May 1997 • NREL/SR-430-22847

Municipal Solid Waste Combustor Bottom Ash Stockpile Runoff and Dust Emissions Evaluation

The Long Island Regional Planning Board

Hauppauge, New York

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393
A national laboratory of the U.S. Department of Energy
Managed by Midwest Research Institute
for the U.S. Department of Energy
under contract No. DE-AC36-83CH10093

NREL/SR-430-22847 • UC Category 600 • DE97000246

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Prepared under Subcontract No. AAE-3-13278

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MUNICIPAL SOLID WASTE COMBUSTOR BOTTOM ASH STOCKPILE RUNOFF AND DUST EMISSIONS EVALUATION

VOLUME I
PART I & PART II

Prepared for

The National Renewable Energy Laboratory
and
The New York/New Jersey Ash Utilization Demonstration Project

Prepared by

The Long Island Regional Planning Board
Hauppauge, New York

March 1997

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ACKNOWLEDGEMENTS

The Project Management Team (PMT), consisting of the representatives of the New York and New Jersey agencies that conceived and executed this demonstration project, wishes to express its profound appreciation to the members of the Pollution Control Financing Authority of Warren County (PCFAWC) and to its staff. Without their cooperation, the stockpile demonstration that is the subject of this report could not have taken place. The PCFAWC not only provided a secure site for the stockpile at its Oxford Township ashfill, but assisted in arranging for the construction of the pad and the placement of the ash and in resolving maintenance and monitoring equipment problems whenever they arose.

The PMT gratefully acknowledges its special debt to Kenneth Miller, Chairman, Warren County Pollution Control Financing Authority; Bart Carhart, Executive Director; and Jim Williams, Landfill Manager; whose invaluable contributions were critical to the success of this undertaking.

The PMT also thanks the many others who have participated, including those individuals whom it has unfortunately failed to list due to ignorance or oversight.

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PREFACE

Residues from municipal waste combustors in the United States are currently managed by disposal, usually as combined ash in permitted monofills. In Europe it is a common practice in many locales to separate the bottom ash produced in municipal solid waste combustors from the fly ash. The bottom ash is processed and used as a substitute aggregate material in road construction and the fly ash is disposed of, sometimes with treatment, in secure landfills. If recycling of residues from combustors is to occur in the U.S., it will most likely require the separation of the bottom ash and fly ash streams, much as it is done in Europe. A major precondition for using bottom ash as an aggregate substitute material in the United States is the identification of and, if needed, the mitigation of all potential environmental impacts associated with the use of bottom ash in construction applications.

The Stockpile Demonstration Program described in this volume is one component of a larger multi-year, multi-agency program consisting of research, analysis and field demonstrations involving the participation of several local and state agencies in the New York Metropolitan area as well as federal government support.

The first phase of the research and demonstration program was designed to provide the information needed to assess the feasibility of ash recycling or waste reduction from an environmental, engineering, economic and institutional perspective. It comprised the collection of bottom ash, combined ash and fly ash from five different facilities and the identification of the chemical and physical properties associated with the various ash streams. It included the identification of potential beneficial uses and the environmental and engineering issues associated with the manufacture, use and ultimate disposal or recycling of products containing ash. It also examined the economics of ash use vs. disposal and the legal and institutional impediments to use. A seven volume report describing the research and the findings has been published (LIRPB, 1993).

A second phase of the research was initiated to demonstrate in the field the engineering and environmental feasibility of actually using bottom ash as an aggregate substitute in asphalt paving. Several agencies, including the New York State Energy Research and Development Authority, the Port Authority of New York and New Jersey, the New Jersey Department of Transportation, and the New Jersey Department of Environmental Protection joined the Long Island Regional Planning Board in undertaking the field demonstrations. Additional financial support was provided by the National Renewable Energy Laboratory for the U.S. Department of Energy, and the U.S. Environmental Protection Agency.

The second phase activities, of which the stockpile demonstration is a part, have included the chemical and physical characterization of ash from the Warren County, New Jersey, waste-to-energy facility; the design, construction and monitoring of an ash stockpile; and the design and bench scale testing of ash/aggregate/asphalt road paving mixes; and the installation of two sections of road -- one paved with an ash modified mix containing

15 percent of the stockpiled bottom ash, by weight, and one, a control section -- to be monitored for dust, runoff, and leachate for a 24-month period. (The test pavement was installed in June 1996.)

In 1992, a bottom ash stockpile monitoring and analytical program was initiated as part of the inter-agency program. The purpose of the program was to identify and evaluate the magnitude of potential groundwater, surface water, air quality and soil quality impacts that could result from the widespread outdoor storage of bottom ash.

This volume presents the results of this stockpile evaluation program. It is divided into three parts: 1) the Summary Report; 2) the Technical Report; and 3) the Technical Report Appendices.

The Summary Report highlights the findings and conclusions derived from the monitoring and analytical activities. It also includes a listing of recommended measures for managing bottom ash processing and stockpiling operations to mitigate potential environmental impacts. For those whose interest extends beyond the Summary Report, Part II, the Technical Report, includes a detailed description of the stockpile; monitoring equipment; ash characterization testing; runoff and precipitation; air and soil quality sampling and testing; and an environmental assessment of potential groundwater, surface water, ambient air, worker environment and soil quality impacts. Part III consists of a series of appendices containing supporting technical data.

PART I

SUMMARY REPORT

Section 1

PROGRAM DESCRIPTION

Section 1 presents a description of the program that was designed and implemented to obtain the data and evaluate the environmental issues associated with the processing and maintenance of a bottom ash stockpile.

1.1 OVERVIEW

To implement this program, bottom ash (BA) collected from the 400 ton per day Warren County Resource Recovery Facility (WCRRF), located in Oxford Township in Warren County, New Jersey, was processed to produce a sand-like aggregate product; stored on a specially constructed pad at the Warren County Landfill site; and monitored for approximately 12 months. During this time, the air, stormwater runoff and soil quality in the vicinity of the stockpile were monitored. An electronic weather station was also installed on site to monitor and record meteorological conditions. The data obtained during the monitoring period were then used to develop a bottom ash stockpile source model to project potential air emissions and runoff loadings from the stockpile. Model generated emissions and loadings figures were used to estimate potential impacts on air, groundwater, surface water and soil quality in the vicinity of the stockpile.

1.2 PRELIMINARY ENVIRONMENTAL EVALUATION

Prior to the construction of the bottom ash stockpile, it was necessary to modify Warren County's landfill permit. This required the preparation of an environmental assessment to assess potential air, water and soil quality impacts that could result from the implementation of the proposed demonstration program. Based on the results of the assessment, it was determined that no significant impact would result from the proposed activities and the landfill permit modification was approved by the New Jersey Department of Environmental Protection. During the actual monitoring effort, measured dust emission impacts and runoff quality were all below those predicted by the model during the preliminary evaluation.

1.3 COLLECTION AND PROCESSING ACTIVITIES

To prepare the residue for use in the demonstration, bottom ash (BA) from the WCCRF combustor was collected separately from the fly ash (FA), loaded into roll off containers and transported to the Warren County Landfill where it was stored for 14 days to allow it to dry enough to permit screening and ferrous metal removal. Approximately 360 tons of minus 3/4 inch material was then placed on one of two specially constructed 65 foot x 65 foot curbed asphalt concrete pads, each equipped with a leachate collection system. The second pad was used as a control.

1.4 SAMPLE COLLECTION AND TESTING

A comprehensive sampling and laboratory testing program was undertaken to characterize the bottom ash, stockpile runoff, air quality, and soil quality in the vicinity of the stockpile. Three laboratories participated in the effort. They included the New Jersey Department of Environmental Protection Laboratory in Trenton, New Jersey; the New York State Department of Health Laboratory in Albany, New York; and the State University of New York Waste Management Institute Laboratory in Stony Brook, New York.

1.4.1 Ash Collection

Bottom ash was collected from the stockpile for characterization testing on 19 separate occasions between December 1992 and December 1993. The ash was subjected to a series of characterization tests including elemental, sequential chemical extraction, moisture content and organic testing and sieve analysis. Samples were collected from the top, middle and bottom portions of the pile in accordance with recommended ASTM practices.

1.4.2 Runoff and Rainfall

Two different methods were used to collect runoff samples during rainfall events. The first, diversion of runoff from the stockpile into a 300 gallon tank from which composite samples were drawn and the second, an automatic sampling system from which discrete samples and runoff flow data were obtained. Precipitation samples were obtained using a wet-dry collection system. Runoff and precipitation samples were collected during a total of 35 and 10 events, respectively.

Runoff samples were analyzed for metal content, chlorides, sulfates, pH, alkalinity, and total and dissolved solids. Selected samples were analyzed for semi-volatile and volatile organics, including dioxins and furans. Rainfall samples were analyzed for metal content, pH and acidity, total and dissolved solids. A selected number of samples were analyzed for volatile and semi-volatile organics.

1.4.3 Air Monitoring

The air monitoring effort was designed to measure fugitive dust emissions associated with the processing of bottom ash and the maintenance of a stockpile. Processing involved conveying, screening and ferrous removal operations. These operations were conducted and monitored during ash processing activities at the Warren County landfill. Stockpile maintenance included two operations. The first involved measurement of emissions during static conditions, when the stockpile was exposed to the elements in the absence of human activity. The second involved loading and unloading operations, "a turnover event" that was undertaken using a front end loader to work the pile, simulating the repeated retrieval and replacement of the ash.

Personal air samplers were used to monitor total suspended particulates (TSP) and respirable particulates (PM_{10}) during ash processing. Five high volume air samplers were used to monitor dust releases during periods when the undisturbed stockpile was exposed to natural weathering. An electronic weather station was installed on the site to record meteorological conditions and to control the on-off operation of the one upwind and four downwind high volume air samplers. High volume samplers and personal air samplers were used for air monitoring during nine turnover events.

All samples collected in the high volume samplers were analyzed for total particulates and trace metal concentrations. Samples collected in the personal air samplers were analyzed for total particulates and trace metals. A number of samples were also analyzed to determine the particle sizes of the dusts.

Direct mercury vapor monitoring of the stockpile was accomplished with the use of a Jerome Sampler.

1.4.4 Soil Sampling

Soil quality sampling and testing were also included in the stockpile evaluation program. Samples were collected at approximately six and eleven months following stockpile construction. On both occasions, surface and subsurface samples were obtained from 12 predefined sectors around the stockpile. The samples were analyzed for trace metals content.

1.5 ASSESSMENT PROCEDURES

Four scenarios or source conditions representing various aggregations (or multiples) of 360 ton stockpiles were evaluated. These four scenarios included the storage of 9, 25, 64 and 100 360 ton stockpiles. Each scenario was analyzed for ground and surface water, air quality and soil quality impacts. The numbers of stockpiles were chosen to permit evaluation of the environmental effects of storage sites containing three to four month accumulations of processed bottom ash from the five municipal waste combustors located in New Jersey.

A stormwater runoff and mass discharge model, developed using field runoff flow rates and elemental concentration data recorded during the year long monitoring period, was employed in the evaluation of stockpile runoff impacts on the groundwater, surface water and sediment environments.

A three-dimensional groundwater model was used to project increases in total dissolved solids and trace metal concentrations in groundwater. The New Jersey Department of Environmental Protection (NJDEP) groundwater quality criteria were used as reference concentrations in assessing the magnitude of the potential impacts.

Mass discharge calculations were used to estimate the potential dilution attenuation factor--the volume or flow of receiving waters needed to reduce unattenuated elemental stockpile runoff loadings to levels below those of the USEPA Chronic National Ambient Water Quality Criteria (NWQC) required to protect aquatic biota.

Analysis of gaged stream flow data was undertaken to determine the percentage of New Jersey stream locations that could provide adequate dilution even under mean annual seven consecutive day, ten year low flow conditions.

Mass discharge calculations of total trace metal loadings were also used to estimate the potential impact of these loadings on soil or sediment quality. NJDEP soil quality clean up standards were used as reference concentrations in assessing potential impacts.

Emission factors recommended by USEPA, and a USEPA ambient air dispersion model were used to project increases in TSP and PM_{10} emissions and trace metal concentrations associated with each of the four previously identified stockpile (source) scenarios. The Industrial Source Complex Short Term Model was used to predict fugitive dust concentrations at downwind receptors.

The significance of the potential air quality impacts was determined by comparing increases in TSP, PM_{10} and trace metal concentrations to USEPA and NJDEP air quality standards or guidelines for maximum 365 day average and highest 24 hour average concentrations.

The magnitude of dust related impacts on worker health and safety was evaluated by projecting particulate levels and corresponding metal concentrations within a pre-selected control volume with a conservative air turnover rate, and comparing estimated concentrations of TSP, PM_{10} and trace metals to OSHA eight-hour permissible exposure levels.

Section 2

FINDINGS AND CONCLUSIONS

Section 2 presents a listing of the major findings and conclusions associated with the one-year bottom ash stockpile demonstration program. Findings and conclusions are divided into several subsections as follows:

2.1 Bottom Ash: Physical Properties
2.2 Bottom Ash: Chemical Properties
2.3 Stockpile Runoff Properties
2.4 Precipitation Properties
2.5 Laboratory Versus Field Runoff Data
2.6 Runoff Quantity, Elemental Concentrations and Mass Loading Estimates
2.7 Ambient Air Quality
2.8 Worker Environment
2.9 Soil Quality, and
2.10 Environmental and Worker Health Impacts
    -- Groundwater Quality
    -- Surface Water Quality
    -- Sediments
    -- Soil Quality -- Runoff Percolation
    -- Ambient Air Quality
    -- Soil Quality -- Dust Impacts
    -- Worker Health Impacts

Each of the subsections presents a list of major findings followed by a list of conclusions.

2.1 BOTTOM ASH: PHYSICAL PROPERTIES

Findings

- **WCRRF Ash Composition**

  Bottom ash constituted roughly 67 percent of the total Warren County Resource Recovery Facility (WCRRF) residue, by weight. Fly ash accounted for 15 percent and ferrous metals, 17 percent.

- **Visual Description**

  Processed bottom ash, screened through a 3/4 in screen and with most of the ferrous metal removed, had the appearance of a gray, silty-sandy, non-plastic material, with pieces of metal (that were not removed in the ferrous metal removal operation) and some oversized (plus 3/4 in) material, which came through the screens during processing.

- **Grain Size**

  Samples of ash collected and analyzed for grain size distribution during the course of the monitoring program revealed a measurable decrease in gravel-size particles (particles greater in size than 4.75 mm) and an increase in both sand (particle sizes between 0.075 mm and 4.75 mm) and silt size particles (particles less than 0.075 mm in size).

- **Moisture Content**

  The moisture content of ash at the surface of the stockpile was much more susceptible to seasonal temperature fluctuations than ash in the interior of the pile. Periodic monitoring of the moisture content of the ash on both the surface and in the interior of the stockpile indicated that surface moisture decreased from an initial moisture content of 22 percent, wet weight, in December 1992 when the stockpile was constructed, to approximately 6.9 to 8.5 percent during the spring and summer seasons (mid-May through early August). Interior moisture content, measured at a depth of three feet, exhibited a gradual decrease from 22 percent in December 1992 to approximately 16 percent in October 1993.

  During the summer season a weak, dry crust formed on the surface of the stockpile, and during cold winter months (January and February) a frozen layer formed on the surface of the stockpile.

Conclusions

- **WCRRF Ash Composition**

  A substantial portion (approximately one-half to two-thirds) of the combined ash generated at the WCRRF can be processed into an aggregate material suitable for construction applications.

- **Visual Description**

  More efficient processing of the bottom ash (screening, ferrous and non-ferrous removal) than that undertaken during the demonstration project would be desirable to produce a higher quality aggregate-like product that contains less plus 3/4-in material.

- **Grain Size**

  Bottom ash is a material containing particles of marginal durability than can be expected to break down into smaller particles when subjected to the pressure associated with the operation of heavy equipment.

- **Moisture Content**

  The surface of bottom ash stockpiles will become dry and crusty during the hot summer season.

2.2 BOTTOM ASH: CHEMICAL PROPERTIES

Findings

- **Elemental Characterization**

  Calcium, iron and aluminum were the dominant cations detected in the stockpiled bottom ash, together comprising over 15 percent of its weight. Other cations with notable concentrations included sodium (0.8 - 0.9%), magnesium (0.7 - 0.9%) and potassium (0.4 - 0.5%). (Note: one percent = 10,000 μg/g = 10,000 ppm.)

  Zinc, copper and lead were the heavy metals present in the highest concentrations. Zinc exhibited concentrations ranging from 3300 to 5100 μg/g, copper exhibited concentrations ranging from 1200 to 4800 μg/g, and lead exhibited concentrations ranging from 1300 to 1800 μg/g. Other elements of environmental interest such as cadmium ranged in concentration from 25 to 30 μg/g; chromium, from 120 to 150 μg/g; mercury, from 0.43 to 0.81 μg/g; arsenic, from 13 to 19 μg/g; and barium, from 680 to 810 μg/g. (Note: one μg/g = one ppm.)

