SR-430-26039

Final Report

Use of Ash From Municipal Solid Waste Combustion

NREL Subcontract # AAP-5-14347-01

Prepared by:

Environmental Solutions, Inc.
5711 Staples Mill Road
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July 1997

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Preface

This report details the results of efforts to integrate municipal solid waste combustion ash into a high strength portland cement concrete matrix comprised of multiple waste materials. The material developed by this research would be used to construct a large underground storage vault to house the "Friendly Mobile Barrier," a safety barrier system for use at highway crossings for the high speed rail system. While research has been undertaken to utilize MSW ash in low strength concrete and as road base, the goal of this project was two fold: First, to utilize the ash in a high strength, structural application, and, secondly, to produce a concrete material composed of 80% recycled materials.

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Abstract

This report details the results of efforts to integrate municipal solid waste combustion ash into a high strength portland cement concrete matrix comprised of multiple waste materials. The material developed by this research was to be used to construct a large underground storage vault to house the "Friendly Mobile Barrier," a safety barrier system for use at highway crossings for the high speed rail system.

The subcontractor, Environmental Solutions, Inc.. of Richmond, Virginia, worked with researchers at Pennsylvania State University and the State University of New York - Stony Brook to develop and test the material. The result of this work is a portland cement concrete matrix which utilizes 80.01% recycled materials, and a field-applicable method for incorporating MSW ash as a component at volumes up to 9.78%. Twenty-eight day strengths of over 4000psi were achieved, with 315 day strengths of 6500 psi. All structural, chemical and environmental testing showed the material to be competitive with conventional concrete.

Introduction

Ash generated by the combustion of municipal solid waste (MSW) in waste-to-energy (WTE) facilities is now disposed in landfills at a cost to the generator. Developing productive, value-added uses for the ash could reduce the volume now disposed, and reduce the cost of operating WTE facilities. There have been research efforts to utilize the ash for several applications, including its use as a road base substitute or as an admixture in bituminous paving compositions in Europe, and as a non-reactive filler in construction blocks.

Environmental Solutions Inc. (ESI), working with Consolidated Launchers Technology (CLT), had a research opportunity to incorporate MSW ash in special portland cement structure. CLT was awarded a contract by the Federal Railway Administration to design a railway crossing barrier for use in conjunction with the introduction of high speed trains. This barrier would deploy from a subgrade concrete vault and provide an energy absorbing system which would stop a vehicle without causing serious injury to the driver. The system was named the "Friendly Mobile Barrier" (FMB) in recognition of its design intent to protect the vehicle's driver. As contractor for the storage vault, ESI proposed that the vaults be constructed using a portland cement concrete formulation which maximized the volume of recycled materials, with a special emphasis on optimizing the volume of MSW ash in the matrix.

The National Renewable Energy Laboratoy (NREL) support was used to develop a formula for the concrete to be used in the FMB vault. ESI worked with researchers at Pennsylvania State University and the State University of New York - Stony Brook (SUNY-SB) to develop and test the material. Simultaneously, ESI was working closely with CLT in the development and testing of the actual barrier unit. The result of this work is a portland cement concrete matrix which utilizes 80.00% recycled materials, and a field-applicable method for incorporating MSW ash as a component at volumes up to 9.8%.

Project Plan

The total project plan for producing the FMB vault was designed for implementation in four phases:

Phase I: Collection and characterization of all raw materials

Preliminary mix design of the FMB concrete was determined to include processed municipal solid waste (MSW) bottom ash, slag cement, coal ash, crushed concrete aggregate, silica fume, sand and portland cement. ESI solicited involvement in this project from the Seamass Partnership who provided the processed MSW bottom ash, Virginia Precast Concrete Products who supplied crushed concrete, portland cement and sand, Koch Minerals who provided blast furnace slag, Monex Resources provided coal ash, and W.R. Grace provided silica fume and plasticizer.

The recycled materials were sent to SUNY-SB for characterization by Dr. Frank Roethel of the Waste Management Institute at the University's Marine Sciences Research Center. The specific materials analyzed were the MSW ash, the coal ash, the crushed concrete, and the blast furnace slag. Testing involved physical and environmental analyses. All tests were conducted in replicate (n=3).

Phase II: Development and Testing of Mix Design

This task represents the central objective of the NREL funded component of the FMB vault project. For this work, the materials scientists at Penn State were to develop the formula for the concrete to be used in the FMB vault. In addition, they were to test the final mix design for physical and chemical stability and environmental impact.

This effort was led by Dr. Barry Scheetz and Dr. Michael Silsbee of The Pennsylvania State's Intercollege Materials Research Laboratory. The objectives for the final formulation were:

A. Maximize the volume of MSW ash and other recycled materials in the mix design. A preliminary goal of 80% was set.

B. Develop a mix which achieves at least 4000 psi compression strength in 28 days and which meets performance and environmental standards for conventional concrete.

C. Develop a mix which is capable of being replicated in large volumes under field conditions.

Phase III: Design, Manufacture and Testing of the Vault Unit

With material specifications and FMB system requirements defined, design of the final structure could begin. ESI established a partnership with Virginia Precast, Inc. to provide all fabrication of the structure, estimated originally to weigh 42 tons.

Phase IV: Monitoring of Vault Performance

A demonstration FMB system, with the vault, would be installed at a test site in Virginia. The vault would be instrumented to characterize the structural and geotechnical performance of the vault and surrounding soil during loading events. Examination of soil chemistry alternations in and around the vault would be conducted both at the site and at a control site nearby. Chemical, physical and mechanical performance of the structure would be monitored to determine the effects of aging, weather cycles, and the cycling of the internal mechanism upon the vault integrity.

Phases III and IV were beyond the scope of this subcontract and are presented for information purposes only. NREL funding was not used for any part of these two phases of the project.

The Friendly Mobile Barrier System

Overview

The Friendly Mobile Barrier System was developed by Consolidated Launchers Technology of Chesapeake, Virginia as a defense conversion project building upon CLT's expertise in designing submarine missile launchers. It was designed to protect high speed rail passengers by stopping vehicles which may attempt to cross the rail ahead of an oncoming high speed train. When activated by an oncoming train, the six foot high barrier rises from its underground vault and expands horizontally into its energy-absorbing position. It retracts and returns to its position under the road surface after the train has passed.

The barrier is considered "Friendly" because it is designed to stop a 4,500 pound oncoming vehicle traveling at 45 mph without causing serious injury to the vehicle driver. It accomplishes this through an accordion styled design which absorbs the energy of the impacting vehicle, reducing the impact of the collision on the driver.

The vault which houses the barrier acts as a receptacle when the device is at rest, and is a component of the protection system when a vehicle hits at speeds above 45 miles per hour, specifically at the attachment points where the mechanism joins the vault.

The Federal Highway Administration projects that approximately 28,300 high sped rail crossings will require safety upgrading. Assuming each crossing requires four FMB (one on each side of the track in each lane), with a recycled vault required for each, at 42 tons each over 5,000,000 tons of recycled materials will be used each year for this application. At 10% MSW ash content, over 500,000 tons of ash could be recycled by this one project.

System Development & Testing

Upon commencement of this subcontract, CLT was finalizing its prototype in preparation for the first in a series of crash tests, without a vault, at a test site in Aquasco, Maryland for the Federal Railway Administration. The success of this fully instrumented test would provide the first real data on the forces which the barrier must sustain. As such, it would give ESI the first data on the structural requirements of the vault needed to support the mechanical system during a crash.

The first test was successful in proving the capability of the system to absorb a collision from a 4,500 pound vehicle at 45 miles per hour without serious damage to the unit and without causing an invasion of the passenger compartment of the vehicle. The vehicle was stopped within six feet of the initial contact. The vehicle was stopped with less than 13 G's of force, well below the 20G limit determined to be the maximum survivable force. Some minor damage to the barrier was incurred, but nothing which hindered its primary objective of stopping the vehicle in a "friendly" way.

Further crash testing was conducted over the next six months to refine the design. In addition, new criteria were tested. The Federal Department of Transportation was concerned about the risk of a smaller vehicle hitting the system, and so tests of 1,800 pound vehicles were conducted, with adjustments to the system made to soften the impact for these smaller units.

As the program progressed, concerns over the use of an expanding and contracting unit led to a proposal to house the barrier in its fully extended mode, thus allowing it to deploy faster. This had major implications for the vault design, as it would require nearly a 50% increase in the size of the vault. This would require close examination of the fabrication methods for so large a unit.

Other tests were requested by the Virginia Department of Transportation (VDOT), including a catastrophic impact of a semi-truck collision at high speed. In addition, VDOT requested that CLT identify options for reducing the weight of the barrier and to consider a design with a lower maximum failure point for smaller vehicles for use in urban areas where traffic speeds are lower and impacts less dramatic.

The additional required crash testing and the new design and test crash requests went beyond the financial limits of CLT's original contract. Therefore, further crash testing was halted until new sources of funding were identified.

With crash tests complete and meeting the FRA's requirements, attention turned to life cycle testing. Though originally proposed for installation at a site in Virginia, the FRA decided that the full unit, including the vault, should be installed and tested at the FRA rail testing center in Colorado. Preliminary life cycle testing at CLT's fabrication site would be conducted without the vault. This decision, to move the life cycle testing to Colorado, had significant impact on the vault development team's efforts, as now transportation of the unit and ongoing monitoring of the structural and environmental integrity would be covering a much greater distance than originally planned.

As of the expiration of this subcontract, sufficient additional funding has not been identified to justify CLT continuing work on the Friendly Mobile Barrier. In addition, there appears to be increasing interest by the Federal Agencies involved in alternate technologies to resolve this problem.. As such, there is now no schedule for installing the system, and no immediate plans at this time by CLT for further development efforts.

Because of the loss of interest in the project by the principal participants, we no longer foresee an opportunity to use the material developed by this subcontract in a vault for the Friendly Mobile Barrier.

Results

Phase I: Characterization

Dr. Roethel's conclusions were that all these materials possessed both the physical and chemical characteristics that would permit their use in concrete structures. Additionally, no data suggested any adverse environmental concerns would be associated with the use of these materials in very large volumes. Dr. Roethel concluded that these materials should be capable of being used in combination together and with other natural aggregates in a portland cement concrete matrix.

Dr. Roethel's full analysis is included as Appendix A.

Phase II: Material Development

Drs. Scheetz and Silsbee were successful in meeting the three goals set for this phase.

Goal 1: Use of 80% Recycled Materials

A final matrix utilizing 80.1% by volume, (9,78% MSW bottom ash), of recycled materials was developed which successfully met the required physical, chemical and environmental standards applied to conventional concrete.

Goal 2: Achieve 4000psi and Conventional Performance Standards

Twenty eight day strengths of over 4000 psi were achieved, and 315 day strengths of 6,500 psi demonstrated that the material is capable of long term strength comparable to conventional high strength concretes. Freeze thaw, alkali aggregate reaction, TCLP and ANSI 16.1 testing were all within acceptable limits.

Use of MSW Ash in the Matrix The Penn State researchers encountered several difficulties with using the MSW ash. They theorized that metallic portions of the ash were being attacked by the highly alkaline pore fluid present in the concrete, releasing hydrogen gas. As a result, there was an overabundance of entrained air, limiting the strength development of the concrete.

In response, the researchers pre-treated the ash by soaking in various hot solutions, then tested the resultant ashes in mortars. Untreated ash achieved less than half the 28 day strengths of treated ash in mortars. In some instances, the treated ash mortars achieved greater strengths that the control mortars. One pretreatment yielded 28 day strengths of 14,110 psi.

Efforts to use high volumes of pretreated ash in concretes were not as successful. Incorporating 41.9% treated coarse MSW ash as a replacement for recycled concrete in the final mix design yielded 28 day strengths of 2,940 psi., less than our 4,000 psi goal. Replacing 29.4% of treated fine MSW ash as a substitute for natural sand yielded only 1,440 psi at 28 days.

Ultimately, in order to achieve our goal of 4,000 psi, MSW ash in volumes of 9.78% was used.

Goal 3: Field Applicability

While some of the MSW pretreatment was successful in achieving higher levels of performance, ESI felt that they were unrealistic for use in a field condition. Thus, a hot water treatment was settled on as the ultimate technique in order to assure that the research results could be replicated during actual production of the vault, or similar products.

Modification of the mix design was also made to allow for greater workability, another critical requirement for field application. The final mix design incorporates these changes and is suitable for field use.

Drs. Scheetz and Silsbee's report is included as Appendix B.

Phase III: Design and Fabrication of a Prototype Vault

Preliminary design of the vault was begun, but ongoing design changes of the mechanical system precluded ESI's ability to produce a final vault design. As such, no prototype was made. With funding for this project very uncertain, we do not anticipate ever being able to produce a FMB vault from the concrete developed for this subcontract.

Phase IV: Monitoring Vault Performance

Again, because the vault was never constructed, there has been no monitoring program initiated.

Appendix A
Materials Characterization Report

Friendly Mobile Barrier Project

Physical and Chemical Characteristics of Recycled Products used in Vault Construction

A Technical Report

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Introduction

A Friendly Mobile Barrier (FMB) is an energy absorbing device designed to stop vehicular traffic from crossing into the path of high speed trains at railroad - roadway intersections. The barrier which resides in a subsurface vault is being designed by Consolidated Launchers Technology with assistance from the Technology Applications Center of Old Dominion University. The barrier is designed to be launched from beneath the road's surface, open to the width of the roadway and stop any vehicle from crossing the railroad tracks. Upon the passing of the train the barrier will fold up and retreat back into a concrete vault until the approach of the next train.

The barrier will be housed in a concrete vault requiring sufficient structural integrity to survive the force associated an vehicular impact at speeds approaching 45 miles per hour into the extended barrier. There is a strong impetus to construct the concrete vault using a maximum of recycled products as potential substitutes for virgin materials.

This investigation evaluated the physical and chemical characteristics of four potential recycled materials being considered for incorporation into the vault concrete design. These materials included Ground Granulated Blast-furnace Slag supplied by Koch Minerals Company, Wichita, Kansas; Crushed Concrete from CSR Precast, Richmond, Virginia; coal fly ash from Monex Resources, San Antonio, Texas and Processed Municipal Solid Waste Bottom Ash from the SEMASS Partnership, Rochester, Massachusetts.

Upon receipt of the above four materials at the University, a chain of custody form was completed and a Laboratory Code was assigned to each of the materials. Table 1 presents the laboratory code assigned to each material:

Table 1. Recycled Material, Vendor and Assigned Laboratory Code

Description	Vendor	Laboratory Code
Blast-furnace Slag	Koch Minerals	950038
Crushed Concrete	CSR Precast	950039
Coal Fly Ash	Monex Resources	950040
MSW Bottom Ash	SEAMASS Partnership	950041

Each of the four materials received were thoroughly mixed to insure samples uniformity and replicate (n=3) samples were removed in an amount appropriate to conduct each test. Tests were undertaken to assess each materials physical and chemical characteristics in order to assist in determining their effectiveness and acceptability as an aggregate substitute in concrete designs being developed for use in fabricating the FMB vault. Table 2 outlines the physical and chemical test conducted on each material.

Table 2. Physical and Chemical Testing Plan

Category	Test	Test Method
Physical Tests	Loss on Ignition	ASTM C-114
	Unit weight	ASTM C-29
	Grain Size	ASTM C-136
	Fineness	Besser, 1985
	Specific Gravity	ASTM C-128
	Absorption	ASTM C-128
	Moisture Content	ASTM 2216
Chemical Tests	pH	EPA/9040
	Total Metals	EPA/SW-846
	TCLP	EPA/1311
	MWEP	EPA/SW-924

The following sections presents data for each of the above tests that were conducted on the different recycled materials.

Physical Characteristics

Table 3 presents the results of the replicate (n=3) evaluations for Loss on Ignition (LOI), Moisture Content and Unit Weight for each of the four recycled materials. Loss on ignition ranged between 0.44%-2.60%. Blast-furnace slag contained the lowest amount of combustible materials while fly ash had 1.0% combustibles and MSW bottom ash 1.68%. The highest LOI measured was asssociated with crushed concrete (2.6%) which probably is due to carbonate decomposition along with the loss of water of hydration affiliated with reaction products and not combustible materials.

Moisture content for all four materials was extremely low ranging between 0.06% for both blast-furnace slag and fly ash and 9.2% for MSW combustor ash. Crushed concrete was found to possess 4.6% moisture.

Unit weight ranged between 67.2 lbs/ft^3 for blast furnace slag and 103.2 lbs/ft^3 for crushed concrete. Fly ash had a unit weight of 68.6 lbs/ft^3 while MSW combustor ash was measured at 77.7 lbs/ft^3.

which is roughly proportional to the average size of the particles in a given aggregate. Thus the coarser the aggregate the higher the Blaine Fineness number will be.

Table 3. Physical Characteristic of Recycled Materials

Material	Sample No.	Statistic	LOI (%)	Moisture (%)	Unit Weight lbs/ft^3
950038	1		0.27	0.06	66.47
	2		0.47	0.09	68.01
	3		0.58	0.02	67.05
		Mean	0.44	0.06	67.18
		Std.Dev	0.16	0.04	0.78
950039	1		2.93	4.48	120.30
	2		2.33	2.12	92.92
	3		2.53	7.28	96.48
		Mean	2.60	4.63	103.23
		Std.Dev	0.31	2.58	14.89
950040	1		1.23	0.01	68.05
	2		0.95	0.01	68.93
	3		0.83	0.15	68.86
		Mean	1.00	0.06	68.61
		Std.Dev	0.21	0.08	0.49
950041	1		1.53	9.14	80.03
	2		1.48	9.23	74.41
	3		2.03	9.21	78.75
		Mean	1.68	9.19	77.73
		Std.Dev	0.30	0.05	2.95

The data is Tables 4-7 indicate that Blast-furnace slag is the slightly finer than the fly ash while crushed concrete was slightly coarser than the MSW combustor ash. Both the crushed concrete and MSW combustor ash were properly graded aggregates suitable for concrete applications as determined by the Blaine fineness value.

Table 8 presents the results of evaluating the specific gravity and percent absorption for each of the four materials. Specific gravity ranged between 1.7 for the MSW combustor ash to 3.0 for the blast furnace slag. The crushed concrete and fly ash had very similar specific gravity's, but the variability in the fly ash data was substantial. As expected, the highest percent moisture was observed for the MSW combustor ash (13.5%), crushed concrete was substantially lower at 2.8%. Fly ash, which is predominately a siliceous material absorbed less than 1% moisture while the blast furnace slag partially dissolved providing unacceptable values.

Table 4. Particle Size Distribution for Blast Furnace Slag

Sieve size (um)	avg % of total	sd
600	0.01	0.00
300	0.01	0.00
250	0.01	0.00
150	0.06	0.01
75	3.51	4.43
45	69.90	16.12
< 45	28.82	15.54

Sample: 950038A
Total Sieved (g): 400.30

Sieve size (um)	grams retained	% retained	accumulative % retained
600	0.05	0.01	0.01
300	0.06	0.01	0.03
250	0.03	0.01	0.03
150	0.28	0.07	0.10
75	34.50	8.62	8.72
45	354.29	88.51	97.23
< 45	43.63	10.90	108.13

Sample: 950038B
Total Sieved (g): 400.23

Sieve size (um)	grams retained	% retained	accumulative % retained
600	0.05	0.01	0.01
300	0.05	0.01	0.02
250	0.05	0.01	0.04
150	0.24	0.06	0.10
75	4.55	1.14	1.23
45	244.30	61.04	62.27
< 45	148.53	37.11	99.39

Sample: 950038C
Total Sieved (g): 401.83

Sieve size (um)	grams retained	% retained	accumulative % retained
600	0.02	0.00	0.00
300	0.05	0.01	0.02
250	0.05	0.01	0.03
150	0.19	0.05	0.08
75	3.14	0.78	0.86
45	241.72	60.15	61.01
< 45	154.56	38.46	99.48

Table 5. Particle Size Distribution for Crushed Concrete

Sieve size (um)	avg % of total	sd
9500	30.45	11.24
4750	21.95	0.38
2360	15.38	2.01
1180	11.85	2.39
600	8.48	3.04
300	6.01	2.96
250	1.11	0.67
150	1.92	1.17
75	1.28	0.74
45	0.68	0.46
< 45	0.94	0.19
FM	4.53	0.85

Sample: 950039A
Total Sieved (g): 420.41

Sieve size (um)	grams retained	% retained	accumulative % retained
9500	85.76	20.40	20.40
4750	91.78	21.83	42.23
2360	59.88	14.24	56.47
1180	55.35	13.17	69.64
600	48.88	11.63	81.27
300	39.05	9.29	90.55
250	7.83	1.86	92.42
150	13.65	3.25	95.66
75	8.95	2.13	97.79
45	5.09	1.21	99.00
< 45	4.86	1.16	100.16
			3.56 Fineness Modulus

Sample: 950039B
Total Sieved (g): 402.69

Sieve size (um)	grams retained	% retained	accumulative % retained
9500	114.27	28.38	28.38
4750	91.47	22.71	51.09
2360	71.30	17.71	68.80
1180	53.53	13.29	82.09
600	33.20	8.24	90.33
300	20.90	5.19	95.53
250	3.62	0.90	96.42
150	5.85	1.45	97.88
75	3.59	0.89	98.77
45	1.86	0.46	99.23
< 45	3.52	0.87	100.10
			4.86 Fineness Modulus

Table 5. (Continued)

Sample: 950039C
Total Sieved (g): 404.30

Sieve size (um)	grams retained	% retained	accumulative % retained
9500	172.18	42.59	42.59
4750	86.09	21.29	63.88
2360	57.43	14.20	78.09
1180	36.73	9.08	87.17
600	22.46	5.56	92.73
300	14.35	3.55	96.28
250	2.35	0.58	96.86
150	4.24	1.05	97.91
75	3.32	0.82	98.73
45	1.53	0.38	99.10
<45	3.24	0.80	99.91
			5.16 Fineness Modulus

Table 6. Particle Size Distribution for Fly Ash

Sieve size (um)	avg % of total	sd
600	0.08	0.01
300	0.26	0.01
250	0.13	0.01
150	1.19	0.05
75	34.20	3.41
45	60.31	2.04
< 45	2.80	2.74

Sample: 950040A
Total Sieved (g): 390.23

Sieve size (um)	grams retained	% retained	accumulative % retained
600	0.31	0.08	0.08
300	1.00	0.26	0.34
250	0.52	0.13	0.47
150	4.88	1.25	1.72
75	121.43	31.12	32.84
45	233.75	59.90	92.74
< 45	23.26	5.96	98.70

Sample: 950040B
Total Sieved (g): 407.64

Sieve size (um)	grams retained	% retained	accumulative % retained
600	0.28	0.07	0.07
300	1.10	0.27	0.34
250	0.48	0.12	0.46
150	4.68	1.15	1.60
75	154.32	37.86	39.46
45	238.53	58.51	97.98
< 45	4.57	1.12	99.10

Sample: 950040C
Total Sieved (g): 400.18

Sieve size (um)	grams retained	% retained	accumulative % retained
600	0.33	0.08	0.08
300	1.04	0.26	0.34
250	0.50	0.12	0.47
150	4.72	1.18	1.65
75	134.54	33.62	35.27
45	250.22	62.53	97.79
< 45	5.25	1.31	99.11

Table 7. Particle Size Distribution for MSW Combustor Ash

Sample: 950041A
Total Sieved (g): 400.05

Sieve size (um)	grams retained	% retained	accumulative % retained
9500	14.22	3.55	3.55
4750	63.44	15.86	19.41
2360	92.64	23.16	42.57
1180	88.34	22.08	64.65
600	65.09	16.27	80.92
300	36.14	9.03	89.96
250	4.80	1.20	91.16
150	10.37	2.59	93.75
75	10.73	2.68	96.43
45	5.12	1.28	97.71
< 45	9.57	2.39	100.10
			3.92 Fineness Modulus

Sample: 950041B
Total Sieved (g): 400.07

Sieve size (um)	grams retained	% retained	accumulative % retained
9500	28.73	7.18	7.18
4750	77.03	19.25	26.44
2360	84.91	21.22	47.66
1180	79.29	19.82	67.48
600	59.39	14.84	82.32
300	32.73	8.18	90.50
250	4.60	1.15	91.65
150	10.05	2.51	94.17
75	9.60	2.40	96.57
45	4.50	1.12	97.69
< 45	8.79	2.20	99.89
			4.09 Fineness Modulus

Sieve size (um)	avg % of total	sd
9500	4.79	2.07
4750	15.61	0.35
2360	21.91	1.08
1180	20.48	1.39
600	15.52	0.72
300	9.24	1.17
250	1.43	0.44
150	3.16	1.06
75	3.83	2.24
45	1.11	0.18
< 45	1.70	1.03
FM	3.92	0.18

Table 7. (Continued)

Sample: 950041C
Total Sieved (g): 400.00

Sieve size (um)	grams retained	% retained	accumulative % retained
9500	14.49	3.62	3.62
4750	61.44	15.36	18.98
2360	85.35	21.34	40.32
1180	78.20	19.55	59.87
600	61.78	15.45	75.32
300	41.97	10.49	85.81
250	7.71	1.93	87.74
150	17.54	4.39	92.12
75	25.63	6.41	98.53
45	3.65	0.91	99.44
< 45	2.04	0.51	99.95
			3.74 Fineness Modulus

Table 8. Percent Absorption and Specific Gravity Data

A = weight of sample removed from pycnometer (dried at 110C)
B = weight of pycnometer filled to calibrated capacity with water
C = total weight of pycnometer with sample and water
(all weights recorded in grams

Specific gravity # 1 = Bulk Specific Gravity
Specific gravity # 2 = Bulk Saturated Surface-dried Basis
Specific gravity # 3 = Apparent Specific Gravity

Sample	Sample wt.	A	B	C	# 1	#2	#3	Percent Absorption
950038A	489.0	514.5	1320	1635	3	2.8	2.6	-4.9
950038B	489.0	519.3	1192	1510	3	2.9	2.6	-5.8
950038C	489.6	509.5	1320	1646	3.1	3	2.8	-3.9
950039A	488.9	476.7	1320	1615	2.5	2.5	2.6	2.6
950039B	489.0	475.2	1320	1610	2.4	2.5	2.6	2.9
950039C	489.0	475.3	1320	1614	2.4	2.5	2.6	2.9
950040A	486.7	483.7	1192	1457	2.2	2.2	2.2	0.6
950040B	484.0	478.3	1320	1460	1.4	1.4	1.4	1.2
950040C	484.9	482.1	1192	1530	3.3	3.3	3.3	0.6
950041A	500.0	441.7	1508	1758	1.8	2	2.3	13.2
950041B	5001.0	440	1508	1747.5	1.7	1.9	2.2	13.7
950041C	500.0	440.4	1508	1742	1.7	1.9	2.1	13.5

CHEMICAL CHARACTERISTICS

The pH of each of the four materials was measured in triplicate in order to determine the appropriate extraction fluid to use in accordance with the TCLP protocol. The most alkaline material was crushed concrete followed by blast furnace slag, both with pH in excess of 11. MSW combustor ash had a pH slightly higher than 9 and fly ash was observed to be slightly acidic with a pH = 5. Table 9 presents the pH measurement for each of the materials and the results of the TCLP screening test.

Table 9. pH of Materials

Sample	pH1	pH2	TCLP Final pH	Fluid used
950038 A	11.18	11.74	11.85	2
B	11.41	12.02	11.89	2
C	11.36	11.82	11.88	2
950039 A	11.78	11.12	6.23	2
B	11.63	10.66	6.79	2
C	11.68	11.19	7.16	2
950040 A	5.02	1.86	5.03	1
B	5.02	1.86	5.04	1
C	5.02	1.86	5.05	1
950041 A	8.45	2.69	6.06	1
B	9.21	2.50	5.99	1
C	9.43	2.48	6.04	1

The alkalinity associated with the blast furnace slag and crushed concrete required the use of Extraction Fluid #2, an solution possessing a pH=2.88 when conducting the TCLP test. Even after adding this acidic extraction fluid to the sample and mixing for eighteen hours, the pH of the leachate remained very high for the blast furnace slag. The final pH of the leachates for the remaining three materials ranged between 7.16 - 5.03.

Table 10 presents the results of conducting the TCLP test. The data indicates that all four recycled materials had leachate concentrations that were below the regulatory threshold. Silver and mercury were below the detection limits for all four materials while arsenic and selenium were detected in only the fly ash leachates. Cadmium was above detection limits for leachates associated with blast furnace slag and MSW combustor ash and chromium was only detected in leachates associated with crushed concrete and fly ash. Barium and lead were detected in leachates from all four materials. Lead concentrations were observed highest in the MSW combustor ash leachates with a mean concentration of 3.5 mg/L, which is still below the regulatory threshold of 5.0 mg/L. Appendix A contains the individual analytical reports along with the appropriate quality control/quality assurance data.

Table 11 provides the data associated with the total metal composition for each of the four materials. Hydrofluoric and boric acid digestions were prepared in triplicate for each of the materials and the digestate was analyzed using both flame and furnace atomic absorption spectrophotometer techniques.

For all four materials, major constituents (<1000 mg/kg) include aluminum, calcium, iron, magnesium, sodium and silicon. Barium copper and zinc are major constituents in MSW combustor ash while manganese was a major constituent for both blast furnace slag and MSW combustor ash. Potassium was a major constituent for every material except blast furnace slag where it was observed in concentrations resulting in it being identified as a minor constituent (<1000 mg/kg->100 mg/kg). Barium was a minor constituent for every material but MSW combustor ash and chromium was a minor constituent in both fly ash and MSW combustor ash. Copper was a minor constituent in fly ash while lead was a minor constituent in all four materials. Manganese was observed in minor concentrations in crushed concrete, while fly ash and MSW combustor ash supported minor concentrations of nickel. Blast furnace slag had minor concentrations of potassium while zinc was observed in fly ash in minor amounts.

Trace constituents (<100 mg/kg) were associated with arsenic, cadmium, mercury, selenium and silver for all four materials. Copper, chromium, nickel and zinc were a trace constituents in both blast furnace slag and crushed concrete. Manganese was a trace constituent in fly ash. Appendix B provides the analytical data sheets for each analyte along with the appropriate quality control and quality assurance data.

The final leaching evaluation conducted on all four materials was the monofilled waste extraction procedure, more commonly referred to as EPA Method SW-924. This leaching test in a four step multiple extraction protocol that provides data more closely affiliated with how materials actually perform in the environment when compared to the data provided by conducting a TCLP test. Tables 12-15 provide the results of this evaluation conducted on triplicate samples of each material.

With the exception of salts, the majority of analytes were observed in concentration that were below detection limits. Cadmium, a metal of environmental concern was also observed below drinking water standards. Lead was measured in blast furnace slag, crushed concrete in concentrations slightly above drinking water standards in only the initial extractions, while only the initial leachates for fly ash and MSW combustor ash were observed slightly above the drinking water limit.

CONCLUSIONS

The results of this evaluation suggests that blast furnace slag, crushed concrete, fly ash and processed MSW combustor ash possess both physical and chemical characteristics that would permit their use in concrete structures. The chemical testing program observed no data that would suggest any adverse environmental concerns would be associated with the use of any of these materials in very large amounts and while no data associated with mix designs in available, the basic physical parameters measured in this study reveal no engineering shortcomings associated with any of these material when blended with either each other or natural aggregates.

