

Progress Report for

A Side-by-Side Comparison of Pervious Concrete and Porous Asphalt

27 January 2009

Prepared for

**RMC Research and Education Foundation
Prince George's County
PA DEP**



VILLANOVA URBAN STORMWATER PARTNERSHIP

Executive Summary

Sampling and monitoring continue at the site. Water quality and quantity data have been collected and inspections at the site have been performed. The site has been cleaned using the vacuum street sweeper. The leak from the outflow pipe has been found and repaired.

Background

The use of stormwater best management practices (BMPs) has increased dramatically over the past five years. Many state BMP manuals and the US EPA lump all pervious pavements together under one category. We propose a study to ascertain the differences between pervious concrete and porous asphalt in regards to durability, maintenance requirements, and ability to transmit or filter key contaminants such as hydrocarbons. Two nearly identical parking areas were constructed on Villanova University's campus to ascertain the performance characteristics of pervious concrete and porous asphalt. This parking area joins a number of other BMPs on Villanova's campus under the direction of the Villanova Urban Stormwater Partnership (VUSP).

As the funding came in from the different agencies at different times, August 2007 will be considered as the beginning of the project.

Table 1 summarizes the instrumentation locations and purpose. Figure 1 provides a sketch of the instrumentation locations.

Table 1. Summary of Instrumentation

Instrument	Number	Location	Purpose
Tipping bucket rain gage	1	Rooftop	Measure amount of rainfall at site
First flush samplers	2	Interface between pervious/porous pavements and conventional pavement	Obtain first flush samples for water quality testing
Pressure transducer with V-notched weir at overflow pipe	2	Drop inlets located at the edge of each bed	Measure depth of water in bed to determine infiltration rates, measure flow and volume of water exiting the site, measure temperature of water in bed
Pressure-vacuum soil water samplers (lysimeters)	6	Three samplers located below each bed	Obtain soil water samples to determine water quality
Temperature sensors	10	One in each first flush sampler and one in each sampling bottle from the lysimeters	Determine impact of the BMP of water temperature