  There was some variability from test period to test period in the concentrations of each of the elements analyzed in the stockpiled ash. Among elements with concentrations greater than 10,000 μg/g, calcium was the most variable element; and among those with concentrations between 1,000 and 10,000 μg/g, nickel was the most variable; among those with concentrations less than 100 μg/g, arsenic was the most variable. Although, in certain instances, elemental data from bottom ash collected over the course of the demonstration suggested that decreasing or in some cases increasing elemental concentrations might be occurring with time, additional evaluations suggested that this may have been due primarily to analytical and/or sample variability and not to any measurable trend within the one-year stockpile sampling period.

- **Organic Characterization**

  Dioxin and furan concentrations in the stockpiled bottom ash were less than 0.01 nanograms per gram or 10 parts per trillion, expressed in terms of USEPA toxic equivalent concentrations. This was more than two orders of magnitude below the Centers for Disease Control (CDC) one nanogram per gram or 1000 parts per trillion threshold for remediation of residential soils. A small number of semi-volatile compounds were detected in the stockpiled bottom ash. However, all measurable concentrations were significantly below New Jersey soil cleanup standards for those compounds for which standards were available.

- **Trace Metal Availability**

  Sequential chemical extractions tests conducted on bottom ash samples collected during the course of the stockpile program failed to reveal any definitive change in the availability (or leaching extractability characteristics) of inorganic elements in the ash. No measurable change in availability was observed for cadmium and lead.

Conclusions

- **Elemental Characterization**

  WCRRF bottom ash contains high concentrations of cations such as calcium, sodium and potassium, some of which can be expected to ionize into solution upon contact with rainfall.

  The processed WCRRF bottom ash used in this demonstration contained substantial quantities of aluminum and iron as measured by atomic adsorption or ICP that were not effectively removed in the processing operation. Additional, more effective processing of the bottom ash could potentially result in improved ferrous and non-ferrous metal removal efficiencies and a more suitable ash product.

  WCRRF bottom ash contains certain trace metals that are present in higher concentrations (one order of magnitude or 10 times higher) than those found in most natural aggregates. These include copper, lead, zinc, cadmium, mercury and barium which are more than one order of magnitude or 10 times higher than concentrations in most natural aggregate sources.

  There was no measurable change in elemental bottom ash concentrations during the one-year stockpile demonstration program.

- **Organic Characterization**

  Trace organic concentrations in bottom ash are below regulatory action cleanup levels.

- **Trace Metal Availability**

  No measurable chemical fixation (i.e., reduction in leachability) resulting from exposure of the stockpile to the elements occurred over the one-year demonstration period.

2.3 STOCKPILE RUNOFF PROPERTIES

Runoff concentrations are described in relation to USEPA drinking water criteria to provide a measure of the magnitude of the concentration. Unless otherwise indicated the following findings are based on analysis of samples collected during 35 separate storm events:

Findings

- **Elemental Concentrations**

  The average dissolved elemental concentrations measured in runoff samples were below USEPA drinking water criteria with the exception of lead, sodium, manganese, chlorides and sulfates. Average calculated concentrations for lead were approximately three to four times drinking water criteria. This lead concentration may be somewhat overstated since the analytical detection limit, which was above the drinking water criteria, was used to represent the concentration of lead in those samples in which lead could not be detected.

  Average sodium concentrations were approximately eight times USEPA drinking water criteria and manganese, chloride and sulfates were all approximately three times USEPA drinking water criteria.

- **Total Dissolved Solids**

  Average total dissolved solids concentrations in stockpile runoff were approximately five times the USEPA drinking water criteria of 500 mg/L.

- **Total Unfiltered Elemental Concentrations**

  There were measurable differences between elemental concentrations in unfiltered runoff samples (particulate and dissolved matter) and concentrations measured in the dissolved fraction only. Unfiltered sample concentrations were higher than filtered concentrations due to the presence of stockpile ash particles in the samples. Individual unfiltered sample values were extremely variable due to the differences in the particulate content of the individual samples collected. Concentrations of aluminum and iron in the unfiltered samples were approximately ten times higher than those in the filtered or dissolved samples. All of the remaining elements exhibited unfiltered concentrations less than five times higher than the filtered or dissolved concentrations.

- **Organic Concentrations**

  Dioxin, furan, volatile and semi-volatile organic analyses of runoff samples from a single storm event revealed measured organic concentrations below existing New Jersey Groundwater Criteria. Runoff concentrations in samples collected from the bottom ash stockpile were similar to those measured in the samples collected from the control pad.

- **pH and Alkalinity**

  Runoff samples were all slightly alkaline, with pH values varying between 7 and 10. The average pH value of the stockpile runoff was 8.6. Runoff alkalinity varied between 15 and 100 mg/L total alkalinity, as $CaCO_3$. The average alkalinity of the stockpile runoff was 44 mg/L, as $CaCO_3$.

Conclusions

- **Elemental Concentrations**

  Lead is the only trace metal in bottom ash stockpile runoff with concentrations that are of concern when compared to those recommended by USEPA in their drinking water criteria.

- **Total Dissolved Solids**

  Total dissolved solids consisting primarily of sodium and manganese, sulfate and chloride salts are ash runoff constituents that are most likely to exceed USEPA drinking water quality criteria.

- **Total Unfiltered Elemental Concentrations**

  Ash particles can migrate from the stockpile and result in increased total trace metal concentrations in runoff samples.

- **Organic Concentrations**

  Trace organic concentrations in stockpile runoff are extremely low relative to NJDEP groundwater criteria.

- **pH and Alkalinity**

  Runoff from bottom ash stockpiles can be expected to be slightly alkaline and exhibit a pH value at which most trace metals exhibit minimum solubility.

2.4 PRECIPITATION PROPERTIES

The following findings are based on the analysis of rainfall samples from 10 separate storm events:

Findings

- **Elemental Concentrations**

  Elemental concentrations in the dissolved fraction of total rainfall samples were all below USEPA drinking water criteria. In the total rainfall sample (particulate plus dissolved), only beryllium concentrations were detected at levels exceeding drinking water criteria.

- **Organic Concentrations**

  Volatile and semi-volatile organic concentrations measured in precipitation samples were detected at levels similar to those levels found in runoff samples collected from both the bottom ash and the control pads. All measured concentrations were below New Jersey practical quantification levels (lowest detectable concentration of a constituent that can be reliably achieved) or groundwater criteria for those compounds for which criteria were available.

- **pH and Acidity**

  Total and wet precipitation exhibited acidic properties, as measured by pH, but contained very little acidity. Total and wet precipitation sample pH values varied between approximately 3 and 6. The average pH values of total and wet precipitation samples were 4.2 and 4.0, respectively. Total and wet precipitation sample acidity varied between approximately 3 and 10 mg/L, as $CaCO_3$. The average acidity values of the total and wet precipitation samples were 6.8 and 6.5 mg/L as $CaCO_3$, respectively.

Conclusions

- **Elemental Concentrations**

  Elemental rainfall concentrations did not substantially influence stockpile runoff elemental concentrations.

- **Organic Concentrations**

  No measurable volatile or semi-volatile organics were released from the stockpile during rainfall events.

- **pH and Acidity**

  The pH and acidity of rainfall in Warren County are typical of acid rainfall in the Northeast United States.

2.5 LABORATORY LEACHING TEST VERSUS FIELD RUNOFF DATA

Findings

Comparisons between measured stockpile runoff analyses and laboratory leaching tests of samples processed in accordance with EPA SW-924 leaching test methods, using synthetic acid rainwater as the extraction fluid, revealed that average arsenic, chromium, lead, mercury, silver, TDS concentrations and pH measured in leaching tests were accurate to within plus or minus 50 percent of the values measured in runoff samples collected in the field. Barium, copper, cadmium and alkalinity values in laboratory samples were two to four times higher than those measured in the field samples. Zinc and TDS were the only parameters with laboratory leaching test values lower than those observed in the field runoff samples. Zinc concentrations were markedly lower in laboratory samples, when compared to those in the field runoff samples.

Conclusions

The first extraction of USEPA SW-924 leaching tests is a useful tool for predicting trace metals and TDS concentrations from a bottom ash stockpile.

The first extraction of the USEPA SW-924 leaching test method is a good, although somewhat conservative (i.e., will tend to over estimate), approximation of arsenic, chromium, lead, mercury and silver concentrations that can be expected in runoff from a bottom ash stockpile.

The same test method will yield more conservative results for barium, copper, cadmium and alkalinity values, but is still a useful first approximation.

SW-924 laboratory test results may tend to underestimate expected TDS and zinc runoff concentrations, but can still provide a reasonable approximation of TDS concentrations.

SW-924 laboratory test results underestimate the quantity of zinc that may leach from a bottom ash stockpile.

2.6 RUNOFF QUANTITY, ELEMENTAL CONCENTRATIONS AND MASS LOADING ESTIMATES

Findings

- **Runoff Quantity**

  An analysis of the relationship between rainfall and runoff from the bottom ash stockpile pad indicated that runoff from a stockpile site is not a function of rainfall quantity (inches of rainfall) alone, but is dependent on both rainfall quantity and rainfall intensity (inches per hour). The greater the intensity of rainfall for a given rainfall event, the greater the runoff volume.

- **Elemental Runoff Concentrations**

  No relationship could be established between elemental stockpile runoff concentrations measured during rainfall events and the first flush, rainfall intensity, rainfall duration, or total rainfall.

- **Mass Loading**

  Seasonal elemental loadings from a bottom ash stockpile can be estimated by multiplying the average elemental concentration by the expected runoff quantity which is a function of total rainfall and rainfall intensity.

Conclusions

- **Runoff Quantity**

  Runoff from a bottom ash stockpile site is a function of rainfall intensity and total rainfall. The highly absorptive characteristics of the ash appear to reduce the runoff coefficient during low intensity storms to a greater degree than during high intensity storms.

- **Elemental Runoff Concentrations**

  The elemental concentration of runoff from a bottom ash stockpile site does not appear to be impacted to a measurable degree by rainfall characteristics. As a result, the average elemental concentration of the samples collected is the best estimate of the expected elemental concentration in the runoff.

- **Mass Loading**

  Monthly loadings during the spring and summer months, when rainfall intensities are generally the greatest, can be expected to be approximately 50 to 100 percent higher than the monthly loadings during the remainder of the year.

2.7 AMBIENT AIR QUALITY

During the one-year stockpile evaluation program, total suspended particulates (TSP) and trace metals associated with total suspended particulates were measured at monitoring stations located upwind and downwind of the bottom ash stockpile sites to determine the effects of wind erosion (static monitoring period) on ambient air quality in the vicinity of the stockpile.

Findings

- **TSP and Trace Metals**

  No measurable differences between ambient air TSP and trace metal concentrations upwind and downwind of the bottom ash stockpile site were detected during the static monitoring period. Measured ambient air TSP concentrations in the vicinity of the bottom ash stockpile were similar to TSP concentrations reported at other air monitoring stations in New Jersey and were below the New Jersey annual average TSP criteria of 75 $\mu g/m^3$. The average TSP concentration downwind of the bottom ash stockpile was 62 $\mu g/m^3$.

Conclusions

- **TSP and Trace Metals**

  During static periods bottom ash stockpiles will not generate sufficient dust quantities to produce a measurable effect on ambient air quality.

2.8 WORKER HEALTH

During the one-year stockpile evaluation program, respirable particulate matter (PM_{10}), total suspended particulates (TSP), particle gradation and trace metals associated with the total suspended particulates were monitored at the time of bottom ash processing (ash screening and magnetic separation) and stockpile turnover periods to determine the effects of heavy equipment handling activities on the air quality of the worker environment. The bottom ash stockpile was turned over with a front end loader for 6 to 8 continuous hours.

Findings

- **Processing Site**

  During bottom ash processing periods, measured PM_{10} dust concentrations and TSP trace metal concentrations were significantly below OSHA permissible exposure limits (PELs).

- **Turnover Periods**

  Visible dust emissions were observed during those stockpile turnover periods that occurred during warm dry weather. There was a measurable increase in ambient PM_{10}, TSP and TSP trace metals concentrations; however PM_{10} concentrations were one to two orders of magnitude, TSP concentrations at least two orders of magnitude, and TSP trace metal concentrations several orders of magnitude below OSHA PELs, respectively.

  Although still orders of magnitude below OSHA eight hour time weighted average trace metal criteria, detectable trace metal concentrations (As, Ba, Pb, Mn, Zn) in the immediate vicinity of the stockpile were up to 4.6 times background concentrations during turnover operations.

- **Dust Particle Sizes**

  Scanning electron microscope analyses of TSP and PM_{10} samples collected during stockpile turnover periods indicated that the major fraction of the TSP particulate matter was in the PM_{10} size ranges (less than 10 microns, with 55 to 95 percent evenly distributed throughout the PM_{10} range).

Conclusions

- **Processing Site**

  As long as the bottom ash is maintained in a moist state (moisture content approximately 20 percent), processing site activities should not produce any significant worker health issues, with respect to OSHA criteria.

- **Turnover Periods**

  During hot, dry periods, active bottom ash storage sites could produce an increase in dust and corresponding trace metal concentrations in the worker environment, if the surface of stockpiles and road surfaces with bottom ash are permitted to dry out; however, even with such drying it is unlikely that dust or trace metal concentrations will exceed OSHA criteria in the vicinity of the stockpile during heavy equipment use.

- **Dust Particle Sizes**

  The major fraction of the dust released during stockpile turnover activities is respirable.

2.9 SOIL QUALITY

Findings

- **Trace Metal Concentrations**

  On the two occasions when soil samples were collected in the vicinity of the stockpile (June 1993 and November 1993), elemental concentrations in the soils adjacent to the stockpile were found to be comparable to values typically present in New Jersey soils.

  The data indicate no detectable increase in trace metal concentrations in soils adjacent to the stockpile pad between the first and second sampling events.

- **Bottom Ash Versus Soil Concentrations**

  Bottom ash contains far greater concentrations of copper, lead, zinc, mercury and cadmium than those present in natural soils at the stockpile site and elsewhere in New Jersey.

Conclusions

- **Trace Metal Concentrations**

  It is unlikely that soils adjacent to bottom ash stockpile sites will be measurably impacted by dust emissions from the stockpile.

- **Bottom Ash Versus Soil Concentrations**

  Due to the relatively high trace metal concentrations in bottom ash as compared with natural soils, it is likely that ash spills or wheel tracking resulting from heavy equipment movement on an ashfill stockpile site will increase the trace metal content of soils contacted by the spills or tracked ash.

2.10 ENVIRONMENTAL AND WORKER HEALTH IMPACTS

Groundwater quality, surface water quality and ambient air quality modeling techniques employing or incorporating highly conservative assumptions were used to examine the potential impacts of stockpile runoff and dust emissions on groundwater, surface water and sediments and on adjacent soils and the worker environment. As a result, the findings and conclusions are admittedly skewed to overstate potential problems and to ensure protection of the environment.

Findings

- **Groundwater Quality**

  Model simulations of Warren County aquifer impacts associated with stockpile runoff suggest that lead, sodium and total dissolved solids warrant concern if runoff is discharged to sensitive fresh groundwater supplies. When maximum monthly loadings were used as input to a three dimensional groundwater quality model (without consideration of the attenuating effects of soils on trace metal concentrations such as lead, which is known to be substantial), the model projected lead, sodium and total dissolved solids concentrations in groundwater that could exceed New Jersey groundwater quality criteria.

- **Surface Water Quality**

  According to mass balance calculations, lead and copper are the trace metals in stockpile runoff, that are the most likely metals to impact sensitive freshwater aquatic environments. Approximately 55 percent of the gaging stations in New Jersey have recorded or projected low flows that should be sufficient to assimilate stockpile runoff loadings and ensure compliance with National Chronic Ambient Water Quality criteria.

- **Sediments**

  Projections of solids loadings from bottom ash stockpiles suggest that uncontrolled particulate runoff from large source areas into small deposition areas could result in the trace metals enrichment of the deposition area sediments. There are no direct criteria for assessing sediment quality impacts. Nonetheless, comparison of estimated annual increase in sediment elemental concentrations within a small control area with New Jersey residential soil cleanup standards indicated that cadmium could accumulate to concentrations that might warrant some remedial action.

- **Soil Quality -- Runoff Percolation**

  Projections were made of potential increases in soil trace metal concentrations due to the seepage of bottom ash stockpile runoff through soils and partitioning of the soluble trace metals onto soil particles. A comparison of increases in soil trace metal concentrations to New Jersey non-residential soil cleanup standards indicated that if all soluble trace metals partitioned onto a six inch layer of soil around the perimeter of a stockpile, 100 to 1000 years of continuous runoff would have to occur before partitioning would reach levels approaching New Jersey standards.

- **Ambient Air Quality**

  According to USEPA AP-42 emissions factor equations, vehicular traffic involving a front or end loader and truck on a bottom ash storage site constitutes the unit operation with the greatest potential for fugitive dust generation, generating emissions exceeding those attributable to wind erosion or lifting and dropping operations.

  In the absence of moisture control to reduce dust emissions from vehicular traffic and wind erosion, short term, 24-hour TSP criteria in the State of New Jersey could be exceeded on sites with more than 35 360-ton stockpiles, especially during the hot summer months.

