Franklin County
Board of Commissioners
ECONOMIC DEVELOPMENT
& PLANNING
1803

Franklin County Board of Zoning Appeals

Franklin County Courthouse
Commissioner's Hearing Room – 26th Floor
Columbus, OH 43215

Monday, March 18, 2019
1:30 p.m.

1. **Call roll for board members**
2. **Introduction of staff**
3. **Swearing in of witnesses**
4. **Approval of minutes from the February 19, 2019 meeting**
5. **Old Business:**

   i. **CU-3922 – Brad Fisher**

Owner/Applicant:	Shelly & Sands Inc.,
Agent:	Tony Ruggiero
Township:	Hamilton Township
Site:	5636 Lockbourne Rd. (PID #150-000125)
Acreage:	106.00-acres
Zoning:	Rural District (R)
Request:	Requesting a Conditional Use from Sections 610.06(7) and 610.091(2) of the Franklin County Zoning Resolution to allow the placement of fill in the floodway fringe and floodway.

6. **New Business:**

   ii. **VA-3937 – Brad Fisher**

Owner/Applicant:	It's Gonna Be Nice, LLC.
Agent:	David Hodge
Township:	Franklin Township
Site:	3339 McKinley Ave. (PID #140-000512)
Acreage:	0.237-acres
Zoning:	Rural and Limited Industrial (LI)
Request:	Requesting a Variance from Sections 541.03(5(a)), (b), and (e) of the Franklin County Zoning Resolution to allow the construction of an area identification sign that is not adjacent to a major access point, does not meet the minimum setback from the road right-of-way, and exceeds the maximum letter area size.

7. **Adjournment of Meeting to April 15, 2019**

MINUTES OF THE
FRANKLIN COUNTY BOARD OF ZONING APPEALS

Tuesday February 19, 2019

The Franklin County Board of Zoning Appeals convened on the 26th floor, Franklin County Courthouse, 373 South High Street, Columbus, Ohio, 43215, on Tuesday February 19, 2019.

Present were:
Christopher Baer, Chairperson
Tim Guyton
Nancy Hunter
Joe Martin

Franklin County Economic Development and Planning Department members:
Jenny Snapp, Assistant Director
Matt Brown, Planning Administrator
Phil Ashear, Planner

Chairperson Baer opened the hearing.

Mr. Matt Brown swore in witnesses.

The First item of business was the approval of the minutes from the January 22, 2019, meeting. Ms. Hunter made a motion to approve the minutes of the January 22, 2019, meeting. It was seconded by Mr. Guyton. The motion was approved by a vote of three yeses and one abstention.

NEW BUSINESS:

The next item of business being Conditional Use Case CU-3935. Mr. Phil Ashear presented Conditional Use Case CU-3935 to the Franklin County Board of Zoning Appeals. A motion was made by Mr. Guyton to approve Conditional Use Case CU-3935 with three recommended staff conditions, seconded by Ms. Hunter. The motion was approved by a four-to-zero vote.

OLD BUSINESS:

The next item of business being Variance Application Case VA-3936. Mr. Phil Ashear presented Variance Application VA-3936 to the Franklin County Board of Zoning Appeals. A motion was made by Mr. Martin to approve Variance Application VA-3936 with one recommended staff condition, seconded by Mr. Guyton. The motion was approved by a four-to-zero vote.

There being no further business to come before the Franklin County Board of Zoning Appeals, the meeting was adjourned. The proceedings were adjourned at 2:02 p.m.

Signature

Minutes of the February 19, 2019, Franklin County Board of Zoning Appeals hearing were approved this 18th day of March, 2019

Franklin County
Board of Commissioners
ECONOMIC DEVELOPMENT
& PLANNING
1803

STAFF REPORT

Board of Zoning Appeals
March 18, 2019

Case: CU-3922

Prepared by: Brad Fisher

Owner/Applicant:	Shelly & Sands, Inc.
Township:	Hamilton Township
Site:	5636 Lockbourne Rd. (PID #150-000125)
Acreage:	106-acres
Zoning:	Rural and General Industrial (GI)
Request:	Requesting a Conditional Use from Sections 610.06(7) and 610.091(2) of the Franklin County Zoning Resolution to allow the placement of fill in the floodway fringe and floodway.

Summary

The applicant is requesting a Conditional Use to allow the placement of fill in the floodway fringe and floodway. The application does not satisfy the criteria necessary to grant a Conditional Use. Staff recommends ***denial***.

Description of the Request

The subject site is located on the east side of Lockbourne Road, north of Rohr Road and bordered by Big Walnut Creek to the north.

The applicant has requested a Conditional Use from the Franklin County Zoning Resolution to allow for a pay-to-dispose of clean hard fill operation in the floodway fringe and floodway. The fill could only include reinforced or non-reinforced concrete, asphalt concrete, brick, block, tile, and/or stone.

History

The applicant applied for and received conditional approval of a similar Conditional Use in 2006, which only allowed for Shelly & Sands material to be used as fill, which was to be monitored and recorded. A complete list of the conditions of approval from 2006, case CU-3623 is as follows:

1. The applicant submits Erosion and Sedimentation Control Plan to Franklin Soil and Water Conservation District and adheres to all requirement of the agency, as the project progresses. The applicant also has to notify Franklin Soil & Water Conservation District for bi-monthly inspections, once the project commences.
2. That annual reports will be provided to the County and Township regarding quantity of fill placed on the site (reporting previous year's activity).
3. The hours of operation shall be limited to 8:00 AM to 8:00 PM, Monday through Sunday.
4. All state and federal permits be obtained.
5. **That only Shelly & Sands material will be dumped at the site and it will be monitored and recorded.**

6. The lakes will be tested for water quality and the water table be tested for any change to the water table and annual reports have to be submitted to Franklin County Economic Development & Planning Department, Hamilton Township and City of Columbus for review and approval.
7. **That there will not be any asphalt products dumped on the site.**
8. Shelly & Sands agrees that the City of Columbus Water Division can put a test well on the site (at the City's expense).
9. The inoperable equipment to be removed from the site by June 30, 2006.

The only change to the previously approved Conditional Use permit is to allow entities other than Shelly & Sands to deposit material and to allow asphalt as clean hard fill.

The request was presented to the Board on November 19, 2018, and the applicant requested to table the case until January 22, 2019. Staff received updated material on December 14, 2018, and routed that information to the City of Columbus, Division of Water, and to the Ohio Environmental Protection Agency (OEPA) for review. As of January 14, 2019, OEPA had not responded and the City had requested denial of the request.

Surrounding Land Use/Zoning

Properties to the north, east and south are zoned Rural in Hamilton township and developed with single-family homes and agricultural uses. The property to the west is zoned Excavation and Quarry in Hamilton Township, owned by the City of Columbus, and up until September, 2018 operated by the National Lime and Stone Company.

Area Plans

The Obetz and Hamilton Township Community Plan, adopted in 1998, contains a Future Land Use Map and Land Use recommendations. The Plan recommends this property for Excavation and Quarry uses and supports land use regulations that protects groundwater resources from possible contamination.

The South Central Accord, adopted in 1997 and amended in 2004, contains a Groundwater Pollution Potential Map that identifies the subject site as being located in the Wellfield Protection Area and having the highest potential for groundwater pollution. The Plan states that an emphasis should be placed on ensuring proper design and operation of facilities within the wellfield in order to lower the risk of contamination.

The applicant provided no information describing how the deposit of fill from entities other than Shelly & Sands will be regulated. If the protection of groundwater cannot be assured, the proposal does not meet the Plan's recommendations.

Staff Review

A Conditional Use from Section 610.06 is permitted, provided it meets all applicable standards and requirements of the Zoning Resolution and any conditions attached by the Board in granting the Conditional Use Permit.

Conditional Use from Section 610.06(7) – Floodway Fringe:

- The permanent placement of material and fill is a Conditional Use in the floodway fringe.
  - The applicant is requesting to allow a pay-to-dispose of clean hard fill in the floodway fringe and floodway.
    - The applicant was approved to allow the permanent placement of clean hard fill in 2006 on the subject site, provided that **only** Shelly & Sands material will be dumped at the site, it will be monitored and recorded, and fill material could not include asphalt products

Conditional Use from Section 610.091(2) – Floodway:

- The permanent placement of material and fill is permitted in the floodway provided hydrologic and hydraulic analysis is performed in accordance with standard engineering practices and demonstrates that the proposed encroachment would not result in any increase in flood levels during the occurrence of the Base Flood Discharge.
  - The applicant is requesting to allow a pay-to-dispose of clean hard fill in the floodway.
    - The required hydrologic and hydraulic analysis was approved in 2006, and there will be no increase in flood levels during the occurrence of the Base Flood Discharge

Technical Review Committee Agency Review

Franklin County Engineer's Office and Franklin Soil and Water Conservation District
Indicated no concerns with the request.

City of Columbus – Division of Water
After reviewing the updated information provided by the applicant, the City is still concerned about asphalt being used as permanent fill. Shelly & Sands has also provided no information as to where these other companies would obtain their "clean hard fill" and how they would verify that all fill material does not contain asphalt and/or other hazardous materials. Because of these concerns, the City of Columbus Division of Water recommends denial of the request.

Staff Analysis

Franklin County Zoning Resolution
Section 815.041 – Approval of Conditional Use:
The Board of Zoning Appeals shall only approve an application for a Conditional Use if the following three (3) conditions are met:

1) *The proposed use is a Conditional Use of the Zoning District, and the applicable Development Standards established in this Zoning Resolution are met;*
   - » The proposed use is a Conditional Use in the Floodplain district and a previously approved hydrologic and hydraulic analysis showed that no increase in Base Flood Elevation would result.
2) *The proposed development is in accordance with applicable plans or policies for the area;*
   - » Staff notes that the existing operation of the subject site is in accordance with the applicable Plans and policies.
   - » However, Staff notes that the applicant has not proposed a way to account for what is being deposited by an entity other than Shelly & Sands. If the proposed fill is not accounted for or includes asphalt materials, there could be a negative impact to the groundwater quality and any future development on the subject site.
3) *The proposed use will be in keeping with the existing land use character of the area.*
   - » The applicant stated that there will be no change to the Reclamation Plan previously approved with Conditional Use case CU-3562, in 2006.
   - » Staff notes that the only change will be that the fill placed on the property will be from outside vendors and may include asphalt materials. There will be no change in the location of fill previously approved.

Recommendation

Staff's recommendation is that the Board of Zoning Appeals ***deny*** a Conditional Use from Sections 610.06(7) and 610.091(2) of the Franklin County Zoning Resolution to allow the placement of fill in the floodway fringe and floodway.

Resolution

For your convenience, the following is a proposed resolution:

Proposed Resolution for Request:

__________________ moves to approve a Conditional Use from Sections 610.06(7) and 610.091(2) of the Franklin County Zoning Resolution as outlined in the request for the applicant identified in Case No. CU-3922.

Seconded by: ____________________________

Voting:

Findings of Fact

For your convenience, the following are proposed findings of fact:

If the resolution fails for lack of support, the following are proposed findings of fact for adoption by the BZA:

__________________ moves that the basis for denying the applicant's request for the Conditional Use from Sections 610.06(7) and 610.091(2) of the Franklin County Zoning Resolution as outlined in the request for the applicant identified in Case No. CU-3922 results from applicant's failure to satisfy the criteria for granting a Conditional Use under Section 815.041.

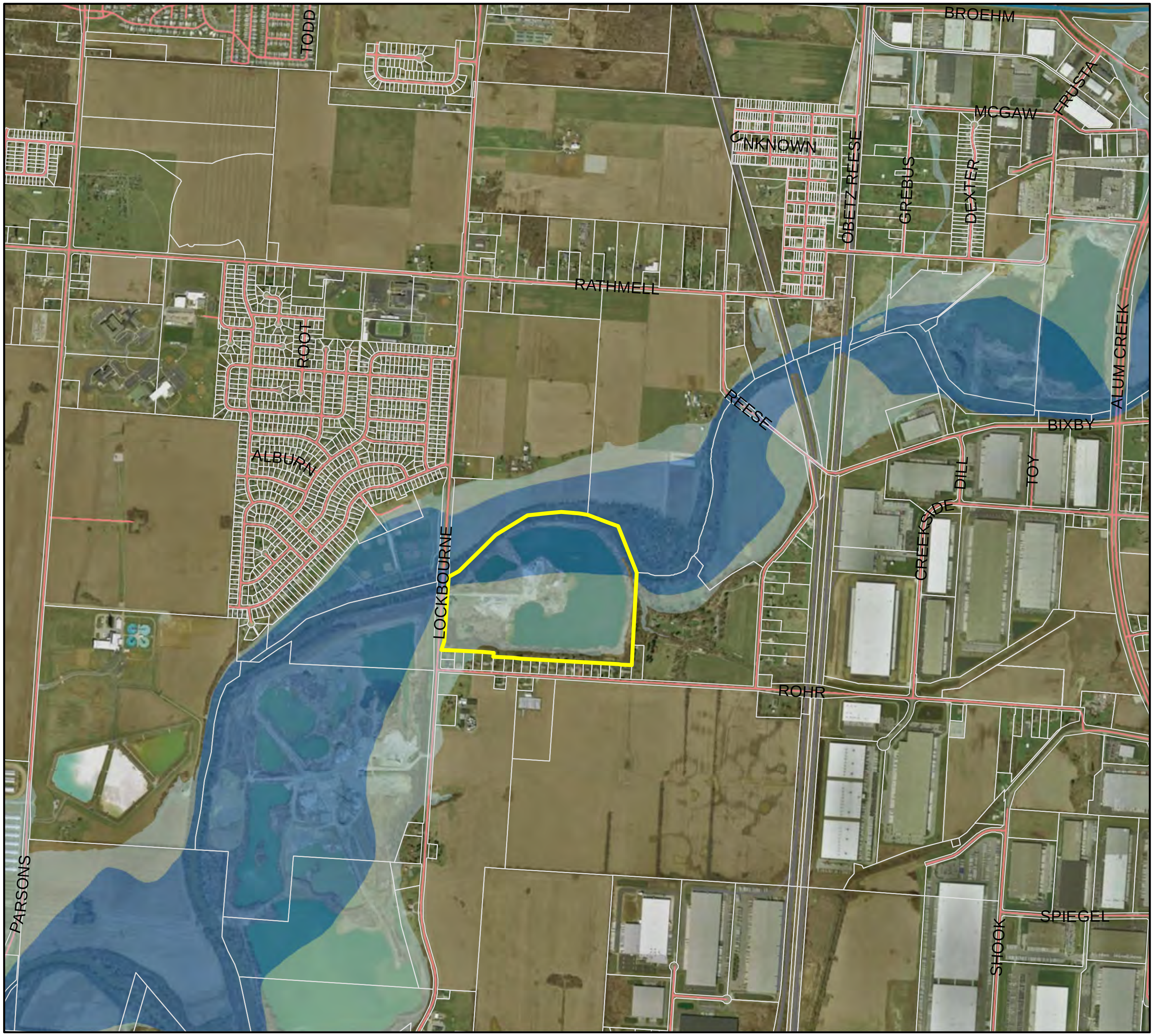
Seconded by: ____________________________

Voting:

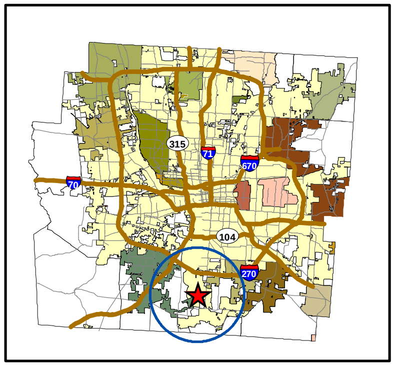
CU-3922

Requesting a Conditional Use from Sections 610.06(7) and 610.091(2) of the Franklin County Zoning Resolution to allow the placement of fill in the floodway fringe and floodway.

Acres: 106.000
Township: Hamilton



☐ 5636 Lockbourne Road
☐ Parcels
— Streets
┼ Railroad
▢ Floodway Fringe (100 year)
🟦 Floodway



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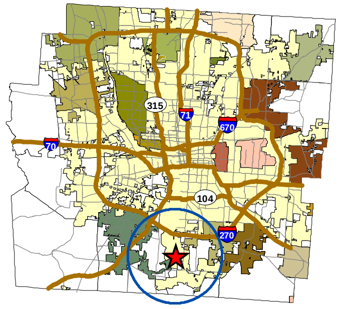
Franklin County
Board of Commissioners
ECONOMIC DEVELOPMENT
& PLANNING
1803

CU-3922

Requesting a Conditional Use from Sections 610.06(7) and 610.091(2) of the Franklin County Zoning Resolution to allow the placement of fill in the floodway fringe and floodway.

Acres: 106.000
Township: Hamilton

- ▭ 5636 Lockbourne Road
- ▭ Parcels
- ― Streets
- ▭ Floodway Fringe (100 year)
- ■ Floodway



Franklin County
Board of Commissioners
ECONOMIC DEVELOPMENT
& PLANNING
1803

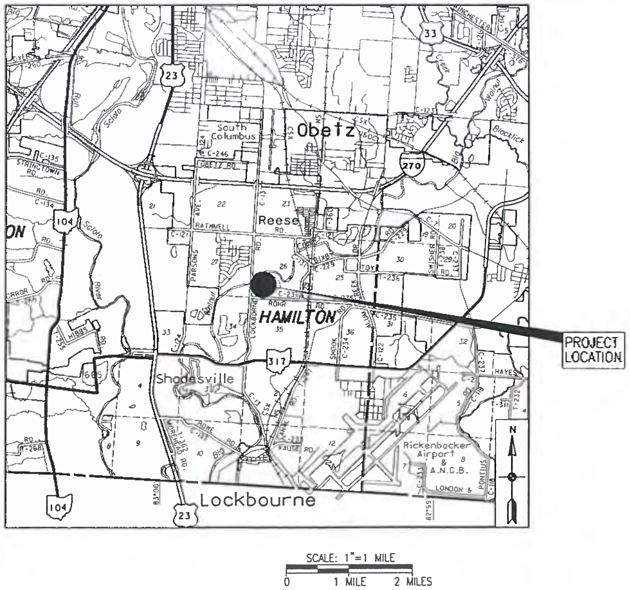
CU-3922

SHELLY AND SANDS

LOCKBORNE ROAD
FILL SITE

SITUATED IN HAMILTON TOWNSHIP
COUNTY OF FRANKLIN, STATE OF OHIO

LOCATION MAP



INDEX OF SHEETS

ONSITE CONTACT

BOB MATTERS
SHELLY AND SANDS
PHONE: (614) 444-5100

PROJECT DATA	
PROJECT EARTH DISTURB AREA:	72.5 ACRES
ESTIMATED CONTRACTOR EARTH DISTURBED AREA:	1.0 ACRES
NOTICE OF INTENT EARTH DISTURBED AREA:	73.5 ACRES

IMMEDIATE RECEIVING WATERS – BIG WALNUT CREEK
SUBSEQUENT RECEIVING WATERS – SCIOTO RIVER
*LATITUDE N39°50'57"
*LONGITUDE W82°57'54"
*LATITUDE AND LONGITUDE TO APPROXIMATE CENTER OF PROJECT

GENERAL NOTES

THE CONDITION OF THE NPDES CONSTRUCTION STORM WATER GENERAL PERMIT (SEE PROPOSAL) SHALL BE MET DURING ALL STAGES OF CONSTRUCTION. THE LOCATION AND TIMING OF ALL EROSION AND SEDIMENT CONTROL ITEMS SHALL BE FIELD ADJUSTED TO PREVENT SIGNIFICANT IMPACTS ON RECEIVING WATERS. IMPLEMENTATION OF THIS STORM WATER POLLUTION PREVENTION PLAN SHALL CONTINUE THROUGHOUT THE DURATION OF THE PROJECT OR UNTIL THE UP SLOPE DISTURBED AREAS ARE STABILIZED.

INSTALLATION OF SEDIMENT BASINS/DAMS, PERIMETER FILTER FABRIC FENCE, AND DITCH CHECKS SHALL BE AS PER ODOT CONSTRUCTION AND MATERIAL SPECIFICATIONS- 207.03.

ALL REASONABLE ATTEMPTS, SHOULD BE MADE TO MINIMIZE THE TOTAL AREA OF DISTURBED LAND.

NO DRAINING OR PUMPING OF WATER FROM THE PROJECT SITE TO THE BIG WALNUT CREEK WILL BE ALLOWED ON THIS PROJECT.

CONTRACTOR / OWNER MUST LIMIT THE HOURS OF OPERATION TO BETWEEN 8:00 AM AND 8:00 PM.

CONTRACTOR / OWNER MUST COMPLETE THE GRADING, RE-SOILING, AND THE SEEDING OF THE SITE AS THE PROJECT PROCEEDS. NO AREAS GREATER THAN APPROXIMATELY 5 ACRES MAY BE LEFT UNGRADED AND OR UNSEEDED AFTER BEING FILLED TO THE PROPER ELEVATION. THE FILL ELEVATION FOR PHASE #1 MUST NOT EXCEED 710'.

TEMPORARY STABILIZATION

ALL DISTURBED AREAS THAT ARE TO REMAIN IDLE FOR MORE THAN 21 DAYS SHALL BE TEMPORARILY STABILIZED WITHIN 7 DAYS OF THE MOST RECENT EARTH DISTURBING ACTIVITY. AREAS WITHIN 50' OF A WETLAND OR OTHER WATER BODY SHALL BE TEMPORARILY STABILIZED WITHIN 2 DAYS. TEMPORARY STABILIZATION MAY INCLUDE SEEDING, MULCHING, MATTING OR SOD.

PERMANENT STABILIZATION

AREAS THAT WILL REMAIN IDLE FOR MORE THAN 1 YEAR, AND AREAS THAT ARE AT FINAL GRADE SHALL BE PERMANENTLY STABILIZED WITHIN 7 DAYS OF THE MOST RECENT EARTH DISTURBING ACTIVITY. AREAS WITHIN 50 FEET OF A WETLAND OR OTHER WATER BODY SHALL BE PERMANENTLY STABILIZED WITHIN 2 DAYS. PERMANENT STABILIZATION MAY INCLUDE SEEDING, MULCHING, MATTING, SODDING, RIP RAP, NATURAL CHANNEL ENGINEERING OR ROCK CHECK DAMS.

MAINTENANCE

PROPERLY MAINTAIN ALL TSEC BMP. DISPOSE OF SILT REMOVED FROM TSEC BMP ACCORDING TO ODOT 2002 CMS 105.16. IF A RECORDED RAIN EVENT IS GREATER THAN 0.5 INCHES ALL TSEC BMP THAT HAVE FAILED MUST BE REPLACED. REMOVE ALL TSEC BEFORE THE PROJECT IS ACCEPTED. DISPOSE OF THE REMOVED MATERIALS ACCORDING TO 2002 CMS 105.16 AND 2002 CMS 105.17. MAINTAIN THE TSEC BMP UNTIL THE UP- SLOPE PERMANENT GRASS COVERAGE IS 70% OR BETTER. AT THIS STAGE, REMOVE THE TSEC BMP.

A. PERIMETER FILTER FABRIC FENCE, FILTER FABRIC DITCH CHECKS, ROCK CHECKS, INLET PROTECTION, DIKES, AND BALE FILTER DIKES. REMOVE TRAPPED SEDIMENT WHEN IT REACHES HALF THE HEIGHT OF THE LOWEST SECTION. MAKE APPROPRIATE CORRECTIONS WHEN THESE TSEC BMP BECOMES NONFUNCTIONAL.

B. SEDIMENT BASINS AND DAMS. REMOVE DEPOSITED SEDIMENT WHEN SEDIMENTS REDUCE INITIAL VOLUME OF THE SEDIMENT BASIN OR DAM BY ONE- HALF. MAKE APPROPRIATE CORRECTIONS WHEN THESE TSEC BMP FAIL. REMOVE DAMS AND BASINS AFTER THE UP-SLOPE HAS BEEN STABILIZED.

ACCEPTABLE BACK FILL MATERIAL

THE CONTRACTOR OR OWNER OF THE SITE WILL PLACE NO ASPHALT OR ASPHALT CONCRETE AT THE SITE SHOWN ON THESE PLANS. THE CONTRACTOR OR OWNER WILL OTHERWISE COMPLY WITH THE DEFINITION OF "CLEAN, HARD FILL", (OAC 3745-400-01(E)), WHICH EXCLUDES "MATERIAL CONTAMINATED WITH HAZARDOUS WASTE, SOLID WASTE, OR INFECTIOUS WASTE", FOR THE MATERIALS PLACED AT THE SITE. THE CONTRACTOR WILL TAKE CARE TO PRECLUDE PETROLEUM CONTAMINATED CONCRETE FROM THE SITE.

SECURITY

THE AREA BEING FILLED SHALL BE SECURED SO THAT NO UNAUTHORIZED PERSONS WILL HAVE ACCESS, AND NO UNAUTHORIZED PERSONS WILL BE ABLE TO TRESPASS OR DUMP MATERIALS AT THE SITE.

ADR & ASSOCIATES, LTD
Newark Office:
88 West Church Street
Newark, OH 43055
(740) 345-1921 (ph)
(740) 345-4994 (fax)
www.adrinnovation.com
OHIO: Newark . Columbus . Cleveland . Marietta
NORTH CAROLINA: Goldsboro . Raleigh

KEITH A. CODY
#E-62352

Keith A. Cody 8-15-07
KEITH A. CODY, P.E. DATE
OHIO PROFESSIONAL ENGINEER #62352

SHELLY AND SANDS DATE

SUBCONTRACTOR DATE

SUBCONTRACTOR DATE

UNDERGROUND UTILITIES
TWO WORKING DAYS
BEFORE YOU DIG
CALL 1-800-362-2764 (TOLL FREE)
OHIO UTILITIES PROTECTION SERVICE
NON-MEMBERS
MUST BE CALLED DIRECTLY

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DRAWN	JWO
DESIGNED	JWO
REVIEWED	KAC

ADR & ASSOCIATES LTD
88 West Church Street • Newark, OH 43055 • (740) 345-1921

REVISIONS
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TITLE

LOCKBORNE ROAD FILL SITE
FRANKLIN COUNTY, OHIO

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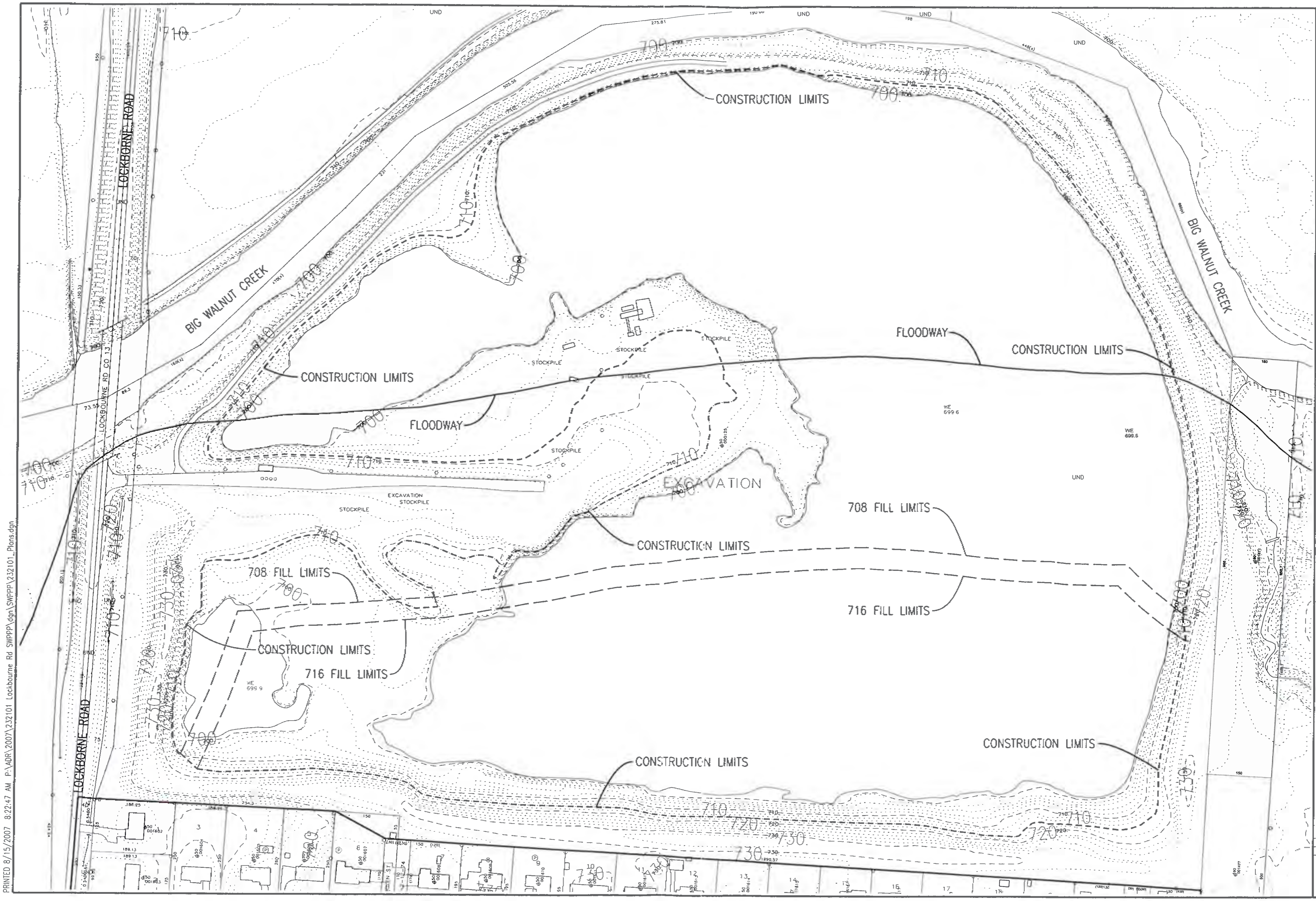

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HORIZONTAL SCALE IN FEET

DRAWN JWO
DESIGNED JWO
REVIEWED KAC

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SWPPP

LOCKBORNE ROAD FILL SITE
FRANKLIN COUNTY, OHIO

15 AUG 07
JOB #232101

2
2

RECEIVED
DEC 13 2018
Franklin County Planning Department
Franklin County, OH

CU-3922

Franklin County Board of Zoning Appeals

Case:	**CU-3922**
Applicant:	**Shelly & Sands Inc.**
Township:	**Hamilton Township**
Site:	**5636 Lockbourne Road (PID 150-000125)**

Shelly & Sands Inc. Submittal to BZA Staff
In Response to Staff's November 19, 2018 Denial Recommendation

Background

Shelly & Sands (S&S) currently has a Conditional Use (CU-3623) which allows S&S to place fill on its site. S&S recently submitted an application for an updated Conditional Use for two discreet updates related to the existing Conditional Use. First, to allow for the placement of Clean Hard Fill ("CHF") from third-parties on the site. Second, to allow Recycled Asphalt Product ("RAP") to be included as fill.

On November 19, 2018, the Staff issued a report recommending that BZA deny S&S's application. Staff provided one reason for the proposed denial:

> "The Applicant has not proposed a way to account for what is being deposited by an entity other than S&S."

Additionally, the City of Columbus raised a second concern:

> "How would they verify that all fill material does not contain asphalt and/or other hazardous material"?

Thus, the concerns raised are:

1. How will S&S verify that the fill does not contain asphalt (City of Columbus);
2. How will S&S have accountability for its site?

Issue One: Use of Asphalt

With respect, S&S does not understand the City's concern about the placement of asphalt, and S&S specifically requested the ability to include RAP in its Conditional Use.

Contrary to the City's assumption, RAP/virgin asphalt is not a hazardous material. In fact, Ohio EPA has specifically included asphalt in its definition of "Clean Hard Fill" materials. Specifically, O.A.C. 3745-400-5(A) defines Clean Hard Fill to consist of "reinforced or nonreinforced concrete, asphalt concrete, brick, block, tile, or stone." Ohio EPA allows Clean Hard Fill to be used to bring a site up to grade with 7-day notice to Ohio EPA. O.A.C. 3745-400-5(C).

Ohio EPA has a legal requirement to assure that, prior to promulgating any rule, it must analyze the rule's impact on the environment. Here, Ohio EPA has previously made the determination that asphalt can and should be included in the definition of Clean Hard Fill.

Ohio EPA's position on asphalt is consistent with all of the national technical literature on the topic, which, likewise has determined that asphalt/RAP is not a hazardous or solid waste and that it can even be used to line water reservoirs (i.e. asphalt does not contaminate water). Additionally, it is well documented that water leachate/run-off from areas with asphalt/RAP are not problematic.

To assist Staff with its confirmation of the safety of asphalt/RAP, S&S has attached a significant number of article and reference materials to support its position.

Issue Two: Accountability

S&S appreciates the question regarding accountability for the third-party materials. For its own protection, S&S will implement a multi-faceted Standard Operating Procedure ("SOP") on-site to assure that only Clean Hard Fill is placed.

The SOP will consist of the following steps:

1. Prior to any new customer bringing Clean Hard Fill on-site, the prospective customer will sign and notarize a document stating that it has been provided the Ohio EPA definition of Clean Hard Fill and certifies that it will not, under penalty of litigation, send any non-conforming materials to the site.

2. Each load will be accompanied by paperwork showing the company, the date, the origin of the load and the content. S&S will reserve the right to reject an load of material based on its own QA/QC.

3. There will be two employees tasked with on-site "gate keepers" for the Clean Hard Fill. First, the truck will need to be approved by the scale house employee. Second, at the unloading point, a second on-site employee will provide a second review/approval. Both employees will be trained to visually "spot-check" the Clean Hard Fill as well as perform "odor reviews."

4. S&S will, at all times, have a hand-monitor on-site for use to spot check materials for hydro-carbons.

5. S&S will maintain the load documentation on-site for a period for five (5) years.

6. S&S will send a copy of each load documentation to Franklin County on a monthly basis, due on or before the 15th of every month for the previous month's documentation.

Upon finalization of this proposed SOP with Franklin County's approval, S&S will maintain a copy on site and forward a copy to Franklin County.

This is an important project for S&S so we welcome additional questions and dialog with Staff prior to the December hearing on this matter. To that end, please do not hesitate to contact me with any questions.

Sincerely,

Anthony Ruggiero III
Environmental Permitting & Compliance Manager
1794 Moxahala Ave.
P.O. Box 1585
Zanesville, Ohio 43702-1585
Office: 740-453-0127
Fax: 740-453-6095
Cell: 614-402-3233
Mail: tonyr@shellyandsands.com
Site: www.shellyandsands.com

Shelly & Sands, Inc.
Lockbourne Site

Material Manifest Form

Company:_____________________________ **Date:** ___________

Truck #:_____________________ **Project #:**____________________

Project Location: ______________________

Amount of Material: __________________

Type of Clean Hard Fill:

- ○ **Concrete**
- ○ **Asphalt**
- ○ **Brick**
- ○ **Tile**
- ○ **Stone**

Number of Loads Today: ________________________

Signature: ____

***** THIS DUMP SITE DOES NOT ACCEPT SOIL OF ANY TYPE *****

STATE OF OHIO :

: **ss**

COUNTY OF____________________ :

AFFIDAVIT

My name is _______________________, and I am the ______________________ (title) for ______________________(company) located at_______________________________(address). I am over 18 years of age and competent to swear this affidavit based on my personal knowledge.

On behalf of __________________________ (company), I certify that we will only bring Clean Hard Fill as that term is defined by Ohio Administrative Code 3745-400-5(A) to the Shelly & Sands Inc. Lockbourne, Ohio site for disposition on the site as Clean Hard Fill.

_________________________ (Affiant)

Sworn to in my presence this __________ day of ________________.

____

Notary Public

ASPHALT INSTITUTE
Executive Offices and Research Center
Research Park Drive
P.O. Box 14052
Lexington, KY 40512-4052
USA
Telephone 859-288-4960
FAX No. 859-288-4999

CU-3922

Asphalt Liners in California Reservoirs Resist Loading Stress and Erosion

by Robert P. Humer, District Engineer, Asphalt Institute

CONTENTS

For more than four decades the Metropolitan Water District of Southern California (MWDSC) has used hot-mix asphalt (HMA) to line its water reservoirs. The liners control erosion, prevent seepage and absorb loading stresses. MWDSC has recently completed two more asphalt-lined water storage reservoirs in its expanding system-a finished water reservoir at the R. A. Skinner Filtration Plant and a raw water storage reservoir at the Etiwanda Control Facility.

Skinner

The Skinner Reservoir; near the city of Murrietta Hot Springs, consists of a 340-acre-foot (111-million-gallon) finished water-finished water is drinking water-storage reservoir with floating Hypalon cover. MWDSC placed 3 inches of open-graded HMA on its sides and bottom for erosion control.

On the $22 million Skinner project, the contractor prepared the subgrade on the native Bedford Canyon formation. He removed the unsuitable material and replaced it with select clay fill. General contractor Kiewit Pacific and paving contractor Matich Corporation of Banning, California, then constructed the 3-inch-thick porous asphalt liner with 22,500 tons of HMA. According to Eric Anderson, MWDSC resident engineer, the lining will not only prevent erosion, but also will relieve back pressures and prevent upheaval of the reservoir lining when draw downs on the water level occur.

Standard Paving Equipment

Matich Corporation first paved the sloping sides of the reservoir; then the bottom. "Because the sides were designed on a 3 to 1 slope, Matich was able to place the 3-inch lift with standard paving equipment without the help of a winch," says Ben Huntsman, head of the MWDSC testing laboratory. The paver started at the top of the slope and paved to the bottom.

Compaction was accomplished with an 8-ton, 2-axle tandem roller attached to steel cables and pulled up by a winch. The rolling pattern on the slopes was up and down with no compaction percentage specified. Bottom rolling was done with a double drum roller. The 3/4-inch topsize porous mix contained 5 percent AR-4000 asphalt cement.

Etiwanda

At Etiwanda, in the city of Rancho Cucamonga, MWDSC constructed a 10-inch-thick lining composed of layers of hydraulic and porous HMA on the sides and bottom of the 490-acre-foot (146-million-gallon) raw water reservoir. Raw water is the resource used for finished drinking water. Advanco Constructors of Upland, California, was the general contractor and Best Western Paving of Walnut, California, did the paving.

Cost of the Etiwanda liner was approximately $4 million of the $22.5 million project total. It was composed of 2 inches of hydraulic asphalt, and 4 inches of porous HMA topped with 4 inches of hydraulic asphalt. Approximately 120,000 tons of HMA were placed on the project.

Subcontractor Southern California Grading, Inc. first removed an extra 5 feet of subgrade material and replaced it with select fill material. The fill was placed in 8-inch lifts and compacted to 95 percent of laboratory density (ASTM D-1557). After priming, Best Western placed the 2-inch lift of impervious, hydraulic asphalt on the reservoir's sides and bottom.

Contents

Porous HMA

The PVC drainage system was then placed on the 2-inch liner and covered with 3/4-inch crushed drain rock. Best Western then placed a 4-inch layer of porous HMA on the drainage system and topped it with 4 inches of hydraulic asphalt placed in two lifts. Best Western placed the 4-inch-thick layer of porous HMA in one lift, rolling the mat just enough to seat the aggregate particles firmly. Excessive rolling could have caused aggregate degradation.

Resident engineer Don Slider says that the Etiwanda liner was specifically designed to withstand long-term loading stresses without cracking and to absorb short-term loadings such as wave impact. Long-term stresses are caused by settlements in the supporting subgrade or porous asphalt layer.

The porous HMA in the liner serves as a drainage layer between the two layers of impermeable hydraulic HMA. The porous mix contained 2.5 percent AR-8000 asphalt cement. See Table 1 for gradation of the porous mix.

Table 1
Gradation of Porous RMA at Etiwanda Reservoir

Sieve Size	Percent Passing
1-inch	100
3/4-inch	93-100
1/2-inch	---
3/8-inch	35-65
No.4	5-25
No.8	2-12
No.16	0-7
Asphalt cement, pct. by wt.	2.5 percent

Hydraulic HMA

Both layers of hydraulic HMA were mixed at the hot-mix facility at 280 to 300 degrees F, which matched the laboratory mixing temperature specified in the Asphalt Institute's mix design manual. The mix contained 8.3 percent asphalt cement. Table 2 shows the gradation for the hydraulic HMA.

Table 2
Aggregate Gradation of Hydraulic Asphalt at Etiwanda Reservoir

Sieve Size	Percent Passing
1/2-inch	100
3/8 inch	95-100
No.4	70-84
No.8	52-69
No.16	38-56
No.30	27-44
No.50	19-33
No.100	13-24
No.200	8-15
Asphalt cement, pct. by wt.	8.3 percent

Contents

Gradations for both the porous liner and the hydraulic HMA match the guidelines contained in the Institute's Asphalt in Hydraulics (MS-12) manual.

MWDSC specified that the 4-inch top layer of hydraulic HMA be compacted to 96 percent of 35-blow Marshall laboratory density. After compaction, the pavement on the reservoir floor contained less than 3.1 percent voids. After placing the final 4-inch layer of hydraulic asphalt, an asphalt sealer was applied on the completed surface of the reservoir lining.

The Etiwanda project began in July 1990 and will be completed in March 1992. As part of its continuing expansion, MWDSC will begin construction of another asphalt-lined reservoir with an 150-acre-foot (49-mIllion-gallon) capacity in the near future.

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CU-3922

Asphalt Reservior Liner Allows For State-Of-The-Art Seepage Monitoring System

by Bob Humer, District Engineer, Asphalt Institute

The California Department of Water (CDWR) recently activated its asphalt-lined Devil Canyon Second Afterbay in San Bernardino County north of Interstates 15 and 215 near the San Andreas fault line.

The kidney-shaped, 31 million gallon Afterbay (reservoir) functions as part of the California State Water Project system that brings water from the Sierra Mountains in Northern California to the metropolitan areas in Southern California. The system runs through the Mohave Desert from a substantially higher elevation than San Bernardino County and the metropolitan Los Angeles area. CDWR uses the difference in altitude to hydraulically generate commercial electricity as well as provide domestic water for the Metropolitan Water District of Southern California.

Several considerations were critical in the design of this large reservoir. The reservoir liner had to be impermeable, durable, flexible, resistant to weather; and able to withstand rapid filling and draw-down cycles based on water usage and power generation demands. Flexibility of the liner was necessary to accommodate differential settlement over its large area.

"Seepage control was very important;' says Nekane Hollister; a principal design engineer for the liner. "Even though soil cement would have limited seepage through the liner; it was still too porous."

Yet another essential design consideration was the high water table in the project area. CDWR engineers did not want to lose significant amounts of water and raise the water table.

Furthermore, high. groundwater levels could potentially push up or lift the liner. Thus, an acceptable liner would have to effectively contain reservoir water as well as accommodate groundwater pressures.

Seepage Monitoring

CDWR decided to use asphalt concrete for both the liner and drain elements of the Second Afterbay because it was both flexible and impervious. Its use allowed for construction of a state-of-the-art leak detection and seepage recovery system. The reservoir liner was divided into 10 sectors, with each sector having a drain pipe running through the second asphalt-treated permeable base layer to a concrete outlet. The drains also provide a means to locate leaks for repair work. CDWR can monitor all seepage and even know the exact volume of seepage. A groundwater drain provides relief for potential uplift forces.

Currently; seepage through the liner under a full reservoir is less than 20 gallons per minute. In a recent inspection by Bob Wu, CDWR Assistant Field Engineer for the Devil Canyon facility, only one of the ten sector drains showed signs of leakage, and that was very small.

Design

The 19 inch thick liner on the bottom of the reservoir was composed of a 7-inch drainage layer of asphalt treated permeable base (ATPB) placed on the prepared subgrade. Two inches of hydraulic asphalt, serving as a secondary liner; was placed on the ATPB. Six inches of ATPB, designed to collect leakage, was then placed on the secondary liner. The ATPB was then overlaid with 4 inches of hydraulic asphalt, which serves as the primary impervious liner. CDWR used the "E" gradation in the Asphalt Institute's Asphalt in Hydraulics (MS-12) manual to provide the required permeability for the open graded asphalt ATPB. Mix design for the hydraulic asphalt was based on Asphalt in Hydraulics gradation "B".

The ATPB has 22 percent air voids and is a well-draining mix. The hydraulic asphalt has 7.5 to 8 percent asphalt cement and a high dust to asphalt ratio. It contains less than 3 percent air voids and is truly impervious, a guard for the leak detection system. Any seepage that gets through the first 4 inches of primary liner is recovered by the asphalt-treated drainage layer and discharged into a monitoring pump.

The reservoir slope is composed of crushed drain rock on prepared sub grade, 3 inches of ATPB, 2 inches of hydraulic asphalt, 3 more inches of ATPB drainage course, topped by 4 inches of hydraulic asphalt.

Design also included a 2 to 3 millimeter-thick mastic seal coat over the entire surface of the liner. After researching reservoirs lined with hydraulic asphalt, Hollister found that an asphaltic mastic seal coat was a common practice on European reservoirs and had been used on some U.S. reservoirs. "Based on our research, we included the mastic seal coat in the specifications" says Hollister.

The mastic seal is a mixture of hot liquid asphalt and pulverized limestone that bonds well with the underlying asphalt. The mastic seals small cracks in the liner surface and protects it from degradation due to ultra-violet rays, oxidation and algae growth.

Compaction

Compaction for the liner was achieved with double drum rollers, rubber-tired rollers and vibratory drum rollers. Paving and compaction equipment were moved down the reservoir slopes with a winch. Hot-mix asphalt placed on slopes were compacted to a minimum of 96 percent of the 35-blow Marshall laboratory maximum density. Hot-mix asphalt placed on the bottom liner was compacted to a minimum of 98 percent of the 35 blow Marshall laboratory maximum density.

In applying the mastic seal to the slopes, the contractor used a three-wheeled vehicle-a trike with an insulated tank and squeegee. He used a crane to haul the trike up and down the slopes while dispensing the mastic. The mastic for the reservoir bottom was dispensed by a tank truck fitted with a squeegee. Although the actual application of the mastic was less than the specified 2 to 3 millimeters, the seal is expected to add many years to the service life of the liner.

The cost of the entire project was approximately $50 million. It required six million cubic yards of excavation. Reservoir liner construction included 149,000 tons of hot asphalt. Advanco Constructors of Upland, California, was the general contractor; Matich Company of Banning, California, paved the reservoir liner. The mastic seal coat was applied by Budka Construction Company of Upland, California.