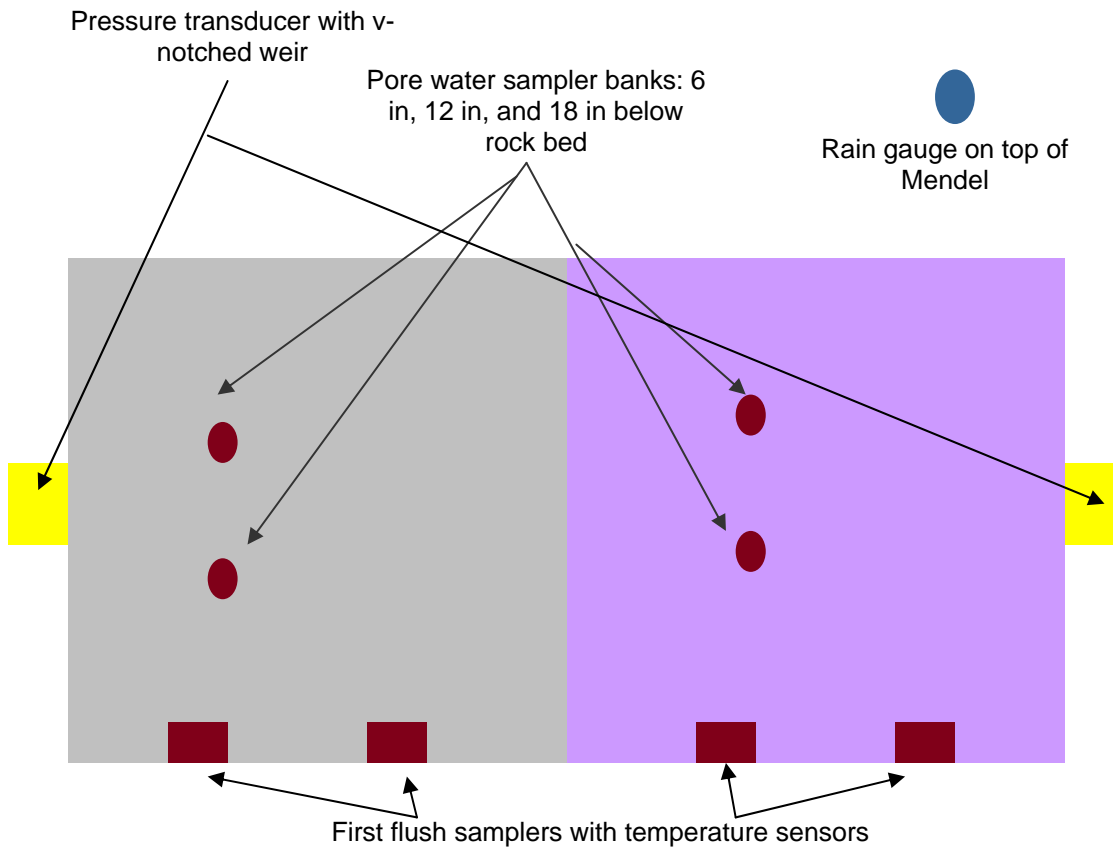


Figure 1. Location of Instrumentation

Planned Work

The major goals for the time period covered by this progress report (July 2008 through December 2008) were:

1. Continue disseminating the results of the work via the website, seminars, etc. This project will be the subject of a presentation at “A Day of Stormwater”, which will be held on Villanova’s campus on 14 August.
2. Repair the leak near the outflow pipes.
3. Sample and test for all rain events over 0.25 in within an 8 hour period, specifically:
 - a. Inflow and outflow
 - b. Infiltration rates
 - c. Temperature
 - d. pH
 - e. Total Suspended Solids (surface samples only)
 - f. Total Dissolved Solids (surface and subsurface)
 - g. Chlorides
 - h. Total N and total P
 - i. Particulate metals: Pb, Cu, Cd, Zn
 - j. PAHs

4. Initiate a bench top, side-by-side comparison of the pavement types focusing only on hydrocarbons.

Progress

Many of the tasks identified above have been completed. The progress for each task is described below. Water quality sampling and hydrologic monitoring continued.

Dissemination of Work

We strive to share the results of our work with all interested in parties. The results of this work were presented at a Seminar on Maintenance and Monitoring of BMPs held at Villanova University on August 14th. The site was included on a tour that followed the presentations.

The website that presents the results of this work can be found at:

http://www3.villanova.edu/VUSP/bmp_research/pc_pa/pc_pa_main.htm. This website is periodically updated with new information.

Inspections

Quarterly inspections of each pavement type continue. The inspection report from November is included in Appendix 1. Some clogging and oil spots have been noted on each side. The site has been vacuumed. We have been noting some icing on the concrete side during precipitation events. We hypothesize that the asphalt, because of its color, gets warmer during the day, allowing the ice to thaw, whereas the concrete side is not getting above freezing.

Repair of the Leak

The source of the leak was detected using a pipe camera. A broken section of the pipe was found under the Jersey barrier separating the two pavement types. Scott contracting was hired to repair the broken pipe. Unfortunately, once this leak was fixed we found that there was a leak at every joint in the overflow pipe. Mar-Allen concrete was hired to grout the pipe on November 26th. The grouting was successful and the site is now holding water (Figure 2). Over flow will be discharged from the drop inlets with submersible pumps. The average infiltration rate is about 0.5 in/hr.

Benchtop Study

The start of the benchtop study was delayed until the beginning of his semester. Monique Philips, a senior at Villanova, is working closely with James Barbis, the graduate student working on this project to perform this work. She has created a plan for her work, which is included as Appendix 2. To date, we have not found any significant differences in the pavement types for TDS, TSS, Total Nitrogen, etc. In other words, the variability of the inflow data exceeds the variability of the data from beneath pavements. We believe that this benchtop study,

in a controlled environment will present a more complete picture of the differences between the pavement types when combined with the field data.

