COAL COMBUSTION BY-PRODUCTS DISPOSAL PRACTICES AT A SURFACE COAL MINE IN NEW MEXICO: LEACHATE & GROUNDWATER STUDY

June 5, 2013

ASMR Presentation

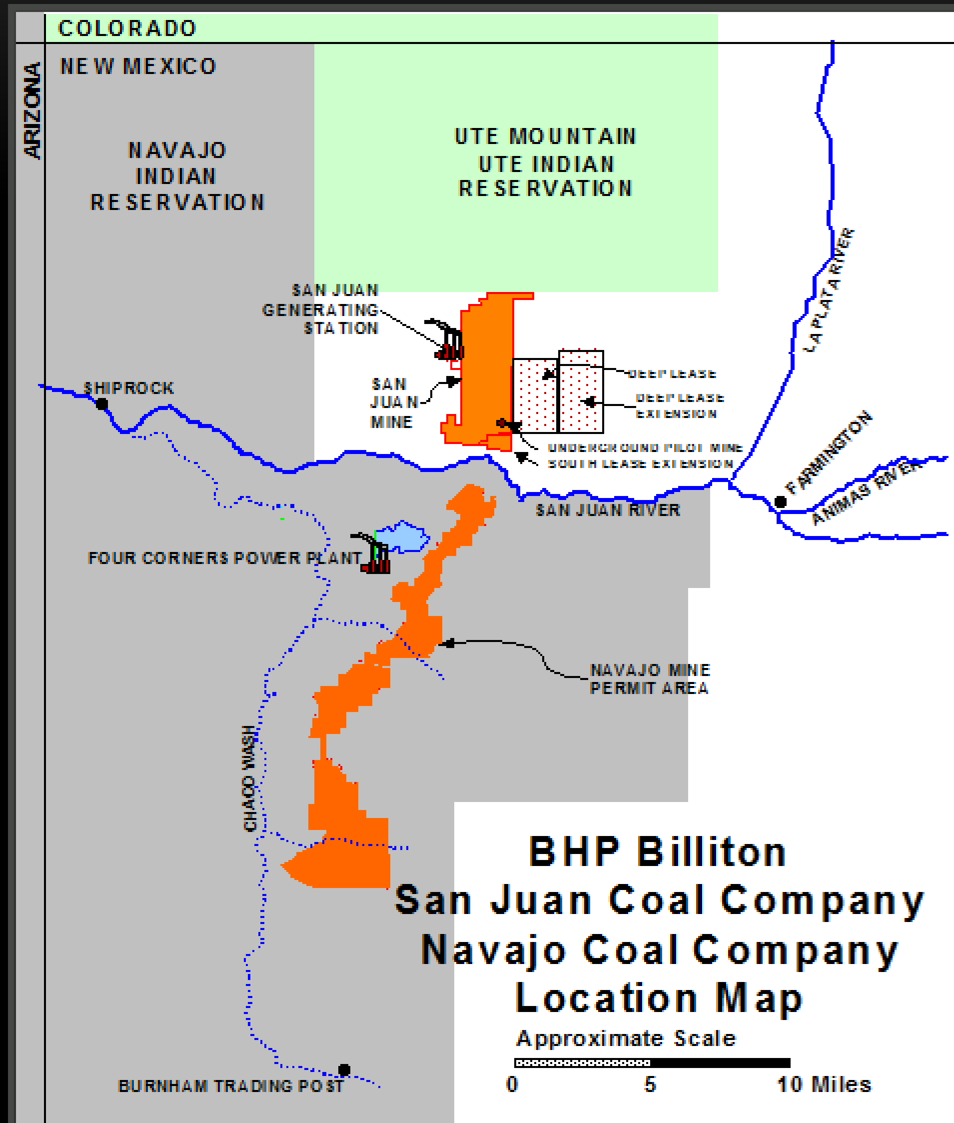
Ryan Webb

Cheryl Parker, Kara Hart, Bruce Thomson, John Stormont, Mark Stone

BACKGROUND

- San Juan Power Generating Station/San Juan Mine (SJM)
- Coal is mined from the Fruitland Formation and disposed of at this location
- 2.7 million tons of CCBs disposed of in landfills each year
- 70% fly ash, 20% bottom ash, 10% FGD gypsum

BACKGROUND



COLORADO
NEW MEXICO
ARIZONA
NAVAJO INDIAN RESERVATION
UTE MOUNTAIN UTE INDIAN RESERVATION
SAN JUAN GENERATING STATION
SAN JUAN MINE
DEEP LEASE
DEEP LEASE EXTENSION
UNDERGROUND PILOT MINE
SOUTH LEASE EXTENSION
LAPLATA RIVER
FARMINGTON
ANIMAS RIVER
SHIPROCK
SAN JUAN RIVER
FOUR CORNERS POWER PLANT
NAVAJO MINE PERMIT AREA
CHACO WASH
BURNHAM TRADING POST
BHP Billiton
San Juan Coal Company
Navajo Coal Company
Location Map
Approximate Scale
0
5
10 Miles

GOALS

- What hazardous constituents are associated with CCBs and what is their potential for leaching from buried wastes?
- What are the geotechnical and hydraulic properties of the CCBs and how do they affect possible infiltration of ground water through the buried waste?
- What is the rate of infiltration through the disposed CCBs?
- Are there identifiable geochemical processes occurring that affect leachate quality or the hydraulic properties of the buried waste?