Table 10. Concentrations (mg/L) measured in TCLP extractions

Residual	Replicate	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
Blast Furnace Slag	1	<0.014	1.49	0.06	<0.01	0.62	<0.021	<0.014	<0.025
	2	<0.014	.067	0.05	<0.01	0.66	<0.021	<0.014	<0.025
	3	<0.014	0.97	0.04	<0.01	0.71	<0.021	<0.014	<0.025
	Mean	<0.014	1.04	0.05	<0.01	0.66	<0.021	<0.014	<0.025
	Std. Dev		0.41	0.01		0.05			
Crushed Concrete	1	<0.014	1.17	0.05	0.13	0.44	<0.021	<0.014	<0.025
	2	<0.014	0.87	<0.05	0.16	0.35	<0.021	<0.014	<0.025
	3	<0.014	1.05	<0.05	0.15	0.39	<0.021	<0.014	<0.025
	Mean	<0.014	1.03	<0.05	0.15	0.39	<0.021	<0.014	<0.025
	Std. Dev		0.15		0.01	0.04			
Fly Ash	1	0.13	0.52	<0.05	0.88	0.17	<0.021	0.28	<0.025
	2	0.13	0.46	<0.05	1.05	0.66	<0.021	0.26	<0.025
	3	0.11	0.46	<0.05	1.01	0.62	<0.021	0.26	<0.025
	Mean	0.12	0.48	<0.05	0.98	0.48	<0.021	0.27	<0.025
	Std. Dev	0.01	0.03		0.09	0.28		0.01	
MSW Bottom Ash	1	<0.014	0.58	0.14	0.01	3.41	<0.021	<0.014	<0.025
	2	<0.014	0.46	0.10	<0.01	3.59	<0.021	<0.014	<0.025
	3	<0.014	0.67	0.10	<0.01	3.50	<0.021	<0.014	<0.025
	Mean	<0.014	0.57	0.11	<0.01	3.50	<0.021	<0.014	<0.025
	Std. Dev		0.11	0.02		0.09			
EPA Threshold		5.0	100	1.0	5.0	5.0	0.2	1.0	5.0

Table 11. Mean inorganic concentrations (mg/kg), and standard deviations,( ), measured in residuals

Residual	Aluminum	Arsenic	Barium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Magnesium
Blast Furnace Slag	36,800 (5370)	<2.75	398 (50)	5.72 (1.05)	321,400 (63,600)	48.2 (1.14)	<25	7,120 (232)	121 (17)	60,100 (2,100)
Crushed Concrete	27,800	<2.75	480	2.92	20,800	23.2	<25	13,300	103	6,100
	(427)		(96)	(0.35)	(1020)	(4.07)		(4,240)	(27)	(1,220)
Coal Fly Ash	151,200	26.2	770	5.71	4,800	192	184	29,800	189	1,930
	(9660)	(1.46)	(111)	(1.04)	(275)	(4.45)	(2)	(1,550)	(13)	(663)
MSW Bottom Ash	48,700	<12.7	1170	8.75	56,300	300	5,920	34,950	258	5,350
	(3460)		(64)	(1.21)	(7980)	(83)	(3,370)	(3,880)	(0)	(638)

Residual	Manganese	Mercury	Nickel	Potassium	Sodium	Silicon	Selenium	Silver	Zinc
Blast Furnace Slag	3,470 (368)	<4.2	55.6 (13.8)	706 (752)	1,830 (100)	147,500 (24,000)	<0.25	<5.0	76.1 (1.8)
Crushed Concrete	376 (15)	<4.2	45.2 (13.6)	5,980 (174)	7,460 (190)	303,300 (15,400)	<0.25	<5.0	48.5 (3.5)
Coal Fly Ash	52.4 (39.3)	<4.2	208 (17)	13,300 (177)	1,270 (214)	275,800 (8,930)	<0.25	<5.0	110 (2)
MSW Bottom Ash	1,020 (60)	<4.2	166 (31)	7,400 (1,100)	43,300 (2,000)	240,600 (15,700)	<0.25	<5.0	5,780 (1,110)

Table 12. SW-924 Leachate Concentrations (mg/L) Measured in Blast Furnace Slag

Analyte	Sample 1				Sample 2				Sample 3			
	1	2	3	4	1	2	3	4	1	2	3	4
Aluminum	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Arsenic	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
Barium	2.64	2.03	1.44	1.03	4.54	2.99	3.19	1.51	3.14	3.49	2.57	1.14
Cadmium	<0.025	<0.025	<0.025	0.032	<0.025	<0.025	<0.025	0.027	<0.025	<0.025	<0.025	0.025
Calcium	1630	795	723	553	1340	1090	650	577	1490	795	1780	504
Chromium	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Copper	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075
Iron	0.18	0.14	0.20	0.18	0.18	0.12	0.18	0.14	0.18	0.16	0.16	0.12
Lead	0.23	0.28	0.18	0.13	0.42	0.28	0.18	0.23	0.28	0.28	0.13	<0.125
Magnesium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	0.17	<0.125	<0.125	<0.125	0.19	<0.125	<0.125	<0.125	0.15	<0.125	<0.125	<0.125
Potassium	60.5	164	55.1	29.9	57.2	59.3	29.9	23.6	103	50.9	105	23.6
Silicon	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Silver	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Selenium	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
Sodium	28.2	16.0	12.5	10.3	28.2	16.0	13.2	<10	21.8	16.8	31.1	42.5
Zinc	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025

Table 13. SW-924 Leachate Concentrations (mg/L) Measured in Crushed Concrete

Analyte	Sample 1				Sample 2				Sample 3			
	1	2	3	4	1	2	3	4	1	2	3	4
Aluminum	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Arsenic	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
Barium	1.11	0.29	0.35	<0.25	1.18	0.59	0.37	0.33	1.20	0.55	0.39	0.29
Cadmium	<0.025	<0.025	<0.025	<0.025	<0.025	0.027	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Calcium	696	393	274	314	683	432	353	274	3470	604	327	248
Chromium	0.026	0.02	0.028	0.033	0.012	0.016	0.022	0.029	0.011	0.015	0.021	0.03
Copper	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075
Iron	<0.12	<0.12	<0.12	<0.12	0.16	<0.12	0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Lead	0.23	0.23	<0.125	<0.125	0.18	0.13	0.13	<0.125	0.13	0.13	<0.125	0.18
Magnesium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125
Potassium	36.0	25.7	<20.1	<20.1	244	<20.1	<20.1	<20.1	42.5	34.1	17.4	13.2
Silicon	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Silver	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Selenium	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
Sodium	12.2	<2.55	<2.55	<2.55	21.5	<2.55	<2.55	<2.55	12.4	<2.55	52.0	<2.55
Zinc	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025

Table 14. SW-924 Leachate Concentrations (mg/L) Measured in Fly Ash

Analyte	Sample 1				Sample 2				Sample 3			
	1	2	3	4	1	2	3	4	1	2	3	4
Aluminum	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Arsenic	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
Barium	<0.25	0.39	0.72	0.98	<0.25	0.44	0.66	0.94	<0.25	0.35	0.70	0.81
Cadmium	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Calcium	136	5.76	1.46	1.90	421	5.63	1.46	0.87	148	5.90	2.21	0.87
Chromium	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Copper	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075
Iron	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Lead	0.18	<0.125	<0.125	<0.125	0.13	<0.125	<0.125	<0.125	0.18	<0.125	<0.125	<0.125
Magnesium	4.96	0.51	0.17	0.10	5.14	0.49	0.18	0.10	5.41	0.49	0.17	0.09
Manganese	0.101	<0.075	<0.075	<0.075	0.158	<0.075	<0.075	<0.075	0.158	<0.075	<0.075	<0.075
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	0.13	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125
Potassium	8.46	5.76	<2.1	<2.1	9.92	4.88	<2.1	<2.1	8.61	4.88	<2.1	<2.1
Silicon	<2.5	<2.5	4.15	<2.5	<2.5	<2.5	4.90	<2.5	<2.5	<2.5	<2.5	<2.5
Silver	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Selenium	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Sodium	4.34	<2.55	<2.55	<2.55	3.71	<2.55	<2.55	<2.55	3.52	<2.55	<2.55	<2.55
Zinc	0.23	<0.025	<0.025	<0.025	0.28	<0.025	<0.025	<0.025	0.36	0.03	<0.025	<0.025

Table 15. SW-924 Leachate Concentrations (mg/L) Measured in MSW Combustor Ash

Analyte	Sample 1				Sample 2				Sample 3			
	1	2	3	4	1	2	3	4	1	2	3	4
Aluminum	8.14	9.54	7.69	7.16	10.86	13.77	13.77	12.97	13.24	16.14	14.29	13.24
Arsenic	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
Barium	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Cadmium	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Calcium	75.8	23.3	15.9	14.5	81.1	23.6	18.8	17.8	94.9	27.4	19.7	16.9
Chromium	0.013	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Copper	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075
Iron	<0.12	<0.12	<0.12	<0.12	0.12	<0.12	<0.12	<0.12	0.12	<0.12	<0.12	<0.12
Lead	0.18	<0.125	<0.125	<0.125	<0.125	<0.125	0.13	<0.125	<0.125	<0.125	<0.125	<0.125
Magnesium	<0.11	<0.11	0.11	0.11	0.30	0.15	<0.11	0.13	0.42	0.23	0.17	0.16
Manganese	<0.075	<0.075	<0.075	<0.075	0.101	<0.075	<0.075	<0.075	0.080	<0.075	<0.075	<0.075
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125
Potassium	5.76	2.25	5.54	5.76	6.63	8.82	5.98	4.66	6.41	8.39	4.44	4.66
Silicon	2.65	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Silver	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Selenium	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13
Sodium	8.20	<2.55	<2.55	<2.55	8.06	<2.55	<2.55	<2.55	6.43	<2.55	<2.55	<2.55
Zinc	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025

APPENDIX A

Arsenic
6/23/95 mw

Virginia Materials (samples 950038-41)
TCLP

Extraction Fluids Used:
950038 fluid #2 (mw)
950039 fluid #2 (mw)
950040 fluid #1 (mw)
950041 fluid #1 (h.s. students)

DET. COEF.	0.9999	0.9996
SLOPE	0.0052	0.0048
Y-INTERCEPT	-0.0001	-0.0010

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC ppb	DF	ABS CONC ppm	AVG CONC ppm	SD	Final pH
NBS 1643c	0.037	7.15		7.15	11	79	96%	recovery	
Blank Fluid #1	0.001	0.22	0.41	0.32	11				4.96
Blank Fluid #2	0.000	0.03	0.20	0.12	11				2.95
950038 1	-0.003	-0.55	-0.43	-0.49	11	< 0.014	< 0.014 *	0 *	11.85
2	-0.002	-0.36	-0.22	-0.29	11	< 0.014			11.89
3	-0.002	-0.36	-0.22	-0.29	11	< 0.014			11.88
950039 1	-0.001	-0.16	-0.01	-0.09	11	< 0.014	< 0.014 *	0 *	6.23
2	-0.004	-0.74	-0.64	-0.69	11	< 0.014			6.79
3	0.001	0.22	0.41	0.32	11	< 0.014			7.16
950040 1	0.057	10.99	12.20	11.60	11	0.13	0.12	0.01	5.03
2	0.059	11.38	12.62	12.00	11	0.13			5.04
3	0.051	9.84	10.94	10.39	11	0.11			5.05
950041 1	0.003	0.60	0.83	0.72	11	< 0.014	< 0.014 *	0 *	6.06
2	-0.001	-0.16	-0.01	-0.09	11	< 0.014			5.99
3	0.003	0.60	0.83	0.72	11	< 0.014			6.04

* = calculations made using detection limit for one or more samples

Sample Spike Recoveries:

950038	-0.003	-0.55	-0.55	106%	9.090
SPIKE	0.047	9.07	9.07		
950039	-0.001	-0.16	-0.16	102%	9.090
SPIKE	0.047	9.07	9.07		
950040	0.057	10.99	10.99	106%	9.090
SPIKE	0.107	20.61	20.61		
950041	0.003	0.60	0.60	95%	9.090
SPIKE	0.048	9.26	9.26		

Barium
9/1/95 mw

Virginia Materials (samples 950038-41)
TCLP

Extraction Fluids Used:

950038	fluid #2	(mw)
950039	fluid #2	(mw)
950040	fluid #1	(mw)
950041	fluid #1	(h.s. students)

DET. COEF.	0.9993	0.9996
SLOPE	0.0071	0.0063
Y-INTERCEPT	-0.0054	0.0020

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC ppb	DF	ABS CONC ppm	AVG CONC ppm	SD	Final pH
NBS 1643c	0.048	7.47		7.47	6	45	90%	recovery	
Blank Fluid #1	0.003	1.17	0.15	0.66	201				4.96
Blank Fluid #2	0.000	0.75	-0.32	0.21	201				2.95
950038 1	0.048	7.47	7.32	7.39	201	1.49	1.04	0.41	11.85
2	0.021	3.69	3.02	3.35	201	0.67			11.89
3	0.031	5.09	4.61	4.85	201	0.97			11.88
950039 1	0.018	3.27	2.54	2.91	402	1.17	1.03	0.15	6.23
2	0.013	2.57	1.75	2.16	402	0.87			6.79
3	0.016	2.99	2.22	2.61	402	1.05			7.16
950040 1	0.016	2.99	2.22	2.61	201	0.52	0.48	0.03	5.03
2	0.014	2.71	1.90	2.31	201	0.46			5.04
3	0.014	2.71	1.90	2.31	201	0.46			5.05
950041 1	0.018	3.27	2.54	2.91	201	0.58	0.57	0.11	6.06
2	0.014	2.71	1.90	2.31	201	0.46			5.99
3	0.021	3.69	3.02	3.35	201	0.67			6.04

Sample Spike Recoveries:

950038	0.048	7.47	7.32	7.39	115%	10.000
SPIKE	0.125	18.25	19.57	18.91		
950039	0.018	3.27	2.54	2.91	111%	10.000
SPIKE	0.092	13.63	14.32	13.97		
950040	0.016	2.99	2.22	2.61	118%	10.000
SPIKE	0.095	14.05	14.80	14.42		
950041	0.018	3.27	2.54	2.91	99%	10.000
SPIKE	0.084	12.51	13.04	12.78		

Cadmium
6/12/95 mw

Virginia Materials (samples 950038-41)
TCLP

Extraction Fluids Used: 950038 fluid #2 (mw)
950039 fluid #2 (mw)
950040 fluid #1 (mw)
950041 fluid #1 (h.s. students)

DET. COEF.	0.9995	0.9993
SLOPE	0.3322	0.3408
Y-INTERCEPT	0.0029	-0.0043

SAMPLE		ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	ABS CONC ppm	AVG CONC ppm	SD	Final pH
BCR 146		0.133	0.39	0.40	0.40	1	79.46	102%	recovery	
Blank Fluid #1		-0.001	-0.01	0.01	0.00	1				4.96
Blank Fluid #2		-0.005	-0.02	0.00	-0.01	1				2.95
950038	1	0.018	0.05	0.07	0.06	1	0.06	0.05	0.01	11.85
	2	0.015	0.04	0.06	0.05	1	0.05			11.89
	3	0.012	0.03	0.05	0.04	1	0.04			11.88
950039	1	0.016	0.04	0.06	0.05	1	0.05	0.05 *	0.01 *	6.23
	2	0.002	0.00	0.02	0.01	1	< 0.05			6.79
	3	-0.001	-0.01	0.01	0.00	1	< 0.05			7.16
950040	1	0.007	0.01	0.03	0.02	1	< 0.05	< 0.05*	0 *	5.03
	2	0.011	0.02	0.04	0.03	1	< 0.05			5.04
	3	0.011	0.02	0.04	0.03	1	< 0.05			5.05
950041	1	0.046	0.13	0.15	0.14	1	0.14	0.11	0.02	6.06
	2	0.032	0.09	0.11	0.10	1	0.10			5.99
	3	0.034	0.09	0.11	0.10	1	0.10			6.04

* = calculations made using detection limit for one or more samples

Sample Spike Recoveries:

950038	0.018	0.05	0.07	0.06	99%	0.909
SPIKE	0.321	0.96	0.95	0.96		
950039	0.016	0.04	0.06	0.05	103%	0.909
SPIKE	0.331	0.99	0.98	0.99		
950040	0.007	0.01	0.03	0.02	102%	0.909
SPIKE	0.318	0.95	0.95	0.95		
950041	0.046	0.13	0.15	0.14	101%	0.909
SPIKE	0.354	1.06	1.05	1.05		

Chromium Virginia Materials (samples 950038-41)
7/9/95 mw TCLP

Extraction Fluids Used: 950038 fluid #2 (mw)
950039 fluid #2 (mw)
950040 fluid #1 (mw)
950041 fluid #1 (h.s. students)

DET. COEF.	0.9983	0.9997
SLOPE	0.0251	0.0207
Y-INTERCEPT	0.0091	0.0018

SAMPLE		ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm	AVG CONC ppm	SD	Final pH
NBS 1643c		0.160	6.02	7.63	6.82	3	20	110%	recovery	
Blank Fluid #1		0.01	0.00		0.00	11				4.96
Blank Fluid #2		0.01	0.00		0.00	11				2.95
950038	1	0.009	0.00		0.00	11	< 0.01	< 0.01 *	0 *	11.85
	2	0.005		0.15	0.15	11	< 0.01			11.89
	3	0.003		0.06	0.06	11	< 0.01			11.88
950039	1	0.316	12.25		12.25	11	0.13	0.15	0.01	6.23
	2	0.297		14.23	14.23	11	0.16			6.79
	3	0.294		14.09	14.09	11	0.15			7.16
950040	1	0.227	8.69		8.69	101	0.88	0.98	0.09	5.03
	2	0.217		10.38	10.38	101	1.05			5.04
	3	0.210		10.04	10.04	101	1.01			5.05
950041	1	0.042	1.31		1.31	11	0.01	0.01 *	0 *	6.06
	2	0.010		0.39	0.39	11	< 0.01			5.99
	3	0.008		0.30	0.30	11	< 0.01			6.04

* = calculations made using detection limit for one or more samples

Sample Spike Recoveries:

950038	0.009	0.00	0.00	114%	4.550
SPIKE	0.139	5.18	5.18		
950039	0.316	12.25	12.25	103%	4.550
SPIKE	0.434	16.95	16.95		
950040	0.227	8.69	8.69	95%	5.000
SPIKE	0.346	13.44	13.44		
950041	0.042	1.31	1.31	96%	4.550
SPIKE	0.152	5.70	5.70		

Lead Virginia Materials (samples 950038-4

7/8/95 mw TCLP

Extraction Fluids Used: 950038 fluid #2 (mw)
950039 fluid #2 (mw)
950040 fluid #1 (mw)
950041 fluid #1 (h.s. students)

DET. COEF.	0.9989	0.9979	0.9998	1
SLOPE	0.0217	0.0210	0.0226	0.02
Y-INTERCEPT	0.0016	0.0097	0.0003	0.01

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm	AVG CONC ppm	SD	Final pH
BCR 146	0.030	1.32	0.98	1.15	5	1151	91%	recovery	
Blank Fluid #1	0.01		0.04	0.04	1				4.96
Blank Fluid #2	0.01		0.08	0.08	1				2.95
950038 1	0.019	0.83	0.41	0.62	1	0.62	0.66	0.05	11.85
2	0.020	0.88	0.45	0.66	1	0.66			11.89
3	0.021	0.92	0.50	0.71	1	0.71			11.88
950039 1	0.015	0.62	0.25	0.44	1	0.44	0.39	0.04	6.23
2	0.013	0.57	0.13	0.35	1	0.35			6.79
3	0.014	0.61	0.18	0.39	1	0.39			7.16
950040 1	0.009	0.39	-0.06	0.17	1	0.17	0.48	0.28	5.03
2	0.020	0.88	0.45	0.66	1	0.66			5.04
3	0.019	0.83	0.41	0.62	1	0.62			5.05
950041 1	0.043	1.90	1.52	1.71	2	3.41	3.50	0.09	6.06
2	0.045	1.98	1.61	1.80	2	3.59			5.99
3	0.044	1.94	1.56	1.75	2	3.50			6.04

Sample Spike Recoveries:

950038	0.019	0.83	0.41	0.62	90%	1.820
SPIKE	0.055	2.43	2.07	2.25		
950039	0.015	0.62	0.25	0.44	103%	1.820
SPIKE	0.055	2.47	2.16	2.31		
950040	0.009	0.34	-0.03	0.16	95%	1.820
SPIKE	0.046	2.05	1.73	1.89		
950041	0.043	1.90	1.52	1.71	91%	1.000
SPIKE	0.063	2.78	2.44	2.61		

Mercury
9/7/95 mw

Virginia Materials (samples 950038-41)
TCLP

Extraction Fluids Used:
950038 fluid #2 (mw)
950039 fluid #2 (mw)
950040 fluid #1 (mw)
950041 fluid #1 (h.s. students)

DET. COEF.	0.9999	0.9997
SLOPE	0.0147	0.0141
Y-INTERCEPT	-0.0072	-0.0056

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm	AVG CONC ppm	SD	Final pH
Blank Fluid #1	-0.001	0.42	0.33	0.38	21				4.96
Blank Fluid #2	-0.002	0.36	0.26	0.31	21				2.95
950038 1	-0.007	0.02	-0.10	-0.04	21	< 0.021	< 0.021	0.00	11.85
2	-0.008	-0.05	-0.17	-0.11	21	< 0.021			11.89
3	-0.007	0.02	-0.10	-0.04	21	< 0.021			11.88
950039 1	-0.006	0.08	-0.03	0.03	21	< 0.021	< 0.021	0.00	6.23
2	-0.007	0.02	-0.10	-0.04	21	< 0.021			6.79
3	-0.006	0.08	-0.03	0.03	21	< 0.021			7.16
950040 1	-0.007	0.02	-0.10	-0.04	21	< 0.021	< 0.021	0.00	5.03
2	-0.007	0.02	-0.10	-0.04	21	< 0.021			5.04
3	-0.007	0.02	-0.10	-0.04	21	< 0.021			5.05
950041 1	-0.006	0.08	-0.03	0.03	21	< 0.021	< 0.021	0.00	6.06
2	-0.007	0.02	-0.10	-0.04	21	< 0.021			5.99
3	-0.006	0.08	-0.03	0.03	21	< 0.021			6.04

Sample Spike Recoveries:

950038	-0.007	0.02	-0.10	-0.04	106%	9.500
SPIKE	0.138	9.86	10.22	10.04		
950039	-0.006	0.08	-0.03	0.03	108%	9.500
SPIKE	0.142	10.13	10.50	10.31		
950040	-0.007	0.02	-0.10	-0.04	106%	9.500
SPIKE	0.138	9.86	10.22	10.04		
950041	-0.006	0.08	-0.03	0.03	99%	4.700
SPIKE	0.061	4.63	4.74	4.69		

Selenium Virginia Materials (samples 950038-41)

8/9/95 mw TCLP

Extraction Fluids Used:	
	950038 fluid #2 (mw)
	950039 fluid #2 (mw)
	950040 fluid #1 (mw)
	950041 fluid #1 (h.s. students)

DET. COEF.	0.9998	0.9983
SLOPE	0.0037	0.0037
Y-INTERCEPT	0.0011	0.0017

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm	AVG CONC ppm	SD	Final pH
NBS 1643c	0.041	10.86	10.72	10.79	1	0.011	85%	recovery	
Blank Fluid #1	-0.001	-0.57	-0.73	-0.65	11				4.96
Blank Fluid #2	-0.001	-0.57	-0.73	-0.65	11				2.95
950038 1	0.000	-0.30	-0.46	-0.38	11	< 0.014	< 0.014	0.00	11.85
2	-0.001	-0.57	-0.73	-0.65	11	< 0.014			11.89
3	0.000	-0.30	-0.46	-0.38	11	< 0.014			11.88
950039 1	-0.001	-0.57	-0.73	-0.65	11	< 0.014	< 0.014	0.00	6.23
2	0.000	-0.30	-0.46	-0.38	11	< 0.014			6.79
3	-0.002	-0.85	-1.00	-0.92	11	< 0.014			7.16
950040 1	0.095	25.56	25.44	25.50	11	0.28	0.27	0.01	5.03
2	0.088	23.66	23.53	23.60	11	0.26			5.04
3	0.087	23.39	23.26	23.32	11	0.26			5.05
950041 1	0.000	-0.30	-0.46	-0.38	11	< 0.014	< 0.014	0.00	6.06
2	0.001	-0.03	-0.18	-0.11	11	< 0.014			5.99
3	0.000	-0.30	-0.46	-0.38	11	< 0.014			6.04

Sample Spike Recoveries:

950038	0.000	-0.30	-0.46	-0.38	97%	18.180
SPIKE	0.065	17.40	17.26	17.33		
950039	-0.001	-0.57	-0.73	-0.65	99%	18.180
SPIKE	0.065	17.40	17.26	17.33		
950040	0.095	25.56	25.44	25.50	102%	18.180
SPIKE	0.163	44.08	43.98	44.03		
950041	0.000	-0.30	-0.46	-0.38	111%	18.180
SPIKE	0.074	19.85	19.72	19.78		

Silver
6/13/95 mw

Virginia Materials (samples 950038-41)
TCLP

Extraction Fluids Used:
950038 fluid #2 (mw)
950039 fluid #2 (mw)
950040 fluid #1 (mw)
950041 fluid #1 (h.s. students)

DET. COEF.	0.9996	0.9990
SLOPE	0.2115	0.2212
Y-INTERCEPT	-0.0043	-0.0079

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm	AVG CONC ppm	SD	Final pH
Blank Fluid #1	-0.004	0.00	0.02	0.01	1				4.96
Blank Fluid #2	-0.005	0.00	0.01	0.00	1				2.95
950038 1	0.003	0.03	0.05	0.04	1	< 0.025	< 0.025 *	0 *	11.85
2	0.002	0.03	0.04	0.04	1	< 0.025			11.89
3	0.000	0.02	0.04	0.03	1	< 0.025			11.88
950039 1	0.002	0.03	0.04	0.04	1	< 0.025	< 0.025 *	0 *	6.23
2	-0.004	0.00	0.02	0.01	1	< 0.025			6.79
3	-0.006	-0.01	0.01	0.00	1	< 0.025			7.16
950040 1	0.001	0.03	0.04	0.03	1	< 0.025	< 0.025 *	0 *	5.03
2	0.000	0.02	0.04	0.03	1	< 0.025			5.04
3	0.003	0.03	0.05	0.04	1	< 0.025			5.05
950041 1	-0.003	0.01	0.02	0.01	1	< 0.025	< 0.025 *	0 *	6.06
2	-0.004	0.00	0.02	0.01	1	< 0.025			5.99
3	-0.005	0.00	0.01	0.00	1	< 0.025			6.04

* = calculations made using detection limit for one or more samples

Sample Spike Recoveries:

950038	0.003	0.03	0.05	0.04	92%	0.909
SPIKE	0.184	0.89	0.87	0.88		
950039	0.002	0.03	0.04	0.04	98%	0.909
SPIKE	0.194	0.94	0.91	0.93		
950040	0.001	0.03	0.04	0.03	98%	0.909
SPIKE	0.194	0.94	0.91	0.93		
950041	-0.003	0.01	0.02	0.01	101%	0.909
SPIKE	0.195	0.94	0.92	0.93		

APPENDIX B

Aluminum Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/18/95 mw

DET. COEF.	0.9998	0.9995	0.9998		0.9999
SLOPE	0.0039	0.0040	0.0044		0.0040
Y-INTERCEPT	-0.0014	-0.0021	-0.001		-0.002

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.057	14.91	14.75	14.829	51	756.28	100	0.5039	150085	107%
Blank	-0.002	-0.29	-0.03	-0.157	21	-3.31	100	0		
										avg
38 A	0.015	4.18	4.26	4.22	51	215.28	100	0.5022	42867	36829
38 B	0.012	2.92	3.48	3.20	51	163.21	100	0.5011	32571	sd
38 C	0.013	3.15	3.73	3.44	51	175.45	100	0.5006	35047	5374
										avg
39 A	0.025	6.74	6.76	6.75	21	141.68	100	0.5005	28309	27815
39 B	0.026	6.13	6.98	6.56	21	137.72	100	0.4996	27566	sd
39 C	0.026	6.13	6.98	6.56	21	137.72	100	0.4995	27571	427
										avg
40 A	0.030	8.01	8.01	8.01	101	808.98	100	0.5025	160991	151226
40 B	0.030	7.05	7.99	7.52	101	759.26	100	0.5028	151006	sd
40 C	0.028	6.59	7.48	7.04	101	710.81	100	0.5017	141680	9657
										avg
41 A	0.046	12.10	12.00	12.05	21	253.07	100	0.5000	50613	48665
41 B	0.049	11.41	12.74	12.07	21	253.56	100	0.5000	50712	sd
41 C	0.043	10.03	11.24	10.64	21	223.34	100	0.5000	44668	3461

Spike Recoveries:

38	0.015	4.18	4.26	4.22	106%
Spike	0.056	14.65	14.50	14.58	9.8 ppm
39	0.025	6.74	6.76	6.75	106%
Spike	0.065	16.95	16.75	16.85	9.5 ppm
40	0.030	8.01	8.01	8.01	99%
Spike	0.069	17.97	17.75	17.86	9.9 ppm
41	0.046	12.10	12.00	12.05	101%
Spike	0.084	21.80	21.50	21.65	9.5 ppm

Arsenic Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/3/95 mw

DET. COEF.	0.9990	0.9987
SLOPE	0.0047	0.0047
Y-INTERCEPT	0.0040	-0.0004

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC ppb	DF	SOL CONC ppb	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.062	12.23	13.24	12.734	51	649.43	100	0.5039	129	89%
Blank	0.001	-0.64	0.29	-0.171	11	-1.88	100	0		
										avg
38 A	0.002	-0.42	0.51	0.04	11	0.45	100	0.5022	< 2.75	< 2.75*
38 B	0.001	-0.64	0.29	-0.17	11	-1.88	100	0.5011	< 2.75	sd
38 C	0.005	0.21	1.14	0.68	11	7.43	100	0.5006	< 2.75	0 *
										avg
39 A	0.006	0.42	1.36	0.89	11	9.76	100	0.5005	< 2.75	< 2.75*
39 B	0.006	0.42	1.36	0.89	11	9.76	100	0.4996	< 2.75	sd
39 C	0.006	0.42	1.36	0.89	11	9.76	100	0.4995	< 2.75	0 *
										avg
40 A	0.057	11.17	12.18	11.68	11	128.44	100	0.5025	25.56	26.18
40 B	0.062	12.23	13.24	12.73	11	140.07	100	0.5028	27.86	sd
40 C	0.056	10.96	11.97	11.46	11	126.11	100	0.5017	25.14	1.46
										avg
41 A	0.006	0.42	1.36	0.89	51	45.23	100	0.5000	< 12.75	< 12.75*
41 B	0.006	0.42	1.36	0.89	51	45.23	100	0.5000	< 12.75	sd
41 C	0.006	0.42	1.36	0.89	51	45.23	100	0.5000	< 12.75	0 *

* = calculations made using detection limit for one or more samples

Spike Recoveries:

38	0.002	-0.42	0.51	0.04	101%
Spike	0.089	17.92	18.97	18.45	18.18 ppm
39	0.006	0.42	1.36	0.89	98%
Spike	0.090	18.13	19.18	18.66	18.18 ppm
40	0.057	11.17	12.18	11.68	116%
Spike	0.107	21.72	22.79	22.25	9.09 ppm
41	0.006	0.42	1.36	0.89	84%
Spike	0.084	16.87	17.91	17.39	19.6 ppm

Barium Virginia Materials (samples 950038-41)
HF/Boric acid Digest
8/22/95 mw

DET. COEF.	0.9988	0.9985
SLOPE	0.0133	0.0132
Y-INTERCEPT	-0.0097	-0.0084

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC ppb	DF	SOL CONC ppb	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.165	13.16	13.10	13.130	603	7917	100	0.5039	1571	105%
NBS 1643 c	0.089	7.44		7.436	6	44.61				90%
Blank	0.009	1.41	1.31	1.362	201	274	100	0		
										avg
38 A	0.136	10.98	10.91	10.94	201	2199	100	0.5022	438	398
38 B	0.128	10.37	10.30	10.34	201	2078	100	0.5011	415	sd
38 C	0.104	8.57	8.49	8.53	201	1714	100	0.5006	342	50
										avg
39 A	0.055	4.88	4.79	4.83	603	2914	100	0.5005	582	480
39 B	0.034	3.29	3.20	3.25	603	1958	100	0.4996	392	sd
39 C	0.042	3.90	3.81	3.85	603	2322	100	0.4995	465	96
										avg
40 A	0.069	5.93	5.85	5.89	603	3550	100	0.5025	707	770
40 B	0.069	5.93	5.85	5.89	603	3550	100	0.5028	706	sd
40 C	0.090	7.51	7.43	7.47	603	4506	100	0.5017	898	111
										avg
41 A	0.115	9.39	9.32	9.36	603	5643	100	0.5000	1129	1174
41 B	0.117	9.54	9.47	9.51	603	5734	100	0.5000	1147	sd
41 C	0.128	10.37	10.30	10.34	603	6234	100	0.5000	1247	64

* = calculations made using detection limit for one or more samples

Spike Recoveries:

38	0.136	10.98	10.91	10.94	109%
Spike	0.280	21.82	21.79	21.81	10 ppb
39	0.055	4.88	4.79	4.83	108%
Spike	0.246	19.26	19.22	19.24	13.4 ppb
40	0.069	5.93	5.85	5.89	96%
Spike	0.240	18.81	18.77	18.79	13.4 ppb
41	0.115	9.39	9.32	9.36	104%
Spike	0.299	23.25	23.23	23.24	13.4 ppb

