# Ash Monofill Mining: An Analysis of the Beneficial Use Potential of Combined Ash

UNIVERSITY OF FLORIDA

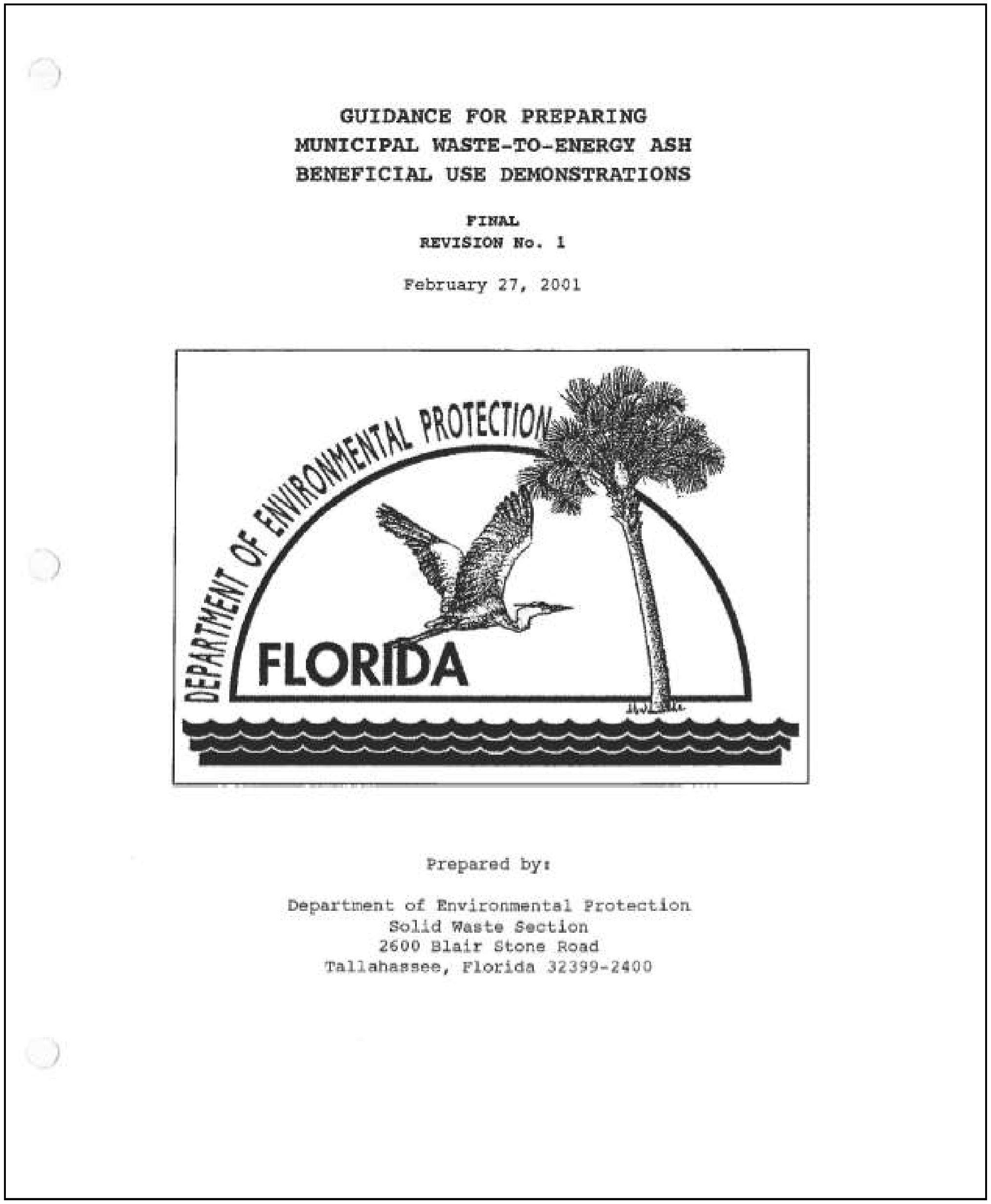
PASCO COUNTY FLORIDA

JMG ENGINEERING INC

- 403.7045(5), F.S.:

  Ash residue generated by a solid waste management facility from the burning of solid waste must be disposed of in a properly designed solid waste disposal area that complies with the standards developed by the department for the disposal of such ash residue. The department shall work with solid waste management facilities that burn solid waste to identify and develop methods for recycling and reuse of ash residue or treated ash residue , and the department may allow recycling or reuse by an applicant who demonstrates that no significant threat to public health will result and that applicable department standards and criteria will not be violated. The Division of Waste Management shall direct the district offices and bureaus on matters relating to the interpretation and applicability of this subsection. The department may adopt rules necessary for administering this subsection, but the department is not required to amend its existing rules.

# 2001 BUD Document



GUIDANCE FOR PREPARING
MUNICIPAL WASTE-TO-ENERGY ASH
BENEFICIAL USE DEMONSTRATIONS

FINAL
REVISION No. 1

February 27, 2001



Prepared by:

Department of Environmental Protection
Solid Waste Section
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

- Authored Primarily By Contaminated Site Cleanup Staff
- Comparison to Soil Cleanup Target Levels (SCTL) and Groundwater Cleanup Target Levels (GCTL)
- Too Prescriptive to be Workable

# 2013 Hinkley Center Whitepaper

## A Critical Assessment of Pathways and Limitations to Recycling Fuel Combustion Residues in Florida

December 19, 2013

Prepared by:

Timothy G. Townsend (Principal Investigator), Justin Roessler, Wesley Oehmig, and Nawaf Blaisi
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Engineering School for Sustainable Infrastructure and the Environment
University of Florida

Prepared under funding provided by:

The Hinkley Center for Solid and Hazardous Waste Management
Gainesville, Florida



- Concise Assessment of Current state of Combustion Residue Management in Florida
- Summary of Relevant Background Information
- Identification of Opportunities and Limitations for Beneficial Ash Reuse

# 2013 Simpson Coal Ash Bill

CS for CS for SB 682 Second Engrossed (ntc)

2013682e2

A bill to be entitled

An act relating to fossil fuel combustion products; creating s. 403.7047, F.S.; providing definitions; providing standards for storage of certain fossil fuel combustion products; providing an exemption for beneficial use of fossil fuel combustion products from certain rules; providing that the act does not prohibit the Department of Environmental Protection from taking appropriate action to regulate a beneficial use in certain circumstances; providing that the act does not limit other requirements applicable to the beneficial use of fossil fuel combustion products; providing that the act does not limit the recovery of beneficial use products or the authority of the department to approve the beneficial use of materials other than fossil fuel combustion products; clarifying that the act does not limit or modify any fossil fuel combustion product beneficial use previously approved by the department; amending s. 403.7222, F.S.; excluding certain types of facilities from provisions on hazardous waste landfills; providing an effective date.

WHEREAS, fossil fuel combustion products are currently used in a variety of beneficial applications, and

WHEREAS, beneficial use of fossil fuel combustion products allows certain industries and end users to avoid the mining and processing of virgin materials through the substitution of fossil fuel combustion products for virgin materials, thereby

Page 1 of 7

**CODING:** Words ~~stricken~~ are deletions; words underlined are additions.

- Provided Legislative Authority to Beneficially Utilize Coal Ash
- Akin to the 1998 Legislative changes providing Authority to Beneficially Utilize WTE Ash

ground water, or otherwise enter the environment such that a threat of contamination in excess of water quality standards and criteria or air quality standards is caused, or a significant threat to public health is caused; and

3. The industrial byproducts are not hazardous wastes;

(e) Phosphogypsum stack systems;

(f) Clean debris which has been segregated from other waste and which is used or stored for use as fill or raw material; and

(g) The collection and processing of soil, rocks, vegetative debris, asphalt, and similar materials normally associated with and actually from construction and routine maintenance of roads, as defined in Section 334.03(23~~24~~), F.S., when such materials are beneficially used or reused by the generator as part of a road construction or maintenance project. Street sweepings, ditch scrapings, shoulder scrapings, and catch basin sediments are included in this exemption provided that any significant amounts of solid waste, such as tires, furniture, white goods, and automobile parts, are removed prior to use or reuse. This exception does not apply when materials are contaminated by a spill or other unusual event. Storage of these materials at transfer stations or off-site waste storage areas is addressed in subparagraph 62-701.710(1)(c)5., F.A.C.

(h) Ash residue as defined in subsection 62-701.200(7), F.A.C., from waste-to-energy facilities as defined in section 403.7061(4), F.S., when beneficially used as a substitute for raw materials, necessary ingredients, or additives in products, according to accepted industry practices, in asphalt, concrete or cement products, flowable fill, and roller-compacted concrete.

(i) Bottom ash as defined in subsection 62-701.200(7), F.A.C., from waste-to-energy facilities as defined in section 403.7061(4), F.S., when beneficially used as a substitute for raw materials, necessary ingredients, or additives in products, according to accepted industry practices, in pavement aggregate or structural fill, as those terms are defined in Sections 403.7047(1)(d) and (e), F.S. This use of bottom ash must be in accordance with the following requirements:

1. The ash is not placed within three feet of ground water or 15 feet of wetlands or natural water bodies, or within 100 feet of a potable well that is being used or might be used for human or livestock water consumption;

2. Placement of the ash does not extend beyond the outside edge of the structure or pavement and is completed as soon as practicable after placement;

3. The ash is not placed so that it, or any constituent thereof, may enter other lands or be emitted into the air or discharged into any waters, including ground water, or otherwise enter the environment in a manner that causes a significant threat to public health or contamination in excess of applicable Department standards and criteria; and,

4. The owner or agent of the property where the ash is placed has given the Department written notice, which may be submitted electronically, of the dates and locations of use of the ash for structural fill or pavement aggregate.

(3) There are several requirements throughout this chapter that requests or demonstrations must be approved by the Department. Unless otherwise specifically stated, this means that the requests or demonstrations must be submitted to the appropriate Department District Office as part of a permit application or request for permit modification. The Department will evaluate such requests or demonstrations in accordance with the applicable criteria set forth in this chapter, and will approve or modify permit conditions if those criteria are met.

(4) In accordance with former Rule 62-701.720, F.A.C., several persons or organizations requested approval of alternate requirements for certain industrial operations. Written determinations made by the Department prior to December 23, 1996, in response to such requests remain in effect even though Rule 62-701.720, F.A.C., has been repealed, until and unless the Department takes action to modify such determinations through rulemaking.

(5) Local zoning. The Department does not evaluate compliance with local zoning or land use ordinances when determining whether to issue or deny any permit under this chapter. Issuance of a permit does not relieve an applicant from compliance with local zoning or land use ordinances, or with any other laws, rules, or ordinances.

(6) There are several references in this chapter to facilities which are constructed or existing. Unless otherwise specified, these terms mean that the facility has received a permit or is exempt from permitting, and has actually been built or is being built in accordance with that permit or exemption. The terms do not include parts of a facility which, although noted in a long-term design plan, were not authorized to be constructed during the life ~~within the five-year term~~ of the facility's permit(s). A landfill with a slurry wall liner system is deemed to have been constructed when the slurry wall was constructed.

