# Environmental Impacts of Reclaimed Asphalt Pavement (RAP)

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# LIST OF ABBREVIATIONS, ACRONYMS & UNITS OF MEASUREMENT

| | |
|---|---|
| BaP TEF | Benzo(a)pyrene toxic equivalency factor |
| COPC | Constituent of potential concern |
| DAF | Dilution attenuation factor |
| DI | Deionized |
| EI | Electron ionization |
| FDOT SMO | Florida Department of Transportation State Materials Office |
| GCTL | Groundwater cleanup target level |
| GC-UHRMS | Gas chromatography ultra-high resolution mass spectrometry |
| ICP-AES | Inductively coupled plasma atomic emissions spectroscopy |
| IWEM | Industrial waste management evaluation model |
| L/S | Liquid to solid ratio |
| LEAF | Leaching environmental assessment framework |
| LOD | Limit of detection |
| NAPA | National Asphalt Pavement Association |
| PAH | Polycyclic aromatic hydrocarbon |
| ppb | Parts per billion |
| ppm | Parts per million |
| RAP | Reclaimed asphalt pavement |
| RSD | Relative standard deviation |
| RSL | Regional screening level |
| SCTL | Soil cleanup target level |
| SIM | Selective ion monitoring |
| SPLP | Synthetic precipitation leaching procedure |
| SR | State road |
| TCLP | Toxicity characteristic leaching procedure |
| UF SMMRL | University of Florida Sustainable Materials Management Research Laboratory |
| US EPA | United States Environmental Protection Agency |
| UV | Ultraviolet |
| VOC | Volatile organic compound |
| g | gram |
| kg | kilogram |
| L | liter |
| mg | milligrams |
| pH | measurement of the hydrogen ion activity or measurement of the acidity of water. |
| µg | microgram |
| ng | nanogram |

# ABSTRACT

Florida, like many states in the US, has an interest in recycling reclaimed asphalt pavement (RAP) for its associated economic and environmental benefits. Two previous Hinkley Center projects, *Leaching Characteristics of Asphalt Road Waste* (1999) and *Risk Assessment of the Reuse and Disposal of Several Asphalt Waste Materials* (2013) have investigated constituent leaching from RAP, concluding that RAP does not pose a significant threat to human health and the environment. However, concerns continue to be raised in some parts of Florida regarding potential environmental issues associated with RAP. Concomitantly, the concerns of reusing RAP have been raised in other states, prompting a call to review work on this topic identifying and characterizing the knowledge gaps remaining with RAP. The University of Florida completed a comprehensive and synthesized literature review, contextualizing the existing body of work on the subject (Spreadbury et al., 2021). Through this process, gaps in the existing body of work were identified, pertaining to use of unrealistic leaching methodologies and limited analysis of polycyclic aromatic hydrocarbons (PAHs). To address these deficits, a modified method was developed based on EPA method 1314 that simulates conditions representative of RAP in stockpiling and reuse scenarios. Leachates were analyzed for heavy metals and an expanded suite of PAHs, comprised of traditionally measured EPA Priority 16 PAHs and 23 emerging PAHs from the literature. Results showed similar conclusions from previous studies. Like previous RAP studies, instances of exceedances of risk-based thresholds for metals and PAHs were observed at concentrations likely to be diluted and attenuated below thresholds. This suggests limited threat to human health and the environment posed by RAP stockpiling and reuse.

# EXECUTIVE SUMMARY

(Dates: November 1st, 2020 to April 30th, 2022)

**PROJECT TITLE:** Environmental Impacts of Reclaimed Asphalt Pavement (RAP)

**PRINCIPAL INVESTIGATOR(S):** Timothy Townsend, John Bowden

**AFFILIATION:** Departments of Environmental Engineering Sciences and Veterinary Medicine, University of Florida

**PROJECT WEB SITE:** https://faculty.eng.ufl.edu/timothy-townsend/research/beneficial-use-of-waste-materials/understanding-the-environmental-impacts-of-reclaimed-asphalt-pavement/

**COMPLETION DATE:** April 30th, 2022

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## PROJECT SUMMARY

The purpose of this project was to address growing concerns related to the environmental risks associated with Reclaimed Asphalt Pavement (RAP) storage and use in Florida. While RAP is one of the most recycled materials by mass in the state and has been shown to pose minimal risk to the environment when properly managed, recent reports have reignited concern over constituent leaching, including emerging contaminants historically unstudied in RAP. Though the existing body of work points to limited risks associated with RAP reuse, perceived risk, especially regarding emerging contaminants must be addressed to ensure best management strategies are appropriate.

A literature review was completed in parallel to this project (Spreadbury et al., 2021). In this review, leaching data from previous studies was synthesized to provide context to constituent leaching in terms of the leaching methodology used. Most studies concluded limited risk associated with RAP leaching with a few studies observing constituent leaching at concentrations above risk-based thresholds when directly compared to thresholds. To critically assess the existing data, constituent concentrations were further investigated with fate and transport modeling. Environmental factors including distance, dilution, and attenuation were considered using the Environmental Protection Agency's (EPA) Industrial Waste Management Evaluation Model (IWEM). Except for lead and naphthalene, constituent concentrations after consideration of dilution and attenuation were reduced below thresholds.

Through this review process and previous Hinkley Center investigations on RAP leaching, deficiencies in the existing body of work were identified. Existing studies utilize leaching methodologies unrealistic to RAP reuse conditions which require modification (e.g., size reduction) of material prior to analysis. Additionally, existing studies often limited polycyclic aromatic hydrocarbon (PAH) analysis to 16 PAHs designated as Priority PAHs by the EPA. In this study, six RAP sources from the state of Florida were physically characterized, leached, and analyzed for leachable and total environmentally available metals and PAHs. To address deficiencies in the existing body of research, RAP leaching was assessed under conditions representative to those experienced by RAP in stockpiling and reuse scenarios using a modified method developed from EPA method 1314. Further, a sensitive analytical method including 23 emerging PAHs and the 16 Priority PAHs was created to determine if existing studies were underestimating PAH release by limiting analysis to Priority compounds.

Using the most up-to-date leaching methodology representative of RAP stockpiling and reuse scenarios, this study found similar conclusions to most existing literature and previous Hinkley Center investigations. Exceedances of risk-based thresholds were found for PAHs and metals in some samples. Though emerging PAHs were found in analysis of total available PAHs, only naphthalene-related, emerging compounds were found above limits of detection in leachate. In comparison to the EPA 16 Priority PAHs, emerging PAHs contributed less to leached PAH concentrations across all samples. This indicates that previous studies assessing Priority PAHs only did not miss large contributions from emerging PAHs. Like other industrial materials, risks associated with beneficial reuse can vary by source; however, results from this investigation suggest that RAP poses minimal risk to human health and the environment regarding metal and PAH leaching. While laboratory-scale studies, like this research, are intended to model leaching risk conservatively, further investigation of constituent leaching at the full-scale, whether at a stockpile or roadway, are critical to understanding influence from factors outside of laboratory-controlled conditions, like temperature, UV exposure, etc.

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**Report details are being withheld from public posting pending peer-reviewed journal publication. For more information please contact Principal Investigators Timothy Townsend (ttown@ufl.edu) or John Bowden (john.bowden@ufl.edu).**