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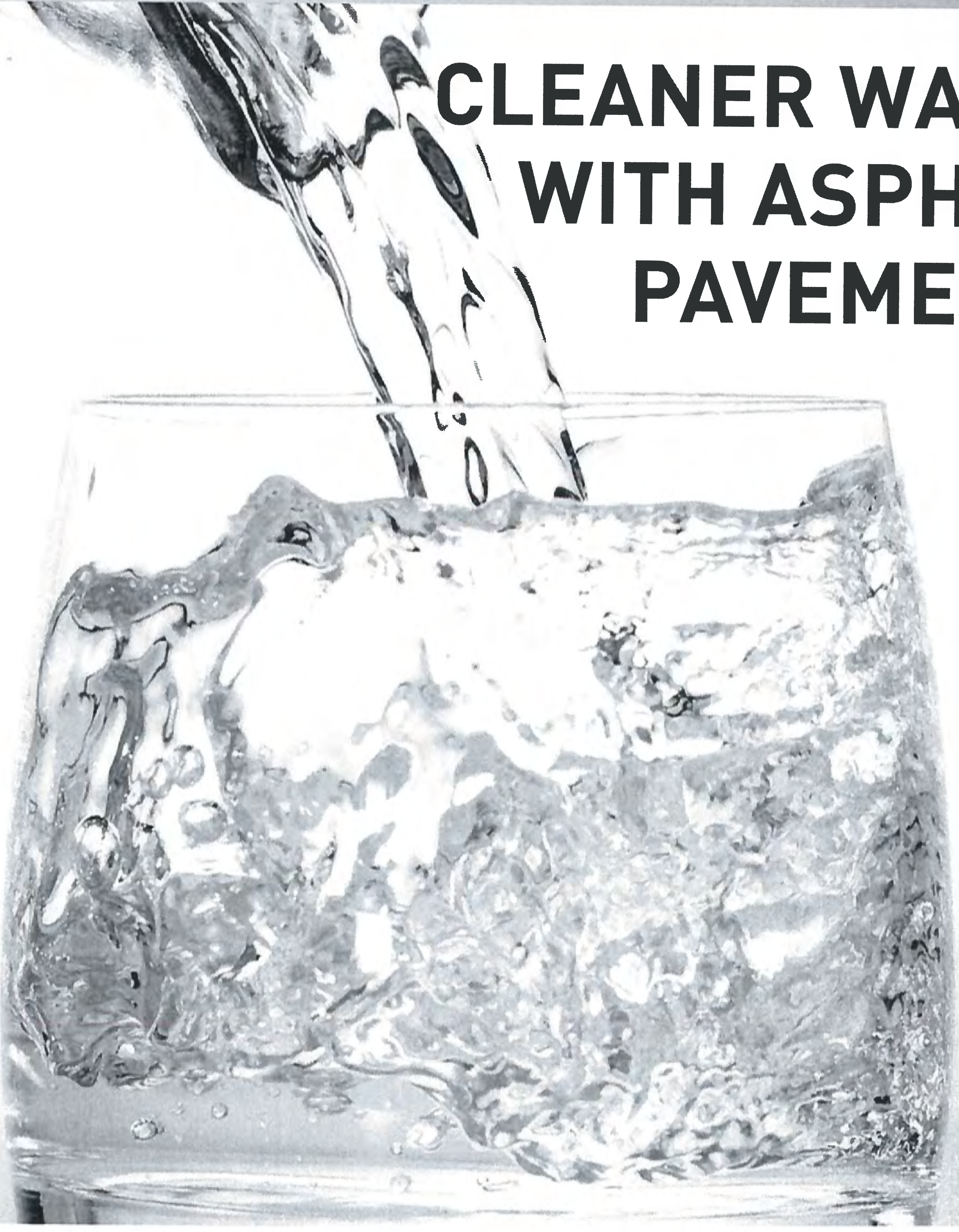
CV-3922

AMERICA RIDES ON US Asphalt.

CLEANER WATER WITH ASPHALT PAVEMENTS



CLEANER WATER WITH ASPHALT PAVEMENTS?

Yes, indeed! New research is standing the conventional wisdom on its head.

Because asphalt is impervious to water as well as many other substances, it has been beneficially used by humans for thousands of years. Noah waterproofed the Ark with asphalt. Deposits of asphalt on the Pacific coast near Santa Barbara were used by native Americans to make their canoes waterproof.

But, can today's asphalt pavements – made of 5 percent asphalt cement, a petroleum product, and 95 percent stone – really provide cleaner water? The answer, although it may not be intuitively obvious, is **YES**. As chemists and engineers know, petroleum-based products do not always look or behave like crude oil; in fact, the list of petroleum-based products includes balloons, aspirin, ice cube trays, toothpaste, and some shampoos.[1]

Read on to find out how asphalt contributes to a cleaner environment. And visit AsphaltRoads.org for even more info.

ASPHALT LINERS

Drinking Water

Today, asphalt liners for reservoirs in California store drinking water safely for millions of people.[2] The Metropolitan Water District of Southern California has been using asphalt pavement-lined water reservoirs for more than four decades. At this writing (2011), the Devil's Canyon Reservoir for storing drinking water is under construction with a 19-inch-thick asphalt liner. On completion, the facility will hold 800 acre-feet of water. In Northern California, the East Bay Municipal Utility District has also been using asphalt liners for reservoirs since the 1950s.

Fish Hatcheries

Fish hatcheries, where the young fry are highly sensitive to chemicals or other contamination, are also lined with asphalt. State fish and wildlife agencies in Oregon and Washington began using asphalt pavements to line their fish rearing ponds in 1987. Typically half an acre in area, the ponds are home to Chinook salmon and other fry for about 18 months before the fish are released into rivers and streams. The asphalt liners allow the fish and game experts to precisely monitor and control the environment during the delicate stages of incubation and early growth for various fish species. Both states' agencies are pleased with the effectiveness of the liners and plan to use them for additional fish hatcheries in the future.

Water Pipes and Industrial Ponds

Products derived from asphalt binders are also used to line water pipes that supply potable drinking water.

Proper Retention

In industrial retention ponds, asphalt pavement keeps liquid industrial waste material from percolating into the soil. This gives industry time to treat the liquid waste, and if needed, provides a platform for moving the material to a processing location. Similarly, asphalt is often used to line and/or cap hazardous waste sites – preventing rainwater from percolating through the hazardous waste and keeping materials from leaching into groundwater.

HIGHWAYS: THE NEW LINEAR WATER TREATMENT SYSTEMS

The Marine Science Institute (MSI) analyzed runoff from pavements in a 1997 study, *Impact of Runoff From Asphaltic Products on Stream Communities In California*.[3] The study concluded that pollutants from pavement stormwater runoff were associated with vehicle emissions, crankcase oil drippings,

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[1] HTTP://WWW.SAVEANDCONSERVE.COM/2007/05/PETROLEUM_BASED_PRODUCTS_A_LONG_LIST.HTML

[2] HTTP://WWW.APACA.ORG/FAQ/#3

[3] COOPER SD, KRATZ KW (1997) IMPACT OF RUNOFF FROM ASPHALTIC PRODUCTS ON STREAM COMMUNITIES IN CALIFORNIA. MARINE SCIENCE INSTITUTE, UNIVERSITY OF CALIFORNIA, SANTA BARBARA, CA (GOVERNMENT REPORTS ANNOUNCEMENTS & INDEX (GRA&I) ISSUE 15), FROM: HTTP://WWW.INCHEM.ORG/DOCUMENTS/CICADS/CICADS/CICAD59.HTM

industrial operations, and so forth – not with the pavements themselves. The Institute found that polycyclic aromatic hydrocarbons (PAHs) were not found in pavement stormwater runoff and that there was no difference in upstream versus downstream heavy-metal concentrations from pavement runoff. Further research has supported the conclusion that pollutants in runoff from asphalt pavements are produced by the vehicles that use the pavements, not by the asphalt pavements themselves.

SOME ASPHALT PAVEMENTS ACTUALLY IMPROVE STORMWATER RUNOFF

Pavement engineers use specialized asphalt surfacings called open-graded friction courses (OGFCs) or permeable friction courses (PFCs) to drain water off highways and runways. (OGFC and PFC mean the same thing, so we'll use the terms interchangeably.) These surfacings have a high level of interconnected voids. The precipitation drains vertically through the OGFC to an impermeable, underlying layer and then laterally to the edge of the pavement.

Recent studies show that an open-graded surface can actually improve the quality of runoff from pavements. During rainstorms, pollutants can wash off the pavement and accumulate in the roadway's right-of-way, and/or eventually make their way to surface water discharges.

In a study by the Texas Department of Transportation, researchers observed reductions in pollutants of up to 90 percent when comparing highways with open-graded surfaces to conventional pavements. They pointed out that "in fact, the improvement in water quality attributed to the switch to PFC was equal or better than the reduction in concentration occurring in the vegetated buffer strip in runoff from the conventional asphalt pavement."[4]

PAHs, which are associated with heavy oils, were not detected at the roadside when looking at stormwater runoff from either conventional or open-graded asphalt pavements. The researchers also measured total suspended solids (including lead and other metals) and found that runoff from the OGFC surfaces contained significantly less of these pollutants. These findings indicate that open-graded surfaces can be used to turn highways into linear water treatment facilities. Table 1 provides a compilation of pollutant reduction efficiency using porous pavements.

Bonus benefits from OGFCs/PFCs include reducing noise pollution from highways and improving visibility by reducing splash and spray from trucks. Studies by state transportation agencies identify a reduction of vehicle accidents, when OGFCs or PFCs have been placed under certain circumstances.[7]

TABLE 1 — COMPILATION OF POLLUTANT REDUCTION EFFICIENCY USING POROUS OR OPEN-GRADED FRICTION COURSE PAVEMENTS

Reference	Percent Reduction					
	Total Suspended Solids	Total Copper	Total Lead	Total Zinc	Chemical Oxygen Demand	Total Petroleum Hydrocarbons
Barrett et al[4]	94	75	93	76	46	
Pagotto et al[5]	81	33	78	66	0	92
Ranchet[6]	7	62	NA	67	NA	47

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[4] BARRETT, M., KEARFOTT, P., MAINA, JR., J. (2006) STORMWATER QUALITY BENEFITS OF A POROUS FRICTION COURSE AND ITS EFFECT ON POLLUTANT REMOVAL BY ROADSIDE SHOULDERS. *WATER ENVIRONMENT RESEARCH,* VOLUME 78, NUMBER 11, NOVEMBER 2006 , PP. 2177-2185(9)

ALSO ACCESSIBLE ON-LINE AT:
HTTP://WWW.PSPARCHIVES.COM/PUBLICATIONS/OUR_WORK/STORMWATER/LID/PAVING_DOCS/POROUS%20FRICTION%20COURSE%20POLLUTANT%20REMOVAL-BARRETT%202006%20.PDF

[5] PAGOTTO, C., M. LEGRET AND LE CLOIREC, P. (2000) COMPARISON OF THE HYDRAULIC BEHAVIOUR AND THE QUALITY OF HIGHWAY RUNOFF WATER ACCORDING TO THE TYPE OF PAVEMENT. *WATER RESOURCES,* VOL. 34, NO. 18, PP. 4446-4454.

[6] RANCHET J. (1995) IMPACTS OF POROUS PAVEMENTS ON THE HYDRAULIC BEHAVIOUR AND THE CLEANSING OF WATER (IN FRENCH). TECHNIQUES SCIENCES ET MEATHODES 11, PP. 869-871.

[7] SEE: OPEN GRADED FRICTION COURSE: A SOLUTION TO SAFETY AND NOISE PROBLEMS (2010) HMAT VOL. 15, PP. 23-25. ACCESSIBLE ON-LINE AT: HTTP://WWW.NXTBOOK.COM/NXTBOOKS/NAYLOR/NAPS0510/INDEX.PHP?STARTPAGE=23&QS=ACCIDENTS#/22

POROUS PAVEMENT ELIMINATES STORMWATER RUNOFF AND IMPROVES WATER QUALITY

Full-depth porous asphalt pavements provide pavements for parking and roads while also serving as stormwater storage and infiltration systems. Their open-graded surfaces allow rainwater to pass into an underlying stone recharge bed with a high level of voids. The stone recharge bed temporarily stores stormwater as it infiltrates into the soil below. Full-depth porous asphalt pavements are recognized by the United States Environmental Protection Agency as a best management practice for stormwater management. See Figure 1 for a cross section.

Full-depth porous pavements can reduce or even eliminate the need for other stormwater management structures such as retention ponds. Another benefit of porous pavements is the ability of these systems to mitigate vehicle metals and oil drippings. Villanova University reviewed the stormwater quality findings on their porous pavement systems and found reductions in PAHs, even when they added oil to the system.[8] The University of New Hampshire has also evaluated porous pavements and has found a reduction of more than 90 percent in total suspended solids, total petroleum hydrocarbons, and zinc when porous pavements were used to enhance stormwater runoff quality.[9] Table 2 provides a compilation of pollutant reduction efficiency using porous pavements.

FIGURE 1 — SCHEMATIC OF A POROUS PAVEMENT

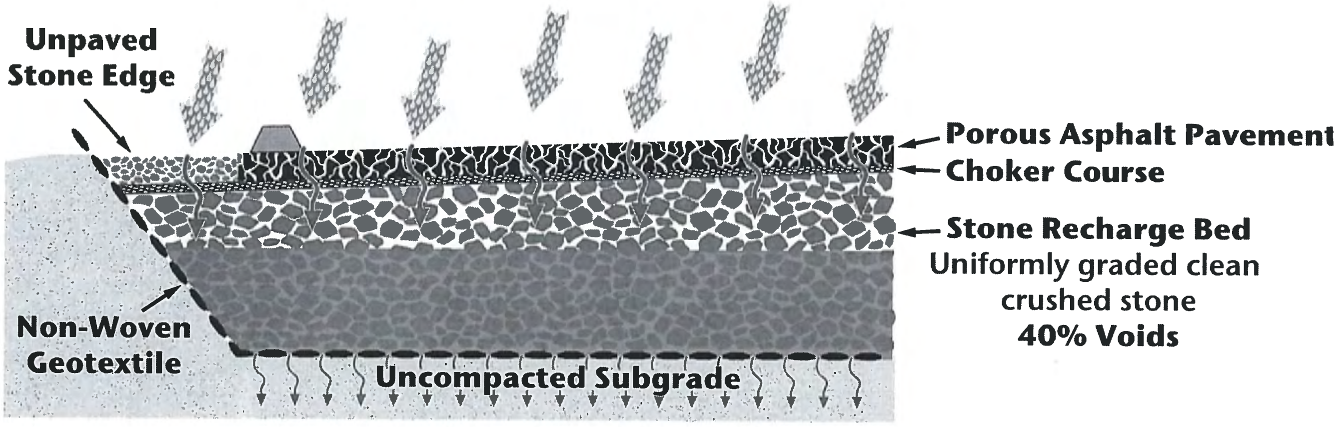

TABLE 2 — COMPILATION OF POLLUTANT REDUCTION EFFICIENCY USING POROUS PAVEMENTS

Reference	Percent Pollutant Removal					
	Total Suspended Solids	Total Nitrogen	Total Phosphorus	Lead	Zinc	Total Petroleum Hydrocarbons in the Diesel Range
Prince William Site[10]	95	85	65	98	99	--
Rockville Site[10]	82	80	65	--	--	--
University of New Hampshire[11]	99	--	38		96	99

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[8] SEE SECTION 2.3 OF: HTTP://WWW3.VILLANOVA.EDU/VUSP/OUTREACH/PDF/THESIS/BARBIS-09.PDF

[9] HTTP://WWW.UNH.EDU/UNHSC/SITES/UNH.EDU.UNHSC/FILES/DOCS/UNHSC_PA_COLDCLIMATE.PDF

[10] WHITNEY, B. AND T. SCHUELER. 1997. *NATIONAL POLLUTANT REMOVAL PERFORMANCE DATABASE FOR STORMWATER BMPS.* ELLICOTT CITY, MD: CENTER FOR WATERSHED PROTECTION.

[11] UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER (2007). *UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER 2007 ANNUAL REPORT.* DURHAM, NH: UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

POROUS PAVEMENTS: NOT JUST FOR PARKING LOTS

Often specified for stormwater management of parking lots, the industry is seeing more roadway applications of full-depth porous pavements. One example can be found in the "green" community of Pringle Creek, Oregon. All the roads in this community were designed with porous asphalt pavement. In Pelham, New Hampshire, there is another example of full-depth porous asphalt roads. In this community, the roadways, driveways, and walkways are all designed with full-depth porous asphalt pavement.[12] Washington State has also investigated the use of porous pavements in a slightly different approach; a preliminary study where porous asphalt pavement was used for the shoulders of heavily-traveled roadways showed almost a 90 percent reduction in both stormwater runoff and pollutant loads.[13] This shoulder application, similar to the use of PFCs on driving surfaces, again demonstrates the exceptional ability of this design to reduce stormwater pollutant loads.

LEACHATE FROM RECYCLING IS NON-EXISTENT

Does either asphalt pavement or reclaimed asphalt pavement (RAP) leach petroleum? The answer to this question is **NO**. Asphalt pavement's inert quality has been observed in a number of studies. In 2002, Kriech et al.[14] conducted a laboratory study to determine 29 PAHs in leachate water of six paving asphalt and four roofing asphalt samples. Samples were leached according to US Environmental Protection Agency (EPA) methods. Results indicated that none of the paving samples tested leached any of the 29 PAHs. Similarly, Brantley and Townsend[15] performed a series of leaching tests on samples of reclaimed asphalt from facilities in Florida. None of 16 EPA priority pollutant PAHs were detected in the water from of any of these samples. These authors pointed out that during normal use of pavement, the asphalt may come in contact with vehicle exhaust, lube oils, gasoline, and metals from brake pads. And yet, no PAHs were detected.

SUMMARY / CONCLUSIONS

Asphalt pavement, which has been used extensively throughout the United States and Europe for over a hundred years, is a tried and true road pavement material. But in this day of increased environmental attention, the green benefits of 100 percent recyclable asphalt pavement might be surprising to some. For improved stormwater management, clean drinking water, and reduced roadside pollution, asphalt pavements are clean and environmentally beneficial. Additionally, smooth asphalt pavements save fuel – potentially billions of gallons every year.[16] And asphalt pavement has a small carbon footprint, especially compared to other paving materials.[17]

For all the right reasons, asphalt is the green pavement choice.

FOR MORE INFORMATION, CONTACT US

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[12] HTTP://WWW.UNH.EDU/NEWS/CJ_NR/2009/DEC/BP07STORM.CFM

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[16] HTTP://ASPHALTROADS.ORG/IMAGES/DOCUMENTS/ASPHALT_SMOOTHNESS_MATTERS_DOWNLOADABLE.PDF

[17] HTTP://ASPHALTROADS.ORG/WHY-ASPHALT/CARBON-FOOTPRINT.HTML

Polycyclic Aromatic Compounds, 22:517–535, 2002
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DETERMINATION OF POLYCYCLIC AROMATIC COMPOUNDS IN ASPHALT AND IN CORRESPONDING LEACHATE WATER

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The environmental impact of polycyclic aromatic compounds (PACs) in asphalt (bitumen) materials is related to their availability for environmental transport and biouptake, rather than their total concentrations. This study examines six Strategic Highway Research Program (SHRP) paving asphalts and four commercial roofing asphalts. Three cleanup procedures for the neat asphalt samples are evaluated. This study reports on analyses for 29 PACs, including the EPA 16 priority pollutant PAHs and additional Persistent Bioaccumulative Toxins. These require reporting by the U.S. EPA under the Emergency Planning and Community Right-to-Know Act (EPCRA) section 313. The analytical protocol for analysis of the higher molecular weight PACs by GC/MS is reported, with inclusion of GC/MS/MS verification of some of the detectable compounds. Additionally, each asphalt was taken through a toxicity characteristic leaching procedure following U.S. EPA method SW846-1311. Results of the paving and roofing asphalts and their corresponding leachate waters are presented in this study.

Keywords EPCRA section 313, GC/MS, leachate, PACs, paving asphalt, roofing asphalt

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CU-3922

Asphalt cement is the nondistillable fraction obtained in the distillation of crude oil. It is a complex mixture of high-molecular-weight aliphatic and aromatic hydrocarbons and organosulfur compounds with smaller amounts of nitrogen and oxygen compounds. While there are many similar components in different asphalt samples, the exact composition and properties are a function of both the source of the crude oil and its processing (1). Asphalt is used widely for highways, parking lots, airport runways, and has also been used in many hydraulic applications for waterproofing reservoirs used for drinking water, fish hatcheries, boat ramps, and canals (2). A significant number of roofing systems also use asphalt in their formulation including asphalt-shingled roofs and flat or sloped built-up roofs (BUR).

Some standard differences between asphalt paving and roofing include application temperatures, hardness of the asphalt, and the presence of aggregates. BUR roofing asphalt is typically harder than paving asphalt cement. Penetration values for BUR roofing asphalt range from 12 to 35; paving asphalt typically has 50 or higher. Roofing application temperatures can be as high as 337°C, but are typically in the range of 232° to 274°C. Application temperatures for paving are generally less than 160°C. Hot mix asphalt composition generally consists of 95% mineral aggregate (rock) and 5% asphalt cement for paving applications.

Because of their widespread use in environmental applications, asphalt paving and roofing materials are subject to storm water runoff from rainfall events. This study examines the presence of PACs in the neat asphalt cement as well as the leachate from asphalt.

This study reports on analyses for 29 PACs, including the U.S. EPA 16 priority pollutant PAHs and additional Persistent Bioaccumulative Toxins (PBT). These require reporting by the U.S. EPA under the Emergency Planning and Community Right-to-Know Act (EPCRA) section 313 (3) if certain conditions are met. Benzo[*g,h,i*]perylene is a separately listed PAC which requires reporting at a much lower threshold. The act also requires reporting if these PACs are released to the environment through air, water, or the land. As such, a thorough understanding of their partitioning in the environment is required.

Previously reported studies show very low content of PAHs in the leachate fraction of asphalt (4). Even in reclaimed asphalt pavement from old roads, which could contain PAHs from crankcase drippings and tire abrasion, studies have found that recycled asphalt pavement (RAP) is nonleachable for the EPA's 16 standard PAHs (5). Other investigations (6–8) concerning leachability of road materials indicate that the PAH concentrations were near or below detectable limits. This study reports the 16 standard PACs, but focuses on the analysis of an extended list of PACs (13 additional compounds not listed before and required by EPCRA), for both the raw asphalt material and its corresponding leachate. The significance of these compounds and their environmental fate are related to their properties, some of which commonly require metabolic activation to produce reactive intermediates before they can express their toxicity, mutagenicity, and carcinogenicity (9). A few compounds on the list are not considered carcinogenic (phenanthrene) or the status is unknown (chrysene has mixed reviews). Others, such as benzo[*a*]pyrene, have been extensively studied and are classified as known carcinogens.

Since these studies were performed on virgin asphalt materials, it does not address spills from traffic and equipment that can lead to leaching of these compounds from other sources which could be released from pavement during storm water runoff. The presence of some of these compounds like 3-methylcholanthrene and 1-nitropyrene would not be expected in neat asphalt, but are on the EPCRA list for other materials.

EXPERIMENT

Specimens

Six paving asphalts were obtained from the Strategic Highway Research Program (SHRP) library. SHRP was a $150 million research study of asphalt sponsored by individual State Departments of Transportation across the United States. The SHRP library stored samples of asphalt cements from petroleum refineries throughout the United States. These six paving asphalts are produced from single-source crudes rather than mixtures and represent a significant portion of the composition variability in asphalt cement produced commercially in the United States.

Four roofing asphalts were obtained from different regions of the United States from commercial sources of roofing asphalt for built-up roofs.

Precipitation of Asphaltenes for Extraction of PACs from Asphalt

Asphaltenes are a component of asphalt, defined by ASTM as soluble in carbon disulfide but insoluble in paraffin naphthas. This component is comprised of polynuclear hydrocarbons of molecular weight up to 20,000, joined by alkyl chains (10). It is precipitated and removed to minimize extraction and analytical complications. Asphalt samples

(~0.4 g) were weighed into a 50 mL beaker, then dissolved in 10 mL of methylene chloride. This was quantitatively transferred to a 100-mL volumetric flask and brought to the mark with hexane. After mixing, samples were allowed to settle overnight prior to aliquot removal for centrifugation and subsequent cleanup. This procedure is similar to the one outlined in ASTM D 4124-97 (10).

CN/Si Cleanup Procedure (Extraction Method A)

This cleanup procedure was initially used since the combination of a cyanopropyl and silica gel chromatographic separation scheme has been shown to be successful for the EPA list of 16 PAHs in asphalt fumes (11). Twenty milliliters of the above hexane solution were concentrated to 2 mL, then passed through a cyanopropyl cartridge and eluted with hexane to 25 mL. This fraction was concentrated to 2 mL, then taken through a silica gel cleanup using 2 g of silica baked at 270°C for 2 hr. Twenty milliliters of hexane was used to elute the aliphatic portion of the samples (this fraction discarded), and 20 mL of methylene chloride was used to elute the PAC fraction.

Acetonitrile/Methylene Chloride Liquid/Liquid Extraction (Extraction Method B)

This extraction procedure was designed to replace Extraction Method A, since dibenz[*a,j*]acridine did not survive the silica gel cleanup and to attempt to minimize the aliphatic background prevalent even after Method A's cleanup. After centrifugation, 20 mL of the hexane/methylene chloride solution (90/10) was transferred into a 40-mL vial. Ten milliliters of 20% methylene chloride in acetonitrile (ACN) was added, then the vial was manually shaken for 2 min. After centrifuging, the bottom layer was transferred to a new 40-mL vial. Using 5 mL of the 20% methylene chloride in ACN solvent, this step was repeated twice. The combined extracts were concentrated to slightly under 1 mL using a nitrogen evaporation system at 54°–59°C. For all asphalt samples, two phases formed after settling overnight. The exact composition of the bottom phase was not investigated, although it is believed to contain high-molecular-weight non-"GC able" material. The top ACN phase was removed and brought to a final volume of 1.0 mL in ACN. For simplicity, this method will subsequently be referred to as the ACN Method B.

DMSO Method (Extraction Method C)

This method is a modification of a method previously developed (IP346/80) (12) for extraction of Polycyclic Aromatics in Petroleum Fractions by Dimethylsulfoxide (DMSO). Twenty milliliters of the original hexane solution after asphalt precipitation was concentrated to 5 mL and extracted in triplicate with 2.5 mL of DMSO. Ten milliliters of water was added to the DMSO extracts, which was then back extracted twice with isooctane, 5 mL first, and then 2 mL. The combined isooctane layers were extracted in triplicate into 2.5 mL of DMSO as before. The DMSO was diluted with water and back extracted three times into isooctane. This isooctane extract was concentrated to 1.0 mL, then an aliquot combined with internal standards (chrysene-d_{12} and perylene-d_{12}) for GC/MS analysis. Surrogates could be added prior to extraction but were not added in this study.

Leachate Procedure

Samples of 10 asphalts were frozen to facilitate breaking the asphalt into small enough pieces to pass through a 9.5-mm sieve. Samples were leached according to SW846 1311, Toxicity Characteristic Leaching Procedure (13), which is designed to emulate what goes on in the environment. This TCLP test is a batch leaching prescribed by the EPA to determine whether a solid waste is hazardous by toxicity characteristic. One hundred grams of the sieved asphalt material were tumbled for 18 h in 2 l of a pH 4.93 buffered solution (acetic acid/sodium hydroxide mix).

Extraction of Leachate Water for PAC Analysis

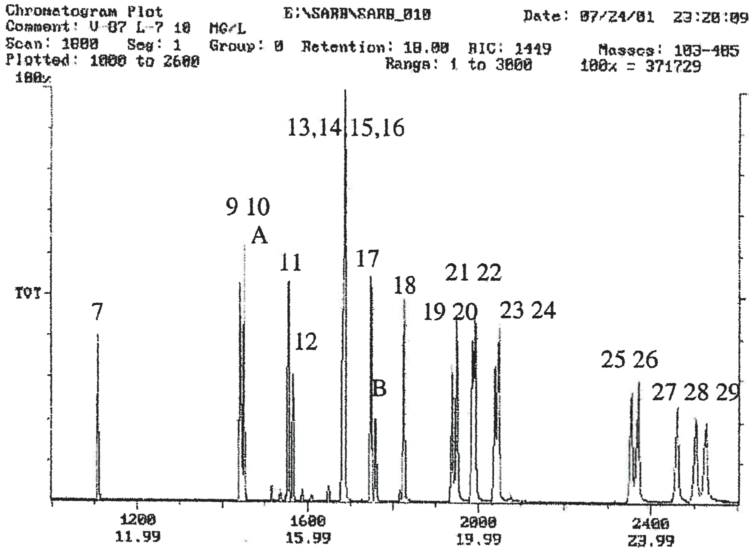
Method SW-846 3510C (14) (Separatory Funnel Liquid-Liquid Extraction) was used for the extraction of the leachate waters. This method involves three triplicate extractions of the water with methylene chloride under neutral, basic, and acidic conditions. The base/neutral and acid extracts were combined prior to concentration to 1.0 mL in methylene chloride.

Analytical Method for EPA's 16 PAHs

EPA SW846-8270 B (15) was used for the analysis of the leachate water extracts and the total asphalt extracts for 8 of the 29 PACs reported (those not on the EPCRA list, but on the EPA's list of 16).

Program Modifications for GC/MS Analysis of 22 EPCRA Section 313 Compounds

Using a Varian Saturn 4 GC/MS/MS, the column (a 25 m × 0.25 mm ID BPX5 0.25 micron film SGE Cat # 054113) was held at 150°C for 3 min and then increased to 300°C at 10°/min and held for 15 min, then increased to 320°C at 2°/min kept for 2 min. With a CT 8200 autosampler, the solvent plug 0.2 μL with upper and lower air gap and sample volume of 2.0 μL was programmed with air-dry after wash at an injection rate of 5.0 μL/sec and hot-needle time of 0.04 min. The mass range was 100 to 410 m/z and the scan time 0.600 sec, segment length 30 min, filament delay 2.70 min, mass defect 40 mμ/100 μ, and background mass 98 m/z. Most importantly, the injector was at 320°C (deactivated 1078 glass insert with glass wool-Varian Cat no. 392611953), transfer line at 325°C, and the trap temperature at 285°C. An internal standard quantification procedure was used. A total of seven calibration standards (dilutions of a custom mix prepared by AccuStandard, USA) were analyzed to provide a concentration range of 0.1 to 10 pg/μL. Figure 1 shows a chromatogram of the 22 compounds on the EPCRA



A = Chrysene d-12
B = Perylene d-12

FIGURE 1. A chromatogram of a 10 pg/μL calibration standard of the 22 EPCRA compounds. The order of elution is outlined in Table 5 for compounds 7 to 29.

section 313 list. The linear range for most of these compounds was between 0.1 and 10 pg/μL. Two compounds, 1-nitropyrene and 7,12-dimethylbenz[*a*]anthracene, produced nonlinear curves. The instrument limit of detection is approximately 0.10 pg/μL for these 29 analytes. Values between 0.05 and 1.0 pg/μL are semiquantitative and reported as estimated.

GC/MS/MS Analytical Method for Verification of Selected Compounds

Using the same system as above, a MS/MS program was developed for selected compounds with mass 228, 252, and 276. The same GC program described above was used. The mass data collection was broken into separate segments by inserting a unique ion preparation method for each molecular ion class. The ion preparation methods are generated by the Saturn software and a unique waveform is applied to the ion trap after electron ionization. This waveform ejects all nontarget ions from the trap allowing increased sensitivity. Collisionally induced dissociation by applying a secondary voltage is then used to obtain the fragmentation pattern of the trapped ions.

RESULTS AND DISCUSSION

Separation and analytical procedures for asphalt materials pose extraction and analytical challenges when attempting to find trace quantities of PACs in a primarily aliphatic high-molecular-weight media. It is one of the most complex, difficult materials to chemically analyze, even after cleanup steps and separation techniques are employed (Figure 2).

Analytically, the heating zones of the instrumentation were elevated to accommodate the higher-molecular-weight compounds on the EPCRA 313 list. To retain the ion trap at 285°C, glass wool was placed over the trap exterior, taking care to place all cables above the glass wool so the protective coatings would not melt.

Initially, a CN/Si cleanup procedure (Method A) was employed and recoveries of these 29 compounds were similar to the other two extraction methods discussed. Two disadvantages, however, caused the abandonment of this approach. First, the dibenz[*a,j*]acridine did not recover from the silica gel cleanup. Second, the injection port liner required frequent changing to retain calibration of the instrument. In an attempt to obtain a "cleaner" extract for injection, the ACN (Method B) was developed and analyte recovery for the Laboratory Control Standard (LCS) and

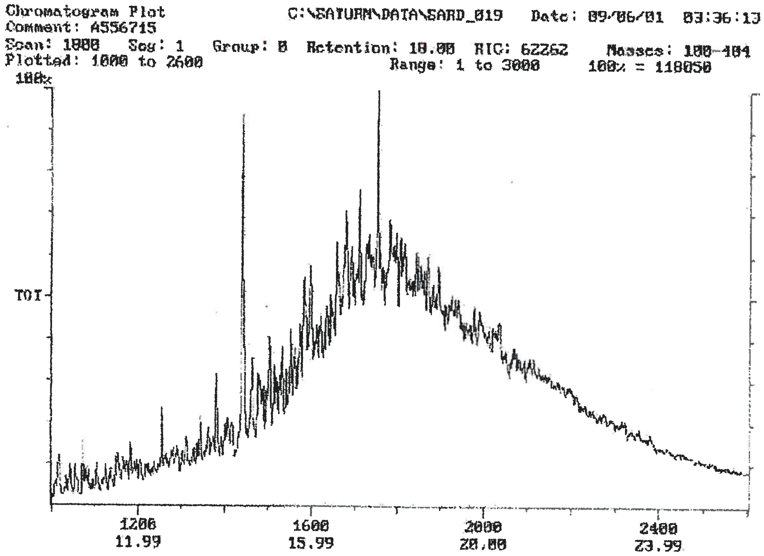


FIGURE 2. A chromatogram of paving sample 2. The complexity of asphalt analysis is evident. This injection is of the DMSO extract, which is even cleaner than the corresponding ACN extract.

Duplicate Control Standard (DLCS) are listed in Table 1. These control standards are spiked with a solution of standard reference compounds. This was performed in duplicate to obtain replicability data. Sample matrix and duplicate matrix spikes are also provided in Table 2 and show the difficulties of recovering the mass 302 compounds. This method eliminated the need to run two separate fractions, since the benz[*a,j*]acridine survived this extraction procedure. The injection port liner, however, still required frequent changing to retain calibration. Third, the DMSO Method C was evaluated and turned out to yield the best extraction approach for this matrix and these analytes. The advantages of the DMSO extraction over the first two methods attempted are twofold, but related. First, the injection port liner did not require as frequent a change as when the CN/Si (Method A) or ACN (Method B) were used. Second, the aliphatic background of the asphalt matrix was greatly reduced and apparent in the chromatogram, allowing better detection of the compounds in the samples. Recoveries comparing the DMSO (Method C) and ACN (Method B) PAC fortified sample results are similar and shown in Tables 1 and 2. The mean of the relative percent difference is 23.3 for the DMSO preparation and 9.9 for the ACN preparation for the laboratory control standards and 10.4 (DMSO) versus 15.8 (ACN) for the asphalt sample spikes.

TABLE 1. Comparison of % Recoveries from Laboratory Control Standards Taken through Two Different Extraction Procedures

	DMSO (Method C)			ACN (Method B)		
EPCRA section 313 compounds	% REC LCS	% REC DLCS	% RPD	% REC LCS	% REC DLCS	% RPD
Fluoranthene	59.7	68.5	13.7	76.3	66.8	13.3
Benzo[*a*]anthracene	76.4	87.1	13.1	75.1	71.9	4.4
Chrysene	78.6	93.4	17.2	73.9	71.7	3.0
5-Methylchrysene	83.0	92.7	11.0	74.1	69.6	6.3
1-Nitropyrene	90.8	124.5	31.3	85.7	75.3	12.9
Benzo[*b*]fluoranthene[a]	81.8	101.1	21.1	79.1	78.3	1.0
7,12-Dimethylbenz[*a*]anthracene[b]	204.0	297.9	37.4	32.6	44.3	30.4
Benzo[*a*]pyrene	89.2	93.1	4.3	78.3	76.7	2.1
3-Methylcholanthrene	63.2	49.1	25.1	71.0	63.8	10.7
Dibenz[*a,h*]acridine	87.9	94.3	7.0	82.1	82.1	0.0
Dibenz[*a,j*]acridine	82.6	84.3	2.0	83.1	87.3	4.9
Indeno[1,2,3-*cd*]pyrene	80.0	94.9	17.0	79.6	77.3	2.9
Dibenz[*a,h*]anthracene	85.9	92.6	7.5	82.2	79.1	3.8
7H-Dibenzo[*c,g*]carbazole	19.3	2.4	156	131.1	89.0	38.3
Benzo[*g,h,i*]perylene	83.6	91.5	9.0	77.4	80.7	4.2
Dibenzo[*a,l*]pyrene	89.8	86.6	3.6	66.9	61.1	9.1
Dibenzo[*a,e*]fluoranthene	86.3	83.2	3.7	80.3	78.0	2.9
Dibenzo[*a,e*]pyrene	83.8	73.9	12.6	83.2	76.6	8.3
Benzo[*r,s,t*]pentaphene	80.2	48.6	49.1	90.8	73.0	21.7
Dibenzo[*a,h*]pyrene	65.4	51.1	24.5	86.0	71.9	17.9
Average	83.6	90.5	23.3	79.4	73.7	9.9
Average excluding compounds in bold	77.2	79.6	22.6	81.9	75.3	8.8

Abbreviation: RPD, relative percent difference.

[a] The *b, j,* and *k* isomers are not resolved and reported as a mix of Benzo[*b*]fluoranthene.

[b] Chromatographic coelution problems with 3 isomers of 252 mass affect precision and accuracy.

Three of the mass 252 compounds are not resolved and the 7,12-dimethylbenz[*a*]anthracene elutes among them, which sometimes causes quantitation problems. A different chromatographic column should help to alleviate these complications.

Sample results for the raw asphalt (DMSO extraction) are listed in Table 3. Roofing asphalts show the sum of all 29 PACs to be between 4.0 and 23 mg/kg (ppm), with a range of 2.4 to 19 mg/kg for the EPCRA listed compounds. This includes benzo[*g,h,i*]perylene which must be reported separately. Neat paving asphalts show the sum of all 29 compounds to be between 1.9 and 66 mg/kg and a range of

TABLE 2. Comparison of Recoveries from Matrix Spikes and Matrix Spike Duplicates Using DMSO and ACN Extractions

	Roofing C					Roofing B				
	% REC DMSO MS	% REC DMSO MSD	% REC DMSO MS	% REC DMSO MSD	Average DMSO recovery	% REC ACN MS	% REC ACN MSD	% REC ACN MS	% REC ACN MSD	Average ACN recovery
Fluoranthene	71.7	65.8	76.9	76.7	72.8	68.8	70.9	62.7	64.9	66.8
Benz[*a*]anthracene	79.8	81.4	91.4	87.9	85.1	74.7	82.3	74.9	76.7	77.2
Chrysene	81.8	79.6	92.8	93.8	87.0	73.4	78.4	73.6	69.0	73.6
5-Methylchrysene	78.5	83.3	87.1	94.4	85.8	73.7	86.7	74.0	73.1	76.9
1-Nitropyrene	71.3	99.8	45.3	42.8	64.8	30.0	39.2	79.5	65.4	53.5
Benzo[*b*]fluoranthene[a]	80.7	83.1	89.9	91.3	86.3	69.1	77.9	70.4	67.9	71.3
7,12-Dimethylbenz[*a*]anthracene[b]	201.2	225.6	192.7	205.9	206	19.3	18.3	17.1	20.1	18.7
Benzo[*a*]pyrene	85.8	82.0	90.6	82.7	85.3	62.8	80.4	56.3	57.4	64.2
3-Methylcholanthrene	32.0	52.3	82.3	76.2	60.7	44.7	46.8	47.0	49.5	47.0
Dibenz[*a,h*]acridine	82.2	82.9	68.4	60.4	73.5	40.1	55.1	50.6	46.5	48.1
Dibenz[*a,j*]acridine	71.5	69.7	53.7	45.8	60.2	44.8	51.2	51.3	45.3	48.2
Indeno[1,2,3-*cd*]pyrene	76.7	76.4	37.7	57.8	62.2	43.5	50.6	44.1	37.6	44.0
Dibenz[*a,h*]anthracene	84.3	78.1	75.2	68.5	76.5	54.1	52.3	53.9	48.3	52.2

7H-Dibenzo[*c*,*g*]carbazole[c]	3.5	3.0	11.5	9.0	6.7	57.8	58.7	97.8	78.2	73.1
Benzo[*g*,*h*,*i*]perylene	79.4	71.1	50.3	67.5	67.1	34.2	42.5	35.9	32.5	36.3
Dibenzo[*a*,*j*]pyrene	62.4	56.9	66.0	59.6	61.2	25.1	29.2	27.2	23.3	26.2
Dibenzo[*a*,*e*]fluoranthene	42.9	42.1	47.1	41.5	43.4	18.2	21.7	25.7	18.5	21.0
Dibenzo[*a*,*e*]pyrene	36.2	33.9	45.1	40.4	38.9	17.1	22.3	21.9	15.5	19.2
Benzo[*r*,*s*,*t*]pentaphene	25.4	24.6	26.8	24.0	25.2	15.3	26.9	14.1	10.5	16.7
Dibenzo[*a*,*h*]pyrene	21.6	23.8	25.9	28.2	24.9	12.6	18.3	15.7	10.8	14.4
Average					68.7					47.4
Average excluding compounds in bold					61.4					48.9

Abbreviations: MS, matrix spike; MSD, matrix spike duplicate.

[a] The *b*, *j*, and *k* isomers are not resolved and are reported as a mix of Benzo[*b*]fluoranthene.

[b] Chromatographic coelution problems with 3 isomers of 252 mass affect precision and accuracy.

[c] Low recoveries for this compound are more apparent in the DMSO extraction compared to the ACN extraction.

TABLE 3. Raw Asphalt PAC Results (mg/kg)—Four Roofing and Six Paving PACs

	Roofing				Paving					
Not on EPCRA section 313 list	A	B	C	D	1	2	3	4	5	6
Naphthalene	<1	<1	<1	<1	<1	<1	0.68 Est.	<1	<1	<1
Acenaphthylene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthalene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluorene	1.2	0.56 Est.	<1	<1	1.1	<1	<1	1.8	<1	0.79 Est.
Phenanthrene	1.9	1.1	0.74	1.0	9.9	1.7	1.2	30	<1	9.3
Anthracene	<1	<1	<1	<1	1.1	<1	<1	1.5	<1	<1
Pyrene	0.86 Est.	<1	<1	<1	3.1	0.64 Est.	<1	9.1	<1	1.9
EPCRA section 313 list										
Fluoranthene	<1	<1	<1	<1	0.75 Est.	<1	<1	<1	<1	<1
Benz[*a*]anthracene	0.76 Est.	<1	<1	<1	**1.3**	<1	<1	**2.0**	<1	0.96 Est.
Chrysene	**9.5**	**2.2**	**1.8**	**2.4**	**6.5**	**3.2**	<1	**12**	**2.9**	**4.3**
5-Methylchrysene	**3.5**	0.72 Est.	0.82 Est.	0.94 Est.	**2.8**	**1.1**	<1	**9.2**	<1	0.75 Est.
1-Nitropyrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[*b*]fluoranthene	**1.0**	<1	0.62 Est.	<1	**1.5**	<1	<1	0.74 Est.	<1	<1
Benzo[*j*]fluoranthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[*k*]fluoranthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
7,12-Dimethylbenz[*a*]anthracene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[*a*]pyrene	<1	<1	<1	<1	3.7	<1	<1	<1	<1	0.54 Est.
3-Methylcholanthrene	<1	<1	<1	<1	**7.8**	<1	<1	<1	<1	<1
Dibenz[*a,h*]acridine	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenz[*a,j*]acridine	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Indeno[1,2,3-*cd*]pyrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenz[*a,h*]anthracene	0.59 Est.	<1	<1	<1	<1	<1	<1	<1	<1	<1
7H-Dibenzo[*c,g*]carbazole	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[*g,h,i*]perylene	**1.4**	0.65 Est.	<1	0.89 Est.	**2.4**	<1	<1	<1	**1.0**	<1
Dibenzo[*a,l*]pyrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzo[*a,e*]fluoranthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzo[*a,e*]pyrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[*r,s,t*]pentaphene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzo[*a,h*]pyrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total of 29 PACs—detectables only	23	4.1	4.0	5.2	43	6.6	1.9	66	3.9	19
Total of EPCRA list only	19	2.4	3.3	4.2	28	4.3	ND	24	3.9	6.5

Abbreviation: Est., estimates, detectable but below calibration.

nondetectable to 28 mg/kg for the EPCRA list. Since the samples had been taken through two different extractions, these results were compared and show good agreement. The primary detectable compounds of benz[*a*]anthracene, chrysene, and 5-methylchrysene are listed in Table 4 showing these comparisons. The 3-methylcholanthrene was detectable in only one sample, but its mass spectrum was a good match. The M-1 ion at 267 was 34% for the standard and 37% for the sample. Also, the 253 ion was 53% and 49% respectively. Quantitation of this compound may be skewed high, as there were shoulders on both sides of the peak. The presence of 3-methylcholanthrene is not understood, since 3-methylcholanthrene is a synthetic compound and therefore not likely to be in the neat asphalt.

Structures for these 29 PACs are readily available in the literature (16). Their presence in the neat asphalt and leachability appear to be varied with different types of asphalt. Three of the 252 mass compounds are not baseline resolved and are integrated as one peak reported as benzo[*b*]fluoranthene (*j* and *k* isomers included). The 7,12-dimethylbenz[*a*]anthracene (mass 256) elutes at a similar retention time and chromatographic problems are evidenced in the recovery data. The 7H-dibenzo[*c,g*]carbazole was also problematic. Recovery of the mass 302 compounds dropped off with all three methods of extraction and seemed to vary depending on which sample was spiked. The sample extracts ranged in color from light yellow to pink and varied in intensity as well as PAC concentration.

Little data on these PACs in asphalt are found in the literature to compare with the data in this study. Malaiyandi et al. showed results for only a subset of this list determined by HPLC (17). Even though HPLC with fluorescence detection is a sensitive analytical technique, HPLC suffers from two problems. One is that matrix problems with complex mixtures such as asphalt may lead to high reported values. Second, it is difficult to verify the identity without a spectroscopic technique. Analysis of the leachate samples by HPLC would be suitable, since the chromatograms are relatively clean. For asphalt, however, the complex background inhibits the identification and quantification, which could easily be in error using HPLC.