Cadmium Virginia Materials (samples 950038-41)
HF/Boric acid Digest
6/12/95 mw

DET. COEF.	0.9992	0.9994
SLOPE	0.3302	0.3333
Y-INTERCEPT	0.0081	0.0069

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
Blank	0.007	0.00	0.00	-0.001	1	0.00	100	0		
										avg
38 A	0.015	0.02	0.02	0.02	1	0.02	100	0.5022	4.51	5.72
38 B	0.018	0.03	0.03	0.03	1	0.03	100	0.5011	6.32	sd
38 C	0.018	0.03	0.03	0.03	1	0.03	100	0.5006	6.33	1.05
										avg
39 A	0.012	0.01	0.02	0.01	1	0.01	100	0.5005	2.72	2.92
39 B	0.013	0.01	0.02	0.02	1	0.02	100	0.4996	3.32	sd
39 C	0.012	0.01	0.02	0.01	1	0.01	100	0.4995	2.72	0.35
										avg
40 A	0.019	0.03	0.04	0.03	1	0.03	100	0.5025	6.90	5.71
40 B	0.016	0.02	0.03	0.03	1	0.03	100	0.5028	5.10	sd
40 C	0.016	0.02	0.03	0.03	1	0.03	100	0.5017	5.11	1.04
										avg
41 A	0.022	0.04	0.05	0.04	1	0.04	100	0.5000	8.75	8.75
41 B	0.024	0.05	0.05	0.05	1	0.05	100	0.5000	9.95	sd
41 C	0.020	0.04	0.04	0.04	1	0.04	100	0.5000	7.54	1.21

Detection Limit = 2.5 ppm

Spike Recoveries:

38	0.015	0.02	0.02	0.02	104%
Spike	0.328	0.97	0.96	0.97	0.909 ppm
39	0.012	0.01	0.02	0.01	101%
Spike	0.318	0.94	0.93	0.94	0.909 ppm
40	0.019	0.03	0.04	0.03	97%
Spike	0.313	0.92	0.92	0.92	0.909 ppm
41	0.022	0.04	0.05	0.04	104%
Spike	0.337	1.00	0.99	0.99	0.909 ppm

Calcium

Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/22/95 mw

DET. COEF.	0.9998	1.0000	0.9998	0.9998
SLOPE	0.0414	0.0389	0.0442	0.0401
Y-INTERCEPT	0.0019	0.0016	0.002	0.001

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.018	0.39	0.42	0.406	101	40.96	100	0.5039	8130	73%
Blank	0.001	-0.02	0.00	-0.007	101	-0.71	100	0		
										avg
38 A	0.158	3.54	3.91	3.72	401	1494	100	0.5022	297415	321441
38 B	0.145	3.24	3.59	3.42	401	1370	100	0.5011	273341	sd
38 C	0.208	4.67	5.16	4.91	401	1970	100	0.5006	393567	63612
										avg
39 A	0.043	0.94	1.05	0.99	101	100.12	100	0.5005	20003	20830
39 B	0.044	0.96	1.07	1.02	101	102.52	100	0.4996	20520	sd
39 C	0.047	1.03	1.15	1.09	101	109.72	100	0.4995	21966	1017
										avg
40 A	0.012	0.23	0.28	0.25	101	25.69	100	0.5025	5113	4796
40 B	0.011	0.21	0.25	0.23	101	23.29	100	0.5028	4633	sd
40 C	0.011	0.21	0.25	0.23	101	23.29	100	0.5017	4643	275
										avg
41 A	0.066	1.55	1.65	1.60	201	322.00	100	0.5000	64399	56313
41 B	0.052	1.14	1.27	1.21	201	242.24	100	0.5000	48448	sd
41 C	0.060	1.32	1.47	1.40	201	280.46	100	0.5000	56092	7978

Spike Recoveries:

38	0.158	3.54	3.91	3.72	102%
Spike	0.201	4.51	4.98	4.75	1 ppm
39	0.043	0.94	1.05	0.99	96%
Spike	0.063	1.39	1.55	1.47	0.495 ppm
40	0.012	0.23	0.28	0.25	91%
Spike	0.050	1.09	1.22	1.16	0.99 ppm
41	0.066	1.46	1.62	1.54	105%
Spike	0.088	1.95	2.17	2.06	0.5 ppm

Chromium Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/9/95 mw

DET. COEF.	0.9982	0.9991
SLOPE	0.0254	0.0232
Y-INTERCEPT	0.0089	0.0095

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC ppb	DF	SOL CONC ppb	SOL VOL	WGHT g	ABS CON. ppm	
NBS 1633a	0.231	8.76	9.55	9.151	101	924	100	0.5039	183	94%
Blank	0.012	0.12	0.11	0.114	101	11.56	100	0		
										avg
38 A	0.122	4.46	4.85	4.65	51	237	100	0.5022	47.26	48.18
38 B	0.127	4.66	5.06	4.86	51	248	100	0.5011	49.46	sd
38 C	0.123	4.50	4.89	4.69	51	239	100	0.5006	47.83	1.14
										avg
39 A	0.134	4.93	5.37	5.15	21	108	100	0.5005	21.60	23.25
39 B	0.170	6.35	6.92	6.63	21	139	100	0.4996	27.89	sd
39 C	0.126	4.62	5.02	4.82	21	101	100	0.4995	20.26	4.07
										avg
40 A	0.236	8.95	9.76	9.36	101	945	100	0.5025	188.08	192
40 B	0.239	9.07	9.89	9.48	101	958	100	0.5028	190.46	sd
40 C	0.246	9.35	10.19	9.77	101	987	100	0.5017	196.69	4.45
										avg
41 A	0.175	6.55	7.13	6.84	201	1375	100	0.5000	274.99	300
41 B	0.246	9.35	10.19	9.77	201	1964	100	0.5000	392.77	sd
41 C	0.150	5.56	6.06	5.81	201	1168	100	0.5000	233.52	83

Spike Recoveries:

38	0.122	4.46	4.85	4.65	99%
Spike	0.240	9.11	9.93	9.52	4.9 ppm
39	0.134	4.93	5.37	5.15	107%
Spike	0.257	9.78	10.67	10.22	4.75 ppm
40	0.236	8.95	9.76	9.36	109%
Spike	0.368	14.16	15.45	14.80	5 ppm
41	0.175	6.55		6.55	111%
Spike	0.316	12.11		12.11	5 ppm

Copper Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/8/95 mw

DET. COEF.	0.9999	0.9998	0.9996
SLOPE	0.0998	0.0919	0.0933
Y-INTERCEPT	0.0001	0.0030	0.0050

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.054	0.54	0.55	0.547	1	0.55	100	0.5039	109	92%
Blank	-0.001	-0.01	-0.04	-0.028	1	-0.03	100	0		
										avg
38 A	0.003	0.03	0.00	0.01	1	0.01	100	0.5022	< 25	< 25*
38 B	0.004	0.01	-0.01	0.00	1	0.00	100	0.5011	< 25	sd
38 C	0.004	0.01	-0.01	0.00	1	0.00	100	0.5006	< 25	0 *
										avg
39 A	0.011	0.11	0.09	0.10	1	0.10	100	0.5005	< 25	< 25*
39 B	0.012	0.10	0.08	0.09	1	0.09	100	0.4996	< 25	sd
39 C	0.012	0.10	0.08	0.09	1	0.09	100	0.4995	< 25	0 *
										avg
40 A	0.047	0.48	0.45	0.46	2	0.93	100	0.5025	185	184
40 B	0.047	0.48	0.45	0.46	2	0.93	100	0.5028	185	sd
40 C	0.046	0.47	0.44	0.45	2	0.91	100	0.5017	181	2
										avg
41 A	0.034	0.34	0.34	0.34	101	34.16	100	0.5000	6832	5916
41 B	0.044	0.45	0.42	0.43	101	43.66	100	0.5000	8731	sd
41 C	0.014	0.12	0.10	0.11	101	10.92	100	0.5000	2185	3368

* = calculations made using detection limit for one or more samples

Spike Recoveries:

38	0.003	0.03	0.00	0.01	101%
Spike	0.181	1.81	1.94	1.87	1.84 ppm
39	0.011	0.11	0.09	0.10	97%
Spike	0.181	1.81	1.94	1.87	1.84 ppm
40	0.047	0.48	0.45	0.46	100%
Spike	0.140	1.49	1.45	1.47	1 ppm
41	0.034	0.34	0.34	0.34	93%
Spike	0.123	1.23	1.31	1.27	1 ppm

	Iron		Virginia Materials (samples 950038-41)
			HF/Boric acid Digest
			7/9/95 mw
DET. COEF.	0.9986	0.9997	0.9998
SLOPE	0.0542	0.0485	0.0519
Y-INTERCEPT	0.0131	0.0145	0.0035

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.124	2.05	2.26	2.153	201	432.67	100	0.5039	85864	91%
Blank	0.010	-0.06	-0.09	-0.075	101	-7.58	100	0		
										avg
38 A	0.049	0.66	0.71	0.69	51	35.04	100	0.5022	6977	7122
38 B	0.051	0.70	0.75	0.73	51	37.03	100	0.5011	7390	sd
38 C	0.049	0.66	0.71	0.69	51	35.04	100	0.5006	6999	232
										avg
39 A	0.056	0.79	0.86	0.82	51	42.01	100	0.5005	8395	13260
39 B	0.095	1.51	1.66	1.59	51	80.88	100	0.4996	16189	sd
39 C	0.090	1.42	1.56	1.49	51	75.90	100	0.4995	15195	4242
										avg
40 A	0.050	0.68	0.73	0.71	201	142.02	100	0.5025	28263	29836
40 B	0.054	0.75	0.82	0.78	201	157.73	100	0.5028	31371	sd
40 C	0.052	0.72	0.77	0.75	201	149.88	100	0.5017	29874	1554
										avg
41 A	0.055	0.77	0.84	0.80	201	161.66	100	0.5000	32332	34951
41 B	0.064	0.94	1.02	0.98	201	197.01	100	0.5000	39402	sd
41 C	0.056	0.79	0.86	0.82	201	165.59	100	0.5000	33118	3875

Spike Recoveries:

38	0.049	0.66	0.71	0.69	107%
Spike	0.150	2.53	2.80	2.66	1.84 ppm
39	0.095	1.51	1.66	1.59	91%
Spike	0.181	3.10	3.44	3.27	1.84 ppm
40	0.050	0.68	0.73	0.71	106%
Spike	0.104	1.68	1.85	1.76	1 ppm
41	0.064	0.94	1.02	0.98	96%
Spike	0.113	1.84	2.03	1.94	1 ppm

Lead Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/8/95 mw

DET. COEF.	0.9985	0.9996	0.9989	0.998
SLOPE	0.0208	0.0210	0.0222	0.022
Y-INTERCEPT	-0.0007	-0.0012	0.002	0.008

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
BCR146	0.023	1.14	1.16	1.149	5	5.74	100	0.5	1149	90%
Blank	0.003	0.18	0.20	0.189	1	0.19	100	0		
										avg
38 A	0.013	0.66	0.68	0.67	1	0.67	100	0.5022	133	121
38 B	0.019	0.76	0.53	0.65	1	0.65	100	0.5011	129	sd
38 C	0.016	0.63	0.39	0.51	1	0.51	100	0.5006	102	17
										avg
39 A	0.010	0.51	0.54	0.53	1	0.53	100	0.5005	105	103
39 B	0.013	0.49	0.25	0.37	1	0.37	100	0.4996	75	sd
39 C	0.019	0.76	0.53	0.65	1	0.65	100	0.4995	129	27
										avg
40 A	0.020	1.00	1.01	1.00	1	1.00	100	0.5025	200	189
40 B	0.026	1.08	0.85	0.97	1	0.97	100	0.5028	192	sd
40 C	0.024	0.99	0.76	0.87	1	0.87	100	0.5017	174	13
										avg
41 A	0.026	1.29	1.30	1.29	1	1.29	100	0.5000	258	258
41 B	0.026	1.29	1.30	1.29	1	1.29	100	0.5000	258	sd
41 C	0.026	1.29	1.30	1.29	1	1.29	100	0.5000	258	0

Spike Recoveries:

38	0.013	0.66	0.68	0.67	103%
Spike	0.052	2.54	2.54	2.54	1.82 ppm
39	0.010	0.51	0.54	0.53	95%
Spike	0.046	2.25	2.25	2.25	1.82 ppm
40	0.020	1.00	1.01	1.00	97%
Spike	0.057	2.78	2.78	2.78	1.82 ppm
41	0.026	1.29	1.30	1.29	96%
Spike	0.045	2.20	2.21	2.20	0.95 ppm

Magnesium Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/21/95 mw

DET. COEF.	0.9981	0.9954
SLOPE	0.0679	0.0588
Y-INTERCEPT	0.0115	0.0136

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.041	0.44	0.47	0.450	51	22.96	100	0.5039	4557	100%
Blank	-0.003	-0.21	-0.28	-0.248	101	-25.02	100	0		
										avg
38 A	0.062	0.74	0.82	0.78	401	314.12	100	0.5022	62549	60122
38 B	0.059	0.70	0.77	0.74	401	295.04	100	0.5011	58879	sd
38 C	0.059	0.70	0.77	0.74	401	295.04	100	0.5006	58937	2103
										avg
39 A	0.029	0.26	0.26	0.26	101	26.25	100	0.5005	5245	6106
39 B	0.036	0.36	0.38	0.37	101	37.46	100	0.4996	7499	sd
39 C	0.030	0.27	0.28	0.28	101	27.85	100	0.4995	5576	1217
										avg
40 A	0.021	0.14	0.13	0.13	101	13.43	100	0.5025	2673	1930
40 B	0.018	0.10	0.07	0.09	101	8.63	100	0.5028	1716	sd
40 C	0.017	0.08	0.06	0.07	101	7.02	100	0.5017	1400	663
										avg
41 A	0.020	0.13	0.11	0.12	201	23.54	100	0.5000	4709	5347
41 B	0.022	0.16	0.14	0.15	201	29.92	100	0.5000	5984	sd
41 C	0.021	0.14	0.13	0.13	201	26.73	100	0.5000	5347	638

Spike Recoveries:

38	0.062	0.74	0.82	0.78	95%
Spike	0.074	0.92	1.03	0.97	0.2 ppm
39	0.029	0.26	0.26	0.26	95%
Spike	0.059	0.70	0.77	0.74	0.499 ppm
40	0.021	0.14	0.13	0.13	111%
Spike	0.056	0.66	0.72	0.69	0.499 ppm
41	0.020	0.13	0.11	0.12	111%
Spike	0.055	0.64	0.70	0.67	0.5 ppm

Manganese Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/9/95 mw

DET. COEF.	0.9984	0.9984
SLOPE	0.0977	0.0926
Y-INTERCEPT	0.0088	0.0201

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.097	0.90	0.83	0.866	1	0.87	100	0.5039	172	90%
Blank	0.018	0.09	-0.02	0.035	1	0.04	100	0		
										avg
38 A	0.030	0.22	0.11	0.16	101	16.33	100	0.5022	3252	3470
38 B	0.033	0.25	0.14	0.19	101	19.52	100	0.5011	3895	sd
38 C	0.030	0.22	0.11	0.16	101	16.33	100	0.5006	3262	368
										avg
39 A	0.102	0.95	0.88	0.92	2	1.84	100	0.5005	367	376
39 B	0.108	1.01	0.95	0.98	2	1.96	100	0.4996	393	sd
39 C	0.102	0.95	0.88	0.92	2	1.84	100	0.4995	368	15
										avg
40 A	0.018	0.09	-0.02	0.04	1	0.04	100	0.5025	7.06	52.43
40 B	0.050	0.42	0.32	0.37	1	0.37	100	0.5028	73.99	sd
40 C	0.051	0.43	0.33	0.38	1	0.38	100	0.5017	76.25	39.31
										avg
41 A	0.167	1.62	1.59	1.60	3	4.81	100	0.5000	961	1018
41 B	0.186	1.81	1.79	1.80	3	5.41	100	0.5000	1081	sd
41 C	0.175	1.70	1.67	1.69	3	5.06	100	0.5000	1012	60

Spike Recoveries:

38	0.030	0.22	0.11	0.16	107%
Spike	0.132	1.26	1.21	1.23	1 ppm
39	0.102	0.95	0.88	0.92	98%
Spike	0.195	1.91	1.89	1.90	1 ppm
40	0.048	0.40	0.30	0.35	95%
Spike	0.215	2.11	2.10	2.11	1.84 ppm
41	0.167	1.62	1.59	1.60	108%
Spike	0.236	2.32	2.33	2.33	0.67 ppm

Mercury

Virginia Materials (samples 950038-41)
HF/Boric acid Digest
9/7/95 mw

DET. COEF.	0.9999	0.9997
SLOPE	0.0147	0.0141
Y-INTERCEPT	-0.0072	-0.0056

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC ppb	DF	SOL CONC ppb	SOL VOL	WGHT g	ABS CON. ppm	
Blank	-0.003	0.29	0.19	0.238	21	5.00	100	0		
38 A	-0.005	0.15	0.05	0.10	21	2.08	100	0.5022	< 4.2	avg < 4.2
38 B	-0.004	0.22	0.12	0.17	21	3.54	100	0.5011	< 4.2	sd
38 C	-0.006	0.08	-0.03	0.03	21	0.62	100	0.5006	< 4.2	0.00
39 A	-0.004	0.22	0.12	0.17	21	3.54	100	0.5005	< 4.2	avg < 4.2
39 B	-0.004	0.22	0.12	0.17	21	3.54	100	0.4996	< 4.2	sd
39 C	-0.005	0.15	0.05	0.10	21	2.08	100	0.4995	< 4.2	0.00
40 A	-0.005	0.15	0.05	0.10	21	2.08	100	0.5025	< 4.2	avg < 4.2
40 B	-0.005	0.15	0.05	0.10	21	2.08	100	0.5028	< 4.2	sd
40 C	-0.005	0.15	0.05	0.10	21	2.08	100	0.5017	< 4.2	0.00
41 A	-0.006	0.08	-0.03	0.03	21	0.62	100	0.5000	< 4.2	avg < 4.2
41 B	-0.007	0.02	-0.10	-0.04	21	-0.84	100	0.5000	< 4.2	sd
41 C	-0.006	0.08	-0.03	0.03	21	0.62	100	0.5000	< 4.2	0.00

Spike Recoveries:

38	-0.005	0.15	0.05	0.10	112%
Spike	0.071	5.31	5.45	5.38	4.7 ppm
39	-0.004	0.22	0.12	0.17	109%
Spike	0.070	5.24	5.38	5.31	4.7 ppm
40	-0.005	0.15	0.05	0.10	109%
Spike	0.069	5.17	5.31	5.24	4.7 ppm
41	-0.006	0.08	-0.03	0.03	112%
Spike	0.070	5.24	5.38	5.31	4.7 ppm

Nickel

Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/8/95 mw

DET. COEF.	0.9969	0.9994
SLOPE	0.0451	0.0434
Y-INTERCEPT	0.0041	0.0118

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS 1633a	0.024	0.44	0.28	0.36	2	0.72	100	0.5039	143	113%
Blank	0.009	0.11	-0.06	0.022	1	0.02	100	0		
										avg
38 A	0.017	0.29	0.12	0.20	1	0.20	100	0.5022	40.47	55.58
38 B	0.023	0.42	0.26	0.34	1	0.34	100	0.5011	67.61	sd
38 C	0.021	0.38	0.21	0.29	1	0.29	100	0.5006	58.65	13.83
										avg
39 A	0.015	0.24	0.07	0.16	1	0.16	100	0.5005	31.58	45.19
39 B	0.018	0.31	0.14	0.23	1	0.23	100	0.4996	45.20	sd
39 C	0.021	0.38	0.21	0.29	1	0.29	100	0.4995	58.78	13.60
										avg
40 A	0.050	1.02	0.88	0.95	1	0.95	100	0.5025	189	208
40 B	0.057	1.17	1.04	1.11	1	1.11	100	0.5028	220	sd
40 C	0.056	1.15	1.02	1.08	1	1.08	100	0.5017	216	17.05
										avg
41 A	0.044	0.89	0.74	0.81	1	0.81	100	0.5000	163	166
41 B	0.052	1.06	0.93	0.99	1	0.99	100	0.5000	199	sd
41 C	0.038	0.75	0.60	0.68	1	0.68	100	0.5000	136	31.74

Spike Recoveries:

38	0.017	0.29	0.12	0.20	104%
Spike	0.101	2.15	2.05	2.10	1.82 ppm
39	0.015	0.24	0.07	0.16	101%
Spike	0.096	2.04	1.94	1.99	1.82 ppm
40	0.050	1.02	0.88	0.95	99%
Spike	0.130	2.79	2.72	2.76	1.82 ppm
41	0.044	0.89	0.74	0.81	89%
Spike	0.116	2.48	2.40	2.44	1.82 ppm

Potassium Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/21/95 mw

DET. COEF.	0.9987	0.9968
SLOPE	0.1005	0.0850
Y-INTERCEPT	0.0040	0.0065

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.083	0.79	0.90	0.843	101	85.13	100	0.5039	16895	90%
Blank	0.001	-0.03	-0.06	-0.048	51	-2.42	100	0		
										avg
38 A	0.009	0.05	0.03	0.04	201	7.91	100	0.5022	1575	706
38 B	0.006	0.02	-0.01	0.01	201	1.36	100	0.5011	272	sd
38 C	0.006	0.02	-0.01	0.01	201	1.36	100	0.5006	272	752
										avg
39 A	0.058	0.54	0.61	0.57	51	29.14	100	0.5005	5823	5978
39 B	0.061	0.57	0.64	0.60	51	30.80	100	0.4996	6166	sd
39 C	0.059	0.55	0.62	0.58	51	29.70	100	0.4995	5945	174
										avg
40 A	0.124	1.19	1.38	1.29	51	65.69	100	0.5025	13073	13261
40 B	0.126	1.21	1.41	1.31	51	66.80	100	0.5028	13286	sd
40 C	0.127	1.22	1.42	1.32	51	67.35	100	0.5017	13425	177
										avg
41 A	0.025	0.21	0.22	0.21	201	42.83	100	0.5000	8566	7402
41 B	0.020	0.16	0.16	0.16	201	31.92	100	0.5000	6384	sd
41 C	0.022	0.18	0.18	0.18	201	36.28	100	0.5000	7257	1099

Spike Recoveries:

38	0.009	0.05	0.03	0.04	113%
Spike	0.061	0.57	0.64	0.60	0.498 ppm
39	0.058	0.54	0.61	0.57	106%
Spike	0.106	1.01	1.17	1.09	0.49 ppm
40	0.124	1.19	1.38	1.29	113%
Spike	0.175	1.70	1.98	1.84	0.49 ppm
41	0.025	0.21	0.22	0.21	105%
Spike	0.073	0.69	0.78	0.73	0.498 ppm

Sodium — Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/19/95 mw

DET. COEF.	0.9999	0.9998	0.9999		0.9999
SLOPE	0.2786	0.2729	0.2990		0.2826
Y-INTERCEPT	0.0013	-0.0006	0.001		-0.001

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.045	0.16	0.17	0.162	51	8.26	100	0.5039	1640	96%
Blank	0.000	0.00	0.00	-0.001	51	-0.05	100	0		
										avg
38 A	0.024	0.08	0.09	0.09	101	8.67	100	0.5022	1727	1835
38 B	0.027	0.09	0.10	0.09	101	9.28	100	0.5011	1853	sd
38 C	0.028	0.09	0.10	0.10	101	9.63	100	0.5006	1924	100
										avg
39 A	0.105	0.37	0.39	0.38	101	38.35	100	0.5005	7662	7458
39 B	0.105	0.35	0.37	0.36	101	36.40	100	0.4996	7285	sd
39 C	0.107	0.35	0.38	0.37	101	37.09	100	0.4995	7426	190
										avg
40 A	0.040	0.14	0.15	0.14	51	7.34	100	0.5025	1460	1272
40 B	0.038	0.12	0.14	0.13	51	6.62	100	0.5028	1316	sd
40 C	0.030	0.10	0.11	0.10	51	5.21	100	0.5017	1039	214
										avg
41 A	0.157	0.56	0.58	0.57	401	227.88	100	0.5000	45576	43292
41 B	0.154	0.51	0.55	0.53	401	212.13	100	0.5000	42426	sd
41 C	0.152	0.50	0.54	0.52	401	209.37	100	0.5000	41874	1997

Spike Recoveries:

38	0.024	0.08	0.09	0.09	103%
Spike	0.081	0.29	0.30	0.29	0.2 ppm
39	0.105	0.37	0.39	0.38	102%
Spike	0.161	0.57	0.59	0.58	0.2 ppm
40	0.040	0.14	0.15	0.14	104%
Spike	0.097	0.34	0.36	0.35	0.198 ppm
41	0.157	0.56	0.58	0.57	111%
Spike	0.218	0.78	0.80	0.79	0.2 ppm

Silicon

Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/18/95 mw

DET. COEF.	0.9992	0.9976
SLOPE	0.0013	0.0013
Y-INTERCEPT	-0.0038	-0.0049

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.012	11.89	13.48	12.685	101	1281	100	0.5039	254258	112%
Blank	-0.006	-1.64	-0.91	-1.276	51	-65	100	0		
										avg
38 A	0.017	15.65	17.48	16.56	51	845	100	0.5022	168206	147453
38 B	0.011	11.14	12.68	11.91	51	607	100	0.5011	121211	sd
38 C	0.015	14.14	15.88	15.01	51	766	100	0.5006	152940	23973
										avg
39 A	0.016	14.90	16.68	15.79	101	1595	100	0.5005	318594	303316
39 B	0.015	14.14	15.88	15.01	101	1516	100	0.4996	303488	sd
39 C	0.014	13.39	15.08	14.24	101	1438	100	0.4995	287865	15365
										avg
40 A	0.014	13.39	15.08	14.24	101	1438	100	0.5025	286146	275843
40 B	0.013	12.64	14.28	13.46	101	1360	100	0.5028	270395	sd
40 C	0.013	12.64	14.28	13.46	101	1360	100	0.5017	270988	8928
										avg
41 A	0.012	11.89	13.48	12.69	101	1281	100	0.5000	256242	240574
41 B	0.010	10.39	11.88	11.13	101	1125	100	0.5000	224906	sd
41 C	0.011	11.14	12.68	11.91	101	1203	100	0.5000	240574	15668

Spike Recoveries:

38	0.017	15.65	17.48	16.56	87%
Spike	0.028	23.92	26.28	25.10	9.8 ppm
39	0.016	14.90	16.68	15.79	86%
Spike	0.027	23.16	25.48	24.32	9.9 ppm
40	0.014	13.39	15.08	14.24	110%
Spike	0.028	23.92	26.28	25.10	9.9 ppm
41	0.012	11.89	13.48	12.69	102%
Spike	0.025	21.66	23.88	22.77	9.9 ppm

Selenium Virginia Materials (samples 950038-41)
HF/Boric acid Digest
8/14/95 mw

The matrix effect was so great that it was necessary to use the method of standard additions
All samples were below the detection limit of 0.25 ppm.
All Det. Coef. > 0.9975

Silver

Virginia Materials (samples 950038-41)
HF/Boric acid Digest
6/13/95 mw

DET. COEF.	0.9999	0.9999	0.9993	0.9998
SLOPE	0.2068	0.2085	0.2088	0.2082
Y-INTERCEPT	0.0035	0.0034	0.0031	0.0031

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
Blank	0.002	-0.01	-0.01	-0.007	1	-0.01	100	0		
38 A	0.007	0.02	0.02	0.02	1	0.02	100	0.5022	< 5.0	avg < 5.0
38 B	0.005	0.01	0.01	0.01	1	0.01	100	0.5011	< 5.0	sd
38 C	0.003	0.00	0.00	0.00	1	0.00	100	0.5006	< 5.0	0
39 A	0.005	0.01	0.01	0.01	1	0.01	100	0.5005	< 5.0	avg < 5.0
39 B	0.001	-0.01	-0.01	-0.01	1	-0.01	100	0.4996	< 5.0	sd
39 C	0.001	-0.01	-0.01	-0.01	1	-0.01	100	0.4995	< 5.0	0
40 A	0.000	-0.01	-0.01	-0.01	1	-0.01	100	0.5025	< 5.0	avg < 5.0
40 B	0.000	-0.01	-0.01	-0.01	1	-0.01	100	0.5028	< 5.0	sd
40 C	-0.001	-0.02	-0.02	-0.02	1	-0.02	100	0.5017	< 5.0	0
41 A	0.002	-0.01	-0.01	-0.01	1	-0.01	100	0.5000	< 5.0	avg < 5.0
41 B	0.001	-0.01	-0.01	-0.01	1	-0.01	100	0.5000	< 5.0	sd
41 C	0.000	-0.01	-0.01	-0.01	1	-0.01	100	0.5000	< 5.0	0

Spike Recoveries:

38	0.007	0.02	0.02	0.02	102%
Spike	0.200	0.95	0.94	0.95	0.909 ppm
39	0.005	0.01	0.01	0.01	101%
Spike	0.196	0.93	0.92	0.93	0.909 ppm
40	0.000	-0.01	-0.01	-0.01	103%
Spike	0.196	0.92	0.93	0.93	0.909 ppm
41	0.002	-0.01	-0.01	-0.01	103%
Spike	0.197	0.94	0.93	0.93	0.909 ppm

Zinc

Virginia Materials (samples 950038-41)
HF/Boric acid Digest
7/9/95 mw

DET. COEF.	0.9988	0.9995	0.9992
SLOPE	0.2372	0.2230	0.2374
Y-INTERCEPT	0.0053	0.0128	0.0062

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC ppm	DF	SOL CONC ppm	SOL VOL	WGHT g	ABS CON. ppm	
NBS1633a	0.251	1.04	1.07	1.052	1	1.05	100	0.5039	209	95%
Blank	0.012	0.03	0.00	0.012	1	0.01	100	0		
										avg
38 A	0.052	0.20	0.18	0.19	2	0.37	100	0.5022	74.24	76.11
38 B	0.054	0.21	0.18	0.20	2	0.39	100	0.5011	77.88	sd
38 C	0.053	0.20	0.18	0.19	2	0.38	100	0.5006	76.22	1.82
										avg
39 A	0.035	0.13	0.10	0.11	2	0.22	100	0.5005	44.94	48.48
39 B	0.039	0.14	0.12	0.13	2	0.26	100	0.4996	51.99	sd
39 C	0.037	0.13	0.11	0.12	2	0.24	100	0.4995	48.52	3.52
										avg
40 A	0.072	0.28	0.27	0.27	2	0.55	100	0.5025	109	110
40 B	0.074	0.29	0.27	0.28	2	0.56	100	0.5028	112	sd
40 C	0.072	0.28	0.27	0.27	2	0.55	100	0.5017	109	2
										avg
41 A	0.039	0.12	0.14	0.13	201	25.72	100	0.5000	5143	5784
41 B	0.039	0.12	0.14	0.13	201	25.72	100	0.5000	5143	sd
41 C	0.050	0.17	0.18	0.18	201	35.33	100	0.5000	7066	1110

Spike Recoveries:

38	0.052	0.20	0.18	0.19	108%
Spike	0.176	0.72	0.73	0.73	0.5 ppm
39	0.035	0.13	0.10	0.11	109%
Spike	0.160	0.65	0.66	0.66	0.5 ppm
40	0.072	0.28	0.27	0.27	106%
Spike	0.194	0.80	0.81	0.80	0.5 ppm
41	0.039	0.14	0.12	0.13	110%
Spike	0.165	0.67	0.68	0.68	0.5 ppm

APPENDIX C

Aluminum
7/18/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9999	0.9998	0.9999	1.000
SLOPE	0.0041	0.0039	0.0040	0.004
Y-INTERCEPT	0.0000	-0.0014	-0.0019	0.00