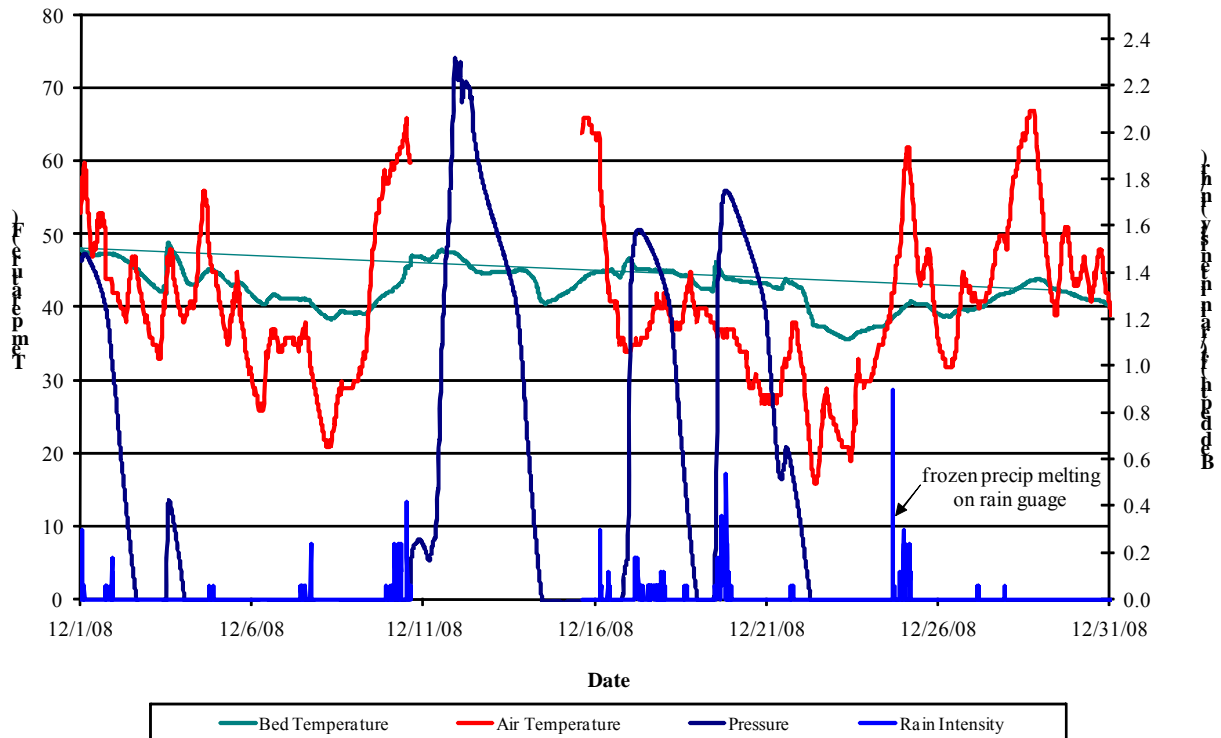


Figure 2. December Flow and Temperature Data

Sampling and Testing

The results of the sampling and testing to date are presented in Figures 3 through 10. Graphs for mean concentrations over the past year are provided for Total Nitrogen (Figure 3), Total Dissolved Solids (Figure 4), pH (Figure 5), and Total Phosphorous (Figure 6). The first flush samples are identified with an FF. The samples from the pore water samplers are identified by their depth. Results from samplers from the same depth are averaged together.

Future Work

Over the next quarter we intend to:

1. Continue monitoring and sampling.
2. Continue our outreach efforts by updating the website and presenting the results of this work at a local meeting. On February 17th, Monique Philips will give a presentation on the bench top study at the Delaware Valley GeoInstitute Student Night to be held on Villanova's campus.
3. Initiate and complete a bench top, side-by-side comparison of the pavement types focusing only on hydrocarbons.

4. Conduct a survey of the people parking on the lot.
5. Develop a final report for Prince George's County.

Conclusions

Despite some difficulties, the project is progressing and we anticipate that we will continue to collect water quality and quantity information to report in the next progress report. The side-by-side benchtop comparison of the pavement types should provide some interesting data.

