it was a hundred years ago." Lake Wingra now suffers from algal blooms caused by overfertilization, beach closures due to bacterial contamination, turbidity, and drying of surrounding wetlands.

Bruce Wilson, a research scientist with the Minnesota Pollution Control Division, is midway through a satellite survey of impervious surface area in that state. What Wilson has seen thus far is enough to cause significant concern about the state's growth and development, and the impact of impervious surfaces on the water system.

"Impervious surfaces are impacting the lakes and streams on a number of fronts," he says. "Velocity of runoff is a big one. Water runs off of these surfaces so rapidly, it creates mini-tsunamis that can cause serious, even irreparable, harm to the stream ecosystem. . . . And of course, the ability to recharge the groundwater system is being impacted. If you get into a twenty- to thirty-percent drop in infiltration [into the aquifer], which means a loss of base flow, the impact on streams being fed by surface water gets magnified still further."

Another big problem for urban areas is the flash flooding that can occur when heavy rains fall over a city, according to hydrometeorologist Matt Kelsch, an authority on urban flash flooding with The University Corporation for Atmospheric Research in Boulder. Since runoff from an acre of pavement is about 10–20 times greater than the runoff from an acre of grass, Kelsch says impervious surfaces can quickly trigger devastating floods that can produce a host of their own environmental health hazards.

Impervious Cover of Various Land Uses



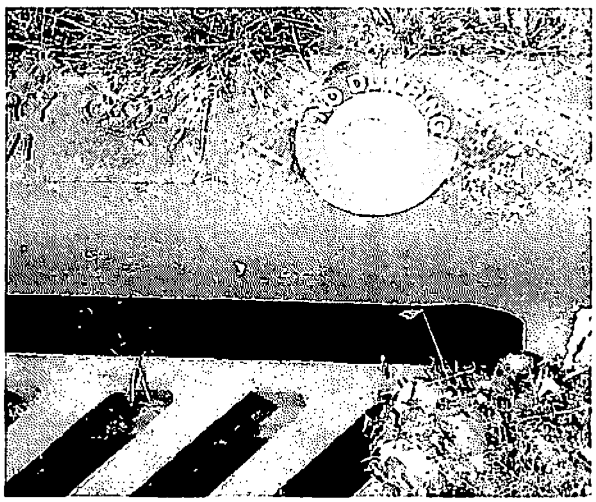
Source: Ferguson B. 2005. Porous Pavements. Boca Raton, FL: Lewis Publishers; page 2.

Background photo: Photodisc

"In urban areas, anywhere from thirty to forty percent of the rainfall runs right into whatever stream is in the area, and in heavily urbanized areas it can be more than fifty percent," he explains (by comparison, he says, the amount of runoff in subsaturated woodlands is often less than 5%). "If the water overflows the stream banks, it's going to seek the path of least resistance. In most cases, that's going to be the roadways."

In many desert areas, Kelsch says, engineers take advantage of the natural topography, building houses at higher elevations and installing roads that lead up to residential areas. What this does is make the roads far more dangerous. More than 50% of the fatalities in flash floods occur on roads, according to Kelsch.

Impervious to change? Despite community efforts, Wisconsin's Lake Wingra still suffers the effects of its urban surroundings including algal blooms, bacterial contamination, and turbidity.



Floods are often given numerical designations such as "hundred year flood," meaning such a flood happens once every 100 years (or has a 1% chance of occurring in any given year). The Federal Emergency Management Agency maintains a national list of flood zones and maps of impacted areas. The problem, says Kelsch, is that we've changed the playing field. "A couple of factors come into play," he says. "First, this is still a pretty new country, so most places haven't been developed long enough to know about the historical risk of a devastating flood. Secondly, when we urbanize an area, we alter the historical frequency of these events. The more we develop an area, the more rainfall we put as runoff directly into streams that have evolved to handle only a fraction of that runoff, and the more that happens, the greater the likelihood of a catastrophic flood." Several such floods hit New Orleans in the 1980s, and three hit St. Paul–Minneapolis between 1990 and 2001.