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.127	30.75	32.78	31.76	21	133407	95%	recovery	
Blank - 1	-0.003	-0.28	0.28	0.00	1				9.04
2	-0.002	-0.03	0.53	0.25	1				5.69
3	-0.002	-0.03	0.53	0.25	1				6.35
4	-0.002	-0.03	0.53	0.25	1				5.18
950038 A-1	0.003	0.74	1.12	0.93	1	< 1.5			11.19
A-2	0.002	0.97	1.53	1.25	1	< 1.5			12.07
A-3	0.003	1.23	1.78	1.50	1	< 1.5			12.09
A-4	0.002	0.97	1.53	1.25	1	< 1.5			12.05
950038 B-1	0.000	0.47	1.03	0.75	1	< 1.5			11.41
B-2	0.002	0.97	1.53	1.25	1	< 1.5			11.91
B-3	0.002	0.97	1.53	1.25	1	< 1.5			11.82
B-4	0.002	0.97	1.53	1.25	1	< 1.5			12.11
950038 C-1	0.000	0.47	1.03	0.75	1	< 1.5			11.79
C-2	0.001	0.72	1.28	1.00	1	< 1.5			11.86
C-3	0.003	1.23	1.78	1.50	1	< 1.5			11.81
C-4	0.002	0.97	1.53	1.25	1	< 1.5			12.05
950039 A-1	0.002	0.49	0.86	0.68	1	< 1.5			11.65
A-2	0.002	0.97	1.53	1.25	1	< 1.5			11.71
A-3	0.003	1.23	1.78	1.50	1	< 1.5			11.65
A-4	0.003	1.23	1.78	1.50	1	< 1.5			11.52
950039 B-1	-0.001	0.22	0.78	0.50	1	< 1.5			11.78
B-2	0.001	0.72	1.28	1.00	1	< 1.5			11.83
B-3	0.001	0.72	1.28	1.00	1	< 1.5			11.81
B-4	0.003	1.23	1.78	1.50	1	< 1.5			11.56
950039 C-1	-0.001	0.22	0.78	0.50	1	< 1.5			12.00
C-2	0.001	0.72	1.28	1.00	1	< 1.5			11.91
C-3	0.001	0.72	1.28	1.00	1	< 1.5			11.83
C-4	0.002	0.97	1.53	1.25	1	< 1.5			11.40

Sample Spike Recoveries:

950038 A-1	0.003	0.74	1.12	0.93	117%	9.800
SPIKE	0.049	11.87	12.86	12.37		
950039 A-1	0.002	0.49	0.86	0.68	117%	9.800
SPIKE	0.048	11.63	12.61	12.12		

Aluminum
7/18/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9999	0.9998	0.9976	1.000
SLOPE	0.0041	0.0039	0.0036	0.004
Y-INTERCEPT	0.0000	-0.0014	-0.0038	0.00

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.127	30.75	32.78	31.76	21	133407	95%	recovery	
Blank - 1	-0.003	-0.28	0.28	0.00	1				9.04
2	-0.002	-0.03	0.53	0.25	1				5.69
3	-0.002	-0.03	0.53	0.25	1				6.35
4	-0.002	-0.03	0.53	0.25	1				5.18
950040 A-1	0.001	0.25	0.61	0.43	1	< 1.5			7.63
A-2	-0.005	-0.34	-0.14	-0.24	1	< 1.5			6.74
A-3	-0.005	-0.34	-0.14	-0.24	1	< 1.5			7.20
A-4	-0.005	-0.34	-0.14	-0.24	1	< 1.5			8.99
950040 B-1	-0.005	-0.34	-0.14	-0.24	1	< 1.5			7.53
B-2	-0.004	-0.06	0.11	0.02	1	< 1.5			7.27
B-3	-0.005	-0.34	-0.14	-0.24	1	< 1.5			7.05
B-4	-0.004	-0.06	0.11	0.02	1	< 1.5			8.36
950040 C-1	-0.005	-0.34	-0.14	-0.24	1	< 1.5			7.53
C-2	-0.005	-0.34	-0.14	-0.24	1	< 1.5			8.61
C-3	-0.005	-0.34	-0.14	-0.24	1	< 1.5			8.35
C-4	-0.004	-0.06	0.11	0.02	1	< 1.5			8.08
950041 A-1	0.032	7.75	8.52	8.14	1	8.14			9.31
A-2	0.032	9.98	9.09	9.54	1	9.54			9.61
A-3	0.025	8.03	7.35	7.69	1	7.69			9.37
A-4	0.023	7.47	6.85	7.16	1	7.16			9.80
950041 B-1	0.037	11.37	10.34	10.86	1	10.86			9.40
B-2	0.048	14.44	13.09	13.77	1	13.77			9.25
B-3	0.048	14.44	13.09	13.77	1	13.77			9.32
B-4	0.045	13.61	12.34	12.97	1	12.97			9.65
950041 C-1	0.046	13.89	12.59	13.24	1	13.24			9.29
C-2	0.057	16.95	15.33	16.14	1	16.14			9.00
C-3	0.050	15.00	13.59	14.29	1	14.29			9.11
C-4	0.046	13.89	12.59	13.24	1	13.24			9.39

Sample Spike Recoveries:

950040 A-1	0.001	0.25	0.61	0.43	114%	9.800
SPIKE	0.046	11.14	12.10	11.62		
950041 A-1	0.032	7.75	8.52	8.14	112%	9.800
SPIKE	0.076	18.40	19.76	19.08		

Arsenic
6/23/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9986	0.9998
SLOPE	0.0058	0.0053
Y-INTERCEPT	0.0003	0.0009

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm		pH
NBS1643c	0.041	6.99	7.60	7.30	11	80.27	98% recovery	
Blank - 1	0.000	-0.05	-0.17	-0.11	11			9.04
2	0.002	0.29	0.21	0.25	11			5.69
3	-0.001	-0.23	-0.36	-0.29	11			6.35
4	-0.001	-0.23	-0.36	-0.29	11			5.18
950038 A-1	-0.001	-0.23	-0.36	-0.29	11	< 0.014		11.19
A-2	0.004	0.63	0.59	0.61	11	< 0.014		12.07
A-3	-0.001	-0.23	-0.36	-0.29	11	< 0.014		12.09
A-4	0.001	0.12	0.02	0.07	11	< 0.014		12.05
950038 B-1	-0.002	-0.40	-0.55	-0.47	11	< 0.014		11.41
B-2	-0.003	-0.57	-0.74	-0.65	11	< 0.014		11.91
B-3	0.000	-0.05	-0.17	-0.11	11	< 0.014		11.82
B-4	0.003	0.46	0.40	0.43	11	< 0.014		12.11
950038 C-1	-0.001	-0.23	-0.36	-0.29	11	< 0.014		11.79
C-2	-0.002	-0.40	-0.55	-0.47	11	< 0.014		11.86
C-3	0.001	0.12	0.02	0.07	11	< 0.014		11.81
C-4	0.001	0.12	0.02	0.07	11	< 0.014		12.05
950039 A-1	-0.001	-0.23	-0.36	-0.29	11	< 0.014		11.65
A-2	0.001	0.12	0.02	0.07	11	< 0.014		11.71
A-3	0.001	0.12	0.02	0.07	11	< 0.014		11.65
A-4	0.002	0.29	0.21	0.25	11	< 0.014		11.52
950039 B-1	-0.001	-0.23	-0.36	-0.29	11	< 0.014		11.78
B-2	0.001	0.12	0.02	0.07	11	< 0.014		11.83
B-3	0.000	-0.05	-0.17	-0.11	11	< 0.014		11.81
B-4	0.003	0.46	0.40	0.43	11	< 0.014		11.56
950039 C-1	0.001	0.12	0.02	0.07	11	< 0.014		12.00
C-2	0.000	-0.05	-0.17	-0.11	11	< 0.014		11.91
C-3	-0.001	-0.23	-0.36	-0.29	11	< 0.014		11.83
C-4	0.001	0.12	0.02	0.07	11	< 0.014		11.40

Sample Spike Recoveries:

950038	-0.001	-0.23	-0.36	-0.29	99%	9.090
SPIKE	0.049	8.37	9.12	8.74		
950039	-0.001	-0.23	-0.36	-0.29	99%	9.090
SPIKE	0.049	8.37	9.12	8.74		

Arsenic
6/23/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9986	0.9998
SLOPE	0.0058	0.0053
Y-INTERCEPT	0.0003	0.0009

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm		pH
NBS1643c	0.041	6.99	7.60	7.30	11	80.27	98% recovery	
Blank - 1	0	-0.05	-0.17	-0.11	11			9.04
2	0.002	0.29	0.21	0.25	11			5.69
3	-0.001	-0.23	-0.36	-0.29	11			6.35
4	-0.001	-0.23	-0.36	-0.29	11			5.18
950040 A-1	0.005	0.81	0.78	0.79	11	< 0.014		7.63
A-2	0.002	0.29	0.21	0.25	11	< 0.014		6.74
A-3	0.002	0.29	0.21	0.25	11	< 0.014		7.20
A-4	-0.002	-0.40	-0.55	-0.47	11	< 0.014		8.99
950040 B-1	0.004	0.63	0.59	0.61	11	< 0.014		7.53
B-2	0.001	0.12	0.02	0.07	11	< 0.014		7.27
B-3	-0.001	-0.23	-0.36	-0.29	11	< 0.014		7.05
B-4	-0.002	-0.40	-0.55	-0.47	11	< 0.014		8.36
950040 C-1	0.003	0.46	0.40	0.43	11	< 0.014		7.53
C-2	0.001	0.12	0.02	0.07	11	< 0.014		8.61
C-3	-0.001	-0.23	-0.36	-0.29	11	< 0.014		8.35
C-4	-0.002	-0.40	-0.55	-0.47	11	< 0.014		8.08
950041 A-1	0.001	0.12	0.02	0.07	11	< 0.014		9.31
A-2	-0.003	-0.57	-0.74	-0.65	11	< 0.014		9.61
A-3	0.000	-0.05	-0.17	-0.11	11	< 0.014		9.37
A-4	-0.003	-0.57	-0.74	-0.65	11	< 0.014		9.80
950041 B-1	-0.002	-0.40	-0.55	-0.47	11	< 0.014		9.40
B-2	0.000	-0.05	-0.17	-0.11	11	< 0.014		9.25
B-3	0.002	0.29	0.21	0.25	11	< 0.014		9.32
B-4	-0.002	-0.40	-0.55	-0.47	11	< 0.014		9.65
950041 C-1	-0.001	-0.23	-0.36	-0.29	11	< 0.014		9.29
C-2	0.003	0.46	0.40	0.43	11	< 0.014		9.00
C-3	0.002	0.29	0.21	0.25	11	< 0.014		9.11
C-4	0.000	-0.05	-0.17	-0.11	11	< 0.014		9.39

Sample Spike Recoveries:

950040	0.005	0.81	0.78	0.79	99%	9.090
SPIKE	0.055	9.40	10.26	9.83		
950041	0.001	0.12	0.02	0.07	99%	9.090
SPIKE	0.051	8.71	9.50	9.10		

Barium
9/6/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9989	0.9987
SLOPE	0.0102	0.0084
Y-INTERCEPT	-0.0080	-0.0064

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm		pH
NBS1633a	0.062	6.84	8.15	7.50	6	44.97	91% recovery	
Blank - 1	0.012	1.95	2.19	2.07	201			9.04
2	0.015	2.25	2.55	2.40	201			5.69
3	0.015	2.25	2.55	2.40	201			6.35
4	0.013	2.05	2.31	2.18	201			5.18
950038 A-1	0.114	11.93	14.34	13.14	201	2.64		11.19
A-2	0.086	9.19	11.01	10.10	201	2.03		12.07
A-3	0.059	6.55	7.79	7.17	201	1.44		12.09
A-4	0.040	4.69	5.53	5.11	201	1.03		12.05
950038 B-1	0.201	20.43	24.71	22.57	201	4.54		11.41
B-2	0.130	13.49	16.25	14.87	201	2.99		11.91
B-3	0.139	14.37	17.32	15.85	201	3.19		11.82
B-4	0.062	6.84	8.15	7.50	201	1.51		12.11
950038 C-1	0.137	14.18	17.09	15.63	201	3.14		11.79
C-2	0.153	15.74	18.99	17.37	201	3.49		11.86
C-3	0.111	11.63	13.99	12.81	201	2.57		11.81
C-4	0.045	5.18	6.12	5.65	201	1.14		12.05
950039 A-1	0.044	5.08	6.00	5.54	201	1.11		11.65
A-2	0.006	1.37	1.47	1.42	201	0.29		11.71
A-3	0.009	1.66	1.83	1.75	201	0.35		11.65
A-4	0.002	0.98	1.00	0.99	201	< 0.25		11.52
950039 B-1	0.047	5.38	6.36	5.87	201	1.18		11.78
B-2	0.020	2.74	3.14	2.94	201	0.59		11.83
B-3	0.010	1.76	1.95	1.85	201	0.37		11.81
B-4	0.008	1.56	1.71	1.64	201	0.33		11.56
950039 C-1	0.048	5.47	6.48	5.98	201	1.20		12.00
C-2	0.018	2.54	2.90	2.72	201	0.55		11.91
C-3	0.011	1.86	2.07	1.96	201	0.39		11.83
C-4	0.006	1.37	1.47	1.42	201	0.29		11.40

Sample Spike Recoveries:

950038	0.040	4.69	4.69	110%	20.000
SPIKE	0.264	26.59	26.59		
950039	0.002	0.98	0.98	104%	20.000
SPIKE	0.215	21.80	21.80		

Barium
9/6/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9989	0.9987
SLOPE	0.0102	0.0084
Y-INTERCEPT	-0.0080	-0.0064

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm		pH
NBS1643c	0.062	6.84	8.15	7.50	6	44.97	91% recovery	
Blank - 1	-0.005	0.29	0.16	0.23	201			9.04
2	-0.006	0.19	0.04	0.12	201			5.69
3	-0.004	0.39	0.28	0.34	201			6.35
4	-0.012	-0.39	-0.67	-0.53	201			5.18
950040 A-1	0.004	1.17	1.24	1.20	201	< 0.251		7.63
A-2	0.011	1.86	2.07	1.96	201	0.394		6.74
A-3	0.026	3.32	3.86	3.59	201	0.722		7.20
A-4	0.038	4.50	5.29	4.89	201	0.983		8.99
950040 B-1	-0.002	0.58	0.52	0.55	201	< 0.251		7.53
B-2	0.013	2.05	2.31	2.18	201	0.438		7.27
B-3	0.023	3.03	3.50	3.26	201	0.656		7.05
B-4	0.036	4.30	5.05	4.67	201	0.940		8.36
950040 C-1	-0.010	-0.20	-0.43	-0.32	201	< 0.251		7.53
C-2	0.009	1.66	1.83	1.75	201	0.351		8.61
C-3	0.025	3.22	3.74	3.48	201	0.700		8.35
C-4	0.030	3.71	4.33	4.02	201	0.809		8.08
950041 A-1	0.001	0.88	0.88	0.88	201	< 0.251		9.31
A-2	-0.007	0.10	-0.08	0.01	201	< 0.251		9.61
A-3	-0.002	0.58	0.52	0.55	201	< 0.251		9.37
A-4	-0.003	0.49	0.40	0.44	201	< 0.251		9.80
950041 B-1	-0.003	0.49	0.40	0.44	201	< 0.251		9.40
B-2	-0.003	0.49	0.40	0.44	201	< 0.251		9.25
B-3	0.000	0.78	0.76	0.77	201	< 0.251		9.32
B-4	-0.003	0.49	0.40	0.44	201	< 0.251		9.65
950041 C-1	-0.005	0.29	0.16	0.23	201	< 0.251		9.29
C-2	0.001	0.88	0.88	0.88	201	< 0.251		9.00
C-3	-0.003	0.49	0.40	0.44	201	< 0.251		9.11
C-4	-0.009	-0.10	-0.31	-0.21	201	< 0.251		9.39

Sample Spike Recoveries:

950040	0.038	4.50	5.29	4.89	103%	20.000
SPIKE	0.228	23.07	27.93	25.50		
950041	-0.003	0.49	0.40	0.44	103%	20.000
SPIKE	0.187	19.06	23.05	21.05		

Cadmium
6/12/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9984	0.9999	0.9996	1.000
SLOPE	0.3612	0.3529	0.3407	0.336
Y-INTERCEPT	0.0093	0.0185	0.0230	0.02

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
BCR 146	0.156	0.41	0.39	0.40	1	79.58	102%	recovery	
Blank - 1	0.018	-0.01	0.00	-0.01	1				9.04
2	0.017	-0.02	0.00	-0.01	1				5.69
3	0.018	-0.01	0.00	-0.01	1				6.35
4	0.018	-0.01	0.00	-0.01	1				5.18
950038 A-1	0.022	0.04	0.01	0.02	1	< 0.025			11.19
A-2	0.026	0.01	0.03	0.02	1	< 0.025			12.07
A-3	0.026	0.01	0.03	0.02	1	< 0.025			12.09
A-4	0.026	0.01	0.03	0.02	1	< 0.025			12.05
950038 B-1	0.031	0.02	0.04	0.03	1	0.032			11.41
B-2	0.026	0.01	0.03	0.02	1	< 0.025			11.91
B-3	0.025	0.01	0.02	0.01	1	< 0.025			11.82
B-4	0.024	0.00	0.02	0.01	1	< 0.025			12.11
950038 C-1	0.029	0.02	0.04	0.03	1	0.027			11.79
C-2	0.026	0.01	0.03	0.02	1	< 0.025			11.86
C-3	0.024	0.00	0.02	0.01	1	< 0.025			11.81
C-4	0.023	0.00	0.02	0.01	1	< 0.025			12.05
950039 A-1	0.023	0.04	0.01	0.03	1	0.025			11.65
A-2	0.019	-0.01	0.01	0.00	1	< 0.025			11.71
A-3	0.021	-0.01	0.01	0.00	1	< 0.025			11.65
A-4	0.019	-0.01	0.01	0.00	1	< 0.025			11.52
950039 B-1	0.027	0.01	0.03	0.02	1	< 0.025			11.78
B-2	0.029	0.02	0.04	0.03	1	0.027			11.83
B-3	0.020	-0.01	0.01	0.00	1	< 0.025			11.81
B-4	0.020	-0.01	0.01	0.00	1	< 0.025			11.56
950039 C-1	0.027	0.01	0.03	0.02	1	< 0.025			12.00
C-2	0.018	-0.01	0.00	-0.01	1	< 0.025			11.91
C-3	0.021	-0.01	0.01	0.00	1	< 0.025			11.83
C-4	0.019	-0.01	0.01	0.00	1	< 0.025			11.40

Sample Spike Recoveries:

950038 A-1	0.022	0.04	0.01	0.02	100%	0.909
SPIKE	0.345	0.93	0.93	0.93		
950039 A-1	0.023	0.04	0.01	0.03	97%	0.909
SPIKE	0.339	0.91	0.91	0.91		

Cadmium
6/12/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9996	0.9991
SLOPE	0.3358	0.3256
Y-INTERCEPT	0.0170	0.0113

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
BCR 146	0.156	0.41	0.39	0.4	1	80	102%	recovery	
Blank - 1	0.018	-0.01	0.00	-0.01	1				9.04
2	0.017	-0.02	0.00	-0.01	1				5.69
3	0.018	-0.01	0.00	-0.01	1				6.35
4	0.018	-0.01	0.00	-0.01	1				5.18
950040 A-1	0.015	-0.01	0.01	0.00	1	< 0.025			7.63
A-2	0.015	-0.01	0.01	0.00	1	< 0.025			6.74
A-3	0.011	-0.02	0.00	-0.01	1	< 0.025			7.20
A-4	0.011	-0.02	0.00	-0.01	1	< 0.025			8.99
950040 B-1	0.016	0.00	0.01	0.01	1	< 0.025			7.53
B-2	0.011	-0.02	0.00	-0.01	1	< 0.025			7.27
B-3	0.011	-0.02	0.00	-0.01	1	< 0.025			7.05
B-4	0.012	-0.02	0.00	-0.01	1	< 0.025			8.36
950040 C-1	0.020	0.01	0.03	0.02	1	< 0.025			7.53
C-2	0.009	-0.02	-0.01	-0.02	1	< 0.025			8.61
C-3	0.011	-0.02	0.00	-0.01	1	< 0.025			8.35
C-4	0.011	-0.02	0.00	-0.01	1	< 0.025			8.08
950041 A-1	0.018	0.00	0.02	0.01	1	< 0.025			9.31
A-2	0.009	-0.02	-0.01	-0.02	1	< 0.025			9.61
A-3	0.010	-0.02	0.00	-0.01	1	< 0.025			9.37
A-4	0.009	-0.02	-0.01	-0.02	1	< 0.025			9.80
950041 B-1	0.010	-0.02	0.00	-0.01	1	< 0.025			9.40
B-2	0.008	-0.03	-0.01	-0.02	1	< 0.025			9.25
B-3	0.012	-0.02	0.00	-0.01	1	< 0.025			9.32
B-4	0.011	-0.02	0.00	-0.01	1	< 0.025			9.65
950041 C-1	0.009	-0.02	-0.01	-0.02	1	< 0.025			9.29
C-2	0.007	-0.03	-0.01	-0.02	1	< 0.025			9.00
C-3	0.006	-0.03	-0.02	-0.02	1	< 0.025			9.11
C-4	0.007	-0.03	-0.01	-0.02	1	< 0.025			9.39

Sample Spike Recoveries:

950040 A-1	0.015	-0.01	0.01	0.00	102%	0.909
SPIKE	0.323	0.91	0.96	0.93		
950041 A-1	0.018	0.00	0.02	0.01	100%	0.909
SPIKE	0.318	0.90	0.94	0.92		

Calcium
rerun 9/22/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9979	0.9982	0.9991	0.999	0.9996	0.9997
SLOPE	0.0305	0.0303	0.0278	0.027	0.0480	0.0421
Y-INTERCEPT	0.0024	0.0021	0.0019	0.000	0.0026	0.0018

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm	pH
Blank - 1	0	0.00	-0.03	-0.02	21		9.04
2	0	0.00	-0.03	-0.02	21		5.69
3	-0.001	-0.02	-0.05	-0.04	21		6.35
4	0.001	0.03	-0.01	0.01	21		5.18
950038 A-1	0.046	1.59	1.68	1.63	1001	1633	11.19
A-2	0.023	0.76	0.83	0.79	1001	795	12.07
A-3	0.021	0.69	0.76	0.72	1001	723	12.09
A-4	0.019	0.55	0.56	0.55	1001	553	12.05
950038 B-1	0.038	1.30	1.38	1.34	1001	1342	11.41
B-2	0.031	1.05	1.13	1.09	1001	1087	11.91
B-3	0.019	0.62	0.68	0.65	1001	650	11.82
B-4	0.017	0.54	0.61	0.58	1001	577	12.11
950038 C-1	0.042	1.44	1.53	1.49	1001	1487	11.79
C-2	0.023	0.76	0.83	0.79	1001	795	11.86
C-3	0.050	1.73	1.83	1.78	1001	1779	11.81
C-4	0.015	0.47	0.54	0.50	1001	504	12.05
950039 A-1	0.055	1.73	1.75	1.74	401	696	11.65
A-2	0.032	0.97	0.99	0.98	401	393	11.71
A-3	0.023	0.68	0.69	0.68	401	274	11.65
A-4	0.026	0.78	0.79	0.78	401	314	11.52
950039 B-1	0.054	1.69	1.71	1.70	401	683	11.78
B-2	0.035	1.07	1.09	1.08	401	432	11.83
B-3	0.029	0.87	0.89	0.88	401	353	11.81
B-4	0.023	0.68	0.69	0.68	401	274	11.56
950039 C-1	0.265	8.61	8.67	8.64	401	3466	12.00
C-2	0.048	1.50	1.52	1.51	401	604	11.91
C-3	0.027	0.81	0.82	0.82	401	327	11.83
C-4	0.021	0.61	0.62	0.62	401	248	11.40

Sample Spike Recoveries:

950038 A-4	0.019	0.55	0.56	0.55	105%	1.000
SPIKE	0.051	1.60	1.61	1.60		
950039 A-4	0.026	0.78	0.79	0.78	109%	1.000
SPIKE	0.059	1.86	1.88	1.87		

Calcium
7/22/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9997	0.9997	0.9999	1.000	0.9979	0.9982
SLOPE	0.0435	0.0400	0.0453	0.043	0.0305	0.0303
Y-INTERCEPT	0.0017	-0.0002	0.0012	0.000	0.0024	0.0021

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm	pH
Blank - 1	0.000	0.00	-0.03	-0.01	21		9.04
2	0.000	0.00	-0.03	-0.01	21		5.69
3	-0.001	-0.02	-0.05	-0.04	21		6.35
4	0.001	0.03	-0.01	0.01	21		5.18
950040 A-1	0.057	1.27	1.43	1.35	101	136.45	7.63
A-2	0.254	5.58	5.94	5.76	1	5.76	6.74
A-3	0.065	1.41	1.52	1.46	1	1.46	7.20
A-4	0.080	1.80	2.01	1.90	1	1.90	8.99
950040 B-1	0.184	4.04	4.30	4.17	101	421.22	7.53
B-2	0.248	5.45	5.80	5.63	1	5.63	7.27
B-3	0.065	1.41	1.52	1.46	1	1.46	7.05
B-4	0.039	0.83	0.91	0.87	1	0.87	8.36
950040 C-1	0.065	1.41	1.52	1.46	101	147.75	7.53
C-2	0.260	5.72	6.08	5.90	1	5.90	8.61
C-3	0.098	2.14	2.29	2.21	1	2.21	8.35
C-4	0.039	0.83	0.91	0.87	1	0.87	8.08
950041 A-1	0.032	0.70	0.80	0.75	101	75.84	9.31
A-2	0.036	1.10	1.12	1.11	21	23.34	9.61
A-3	0.034	0.72	0.79	0.76	21	15.91	9.37
A-4	0.031	0.66	0.72	0.69	21	14.47	9.80
950041 B-1	0.036	0.77	0.84	0.80	101	81.11	9.40
B-2	0.050	1.08	1.17	1.12	21	23.55	9.25
B-3	0.040	0.86	0.93	0.89	21	18.78	9.32
B-4	0.038	0.81	0.89	0.85	21	17.82	9.65
950041 C-1	0.042	0.90	0.98	0.94	101	94.90	9.29
C-2	0.058	1.25	1.35	1.30	21	27.38	9.00
C-3	0.042	0.90	0.98	0.94	21	19.73	9.11
C-4	0.036	0.77	0.84	0.80	21	16.86	9.39

Sample Spike Recoveries:

950040 A-1	0.057	1.27	1.43	1.35	94%	1.00
SPIKE	0.096	2.17	2.41	2.29		
950041 A-1	0.032	0.70	0.80	0.75	94%	1.00
SPIKE	0.071	1.59	1.78	1.69		
950040 A-4	0.080	1.80	2.01	1.90	92%	0.909
SPIKE	0.115	2.61	2.88	2.74		
950041 A-2	0.036	1.10	1.12	1.11	100%	0.950
SPIKE	0.065	2.05	2.08	2.07		

Chromium
7/15/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9983	0.9997
SLOPE	0.0251	0.0207
Y-INTERCEPT	0.0091	0.0018

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm			pH
NBS 1643c	0.185	7.02		7.02	3	21.05	111%	recovery	
Blank - 1	-0.002	-0.44	-0.18	-0.31	11				9.04
2	-0.003	-0.48	-0.23	-0.36	11				5.69
3	-0.004	-0.52	-0.28	-0.40	11				6.35
4	-0.004	-0.52	-0.28	-0.40	11				5.18
950038 A-1	0.008	-0.04	0.30	0.13	11	< 0.006			11.19
A-2	-0.005	-0.56	-0.33	-0.45	11	< 0.006			12.07
A-3	-0.006	-0.60	-0.38	-0.49	11	< 0.006			12.09
A-4	-0.007	-0.64	-0.43	-0.53	11	< 0.006			12.05
950038 B-1	-0.008	-0.68	-0.47	-0.58	11	< 0.006			11.41
B-2	-0.008	-0.68	-0.47	-0.58	11	< 0.006			11.91
B-3	-0.007	-0.64	-0.43	-0.53	11	< 0.006			11.82
B-4	-0.009	-0.72	-0.52	-0.62	11	< 0.006			12.11
950038 C-1	-0.009	-0.72	-0.52	-0.62	11	< 0.006			11.79
C-2	-0.008	-0.68	-0.47	-0.58	11	< 0.006			11.86
C-3	-0.008	-0.68	-0.47	-0.58	11	< 0.006			11.81
C-4	-0.009	-0.72	-0.52	-0.62	11	< 0.006			12.05
950039 A-1	0.059	1.99	2.76	2.37	11	0.026			11.65
A-2	0.046	1.47	2.13	1.80	11	0.020			11.71
A-3	0.062	2.11	2.90	2.51	11	0.028			11.65
A-4	0.073	2.55	3.43	2.99	11	0.033			11.52
950039 B-1	0.029	0.79	1.31	1.05	11	0.012			11.78
B-2	0.038	1.15	1.74	1.45	11	0.016			11.83
B-3	0.050	1.63	2.32	1.98	11	0.022			11.81
B-4	0.065	2.23	3.05	2.64	11	0.029			11.56
950039 C-1	0.027	0.71	1.21	0.96	11	0.011			12.00
C-2	0.037	1.11	1.70	1.40	11	0.015			11.91
C-3	0.049	1.59	2.28	1.93	11	0.021			11.83
C-4	0.066	2.27	3.09	2.68	11	0.030			11.40

Sample Spike Recoveries:

950038	0.008	-0.04	-0.04	109%	4.550
SPIKE	0.132	4.90	4.90		
950039	0.059	1.99	1.99	108%	4.550
SPIKE	0.182	6.90	6.90		

Chromium
7/15/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9983	0.9997
SLOPE	0.0251	0.0207
Y-INTERCEPT	0.0091	0.0018

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm			pH
NBS1643C	0.185	7.02		7.02	3	21	111%	recovery	
Blank - 1	-0.002	-0.44	-0.18	-0.31	11				9.04
2	-0.003	-0.48	-0.23	-0.36	11				5.69
3	-0.004	-0.52	-0.28	-0.40	11				6.35
4	-0.004	-0.52	-0.28	-0.40	11				5.18
950040 A-1	0.011	0.08	0.44	0.26	11	< 0.006			7.63
A-2	0.013	0.16	0.54	0.35	11	< 0.006			6.74
A-3	0.005	-0.16	0.15	-0.01	11	< 0.006			7.20
A-4	0.001	-0.32	-0.04	-0.18	11	< 0.006			8.99
950040 B-1	-0.001	-0.40	-0.14	-0.27	11	< 0.006			7.53
B-2	0.000	-0.36	-0.09	-0.23	11	< 0.006			7.27
B-3	-0.001	-0.40	-0.14	-0.27	11	< 0.006			7.05
B-4	0.000	-0.36	-0.09	-0.23	11	< 0.006			8.36
950040 C-1	0.000	-0.36	-0.09	-0.23	11	< 0.006			7.53
C-2	-0.001	-0.40	-0.14	-0.27	11	< 0.006			8.61
C-3	-0.001	-0.40	-0.14	-0.27	11	< 0.006			8.35
C-4	-0.002	-0.44	-0.18	-0.31	11	< 0.006			8.08
950041 A-1	0.031	0.87	1.41	1.14	11	0.013			9.31
A-2	0.015	0.24	0.64	0.44	11	< 0.006			9.61
A-3	0.008	-0.04	0.30	0.13	11	< 0.006			9.37
A-4	0.015	0.24	0.64	0.44	11	< 0.006			9.80
950041 B-1	0.004	-0.20	0.11	-0.05	11	< 0.006			9.40
B-2	0.003	-0.24	0.06	-0.09	11	< 0.006			9.25
B-3	0.002	-0.28	0.01	-0.14	11	< 0.006			9.32
B-4	0.002	-0.28	0.01	-0.14	11	< 0.006			9.65
950041 C-1	0.003	-0.24	0.06	-0.09	11	< 0.006			9.29
C-2	0.002	-0.28	0.01	-0.14	11	< 0.006			9.00
C-3	0.002	-0.28	0.01	-0.14	11	< 0.006			9.11
C-4	0.001	-0.32	-0.04	-0.18	11	< 0.006			9.39

Sample Spike Recoveries:

950040	0.011	0.08	0.08	106%	4.550
SPIKE	0.132	4.90	4.90		
950041	0.031	0.87	0.87	103%	4.550
SPIKE	0.149	5.58	5.58		

Copper
7/8/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9998	0.9999	0.9999	1.000
SLOPE	0.0928	0.0931	0.0996	0.093
Y-INTERCEPT	0.0022	0.0011	0.0007	0.005