OBJECTIVES

- Results of leaching tests to characterize contaminant release from fresh and buried CCBs under saturated and unsaturated conditions
- Summary of the physical properties of soils and CCBs that govern the unsaturated flow of water through them
- Results of a one-dimensional unsaturated water flow model that estimates infiltration of water through disposed CCB materials.

METHODS

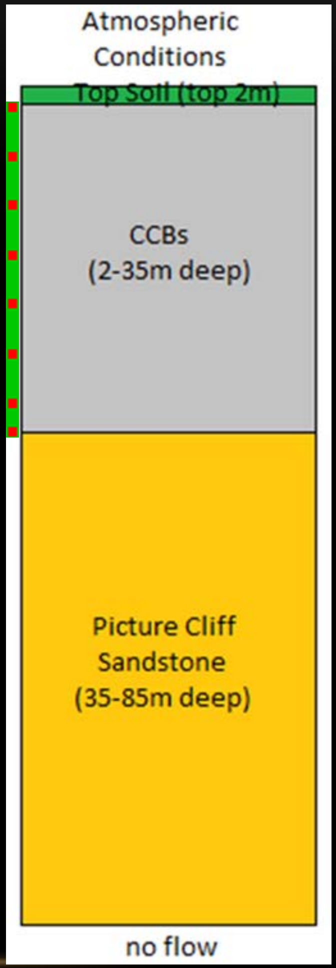
- Physical Properties of CCBs
- 1-D Model Development from Lab Results
- Leach Tests
- Geochemical Characterization
- Column Tests

METHODS (PHYSICAL PROPERTIES)

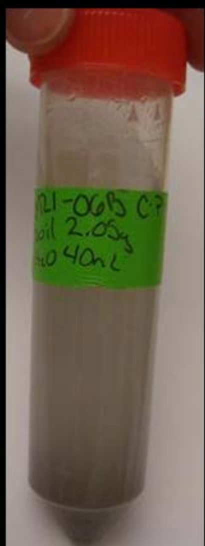
- Grain size distribution
- Specific Gravity
- Moisture Content
- Density
- Saturated Hydraulic Conductivity
- Moisture Characteristic Curves

METHODS (MODELING)

- HYDRUS 1D
- 33 m of buried CCBs (FGD not included)
- 10 years of available daily climate data

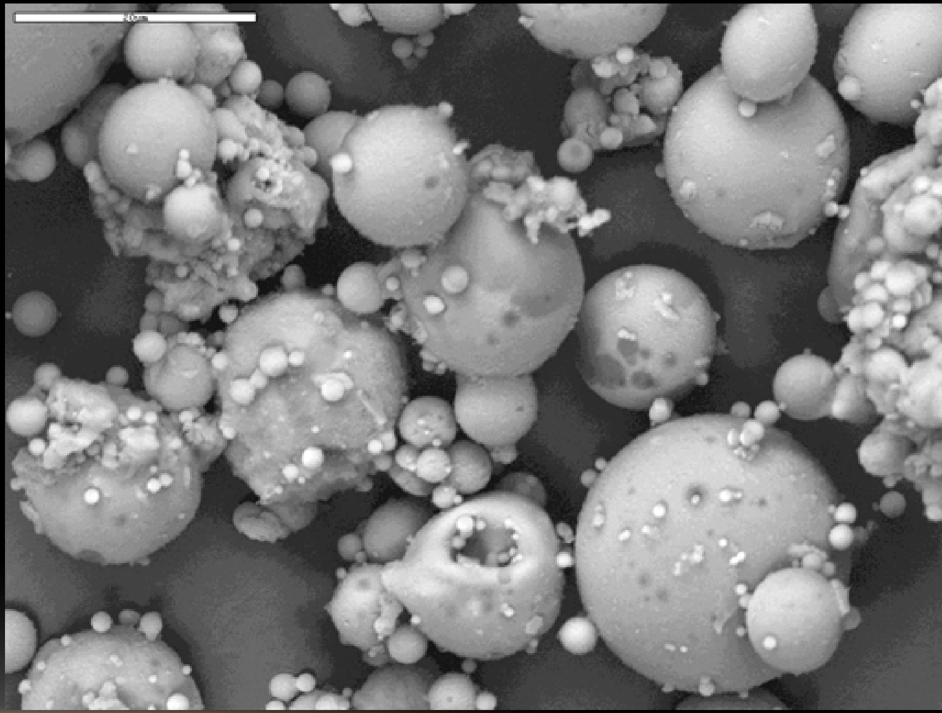


METHODS
(LEACH TESTS)



METHODS (GEOCHEMICAL CHARACTERIZATION)