Leachate results are presented in Table 5 for the 10 asphalt samples tested. Results for all 29 compounds are below the regulatory limit, with only two results above the detection limits of 0.1 ppb. A few samples contain results reported as estimated data (detectable but below the calibration). One sample (Paving 3) had a result of 0.18 μg/L (ppb) of naphthalene. Another sample (Paving 1) had 0.1 μg/L of phenanthrene, which is right at the detection limit. All four roofing samples and three

TABLE 4. Sample Results (mg/kg) Comparing Both the DMSO and ACN Extraction Procedures

Compound	DMSO	ACN	DMSO	ACN	DMSO	ACN	DMSO	ACN	DMSO	ACN
	PG 64-22		Roofing A		Roofing B		Roofing C		Roofing D	
Benz[*a*]anthracene	0.96	<1	0.76	0.88	—	—	—	—	—	—
Chrysene	3.6	2.6	9.5	7.9	2.2	2.2	1.8	1.6	2.4	1.7
5-Methylchrysene	1.2	1.0	3.5	2.5	0.72	<1	0.82	1.3	0.94	<1
	Paving 1		Paving 2		Paving 4		Paving 5		Paving 6	
Benz[*a*]anthracene	1.3	2.9	—	—	—	—	—	—	0.96	<1
Chrysene	6.5	7.0	3.2	3	12	16	2.9	3.5	4.3	3.2
5-Methylchrysene	2.8	5.5	1.1	1.7	9.2	11	—	—	0.75	1.9

TABLE 5. Quantification Ion, Retention Times, and Leachate Results for Detectable Samples

Relative order of elution	PAC not on EPCRA section 313 list	Quant. ion	Retention time (min)	Paving 1	Paving 3	Paving 4
					(mg/liter)	
1	Naphthalene	128	6.67	<0.1	**0.18**	<0.1
2	Acenaphthylene	152	12.11	<0.1	<0.1	<0.1
3	Acenaphthalene	154	12.69	<0.1	<0.1	<0.1
4	Fluorene	165	14.15	<0.1	<0.1	<0.1
5	Phenanthrene	178	16.66	**0.1**	<0.1	0.06 Est.
6	Anthracene	178	16.76	<0.1	<0.1	<0.1
8	Pyrene	202	20.20	<0.1	<0.1	<0.1
	EPCRA section 313 list[a]					
7	Fluoranthene	202	11.02	<0.1	<0.1	<0.1
9	Benz[*a*]anthracene	228	14.39	<0.1	<0.1	<0.1
10	Chrysene	228	14.50	<0.1	<0.1	<0.1
11	5-Methylchrysene	242	15.54	<0.1	<0.1	<0.1
12	1-Nitropyrene	247	15.65	<0.1	<0.1	<0.1
13	Benzo[*b*]fluoranthene	252	16.81	<0.1	<0.1	<0.1
14	Benzo[*j*]fluoranthene	252	16.81	<0.1	<0.1	<0.1
15	Benzo[*k*]fluoranthene	252	16.81	<0.1	<0.1	<0.1
16	7,12-Dimethylbenz[*a*]-anthracene	256	16.89	<0.1	<0.1	<0.1
17	Benzo[*a*]pyrene	252	17.47	<0.1	<0.1	<0.1
18	3-Methylcholanthrene	268	18.26	<0.1	<0.1	<0.1
19	Dibenz[*a,h*]acridine	279	19.39	<0.1	<0.1	<0.1
20	Dibenz[*a,j*]acridine	279	19.48	<0.1	<0.1	<0.1
21	Indeno[1,2,3-*cd*]pyrene	276	19.87	<0.1	<0.1	<0.1
22	Dibenz[*a,h*]anthracene	278	19.92	<0.1	<0.1	<0.1
23	7H-Dibenzo[*c,g*]carbazole	267	20.39	<0.1	<0.1	<0.1
24	Benzo[*g,h,i*]perylene	276	20.45	<0.1	<0.1	<0.1
25	Dibenzo[*a,l*]pyrene	302	23.53	<0.1	<0.1	<0.1
26	Dibenzo[*a,e*]fluoranthene	302	24.57	<0.1	<0.1	<0.1
27	Dibenzo[*a,e*]pyrene	302	24.64	<0.1	<0.1	<0.1
28	Benzo[*r,s,t*]pentaphene	302	24.96	<0.1	<0.1	<0.1
29	Dibenzo[*a,h*]pyrene	302	25.20	<0.1	<0.1	<0.1

Note. All four roofing asphalts were nondetectable (ND) for all 29 compounds. Three of six paving asphalt samples were also ND.

[a] A separate analytical program was designed for this list.

TABLE 6. Leachate Recovery Data for EPCRA Section 313 Compounds

EPCRA section 313 compounds	LCS	DLCS	% RPD
Fluoranthene	95.4	86.7	9.5
Benz[*a*]anthracene	96.9	101.7	4.8
Chrysene	96.6	94.3	2.4
5-Methylchrysene	101.5	103.1	1.5
1-Nitropyrene	101.8	141.3	32.5
Benzo[*b*]fluoranthene + other isomers	98.8	95.8	0.3
7,12-Dimethylbenz[*a*]anthracene	83.5	88.4	5.7
Benzo[*a*]pyrene	101.6	103.2	1.6
3-Methylcholanthrene	100.1	110.0	9.4
Dibenz[*a,h*]acridine	94.1	98.9	5.0
Dibenz[*a,j*]acridine	93.9	102.2	8.5
Indeno[1,2,3-*cd*]pyrene	95.0	99.1	4.2
Dibenz[*a,h*]anthracene	93.1	100.7	7.9
7H-Dibenzo[*c,g*]carbazole	111.2	121.6	8.9
Benzo[*g,h,i*]perylene	93.1	93.8	0.7
Dibenzo[*a,l*]pyrene	86.9	102.8	16.8
Dibenzo[*a,e*]fluoranthene	90.1	107.8	17.9
Dibenzo[*a,e*]pyrene	88.2	102.9	15.4
Benzo[*r,s,t*]pentaphene	88.1	103.7	16.2
Dibenzo[*a,h*]pyrene	84.4	108.5	25.0
Average	94.7	103.3	9.7

The LCS was spiked at 2.0 ug/L and the DLCS spiked at 4.0 ug/L.

of six paving samples showed no trace of any of these PACs. None of the EPCRA 22 PACs were found in the leachate of any asphalt. Recoveries within a leachate matrix laboratory control standard (LCS) are shown in Table 6.

Excellent recoveries and repeatability for most compounds are demonstrated, with the relative percent difference (%RPD) being under 20% for all compounds except 1-nitropyrene, which showed 141.3% recovery for the Duplicate Laboratory Control Standard (DLCS) and a 32.5% RPD. Eight of the traditional 16 PAH compounds not within the EPCRA section 313 list were also tested for recoveries and repeatability with all results between 101.2% and 124.6% recovery and RPDs all below 5%.

Results for the leachate samples are consistent with previous data (5–8), although data for the bulk of the EPCRA section 313 list has not been previously studied in asphalt or their leachates.

Finally, the use of GC/MS/MS to validate the presence of these low levels was pursued. The GC/MS mass spectra were sometimes not

TABLE 7. GC/MS/MS Results on Selected Masses (mg/kg)

		Roofing A		Paving 1		Paving 4	
Mass	Compound	GC/MS/MS	GC/MS	GC/MS/MS	GC/MS	GC/MS/MS	GC/MS
228	Benz[*a*]anthracene	0.94	0.76	3.9	1.3	2.8	2.0
228	Chrysene	4.9	9.5	8.5	6.5	12.0	12.0
252	Benzo[*b*]fluroanthene	0.92	1.0	1.9	1.5	+	0.74
252	Benzo[*k*]fluoranthene	–	<1.0	1.5	<1.0	+	<1.0
252	Benzo[*a*]pyrene	<0.5	<1.0	3.4	3.7	+	<1.0
276	Indeno[1,2,3-*cd*]pyrene	0.40	<1.0	2.5	<1.0	–	<1.0
278	Dibenz[*a*,*h*]anthracene	0.75	0.59	–	<1.0	–	<1.0
276	Benzo[*g*,*h*,*i*]perylene	1.9	1.4	3.2	2.4	0.38	1.0

+, Detectable but not quantifiable; –, Nondetected.

definitive when concentrations were too low relative to the background. The GC/MS/MS technique improved the sensitivity by a factor of about 10 for the masses investigated, providing more definitive confirmation for the presence or absence of some of these PACs. Using this technique, Roofing Sample A and Paving Samples 1 and 4 were further investigated. Results show good agreement with the MS data both qualitatively and quantitatively and are shown in Table 7.

CONCLUSIONS

Recovery of 29 environmentally relevant polycyclic aromatic compounds from leachate waters is excellent using traditional liquid/liquid extraction (Method SW 846-3510C), with trace levels of naphthalene and phenanthrene in 3 of 10 samples. None of the compounds on the EPCRA section 313 list showed evidence of leachability from the asphalts tested. None of the roofing asphalts tested leached any of the 29 compounds. The two paving asphalts that do contain detectable levels of naphthalene and phenanthrene are well below drinking water limits. Determination of these compounds in the raw asphalt is, as expected, much more challenging. All three extraction procedures yielded similar recoveries, however the DMSO extraction (Method C) provides the least interferences in the analysis of these 29 PAC compounds. The analytical method described here for the nontraditional list of these PACs works well to provide quantitative recoveries of these higher-molecular-weight compounds. GC/MS/MS analyses provided verification of some compounds that were too low to obtain a confirmatory mass spectrum.

FUTURE RESEARCH

Although none of the EPCRA section 313 compounds appear to be leached from asphalt, literature findings show release of some of these PACs at extremely low levels during the application of hot mix asphalt (18). Collection of data for these same compounds within asphalt fumes from field applications is a key component to their environmental release requiring additional study.

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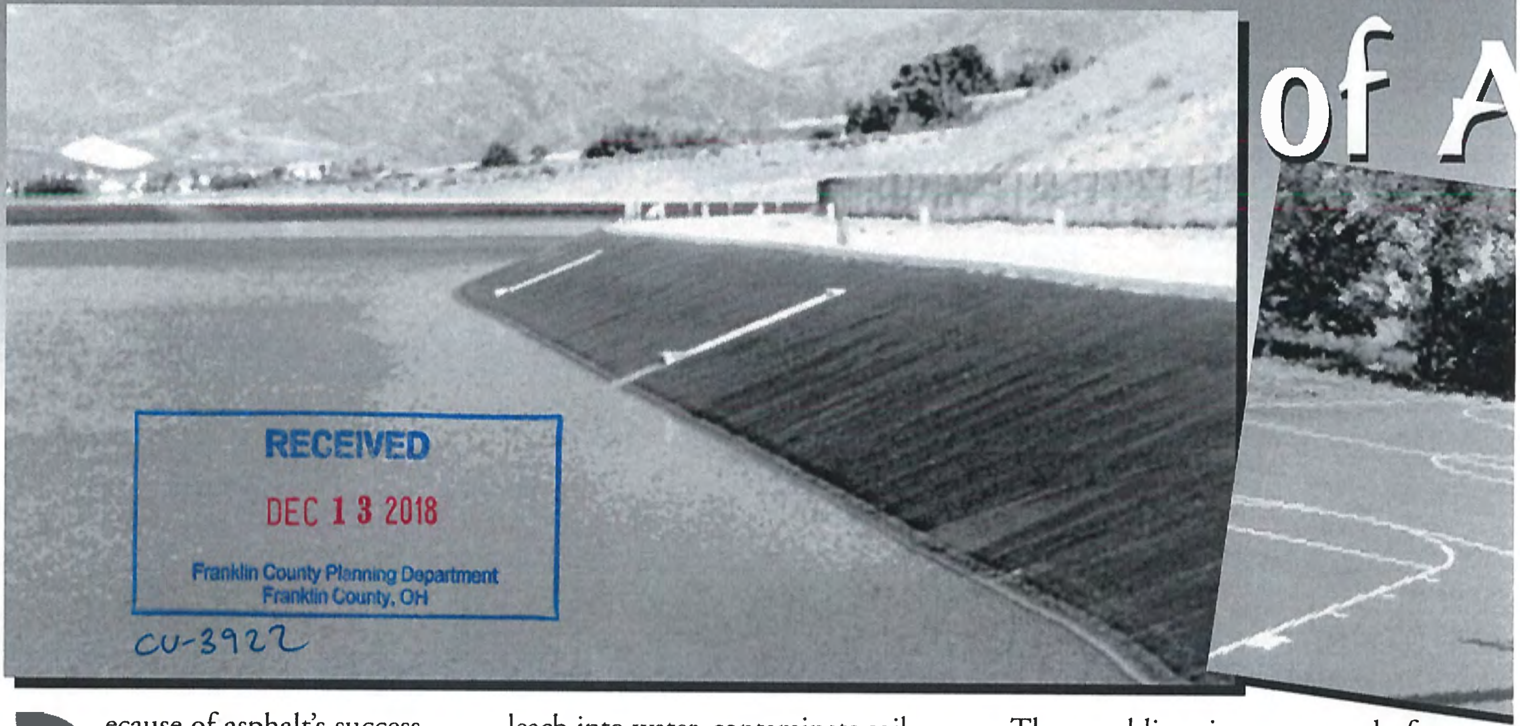

CU-3922

Because of asphalt's success as a highway paving material, we can easily lose sight that it is also a wonderfully versatile material. It has many diverse applications and can be adapted to a variety of environmental and recreational settings.

For decades, many civil engineering solutions to environmentally sensitive projects have incorporated asphalt. It has been used because it is flexible, strong, chemically stable and nonreactive, impermeable—or permeable—as needed, recyclable, economical and readily available. It has been used to encapsulate landfills, line drinking water reservoirs, canals and fish hatcheries, and to reduce traffic noise.

Contrary to fears by some environmental groups, scientists have established that asphalt, in the form of an emulsion or incorporated into a mixture with aggregates, does not leach into water, contaminate soil or kill fish. The results of tests for leachability of new hot mix asphalt (HMA) show very low levels of leachable compounds—well below any current Environmental Protection Agency guidelines. Scientists have proved that asphalt is an environmentally safe material.

In addition to its environmental applications, asphalt has many recreational uses. Playgrounds, golf-cart paths and NASCAR tracks are other recreational facilities that take advantage of asphalt's versatility.

Fish Hatcheries

There are more than 35 asphalt-lined fish hatchery ponds in Oregon and Washington. These ponds are used to raise fingerling fish until they are large enough to release. A typical Washington hatchery pond is five to seven feet deep and covers about a half-acre. The pond liner is constructed of two or three inches of HMA over eight inches of aggregate base. Most liner surfaces are sealed with an asphalt emulsion so that bacteria cannot inhabit the tiny surface irregularities in the HMA mat.

Water Reservoir Liners

California has more than 20 asphalt-lined water reservoirs. The design of a reservoir liner must address permeability, durability, flexibility, resistance to weathering, the ability to absorb stresses during filling and draw-down cycles, and long-term loading stresses caused by settlement in the supporting subgrade.

The composite liners required for large drinking water reservoirs are typically designed using both dense-graded and open-graded HMA. Dense-graded mixes are used to provide an impermeable barrier. Open-graded interlayers are used in the

Recreational Uses
sphalt

liner structure to monitor and intercept any leakage that may occur.

Landfill Caps
HMA can be used to protect the environment by providing impermeable caps for abandoned landfills and pads for storing hazardous or waste materials. These caps or pads typically consist of hydraulic (impermeable) asphalt, paving fabric and aggregate base. Many of the caps are designed to support haul traffic.

Tacoma, Washington, covered three acres of its landfill for use as a solid waste processing station. The cap consisted of 12 inches of sand to cover the refuse, a high density polyethylene membrane, then 12 inches more sand to protect the membrane from construction equipment. An 8-inch layer of dense-graded aggregate was placed over the sand and topped with 3 inches of HMA.

Noise Mitigation
Management of roadway noise is becoming an increasingly important part of Departments of Transportation's roadway administration. A number of states have addressed complaints about traffic-generated noise. The standard remedy of installing noise walls is expensive and often ineffective. The walls only lessen sound in a line-of-sight path and can actually increase noise if sounds echo off the walls.

Selection of the proper type of asphalt mix for the surface course can reduce the noise level by 3 to 6 decibels. For more on noise reduction, see page 18.

Recreational Uses
Because of its adaptability, asphalt fits into many recreational uses. Its smooth surface offers obvious advantages for tennis and basketball courts and running tracks. Its ease of construction and contour-conforming nature is well suited for bike and golf-cart paths. Professional baseball and football fields are using drainable asphalt mixes as an underlying course for turf playing fields. See the article on HMA racetracks on page 14.

Recyclable, too
In addition to its use in environmental and recreational applications, asphalt is completely recyclable. Reclaimed asphalt pavement (RAP) can be used as an ingredient in hot mix asphalt or it can be used as a foundation material. As RAP, it saves asphalt, aggregate and fuel resources. As a bedding material, RAP substitutes for clean fill or granular material.

Because of its compatibility with the earth, asphalt pavement will continue to be a friend of the environment. Its adaptability, recyclability and economy make it a desirable choice. ▲

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CU-3922

LEACHABILITY OF ASPHALT AND CONCRETE PAVEMENTS

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CONTENTS

0. INTRODUCTION

The IAPA (Illinois Asphalt Pavement Association) contracted with Heritage Research Group to study the leachability of both Portland Cement Concrete (PCC) and Hot Mix Asphalt Pavements (HMA). Granular materials, including soil from the edge of each pavement type, were also tested to determine leachability. The design of this experiment was through the joint cooperation of the Illinois Environmental Protection Agency, Illinois Department of Transportation and IAPA. The purpose of the study was to determine the suitability of using concrete, asphalt, or soils from the surrounding roadway for use as clean fill. The concern is that the incidental spills onto the road from cars and trucks could contaminate the pavement and surrounding road side, and make these road materials unsuitable for use in clean fill situations below the water table. Specifically, unsubstituted Polynuclear Aromatic Hydrocarbons (PAH's) and heavy metals were studied. These were chosen because volatile and semi-volatile compounds, which may be spilled on the road, evaporate quickly. Previous studies by Heritage Research Group[1,2] have not found these compounds present. Only the metals and high molecular weight organic compounds tend to remain.

1.0 SITE LOCATIONS

The Illinois Department of Transportation located a section of pavement on Route #4 south of Springfield. The unique feature of the pavement section was that it contained Portland Cement Concrete, which was built in 1976 and a Hot Mix Asphalt pavement, which abuts this section and was also built at the same time. Because these sections are contiguous, the traffic on each are identical. Three sites were randomly selected in each pavement type, as to longitudinal location. Coring occurred on December 17, 1991 by IDOT District personnel. Once a site was selected, three four inch specimens were taken across the pavement. The first is between the wheel paths, the second was in the outer wheel path, and the third was taken outside the outer wheel path. A sample of soil and granular material was also taken from the shoulder of the road. The sample identification and locations are listed in Figure A. The "W" proceeding the numbers indicates white (PCC) pavements and "B" indicates black (HMA) pavements.

Heritage Research also received some laboratory prepared samples from IDOT laboratories. Sample W-0 is a Portland Cement Concrete laboratory cylinder and is considered typical of Portland Cement Concrete by IDOT. Sample B-0 is a Hot Mix Asphalt sample prepared by IDOT and the compositional mix design is also considered typical by IDOT. These samples were used as controls and are free of any potential contamination, which the road samples may have received since they were placed in 1976.

2.0 SAMPLE PREPARATION

To prepare the sample for Toxic Characteristics Leachability Procedure (TCLP) in accordance with EPA guidelines, the samples were crushed to pass the 9.5 mm. sieve size. An impact crusher was used to reduce the samples to below this size.

Representative materials from each sample location were combined with other samples sites to test various hypothesis about pavement contamination. The first was that contamination may be greater between the wheel path, because this is where crankcase drippings tend to fall. To test this theory, all samples from between the wheel path were combined for each pavement type to make one sample. A second hypothesis was that the samples taken from the wheel path would be cleaner, because the tires are constantly wearing this pavement away. This idea was tested by combining all samples in the wheel path for each pavement. Samples outside the wheel path were also combined to make a sample to determine if there was a similar trend in the data. The soil samples from the shoulder were also combined to determine if the soil was higher or lower than the pavement in leachability. Finally, one transverse sample was taken from one location of each pavement type and compared to longitudinal samples to test for site specific contamination. All of these combined samples were compared to the laboratory samples of each pavement type, which had been prepared in the laboratory as a control. Table A lists the combination of sites used to make each sample for TCLP testing.

3.0 METHODS

After the combined samples were prepared by Heritage Research, they were submitted to EMS Heritage Laboratories for TCLP testing. EMS Heritage is an EPA certified laboratory. The test methods used are listed below.

Contents

Test	Method/Procedure
TCLP Procedure	SW-846-1311
PAH's	SW-846-8310
Metals	
Barium	SW-846-7080
Cadmium	SW-846-7130
Chromium	SE-846-7190
Lead	SW-846-7420
Silver Arsenic	SW-846-7760
Selenium	SW-846-7740
Mercury	SW-846-7470

4.0 SAMPLE ANALYSES

A summary of the test results from the TCLP are listed in Table B for the Portland Cement Concrete Pavement and soil located next to this pavement type. Table C lists the leachability of Hot Mix Asphalt samples and soil corresponding to this pavement.

Please note that PAH's are measured in ?g/L, which is parts per billion. The metal leachability is in mg/L or parts per million. The detection limit of the barium analyses varied with the sample. Because of high calcium in the leachate of some samples, the detection levels varied from 0.2 to 2.0. Matrix effects do impact on the detection level achievable in these samples.

5.0 COMMENTS

5.1 Both the PCC and HMA laboratory prepared samples from IDOT had measurable amounts of metals leaching, but no measurable PAH's. The PCC sample indicated a small amount of leachable chrome. The HMA had measurable barium in the leachate.

5.2 Samples taken in the PCC section, whether taken longitudinally or transversely, showed trace amounts of naphthalene and phenanthrene in two samples. Both samples contained material from site W-3, so it could be the same contaminant. Four samples contained a small amount of Naphthalene. These values were, in all cases, less than one part per billion. One sample from the wheel path had measurable barium on the leachate.

5.3 The soil samples taken from the PCC shoulder produced no leachable PAH's. However, a measurable (3.5 ppm.) level of barium was found.

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5.4 The HMA pavement appeared quite similar to the PCC pavement in leachate results. Only naphthalene and phenanthrene were found in the pavement leachate. In all cases, the level was under one part per billion. Metal leachate was confined to barium, which was present in both the laboratory and field samples. This would indicate that barium is not coming from contamination, but rather is most likely coming from the aggregate in the mixture. These values would probably be lower if the sample was not crushed, which exposes the uncoated aggregate surfaces and increasing the exposed surface area greatly.

5.5 The soil from the HMA shoulder also contained a measurable level (0.76 parts per billion) of naphthalene. Since the laboratory samples did not have measurable levels, it is possible that this came from surface contamination. Used crankcase oils and tire composition contains measurable quantities of both naphthalene and phenanthrene, and could be potential sources for these very low, but measurable values.

5.6 The hypothesis that contamination would be greater between the wheel paths than at other location was not supported by these results. Overall, the level of leachable PAH materials was too low to determine trends in the data.

6.0 CONCLUSIONS

This study found that both PCC and HMA pavements each have very low levels of leachable metals and PAH materials. The relative low levels of leachable materials from both pavement types are quite similar. Soils from the shoulder of the road are quite similar in characteristics to the PCC and HMA pavements.

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TABLE A

Sample Identification

Sample #	Sample Identification	Description
1	W-0	PCC Uncontaminated, Laboratory Specimen
2	W-1, 2, 3	PCC Transverse Across the Pavement
3	W-1, 5, 9	PCC Between Wheel Path, Longitudinal Sample
4	W-2, 6, 10	PCC In Wheel Path, Longitudinal Sample
5	W-3, 7, 11	PCC Outside Wheel Path, Longitudinal Sample
6	W-4, 8, 12	PCC Soil from Shoulder, Longitudinal Sample
7	B-0	HMA Uncontaminated, Laboratory Specimen
8	B-1, 2, 3	HMA Transverse Across the Pavement
9	B-1, 5, 9	HMA Between Wheel Path, Longitudinal Sample
10	B-2, 6, 10	HMA In Wheel Path, Longitudinal Sample
11	B-3, 7, 11	HMA Outside Wheel Path, Longitudinal Sample
12	B-4, 8, 12	HMA Soil from Shoulder, Longitudinal Sample

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TABLE B

Illinois TCLP Test Results for Portland Cement Concrete Cores

Sample Number	**1 (Control)**	**2**	**3**	**4**	**5**	**6 (Soil)**	**--**
Site Number	**W-0**	**W-1,2,3**	**W-1,3,9**	**W-2,6,10**	**W-3,7,11**	**W-4,8.12**	**Heritage Det. Limit**
PAH's, µ/L							
Naphthalene	BDL	0.44	0.21	0.23	0.26	BDL	0.16
Acenaphthylene	BDL	BDL	BDL	BDL	BDL	BDL	0.25
Acenaphthene	BDL	BDL	BDL	BDL	BDL	BDL	0.16
Fluorene	BDL	BDL	BDL	BDL	BDL	BDL	0.019
Phenanthrene	BDL	0.44	BDL	BDL	0.26	BDL	0.16
Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	0.021
Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	0.021
Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	0.075
Benzo(A)Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	0.013
Chrysene	BDL	BDL	BDL	BDL	BDL	BDL	0.041
Benzo(B)Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	0.029
Benzo(K)Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	0.013
Benzo(A)Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	0.023
Dibenzo(A,H)Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	0.085
Benzo(G,H,I)Perylene	BDL	BDL	BDL	BDL	BDL	BDL	0.14
Indeno(1,2,3-cd)Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	0.028
Metals, mg/L							
Barium	BDL	BDL	BDL	1.2*	BDL	3.5	2.000
Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	0.020
Chromium	0.072	BDL	BDL	BDL	BDL	BDL	0.050
Lead	BDL	BDL	BDL	BDL	BDL	BDL	0.200
Silver	BDL	BDL	BDL	BDL	BDL	BDL	0.040
Arsenic	BDL	BDL	BDL	BDL	BDL	BDL	0.005
Selenium	BDL	BDL	BDL	BDL	BDL	BDL	0.010
Mercury	BDL	BDL	BDL	BDL	BDL	BDL	0.005

- This sample had a detection limit for barium of 0.2.

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TABLE C

Illinois TCLP Test Results for Portland Cement Concrete Cores

Sample Number	**7 (Control)**	**8**	**9**	**10**	**11**	**12 (Soil)**	**--**
Site Number	**B-0**	**B-1,2,3**	**B-1,3,9**	**B-2,6,10**	**B-3,7,11**	**B-4,8.12**	**Heritage Det. Limit**
PAH's, μ/L							
Naphthalene	BDL	0.26	0.26	0.31	0.28	0.76	0.16
Acenaphthylene	BDL	BDL	BDL	BDL	BDL	BDL	0.25
Acenaphthene	BDL	BDL	BDL	BDL	BDL	BDL	0.16
Fluorene	BDL	BDL	BDL	BDL	BDL	BDL	0.019
Phenanthrene	BDL	BDL	BDL	0.30	BDL	BDL	0.16
Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	0.021
Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	0.021
Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	0.075
Benzo(A) nthracene	BDL	BDL	BDL	BDL	BDL	BDL	0.013
Chrysene	BDL	BDL	BDL	BDL	BDL	BDL	0.041
Benzo(B) Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	0.029
Benzo(K) Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	0.013
Benzo(A)Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	0.023
Dibenzo(A,H) Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	0.085
Benzo(G,H,I)Peryle	BDL	BDL	BDL	BDL	BDL	BDL	0.14
Indeno(1,2,3-cd) Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	0.028
Metals, mg/L							
Barium	2.9	3.7	BDL	3.1	2.6	3.5	2.000
Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	0.020
Chromium	BDL	BDL	BDL	BDL	BDL	BDL	0.050
Lead	BDL	BDL	BDL	BDL	BDL	BDL	0.200
Silver	BDL	BDL	BDL	BDL	BDL	BDL	0.040
Arsenic	BDL	BDL	BDL	BDL	BDL	BDL	0.005
Selenium	BDL	BDL	BDL	BDL	BDL	BDL	0.010
Mercury	BDL	BDL	BDL	BDL	BDL	BDL	0.005

Contents

LEACHING CHARACTERISTICS OF ASPHALT ROAD WASTE

June 1998

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Leaching Characteristics of Asphalt Road Waste

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LIST OF ACRONYMS AND UNITS OF MEASUREMENT

BDL	Below Detection Limit
COD	Chemical Oxidation Demand
DI	Deionized Water
EPA	Environmental Protection Agency
FDEP	Florida Department of Transportation
FDOT	Florida Department of Transportation
FL/AA	Flame Atomic Absorption
GC/MS	Gas Chromatography/Mass Spectrophotometry
GF/AA	Graphite Furnace Atomic Absorption
HMA	Hot Mix Asphalt
ITD	Ion Trap Detector
mg/L	milligrams per liter
NPOC	Non-Purgeable Organic Carbon
PAH	Polycyclic Aromatic Hydrocarbons
RCRA	Resource Conservation Recovery Act
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
µg/L	micrograms per liter
VOC	Volatile Organic Compounds

KEYWORDS

Asphalt

Leachate

Reclaimed Asphalt Pavement (RAP)

Polycyclic Aromatic Hydrocarbons (PAHs)

Leaching Columns

Synthetic Precipitation Leaching Procedure (SPLP)

Toxicity Characteristic Leaching Procedure (TCLP)

Batch Test

ABSTRACT

The construction and expansion of asphalt roadways result in the production of a large amount of asphalt road waste also known as reclaimed asphalt pavement (RAP). A major fraction of this RAP is recycled by incorporation into a new asphalt mixture. However, some of this material may remain as a solid waste and require disposal or reuse in some other form. One proposed alternative for the management of RAP is in the use as fill material, in applications such as embankments or construction fill. One limitation to using RAP as fill material stems from the unknown risks of pollutants leaching from the waste to the environment.

Data regarding the composition of leachate from RAP is limited. It has been suggested that chemical compounds such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals might be present in RAP and therefore leach from RAP. This might occur as a result of the chemical composition of asphalt and from contamination occurring from vehicle traffic on the roadway. An investigation was performed to address concerns associated with leaching of chemicals from RAP under simulated environmental conditions. Such an investigation also provides valuable information regarding possible environmental impacts associated with leaching of pollutants from large stockpiles of RAP.

A series of leaching tests were performed at both batch-scale and in leaching columns. This study focused on leachable pollutants and did not attempt to characterize the total concentration of pollutants in the RAP. The primary chemicals investigated were volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals. The results of the TCLP tests performed indicated that the RAP tested was not a hazardous waste. None of the compounds analyzed for were detected in the SPLP leachate. Based on existing waste management policy in Florida, the SPLP results indicated that RAP of the nature tested in this study would result in exceedances of groundwater guidance concentrations for the pollutants studied. In the column study, lead was detected in amounts slightly above the groundwater guidance concentration but decreased over time. One unsaturated column and three saturated columns (two sites) exceeded the 15 ppb groundwater guidance concentration. All but one column dropped to below 1 ppb by the end of the study.

The differences in lead concentrations observed in the batch study and column study were a result of the much greater solid-to-liquid ratio in the columns. It is standard practice to apply a dilution factor to actual leachate concentrations such as those from column tests (dilution is assumed to already occur in batch tests). Using typical dilution factors for land-applied waste, even the greatest concentration of lead measured in the leachate would be lower than the groundwater guidance concentration. Lead was observed at the greatest concentrations in the oldest RAP samples. This indicated that the lead was not a result of the aggregate or asphalt cement, but rather a result of vehicle traffic and emissions. The results of this research project indicated that RAP of the nature examined in this study poses minimal risk to groundwater as a result of pollutant leaching under normal land disposal or beneficial reuse scenarios. Conditions of possible concern would be RAP used in saturated environments where little dilution occurred.

EXECUTIVE SUMMARY

OBJECTIVES

Approximately 2.5 million miles of paved roads currently exist in the United States (NAPA, 1997). Due to daily wear and tear, roadway expansion, and construction related activities, these roadways sometimes need to be removed or repaired. During reconstruction or removal of a road surface, reclaimed asphalt pavement (RAP) is commonly obtained by milling or removing the existing pavement. RAP is typically recycled back into new hot mix asphalt, but in some instances all of it can not be re-used. A proposed alternative for the management of RAP is use as fill material. One limitation to using RAP as fill material stems from a lack of knowledge regarding possible environmental impacts of RAP.

Two different types of environmental concerns relate to leaching of pollutants from RAP. The first is the leachate produced when rainfall infiltrates RAP stockpiles. These RAP stockpiles can range in size up to 2000 yd^3. Concerns have been expressed that the leachate produced could potentially be contaminated with trace amounts of hazardous chemicals, namely organic compounds or heavy metals. These chemicals could be the result of accidental spills onto the roadway from vehicles or possibly due to the virgin material used to make asphalt. A second environmental concern is the use of RAP as fill material. RAP used as fill material could potentially leach off contaminants when rainfall infiltrates the waste (an unsaturated condition). In some instances the RAP may be proposed to be used as fill below the water table (a saturated condition). In both situations, the leachate produced could potentially be contaminated with trace amounts of hazardous chemicals, such as organic compounds and heavy metals.

This project was conducted to address some of the environmental concerns expressed by regulators and others related to the leaching of pollutants from asphalt road waste, primarily RAP. A series of leaching tests were performed at both batch-scale and in leaching columns. The primary chemicals investigated were volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals. While it is generally recognized that RAP does not present a great risk to human health or the environment, a better characterization of the amount and type of chemicals that leach in the environment helps provide a better means to correctly manage this material.

ORGANIZATION OF REPORT

This research report is organized as follows: Chapter one provides a brief overview of the issues surrounding RAP and its potential environmental impacts. Chapter two reviews the relevant literature pertaining to asphalt road waste and its impact on the environment. This chapter also gives a background of different asphalt materials. Chapter three presents the experimental methodology for the study. Chapter four presents and discusses the results of the leaching studies. The final chapter discusses the results and provides conclusions.

METHODOLOGY

In light of the environmental concerns about RAP, a project involving a series of leaching tests was performed at the University of Florida Solid and Hazardous Waste Laboratory. The first step included collection of six RAP samples throughout the state of Florida. After sample collection, the FDOT bituminous laboratory physically characterized the RAP samples. Then a series of leaching tests were performed on the RAP samples. The first tests were typical batch-leaching tests including the TCLP, SPLP, and DI leaching procedure. The second test was a column leaching test performed to simulate a more realistic environmental condition. Leachate samples obtained from the batch experiments and column experiments were analyzed for the same parameters. The primary chemicals investigated were volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals. The total concentrations of pollutants in the RAP were not measured.

RESULTS AND DISCUSSION

Batch tests were performed on all six RAP samples. In the leachate generated during the TCLP batch test, measurements of volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals all were below detection limit (BDL) and below any applicable TCLP limits. The RAP samples evaluated were therefore not a hazardous waste. This result was expected, as the literature had demonstrated this.

Batch tests are also used by regulatory agencies to determine whether a waste presents a potential leaching threat to groundwater. Concentrations of pollutants from batch tests are usually compared directly to groundwater limits or guidance concentrations. TCLP test are sometimes used. The literature did present some TCLP results that were above applicable groundwater limits for some heavy metals (Kriech 1990, 1991, 1992). The TCLP test is a somewhat aggressive test that represents the conditions inside an anaerobic landfill. Less aggressive tests were therefore also conducted in this study (SPLP and deionized water). The SPLP is currently the method of choice for evaluating leaching from waste or contaminated soils in Florida when exposed to rainfall.

In all of the batch tests, measurements of VOCs, PAHs, and selected heavy metals (Ba, Ca, Cr, Cu, Pb, Ni, and Zn) all were below detection limit (BDL) and were below applicable regulatory groundwater guidance concentrations. This indicated that the RAP samples tested did not pose an undue risk (in regard to leaching of the pollutants tested) under current waste policy in Florida. No comparisons can be made regarding the effectiveness of each test to leach pollutants because no pollutants were measured.

Column (lysimeter) tests were then performed on the same six RAP samples. Column tests are not a prescribed test procedure by regulatory agencies. They were conducted in this case to investigate leachate production from RAP under more realistic environmental scenarios. Approximately 60 lbs of RAP material filled a three foot section of each column. Duplicate columns were subjected to saturated and unsaturated conditions. Column leachate samples were analyzed for the same parameters as the batch tests and continued for a total of 42 days. The columns did leach large concentrations of ions such as calcium, sodium, sulfate, fluoride, and carbonate as a result of mineral leaching from the aggregate used in the asphalt pavement manufacture. All VOC and PAH analytical results were similar to the batch test -- no compounds were detected. Leachate concentrations for selected heavy metals (Ba, Ca, Cr, Cu, Ni, and Zn) were always below detection limits (BDL). An exception was lead (Pb), which was detected.

Only one unsaturated lysimeter resulted in a leachate with a lead concentration above the groundwater guidance concentration (15 ppb). Leachate from the unsaturated lysimeter containing the Jacksonville sample had a lead concentration of approximately 24 ppb twelve days into the sampling period. The concentration of lead decreased over time and then leveled off well below the regulatory guidance concentrations. In the saturated columns, all columns had detectable concentrations of lead ranging from 5 ppb to 38 ppb. Three out of the six lysimeters (two sites) were above the regulatory guideline. The lysimeters decreased over time to lead concentrations below the guidance concentration (and the detection limit) except the Jacksonville sample. The Jacksonville sample concentration decreased slightly but was still above the guidance concentration at approximately 18 ppb.

The batch tests were more dilute than the column tests. This condition helps to explain why lead concentrations were observed in the column study but not in the batch test. In a real world situation, rainfall would ultimately dilute leachate produced from a stockpile before it reached the groundwater table or a nearby receiving body of water. This phenomenon is commonly referred to as dilution-attenuation. Attenuation models, used to determine the concentration of a pollutant in the groundwater resulting from waste piles and landfills, commonly use a dilution factor of 20 in their models. This dilution factor is accounted for in the batch test by the 20 to 1 liquid to solid ratio. In the column study, somewhat no dilution is involved. If the concentrations produced from the column studies were used as part of a groundwater dilution model, results would likely be below any regulatory guideline.

Lead was observed in the greatest concentrations in the oldest RAP samples. This indicated that the lead was not a result of the aggregate or asphalt cement, but rather a result of vehicle traffic and emissions. Lead has been used for many years in leaded gasoline and in crankcase oil. Since vehicle accidents and accidental spills contribute to this contamination, there is a possibility that this contamination was site specific. Previous studies regarding asphalt road waste also found trace amounts of lead in some circumstances. Since lead was encountered in greater concentrations in older samples, the source of lead was likely prolonged exposure to vehicle traffic and emissions. Under most reuse circumstances, even if lead were encountered at levels of the highest concentration measured in this study, the concentrations in the environment would be below acceptable regulatory levels for drinking water. Possible exceptions would be older RAP placed below the water table in areas with little or no dilution.

Most of the previous studies regarding RAP leaching were consistent with the results found in this study. Organic compounds do not leach from typical RAP under the conditions tested. Heavy metals are sometimes encountered. The literature indicated the presence of chromium, lead, and barium. Only lead was detected in this study and was ascribed to prolonged exposure to traffic and vehicle emissions. The literature often referred to chromium resulting from slag used as aggregate. It should be noted that the aggregate used in the asphalt samples collected for this study was assumed to be natural aggregate (e.g. limerock). If other materials -- especially waste materials such as slag, spent sandblast grit and ash -- are used as aggregate, the results gathered here may not be applicable. It should also be noted that fresh asphalt was not tested, nor were extremes in temperatures evaluated.

CHAPTER 1

INTRODUCTION

In 1870 Professor E.J. DeSmedt laid the first asphalt pavement in Newark, New Jersey. Ever since this time, roadways have undergone a continuous process of construction and reconstruction. Today, approximately 2.5 million miles of paved roads exist in the United States (Roberts et al., 1996). Of these roads, approximately 95% are paved with asphalt, typically in hot mix asphalt (HMA) form. Even though HMA is considered to be the most durable and longest lasting paving material on the market, there are times when the asphalt must be removed and repaired. Daily wear and tear, roadway expansion, and construction related activities are some of the major factors that necessitate roadway removal. During reconstruction or removal of a road surface, reclaimed asphalt pavement (RAP) is commonly obtained by milling or removing the existing pavement. For this study, reclaimed asphalt pavement (RAP) is defined as all asphalt road waste, large chunks or milled material, that has been size-reduced, making it reusable as part of a new asphalt mixture.

Reclaimed asphalt pavement has been successfully re-used and recycled for many years. It has been stated that, "the recycling of old pavements [RAP] into new pavements is the largest single recycling practice in the United States" (FHWATWG, 1997). The recycling of RAP has resulted in many beneficial effects including saving landfill space, conserving natural resources, and reducing costs of new asphalt mixtures. RAP is typically recycled back into new hot mix asphalt, but in some instances all of it can not be re-used. Typically the unused material remains on-site for long periods of time until re-use options develop or until landfilled in a permitted construction and demolition (C&D) waste landfill, which tends to be costly. Regulations governing C&D landfills have recently undergone revision at the state and federal level, resulting in stricter operational and monitoring requirements (FAC, 1998), and thus an increase in waste disposal fees.

Other proposed uses for the unused RAP have included roadbase material to stabilize dirt roads, pothole/rut filler, and roadway shoulder material. A proposed alternative for the management of RAP is use as fill material, whether by disposal in asphalt-only monofills or in beneficial reuse applications. Some states have classified asphalt road waste as clean fill (NAPA, 1998).

The Florida Department of Environmental Protection may consider provisions to categorize some waste materials as clean debris, typically less costly option than traditional landfilling. The Florida Administrative Code (FAC) states that "clean debris used as a fill material is not solid waste, and such use does not require a solid waste permit under this rule" (FAC, 1998). The limitation to using RAP as clean debris or fill material stems from the lack of knowledge related to the environmental impacts of RAP. There have been some concerns over the potential problems related to the unknown risks of pollutants leaching from this material to the environment (Binkley, 1994).

There are two different types of environmental concerns related to leaching of pollutants from RAP. The first is the leachate produced when rainfall infiltrates the RAP stockpiles. These RAP stockpiles can range in size up to 2000 yd^3. There are concerns that the leachate produced may be contaminated with trace amounts of hazardous chemicals, primarily organic compounds or heavy metals. These chemicals could be the result of spills onto the roadway from vehicles or possibly due to the virgin material used to make asphalt. The second environmental concern is the use of RAP as fill material, either in a beneficial reuse option or simply as monofill disposal. RAP used as fill material could potentially leach off contaminants when rainfall infiltrates the waste in an unsaturated condition. In some instances the RAP material could be placed below the water table in a saturated condition. In both situations, the leachate produced could potentially be contaminated with trace amounts of hazardous chemicals, namely organic compounds or heavy metals.

This project was conducted to address some of the environmental concerns expressed by regulators and others related to the leaching of pollutants from asphalt road waste, primarily RAP. The study focused on leachable pollutants and did not attempt to characterize the total concentration of pollutants present in the RAP. A series of leaching tests were performed at both batch-scale and in leaching columns. The primary chemicals investigated were volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals. While it is generally recognized that RAP does not present a great risk to human health or the environment, a better characterization of the amount and type of chemicals that leach in the environment will help provide a better means to correctly manage this material.

This report is organized into five chapters. Chapter two of this report presents a review of the relevant literature pertaining to asphalt road waste and its impact on the environment. Chapter three presents the experimental methodology for the study. Chapter four presents and discusses the results of the leaching studies. The results are discussed and conclusions are provided in the final chapter.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a general background about asphalt and discusses existing literature related to reclaimed asphalt pavement (RAP) and its environmental impact. The first section provides a description of asphalt. The next section describes how asphalt concrete is manufactured and how roads are constructed. The third section gives an overview of asphalt concrete removal and recycling. The fourth section discusses alternate uses for asphalt. The fifth section discusses potential environmental impacts of RAP. The final section reviews existing studies related to asphalt, typically RAP.

2.2 DESCRIPTION OF ASPHALT

Asphalt is a natural component of nearly all types of petroleum found in nature (Asphalt Institute, 1989). By refining crude petroleum, various components can be separated and recovered, including asphalt. Asphalt has physical and chemical properties that make it of great interest to many engineers. It is a strong cement, extremely durable, readily adhesive, highly waterproof, and considered to be chemically inert. Asphalt is highly resistant to the reaction of many acids, alkalis, and salts. Asphalt is a viscoelastic substance that imparts both controllable elasticity and viscous flow to mixtures of aggregates with which it is commonly combined. Asphalt for pavement construction is called asphalt cement.

Asphalt cement is often added to aggregate to make asphalt concrete for construction of asphalt pavements for highways and parking lots. When these asphalt pavements are removed from a road surface, the by-product is commonly called reclaimed asphalt pavement (RAP). RAP consists of ground up asphalt pavement. For this study, RAP is defined as all asphalt road waste, large chunks or milled material, that has been size-reduced, making it reusable as part of a new asphalt mixture.

2.3 ASPHALT PRODUCTION AND ROADWAY CONSTRUCTION

Detailed descriptions of asphalt production and roadway construction have been presented elsewhere (NAPA, 1997), but a general overview is presented here. The most typical type of asphalt mixture produced is hot mix asphalt (HMA). HMA is generally a combination of 95% aggregate (rock, gravel, sand, or stone) and 5% asphalt cement. These percentages can change according to the specifications of the road being constructed. A typical site layout of a hot mix asphalt facility is shown in Figure 2.1.

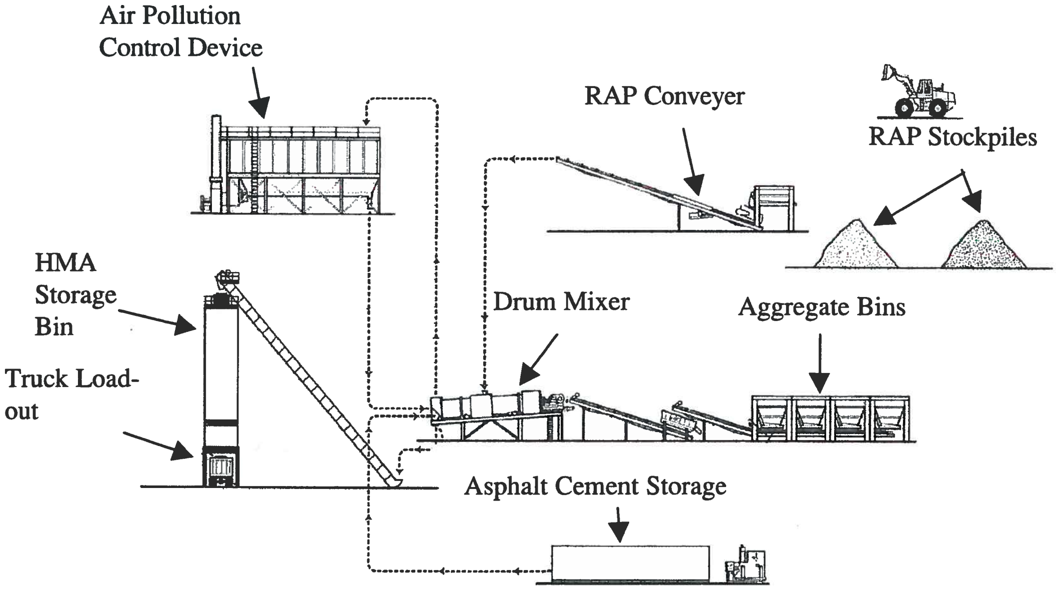


Figure 2.1 Typical Site Layout of a HMA Plant (Adapted from EPA, 1997)

Once the amounts of aggregate and asphalt cement are determined, the manufacturing of HMA is a rather simple process. The asphalt cement is heated and then mixed with the appropriate aggregate at a hot mix asphalt facility. Once the material is mixed, it is stored on site and then loaded into hauling trucks and transported to the paving site. When the truck reaches the site, it is a matter of minutes before the HMA is used. Waiting paving machines, with hoppers at the front end, are loaded with the HMA. The paving machine evenly spreads the asphalt mixture on the road while a vibratory roller follows behind and uniformly compacts the material. This entire process takes place in a matter of minutes. Since the temperature of HMA drops rapidly, it must be compacted to its specific density before the temperature drops below 175 degrees F. Once the road has been laid down and compacted, traffic is generally allowed to drive on the new asphalt.

2.4 ASPHALT REMOVAL AND RECYCLING

Hot mix asphalt is considered to be the one of the most durable and longest lasting paving materials on the market. As a result of daily wear and tear, roadway expansion, and construction related activities, there are times that roadways have to be rehabilitated or removed. This process is accomplished in two different ways. The typical method of choice for rehabilitation is the use of an excavation device known as a roadway milling machine or roadmiller.