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.054	0.56	0.57	0.56	1	113	95%	recovery	
Blank - 1	-0.001	-0.03	-0.02	-0.03	1				9.04
2	-0.001	-0.03	-0.02	-0.03	1				5.69
3	0.000	-0.02	-0.01	-0.02	1				6.35
4	-0.001	-0.03	-0.02	-0.03	1				5.18
950038 A-1	0.001	-0.01	0.00	-0.01	1	< 0.075			11.19
A-2	0.002	0.00	0.01	0.00	1	< 0.075			12.07
A-3	0.001	-0.01	0.00	-0.01	1	< 0.075			12.09
A-4	0.001	-0.01	0.00	-0.01	1	< 0.075			12.05
950038 B-1	0.002	0.00	0.01	0.00	1	< 0.075			11.41
B-2	0.001	-0.01	0.00	-0.01	1	< 0.075			11.91
B-3	0.001	-0.01	0.00	-0.01	1	< 0.075			11.82
B-4	0.003	0.01	0.02	0.01	1	< 0.075			12.11
950038 C-1	0.004	0.02	0.03	0.03	1	< 0.075			11.79
C-2	0.002	0.00	0.01	0.00	1	< 0.075			11.86
C-3	0.001	-0.01	0.00	-0.01	1	< 0.075			11.81
C-4	0.001	-0.01	0.00	-0.01	1	< 0.075			12.05
950039 A-1	0.002	0.00	0.01	0.00	1	< 0.075			11.65
A-2	0.001	-0.01	0.00	-0.01	1	< 0.075			11.71
A-3	0.000	-0.02	-0.01	-0.02	1	< 0.075			11.65
A-4	0.001	-0.01	0.00	-0.01	1	< 0.075			11.52
950039 B-1	0.001	-0.01	0.00	-0.01	1	< 0.075			11.78
B-2	0.001	-0.01	0.00	-0.01	1	< 0.075			11.83
B-3	0.002	0.00	0.01	0.00	1	< 0.075			11.81
B-4	0.001	-0.01	0.00	-0.01	1	< 0.075			11.56
950039 C-1	0.001	-0.01	0.00	-0.01	1	< 0.075			12.00
C-2	0.001	-0.01	0.00	-0.01	1	< 0.075			11.91
C-3	0.000	-0.02	-0.01	-0.02	1	< 0.075			11.83
C-4	0.000	-0.02	-0.01	-0.02	1	< 0.075			11.40

Sample Spike Recoveries:

950038 A-1	0.003	0.02	-0.02	0.00	91%	1.820
SPIKE	0.163	1.63	1.70	1.66		
950039 A-1	0.003	0.02	-0.02	0.00	100%	1.820
SPIKE	0.178	1.78	1.86	1.82		

Copper
7/8/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9998	0.9999	0.9999	1.000
SLOPE	0.0928	0.0931	0.0996	0.093
Y-INTERCEPT	0.0022	0.0011	0.0007	0.005

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.054	0.56	0.57	0.56	1	113	95%	recovery	
Blank - 1	-0.001	-0.03	-0.02	-0.03	1				9.04
2	-0.001	-0.03	-0.02	-0.03	1				5.69
3	0.000	-0.02	-0.01	-0.02	1				6.35
4	-0.001	-0.03	-0.02	-0.03	1				5.18
950040 A-1	0.001	-0.01	0.00	-0.01	1	< 0.075			7.63
A-2	0.001	-0.01	0.00	-0.01	1	< 0.075			6.74
A-3	-0.001	-0.03	-0.02	-0.03	1	< 0.075			7.20
A-4	0.001	-0.01	0.00	-0.01	1	< 0.075			8.99
950040 B-1	0.002	0.00	0.01	0.00	1	< 0.075			7.53
B-2	0.001	-0.01	0.00	-0.01	1	< 0.075			7.27
B-3	-0.001	-0.03	-0.02	-0.03	1	< 0.075			7.05
B-4	0.001	-0.01	0.00	-0.01	1	< 0.075			8.36
950040 C-1	0.008	0.06	0.07	0.07	1	< 0.075			7.53
C-2	0.001	-0.01	0.00	-0.01	1	< 0.075			8.61
C-3	-0.001	-0.03	-0.02	-0.03	1	< 0.075			8.35
C-4	0.000	-0.02	-0.01	-0.02	1	< 0.075			8.08
950041 A-1	0.001	-0.01	0.00	-0.01	1	< 0.075			9.31
A-2	0.000	-0.02	-0.01	-0.02	1	< 0.075			9.61
A-3	0.000	-0.02	-0.01	-0.02	1	< 0.075			9.37
A-4	0.000	-0.02	-0.01	-0.02	1	< 0.075			9.80
950041 B-1	0.000	-0.02	-0.01	-0.02	1	< 0.075			9.40
B-2	-0.002	-0.05	-0.03	-0.04	1	< 0.075			9.25
B-3	0.000	-0.02	-0.01	-0.02	1	< 0.075			9.32
B-4	0.000	-0.02	-0.01	-0.02	1	< 0.075			9.65
950041 C-1	-0.001	-0.03	-0.02	-0.03	1	< 0.075			9.29
C-2	-0.001	-0.03	-0.02	-0.03	1	< 0.075			9.00
C-3	0.000	-0.02	-0.01	-0.02	1	< 0.075			9.11
C-4	-0.001	-0.03	-0.02	-0.03	1	< 0.075			9.39

Sample Spike Recoveries:

950040 A-1	0.004	0.03	-0.01	0.01	101%	1.820
SPIKE	0.181	1.81	1.89	1.85		
950041 A-1	0.002	0.01	-0.03	-0.01	92%	1.820
SPIKE	0.164	1.64	1.71	1.67		

Iron
7/9/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9997	0.9998
SLOPE	0.0478	0.0519
Y-INTERCEPT	0.0125	0.0035

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.124	2.33	2.32	2.33	201	93586	100%	recovery	
Blank - 1	0.013	0.01	0.18	0.10	1				9.04
2	0.011	-0.03	0.14	0.06	1				5.69
3	0.009	-0.07	0.11	0.02	1				6.35
4	0.011	-0.03	0.14	0.06	1				5.18
950038 A-1	0.017	0.09	0.26	0.18	1	0.18			11.19
A-2	0.015	0.05	0.22	0.14	1	0.14			12.07
A-3	0.018	0.12	0.28	0.20	1	0.20			12.09
A-4	0.017	0.09	0.26	0.18	1	0.18			12.05
950038 B-1	0.017	0.09	0.26	0.18	1	0.18			11.41
B-2	0.014	0.03	0.20	0.12	1	0.12			11.91
B-3	0.017	0.09	0.26	0.18	1	0.18			11.82
B-4	0.015	0.05	0.22	0.14	1	0.14			12.11
950038 C-1	0.017	0.09	0.26	0.18	1	0.18			11.79
C-2	0.016	0.07	0.24	0.16	1	0.16			11.86
C-3	0.016	0.07	0.24	0.16	1	0.16			11.81
C-4	0.014	0.03	0.20	0.12	1	0.12			12.05
950039 A-1	0.012	-0.01	0.16	0.08	1	< 0.12			11.65
A-2	0.011	-0.03	0.14	0.06	1	< 0.12			11.71
A-3	0.011	-0.03	0.14	0.06	1	< 0.12			11.65
A-4	0.013	0.02	0.19	0.10	1	< 0.12			11.52
950039 B-1	0.016	0.07	0.24	0.16	1	0.16			11.78
B-2	0.012	-0.01	0.16	0.08	1	< 0.12			11.83
B-3	0.014	0.03	0.20	0.12	1	0.12			11.81
B-4	0.011	-0.03	0.14	0.06	1	< 0.12			11.56
950039 C-1	0.012	-0.01	0.16	0.08	1	< 0.12			12.00
C-2	0.010	-0.05	0.13	0.04	1	< 0.12			11.91
C-3	0.013	0.01	0.18	0.10	1	< 0.12			11.83
C-4	0.013	0.01	0.18	0.10	1	< 0.12			11.40

Sample Spike Recoveries:

950038 A-1	0.017	0.09	0.26	0.18	91%	1.820
SPIKE	0.099	1.81	1.84	1.83		
950039 A-1	0.012	-0.01	0.16	0.08	102%	1.820
SPIKE	0.104	1.92	1.94	1.93		

Iron
7/9/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9997	0.9998
SLOPE	0.0478	0.0519
Y-INTERCEPT	0.0125	0.0035

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.124	2.33	2.32	2.33	201	93586	100%	recovery	
Blank - 1	0.013	0.01	0.18	0.10	1				9.04
2	0.011	-0.03	0.14	0.06	1				5.69
3	0.009	-0.07	0.11	0.02	1				6.35
4	0.011	-0.03	0.14	0.06	1				5.18
950040 A-1	0.008	-0.09	0.09	0.00	1	< 0.12			7.63
A-2	0.009	-0.07	0.11	0.02	1	< 0.12			6.74
A-3	0.011	-0.03	0.14	0.06	1	< 0.12			7.20
A-4	0.011	-0.03	0.14	0.06	1	< 0.12			8.99
950040 B-1	0.012	-0.01	0.16	0.08	1	< 0.12			7.53
B-2	0.006	-0.14	0.05	-0.04	1	< 0.12			7.27
B-3	0.011	-0.03	0.14	0.06	1	< 0.12			7.05
B-4	0.009	-0.07	0.11	0.02	1	< 0.12			8.36
950040 C-1	0.013	0.01	0.18	0.10	1	< 0.12			7.53
C-2	0.009	-0.07	0.11	0.02	1	< 0.12			8.61
C-3	0.013	0.01	0.18	0.10	1	< 0.12			8.35
C-4	0.010	-0.05	0.13	0.04	1	< 0.12			8.08
950041 A-1	0.007	-0.11	0.07	-0.02	1	< 0.12			9.31
A-2	0.004	-0.18	0.01	-0.08	1	< 0.12			9.61
A-3	0.008	-0.09	0.09	0.00	1	< 0.12			9.37
A-4	0.009	-0.07	0.11	0.02	1	< 0.12			9.80
950041 B-1	0.014	0.03	0.20	0.12	1	0.12			9.40
B-2	0.010	-0.05	0.13	0.04	1	< 0.12			9.25
B-3	0.011	-0.03	0.14	0.06	1	< 0.12			9.32
B-4	0.013	0.01	0.18	0.10	1	< 0.12			9.65
950041 C-1	0.014	0.03	0.20	0.12	1	0.12			9.29
C-2	0.011	-0.03	0.14	0.06	1	< 0.12			9.00
C-3	0.011	-0.03	0.14	0.06	1	< 0.12			9.11
C-4	0.008	-0.09	0.09	0.00	1	< 0.12			9.39

Sample Spike Recoveries:

950040 A-1	0.008	-0.09	0.09	0.00	91%	1.820
SPIKE	0.090	1.62	1.67	1.64		
950041 A-1	0.007	-0.11	0.07	-0.02	95%	1.820
SPIKE	0.093	1.69	1.72	1.70		

Lead
7/8/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9993	0.9999	0.9999	1
SLOPE	0.0220	0.0215	0.0207	0.02
Y-INTERCEPT	-0.0004	0.0065	0.0072	0.01

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm		pH
BCR 146	0.030	1.39	1.11	1.25	5	1250	98% recovery	
Blank - 1	0.01	0.09	-0.02	0.03	1			9.04
2	0.01	0.09	-0.02	0.03	1			5.69
3	0.01	-0.01	-0.12	-0.06	1			6.35
4	0.01	-0.01	-0.12	-0.06	1			5.18
950038 A-1	0.008	0.38	0.07	0.23	1	0.23		11.19
A-2	0.014	0.33	0.22	0.28	1	0.28		12.07
A-3	0.012	0.23	0.13	0.18	1	0.18		12.09
A-4	0.011	0.19	0.08	0.13	1	0.13		12.05
950038 B-1	0.017	0.47	0.37	0.42	1	0.42		11.41
B-2	0.014	0.33	0.22	0.28	1	0.28		11.91
B-3	0.012	0.23	0.13	0.18	1	0.18		11.82
B-4	0.013	0.28	0.17	0.23	1	0.23		12.11
950038 C-1	0.014	0.33	0.22	0.28	1	0.28		11.79
C-2	0.014	0.33	0.22	0.28	1	0.28		11.86
C-3	0.011	0.19	0.08	0.13	1	0.13		11.81
C-4	0.010	0.14	0.03	0.08	1	< 0.125		12.05
950039 A-1	0.008	0.38	0.07	0.23	1	0.23		11.65
A-2	0.013	0.28	0.17	0.23	1	0.23		11.71
A-3	0.010	0.14	0.03	0.08	1	< 0.125		11.65
A-4	0.010	0.14	0.03	0.08	1	< 0.125		11.52
950039 B-1	0.012	0.23	0.13	0.18	1	0.18		11.78
B-2	0.011	0.19	0.08	0.13	1	0.13		11.83
B-3	0.011	0.19	0.08	0.13	1	0.13		11.81
B-4	0.009	0.09	-0.02	0.03	1	< 0.125		11.56
950039 C-1	0.011	0.19	0.08	0.13	1	0.13		12.00
C-2	0.011	0.19	0.08	0.13	1	0.13		11.91
C-3	0.009	0.09	-0.02	0.03	1	< 0.125		11.83
C-4	0.012	0.23	0.13	0.18	1	0.18		11.40

Sample Spike Recoveries:

950038 A-1	0.008	0.38	0.07	0.23	91%	1.820
SPIKE	0.044	2.02	1.75	1.88		
950039 A-1	0.008	0.38	0.07	0.23	96%	1.820
SPIKE	0.046	2.11	1.84	1.97		

Lead
7/8/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9993	0.9999	0.9999	1
SLOPE	0.0220	0.0215	0.0207	0.02
Y-INTERCEPT	-0.0004	0.0065	0.0072	0.01

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
BCR 146	0.030	1.39	1.11	1.25	5	1250	98%	recovery	
Blank - 1	0.01	0.09	-0.02	0.03	1				9.04
2	0.01	0.09	-0.02	0.03	1				5.69
3	0.01	-0.01	-0.12	-0.06	1				6.35
4	0.01	-0.01	-0.12	-0.06	1				5.18
950040 A-1	0.007	0.34	0.02	0.18	1	0.18			7.63
A-2	0.008	0.04	-0.07	-0.01	1	< 0.125			6.74
A-3	0.009	0.09	-0.02	0.03	1	< 0.125			7.20
A-4	0.009	0.09	-0.02	0.03	1	< 0.125			8.99
950040 B-1	0.011	0.19	0.08	0.13	1	0.13			7.53
B-2	0.010	0.14	0.03	0.08	1	< 0.125			7.27
B-3	0.008	0.04	-0.07	-0.01	1	< 0.125			7.05
B-4	0.009	0.09	-0.02	0.03	1	< 0.125			8.36
950040 C-1	0.012	0.23	0.13	0.18	1	0.18			7.53
C-2	0.010	0.14	0.03	0.08	1	< 0.125			8.61
C-3	0.009	0.09	-0.02	0.03	1	< 0.125			8.35
C-4	0.008	0.04	-0.07	-0.01	1	< 0.125			8.08
950041 A-1	0.007	0.34	0.02	0.18	1	0.18			9.31
A-2	0.008	0.04	-0.07	-0.01	1	< 0.125			9.61
A-3	0.010	0.14	0.03	0.08	1	< 0.125			9.37
A-4	0.010	0.14	0.03	0.08	1	< 0.125			9.80
950041 B-1	0.008	0.04	-0.07	-0.01	1	< 0.125			9.40
B-2	0.009	0.09	-0.02	0.03	1	< 0.125			9.25
B-3	0.011	0.19	0.08	0.13	1	0.13			9.32
B-4	0.010	0.14	0.03	0.08	1	< 0.125			9.65
950041 C-1	0.010	0.14	0.03	0.08	1	< 0.125			9.29
C-2	0.007	-0.01	-0.12	-0.06	1	< 0.125			9.00
C-3	0.008	0.04	-0.07	-0.01	1	< 0.125			9.11
C-4	0.010	0.14	0.03	0.08	1	< 0.125			9.39

Sample Spike Recoveries:

950040 A-1	0.007	0.34	0.02	0.18	96%	1.820
SPIKE	0.045	2.06	1.79	1.93		
950041 A-1	0.007	0.34	0.02	0.18	91%	1.820
SPIKE	0.043	1.97	1.70	1.84		

Magnesium
7/21/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9704	0.9803	0.9835	0.980
SLOPE	0.1414	0.1711	0.5215	0.537
Y-INTERCEPT	0.0122	0.0128	0.0088	0.014

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.068	0.11	0.10	0.11	201	4308	95%	recovery	
Blank - 1	0.005	-0.05	-0.05	-0.05	1				9.04
2	0.004	-0.06	-0.05	-0.05	1				5.69
3	0.002	-0.07	-0.06	-0.07	1				6.35
4	0.003	-0.06	-0.06	-0.06	1				5.18
950038 A-1	0.004	-0.06	-0.05	-0.05	1	< 0.05			11.19
A-2	0.003	-0.01	-0.02	-0.02	1	< 0.05			12.07
A-3	0.003	-0.01	-0.02	-0.02	1	< 0.05			12.09
A-4	0.003	-0.01	-0.02	-0.02	1	< 0.05			12.05
950038 B-1	0.002	-0.01	-0.02	-0.02	1	< 0.05			11.41
B-2	0.003	-0.01	-0.02	-0.02	1	< 0.05			11.91
B-3	0.002	-0.01	-0.02	-0.02	1	< 0.05			11.82
B-4	0.003	-0.01	-0.02	-0.02	1	< 0.05			12.11
950038 C-1	0.004	-0.01	-0.02	-0.01	1	< 0.05			11.79
C-2	0.001	-0.01	-0.02	-0.02	1	< 0.05			11.86
C-3	0.001	-0.01	-0.02	-0.02	1	< 0.05			11.81
C-4	0.005	-0.01	-0.02	-0.01	1	< 0.05			12.05
950039 A-1	0.007	-0.04	-0.03	-0.04	1	< 0.05			11.65
A-2	0.001	-0.01	-0.02	-0.02	1	< 0.05			11.71
A-3	0.003	-0.01	-0.02	-0.02	1	< 0.05			11.65
A-4	0.002	-0.01	-0.02	-0.02	1	< 0.05			11.52
950039 B-1	0.000	-0.02	-0.03	-0.02	1	< 0.05			11.78
B-2	0.002	-0.01	-0.02	-0.02	1	< 0.05			11.83
B-3	-0.001	-0.02	-0.03	-0.02	1	< 0.05			11.81
B-4	0.003	-0.01	-0.02	-0.02	1	< 0.05			11.56
950039 C-1	-0.001	-0.02	-0.03	-0.02	1	< 0.05			12.00
C-2	0.002	-0.01	-0.02	-0.02	1	< 0.05			11.91
C-3	-0.001	-0.02	-0.03	-0.02	1	< 0.05			11.83
C-4	0.001	-0.01	-0.02	-0.02	1	< 0.05			11.40

Sample Spike Recoveries:

950038 A-1	0.004	-0.06	-0.05	-0.05	104%	0.545
SPIKE	0.092	0.56	0.46	0.51		
950039 A-1	0.007	-0.04	-0.03	-0.04	103%	0.545
SPIKE	0.094	0.58	0.47	0.53		

Magnesium
7/21/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9785	0.9847	0.9805	0.986
SLOPE	0.2449	0.2664	0.5366	0.578
Y-INTERCEPT	0.0173	0.0192	0.0139	0.004

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.068	0.11	0.10	0.11	201	4308	95%	recovery	
Blank - 1	0.005	-0.05	-0.05	-0.05	1				9.04
2	0.004	-0.06	-0.05	-0.06	1				5.69
3	0.002	-0.07	-0.06	-0.07	1				6.35
4	0.003	-0.06	-0.06	-0.06	1				5.18
950040 A-1	0.063	0.09	0.10	0.10	51	4.96			7.63
A-2	0.295	0.52	0.50	0.51	1	0.51			6.74
A-3	0.101	0.16	0.17	0.17	1	0.17			7.20
A-4	0.064	0.09	0.10	0.10	1	0.10			8.99
950040 B-1	0.065	0.10	0.11	0.10	51	5.14			7.53
B-2	0.279	0.49	0.48	0.49	1	0.49			7.27
B-3	0.109	0.18	0.18	0.18	1	0.18			7.05
B-4	0.064	0.09	0.10	0.10	1	0.10			8.36
950040 C-1	0.068	0.10	0.11	0.11	51	5.41			7.53
C-2	0.279	0.49	0.48	0.49	1	0.49			8.61
C-3	0.101	0.16	0.17	0.17	1	0.17			8.35
C-4	0.059	0.08	0.10	0.09	1	0.09			8.08
950041 A-1	0.018	0.00	0.00	0.00	21	< 0.11			9.31
A-2	0.014	0.00	0.02	0.01	6	< 0.11			9.61
A-3	0.019	0.01	0.03	0.02	6	0.11			9.37
A-4	0.019	0.01	0.03	0.02	6	0.11			9.80
950041 B-1	0.017	0.01	0.02	0.01	21	0.30			9.40
B-2	0.023	0.02	0.03	0.03	6	0.15			9.25
B-3	0.018	0.01	0.02	0.02	6	< 0.11			9.32
B-4	0.021	0.01	0.03	0.02	6	0.13			9.65
950041 C-1	0.020	0.01	0.03	0.02	21	0.42			9.29
C-2	0.030	0.03	0.05	0.04	6	0.23			9.00
C-3	0.025	0.02	0.04	0.03	6	0.17			9.11
C-4	0.024	0.02	0.04	0.03	6	0.16			9.39

Sample Spike Recoveries:

950040 A-1	0.063	0.09	0.10	0.10	102%	0.196
SPIKE	0.174	0.30	0.29	0.30		
950041 A-1	0.018	0.00	0.00	0.00	105%	0.475
SPIKE	0.145	0.52	0.47	0.50		
950041 A-4	0.064	0.09	0.10	0.10	95%	0.470
SPIKE	0.313	0.56	0.54	0.55		

Manganese
7/9/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9995	0.9977	0.9985	0.999
SLOPE	0.0989	0.0985	0.0927	0.090
Y-INTERCEPT	0.0024	0.0078	0.0198	0.02

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm		pH
NBS1633a	0.087	0.86		0.86	1	171.21	90% recovery	
Blank - 1	0.012	-0.08	-0.08	-0.08	1			9.04
2	0.015	-0.05	-0.05	-0.05	1			5.69
3	0.015	-0.05	-0.05	-0.05	1			6.35
4	0.013	-0.07	-0.07	-0.07	1			5.18
950038 A-1	0.005	0.03	-0.03	0.00	1	< 0.075		11.19
A-2	0.012	-0.08	-0.08	-0.08	1	< 0.075		12.07
A-3	0.017	-0.03	-0.03	-0.03	1	< 0.075		12.09
A-4	0.016	-0.04	-0.04	-0.04	1	< 0.075		12.05
950038 B-1	0.019	-0.01	0.00	-0.01	1	< 0.075		11.41
B-2	0.022	0.02	0.03	0.03	1	< 0.075		11.91
B-3	0.017	-0.03	-0.03	-0.03	1	< 0.075		11.82
B-4	0.018	-0.02	-0.01	-0.02	1	< 0.075		12.11
950038 C-1	0.019	-0.01	0.00	-0.01	1	< 0.075		11.79
C-2	0.016	-0.04	-0.04	-0.04	1	< 0.075		11.86
C-3	0.018	-0.02	-0.01	-0.02	1	< 0.075		11.81
C-4	0.023	0.03	0.04	0.04	1	< 0.075		12.05
950039 A-1	0.009	0.07	0.01	0.04	1	< 0.075		11.65
A-2	0.020	0.00	0.01	0.00	1	< 0.075		11.71
A-3	0.017	-0.03	-0.03	-0.03	1	< 0.075		11.65
A-4	0.021	0.01	0.02	0.02	1	< 0.075		11.52
950039 B-1	0.021	0.01	0.02	0.02	1	< 0.075		11.78
B-2	0.018	-0.02	-0.01	-0.02	1	< 0.075		11.83
B-3	0.017	-0.03	-0.03	-0.03	1	< 0.075		11.81
B-4	0.018	-0.02	-0.01	-0.02	1	< 0.075		11.56
950039 C-1	0.021	0.01	0.02	0.02	1	< 0.075		12.00
C-2	0.021	0.01	0.02	0.02	1	< 0.075		11.91
C-3	0.021	0.01	0.02	0.02	1	< 0.075		11.83
C-4	0.015	-0.05	-0.05	-0.05	1	< 0.075		11.40

Sample Spike Recoveries:

950038 A-1	0.005	0.03	-0.03	0.00	94%	0.909
SPIKE	0.089	0.88	0.82	0.85		
950039 A-1	0.009	0.01	-0.12	-0.05	101%	1.820
SPIKE	0.184	1.79	1.77	1.78		

Manganese
7/9/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9995	0.9985	0.9993
SLOPE	0.0989	0.0927	0.0904
Y-INTERCEPT	0.0024	0.0198	0.0193

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm		pH
NBS 1633a	0.087	0.86		0.86	1	171.21	90% recovery	
Blank - 1	0.012	-0.08	-0.08	-0.08	1			9.04
2	0.015	-0.05	-0.05	-0.05	1			5.69
3	0.015	-0.05	-0.05	-0.05	1			6.35
4	0.013	-0.07	-0.07	-0.07	1			5.18
950040 A-1	0.021	0.19	0.01	0.10	1	0.101		7.63
A-2	0.015	-0.05	-0.05	-0.05	1	< 0.075		6.74
A-3	0.017	-0.03	-0.03	-0.03	1	< 0.075		7.20
A-4	0.018	-0.02	-0.01	-0.02	1	< 0.075		8.99
950040 B-1	0.034	0.15	0.16	0.16	1	0.158		7.53
B-2	0.018	-0.02	-0.01	-0.02	1	< 0.075		7.27
B-3	0.016	-0.04	-0.04	-0.04	1	< 0.075		7.05
B-4	0.018	-0.02	-0.01	-0.02	1	< 0.075		8.36
950040 C-1	0.034	0.15	0.16	0.16	1	0.158		7.53
C-2	0.023	0.03	0.04	0.04	1	< 0.075		8.61
C-3	0.017	-0.03	-0.03	-0.03	1	< 0.075		8.35
C-4	0.015	-0.05	-0.05	-0.05	1	< 0.075		8.08
950041 A-1	0.002	0.00	-0.19	-0.10	1	< 0.075		9.31
A-2	0.015	0.13	-0.05	0.04	1	< 0.075		9.61
A-3	0.013	0.11	-0.07	0.02	1	< 0.075		9.37
A-4	0.018	0.16	-0.02	0.07	1	< 0.075		9.80
950041 B-1	0.021	0.19	0.01	0.10	1	0.101		9.40
B-2	0.014	0.12	-0.06	0.03	1	< 0.075		9.25
B-3	0.012	0.10	-0.08	0.01	1	< 0.075		9.32
B-4	0.015	0.13	-0.05	0.04	1	< 0.075		9.65
950041 C-1	0.019	0.17	-0.01	0.08	1	0.080		9.29
C-2	0.018	0.16	-0.02	0.07	1	< 0.075		9.00
C-3	0.015	0.13	-0.05	0.04	1	< 0.075		9.11
C-4	0.015	0.13	-0.05	0.04	1	< 0.075		9.39

Sample Spike Recoveries:

950040 A-1	0.021	0.19	0.01	0.10	97%	0.909
SPIKE	0.105	1.04	0.92	0.98		
950041 A-1	0.002	0.00	-0.19	-0.10	101%	0.909
SPIKE	0.090	0.89	0.76	0.82		

Mercury
9/8/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9996	0.9999
SLOPE	0.0151	0.0147
Y-INTERCEPT	-0.0006	-0.0072

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm	pH
Blank - 1	-0.009	-0.56	-0.12	-0.34	10		9.04
2	-0.006	-0.36	0.08	-0.14	10		5.69
3	-0.008	-0.49	-0.05	-0.27	10		6.35
4	-0.009	-0.56	-0.12	-0.34	10		5.18
950038 A-1	-0.001	-0.03	0.42	0.2C	10	< 0.01	11.19
A-2	-0.003	-0.16	0.29	0.06	10	< 0.01	12.07
A-3	-0.004	-0.23	0.22	0.00	10	< 0.01	12.09
A-4	-0.003	-0.16	0.29	0.06	10	< 0.01	12.05
950038 B-1	0.002	0.17	0.63	0.40	10	< 0.01	11.41
B-2	-0.003	-0.16	0.29	0.06	10	< 0.01	11.91
B-3	-0.004	-0.23	0.22	0.00	10	< 0.01	11.82
B-4	-0.003	-0.16	0.29	0.06	10	< 0.01	12.11
950038 C-1	-0.003	-0.16	0.29	0.06	10	< 0.01	11.79
C-2	-0.003	-0.16	0.29	0.06	10	< 0.01	11.86
C-3	-0.004	-0.23	0.22	0.00	10	< 0.01	11.81
C-4	-0.003	-0.16	0.29	0.06	10	< 0.01	12.05
950039 A-1	-0.003	-0.16	0.29	0.06	10	< 0.01	11.65
A-2	-0.004	-0.23	0.22	0.00	10	< 0.01	11.71
A-3	-0.004	-0.23	0.22	0.00	10	< 0.01	11.65
A-4	0.000	0.04	0.49	0.26	10	< 0.01	11.52
950039 B-1	-0.004	-0.23	0.22	0.00	10	< 0.01	11.78
B-2	-0.005	-0.29	0.15	-0.07	10	< 0.01	11.83
B-3	-0.003	-0.16	0.29	0.06	10	< 0.01	11.81
B-4	0.001	0.10	0.56	0.33	10	< 0.01	11.56
950039 C-1	-0.003	-0.16	0.29	0.06	10	< 0.01	12.00
C-2	-0.004	-0.23	0.22	0.00	10	< 0.01	11.91
C-3	-0.005	-0.29	0.15	-0.07	10	< 0.01	11.83
C-4	-0.001	-0.03	0.42	0.20	10	< 0.01	11.40

Sample Spike Recoveries:

950038	-0.003	-0.16	0.29	0.06	104%	9.50
SPIKE	0.145	9.64	10.33	9.98		
950039	0.000	0.04	0.49	0.26	104%	9.50
SPIKE	0.148	9.84	10.54	10.19		

Mercury
9/8/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9996	0.9999
SLOPE	0.0151	0.0147
Y-INTERCEPT	-0.0006	-0.0072

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm	pH
Blank - 1	-0.009	-0.56	-0.12	-0.34	10		9.04
2	-0.006	-0.36	0.08	-0.14	10		5.69
3	-0.008	-0.49	-0.05	-0.27	10		6.35
4	-0.009	-0.56	-0.12	-0.34	10		5.18
950040 A-1	-0.003	-0.16	0.29	0.06	10	< C:01	7.63
A-2	-0.005	-0.29	0.15	-0.07	10	< 0.01	6.74
A-3	-0.006	-0.36	0.08	-0.14	10	< 0.01	7.20
A-4	-0.003	-0.16	0.29	0.06	10	< 0.01	8.99
950040 B-1	-0.003	-0.16	0.29	0.06	10	< 0.01	7.53
B-2	-0.005	-0.29	0.15	-0.07	10	< 0.01	7.27
B-3	-0.005	-0.29	0.15	-0.07	10	< 0.01	7.05
B-4	-0.003	-0.16	0.29	0.06	10	< 0.01	8.36
950040 C-1	-0.003	-0.16	0.29	0.06	10	< 0.01	7.53
C-2	-0.005	-0.29	0.15	-0.07	10	< 0.01	8.61
C-3	-0.006	-0.36	0.08	-0.14	10	< 0.01	8.35
C-4	-0.004	-0.23	0.22	0.00	10	< 0.01	8.08
950041 A-1	-0.007	-0.43	0.02	-0.20	10	< 0.01	9.31
A-2	-0.008	-0.49	-0.05	-0.27	10	< 0.01	9.61
A-3	-0.008	-0.49	-0.05	-0.27	10	< 0.01	9.37
A-4	-0.003	-0.16	0.29	0.06	10	< 0.01	9.80
950041 B-1	-0.003	-0.16	0.29	0.06	10	< 0.01	9.40
B-2	-0.005	-0.29	0.15	-0.07	10	< 0.01	9.25
B-3	-0.006	-0.36	0.08	-0.14	10	< 0.01	9.32
B-4	-0.003	-0.16	0.29	0.06	10	< 0.01	9.65
950041 C-1	-0.003	-0.16	0.29	0.06	10	< 0.01	9.29
C-2	-0.005	-0.29	0.15	-0.07	10	< 0.01	9.00
C-3	-0.006	-0.36	0.08	-0.14	10	< 0.01	9.11
C-4	-0.003	-0.16	0.29	0.06	10	< 0.01	9.39

Sample Spike Recoveries:

950040	-0.003	-0.16	0.29	0.06	102%	9.50
SPIKE	0.141	9.37	10.06	9.72		
950041	-0.003	-0.16	0.29	0.06	101%	9.50
SPIKE	0.140	9.31	9.99	9.65		

Nickel
7/8/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9986	0.9987	0.9987
SLOPE	0.0457	0.0431	0.0419
Y-INTERCEPT	0.0053	0.0151	0.0183

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.022	0.37		0.37	2	146	115%	recovery	
Blank - 1	0.012	-0.07	-0.15	-0.11	1				9.04
2	0.013	-0.05	-0.13	-0.09	1				5.69
3	0.014	-0.03	-0.10	-0.06	1				6.35
4	0.019	0.09	0.02	0.05	1				5.18
950038 A-1	0.018	0.28	0.07	0.17	1	0.17			11.19
A-2	0.019	0.09	0.02	0.05	1	< 0.125			12.07
A-3	0.019	0.09	0.02	0.05	1	< 0.125			12.09
A-4	0.018	0.07	-0.01	0.03	1	< 0.125			12.05
950038 B-1	0.025	0.23	0.16	0.19	1	0.19			11.41
B-2	0.019	0.09	0.02	0.05	1	< 0.125			11.91
B-3	0.019	0.09	0.02	0.05	1	< 0.125			11.82
B-4	0.012	-0.07	-0.15	-0.11	1	< 0.125			12.11
950038 C-1	0.023	0.18	0.11	0.15	1	0.15			11.79
C-2	0.018	0.07	-0.01	0.03	1	< 0.125			11.86
C-3	0.020	0.11	0.04	0.08	1	< 0.125			11.81
C-4	0.018	0.07	-0.01	0.03	1	< 0.125			12.05
950039 A-1	0.015	0.21	0.00	0.11	1	< 0.125			11.65
A-2	0.019	0.09	0.02	0.05	1	< 0.125			11.71
A-3	0.018	0.07	-0.01	0.03	1	< 0.125			11.65
A-4	0.016	0.02	-0.06	-0.02	1	< 0.125			11.52
950039 B-1	0.021	0.14	0.06	0.10	1	< 0.125			11.78
B-2	0.016	0.02	-0.06	-0.02	1	< 0.125			11.83
B-3	0.021	0.14	0.06	0.10	1	< 0.125			11.81
B-4	0.014	-0.03	-0.10	-0.06	1	< 0.125			11.56
950039 C-1	0.022	0.16	0.09	0.12	1	< 0.125			12.00
C-2	0.017	0.04	-0.03	0.01	1	< 0.125			11.91
C-3	0.019	0.09	0.02	0.05	1	< 0.125			11.83
C-4	0.019	0.09	0.02	0.05	1	< 0.125			11.40

Sample Spike Recoveries:

950038 A-1	0.018	0.28	0.07	0.17	99%	1.820
SPIKE	0.098	2.03	1.92	1.97		
950039 A-1	0.015	0.21	0.00	0.11	94%	1.820
SPIKE	0.091	1.87	1.76	1.82		

Nickel
7/8/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.		0.9986	0.9987	0.9987
SLOPE		0.0457	0.0431	0.0419
Y-INTERCEPT		0.0053	0.0151	0.0183

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.022	0.37		0.37	2	146	115%	recovery	
Blank - 1	0.012	-0.07	-0.15	-0.11	1				9.04
2	0.013	-0.05	-0.13	-0.09	1				5.69
3	0.014	-0.03	-0.10	-0.06	1				6.35
4	0.019	0.09	0.02	0.05	1				5.18
950040 A-1	0.016	0.23	0.02	0.13	1	0.13			7.63
A-2	0.015	0.00	-0.08	-0.04	1	< 0.125			6.74
A-3	0.015	0.00	-0.08	-0.04	1	< 0.125			7.20
A-4	0.015	0.00	-0.08	-0.04	1	< 0.125			8.99
950040 B-1	0.021	0.14	0.06	0.10	1	< 0.125			7.53
B-2	0.017	0.04	-0.03	0.01	1	< 0.125			7.27
B-3	0.018	0.07	-0.01	0.03	1	< 0.125			7.05
B-4	0.019	0.09	0.02	0.05	1	< 0.125			8.36
950040 C-1	0.019	0.09	0.02	0.05	1	< 0.125			7.53
C-2	0.014	-0.03	-0.10	-0.06	1	< 0.125			8.61
C-3	0.017	0.04	-0.03	0.01	1	< 0.125			8.35
C-4	0.016	0.02	-0.06	-0.02	1	< 0.125			8.08
950041 A-1	0.013	0.17	-0.05	0.06	1	< 0.125			9.31
A-2	0.019	0.09	0.02	0.05	1	< 0.125			9.61
A-3	0.018	0.07	-0.01	0.03	1	< 0.125			9.37
A-4	0.015	0.00	-0.08	-0.04	1	< 0.125			9.80
950041 B-1	0.013	-0.05	-0.13	-0.09	1	< 0.125			9.40
B-2	0.016	0.02	-0.06	-0.02	1	< 0.125			9.25
B-3	0.016	0.02	-0.06	-0.02	1	< 0.125			9.32
B-4	0.015	0.00	-0.08	-0.04	1	< 0.125			9.65
950041 C-1	0.016	0.02	-0.06	-0.02	1	< 0.125			9.29
C-2	0.019	0.09	0.02	0.05	1	< 0.125			9.00
C-3	0.012	-0.07	-0.15	-0.11	1	< 0.125			9.11
C-4	0.014	-0.03	-0.10	-0.06	1	< 0.125			9.39

Sample Spike Recoveries:

950040 A-1	0.016	0.23	0.02	0.13	104%	1.820
SPIKE	0.100	2.07	1.97	2.02		
950041 A-1	0.013	0.17	-0.05	0.06	104%	1.820
SPIKE	0.097	2.00	1.90	1.95		

Potassium
7/21/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9996	0.9986	0.9996
SLOPE	0.0917	0.1061	0.0874
Y-INTERCEPT	0.0022	-0.0017	0.0027

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.083	0.88		0.88	101	17813	95%	recovery	
Blank - 1	0.000	0.02	-0.03	-0.01	21				9.04
2	-0.002	0.00	-0.05	-0.03	21				5.69
3	-0.001	0.01	-0.04	-0.02	21				6.35
4	-0.002	0.00	-0.05	-0.03	21				5.18
950038 A-1	0.030	0.30	0.30	0.30	201	60.54			11.19
A-2	0.079	0.76	0.87	0.82	201	164.16			12.07
A-3	0.027	0.27	0.28	0.27	201	55.10			12.09
A-4	0.015	0.16	0.14	0.15	201	29.94			12.05
950038 B-1	0.028	0.28	0.29	0.28	201	57.20			11.41
B-2	0.029	0.29	0.30	0.30	201	59.30			11.91
B-3	0.015	0.16	0.14	0.15	201	29.94			11.82
B-4	0.012	0.13	0.11	0.12	201	23.64			12.11
950038 C-1	0.050	0.49	0.54	0.51	201	103.34			11.79
C-2	0.025	0.25	0.25	0.25	201	50.91			11.86
C-3	0.051	0.50	0.55	0.52	201	105.44			11.81
C-4	0.012	0.13	0.11	0.12	201	23.64			12.05
950039 A-1	0.018	0.17	0.19	0.18	201	36.02			11.65
A-2	0.013	0.14	0.12	0.13	201	25.74			11.71
A-3	0.009	0.10	0.07	0.09	201	< 20.1			11.65
A-4	0.005	0.06	0.03	0.04	201	< 20.1			11.52
950039 B-1	0.117	1.12	1.31	1.21	201	243.86			11.78
B-2	0.010	0.11	0.08	0.10	201	< 20.1			11.83
B-3	0.007	0.08	0.05	0.07	201	< 20.1			11.81
B-4	0.003	0.04	0.00	0.02	201	< 20.1			11.56
950039 C-1	0.021	0.21	0.21	0.21	201	42.52			12.00
C-2	0.017	0.18	0.16	0.17	201	34.13			11.91
C-3	0.009	0.10	0.07	0.09	201	17.35			11.83
C-4	0.007	0.08	0.05	0.07	201	13.16			11.40

Sample Spike Recoveries:

950038 A-1	0.030	0.30		0.30	92%	0.498
SPIKE	0.072	0.76		0.76		
950039 A-1	0.018	0.17		0.17	94%	0.498
SPIKE	0.061	0.64		0.64		

Potassium
7/21/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9996	0.9986	0.9996
SLOPE	0.0917	0.1061	0.0874
Y-INTERCEPT	0.0022	-0.0017	0.0027

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.083	0.88		0.88	101	17813	95%	recovery	
Blank - 1	0	0.02	-0.03	-0.01	21				9.04
2	-0.002	0.00	-0.05	-0.03	21				5.69
3	-0.001	0.01	-0.04	-0.02	21				6.35
4	-0.002	0.00	-0.05	-0.03	21				5.18
950040 A-1	0.040	0.41	0.39	0.40	21	8.46			7.63
A-2	0.027	0.27	0.28	0.27	21	5.76			6.74
A-3	0.007	0.08	0.05	0.07	21	< 2.1			7.20
A-4	0.006	0.07	0.04	0.06	21	< 2.1			8.99
950040 B-1	0.046	0.45	0.50	0.47	21	9.92			7.53
B-2	0.023	0.23	0.23	0.23	21	4.88			7.27
B-3	0.006	0.07	0.04	0.06	21	< 2.1			7.05
B-4	0.002	0.03	-0.01	0.01	21	< 2.1			8.36
950040 C-1	0.040	0.39	0.43	0.41	21	8.61			7.53
C-2	0.023	0.23	0.23	0.23	21	4.88			8.61
C-3	0.007	0.08	0.05	0.07	21	< 2.1			8.35
C-4	0.007	0.08	0.05	0.07	21	< 2.1			8.08
950041 A-1	0.027	0.27	0.28	0.27	21	5.76			9.31
A-2	0.011	0.12	0.09	0.11	21	2.25			9.61
A-3	0.026	0.26	0.27	0.26	21	5.54			9.37
A-4	0.027	0.27	0.28	0.27	21	5.76			9.80
950041 B-1	0.031	0.31	0.32	0.32	21	6.63			9.40
B-2	0.041	0.40	0.44	0.42	21	8.82			9.25
B-3	0.028	0.28	0.29	0.28	21	5.98			9.32
B-4	0.022	0.22	0.22	0.22	21	4.66			9.65
950041 C-1	0.030	0.30	0.31	0.31	21	6.41			9.29
C-2	0.039	0.38	0.42	0.40	21	8.39			9.00
C-3	0.021	0.21	0.21	0.21	21	4.44			9.11
C-4	0.022	0.22	0.22	0.22	21	4.66			9.39

Sample Spike Recoveries:

950040	0.040	0.41	0.41	92%	0.475
SPIKE	0.080	0.85	0.85		
950041	0.027	0.27	0.27	101%	0.475
SPIKE	0.071	0.75	0.75		

Silicon
7/18/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9997	0.9994	0.9998	0.998
SLOPE	0.0014	0.0013	0.0013	0.001
Y-INTERCEPT	-0.0002	-0.0035	-0.0018	-0.01

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.013	9.42	12.81	11.11	101	224500	98%	recovery	
Blank - 1	-0.003	-0.89		-0.89	1				9.04
2	-0.003	-0.89		-0.89	1				5.69
3	-0.002	-0.13		-0.13	1				6.35
4	-0.003	-0.89		-0.89	1				5.18
950038 A-1	-0.002	-0.13	3.94	1.90	1	< 2.5			11.19
A-2	-0.002	-0.13	3.94	1.90	1	< 2.5			12.07
A-3	-0.003	-0.89	3.20	1.15	1	< 2.5			12.09
A-4	-0.002	-0.13	3.94	1.90	1	< 2.5			12.05
950038 B-1	-0.003	-0.89	3.20	1.15	1	< 2.5			11.41
B-2	-0.002	-0.13	3.94	1.90	1	< 2.5			11.91
B-3	-0.002	-0.13	3.94	1.90	1	< 2.5			11.82
B-4	-0.003	-0.89	3.20	1.15	1	< 2.5			12.11
950038 C-1	-0.002	-0.13	3.94	1.90	1	< 2.5			11.79
C-2	-0.003	-0.89	3.20	1.15	1	< 2.5			11.86
C-3	-0.002	-0.13	3.94	1.90	1	< 2.5			11.81
C-4	-0.002	-0.13	3.94	1.90	1	< 2.5			12.05
950039 A-1	-0.002	-0.13	3.94	1.90	1	< 2.5			11.65
A-2	-0.005	-2.41	1.71	-0.35	1	< 2.5			11.71
A-3	-0.003	-0.89	3.20	1.15	1	< 2.5			11.65
A-4	-0.002	-0.13	3.94	1.90	1	< 2.5			11.52
950039 B-1	-0.004	-1.65	2.45	0.40	1	< 2.5			11.78
B-2	-0.002	-0.13	3.94	1.90	1	< 2.5			11.83
B-3	-0.003	-0.89	3.20	1.15	1	< 2.5			11.81
B-4	-0.003	-0.89	3.20	1.15	1	< 2.5			11.56
950039 C-1	-0.003	-1.04	3.05	1.00	1	< 2.5			12.00
C-2	-0.002	-0.13	3.94	1.90	1	< 2.5			11.91
C-3	-0.003	-0.89	3.20	1.15	1	< 2.5			11.83
C-4	-0.003	-0.89	3.20	1.15	1	< 2.5			11.40

Baseline drift shown by second line occurred after all these samples were run, so it is safe to say they are all below the detection limit.

Sample Spike Recoveries:

950038	-0.002	-1.31	1.17	-0.07	99%	9.800
SPIKE	0.011	7.99	11.26	9.62		
950039	-0.003	-2.03	0.39	-0.82	98%	9.900
SPIKE	0.010	7.27	10.48	8.88		

Silicon
7/18/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9997	0.9992	0.9998	0.998	0.9993
SLOPE	0.0014	0.0013	0.0013	0.001	0.0015
Y-INTERCEPT	-0.0002	-0.0038	-0.0018	-0.01	0.0006

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.013	9.42	12.64	11.03	101	222792	98%	recovery	
Blank - 1	-0.003	-0.89		-0.89	1				9.04
2	-0.003	-0.89		-0.89	1				5.69
3	-0.002	-0.13		-0.13	1				6.35
4	-0.003	-0.89		-0.89	1				5.18
950040 A-1	-0.004	-1.65	2.45	0.40	1	< 2.5			7.63
A-2	-0.003	-0.89	3.20	1.15	1	< 2.5			6.74
A-3	0.001	2.14	6.16	4.15	1	4.15			7.20
A-4	-0.002	-0.13	3.94	1.90	1	< 2.5			8.99
950040 B-1	-0.003	-0.89	3.20	1.15	1	< 2.5			7.53
B-2	-0.002	-0.13	3.94	1.90	1	< 2.5			7.27
B-3	0.002	2.90	6.91	4.90	1	4.90			7.05
B-4	-0.002	-0.13	3.94	1.90	1	< 2.5			8.36
950040 C-1	-0.003	-0.89	3.20	1.15	1	< 2.5			7.53
C-2	-0.002	-0.13	3.94	1.90	1	< 2.5			8.61
C-3	-0.004	-1.65	2.45	0.40	1	< 2.5			8.35
C-4	-0.002	-0.13	3.94	1.90	1	< 2.5			8.08
950041 A-1	-0.001	0.62	4.68	2.65	1	2.65			9.31
A-2	-0.002	-0.13	3.94	1.90	1	< 2.5			9.61
A-3	-0.003	-0.89	3.20	1.15	1	< 2.5			9.37
A-4	-0.004	-1.65	2.45	0.40	1	< 2.5			9.80
950041 B-1	-0.004	-1.65	2.45	0.40	1	< 2.5			9.40
B-2	-0.004	-1.65	2.45	0.40	1	< 2.5			9.25
B-3	-0.004	-1.65	2.45	0.40	1	< 2.5			9.32
B-4	-0.004	-1.65	2.45	0.40	1	< 2.5			9.65
950041 C-1	-0.004	-1.65	2.45	0.40	1	< 2.5			9.29
C-2	-0.004	-1.65	2.45	0.40	1	< 2.5			9.00
C-3	-0.004	-1.65	2.45	0.40	1	< 2.5			9.11
C-4	-0.004	-1.65	2.45	0.40	1	< 2.5			9.39

Sample Spike Recoveries:

950040 A-1	0.004	2.98	5.88	4.43	97%	9.800
SPIKE	0.017	12.28	15.65	13.96		
950041 A-1	-0.001	-1.13		-1.13	112%	9.800
SPIKE	0.015	9.86		9.86		

Silver
6/13/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9999	1.0000	0.9999	1.000
SLOPE	0.2067	0.2057	0.2032	0.205
Y-INTERCEPT	-0.0016	-0.0055	-0.0111	-0.01

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm	pH
Blank - 1	-0.004	-0.01	0.01	0.00	1		9.04
2	-0.004	-0.01	0.01	0.00	1		5.69
3	-0.006	-0.02	0.00	-0.01	1		6.35
4	-0.004	-0.01	0.01	0.00	1		5.18
950038 A-1	0.002	0.02		0.02	1	< 0.025	11.19
A-2	-0.002	0.00	0.02	0.01	1	< 0.025	12.07
A-3	-0.003	-0.01	0.01	0.00	1	< 0.025	12.09
A-4	-0.003	-0.01	0.01	0.00	1	< 0.025	12.05
950038 B-1	-0.003	-0.01	0.01	0.00	1	< 0.025	11.41
B-2	-0.003	-0.01	0.01	0.00	1	< 0.025	11.91
B-3	-0.003	-0.01	0.01	0.00	1	< 0.025	11.82
B-4	-0.001	0.00	0.02	0.01	1	< 0.025	12.11
950038 C-1	-0.003	-0.01	0.01	0.00	1	< 0.025	11.79
C-2	-0.002	0.00	0.02	0.01	1	< 0.025	11.86
C-3	-0.003	-0.01	0.01	0.00	1	< 0.025	11.81
C-4	0.000	0.01	0.03	0.02	1	< 0.025	12.05
950039 A-1	-0.007	-0.01	0.02	0.01	1	< 0.025	11.65
A-2	-0.008	-0.01	0.02	0.00	1	< 0.025	11.71
A-3	-0.007	-0.01	0.02	0.01	1	< 0.025	11.65
A-4	-0.009	-0.02	0.01	0.00	1	< 0.025	11.52
950039 B-1	-0.008	-0.01	0.02	0.00	1	< 0.025	11.78
B-2	-0.009	-0.02	0.01	0.00	1	< 0.025	11.83
B-3	-0.007	-0.01	0.02	0.01	1	< 0.025	11.81
B-4	-0.009	-0.02	0.01	0.00	1	< 0.025	11.56
950039 C-1	-0.007	-0.01	0.02	0.01	1	< 0.025	12.00
C-2	-0.007	-0.01	0.02	0.01	1	< 0.025	11.91
C-3	-0.010	-0.02	0.01	-0.01	1	< 0.025	11.83
C-4	-0.008	-0.01	0.02	0.00	1	< 0.025	11.40

Sample Spike Recoveries:

950038 A-1	0.002	0.02	0.04	0.03	97%	0.909
SPIKE	0.184	0.90	0.92	0.91		
950039 A-1	-0.007	-0.01	0.02	0.01	101%	0.909
SPIKE	0.181	0.91	0.95	0.93		

Silver
6/13/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	1.0000	0.9999	0.9999
SLOPE	0.2057	0.2032	0.2053
Y-INTERCEPT	-0.0055	-0.0111	-0.0141

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm	pH
Blank - 1	-0.004	-0.01	0.01	0.00	1		9.04
2	-0.004	-0.01	0.01	0.00	1		5.69
3	-0.006	-0.02	0.00	-0.01	1		6.35
4	-0.004	-0.01	0.01	0.00	1		5.18
950040 A-1	-0.012	0.00	0.01	0.00	1	< 0.025	7.63
A-2	-0.014	-0.01	0.00	-0.01	1	< 0.025	6.74
A-3	-0.015	-0.02	0.00	-0.01	1	< 0.025	7.20
A-4	-0.016	-0.02	-0.01	-0.02	1	< 0.025	8.99
950040 B-1	-0.014	-0.01	0.00	-0.01	1	< 0.025	7.53
B-2	-0.012	0.00	0.01	0.00	1	< 0.025	7.27
B-3	-0.013	-0.01	0.01	0.00	1	< 0.025	7.05
B-4	-0.012	0.00	0.01	0.00	1	< 0.025	8.36
950040 C-1	-0.014	-0.01	0.00	-0.01	1	< 0.025	7.53
C-2	-0.015	-0.02	0.00	-0.01	1	< 0.025	8.61
C-3	-0.013	-0.01	0.01	0.00	1	< 0.025	8.35
C-4	-0.015	-0.02	0.00	-0.01	1	< 0.025	8.08
950041 A-1	-0.010	-0.02	0.01	-0.01	1	< 0.025	9.31
A-2	-0.010	-0.02	0.01	-0.01	1	< 0.025	9.61
A-3	-0.011	-0.03	0.00	-0.01	1	< 0.025	9.37
A-4	-0.010	-0.02	0.01	-0.01	1	< 0.025	9.80
950041 B-1	-0.009	-0.02	0.01	0.00	1	< 0.025	9.40
B-2	-0.010	-0.02	0.01	-0.01	1	< 0.025	9.25
B-3	-0.012	-0.03	0.00	-0.02	1	< 0.025	9.32
B-4	-0.009	-0.02	0.01	0.00	1	< 0.025	9.65
950041 C-1	-0.012	-0.03	0.00	-0.02	1	< 0.025	9.29
C-2	-0.012	-0.03	0.00	-0.02	1	< 0.025	9.00
C-3	-0.012	-0.03	0.00	-0.02	1	< 0.025	9.11
C-4	-0.012	-0.03	0.00	-0.02	1	< 0.025	9.39

Sample Spike Recoveries:

950040 A-1	-0.012	0.00	0.01	0.00	103%	0.909
SPIKE	0.180	0.94	0.95	0.94		
950041 A-1	-0.010	-0.02	0.01	-0.01	100%	0.909
SPIKE	0.176	0.88	0.92	0.90		

Selenium
8/11/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9995	0.9992
SLOPE	0.0030	0.0026
Y-INTERCEPT	0.0015	0.0028

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm			pH
NBS 1643c	0.017	5.42		5.42	2	10.84	85%	recovery	
Blank - 1	0.001	-0.17	-0.69	-0.43	11				9.04
2	0.002	0.17	-0.31	-0.07	11				5.69
3	0.001	-0.17	-0.69	-0.43	11				6.35
4	0.001	-0.17	-0.69	-0.43	11				5.18
950038 A-1	0.001	-0.17	-0.69	-0.43	11	< 0.014			11.19
A-2	0.002	0.17	-0.31	-0.07	11	< 0.014			12.07
A-3	0.001	-0.17	-0.69	-0.43	11	< 0.014			12.09
A-4	0.002	0.17	-0.31	-0.07	11	< 0.014			12.05
950038 B-1	0.002	0.17	-0.31	-0.07	11	< 0.014			11.41
B-2	-0.001	-0.84	-1.45	-1.14	11	< 0.014			11.91
B-3	0.000	-0.50	-1.07	-0.79	11	< 0.014			11.82
B-4	0.000	-0.50	-1.07	-0.79	11	< 0.014			12.11
950038 C-1	0.001	-0.17	-0.69	-0.43	11	< 0.014			11.79
C-2	0.001	-0.17	-0.69	-0.43	11	< 0.014			11.86
C-3	0.002	0.17	-0.31	-0.07	11	< 0.014			11.81
C-4	0.001	-0.17	-0.69	-0.43	11	< 0.014			12.05
950039 A-1	-0.001	-0.84	-1.45	-1.14	11	< 0.014			11.65
A-2	-0.001	-0.84	-1.45	-1.14	11	< 0.014			11.71
A-3	0.001	-0.17	-0.69	-0.43	11	< 0.014			11.65
A-4	0.001	-0.17	-0.69	-0.43	11	< 0.014			11.52
950039 B-1	0.001	-0.17	-0.69	-0.43	11	< 0.014			11.78
B-2	0.001	-0.17	-0.69	-0.43	11	< 0.014			11.83
B-3	0.003	0.50	0.08	0.29	11	< 0.014			11.81
B-4	0.000	-0.50	-1.07	-0.79	11	< 0.014			11.56
950039 C-1	0.000	-0.50	-1.07	-0.79	11	< 0.014			12.00
C-2	0.000	-0.50	-1.07	-0.79	11	< 0.014			11.91
C-3	0.002	0.17	-0.31	-0.07	11	< 0.014			11.83
C-4	0.002	0.17	-0.31	-0.07	11	< 0.014			11.40

Sample Spike Recoveries:

950038	0.001	-0.17	-0.69	-0.43	106%	18.180
SPIKE	0.055	17.87	19.93	18.90		
950039	-0.001	-0.84	-1.45	-1.14	106%	18.180
SPIKE	0.053	17.20	19.16	18.18		

Selenium
8/11/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9995	0.9992
SLOPE	0.0030	0.0026
Y-INTERCEPT	0.0015	0.0028

SAMPLE	ABS	CONC ppb	CONC ppb	AVG CONC	DF	ABS CONC ppm			pH
NBS1643C	0.017	5.42		5.42	2	11	85%	recovery	
Blank - 1	0.001	-0.17	-0.69	-0.43	11				9.04
2	0.002	0.17	-0.31	-0.07	11				5.69
3	0.001	-0.17	-0.69	-0.43	11				6.35
4	0.001	-0.17	-0.69	-0.43	11				5.18
950040 A-1	0.002	0.17	-0.31	-0.07	201	< 0.25			7.63
A-2	0.001	-0.17	-0.69	-0.43	201	< 0.25			6.74
A-3	0.002	0.17	-0.31	-0.07	201	< 0.25			7.20
A-4	0.004	0.83	0.46	0.65	201	< 0.25			8.99
950040 B-1	0.004	0.83	0.46	0.65	201	< 0.25			7.53
B-2	0.002	0.17	-0.31	-0.07	201	< 0.25			7.27
B-3	0.001	-0.17	-0.69	-0.43	201	< 0.25			7.05
B-4	0.002	0.17	-0.31	-0.07	201	< 0.25			8.36
950040 C-1	0.003	0.50	0.08	0.29	201	< 0.25			7.53
C-2	0.002	0.17	-0.31	-0.07	201	< 0.25			8.61
C-3	0.001	-0.17	-0.69	-0.43	201	< 0.25			8.35
C-4	0.003	0.50	0.08	0.29	201	< 0.25			8.08
950041 A-1	-0.001	-0.84	-1.45	-1.14	101	< 0.13			9.31
A-2	0.001	-0.17	-0.69	-0.43	101	< 0.13			9.61
A-3	0.000	-0.50	-1.07	-0.79	101	< 0.13			9.37
A-4	0.002	0.17	-0.31	-0.07	101	< 0.13			9.80
950041 B-1	0.001	-0.17	-0.69	-0.43	101	< 0.13			9.40
B-2	0.002	0.17	-0.31	-0.07	101	< 0.13			9.25
B-3	0.002	0.17	-0.31	-0.07	101	< 0.13			9.32
B-4	0.002	0.17	-0.31	-0.07	101	< 0.13			9.65
950041 C-1	0.002	0.17	-0.31	-0.07	101	< 0.13			9.29
C-2	0.001	-0.17	-0.69	-0.43	101	< 0.13			9.00
C-3	0.000	-0.50	-1.07	-0.79	101	< 0.13			9.11
C-4	0.000	-0.50	-1.07	-0.79	101	< 0.13			9.39

Sample Spike Recoveries:

950040 A-1	0.002	0.17	-0.31	-0.07	101%	19.900
SPIKE	0.058	18.87	21.07	19.97		
950041 A-1	-0.001	-0.84	-1.45	-1.14	101%	19.800
SPIKE	0.055	17.87	19.93	18.90		

Sodium
7/19/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9999	0.9999	0.9996
SLOPE	0.2990	0.2826	0.2790
Y-INTERCEPT	0.0012	-0.0005	-0.0043

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.045	0.15	0.16	0.15	51	1570	92%	recovery	
Blank - 1	-0.005	-0.02	0.00	-0.01	51				9.04
2	-0.006	-0.02	-0.01	-0.01	51				5.69
3	-0.004	-0.01	0.00	-0.01	51				6.35
4	-0.008	-0.03	-0.01	-0.02	51				5.18
950038 A-1	0.041	0.13	0.15	0.14	201	28.16			11.19
A-2	0.020	0.07	0.09	0.08	201	16.04			12.07
A-3	0.015	0.05	0.07	0.06	201	12.46			12.09
A-4	0.012	0.04	0.06	0.05	201	10.31			12.05
950038 B-1	0.037	0.13	0.15	0.14	201	28.21			11.41
B-2	0.020	0.07	0.09	0.08	201	16.04			11.91
B-3	0.016	0.06	0.07	0.07	201	13.17			11.82
B-4	0.007	0.03	0.04	0.03	201	< 10.05			12.11
950038 C-1	0.028	0.10	0.12	0.11	201	21.76			11.79
C-2	0.021	0.08	0.09	0.08	201	16.75			11.86
C-3	0.041	0.15	0.16	0.15	201	31.07			11.81
C-4	0.057	0.20	0.22	0.21	201	42.52			12.05
950039 A-1	0.070	0.23	0.25	0.24	51	12.24			11.65
A-2	0.002	0.01	0.02	0.02	51	< 2.55			11.71
A-3	0.002	0.01	0.02	0.02	51	< 2.55			11.65
A-4	0.001	0.01	0.02	0.01	51	< 2.55			11.52
950039 B-1	0.116	0.41	0.43	0.42	51	21.50			11.78
B-2	0.004	0.02	0.03	0.02	51	< 2.55			11.83
B-3	0.006	0.02	0.04	0.03	51	< 2.55			11.81
B-4	0.005	0.02	0.03	0.03	51	< 2.55			11.56
950039 C-1	0.066	0.24	0.25	0.24	51	12.42			12.00
C-2	0.005	0.02	0.03	0.03	51	< 2.55			11.91
C-3	0.284	1.01	1.03	1.02	51	52.02			11.83
C-4	-0.001	0.00	0.01	0.01	51	< 2.55			11.40

Sample Spike Recoveries:

950038 A-1	0.041	0.13	0.15	0.14	103%	0.500
SPIKE	0.190	0.63	0.67	0.65		
950039 A-1	0.070	0.23	0.25	0.24	103%	0.190
SPIKE	0.127	0.42	0.45	0.44		

Sodium
7/19/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9999	0.9999	0.9996
SLOPE	0.2990	0.2826	0.2790
Y-INTERCEPT	0.0012	-0.0005	-0.0043

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.045	0.15	0.16	0.15	51	1570	92%	recovery	
Blank - 1	-0.005	-0.02	0.00	-0.01	51				9.04
2	-0.006	-0.02	-0.01	-0.01	51				5.69
3	-0.004	-0.01	0.00	-0.01	51				6.35
4	-0.008	-0.03	-0.01	-0.02	51				5.18
950040 A-1	0.025	0.08	0.09	0.09	51	4.34			7.63
A-2	-0.004	-0.01	0.00	-0.01	51	< 2.55			6.74
A-3	0.007	0.03	0.04	0.03	51	< 2.55			7.20
A-4	-0.005	-0.02	0.00	-0.01	51	< 2.55			8.99
950040 B-1	0.018	0.07	0.08	0.07	51	3.71			7.53
B-2	-0.005	-0.02	0.00	-0.01	51	< 2.55			7.27
B-3	-0.004	-0.01	0.00	-0.01	51	< 2.55			7.05
B-4	-0.006	-0.02	-0.01	-0.01	51	< 2.55			8.36
950040 C-1	0.017	0.06	0.08	0.07	51	3.52			7.53
C-2	-0.001	0.00	0.01	0.01	51	< 2.55			8.61
C-3	-0.003	-0.01	0.00	0.00	51	< 2.55			8.35
C-4	-0.006	-0.02	-0.01	-0.01	51	< 2.55			8.08
950041 A-1	0.047	0.15	0.17	0.16	51	8.20			9.31
A-2	0.006	0.02	0.04	0.03	51	< 2.55			9.61
A-3	0.003	0.01	0.03	0.02	51	< 2.55			9.37
A-4	-0.004	-0.01	0.00	-0.01	51	< 2.55			9.80
950041 B-1	0.042	0.15	0.17	0.16	51	8.06			9.40
B-2	0.005	0.02	0.03	0.03	51	< 2.55			9.25
B-3	-0.002	-0.01	0.01	0.00	51	< 2.55			9.32
B-4	0.001	0.01	0.02	0.01	51	< 2.55			9.65
950041 C-1	0.033	0.12	0.13	0.13	51	6.43			9.29
C-2	0.007	0.03	0.04	0.03	51	< 2.55			9.00
C-3	-0.002	-0.01	0.01	0.00	51	< 2.55			9.11
C-4	-0.005	-0.02	0.00	-0.01	51	< 2.55			9.39