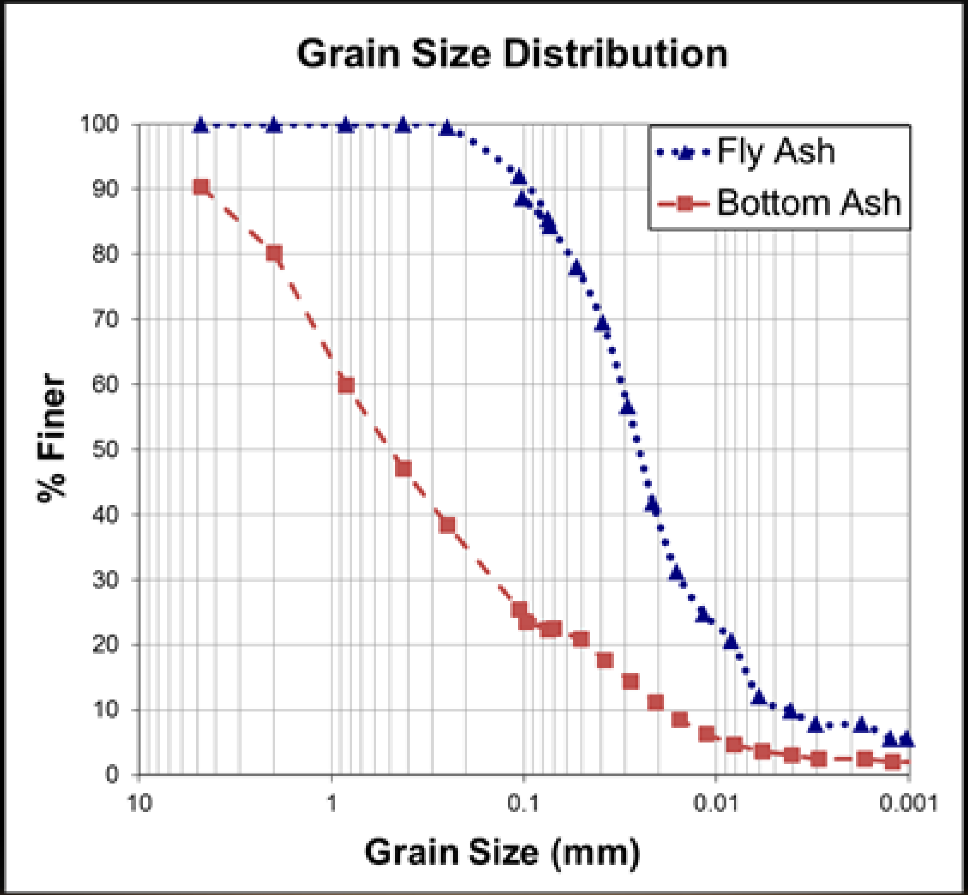
- Scanning Electron Microscopy
- X-Ray Diffraction



METHODS
(GEOCHEMICAL CHARACTERIZATION)

- Unsaturated flow columns (30 days)
- No. 8 coal seam water (2 columns) & DI water (6 columns)
- One pore volume per day

RESULTS (PHYSICAL CHARACTERISTICS)



RESULTS
(PHYSICAL CHARACTERISTICS)

Property	Fly Ash	Bottom Ash
% finer #200 sieve (0.075 mm)	85.4	22.3
% larger #200 sieve (0.075 mm)	14.6	77.7
Minimum Relative Density (kg/m^3)	1007.4	692.2
Maximum Relative Density (kg/m^3)	1184.4	813.8
Average Specific Gravity	2.00	2.06

RESULTS
(PHYSICAL CHARACTERISTICS)

Material	Target Dry Density (kg/m^3)	Actual Dry Density (kg/m^3)	Sample 1 K_{SAT} (cm/s)	Sample 2 K_{SAT} (cm/s)
Fly Ash	1028.4	1024.0	7.81E-05	1.30E-04
Fly Ash	1113.3	1108.2	6.62E-05	8.10E-05
Fly Ash	1169.3	1163.0	5.45E-05	5.96E-05
Bottom Ash	727.2	724.4	3.53E-03	6.45E-03
Bottom Ash	800.9	796.9	2.27E-03	6.26E-03
Bottom Ash	913.1	910.4	1.48E-03	3.90E-03
Top Soil		1680.0	8.45E-06	

RESULTS (PHYSICAL CHARACTERISTICS)