A road miller has several hundred rotating steel/carbide teeth that scrape off a desired depth of the existing road surface. A typical road milling operation is shown in Figure 2.2. Depending on the type of machine and material in the pavement, asphalt road waste is produced with a maximum particle size of approximately ¾ to ½ inches. The milled material is conveyed directly to an awaiting dump truck for transport back to the asphalt plant and re-used in a new asphalt mixture. This milled material is what this report commonly refers to as reclaimed asphalt pavement (RAP).

Figure 2.2 Typical Roadway Excavation Process

If a project is small or a roadway area is inaccessible by a road miller, the road will be excavated with a front-end loader or backhoe. This process tends to produce large chunks of asphalt. According to this project's definition of RAP, this material is not considered as reclaimed asphalt pavement until the large pieces are taken back to an asphalt plant and crushed into an appropriate size to be re-used in a new asphalt mixture.

2.4.1 Uses of Recycled RAP

One hundred percent of RAP is recyclable unless otherwise contaminated with debris. RAP is typically recycled back into new hot mix asphalt, but in some instances not all of it can be re-used. It has been estimated that approximately 90% of all RAP in the state of Florida is recycled back into new asphalt mixtures (Musselman, 1998). The procedure for recycling RAP into a new asphalt concrete mixture is simple. Once the road surface is milled, the RAP is transported back to the asphalt facility and re-crushed to a specific size needed for the new mixture's specifications. RAP may make up to 25% by weight of the total asphalt mixture. It is mixed with additional virgin aggregate and heated asphalt cement. The mixture is re-mixed and ready to be placed down as a new road (NAPA, 1997).

During the Strategic Highway Research Program (SHRP) in 1992, a new method of mix design came about. This new mix design is known as "Superpave" (SUperior PERforming Asphalt PAVEments). Superpave was developed to produce asphalt pavements that could withstand temperature extremes and increased traffic loads. Material selection was very important with "Superpave" mixes. As a result, the amount of RAP allotted for recycling back into a new asphalt mixture decreased (FHWA, 1997). This change in RAP allocation was small, but this in turn decreased the amount of RAP material recycled at any given time. This has caused the size of RAP stockpiles to increase, but for the most part the unused RAP is recycled back into new mixtures at later times.

Other uses for the unused RAP have included the following: roadbase material for stabilizing dirt roads, pothole/rut filler, and roadway shoulder material. A proposed alternative for the management of RAP is use as fill material, whether by disposal in asphalt-only monofills or in beneficial reuse applications as clean fill. According to the National Asphalt Pavement Association (1998) "many states have tested discarded asphalt pavement and determined that it should be categorized as clean fill." The characteristics of a material that determines its status as clean fill are discussed in a future section.

2.4.2 Recycling Benefits

Recycling of RAP has both environmental and economical benefits. Environmentally, recycling of RAP saves natural resources and landfill space. Economically, recycling of RAP saves the asphalt facility owner money. In comparison to the use of virgin material, a cost saving of 25% can be achieved when RAP is recycled. It is not only the aggregate that saves the money, but the amount of asphalt cement obtained from the RAP. If RAP is not recycled, it must be disposed of in a construction and demolition (C&D) landfill which requires hauling costs and tipping fees. In 1994, it was estimated that recycling of RAP saved taxpayers in the U.S. over $300 million a year (NAPA, 1997).

2.5 OTHER USES FOR ASPHALT

The common use for asphalt has been in asphalt concrete mixtures but there are several different applications in which asphalt has been used. Asphalt paving mixtures have been used to line fish hatcheries and industrial retention ponds. They have also been used as liners for water reservoirs. Asphalt cement has been used to line potable water lines and also to make shingles. Other uses for asphalt have been as a landfill liner and landfill cap. Detailed descriptions of alternate uses of asphalt have been presented elsewhere (NAPA, 1998).

2.6 POTENTIAL ENVIRONMENTAL IMPACTS OF RAP

In the past, there have been some environmental concerns regarding asphalt cement plants. These concerns dealt with the emissions produced at the plant, mainly gaseous and aerosol organic compounds and combustion products (EPA, 1997). The management and disposal of RAP has recently raised other environmental concerns.

A study performed in 1994 by Dr. Robert Livingston from Florida State University has resulted in some of these environmental concerns. Dr. Livingston performed studies on lake sediments near asphalt roads and highways in Leon County. He tested for polycyclic aromatic hydrocarbons (PAHs), a compound commonly found in vehicle exhaust, lubricating oils, gasoline, and asphalt. Dr. Livingston found elevated concentrations of these PAHs in several of the lake sediment samples collected. His results suggested that this contamination was due to pollution runoff. Heavy roadway traffic caused the asphalt pavement to loosen and then the elevated temperatures of Florida caused these PAHs to "boil out" of the asphalt (Livingston and McGlynn, 1994).

From this study, an article was published in the Wall Street Journal, Florida Journal titled "Heat, Rain Draw Asphalt Poisons Into Florida's Lakes, Study Shows" (Binkley, 1994). It was stated in this article that "Florida's hot, wet climate aids the release of cancer-causing toxins from asphalt into the environment." As a result of this study and the ensuing article, the number of people with environmental concerns related to asphalt materials, including RAP, increased.

There are two different types of environmental concerns related specifically to the leaching of pollutants from RAP. The first is the leachate produced when rainfall infiltrates RAP stockpiles. The major concern is that the leachate produced could potentially be contaminated with trace amounts of hazardous chemicals. The second environmental concern is the use of RAP material as fill material, either in a beneficial reuse scenario or in a monofill disposal situation. RAP used as fill material could potentially leach off contaminants when rainfall infiltrates the waste in an unsaturated condition. In some instances the RAP material could be placed below the water table in a saturated condition. In both situations, the leachate produced could potentially be contaminated with trace amounts of hazardous chemicals, namely organic compounds or heavy metals.

The major chemicals raised as a concern are Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals. "It has long been recognized that motor vehicles are an important source of metals and other contaminants [PAHs] to the environment" (Hewitt and Rashed, 1991). These hazardous chemicals may be the result of accidental spills onto the roadway from vehicles or possibly due to the virgin material used to make the RAP. Asphalt cement is a petroleum-derived material, and thus is composed of organic chemicals. Most volatile organic compounds and other semi-volatile compounds are not likely to be a major concern because they tend to evaporate over time when spilled on the roadway, or they are not likely to be present at all.

2.6.1 Description of Heavy Metals

Heavy metals are often cited as a concern when dealing with materials from roadways. Vehicle wear, fuel emissions, and fuel leakage could all result in contamination with heavy metals. In the case of lead (Pb), it is well documented that vehicular emissions cause contamination of roadside soils (Harrison and Wilson, 1981). Lead could result from leaded gasoline spills or from crankcase drippings. Other metals such as barium and chromium could result from a lubrication additive or from crankcase drippings. These heavy metals could remain on the roadway surface or be washed off in surface runoff.

Because of this heavy metal contamination, there is a concern that these heavy metals might be present in RAP. Table 2.1 presents a list of the TCLP (Toxicity Characteristic Leaching Procedure) metals under RCRA. These metals represent the more commonly evaluated heavy metals in regard to environmental contamination. The TCLP test will be discussed in a future chapter.

Table 2.1 TCLP Metals

Parameter
Barium
Cadmium
Chromium
Lead
Silver
Arsenic
Selenium
Mercury

2.6.2 Description of Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) are a group of chemicals formed primarily during the incomplete burning of coal, oil and gas, or other organic substances. It has been reported that sources of PAHs have included vehicle exhaust, weathered material from asphalt roads, lubricating oils, gasoline, diesel fuel, and tire particles (Takada et al., 1990). PAHs are also present throughout the environment in the air, water, and soil. In the environment, one is exposed to PAH vapors or PAHs that are attached to dust and other particles in the air. There are more than 100 different PAH compounds. The EPA has characterized 16 PAHs as priority pollutants and these are listed in Table 2.2.

The U.S. Department of Health and Human Services has determined that many PAHs may be considered carcinogenic (ATSDR, 1990). Several of the PAHs have caused tumors in laboratory animals upon ingestion, when applied to skin, or when inhaled. Reports in humans have demonstrated that exposure to PAHs for long periods has been associated with cancer.

Since PAHs are among the highest molecular weight group of organic compounds and asphalt has a high molecular weight, there is a concern that these compounds may be present in RAP. While it is generally recognized that RAP materials do not present a great risk to human health or the environment, a better characterization of the amount and type of chemicals that leach in the environment will help provide a better means to correctly manage this material.

Table 2.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Parameter
Naphthalene
Acenaphthylene
Acenaphthene
Fluorine
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benz(A)Anthracene
Chrysene
Benzo(B)Fluoranthene
Benzo(K)Fluoranthene
Benzo(A)Pyrene
Dibenzo(A,H)Anthracene
Benzo(G,H,I)Perylene
Indeno(1,2,3-CD)Pyrene

2.6.3 RAP Used as Clean Fill

A proposed alternative for the management of RAP is use as fill material, whether by disposal in asphalt-only monofills or beneficial reuse. The state of Florida states that "clean [fill] may be used as fill material in any area, including waters of the State" (F.A.C., 1997). Clean fill is defined as "any solid waste which is virtually inert, which is not a pollution threat to ground water or surface waters, is not a fire hazard, and is likely to retain its physical and chemical structure under expected conditions of disposal or use" (F.A.C., 1997). Many states have already determined that asphalt road waste should be classified as clean fill (NAPA, 1998).

The determination of whether something is "clean" can be a difficult process. It depends on the intended disposition of the material, the possible pathways of risk, and appropriate environmental agency's regulations and policies. This issue is an ongoing and evolving process. In most cases, two major pathways of risk are considered. The first is direct exposure to humans through inhalation, ingestion, or dermal contact. The second is leaching to groundwater. In some cases, the risk to ecosystems may be considered.

The study reported here focused on the leaching risk resulting from RAP. Direct exposure was not addressed. There were a number of reasons for this. First, the issue of leaching has been the primary concern expressed in the literature and was the issue solicited in the request for proposals for this research project. Second, RAP management practices where direct exposure would be a great concern are few. RAP stockpiles at HMA facilities are restricted, and concern of direct exposure at these facilities by workers is much more likely to be targeted toward air emissions from HMA operation. RAP would not tend to be used as fill material in the same nature as soil, which most of the direct exposure limits or guidelines are developed for. It is not a material with soil-like characteristics amenable to a human child digging or playing in. Most RAP particle sizes are much larger than soil. In construction, RAP would typically be used as structural fill below a layer of topsoil or other dirt. The scenario where RAP would be most likely in contact with humans is where the material was used as a surface material for a road, driveway or parking lot. It should be noted that this practice is already common in Florida.

Another issue complicating the analysis of RAP for the total concentration of pollutants is the fact that asphalt cement is an organic chemical. Typical environmental analyses for organic pollutants in solid waste or contaminated soil utilize an organic solvent to extract the pollutant from the waste or soil particles. Such organic solvents would simply dissolve the asphalt cement and its great variety of organic compounds. Asphalt is an organic, petroleum-derived material.

This study therefore addresses leaching concerns. If a scenario existed where direct exposure was a concern, different testing may be required by the regulatory agency. Under most current waste management policies, the evaluation of leaching risk is performed by determining the concentration of a pollutant that would occur in the groundwater after leaching from a waste, and comparing that concentration to the applicable groundwater guidance concentration. This can be done in a number of ways. The theoretical leachate concentration resulting from a total concentration present in the waste may be calculated, and a dilution factor applied. This was the process used to develop the soil clean up target levels for leaching currently used by Florida. A batch test such as TCLP or SPLP may be used to create a leachate, and the concentrations of pollutants in the leachate can be measured. A dilution factor is *not* applied in this case because dilution already occurs in the test. Finally, actual leachate can be produced using a test cell or a leaching column and applying an appropriate dilution factor.

As will be described in the following chapter, both batch leaching tests (TCLP and SPLP) and column tests were conducted on the RAP samples evaluated here.

2.7 LEACHING STUDIES

This section reviews existing literature regarding leaching from asphalt and reclaimed asphalt pavement (RAP). Two main types of studies were encountered in the literature. The first was the typical TCLP leaching test performed on different types of asphalt material. The TCLP test is a batch leaching prescribed by the EPA to determine whether a solid waste is hazardous by toxicity characteristic and will be discussed in a future chapter. The second type were field studies performed to test leachate contamination from stockpiled asphalt materials.

The first experiment discussed is a TCLP leaching test performed on a new hot asphalt mixture. The next project discussed is a TCLP leaching test performed on six RAP samples. The third study discussed is a TCLP leaching test performed on Portland cement concrete and hot mix asphalt core samples taken from the same section of a road. The fourth investigation discussed is a field leaching test performed on a RAP stockpile. The final study discussed is a laboratory investigation conducted on slabs of asphalt pavement to simulate the release of hydrocarbons from the surface of asphalt pavements during a rainstorm.

2.7.1 Evaluation of Hot Mix Asphalt for Leachability

The purpose of this research was to determine what materials, if any, could leach from a new asphalt mixture (Kriech, 1990). This helped to evaluate whether or not the virgin material was initially contaminated and was also used as a control sample to test other RAP materials.

A #11 asphalt surface mixture was prepared and then tested for TCLP (Toxic Characteristic Leachability Procedure) by EPA method SW846-1311. The leachate produced from the TCLP testing procedures was then tested for the following: metals, VOCs, and Semi-VOCs, including PAHs.

The metals tested for were those heavy metals commonly tested by the EPA. All results were BDL (Below Detection Limit) except that of chromium. The results are summarized in Table 2.3. Chromium was measured at 0.1 mg/l. This was 50 times below the level considered hazardous by characteristic under RCRA (Resource Conservation Recovery Act). Since asphalt does not normally contain chromium compounds, it was ascertained that the chromium came from the slag material used as aggregate. The slag was a by-product of steel making. Slag and other waste materials are sometimes used as aggregate in some parts of the U.S..

Table 2.3 TCLP Metals

Parameter	Result (mg/L)	Detection limit (mg/L)
Barium	BDL	2.00
Cadmium	BDL	.020
Chromium	0.10	.010
Lead	BDL	.200
Silver	BDL	.040
Arsenic	BDL	.005
Selenium	BDL	.005
Mercury	BDL	.005

Using the TCLP zero head space extraction (ZHE) method, VOCs were tested for and all results were BDL. Semivolatile organic compounds were also tested for and results were BDL. PAHs are also a part of the semivolatile organic compounds, but are a concern of their own. All PAHs tested for were BDL except that of naphthalene. Naphthalene was detected at 0.25 µg/L but was still well below the regulatory guideline of 7.5 µg/L. Table 2.4 lists the PAH compounds of interest and results.

Table 2.4 Polycyclic Aromatic Hydrocarbons (PAHs)

Parameter	Result, (µg/L)	Detection limit (µg/L)
Naphthalene	.25	.096
Acenaphthylene	BDL	.150
Acenaphthene	BDL	.194
Fluorine	BDL	.023
Phenanthrene	BDL	.033
Anthracene	BDL	.015
Fluoranthene	BDL	.037
Pyrene	BDL	.040
Benz(A)Anthracene	BDL	.048
Chrysene	BDL	.017
Benzo(B)Fluoranthene	BDL	.020
Benzo(K)Fluoranthene	BDL	.022
Benzo(A)Pyrene	BDL	.023
Dibenzo(A,H)Anthracene	BDL	.018
Benzo(G,H,I)Perylene	BDL	.036
Indeno(1,2,3-CD)Pyrene	BDL	.021

Based on this study, it was concluded that the new #11 asphalt mixture produced very low levels of leachable compounds under TCLP conditions. All levels were well below any guidelines and regulatory standards.

2.7.2 Evaluation of RAP for use as a Clean Fill

The Heritage Research Group was contracted by the Illinois Asphalt Pavement Association (IAPA) to evaluate six RAP samples for their potential use as a clean fill material (Kriech, 1991). IAPA discussed that in certain situations, RAP is unsuitable for recycling back into a new asphalt mixture and could be used on-site for clean fill. The purpose of this study was to determine if RAP contained materials making it environmentally unsuitable for use as clean fill.

Six RAP samples were taken from different locations throughout the state of Illinois. These samples were analyzed in two parts. Physical tests were performed on each sample that included asphalt content, gradation, and Abson Recovery (physical properties of the recovered asphalt cement). The environmental testing consisted of Toxicity Characteristic Leaching Procedure (TCLP) for each RAP sample and a Polychlorinated Biphenyls (PCBs) test on the RAP samples prior to leaching. The leachate produced from the TCLP testing procedure was then analyzed for the following constituents: metals, VOCs, and PAHs.

The metals tested for were those heavy metals commonly tested by the EPA under RCRA and can be found in Table 2.5. Results were BDL (Below Detection Limit) except for three samples (2,3,4). These results are summarized in Table 2.5. Barium was present in all three samples but was 200 to 300 times below the maximum concentration of contamination for TCLP under RCRA (100 mg/L). Barium was also below national drinking water standards (2 mg/L). Chromium and lead were also present in sample #2. They were both below the maximum concentration of contamination for TCLP under RCRA (5 mg/L and 5 mg/L respectively), but did not meet drinking water standards (0.1 mg/L and 0.015 mg/L respectively). Since sample #1 and sample #2 were both taken from the same project but at different sites, it was concluded that contamination possibly occurred on the surface from a vehicle. Lead contamination could have resulted from leaded gasoline or from crankcase oil. Chromium could have resulted from the wearing metal on vehicles or could have been in the slag aggregate (a by-product of steel making) used to make the asphalt.

Table 2.5 TCLP Metals

Parameter	Sample #1, (mg/L)	Sample #2, (mg/L)	Sample #3, (mg/L)	Sample #4, (mg/L)	Sample #5, (mg/L)	Sample #6, (mg/L)	Detection limit (mg/L)
Barium	BDL	.400	.360	.330	BDL	BDL	2.00
Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	.020
Chromium	BDL	.520	BDL	BDL	BDL	BDL	.050
Lead	BDL	1.80	BDL	BDL	BDL	BDL	.200
Silver	BDL	BDL	BDL	BDL	BDL	BDL	.040
Arsenic	BDL	BDL	BDL	BDL	BDL	BDL	.005
Selenium	BDL	BDL	BDL	BDL	BDL	BDL	.005
Mercury	BDL	BDL	BDL	BDL	BDL	BDL	.005

Polychlorinated Biphenyls (PCBs) were tested for and all results were BDL. Semivolatile organic compounds were also tested for and all results were BDL. Polycyclic Aromatic Hydrocarbons are a part of the semivolatile organic compounds, but are a concern of their own. Table 2.6 lists the PAH compounds of interest and results.

Table 2.6 Polycyclic Aromatic Hydrocarbons (PAHs)

Parameter	Sample #1, (µg/L)	Sample #2, (µg/L)	Sample #3, (µg/L)	Sample #4, (µg/L)	Sample #5, (µg/L)	Sample #6, (µg/L)	Detection limit, (µg/L)
Naphthalene	.490	BDL	.490	.300	BDL	BDL	.130
Acenaphthylene	BDL	BDL	BDL	BDL	BDL	BDL	.200
Acenaphthene	.140	BDL	.140	BDL	BDL	BDL	.130
Fluorine	BDL	BDL	BDL	BDL	BDL	BDL	.015
Phenanthrene	BDL	BDL	BDL	BDL	BDL	BDL	.130
Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	.017
Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	.017
Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	.060
Benz(A)Anthracene	BDL	BDL	BDL	BDL	.017	BDL	.017
Chrysene	BDL	BDL	BDL	BDL	BDL	BDL	.033
Benzo(B)Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	.023
Benzo(K)Fluoranthene	BDL	BDL	BDL	BDL	.050	BDL	.017
Benzo(A)Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	.240
Dibenzo(A,H) Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	.068
Benzo(G,H,I)Perylene	BDL	BDL	BDL	BDL	BDL	BDL	.110
Indeno(1,2,3-CD) Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	.022

Conclusions reached by the authors from this study were that all of the samples met current guidelines for maximum concentration of contamination for TCLP under RCRA. The migration of metals was greatly impaired by the matrix of the asphalt and aggregate. The contamination encountered could possibly have been spread by vehicles through fluid spills, accidents, and general wear and tear on a vehicle. The researchers concluded that reclaimed asphalt pavement (RAP) should give no concern if used as a clean fill material.

2.7.3 Leachability of Asphalt and Concrete Pavements

The purpose of this study was to determine if the use of concrete, asphalt, or soils from the surrounding roadway would be appropriate for use as a clean fill (Kriech, 1992). The major concern was that accidental spills onto the road surface from vehicles could contaminate the pavement and the surrounding road site. This possible contamination could make the material unsuitable for use in clean fill applications below the water table. The compounds of interest were the PAHs and heavy metals. These were chosen because volatile and semi-volatile compounds spilled onto the roadway would evaporate quickly.

The Illinois Department of Transportation (IDOT) located a segment of roadway that contained a Portland Cement concrete section joined by a hot mix asphalt (HMA) section. Both sections were built at the same time and traffic on each was identical. Three sites were randomly selected from each pavement and three 4-inch core samples were taken longitudinally from each. The first sample was taken between the wheel path of the vehicles, the second was in the outer wheel path, and the third was outside the outer wheel path. A soil sample was also taken of the shoulder roadway. Laboratory prepared samples of Portland Cement concrete and hot mix asphalt were also tested. These samples had compositional mixtures considered typical by the IDOT and were used as control samples.

To test different hypothesis about pavement contamination, representative samples from each sample location were combined with other sample sites. The first hypothesis was that contamination would be greater between the wheel path due to crankcase drippings. Thus all samples taken between the wheel path were combined into one sample. The second hypothesis was that all samples taken from the wheel path would be cleaner due to the constant wear on the pavement. Thus all samples taken from the wheel path were combined into one sample. Samples outside the wheel path were also combined, as were the soil samples.

The samples were prepared and then tested for TCLP (Toxic Characteristic Leachibility Procedure) by EPA method SW846-1311. The leachate produced from the TCLP testing procedure was then tested for selected metals and PAHs.

The laboratory prepared samples both had measurable amounts of metals, but no measurable amounts of PAHs. Small amounts of chromium (0.072 mg/L) were detected in the laboratory concrete sample and barium (2.9 mg/L) in the laboratory HMA sample. Two of the concrete samples had trace amounts of phenanthrene detected while four samples had trace amounts of naphthalene detected. Barium was detected at 1.2 mg/L in one of the concrete samples while the soil sample had a concentration of 3.5 mg/L.

The leachate results for the HMA samples appeared quite similar to the Portland Concrete cement leachate results. One of the HMA samples had trace amounts of phenanthrene detected while four samples had trace amounts of naphthalene detected. Barium was detected in three of the HMA samples as well as the control sample and soil sample.

The hypothesis that contamination would be greater between the wheel paths was not supported by the results. Overall the PAH concentrations were too low to determine any trends. Conclusions from this study were that all of the samples met current guidelines for maximum concentration of contamination for TCLP under RCRA. Both the Portland Concrete cement and HMA samples had relatively low concentrations of leachable metals and PAHs. The levels for both are quite similar to that of the soil samples and laboratory control samples.

2.7.4 An Investigation of Water Quality in Runoff from Stockpiles of SalvagedConcrete and Bituminous Paving

The purpose of this study was to determine the quality of runoff water from salvaged pavement stockpiles (Sadecki et al., 1996). The Minnesota Department of Transportation (MN/DOT) performed test on three stockpiles: coarse concrete material, fine concrete material and reclaimed asphalt pavement (RAP). Discussion will only be about the RAP stockpile.

A pile of RAP was placed on top of a plastic liner open to the environment. The liner was an impermeable barrier that allowed the leachate produced to be collected. Leachate was automatically collected by a catch basin and periodically collected and tested. The site layout is shown in Figure 2.3. The Minnesota Department of Health Laboratory, using US EPA approved methods, analyzed the leachate samples. Some physical tests were performed including: pH, conductivity, turbidity, total solids, total dissolved solids, and alkalinity. The leachate collected was also tested for metals and PAHs.

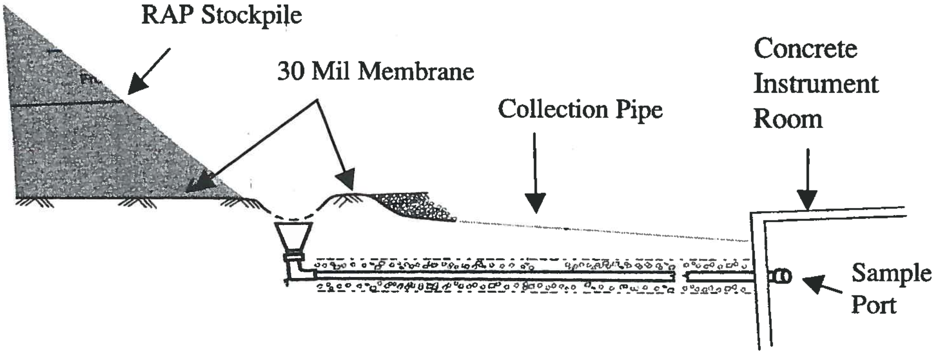


Figure 2.3 Site Layout of Experimental RAP Pile (Sadecki et al., 1996)

The primary concerns encountered in the leachate from the RAP material reduced to solids, pH, and chromium. In some instances, the dissolved solids were detected at levels higher than the secondary drinking water standards. The sediments washing from a pile could potentially cause erosion problems by forming deltas and reducing the depth of an aquatic habitat. The median pH value of the RAP material (8.1) exceeded the Minnesota standard of 8.0 for surface water quality suitable for fishing and recreation. Chromium also exceeded the standards for surface waters. It was concluded that chromium could have resulted from the wearing metal on vehicles or could have been in the slag aggregate (a by-product of steel making) used to make asphalt. PAHs are always a concern when dealing with RAP because of the possible carcinogenic effect it might have. PAH concentrations from the RAP material were nearly at or below detection limits.

The results of this study were used to assist the state, county, and city engineers in choosing storage sites for the stockpiles. It was concluded that careful planning for RAP stockpiles should include management practices of controlling runoff similar to those used for construction sites (berms, straw bales, grass or other filter channels, etc.). There could be possible impacts to the ground water system if stockpiles were located in areas sensitive to pollution. It was suggested that future studies are needed to assist in these problems.

2.7.5 The Geochemical Cycling of Hydrocarbons in Lake Jackson, Florida

The purpose of this study was to identify and quantify hydrocarbons in Lake Jackson (Byrne, 1980). As part of this study, a separate experiment was performed in the lab to simulate stormwater runoff from asphalt pavement. Discussion will only be about this laboratory experiment.

The investigation began by preparing four asphalt sheets (36 cm^2). Two were used as control blanks and the other two had three milliliters of used crankcase oil added to each. The asphalt sheets were then allowed to dry for five days. They asphalt sheets were then rinsed with deionized water to simulate rainfall runoff conditions. Figure 2.4 illustrates the experimental setup. Tests were performed to simulate summer and winter-like conditions. Six samples were collected over a five-hour period and then analyzed for total dissolved petroleum hydrocarbons.

Results for this experiment are presented in Table 2.7. In the winter simulation sample, the initial runoff was higher than that of the control. It was ascertained that this might have indicated "oil bleed" into the initial runoff. All other sample times resulted in hydrocarbon concentration less than the control. In the summer simulation sample, five out of the six samples resulted in higher concentration than the control. It was concluded that there was a possibility of organics being leached from asphalt during an extended period of time. It was also suggested that an increase in temperature during summer months could also result in an increase in hydrocarbons released into stormwater runoff.

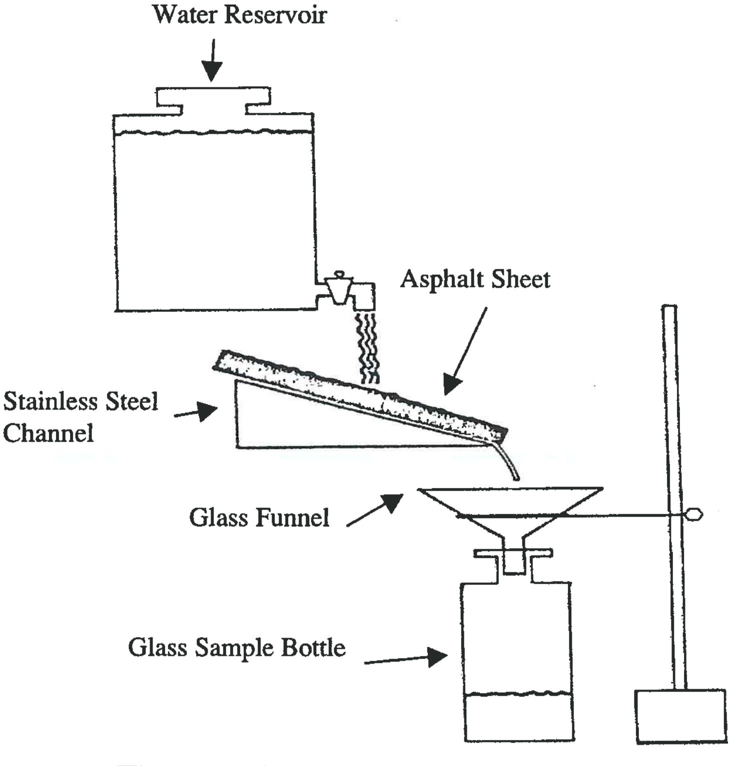


Figure 2.4 Experimental Setup (Byrne, 1980)

Table 2.7 Total Dissolved Petroleum Hydrocarbons

Time (hrs)	Winter Control (µg/l)	Winter Sample (µg/l)	Summer Control (µg/l)	Summer Sample (µg/l)
0	28	38	9	18
.5	16	11	4	10
1	16	11	29	13
2	35	23	6	7
3	13	10	2	9
5	35	13	6	10

2.7.6 Synopsis of Literature Studies

A few chemicals were observed to leach from asphalt road waste. The primary chemicals encountered were the heavy metals lead, chromium, and barium. The asphalt tested by TCLP was never found to be hazardous. Some concentrations in the TCLP leachate were greater than drinking water standards. The TCLP test is an aggressive test designed to simulate the interior of an anaerobic landfill. Other leaching tests are likely more suitable to measure actual leaching in non-landfilled environments.

CHAPTER 3

METHODOLOGY

The methodology for this project involved collecting reclaimed asphalt pavement (RAP) samples from different facilities around the state of Florida, physically characterizing the material, performing a series of leaching tests on the samples, and measuring the concentrations of various chemical constituents that leached off the material. Field sampling was performed according to FDEP standard operating procedures and laboratory analysis was conducted according to EPA and Standard Methods methodology. Field sampling and laboratory analysis methodologies are both outlined in the University of Florida Environmental Engineering Sciences Solid and Hazardous Waste Research Program's Comprehensive Quality Assurance Plan (COMPQAP #960218).

3.1 SAMPLE SITES

The first task was to select six different RAP sources throughout the state of Florida. Emphasis was placed on collecting samples that could characterize the state as a whole. Four of the samples were collected from mixed source, crushed RAP stockpiles at hot mix asphalt plants. The crushed RAP piles were a combination of many different sources. The remaining two samples were collected from specific milling projects. Table 3.1 provides the sample location, sample date, and sample pile description. The sampling locations throughout the state are shown in Figure 3.1. This map shows that the farthest northwest sample collected came from I-10 in Suwannee County. No sample was collected from Northwest Florida because RAP was fairly scarce at the time of sampling. A RAP pile seemingly parallels population density—as population density increases, more construction activity occurs, thus generating more RAP piles (Warren, 1998). It should also be noted that the site-specific milled asphalt samples (I-10 and Indian Town Road) were not collected at the actual road site, but were collected from nearby hot mix asphalt plants where the RAP was hauled to.

Table 3.1 Sample Location, Sample Date, and Sample Pile Description

Facility/Sample Location	Date Sampled	Sample Pile Description
Miami	September 16, 1997	½" Crushed mixed source pile
Tampa	September 16, 1997	¾" Crushed mixed source pile
Jacksonville	October 2, 1997	¾" Crushed mixed source pile
Lake City	October 2, 1997	¾" Crushed mixed source pile
SR –8 (I-10)/ Suwannee County	October 2, 1997	½" Milled asphalt
Indian Town Road/ Palm Beach County	November 25, 1997	½" Milled asphalt

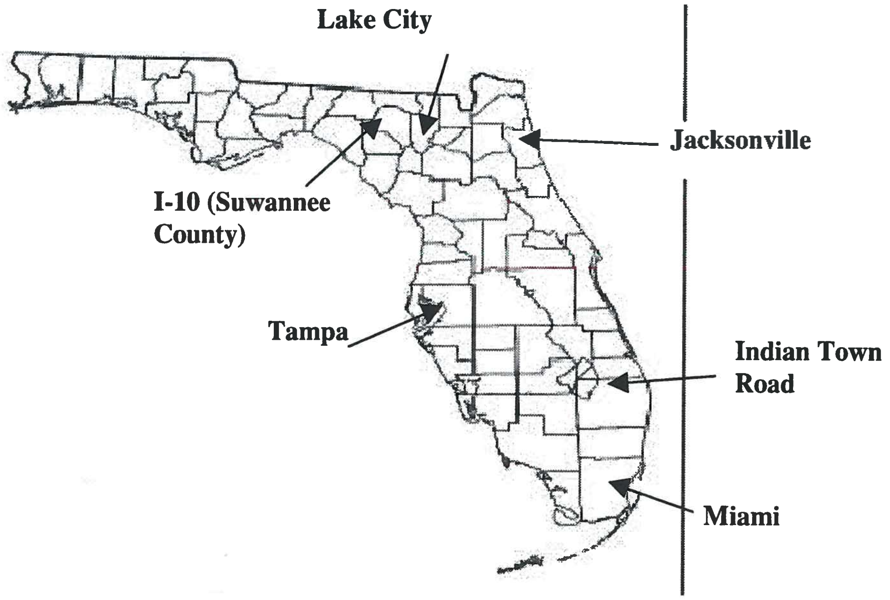


Figure 3.1 Sampling Locations throughout the State

3.2 SAMPLE COLLECTION

The main objective involved in collecting the RAP samples was to obtain a representative sample from a given source pile. All field sampling was performed according to FDEP standard operating procedures (FDEP, 1992). The field sampling methodology is outlined in the University of Florida Environmental Engineering Sciences Solid and Hazardous Waste Research Program's Comprehensive Quality Assurance Plan (COMPQAP #960218).

The following sampling routine was employed at every sampling site. Eight specific subsamples were removed from the interior of the RAP pile with on-site equipment such as a front-end loader. The interior of the pile was used to avoid surface material that had been exposed to the environment for an extended period of time. This may often result in a "crusting" of the surface. The subsamples were then placed on the ground in one large pile and mixed thoroughly together. The pile was then leveled to approximately one foot in height, thus providing more surface area to sample from.

Samples were collected in order of sensitivity: volatile organic compounds (VOCs), semivolatile organic compounds (Semi-VOCs), metals, and then bulk samples. The sample containers and equipment included: two 1-liter glass jars with Teflon-lined lids, four cloth sampling bags (those commonly used by the FDOT), non-powdered latex gloves, stainless steel spoons, an insulated ice chest, and ice. All sampling equipment was pre-cleaned and decontaminated prior to the sampling trip. This process was performed at the University of Florida Solid and Hazardous Waste Lab.

Using gloves and a stainless steel spoon, approximately 25 RAP subsamples were taken from random spots in the pile and placed into the 1-liter glass jars for VOC analysis. The procedure was repeated for Semi-VOCs and metals analysis. The four cloth bags were then filled with RAP samples from the same areas in which the 25 subsamples were taken. One bag was delivered to the FDOT State Materials Lab in Gainesville, Florida for physical characterization. The remaining three were collected for filling the leaching columns. All materials were stored in a cold room at 4 °C until analysis.

3.3 SAMPLE ANALYSIS

Sample analysis included physically characterizing the material, performing a series of leaching tests on the samples, and measuring the concentrations of various parameters that leached off the material. The leaching experiments included batch leaching as well as column leaching tests.

3.3.1 Physical Characterization

The RAP samples collected from each site were physically characterized at the FDOT State Materials Lab in Gainesville Florida by FDOT technicians. The analytical tests and testing methods are presented in Table 3.2.

Table 3.2 Analytical Tests and Methods for RAP Physical Characterization

Analytical Test	Method
Asphalt Content	Florida Methods FM-5-544, Quantitative Extraction of Bitumin from Bituminous Paving Mixtures by Use of a Non-chlorinated Solvent
Absolute Viscosity	Florida Methods FM-1-T202, Viscosities of Asphalt by Vacuum Capillary Viscometer
Gradation	Florida Methods F5-5-545, Mechanical Analysis of Aggregate Extracted by Use of a Non-chlorinated Solvent
Penetration	AASHTO 49-96, Penetration of Bituminous Material

An extraction procedure, which separated the asphalt cement from the aggregate, was the basis for determining the asphalt content (% asphalt) of the RAP samples. The purpose of the viscosity tests was to determine the flow characteristics of asphalt cement in a range of temperatures used during application. Gradation tests determined the relative particle size distribution of fine and coarse aggregates by use of a sieve analysis. The penetration test determined the relative hardness or consistency of the asphalt cement by measuring the distance that a standard needle penetrated vertically into the sample or asphalt under known conditions of temperature, loading, and time. These physical characterization tests were useful in assessing the condition and age of the milled asphalt samples.

3.3.2 Leaching Experiments

Two primary leaching methodologies were used: batch leaching and column leaching. The batch leaching tests consisted of three types: the toxicity characteristic leaching procedure (TCLP), the synthetic precipitation leaching procedure (SPLP), and a deionized water leaching procedure. The SPLP leaching solution was chosen for the column study because it was more representative of Florida rainfall and was a preferred choice by regulators for determining impacts of non-landfilled waste on groundwater. Leachate samples obtained from the batch experiments and column experiments were both analyzed for the same parameters. The analytical testing methods for the leaching experiments are presented in Table 3.3.

TABLE 3.3 Analytical Tests and Methods for Leaching Experiments

Analytical Test	Method
Toxicity Characteristic Leaching Procedure (TCLP)	SW846-1311
Synthetic Precipitation Leaching Procedure (SPLP)	SW846-1312
Deionized Water Leaching Procedure	-
Column Leaching Procedure	-

The TCLP test is the assay prescribed by the EPA to determine whether a solid waste is hazardous by toxicity characteristic. A solid sample is size-reduced to a particle size below 9.5 mm and added to a leaching solution at a 20-to-1 liquid-to-solid ratio. The leaching solution is an acetic-acid based solution, with a pH dependent on the buffering capacity of the waste. The TCLP leaching solution was designed to simulate anaerobic conditions within a landfill. The mixture is agitated for 18 hours in a rotary extractor, and then the leachate is filtered, preserved, and stored according to the parameter of interest.

Although the TCLP test is primarily used to determine hazardous characteristics, it is sometimes used to determine the impact of a waste on groundwater even when the waste is stored or disposed in nonlandfill conditions. A more suitable test for this scenario is SPLP. The SPLP assay uses a leaching solution that simulates acid rain. It is a preferred choice by many regulators for determining impacts of waste on groundwater. Other than the leaching solution, all other aspects of the test remain the same. A third leaching test using deionized water was performed to examine the impact of a non-aggressive solution.

Two main differences were prominent between the batch test and column test: the liquid-to-solid ratio and the testing time. The batch test consisted of a 100-gram sample combined with 2 liters of leaching solution. This resulted in a 20-to-1 liquid-to-solid ratio. For the unsaturated column leaching test, the columns contained 60 lbs of RAP with the addition of 1 liter of leaching solution. This resulted in a 0.0367-to-1 liquid-to-solid ratio. For the saturated leaching test, the columns contained the same 60 lbs of asphalt sample but with the addition of 7 liters of leaching solution. This resulted in a 0.257-to-1 liquid-to-solid ratio. The batch test had less solid sample in contact with the leaching solution than either of the column test conditions.

The other prominent difference between the two tests was the time of contact between the RAP and the leaching solution. The batch study was a one-cycle test with a continuous contact time of 18-hours. For the unsaturated columns, 1 liter of leaching solution was added over a 20-minute interval and allowed to travel through the RAP material. The columns were drained and samples were collected every two days and then the process was repeated. The contact time between the leaching solution and RAP sample was the amount of time needed to travel through 3 feet of RAP material. In the saturated columns, seven liters of leaching solution were added to the columns saturating the entire RAP sample. Since the columns were drained and samples taken every 14 days, the contact time between the leaching solution and the RAP material was 14 days. The two column scenarios allowed observation of simulated environmental conditions where RAP was either rained upon or saturated with water. It also allowed for observation of a possible "first-flush" scenario where leachate concentrations decrease over time. Comparisons of all testing parameters for the batch and column tests are presented in Table 3.4.

Table 3.4 Comparison of Testing Parameters for Batch and Column Test

	Batch	Column (Sat)	Column (Unsat)
Sample Mass	100 gram	60 lbs.	60 lbs.
Sample Size	< 9.5 mm	< ¾"	< ¾"
Leaching Solution Vol.	2 liters	7 liters	1 liter
Liquid:Solid Ratio	20:1	.257:1	.0367:1
Leaching Solution Contact Time	18 hrs	14 days	Unsaturated travel time through column
Samples Collected	1	Every 14 days	Every 2 days

3.3.3 Batch Experiments

The batch studies were conducted prior to the lysimeter experiment. The batch leaching tests consisted of the TCLP, SPLP, and DI leaching procedure. The procedure for all three tests was the same except for the addition of the appropriate leaching solution. The batch studies were performed on all six RAP samples with analysis of VOCs, PAHs, metals, and general water quality parameters.

To test for VOCs, a zero headspace method was used. Zero headspace extractors (ZHEs) were used to measure the leaching of volatile components of from the RAP samples. The procedure began by transferring the RAP sample collected for VOC analysis to a stainless steel bowl, and then size reducing the material to less than 9.5 mm. This was performed in a 4 °C cold room to minimize loss of VOCs. A 25-gram sample was then transferred to a stainless steel zero headspace extractor (ZHE). A 0.45µm glass-fiber filter, placed in between two stainless steel filters, was placed on top of the sample. The ZHE was sealed and a calibrated tool was used to force air out of the ZHE to achieve minimum headspace. Then, 500 ml of the appropriate leaching solution were added to the ZHE and then the vessel was rotated for 18(+/-2) hours. The ZHE method allowed for the VOCs present in the RAP sample (if any) to be leached to the liquid phase with minimal loss to the headspace (air phase). After rotation, samples were collected for VOC analysis using a glass syringe and then transferred to 40-ml glass vials. The samples were then analyzed on a GC/MS for VOCs of interest.

To test for PAHs and metals, a 2-liter extraction method was used. The procedure began by transferring the RAP sample collected for PAHs and metals analysis to a stainless steel bowl and then size reducing the material to less than 9.5 mm. This was performed in a 4 °C cold room to minimize loss of PAHs. A 100-gram sample was then transferred to a 2-liter glass jar. Two liters of the appropriate leaching solution were added and then the jar was sealed with Teflon tape and a Teflon lined lid. The sample container was rotated for 18(+/-2) hours. Following rotation, the liquid extract was filtered through a stainless steel pressure filter rotation device containing a 0.45-µm glass fiber-filter. The filter device was pre-rinsed with nitric acid and analyte free water prior to sample filtration. Samples were collected for analysis of metals, PAHs, and general water quality parameters.

3.3.4 Column Leaching Experiments (Lysimeters)

Column leaching tests were performed to simulate more realistic environmental condition. There were two environmental conditions simulated with this column study. A saturated condition in which the asphalt was completely submerged with the SPLP leaching solution was observed. This type of test helps to simulate scenarios where RAP might be used as a fill below the water table. An unsaturated condition in which the SPLP leaching solution was added in doses was also observed. This type of test helped to simulate environmental conditions in which rainfall occurred in daily doses. As mentioned above, the SPLP leaching solution was chosen for the column study because it was more representative of Florida rainfall and was a preferred choice by many regulators. While batch conditions were easier to perform, the column tests allowed for determination of effects such as "first-flush" (Harrison and Wilson, 1985). This effect occurs when contaminants are leached off when first exposed to leaching solution but diminish in concentration over time.

The testing apparatus consisted of sixteen stainless steel leaching columns (also known as lysimeters). Eight of the columns were used for the saturated condition and the other eight were used for the unsaturated condition. The lysimeters were constructed of 6" diameter Type 316 stainless steel, Teflon O-Rings, and Type 316 S.S. filter screens. The entire column apparatus is shown in Figure 3.2. A diagram of a lysimeter is provided in Figure 3.3.

The SPLP leaching solution was pumped from a 16-gallon Type 316 S.S. reservoir, through a flow meter, and then to the individual flow meters and columns. The pump (FMI Lab Pump, Model QD-Q2) was constructed of Type 316 S.S., Teflon, ceramic, and had a maximum flow rate of 1242 ml/min. The flow meters were constructed of Teflon, Type 316 S.S., and glass. Samples were collected from the bottom port through a Type 316 S.S. valve and Teflon tube. It is important to note that the entire apparatus was constructed of Type 316 S.S., Teflon, glass, or ceramic material.

FDEP sampling protocols suggest using these types of material when sampling for the parameters of interest in this study. This was performed to ensure the integrity of the results. There is currently no standard methodology for a column study, but the procedure followed was felt to meet the needs of this study.