# Leaching Environmental Assessment Framework (LEAF)

- Challenges assumptions that are prescribed by TCLP and SPLP
- Much better tool for understanding leaching behavior of a material (including a waste)
- Developed by Vanderbilt University in collaboration with USEPA

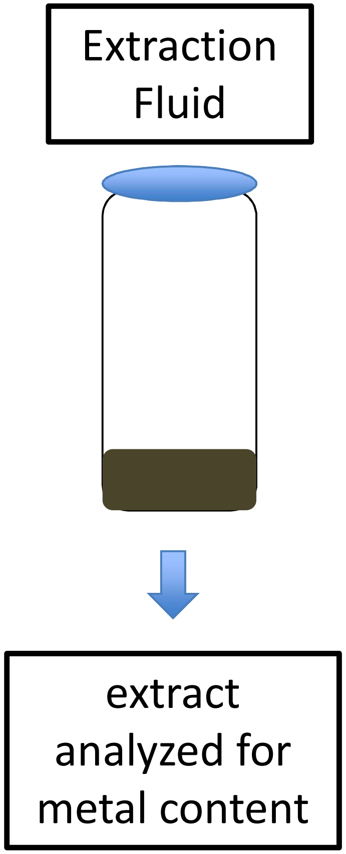
# LEAF Testing on Ash and Ash Amended Products at Pasco County RRF

- LEAF testing conducted on three products
  - Raw ash used as roadbase
  - Ash amended concrete
  - Ash amended asphalt
- Tests Conducted:
  - EPA Methods 1311-1316

# Methods 1311 and 1312 – TCLP/SPLP

Batch extraction done at a 20:1 liquid to solid ratio

Sample crushed and rotated rotated for 18 hours

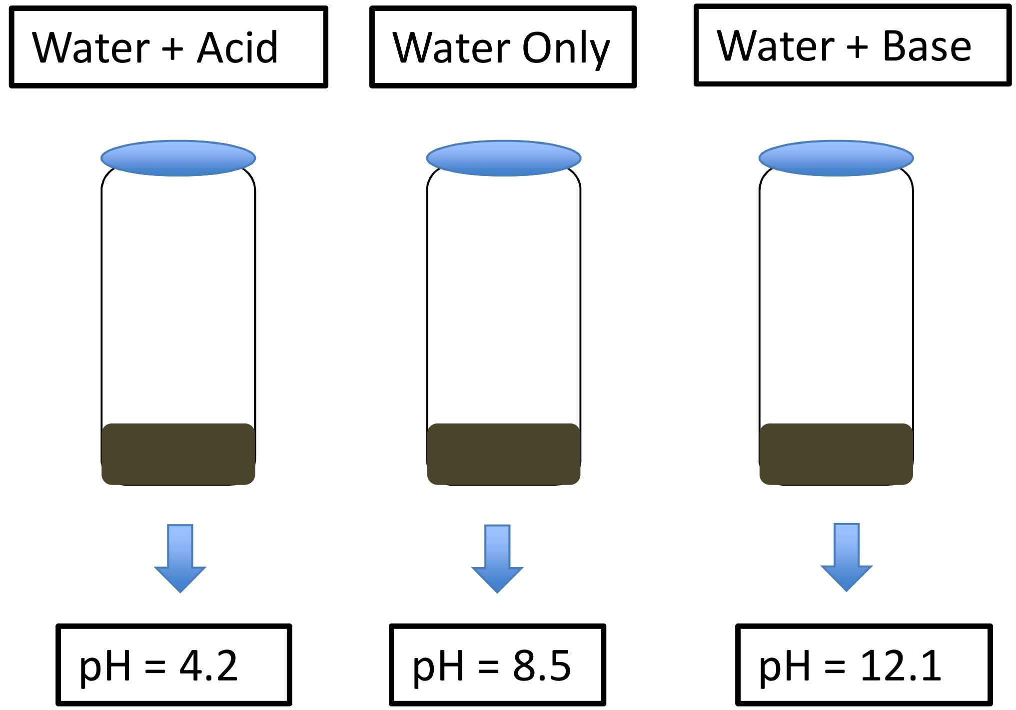


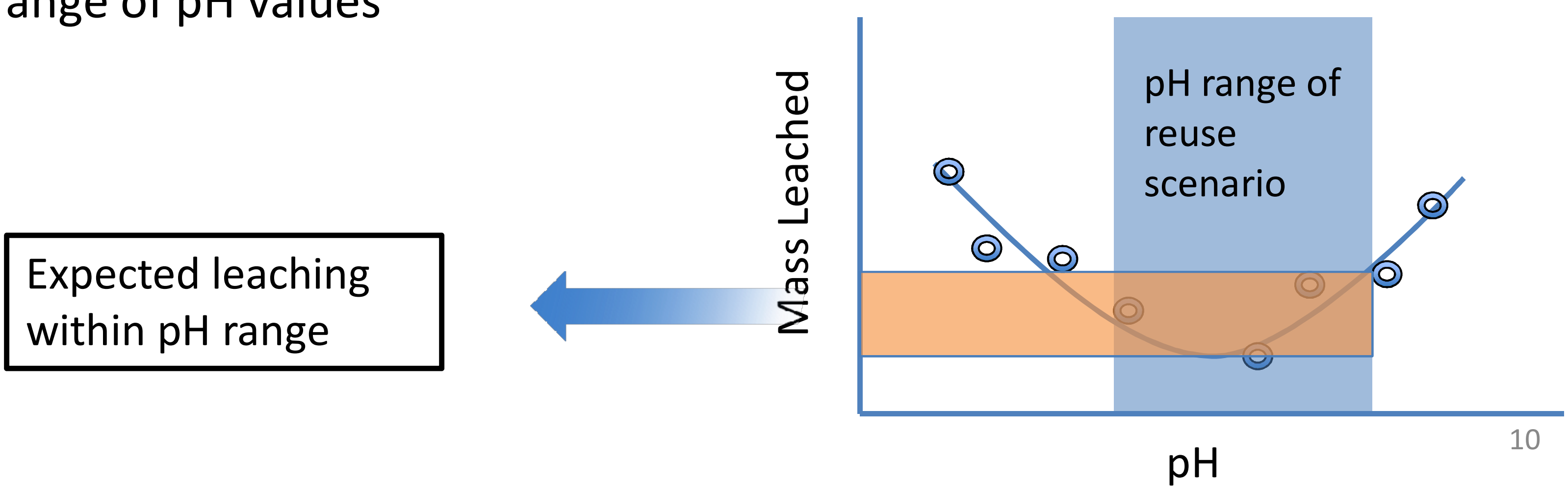
# Method 1313 – challenges TCLP Fluid assumption

Parallel batch extraction done at a 10:1 liquid to solid ratio (10ml/g-dry) at up to 9 final pH values

Samples rotated for 24-72 hours

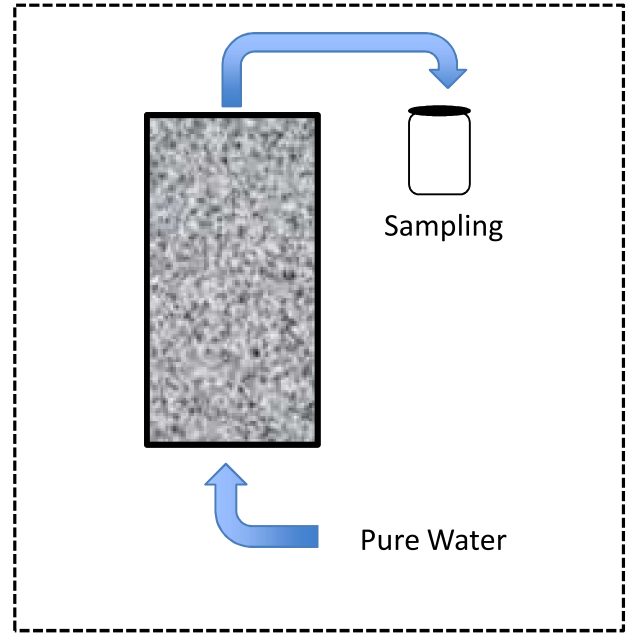
Goal: determine the leachability of the material for a range of pH values



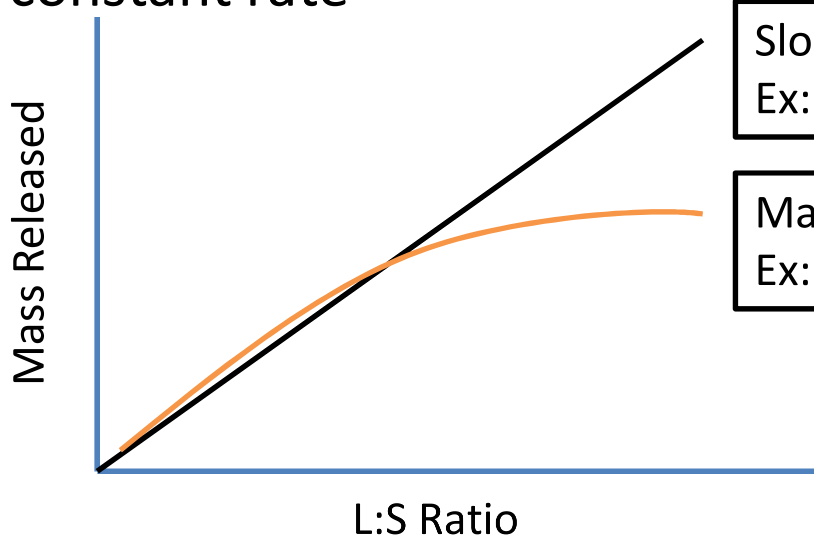



# Method 1314 – challenges TCLP 20:1 ratio

Column leaching test with constant upward flow of pure water. Samples are taken at prescribed days to achieve specific L/S ratios




Goal: Determine which constituents wash out quickly and which dissolve into the water at a constant rate



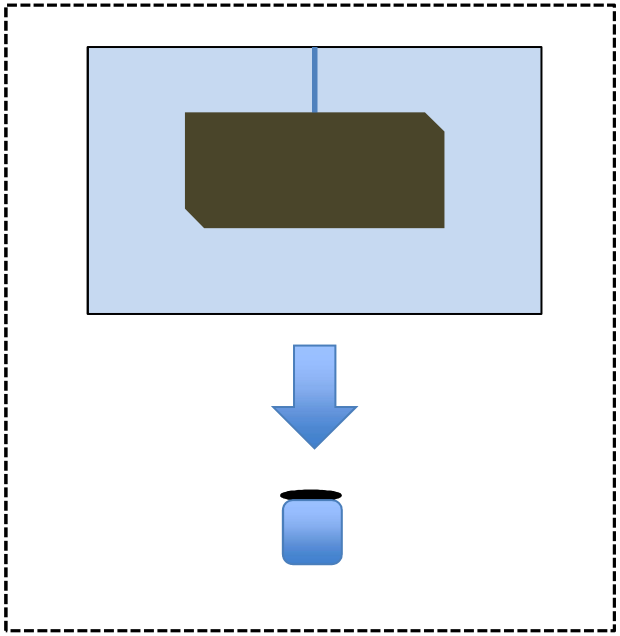

Slope ~ 1: Mass release controlled by dissolution
Ex: As, Fe (mineral bound)

