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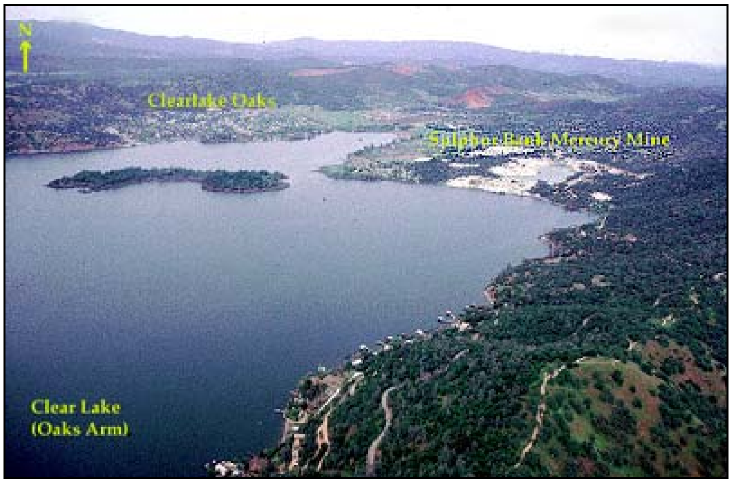
September 2001

Final Report

Characterization and Eh/pH-Based Leaching Tests of Mercury-Containing Mining Wastes from the Sulfur Bank Mercury Mine, Lake County, California



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Notice

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Foreword

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threatens human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
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Mr. Paul de Percin was the U.S. EPA Project Officer for this contract and Mr. Paul Randall was the Task Order Manager (TOM) for this TO. Dr. Victor Magar was the Battelle Program Manager for this contract. Dr. Sandip Chattopadhyay was the Battelle Task Order Leader (TOL) and Project Manager. The members of the Battelle project staff included Ms. Jennifer Ickes, Ms. Kirsten Hartzell, Ms. Jody Lipps, and Mr. Daniel Janke. Editorial and graphical support was provided by Mr. Thomas Wilk, Mr. Dean Sutton, and Ms. Loretta Bahn.

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ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
BDL	below detection limit
BEI	backscattered electron image
ccm	cubic centimeters per minute
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CVAA	cold vapor atomic absorption
EDS	energy dispersive spectrophotometer
Eh	redox equilibria (volt difference between platinum electrode and standard hydrogen electrode)
Fe	iron
$Fe(NO_3)_3$	ferric nitrate
Hg	mercury
HgS	cinnabar
H_2O_2	hydrogen peroxide
H_2SO_4	sulfuric acid
ICDD	International Centre for Diffraction Data
MDI	Materials Data, Inc.
NaOH	sodium hydroxide
NPL	National Priorities List
NRMRL	National Risk Management Research Laboratory
NS	not sampled
NTU	nephelometric turbidity unit(s)
ORP	oxidation-reduction potential
pH	negative logarithm of the activity of aqueous H^+
QAPP	Quality Assurance Project Plan
RO	reverse osmosis
SBMM	Sulfur Bank Mercury Mine
SEI	secondary electron image
SEM	scanning electron microscope
SiO_2	silicon oxide, quartz
TCLP	Toxicity Characteristic Leaching Procedure
TiO_2	anatase
TO	Task Order
TOL	Task Order Leader
TOM	Task Order Manager

UC	University of Cincinnati
UHP	ultrahigh purity
U.S. EPA	United States Environmental Protection Agency
XRD	x-ray diffractometer

1.0 INTRODUCTION

Clear Lake in northern California has received inputs of mercury (Hg) mining wastes from the Sulfur Bank Mercury Mine (SBMM) (Figure 1-1). About 1.2 million tons of Hg-contaminated overburden and mine tailings were distributed over a 50-ha surface area due to mining operations from 1865 to 1957 (Gerlach et al., 2001). The SBMM includes an open, unlined mine pit, Herman Pit, which covers approximately 23 acres and is 750 feet upgradient of Clear Lake. Reynolds et al. (1997) analyzed water samples collected from Herman Pit and Clear Lake and reported the pH values at those locations as 3 and 8, respectively. The SBMM was placed on the Final National Priorities List (NPL) list in 1990. The site has been under investigation as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site and has experienced some minor corrective actions. Clear Lake remains under a fish advisory due to the mercury contamination.

Figure 1-1. Location Map of Sulfur Bank Mercury Mine

Mercury in contaminated soils is a unique pollutant that requires innovative remediation solutions. Conventional stabilization/solidification treatments cannot effectively reduce the leachability of Hg (Conner, 1990). As part of the remediation effort at the SBMM site, the U.S. EPA is assisting in the development of treatment alternatives for waste material from the site. Waste materials consist of waste ore, waste rock, and roaster tailings. To support this work, leaching profiles of waste ore over a range of different pH and oxidation-reduction (Eh) conditions were performed. Chemical and biological processes affecting the mobility of metals may be initiated by altering the physicochemical environment (i.e., pH and Eh conditions). Important processes influencing the chemistry and availability of trace and toxic metals include (1) precipitation as insoluble sulfides under highly reduced conditions (Morel et al., 1974); (2) formation of discrete metal oxides and hydroxides of low solubility (Morel et al., 1974); (3) adsorption of colloidal hydrous oxides of iron and manganese, primarily in aerobic, neutral, or alkaline environments (Windom, 1973); and (4) complex formation with soluble and insoluble organic matter (Loganathan et al., 1977).

Each experiment has been designed to evaluate leachability of Hg from the waste materials under controlled conditions in order to assess conditions that may contribute to the destabilization of Hg in the waste ore.

1.1 Project Objective

The objective of this TO was to study a range of different pH and Eh values in order to evaluate the potential of SBMM waste ore to leach Hg. This study was conducted in accordance with the Quality Assurance Project Plan (QAPP) No. 63-Q1-3 (Battelle, 2001).

2.0 LABORATORY EXPERIMENT AND ANALYTICAL METHODS

Table 2-1 identifies both critical and noncritical measurements that were made during the course of this study. All analytical methods are described in QAPP No. 63-Q1-3 (Battelle, 2001) except the method for chloride analysis. (Chloride analysis was requested by the U.S. EPA TOM via e-mail on May 22, 2001.)

Table 2-1. Critical and Noncritical Measurements and Methods

Measurement	Method
Critical	
Mercury	U.S. EPA SW-846 Method 7470A
ORP	ORION® 96-78-00 Combination Redox Probe
pH	U.S. EPA Method 9045C
Noncritical	
Turbidity	Hach 2100N Turbidimeter
Alkalinity/Acidity	U.S. EPA Method 310.1/305.1
Chloride	U.S. EPA Method 407A

ORP = oxidation-reduction potential.

2.1 Solid Material Preparation

The waste ore used in this study was obtained from the SBMM by the U.S. EPA. After receipt at Battelle, the waste material was homogenized, and then was ground for 8 hours and passed through American Society for Testing and Materials (ASTM)-approved No. 30 and No. 100 sieves to achieve particle sizes between 150 µm and 600 µm. The moisture from the samples was removed according to ASTM Method D2261-80.

2.2 Variable pH Leaching Procedure

The pH leaching procedure was based on University of Cincinnati's constant pH leaching procedure from QAPP No. 63-Q1-2 (UC, 1999). All experiments were conducted in accordance with the approved QAPP (QAPP ID No. 63-Q1-3) (Battelle, 2001).

To measure leachability at different pH values (2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12), 25 g of dry solid sample were added in each 1-L bottle. Leachant at different pH values was prepared by adding nitric acid (0.1 N) or sodium hydroxide (0.1 N) in deionized reverse osmosis (RO) water. Duplicate samples were prepared for pH values 2, 5, 9, and 12. A solution to solid ratio of 20:1 was maintained in each of the bottles containing soil waste materials. The bottles were placed on a tumbler (Model 3740-12-BRE, Associated Design & Mfg. Co., VA) and equilibrated overnight. The pH was monitored frequently and adjusted as needed over the 24-hour time period. At the end of the reaction period, the pH of the leachant and the equilibrium pH of the solid-liquid suspension were recorded. ORPs of the leachate also were recorded after equilibration. Both pH and ORP were measured by a Corning pH/ion meter (Model 450). The ORP values were converted and are reported as Eh.

The above leaching procedure was followed in presence of ferric nitrate ($Fe[NO_3]_3 \cdot 9H_2O$) (J.T. Baker, NJ) at four different pH values (3, 6, 9, and 11) to determine the effect of iron (Fe) on leaching of Hg. The amount of $Fe(NO_3)_3 \cdot 9H_2O$ added to each sample was based on the Hg concentration as observed from the previous set of experiments where no Fe was added. The amount of ferric nitrate was based on a final Fe concentration equal to the Hg concentration from the variable pH experiments (Table 2-2).

Table 2-2. Fe(III) Concentrations

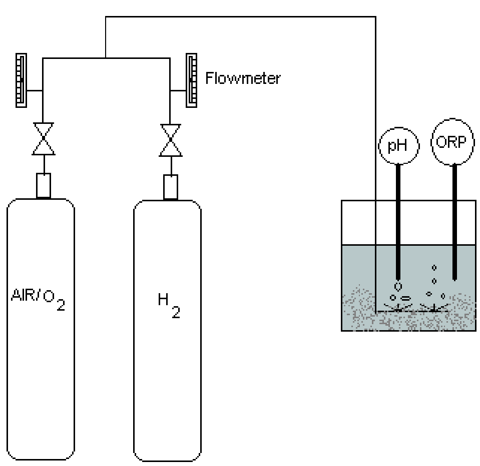
pH	Hg Concentration in Absence of Fe(III) (µg/L)	$Fe(NO_3)_3$ $9H_2O$ (mg)
3	15.3	0.055
6	728	2.633
9	1,938	7.009
11	4,020	14.540

2.3 Variable Eh Leaching Procedure

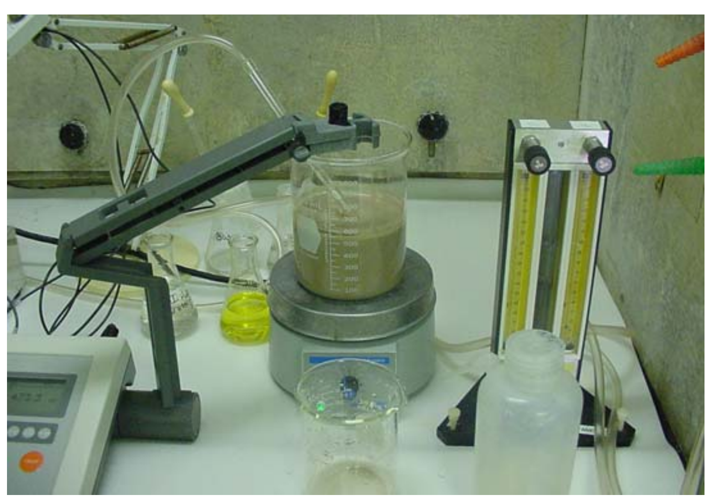
This section describes the experimental plan to determine the effect of Eh at two different pH values, on the mercury concentrations in the leachate. The pH of the leachant was maintained by adding suitable amounts of sulfuric acid (H_2SO_4) or sodium hydroxide (NaOH). The pH values selected by the U.S. EPA were 3.2 and 6.0. About 500 mL of the leachant was added to 25 g of prepared waste ore material, and the solution was readjusted to the desired pH. The Eh of the suspension then was varied by using one of the following three methods, without adding any chemicals: (1) purging the suspension with O_2 (to make the water aerobic); (2) purging the suspension with a mixture of H_2 and O_2; and (3) purging the suspension with N_2 or H_2 (to make the water anaerobic). About 1,670 µL of 3% hydrogen peroxide (H_2O_2) was added to achieve a higher Eh value of 0.63 V during only one set of experiments. All other experiments were conducted using different proportions of gas and gas flow control to establish target Eh values within the upper and lower Eh boundary conditions. To determine the effect of Fe(III), 0.01 g of $Fe(NO_3)_3{\cdot}9H_2O$ was added in three samples during the variable Eh experiments (Table A-4). A schematic diagram and a photograph of the experimental setup are shown in Figure 2-1.