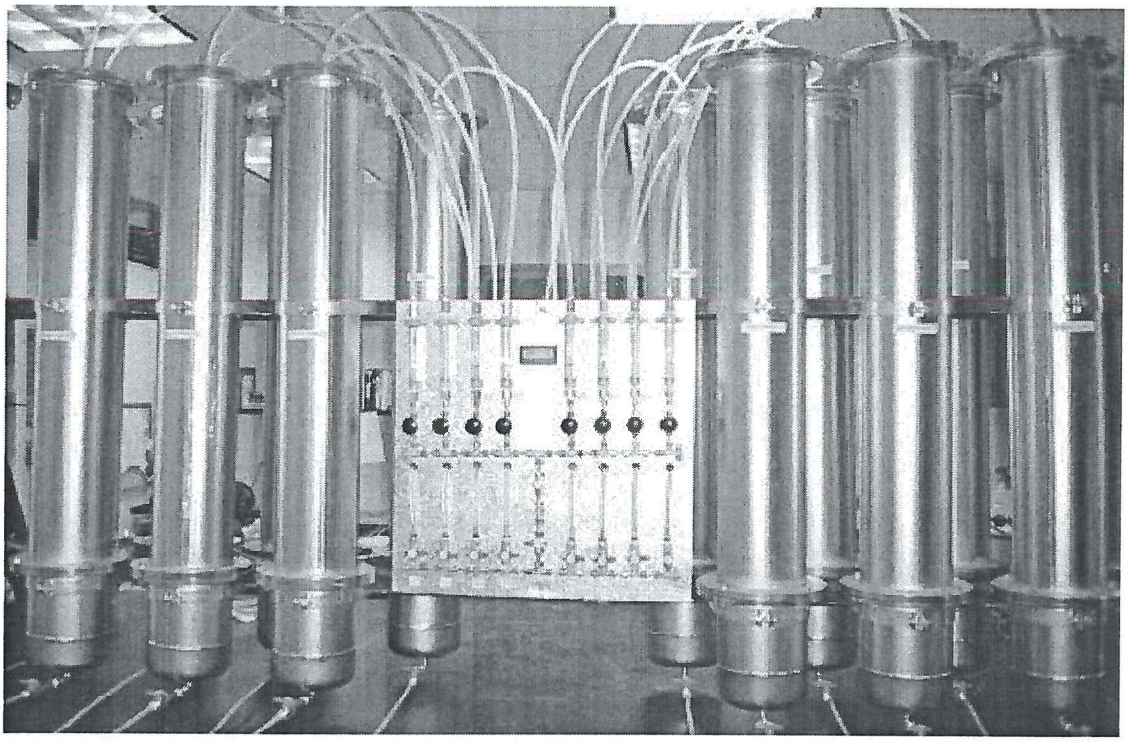


Figure 3.2 Column Leaching Apparatus

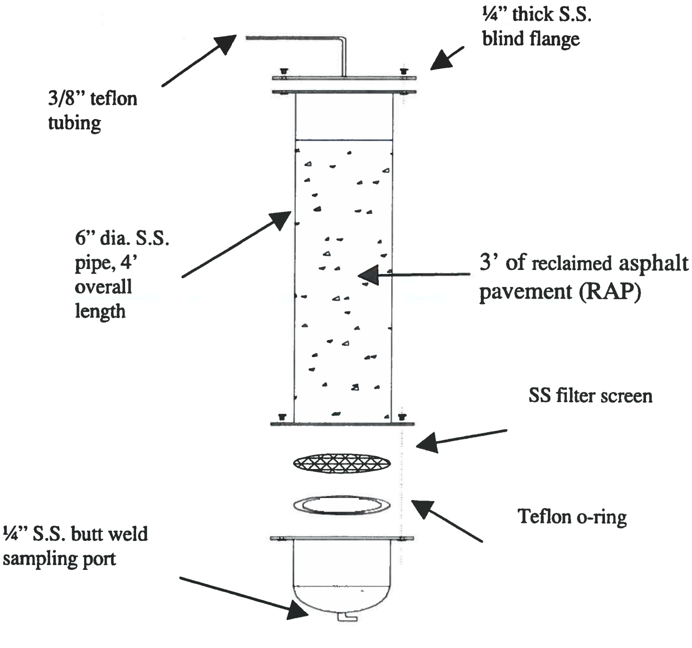


Figure 3.3 Typical Leaching Column (Lysimeter)

3.3.5 Sample Loading and Collection

Loading of the columns took place on December 14, 1997. The columns were pre-cleaned with deionized water and then rinsed with a dilute nitric acid solution. The columns were then rinsed again with deionized water and then pre-rinsed with SPLP leaching solution. The loading process began by placing a stainless steel filter screen at the bottom of the column. Approximately 6-inches of gravel was placed on top of the screen and then another stainless steel screen was placed on top of the gravel. The gravel and screen were cleaned, rinsed with nitric acid, and heated in an oven at 110 °C over night. The addition of the gravel allowed for the unsaturated leachate samples to remain separated from the RAP sample after draining to the bottom of the lysimeter. The stainless steel filter screen (#50) protected against infiltration of particles into the leachate samples.

The RAP samples were then loaded into the columns with approximately 3 feet of RAP material placed into each column. Three inches of fine sand were placed on top of the RAP to help distribute the leaching solution evenly through the column. The sand was pre-cleaned in the same manner as the gravel. It should be noted that a duplicate and control blank were also tested to ensure the integrity of the results. The RAP sample and corresponding lysimeter, sample mass, and bulk density are presented in Table 3.5.

Table 3.5 RAP Sample, Corresponding Lysimeter, and Sample Mass

Lysimeter #	RAP Sample	Sample Mass (lbs.)	Bulk Density (lb/ft^3)
Lysimeter 1	Miami	61.07	103.68
Lysimeter 2	Lake City	66.64	113.13
Lysimeter 3	Indian Town Road	63.33	107.51
Lysimeter 4	I-10 (Suwannee County)	59.51	101.03
Lysimeter 5	Tampa	64.83	110.06
Lysimeter 6	Jacksonville	65.91	111.89
Lysimeter 7	Indian Town Road Duplicate	63.06	107.05
Lysimeter 8	Control Blank	-	-

As discussed earlier, the synthetic precipitation leaching procedure (SPLP) solution was the leaching solution used for the column experiments. The saturated columns were the first columns to be filled with this solution. The SPLP solution was pumped to each column at a flow rate of approximately 500 ml per minute. The solution was allowed to saturate the RAP material and it filled the column to approximately 2 inches higher than the RAP material. It took approximately 7 liters of the SPLP solution to fill each column. This process was repeated every fourteen days after the columns were drained.

The unsaturated columns were dosed with the SPLP solution every two days. Over a fourteen-day period, the total volume of solution added to the unsaturated columns was equal to that of the total volume added to the saturated columns. Therefore, one liter of solution was added to each column every two days. The solution was pumped at a flow rate of 50 ml/min for twenty minutes (6.47 inches/hour). The reason for adding solution at this flow rate was to try and simulate an aggressive rain storm in Florida (4 to 6 inches/hour). The volume of solution added to each column every two days was also equivalent to 1.24 inches of rain per day.

Samples were collected every two days from the unsaturated columns and every fourteen days from the saturated columns. Samples were collected in order of sensitivity: volatile organic compounds (VOCs), semivolatiles organic compounds (Semi-VOCs), metals, and then preserved and unpreserved samples for general water quality parameter analysis. The sample containers and equipment included 40-ml glass vials, 1-liter glass jars, and 1-liter plastic jars.

3.4 LEACHATE ANALYSIS

The leachate collected was analyzed for the parameters listed in Table 3.6. Laboratory analysis was conducted according to EPA and Standard Methods (APHA, 1995) methodology for liquid aqueous samples. The cations measured included magnesium, sodium, potassium, and calcium. The anions measured included chloride, fluoride, nitrate, phosphate, and sulfate.

The pH is a measure of how acidic or basic the leachate is. Alkalinity is a measure of the ability of the leachate to neutralize hydrogen ions. Conductivity is a means to quickly gage the ionic concentration of a solution. TDS is a measure of all dissolved solids in solution, including the ions that promote conductivity. COD provides a good approximation of the amount of organic matter in the leachate (Ross, 1990). NPOC measures the amount of non-purgeable organic carbon in the leachate samples. DO measures the amount of dissolved oxygen in the leachate and can help indicate any dominant physiochemical processes that might occur in the system. ORP is a measure of the oxidation/reduction potential and helps assess whether the column is operating under reducing or oxidizing conditions.

Table 3.6 Analyzed Parameters

Analytical Test	Method
VOC Analysis	SW846-8260A
PAH Analysis	SW846-8270B
PAH Extraction	SW846-3510B
Metals Analysis	Pb-EPA 7420-21, Cr-7190-91, Zn-7950-51, Ba-7080A-81, Ca-7130-31A, Cu-7210-11, Ni-7520,
Metals Digestion (FLAA)	SW846-3010
Metals Digestion (GFAA)	SW846-3020
Alkalinity	Standard Method 2320
Anions	Standard Method 9056
Cations	EPA Method 300.7
Chemical Oxygen Demand (COD)	Standard Method 5220C
Conductivity	Standard Method 2510
Dissolved Oxygen	Standard Method 4500-OG
pH	Standard Method 4500
Oxidation/Reduction Potential (ORP)	Standard Method 2580B
Total Dissolved Solids (TDS)	Standard Method 2540C
Non Purgeable Organic Carbon (NPOC)	Standard Method 5310B

APHA (1995), US EPA (1994)

CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents results from the asphalt road waste leaching project. The results reported here include the physical characterization tests performed by the FDOT, the results from the TCLP, SPLP, and DI batch leaching tests, and the results from the SPLP column leaching study. When appropriate, applicable groundwater standards or guidance concentrations are presented. Comparing the results of a leaching test with the appropriate regulatory limit typically helps access the impact of a waste on groundwater. Appendix B contains a complete list of analytical results including all samples, lab blanks, matrix spikes, and Quality Assurance/Quality Control (QA/QC) data.

4.1 PHYSICAL CHARACTERIZATION RESULTS

The RAP samples collected from each site were physically characterized at the FDOT State Materials Lab in Gainesville, Florida by FDOT technicians. Refer to chapter three for the analytical tests and testing methods used by the FDOT lab. The results of the physical characterization of all RAP samples are presented in Table 4.1.

Table 4.1 FDOT Physical Characterization Results

Sample	Viscosity (poise)	% Asphalt Concentration	Penetration (.10mm)
Miami	118,942	6.23	16
Tampa	99,524	7.90	17
Jacksonville	969,644	6.62	8
Lake City	145,293	5.14	14
I-10 (Suwannee Cty.)	820,109	6.39	15
Indian Town Road	270,774	6.04	10

These physical characterization tests were useful in assessing the condition and age of the milled asphalt samples. As asphalt ages and is exposed to the elements, it tends to harden and become brittle. As a result the viscosity of the asphalt cement increases. The viscosity of virgin asphalt cement added to a new HMA mix is approximately 3000 poise. The viscosity of all RAP samples indicated older roadways. The Jacksonville site appeared to be the oldest. As the asphalt pavement hardens, the penetration of the RAP material should decrease. It was shown that the Jacksonville site had the smallest penetration and again was considered the oldest. The percent asphalt content of all samples were an average of 6.39%. This value is very similar to the percent asphalt cement added to new HMA mixes. There is generally minimal loss of asphalt cement over time.

The FDOT lab also performed gradation test on the RAP samples. The gradation of a design mix is usually dependent on the intended use of the material, unless otherwise stated. The Department of Transportation is responsible for setting all guidelines and regulations governing asphalt mixtures for state roads. As illustrated in Figure 4.1, all samples were of similar gradation. This was expected since the majority of the samples were taken from major highways in Florida and the design mix for these roadways should have been similar. These results show that all samples were of comparable gradation and that there was little physical difference between them. The individual gradation results are presented in Appendix A.

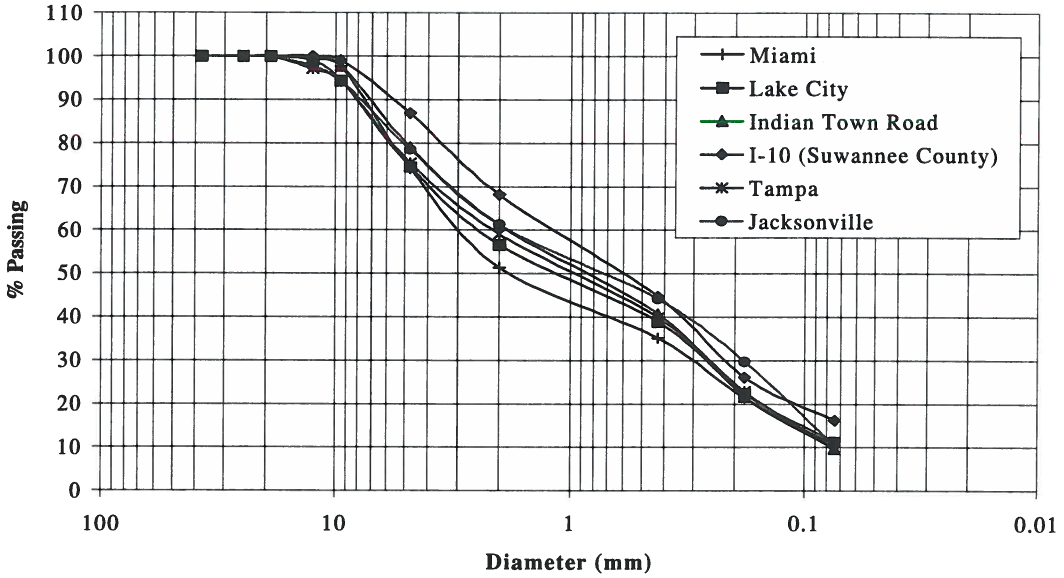


Figure 4.1 Grain Size Distribution

4.2 BATCH TEST RESULTS

The batch study was conducted prior to the lysimeter experiment. The batch leaching tests consisted of three types: the toxicity characteristic leaching procedure, the synthetic precipitation leaching procedure, and a deionized water leaching procedure. As discussed in chapter 3, the batch tests were a one-day test and produced one leachate sample for analysis. The main constituents analyzed were VOCs, PAHs, metals, and general parameters.

4.2.1 General Parameters

After the 18 hour rotation, the initial parameters measured were pH, ORP, DO, and conductivity. The results for these parameters are listed in Table 4.2.

Table 4.2 pH, ORP, DO, and Conductivity

Sample	pH			ORP (mv)			DO			Conductivity (µs)		
	DI	TCLP	SPLP	DI	TCLP	SPLP	DI	TCLP	SPLP	DI	TCLP	SPLP
Miami	9.70	9.68	9.50	3	2	2	5.55	5.70	5.60	53.2	55.4	54.8
Tampa	9.61	9.58	9.49	3	3	3	5.25	5.30	5.37	69.5	68.5	67.6
Jacksonville	9.54	9.50	9.28	9	10	10	6.02	5.95	5.96	69.5	70.2	71.6
Lake City	9.49	9.53	9.35	5	5	4	5.55	5.40	5.46	50.3	51.2	51.7
I-10 (Suwannee Cty.)	9.50	9.60	9.34	8	8	8	5.42	5.50	5.43	55.2	54.2	53.9
Indian Town Road	9.47	9.57	9.41	6	6	7	6.41	6.45	6.49	50.4	49.8	48.7

The resulting pH of the leachate produced was consistent for all samples. The initial pH of the leaching solutions was 7.0 (DI), 4.2 (SPLP), and 4.8 (TCLP) respectively, while the final pH of the leachate produced a mean of 9.51. Since the aggregate used in the RAP material contained large amounts of calcium carbonate, the increase in pH was caused by the ability of CO_3^{-2} to neutralize the acidic nature of the leaching solution. The DO measured was consistently the same for all samples. The conductivity was similar for all samples and averaged 58µs. The conductivity was an indirect measure of the ions released into the leachate.

The results of laboratory tests performed to test for TDS, alkalinity, COD, and NPOC are listed in Table 4.3.

Table 4.3 TDS, Alkalinity, COD, and NPOC

Sample	TDS (mg/L)			Alkalinity (mg $CaCO_3$/L)			COD (mg/L)			NPOC (mg/L)		
	DI	TCLP	SPLP	DI	TCLP	SPLP	DI	TCLP	SPLP	DI	TCLP	SPLP
Miami	15	18	11	20	22	22	105	115	115	20.5	21.6	22.5
Tampa	20	8	15	38	41	40	135	135	125	43.4	44.1	40.2
Jacksonville	7	5	0	42	43	43	153	144	144	42.3	42.5	44.3
Lake City	22	20	18	34	35	35	89	82	82	36.9	33.4	32.4
I-10 (Suwannee Cty.)	18	18	14	45	47	47	120	120	120	30.5	33.3	33.1
Indian Town Road	11	14	10	25	27	26	81	82	82	19.3	21.5	20.5

There were little dissolved solids in the samples with an average of 14 mg/L. The CO_3^{-2} ion, from the soluble $CaCO_3$ in solution, also contributed to the alkalinity. The COD and NPOC were both relatively low indicating that small levels of leachable organic material were present in the RAP samples.

4.2.2 Anions/Cations

The anions and cations analyzed for in the leachate samples were (fluoride, chloride, bromide, nitrate, sulfate) and (sodium, potassium, magnesium, calcium) respectively. These ions were dissolved into solution and contributed to other parameters such as TDS and conductivity. As a result of the sodium hydroxide used in the TCLP solution, some Na^{+1} was expected to be present. Similarly, because of the sulfuric and nitric acid used in the SPLP solution, SO_4^{-2} and NO_3^{-1} were expected to be present. The DI solution should not have any ions present. Table 4.4 lists the results for these ion measurements.

Table 4.4 Anions and Cations

Target Compounds	Miami (mg/L)	Tampa (mg/L)	Jacksonville (mg/L)	Lake City (mg/L)	I-10 (mg/L)	Indian Town Road (mg/L)
			Anions			
Fluoride	1.05	1.503	1.217	1.225	BDL	1.186
Chloride	3.477	3.883	3.506	3.359	3.367	3.493
Bromide	BDL	BDL	BDL	BDL	BDL	BDL
Sulfate	5.976	8.604	11.363	5.17	6.226	5.886
Nitrate	3.437	3.434	3.57	3.276	3.424	3.368
			Cations			
Sodium	BDL	BDL	1.291	BDL	BDL	BDL
Potassium	BDL	1.917	BDL	1.954	BDL	BDL
Magnesium	1.039	1.484	1.996	1.226	1.273	BDL
Calcium	8.049	11.504	16.665	9.748	25.083	10.94

*Note: Results are only for the SPLP extraction and detection limit for all was 1 mg/L

All measurements resulted in relatively low concentrations compared to secondary drinking water standards. Chloride has a limit of 250 mg/L, fluoride 2 mg/L, and sulfate 250 mg/L. Calcium was the prominent cation species measured. As mentioned earlier, the type of aggregate used to make asphalt concrete in Florida is limerock ($CaCO_3$). During the leaching procedure, this aggregate was dissolved into calcium and carbonate ions, as well as other trace minerals.

4.2.3 Volatile Organic Compounds (VOCs)

Volatile organic compounds (VOCs) were not expected to be a major concern in regard to leaching from RAP. Because of their volatility, most of these compounds would tend to evaporate quickly when spilled on the roadway or be expected to leave the RAP samples in the field.

The analytical results of volatile organic compounds in the leachate from the TCLP, SPLP, and DI tests are presented in Table 4.5. When applicable, the appropriate Florida groundwater guidance concentration is included for comparison. No VOCs on a large list of commonly encountered environmental contaminants were found above the detection limit. All results were below the detection limit (BDL) of 1 mg/L.

4.2.4 Polycyclic Aromatic Hydrocarbons (PAHs)

The analytical results of PAHs in the leachate from the TCLP, SPLP, and DI tests are presented in Table 4.6. The appropriate Florida groundwater guidance concentration is also included for comparison. Calibration curves for all PAH compounds can be found in Appendix C. The results indicated that there was no PAH occurrence greater than the groundwater guidance concentrations in the extracted leachate. For Benzo(a)pyrene, the detection limit (0.25 µg/L) was slightly higher than the guidance concentration (.20 µg/L). The responses measured by the mass spectrometer for the chromatogram retention time where Benzo(A)pyrene occurred, indicated no difference relative to the chromatogram of a deionized water blank.

Table 4.5 Volatile Organic Compounds

Target Compounds	Miami (µg/L)	Tampa (µg/L)	Jacksonville (µg/L)	Lake City (µg/L)	I-10 (µg/L)	Indian Town Road (µg/L)	Detection Limit (µg/L)	GW Guidance Concentration (µg/L)
bromomethane	BDL	BDL	BDL	BDL	BDL	BDL	1	10
chloroethane	BDL	BDL	BDL	BDL	BDL	BDL	1	140
trichlorofluoromethane	BDL	BDL	BDL	BDL	BDL	BDL	1	2100
1,1-dichloroethene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
methylene chloride	BDL	BDL	BDL	BDL	BDL	BDL	1	2.7
trans-1,2-dichloroethene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
1,1-dichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	1	700
1,2-dichloropropane	BDL	BDL	BDL	BDL	BDL	BDL	1	5
cis-1,2-dichloroethene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
bromochloromethane	BDL	BDL	BDL	BDL	BDL	BDL	1	.6
chloroform	BDL	BDL	BDL	BDL	BDL	BDL	1	6
carbon tetrachloride	BDL	BDL	BDL	BDL	BDL	BDL	1	3
1,1-dichloropropene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
benzene	BDL	BDL	BDL	BDL	BDL	BDL	1	1
trichloroethene	BDL	BDL	BDL	BDL	BDL	BDL	1	2
dibromomethane	BDL	BDL	BDL	BDL	BDL	BDL	1	.02
1,3-dichloropropane	BDL	BDL	BDL	BDL	BDL	BDL	1	-
toluene	BDL	BDL	BDL	BDL	BDL	BDL	1	1000
trans-1,3-dichloropropene	BDL	BDL	BDL	BDL	BDL	BDL	1	1
1,1,2-trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	1	5
tetracholoroethene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
cis-1,3-dichloropropene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
dibromochloromethane	BDL	BDL	BDL	BDL	BDL	BDL	1	1
1,2-dibromoethane	BDL	BDL	BDL	BDL	BDL	BDL	1	.02
chlorobenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
1,1,1,2-tetrachloroethane	BDL	BDL	BDL	BDL	BDL	BDL	1	1
ethylbenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	700
m/p-xylene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
o-xylene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
total-xylene	BDL	BDL	BDL	BDL	BDL	BDL	1	10000
styrene	BDL	BDL	BDL	BDL	BDL	BDL	1	100
bromoform	BDL	BDL	BDL	BDL	BDL	BDL	1	4
isopropylbenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	.8
bromobenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
1,2,3-trichloropropane	BDL	BDL	BDL	BDL	BDL	BDL	1	42
1,1,2,2-tetrachloroethane	BDL	BDL	BDL	BDL	BDL	BDL	1	1
n-propylbenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
2-chlorotoluene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
4-chlorotoluene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
1,2,4-trimethylbenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	10
n-butylbenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
1,3,5-trimethylbenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	10
sec-butylbenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
1,3-dichlorobenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	10
1,4-dichlorobenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	75
4-isopropyltoluene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
1,2-dichlorobenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	600
1,2,3-trichlorobenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	-
Naphthalene	BDL	BDL	BDL	BDL	BDL	BDL	1	6.8
1,2,4-trichlorobenzene	BDL	BDL	BDL	BDL	BDL	BDL	1	70

*Note: BDL = Below Detection Limit and results are for TCLP, SPLP, and DI test

To confirm that samples were below the guidance concentration, additional tests were performed on twelve of the most aggressive samples. A list of the twelve samples is provided in Appendix A. Initially, samples were concentrated down to 2 ml following method 8270 for semivolatile extractions with a resulting detection limit of 0.25 µg/L. During the additional tests, the twelve samples were concentrated down to 1 ml, which resulted in a detection limit of 0.125 µg/L. All twelve of these samples did not detect Benzo(A)pyrene, even at the lower detection limit.

Table 4.6 Polycyclic Aromatic Hydrocarbons

Target Compounds	Miami (µg/L)	Tampa (µg/L)	Jacksonville (µg/L)	Lake City (µg/L)	I-10 (µg/L)	Indian Town Road (µg/L)	Detection Limit (µg/L)	GW Guidance Concentration (µg/L)
Acenaphthene	BDL	BDL	BDL	BDL	BDL	BDL	5	20
Acenaphtylene	BDL	BDL	BDL	BDL	BDL	BDL	5	10
Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	5	2100
Benz[a]anthracene	BDL	BDL	BDL	BDL	BDL	BDL	5	4
Benzo[a]pyrene	BDL	BDL	BDL	BDL	BDL	BDL	.25	.2
Benzo[b]fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	1	4
Benzo[ghi]perylene	BDL	BDL	BDL	BDL	BDL	BDL	5	10
Benzo[k]fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	2.5	4
Chrysene	BDL	BDL	BDL	BDL	BDL	BDL	5	5
Dibenz[a,h]anthracene	BDL	BDL	BDL	BDL	BDL	BDL	2.5	7.5
Fluoranthene	BDL	BDL	BDL	BDL	BDL	BDL	5	280
Fluorine	BDL	BDL	BDL	BDL	BDL	BDL	1	280
Indeno[1,2,3-cd]pyrene	BDL	BDL	BDL	BDL	BDL	BDL	1	7.5
Napthalene	BDL	BDL	BDL	BDL	BDL	BDL	1	6.8
Phenanthrene	BDL	BDL	BDL	BDL	BDL	BDL	2.5	10
Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	.5	210

*Note: BDL = Below Detection Limit and results are for TCLP, SPLP, and DI test

4.2.5 Heavy Metals

Heavy metals are often cited as a concern when dealing with materials from roadways. Vehicle wear, fuel emissions, and fuel leakage could all result in contamination with heavy metals. Leachate samples were analyzed on both the Flame AA spectrometer and Graphite Furnace AA spectrometer in order to reach a detection limit below the groundwater guidance concentration. The metals tested were those commonly found in previous studies. The results of the analysis for selected heavy metals are presented in Table 4.7. No concentrations of the selected heavy metals in the extracted leachate were detected greater than the groundwater guidance concentrations.

Table 4.7 Heavy Metals

Target Compounds	Miami (mg/L)	Tampa (mg/L)	Jacksonville (mg/L)	Lake City (mg/L)	I-10 (mg/L)	Indian Town Road (mg/L)	Detection Limit (mg/L)	GW Guidance Concentration (mg/L)
Barium	BDL	BDL	BDL	BDL	BDL	BDL	0.5	2
Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	.005	.005
Chromium	BDL	BDL	BDL	BDL	BDL	BDL	0.1	0.1
Copper	BDL	BDL	BDL	BDL	BDL	BDL	0.5	1
Lead	BDL	BDL	BDL	BDL	BDL	BDL	.010	.015
Nickel	BDL	BDL	BDL	BDL	BDL	BDL	0.1	0.1
Zinc	BDL	BDL	BDL	BDL	BDL	BDL	0.5	5

*Note: BDL = Below Detection Limit and results are for TCLP, SPLP, and DI test

4.3 LYSIMETER STUDY RESULTS

While the batch tests were used to assess pollutant leaching according to existing regulatory policies, the lysimeter study was performed to simulate more realistic environmental conditions. As discussed earlier, two environmental conditions were simulated: unsaturated conditions and saturated conditions

The columns were loaded on December 14, 1997 and proceeded forty days until January 25, 1998. Table 4.8 lists the sampling date and the appropriate sampling day. The parameters analyzed included VOCs, PAHs, metals, and conventional water quality parameters. For a comparison purpose, it should be noted that these were the same as the batch test. A control blank (no RAP) and a duplicate (Indian Town Road) were used to ensure the integrity of the results. The leachate volume collected is presented in Appendix D.

Table 4.8 Sampling Date and Sampling Day

Sample Date	Sample Day
12/18/97	2
12/20/97	4
12/22/97	6
12/24/97	8
12/26/97	10
12/28/97	12
12/30/97	14
1/1/98	16
1/3/98	18
1/5/98	20
1/7/98	22
1/9/98	24
1/11/98	26
1/13/98	28
1/15/98	30
1/17/98	32
1/19/98	34
1/21/98	36
1/23/98	38
1/25/98	40

4.3.1 General Water Quality Parameters

After sample collection, the initial parameters measured were pH, DO, and conductivity. Graphs for the individual parameters and for all lysimeters are presented below. All graphs plot concentration versus sample day. Figure 4.2 and Figure 4.3 show the different pH ranges for the unsaturated and saturated lysimeters, respectively.

The initial pH of the unsaturated lysimeters started out around 7 and then gradually increased to approximately 7.5 over the next 28-days. After this time it began to level off around 7. The initial pH of the leaching solution added to the system was 4.20. The increase in pH was attributed to the release of CO_3^{+2} species from the aggregate in the lysimeters. The CO_3^{+2} ions neutralized the acidic nature of the SPLP solution and buffered the leachate, thus causing an increase in pH. For the saturated lysimeters, the pH remained close to 7.5. It should be noted that the pH increase measured in the control column was also attributed to the CO_3^{+2} ions dissolved from the sand distribution layer. It can therefore be stated that although rainwater has a slightly acidic pH, the actual solution conditions in a RAP stockpile will be neutral from carbonate alkalinity in the aggregate.

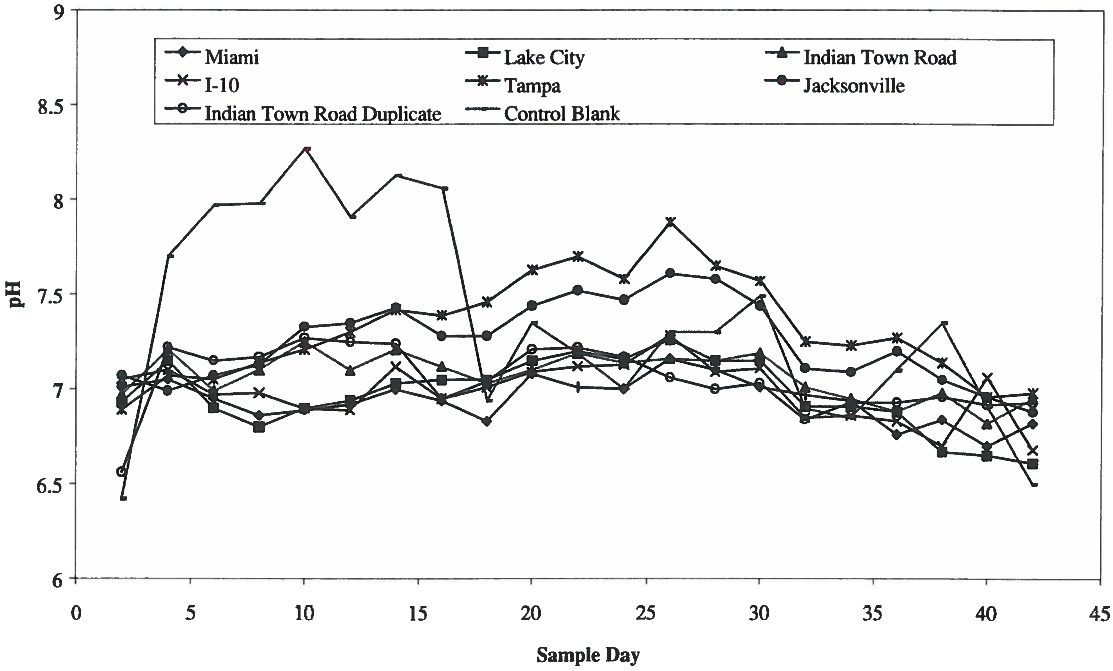


Figure 4.2 Unsaturated pH vs. Time

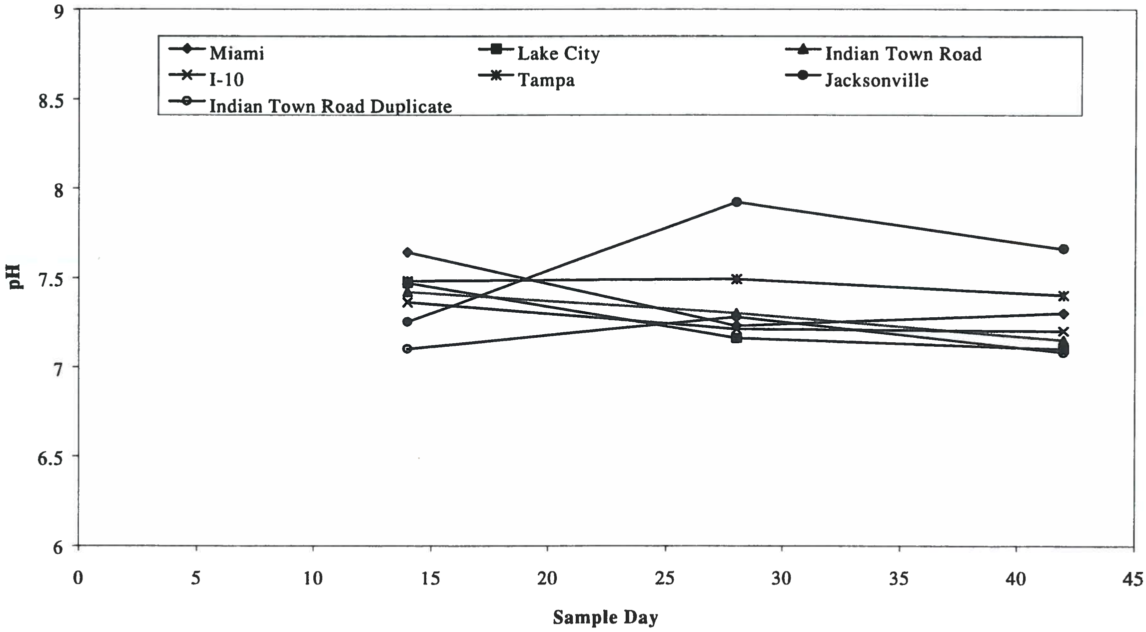


Figure 4.3 Saturated pH vs. Time

Figure 4.4 and Figure 4.5 show the DO measurements for the unsaturated and saturated lysimeters. DO is a measurement of the dissolved oxygen in the leachate.

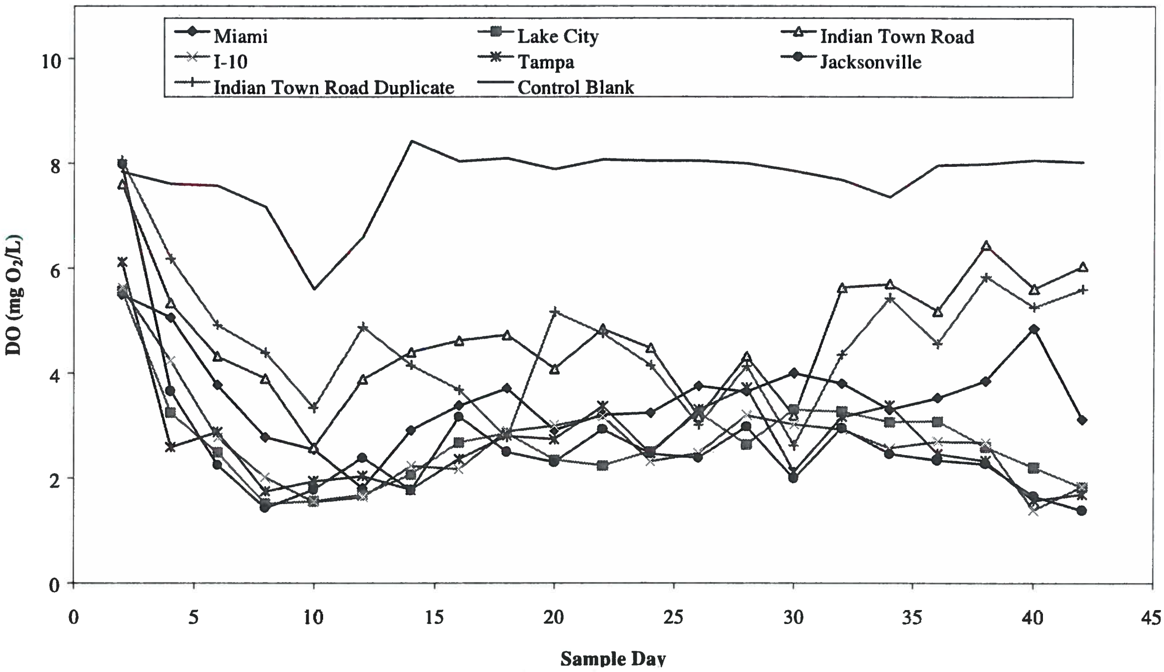


Figure 4.4 Unsaturated DO vs. Time

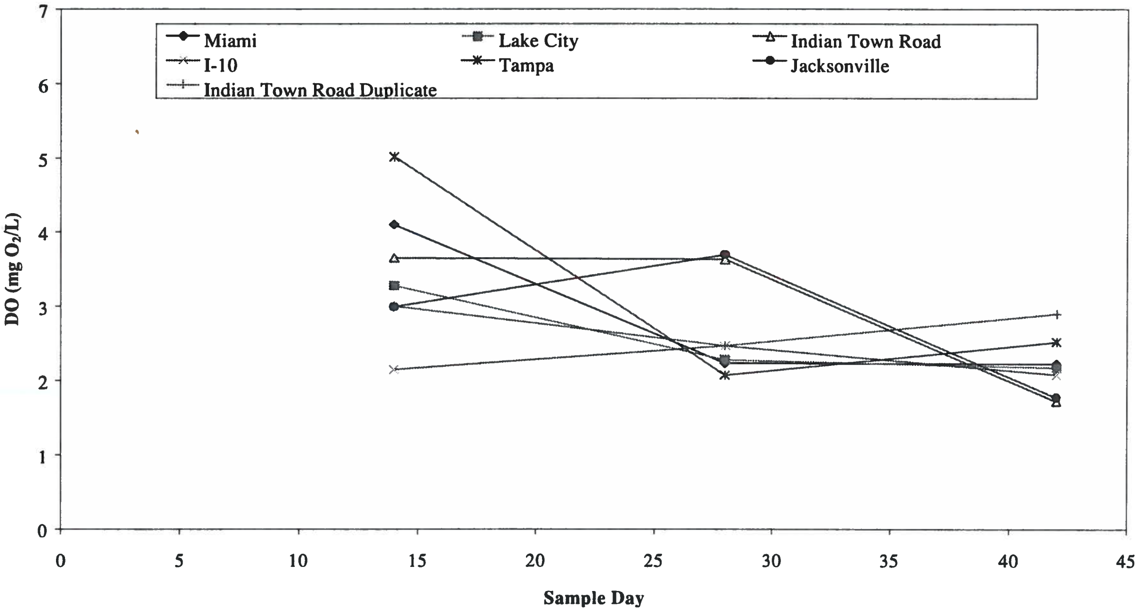


Figure 4.5 Saturated DO vs. Time

The DO in the unsaturated lysimeters initially started off between 6 and 8 mg O_2/L. Over the sample period, the DO leveled off into a range of 2 to 6 mg O_2/L for lysimeters 1 through 7. The control blank stayed relatively constant at approximately 7.5 mg O_2/L. In the saturated lysimeters, the DO stayed in the range of 2 to 5 mg O_2/L but dropped slightly over time. This slight decline occurred in both column situations. The results indicated that reactions occurring in the columns were exerting some oxygen demand.

Figure 4.6 and Figure 4.7 show the conductivity of the leachate samples over time. The conductivity was used to measure the dissolved ion species in the leachate solution.

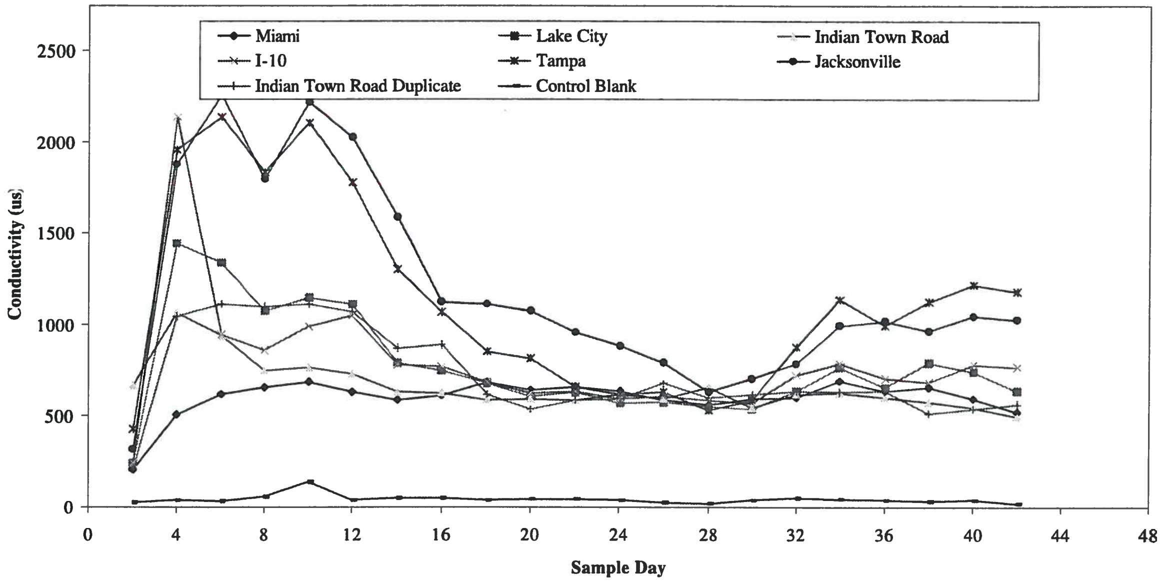


Figure 4.6 Unsaturated Conductivity vs. Time

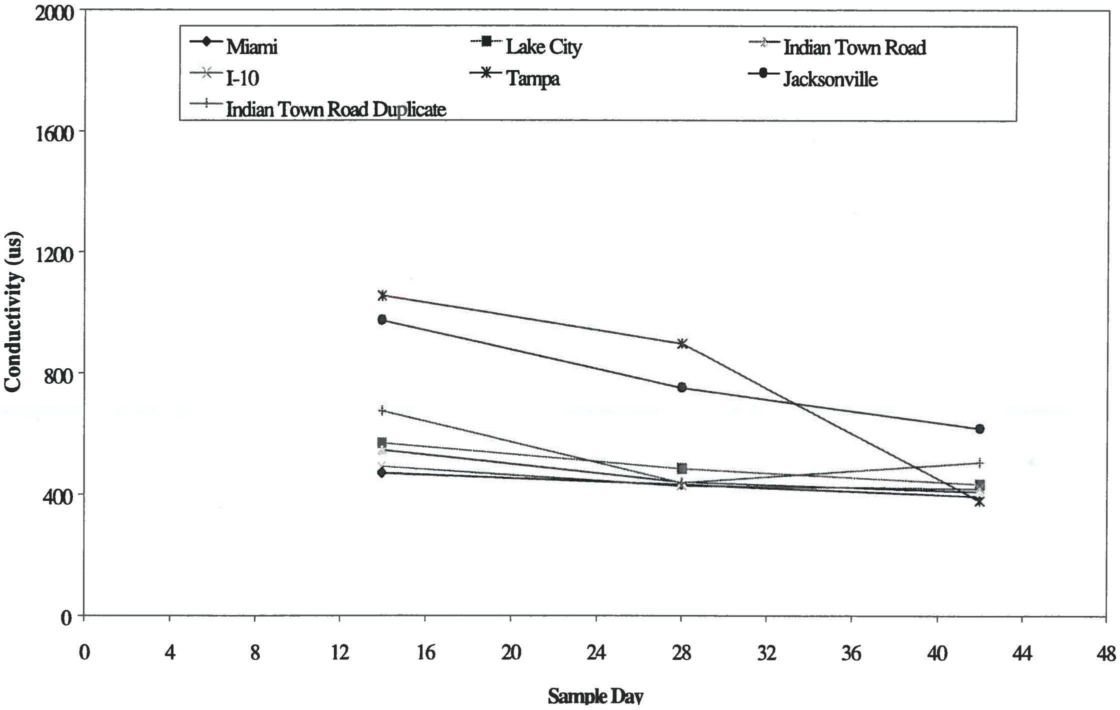


Figure 4.7 Saturated Conductivity vs. Time

The conductivity started around 500 µs and then increased rapidly over the next six days to a maximum of 2,300 µs. At this point the conductivity started to decrease and quickly leveled off around 600 µs. A slight increase in conductivity occurred soon after but started to decrease around 600 µs over time.

All RAP samples illustrated the typical leaching curve as the initial "first flush" of the ions occurred and then soon decreased over time. The term "first flush" refers to the release of the greatest concentration of contaminants in the beginning stages of leaching. The control blank remained constant around 50 µs as was expected. The small amount of conductivity found in the control blank was attributed to the ion species dissolved from the drainage sand and SPLP solution. The small increase in conductivity at the end of the experiment was potentially the result of a different flow pattern in the lysimeters, thus dissolving more ionic species. The saturated columns follow the same pattern for conductivity, as did the unsaturated columns. The conductivity started out high and decreased over time.

Laboratory tests were then performed to test for TDS, alkalinity, COD, and NPOC. Figure 4.8 and Figure 4.9 show the results for unsaturated and saturated TDS.

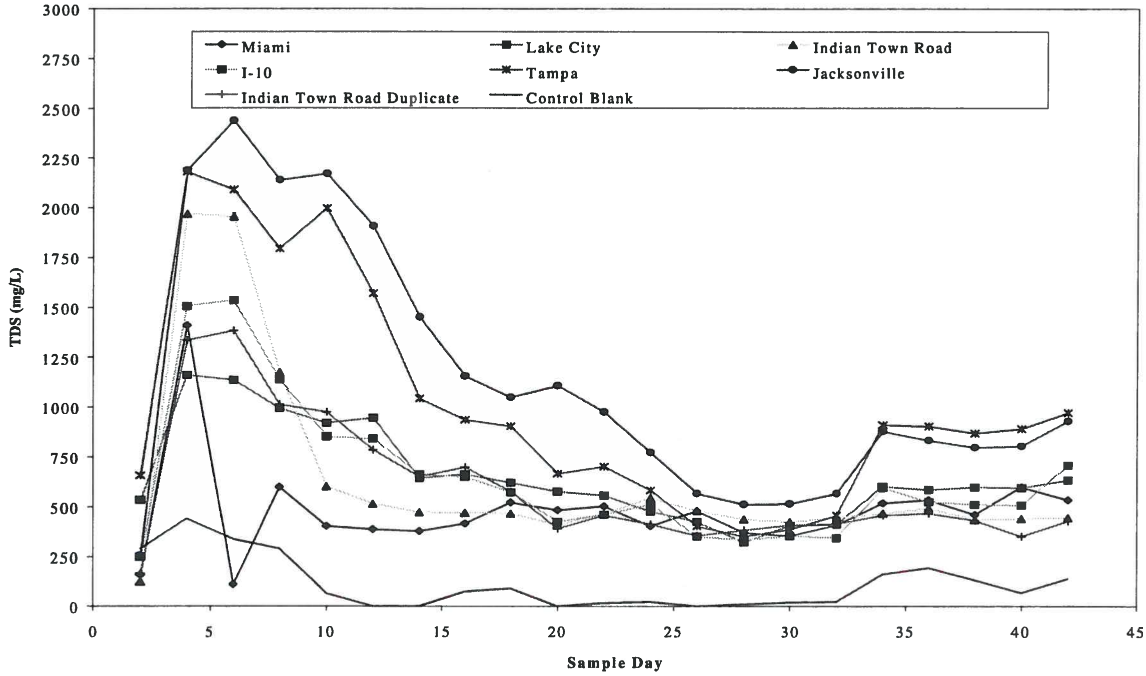


Figure 4.8 Unsaturated TDS vs. Time

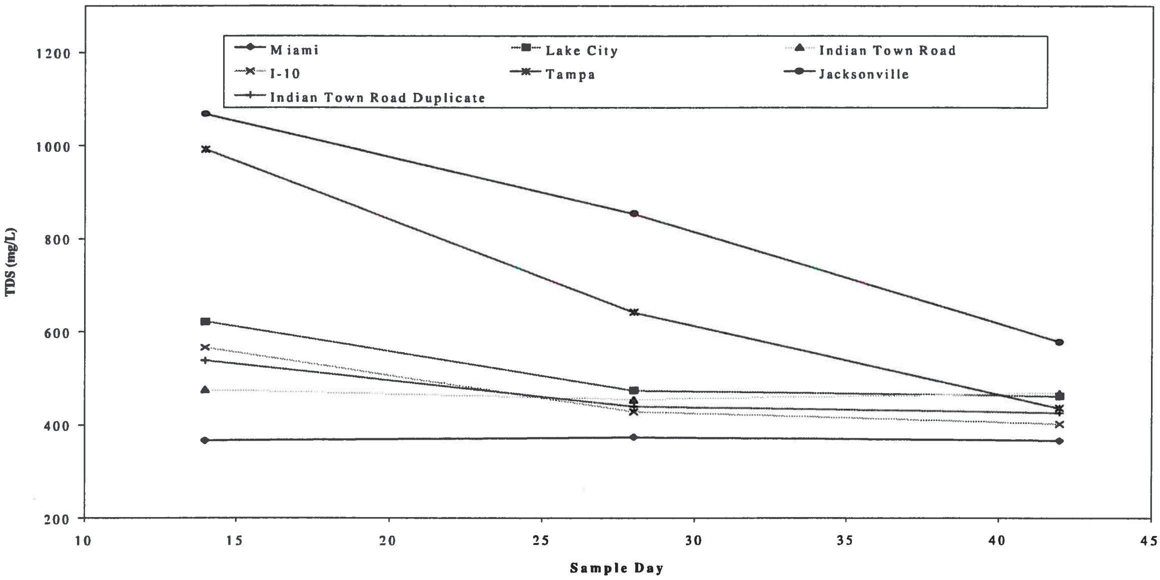


Figure 4.9 Saturated TDS vs. Time

The TDS for the unsaturated columns followed the typical leaching curve. The TDS started out low and then increased to values close to 2,500 mg/L. The TDS then decreased and leveled off around 500 mg/L. A slight increase was observed toward the end of the experiment in some of the unsaturated columns. This slight increase at the end was attributed to new flow patterns in the columns, or simply experimental error.