Sample Spike Recoveries:

950040 A-1	0.025	0.08	0.09	0.09	111%	0.475
SPIKE	0.178	0.59	0.63	0.61		
950041 A-1	0.047	0.15	0.17	0.16	109%	0.475
SPIKE	0.198	0.66	0.70	0.68		

Zinc
7/8/95 mw

Virginia Materials (samples 950038-39)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9989	0.9994	0.9998
SLOPE	0.2377	0.2236	0.2189
Y-INTERCEPT	0.0046	0.0119	0.0136

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.251	1.04	1.07	1.05	1	211	96%	recovery	
Blank - 1	0.007	-0.02	-0.03	-0.03	1				9.04
2	0.009	-0.01	-0.02	-0.02	1				5.69
3	0.011	0.00	-0.01	-0.01	1				6.35
4	0.009	-0.01	-0.02	-0.02	1				5.18
950038 A-1	0.014	0.04	0.01	0.02	1	< 0.025			11.19
A-2	0.014	0.04	0.01	0.02	1	< 0.025			12.07
A-3	0.010	0.02	-0.01	0.01	1	< 0.025			12.09
A-4	0.012	0.03	0.00	0.02	1	< 0.025			12.05
950038 B-1	0.015	0.04	0.01	0.03	1	< 0.025			11.41
B-2	0.014	0.04	0.01	0.02	1	< 0.025			11.91
B-3	0.013	0.04	0.00	0.02	1	< 0.025			11.82
B-4	0.012	0.03	0.00	0.02	1	< 0.025			12.11
950038 C-1	0.014	0.04	0.01	0.02	1	< 0.025			11.79
C-2	0.013	0.04	0.00	0.02	1	< 0.025			11.86
C-3	0.013	0.04	0.00	0.02	1	< 0.025			11.81
C-4	0.012	0.03	0.00	0.02	1	< 0.025			12.05
950039 A-1	0.013	0.00	0.00	0.00	1	< 0.025			11.65
A-2	0.013	0.00	0.00	0.00	1	< 0.025			11.71
A-3	0.012	0.00	-0.01	0.00	1	< 0.025			11.65
A-4	0.012	0.00	-0.01	0.00	1	< 0.025			11.52
950039 B-1	0.014	0.01	0.00	0.01	1	< 0.025			11.78
B-2	0.013	0.00	0.00	0.00	1	< 0.025			11.83
B-3	0.013	0.00	0.00	0.00	1	< 0.025			11.81
B-4	0.012	0.00	-0.01	0.00	1	< 0.025			11.56
950039 C-1	0.014	0.01	0.00	0.01	1	< 0.025			12.00
C-2	0.011	0.00	-0.01	-0.01	1	< 0.025			11.91
C-3	0.012	0.00	-0.01	0.00	1	< 0.025			11.83
C-4	0.011	0.00	-0.01	-0.01	1	< 0.025			11.40

Sample Spike Recoveries:

950038 A-1	0.014	0.04	0.01	0.02	91%	1.820
SPIKE	0.395	1.64	1.71	1.68		
950039 A-1	0.013	0.04	0.00	0.02	91%	1.820
SPIKE	0.394	1.64	1.71	1.67		

Zinc
7/8/95 mw

Virginia Materials (samples 950040-41)
SW924 Leachates
extraction fluid: DID

DET. COEF.	0.9989	0.9994	0.9998
SLOPE	0.2377	0.2236	0.2189
Y-INTERCEPT	0.0046	0.0119	0.0136

SAMPLE	ABS	CONC ppm	CONC ppm	AVG CONC	DF	ABS CONC ppm			pH
NBS1633a	0.251	1.04	1.07	1.05	1	211	96%	recovery	
Blank - 1	0.007	-0.02	-0.03	-0.03	1				9.04
2	0.009	-0.01	-0.02	-0.02	1				5.69
3	0.011	0.00	-0.01	-0.01	1				6.35
4	0.009	-0.01	-0.02	-0.02	1				5.18
950040 A-1	0.063	0.23	0.23	0.23	1	0.23			7.63
A-2	0.013	0.00	0.00	0.00	1	< 0.025			6.74
A-3	0.013	0.00	0.00	0.00	1	< 0.025			7.20
A-4	0.010	-0.01	-0.02	-0.01	1	< 0.025			8.99
950040 B-1	0.075	0.28	0.28	0.28	1	0.28			7.53
B-2	0.016	0.02	0.01	0.01	1	< 0.025			7.27
B-3	0.012	0.00	-0.01	0.00	1	< 0.025			7.05
B-4	0.010	-0.01	-0.02	-0.01	1	< 0.025			8.36
950040 C-1	0.093	0.36	0.36	0.36	1	0.36			7.53
C-2	0.020	0.04	0.03	0.03	1	0.03			8.61
C-3	0.013	0.00	0.00	0.00	1	< 0.025			8.35
C-4	0.008	-0.02	-0.03	-0.02	1	< 0.025			8.08
950041 A-1	0.010	-0.01	-0.02	-0.01	1	< 0.025			9.31
A-2	0.009	-0.01	-0.02	-0.02	1	< 0.025			9.61
A-3	0.009	-0.01	-0.02	-0.02	1	< 0.025			9.37
A-4	0.010	-0.01	-0.02	-0.01	1	< 0.025			9.80
950041 B-1	0.011	0.00	-0.01	-0.01	1	< 0.025			9.40
B-2	0.009	-0.01	-0.02	-0.02	1	< 0.025			9.25
B-3	0.010	-0.01	-0.02	-0.01	1	< 0.025			9.32
B-4	0.009	-0.01	-0.02	-0.02	1	< 0.025			9.65
950041 C-1	0.012	0.00	-0.01	0.00	1	< 0.025			9.29
C-2	0.010	-0.01	-0.02	-0.01	1	< 0.025			9.00
C-3	0.009	-0.01	-0.02	-0.02	1	< 0.025			9.11
C-4	0.010	-0.01	-0.02	-0.01	1	< 0.025			9.39

Sample Spike Recoveries:

950040 A-1	0.063	0.23	0.23	0.23	90%	1.820
SPIKE	0.426	1.85	1.88	1.87		
950041 A-1	0.010	-0.01	-0.02	-0.01	93%	1.820
SPIKE	0.383	1.66	1.69	1.67		

Appendix B
Materials Design Research Report

PENNSTATE

"Green" Concrete for the Friendly Mobile Barrier

By

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1997

<u>Table of Contents</u>

Introduction

The goal of this study was to design concrete for use in the construction of the vault system, for the friendly mobile barrier. Additionally, it was desired that the concrete be as "green" as possible. Namely, the goal was that the proportion of recycled materials used in the concrete be as large as possible while still maintaining suitable engineering properties.

The addition of new materials to a concrete formulation will affect the characteristics the resulting cementitious composite in one of two ways. The additions will either 1) change the structure (macro and micro) and/or 2) change the chemical composition of the binding phase. The following sections will attempt to first provide a *brief* background on the use of recycled materials in cement and concrete and second to discuss the effect of using specific materials in the formulation under consideration.

Materials

Table 1 shows the materials that were collected for use in this study:

Table 1 - Materials used during the course of this study

Recycled concrete from CSR Virginia Precast
Processed MSW bottom ash from SEMASS Partnership
Ground granulated blast furnace slag from Koch Minerals Co.
Coal fly ash from MONEX Resources, Inc.
Type I portland cement from Allentown Cement Co.
Superplasticizer (Mighty 150) from Boremco
Darex air agent from W.R. Grace
#57 - limestone aggregate
Siliceous natural sand
ASTM C109 sand

Nominal Concrete Design

Using American Concrete Institute guidelines, the following mixture was calculated. Unless otherwise noted all aggregates were used in a saturated surface dry condition. The mixture was developed on the following basis:

Slump - adequate for plain footings, caissons and substructure walls, beams and reinforced walls

Air content - adequate for moderate exposure conditions

Strength - 4000-5000 PSI

All weights per yard of concrete

Coarse aggregate (nominal 1/2" max.)	1542 lbs.
Fine aggregate	1081 lbs
Cement	488 lbs
Slag	284 lbs
Silica fume**	41 lbs
Slump	3"
Air	5%

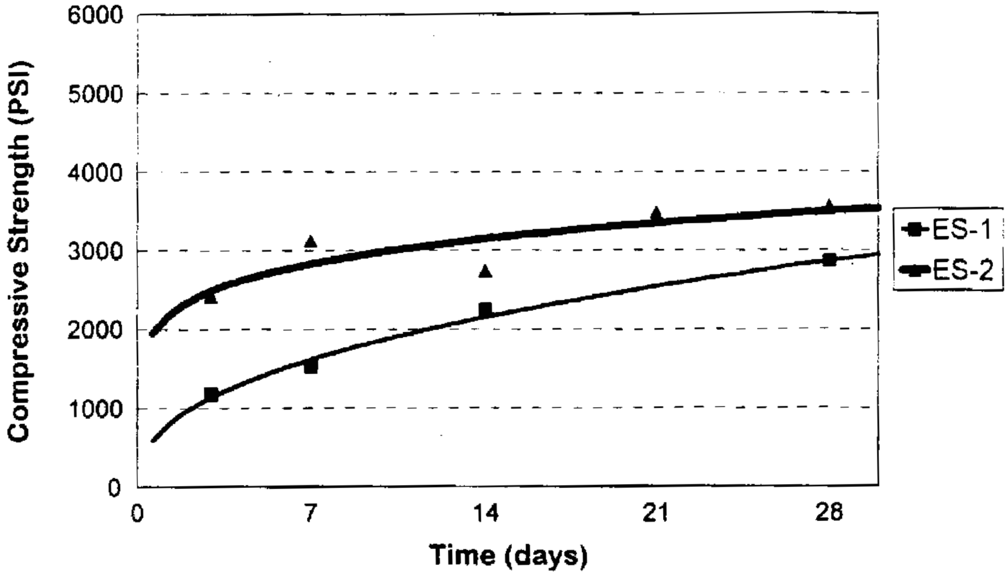
W/C = 0.45

** - Dry weight

Use Darvair to adjust air content as needed.

Initial Trials

Initially, trial concrete mixtures were prepared where the as received materials were substituted on a one for one basis for the more conventional concrete constituents. The concretes were mixed and molded according to ASTM Standard C192. The concretes were cured at 25°C and high humidity until testing. The rate of strength gain over the first 28 days of curing for two mixtures is shown in figure 1.



	ES-1	ES-2
Recycled Concrete	44.88	41.85
MSW Bottom Ash	31.46	29.34
Cement	14.20	20.00
Slag	4.13	3.85
Fly ash	4.13	3.85
Silica fume	1.19	1.11
W/C	0.33	0.35

Figure 1. Results of compressive strength measurements of two trial batches of concrete based on recycled materials. The mixture exhibited a nominal 3 1/2" slump and a 5% air content. Mighty 150, a superplasticizer was used at a 0.41 wt.% (of cementitious solids) level.

The concretes gained strength rapidly during the first few days of curing then at a slower rate as curing continued. While the pattern of strength gain in the concretes was similar to that observed in concretes prepared using more conventional materials the 28 day strengths were lower than expected, falling in the 3000-3500 PSI range rather than the 4000-5000 PSI target range. As expected the mixture with the higher cement content reached a higher strength.

Screening Tests

To categorize essential variables and to identify practices that would increase the performance of the system a series of screening tests were carried. For the purposes of the screening, all mixtures can be assumed to have possessed the same W/C, entrained air, and slump. The mixtures also used Mighty 150 and Daravair as necessary to maintain slump and entrained air. The following paragraphs will discuss the results of the screening. Mixture ES-2 will be used throughout the following paragraphs for comparison.

Role of Conventional Mineral Admixtures
Silica Fume, Blast furnace slag

The use of silica fume and blast furnace slag to increase the strength and durability of concrete is a well-documented procedure. The effectiveness of these admixtures is the result of two interrelated phenomena, one chemical and one physical. The chemical effect is the result of increased production of calcium silica hydrate (CSH). CSH is the principal hydration product of portland cement responsible for strength development. The hydration of tricalcium silicate a major constituent of portland cement occurs as follows:

$$3CaO \cdot SiO_2 + (y+3-x)H_2O \longrightarrow xCaO \cdot SiO_2.yH_20 + (3-x)Ca(OH)_2 \quad (1)$$

When, for instance, silica fume is added:

$$Si + xCa(OH)_2 + (y-x)H_2O \longrightarrow xCaO \cdot SiO_2.yH_20 \quad (2)$$

The net result is an increased production of CSH resulting in concrete with increased strength and presumably durability. The consumption of the relatively soluble phase CH also results in improved durability. In addition, CH commonly forms as large platelets that may act as critical flaws when the composite is under loading. As the CH content is

Table 2 - Comparison of mixture ES-2 to mixture ES-4 showing increased silica fume content.

	ES-2	ES-4
Recycled Concrete	41.85	39.62
MSW Bottom Ash	29.34	29.34
Cement	20.00	20
Slag	3.85	3.85
Fly ash	3.85	3.85
Silica fume	1.11	3.34

reduced, strength commonly increases. The use of a glassy blast furnace slag will also result in increased CSH production and reduction in CH content.

The physical effect of the use of mineral admixtures is the result of an increased packing efficiency among the fine particles composing the composite. Most slags, fly ashes and silica fumes that are used as mineral admixtures have characteristic sizes that are much smaller than those found in portland cement. As shown in figure 2, optimum packing efficiency in a binary system is achieved when the second size particles just fill the space between the larger particles. If the second particle is either too small or too large the overall packing density will decrease.

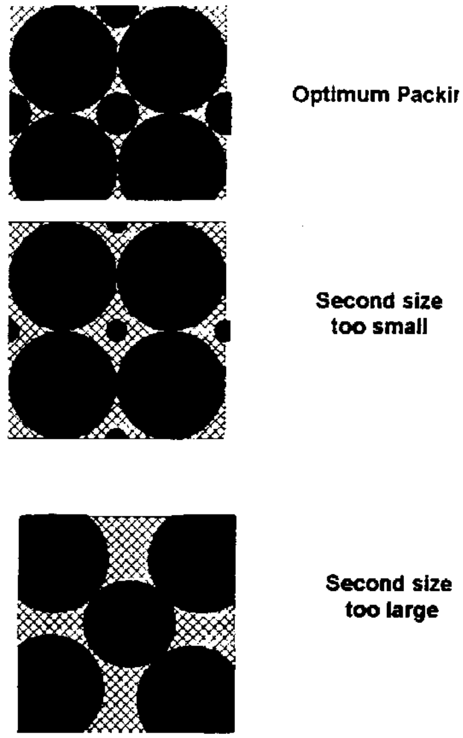


Figure 2. Optimum packing in a binary system

Figure 3 is provided to demonstrate that further packing density can be further increased by the use of ternary systems (i.e.- portland cement, glassy blast furnace slags and silica fume).

The beneficial aspects of the use of these relatively fine, reactive mineral admixtures must be balanced against the possible detrimental effects of their use.

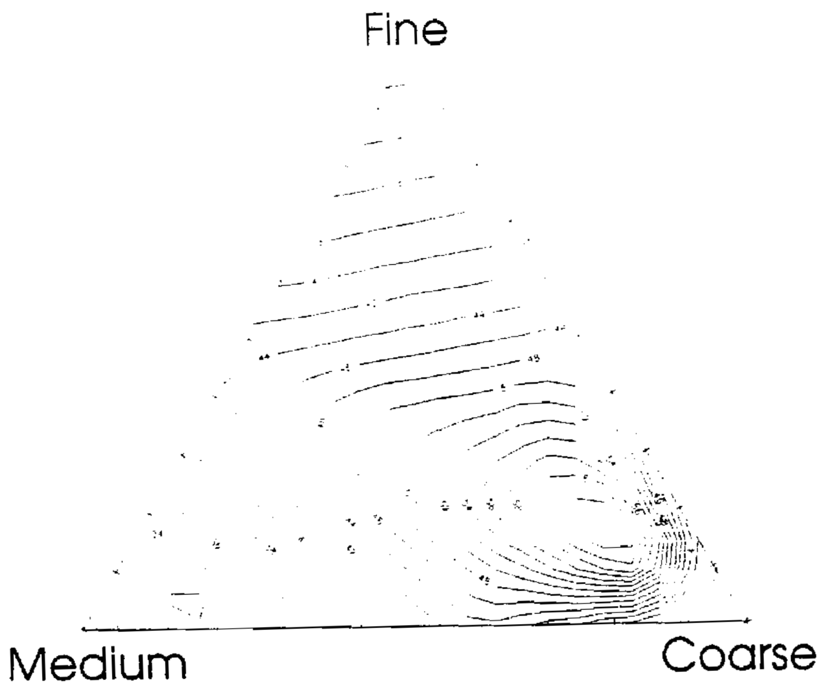


Figure 3. Typical packing diagram showing isodenisty curves as a function of relative particle size.

For example, at high levels of replacement of portland cement the use of silica fume may adversely effect the water demand of the resulting concrete. The increased water demand, results in increased porosity counteracting the improvements in packing efficiency. The net result may be a poorer quality concrete. In practice, the competing effects must be balanced. Silica fume, while occasionally being used at levels as high as 20 percent is typically used at levels of 0-7 percent. Replacement of portland cement by glassy blast furnace slags may occur at levels as high as 65 percent, however, more typically usage levels fall in the 20-35 percent range. While increased water demand commonly limits the use of the mineral admixtures, chemical constraints also apply. The calcium/silica ratio in the formulation must remain at levels of approximately 1.3 to 1.5 in order to be practical for most operations.

To optimize the use of the silica fume in this formulation, a trial mixture as shown in Table 2 where the silica fume content of the mixture was increased was prepared. When compared to ES-2 the observed 3 day strength in the formulation containing silica fume(ES-4) had decreased from 2860 PSI to 2260 PSI. As discussed in the preceding paragraphs, the upper limit for the use of silica fume as a mineral admixture is often determined by the packing efficiency of the fume relative to the other cementitious components in the mixture. In this case, a possible explanation for the reduction in strength may lie in the excess fine materials added to the mixture when using the as received recycled concrete and MSW bottom ash. The fine component present in the aggregates, could have when combined with the silica fume result in an excess of fine materials being present in the mixture. Based on these results the silica fume concentration used in mixture ES-2 was selected for further study. The use of silica fume at this level ~3.8 percent of the cementitious component falls near the mid range of the typical usage levels of 0-7 percent, as discussed earlier.

Effect of Fly Ash Additions on Strength Development

Coal fly ashes are a commonly used mineral admixture for portland cement concretes. The beneficial aspects of the use of coal fly ashes are similar to the effects discussed for glassy blast furnace slags and silica fume in the preceding section. Coal fly ashes can be broadly divided into several categories high calcium content pulverized fuel ash (PFA), low calcium content PFA and ashes from fluidized bed combustors. In the eastern US the overwhelming majority of ashes and the ash considered for use in this project are low calcium ashes, often referred to as Class F ashes. Low calcium ashes are useful as cement extenders, to control the rate of hydration and as a rheological aid. The rate of strength development in concretes utilizing low calcium content ashes tends to be slower, not reaching its full potential until later ages. The hydration of the ash relies on the excess calcium present in the cement reacting with the silica rich ash to produce CSH, the phase responsible for strength development. In the system under consideration here, the slag and silica fume being used as a mineral admixture in the system is also competing with the fly ash for the excess calcium. To examine the effect of the fly ash on the strength development in the concrete a mixture, as shown in Table 3, containing no ash was prepared. The 3 day strength on the mixture (ES-8) with no ash was 2880 PSI as compared to the mixture containing ash at 2860. The use of an additional component represents an increase in the complexity of the mixing operation and hence ultimately greater expense. Also the use of eastern, low calcium content fly ashes in concrete formulations is also know to limit the rate of strength development. Therefore, fly ash was eliminated as a component of the concrete.

Table 3 - Concrete formulations with and without coal fly ash.

	ES-2	ES-7
Recycled Concrete	41.85	41.85
MSW Bottom Ash	29.34	29.34
Cement	20.00	20.00
Slag	3.85	7.71
Fly ash	3.85	
Silica fume	1.11	1.11

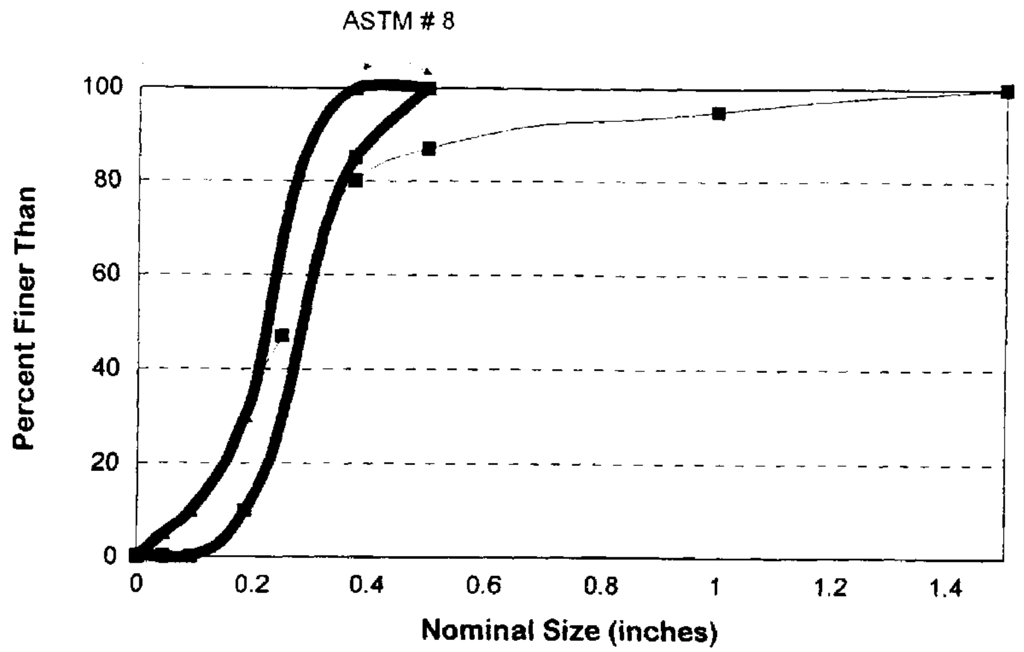


Figure 4. Comparison of size distribution found in as received recycled concrete aggregate to ASTM # 8 limits.

Influence of Ratio of Coarse to Fine Aggregate

Figure 4 compares the size distribution found in the as received recycled concrete aggregate to the ASTM limits for a number 8 aggregate. Examination of figure 4 reveals that based on this comparison the as received recycled concrete aggregate contained a significant amount of over sized material.

Table 4 - Formulations based on mixtures of as received aggregates

	ES-2	ES-5	ES-6
Recycled Concrete	41.85	35.59	
MSW Bottom Ash	29.34	35.59	71.18
Cement	20.00	19.99	20.00
Slag	3.85	3.85	3.85
Fly ash	3.85	3.85	3.85
Silica fume	1.11	1.11	1.11

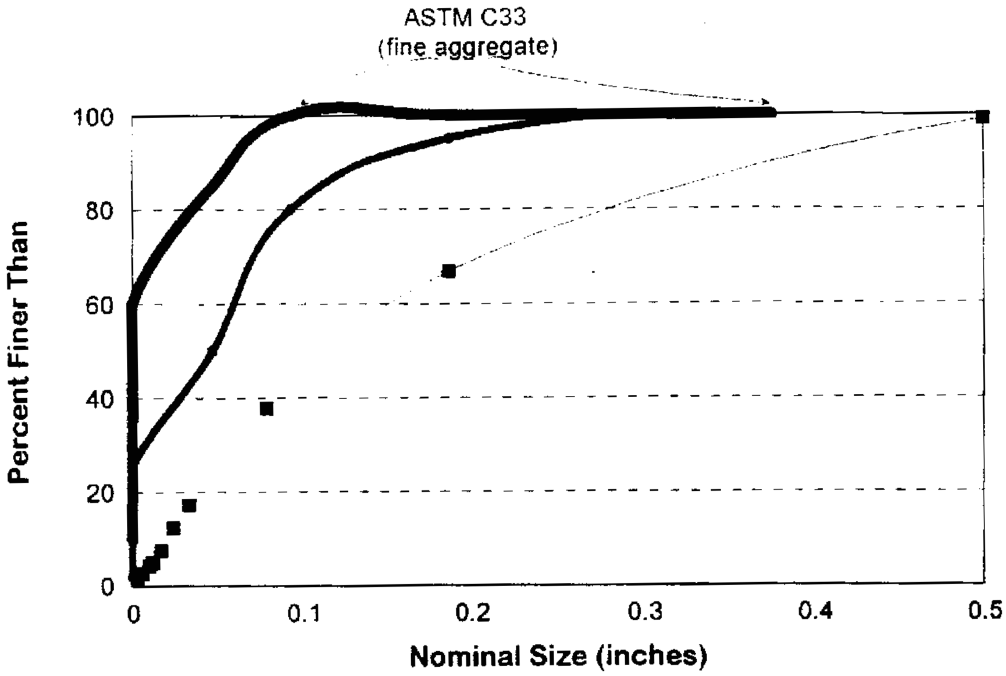


Figure 5. Comparison of the size distribution found in the as received MSW ash with ASTM C33 limits for fine aggregates.

Figure 5 compares the size distribution in the as received MSW ash with the ASTM limits for fine aggregate. Again, comparison of the size distribution with the limits suggests a considerable excess of over size material is present. An attempt was made to compensate for these unusual distributions by blending as shown in Table 4, different proportions of the as received aggregates. The results were not promising. When equal amount of the two aggregates were used 3 day strength of 2550 was the result. When only the finer MSW ash was used as the aggregate the 3 day strength dropped to 2080.

Comparison of Conventional Aggregates With Recycled Aggregates

To compare the performance of the recycled aggregate with more conventional aggregates, two mixtures based on the same formulation were used. Table 5 shows the mixtures used for this comparison. The result of the comparison was the mixture prepared using the conventional aggregate reached a 3 day strength of 3950 versus 2880 for the mixture based on the recycled materials.

Optimization of "Green" Concrete Formulation

The results of the studies discussed in the previous section strongly suggest that the limiting factor for strength development in concrete formulations containing recycled materials was the aggregates. Table 6 shows a number of formulations that were used to isolate the effect of the various aggregates and to explore methods to improve their performance.

Mixture ES-10 was prepared to serve as a basis for comparison. Formulation ES-10 was prepared using conventional aggregates and reached 3 day strength of 3950 PSI. To confirm that the problem did lie with the recycled materials being used as aggregates a formulation, ES-9, was prepared using only portland cement as the cementitious component of the mixture (no slag, fly ash or silica fume), the overall proportions were the same employed for ES-10.

Table 5 - Formulations used for comparison of as received recycled material aggregate with conventional aggregates

	ES-7	ES-10
Recycled Concrete	41.85	
MSW Bottom Ash	29.34	
Conventional Coarse		41.85
Conventional Fine		29.34
Cement	20.00	20.00
Slag	7.71	7.71
Fly ash		
Silica fume	1.11	1.11

Table 6 - Formulations used during the optimization of the "Green" concrete formulation

	ES-10	ES-9	ES-11	ES-12	ES-13	ES-14	ES-15
Recycled Concrete		41.85		41.85			
MSW Bottom Ash		29.34	29.38	29.34			
Sized, Washed Recycled Concrete						41.9	41.9
MSW Bottom Ash, Sized as Fine Aggregate					29.37		29.37
Conventional Coarse	41.85		41.9		41.90		
Conventional Fine	29.34					29.37	
Cement	20.00	28.82	28.70	28.82	20.02	20.02	20.02
Slag	7.71				7.72	7.72	7.72
Silica fume	1.11				0.99	0.99	0.99
Three-day Compressive Strength	3950	3330	2150	2990	3243	5870	3690

The 3 day strength found in formulation ES-9 was 3330 PSI , 620 PSI less than the same formulation when using conventional aggregates. Formulation ES-13 uses conventional coarse aggregate and MSW ash sized according to ASTM C33 as the fine aggregate. When compared to a formulation using conventional aggregates (ES10) the 3 day strengths were 1850 PSI less at 2150 PSI. On the other hand when sized, washed recycled concrete was used as the coarse aggregate in combination with a conventional fine aggregate the strengths jumped to 5870 PSI at 3 days 1920 PSI higher than a similar formulation containing all conventional aggregate (ES-10). When sized, washed recycled concrete was used as the coarse aggregate and sized MSW ash as the fine the 3 day strength was 3690 PSI a considerable improvement over the 2880 PSI found at three days where the as received materials were used as the aggregates. Formulations ES-9 and ES-12 employed the basic components, however, ES-9 used Mighty 150 to control the flow, whereas ES-12, did not. The use of the Mighty 150 improved the 3 day strengths by 340 PSI.

As discussed during the background section, the potential for alkali aggregate reaction is normally lessened when recycled concrete materials are used as aggregates. However, for MSW material the situation was less clear. MSW ash may contain significant fractions of glass and ceramics that may be susceptible to alkali aggregate reactivity. Hence, a rapid test method useful for determining the potential reactivity of aggregates was used to characterize the behavior of the MSW ash employed in the "Green" concrete. The test was modified slightly in that 69.64 wt. % cement, 26.84 slag, and 3.48 wt. % silica fume was used in the place of the cement.

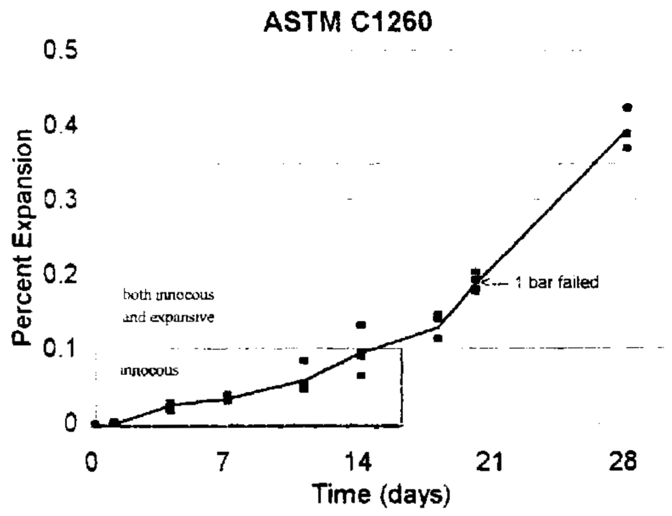


Figure 6. Results of expansion measurements on a mortar (Table 7) containing MSW ash during ASTM C1260 characterization.

Figure 6 shows the results of the expansion measurements. The results of the testing show that at 14 days the expansion found in the mortar was near the upper limit for innocuous behavior and near the area where materials can show either innocuous or expansive behavior could be reasonably expected. When tested beyond the 14 days required by ASTM, the mortar continued to expand. In one case, catastrophic cracking in a mortar bar occurred.

Deterioration due to alkali aggregate reactions occurs as a result of the formation of an expansive gel when an aggregate interacts with the highly alkaline pore fluid form in cements. When a material is being used as the fine aggregate, as is the case for the MSW ash here, the potential for any deleterious effect due to alkali aggregate reaction is greatly reduced. If expansive gels do form, they will be more uniformly distributed throughout the matrix. The gel areas that do form will be small and have more access to pore space where expansion can occur without developing stress. Hence, while there may be more areas of gel formation the likelihood that at any particular point of enough stress developing to cause cracking is greatly decreased. The net result is that when this MSW ash is used as a partial replacement for the fine aggregate no deleterious effect due to alkali aggregate reactivity is likely. Other ashes may exhibit different characteristics and must be evaluated on a case-by-case basis.

Final Formulation Testing and Characterization

Setting Time and Rate of Strength Development

Based on the results discussed in the previous sections a final formulation was arrived at and is shown in Table 7. Since earlier results had shown that the use of sized, washed, recycled concrete had a positive effect on strength development its use was maximized. The MSW ash seemed to be limiting the performance of the system, so its use was restricted to a partial replacement of the fine aggregate. Crushed recycled concrete was used for the remainder of the fine fraction. Slag and silica fume where used a partial replacement of the cementitious portion of the formulation to improve the ultimate durability and strength characteristics of the mix.