2.4 Filtration

After leaching, the suspended samples were filtered prior to Hg analysis. The suspension was passed through 0.7-µm Toxic Characteristic Leaching Procedure (TCLP) acid-treated low metal glass fiber filters (Whatman, UK) using a pressure filtration unit (Millipore Corp., MA) pressurized with ultrahigh purity



a. Schematic Diagram



b. Photograph

Figure 2-1. Variable Eh Experimental Setup

(UHP) nitrogen (see Figure 2-2). The filtrate from each sample was collected in a 500-mL bottle; a portion of the sample was acidified with nitric acid to obtain a pH less than 2 and stored inside the refrigerator at 4°C until analyzed for Hg. The remainder of the sample was sent to Wilson Environmental Laboratories (Columbus, OH) for either alkalinity/acidity analysis or chloride analysis.

Figure 2-2. Millipore Pressure Filtration Unit Pressurized with UHP Nitrogen

2.5 Analytical Procedures

The samples were prepared and analyzed according to U.S. EPA SW-846 Method 7470A: Mercury in Liquid Waste and Method 7471A: Mercury in Solid or Semisolid Waste by using a cold vapor atomic absorption (CVAA) spectrophotometry (Perkin Elmer 5100PC Atomic Absorption Spectrophotometer attached with Flow Injection Automated System), in which the mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passed through a quartz cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) was measured at the 253.7-nm wavelength as a function of mercury concentration. The detection limit was 0.2 µg/L. Total elemental analysis was conducted by acid digestion as per U.S. EPA Method 3050B of 1 g of solid sample to a final volume of 100 mL.

The turbidity of the filtrate was measured by using a Hach 2100N turbidimeter. Alkalinity and acidity were analyzed using U.S. EPA Methods 310.1 and 305.1, respectively. Chloride was analyzed using U.S. EPA Method 407A.

3.0 RESULTS AND DISCUSSION

The results of the experiments are discussed and analyzed below; analytical results are tabulated in Appendix A.

3.1 Characterization of Waste Materials

Selected physical and chemical properties of the SBMM waste ore material are given in Table 3-1. The material has an acidic pH and was moderately oxidizing. The homogenized and sieved solid samples were analyzed with an x-ray diffractometer (XRD), scanning electron microscope (SEM), and energy dispersive spectrophotometer (EDS). The XRD patterns (Figure 3-1) of the recovered crystalline phases were compared using organic and inorganic databases from the International Centre for Diffraction Data (ICDD) Powder Diffraction Database, and Materials Data, Inc. (MDI) Jade software for pattern treatment and search-match. In this analysis, the crystals anatase (synthetic TiO_2), cinnabar (HgS), and silicon oxide (SiO_2) were identified. The secondary electron images (SEIs), backscattered electron images (BEIs), and EDS elemental analyses are shown in Figures 3-2a through 3-2c. Secondary electron imaging shows topographic contrast, with highest resolution at low operating current. Backscattered electron imaging shows compositional contrasts, which are greatest at higher operating current.

3.2 Effect of Eh and pH Conditions

Eh and pH conditions are important influences on the mobility of Hg. Figure 3-3 illustrates different chemical forms of Hg under specific Eh and pH conditions. The data points (◆) on the stability diagram show the different conditions achieved during the experiments. In general, metallic mercury is very insoluble in sediments over a wide pH range. Dissolved inorganic Hg combines with chloride up to a pH of 7. It exhibits a very high affinity for sulfide in mildly reducing environments, such as stream and lake sediments, forming insoluble mercuric sulfides (Wang and Driscoll, 1995). Dissolved Hg also sorbs strongly to sediment and suspended solids, including iron oxyhydroxides (Balogh et al., 1997). Gagnon and Fisher (1997) demonstrated that the binding strength of mercury to sediments is high and that less desorption occurs under acidic conditions.

Table 3-1. Selected Physical and Chemical Properties of SBMM Waste Ore

Properties	Analytical Result
pH	3.2±0.10
Eh	0.44±0.055 V
Particle Size Distribution	
Sand (>50 µm)	81%
Silt (2-50 µm)	41%
Clay (< 2 µm)	36%
Carbon Content	
Organic	0.44% C
Total	0.46% C
Cation Exchange Capacity	6.5 mequiv/100g
Elemental Analysis	
Mercury	206 µg/g
Arsenic	3.9 µg/g
Titanium	364.9 µg/g
Lead	36.5 µg/g
Sulfide	3285.4 µg/g

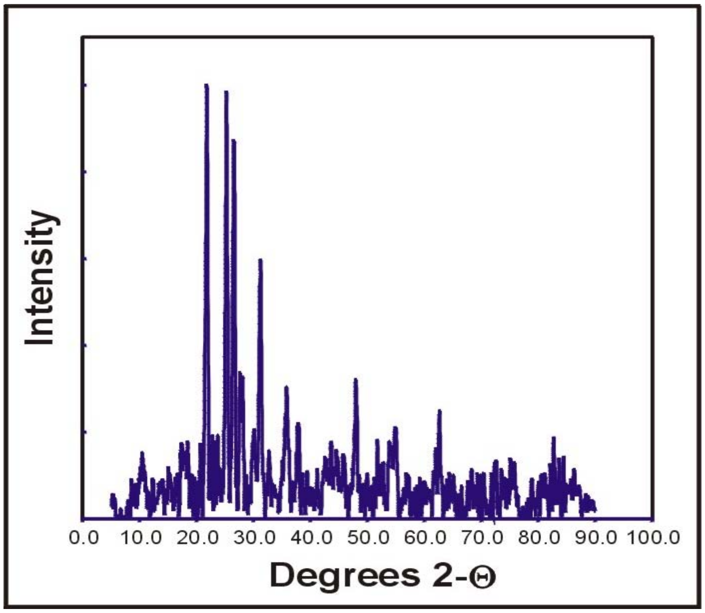
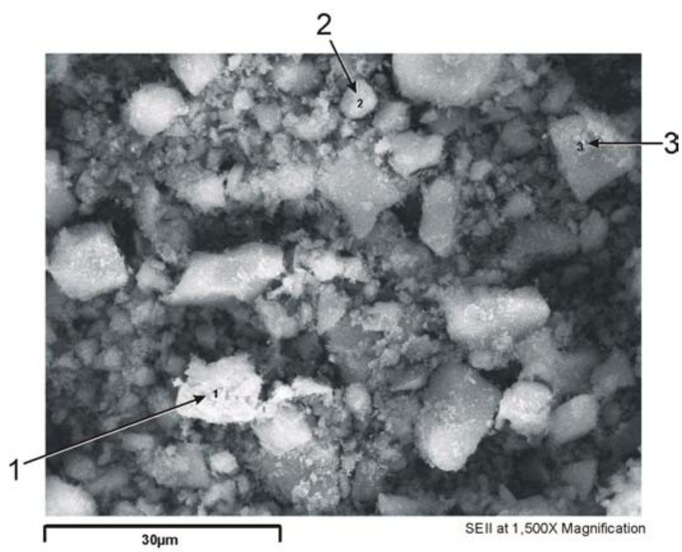


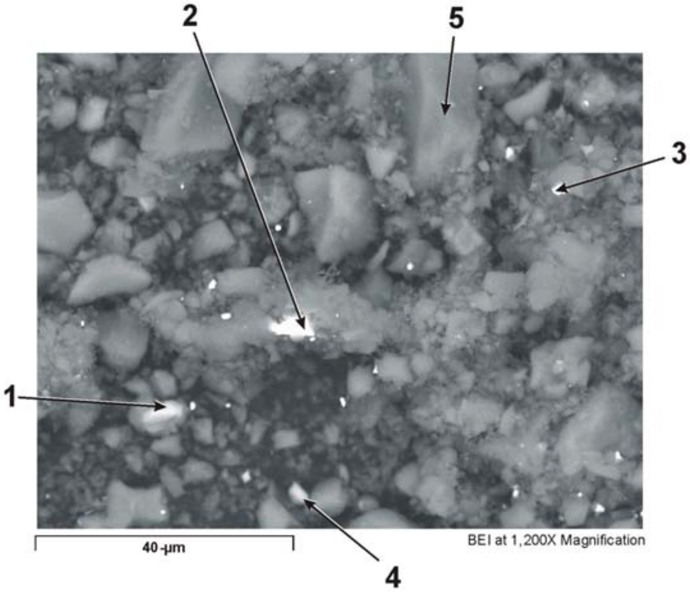
Figure 3-1. X-ray Diffractogram of the Waste Matrix



Spectrum	C	O	Al	Si	S	K	Ti	V	Fe	Cu	Hg	Total
1	6.50	13.14		2.24	9.20					0.78	68.13	100.00
2	18.90	53.74	0.31	12.07	0.19		14.27	0.28	0.24			100.00
3	24.80	47.84	3.43	22.10		1.19	0.38		0.27			100.00

All results in wt% and all elements are normalized.

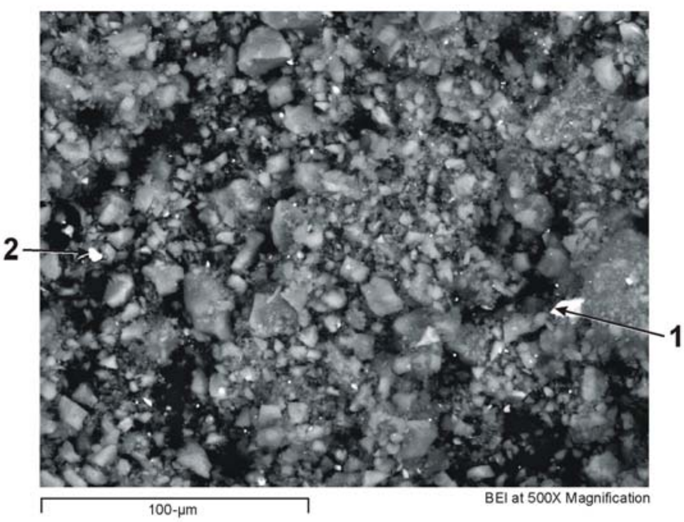
Figure 3-2a. SEI at 1500X, and EDS Analysis of Hg-Contaminated Waste Ore



Spectrum	C	O	Al	Si	S	K	Ti	Fe	Cu	Hg	Total
1	18.62	42.15	0.37	13.25			10.15	15.46			100.00
2	14.87	45.22	0.30	11.94	2.18	0.09	0.51		0.22	24.67	100.00
3	23.99	57.00	0.54	17.46	0.11	0.07	0.70	0.14	0.00		100.00
4	11.64	52.19	0.26	12.84	0.20		22.34	0.52			100.00
5	14.68	58.68	0.00	26.64							100.00

All results in wt% and all elements are normalized.