  Ambient air modeling results for uncontrolled stockpile emissions indicated that annual average and 24-hour concentrations of respirable particulates (PM_{10}) would not exceed USEPA ambient air PM_0 criteria; however, the risks associated with annual average cadmium and hexavalent chromium ambient air concentrations could exceed New Jersey Department of Environmental Protection (NJDEP) risk criteria for bottom ash storage sites containing more than 35 360-ton stockpiles. Simulations incorporating moisture control to remediate vehicular movement emissions indicated that such a remediation strategy could reduce cadmium and hexavalent chromium emissions to acceptable levels.

  Short-term 24-hour total chromium, lead and zinc ambient air concentrations could exceed NJDEP reference concentrations for bottom ash storage sites containing approximately 9 to 25 360-ton stockpiles if dust suppression measures are not used. Simulations using moisture control dust suppression measures indicated that, with the exception of total chromium, all trace metal emissions could be reduced to acceptable levels.

- **Soil Quality -- Dust Impacts**

  Modeling of expected soil quality impacts in the vicinity of the stockpile indicate that even without moisture control, soil quality in areas adjacent to the stockpile site would not be measurably impacted by stockpile activities.

- **Worker Health Impacts**

  An analysis of expected increases in TSP, PM_{10} and trace metal concentrations in the worker environment during bottom ash storage operations indicates that TSP, PM_{10} and trace metal concentrations would be between 100 and 1000 times lower than OSHA permissible exposure limits (PELs).

Conclusions

- **Groundwater Quality**

  High salt loadings from bottom ash storage sites represent a potential environmental concern due to their potential ability to impact fresh drinking water aquifers. Given the known low concentrations released and the likelihood of soil attenuation, it is not expected that the release of trace metals, including lead, will produce any groundwater quality impacts.

- **Surface Water Quality**

  Very small drainage basins with low stream flow could potentially be susceptible to long-term ecosystem impacts resulting from uncontrolled trace metal loadings from bottom ash stockpiles.

- **Sediments**

  Sediment buildup in locations where particulate runoff from bottom ash stockpiles is left to accumulate could increase concentrations of trace metals to levels that would exceed NJDEP residential soil cleanup standards.

- **Soil Quality -- Runoff Percolation**

  The soluble trace metals present in runoff discharges to soil adjacent to a stockpile are not expected to have a significant impact on soil quality as measured by non-residential soil cleanup standards in the State of New Jersey.

- **Ambient Air Quality**

  Bottom ash processing and storage areas should be managed to control dust emissions, particularly during the hot, dry season when the surface of the bottom ash stockpile is susceptible to drying and caking. The control of dust generated by vehicular movement on the stockpile site, which is the major source of dust emissions, is of particular importance.

- **Soil Quality -- Dust Impacts**

  Soil quality would not be measurably impacted by trace metals due to dust emissions from a bottom ash stockpile; however, spillage or vehicular wheel tracking could be expected to impact local soil quality.

- **Worker Health Impacts**

  Dust and trace metal air concentrations in the worker environment are not expected to exceed OSHA PELs.

Section 3

RECOMMENDATIONS

Section 3 presents a listing of recommended strategies for assessing runoff impacts and managing bottom ash processing and storage operations for ash that is intended for use as an aggregate substitute material in construction applications. The recommendations are based on the findings and conclusions of the one-year demonstration program presented in Part 1, Section 2 of this report. They reflect an environmentally conservative approach to ensure protection of the environment in which these operations may occur.

A. The first extraction of USEPA's SW-924 leaching test method using synthetic acid rainwater should be considered a reasonable method for estimating the expected levels of trace metals and total dissolved solids that could be released in the runoff from a bottom ash stockpile.

B. Mass loadings of elemental constituents contained in the runoff of a bottom ash stockpile should be predicted using the mass loading model presented in this report. This model takes into account both total rainfall and rainfall intensity to project expected runoff volumes.

C. Locations for bottom ash processing and storage sites should be selected to control and prevent any leaching or runoff impacts

D. Site maintenance and site management practices should be instituted to control and prevent the release of leachate, runoff, runoff particulates, fugitive dust emissions, and spillage or particulate tracking (e.g., vehicular wheel tracking) into the adjacent environment.

E. Ash stockpiles should be located on existing ashfill or landfill sites. These sites are most suitable for mitigating leachate, and fugitive dust emissions associated with the storage and handling of large quantities of ash.

F. Unless bottom ash storage facilities are located within the lined portion of an ashfill or landfill site, stockpiles should be placed on impermeable pads (e.g., asphalt or concrete) and covered, incorporating practices that are commonly used in the management of road salt storage. Any runoff should be discharged to the lined landfill's leachate collection system or suitable wastewater treatment facilities.

G. Whenever possible, bottom ash processing, which can include screening, ferrous and non-ferrous removal, should occur within an enclosed operating facility. The waste-to-energy facility where the bottom ash is generated would be the preferred location. A dedicated enclosed facility could be designed to mitigate potential leaching, fugitive dust emissions or particulate migration associated with ash processing operations. Outdoor processing facilities, however, should be acceptable if fugitive dust and runoff and leachates are managed and if the stockpiled ash is contained to prevent wheel tracking of ash beyond the immediate storage area, in order to minimize the transfer of trace metals in the ash to adjacent soils.

H. Roadways used for vehicular traffic in the vicinity of outdoor bottom ash stockpile locations should be managed to control fugitive dust emissions through dust control measures (e.g., wetting down) similar to those used on conventional aggregate storage or mineral processing sites. This is of particular importance during the period from May to October when warm temperatures facilitate ash drying on pavements and increase the potential for fugitive dust emissions and particulate migration.

I. Whenever bottom ash stockpiles on an ashfill or landfill site are to be left uncovered, dust control measures similar to those used on conventional aggregate storage sites should be applied to the roadway surface of the stockpile area prior to the commencement of ash handling activities.

J. Bottom ash should be transported in enclosed water tight vehicles to control fugitive dust emissions and runoff discharges.

K. If bottom ash is intended for use in the production of asphalt pavements, and if storage at an asphalt production facility is necessary, the bottom ash should be placed on a dedicated pad or hopper and covered.

L. To minimize the trace metal and trace organic content and to provide a better engineering product for use in asphalt paving mixes, the bottom ash produced in waste-to-energy facilities should be managed separately from the fly ash. This separate management scenario should also include the segregation of the boiler ash and grate siftings from the bottom ash stream.

M. To further reduce the potential contaminants (i.e., trace metals) in the ash stream, source reduction and source separation programs should be implemented. These programs should focus on products containing cadmium, lead and mercury. For the source reduction program, this would include items such as batteries, fluorescent and high intensity discharge lamps, and consumer electronics. For the source separation program this would include discarded products such as rechargeable batteries, mercury oxide batteries, fluorescent and high intensity discharge lamps, mercury switches, thermostats, thermometers and consumer electronics including circuit boards and cathode ray tubes.

PART II

TECHNICAL REPORT

Section 1

INTRODUCTION

Early in the planning for the ash paving demonstration project, the participating agencies recognized the need to identify and document the environmental problems, if any, that might be associated with the preliminary processing and storage of waste-to-energy facility ash destined for use in various construction applications.

To implement this program, bottom ash (BA) collected from the Warren County Resource Recovery Facility (WCRRF), located in Oxford Township in Warren County, New Jersey, was processed to produce a sand-like aggregate product; stored on a specially constructed pad; and monitored for approximately 12 months. During this time, the air, stormwater runoff and soil quality in the vicinity of the stockpile were monitored. An electronic weather station was also installed on site to monitor and record the meteorological conditions. The data obtained during the monitoring period were used to develop a bottom ash stockpile source model to project potential runoff loadings and air emissions from the stockpile. Model generated loadings and emissions figures were then used to estimate potential impacts on air, groundwater, surface water and soil quality in the vicinity of the stockpile.

The seven additional sections that make up Part II of this report discuss the program activities and results that form the basis for the findings, conclusions and recommendations set forth in Part I. The sections and the topics covered are as follows:

Section 2, Bottom Ash Collection, Processing and Storage Operations, discusses the activities involved in the collection, processing and storage of the BA used in the evaluation program;

Section 3, Bottom Ash Characterization Testing, describes the tests that were conducted on the BA from the stockpile and the results of these tests;

Section 4, Stockpile Runoff and Precipitation Sampling and Testing, summarizes the runoff and precipitation monitoring program and the results of the program;

Section 5, Ambient Air Sampling and Testing, describes the ambient air monitoring program and the results of the program;

Section 6, Soil Quality Testing, describes the soil quality monitoring program and the results of the program;

Section 7, Groundwater, Surface Water and Sediment Quality Impact Assessment, discusses the methods used and the results of the groundwater and surface water quality impact assessment; and

Section 8, Ambient Air Quality, Soil Quality and Worker Environment Assessment, describes the methods used and the results of the ambient air quality impact assessments.

Section 2

BOTTOM ASH COLLECTION, PROCESSING AND STORAGE OPERATIONS

Section 2 describes the activities involved in the collection, processing and storage of the bottom ash (BA) used in the stockpile demonstration program. Section 2 is divided into four subsections. Section 2.1 presents a brief description of the Warren County Resource Recovery Facility (WCRRF) and the ash conveying arrangements at the facility. Section 2.2 describes the fly ash (FA) and BA management procedures used to segregate the BA and FA streams at the facility so that a portion of the BA could be diverted for use in the stockpile evaluation program. Section 2.3 outlines the BA processing operations used to produce a finished ash-aggregate product for use in the stockpile monitoring program and ultimately for the paving demonstration. Section 2.4 discusses the design of the stockpile pad that was used for storage of ash during the monitoring program.

2.1 WARREN COUNTY RESOURCE RECOVERY FACILITY

The WCRRF is a 400 ton per day waste-to-energy municipal solid waste combustor that is owned and operated by the Warren Energy Resource Corporation. The facility, which began operations in 1988, is located in Oxford Township in Warren County, New Jersey, at the intersection of Quarry Road (also known as Edison Road) and Mount Pisgah Avenue. An Oxford Township location map is presented in Figure 2-1. Figure 2-2 presents a more detailed Warren County Landfill and Resource Recovery Facility site location map.

The WCRRF produces approximately 100 tons of combined ash (CA) daily. The fly ash constitutes approximately 15 percent of the combined ash by weight. The facility contains two solid waste combustion furnaces and water-walled boilers, each rated at 200 tons per day. Air pollution control equipment consists of spray tower absorbers with wet atomized lime injection and baghouses for acid gas and particulate control.

The BA collected at the facility consists of grate ash, siftings and boiler ash. After leaving the furnace, this composite BA stream is quenched and moved by a BA cross conveyor to a 2-inch grizzly screen, where the plus 2-inch materials are segregated (scalped) from the BA ash stream. The minus 2-inch BA fraction exiting the grizzly screen is subsequently conveyed under a belt magnet where ferrous metals are removed. The minus 2-inch, nonferrous BA fraction is then conveyed to the BA/FA mixing building. A plan view of the ash conveying arrangement at the facility is presented in Figure 2-3.

The FA stream, which consists of spray dryer absorber ash and baghouse ash, is conveyed from the baghouse and spray dryer absorber to the FA/BA mixing building where the FA is mixed with the bottom ash