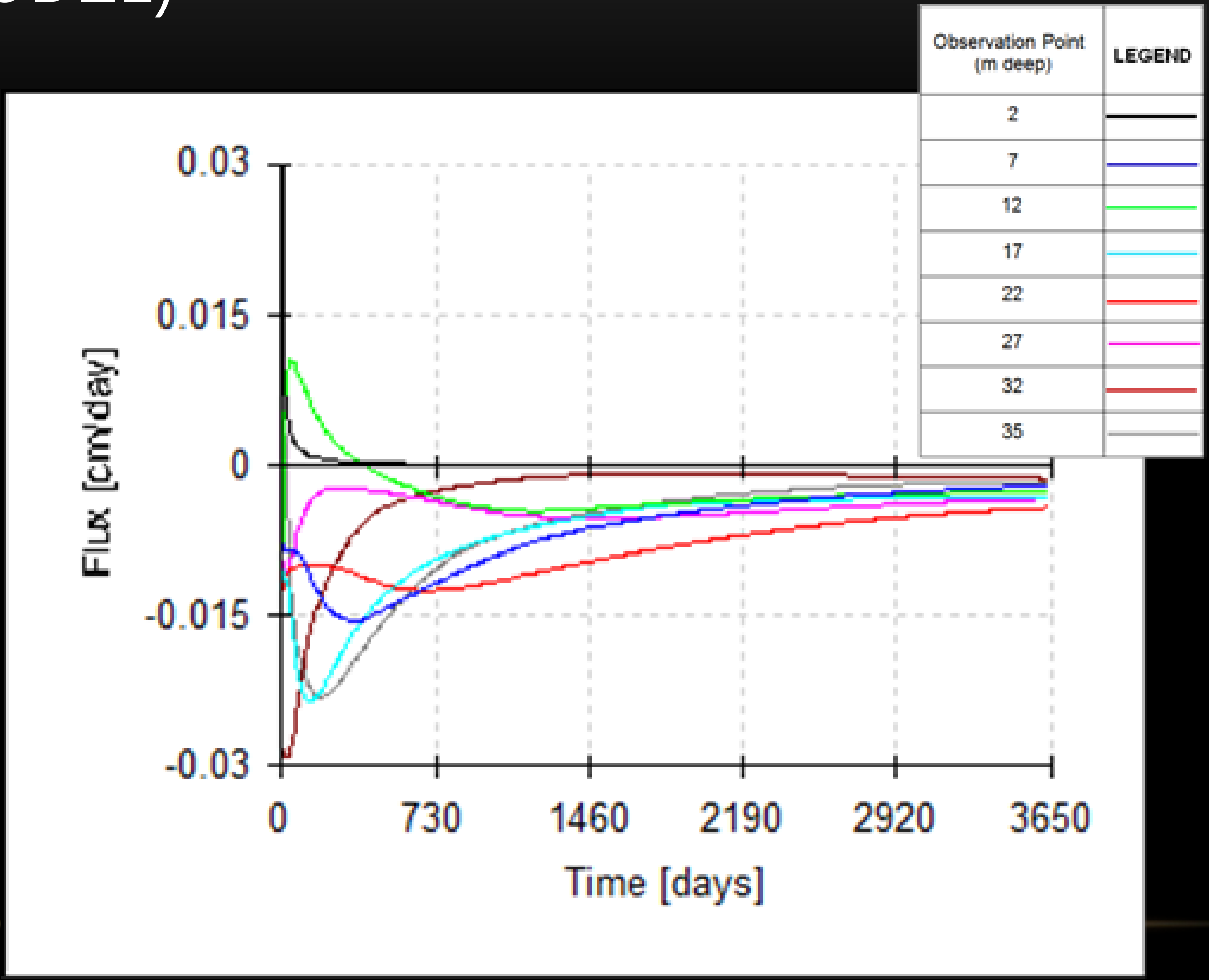
Material	Target Dry Density (kg/m^3)	θ_r (cm^3/cm^3)	θ_s (cm^3/cm^3)	α (1/cm)	n
Fly Ash	1028.4	0.003	0.55	3.9E-03	1.68
Fly Ash	1113.3	0.00	0.52	2.4E-03	1.66
Fly Ash	1169.3	0.00	0.47	1.1E-03	1.85
Bottom Ash	727.2	0.00	0.56	4.1E-02	1.46
Bottom Ash	800.9	0.00	0.66	4.3E-02	1.52
Bottom Ash	913.1	0.00	0.63	2.5E-02	1.54
Top Soil		0.202	0.44	3.23E-02	0.73
Pictured Cliffs		0.00	0.26	5.62E-03	0.21

RESULTS (1D MODEL)

- Water flux through the top soil predicted to be virtually zero

Profile	Range of Calculated Point Fluxes (cm/day)	Range of Calculated Water Contents (cm/cm)	Range of Observed Water Contents (cm/cm)
FA only	-0.02 - 0.09	0.01 - 0.33	0.16 - 0.33
BA only	0.0 - 0.12	0.01 - 0.27	0.19 - 0.27
Baseline profile	-0.03 - 0.02	0.08 - 0.32	0.08 - 0.32