Heat Islands and the Stream

Wilson is also studying the "heat island" impact on Minnesota's trout streams, an impact he says evidence and experience suggest is significant. Impervious surfaces, particularly roads and parking lots, are generally dark, and thus heat-absorbing, so they heat the rainwater as it hits. A sudden thunderstorm striking a parking lot that has been sitting in hot sunshine (where surface temperatures of 120°F are not unheard of) can easily yield a 10°F increase in rainfall temperature. And that heated water isn't coming off just one parking lot or one street, but more likely several, all adding heated water to a stream or river.

Many aquatic organisms, at different stages of their lives, are vulnerable to even small increases in water temperature. "I've seen trout streams in Wisconsin and elsewhere in the Midwest lose whole populations because of—at least in part—the rise in temperature caused by runoff from impervious surfaces," Wilson says. "Increased temperature also decreases the water's ability to hold oxygen, which has a further detrimental effect on the aquatic life." Warm temperatures can cause a variety of problems for fish, including decreased egg survival, retarded growth of fry and smolt, increased susceptibility to disease, and decreased ability of young fish to compete for food and to avoid predation. Especially affected are species that require cold water throughout most stages of their lives, such as trout and salmon.

Eventually, given no additional changes, the temperatures would drop, but in the interim the impact on wildlife could be serious. Oregon is one state that is examining the science of water temperature effects on stream life. Oregon standards for optimal salmon and trout rearing and migration call for water temperatures of 64.4°F. According to a 2004 report by the Oregon Independent Multidisciplinary Science Team, which advises the state government on scientific matters related to the Oregon salmon and watershed management, studies have shown that adult salmon begin to die off at temperatures of 69.8–71.6°F, and some species of trout at slightly higher temperatures. Although young salmon can survive slightly higher temperatures, the impact on their growth and survival rate is well documented.

Impact of Building Materials

Not yet as well documented is the impact of pollutants released into stormwater runoff by building and paving materials themselves. Asphalt is one concern, as it contains coal tar pitch, a recognized human carcinogen, as well as polycyclic aromatic hydrocarbons (PAHs) including benzo[*a*]pyrene, another carcinogen. Another potential source of pollution is wood used for utility poles, play structures, and other structures that has been treated with chromated copper arsenate (CCA; a substance now being phased out due to health concerns), pentachlorophenol, or creosote. According to a paper presented at the 2004 Annual Water Resources Conference by Melinda Lalor, a professor of environmental engineering at the University of Alabama at Birmingham, in 1987 the United States alone produced some 11.9 million cubic meters of CCA-treated wood, 1.4 million cubic meters of pentachlorophenol-treated wood, and 2.8 million cubic meters of creosote-treated wood. And structures, once built from such materials, are intended to last a long time. The health risks of arsenic and chromium are well known, and while copper is not generally a human health risk, low concentrations of certain ionic forms of this metal are toxic to marine flora and fauna.

"In general," says Lalor, "pollutant level tends to vary depending upon the age of the material, and the harshness of the environment to which it is exposed. As material ages and is exposed to high levels of sunlight, temperature extremes, chemicals in the environment such as salt from roads, and so on, leaching out will increase."

If the pollutant source is a coating, then pollution levels decrease with age, but can still have a significant impact, she says. "If you look at the asphalt used in a parking lot, the top coat is quite toxic. So if you have a heavy rain [soon] after the parking lot goes in, it's not unusual to see fish kills downstream."

Lalor cites research published in volume 35, issue 9 (1997) of *Water Science and Technology* showing that stormwater from roofs and streets contributed 50–80% of the cadmium, copper, lead, and zinc measured in Swiss combined sewer system flows. Polyester roofing materials shed the highest concentrations of metals, followed by tile roofs, then flat gravel roofs. The Swiss researchers also found PAHs and organic halogens in the roof runoff.

The chemicals released can have a significant impact on environmental and potentially human health. "Some materials, such as metals, are especially toxic to fauna at various stages of their life cycle," says Lalor, "while some organics, particularly petroleum-based organics, can function as pseudoestrogens. So while they may not cause death, they can trigger a significant disruption in the physiology of the organisms exposed to these pollutants."

According to Lalor, although there are mandated tests for urban stormwater discharge, there are currently no tests mandated for building materials to determine their potential for toxics release. "If a community wants to develop around their drinking water source, they should know about release potential from building materials so they can carefully select those with which they build," she says. "We don't yet have the science to support it, but it would be a positive step to be able to go to a builder and say, 'Look, here's a list of twelve building material alternatives that would be most environmentally benign for this site and these conditions.'"