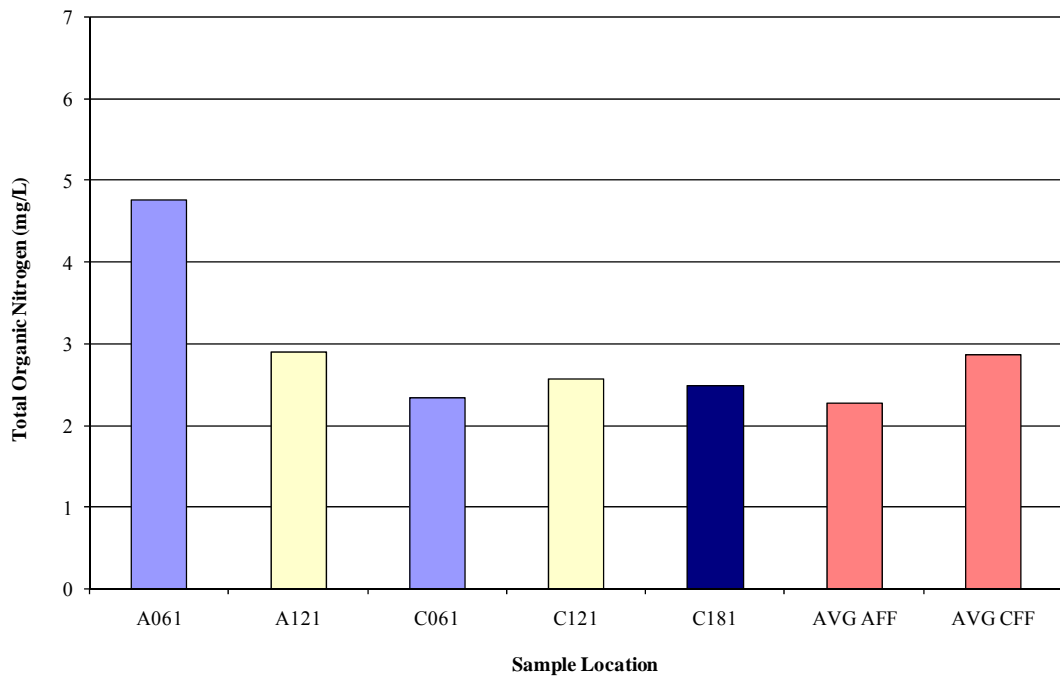


Figure 3. Mean Total Nitrogen

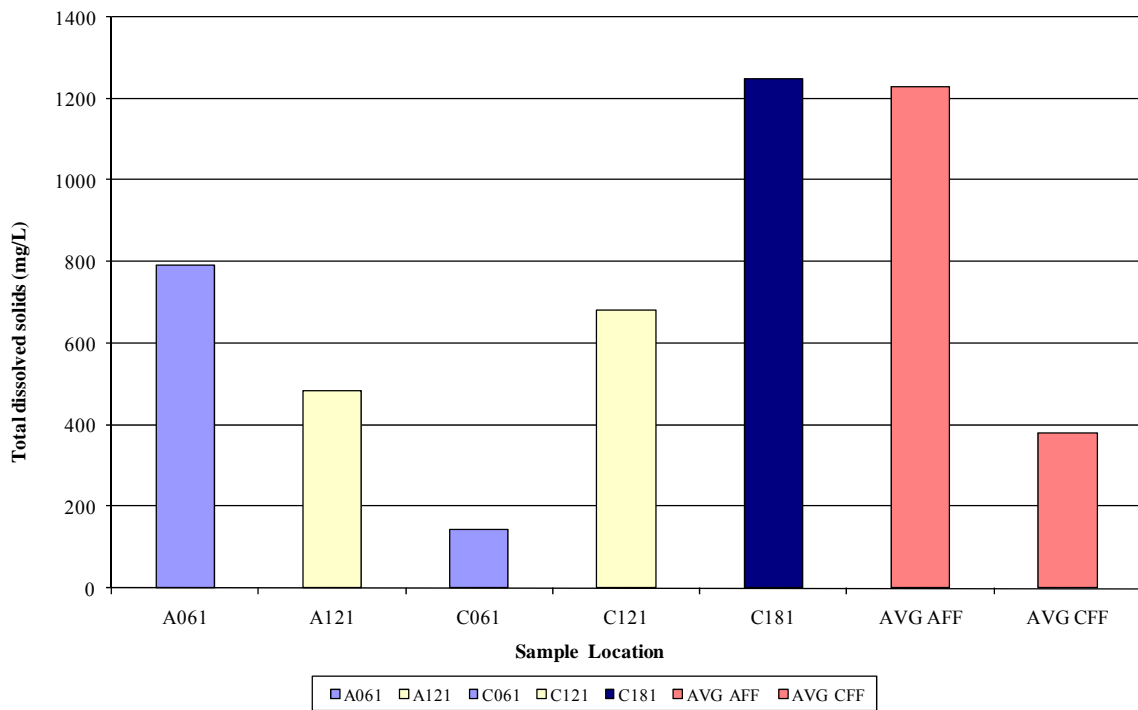


Figure 4. Mean Total Dissolved Solids

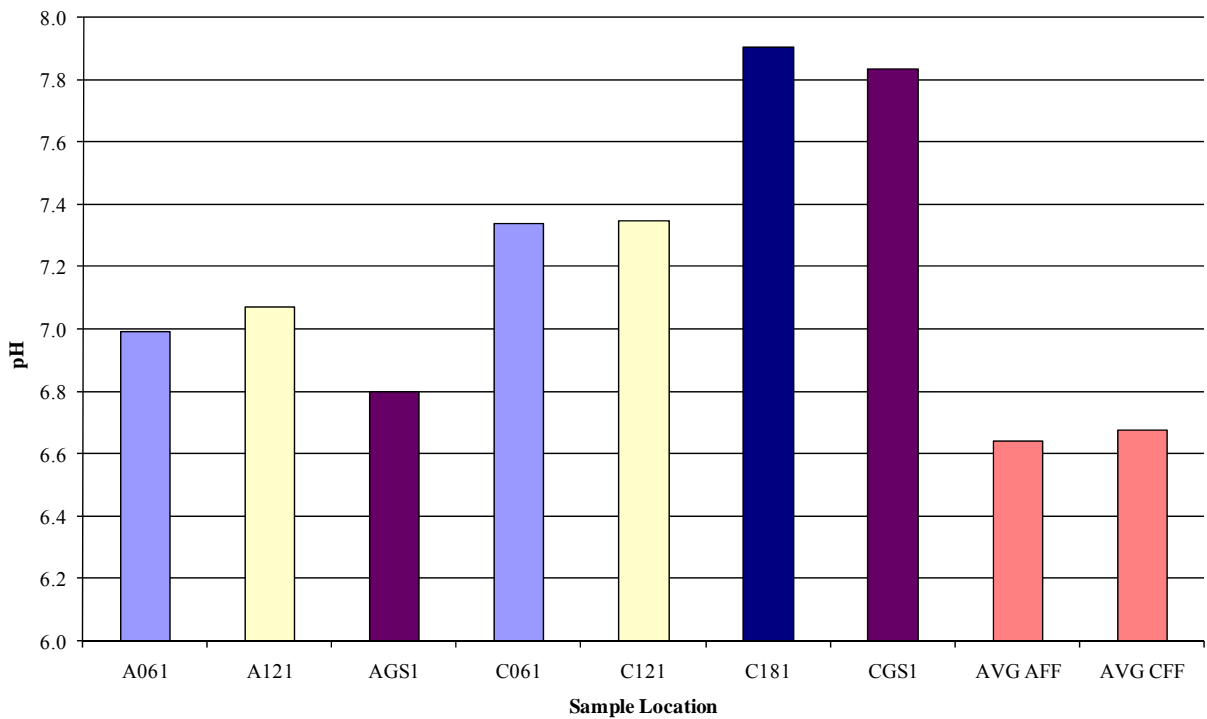


Figure 5. Mean pH Value

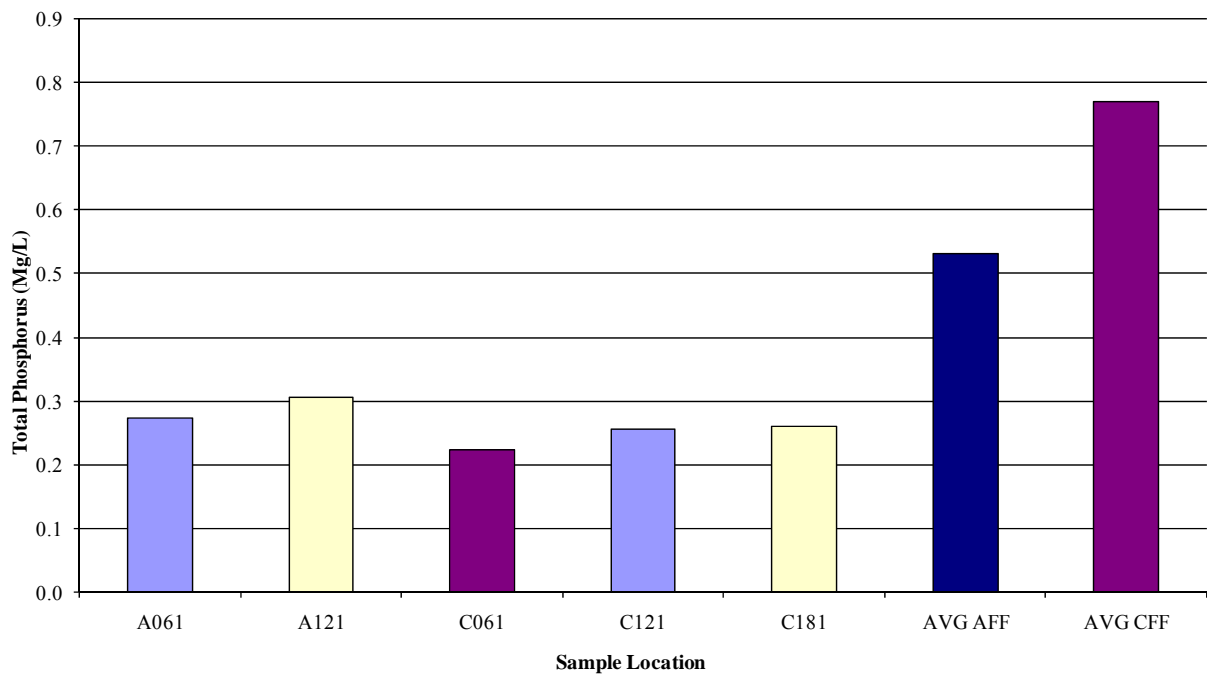


Figure 6. Mean Total Phosphorus

Appendix 1: Site inspection from November 2008

Site Observation Report

Date: 11/17/08 Observer(s) Pat Jeffers & James Barber

Procedure: Walk around site with a hose and note on the drawing below any locations where clogging, sealing, ponding, icing, spalling, or any other features of interest are observed. Attach site pictures.

Porous Asphalt

Pervious Concrete

Mendel Hall

↓

C.C. - 1:02 min
 UCC - 20.24 sec
 CA - 1:20 min
 UCA - 42 sec
 CENTRAL - 6:45 min

Appendix 2: *Draft* plan for benchtop study

A. Purpose