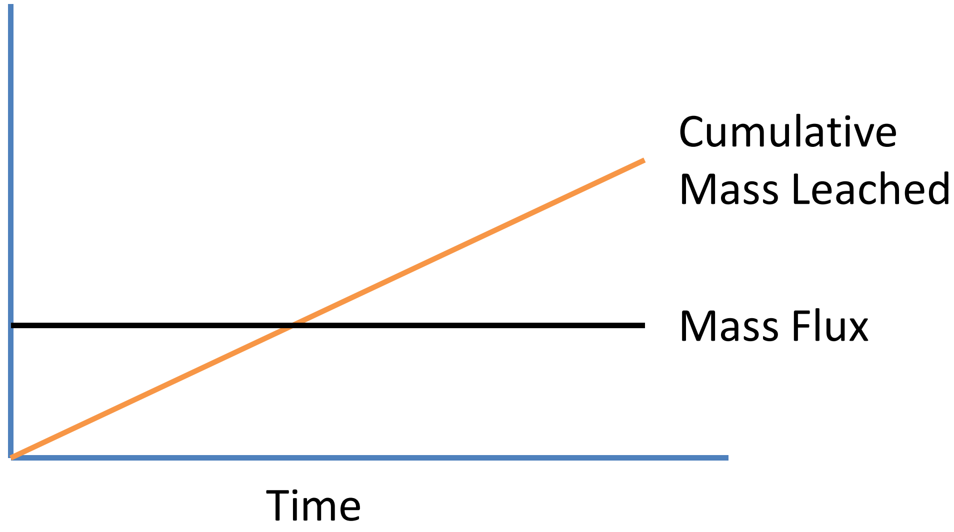
Mass release controlled by surface availability
Ex: K, Na, Cl (very soluble elements)

# Method 1315 – challenges TCLP size reduction assumption

Monolithic material sample (e.g. a brick) or a compacted granular material is submerged in a tank of water and allowed to soak for prescribed times. Water is periodically sampled and analyzed for constituents of concern. New water replaces the old.

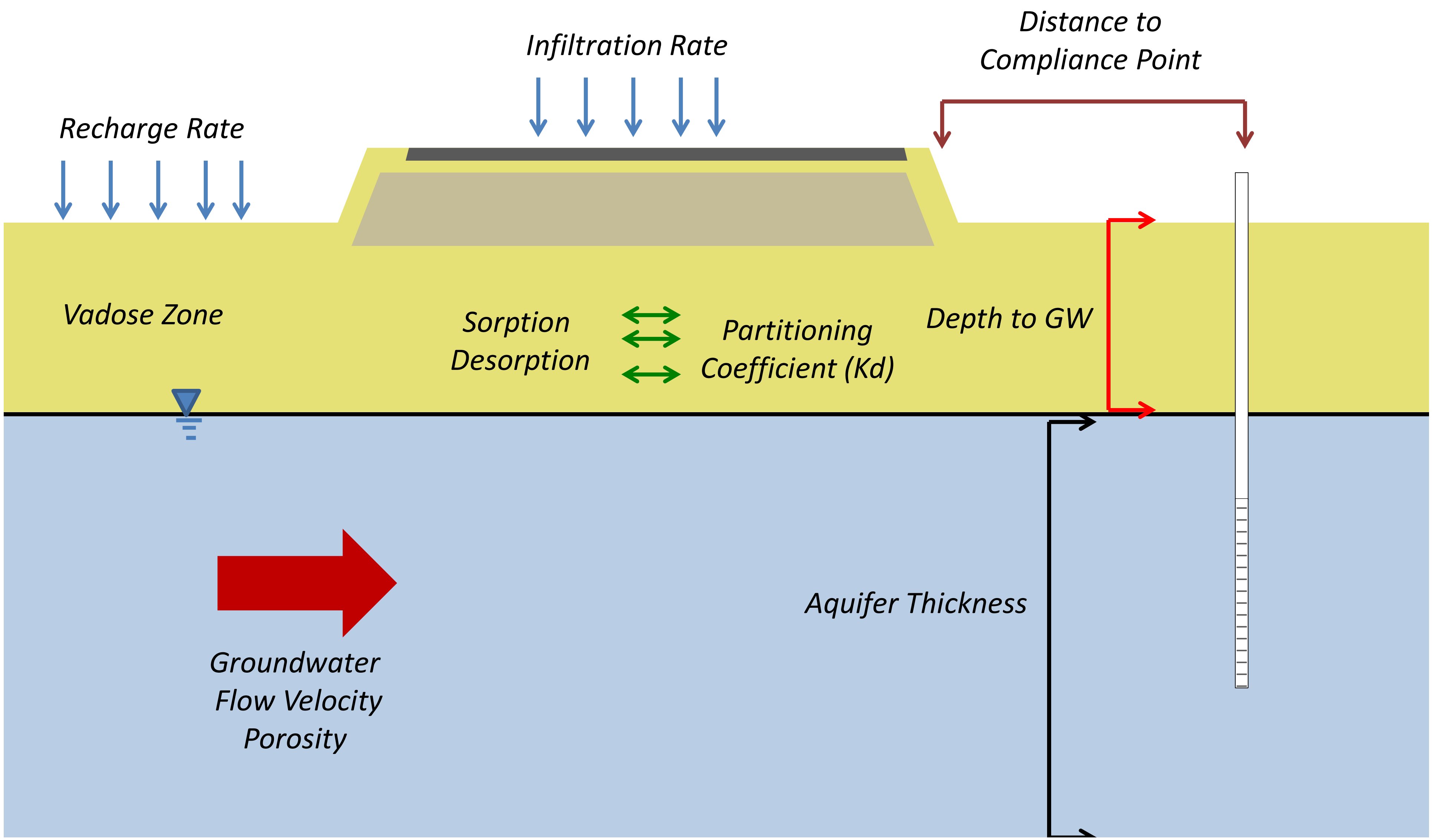
Goal: Determine time-dependent release rates under monolithic conditions





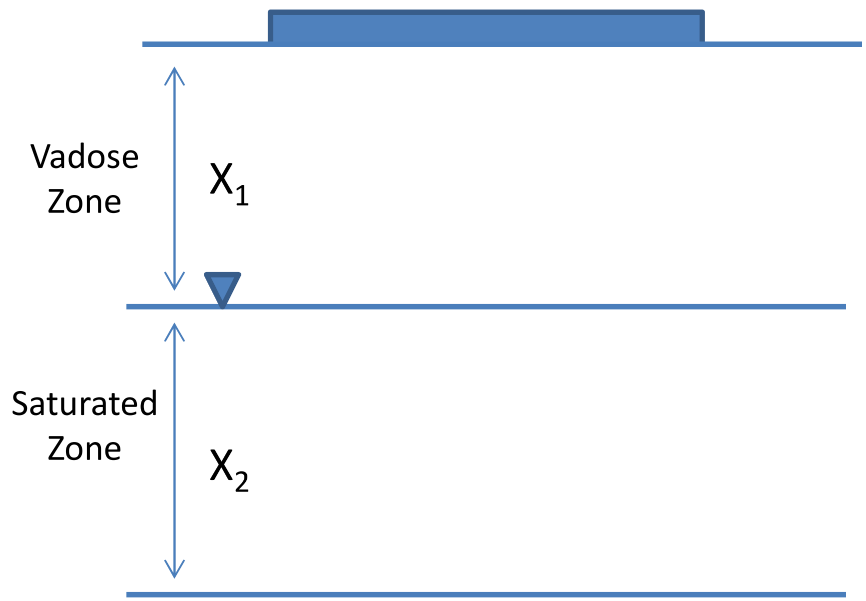

This information can help in predicting mass release in the long run

# Modeling Evaluation



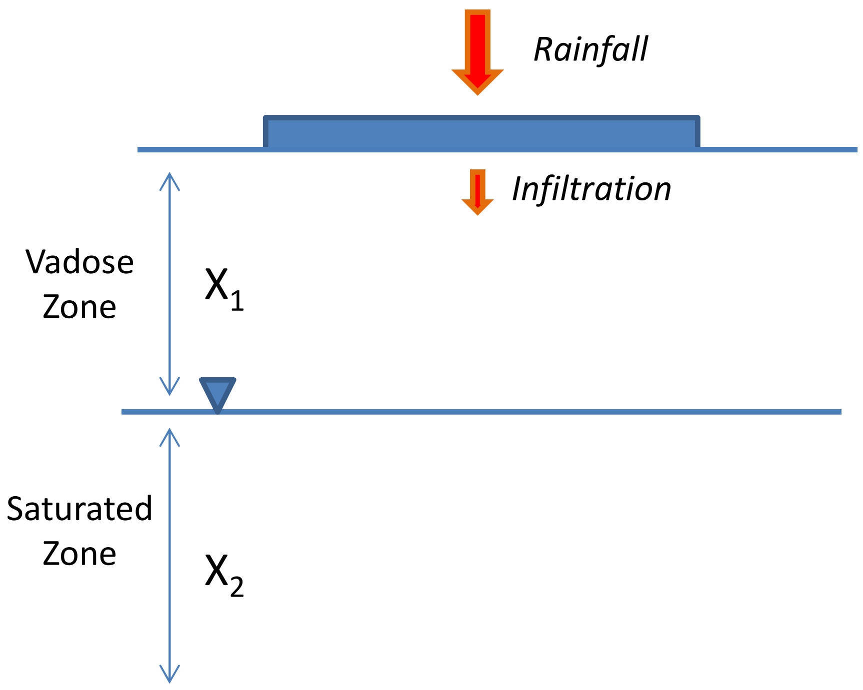
# Predicting Behavior in the Real World

- Construct simple model of roadway and underlying environment.
- Use existing ash data, leaching data, and construction product information, along with a range of site conditions, to estimate COC releases.
- Use EPA-developed fate and transport model to evaluate likely impact on groundwater.