Lalor says New Zealand has been the leader in this sort of study, and that nation is preparing to put regulations in place regarding building materials and environmental impact. But such studies haven't been elevated to a high enough priority in the United States to build the science we need for setting new policies. She adds, "We need to address the entire life cycle of building materials, from what goes into their creation, to the impact of construction on the environment, to the impact of whatever might leach out during their lifetime, to the end-of-life disposal issues."

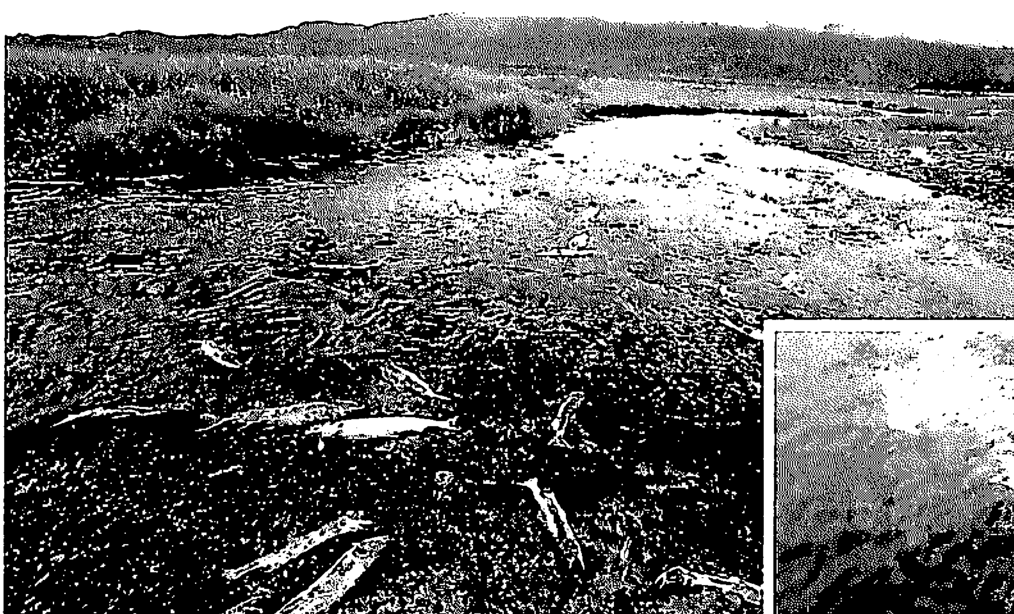
The Promise of Porous Pavements

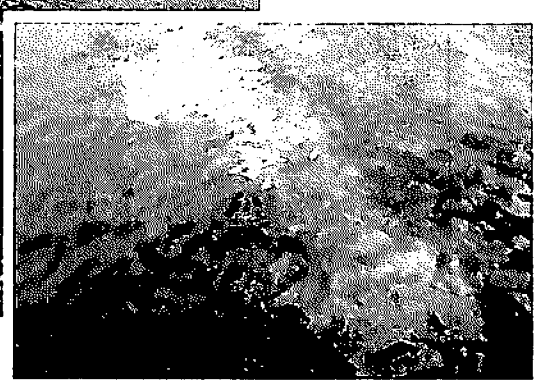
Despite the overwhelming body of evidence supporting the negative relationship between impervious surfaces and the environment, no one would seriously suggest that we stop paving streets or building parking lots. What, then, are the options?

According to Ferguson, there are nine different families of porous pavement materials. Some of these materials are already well known in the United States; they include open-jointed pavers that can be filled with turf or aggregate, "soft" paving materials such as wood mulch and crushed shell, and traditional decking.