Figure 3-2b. BEI at 1200X, and EDS Analysis of Hg-Contaminated Waste Ore



Spectrum	C	O	Al	Si	S	K	Ca	Ti	Fe	Cu	Hg	Total
1		48.77	0.55	35.37	0.38	0.21	0.20	5.89	0.89	0.74	68.13	100.00
2	18.520	62.78	0.38	17.29	0.09	0.04		0.78	0.11	0.00		100.00

All results in wt% and all elements are normalized.

Figure 3-2c. BEI at 500X, and EDS Analysis of Hg-Contaminated Waste Ore

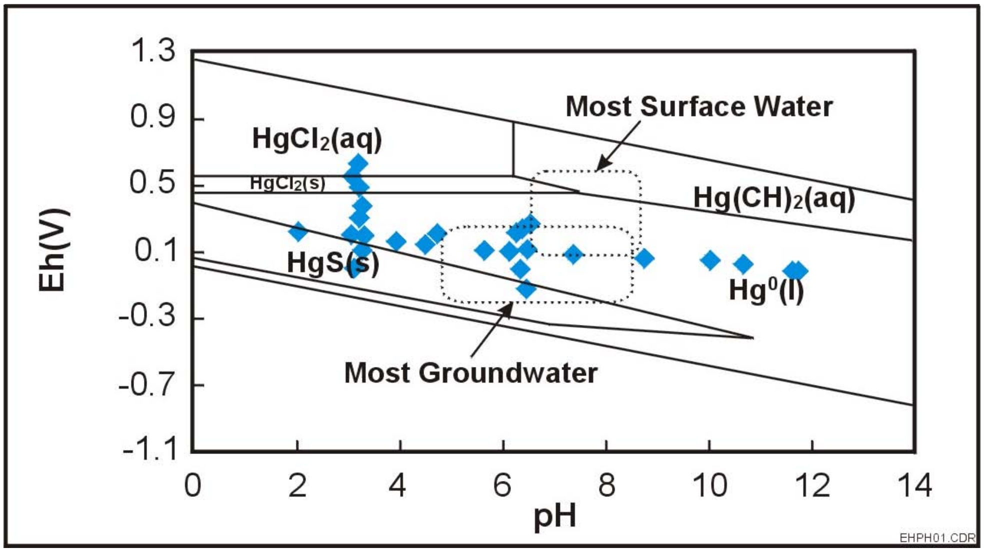


Figure 3-3. Leachability of Hg Conducted by TCLP Method at Different pH and Eh Conditions (modified after Davis et al., 1997; and surface and groundwater information obtained from Garrels and Christ, 1965). The data points (◆) on the stability diagram show the different conditions attended during the experiments.

The effect of pH on leaching of Hg from the waste materials is plotted in Figure 3-4. The Hg concentration increased as the equilibrium pH of the suspension increased to a pH value of 10.65. Thereafter, the Hg concentration decreased sharply. Acidity and alkalinity were measured for pH experiments and results are shown in Tables A-1 and A-2. Alkalinity concentrations were below detection level (BDL) (<1 mg/L) at low pH and increased as the sample pH increased. Acidity was highest at low pH and decreased BDL at pHs greater than 5. Eh of the suspension decreased as the pH increased. The Hg concentration, in presence of Fe(III), decreased significantly. The resulting Eh conditions, in presence and absence of Fe(III), during the experiments at different pH values are shown in Figure 3-5. The turbidity of the filtrate increased as the pH increased even though the same filters were used in all experiments (Figure 3-6).

The concentration of Hg in the leachate at variable Eh conditions is shown in Figure 3-7. During the experiments with variable Eh, the pH values were maintained 3.2 ± 0.08 and 6.4 ± 0.10 and both Eh and pH were monitored for about 24 hours. Each data point represents individual experiment and there were no replicates. Hg concentration, at pH 3.2, increased with increase in oxidation potential until the Eh value reached 0.2 V. Further oxidizing conditions reduced the leaching of Hg from the waste matrix. The concentration of Hg in the leachate increased sharply when H_2O_2 was added to attain a higher oxidation potential (Eh = 0.63 V). At pH 3.2, Fe(III) did not show any effect on leaching of Hg. The Hg concentration varied from 2.5 to 5.7 mg kg^{-1} during the experiments, when the pH was maintained at 6.4. These experiments were conducted for about 24 hours. The rate of leaching of Hg at pH 3.2 in absence, and in presence of Fe(III) is shown in Figure 3-8. At the beginning of the experiment, Fe(III) releases Hg through oxidation. Burkstaller et al. (1975) reported leaching of Hg through oxidation of cinnabar in presence of Fe(III) in acid mine waters (pH <2.0). However, presence of Fe(III) reduces the rate of Hg leaching over a 24-hour period. The rates of dissolution of Hg from the waste ore at pH 3.2 are calculated as 1.02×10^{-7} s^{-1} and 3.32×10^{-8} s^{-1} in absence of Fe(III) and in presence of Fe(III), respectively. The change in chloride concentration as the Eh values change is shown in Figure 3-9.

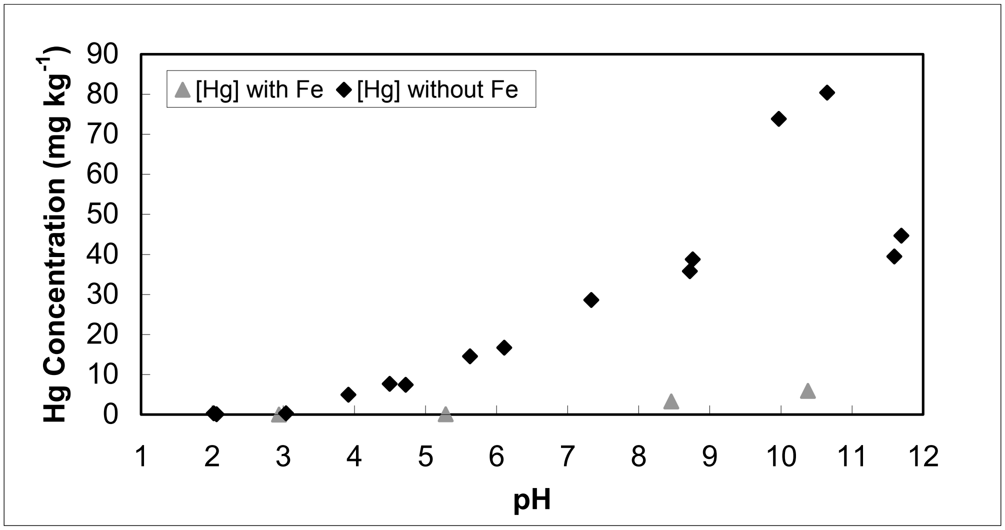


Figure 3-4. Concentration of Hg in the Leachate at Different pH Conditions

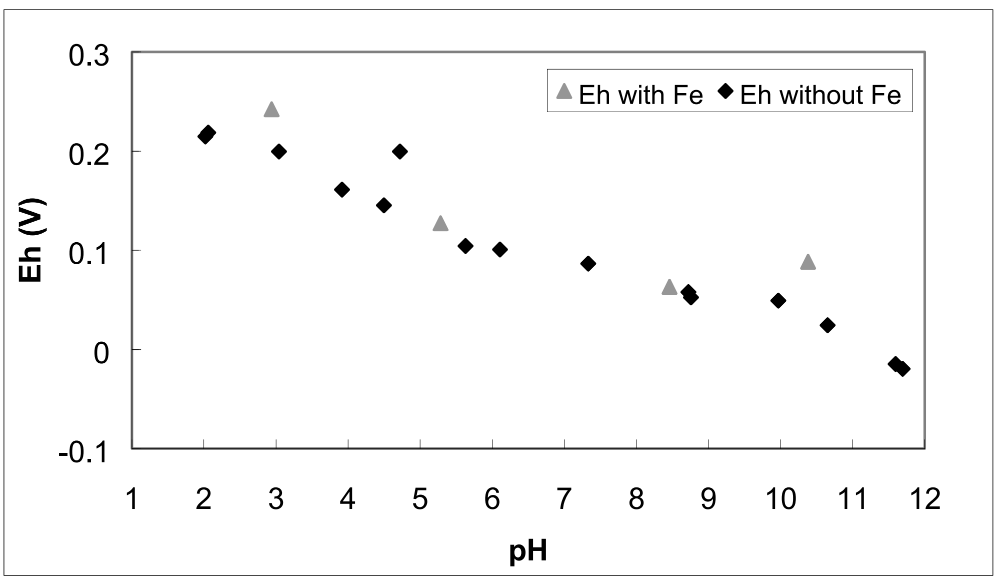


Figure 3-5. Eh Values at Variable pH Conditions Maintained During the Experiments