The purpose of this standard operating procedure (SOP) is to demonstrate the extraction procedure to quantify the total hydrocarbons content in a storm water sample.

B. Scope

This SOP scope refers to the HP 6890 gas chromatograph (Hewlett Packard, Rolling Meadows, IL) equipped with flame ionization detector and capillary column (DB-PETRO) 50m x 0.198mm x 0.50um.

C. Materials

The following materials are required to perform this method:

- Separatory Funnels, capacity 500 mL
- Laboratory Scale
- Oven, capacity 500 °C
- Vacuum Pump
- Vacuum Volumetric Flask
- Beakers, capacity 500 mL
- Beakers, capacity 50 mL
- Pyrene Internal Standard
- 9" Disposable Pasteur Pipettes
- Glass Filter Paper (Whatman 47 mm Grade GF/F particle down to 0.7µm)
- Silica Gel (pore size 60 Å, pore size 0.75 cm³/g pore volume, 70-230 mesh, for column chromatography 1kG)
- 4mm glass beads
- 1 mL SGE Gas-Tight Syringe
- Pyrek disposable cleanup/drying column, capacity 10mL
- Methylene Chloride, GC Reslv Grade
- Hexane, GC Reslv Grade
- Methanol, GC Reslv Grade
- Magnetic Stirrer
- Supelco GC 2mL amber vials with screw tops
- Supelco Screw caps for 12 x 32 Vials with 8 mm Teflon faced silicone septa.

D. Work Instructions

Prior collecting sample, perform the following

1.0 Cleaning

1.1 Sample Bottle

1.1.1 Wash bottle with detergent

- 1.1.2 Rinse with 10% acid solution
- 1.1.3 Rinse with DI water
- 1.1.4 Bake at 300 °C for at least 1 hour
- 1.1.5 Seal the bottle with aluminum foil

Note: An abrupt change in temperature could result in cracking the glassware

1.2 TFE

- 1.2.1 Wash the bottle caps with detergent
- 1.2.2 Rinse with 10% acid solution
- 1.2.3 Rinse repeatedly with organic free water