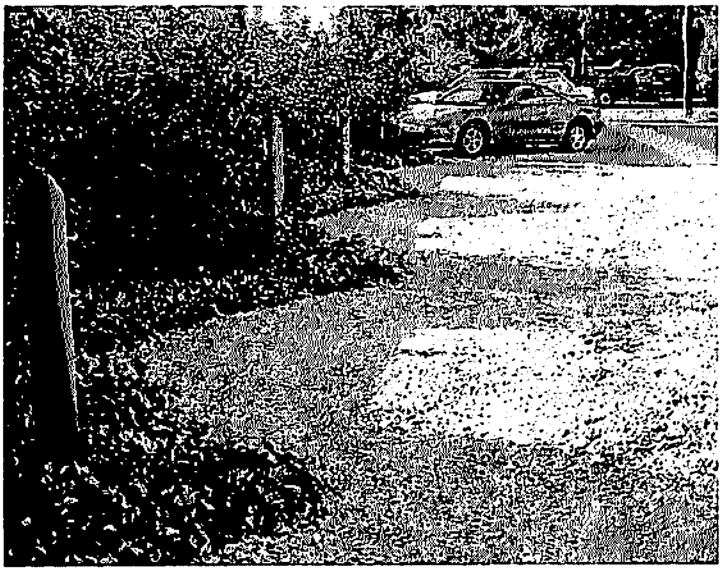
Other families include porous concretes and asphalts being developed by engineers and landscape architects. Ferguson says these materials use the same components and manufacturing processes as conventional impervious materials, "and as a general rule, carry the same health and environmental issues. . . . Same chemicals, same energy costs to manufacture, but far different benefits in its use." These new formulations still provide solid, safe surfaces for foot and vehicle traffic, but also allow rainwater to percolate down into subsurface soils.

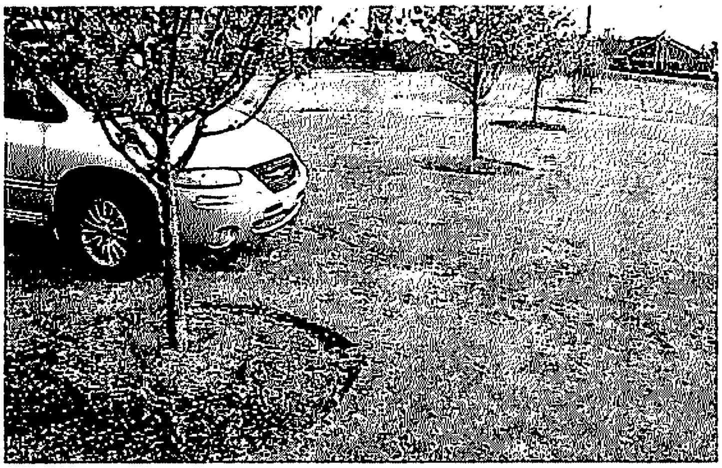
The porosity of porous asphalt is achieved simply by using a lower concentration of fine aggregate than in traditional asphalt; it can be mixed at a conventional

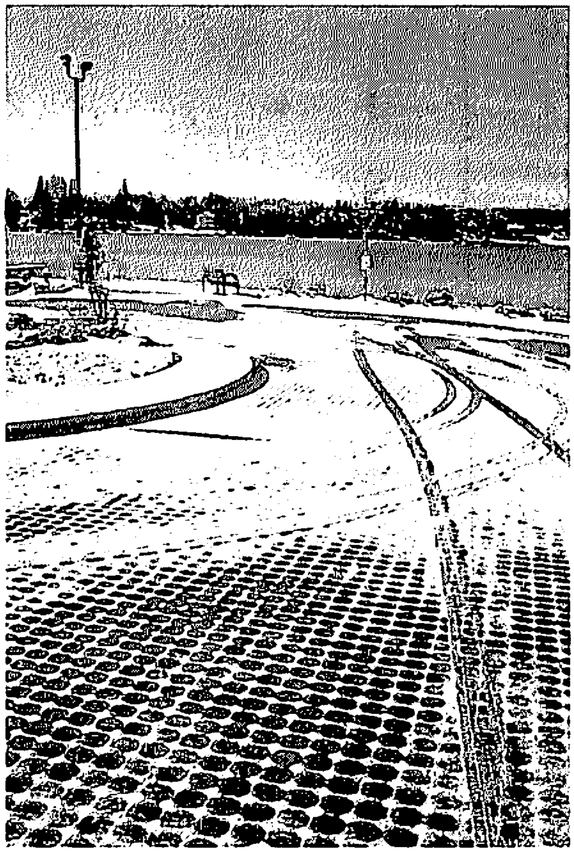




Awash in toxicants. Chemicals used in paved surfaces can be toxic to fish, wildlife, and possibly humans.