All RAP samples reached TDS measurements above the secondary drinking water standard of 500 mg/L. As will be seen later, the TDS was a result of mineral leaching from the aggregate, and would be similar to any limestone aggregate. The saturated columns also illustrated a decrease in TDS over time. Both saturated and unsaturated columns had measurements above the secondary drinking water limits of 500 mg/L. The results for alkalinity are presented in Figure 4.10 and 4.11.

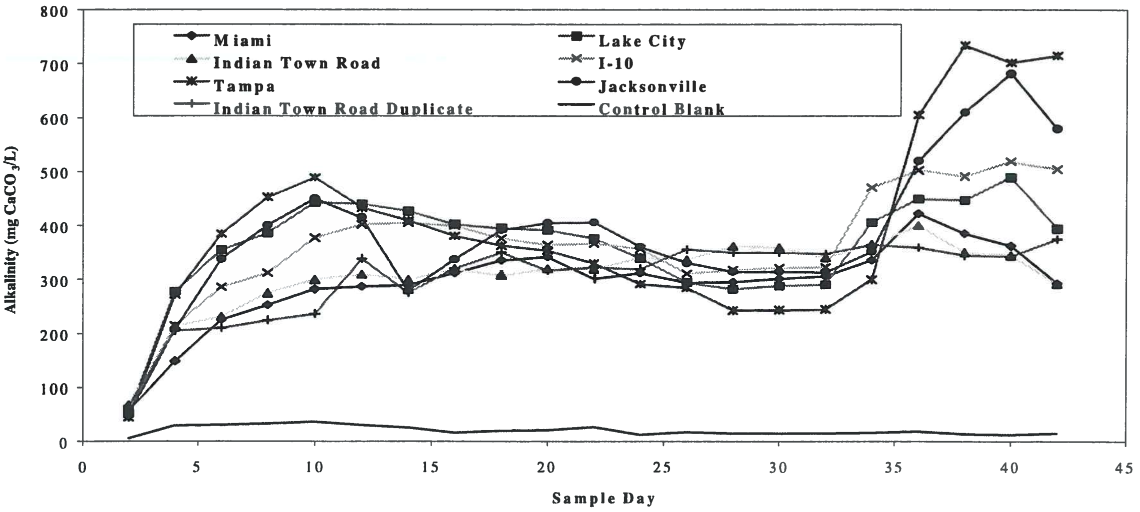


Figure 4.10 Unsaturated Alkalinity vs. Time

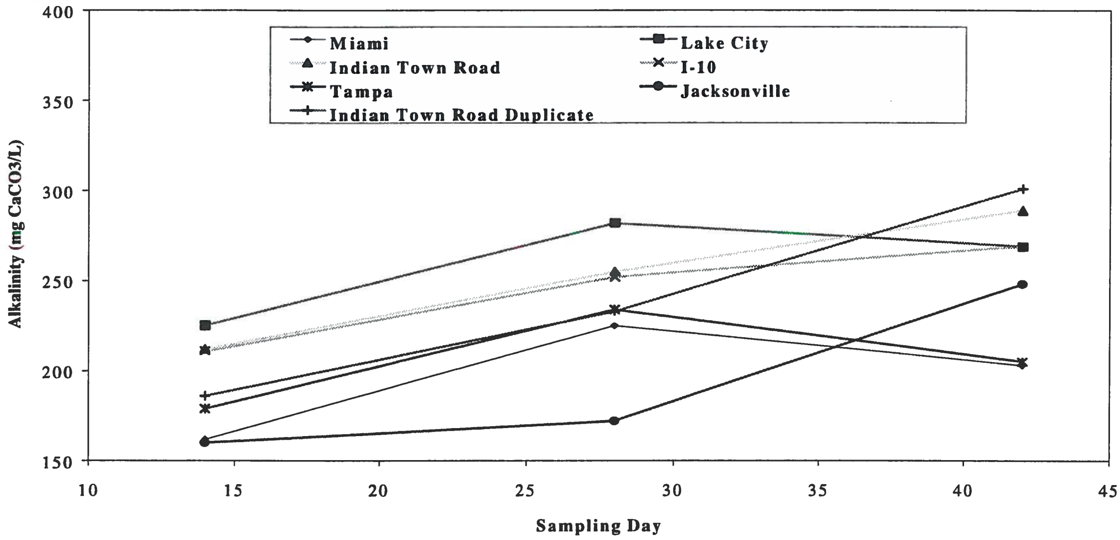


Figure 4.11 Saturated Alkalinity vs. Time

Alkalinity (attributed to the carbonate aggregate), increased somewhat over time, but remained relatively constant during most of the unsaturated experiment. Towards the end of the experiment the alkalinity showed a more dramatic increase and then leveled off again. Since alkalinity was attributed to the release of CO_3^{-2} into solution, the conclusion was that a changed flow pattern caused more of these ions to be dissolved.

Figure 4.12 and Figure 4.13 display the COD results for the unsaturated and saturated lysimeters. COD measurements were useful in estimating the amount of organics in the leachate.

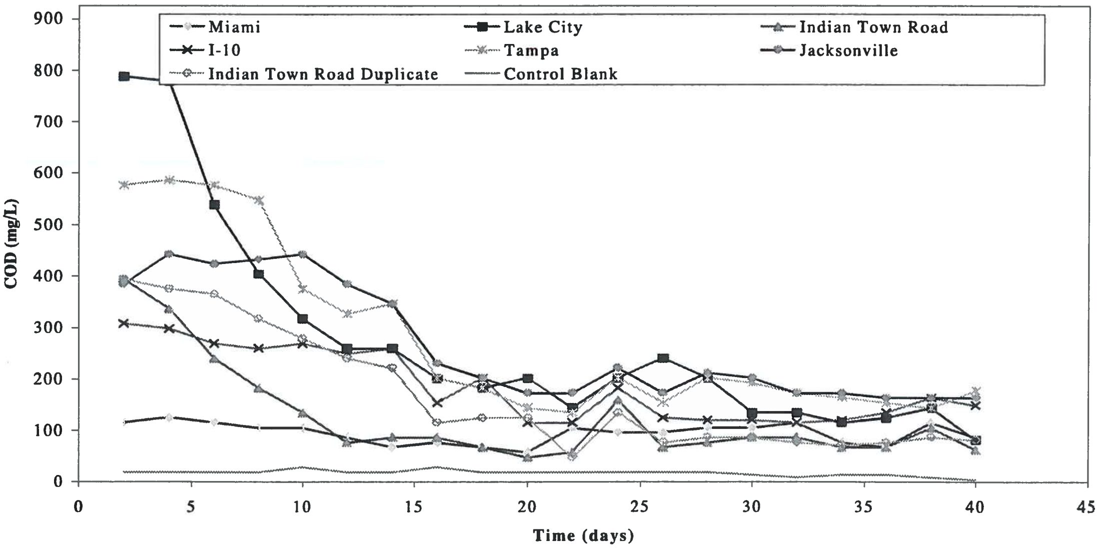


Figure 4.12 Unsaturated COD vs. Time

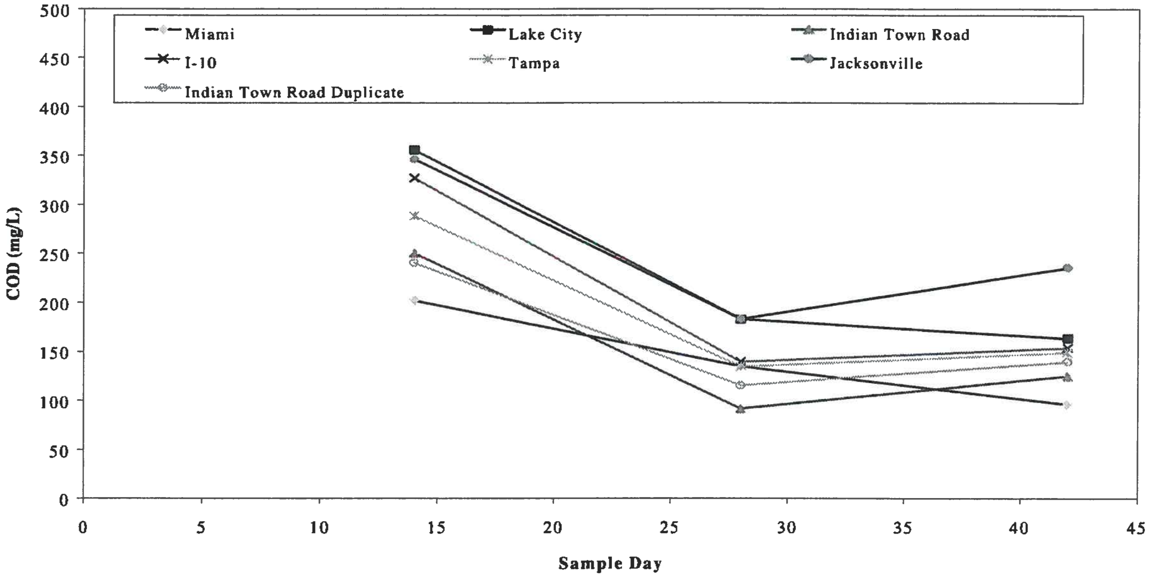


Figure 4.13 Saturated COD vs. Time

In the unsaturated columns, the typical leaching curve was illustrated. The initial COD values ranged from 300-800 mg/L but soon decreased to a constant value of approximately 200 mg/L. The saturated columns also decreased over time. The decrease in organic matter in the system contributed to the decrease in COD. Without the organic matter to be oxidized the COD demand goes down.

NPOC results are illustrated in Figure 4.14 and Figure 4.15. NPOC was also used to estimate the amount of organic material in the leachate samples. The trend illustrated with NPOC results were similar the COD results, as was expected. The unsaturated column illustrated the leaching curve and the saturated column decreased over the sampling period. Although some organic matter was leached, its nature was not characterized. Priority pollutant organic compounds are discussed in the next section.

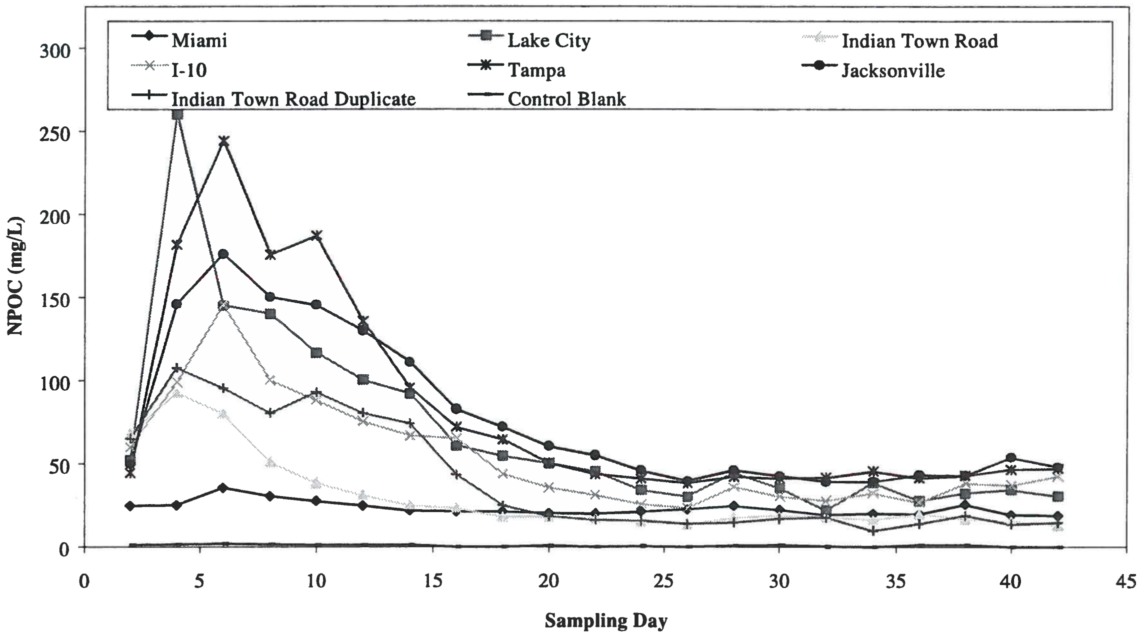


Figure 4.14 Unsaturated NPOC vs. Time

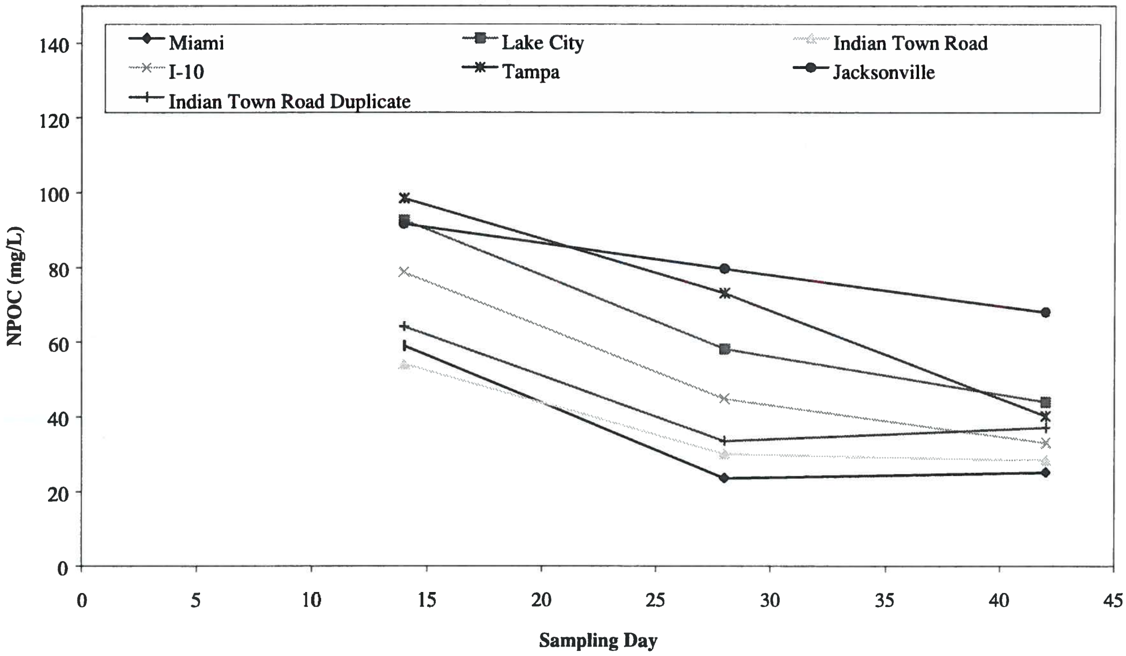


Figure 4.15 Saturated NPOC vs. Time

4.3.2 Anions/Cations

As discussed earlier, the anions and cations tested for in the leachate samples were fluoride, chloride, bromide, nitrate, sulfate) and (sodium, potassium, magnesium, and calcium. The presence of these ions also contributed to TDS and conductivity measurements. Dissolved ions such as SO_4^{-2} and NO_3^{-1} were expected due to the nature of the leaching solutions used in the experiments. Figure 4.16 through Figure 4.19 and Figure 4.24 through Figure 4.27

illustrate the results for anion analysis. Figure 4.20 through Figure 4.23 and Figure 4.28 through Figure 4.31 illustrate the results for cation analysis.