# How Much "Leachate"?

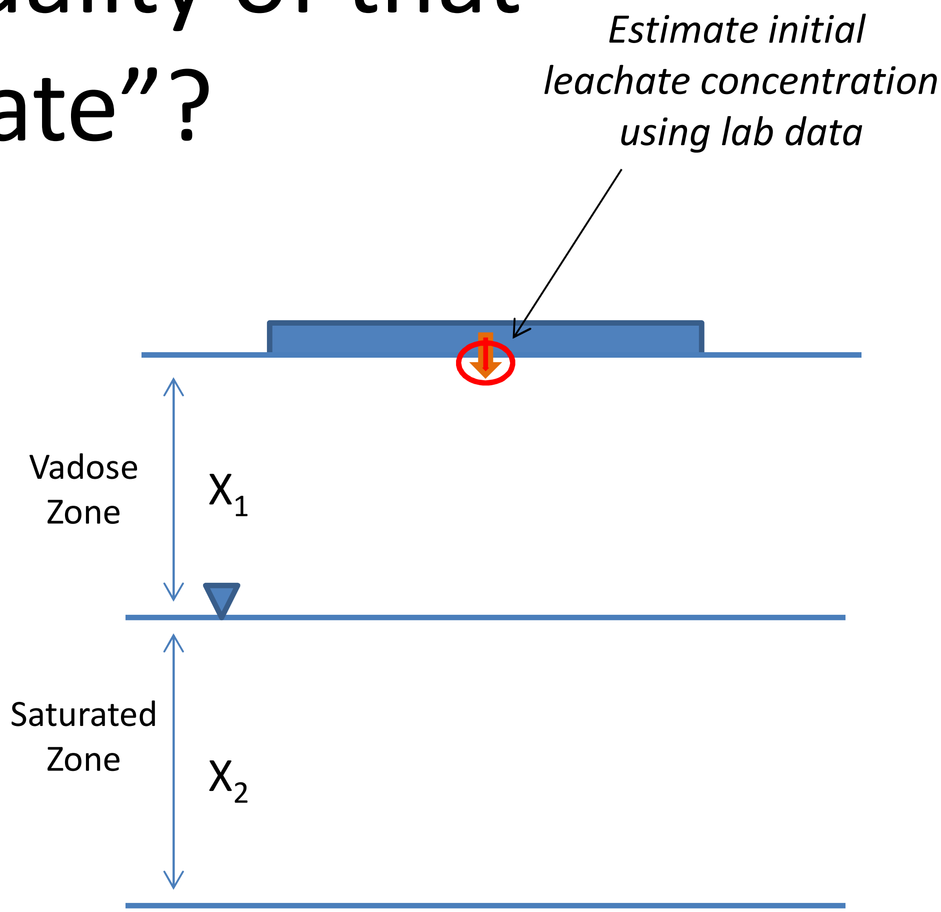
- Estimate the infiltration rate of "leachate" resulting from the roadway. This will be some fraction of the rainfall.
- Use data for hydraulic conductivity, HELP modeling, and literature to estimate infiltration.
- Construct detailed flow model representing actual road construction dimensions.



# What is the Quality of that "Leachate"?

- Estimate leachate concentration.

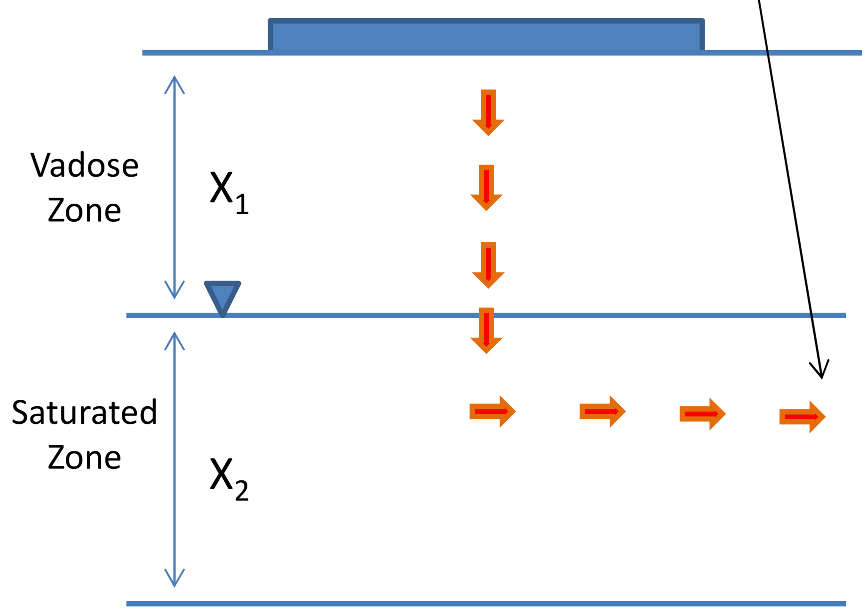
- Use the LEAF testing results from the products constructed in the RD&D project.



# How Will the "Leachate" Attenuate?

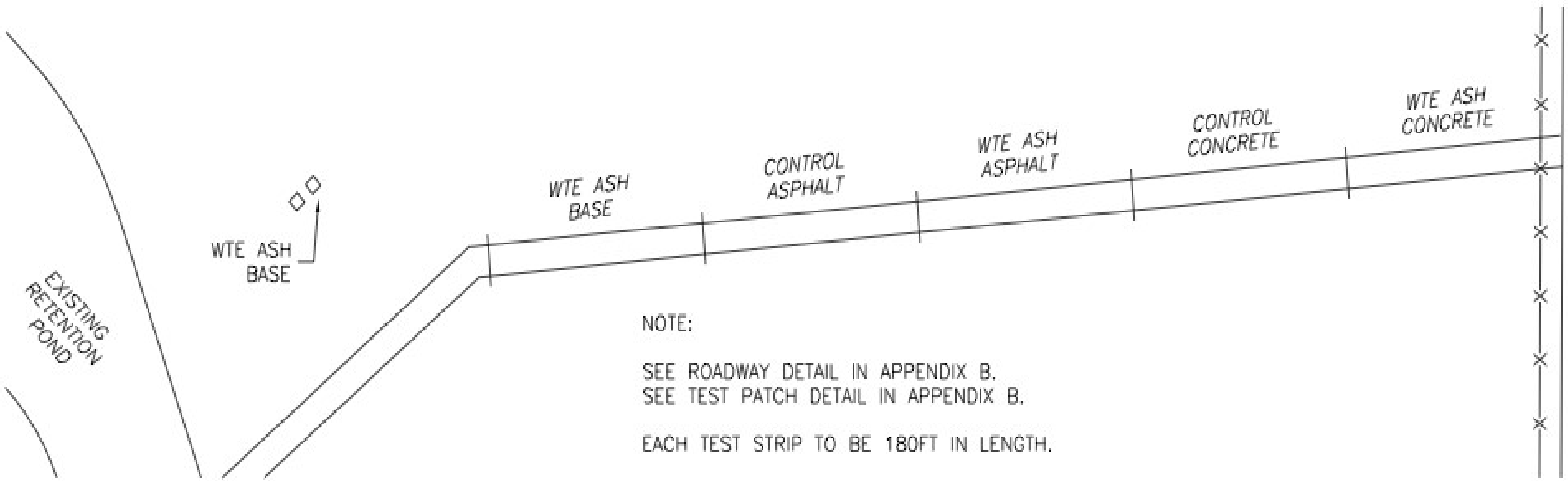
*Use fate and transport model to predict range of likely concentrations at a target point*

- Estimate groundwater concentration.
- Apply sophisticated fate and transport models



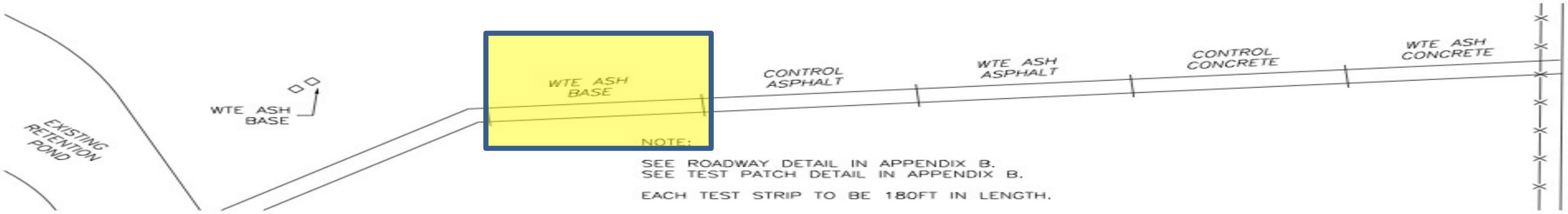
# Pilot Project Overview

- Bottom ash used as an aggregate in concrete pavement, hot mix asphalt, and as a road base course
  - Control test sections with conventional materials were also constructed
- Two bottom ash size fractions produced
  - Ash separated into greater than 3/8”  and less than 3/8” fractions
- How to best incorporate both fractions?



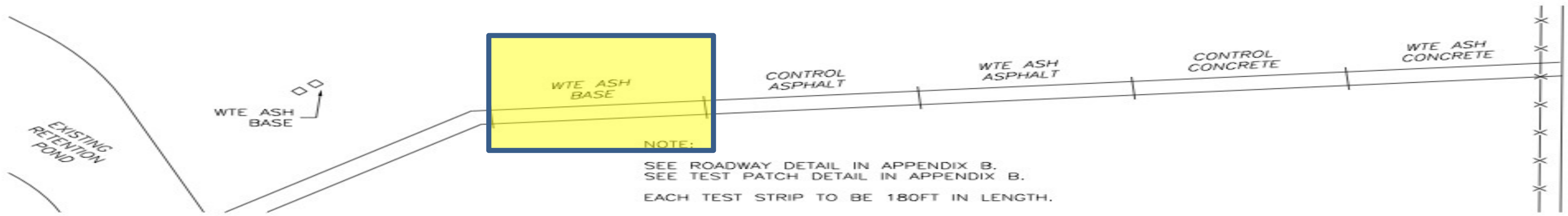

# 3 Test Sections and 2 Control Sections

- Test Section 1: Bottom Ash as Road Base with Traditional Asphalt Paving
- Test Section 2: Traditional Limerock Road Base with Bottom Ash/Asphalt Paving
- Test Section 3: Traditional Limerock Road Base with Bottom Ash/Portland Concrete Paving