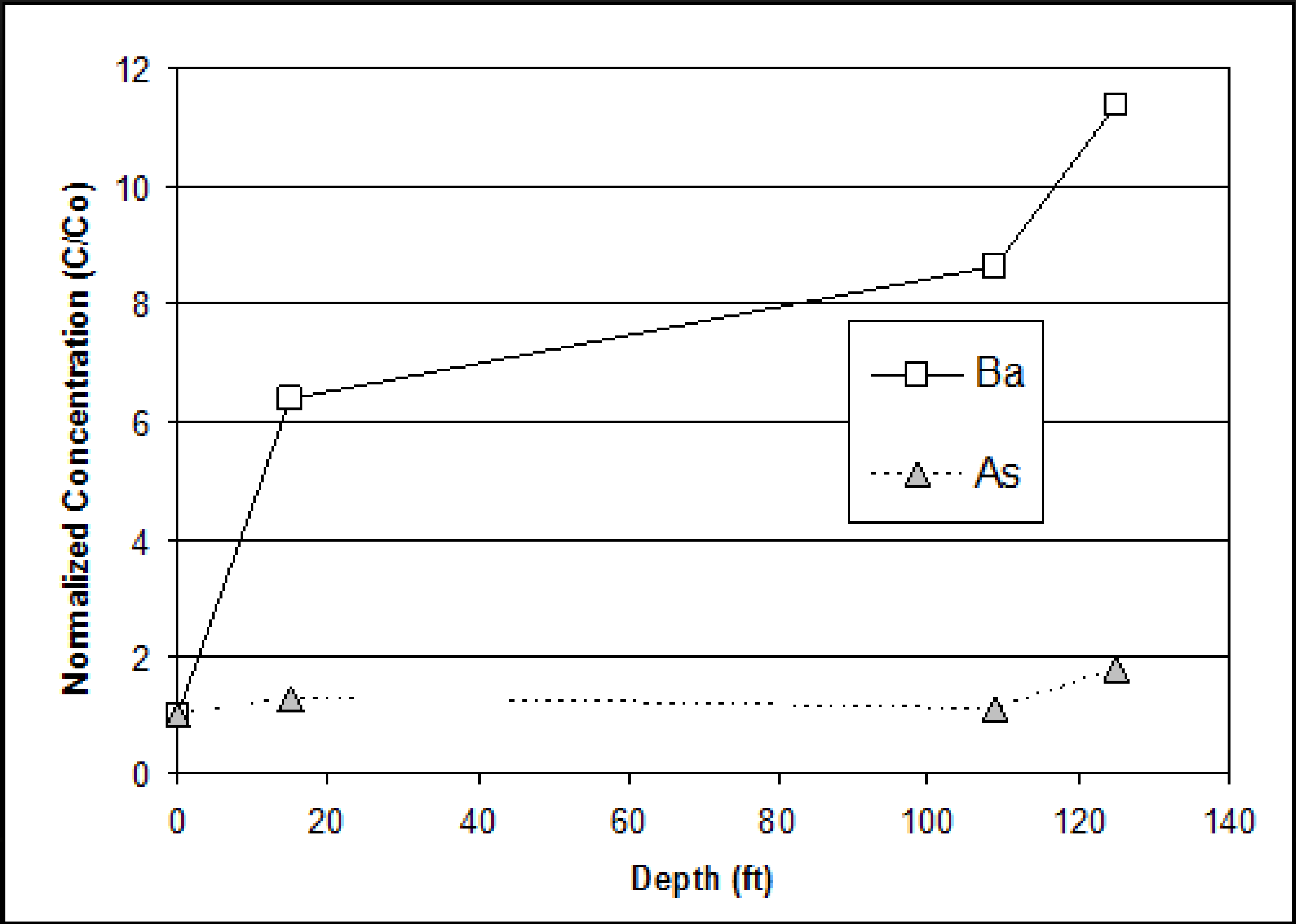
RESULTS (1D MODEL)



RESULTS
(LEACH TESTS)