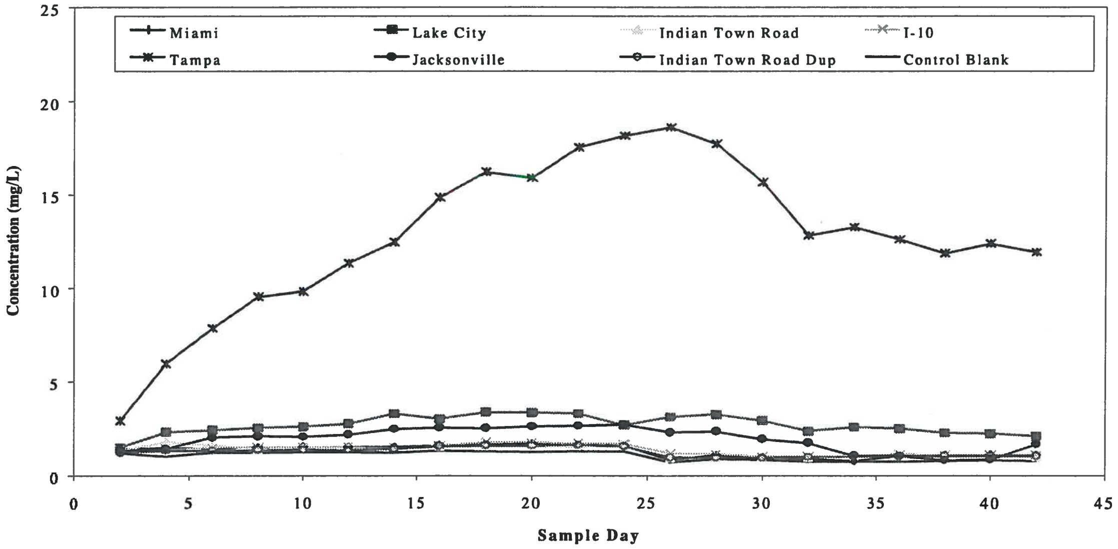


Figure 4.16 Unsaturated Fluoride vs. Time

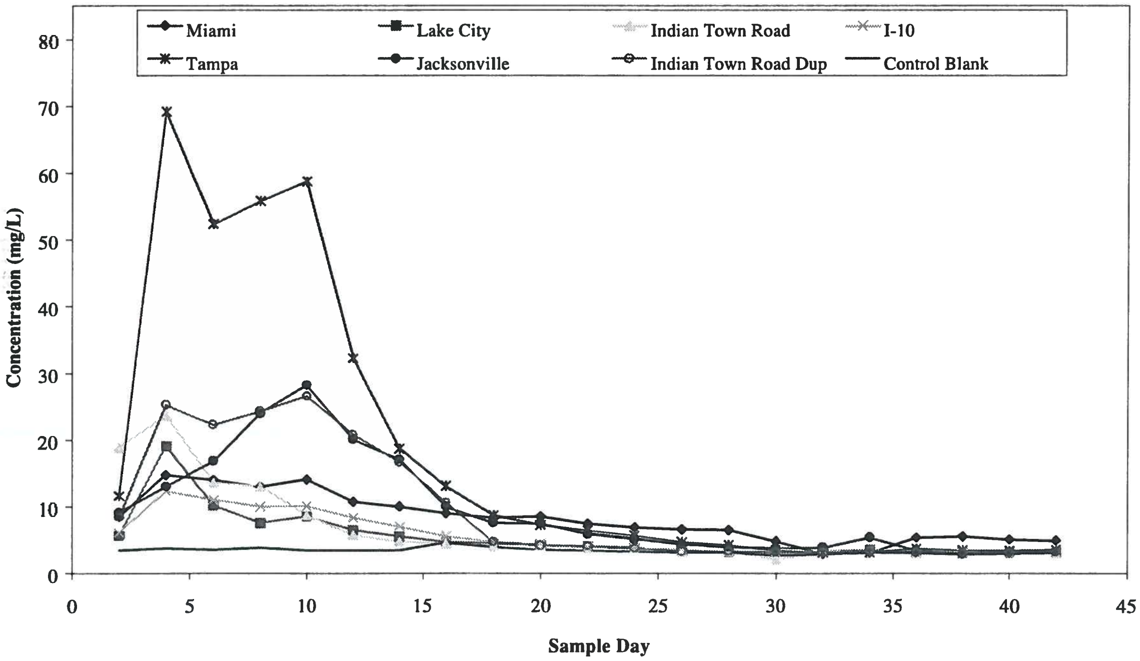


Figure 4.17 Unsaturated Chloride vs. Time

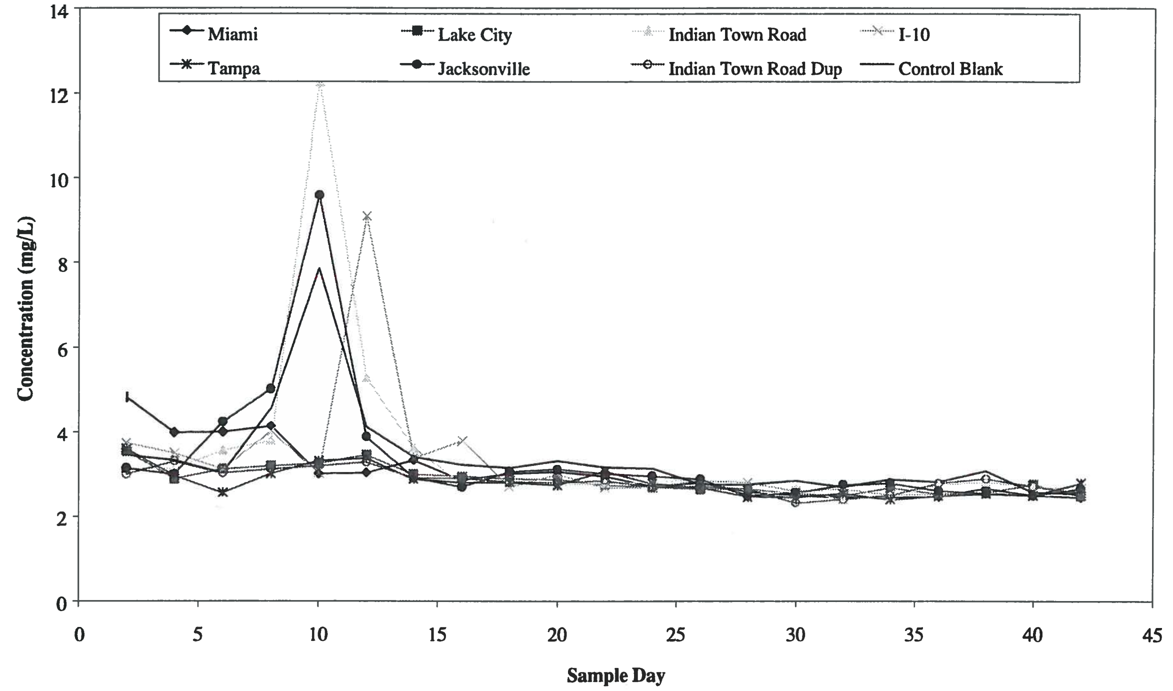


Figure 4.18 Unsaturated Nitrate vs. Time

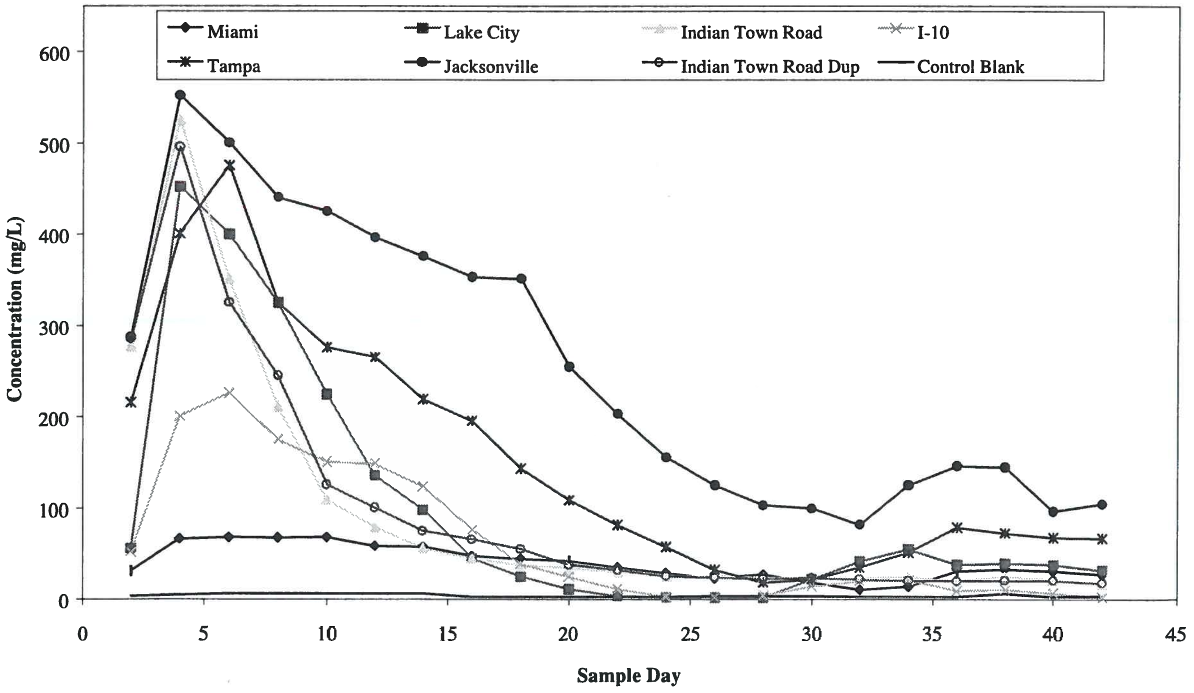


Figure 4.19 Unsaturated Sulfate vs. Time

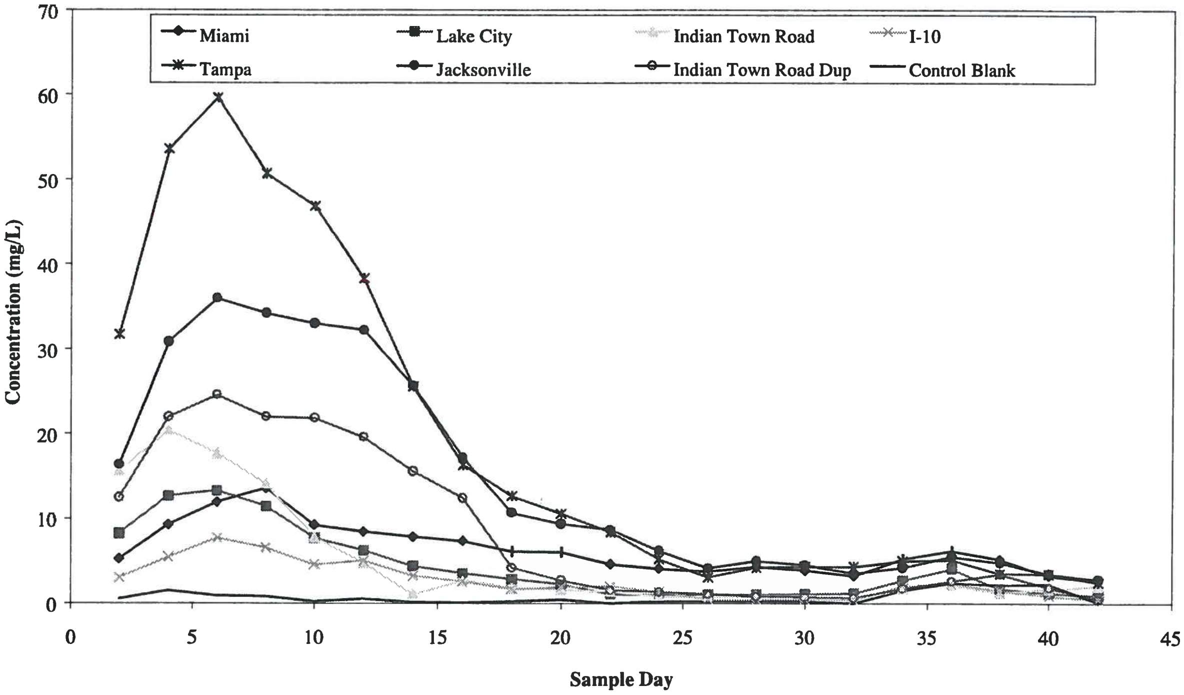


Figure 4.20 Unsaturated Sodium vs. Time

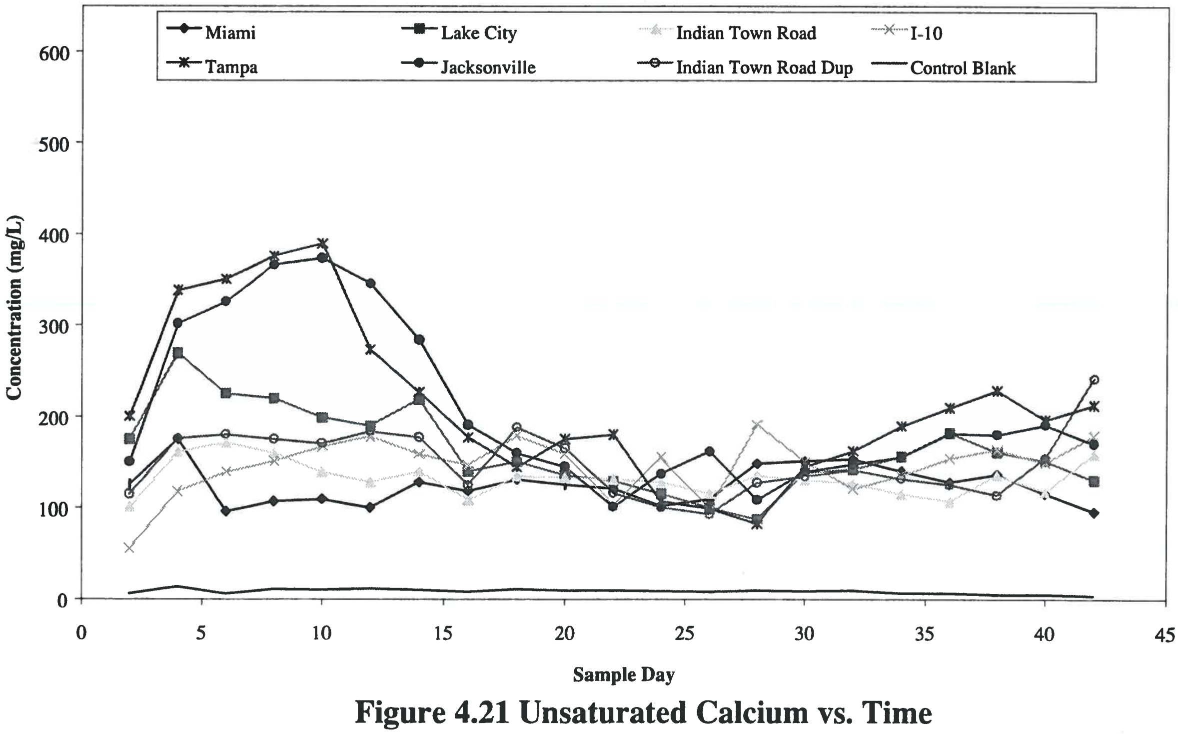


Figure 4.21 Unsaturated Calcium vs. Time

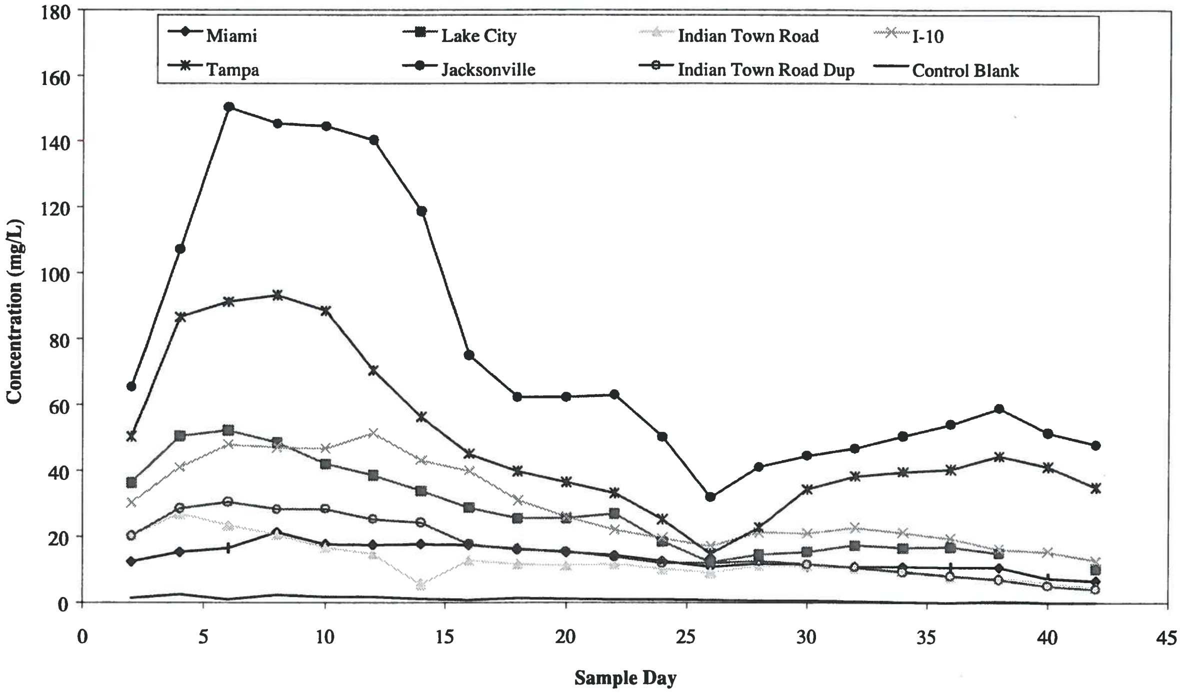


Figure 4.22 Unsaturated Magnesium vs. Time

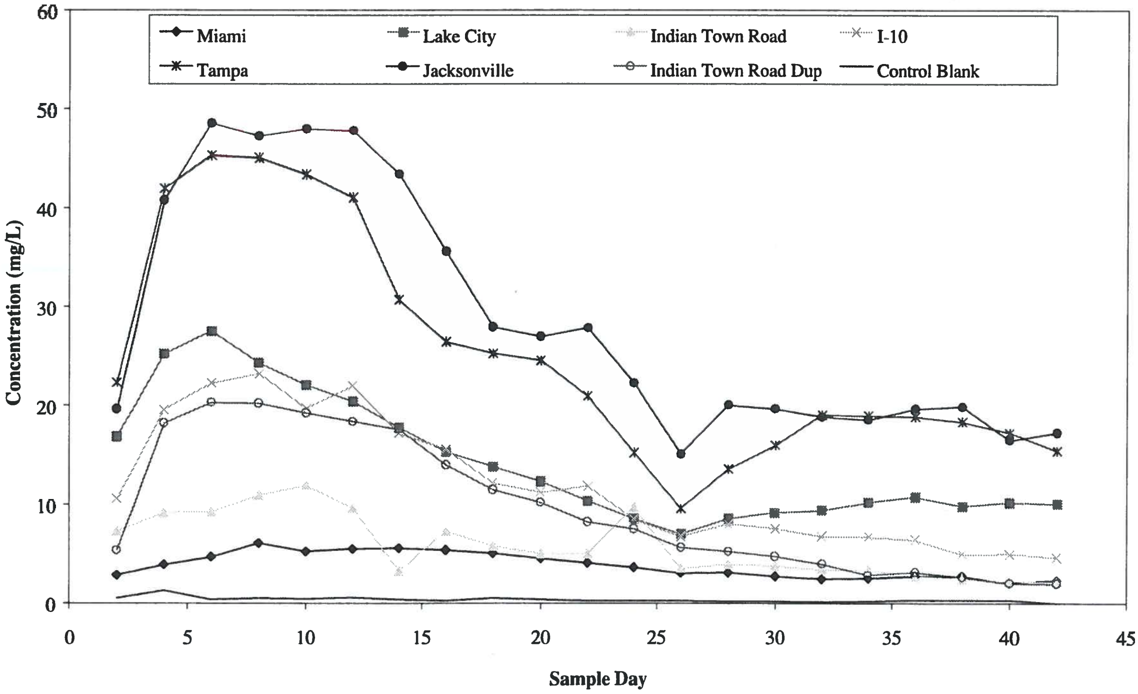


Figure 4.23 Unsaturated Potassium vs. Time

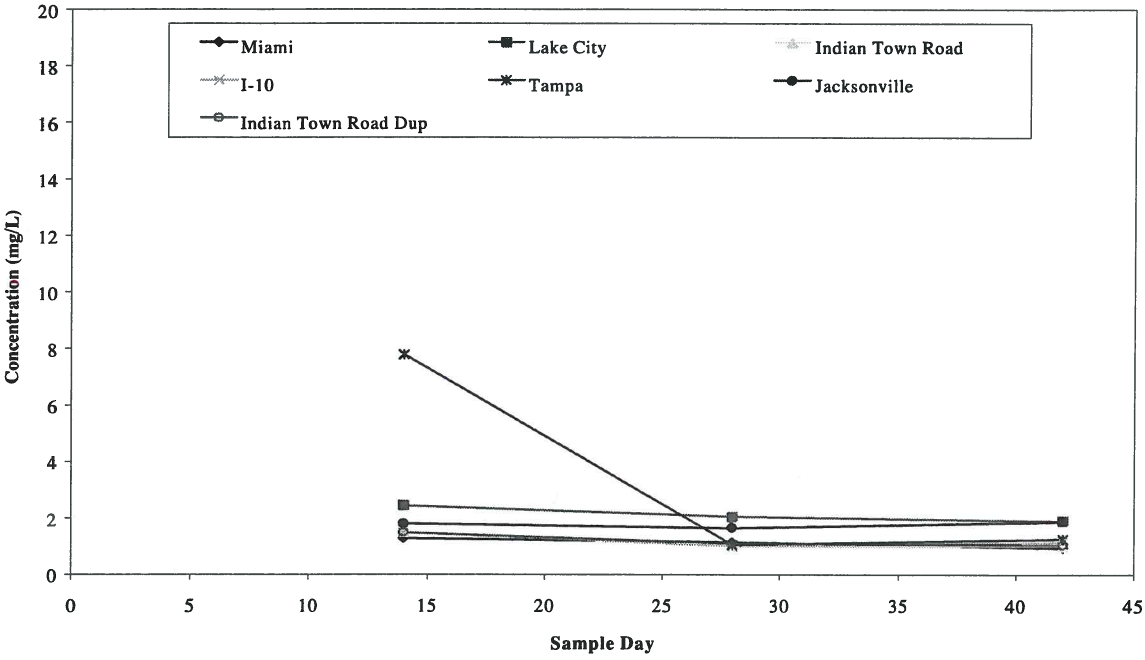


Figure 4.24 Saturated Fluoride vs. Time

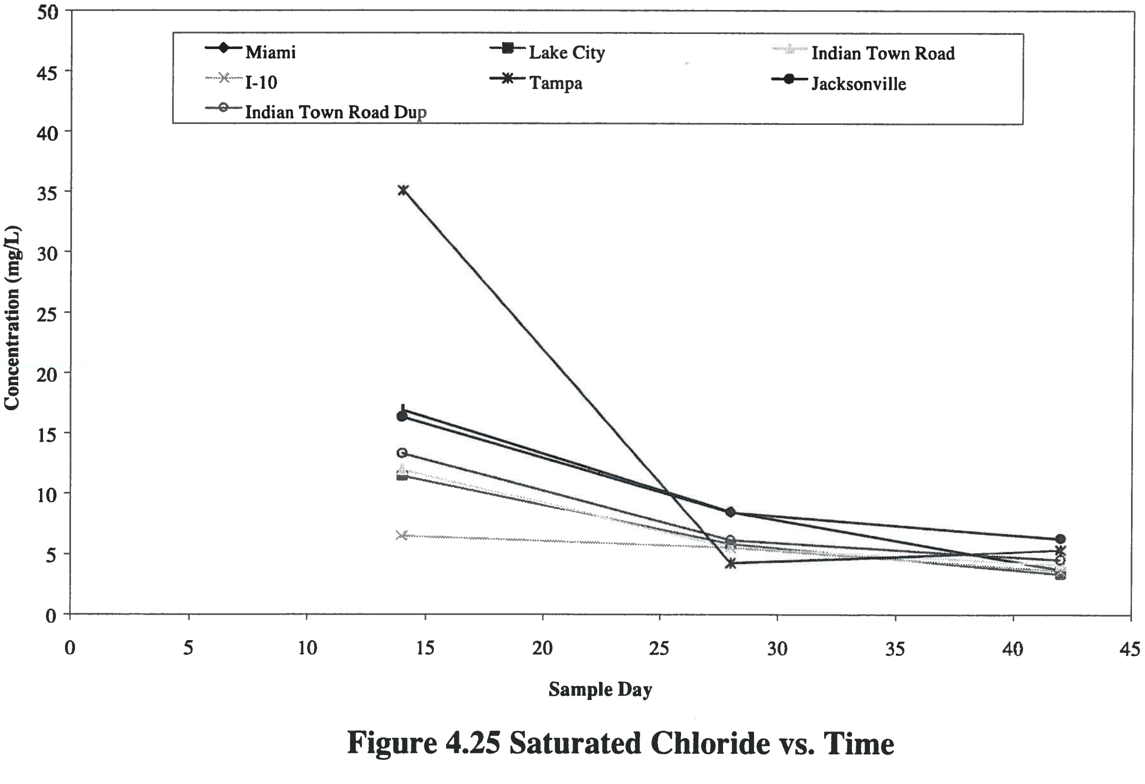


Figure 4.25 Saturated Chloride vs. Time

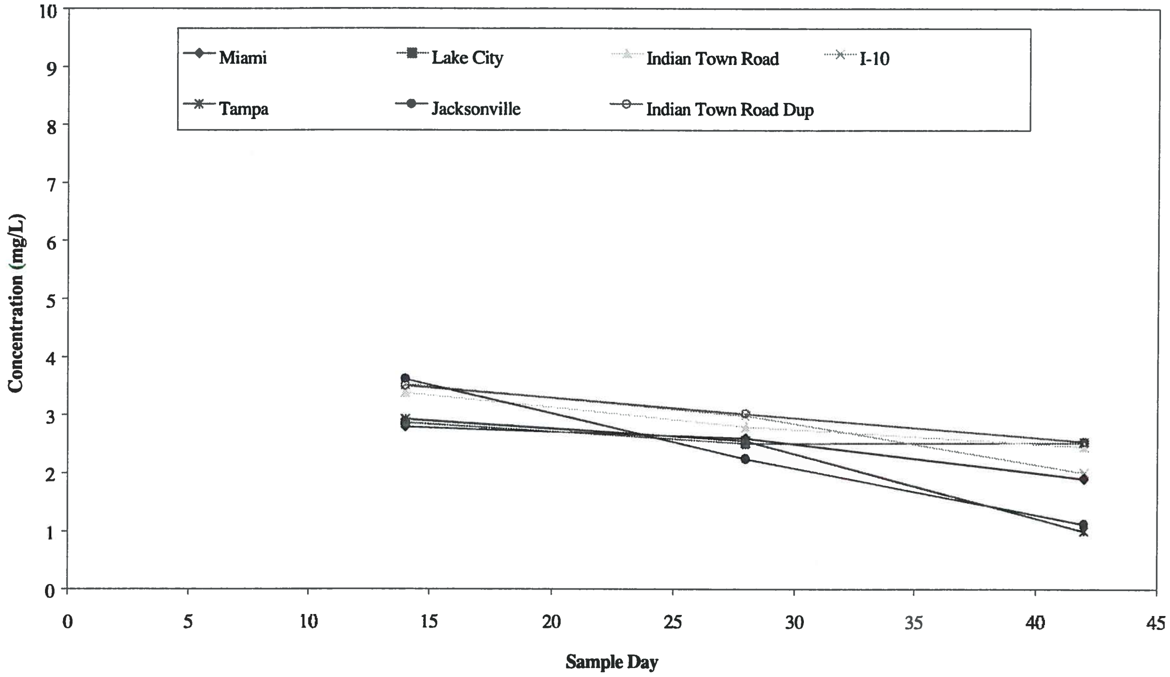


Figure 4.26 Saturated Nitrate vs. Time

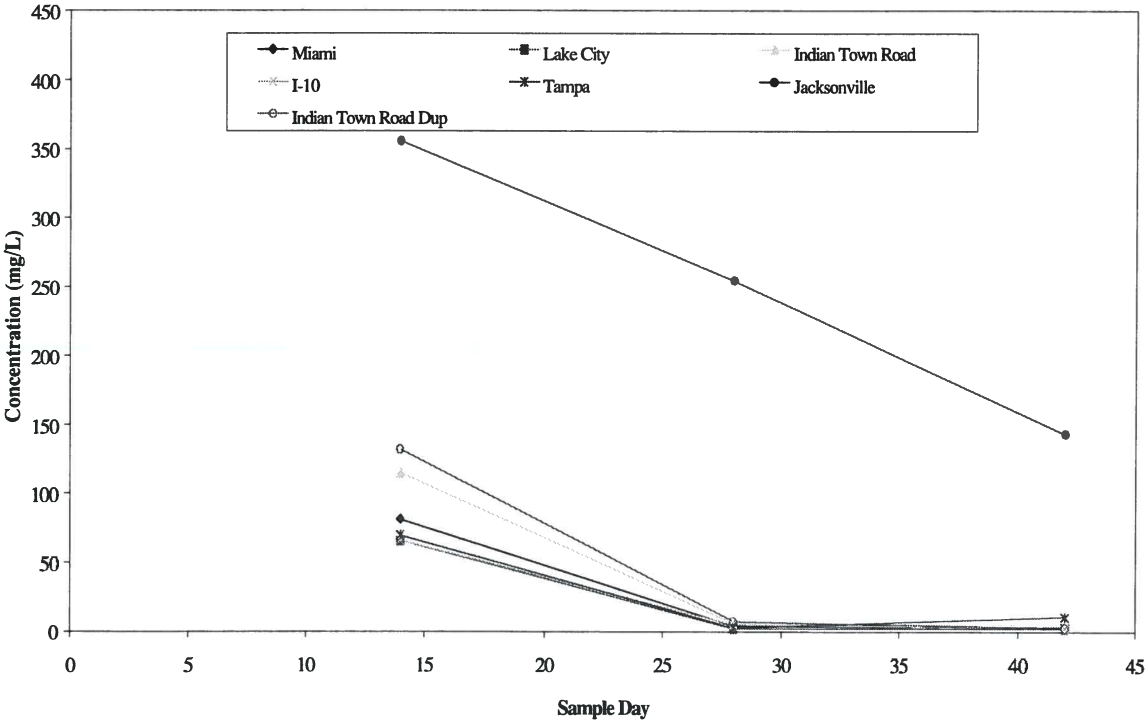


Figure 4.27 Saturated Sulfate vs. Time

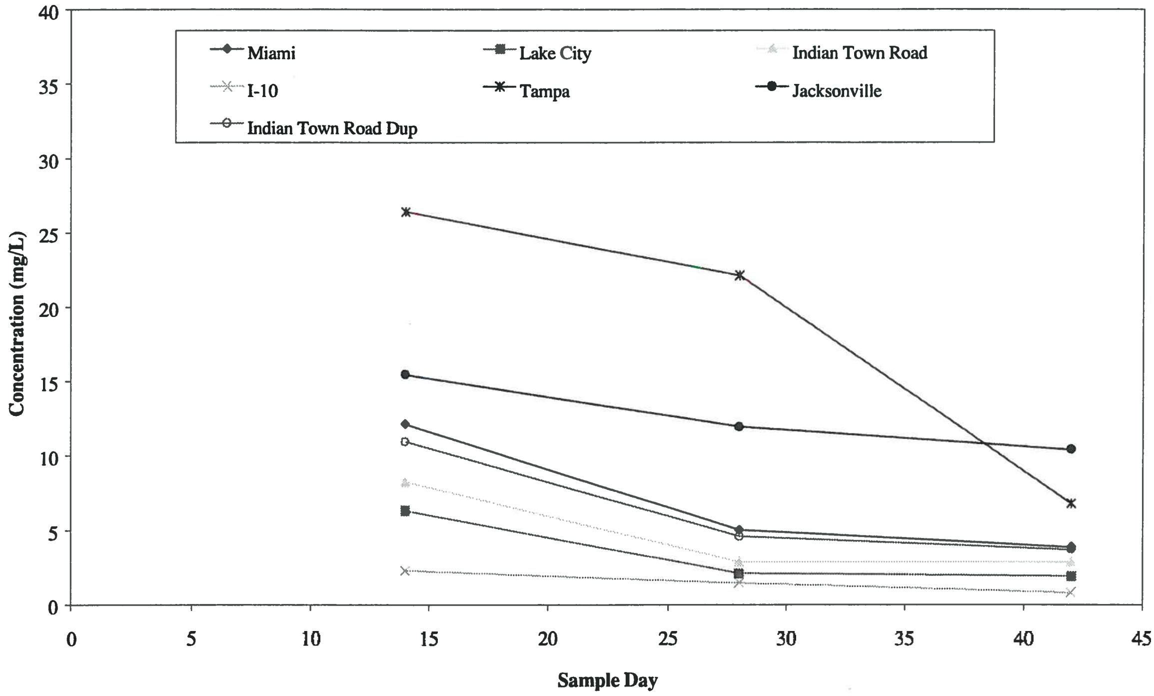


Figure 4.28 Saturated Sodium vs. Time

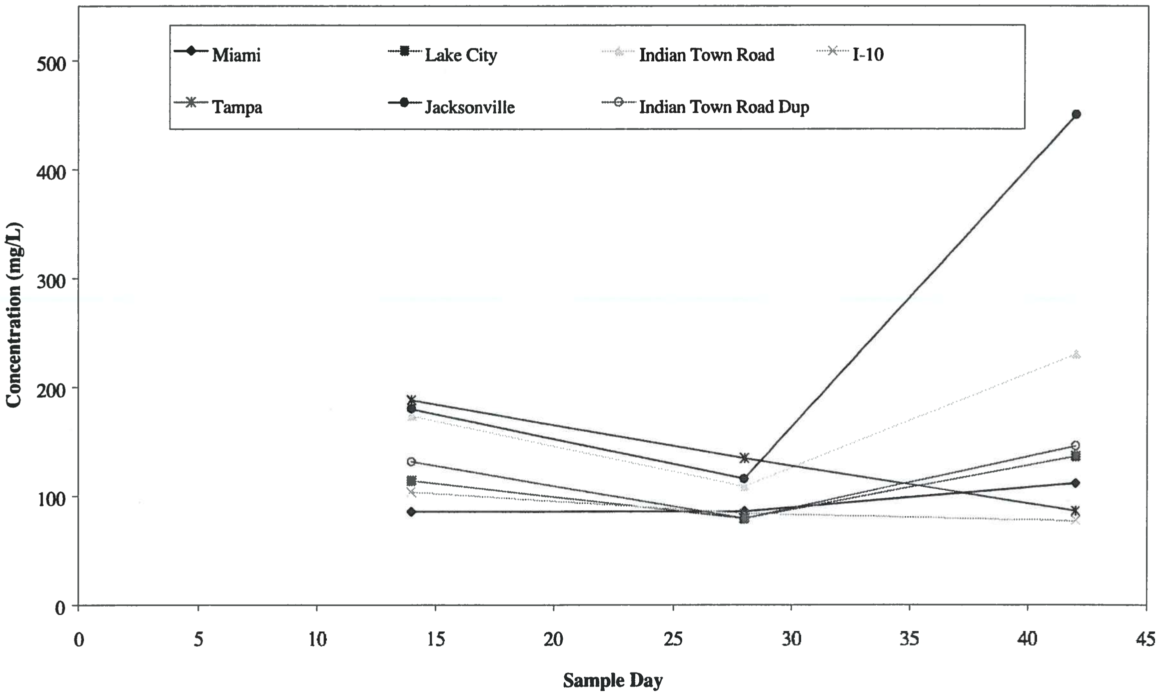


Figure 4.29 Saturated Calcium vs. Time

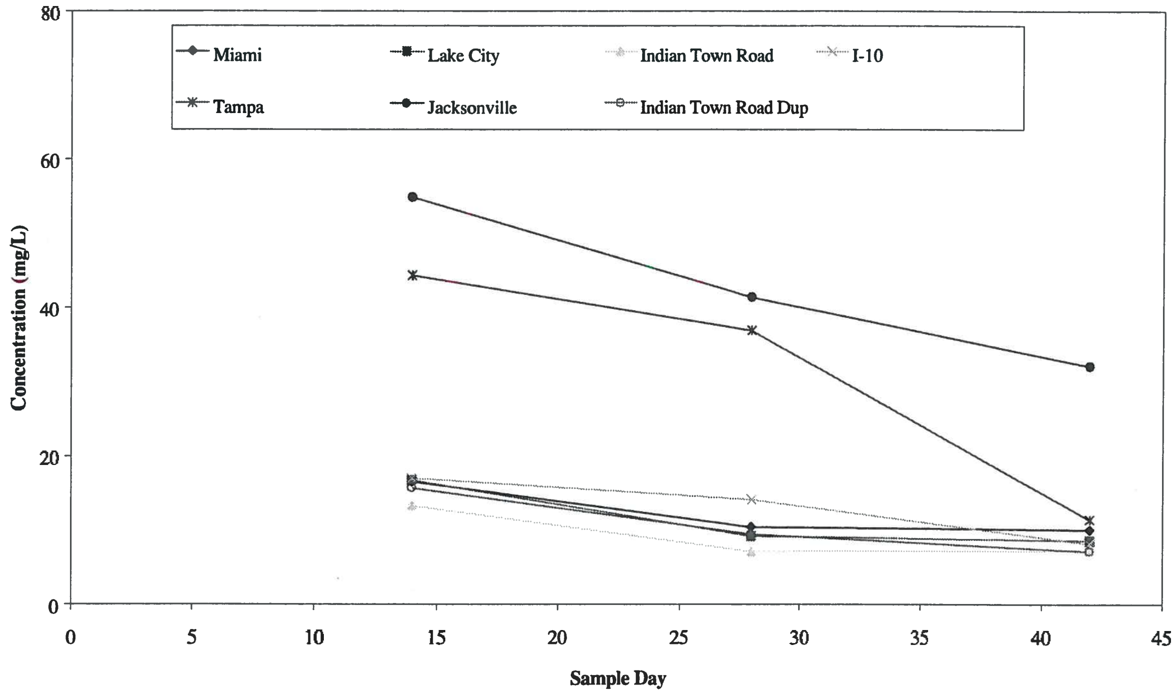


Figure 4.30 Saturated Magnesium vs. Time

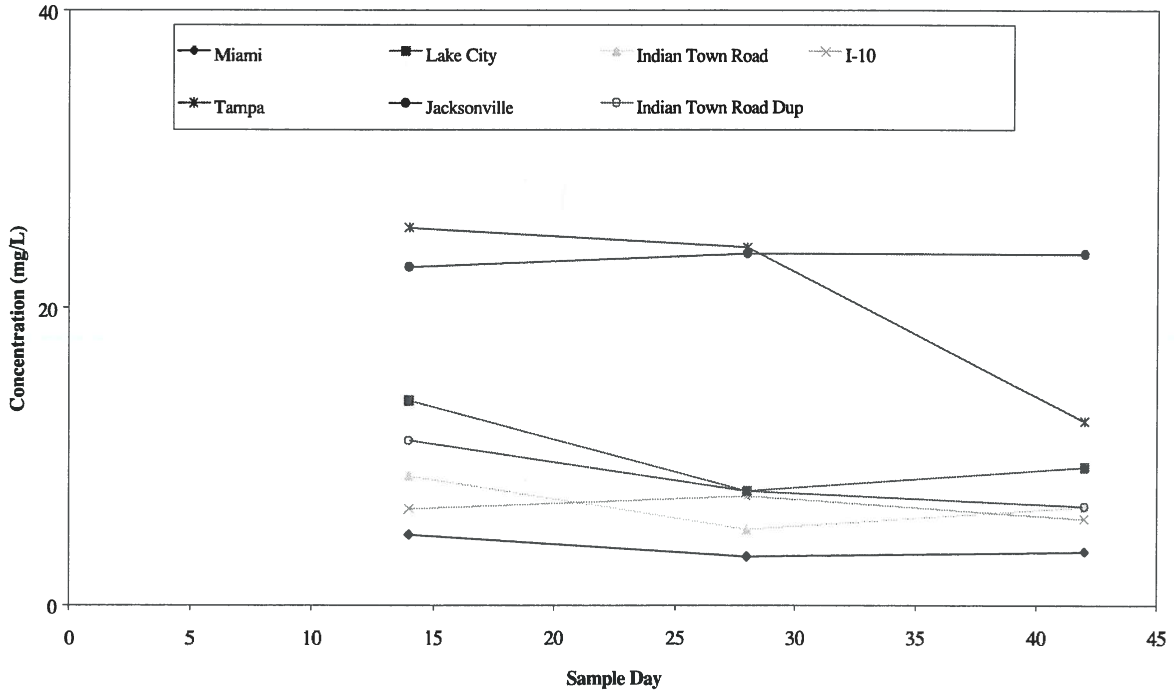


Figure 4.31 Saturated Potassium vs. Time

In the unsaturated and saturated columns, fluoride and chloride were detected in low concentrations. It is interesting to note that the Tampa samples had greater amounts of fluoride detected than all other samples. Fluoride must have been a larger component of the mineral aggregate. Small amounts of nitrate were detected in both column studies and remained constant throughout the study. Nitrate concentrations were similar to the control blank and DI blanks. Sulfate was detected in the unsaturated columns and leached following a typical leaching curve. The highest sulfate concentrations reached were approximately 550 mg/L but declined to a concentration around 50 mg/L. Sulfate was likely a mineral component of the aggregate. The saturated columns also followed this same pattern for sulfate. This ion was expected to be present in small amounts due to the nature of the leaching solution.

For both column conditions, all cations tested displayed the typical leaching curve. Sodium is typically found in Florida aggregates due to the increased amounts of NaCl in Florida and was expected to be present. Calcium was also expected to be present due to the type of aggregate use in HMA production. Typically, the aggregate used in the state of Florida is limerock ($CaCO_3$). Calcium was detected and followed the typical leaching trend. Towards the end of analysis, there was a slight increase in Ca^{+2} ions. This was contributed to a changed flow pattern in the columns. Magnesium is another ion usually found in Florida aggregate. Magnesium was detected in both column studies and followed a typical leaching trend. In the unsaturated columns, magnesium followed the same trend as calcium as well as potassium. These slight increases at the end of analysis were attributed to a changed flow pattern.

4.3.3 Volatile Organic Compounds (VOCs)

As mentioned earlier, VOCs were not expected to be a major concern in regard to leaching from RAP. Because of their volatility, most of these compounds would tend to evaporate quickly when spilled on the roadway or be expected to leave the RAP samples in the field.

Samples were taken directly from the columns and analyzed on a GC/MS. The results for all samples analyzed were below detection limit (BDL) of 1 ppb and never went above any regulatory guidelines. Appendix B has a detailed description of all samples analyzed and compounds of interest. It also includes QA/QC data for these samples.

4.3.4 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs were one of the major concerns related to this project. PAHs are generally formed during the incomplete combustion of coal, oil, or gas, but are found in other sources including vehicle exhaust, tire particles, and weathered material from asphalt roads.

Sixteen priority pollutant PAHs were analyzed for in the leachate samples collected from the lysimeters. The results for all samples analyzed were below detection limit (BDL) and thus were never above any regulatory guidelines. As discussed earlier, the detection limit for Benzo(A)pyrene had to be lowered accordingly. A list of the twelve samples used in that additional work is provided in Appendix A. Appendix B has a detailed description of all samples analyzed and compounds of interest. It also includes QA/QC data for these samples.

4.3.5 Heavy Metals

The other major compounds of interest were heavy metals. Heavy metals are often cited as a concern when dealing with materials from roadways. In the case of lead, it has been well documented that vehicular emissions have caused contamination to roadside soils (Harrison and Wilson, 1985a). The heavy metals selected for analysis are listed in Table 4.9.

Table 4.9 Heavy Metals

Target Compounds	Detection Limit (mg/L)	GW Guidance Concentration (mg/L)	Result
Barium	0.5	2	BDL
Cadmium	.005	.005	BDL
Chromium	0.1	0.1	BDL
Copper	0.5	1	BDL
Lead	.010	.015	****
Nickel	0.1	0.1	BDL
Zinc	0.5	5	BDL

Note: **** Pb will be discussed in greater detail

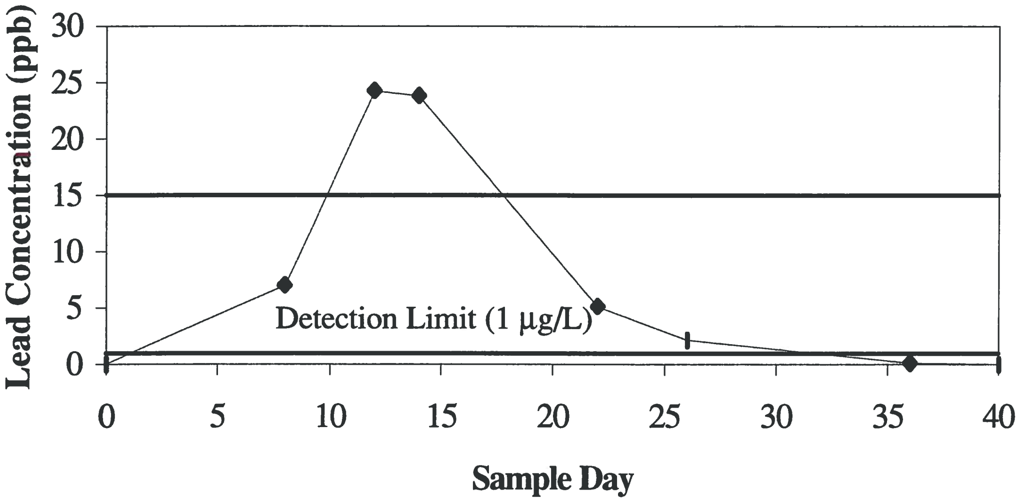
All metals analyzed for were below detection limit (BDL) (except for lead) and were thus below ground water guidance concentrations. The results for lead concentrations (μg/L) measured in the lysimeter leachate and the regulatory guidelines are listed in Table 4.10. Appendix B has a detailed description of all samples analyzed and compounds of interest. It also includes QA/QC data for these samples.

Table 4.10 Lead Results (μg/L)

Sample Day	Miami	Lake City	Indian Town Road	I-10	Tampa	Jacksonville	Indian Town Road Dup	Control Blank
				Unsaturated Columns				
Day 8	BDL	BDL	BDL	BDL	BDL	7.00	BDL	BDL
Day 12	BDL	1.00	BDL	3.51	5.04	24.28	BDL	BDL
Day 14	BDL	1.64	BDL	3.72	5.80	22.87	BDL	BDL
Day 22	BDL	2.79	BDL	BDL	3.80	5.35	BDL	BDL
Day 26	BDL	BDL	BDL	BDL	1.17	2.29	BDL	BDL
Day 36	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Day 40	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
				Saturated Columns				
Day 14	10.38	5.25	38.27	12.7	5.60	26.5	33.4	-
Day 28	BDL	BDL	7.69	BDL	2.90	25	4.48	-
Day 42	BDL	BDL	BDL	BDL	BDL	18.7	BDL	-

The groundwater guidance concentration for lead is 15 μg/L and the detection limit used for lead analysis for the columns was 1 μg/L. In the unsaturated columns, lead was detected above the guidance concentration in only the Jacksonville sample. In the saturated columns, lead was detected above the guidance concentration in three out of the six samples while trace amounts were detected in the other three. The leaching curve for the amount of lead detected in the Jacksonville site followed a typical leaching pattern. Figure 4.32 illustrates the leaching trend in the unsaturated Jacksonville sample. The amount of lead leached off the RAP material increased initially and at around 20 to 25 days started to decrease down to BDL.

Figure 4.32 Lead Leaching Curve



The fact that lead was observed in the column and not in the batch test was a result of the dilution associated with each test. The batch tests used a 20 to 1 ratio of leaching solution to waste material. The ratios used in the column tests reported here were 0.257-to-1 for saturated conditions and 0.0367-to-1 for unsaturated conditions. When waste is applied in the environment, dilution and attenuation of chemicals in the leachate occur in most scenarios. Batch tests are typically compared to groundwater standards directly because a degree of dilution is already incorporated. With column tests, a dilution attenuation factor is typically applied to leachate concentrations to more accurately gage the impact of the waste material on groundwater quality.

The initial period of increase may be explained by the time needed to "wet" the RAP. The initial leachate samples consisted largely of fluid that, for the most part, washed through the column with little contact time with the RAP. Only after the first few leaching solution additions did the leachate that had been in contact with RAP for extended periods start being flushed out. During this contact, minerals in the RAP aggregate and some lead partitioned into the leachate. The fact that asphalt is a hydrophobic materials may magnify this effect, as seen possibly in the lead leaching curve for the Jacksonville RAP sample (Figure 4.32).

The total mass (µg) of lead leached from the columns is presented in Table 4.11. It was shown that the saturated columns had more mass leached than did the unsaturated columns. The reason for this was available contact time between the leaching solution and RAP sample. The unsaturated columns had less than two days of contact time while the saturated columns had fourteen days of contact time. The increased contact time in the saturated columns allowed for more dissolution of lead in the columns.

Contact time was also involved in the amount of lead being leached. In the saturated columns, the entire RAP sample had complete contact with the leaching solution. In the unsaturated columns, one liter of leaching solution was introduced every two days. Since asphalt is a material made to be impervious to water, the leaching solution introduced had minimal contact with the RAP relative to the saturated columns.

Table 4.11 Total Mass (μg) of Lead Leached in Columns.

	Miami	Lake City	Indian Town Road	I-10	Tampa	Jacksonville	Indian Town Road Dup.
Unsaturated	0	25.36	0	36.85	44.23	126.58	0
Saturated	72.66	36.75	321.72	88.90	59.50	491.40	265.16

The lead concentration was greatest in the Jacksonville RAP sample, which also corresponded to the oldest RAP sample as determined by the physical characteristics. As previously stated, the viscosity of RAP increases with age and the penetration decreases with age. Older roads tend to have more exposure to accidental spills and to the use of leaded gasoline from previous years. The total mass of lead leached from the saturated columns is plotted as a function of viscosity in Figure 4.33 and as a function of penetration in Figure 4.34. These results indicate that the older samples likely contained more lead as a result of longer exposure to vehicle traffic and emissions.

The Jacksonville site, which has the highest viscosity, had the highest concentration of lead. Even though this was an older road, there may have been other factors involved in why lead was detected. The Jacksonville sample came from a mixed source pile. This material could have come from a parking lot or a downtown road where stop and go traffic occurred. Highways with large amounts of stop-and-go traffic would also tend to have more exposure time to spills and leaks. The I-10 sample, which has the second highest viscosity, has a very low concentration of lead. Even though I-10 is an older highway, it is a main interstate with no stop-and-go traffic.

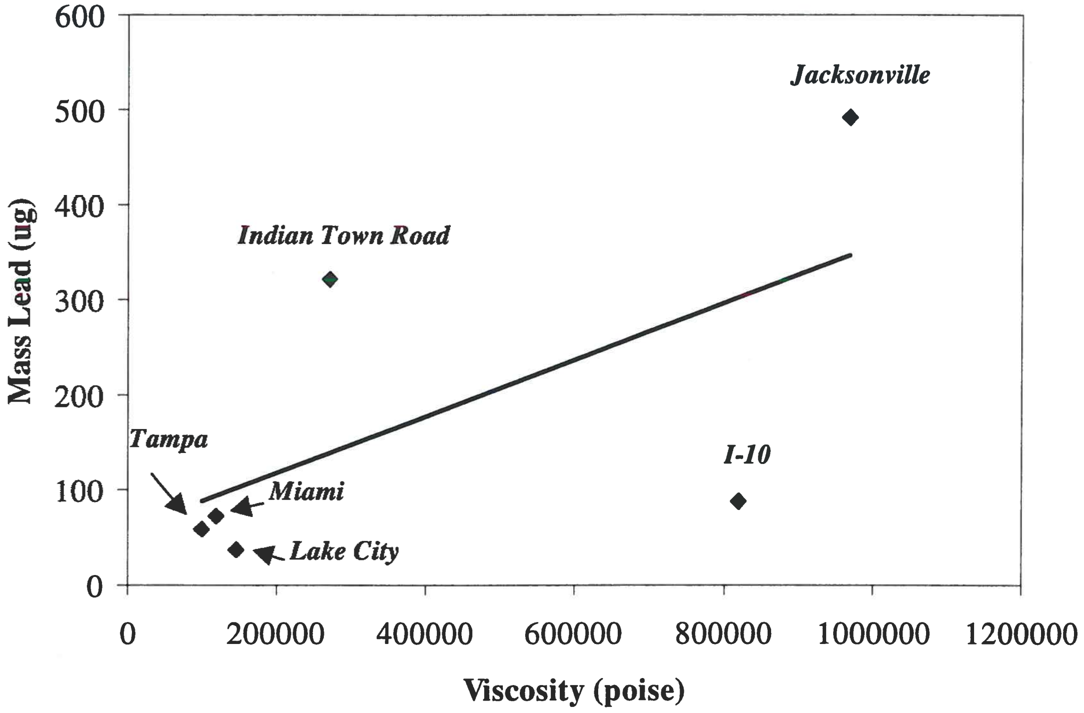


Figure 4.33 Viscosity vs. Total Lead (μg) Leached in Saturated Columns

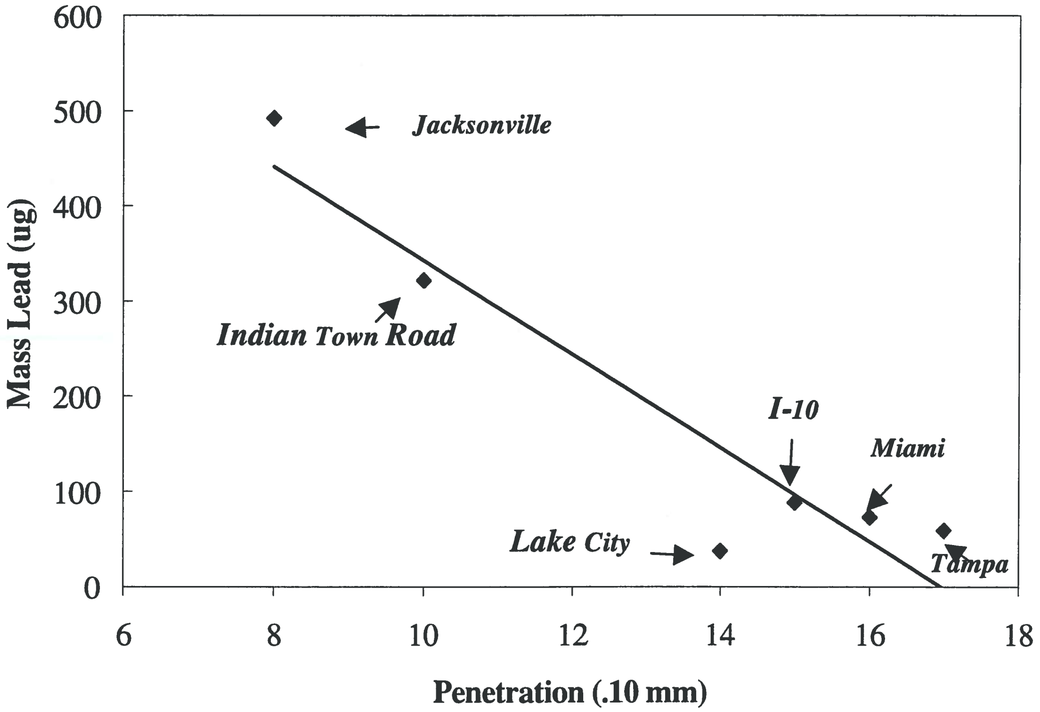


Figure 4.33 Penetration vs. Total Lead (μg) Leached in Saturated Columns

CHAPTER 5
CONCLUSIONS/RECOMMENDATIONS

Reclaimed asphalt pavement is a solid waste that in most cases can be directly recycled into new asphalt. Under some circumstances, recycling is not immediately possible, and the RAP may have to be stockpiled or managed in some other manner. This may include circumstances where the RAP is exposed to rainwater that could leach chemicals to the environment.

A series of batch tests and column studies were performed to evaluate the leaching characteristics of reclaimed asphalt pavement. Samples of RAP were collected from six sites in Florida. The batch tests performed consisted of the Toxicity Characteristic Leaching Procedure (TCLP), the Synthetic Precipitation Leaching Procedure (SPLP), and a deionized water test. The column study utilized 16 stainless steel columns (lysimeters) assembled at the University of Florida Solid and Hazardous Waste Lab.

Batch tests were performed on all six RAP samples. In leachate generated during the TCLP batch test, measurements of volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals all were below detection limit (BDL) and below any applicable TCLP limits. The RAP samples evaluated were therefore not hazardous waste. This result was expected, as the literature had demonstrated this.

Batch tests are also used by regulatory agencies to determine whether a waste presents a potential leaching threat to groundwater. Concentrations of pollutants from batch tests are usually compared directly to groundwater limits or guidance concentrations. TCLP test is sometimes used. The literature did present some TCLP results that were above appropriate groundwater limits for some heavy metals (Kriech 1990, 1991, 1992). The TCLP test is a more aggressive test and represents the conditions inside an anaerobic landfill. Less aggressive tests were therefore also conducted in this study (SPLP and deionized water). The SPLP is currently the method of choice for evaluating leaching from waste or contaminated soils in Florida.

In all of the batch tests, measurements of VOCs, PAHs, and selected heavy metals (Ba, Ca, Cr, Cu, Pb, Ni, and Zn) all were below detection limit (BDL) and were below applicable regulatory groundwater guidance concentrations. This indicates that the RAP samples tested posed minimal risk (in regard to leaching of the pollutants tested) under current waste policy in Florida. No comparisons can be made regarding the effectiveness of each test to leach pollutants because no pollutants were measured.

Column (lysimeter) tests were then performed on the same six RAP samples. Column tests are not a prescribed test procedure by regulatory agencies. They were conducted in this case to investigate leachate production from RAP under more realistic environmental scenarios. Approximately 60 lbs of RAP material filled a three foot section of each column. The RAP in these columns were subjected to either a saturated or unsaturated condition. Samples were analyzed for the same parameters as in the batch tests, but leaching was continued for a total of 42 days. The columns did leach large concentrations of ions such as calcium, sodium, sulfate, fluoride, and carbonate as a result of mineral leaching from the aggregate used in the asphalt pavement manufacture. Some organic material was leached. However, all priority pollutant VOC and PAH analyses had results similar to the batch test -- none were detected. Leachate concentrations for selected heavy metals (Ba, Ca, Cr, Cu, Ni, and Zn) were below detection limit (BDL) except lead (Pb).

Only one unsaturated lysimeter resulted in a leachate with a lead concentration above the groundwater guidance concentration (15 ppb). Leachate from the unsaturated lysimeter containing the Jacksonville sample had a lead concentration of approximately 28 ppb eight days into the sampling period. The concentration of lead decreased over time and then leveled off below the regulatory guidance concentration. In the saturated columns, all columns had detectable concentrations of lead ranging from 5 ppb to 38 ppb. Three out of the six lysimeters (two sites) were above the regulatory guideline. The lysimeters decreased over time to lead concentrations below the guidance concentration (and the detection limit) except the Jacksonville sample. The Jacksonville sample concentration decreased slightly but was still above the guidance concentration at approximately 18 ppb.

As discussed previously, the batch tests were more dilute than the column test. This condition helps to explain why lead concentrations were observed in the column study but not in the batch test. In a real world situation, rainfall and other surface water runoff would ultimately dilute leachate produced from a stockpile before it reaches the groundwater table or a nearby receiving body of water. This phenomenon is commonly referred to as dilution attenuation. Dilution-attenuation models used to determine the concentration of groundwater underneath waste piles and landfills commonly apply a dilution factor of 20 (EPA, 1996 In batch tests, dilution is usually assumed to be accounted for because of the high liquid-to-solid ratio. In the column study there was no dilution-attenuation factor involved. If the concentrations produced from the column studies were placed into a groundwater dilution model, results would likely be well below any regulatory guideline. Under most reuse circumstances, even if lead was encountered at levels of the highest amount measured in this study, the concentrations in the environment would be below acceptable regulatory levels for drinking water. Possible conditions of risk would be from RAP used as fill below the groundwater table in areas with little dilution.

Lead was observed in the greatest concentrations in the oldest RAP samples. This indicated that the lead was not a result of the aggregate or asphalt cement, but rather a result of vehicle traffic and emissions. Lead has been used for many years in leaded gasoline and in crankcase oil. Since vehicle accidents and accidental spills contribute to this contamination, there is a possibility that this contamination was site specific. Previous studies regarding asphalt road waste also found trace amounts of lead in some circumstances (Kriech, 1991). Lead was encountered in greater concentrations in older samples, indicating that the source of lead was prolonged exposure to vehicle traffic and emissions.

Most of the previous studies reviewed in Chapter 2 regarding RAP leaching were consistent with the results found in this study. Organic compounds do not leach from typical RAP under the conditions tested. Heavy metals are sometimes encountered. The literature indicated the presence of chromium, lead, and barium. Only lead was detected in this study and was attributed to prolonged exposure to traffic and vehicle emissions. The literature often referred to chromium resulting from slag used as aggregate. It should be noted that the aggregate used in the asphalt samples collected for this study was assumed to be natural aggregate (e.g. limerock). If other materials -- especially waste materials such as slag, spent sandblast grit and ash -- are used as aggregate, the results gathered here may not be applicable. It should also be noted that fresh asphalt was not tested, nor were extremes in temperatures evaluated.

The results of this research project indicated that reclaimed asphalt pavement of the nature examined in this study poses minimal risk to groundwater as a result of pollutant leaching under normal land disposal scenarios. The results of the leaching tests indicated that in most cases RAP would pose minimal environmental risk when used as fill in regard to the leaching of the pollutants. This study did not, however, address that implication of direct exposure.

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SPECIAL REPORT

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Reclaimed Asphalt Pavement (RAP) as a Clean Fill Material

The asphalt pavement industry is America's biggest recycler. More than 60 million tons of asphalt pavement material is reclaimed each year during road widening and resurfacing projects, and nearly all of that material is reused. Incorporating reclaimed asphalt pavement (RAP) into new pavements reduces demands for virgin asphalt binder, helping to keep costs down as well as improving the environmental footprint of projects.

Not all RAP is recycled into new asphalt pavements, however. Occasionally, the question arises as to whether or not RAP can be used as "clean fill." Although obviously not the highest and best use of this vital resource, regulations regarding when and where RAP can be placed as fill material vary from state to state and can be complex. In most instances, RAP falls under state solid-waste requirements and purview.

Because state environmental agencies often have more restrictive solid-waste disposal regulations than the federal Environmental Protection Agency, it is important to understand how RAP is defined. U.S. EPA classifies RAP as construction and demolition (C&D) debris that is part of the federal solid-waste chain. Federal regulations also identify that if materials are "recycled," then they are not considered solid waste. However, there is a "speculative accumulation" federal definition that requires a 75 percent annual "turnover" to maintain the recycled material classification vs. solid waste.

RAP is not, and never has been, considered a "hazardous" solid waste. Years of leaching studies show that there are no harmful components leached from RAP under the most stringent waste definition extraction conditions. (See NAPA Special Report 190: "Reclaimed Asphalt Pavement (RAP) Stockpile Emissions and Leachate.")

In general, it is acceptable for RAP to be used as a road material — as part of the base, recycled back into pavement, etc. — both from a federal and state perspective. Although U.S. EPA does not appear to have a strict definition of "clean fill", specific requirements do apply to solid-waste materials applied to land.

In contrast, a number of state environmental agencies do have specific definitions for "clean fill" and many state regulations prescribe how RAP can or cannot be used as a

CU-3972

fill-like material. In a number of states, the use of RAP fill is specifically restricted, for example, near surface or subsurface sources of water.

The bottom line is that each state's environmental agency will likely dictate whether or not RAP can be used as a clean fill material. Under normal use and circumstances, RAP should never be considered as hazardous waste.

See Also

- NAPA Special Report 190: "Reclaimed Asphalt Pavement (RAP) Stockpile Emissions and Leachate
  http://www.asphaltpavement.org/images/stories/SR-190revised.pdf
- IS-123: Recycling Hot-Mix Asphalt Pavements
  http://store.asphaltpavement.org/index.php?productID=171

ENVIRONMENTAL CONSIDERATIONS IN THE USE OF SALVAGED ASPHALT PAVEMENT

Prepared for

STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION
RESEARCH PROGRAM

in cooperation with

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

JULY 1994

By

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16. Abstract

The purpose of this sub-study (part of a larger research project on salvaged asphalt) was to investigate the potential for soil and/or groundwater and/or surface water contamination arising from the stockpiling, use, or disposal of salvaged asphalt pavement in Montana. The investigation was keyed to the four asphalt sources generally used in Montana highway pavements, those sources being the four Montana oil refineries. Asphalt from each refinery exhibits unique molecular and chemical attributes. Road surface contamination resulting from vehicular road use was recognized as a factor impacting this study, but was not researched.

Asphalt paving materials (actually, core samples from newly placed bituminous pavements) representing each of the four refinery sources were analyzed using widely accepted test methods. These included the EPA Toxic Characteristics Leachability Procedure (TCLP) and related tests to determine the presence and/or amount of volatile and semi-volatile organic compounds, polynuclear aromatics (PNA's) and certain metals. Test results are included.

In summary, no substances tested for in these test groups were observed to be above the stated minimum threshold values in any of the four representative samples. The potential of soil or water contamination arising from the use, storage, or disposal of any of the typical Montana asphalt paving mixtures appears to be minimal.

17. Key Words
Salvaged Asphalt Paving Materials, Environmental Soil/Water Impacts, Volatile/Semi-Volatile Organic Compounds, Polynuclear Aromatic Compounds, EPA/TCLP Testing

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ABSTRACT

The purpose of this sub-study (part of a larger research project on salvaged asphalt) was to investigate the potential for soil and/or groundwater and/or surface water contamination arising from the stockpiling, use, or disposal of salvaged asphalt pavement in Montana. The investigation was keyed to the four asphalt sources generally used in Montana highway pavements, those sources being the four Montana oil refineries. Asphalt from each refinery exhibits unique molecular and chemical attributes. Road surface contamination resulting from vehicular road use was recognized as a factor impacting this study, but was not researched.

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ENVIRONMENTAL CONSIDERATIONS IN THE USE OF SALVAGED ASPHALT PAVEMENT

INTRODUCTION

Asphalt cement is a chemically complex material derived from crude petroleum. It has been used for many years to pave thousands of miles of highways. Because of its availability, convenience, relatively low cost and long history of use, to say nothing of the difficulty of determining its chemical composition, we have been rather casual about its potential toxicity. With increasing awareness of hazards to health and the environment, however, asphalt has come under closer scrutiny. The issue with asphalt really arises because of its complexity. What potentially hazardous compounds might be present and in what concentrations and, more important, are they available to the atmosphere, the soil or to groundwater?

Our purpose under this contract has been to investigate the potential for soil and/or water contamination arising from the storage, use or disposal of salvaged asphalt pavement. In the process of searching for information already in the literature, we found that the emphasis has been largely on air quality and on the threat from polynuclear aromatic compounds (also called PNA's or PAH's, polyaromatic hydrocarbons. PNA will be used here). Relatively little has been published on soil or water contamination from asphalt in any form.

In this report, we will discuss briefly a few chemical considerations, followed by notes on the experiences of others with regard to soil/water contamination. The rationale for and results from our investigation will then be presented. Finally, there will be a few comments on the subject of air quality and asphalt safety in general.

ASPHALT CHEMISTRY

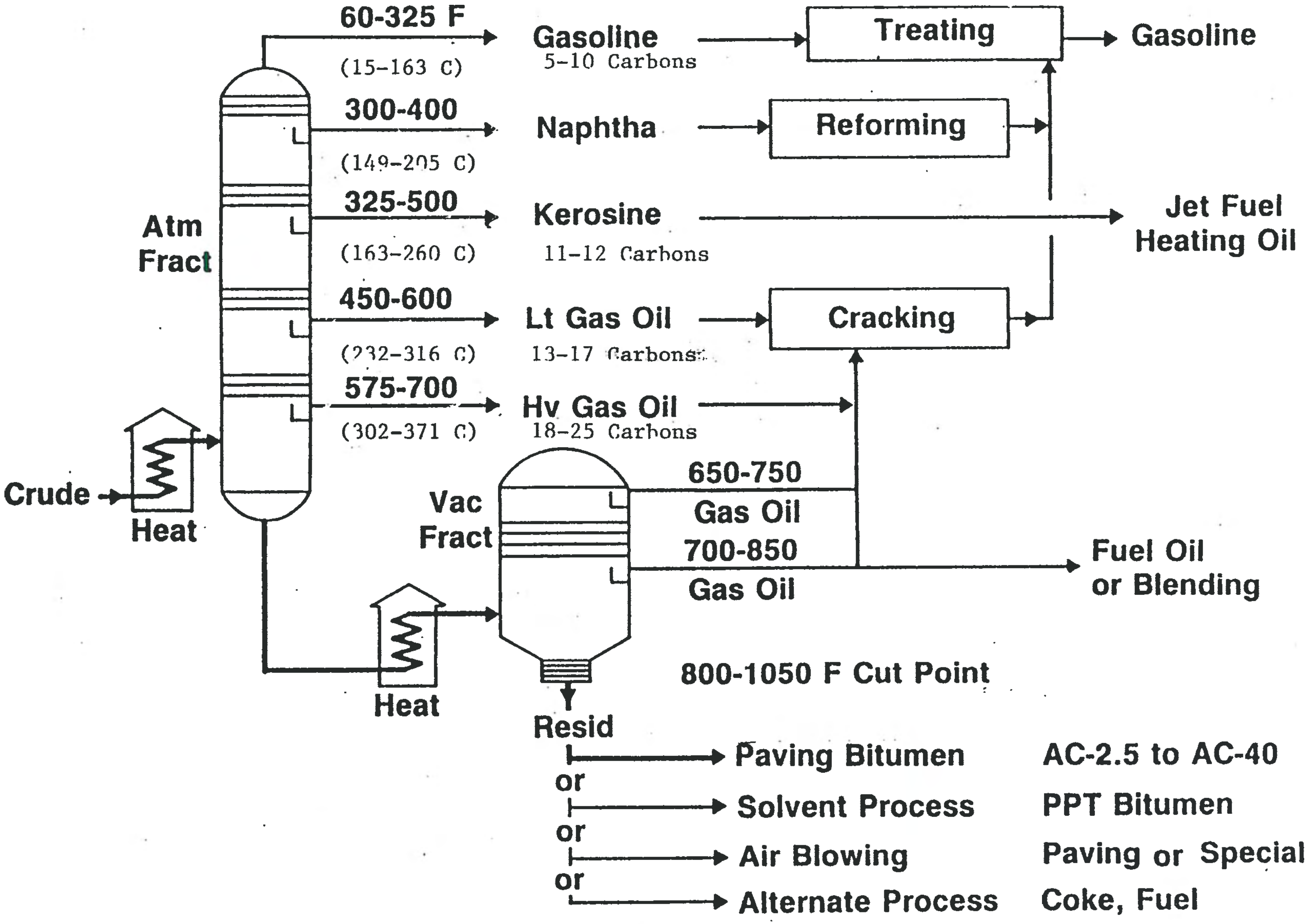
The refinery processes by which asphalt is produced are, of course, principally intended to make gasoline, jet fuel and other products--the money-makers for the refiner. A simplified diagram of such a process is shown in Figure 1 (1). The most important thing to notice is that most components of the crude oil which boil below 800°F, including gasoline and diesel fuel, have been removed before the residuum, asphalt, is collected. This asphalt cut-point may vary slightly depending on the crude oil and the processing conditions, but the principle remains, i.e., asphalt is a very high boiling material. It is possible for some molecules with boiling points somewhat below this cut-point to remain in the asphalt if they are tightly associated with other molecules to form even higher-boiling assemblies.

Asphalt is composed mostly of carbon (82-87%) and hydrogen with small amounts of nitrogen (usually <1.0%), oxygen (<1.1%) and sulfur (usually less that 7%) plus small amounts of vanadium, nickel or iron (only asphalts from certain South American sources contain more than a 2-300 parts per million of vanadium). There is a very large number of different kinds of molecules (see Figure 2)--aliphatic, alicyclic and aromatic molecules as well as molecules in which all are combined. Most of the nitrogen seems to be contained in aromatic systems (perhaps pyridine derivatives, but not pyridine itself). Oxygen may be found in a number of functional groups, including ketones, carboxylic acids or esters and aromatic forms whereas sulfur exists in aromatic rings and as sulfides that are readily oxidized to sulfoxide (in aliphatic chains, not as free sulfur oxides). Halogens (chlorine, for example) do not occur naturally in asphalt.

Aromatic molecules are of concern because certain kinds of polynuclear aromatic compounds (PNA's) are known to be carcinogenic. There seems to be little doubt that some of these compounds are present in asphalts with concentrations depending on the asphalt source (Table 1)(2). Nevertheless, the quantities of individual compounds are very small and the total concentrations of PNA's are also low. Further, small quantities of PNA's are present as substituted derivatives, that is, they have additional alicyclic or aliphatic structures attached. There is some question as to whether these substituted PNA's are as carcinogenic as their unsubstituted counterparts. It is also necessary to keep in mind that not all PNA's are considered to be toxic, mutagenic or carcinogenic. In Table 1, we have marked those known to have one or more of these hazardous characteristics.

FIGURE 1

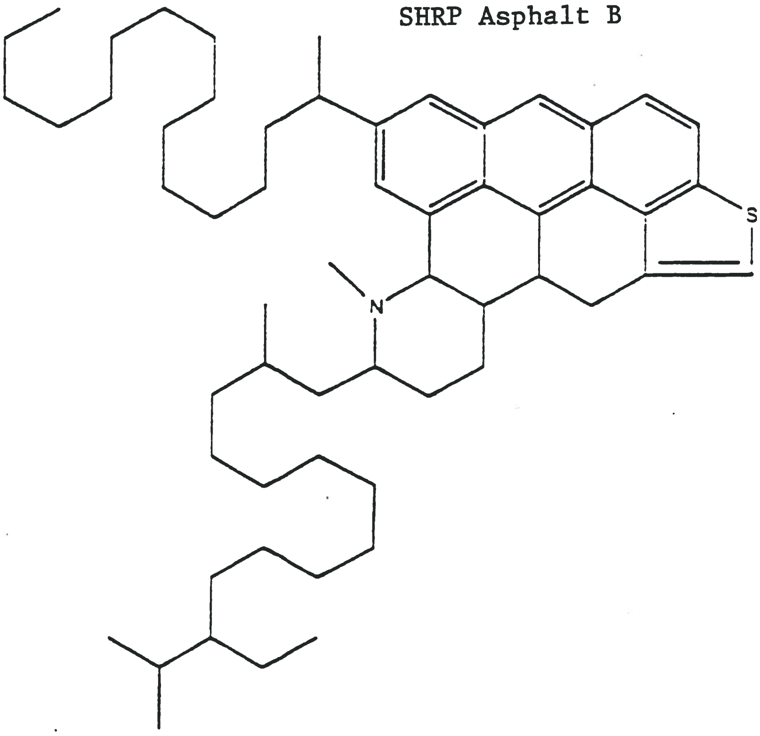
CRUDES INITIALLY SEPARATED BY DISTILLATION



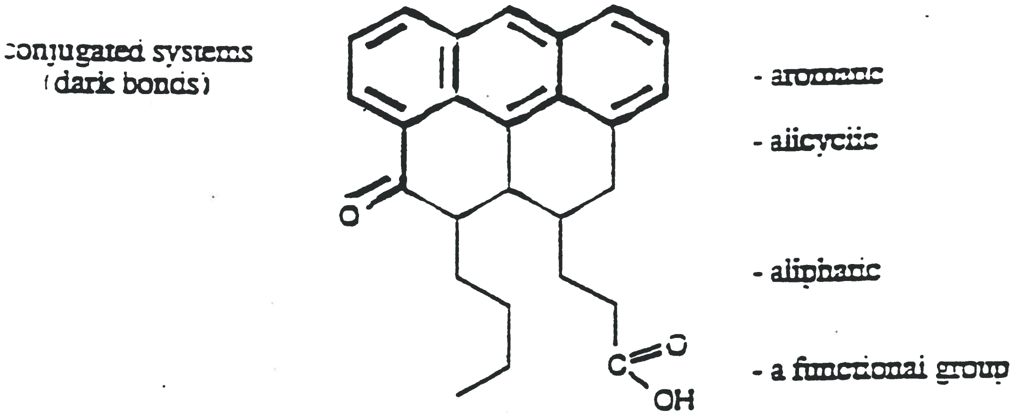
Source: L.W. Corbett, 1984

FIGURE 2

Examples of Hydrocarbon and Functional Group Types and an Average Molecule of SHRP Asphalt B



An Average Molecule of SHRP Asphalt B



Examples of Hydrocarbon and Functional Group Types

TABLE 1. POLYNUCLEAR AROMATIC HYDROCARBONS IN DIFFERENT ASPHALTS

	<------------------------Concentration, ppm------------------------>			
	Asphalt			
Compound	1	2	3	4
a anthracene d	–	–	–	–
a phenanthrene d	2.3(4.5)	0.4(7.5)	35[c]	2.3[c]
a pyrene	0.6(1.2)	1.8(18.0)	38(89)	0.08(0.8)
a fluoranthene	b	b	5(b)	–
a benzofluorenes	b	b	b	–
a benz[a]anthracene g	0.15(1.1)	2.1(46)	35(109)	–(0.05)
triphenylene	0.25(2.4)	6.1(31)	7.6(43)	0.3(0.7)
a chrysene e,g	0.2(4.0)	8.9(101)	34(158)	0.04(0.4)
a benz[a]pyrene e,g	0.5(2.9)	1.7(12)	27(69)	–
benz[e]pyrene h	3.8(11.0)	13(30)	52(141)	0.03(0.06)
a benz[k]fluoroanthene d,e	**(–)	–	–	–
perylene	–	39(9.7)	3.0(–)	–
anthanthrene ?	–	trace	1.8(–)	–
a benz[g,h,i]perylene	2.1(7.4)	4.6(9.4)	15(41)	trace
indeno[1,2,3-c,d]pyrene ?	trace	–	1.0(–)	–
picene	b	b	1.9(b)	–
coronene	1.9(–)	0.8(0.5)	2.8(1.9)	–
TOTAL	11.8(34.5)	78.4(265)	258(652)	2.7(1.24)

Adapted from Table 2.3, Ref. 2

a targeted in EPA analyses
– not detected
b not estimated but present in small amount
c incl. alkyl derivatives
d irritant
e suspected carcinogen
f mutagen
g toxic
h teratogen
? no reference found
() concentrations of substituted derivatives

Lower molecular weight compounds might be volatile and/or leachable. As noted above, asphalt is composed of very high-boiling, high molecular weight components. In pavements, the asphalt has again been subjected to high temperatures during construction so that any volatile materials should have been removed. It is, however, conceivable that some molecules could be mobilized by water. Strictly speaking, water solubility is not very likely because asphalt is highly nonpolar and, therefore, hydrophobic.