Breaking through barriers. Porous pavements come in many forms. Parking spaces in Columbus, Ohio (top left) are made of recycled clay aggregate. Shoppers at the Mall of Georgia, the largest mall in the U.S. Southeast, can park in a turf overflow lot (bottom left). The spaces between open-jointed pavers at Ontario's Sunset Beach Park lakefront access lot (above) admit water and prevent pollution of Lake Wilcox.

asphalt plant. Under the porous asphalt coating is a bed of clean aggregate. Importantly, this aggregate is all of the same size, which maximizes the void spaces between the rocks, allowing water to filter through. A layer of geotextile fabric beneath this bed lets water drain into the soil and keeps soil particles from moving up into the stone.

Porous asphalt was actually developed more than 30 years ago, according to Ferguson, but it didn't pan out at that time. Part of the problem, he believes, was—and continues to be—the low level of federally funded research. "Back in the early eighties, when porous pavement was new, the Environmental Protection Agency [EPA] was really interested, especially in porous asphalt," he says. "But one of the problems with porous asphalt back then was that on a hot day, the binder softened and migrated down to a cooler layer. That released the surface aggregate and clogged the lower layer." According to Ferguson, the EPA became discouraged and discontinued studies.

Since then, however, porous asphalt technology has been improved by French, Belgian, and Irish researchers, Ferguson says. During the late 1980s and early 1990s, they discovered that adding polymer fibers and liquid polymers to the asphalt prevented the binder from draining down through the aggregate. "Today, even though [porous asphalt] started out here, what we're using has been imported back from Europe," he says.

Ferguson says porous pavement constitutes only a minute fraction of all the paving done each year in the United States. "However," he continues, "the rate of growth of porous paving, on a percentage basis, is very high, primarily because of public concern about and legal requirements for urban stormwater management. This growth is happening both in the big asphalt and concrete industries, and in the smaller industries that supply competing materials such as concrete blocks and plastic geocells."

One argument against pervious surfaces in high-traffic areas is that they're not as durable as their impervious ancestors. That, says Ferguson, is simply not true. "I've seen pervious pavement in good shape in places like Minnesota and Alaska, where you have tremendous climatic extremes," he says. "In Georgia and Oregon, it's now routine to resurface highways by putting a layer of pervious asphalt over the impervious surface below. That way, water drains laterally below the surface, giving you better traction and visibility." Although the major advantage to this practice is highway safety, rather than reinfiltration of the water into the groundwater, it still allows for more water to return to the groundwater table than would be the case with an impervious surface, where it merely evaporates back into the atmosphere.

Some pervious surfaces have the additional benefit of allowing pollutants to come into contact with microbes beneath the surface. According to Ferguson, these naturally occurring microbial communities thrive on the large surface area of the pervious pavements' internal pores and break

All images: Bruce K. Ferguson

down contaminants (particularly petroleum by-products) before they can leach down into the water supply.

"Coventry University scientists did a study recently, where they applied oil to a lab mockup of a porous road surface," he says. "They dumped far more used oil on the surface than you'd ever find accumulating on a parking lot, and none of it reached the soil layer below"—instead, microbes digested it all. The Coventry team, led by Christopher J. Pratt, published an overview of their work in the November 2004 issue of the *Quarterly Journal of Engineering Geology and Hydrogeology*.