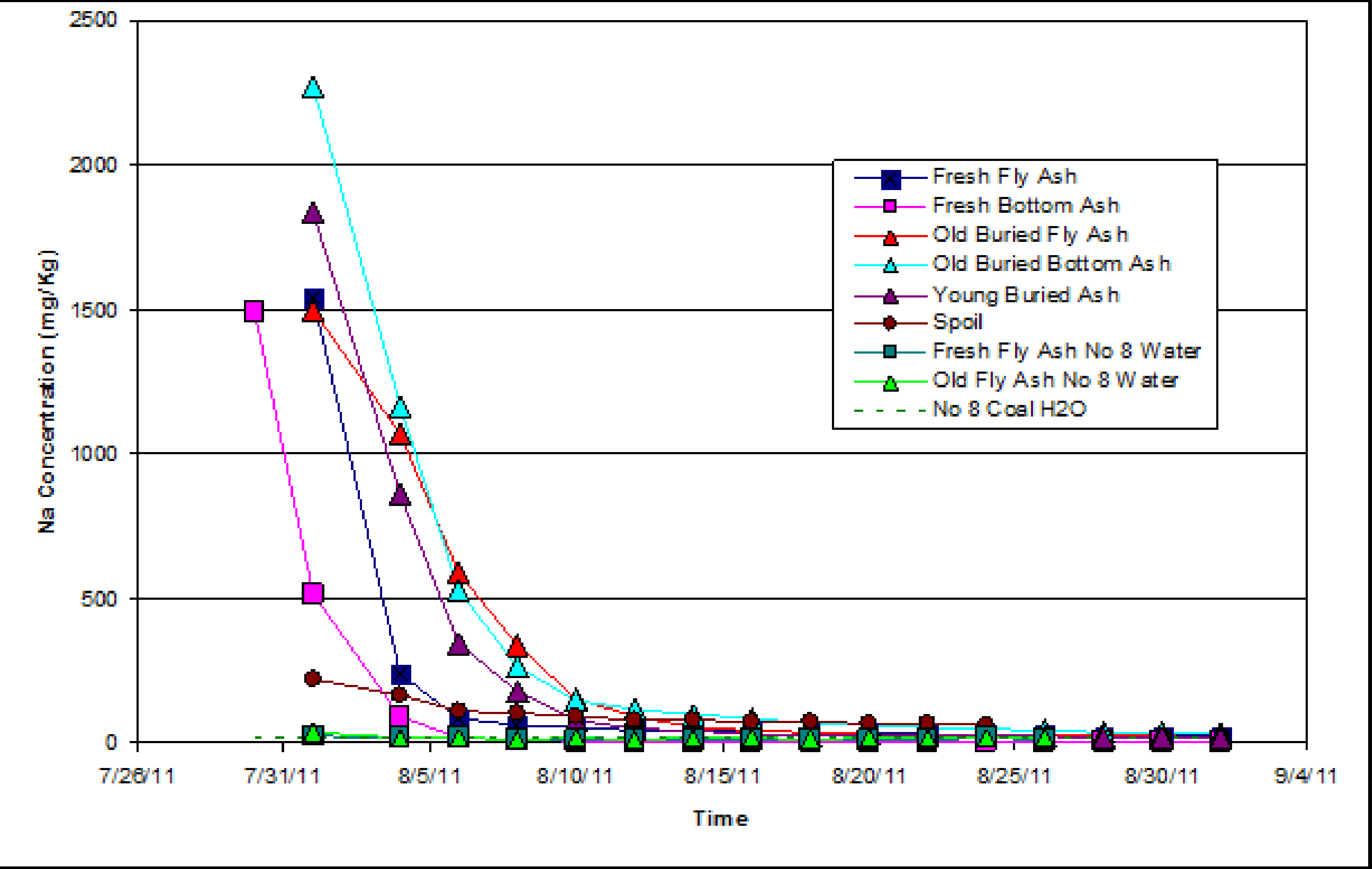
- High concentrations of Al, Ba, Ca, Fe, Si, and Na
- High amounts of Ba may be due to water being added for CCB transport
- As concentration roughly twice as high in fly ash
- Samples deeper in landfill show increasing concentration of Ba and possibly B