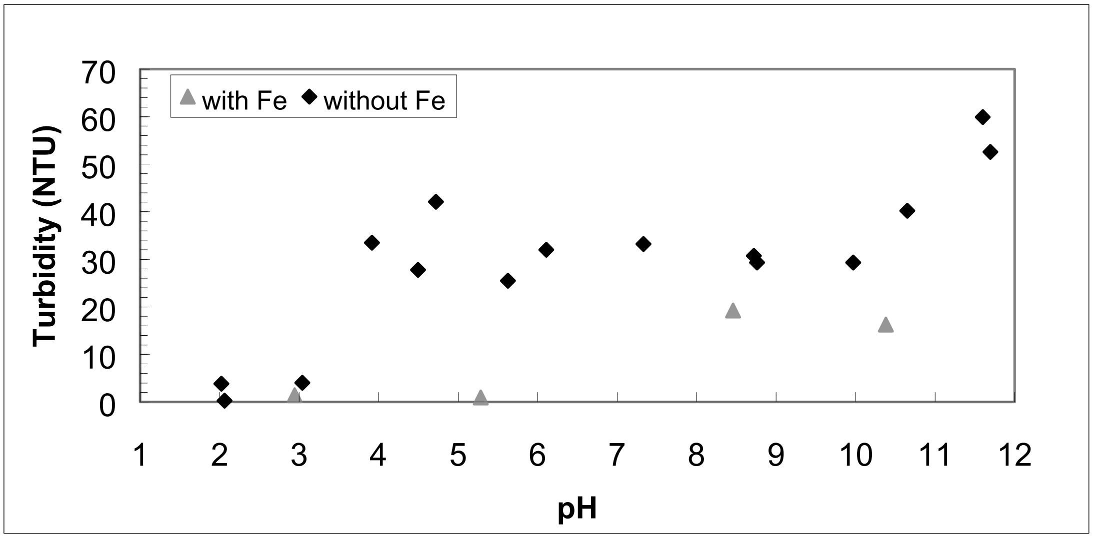


Figure 3-6. Turbidity of the Leachate at Different pH Conditions

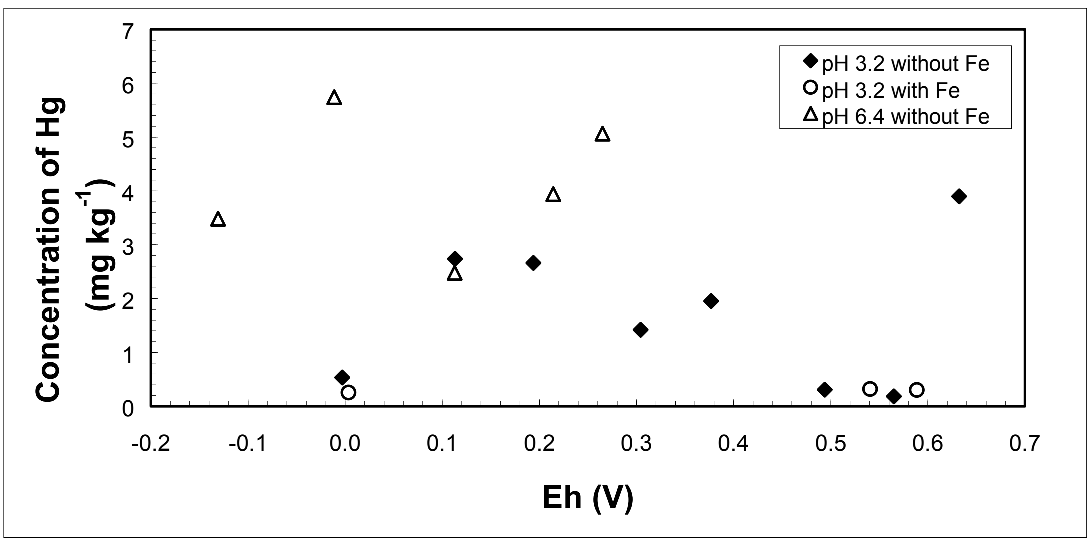


Figure 3-7. Concentration of Hg in the Leachate at Different Eh Conditions

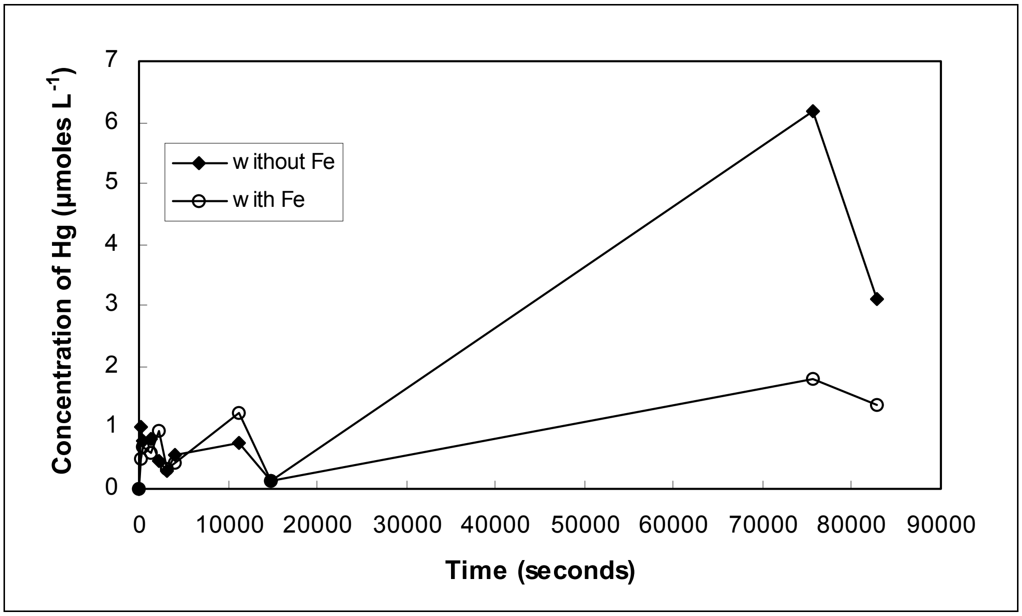


Figure 3-8. Leaching Rate of Hg With Fe (Eh 0.55 V) and Without Fe (Eh 0.5 V) at pH 3.2

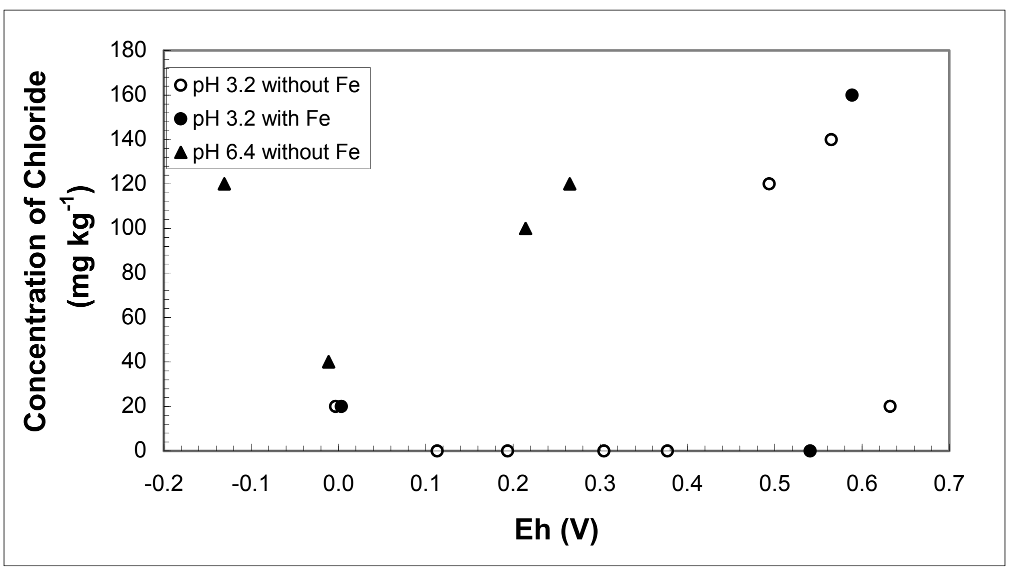


Figure 3-9. Concentration of Chloride in the Leachate at Different Eh Conditions

Alkaline and reduced conditions were found to enhance soluble levels of Hg. Wollast et al. (1975) reported that although the insoluble mercuric sulfide (cinnabar) will form in reducing environments, dissolved levels of Hg may increase in more strongly reducing conditions by conversion of the mercuric ion to the free metal form. Although the SBMM-water system studied for this report may differ from the Belgium River water described by Wollast et al. (1975), it is interesting to note that this study also detected higher levels of soluble Hg under strongly reducing conditions. The Eh-pH diagram (Figure 3-3) showed the comparatively soluble free metallic form to be stable compared to less soluble sulfide forms.

A composite leaching profile of Hg at different Eh and pH conditions is shown in Figure 3-10. Based on the leaching experiments, the concentration of Hg in the leachate (mg/L) was correlated to the different Eh (V) and pH values as follows:

$$\text{Concentration of Hg in the leachate} = 6.78 - 8.16 \times \text{pH} + 3.56 \times \text{pH}^2 - 0.7 \times \text{pH}^3 + 0.06 \times \text{pH}^4 - 0.002 \times \text{pH}^5 + 0.0004/\text{Eh}.$$

The r^2 of the fitted equation was 0.96. The above correlation was obtained by using TableCurve 3D™ (Jandel Scientific) software.

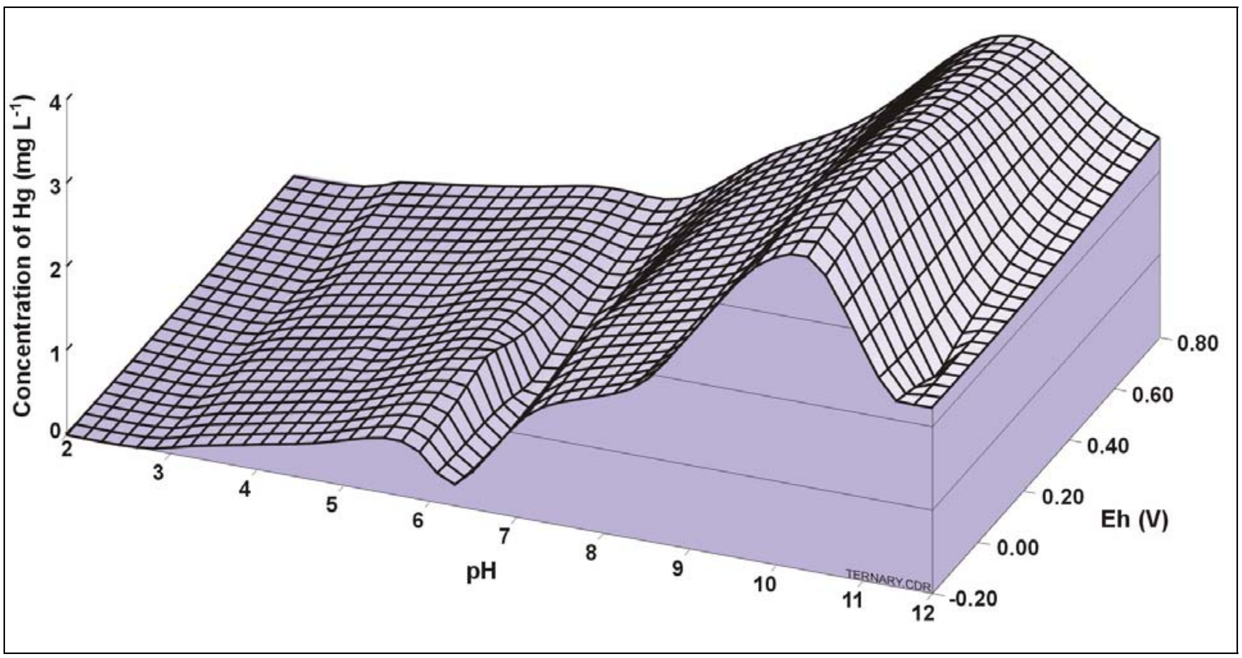


Figure 3-10. Composite Leaching Profile of Hg from the Waste Material at Different Eh and pH Conditions

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APPENDIX A

ANALYTICAL RESULTS

Table A-1. Analytical Results for pH Experiments

Sample ID	Hg (µg/L)	Hg (mg/kg)	Final pH	Final Eh (V)	Turbidity (NTU)	Acidity (mg/L)	Alkalinity (mg/L)
pH=2	4	0.08	2.06	0.22	0.28	1,050	<1
pH=2 DUP	17.5	0.35	2.02	0.21	3.85	1,275	<1
pH=3	15.3	0.31	3.04	0.20	4.05	110	<1
pH=4	248	4.96	3.91	0.16	33.5	3	32
pH=5	373	7.46	4.72	0.20	42.1	8	44
pH=5 DUP	385	7.70	4.49	0.15	27.8	<1	38
pH=6	728	14.56	5.62	0.10	25.5	<1	38
pH=7	835	16.70	6.10	0.10	32.0	<1	36
pH=8	1,431	28.62	7.33	0.09	33.2	<1	55
pH=9	1,938	38.76	8.75	0.05	29.3	<1	72
pH=9 DUP	1,790	35.80	8.72	0.06	30.7	<1	75
pH=10	3,691	73.82	9.96	0.05	29.3	<1	310
pH=11	4,020	80.40	10.65	0.02	40.2	<1	1,020
pH=12	2,236	44.72	11.69	-0.02	52.6	<1	4,150
pH=12 DUP	1,976	39.52	11.59	-0.01	59.9	<1	4,000
Blank	<2.5	BDL	5.58	0.17	0.179	17	19

BDL = below detection limit.