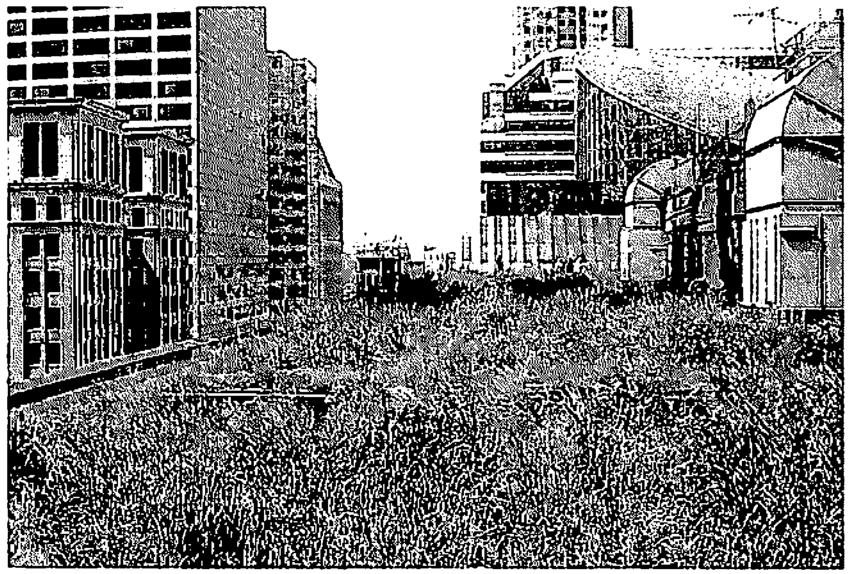
Other Ways of Controlling Runoff

Approaches to dealing with the spread of impervious surfaces go beyond changing the building material itself. Kelsch says a return to more reasonable street width is one measure, and many communities are increasing their number of green areas as a means of allowing rainfall to infiltrate back into the ground.

For urban areas with nearby lakes, Bannerman says construction of "rain gardens" is becoming a popular method that homeowners and businesses can use to help control stormwater runoff. Such gardens are designed with dips in the center to capture water, which then can slowly filter into the ground rather than run off into the storm sewer. Ideally these gardens are situated next to a hard surface such as a sidewalk or driveway, and are planted with hardy native species that can thrive without chemical fertilizers or pesticides.

Ponding basins like those used in Fresno are another option. This city of just over half a million in Southern California's San Joaquin Valley gets less than 12 inches of rain annually and draws most of its water from underground aquifers and the nearby Kings and San Joaquin rivers. Beginning in the late 1960s, the city started constructing several ponding basins—large basins where stormwater can settle, then drain down through the soil. Water systems manager Lon Martin says the city had two goals in establishing these ponding basins: "First was to keep stormwater runoff from flooding the city and from going into the rivers, potentially causing water quality problems. Secondly, the city has begun a program of intentional aquifer recharging."

To date, he says, the city has connected nearly 80 of the possible 150 ponding basins to its groundwater recharge system. Recharge from stormwater is one part of the equation, but the city also takes its May–October water allotment from the two rivers, diverts the water to these basins, and then allows gravity to pull the water down through the sandy loam soil into the aquifer.



On top of the problem. The green roof atop Chicago City Hall contains more than 100 plant species that absorb stormwater and reduce the ambient air temperature by as much as 7–8°F compared to a nearby tar roof.

Conservation Design Forum

Green roofs, another method of controlling rainwater runoff, are just what the name implies: roofs planted with all types of vegetation. Also known as "eco-roofs," these surfaces can be either extensive (lighter in weight, relying on a few inches of soil and using plants like herbs, grasses, and wildflowers) or intensive (much heavier, with a 12-inch soil depth that can accommodate trees and shrubs). According to the nonprofit Earth Pledge Foundation, green roofs can absorb nearly 75% of the rainfall that lands on them, and they can also reduce the urban heat island effect.

Green roofs perform several roles, one of which is water harvesting, or basically catching rainwater for use elsewhere. "This water is cleaner than that off the pavement," Ferguson says. "[Water harvesting] is now being practiced in areas where water is less available, such as the Southwest or the Pacific Northwest, with their dry summers. . . . [It] can be a valuable tool in areas where water is scarce."

In Germany, approximately 10% of the buildings have green roofs, and the city of Tokyo recently mandated that usable rooftop space of greater than 1,000 square meters atop new buildings must be 20% green. Green roofs are also found in North American cities including Chicago, Toronto, and Portland, Oregon.

Beyond Imperviousness

Recognizing the environmental health threat of impervious surfaces as well as other point sources of pollution, the EPA established a stormwater permitting program under the National Pollutant Discharge Elimination System. Phase I of the stormwater program, promulgated in 1990, required permits for separate stormwater systems serving communities of 100,000 or more people, and for stormwater discharges associated with industrial and construction activity involving at least five acres. Phase II, promulgated in 1999, addressed remaining issues and urban areas of fewer than 100,000 people, as well as smaller construction sites and retail, commercial, and residential activities.

But further change will require a shift in how we think about runoff. Bannerman says, "What we've begun to do, and must continue to do, is to get away from the idea that rain is wastewater—something to get rid of, to pass along to our neighbors downstream. We need to keep it where it falls, and the way to keep it is to get it back into the ground."