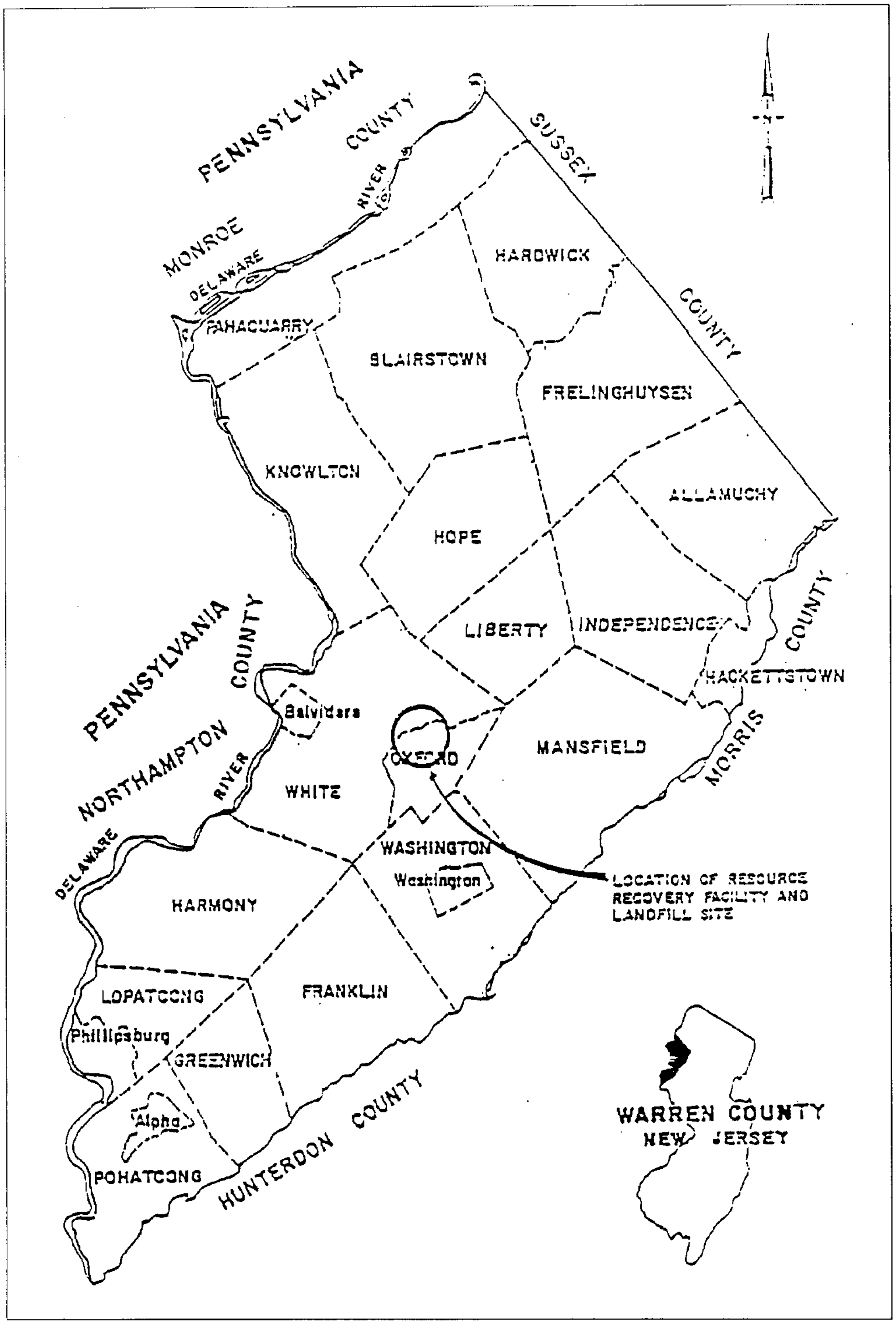

Figure 2-1

WARREN COUNTY RRF AND LANDFILL GENERAL LOCATION MAP

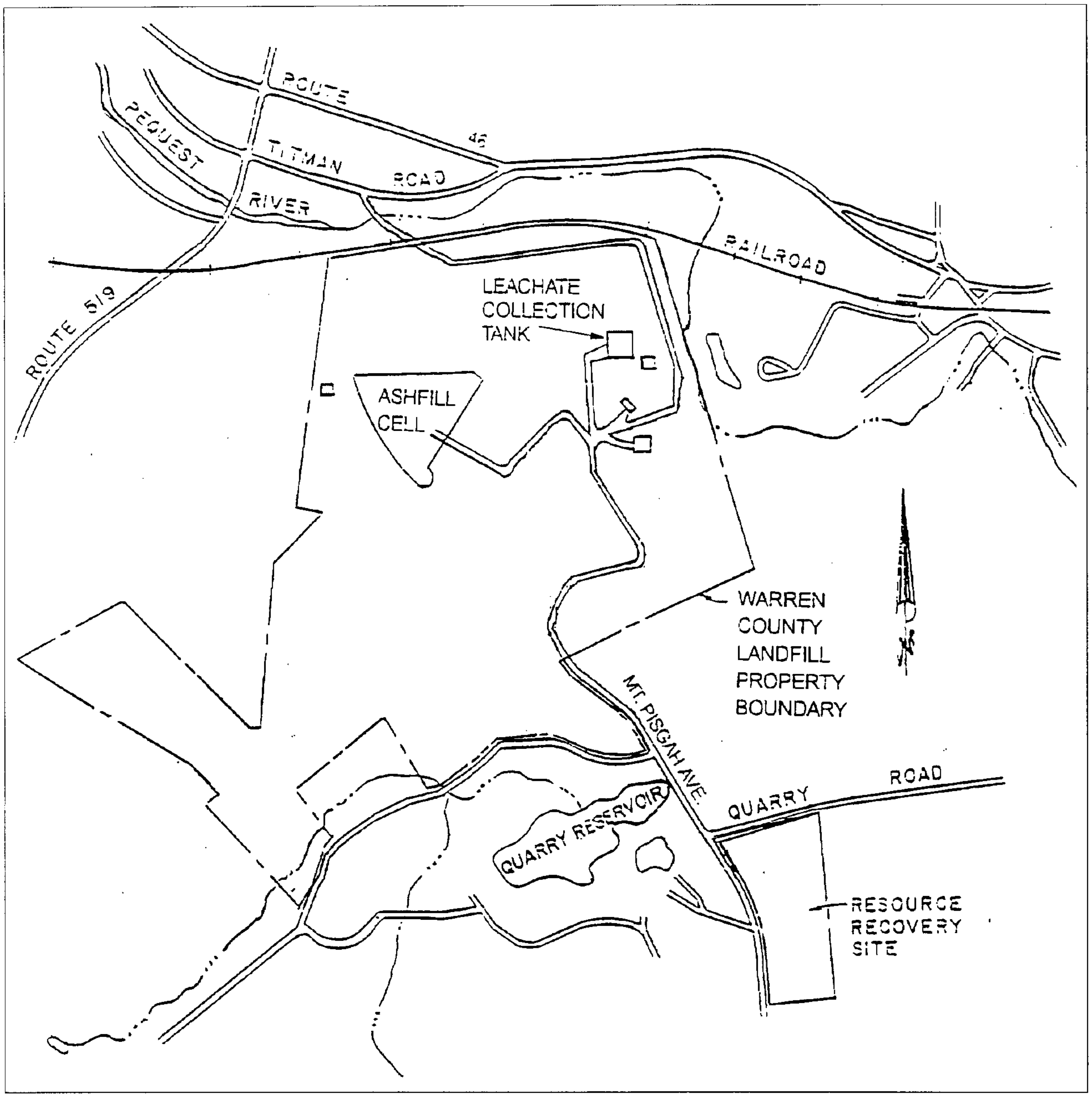

Figure 2-2

WARREN COUNTY LANDFILL AND RESOURCE RECOVERY FACILITY MAP

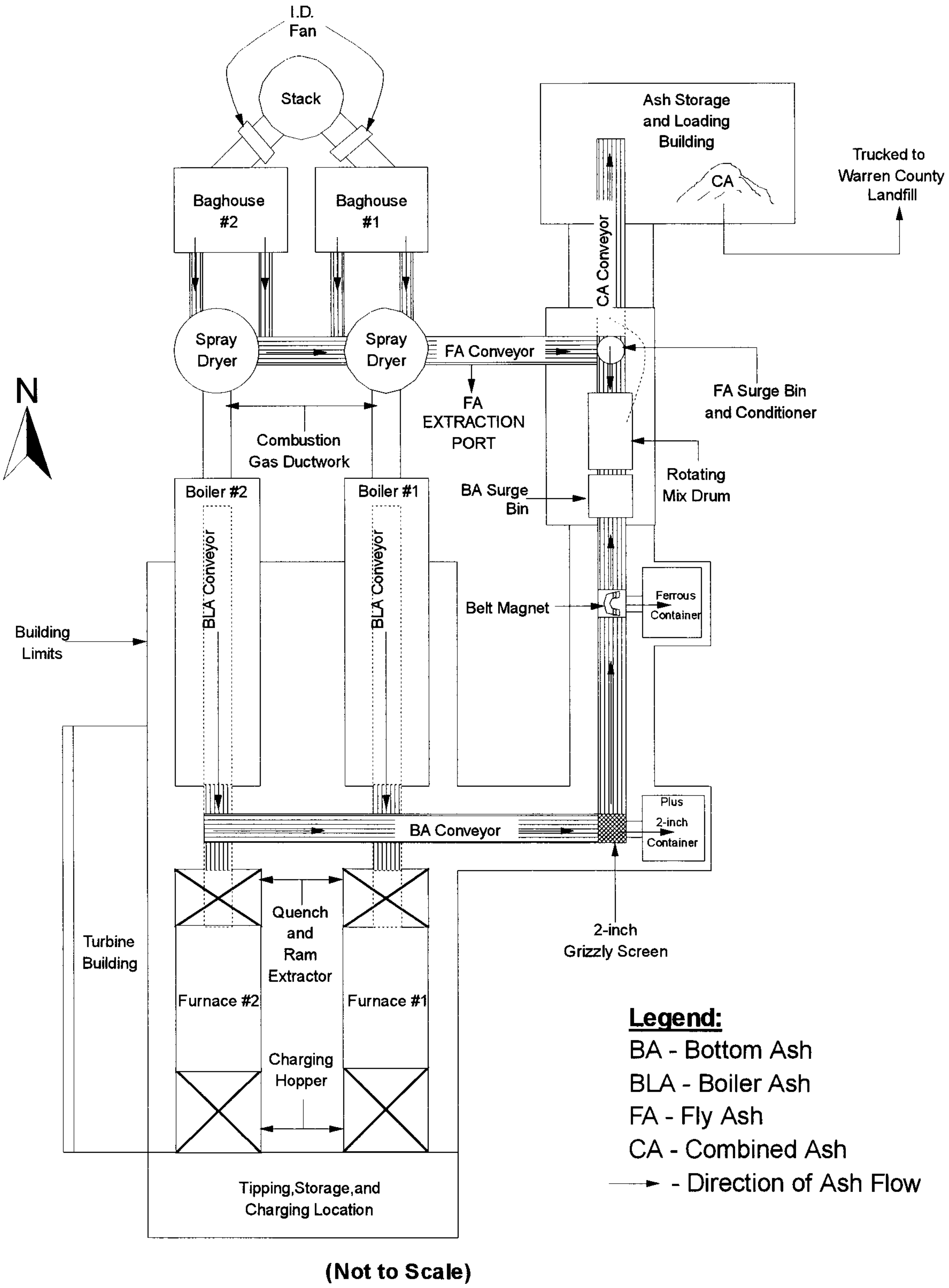

Figure 2-3

WCRRF ASH COLLECTION AND CONVEYING ARRANGEMENT

in a rotating drum.[1] The mixed BA and FA stream (the combined ash) is then conveyed to an ash storage building where the CA is stored and subsequently deposited into trucks for transport to the Warren County landfill. The Warren County landfill is located approximately one half mile north of the WCRRF. Figure 2-2 shows the location of the Warren County landfill.

2.2 FLY ASH AND BOTTOM ASH MANAGEMENT

To collect BA for the stockpile evaluation program, FA was diverted from the FA conveyor through a valve-controlled extraction port located under the conveyor. Figure 2-3 shows the location of the FA extraction point. FA diverted from the conveyor was discharged into air tight one cubic yard polypropylene bags, referred to commercially as Supersacks. The Supersacks were mounted on wooden skids that were used to assist in transporting the polypropylene bags by forklift. During FA collection, a plastic tarp was placed on the ground and a plastic curtain was hung on a wooden frame constructed around the fly ash collection area to contain any escaping dust particles. An industrial vacuum was also present as a safeguard in the event of any spills. Photograph 2-1 shows the FA extraction arrangements.

The sequence of operations used to collect the FA involved a number of steps. First, the FA conveyor was turned on and FA was extracted until a Supersack was filled. After the Supersack was filled, the FA conveyor was stopped, the Supersack was removed, and a new Supersack was inserted under the conveyor. The Supersack containing the FA was then transported by forklift and placed in an enclosed trailer for removal and disposal. The FA conveyor was then restarted and the process was repeated.

Using the sequence of operations outlined above, a total of 118 tons of FA were collected over a nine-day period from November 9 to November 16, 1992. During this same period, approximately 526 tons of BA were collected. The quantity of ferrous metals removed from the bottom ash during the collection period totaled 136 tons. The total amount of municipal solid waste combusted during the collection period was 2,826 tons. The quantities of municipal solid waste processed and residues collected during this period are listed in Table 2-1.

2.3 BOTTOM ASH PROCESSING OPERATIONS

The separate extraction of FA from the ash collection system permitted the CA conveyor to move BA only to the ash storage building (see Figure 2-3). There the BA was loaded in roll-off containers and transported to the Warren County Landfill.

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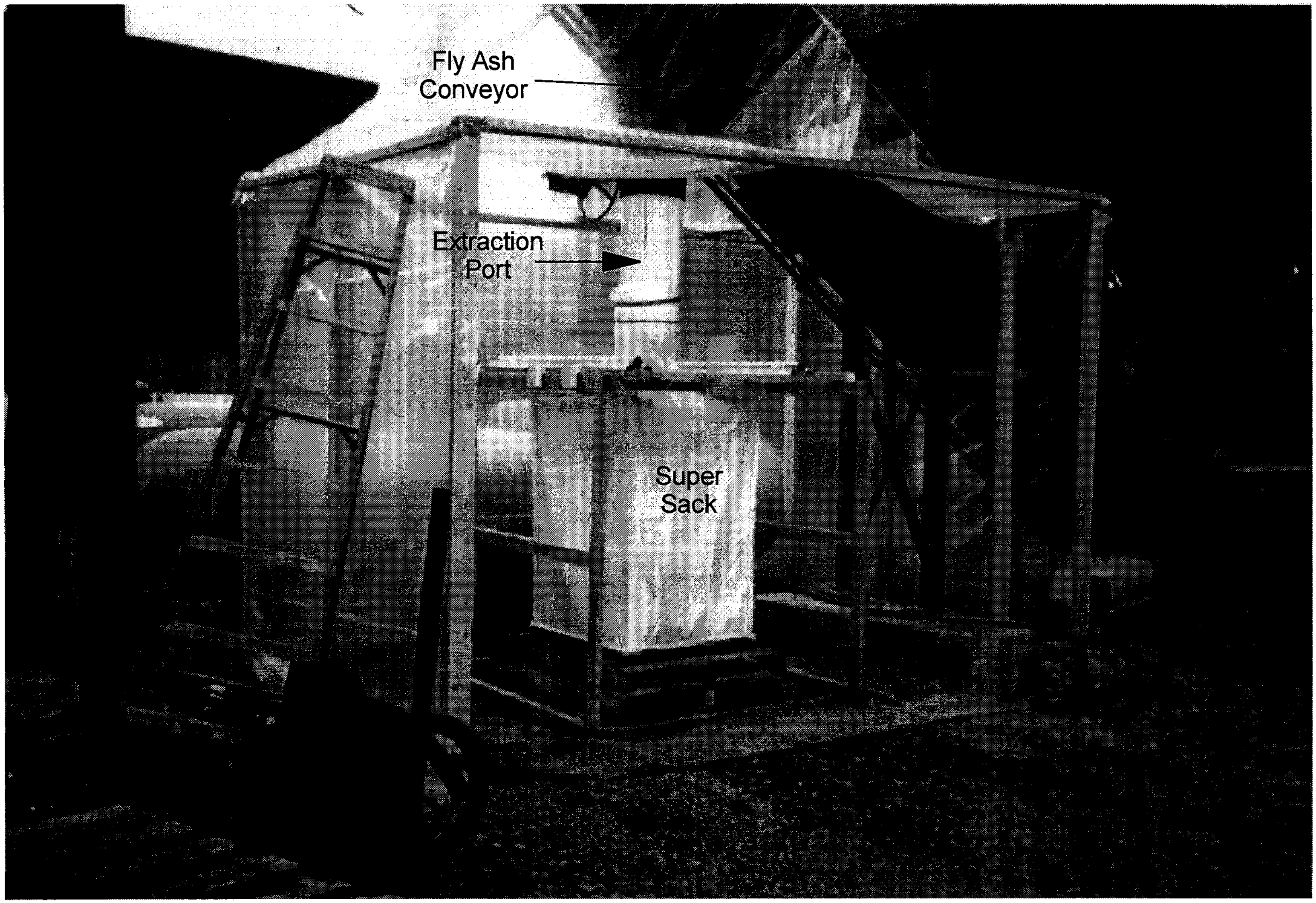
[1] Note: At this writing, the BA and FA are no longer mixed in the mixing building. During the period when the BA was collected for the stockpile demonstration (11/9/92 to 11/16/92), the mixing drum was operational.



Photograph 2-1

FLY ASH EXTRACTION PORT

Table 2-1

MUNICIPAL SOLID WASTE PROCESSED AND RESIDUE PRODUCED DURING BOTTOM ASH COLLECTION PERIOD

Bottom Ash Collection Period
November 9-16, 1992

Municipal Solid Waste or Residues	Tons	% of MSW[1]	% of CA[2] Ash
Municipal Solid Waste (MSW) Processed	2826	--	--
Bottom Ash (BA) Collected	526	18.6	67
Fly Ash (FA) Collected	118	4.2	15
Ferrous Metal (Fe) Collected	136	4.8	17
Total Combined Ash (CA)[3]	780	27.6	--

1. % of MSW = (Tons Collected ÷ 2826) × 100
2. % of CA = (Tons Collected ÷ [BA + FA + Fe]) × 100
3. CA = (BA + FA+ Fe)

Prior to processing, the BA was stored for 14 days, primarily for drying purposes.[1] A tarpaulin was placed over the ash during periods of rainfall but the ash was exposed to sunlight during dry periods. BA processing at the Warren County landfill included screening of the ash through a 3/4-inch screen size and additional ferrous metals removal. Oversized, plus 3/4-inch materials and ferrous metals removed from the BA stream during this processing were discarded in the Warren County Landfill.

After processing, the quantity of BA used in the stockpile demonstration was estimated by calculating the volume of the constructed stockpile and assuming an average bottom ash density of 81.4 lbs per cubic foot (pcf) (LIRPB, 1993). Using this approach, it was projected that approximately 360 tons of BA were used in the stockpile demonstration. Since the weight of the bottom ash collected from the WCRRF totaled 526 tons, it was estimated -- on the basis of the stockpile volumetric and ash unit weight assumptions previously presented -- that approximately 166 tons or 31 percent of the BA processed was removed and discarded during processing operations. This 166 ton value was significantly higher than expected,[2] and was the result of the inadvertent disposal of excess ash in the landfill during processing operations.

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[1] Because of its high moisture content the BA was too wet for effective handling and screening upon receipt at the landfill.

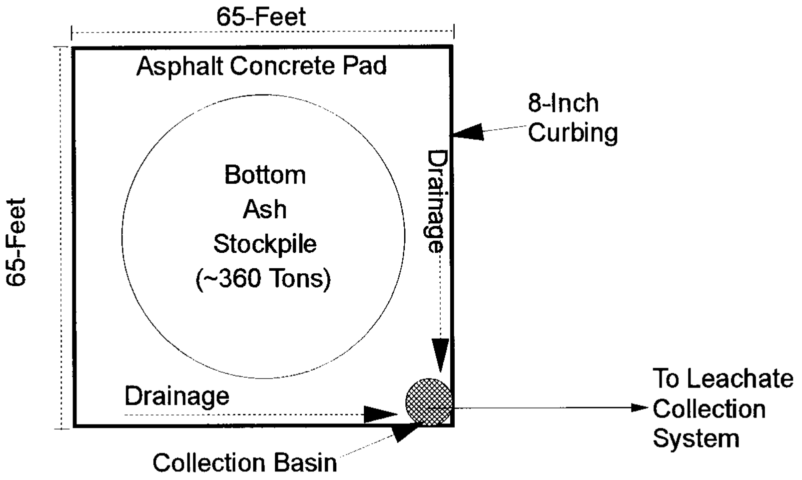
[2] The total quantity of plus 3/4-inch and ferrous metals in the ash was expected to be less than 10 percent.

2.4 BOTTOM ASH STOCKPILE PAD AND CONTAINMENT SYSTEM

In the fall of 1992, two 65 foot square asphalt concrete pads were constructed at the Warren County Landfill to store the processed BA during the evaluation period. One pad was used to store the 360 ton BA stockpile. The second pad was used as a control test pad. Each pad was constructed with a runoff drainage and collection system and curbing along the periphery to contain and divert runoff into sampling containers and the landfill's leachate collection system. Additional discussion of the runoff containment system is presented in Section 4, Stockpile Runoff and Precipitation Testing.

Figure 2-4 presents a schematic of the plan and profile view of the pads' general design dimensions and the drainage system. The asphalt concrete pad was constructed with a 2 inch thick asphalt concrete surface (NJDOT I-4 mix), which was underlain by a 6 inch dense granular base, 3 inches of 3/8 inch stone, 3 inches of clean sand, and a 36 mil Hypalon geomembrane liner. The liner was installed on top of 3 inches of clean sand. An 8 inch asphalt-concrete curb was constructed around the periphery of the pad. The Hypalon liner was tied into the top of the 8 inch curbing so that any leakage through the asphalt pad would be retained on the liner and could drain into the runoff collection system piping. Figure 2-4 presents a schematic of the underdrain system arrangements. The system design also included a special drain connection tied into the 3 inch sand layer above the Hypalon liner to drain any water trapped above the liner into the runoff piping system. Construction of the two pads was completed in October, 1992. The bottom ash was placed on one of the pads on December 7, 1992. Photograph 2-2 presents a picture of the stockpile on the pad.