Table A-2. Analytical Results for pH Experiments with Iron Addition

Sample ID	Hg (µg/L)	Hg (mg/kg)	Final pH	Final Eh (V)	Turbidity (NTU)	Acidity (mg/L)	Alkalinity (mg/L)
pH3-With Fe	0.9	0.018	2.94	0.24	1.42	59	<1
pH6-With Fe	2.6	0.052	5.28	0.13	0.946	6	29
pH9-With Fe	164	3.28	8.45	0.06	19.2	10	69
pH11-With Fe	296	5.92	10.38	0.09	16.3	<1	750
Blank-With Fe	<2.5	BDL	7.06	0.09	0.479	2	30

Table A-3. Analytical Results for Eh Experiments at Target pH = 3.2

Gas (Flow rate, ccm)	Hg (µg/L)	Hg (mg/kg)	Average pH	Average Eh (V)	Chloride (mg/L)
H_2 (150)	26.7	0.53	3.10	–0.01	1
H_2 (110)/O_2 (85)	137	2.74	3.25	0.11	<1
O_2 (94)/H_2 (70)	133	2.66	3.30	0.19	<1
O_2 (110)/H_2 (38)	71.1	1.42	3.20	0.30	<1
N_2 (65)	97.6	1.95	3.24	0.37	<1
O_2 (75)	15.5	0.31	3.18	0.49	6
O_2 (150)	9.1	0.18	3.05	0.56	7
O_2 (150) + peroxide	195	3.90	3.18	0.63	1

ccm = cubic centimeters per minute.

Table A-4. Analytical Results for Eh Experiments at Target pH = 3.2 with Iron Addition

Gas (Flow rate, ccm)	Hg (µg/L)	Hg (mg/kg)	Average pH	Average Eh (V)	Chloride (mg/L)
H_2 (150)	12.8	0.26	3.18	0.00	1
O_2 (75)	16.1	0.32	3.12	0.54	<1
O_2 (150)	15.2	0.30	2.99	0.59	8

Table A-5. Analytical Results for Eh Experiments at Target pH = 6.4

Gas (Flow rate, ccm)	Hg (µg/L)	Hg (mg/kg)	Average pH	Average Eh (V)	Chloride (mg/L)
H_2 (150)	174	3.48	6.42	–0.13	6
H_2 (55)	287	5.74	6.31	–0.01	2
H_2 (30)/O_2 (122)	124	2.48	6.47	0.11	NS
N_2 (150)	197	3.94	6.26	0.21	5
O_2 (150)	253	5.06	6.48	0.26	6

NS = not sampled.

Table A-6. Analytical Results for Eh Kinetics Experiments at Target pH = 3.2 Without Iron (Flow rate = 50 ccm)

Time (seconds)	Hg (µg/L)	Hg (mg/kg)	Hg (µmol/L)	pH	Eh (V)
120	202.29	4.05	1.01	3.36	0.48
420	155.88	3.12	0.78	3.18	0.48
1320	164.24	3.28	0.82	3.19	0.49
2220	91.43	1.83	0.46	3.20	0.48
3120	60.26	1.21	0.30	3.32	0.49
4020	114.24	2.28	0.57	3.20	0.49
11220	152.39	3.05	0.76	3.21	0.49
14820	27.89	0.56	0.14	3.14	0.56
75720	1,238.05	24.76	6.17	3.36	0.53
82920	623.51	12.47	3.11	3.40	0.49

Table A-7. Analytical Results for Eh Kinetics Experiments at Target pH = 3.2 With Iron (Flow rate = 50 ccm)

Time (seconds)	Hg (µg/L)	Hg (mg/kg)	Hg (µmol/L)	pH	Eh (V)
120	98.31	1.97	0.49	3.27	0.52
420	136.06	2.72	0.68	3.08	0.58
1320	117.63	2.35	0.59	3.31	0.57
2220	187.55	3.75	0.93	3.33	0.53
3120	65.64	1.31	0.33	3.21	0.52
4020	85.86	1.72	0.43	3.25	0.52
11220	252.59	5.05	1.26	3.21	0.52
14820	25.50	0.51	0.13	3.33	0.58
75720	360.56	7.21	1.80	3.13	0.55
82920	275.90	5.52	1.38	3.18	0.55

APPENDIX B

LABORATORY REPORTED MERCURY DATA WITH QC SUMMARY FOR VARIABLE Eh AND pH EXPERIMENTS

Variable pH Experiments

Project #	G466507-UC41
Samples Received	3/29/01
Samples Analyzed	4/3/01
Method Used	EPA SW-846-7470

SAMPLE I.D.	Hg CONCENTRATION
	(µg/L)
pH=2	4
pH=2 DUP	17.5
pH=3	15.3
pH=4	248
pH=5[(a)]	8713
pH=5 DUP[(a)]	< 500 *
pH=6	728
pH=7	835
pH=8	1431
pH=9	1938
pH=9 DUP	1790
pH=10	3691
pH=11	4020
pH=12	2236
pH=12 DUP	1976

* Sample "pH=5 DUP" was diluted 1 TO 1000. This dilution was beyond the range of the calibration curve. This sample will be properly re-analyzed with the subsequent sample set.
(a) Samples pH=5 and pH=5 Dup were rerun because of problems filtering the samples.

QC SUMMARY	Corr. Coefficient	Recovery
Calibration Curve 1	0.9995	
Calibration Curve 2	0.9974	
Continuing Calibration Verification (CCV) 1		108%
CCV 2		110%

Variable pH Experiments

Project #	G466507-UC41
Samples Received	4/17/01
Samples Analyzed	4/18/01
Method Used	EPA SW-846-7470

Sample ID	Hg Concentration (µg/ L)
pH5-rerun	373
pH5-rerun DUP	385
pH3-With Fe	0.9
pH6-With Fe	2.6
pH9-With Fe	164
pH11-With Fe	296
Blank-With Fe	<2.5

Quality Control **Date: 4/18/01**

Sample ID	Mercury (µg/L)
Blank	0
CCV 5 ppb	4.9
Percent Recovery	98%
pH11 w Fe	373
pH11 w Fe Dup	385
Relative Percent Difference	3%
CCV 5 ppb	4.9
Percent Recovery	98%
CCV 5 ppb	5.2
Percent Recovery	104%

Variable Eh Experiments

Project #	G466507-UC41
Title	Mercury Leaching
Samples Received	6/29/01
Samples Analyzed	7/3/01
Results Reported	7/5/01
Method Used	EPA SW-846 7470

SAMPLE I.D.	Concentration of mercury (µg/L)
REPORTING LIMIT	**0.2 µg/ L**
1 Hg	9.0637
2 Hg w/ Fe	15.2390
3 Hg	26.6932
4 Hg w/ Fe	12.8486
5 Hg	15.5378
6 Hg w/ Fe	16.1355
7 Hg	137.0518
8 Hg	133.1673
9 Hg	97.6096
10 Hg	71.1155
11 Hg	194.9203
T = 0 m	202.2908
T = 0 m Fe	98.3068
T = 5 m	155.8765
T = 5 m Fe	136.0558
T = 15 m	164.2430
T = 15 m Fe	117.6295
T = 30 m	91.4343
T = 30 m Fe	187.5498
T = 45 m	60.2590
T = 45 m Fe	65.6375
T = 1 hr	114.2430
T = 1 hr Fe	85.8566
T = 3 hr	152.3904
T = 3 hr Fe	252.5896
T = 5 hr	27.8884
T = 5 hr Fe	25.4980
T = 21 hr	1238.0478
T = 21 hr Fe	360.5578
T = 23 hr	623.5060
T = 23 hr Fe	275.8964

Variable Eh Experiments

Project #	G466507-UC41
Title	TO26 - Mercury Leaching
Samples Received	6/29/01
Samples Analyzed	7/4/01
Results Reported	7/5/01
Method Used	EPA SW-846 7470

SAMPLE I.D.	Hg
CCB	0.1
CCV 5 ppb	5.0
CCV Percent Recovery	100%
METHOD BLANK 7-4-01	0.0
1 Hg	9.1
1 Hg Method Duplicate	9.0
Duplicate Relative Percent Difference	1%
CCB	0.19
CCV 5 ppb	5.07
CCV Percent Recovery	101%
10 Hg DILUTED 1 TO 10	7.1
10 Hg DIL 1 TO 10 Method Spike	11.6
Spike Percent Recovery	90%
11 Hg DILUTED 1 TO 10	19.5
11 Hg DIL 1 TO 10 Method Duplicate	19.6
Duplicate Relative Percent Difference	1%
T = 45 m DILUTED 1 TO 10	6.0
T = 45 m DIL 1 TO 10 Method Spike	11.0
Spike Percent Recovery	99%
CCB	0.1
CCV 5 ppb	5.0
CCV Percent Recovery	100%
T = 24 hr Fe DILUTED 1 TO 100	2.8
T = 24 hr Fe DIL 1 TO 100 Method Spike	7.0
Spike Percent Recovery	84%
CCB	0.1
CCV 5 ppb	5.1
CCV Percent Recovery	102%
1 Hg	9.0
1 Hg Method Duplicate	9.2
Duplicate Relative Percent Difference	2%
CCB	0.0
CCV 5 ppb	4.6
CCV Percent Recovery	92%

Variable Eh Experiments

Project #	G466507-UC41
Title	Mercury Leaching
Samples Received	7/26/01
Samples Analyzed	8/10/01
Method Used	EPA SW-846 7470

SAMPLE I.D.	Concentration of mercury
	(µg/L)
Reporting Limit	0.2 µg/ L
14 Hg	253
15 Hg	197
16 Hg	174
17 Hg	124
18 Hg	287

Analyte	Hg	Hg	Hg
Mass	199	200	202
Sample Unit	µg/L	µg/L	µg/L
Blank			
Standard 1	1.00	1.07	1.01
Standard 2	0.15	0.17	0.15
Standard 3	3.30	3.31	3.30
Standard 4	5.22	5.32	5.34
Standard 5	10.69	10.75	10.92
Standard 6	25.41	25.66	25.44
Standard 7	50.08	50.53	49.97
Standard 8	100.65	100.92	100.68
Standard 9	249.64	249.42	249.64
CCV-25	25.52	25.60	25.54
	102%	102%	102%
14 Hg 1-10	26.15	25.34	26.20
14 Hg 1-10 Analytical Duplicate	25.16	25.83	26.02
	4%	2%	1%
18 Hg 1-10	28.38	28.67	28.63
18 Hg 1-10 Analytcial Spike	56.67	57.52	58.70
	113%	115%	120%
CCV-25	23.31	23.88	23.73
	93%	96%	95%

APPENDIX C

LABORTORY REPORTED ACIDITY, ALKALINITY, AND CHLORIDE DATA WITH QC SUMMARY FOR VARIABLE Eh AND pH EXPERIMENTS

WILSON
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401 Venture Drive • Suite C • Westerville, Ohio 43081 • (614) 431-0010 • Fax: (614) 431-1650

Lab Number: WE10685-1

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH2	Aqueous	K. HARTZELL	27 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	1050	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	<1	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-2

PROJECT: G466507-UC41

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH2 DUP	Aqueous	K. HARTZELL	27 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	1275	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	<1	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
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COLUMBUS,OHIO 43201-2693

Lab Number: WE10685-3

PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH3	Aqueous	K. HARTZELL	27 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	110	1	mg/L	305.1	04-10-01		
Alkalinity	<1	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

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Wilson T. Walker

MS. JENNIFER ICKES
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COLUMBUS,OHIO 43201-2693