PREVIOUS STUDIES

In a review of the literature prepared for SHRP (2), Barksdale cites only two studies addressing the question of soil or water contamination from asphalt. The first of these (3) was intended to demonstrate how much asphalt could be washed from a pavement newly-constructed using emulsified asphalt or standard hot-mix. Rather substantial amounts of asphalt were removed. However, the experiments were poorly designed and are probably of little value. The second study (4) was concerned with the concentrations of PNA's in stormwater runoff. These increased during heavy rainfall and the authors suggest but do not verify that the sources include PNA's washed from the air, washed from road surfaces and leached from asphalt pavement. Thus, neither of these studies helps to resolve our concerns.

The State of Washington has conducted some studies concentrating on runoff which poses a more serious potential problem in the heavy traffic / heavy rainfall environment of the Seattle area (5). The reports on this study have been made available to the MDT and merit attention. However, they are not directly applicable to our present question.

Heritage Research Group for the Indiana and Illinois Departments of Transportation, conducted a series of studies (6-9) which address the question of potential leachates in direct fashion. We shall review these studies carefully in this report because they have not been formally published, to our knowledge.

An asphalt surfacing mixture using an AC-20 asphalt and an aggregate mixture containing slag from steel manufacturing was tested (6). The TCLP (Toxic Characteristic Leachability Procedure) was performed, and standard EPA tests were done for semi-volatile and volatile organic compounds, PNA's and metals. Each of these tests targets a very specific set of compounds or elements (Table 2).

TABLE 2. EPA TESTS ON TCLP LEACHATES

1) Semivolatile materials--method SW846-3510
   - 1,4-dichlorobenzene (flash point 65°C)
   - 2,4-dinitrotoluene (mp 67-70°C)
   - hexachlorobenzene (bp 326°C)
   - hexachlorobutadiene (bp 210°C)
   - hexachloroethane (bp 195°C)
   - nitrobenzene (fp 190°C)
   - pyridine (bp 115°C)
   - cresylic acid (aka cresol--bp 202°C)
   - 2-methyl phenol (aka o-cresol--bp 191°C)
   - 3-methyl phenol (bp 203°C
   - 4-methyl phenol (bp 202°C)
   - pentachlorophenol (bp 310°C)
   - 2,4,5-trichlorophenol (bp 248°C)
   - 2,4,6-trichlorophenol (bp 246°C)

2) Metals--method SW846-3010
   - barium
   - cadmium
   - chromium
   - lead
   - silver
   - arsenic
   - selenium
   - mercury

3) Volatile organic compounds--method SW846-3510
   - benzene (bp 80°C)
   - carbon tetrachloride (bp 77°C)
   - chlorobenzene (bp 132°C)
   - 1,2-dichloroethylene (bp 32°C)
   - 1,1-dichloroethylene (bp 48°C)
   - methyl ethyl ketone (bp 80°C)
   - tetrachloroethylene (bp 121°C)
   - trichloroethylene (bp 87°C)
   - vinyl chloride

(Continued)

TABLE 2. CONTINUED.

4) Polynuclear aromatic compounds--method SW846-8310
    naphthalene (bp 217°C)
    acenaphthalene (bp 280°C)
    acenaphthene (bp 279°C)
    fluorene (bp 298°C)
    anthracene
    fluoranthene (bp 384°C)
    pyrene
    benz[a]anthracene (bp 438°C)
    chrysene (bp 448°C)
    benz[b]fluoranthene
    benz[k]fluoranthene
    benz[a]pyrene (bp 495°C)
    dibenz[a,h]anthracene (bp 524°C)
    benz[g,h,i,]perylene (bp >500°C)
    indeno[1,2,3-c,d]pyrene

Several important points should be made regarding these lists. First, they contain compounds or elements which are known to be harmful to the environment or to animals and humans. Second, none of the metals of concern is found naturally in asphalt. Likewise, chlorine is not a natural component of asphalt. Further, you will note that none of the compounds listed as volatile or semi-volatile has a boiling point above 326°C. Thus, if asphalt is that portion of petroleum boiling above 400°C, then such materials would be likely to have been distilled away unless they were very tightly associated with other components to make an even higher-boiling assembly of molecules. (The 400° temperature is an approximation and may vary depending on the crude stock and grade of the asphalt being produced.)

For the surfacing mentioned above, chromium was detected and is believed to arise from the steel slag used as part of the aggregate. At a concentration of 0.10 ppm, that is below the regulatory "hazardous" level of 5 ppm. However, it does point out the need to be cautious about the odd kinds of materials used in paving. For all remaining organic compounds except naphthalene, no amounts above detectable limits were found. Naphthalene was present at 0.25 ppb., well below any guidelines.

In the next study, "Evaluation of RAP for use as a Clean Fill" (Jan., 1991) (7), six RAP samples representing different asphalt and aggregate sources were analyzed using TCLP and tests for semivolatiles, metals and PNA's. No semivolatile compounds above detectable limits were found in any sample. Naphthalene (0.49 ppb) and acenaphthene

(0.14 ppb) were found at site #1; 0.30 ppb naphthalene at site #2; benz[a]anthracene (0.017 ppb) and benz[k]fluoranthene (0.05 ppb) at site #5. Very small amounts of barium, chromium or lead were found at some of the sites, but none was near the regulatory limit. These are site specific and may result from surface contamination (eg., tire composition, crankcase oils including worn engine metals, lead from gasoline).

In March, 1992, Heritage issued a report, "Leachability of Asphalt and Concrete Pavements" (8), on a study intended "to determine the suitability of using concrete, asphalt or soils from the surrounding roadway as clean fill". In the TCLP leachates from asphalt concrete pavements samples taken at different sites across the road profile, naphthalene concentrations between 0.26 and 0.31 ppb were found; from the roadside soil, 0.76 ppb naphthalene was detected. Except for one example of phenanthrene at 0.30 ppb, no other PNA's were found above detectable limits. Kriech notes that naphthalene is present in measurable amounts in both crankcase oils and tire compositions. Barium levels between 2.6 and 3.7 ppm were found in all but one pavement sample and in the soil sample.

A study titled "Leachability of Cold Mix Asphalts" (Nov., 1992) (9) is particularly important since it involves emulsified and cutback asphalts. These materials are somewhat different from hot-mix asphalts and are often stockpiled. Heritage investigated an asphalt emulsion, AE-150, an MC-3000 cutback and a CM-150 cold mix multigrade, modified gelled asphalt using the same battery of tests. No metals, semi-volatile or volatile compounds were detected. Several PNA's were detected (all values in ppb):

	AE-150	MC-3000	CM-150
acenaphthene	0.41	--	2.7
naphthalene	4.4	8.0	14
fluorene	1.8	0.34	1.0
phenanthrene	1.3	0.74	1.1
anthracene	0.14		0.090
fluoranthene			0.19
pyrene			0.10

Kriech states that the levels are well below any known regulatory requirements.

Obviously, the asphalt and aggregate supplies available in Indiana and Illinois, where the Heritage studies were conducted, are different from those available in Montana. Therefore, we felt it necessary to test local materials. This work will be described in the next section.

MONTANA ASPHALTS

With few exceptions, Montana asphalt pavements are constructed with material from just four refineries: Cenex, Conoco, Exxon and Montana Refining. Therefore, since any salvaged asphalt is likely to represent one of these refineries, we wanted to include all four in our testing. In 1983, a series of test sections were constructed on I-90 near Big Timber. We have a large collection of samples from these pavements. We selected a set for testing for the following reasons:

1) includes all four refineries,
2) samples were not aged in the pavement, and so represent a "worst case" in that any lower molecular weight components would be likely to remain in the sample,
3) because all are of the same age, a fair comparison can be made among the refineries;
4) the same aggregate source was used throughout, thus eliminating this as a variable.

In choosing pavement samples which have not seen service in pavement, we have eliminated the possibility of observing materials resulting from surface contamination. (You will note that occurrences of such molecules as naphthalene in the Heritage Group's samples probably come from tire wear and crankcase drippings.) Since these materials do not derive from the asphalt, since they are available to the environment with every rain-event on the pavement, and since, even in the heavy-traffic environment of Indiana and Illinois, such molecules are found only in very small concentrations, this seems a reasonable choice. If a spill of hazardous material were to occur on a pavement, appropriate testing should be done before recycling or otherwise disposing of that pavement.

The TCLP is the best procedure to use when trying to determine what materials might leach from a sample in the field. It represents a "worst case" with regard to acid rain because low pH water is used as the solvent. Considering arguments made earlier and the experience of the Heritage Group, there seemed to be no reason to conduct the testing for the presence of the volatile or semivolatile compounds targeted by EPA. But we did want to test for metals and PNA's. In addition, we elected to test for the presence of "diesel-range organics", or "total extractable hydrocarbons". The rationale for this test is that some organic compounds, not necessarily considered to be hazardous in the usual sense but certainly undesirable in surface or ground water, could be mobilized in the leaching process. The compounds detected by the test have an approximate molecular weight range of 100 to 400 (about 10 to 28 carbon atoms).

Thus, we submitted samples to Energy Laboratories, Inc., in Billings for TCLP, PNA, metals and diesel-range organic procedures. Copies of the results are appended to this report. In summary, no leachable polynuclear aromatic compounds above detectable levels were observed in samples from any of the four refineries. Similarly, no hydrocarbons above detectable limits were extracted from any of the samples. Also, none of the metals targeted in the test were observed.

These results are, of course, reassuring. This is particularly true of the asphalt from the Cenex refinery in which we have observed a rather unusual composition that we thought might include elevated levels of aromatic compounds. We must caution, however, that answers to questions not asked are not found. That is, these tests respond only to the level of knowledge available at this time.

CONSIDERATIONS REGARDING BURIAL OF ASPHALT

Leaching of asphalt components is an obvious potential means of introducing undesirable materials into the environment. However, we questioned what the consequences of bacterial action upon buried asphalt might be. We found that there is active research on this topic as it is related to using asphalt concrete in containment vessels for low-level atomic waste (10-12). In general, researchers have found that bacterial activity does occur, that the aliphatic compounds are metabolized to carbon dioxide and water (aerobically), and that the rate of consumption is extremely slow (so slow that using this material to store these wastes is considered to be practical). It does not appear that toxic substances are formed, although that question is not addressed directly.

SUMMARY

Asphalt cement is composed of a multitude of high-boiling organic compounds, predominantly aromatic, aliphatic and alicyclic hydrocarbons, with small amounts of nitrogen, oxygen and sulfur. Only small quantities of vanadium, nickel or iron are present is most cases. No chlorine occurs naturally in asphalt. Polynuclear aromatic compounds, some of which are known to be toxic and/or carcinogenic, have been found in small amounts in whole asphalts. In studies conducted by Heritage Research Group for the Indiana and Illinois Departments of Transportation, only a few PNA's were observed in the TCLP leachates from some of the hot mix asphalt pavement samples, and always at concentrations less than 1 part per billion. Volatile and semivolatile organic compounds targeted in EPA tests were not found.

Pavements constructed with asphalt from each of the Montana refineries were subjected to the TCLP procedure and analyzed for leachable PNA's, metals and diesel-range organics. No leachable materials above detectable limits were observed in any of these categories in any of the samples. This is significant because the vast majority of Montana pavements which might be candidates for salvage will have been constructed with asphalts from these four refineries. Thus, it appears that contamination of water by organic compounds leached from reclaimed hot mix asphalt pavement when it is stockpiled or used as shoulder cover is not likely, considering present tests and standards.

ADDITIONAL NOTES

It was mentioned earlier that most of the work regarding potential hazards from asphalt concentrates on exposure of humans and the environment to paving asphalt emissions. There are also studies regarding direct contact of asphalt with the skin. This body of work seems to have been thoroughly reviewed for SHRP (2).
However, we are aware of a more recent development in California which we want to bring to the attention of the Highways Division.

When paving with polymer-modified asphalts under a property-based specification, workers on some (not all) projects experienced a variety of problems, including eye, nose and throat irritation, headache and nausea. As California is well aware, a specification such as they have for modified material allows the supplier to use an unknown number of possible blends. The supplier must solve some very practical problems--polymers do not necessarily combine easily with asphalts, especially to make a stable mixture. Moreover, the properties of the mixture may be such as to make the paving process very difficult, if not impossible. Therefore, the producer may use a "carrier" of some kind. In conducting a literature search to answer a different question, I noted a variety of possibilities, including tall oil, tung oil, long-chain fatty acid amines, gas oil, "aromatic" oils, used motor oil and even more exotic materials.

Similarly, a variety of polymers could be used and, although one would expect them to be heat-stable, there is a possibility that the polymer contains unreacted monomer or short polymer chains that could be volatile.

California has not yet pinpointed the source of the problem. They have issued respirators to their personnel and have suggested to contractors that they make respirators available to their workers on polymer-modified and rubber-asphalt paving projects. If modified materials are to be used in Montana, it seems wise to be aware of this potential and to have some contingency plans for coping with the situation.

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11) L.P. Buckley, et al., "Microbial Activity on Bituminized Radioactive Waste", Radioact. Waste Mgmt. Nucl. Fuel Cycle, (1985) 6 19.

12) T.K. Jones, "Effect of Bacteria and Fungi on Asphalt", Matls. Protection, (1965) Dec. 39.

APPENDIX A

TEST RESULTS

ENERGY
LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Joan Pribanic
ADDRESS: Montana State University
Dept. of Chemistry & Biology
Bozeman, MT 59717-0340

LAB NO.: 94-16753
DATE: 05/27/94 jmw

WASTE ANALYSIS

EXXON
MSU-IJ-T-1A&B, Sample #1
Submitted 04/21/94
Extracted 05/02/94
Analyzed 05/24/94

Extraction Method: EPA Method 3510
Amount Extracted: 760 ml
Analysis Method: EPA Method 8310

Compound	µg/l
Naphthalene	<0.2
Acenaphthylene	<0.2
Acenaphthene	<0.2
Fluorene	<0.2
Phenanthrene	<0.1
Anthracene	<0.1
Fluoranthene	<0.1
Pyrene	<0.1
Benzo(a)anthracene	<0.01
Chrysene	<0.1
Benzo(b)fluoranthene	<0.01
Benzo(k)fluoranthene	<0.01
Benzo(a)pyrene	<0.02
Dibenzo(a,h)anthracene	<0.02
1,12, Benzoperylene	<0.02
Indeno-1,2,3-c,d pyrene	<0.02

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LABORATORY REPORT

TO: Joan Pribanic
ADDRESS: Montana State University
Dept. of Chemistry & Biology
Bozeman, MT 59717-0340

LAB NO.: 94-16750
DATE: 05/27/94 jmw

WASTE ANALYSIS

CENEX
MSU-IJ-T-6A&B, Sample #6
Submitted 04/21/94
Extracted 05/02/94
Analyzed 05/24/94

Extraction Method: EPA Method 3510
Amount Extracted: 970 ml
Analysis Method: EPA Method 8310

Compound	µg/l
Naphthalene	<0.2
Acenaphthylene	<0.2
Acenaphthene	<0.2
Fluorene	<0.2
Phenanthrene	<0.1
Anthracene	<0.1
Fluoranthene	<0.1
Pyrene	<0.1
Benzo(a)anthracene	<0.01
Chrysene	<0.1
Benzo(b)fluoranthene	<0.01
Benzo(k)fluoranthene	<0.01
Benzo(a)pyrene	<0.02
Dibenzo(a,h)anthracene	<0.02
1,12, Benzoperylene	<0.02
Indeno-1,2,3-c,d pyrene	<0.02

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO:	Joan Pribanic	**LAB NO.:**	94-16751
ADDRESS:	Montana State University Dept. of Chemistry & Biology Bozeman, MT 59717-0340	**DATE:**	05/27/94 jmw

WASTE ANALYSIS

MRC
MSU-IJ-T-10A&B, Sample #10
Submitted 04/21/94
Extracted 05/02/94
Analyzed 05/24/94

Extraction Method: EPA Method 3510
Amount Extracted: 970 ml
Analysis Method: EPA Method 8310

Compound	μg/l
Naphthalene	<0.2
Acenaphthylene	<0.2
Acenaphthene	<0.2
Fluorene	<0.2
Phenanthrene	<0.1
Anthracene	<0.1
Fluoranthene	<0.1
Pyrene	<0.1
Benzo(a)anthracene	<0.01
Chrysene	<0.1
Benzo(b)fluoranthene	<0.01
Benzo(k)fluoranthene	<0.01
Benzo(a)pyrene	<0.02
Dibenzo(a,h)anthracene	<0.02
1,12, Benzoperylene	<0.02
Indeno-1,2,3-c,d pyrene	<0.02

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LABORATORIES

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Joan Pribanic
ADDRESS: Montana State University
Dept. of Chemistry & Biology
Bozeman, MT 59717-0340

LAB NO.: 94-16752
DATE: 05/27/94 jmw

WASTE ANALYSIS

CONOCO
MSU-IJ-T-15A&B, Sample #15
Submitted 04/21/94
Extracted 05/02/94
Analyzed 05/24/94

Extraction Method: EPA Method 3510
Amount Extracted: 970 ml
Analysis Method: EPA Method 8310

Compound	µg/l
Naphthalene	<0.2
Acenaphthylene	<0.2
Acenaphthene	<0.2
Fluorene	<0.2
Phenanthrene	<0.1
Anthracene	<0.1
Fluoranthene	<0.1
Pyrene	<0.1
Benzo(a)anthracene	<0.01
Chrysene	<0.1
Benzo(b)fluoranthene	<0.01
Benzo(k)fluoranthene	<0.01
Benzo(a)pyrene	<0.02
Dibenzo(a,h)anthracene	<0.02
1,12, Benzoperylene	<0.02
Indeno-1,2,3-c,d pyrene	<0.02

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LABORATORY REPORT

TO: Joan Pribanic
ADDRESS: Montana State University
Dept. of Chemistry & Biology
Bozeman, MT 59717-0340

LAB NO.: 94-16753
DATE: 05/27/94 jmw

WASTE ANALYSIS

MSU-IJ-T-1A&B, Sample #1
Submitted 04/21/94
Extracted 04/21/94

TOXICITY CHARACTERISTIC LEACHING PROCEDURE
EPA SW-846 METHOD 1311

Metals	CAS No.	Regulatory Limit, mg/l	Minimum Reporting Limit, mg/l	Result, mg/l in Extract	Spike Percent Recovery	Date Analyzed
Arsenic	7440-38-2	5.0	0.5	<0.5	105	04/27/94
Barium	7440-39-3	100.0	10.0	<10	91	04/25/94
Cadmium	7440-43-9	1.0	0.1	<0.1	90	04/25/94
Chromium	7440-47-3	5.0	0.5	<0.5	95	04/25/94
Lead	7439-92-1	5.0	0.5	<0.5	88	04/25/94
Mercury	7439-97-6	0.2	0.02	<0.02	109	04/26/94
Selenium	7782-49 2	1.0	0.1	<0.1	113	04/27/94
Silver	7440-22-4	5.0	0.5	<0.5	81	04/25/94

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LABORATORY REPORT

TO: Joan Pribanic
ADDRESS: Montana State University
Dept. of Chemistry & Biology
Bozeman, MT 59717-0340

DATE: 05/27/94 jmw

WASTE ANALYSES
TCLP EXTRACTS

Submitted: 04/21/94

			mg/liter (ppm)			
Identification Lab No.	Date Extracted	Date Analyzed	Diesel Range Organics	Diesel Range Organics as Diesel	Total Extractable Hydrocarbons	(1)Surrogate Recovery, %
MSU-IJ-T-6A&B, Sample #6						
94-16750	04/26/94	04/28/94	<2.5	<2.5	<2.5	97
MSU-IJ-T-10A&B, Sample #10						
94-16751	04/26/94	04/29/94	<2.5	<2.5	<2.5	91
MSU-IJ-T-15A&B, Sample #15						
94-16752	04/26/94	04/29/94	<2.5	<2.5	<2.5	74
MSU-IJ-T-1A&B, Sample #1						
94-16753	04/26/94	04/28/94	<2.5	<2.5	<2.5	76
Method Blank	04/26/94	04/28/94	<2.5	<2.5	<2.5	82

COMMENTS:

(1) Surrogate added to the sample for quality assurance purposes.

NOTE1: Diesel Range Organics are defined as all hydrocarbons eluting between C10 and C28.

NOTE2: Diesel Range Organics as Diesel Fuel are defined by the analyst as that portion of the chromatogram between C10 and C28 that resembles diesel fuel.

NOTE3: Total Extractable Hydrocarbons are defined as the total hydrocarbon responses regardless of elution time. This value is equivalent to EPA method 8015 Modified TPH as Diesel.

File No. 16750-3

Special Report

NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION
5100 Forbes Boulevard, Lanham, MD USA 20706-4407
TF: 888.468.6499 T: 301.731.4748 F:301.731.4621
www.hotmix.org

Reclaimed Asphalt Pavement ("RAP"): Stockpile Emissions and Leachate

The hot-mix asphalt ("HMA") industry is America's biggest recycler. More than 90 million tons of asphalt pavement is reclaimed each year during widening and resurfacing projects, and of that total, more than 80 percent is reused. More than 92 percent of the nation's highways and roads are surfaced with asphalt. RAP is incorporated into new pavements, shoulders, and embankments. Recycling is a vital part of the asphalt pavement industry, as it creates great benefits for the general public.

- RAP has economic benefits for taxpayers, as well as environmental benefits. Using RAP results in lower costs because less virgin material is used.
- Research conducted for more than three decades has proven that recycled pavements offer the same durability as pavements constructed with virgin materials, but with significant cost savings to the public and private consumer.
- Milled RAP has the additional benefit of being ready to recycle without extensive processing.
- RAP reduces the amount of new petroleum products and aggregates used in building pavements.
- Until recycling became widespread in the 1970s, RAP was disposed of in landfills. Thanks to recycling, government savings have been in excess of hundreds of millions of dollars, and space is not taken up at our landfills.

Recycling of asphalt pavement is a well-accepted practice throughout the United States that conserves our precious natural resources while allowing highway agencies to deliver quality pavements to the traveling public in a cost-effective manner.

EPA recognizes that RAP piles are not likely to cause significant fugitive dust problems because the aggregate is coated with asphalt cement (see Section 2.2.1 at: http://www.epa.gov/ttnchie1/eiip/techreport/volume02/ii03.pdf) Also, EPA and other agencies recognize that RAP can be used as an effective control to reduce general fugitive dust emissions from unpaved roads and areas; providing up to a 70 percent reduction [see Table 1 at: http://www.npi.gov.au/publications/emission-estimation-technique/pubs/fasphalt.pdf].

Regarding runoff or leachate from RAP, it is well documented that leachate or runoff from RAP storage is not problematic [see http://www.hinkleycenter.com/images/stories/publications/townsend_98-2.pdf]; for additional references, see the World Health Organization's CICAD, No. 59 (Sec. 6.1) or contact NAPA]. In fact, RAP is commonly used as clean fill material in highway construction.

NAPA believes that vital natural resources are preserved by the wise and appropriate use of reclaimed asphalt pavement. We support and encourage thoughtful approaches to environmental protection, and we believe that RAP is an important tool for environmental stewardship

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CU-3922

Special Report

NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION
5100 Forbes Boulevard, Lanham, MD USA 20706-4407
TF: 888.468.6499 T: 301.731.4748 F:301.731.4621
www.hotmix.org

Reclaimed Asphalt Pavement (RAP): Stockpile Emissions and Leachate

The asphalt pavement industry is America's biggest recycler. More than 75 million tons of asphalt pavement is reclaimed each year during widening and resurfacing projects, and about 95 percent of that reclaimed material is reused in new pavement mixes; the remainder is used in other road-building activities or stockpiled for future use. About 94 percent of the nation's highways and roads are surfaced with asphalt. RAP is incorporated into new pavements, shoulders, and embankments. Recycling is a vital part of the asphalt pavement industry, as it creates great benefits for the general public.

- RAP has economic benefits for taxpayers, as well as environmental benefits. Using RAP results in lower costs because less virgin material is used.
- Research conducted for more than three decades has proven that recycled pavements offer the same durability as pavements constructed with virgin materials, but with significant cost savings to the public and private consumer.
- Milled RAP has the additional benefit of being ready to recycle without extensive processing.
- RAP reduces the amount of new petroleum products and aggregates used in building pavements.
- Until recycling became widespread in the 1970s, RAP was disposed of in landfills. Thanks to recycling, government savings have been in excess of hundreds of millions of dollars, and space is not taken up at our landfills.

Recycling of asphalt pavement is a well-accepted practice throughout the United States that conserves our precious natural resources while allowing highway agencies to deliver quality pavements to the traveling public in a cost-effective manner.

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NAPA believes that vital natural resources are preserved through the wise and appropriate use of reclaimed asphalt pavement. We support and encourage thoughtful approaches to environmental protection, and we believe RAP is an important tool for environmental stewardship.

CU-3922

ver. 11.3.16

SR-190g

STAFF REPORT

Board of Zoning Appeals
March 18, 2019

Case: VA-3937

Prepared by: Brad Fisher

Owner:	It's Gonna Be Nice, LLC.
Applicant:	Preferred Living
Agent:	David Hodge – Underhill & Hodge
Township:	Franklin Township
Site:	3339 McKinley Avenue (PID #140-000512)
Acreage:	0.23-acres
Zoning:	Rural and Limited Industrial (LI)
Request:	Requesting a Variance from Sections 541.03(5(a)), (b), and (e) of the Franklin County Zoning Resolution to allow the construction of an area identification sign that is not adjacent to a major access point, does not meet the minimum setback from the road right-of-way, and exceeds the maximum letter area size.

Summary

Requesting a Variance from Sections 541.03(5(a)), (b), and (e) of the Franklin County Zoning Resolution to allow the construction of an area identification sign that is not adjacent to a major access point, does not meet the minimum setback from the road right-of-way, and exceeds the maximum letter area size. The request meets the criteria for granting a Variance. Staff recommends ***conditional approval***.

Description of the Request

The subject site is located at the southwest intersection of Trabue Road and McKinley Avenue in Franklin Township. The subject site is vacant and surrounded by properties located in the City of Columbus.

The applicant desires to construct a gateway sign for the historic village of San Margherita to celebrate and preserve the history of the neighborhood. The requested Variance is for one (1) area identification sign that measures 62 feet wide by 33 feet high, with a letter area of 121 square feet. The sign fails to meet the area identification sign requirements by not being located adjacent to any major access points to a subdivision, complex, or institution, not meeting the minimum setback from both the Trabue Road and Mckinley road right-of-way, and exceeding the maximum letter area size.

Surrounding Land Use and Zoning

The surrounding properties are located in the City of Columbus. Properties to the south are zoned multi-family residential, to the west are commercial, to the north are residential and manufacturing, and to the east are multi-family residential. The properties adjacent to the subject site to the west and south are proposed to be a mixed-use development.

Comprehensive Plan
The Scioto-Franklin Neighborhood Plan, adopted in 2011, includes a Future Land Use Map and Development Guidelines to help guide development. The Future Land Use Map recommends the area for a limited range of commercial and residential uses. The recommended commercial districts are Suburban Office (SO) and Neighborhood Commercial (NC). The Development Guidelines reflect the community's desire to create great neighborhoods and recommends encouraging a mix of commercial uses and protecting the neighborhood character.

Staff believes that the proposed sign promotes the history of the neighborhood, enhances the aesthetics of the intersection, and is in line with the recommendations of the Plan.

Staff Review
Section 541.03(5) – Development Area Identification Signs: A Development Area Identification Sign shall be permitted for residential sub-divisions, multi-family residential complexes, or institutions provided they are located at a major access point, and meet the minimum setback to the public right-of-way and the maximum sign size.

<u>Variance from Section 541.03(5(a))</u> – A Development Area Identification Sign shall be permitted adjacent to arterial streets as defined by the Franklin County Thoroughfare Plan at major access points to the subdivision, complex, or institution.

- The sign is not located at a major access point to any subdivision, complex, or institution
  - A Variance to allow the sign to not be located at a major access point is required

<u>Variance from Section 541.03(5(b))</u> – A Development Area Identification Sign shall not be located within fifteen (15) feet of the public right-of- way of the arterial street abutting the Development Area.

- The proposed sign is 11.27 feet from the right-of-way line
  - A Variance of 3.73 feet is required

<u>Variance from Section 541.03(5(e))</u> – The size of the Development Area Identification Sign shall not exceed ninety-six (96) square feet and the height or width of the sign shall not exceed twelve (12) feet.

- The proposed size of lettering is 121 square feet
  - A Variance of 25 square feet is required
- The proposed height is 33 feet
  - A Variance of 21 feet is required
- The proposed width is 62 feet
  - A Variance of 50 feet is required

<u>Technical Review Committee Agency Review</u>
No Technical Review Committee Agencies expressed any concerns.

Staff Analysis

Section 810.041 – Approval of Variance:

The Franklin County Zoning Resolution identifies five (5) criteria in Section 810.041 that must be satisfied to approve a Variance request.

1) *Special conditions and circumstances exist which are peculiar to the land or structure involved and which are not applicable to other lands or structures in the same zoning district;*
   - » The applicant stated that the proposed sign would make a beneficial use of the property for the good of the neighborhood, and the size and location of the lot are a special circumstance that are not applicable to surrounding lots.
   - » Staff agrees that the triangular shape and size of the lot creates a special circumstance that is not applicable to surrounding lots.
2) *A literal interpretation of the provisions of this Zoning Resolution would deprive the applicant of rights commonly enjoyed by other properties in the same zoning district under the terms of this Zoning Resolution;*
   - » The applicant stated that the lot is just under a quarter acre, may not be able to provide access to both Trabue Road and McKinley Avenue and is generally undevelopable.
   - » Staff agrees that the lot size, configuration and zoning restricts the ability to develop the site, and that the proposed identification sign is an appropriate use of this site.
3) *The special conditions and circumstances do not result from the action of the applicant;*
   - » Staff does not believe that the special circumstance is due to any action of the applicant.
4) *Granting the variance requested will not confer on the applicant any special privilege that is denied by this Zoning Resolution to other lands or structures in the same Zoning District;*
   - » Staff notes that no other lots in the general area are in unincorporated Franklin County and no other lots share the common characteristics of the subject site.
5) *Granting the variance will not adversely affect the health or safety of persons residing or working in the vicinity of the proposed development, be materially detrimental to the public welfare or injurious to private property or public improvements in the vicinity;*
   - » The applicant stated and staff agrees that the proposed development would not adversely affect the health or safety of persons residing or working in the area, and the overall development will improve the neighborhood character and create a sense of place in the community.

Recommendation:

Staff's recommendation is that the Board of Zoning Appeals ***conditionally approve*** a Variance from Sections 541.03(5(a)), (b), and (e) of the Franklin County Zoning Resolution to allow the construction of an area identification sign that is not adjacent to a major access point, does not meet the minimum setback from the road right-of-way, and exceeds the maximum letter area size in an area zoned Rural and Limited Industrial (LI). The conditions are as follows:

1. The applicant must apply for and receive approval of a Certificate of Zoning Compliance with the Franklin County Economic Development and Planning Department.
2. The applicant must apply for and receive approval of a Building permit with the Franklin Township Building Department, if required.

Resolution
For your convenience, the following is a proposed resolution:

Proposed Resolution:
__________________ moves to approve a variance from Sections 541.03(5(a)), (b), and (e) of the Franklin County Zoning Resolution as outlined in the request for the applicant identified in Case No. VA-3937 with staff's recommended conditions.

Seconded by: ____________________________

Voting:

Findings of Fact
For your convenience, the following are proposed findings of fact:

If the resolution fails for lack of support, the following are proposed findings of fact for adoption by the BZA:
__________________ moves that the basis for denying the applicant's request for the variance from Sections 541.03(5(a)), (b), and (e) of the Franklin County Zoning Resolution as outlined in the request for the applicant identified in Case No. VA-3937 results from applicant's failure to satisfy the criteria for granting a variance under Section 810.041.

Seconded by: ____________________________

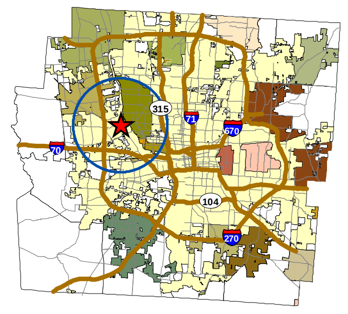
Voting:

VA-3937

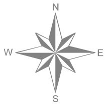
Requesting a Variance from Sections 541.03(5(a)), (b), and (e) of the Franklin County Zoning Resolution to allow the construction of an area identification sign that is not adjacent to a major access point, does not meet the minimum setback from the road right-of-way, and exceeds the maximum letter area size in an area zoned Rural and Limited Industrial (LI).

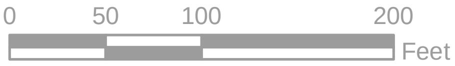
Acres: 0.237
Township: Franklin

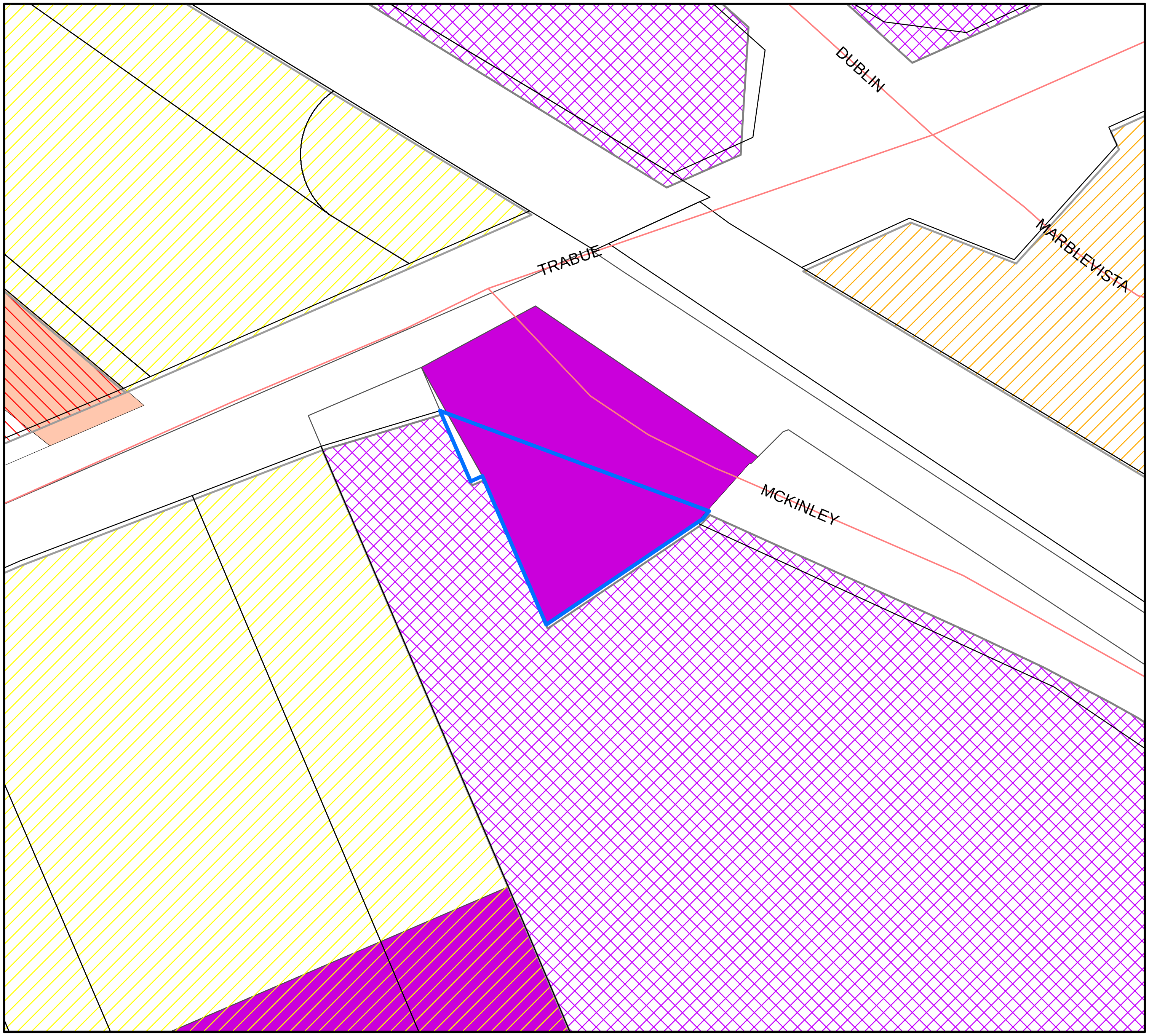
🟨	3339 McKinley Avenue
☐	Parcels
—	Streets



Franklin County
Board of Commissioners
ECONOMIC DEVELOPMENT
& PLANNING
1803







VA-3937

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Acres: 0.237
Township: Franklin

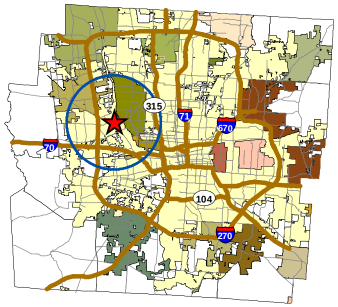
- ▭ 3339 McKinley Avenue
- ▭ Parcels
- — Streets

Franklin County Zoning

- ▭ Exceptional Use
- ■ Limited Industrial
- ▭ Rural
- ■ Suburban Office and Institutional

Columbus Zoning

- ▨ Residential
- ▨ Multi-family
- ▨ Commercial
- ▦ Manufacturing



Franklin County
Board of Commissioners
ECONOMIC DEVELOPMENT
& PLANNING
1803

VA-3937

Requesting a Variance from Sections 541.03(5(a)), (b), and (e) of the Franklin County Zoning Resolution to allow the construction of an area identification sign that is not adjacent to a major access point, does not meet the minimum setback from the road right-of-way, and exceeds the maximum letter area size in an area zoned Rural and Limited Industrial (LI).

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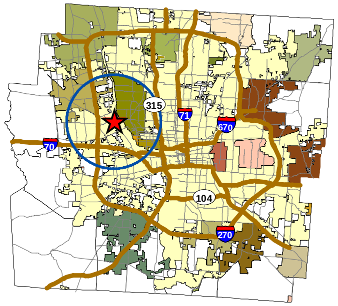

Franklin County
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1803

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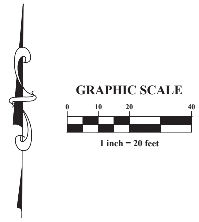
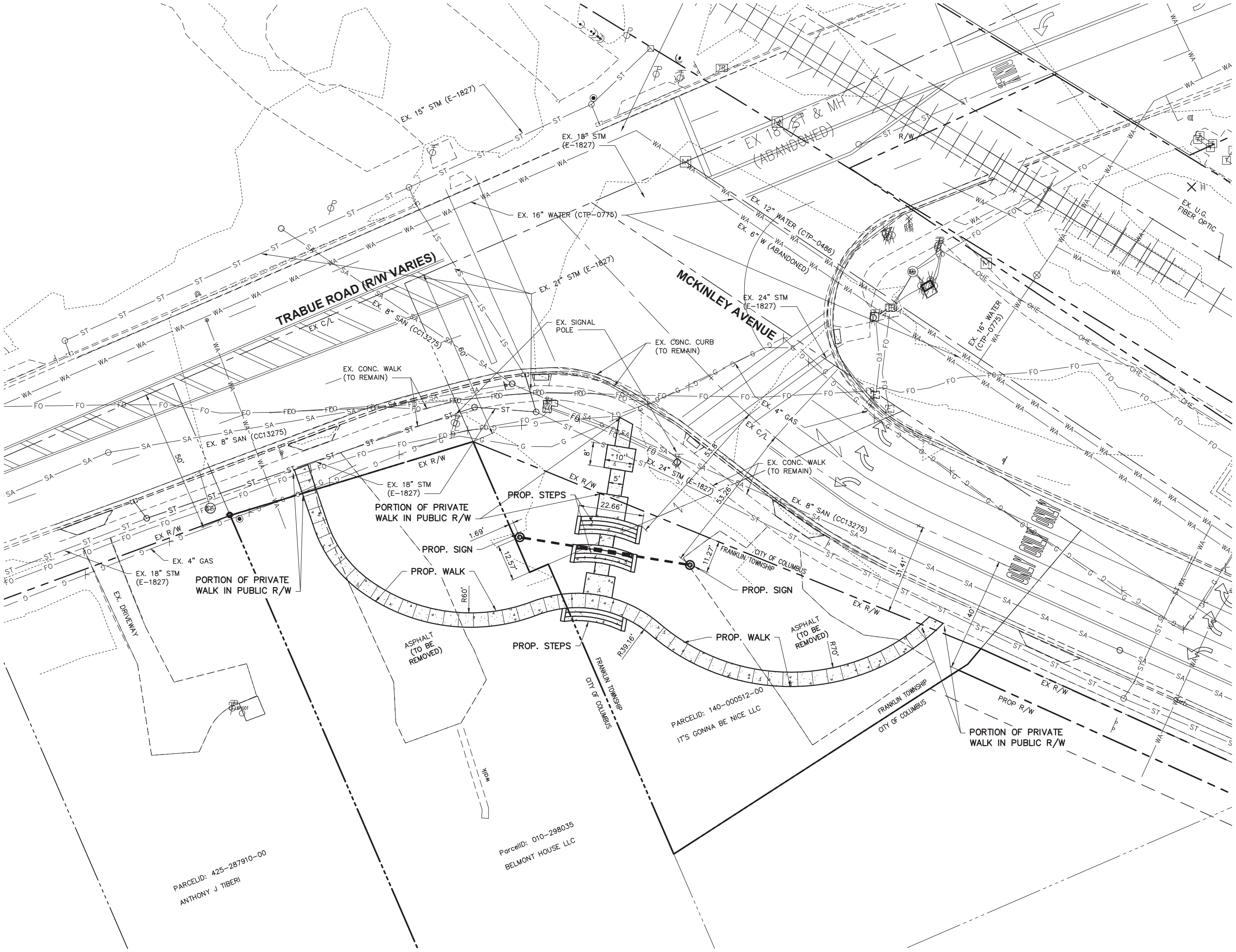
Case: VA-3937
Received: 3/4/19

VICINITY MAP
SCALE: NTS





FRANKLIN TWP./FRANKLIN COUNTY,
OHIO/CITY OF COLUMBUS, OHIO

SITE ZONING COMPLIANCE PLAN
FOR
PREFERRED LIVING
SIGN SITE PLAN

ADVANCED
CIVIL DESIGN
ENGINEERS SURVEYORS

422 Beecher Road
Gahanna, Ohio 43230
ph 614.428.7750
fax 614.428.7755

#S1-34589-R4: ILLUMINATED STEEL ARCHWAY 3/16" = 1'-0"

- SUPPORT POLES: 18" DIAMETER STEEL POLES PAINTED BLACK.
- "SAN MARGHERITA": 5" DEEP CHANNEL LETTERS WITH BLACK TRIM-CAP AND RETURNS WITH PERFORATED BLACK VINYL OVERLAY.
- CHANNEL LETTER ILLUMINATION: WHITE LED.
- ARCH: STEEL POLES AS NOTED.
- FOUNDATION: 48" DIAMETER X 12'-6" DEEP CAISSON FOUNDATIONS.
- ILLUMINATION: QTY (44) WHITE LED BULBS - SIMILAR TO SHORT NORTH ARCH BULBS.

VA-3937

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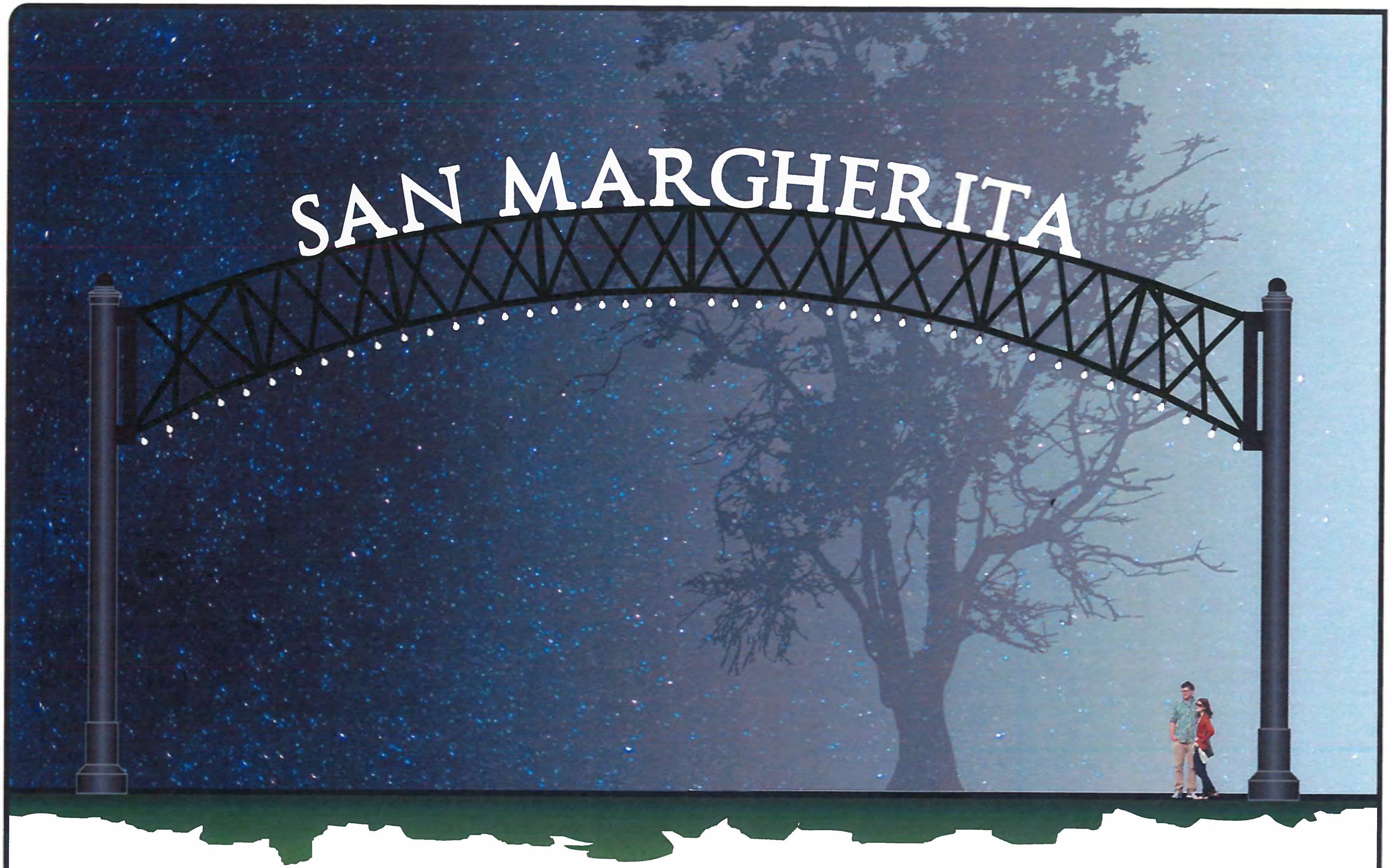

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