RESULTS

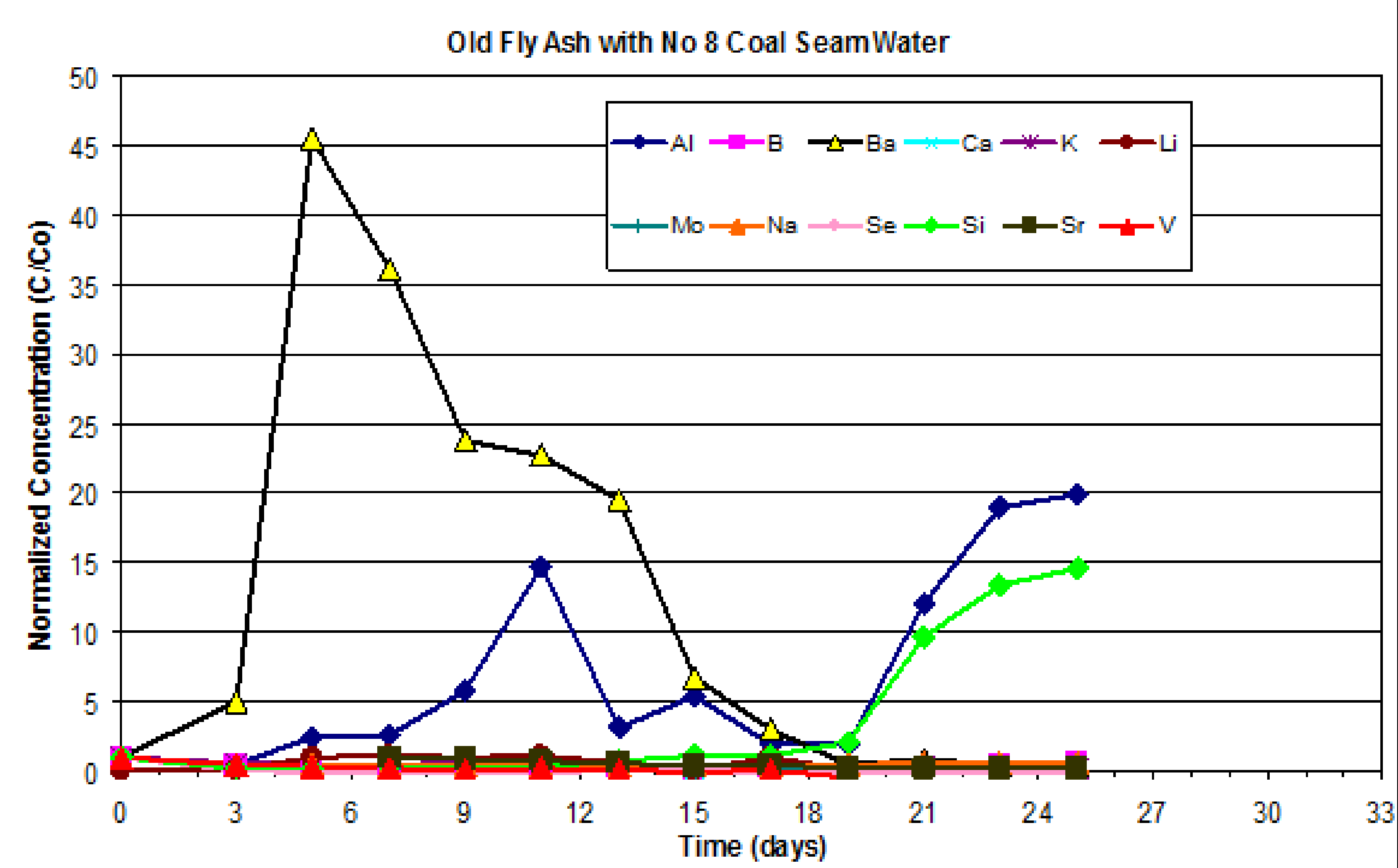


Normalized Concentration (C/Co)
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
Depth (ft)
Ba
As

RESULTS
(COLUMN TESTS)



RESULTS
(COLUMN TESTS)

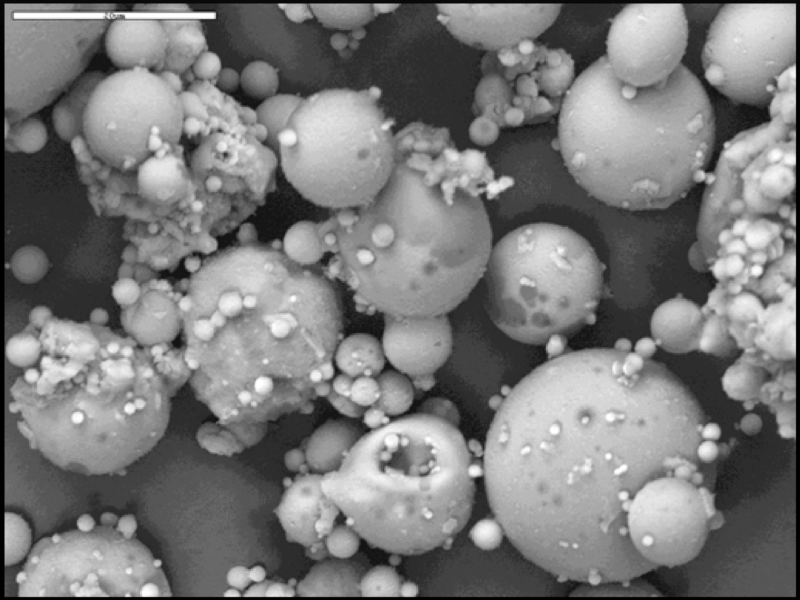


DISCUSSION
(COLUMN TESTS)

- Concentrations depend largely upon water characteristics
- Expected leaching is similar to No. 8 Coal Seam Water
- Column tests are HIGHLY accelerated (1 pore volume/day)
- Actual flow is expected to be much less

RESULTS
(GEOCHEMICAL ANALYSIS)

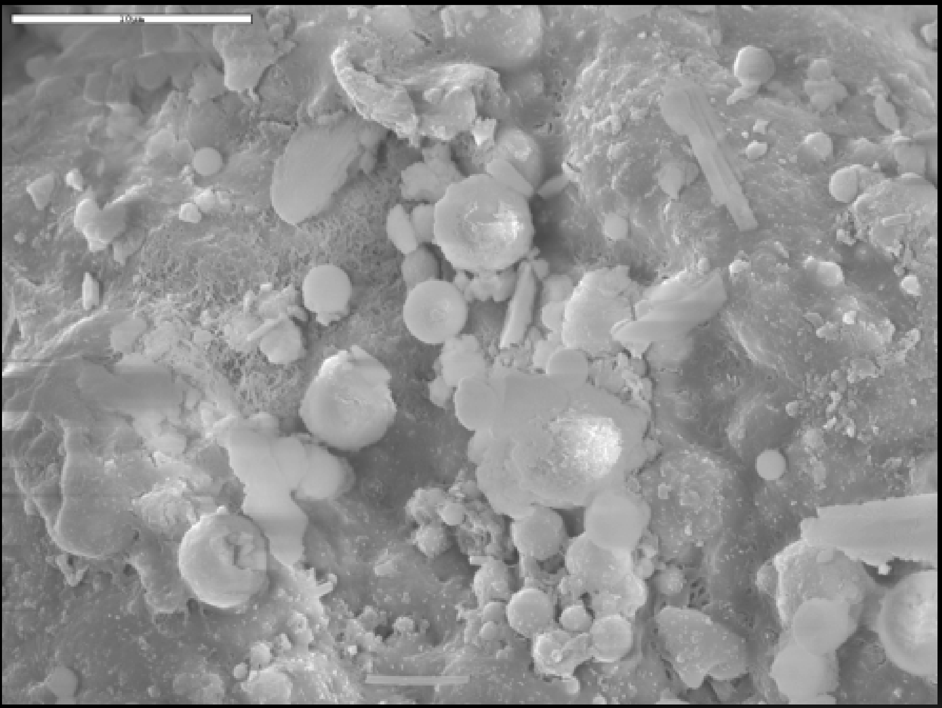
- SEM – fly ash particles are small spheres of mostly Si, Al, and O