Plan View (not to scale)



Profile View (not to scale)

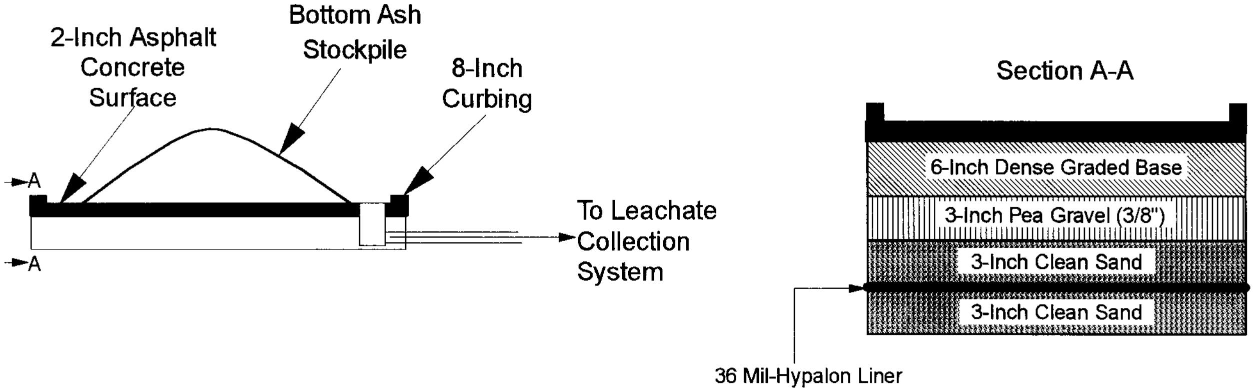


Figure 2-4

**PLAN AND PROFILE VIEW
BOTTOM ASH STOCKPILE PAD**

Photograph 2-2

BOTTOM ASH STOCKPILE AND STOCKPILE PAD

Section 3

BOTTOM ASH CHARACTERIZATION TESTING

From December 1992 to December 1993, bottom ash (BA) was periodically collected from the stockpile and subjected to a series of characterization tests. Section 3 discusses the testing program and the results. Section 3 is divided into two subsections. Section 3.1 covers the BA testing program, including the ash collection procedures and the ash sampling schedule, and Section 3.2, outlines the results of the program.

3.1 BOTTOM ASH TESTING PROGRAM

3.1.1 Analytical Tests

BA samples were collected from the stockpile for elemental testing, sequential chemical extraction testing, moisture content testing, organic testing, and sieve analysis. Table 3-1 presents a list of the tests, the laboratory that performed each test, and the respective reference method. See Appendix A1 for a more detailed description of the analytical test procedures.

3.1.2 Sample Collection Schedule

BA samples were collected for analysis on a total of 19 occasions. Table 3-2 presents a list of the sample collection dates and the tests to which the collected samples were subjected. During the course of the program, six sets of samples were collected for use in elemental composition testing; 14, for moisture content testing; six, for sequential chemical extraction; one, for organic characterization; and four, for sieve analysis.

3.1.3 Sampling Procedures

Samples were collected from the stockpile using the procedures outlined in ASTM Method D-75, "Standard Practice for Sampling Aggregates." Samples were collected from the top, middle and bottom portions of the pile. Discrete samples were composited, coned and quartered, and placed in three 5-gallon buckets in accordance with the methods outlined in ASTM Method C702-87, "Standard Practice for Reducing Field Samples of Aggregates to Testing Size."

Table 3-1

TEST METHODS AND LABORATORY PERFORMING ANALYSES FOR BOTTOM ASH CHARACTERIZATION TESTING PROGRAM

Test	Lab	Method
Elemental Characterization[1]	NJDEP	SW-846
Moisture Content[2]	NJDEP	ASTM D2216-80
Sequential Chemical Extraction[3]	SUNY	Tessler (1979)
Grain Size Analysis	NJDOT	ASSHTO T-27
Dioxins and Furans	NYSDOH	EPA-8280
Semi-Volatile Organics	NYSDOH	EPA-625 & OLMO1,O CLP

1. Atomic adsorption or ICP used for metals analysis of Al, As, Ba, Be, Cd Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Zn, Ca, Mg, K, Si and Na.
2. Moisture samples were collected from the stockpile at two heights (6-feet and 12-feet) and from two depths (0-feet and 3-feet).
3. Sequential Chemical Extraction tests included elemental characterization and an evaluation of the relative leachability of the metals found in ash as defined by five extraction phases (see Appendix A).

Table 3-2

BOTTOM ASH SAMPLE COLLECTION AND TEST SCHEDULE

Date[1]	T[2]	Elemental Characterization	Moisture Content	Sequential Chemical Extraction	Organic Testing	Sieve Analysis
12/4/92		×	×	×		×
12/19/92			×			
1/5/93			×			
2/2/93			×	×		×
3/2/93			×			
4/2/93				×		×
4/6/93			×			
4/27/93			×			
5/5/93	T	×		×	×	
5/13/93			×			
5/28/93			×			
6/23/93	T	×		×		
7/27/93	T	×	×	×		
8/3/93			×			
8/10/93			×			
8/23/93	T	×				×
10/1/93			×			
10/5/93	T	×				
10/14/93			×			

1. Stockpile construction occurred on 12/4/92.
2. T represents dates on which samples were collected after a turnover event.

Special provisions were made to collect samples for testing the moisture content of the BA at the surface and within the pile (i.e., at a depth of 3 feet). Both surficial and subsurface samples were collected from pile heights of 6 and 12 feet above ground level, respectively. All moisture samples were collected using a stainless steel soil auger. Discrete samples from each location were placed in individual plastic 120 mL containers with airtight lids. Three sides of the pile were sampled for moisture. Samples were collected from the north, southeast, and southwest or south, northeast, and northwest. Appendix A1, Figure A1-1, depicts the stockpile moisture sampling protocol.

Table 3-2 identifies, by the notation "T," five special sample collection dates on which samples were collected immediately following stockpile turnover events.

A "stockpile turnover event" was a planned activity that consisted of using a front end loader to mix the stockpile contents for a period of six hours. The end of a turnover event provided a special time for sampling ash from the stockpile, since the mechanical agitation provided by the front end loader produced a relatively well mixed pile of BA for sampling. There were a total of nine turnover events during the course of the demonstration. Sampling occurred after five of these events (Events 1, 2, 4, 6 and 8). See Section 5 for a more detailed description of a stockpile turnover event.

3.2 BOTTOM ASH TEST RESULTS

3.2.1 Elemental Characterization

Bottom ash from the stockpile was sampled for elemental characterization testing on six occasions (see Table 3-2). Table 3-3 lists the average elemental concentrations and standard deviation for each element analyzed during each of the six sample collection periods. The average values and standard deviations are based on the results of five composite samples collected during the first collection period and three composite samples collected during each subsequent period. Appendix A2, Table A2-1, presents the individual sample test results.

An examination of the elemental characterization data in Table 3-3 indicates some minor variability in recorded elemental concentrations during the course of the program; however, these results can be attributed primarily to the variability of the respective elemental concentrations in the ash rather than to any increasing or decreasing trend in elemental concentration caused by leaching or volatilization over the one-year sampling period. This examination is described in greater detail in Appendix A2.

Table 3-3

STOCKPILED BOTTOM ASH ELEMENTAL CHARACTERIZATION RESULTS (µg/g)

Date[1] Months[2] Days[3]	12/4/92 0 0		05/18/93 6 165		06/23/93 7 201		07/27/93 8 235		8/23/93 9 262		10/05/93 10 305	
Element	**Avg[4]**	**SD[5]**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
As	13	2.4	18	0.9	19	1.6	18	0.52	17	0.4	15	1
Ba	720	27	810	8.1	690	41	750	55	680	17	710	17
Cd	30	0.7	28	3.2	29	1.7	29	1.1	25	1.0	25	1.0
Cu	2,200	250	1,500	690	1,200	6	1,900	270	2,500	320	4,800	510
Cr	120	11	130	6.4	130	7.5	130	12	130	4.7	150	39
Pb	1,800	170	1,300	160	1,300	140	1,500	40	1,500	30	1,300	85
Hg	0.81	0.038	0.43	0.02	0.54	0.06	0.49	0.017	0.54	0.01	0.49	0.02
Mn	1,100	51	2,100	150	900	61	1,100	180	900	26	1,100	64
Ni	130	15	140	7.5	130	13	160	11	170	9	140	15
Ag	12	0.47	9.2	0.7	11	3.0	11	1.8	9.5	1.5	8.8	1.6
Zn	5,100	290	4,800	500	3,300	150	4,500	550	4,900	150	4,100	180
Al	44,000	910	48,000	3,500	45,000	2,000	47,000	1,553	44,000	2,200	45,000	810
Be	1.0	0.0055	< 1	-	< 1	-	< 1	-	< 1	-	< 1	-
Fe	57,000	2,100	53,000	3,200	54,000	4,200	59,000	4,500	58,000	3,100	75,000	8,300
Se	0.82	0.042	1	0.11	1.1	0.06	0.99	0.1	1	0.06	0.98	0.11
Ca	75,000	1,600	49,000	2,400	51,000	1,600	51,000	3,700	43,000	2,300	43,000	1,100
K	4,500	130	4,700	76	4,400	380	5,200	220	4,900	730	4,500	160
Mg	7,500	170	7,900	240	8,600	370	8,600	340	7,600	250	7,900	460
Na	8,000	220	9,100	240	8,200	480	9,200	330	8,500	170	8,300	330
Si	-	-	340	44	260	31	250	17	250	90	120	10
N[6]	5		3		3		3		3		3	

1. Date represents the date the sample was collected.
2. Months represents the number of months from stockpile construction to sample collection.
3. Days represents the number of days from stockpile construction to sample collection.
4. Avg. represents the average concentration for that sampling period.
5. SD represents the standard deviation for that sampling period.
6. N represents the number of composite samples collected for analysis.

3.2.2 Organic Characterization

Table 3-4 presents dioxin and furan bottom ash test results for two bottom ash samples collected on May 5, 1995. The data are presented in terms of toxic equivalents. Toxic equivalents are used for the conversion of concentrations of various dioxins and furan isomers into equivalent concentrations of 2,3,7,8 TCDD on the basis of relative toxicity (USEPA, 1987). The 2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8 TCDD) isomer is considered the most toxic compound in the dioxin/furan group (USEPA, 1987). The Centers for Disease Control (CDC) has recommended one nanogram per gram (ng/g) as the level in residential soils above which remediation should be undertaken. Most regulatory agencies use this guideline to assess the degree of soil contamination by dioxin and furans. Toxic equivalent concentrations recorded in the BA were more than two orders of magnitude below this 1 ng/g level. Individual dioxin and furan sample test results are presented in Appendix A3.

Table 3-4

Bottom Ash
Dioxin and Furan
Toxic Equivalent Results
(ng/g)

Bottom Ash[1] Sample 1	0.0076
Bottom Ash[1] Sample 2	0.0080
Lab Blank[2]	0.0003

1. BA sample collected from stockpile on May 5, 1993.
2. The lab blank is a dioxin and furan analysis run on the extraction fluids to acquire background results.

Table 3-5 presents the test data for semi-volatile organics detected in the BA samples collected on May 5. Most semi-volatile concentrations fell below detection limits and are not included in the table. With the exception of N-Nitrosodi-N-Propylamine, which was tentatively identified in one replicate, all measured concentrations fell below New Jersey residential and non-residential soil criteria by several orders of magnitude. The New York State Department of Health (NYSDOH) indicated that the concentration of N-Nitrosodi-N-Propylamine detected was an estimated value since the reported concentration was below the minimum value for the method of detection. Appendix A3, Tables A3-2 and A3-3 presents a complete listing of all semi-volatile organics tested.

3.2.3 Moisture Content

Table 3-6 lists the ash moisture content test results. Figure 3-1 displays the results of samples collected at the stockpile surface and at a depth of three feet during the period from December, 1992 through December, 1993.

Ash at the surface of the pile and ash at a depth of three feet initially exhibited a similar moisture content (i.e., approximately 23 percent wet weight). Over the course of the stockpile testing period, the moisture content at a depth of three feet showed a generally decreasing trend. The moisture content at the surface exhibited a more dramatically decreasing trend, followed by an increasing trend.

During the year, the moisture content at a depth of three feet dropped into the range of 15 to 20 percent. However, in the spring and summer months, the moisture content of the ash at the surface of the pile fell to between five and ten percent. These results suggest that the moisture content of the ash at the surface of the pile is sensitive to the warmer conditions and the higher radiant energy of the sun, which occurs during the spring and

Table 3-5

PRIORITY POLLUTANTS (SEMI-VOLATILES) ABOVE DETECTION LEVELS
STOCKPILE BOTTOM ASH
(ng/g)

Compound	Replicate				New Jersey Soil Standards[1]	
	1	2	3	4	Residential	Non-residential
Dibenzofuran	<3,900	7	8	<4,200	-	-
Diethylpthalate	<3,900	17	20	23	10,000,000	10,000,000
Flourene	<3,900	14	17	13	2,300,000	10,000,000
Phenanthrene	56	74	82	68	-	-
Anthracene	<3,900	<3,900	12	14	10,000,000	10,000,000
Di-N-Butyl Pthalate	140	100	98	69	5,700,000	10,000,000
Flouranthene	27	40	40	27	2,300,000	10,000,000
Pyrene	28	46	40	27	1,700,000	10,000,000
Butyl Benzyl Pthalate	110	140	93	82	1,100,000	10,000,000
Bis (2-Ethylhexyl) Pthalate	710	630	680	580	49,000	210,000
Di-N-Octyl Pthalate	46	65	49	52	1,100,000	10,000,000
N-Nitrosodi-N-Propylamine	<3,900	780[2]	<3,700	<4,200	660	660
Naphthalene	49	77	81	<4,200	230,000	4,200,000
2-Methylnaphthalene	13	25	22	17	-	-
Acenaphthylene	15	27	25	16	-	-

1. NJDEP 1994.
2. Estimated value -- concentration tentatively identified, but below Method Detection Limit.

summer months. Surficial samples collected during the fall and winter of 1993 exhibited an increasing moisture content, reducing the disparity between the surficial and the subsurface moisture content.

3.2.4 Sequential Chemical Extraction

The Sequential Chemical Extraction (SCE test) is a test that is used to evaluate the degree to which trace metals are bound to ash particles. The test is conducted by subjecting the sample to a series of five sequential extractions involving extraction fluids of increasing strength. These five sequential extractions are referred to as Extractions A, B, C, D and E. See Appendix A1 for a more detailed description of the method.

Samples for sequential extraction testing were collected at various intervals during the stockpile evaluation period (see Table 3-2) to determine whether storage could result in increased or reduced bonding of trace metals in the bottom ash. Recent results reported in a French study (Sinquin, R., et al.) suggest that long-term storage can stabilize some of the metals in bottom ash. The evaluation of SCE data focused on Extraction A, the least aggressive extraction fluid involving a simple one molar magnesium chloride solution designed to extract readily exchangeable metals. Extraction A was selected for analysis because it was deemed most likely to reveal any changes in bonding, should they occur and, because unlike the other extractions (i.e., B, C, D and E), it is unaffected by prior extractions that complicate the analysis.

Table 3-6

STOCKPILE MOISTURE CONTENT[1]
(%)

	Surface Sample		Subsurface Sample (3 ft)	
Date	**Avg[2]**	**SD[3]**	**Avg**	**SD**
12/04/92	22	1.7	22	1.8
12/19/92	24	0.60	23	0.91
01/05/93	23	1.9	21	2.9
01/15/93	23	1.2	20	1.4
02/02/93	17	3.4	23	2.3
03/02/93	18	3.6	22	1.1
04/06/93	18	1.2	21	2.7
04/27/93	16	2.8	23	0.65
05/13/93	6.9	7.6	22	2.2
05/28/93	8.5	2.5	19	5.3
07/27/93	-	-	18	1.1
08/03/93	8.6	2.9	16	0.53
08/10/93	11	2.0	18	0.81
10/01/93	15	0.91	16	0.81
10/14/93	16	1.1	16	1.7

1. Moisture content is based on wet weight.
2. Avg represents the average moisture for 3 replicates.
3. SD represents the standard deviation for that sampling period.