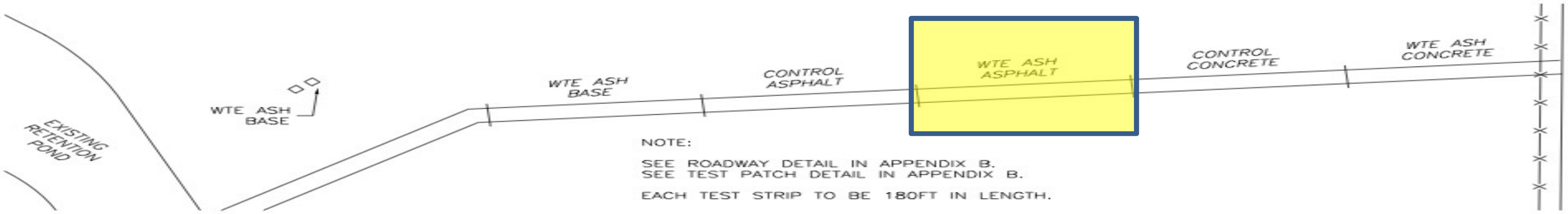




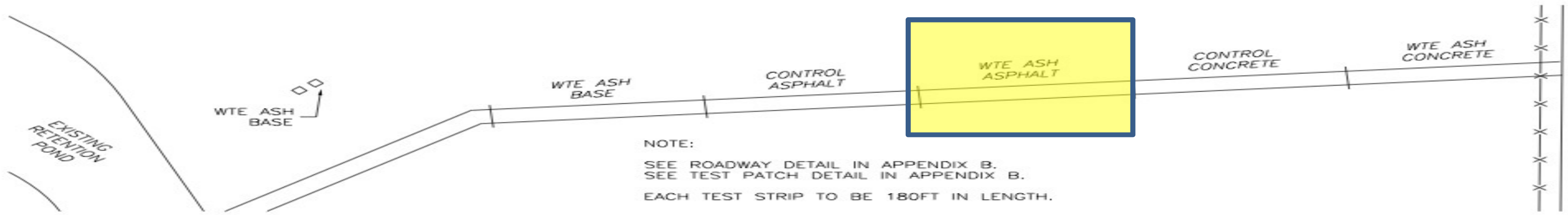
Bottom Ash As Road Base



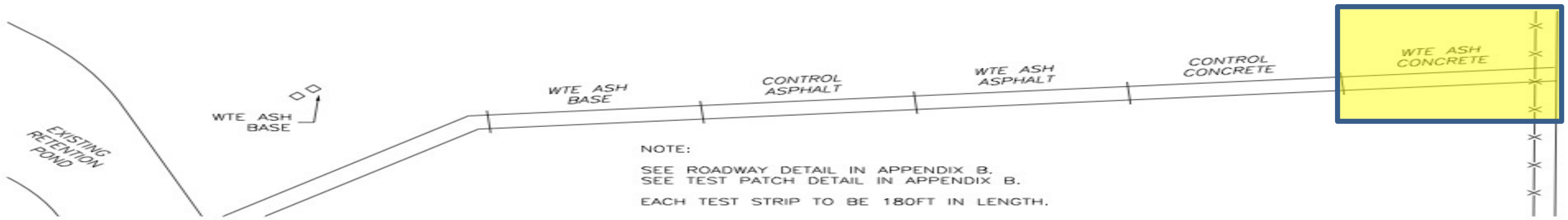

Bottom Ash Being Graded as Road Base




Bottom Ash as Hot Mix Asphalt Aggregate


EXISTING RETENTION POND
WTE ASH BASE
WTE ASH BASE
CONTROL ASPHALT
WTE ASH ASPHALT
CONTROL CONCRETE
WTE ASH CONCRETE
NOTE:
SEE ROADWAY DETAIL IN APPENDIX B.
SEE TEST PATCH DETAIL IN APPENDIX B.
EACH TEST STRIP TO BE 180FT IN LENGTH.


Bottom Ash as Hot Mix
Asphalt Aggregate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NOTE:
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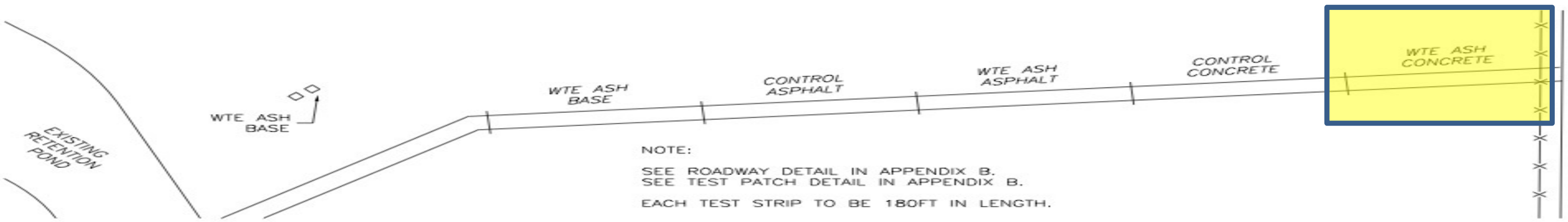
EACH TEST STRIP TO BE 180FT IN LENGTH.


Bottom Ash as aggregate in Portland Cement Concrete




Bottom Ash as aggregate in Portland Cement Concrete

# FDEP Approval

- STANDING Authorization to Utilize Bottom Ash as a Road Construction Material
- Certain Limitations Still Apply (no use in wetlands, material must be aged, etc.), but NO FURTHER PERMITS ARE NECESSARY

Florida Department of Environmental Protection
BOB MARTINEZ CENTER
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32399-2400

RICK SCOTT
GOVERNOR

CARLOS LOPEZ-CANTERA
LT. GOVERNOR

CLIFFORD D. WILSON III
INTERIM SECRETARY

December 5, 2014

via electronic mail

Michelle L. Baker, M.B.A.
County Administrator
8731 Citizens Drive
New Port Richey, Florida 34654-5598

**RE:** Approval of Specified Materials for Recycling and Reuse of Treated Bottom Ash Residue from the Pasco County Resource Recovery Facility, WACS ID No. 26254

Dear Ms. Baker

The Department has completed our review of your August 14, 2014, request for approval for recycling and reuse of the above referenced bottom ash materials under the provisions of Section 403.7045(5), Florida Statutes (F.S.). Your letter transmitted the results of use case analyses in the report, "Pasco County Use Case Scenarios to Examine the Recycling of Waste to Energy Ash in Road Construction Applications," which was prepared for the Pasco County Utilities Department by Dr. Timothy Townsend at the University of Florida.

The Department appreciates the time and care which your utilities department, and your Solid Waste Director, Mr. John Power, have taken to meet with the Department on several occasions during the preparation of the use case analyses and corresponding report that were provided with your request.

Based on our review of your August 14, 2014, application requesting the Department's authorization to utilize bottom ash from facilities owned or operated by you, Pasco County is hereby authorized and allowed to perform the proposed recycling or reuse activities in accordance with Section 403.7045(5), F.S., and the conditions of this Department Order.

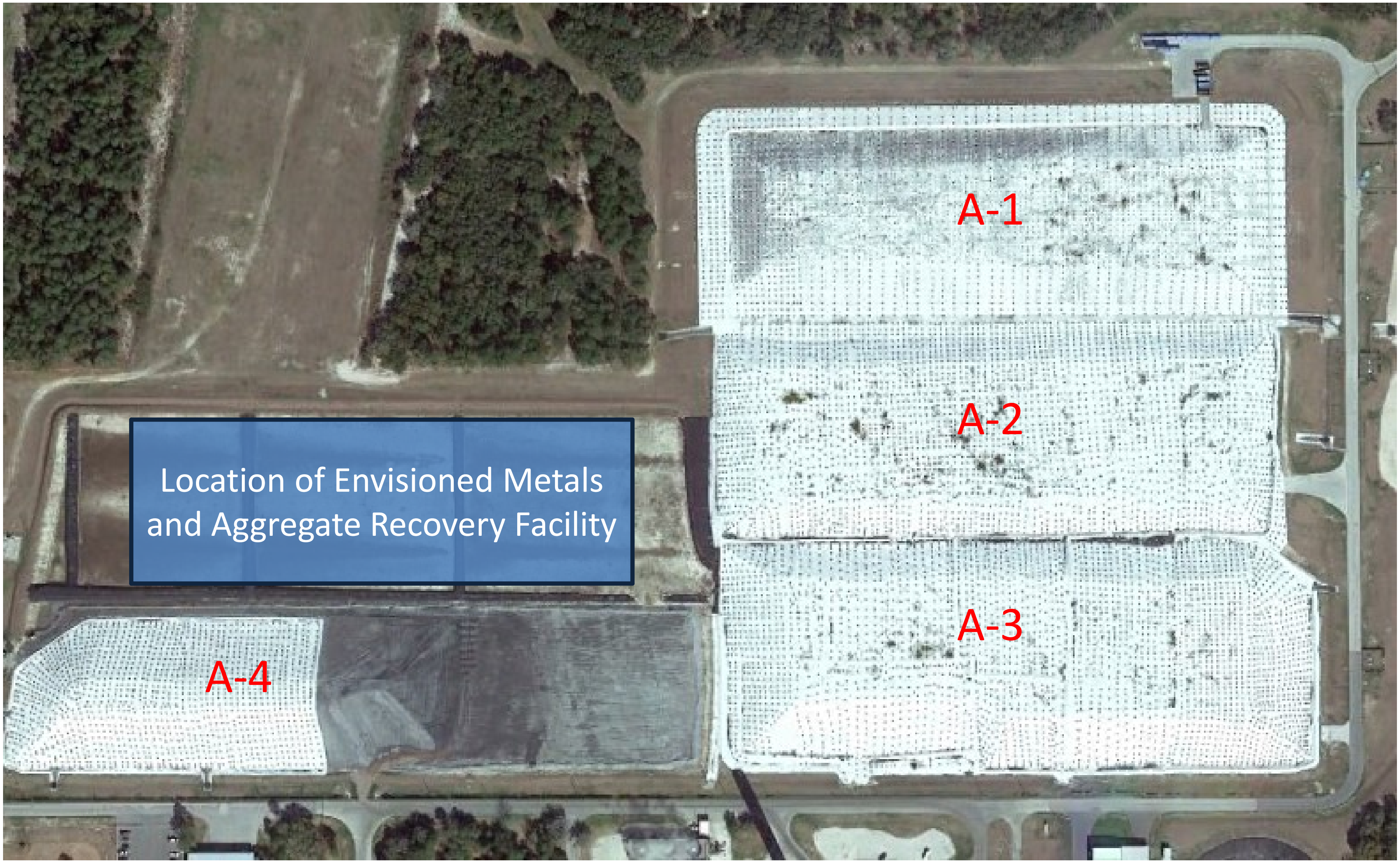
Specified Materials:

The following material or materials (Specified Materials) are allowed for recycling or reuse within Pasco County by, or under the direction of, the Pasco County Utilities Department:

- Bottom Ash Residue as defined in Rule 62-701.200(7)(a), F.A.C., from the Pasco County Resource Recovery Facility (Facility), a waste-to-energy facility as defined in Section 403.7061(4), F.S. (bottom ash), and