For flash floods, Kelsch says, "there is no solution. Flooding is going to happen, in spite of everything we can do. What we need to do is what we can to lessen the impact of the inevitable. That means building out of flood plains, and increasing the amount of rainwater we send back into the aquifers while decreasing the amount we discharge into streams." Building design and use of permeable paving materials will help, he says, but we need to realize these aren't total solutions. Further, he adds, "If we get stuck in the mindset that we have to have a solution, we may not do anything. And that will make the problem still worse."

Lance Frazer

of phthalates). Vanderbergh and Huggett (1995) found the same to be true in rodents. The fact that there was some variation of AGI with age is to be expected; not all 1-year-olds have the same length, either.

McEwen and Renner point out potential sources of "exposure misclassification" which, we agree, may have been present (and we stated so) (Swan et al. 2005). However, unless these sources of measurement error were related to AGD, their presence would lead to underestimates of the strength of the associations we presented.

We examined a number of potential confounders, such as maternal smoking and alcohol consumption; the prevalence of both was quite low (Swan et al. 2005). None affected results appreciably. Of course, the phantom "unmeasured confounder" always lurks in the wings of any observational study, can never be ruled out, and is a favorite of critics of epidemiologic studies. Any constructive suggestions for alternatives to observational studies would be appreciated; the only alternative we know of, randomizing pregnant women to receive phthalates (or not), hardly seems ethical.

Rodent studies test only one phthalate at a time. As we demonstrated (Swan et al. 2005), women were exposed to measurable levels of multiple phthalates, many known to be reproductively toxic. Until we have data on the toxicology of this complex mixture, we do not have the information to draw conclusions about the relative toxicity of these compounds in rodents versus humans. Furthermore, although doses in rodent studies of specific phthalates are high, effects have been demonstrated at lower doses used in recent studies (Lehmann et al.). Unfortunately no toxicologic study has yet examined effects of phthalates at environmental levels. Because we did find a significant association with phthalates at such levels, we can only conclude that environmental levels, however low, are associated with somatic alterations in humans.

Our study (Swan et al. 2005) is relatively small and must be replicated; subsequent studies will undoubtedly eliminate many of the sources of potential exposure and outcome misclassification. Nonetheless, in this first study of its kind, we set out to test the hypothesis, suggested by a large toxicologic literature (Gray et al. 2000), that prenatal phthalate exposure is associated with several measures in humans that reflect the antiandrogenic action of these chemicals. Using similar outcome measures to those utilized in these toxicologic studies, that is what we found.

The authors declare they have no competing financial interests.

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Errata

In the October articles "Children's Centers Study Kids and Chemicals" [Environ Health Perspect 113:A664–A668 (2005)] and "Are EDCs Blurring Issues of Gender?" [Environ Health Perspect 113:A670–A677 (2005)], photographs and their captions erroneously imply that plastic drink bottles contain *ortho*-phthalates. Plastic drink bottles sold in the United States are made from polyethylene terephthalate and do not contain *ortho*-phthalates. Also, at the end of the EDCs article, references are made to plastic wrap and Saran Wrap. For clarification, neither plastic wrap nor Saran Wrap contains *ortho*-phthalates. *EHP* regrets these errors.

EHP regrets the incorrect and unintentional inference in "Paving Paradise: The Peril of Impervious Surfaces" [Environ Health Perspect 113:A456–A462 (2005)] that coal tar pitch is used in the actual hot-mix asphalt used to pave roads. Coal tar pitch is instead used in many sealcoat formulations used atop asphalt pavement. Findings published in the 1 August 2005 issue of *Environmental Science & Technology* suggest, in fact, that coal tar-based parking lot sealant may be a major contributor to stream loads of polycyclic aromatic hydrocarbons, including many known carcinogens.

In Figure 1 of the article by Chen et al. [Environ Health Perspect 113:1723–1729 (2005)], the legend should have read (*A*) PM_{10}; (*B*) $PM_{2.5}$, instead of (*A*) $PM_{2.5}$; (*B*) PM_{10}.

In Figure 1 of the article by Tsan et al. [Environ Health Perspect 113:1784–1786 (2005)], the double bond between HN and boron was incorrect. The corrected figure appears below.