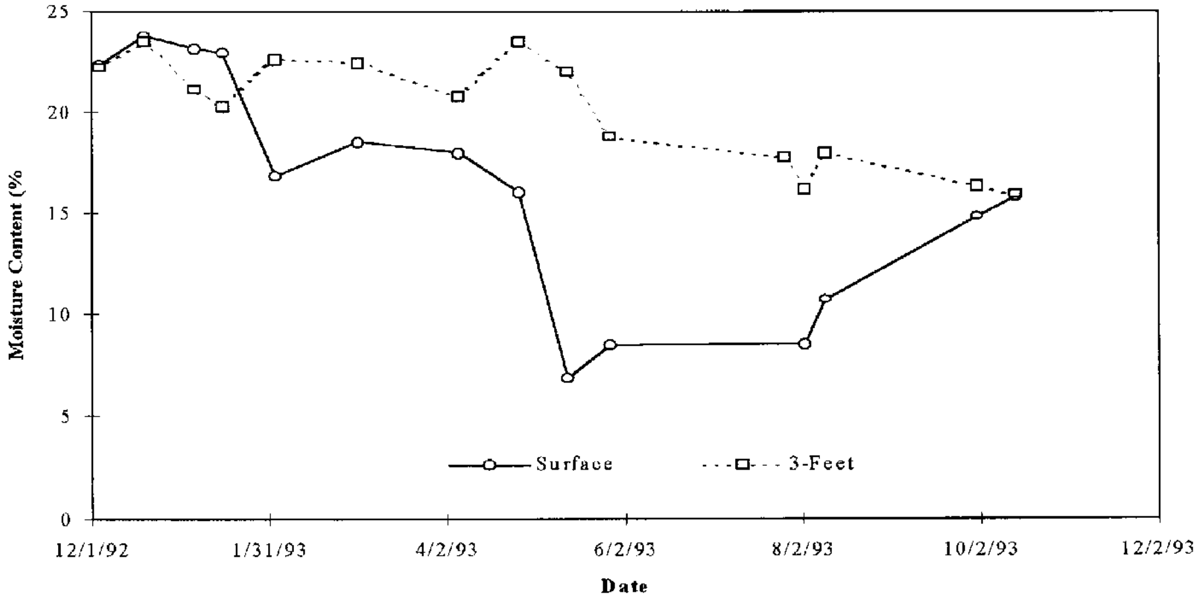


Figure 3-1

STOCKPILE MOISTURE CONTENT

Table 3-7 presents SCE results for Fraction A (exchangeable metals fraction). The data presented in Table 3-7 are expressed in terms of the percent of the metal extracted from the bottom ash sample during the Extraction A procedure. For example, a 20 percent extraction of silver indicates that 20 percent of the available Ag in the ash was extracted during the test. Results are presented for each metal and for each sample collection period. In cases where measured metal concentrations were below detection limits, the detection limit was used as a surrogate value. A complete presentation of SCE data can be found in Appendix A4, Table A4-1.

Table 3-7

**SEQUENTIAL CHEMICAL EXTRACTION RESULTS
EXTRACTION A: PERCENT OF ALL AVAILABLE METAL
FOR SAMPLES COLLECTED AT MOS. 0, 2, 4, 5, 6 AND 7[1]
(%)**

Parameter	Months							
	0	2	4	5	6	7	Slope (%/month)	R^2
Ag[2]	20	20	20	12	14	11	-1.4	0.69
As[2]	2.7	2.0	2.3	1.4	3.9	1.9	-0.0016	0.000020
Ba	2.6	1.9	1.8	1.4	1.6	1.1	-0.19	0.91
Ca	31	11	4.5	5.4	5.3	12	-2.7	0.52
Cd	0.12	6.9	10	8.4	8.1	9.2	1.1	0.65
Co[2]	1.29	1.3	1.1	0.10	0.089	0.088	-0.21	0.78
Cr	2.5	0.11	0.10	0.19	0.17	0.17	-0.27	0.54
Cu	0.92	0.67	0.27	0.29	0.48	0.42	-0.074	0.60
Fe	0.021	0.013	0.0055	0.0032	0.0029	0.0056	-0.0025	0.82
K	7.7	4.3	3.6	6.0	4.7	8.1	0.013	0.00033
Ni	7.4	5.4	5.1	4.5	4.0	2.5	-0.60	0.93
Pb	0.12	0.18	0.33	0.065	0.10	0.21	0.0025	0.0046
Zn	0.058	0.12	0.12	0.065	0.059	0.12	0.0022	0.026

1. % = (Fraction A ÷ Fraction (A+B+C+D+E))×100.
2. Ag, As and Co values were below detection limits in many samples and results were not considered to be representative of any trend.

The data presented in Table 3-7 suggest the possibility of some potential decrease in the extractability of selected elements measured in Extraction A over the course of the demonstration. Evidence of a decrease in the concentration of a metal in Extraction A with time could indicate some bonding of the subject metal. The data, however, were not sufficiently compelling to support definitive conclusions. Additional studies are required to assess these potential effects.

3.2.5 Grain Size Distribution

Table 3-8 presents the results of the grain size distribution analysis for stockpiled bottom ash samples. Samples were collected at t=0, 2, 4 and 9. The data suggest that, with time, there was an increase in the

Table 3-8

BOTTOM ASH STOCKPILE
GRAIN SIZE ANALYSIS RESULTS
PERCENT PASSING

Sieve #	Sieve Size (inches)	Sample[1]			
		12/05/92 t=0	02/05/93 t=2	04/05/93 t=4	08/24/93 t=9
-	1.5	100	100	100	100
-	1	97	100	100	100
-	0.75	94	99	100	100
-	0.5	84	94	94	97
-	0.375	73	87	85	91
4	0.19	50	66	61	69
8	0.094	35	49	42	54
16	0.047	24	34	32	40
30	0.023	18	25	24	28
50	0.012	13	18	18	20
200	0.0029	5.5	7.3	7.6	9.3

1. Measurements represents values for one test run (i.e., N=1).

proportion of finer particulates in the samples. This was primarily a result of the turnover events, during which front end loader activity provided sufficient mechanical agitation of the pile to break down weakly bonded larger ash particles to finer sized particles.

Section 4

STOCKPILE RUNOFF AND PRECIPITATION SAMPLING AND TESTING

Section 4 presents a description of the runoff and precipitation collection and testing efforts that were undertaken as part of the stockpile evaluation program. Section 4 is divided into five subsections. Section 4.1 describes the runoff collection system that was installed and used to collect samples for testing. Section 4.2 describes the rainfall collection and sampling equipment. Sections 4.3, 4.4 and 4.5 discuss the sample collection schedule, the tests performed, and the results of the analytical program, respectively.

4.1 RUNOFF SAMPLE COLLECTION SYSTEM

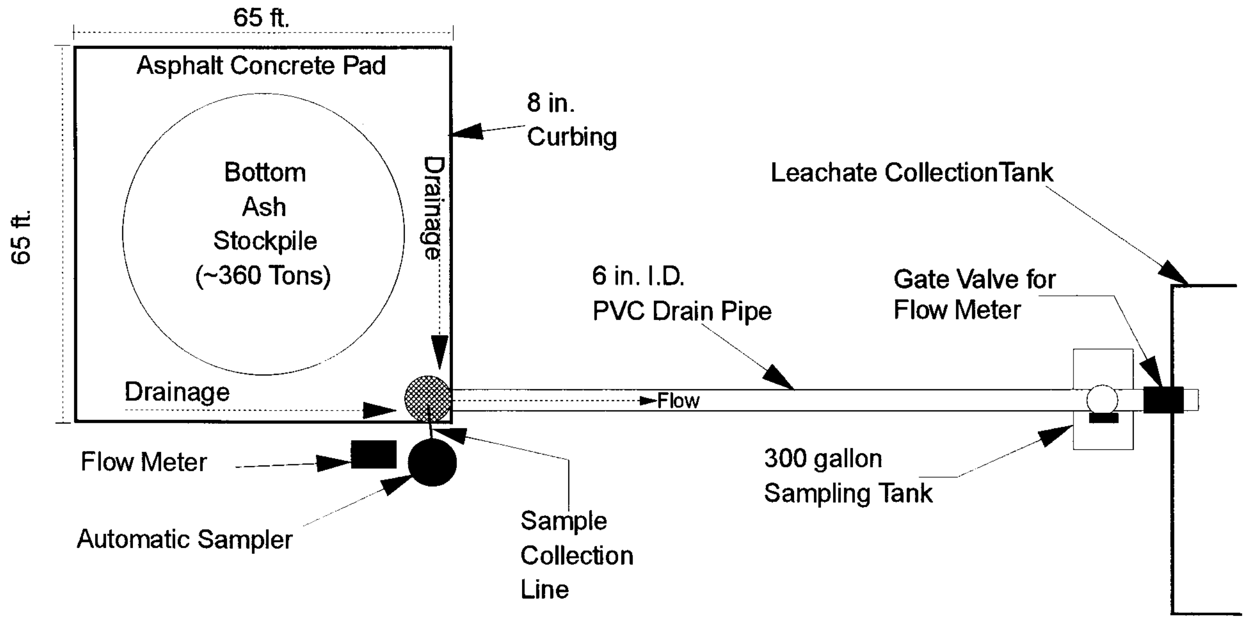
Figure 4-1 presents a schematic representation of the runoff containment and sample collection system. Two different methods were used to collect runoff samples during rainfall events. The first method involved the diversion of runoff from the stockpile pad into a 300-gallon sample collection tank installed during the construction of the pad and drainage system in October 1992. The location of the 300 gallon tank is shown in Figure 4-1. This procedure was effective in collecting composite samples, but did not allow the collection of discrete runoff samples during storm events. Photograph 4-1 shows the stockpile pad drainage piping and sampling tank.

In April 1993, an automatic sampling system was installed to facilitate the collection of discrete samples and to provide a means to monitor runoff flow. The location of the automatic sampler is shown in Figure 4-1. This system included an ISCO model 3240 Variable Gate Flow Meter and an ISCO 3700 Automatic Sampler. The automatic sampling system provided the capability to collect discrete runoff samples during rainfall and runoff events. Flow was monitored by a flow meter (positioned adjacent to the automatic sampler) using a gate valve located in the drainage pipe upstream of the 300-gallon tank. The location of the gate valve is shown in Figure 4-1. The automatic sampler and flow meter can be seen in Photograph 4-2. See Appendix B1 for additional discussion concerning the operation of the automatic samplers and flow monitors.

4.2 PRECIPITATION COLLECTION SYSTEM

In December 1992, a wet-dry precipitation collection system (Aerochem Metrics, Inc., Model 301 Precipitation Collector) was installed approximately 250-feet south of the stockpile. The Aerochem Metrics system is designed to collect wet atmospheric deposition (i.e., rainfall) and dry atmospheric deposition (i.e., particulate matter). Total precipitation samples (i.e., rainfall plus dry particulate deposition) were simultaneously collected in rainfall collection buckets located next to the wet-dry precipitation collection system. Photograph 4-3 shows the precipitation collection equipment.

Plan View (not to scale)



Sectional View (not to scale)

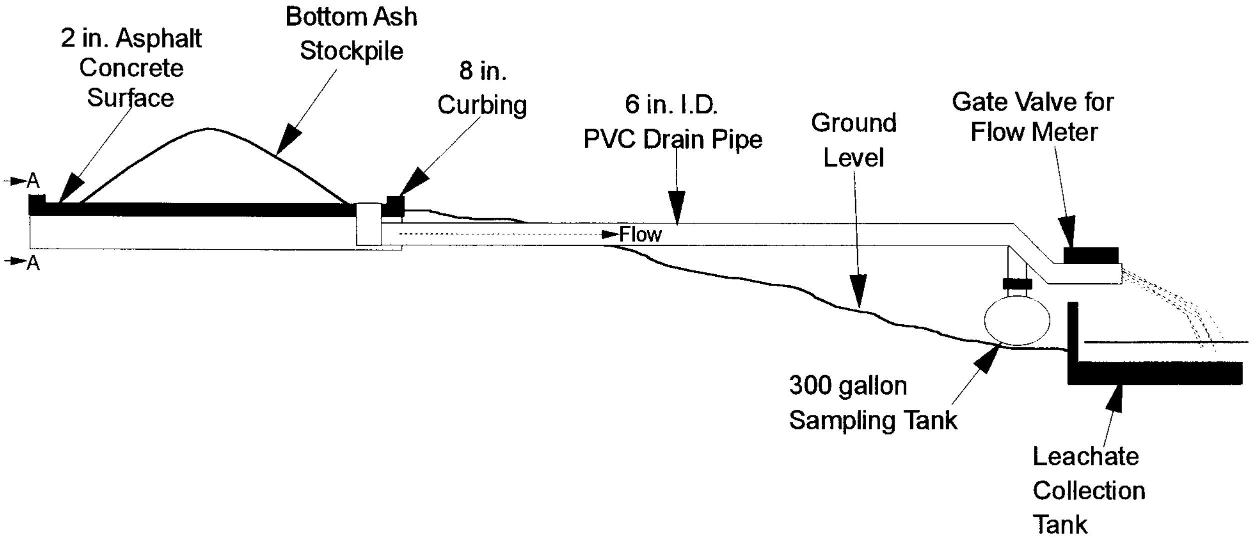
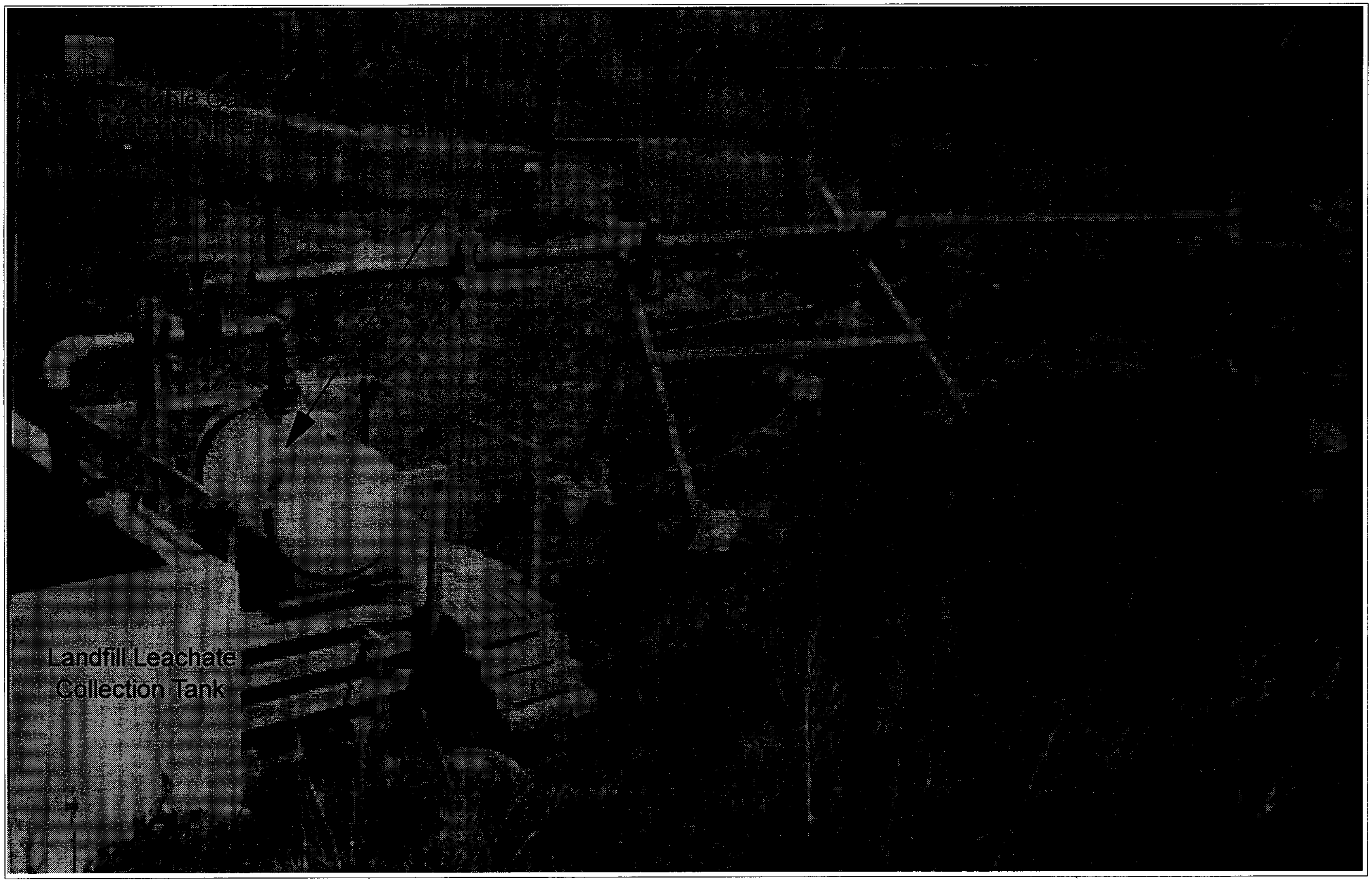
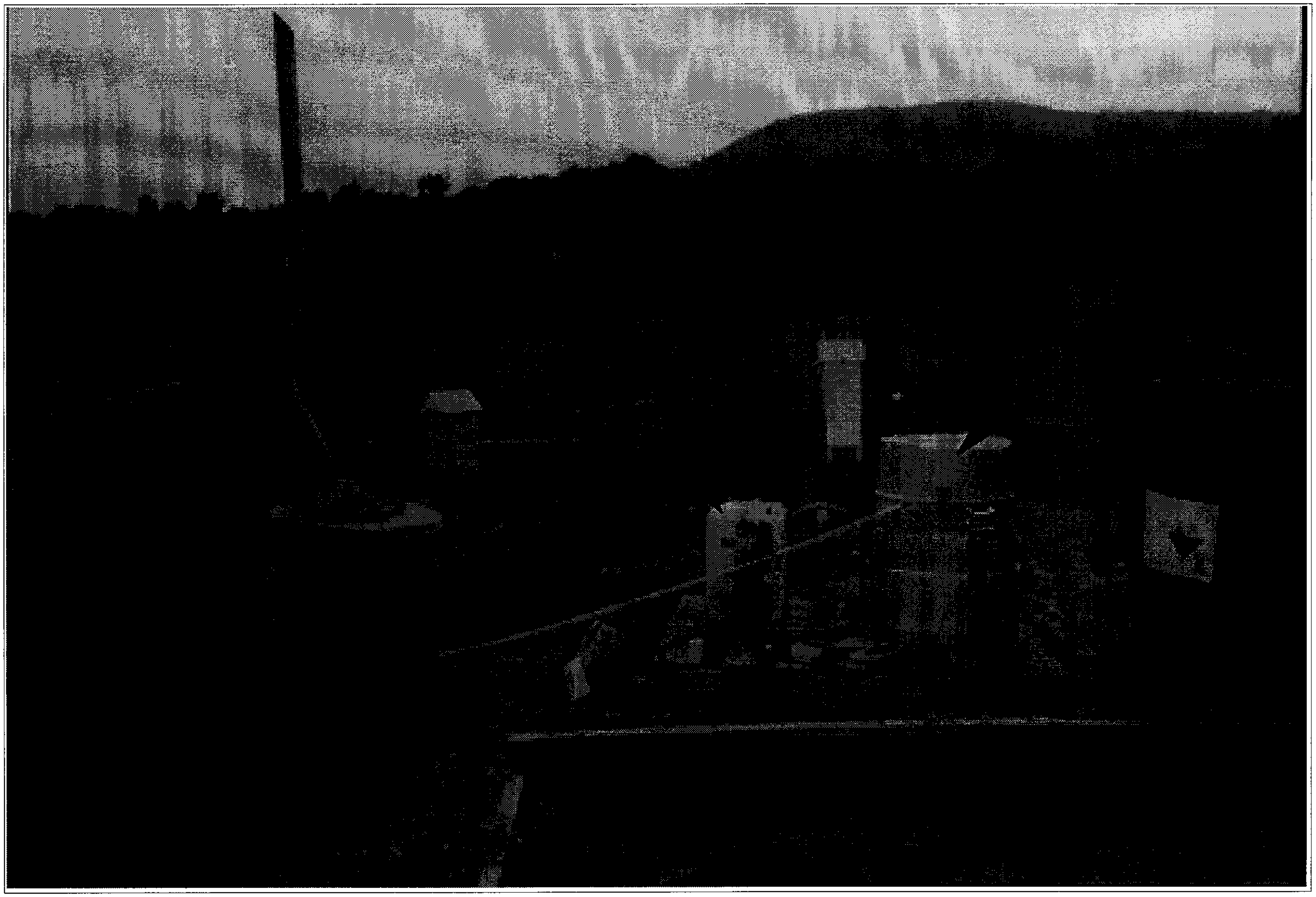