# Transitioning from Bottom Ash to Combined Ash

# Pasco County Monofill

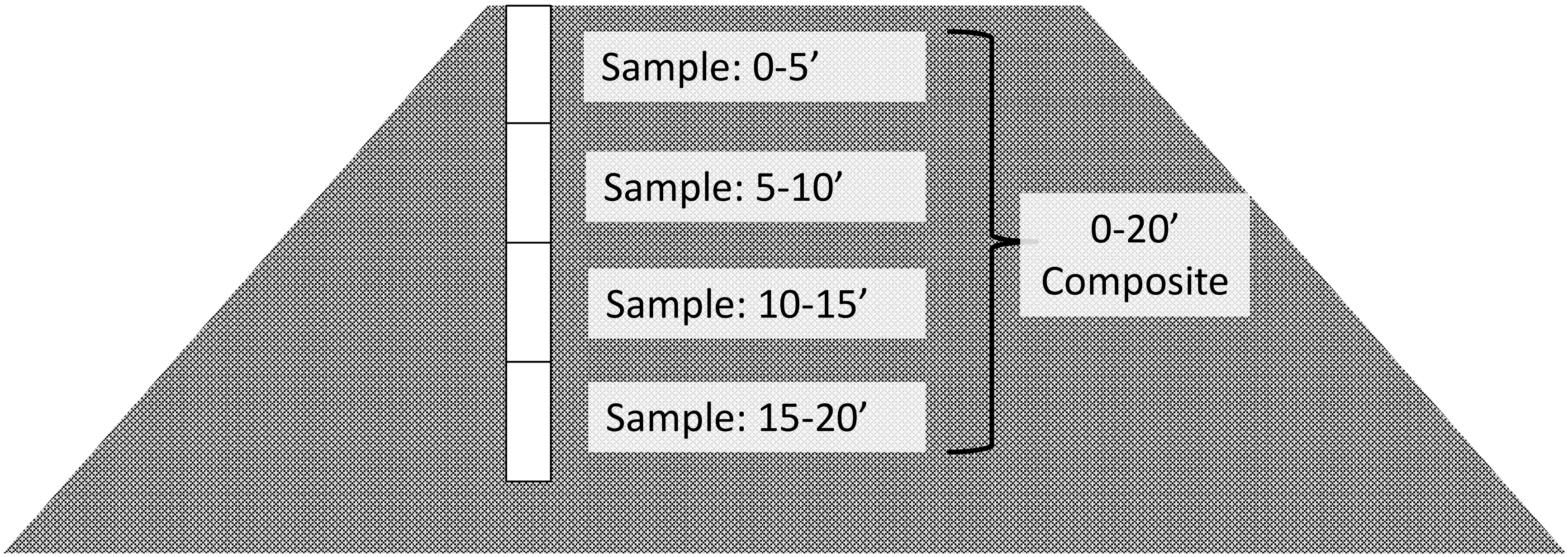


# Drill Locations – Feb 2016

| Cell | Location | Estimated Age Range | Depth | Number of Samples | Sample Code |
|---|---|---|---|---|---|
| A-1 | Center of Sub-Cell 1 | Feb 1991- July 1992 | 20’ | 4 (5’ intervals) | A1E |
| A-1 | Center of Sub-Cell 2 | Aug 1992 – Nov 1993 | 20’ | 4 (5’ intervals) | A1C |
| A-1 | Center of Sub-Cell 3 | Dec 1993 – March 1995 | 20’ | 4 (5’ intervals) | A1W |
| A-2 | Center of Sub-Cell 1 | Dec 1996 – July 1998 | 20’ | 4 (5’ intervals) | A2E |
| A-2 | Center of Sub-Cell 2 | Aug 1998 – December 1999 | 20’ | 4 (5’ intervals) | A2C |
| A-2 | Center of Sub-Cell 3 | Dec 1999 – June 2001 | 20’ | 4 (5’ intervals) | A2W |
| A-3 | Center of Sub-Cell 1 | May 2003 – Jan 2005 | 25’ | 5 (5’ intervals) | A3E |
| A-3 | Center of Sub-Cell 3 | Jan 2007 – Nov 2008 | 25’ | 5 (5’ intervals) | A3W |

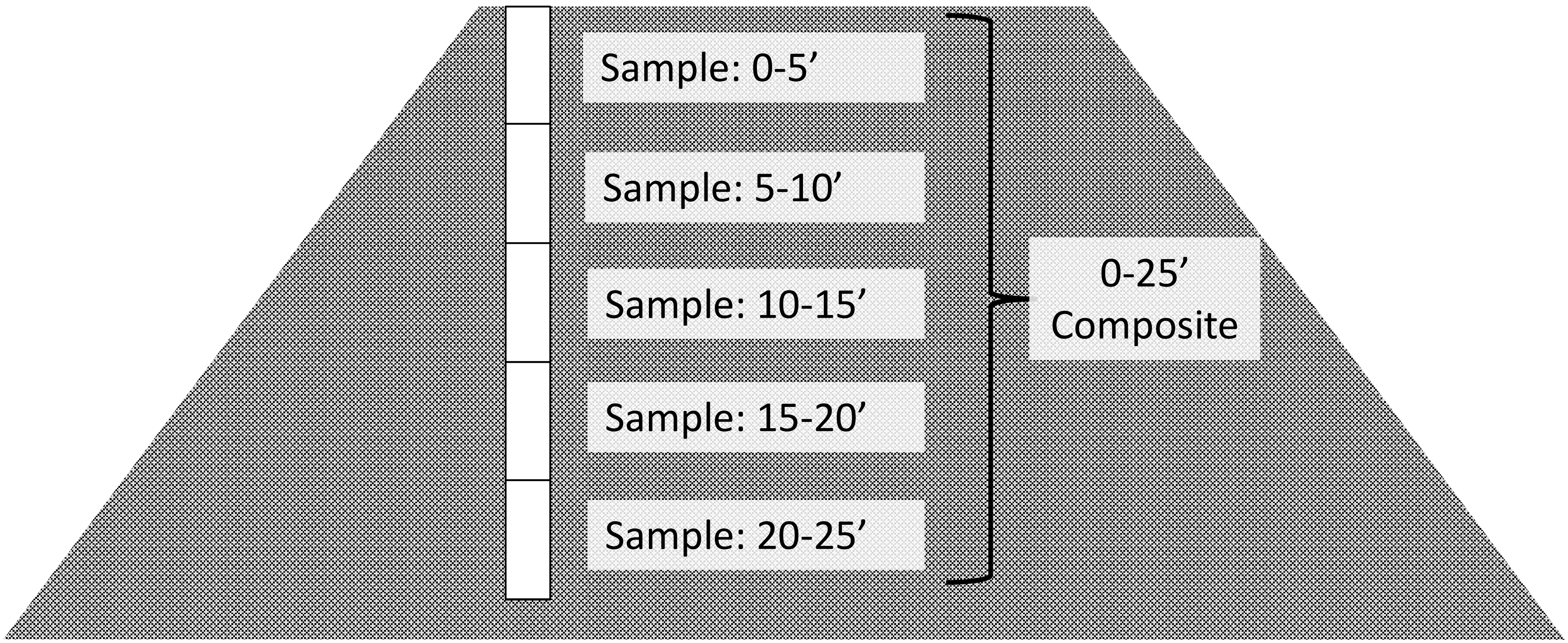
# Sampling Profile A-1 and A-2

Example Monofill Bore (A-1,A-2)



# Sampling Profile A-3

Example Monofill Bore (A-3)

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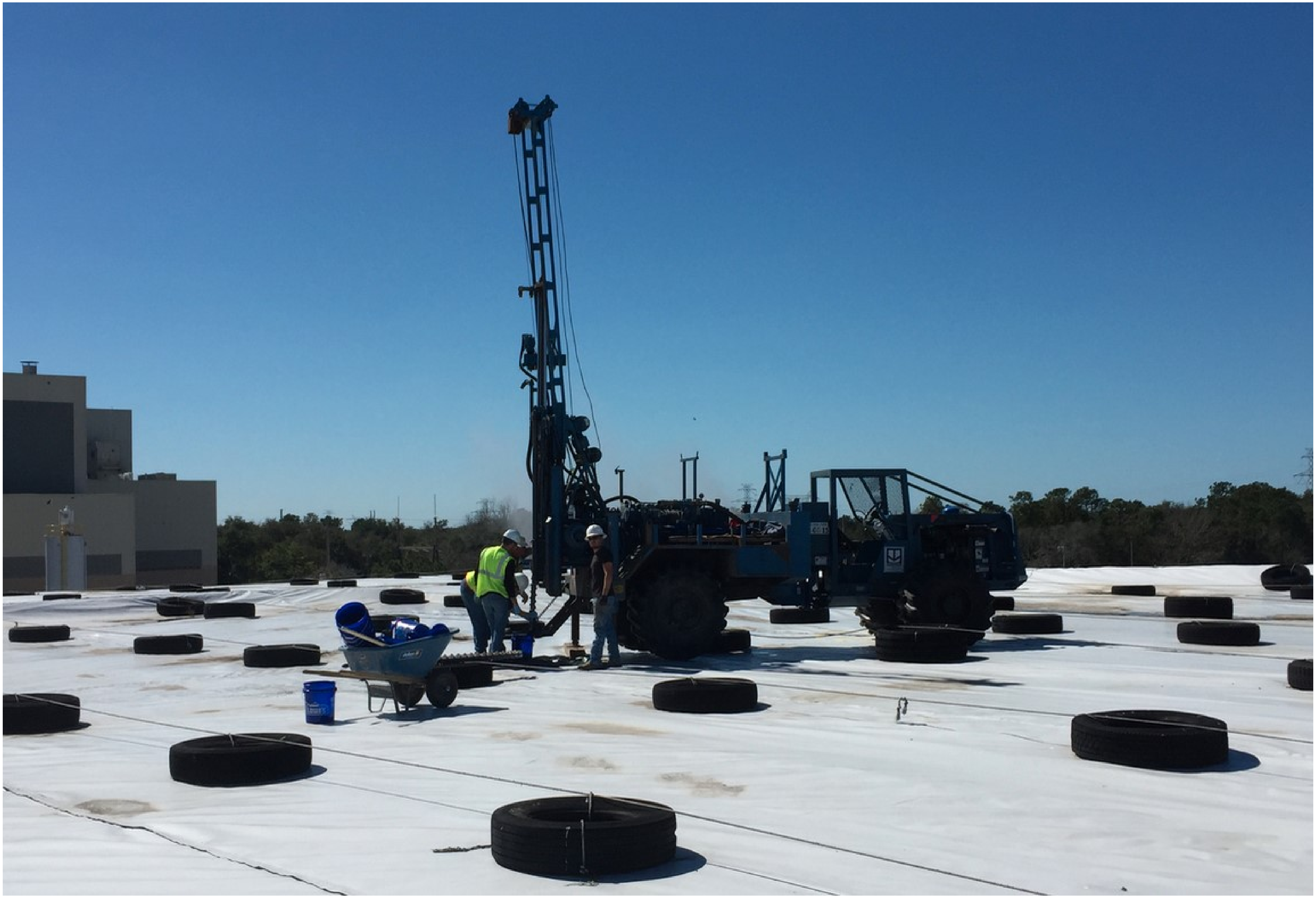


| Sample Code | Samples | Test | Samples | Test |
|---|---|---|---|---|
| **A1E** | 0-5’; 5-10’; 10-15’; 15-20’; | SPLP (x3)<br>Totals (x5)<br>Moisture Cont. (x2) | Composite (0-20’) | TCLP (x2) |
| **A1C** | 0-5’; 5-10’; 10-15’; 15-20’; | SPLP (x3)<br>Totals (x5)<br>Moisture Cont. (x2) | Composite (0-20’) | TCLP (x2) |
| **A1W** | 0-5’; 5-10’; 10-15’; 15-20’; | SPLP (x3)<br>Totals (x5)<br>Moisture Cont. (x2) | Composite (0-20’) | TCLP (x2) |
| **A2E** | 0-5’; 5-10’; 10-15’; 15-20’; | SPLP (x3)<br>Totals (x5)<br>Moisture Cont. (x2) | Composite (0-20’) | TCLP (x2) |
| **A2C** | 0-5’; 5-10’; 10-15’; 15-20’; | SPLP (x3)<br>Totals (x5)<br>Moisture Cont. (x2) | Composite (0-20’) | TCLP (x2) |
| **A2W** | 0-5’; 5-10’; 10-15’; 15-20’; | SPLP (x3)<br>Totals (x5)<br>Moisture Cont. (x2) | Composite (0-20’) | TCLP (x2) |
| **A3E** | 0-5’; 5-10’; 10-15’; 15-20’; 20-25’ | SPLP (x3)<br>Totals (x5)<br>Moisture Cont. (x2) | Composite (0-25’) | TCLP (x2) |
| **A3W** | 0-5’; 5-10’; 10-15’; 15-20’; 20-25’ | SPLP (x3)<br>Totals (x5)<br>Moisture Cont. (x2) | Composite (0-25’) | TCLP (x2) |
| **A1, A2, A3** | Composite of Each Cell | | Dioxin and Furan - EPA 8290 | |