Lab Number: WE10685-4

PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH4	Aqueous	K. HARTZELL	27 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	3	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	32	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

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Lab Number: WE10685-6

MS. JENNIFER ICKES
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505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH5 DUP	Aqueous	K. HARTZELL	27 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	38	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-7

MS. JENNIFER ICKES
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COLUMBUS,OHIO 43201-2693

PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH6	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	38	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-8

PROJECT: G466507-UC41

MS. JENNIFER ICKES
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REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH7	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	36	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-9

PROJECT: G466507-UC41

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COLUMBUS,OHIO 43201-2693

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH8	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	55	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

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Lab Number: WE10685-10

PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH9	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	72	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-11

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PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH9 DUP	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	75	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-12

PROJECT: G466507-UC41

MS. JENNIFER ICKES
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REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH10	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	310	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-13

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COLUMBUS,OHIO 43201-2693

PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH11	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	1020	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-14

PROJECT: G466507-UC41

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COLUMBUS,OHIO 43201-2693

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH12	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	4150	1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10685-15

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COLUMBUS,OHIO 43201-2693

PROJECT: G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH12 DUP	Aqueous	K. HARTZELL	29 MAR 01	30 MAR 01

CONSTITUENT	RESULT		*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY		<1	1	mg/L	305.1	04-10-01	WTW	
Alkalinity	4000		1	mg/L	310.1	04-10-01	WTW	

* Detection Limit

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Lab Number: WE10711-1

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COLUMBUS,OHIO 43201-2693

PROJECT: T026 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH=5 RERUN	Aqueous	J. ICKES	10 APR 01	11 APR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	8	1	mg/L	305.1	04-19-01	WTW	
Alkalinity	44	1	mg/L	310.1	04-19-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10711-2

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: T026 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH=3 w/ Fe	Aqueous	J. ICKES	10 APR 01	11 APR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	59	1	mg/L	305.1	04-19-01	WTW	
Alkalinity	<1	1	mg/L	310.1	04-19-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

Lab Number: WE10711-3

PROJECT: T026 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH=6 w/ Fe	Aqueous	J. ICKES	10 APR 01	11 APR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	6	1	mg/L	305.1	04-19-01	WTW	
Alkalinity	29	1	mg/L	310.1	04-19-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

Lab Number: WE10711-4

PROJECT: T026 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH=9 W/Fe	Aqueous	J. ICKES	10 APR 01	11 APR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	10	1	mg/L	305.1	04-19-01	WTW	
Alkalinity	69	1	mg/L	310.1	04-19-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10711-5

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: T026 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
PH=11 w/ Fe	Aqueous	J. ICKES	10 APR 01	11 APR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	<1	1	mg/L	305.1	04-19-01	WTW	
Alkalinity	750	1	mg/L	310.1	04-19-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

[signature]

Wilson T. Walker

Lab Number: WE10711-6

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: T026 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
BLANK w/ Fe	Aqueous	J. ICKES	10 APR 01	11 APR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	2	1	mg/L	305.1	04-19-01	WTW	
Alkalinity	30	1	mg/L	310.1	04-19-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

Lab Number: WE10711-7

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: T026 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
BLANK WITHOUT FE	Aqueous	J. ICKES	10 APR 01	11 APR 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
ACIDITY	17	1	mg/L	305.1	04-19-01	WTW	
Alkalinity	19	1	mg/L	310.1	04-19-01	WTW	

* Detection Limit

Wilson Environmental Laboratories, Inc.

Wilson T. Walker

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MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

Lab Number: WE10865-1

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
1 Hg	Aqueous	J. ICKES	19 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	7	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-2

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
2 Hg w/Fe	Aqueous	J. ICKES	19 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	8	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-3

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
3 Hg	Aqueous	J. ICKES	20 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	1	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-4

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
4 Hg w/Fe	Aqueous	J. ICKES	20 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	1	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-5

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
5 Hg	Aqueous	J. ICKES	21 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	6	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

Lab Number: WE10865-6

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
6 Hg w/Fe	Aqueous	J. ICKES	21 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	<1	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-7

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
7 Hg	Aqueous	J. ICKES	22 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	<1	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-8

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
8 Hg	Aqueous	J. ICKES	26 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	<1	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-9

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: T026 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
9 Hg	Aqueous	J. ICKES	26 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	<1	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-10

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
10 Hg	Aqueous	J. ICKES	27 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	<1	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

Lab Number: WE10865-11

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO26 G466507-UC41

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
11 Hg	Aqueous	J. ICKES	28 JUN 01	02 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	1	1	mg/L	407A	07-10-01	WMB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

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Lab Number: WE10902-1

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO 26

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
14.Hg	Aqueous	J. ICKES	30 JUL 01	31 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	6	1	mg/L	407A	08-17-01	MWB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell
W. Martin Bell

Lab Number: WE10902-2

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO 26

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
15.Hg	Aqueous	J. ICKES	30 JUL 01	31 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	5	1	mg/L	407A	08-17-01	MWB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

W. Martin Bell

Lab Number: WE10902-3

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO 26

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
16.Hg	Aqueous	J. ICKES	30 JUL 01	31 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	6	1	mg/L	407A	08-17-01	MWB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell
W. Martin Bell

Lab Number: WE10902-4

MS. JENNIFER ICKES
BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS,OHIO 43201-2693

PROJECT: TO 26

REPORT OF ANALYTICAL RESULTS

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE/TIME	RECEIVED
18.Hg	Aqueous	J. ICKES	30 JUL 01	31 JUL 01

CONSTITUENT	RESULT	*D.L.	UNITS	METHOD	ANALYZED	BY	NOTES
Chloride	2	1	mg/L	407A	08-17-01	MWB	

* Detection Limit

Wilson Environmental Laboratories, Inc.

W. Martin Bell

W. Martin Bell

FROM : WILSON ENVIRONMENTAL LABS PHONE NO. : Aug. 09 2001 12:02PM P6

Chain of Custody Record

WILSON
ENVIRONMENTAL LABORATORIES, INC.
401 Venture Drive • Suite C • Westerville, Ohio 43081 • (614) 431-0010 • Fax (614) 431-1850

Section A

Company Name: Battelle	Contact Person: Jennifer Ickes
Address: 505 King Ave. Columbus, OH 43201	Phone: 614-424-3723 Fax: 614-424-3667
Project Name/No.: PO # 164964 (TO 26)	Sampler's Signature: Jennife L. Ickes
WEL Qoute No.: WE 10865	

Section B / **Section C**

Analyses Requested

ID No.	Date	Time	Comp	Grab	Sample Type*	Station Location	No. of Containers	Chloride						Remarks (WE10902)
14. Hg	7/30/01				AQ		1	X					-1	Mercury
15. Hg	7/30/01				AQ		1	X					-2	concentration
16. Hg	7/30/01				AQ		1	X					-3	~300-800ug/L
~~19~~	~~7/30/01~~				~~AQ~~		~~1~~	~~X~~						
18. Hg	7/30/01				AQ		1	X					-4	

Section D

*AQ= water/waste water; DW= drinking water; SL= solid; SW= solid waste; OW= oily waste; WP= wipe

Relinquished by:	Date	Time	Received By:	Date	Time
Jody Lizor	7/30/01	9:00	Sandra Ashe	7/31/01	1030
Relinquished by:	Date	Time	Received By:	Date	Time
Relinquished by:	Date	Time	Received By:	Date	Time

WILSON
ENVIRONMENTAL LABORATORIES, INC.

MEMBER ACIL

401 Venture Drive • Suite C • Westerville, Ohio 43081 • (614) 431-0010 • Fax: (614) 431-1650

August 24, 2001

Ms. Jennifer Ickes
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

RE: QC Report - Project TO26 G466507-UCC41

Dear Ms. Ickes,

Enclosed please find the quality control data associated with the above referenced project and the following Wilson Environmental Laboratories' orders:

WE10685	Alkalinity and Acidity
WE10711	Alkalinity and Acidity
WE10865	Total Chloride
WE10902	Total Chloride

As the QC report reflects, standard quality control procedures for the Alkalinity and Acidity analyses included a laboratory control sample, method blank and duplicate analysis. Matrix spike and matrix spike duplicate QC samples were not included. The Total Chloride runs included the matrix spikes and matrix spike duplicates, in addition to the laboratory control sample, method blank and duplicate analysis.

Please do not hesitate to contact W. Martin Bell, Vice President, or me if you should have any questions, require further information or any other assistance pertaining to this QC report.

Sincerely,

WILSON ENVIRONMENTAL LABORATORIES, INC.

Sandy Ashe

Sandy Ashe

encl QC Report

WILSON ENVIRONMENTAL LABORATORIES, INC.
401 Venture Drive, Suite C · Westerville, Ohio 43081
Phone: (614) 431-0010 · FAX: (614) 431-1650

Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Order No.: WE10685
WE10711

Project: TO26 G466507-UC41

QC Report

Laboratory Control Sample (LCS)

Parameter	Analysis Date	Result	True Value	Units	% Recovery
Alkalinity, Total	4/10/01	40	37.69	mg/L	106
Acidity, Total	4/10/01				
Alkalinity, Total	4/19/01	39	37.69	mg/L	103
Acidity, Total	4/19/01				

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Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Order No.: WE10685
WE10711

Project: TO26 G466507-UC41

Method Blank Report

Parameter	Analysis Date	Result
Alkalinity, Total	4/10/01	<1 mg/L
Acidity, Total	4/10/01	<1 mg/L
Alkalinity, Total	4/19/01	<1 mg/L
Acidity, Total	4/19/01	<1 mg/L

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Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Order No.: WE10685
WE10711

Project: TO26 G466507-UC41

QC Report

Sample Duplicate Report

Parameter	Analysis Date	Duplicate Result	Sample Result	RPD (%)
Alkalinity, Total	4/10/01	205	208	1
Acidity, Total	4/10/01	1050	1050	0
Alkalinity, Total	4/19/01	18	19	5
Acidity, Total	4/19/01	17	17	0

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Phone: (614) 431-0010 · FAX: (614) 431-1650

Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Order No: WE10865
WE10902

Project: TO26 G466507-UC41

QC Report

Laboratory Control Sample (LCS)

Parameter	Analysis Date	Result	True Value	Units	% Recovery
Chloride, Total	7/10/01	50	50	mg/L	100
	8/17/01	48	50	mg/L	96

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Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Order No: WE10865
WE10902

Project: TO26 G466507-UC41

Matrix Spike Report

Parameter	Analysis Date	Spike Result	Sample Amount	Spike Amount	% Recovery
Chloride, Total	7/10/01	25	15	10	100
	8/17/01	58	32	25	104

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Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Order No: WE10865
WE10902

Project: TO26 G466507-UC41

Matrix Spike Duplicate Report

Parameter	Analysis Date	Spike Dup. Result	Sample Amount	Spike Amount	% Recovery	MS/MSD RPD (%)
Chloride, Total	7/10/01	25	15	10	100	0
	8/17/01	57	32	25	100	4

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Phone: (614) 431-0010 · FAX: (614) 431-1650

Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Order No: WE10865
WE10902

Project: TO26 G466507-UC41

Method Blank Report

Parameter	Analysis Date	Result
Chloride, Total	7/10/01	<1 mg/L
	8/17/01	<1 mg/L

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Phone: (614) 431-0010 · FAX: (614) 431-1650

Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Order No: WE10865
WE10902

Project: TO26 G466507-UC41

QC Report

Sample Duplicate Report

Parameter	Analysis Date	Duplicate Result	Sample Result	RPD (%)
Chloride, Total	7/10/01	15	15	0
	8/17/01	32	32	0

APPENDIX D

LABORATORY REPORTED DATA FOR SULFUR BANK MERCURY MINE WASTE ORE

Solid Mercury Ore

Project ID: G466507-UC61 **Analyst:** C. BURTON
Date: 8/29/01

Sample ID	Date	Weight mg	ug of C	%C	Average	%RSD
Mercury Waste Rock TOC	8/29/01	42.86	193.59	0.452		
		32.22	140.39	0.436		
		33.76	143.18	0.424	**0.437**	**3.17**
Mercury Waste Rock TC	8/29/01	24.42	120.69	0.494		
		30.97	141.01	0.455		
		42.83	183.14	0.428	**0.459**	**7.29**

Project ID: G466507-UC61 **Analyst:** C. BURTON
Date: 8/29/01

Calibration Check Standards

Time	Calcium Carbonate (mg)	Theoretical µg of C	Actual µg of C	% Error	Average % Error
13:30	16.69	2002.83	1972.37	1.521	2.152
	17.12	2054.43	1956.75	4.755	
	12.89	1546.83	1544.02	0.181	
14:45	18.23	2187.64	2144.55	1.970	3.000
	15.13	1815.63	1693.42	6.731	
	14.27	1712.43	1707.30	0.299	

CLC LABS 325 Venture Drive • Westerville, Ohio 43081 • (614) 888-1663 • Fax (614) 888-1330

SUBMITTED BY:
BATTELLE ENV. RESTORATION
ATTN: S. CHATTOPADHYAY
505 KING STREET
COLUMBUS, OH 43201-2693
ACCOUNT NO.: T5343

SUBMITTED FOR:
PO# 167307

REPORT DATE: SEPT. 4, 2001
REPORT REF.: 1512.100CEC

REPORT OF ANALYSIS

Lab. No.	Sample ID	pH	SMP Buffer pH	Exchangeable Cations Measured K	Ca	Mg	Na	H	Cation Exchange Capacity
				----- ppm in soln.			-----	meq.	Meq./100g
20551A	MERCURY ROCK	3.6	6.57	1.9	17.2	3.5	2.0	5.2	6.5

Method using 1N neutral ammonium acetate exchange solution. Exchangeable hydrogen estimated by the use of the SMP Buffer. Cation exchange capacity determined by summation of the measured cations according to Amer. Soc. of Agronomy Monograph 9, Part 2, Chapter 8 & 9.

Solid Mercury Ore Analysis

Project #	G466507-UC41
Title	Mercury Leaching
Samples Received	8/24/01
Samples Analyzed	9/6/01
Results Reported	9/7/01
Method Used	EPA Method 7471A

SAMPLE I.D.	Concentration of mercury (ug/ g)
1 HG	3125
1 HG-DUP	3125

** results based on sample weight of 0.32g into volume of 5 mL*

Project #	G466507-UC41
Title	Mercury Leaching
Samples Received	8/24/01
Samples Analyzed	9/6/01
Results Reported	9/7/01
Method Used	EPA Method 7471A

SAMPLE I.D.	Hg
CCV 10 ppb	10.0
CCV Percent Recovery	100%
1 HG	20.0
1 HG-DUPLICATE	20.0
DUPLICATE RELATIVE PERCENT DIFFERENCE	0%
CCV 10 ppb	10.0
CCV Percent Recovery	100%
CCV 10 ppb	8.0
CCV Percent Recovery	80%
CCV 10 ppb	8.0
CCV Percent Recovery	80%

Project #	G466507-UC41
Title	Mercury Leaching
Samples Received	8/24/01
Samples Analyzed	9/6/01
Results Reported	9/7/01
Method Used	U.S. EPA Method 3050

METHOD BLANK

Friday September 07 2001 11:22:35
Sample
c:\elandata\dataset\er 9-6-01 totalquant\Blank.012
1
Average
Average
Dual
35
35
1
C:\elandata\Sample\CDC SOILS 9-07-01.sam
C:\elandata\Method\TotalQuant.mth
c:\elandata\dataset\er 9-6-01 totalquant\METHOD BLANK.014
default.tun
default.dac
c:\elandata\System\current.rsp

Analyte	Concentration (mg/L)	Intensity	Intensity Units
H			Not Measured
He			Not Measured
Li	0.00002	29	
Be	0.0001	51	
B	0.00318	5815	
C	0	0	
N	129744.8458	13496167	
O			Not Measured
F		0	
Ne		0	
Na	0.03186	470522	
Mg	0.009	40856	
Al	0.01076	92221	
Si	0.0197	246760	
P	0.02919	38264	
S	42.31853	17936083	
Cl	0	0	
Ar		0	
K	0.0027	28122	
Ca	0	0	
Sc	0.0004	5528	
Ti	0.0008	9051	
V	0.00016	1698	
Cr	0.00031	3473	
Mn	0.00058	8374	
Fe	0.08423	1092652	
Co	0.00005	587	

Analyte	Concentration (mg/L)	Intensity	Intensity Units
Ni	0.00039	2898	
Cu	0.0005	3373	
Zn	0.00338	12498	
Ga	0.00001	93	
Ge	0.00001	64	
As	0.0003	314	
Se	0	0	
Br	0.00264	607	
Kr		0	
Rb	0.00001	167	
Sr	0.00069	8114	
Y	0.00002	211	
Zr	0.00635	82096	
Nb	0.00001	61	
Mo	0.00136	12879	
Ru	0	0	
Rh	0	0	
Pd	0	0	
Ag	0.00013	990	
Cd	0	0	
In	0.01222	76180	
Sn	0.01524	98882	
Sb	0.00022	874	
Te	0	0	
I	0.00001	121	
Xe		0	
Cs	0	7	
Ba	0.00094	8731	
La	0.00001	94	
Ce	0.00004	573	
Pr	0	27	
Nd	0.00001	111	
Sm	0	50	
Eu	0	0	
Gd	0	14	
Tb	0.00139	30082	
Dy	0	27	
Ho	0	7	
Er	0	0	
Tm	0	0	
Yb	0	19	
Lu	0.00002	428	
Hf	0.00002	388	
Ta	0	24	
W	0.00035	8335	
Re	0	0	
Os	0	0	
Ir	0	0	
Pt	0	0	
Au	0.00005	333	
Hg	0.00015	984	
Tl	0	10	
Pb	0.00417	94139	
Bi	0.00002	424	
Th	0.00004	471	
U	0.00009	1231	

1 HG
Friday September 07 2001 11:27:24
Sample
c:\elandata\dataset\er 9-6-01 totalquant\Blank.012
1
Average
Average
Dual
35
35
1
C:\elandata\Sample\CDC SOILS 9-07-01.sam
C:\elandata\Method\TotalQuant.mth
c:\elandata\dataset\er 9-6-01 totalquant\1 HG.015
default.tun
default.dac
c:\elandata\System\current.rsp

Analyte	Concentration (mg/L)	Intensity	Intensity Units
H			Not Measured
He			Not Measured
Li	0.00105	1462	
Be	0.00012	57	
B	0.0051	9337	
C	0.41934	398082	
N	118864.4815	12364382	
O			Not Measured
F		0	
Ne		0	
Na	0.48039	7094953	
Mg	0.71365	3240711	
Al	3.908	33493416	
Si	3.18869	39934174	
P	0.10623	139261	
S	28.33976	12011390	
Cl	0	0	
Ar		0	
K	2.22665	23222299	
Ca	0	0	
Sc	0.01179	163474	
Ti	5.02087	56619073	
V	0.04579	499690	
Cr	0.02517	279546	
Mn	0.03387	486015	
Fe	12.04184	156214499	
Co	0.00534	59250	
Ni	0.00349	25880	
Cu	0.0451	307205	
Zn	0.03495	129386	
Ga	0.0152	124086	
Ge	0.00069	4598	
As	0.05787	60977	
Se	0	0	
Br	0.02607	5997	
Kr		0	
Rb	0.02257	268635	

Analyte	Concentration (mg/L)	Intensity	Intensity Units
Sr	0.52803	6231008	
Y	0.00631	82408	
Zr	0.31658	4093259	
Nb	0.00127	13987	
Mo	0.00187	17632	
Ru	0	27	
Rh	0.00004	287	
Pd	0.00085	6104	
Ag	0.00107	8221	
Cd	0.00026	1311	
In	0.00077	4783	
Sn	0.03348	217291	
Sb	0.04187	162883	
Te	0.00009	137	
I	0.00091	8406	
Xe		0	
Cs	0.00378	36634	
Ba	24.94128	231541784	
La	0.02789	336200	
Ce	0.02821	382986	
Pr	0.00317	40705	
Nd	0.00931	143771	
Sm	0.00156	28773	
Eu	0.00297	53031	
Gd	0.00148	29830	
Tb	0.00023	4928	
Dy	0.00118	24486	
Ho	0.0002	4801	
Er	0.00062	14635	
Tm	0.00009	2077	
Yb	0.00062	13951	
Lu	0.00009	2242	
Hf	0.00808	206540	
Ta	0.00004	864	
W	0.00031	7423	
Re	0	6	
Os	0	0	
Ir	0	54	
Pt	0.00007	1075	
Au	0.00008	579	
Hg	0.1133	749351	
Tl	0.00299	72162	
Pb	0.54435	12292449	
Bi	0.00155	27387	
Th	0.01245	162372	
U	0.00737	102838	

1 HG-DUP
Friday September 07 2001 11:33:22
Sample
c:\elandata\dataset\er 9-6-01 totalquant\Blank.012
1
Average
Average
Dual
35
35
1
C:\elandata\Sample\CDC SOILS 9-07-01.sam
C:\elandata\Method\TotalQuant.mth
c:\elandata\dataset\er 9-6-01 totalquant\1 HG-DUP.016
default.tun
default.dac
c:\elandata\System\current.rsp

Analyte	Concentration (mg/L)	Intensity	Intensity Units
H			Not Measured
He			Not Measured
Li	0.00119	1653	
Be	0.00019	91	
B	0.00611	11191	
C	0.42052	399202	
N	114931.4738	11955267	
O			Not Measured
F		0	
Ne		0	
Na	0.45353	6698295	
Mg	0.79725	3620344	
Al	3.91865	33584654	
Si	3.4684	43437118	
P	0.10196	133675	
S	22.22825	9421117	
Cl	0	0	
Ar		0	
K	2.55835	26681734	
Ca	0	0	
Sc	0.01219	169072	
Ti	5.33539	60165841	
V	0.04971	542560	
Cr	0.02641	293287	
Mn	0.04026	577690	
Fe	11.7318	152192522	
Co	0.00531	58878	
Ni	0.00358	26503	
Cu	0.04284	291772	
Zn	0.03755	139024	
Ga	0.01609	131393	
Ge	0.00082	5465	
As	0.05886	62022	
Se	0	0	
Br	0	0	
Kr		0	