Figure 4-1

PLAN VIEW AND SECTION:
STOCKPILE PAD AND RUNOFF COLLECTION SYSTEM

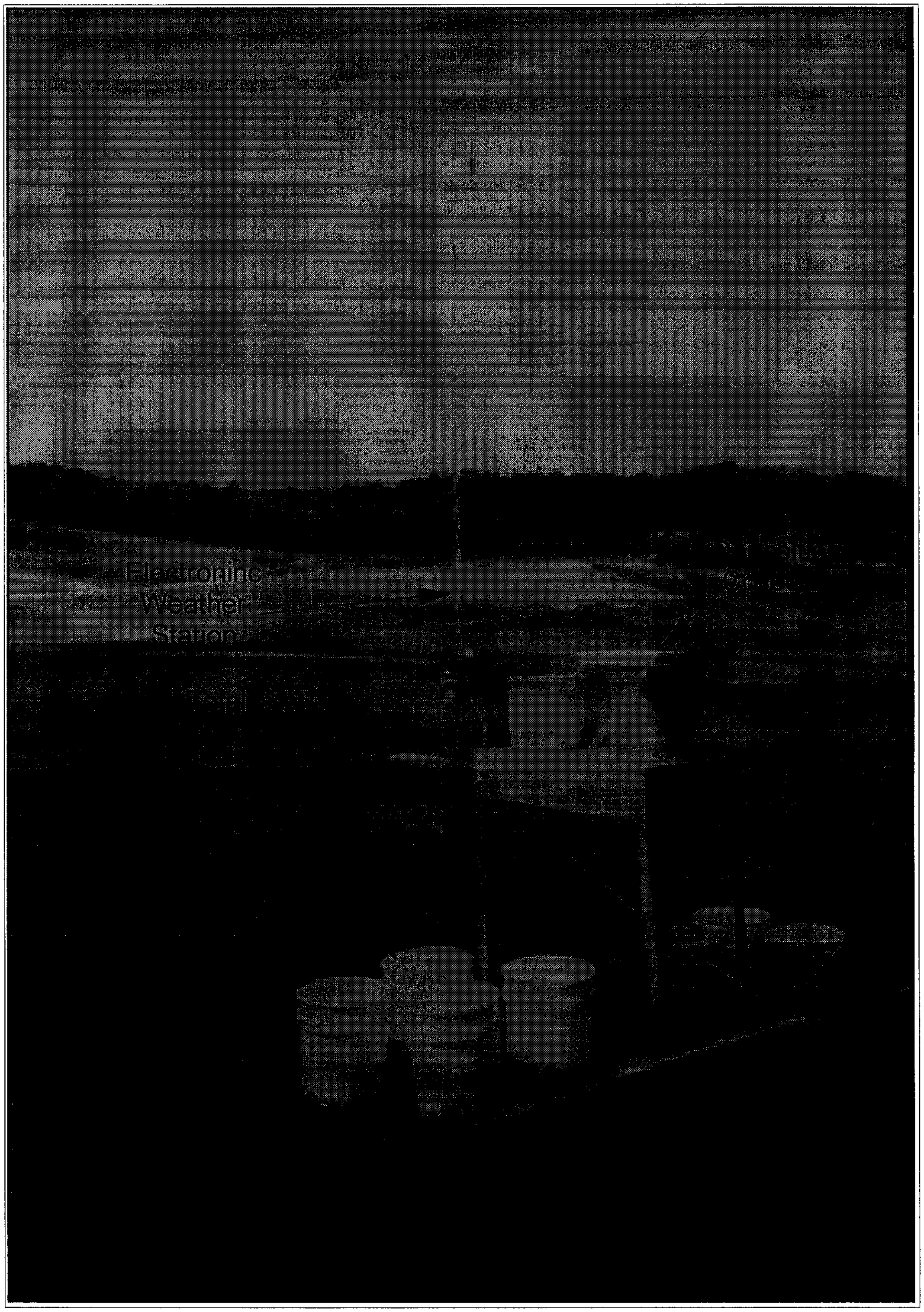


Photograph 4-1
STOCKPILE PAD PIPING AND SAMPLING TANK



Photograph 4-2

AUTOMATIC SAMPLER AND FLOW METER



Photograph 4-3

PRECIPITATION COLLECTION EQUIPMENT

4.3 SAMPLING SCHEDULE

Rainfall and runoff samples were collected for analysis during the stockpile monitoring period, from December 1992 to December 1993. Table 4-1 lists the dates and the amount of precipitation that fell during each sample collection period. It also identifies the runoff sample collection method that was employed to collect samples during each sampling event.

4.4 ANALYTICAL TEST PROCEDURES

Table 4-2 lists the test procedures used to analyze the runoff and precipitation samples collected during the monitoring period, as well as the laboratories responsible for each test.

Elemental characterization was performed on total precipitation (i.e., wet and dry deposition) samples and on stockpile runoff samples. Each sample was split into two subsamples. One sample was analyzed for dissolved elements, and the second sample was analyzed for total (dissolved plus particulate) elements.

Runoff samples and precipitation samples were tested for pH, total solids, total dissolved solids, and alkalinity or acidity (i.e., runoff samples were tested for alkalinity and precipitation samples for acidity.) All samples were immediately tested for pH and alkalinity or acidity upon collection at the Warren County Landfill. Hach Field pH Measurement Kits (Models 17-D, 17-J and 17-S) were used for pH analysis. Acidity and alkalinity testing was also undertaken at the Warren County Landfill using a Hach Field Alkalinity or Acidity Measurement Test Kit (Model AC-DT).

The New Jersey Department of Environmental Protection (NJDEP) Laboratories in Trenton, New Jersey, tested the total precipitation samples and stockpile pad runoff samples for total solids and total dissolved solids. New York State Department of Health (NYSDOH) laboratories in Albany, New York, analyzed control pad runoff and filtered bottom ash runoff for dioxins and furans. Both NJDEP and NYSDOH laboratories analyzed control pad runoff, bottom ash runoff and total precipitation samples for volatile and semi-volatile organics.

4.5 STOCKPILE RUNOFF AND PRECIPITATION TEST RESULTS

4.5.1 Elemental Characterization Results

Table 4-3 lists the average BA stockpile runoff concentration results, expressed in terms of average dissolved and average total elemental concentrations. The average runoff concentrations presented in Table 4-3 represent the average event concentrations (i.e., individual event concentrations were averaged to calculate the average runoff concentrations presented in the table). Where measured concentrations were below detection limits, the detection limit was used as a surrogate in the calculations to generate an average value. Appendix B2, Tables B2-1 through B2-44, present specific date, time of collection, precipitation prior to sample collection, flow recorded at the time of sample collection, and sample concentrations for the individual runoff samples collected

Table 4-1

WARREN COUNTY STOCKPILE PRECIPITATION, RUNOFF COLLECTION SCHEDULE AND SAMPLING METHOD

Collection Date	Precipitation (in.)	Runoff Sample Collection Method[1]
12/10/92	0.23	300-Gallon Tank
12/11/92	1.45	300-Gallon Tank
12/17/93	0.94	300-Gallon Tank
12/28/92	0.14	300-Gallon Tank
12/29/92	0.10	300-Gallon Tank
01/05/93	0.65	300-Gallon Tank
02/13/93	0.15	300-Gallon Tank
02/16/93	0.63	300-Gallon Tank
03/04/93	0.52	300-Gallon Tank
03/09/93	0.04	300-Gallon Tank
03/11/93	0.04	300-Gallon Tank
03/17/93	0.97	300-Gallon Tank
03/24/93	0.98	300-Gallon Tank
03/31/93	0.36	300-Gallon Tank
04/02/93	1.69	300-Gallon Tank
04/12/93	0.43	300-Gallon Tank
04/16/93	0.24	Auto Sampler
04/21/93	0.23	Auto Sampler
04/22/93	0.64	Auto Sampler
04/26/93	1.13	Auto Sampler
04/27/93	0.00	Auto Sampler
05/06/93	0.12	300-Gallon Tank
05/21/93	0.37	Auto Sampler
06/04/93	0.06	Auto Sampler
06/05/93	0.06	Auto Sampler
06/09/93	0.23	Auto Sampler
06/10/93	0.23	Auto Sampler
06/20/93	0.80	Auto Sampler
06/21/93	1.19	300-Gallon Tank
07/02/93	0.40	300-Gallon Tank
07/06/93	0.32	300-Gallon Tank
07/14/93	0.39	300-Gallon Tank
08/09/93	0.37	300-Gallon Tank
09/21/93	-	300-Gallon Tank
10/20/93	0.40	Auto Sampler
10/21/93	0.21	Auto Sampler
10/30/93	0.74	Auto Sampler
10/31/93	0.45	Auto Sampler
11/28/93	1.05	Auto Sampler

1. Samples collected were tested for elemental concentrations, pH, alkalinity or acidity, total solids, and total dissolved solids, with the exception of the sample collected on 9/21/93 which was tested for dioxin/furans and priority pollutants.

Table 4-2

STOCKPILE SITE RUNOFF AND PRECIPITATION ANALYTICAL METHODS AND RESPONSIBLE LABORATORIES

Test	Lab[7]	Method
Elemental Characterization[1,2]	NJDEP	SW-846
pH[3]	Field Tested	Hach field kit (Model 17D,J,S)
Alkalinity[3,4]	Field Tested	Hach field kit (Model AC-DT)
Acidity[3,5]	Field Tested	Hach field kit (Model AC-DT)
Total Solids	NJDEP	USEPA, 2540B
Total Dissolved Solids	NJDEP	USEPA, 2540C
Priority Pollutants[6]	NJDEP	USEPA 625
Dioxins and Furans[6]	NYSDOH	USEPA 8280

1. Atomic adsorption (AA) or Inductively Coupled Plasma (ICP) used for metals analysis of Al, As, Ba, Be, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Zn, Ca, Mg, K, Si, Na, Cl AND SO_4.
2. Tests performed on stockpile runoff and total precipitation samples only.
3. Analyses performed in the field with Hach field test kits.
4. Tests performed on stockpile runoff samples only.
5. Tests performed on wet and total precipitation samples only.
6. Samples from BA stockpile runoff and total precipitation were tested once during the stockpile program.
7. NJDEP: New Jersey Department of Environmental Protection Laboratory in Trenton, NJ. NYSDOH: New York State Department of Health Laboratories in Albany, NY.
8. pH, alkalinity, and acidity were analyzed in the field using portable testing kits.

during the program.

Table 4-4 lists the average precipitation concentration results, expressed in terms of average dissolved and average total elemental concentrations. The average precipitation concentrations presented in Table 4-4 also represent the average event concentrations and, where recorded concentrations were below detection limits, the detection limit was again used to generate an average value. Appendix B2, Tables B2-45 through B2-88, present specific date, time of collection, amount of rainfall prior to sample collection, and sample concentrations for individual precipitation samples.

Both Tables 4-3 and 4-4 list current USEPA drinking water limits (DWL) for the parameters tested. Average dissolved concentrations for As, Be, Cd, Cr, Fe,Ni, and Pb and total concentrations for Be, Cd, Cr and Ni are based on calculations where 80 to 98% of the samples tested resulted in values that were below the method detection limit (MDL). In all cases where the recorded value was below the method detection limit, the method detection limit was used in the calculation of the average concentration. The dissolved cadmium concentration in Table 4-3 is just above the USEPA drinking water limit of 0.005 mg/L. It is likely that the actual concentration is below 0.005mg/L since the majority of values, 89 percent, are MDL values of <0.005 μg/L and <0.004 mg/L (see Appendix B2, Table B2-10). The average dissolved Pb concentration listed in Table 4-3 of 0.056 mg/L is above the USEPA drinking water level of 0.015 mg/L. It is expected that actual average Pb concentrations are

Table 4-3

STOCKPILE RUNOFF CONCENTRATIONS (mg/L)

Parameter	Dissolved		Total		USEPA DWL[3]
	Avg.[1]	SD.[2]	Avg.[1]	SD.[2]	
Ag	0.010	0.001	0.010	0.001	0.1
Al	0.17	0.39	2.1	3.3	0.2
As	0.0010[4]	0.00003	0.0029	0.0033	0.05
Ba	0.065	0.039	0.087	0.062	2
Be	0.0028[4]	0.0036	0.0031[4]	0.0036	0.004
Ca	172	80	241	310	-
Cd	0.0052[4]	0.0026	0.0066[4]	0.0065	0.005
Cr	0.026[4]	0.012	0.026[4]	0.012	0.1
Cu	0.10	0.11	0.30	0.41	1.3
Fe	0.04[4]	0.03	0.48	0.69	0.3
Hg	<0.0010	-	<0.0010	-	0.002
K	129	87	135	92	-
Mg	36	44	37	43	-
Mn	0.12	0.15	0.17	0.17	0.05
Na	390	260	390	280	50
Ni	0.049[4]	0.005	0.053[4]	0.014	0.1
Pb	0.056[4]	0.014	0.24	0.31	0.015
Se	0.0015	0.0016	0.0021	0.0030	0.05
Si	1.0	0.8	1.9	2.1	-
Zn	0.11	0.08	0.54	0.86	
Solids	2400	1300	3500	1500	500
Cl	660	380	-	-	250
SO_4	740	430	-	-	250

1. Avg = Average of 35 events.
2. SD = standard deviation of 35 events.
3. United States Environmental Protection Agency drinking water limits.
4. Over 80% of the values used to calculate the average concentrations were method detection limit values.

likely to be in the range of 0.01 mg/L to 0.05 mg/L, since 85 percent of the Pb values used in the calculation of the average Pb concentration were below the MDL of 0.05 mg/L.

Measured runoff concentrations of Pb, Na and Mn were above drinking water limits in both the total and dissolved fractions. Al and Fe concentrations were above drinking water limits in the total fraction only. Measured values for Cd, TDS, Cl and SO_4 were above drinking water limits in the dissolved fraction.

With the exception of Be in the total precipitation samples, all precipitation concentrations were below drinking water limits. Measured values of <0.05 for Pb were below the Pb method detection limit (MDL) of 0.05 mg/L; however, the MDL is higher than the drinking water limit of 0.015 mg/L.