# First Step - TCLP

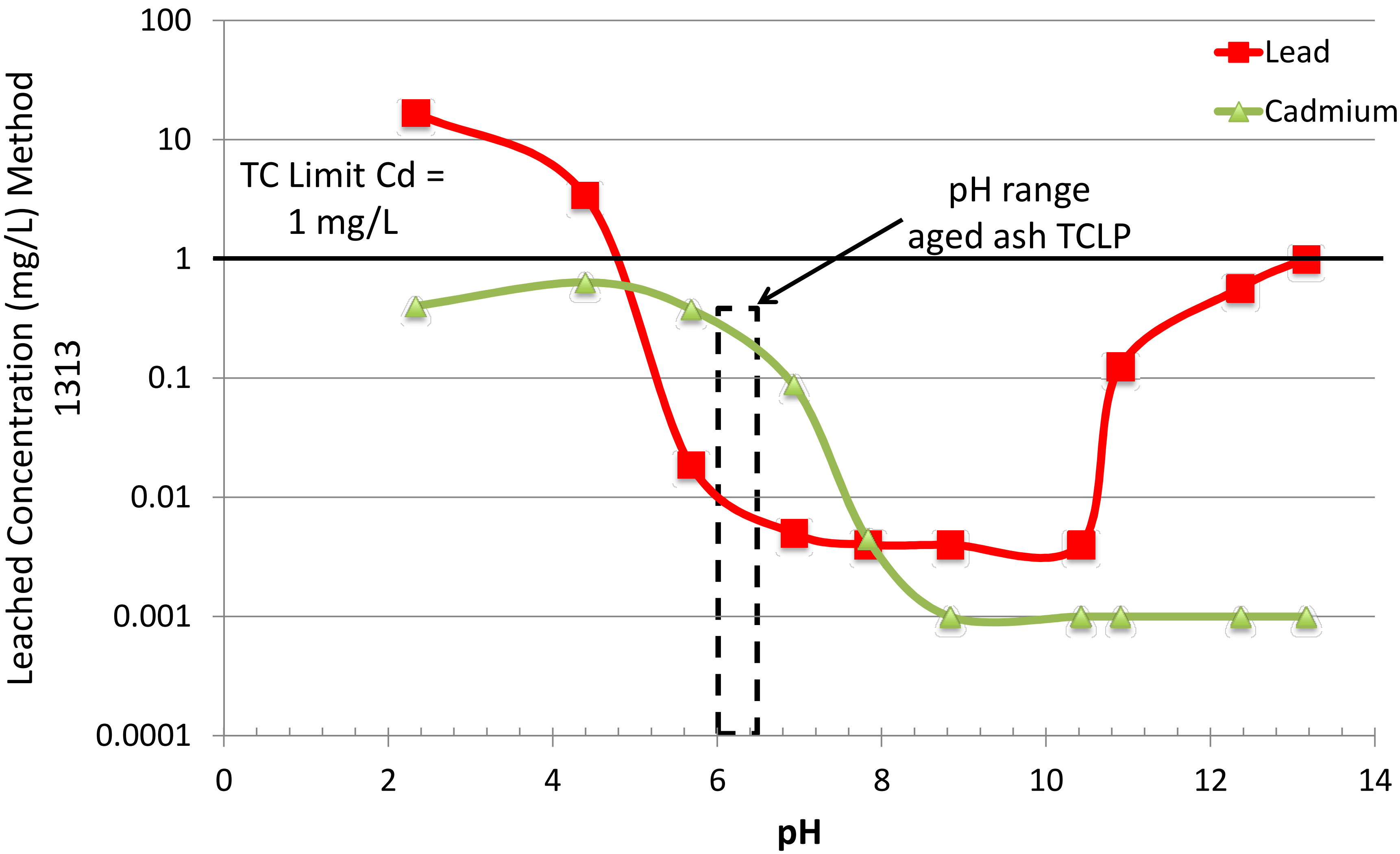
- Tested composite sample from each bore in duplicate (16)
- TCLP: Duplicate fluid determinations from each monofill bore indicate TCLP Fluid 1 for all samples
  - Final pH value between 2-3
- Loss of alkalinity supported by pH decrease seen in SPLP
- Aged ash will should result in fluid 1
  - Supported by data seen from an Ash Processing Facility in the Northeast
- Final pH of TCLP extractions 6.9-6.3
  - Low lead solubility (ampho)
  - Higher cadmium solubility (oxyanion)

# TCLP Results

| Element | 95% UCL (mg/L) | TC Limit (mg/L) |
|---|---|---|
| As | 0.015 | 5 |
| Ba | 0.183 | 100 |
| Cd | 0.885 | 1 |
| Cr | 0.058 | 5 |
| Pb | 0.917 | 5 |
| Se | 0.025 | 1 |

- The resulting 95% UCL for all samples fell below TC thresholds
- Elements of most concern typically Pb and Cd
- Pb leaching low (pH)
- Cd leaching close to threshold (pH)

# Leaching of Pb and Cd as a Function of Final pH



# Summary of TCLP Findings

- As characterized the 95% UCL of the RCRA metals evaluated fell below TC limits
- Low pH solubility of Cadmium resulted in concentrations closest to TC limit
- Cadmium concentration in ash (mg/kg) possible correlation with increased TCLP leaching (i.e. the TCLP results were driven by the amount of Cd in the ash and not by the alkalinity of the ash)

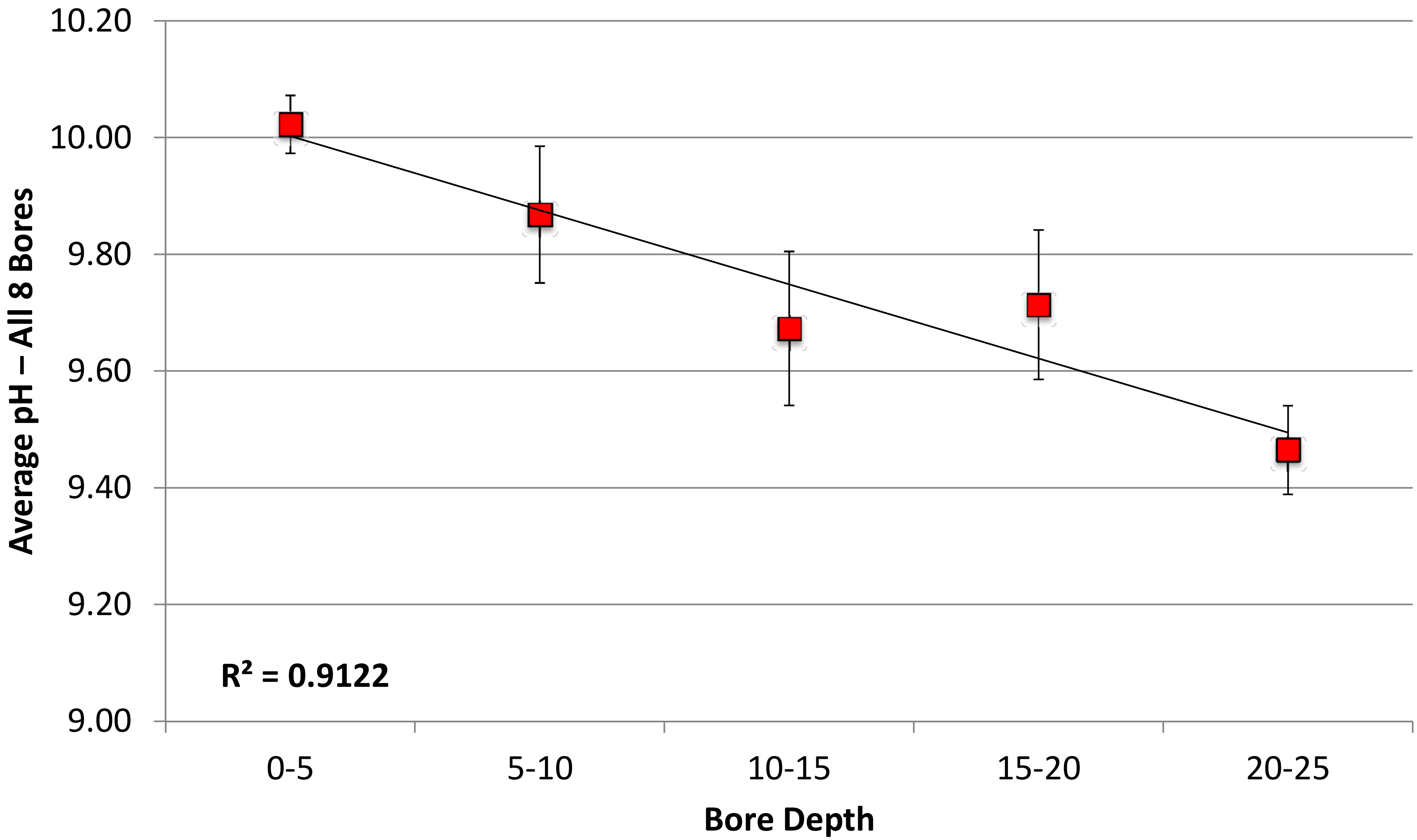
# Second Step - SPLP

- Conducted on each of the discrete depth intervals for each bore (in triplicate)
- pH and element release evaluated
- 95% UCL Calculated for entirety of data set (90 + samples) used to identify elements in exceedance of GCTLs
  - Designated as COPC for further evaluation

# SPLP pH

- pH ranged from 10.3 to 9.3
- Trend of decreasing pH with decreasing depth was seen in the majority (6/8) of the monofill bores and overall averages
  - Supports data from previous study
  - Temperature increase a hypothesis
- No clear trends in differences between cells
- Significantly lower than fresh combined ash
  - nat. pH = 12-11.5
- Aged to region of lower element solubilty