1.3 Laboratory Pipettes

- 1.3.1 Wash pipettes with detergent
- 1.3.2 Rinse with 10% acid solution and methanol
- 1.3.3 Rinse with DI water
- 1.3.4 Bake at 150 °C for at least 1 hour

1.4 Laboratory Separators

- 1.4.1 Wash separators with detergent
- 1.4.2 Rinse with 10% acid solution and methanol
- 1.4.3 Rinse with DI water
- 1.4.4 Bake at 300 °C for at least 1 hour

1.5 Magnetic Funnels

- 1.5.1 Wash with detergent
- 1.5.2 Rinse with methanol

2.0 Filter Preparation

- 2.1 Insert filter in filtration equipment
- 2.2 Apply vacuum
- 2.3 Wash with 3 succession 20 mL portion of reagent-grade water
- 2.4 Place the filter in the aluminum dish
- 2.5 Dry in oven at 103 °C to 105 °C for 1hr
- 2.6 Cool in desiccator to balance temperature

3.0 Silica gel

- 3.1 Weight 3 g per sample in an aluminum dish
- 3.2 Pre-activate at 450 °C for 2hr
- 3.3 Store at 100 °C prior use

4.0 Adsorption Column Setup

- 4.1 Add twenty 4 mm glass beads to the bottom of the column
- 4.2 When the silica gel section is completed add ten 4mm glass beads to the top

After completion of these steps, collect samples at the designated area and perform the following:

1. Find the pore volume of voids in both asphalt and concrete samples.
 - i. Fill bucket with water and measure displacement volume.
 - ii. Subtract solid volume of object from displacement volume to get volume of voids.

2. Use pore volume to run tests starting with deionized water (DI).
 - i. Set asphalt sample on apparatus with a beaker underneath.
 - ii. Start by running one pore volume (___ mL) through the sample.
 - iii. Use collected sample to run Lysmeter samples Liquid-Liquid phase.
 1. Prime the separator with solvent to remove any small contaminant
 2. Add sample to separators
 3. Rinse the glass beaker, with the magnetic stirrer inside the beaker, with 20 mL methylene chloride and add to the designated separatory funnel. Repeat 1 more time
 4. Insert 15 mL of the solvent.
 5. Shake the sample vigorously for 1 min
 6. Wait for both phases to separate, between 5 to 10 min
 7. Remove the solvent. Make sure the sample stays behind.
 8. Repeat 1 more time with 50 mL total solvent
 9. Discard the initial sample
 10. Insert 30 mL of solvent into empty separatory funnel.
 11. Shake for 2 min
 12. Remove solvent from separator
 13. Transfer the solvent solution to the adsorption column (silica gel)

3. Water Bath
 - i. Add 2 L of DI water to the water bath
 - ii. Set the water bath to 45 °C (± 2 °C)P. (Set the dial to number 6)
 - iii. Place the extracted samples in the water bath
 - iv. Concentrate the fractioned solution using N₂ flux to 1.9 mL at 2 psi and turn the sample valves at 2 revolution
 - v. Transfer to GC vial. The vial must be filled with at least 1.9 mL of the concentrated sample.

4. Gas Chromatography analysis
 - i. Turn on the GC equipment
 - ii. Turn on the Computer
 - iii. Setup the GC System with the following operation parameters
 - iv. Equipment: HP5890 GC
 - v. Column: DB-Petro 50mx200umI.D.x0.5um
 - vi. Carrier: Helium at 21 cm/sec
 - vii. Oven
 1. Initial Temperature, 70 °C
 2. Final Temperature, 300 °C

3. Rate, 8°C/min
4. Run Time, 90.75 min
5. Post Temperature, 342°C
6. Post Run Time, 15 min
- viii. Wait for system to be ready
- ix. Inject 2µL of sample into system
- x. Hit start on the GC to run the analysis

5. Calibration

The following calibration curve is used to measure the total hydrocarbon content from the DI water sample. This calibration curve gives results to samples with concentration ranging from 0.2 – 2.0 mg/L.

Tests will start by running one pore volume through the asphalt and increase by one pore volume until the student feels that the results are insignificant. Once this point is reached, the student will then switch to the concrete sample and repeat. After, the student will add an amount of Pyrene (TBD) to the optimum pore volume sample size to determine if the PAHs were increased or decreased after filtering through both asphalt and concrete.