Analyte	Concentration (mg/L)	Intensity	Intensity Units
Rb	0.02109	251052	
Sr	0.53985	6370492	
Y	0.00694	90617	
Zr	0.34172	4418355	
Nb	0.00114	12556	
Mo	0	0	
Ru	0	0	
Rh	0.00003	234	
Pd	0.00078	5564	
Ag	0.00063	4802	
Cd	0.00046	2339	
In	0.00037	2336	
Sn	0.03321	215531	
Sb	0.03829	148933	
Te	0.00002	36	
I	0.00105	9677	
Xe		0	
Cs	0.00383	37152	
Ba	25.97077	241099021	
La	0.02884	347696	
Ce	0.03048	413828	
Pr	0.00351	45092	
Nd	0.01005	155266	
Sm	0.0017	31335	
Eu	0.00286	51139	
Gd	0.00159	31987	
Tb	0.00023	4958	
Dy	0.00139	28908	
Ho	0.00025	6038	
Er	0.00066	15578	
Tm	0.0001	2481	
Yb	0.00067	15111	
Lu	0.00009	2389	
Hf	0.00847	216664	
Ta	0.00005	1044	
W	0.00026	6085	
Re	0	16	
Os	0	0	
Ir	0	9	
Pt	0.00009	1292	
Au	0.00007	492	
Hg	0.14052	929416	
Tl	0.0031	74734	
Pb	0.49236	11118357	
Bi	0.00149	26375	
Th	0.01295	168890	
U	0.0082	114419	

APPENDIX E

CHAIN OF CUSTODY FORMS

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ______

Proj. No.	Project Title
G466507-UC41	TO 26 Mercury Leaching

SAMPLERS: (Signature) Jennifer A. Ickes

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√): Hg	Container No.	Number of Containers	Remarks
3/27/01		pH = 2	X			Acid was
3/27/01		pH = 2 DUP	X			added
3/27/01		pH = 3	X			to all
3/27/01		pH = 4	X			Samples
3/27/01		pH = 5	X			
3/27/01		pH = 5 DUP	X			
3/29/01		pH = 6	X			
3/27/01		pH = 7	X			
3/29/01		pH = 8	X			
3/29/01		pH = 9	X			
3/29/01		pH = 9 DUP	X			
3/29/01		pH = 10	X			
3/29/01		pH = 11	X			
3/29/01		pH = 12	X			
3/29/01		pH = 12 DUP	X			

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Jennifer A. Ickes	3/29/01	[illegible]			

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks

Page 1 of 1

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ____

Proj. No.	Project Title
6466507-UC41	TO 26 - Mercury Leaching

SAMPLERS: (Signature) Jennifer A. [signature]

DATE	TIME	SAMPLE I.D.	Hg	Container No.	Number of Containers	Remarks
6/19/01		1 Hg	X		1	
6/19/01		2 Hg w/ Fe	X		1	
6/20/01		3 Hg	X		1	
6/20/01		4 Hg w/ Fe	X		1	
6/21/01		5 Hg	X		1	
6/21/01		6 Hg w/ Fe	X		1	
6/22/01		7 Hg	X		1	
6/26/01		8 Hg	X		1	
6/26/01		9 Hg	X		1	
6/27/01		10 Hg	X		1	
6/28/01		11 Hg	X		1	
6/29/01		T = 0m	X		1	
6/29/01		T = 0m Fe	X		1	
6/28/01		T = 5m	X		1	
6/28/01		T = 5m Fe	X		1	
6/28/01		T = 15m	X		1	
6/28/01		T = 15m Fe	X		1	

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Jennifer A. [signature]	6/29/01 1500	[signature]			
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks

Page 1 of 2

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ____

Proj. No.: G466507-UC41

Project Title: TO 26 - Mercury Leaching

SAMPLERS: (Signature) Jody Lipps

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√): Hg	Container No.	Number of Containers	Remarks
6/28/01		T = 30m	X			
6/28/01		T = 30m Fe	X			
6/28/01		T = 45m	X			
6/28/01		T = 45m Fe	X			
6/28/01		T = 1hr	X			
6/28/01		T = 1hr Fe	X			
6/28/01		T = 3hr	X			
6/28/01		T = 3hr Fe	X			
6/28/01		T = 5hr	X			
6/28/01		T = 5hr Fe	X			
6/29/01		T = 21hr	X			
6/29/01		T = 21hr Fe	X			
6/29/01		T = 23hr	X			
6/29/01		T = 23 hr Fe	X			

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Jerrit A Icke	6/29/01 1500	[signature]			
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	

Chain of Custody Record

WILSON
ENVIRONMENTAL LABORATORIES, INC.
401 Venture Drive • Suite C • Westerville, Ohio 43081 • (614) 431-0010 • Fax (614) 431-1650

Section A

Company Name: Battelle	Contact Person: Kristen Hartzell / Jennifer Ickes
Address: 505 King Ave	Phone: 424-7989 Fax: 424-3667
Project Name/No. G466507-UC41 WEL Qoute No. 002928	Sampler's Signature: Kristen Hartzell

Section B / **Section C**

Analyses Requested

ID No.	Date	Time	Comp	Grab	Sample Type*	Station Location	No. of Containers	Alkalinity	Acidity					Remarks WE10685
PH2	3/27/01				~~Water~~ AQ			✓	✓					1
PH2 Dup	3/27/01				AQ			✓	✓					2
PH3	3/27/01				AQ			✓	✓					3
PH4	3/27/01				AQ			✓	✓					4
PH5	3/27/01				AQ			✓	✓					5
PH5 Dup	3/27/01				AQ			✓	✓					6
PH6	3/29/01				AQ			✓	✓					7
PH7	3/29/01				AQ			✓	✓					8
PH8	3/29/01				AQ			✓	✓					9
PH9	3/29/01				AQ			✓	✓					10

*AQ= water/waste water; DW= drinking water; SL= solid; SW= solid waste; OW= oily waste; WP= wipe

Section D

Relinquished by:	Date	Time	Received By:	Date	Time
Kristen Hartzell	3/29/01	15:30	Sandra J. Ashe	3/30/01	10:45

Chain of Custody Record

WILSON
ENVIRONMENTAL LABORATORIES, INC.
401 Venture Drive • Suite C • Westerville, Ohio 43081 • (614) 431-0010 • Fax (614) 431-1650

Section A

Company Name: Battelle	Contact Person: Kristen Hartzell / Jennifer Ickes
Address: 505 King Ave	Phone: 424-7989
	Fax: 424-3667
Project Name/No.: G466507-UC41	Sampler's Signature: Kristen Hartzell
WEL Qoute No.: ~~007~~ 002928	

Section B / **Section C** — Analyses Requested

ID No.	Date	Time	Comp	Grab	Sample Type*	Station Location	No. of Containers	Alkalinity	Acidity					Remarks (WE10685)
PH9dup	3/29/01	~~AQ~~			AQ			✓	✓					11
PH10	3/29/01				AQ			✓	✓					12
PH11	3/29/01				AQ			✓	✓					13
PH12	3/29/01				AQ			✓	✓					14
PH12dup	3/29/01				AQ			✓	✓					15

Section D

*AQ= water/waste water; DW= drinking water; SL= solid; SW= solid waste; OW= oily waste; WP= wipe

Relinquished by:	Date	Time	Received By:	Date	Time
Kristen Hartzell	3/29/01	15:30	Sandra J. Ashe	3/30/01	10:45

Chain of Custody Record

WILSON
ENVIRONMENTAL LABORATORIES, INC.
401 Venture Drive • Suite C • Westerville, Ohio 43081 • (614) 431-0010 • Fax (614) 431-1650

Section A

Company Name: Battelle	Contact Person: Jennifer Ickes
Address: 505 King Ave, Columbus, OH 43201	Phone: 424-3723
	Fax: 424-3667
Project Name/No.: TO26 G466507-UC41	Sampler's Signature: Jennifer A. Ickes
WEL Qoute No.: 002928	

Section B / **Section C** — Analyses Requested

WE10711

ID No.	Date	Time	Comp	Grab	Sample Type*	Station Location	No. of Containers	Acidity	Alkalinity					Remarks
	4/10/01	-			AQ	pH = 5 Rerun	1						-1	Samples
	4/10/01	-			AQ	pH = 3	1						-2	contain
	4/10/01	-			AQ	pH = 6	1						-3	~ 1 mg/L
	4/10/01	-			AQ	pH = 9	1						-4	Mercury
	4/10/01	-			AQ	pH = 11	1						-5	
	4/10/01	-			AQ	Blank	1						-6	
	4/10/01	-			AQ	Blank without Fe	1						-7	

Section D

*AQ= water/waste water; DW= drinking water; SL= solid; SW= solid waste; OW= oily waste; WP= wipe

Relinquished by:	Date	Time	Received By:	Date	Time
Jennifer A. Ickes	4/10/01	0845	Sandra J. Ashe	4/11/01	1430

Chain of Custody Record

WILSON
ENVIRONMENTAL LABORATORIES, INC.
401 Venture Drive • Suite C • Westerville, Ohio 43081 • (614) 431-0010 • Fax: (614) 431-1650

PO# 164464

Section A

Company Name: Battelle	Contact Person: Jennifer Ickes
Address: 505 King Ave. Columbus OH 43201	Phone: 614-424-3723 Fax: 614-424-3667
Project Name/No. TO26 G466507-UC41 WEL Qoute No. 002942	Sampler's Signature: Jennifer A. Ickes

Section B / **Section C**

Analyses Requested: Chloride

WE10865

ID No.	Date	Time	Comp	Grab	Sample Type*	Station Location	No. of Containers	Chloride						Remarks
	6/19/01				AQ	1 Hg	1	X					-1	Hg conc.
	6/19/01				AQ	2 Hg w/ Fe	1	X					-2	is ~100ug/L
	6/20/01				AQ	3 Hg	1	X					-3	↓
	6/20/01				AQ	4 Hg w/ Fe	1	X					-4	
	6/21/01				AQ	5 Hg	1	X					-5	
	6/21/01				AQ	6 Hg w/ Fe	1	X					-6	
	6/22/01				AQ	7 Hg	1	X					-7	
	6/26/01				AQ	8 Hg	1	X					-8	
	6/26/01				AQ	9 Hg	1	X					-9	
	6/27/01				AQ	10 Hg	1	X					-10	

Section D

*AQ= water/waste water; DW= drinking water; SL= solid; SW= solid waste; OW= oily waste; WP= wipe

Relinquished by:	Date	Time	Received By:	Date	Time
Jennifer A. Ickes	7/2/01	0815	Sandra Ashe	7/2/01	1600

Chain of Custody Record

WILSON
ENVIRONMENTAL LABORATORIES, INC.
401 Venture Drive • Suite C • Westerville, Ohio 43081 • (614) 431-0010 • Fax: (614) 431-1650

Section A

Company Name: Battelle	Contact Person: Jennifer Ickes
Address: 505 King Ave, Columbus, OH 43201	Phone: 614-424-3723 Fax: 614-424-3667
Project Name/No.: G466507-UC41/PO# 64464 WEL Qoute No.: 002942	Sampler's Signature: Jennif A. Ickes

Section B / **Section C**

Analyses Requested: Chloride — WE 10865

ID No.	Date	Time	Comp	Grab	Sample Type*	Station Location	No. of Containers	Chloride						Remarks
	6/28/01				AQ	11 Hg	1	X					-11	Hg Conc
														~100 ug/L

Section D

*AQ= water/waste water; DW= drinking water; SL= solid; SW= solid waste; OW= oily waste; WP= wipe

Relinquished by:	Date	Time	Received By:	Date	Time
Jennif A. Ickes	7/2/01	0815	Sandra Ashe	7/2/01	1600