# SPLP pH; Function of Depth



| Element | 95% UCL SPLP Conc. (mg/L) | FL- GCTL | 95% UCL Exceeds |
|---|---|---|---|
| **Aluminum** | 27.9 | 0.2/7 | yes |
| **Arsenic** | 0.004 | 0.01 | no |
| **Boron** | 0.142 | 1.4 | no |
| **Barium** | 0.162 | 2 | no |
| **Beryllium** | 0.001 | 0.004 | no |
| **Calcium** | 269 | N/A | - |
| **Cadmium** | 0.001 | 0.005 | no |
| **Cobalt** | 0.006 | 0.14 | no |
| **Chromium (tot.)** | 0.014 | 0.1 | no |
| **Copper** | 0.027 | 1 | no |
| **Iron** | 0.094 | 0.3 | no |
| **Potassium** | 74.7 | N/A | - |
| **Magnesium** | 0.107 | N/A | - |
| **Manganese** | 0.002 | 0.05 | no |
| **Molybdenum** | 0.037 | 0.035 | yes |
| **Sodium** | 140 | N/A | - |
| **Nickel** | 0.004 | 0.1 | no |
| Lead | 0.004 | 0.015 | no |
| **Antimony** | 0.058 | 0.006 | yes |
| **Selenium** | 0.006 | 0.05 | no |
| **Tin** | 0.002 | 4.2 | no |
| **Strontium** | 0.881 | 4.2 | no |
| **Vanadium** | 0.004 | 0.049 | no |
| **Zinc** | 0.011 | 5 | no |

# SPLP Conclusions

- Aluminum, Molybdenum, and Antimony leached above respective GCTLs
- No lead leaching
  - Due to pH decrease, lower solubility, mineral encapsulation
- Limited barium and strontium leaching
  - See in other combined ashes
  - Literature/historic data supports “wash off mechanism”
- Molybdenum leaching decreased in comparison to fresh MA and BA
  - Wash off

# Measured COPC

| COPC | 95% UCL SPLP - Bores (mg/L) | GCTL | Dilution and Attenuation Factor | Pasco Bottom Ash Required DAF |
|---|---|---|---|---|
| Al | 27.9 | 7* | 4 | 5.4 |
| Mo | 0.037 | 0.035 | 1.1 | 3.5 |
| Sb | 0.058 | 0.006 | 9.66 | 5 |

* Secondary drinking water standard

# Previous Modeling Approach

- Conduct leaching test to determine initial concentration
  - Column test (base)
  - SPLP (asphalt and concrete)
- Determine infiltration rate through roadway
  - Used HELP model
  - Range of Data (0.5 – 10.4% of precipitation)
- Conduct modeling
  - US EPA - IWEM (screening)
  - EPRI - MYGRT (site specific)

# IWEM

- US EPA
- Stochastic model
- Pulls aquifer characteristics and climate data from database developed by EPA
  - Matched to data most close to Pasco Co.
- Reports 90$^{th}$ percentile modeled concentration of 10,000 realization
- At the time of the bottom ash evaluation there was no specific module for roadways
  - Since updated in 2015

# MYGRT

- Electric Power Research Institute
- User based inputs
- Partitioning coefficients not specified
  - Used a range of values
- Direct concentration output (one scenario)
  - No stochastic analysis
- Modeled most conservative aquifer characteristics from a previous FDEP dataset

# Prior Evaluation (Bottom Ash) Summary

- Modeled results for IWEM and MYGRT demonstrated that results would be below GCTLs at 100’
- Infiltration rate most critical parameter
- MYGRT less conservative then IWEM
- Did show exceedance of Sb, Mo, Al at distances < 100’

# Summary of Previous Results in Bottom Ash BUD Application – IWEM Roadbase

| Leachate Concentration at a Receptor Location of 10ft (mg/L) | | | | |
|---|---|---|---|---|
| **Infiltration (in/yr) →** | **0.1** | **0.5** | **1** | **5** |
| Molybdenum | 0.0034 | 0.0131 | 0.0256 | 0.112 |
| Antimony | 9.41E-05 | 0.0034 | 0.0067 | 0.0218 |
| Aluminum | 0.0055 | 0.133 | 0.585 | 8.300 |

10 feet

| Leachate Concentration at a Receptor Location of 35ft (mg/L) | | | | |
|---|---|---|---|---|
| **Infiltration (in/yr) →** | **0.1 (0.2%)** | **0.5 (1.0%)** | **1 (2.1 %)** | **5 (10.4%)** |
| Molybdenum | 0.0026 | 0.0081 | 0.0145 | 0.0655 |
| Antimony | 0.0002 | 0.0018 | 0.0031 | 0.0112 |
| Aluminum | 0.0048 | 0.0858 | 0.300 | 4.13 |

35 feet

| Leachate Concentration at a Receptor Location of 50ft (mg/L) | | | | |
|---|---|---|---|---|
| **Infiltration (in/yr) →** | **0.1** | **0.5** | **1** | **5** |
| Molybdenum | 0.002 | 0.0066 | 0.0112 | 0.0479 |
| Antimony | 0.0001 | 0.0013 | 0.0022 | 0.0085 |
| Aluminum | 0.0041 | 0.0691 | 0.235 | 3.24 |

50 feet

| Leachate Concentration at a Receptor Location of 100ft (mg/L) | | | | |
|---|---|---|---|---|
| **Infiltration (in/yr) →** | **0.1** | **0.5** | **1** | **5** |
| Molybdenum | 0.0011 | 0.0037 | 0.0061 | 0.0256 |
| Antimony | 7.24E-05 | 0.0006 | 0.0011 | 0.0044 |
| Aluminum | 0.0025 | 0.04 | 0.130 | 1.47 |

100 feet

# IWEM Model Concentrations

| Input Concentration | | | |
|---|---|---|---|
| **Scenario (mg/L)** | **Antimony** | **Molybdenum** | **Aluminum** |
| Pasco Base (previous) | 0.030 | 0.121 | 37.9 |
| Current (combined ash) | 0.058 | 0.037 | 27.9 |
| Max that "passes" | 0.038 | 0.140 | 175* |

**IWEM Combined Ash Output 5" Infiltration 100'**

Output (Details)

Results - User-Defined Liner (18)

| CAS | Constituent Name | Leachate Concentration (mg/L) | DAF | Toxicity Standard | Exposure Duration (y) | Reference Groundwater Concentration (mg/L) | 90th Percentile Exposure Level (mg/L) | Below Benchmark? |
|---|---|---|---|---|---|---|---|---|
| 7440-36-0 | Antimony | 0.058 | 6.3 | MCL | 1 | 0.006 | 0.0093 | No |
| 7439-98-7 | Molybdenum | 0.037 | 4 | User Defined | 1 | 0.035 | 0.0092 | Yes |
| 25116-44-6 | Aluminium | 27.9 | 29 | MCL | 1 | 7 | 0.9515 | Yes |

# Predicted Downgradient Concentrations Combined vs Bottom Ash

**Combined Ash as Base**

| Leachate Concentration at a Receptor Location of 10ft (mg/L) | | | | |
|---|---|---|---|---|
| Infiltration (in/yr) → | 0.1 | 0.5 | 1 | 5 |
| Molybdenum | OK | 0.0038 | 0.0078 | 0.044 |
| Antimony | OK | 0.007 | 0.013 | 0.035 |
| Aluminum | OK | 0.1815 | 0.8187 | 7.659 |
| | | | | |
| **Leachate Concentration at a Receptor Location of 35ft (mg/L)** | | | | |
| Infiltration (in/yr) → | 0.1 (0.2%) | 0.5 (1.0%) | 1 (2.1 %) | 5 (10.4%) |
| Molybdenum | OK | OK | 0.0049 | 0.0248 |
| Antimony | OK | OK | 0.0053 | 0.0273 |
| Aluminum | OK | OK | 0.323 | 3.435 |
| | | | | |
| **Leachate Concentration at a Receptor Location of 50ft (mg/L)** | | | | |
| Infiltration (in/yr) → | 0.1 | 0.5 | 1 | 5 |
| Molybdenum | OK | OK | 0.0039 | 0.0174 |
| Antimony | OK | OK | 0.0045 | 0.0208 |
| Aluminum | OK | OK | 0.277 | 2.17 |
| | | | | |
| **Leachate Concentration at a Receptor Location of 100ft (mg/L)** | | | | |
| Infiltration (in/yr) → | 0.1 | 0.5 | 1 | 5 |
| Molybdenum | OK | OK | 0.0018 | 0.0092 |
| Antimony | OK | OK | 0.0022 | 0.0093 |
| Aluminum | OK | OK | 0.095 | 0.95 |

**Bottom Ash as Base**

| Leachate Concentration at a Receptor Location of 10ft (mg/L) | | | | |
|---|---|---|---|---|
| Infiltration (in/yr) → | 0.1 | 0.5 | 1 | 5 |
| Molybdenum | 0.0034 | 0.0131 | 0.0256 | 0.112 |
| Antimony | 9.41E-05 | 0.0034 | 0.0067 | 0.0218 |
| Aluminum | 0.0055 | 0.133 | 0.585 | 8.300 |
| | | | | |
| **Leachate Concentration at a Receptor Location of 35ft (mg/L)** | | | | |
| Infiltration (in/yr) → | 0.1 (0.2%) | 0.5 (1.0%) | 1 (2.1 %) | 5 (10.4%) |
| Molybdenum | 0.0026 | 0.0081 | 0.0145 | 0.0655 |
| Antimony | 0.0002 | 0.0018 | 0.0031 | 0.0112 |
| Aluminum | 0.0048 | 0.0858 | 0.300 | 4.13 |
| | | | | |
| **Leachate Concentration at a Receptor Location of 50ft (mg/L)** | | | | |
| Infiltration (in/yr) → | 0.1 | 0.5 | 1 | 5 |
| Molybdenum | 0.002 | 0.0066 | 0.0112 | 0.0479 |
| Antimony | 0.0001 | 0.0013 | 0.0022 | 0.0085 |
| Aluminum | 0.0041 | 0.0691 | 0.235 | 3.24 |
| | | | | |
| **Leachate Concentration at a Receptor Location of 100ft (mg/L)** | | | | |
| Infiltration (in/yr) → | 0.1 | 0.5 | 1 | 5 |
| Molybdenum | 0.0011 | 0.0037 | 0.0061 | 0.0256 |
| Antimony | 7.24E-05 | 0.0006 | 0.0011 | 0.0044 |
| Aluminum | 0.0025 | 0.04 | 0.130 | 1.47 |

# Conclusions and Next Steps

- SPLP Data and Modeling Results indicate that Combined Ash in a monofill is not dissimilar to fresh bottom ash
- The material tested (monofill borings) may/will behave differently than material generated by the Metals Recovery Facility – more testing needs to be done
- It is likely that a Beneficial Use approval CAN be obtained for combined ash