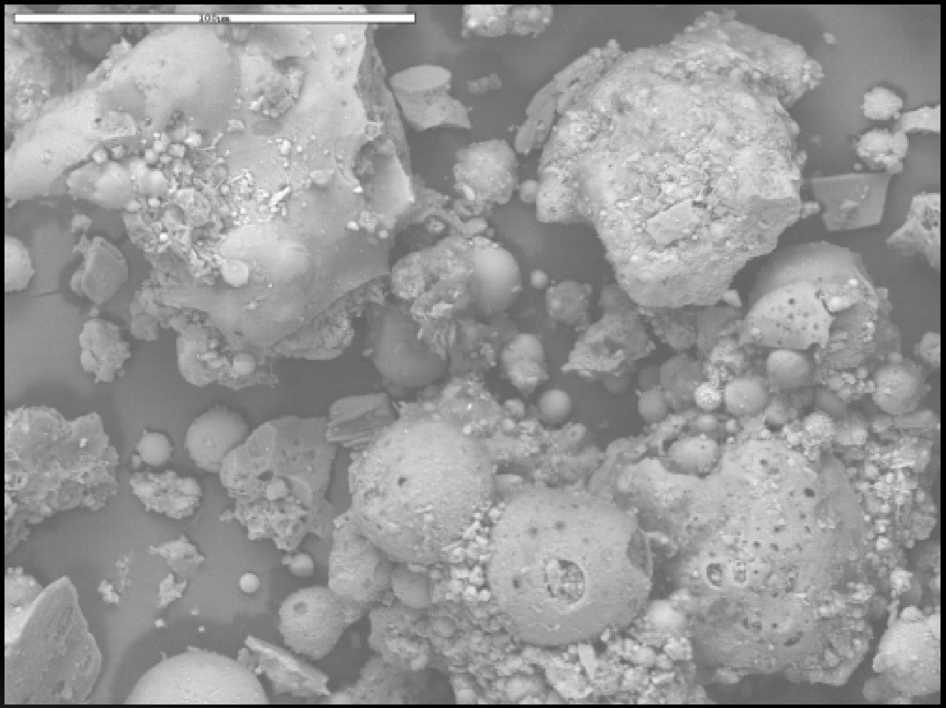


- Bottom ash “rougher” particles and higher amounts of carbon

RESULTS
(GEOCHEMICAL ANALYSIS)

- Deepest cores show significant degradation





RESULTS
(X-RAY DIFFRACTION)

- Fresh bottom ash – suggests mullite and quartz are dominant
- Amorphous peak less distinctive as in fly ash samples
- Two peaks consistent with the presence of Calcite and Feldspar
- Patterns display aging from a glassy amorphous phase to a more clay/crystalline structure

DISCUSSION

- Column tests show highly accelerated rates and DI water is a much more aggressive leaching solution than ground water.
- B, Ca, Mo, and Sr will likely follow decreasing trend quickly
- Flow may be either unsaturated water or groundwater in aquifer, depending on future water table levels

DISCUSSION

		Column Tests							
	Ground	DI WATER						Ground Water	
Analyte	Water	FFA	FBA	OFA	OBA	YFA	Spoil	FFA	OFA
Al	0	1.503	0.273	0.315	1.55	5.667	0.031	2.064	3.273
B	0.33	2.146	67.64	29.6	33.51	33.26	7.406	40.26	11.34
Ba	0	6.42	0.067	0.058	0.053	0.052	0.154	0.057	4.32
Ca	45	436.6	665.2	605.7	454.2	591.2	317.5	403.4	472.7
Se	0	0.125	0.244	0.182	0.088	0.078	1.934	0.191	0.935
Si	1.4	0.768	6.334	8.093	4.316	2.256	8.766	1.97	27.12
V	0	0.026	0.147	0.24	0.141	0.136	-0.024	0.757	0.49

CONCLUSION

- No evidence of groundwater contamination from CCB disposal has been found
- Element concentrations may be higher than native groundwater, although mostly of the same order of magnitude
- Little to zero vertical flux through cover materials is expected
- The potential for contamination of the underlying regional aquifer at the SJCM is small

ACKNOWLEDEMENTS

- bhp Billiton
- PNM
- NMMMD
- Advisory committee
- DBS&A
- Undergraduate laboratory assistance

QUESTIONS?