Figure 7 shows the setting time of formulation ES-18. The results show that the setting behavior of the "Green" concrete is similar to ones that are more conventional. The rate of strength development in the "Green" concrete is shown in figure 8. Comparisons of the results for ES-18 where the aggregates have been sized, washed and are in proper proportions with ES-1 and ES-2 that used recycled aggregates show the importance of properly preparing the aggregates. The 315 day data shows that the concrete maintains its properties over a long period of time.

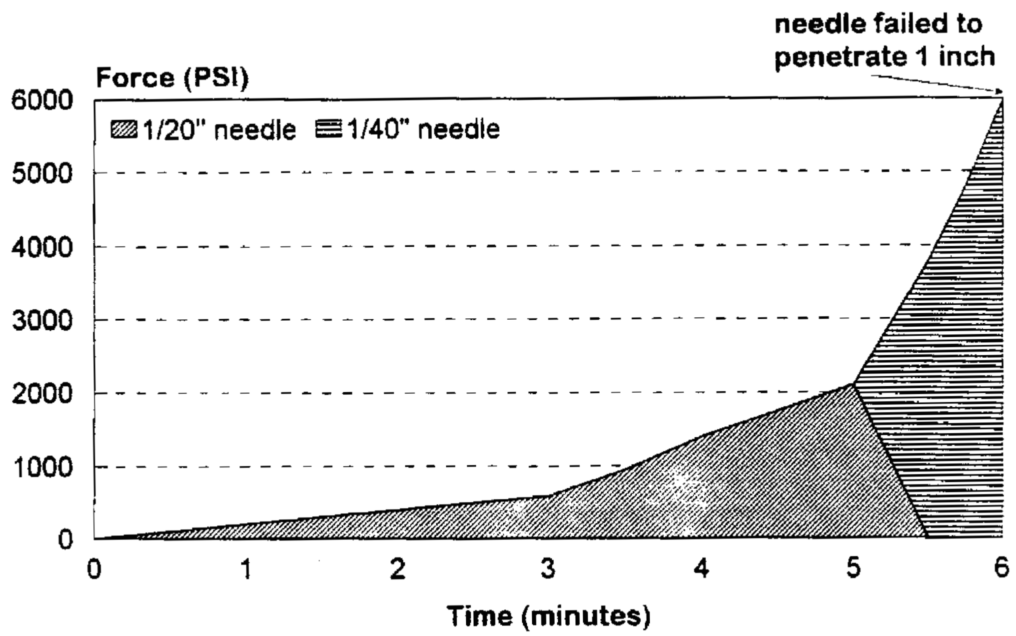


Figure 7. Setting time by penetration resistance.

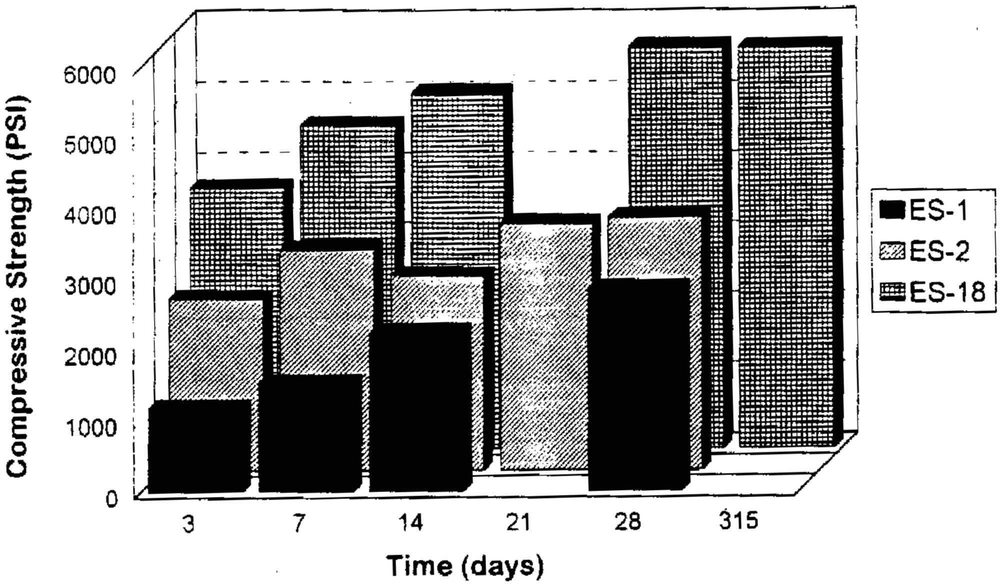


Figure 8. Strength development in concretes containing 80 percent recycled materials on a solid basis. . Data for ES-1 and ES-2 from figure 1 are replotted here for comparison. The formulation for ES-18 is given in Table 7.

Table 7 - "Green" concrete formulation

	ES-18
Sized, Washed Recycled Concrete	41.85
Recycled Concrete, Sized as Fine Aggregate	19.56
MSW Bottom Ash, Sized as Fine Aggregate	9.78
Cement	20.00
Slag	7.71
Silica fume	1.11

Freeze-Thaw Characteristics

The concretes were tested for freeze thaw resistance using ASTM Standard E555. Using formulation ES-18 a series of concrete cylinders were cast and exposed to rapid

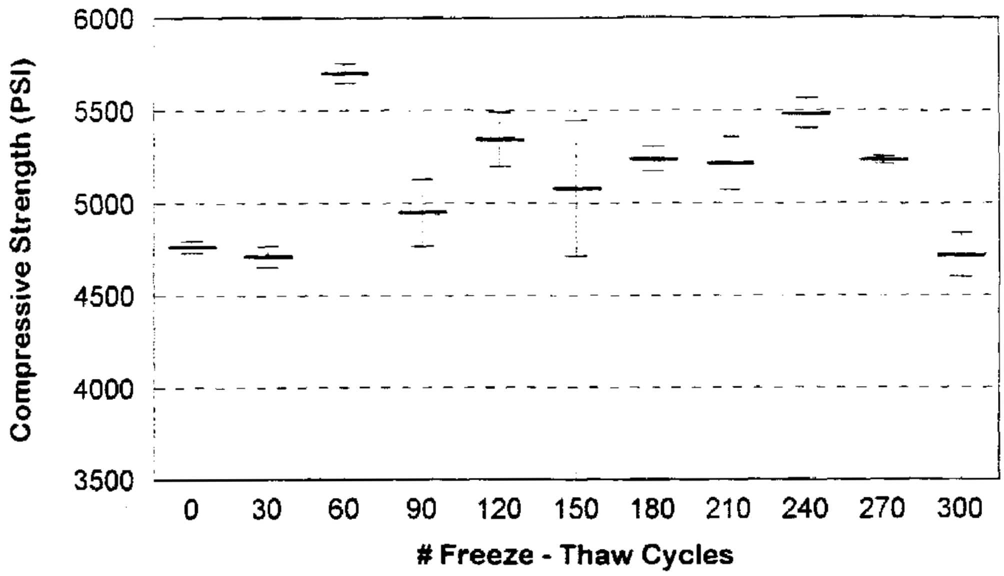


Figure 8. Strength behavior during freeze thaw testing.

freeze-thawing. Every 30 cycles, 3 specimens were removed an their compressive strength determined. The results are shown in Figure 8. The result shows that the "Green" concrete withstood the freeze-thaw cycling well.

Environmental Considerations

Whenever waste materials are being utilized the potential for adverse environmental effects must be addressed. For the types of materials, being considered here the main potential area of concern was leaching from the hardened concrete. Portland cement based systems have been found effective hosts for many potentially hazardous species. The reasons for this are twofold. First, most heavy metals are least soluble at elevated pH ranges generally precipitating as metal hydroxides. For instance, in an extensive study, Silsbee and Scheetz[7] have demonstrated lead extracted from the pore fluids of lead-bearing portland cement/soluble silicate waste forms was limited by the solubility of lead hydroxide, figure 9.

As noted previously, the reaction of relatively silica rich mineral admixtures with portlandite formed during the progressive hydration of both di- and tri-calcium silicate contributes to the enhanced formation of C-S-H in the matrix. Effectively there is more "glue" per unit volume, therefore, physical properties of the composite are improved. C-S-H can act as an encapsulate for waste species, as a template for chemisorption of waste

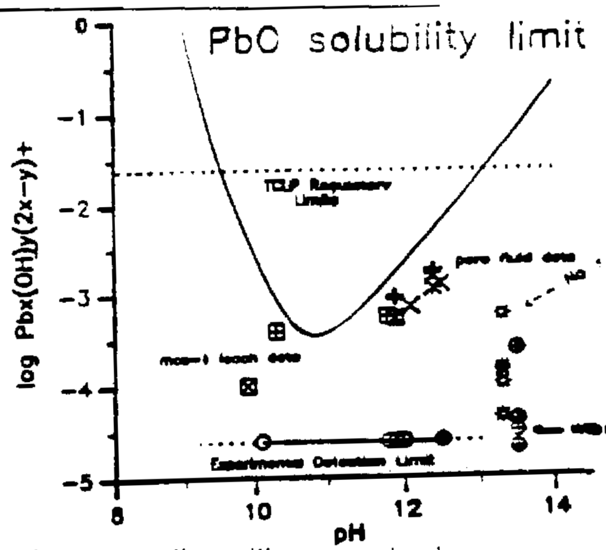


Figure 9. Solubility of lead in sodium silicate/portland cement waste forms.

species or as a crystal chemical host[8]. The most comprehensive model for C-S-H as a crystal chemical host was presented by Richardson and Groves[9]:

$$Ca_xH_{(6n-2x)}(Si_{1-a}R_a^{[IV]})_{(3n-1)}O_{(9n-2)} \cdot A^{c+}_{a(3n-1)/c} \cdot zCa(OH)_2 \cdot mH_2O$$

where:

x = 0.5(6n-w)
z = 0.5[w−n(y-2)]
for 0<y<4; n(2-y)<w,2n
2<y<4; 0<w<2n
4<y<6; 0<w,n(6-y)
and 0<a<(n-1)(3n-1)
$R^{[IV]}$ = trivalent, tetrahedrally coordinated cation (usually Al or Fe)
A^{c+} = interlayer ion which charge balances the R^{3+} substitution for Si^{4+} (M⁺)

Ni, Co[10], U, I and Sn[11] are reported to be substituted for Ca^{2+} on the surface of C-S-H. Cr^{3+} is reportedly exchanged for Al^{3+} in poorly crystalline C-S-H[12]. Both Ni[10] and Cd[8] are reported to precipitate as $M(OH)_2$ species. To examine the potential for hazardous leaching from the "green" concrete developed here two approaches were taken. In the first approach, samples of mature concrete (ES-18) were examined using two leaching procedures a deionized water leach and EPA 1312 known as TCLP. The results of these 2 procedures are shown in Table 8. The heavy metals As, Cd, Cr, Hg, Mn, Sb and Se were below detection limits. Lead leached at a level just above our detection limit in one case. No cyanide was detected in the leachates.

Table 8 - Regulatory leach testing of "Green" concretes

mg/L	Deionized water	TCLP
Ag	<0.02	0.03
Al	1.01	0.37
As	<0.005	<0.005
B	<0.02	0.21
Be	<0.02	<0.02
Ba	0.5	0.86
Ca	330	1860
Cd	<0.01	<0.01
Co	<0.02	<0.02
Cr	<0.02	<0.02
Cu	<0.02	<0.02
Fe	0.05	<0.02
Hg	<0.002	<0.002
K	80	85
Mg	0.1	10.9
Mn	<0.02	<0.02
Mo	0.03	<0.02
Na	32	37
Ni	<0.02	<0.02
Pb	0.02	<0.005
Sb	<0.005	<0.005
Se	<0.005	<0.005
Si	0.65	16.7
Sr	3.8	8.8
Ti	<0.02	<0.02
Tl	<0.005	<0.005
V	<0.02	0.05
Zn	<0.02	<0.02
Zr	0.07	0.32
CN	<0.1	<0.1
F	0.6	xxx
Cl	1.6	4.1
NO2	<0.05	<0.05
NO3	1.8	1.9
PO4	<0.1	<0.1
SO3	<0.2	<0.2
SO4	8.8	145
pH	12.31	10.7

The second approach used a more rigorous leaching procedure developed for the testing of radioactive waste forms, ANS 16.1. In this test samples of the "Green" concrete was exposed to the leachate for up to 1088 hours. The results of the testing are shown in Table 9. As during the regulatory testing, heavy metals were detected at levels near or below detection limits.

Pretreatment of MSW Ash

During the development of the green concrete, it became apparent that the behavior of the MSW ash was limiting the property development in the concrete. Observations indicated that gas was evolving as the MSW as came into contact with the highly alkaline pore fluids of the concrete. As indicated earlier a possible cause has been postulated for this effect. In this scenario, a metallic portion of the ash is being attacked by the highly alkaline pore fluid present in the concrete releasing hydrogen gas. Assuming the metallic portion to be aluminum the reaction would occur as shown below:

$$2Al(s) + 2OH^- + 6H_20 \longrightarrow Al(OH)_4^- + \uparrow H_2\,(g)$$

The net result is that an overabundance of "entrained" air is limiting the strength development of the concrete. The second effect commonly observed when using MSW ash in concrete applications is a delayed set or reduced rate of hydration.

The use of X-ray powder diffraction to characterize the as received ash reveal that the ash is composed largely of quartz, anorthite and maghematie in descending order of abundance. Figure 10 and Table 10 show the results of the X-ray analysis.

Given the observations discussed in the preceding paragraph, an attempt was made to "prereact" the ash by soaking the MSW ash in various hot solutions. The treatments consisted of soaking the crushed ash in the prescribed solution for 1 hour, repeated three times. The chemical additions were made at the rate of 0.1 mole/liter. The ashes were incorporated into mortars and strength development determined. The results are shown in Table 11. For comparison, a control mortar using ASTM C109 sand was also prepared. When untreated ash was used the 28 day strengths observed in the mortars was less than one-half that of the control mortar. The use of alkaline solutions during the treatment results in improved performance. When a mixture of $Ca\,(OH)_2$ and Na_2SO_4 was used, the strengths in the mortar exceed that of the control mortar. When the solution was neutral or acidic lower strength resulted. As shown in Table 12, when the treated ashes where used in concretes the results were less promising.

Table 9 - ANS 16.1 testing of "Green" concrete.

(mg/L) / Hours	0	2	7	24	48	72	96	120	336	672	1008
Ag	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Al	0.43	0.47	0.59	0.98	1.05	1.03	1.04	1.17	2.23	2.40	1.55
As	<0.01	<0.01	0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
B	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.08	0.10	0.11	0.02
Ba	0.02	0.02	0.03	0.04	0.04	0.04	0.04	0.04	0.09	0.10	0.05
Be	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ca	0.39	7.3	7.8	27.5	25.9	9.7	13.1	19.1	85	90	135
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Co	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Cr	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0
Cu	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fe	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0
K	0.07	6.6	3.75	7.9	6.1	4.4	3.63	3.10	17.1	15.3	12.5
Mg	<0.02	<0.02	0.02	0.04	0.04	0.05	0.04	0.04	0.03	0.03	<0.002
Mn	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
Mo	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Na	<0.02	2.10	1.11	2.45	1.91	1.40	1.23	1.00	6.0	5.6	5.7
Ni	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Pb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Se	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	<0.02	0.51	0.57	1.55	1.71	1.94	1.57	1.88	4.31	4.47	5.7
Sr	<0.02	0.04	0.06	0.14	0.13	0.11	0.09	0.10	0.48	0.47	0.52
Ti	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Tl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
V	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Zn	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zr	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
F	<0.001	0.06	0.03	0.05	0.04	0.02	0.02	0.02	0.15	0.16	0.11
Cl	<0.005	0.22	0.10	0.16	0.09	0.07	0.09	0.05	0.15	0.18	0.10
NO2	<0.005	0.03	0.01	0.01	0.01	0.01	<0.005	<0.005	0.01	0.01	<0.005
NO3	0.02	0.08	0.11	0.05	0.05	0.02	0.02	0.03	0.03	0.02	<0.01
PO4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SO4	0.01	1.85	1.24	2.38	2.06	1.72	1.34	1.31	4.21	4.35	4.11

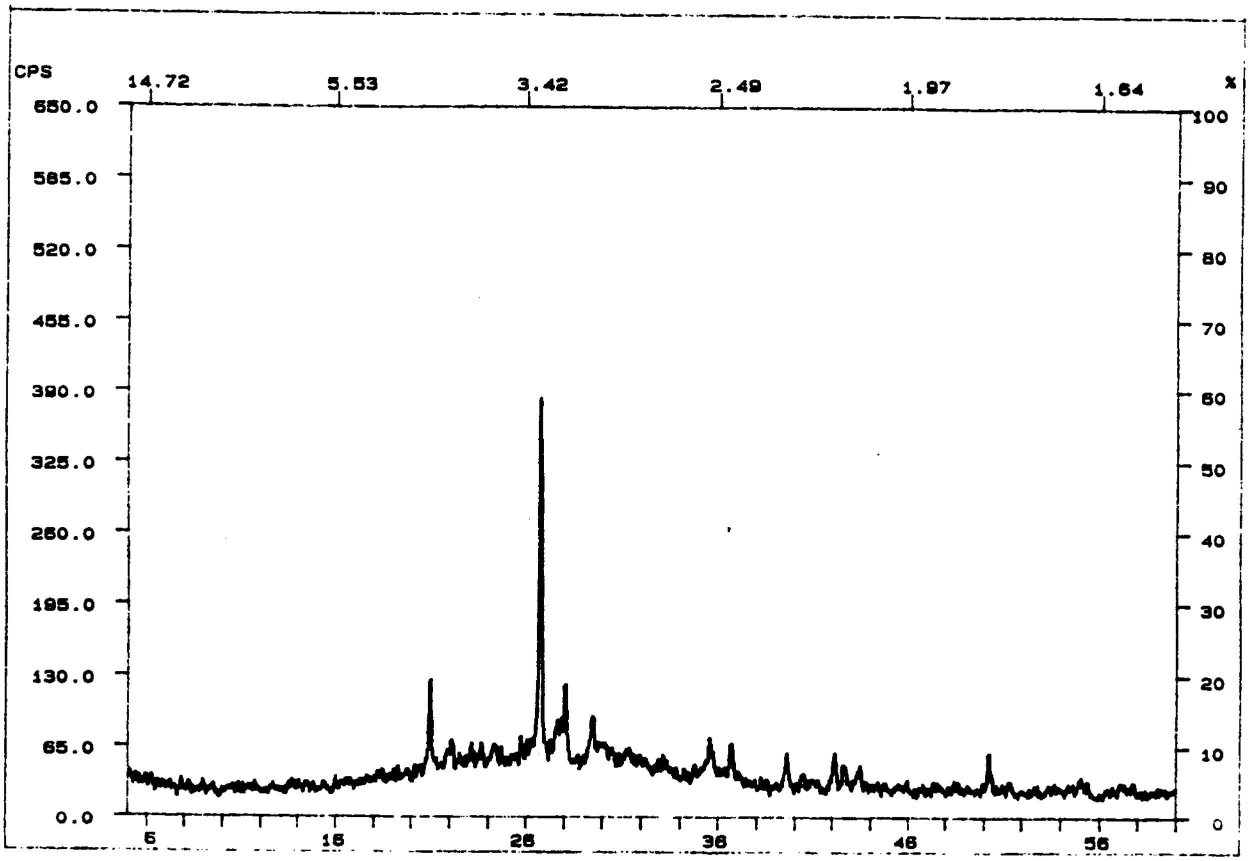


Figure 10 - Powder X-Ray diffraction study of as received Seamass boiler ash.

Table 10 – JCPDS comparison of peaks found in as received Seamass bolier ash.

PATTERN 1 IS JCPDS-ICDD PDF NUMBER 33 1161 SILICON OXIDE / QUARTZ, SYN

PATTERN 2 IS JCPDS-ICDD PDF NUMBER 25 1402 IRON OXIDE / MAGHEMITE-Q, SYN

PATTERN 3 IS JCPDS-ICDD PDF NUMBER 41 1486 CALCIUM ALUMINUM SILICATE / ANORTH

ERROR(DEG):0.200

DSPACE	I/I1	33-1161		25-1402		41-1486	
4.236	19	4.257	22				
4.016	6					4.040	22
3.461	6					3.466	4
3.419	6			3.400	7		
3.334	100	3.342	100				
3.203	10			3.200	3	3.209	88
3.180	23					3.181	100
3.032	12					3.038	9
2.970	5					2.952	17
2.933	6			2.950	30	2.934	11
2.527	9					2.524	10
2.513	7			2.514	100	2.505	9
2.449	7	2.457	8				
2.276	9	2.282	8				
2.145	8					2.140	14
2.123	7	2.127	6			2.119	7
2.081	5			2.086	15		
1.973	5	1.979	4				
1.868	6			1.865	1		
1.814	15	1.818	14	1.820	3		

Table 11 - Effect of chemical pretreatment of MSW ash on compressive strength development in mortars.

Mixture Composition						Compressive Strength (PSI)	
OPC	ASTM C109 Sand	Crushed ash	Water	Treatment*	W/C	3 day	28 day
65.2	16.3	-.-	18.5	N.A.**		12,190	13,720
65.2		16.3	18.5	none	0.28	3,820	6,100
65.2		16.3	18.5	25°C	0.28	4,080	5,380
65.2		16.3	18.5	Boiling Water	0.28	6,170	5,880
65.2		16.3	18.5	Boiling NaOH soln.	0.28	8,820	10,650
65.2		16.3	18.5	Boiling $Ca(OH)_2$ soln.	0.28	8,270	11,880
65.2		16.3	18.5	Boiling $CaSO_4$ soln.	0.28	8,920	12,060
65.2		16.3	18.5	Boiling $Ca(OH)_2$ + Na_2SO_4 soln.	0.28	9,330	14,110
65.2		16.3	18.5	Boiling H_3PO_4 soln.	0.28	6,040	7,280
65.2		16.3	18.5	60°C treated $Ca(OH)_2$ + Na_2SO_4	0.28	4,920	3,540
65.2		16.3	18.5	60°C treated $Ca(OH)_2$	0.28	5,520	2,280

* The treatment consists of soaking the crushed ash in the prescribed solution for 1 hour, repeated three times. The chemical additions were made at the rate of 0.1 mole/liter. ** N.A. - Not applicable

Table 12 - Testing of concretes using treated* MSW ash

								Compressive (days)	
Treated Coarse MSW ash	Recycled Concrete	Natural Sand	Treated Fine MSW ash	OPC	Slag	Water	S.P.[1]	7	28
41.9		29.4		28.7		10.7	0.3	2,640	2,940
	41.9		29.4	20	7.7	10.17	0.42	920	1,440

S.P.[1] - Mighty 150

The results in all cases were strengths significantly lower that when using untreated ash. One possible explanation was a loss of workability. Clearly, this area deserves more investigation.

Powder X-ray diffraction was used to compare the crystalline phase development occurring in mortars prepared using both a conventional quartz sand and crushed, sized boiler ash. The results of the X-ray analysis are shown in Figures 11 and 12. Figure 11 shows the analysis of the mortar prepared using standard quartz sand. As shown in the figure the analysis reveals that as expect the quartz remains unreacted. In addition, apparently some dicalcium silicate remians unreacted. This is also quite typical. The crystalline hydration products observed are calcium hydroxide, calcium aluminum sulfate hydrate and a calcium silicate hydrate. Some calcium carbonate is also present most likely because of atmospheric carbon reacting with the calcium hydroxide hydration product. Figure 12 compares the pattern obtained from a mortar prepared using standard quartz aggregate with that from a mortar prepared using Seamass boiler ash. The results indicate that hydration products forming in the mortar prepare using the boiler ash are not significantly different from those prepared using the standard sand. These results indicate that the largest fraction of the boiler ash is not reacting during the hydration of the cement. The effect of the boiler ash on the hydration process is due to the presence of small amounts of soluble phases that are acting as retarders to the hydration process.

Project Summary

A "Green" concrete formulation using 80 percent recycled materials (on a solids basis) was developed. When tested using conventional concrete testing techniques the "Green" concrete exhibits properties similar to concretes that are more conventional. The lessons learned during the coarse of this study were:

1. When using recycled materials care must be taken during their preparation. Grading, washing and chemical pretreatments were all found to be viable ways of improving the performance of the recycled materials

2. In a properly designed concrete, recycled materials can be used in a manner that results in an environmental impact similar to that of materials that are more conventional.

3. MSW ash may under certain circumstances be used in concreting applications. However, the volume fraction of ash that may be employed will be limited.

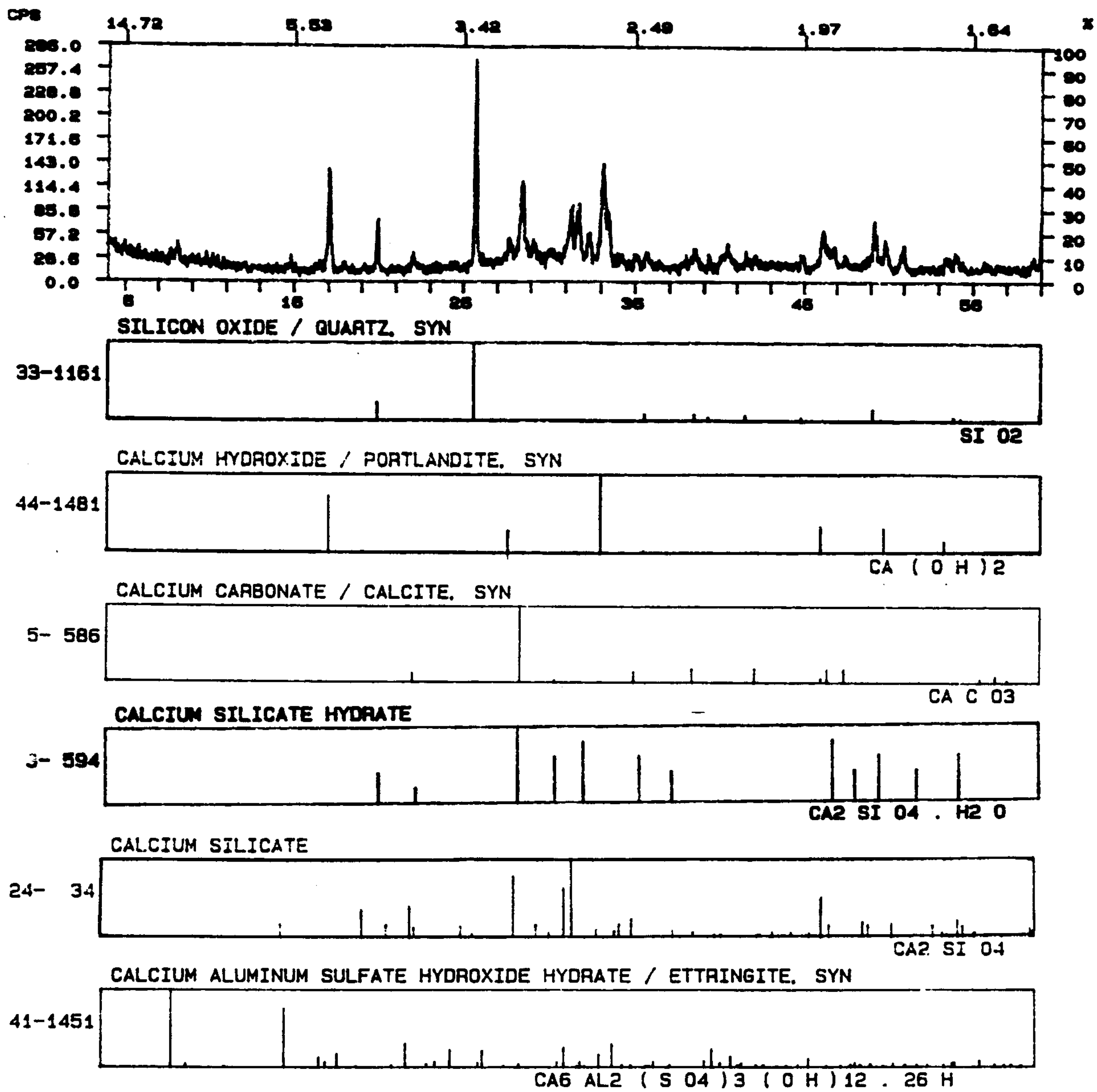


Figure 11- Analysis of the mortar prepared using standard quartz sand.

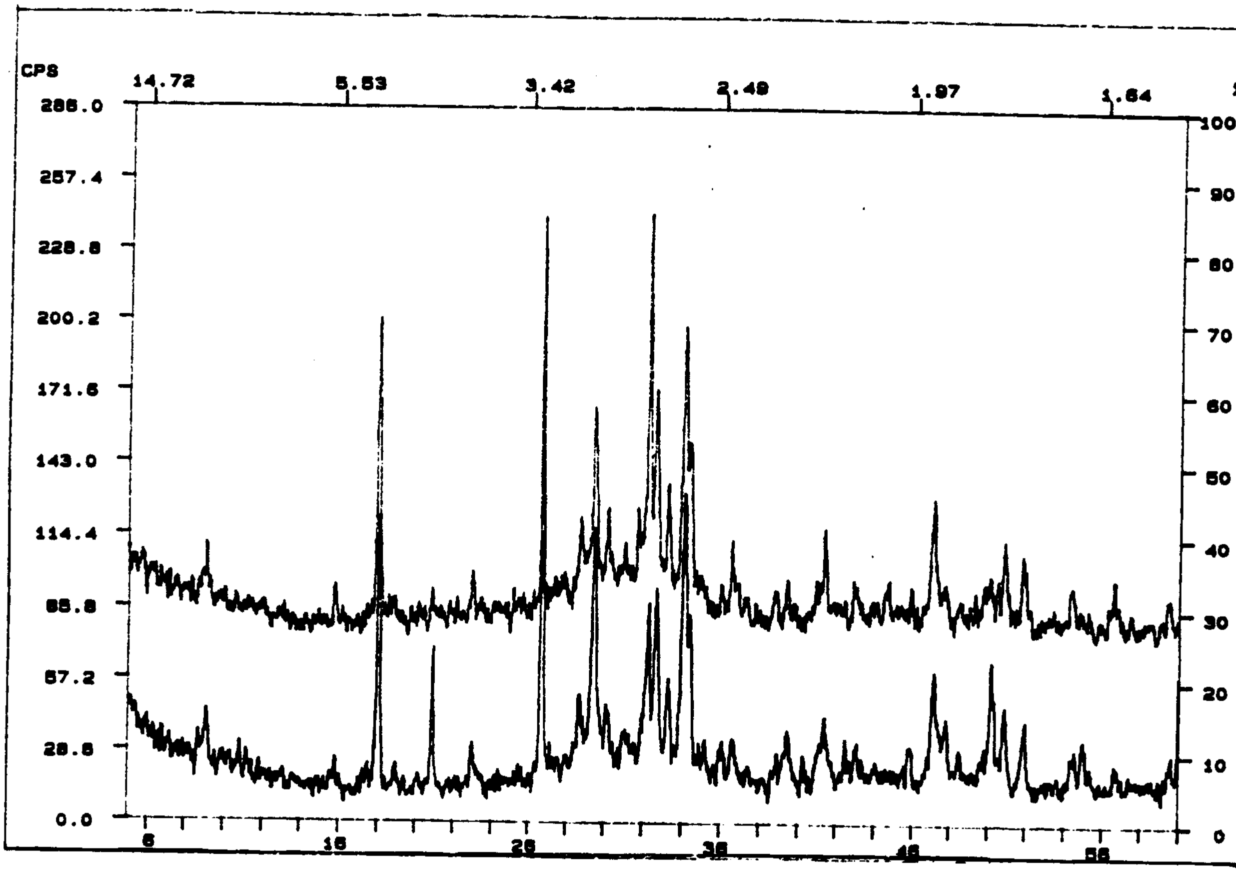


Figure 12 – Comparison of the X-ray patterns obtained from mortars prepared using standard quartz sand to a mortar prepared using Seamass boiler ash.

References

1. National Cooperative Highway Research Program Synthesis of Highway Practice 154, Recycling of Portland Cement Concrete Pavements, Transportation Research Board, National Research Council, Washington, D.C., Dec. 1989.

2. Steisel, N., Morris, R. and Clark, M.J., " The Impact of The Dioxin Issue on Resource Recovery in the United States," Waste Mgt. Res. **5** 381-394 (1987).