Table 4-4

TOTAL PRECIPITATION CONCENTRATIONS (mg/L)

Parameter	Dissolved		Total		USEPA DWL[3]
	Avg.[1]	SD.[2]	Avg.[1]	SD.[2]	
Ag	<0.01	-	<0.01	-	0.1
Al	0.046	0.05	0.043	0.03	0.2
As	<0.001	-	<0.001	-	0.05
Ba	0.015	0.012	0.02	0.01	2
Be	0.0028	0.0024	0.032	0.002	0.004
Ca	2.8	1.6	3.9	2	-
Cd	0.0035	0.0016	0.0035	0.0016	0.005
Cr	0.018	0.0079	0.018	0.0079	0.1
Cu	0.0053	0.005	0.0053	0.005	1.3
Fe	0.018	0.0071	0.034	0.022	0.3
Hg	<0.001	-	<0.001	-	0.002
K	0.68	1.1	2.2	3.3	-
Mg	0.11	0.23	0.071	0.2	-
Mn	0.0083	0.0085	0.013	0.0088	0.05
Na	6.9	3.6	8	3.6	50
Ni	0.023	0.0026	0.023	0.0026	0.1
Pb	<0.05	-	<0.05	-	0.015
Se	<0.001	-	<0.001	-	0.05
Si	0.029	0.012	0.088	0.2	-
Zn	0.016	0.012	0.023	0.021	
Solids	42	31	80	54	500
Cl	0.88	0.56	-	-	250
SO4	3.3	1.2	-	-	250

1. Avg = Average of 10 samples.
2. SD = standard deviation of 10 samples.
3. United States Environmental Protection Agency drinking water limits.

Table 4-5 presents the ratio of dissolved precipitation concentrations to dissolved runoff concentrations. The data indicate that the concentrations of Ag, As, Ca, Cu, Hg, K, Mg, Mn, Na, Pb, Se, Si, TDS, Cl and SO_4 in rainfall were less than 10 percent of those detected in the runoff. Concentrations of Al, Ba and Zn in rainfall were between 10 and 30 percent of those in runoff. Cd, Cr, Fe and Ni concentrations in the rainfall were 45 to 70 percent of those found in stockpile runoff. The concentration of Be in the rainfall was equal to that found in the stockpile runoff.

Table 4-5

RATIO OF AVERAGE PRECIPITATION TO RUNOFF CONCENTRATIONS (mg/L)

Parameter	Precipitation÷Runoff
	Dissolved
Ag	<[1]
Al	0.27
As	<[1]
Ba	0.23
Be	0.99
Ca	0.02
Cd	0.68
Cr	0.69
Cu	0.05
Fe	0.44
Hg	<[1]
K	0.01
Mg	0.00
Mn	0.07
Na	0.02
Ni	0.47
Pb	<[1]
Se	<[1]
Si	0.03
Zn	0.14
TDS	0.02
Cl	0.0013
SO_4	0.0045

1. < indicates both precipitation and runoff values were below the Method Detection Limit.

4.5.2 Organic Characterization Results

Table 4-6 presents dioxin and furan results for runoff collected from the stockpile and the control pad. Results are presented in terms of Toxic Equivalent (TE) concentrations. A brief description of TE concentrations is presented in Section 3.2.2. Table B3-1 in Appendix B3 presents a listing of individual sample test data.

Both the control pad and stockpile runoff pad concentrations were of the same order of magnitude and both were one order of magnitude below New Jersey Department of Environmental Protection Groundwater Quality Criteria (NJDEP, 1993).

Very few volatile or semi-volatile organic compounds were detected in either the control or stockpile runoff samples. Table 4-7 lists the volatile and semi-volatile organic compounds that were detected in the stockpile runoff and control pad samples, respectively. A complete list of the measured compounds and reported

Table 4-6

DIOXIN AND FURAN STOCKPILE AND CONTROL PAD RUNOFF TOXIC EQUIVALENT CONCENTRATIONS (mg/L)

Sample[1]	Concentration
Stockpile Pad Runoff	5.7×10^{-6}
Control Pad Runoff	2.2×10^{-6}
New Jersey Groundwater Criteria	1.0×10^{-5}

1. Represents the results of one sample collected 9/21/93.

Table 4-7

VOLATILE AND SEMI-VOLATILE DETECTED ORGANICS IN RUNOFF AND PRECIPITATION SAMPLES[1] (µg/L)

Organic Compound	Stockpile Runoff	Control Pad Runoff	Precipitation	NJ Groundwater Criteria Limit
Volatiles				
Benzene-d6 SURR	36	37	37	-
Flourobenzene SURR	35	36	37	-
p-Bromoflourobenzene SURR	19	20	20	-
Semi-Volatiles				
Di-N-Butyl Phthalate	0.3	0.5	-	900,000
Bis (2-Ethylhexyl) Phthalate)	0.4	0.4	-	30,000

1. A full listing of results is presented in Appendix B3.

detection limits is presented in Appendix B3, Tables B3-2 to B3-3. All measured concentrations were below New Jersey Practical Quantification Levels or Groundwater Criteria (NJDEP, 1993).

4.5.3 Bulk Properties

Table 4-8 lists the statistically summarized pH measurement results for total and wet precipitation samples, and for stockpile and control pad runoff samples. Each pH value in Table 4-8 represents the average of 17 to 25 events. One sample was tested during each event. Appendix B4 presents a more detailed listing of individual sample results.

Table 4-8

STOCKPILE RUNOFF AND PRECIPITATION BULK PROPERTIES TEST RESULTS

Sample	pH			Alkalinity (mg/L)			Acidity (mg/L)		
	Avg.[1]	SD.[2]	N[3]	Avg.[1]	SD.[2]	N[3]	Avg.[1]	SD.[2]	N[3]
Stockpile Runoff	8.6	0.61	25	44	17	36	-	-	-
Total Precipitation	4.2	0.95	18	-	-	-	6.8	3.3	27
Wet Precipitation	4.0	0.92	17	-	-	-	6.5	2.7	25

1. Avg = average of N samples.
2. SD = standard deviation samples.
3. N = number of samples tested.

The average stockpile runoff pH value was 8.6. Total precipitation samples exhibited an average pH value of 4.2, while wet precipitation samples exhibited an average pH value of 4.0. From December 1992 through December 1993, precipitation pH varied between 3 and 5.5, while stockpile runoff varied between 7 and 9.7. Figure 4-2 depicts the variation in pH of rainfall and runoff during the monitoring period. There was little difference between total and wet precipitation pH values.

Table 4-8 lists the results of acidity analyses performed on the total and wet precipitation samples. Each acidity value represents the average of 25 or 27 events. The acidity values presented in Table 4-8 are expressed in terms of mg/L as $CaCO_3$ phenolphthalein acidity. Total precipitation samples exhibited an average acidity of 6.8 mg/L. Wet samples exhibited an average acidity of 6.5 mg/L. Acidity values of total and wet samples varied between 5 and 15 mg/L, as shown in Figure 4-2. A more detailed listing of individual sample results is presented in Appendix B4.

Table 4-8 lists the results of the alkalinity analyses performed on the stockpile runoff samples. The stockpile runoff alkalinity values represent the average of 36 events. The alkalinity values for BA stockpile runoff presented in Table 4-8 are also expressed in terms of mg/L as $CaCO_3$ total alkalinity. The average runoff alkalinity was 44 mg/L as $CaCO_3$. Values for stockpile runoff alkalinity varied from approximately 13 to 100 mg/L, as shown in Figure 4-3. A more detailed listing of individual sample results is presented in Appendix B4.

4.5.4 Laboratory Versus Field Runoff Concentration

As part of the data evaluation, actual stockpile runoff sample concentrations were compared to the results of SW-924 laboratory leaching tests previously performed on Warren County ash to determine the differences between actual measured runoff and laboratory leaching test values. The SW-924 test is a batch extraction procedure, similar to the TCLP test, except that a liquid to solid ratio of 10 to 1 is used instead of 20 to 1, the sample is agitated for 24 hours instead of 18 hours and, in this case, a synthetic acid rain extract was used instead

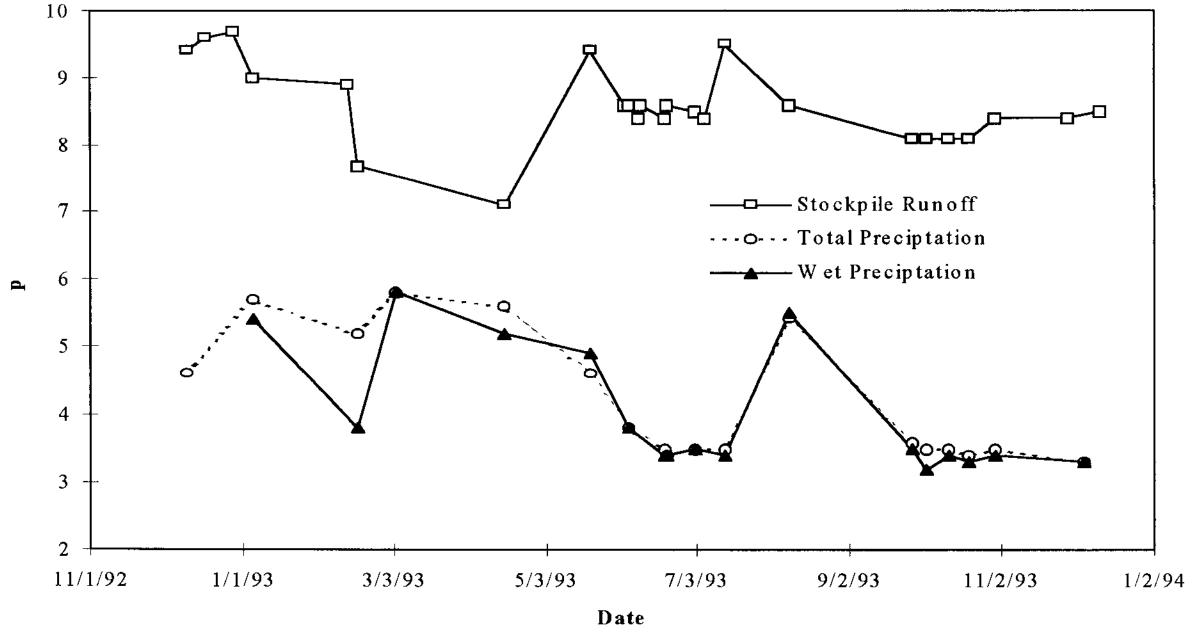


Figure 4-2
STOCKPILE RUNOFF AND PRECIPITATION pH

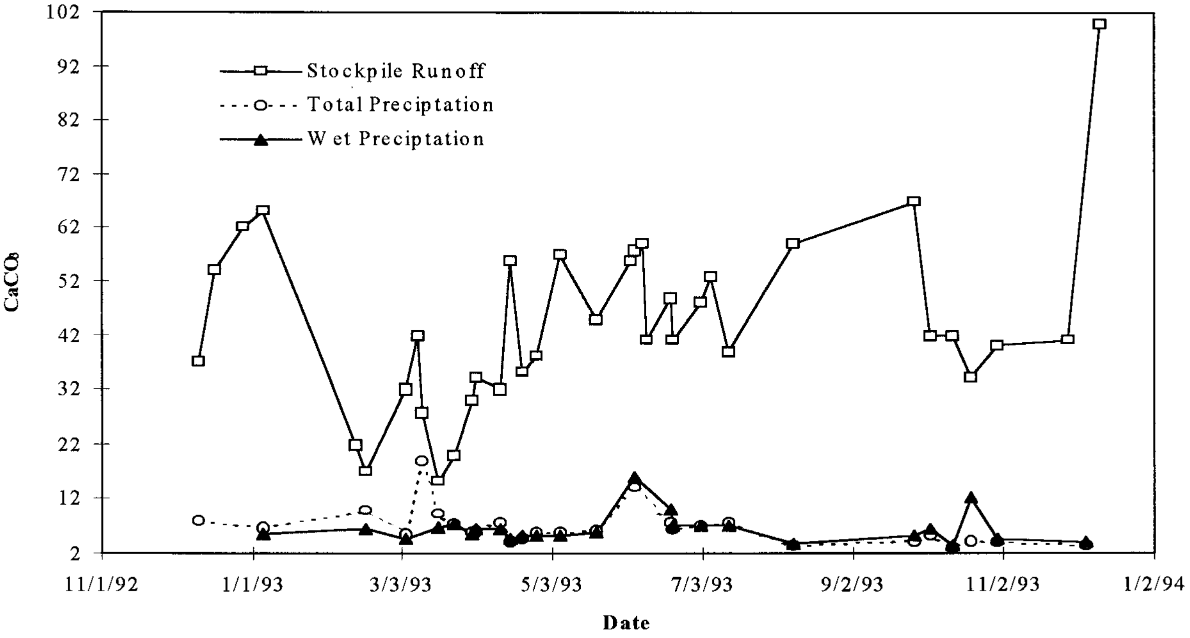


Figure 4-3
STOCKPILE RUNOFF ALKALINITY AND PRECIPITATION ACIDITY

of a TCLP extract. The laboratory tests were performed on samples collected from the WCRRF during 1992 (LIRPB, 1993).

Table 4-9 lists the average dissolved runoff concentrations results of the stockpile runoff elemental characterization and the SW-924 leaching test results. Table 4-9 includes both the average and the standard deviation for each parameter tested. A comparison between laboratory and field data was made by dividing laboratory values by the runoff values.

The results suggest that for certain elements the laboratory leaching test yield values that are comparable to values observed in the field. For example, for As, Cr, Pb, Hg, Ag, TDS and pH, the SW-924 laboratory leaching results were accurate to within 50 percent of the actual stockpile runoff value (i.e., laboratory to field ratio between 0.5 and 1.5). However, the SW-924 laboratory data appeared to over-predict Ba, Cu, Cd and alkalinity values by about two to four times the field value (i.e., laboratory to field ratio between approximately 2 and 4). Zn laboratory values were the only values that were significantly less than observed runoff values (i.e., under-predicted by the SW-924 data with a laboratory to field ratio of 0.15).

Table 4-9

STOCKPILE RUNOFF ELEMENTAL CHARACTERIZATION RESULTS COMPARED TO LABORATORY TEST MEASUREMENTS

Parameter	Dissolved Fraction		SW-924 (SAR)		Laboratory ÷ Field
	Avg.[1]	SD[2]	Avg.[1]	SD[2]	
As	0.001	0.00015	0.0014	0.0011	1.4
Ba	0.065	0.038	0.261	0.13	4.0
Cd	0.0052	0.0019	0.01	0.002	1.9
Cr	0.026	0.0062	0.032	0.009	1.2
Cu	0.1	0.1	0.414	0.16	4.1
Pb	0.056	0.022	0.069	0.03	1.2
Hg	<0.001	-	0.0005	0.00023	0.50
Ag	<0.01	0.0015	<0.01	0.001	1.00
Zn	0.11	0.077	0.017	0.02	0.15
TDS	2397	1300	1467	115	0.61
pH	8.6	0.61	10.2	0.47	1.2
Alk	44	17	167	50	3.8
N	35	-	22	-	-

1. Avg = Average.
2. SD = standard deviation.

Section 5

AMBIENT AIR SAMPLING AND TESTING

Section 5 describes the ambient air monitoring effort that was undertaken as part of the stockpile evaluation program and the results of this effort. Section 5 is divided into three subsections. Section 5.1 summarizes the ambient air monitoring plan. Section 5.2 reviews the test methods used to analyze the samples that were collected, and Section 5.3 presents the test results.

5.1 AMBIENT AIR MONITORING PLAN

Ambient air monitoring was designed and implemented to provide fugitive dust emissions data for three distinct activities or conditions anticipated at the stockpile:

1. Processing of BA,
2. Stockpile maintenance subject to wind erosion (static conditions), and
3. Stockpile turnover simulating loading and unloading of bottom ash.

The remainder of Section 5.1 describes the specific activities associated with each of the aforementioned periods.

5.1.1 BA Processing Period

The BA ash processing period, which included activities associated with conveying, screening and ferrous removal operations (magnetic separation) at the Warren County landfill, was undertaken to detect any increase in ambient air fugitive dust concentrations resulting from these activities. Operations were conducted by S & L Equipment Rental in the active landfill cell located approximately 1,000 feet to the west of the stockpile pad. BA processing took place on December 2, 1992. At that time, BA was fed through a Power Grid MK2 3/4-inch power screener over a period of approximately six hours. BA was loaded onto the power screener with a Caterpillar 936 front-end loader, which had 4-wheel drive and a 4 cu. yd bucket. Two 40-foot Barber Greene conveyors were used to transport the minus 3/4-inch bottom ash from the power screener to a Dings belt magnetic separator. The minus 3/4-inch ferrous free BA was discharged from the magnetic separator into one of two dump trucks for transport to the stockpile pad. Figure 5-1 provides a schematic layout of the processing operations. Photograph 5-1 shows a picture of the processing equipment.

Personal air samplers (PAS) were used to monitor total suspended particulates (TSP) and respirable particulates (PM_{10}) during ash processing. Total suspended particulates (TSP) are particles less than 30 microns ($<30\mu$) in diameter. Respirable particulates (PM_{10}) are those particles that are less than 10 microns ($<10\mu$) in diameter. These size classifications are relevant because they comprise particulates that, once

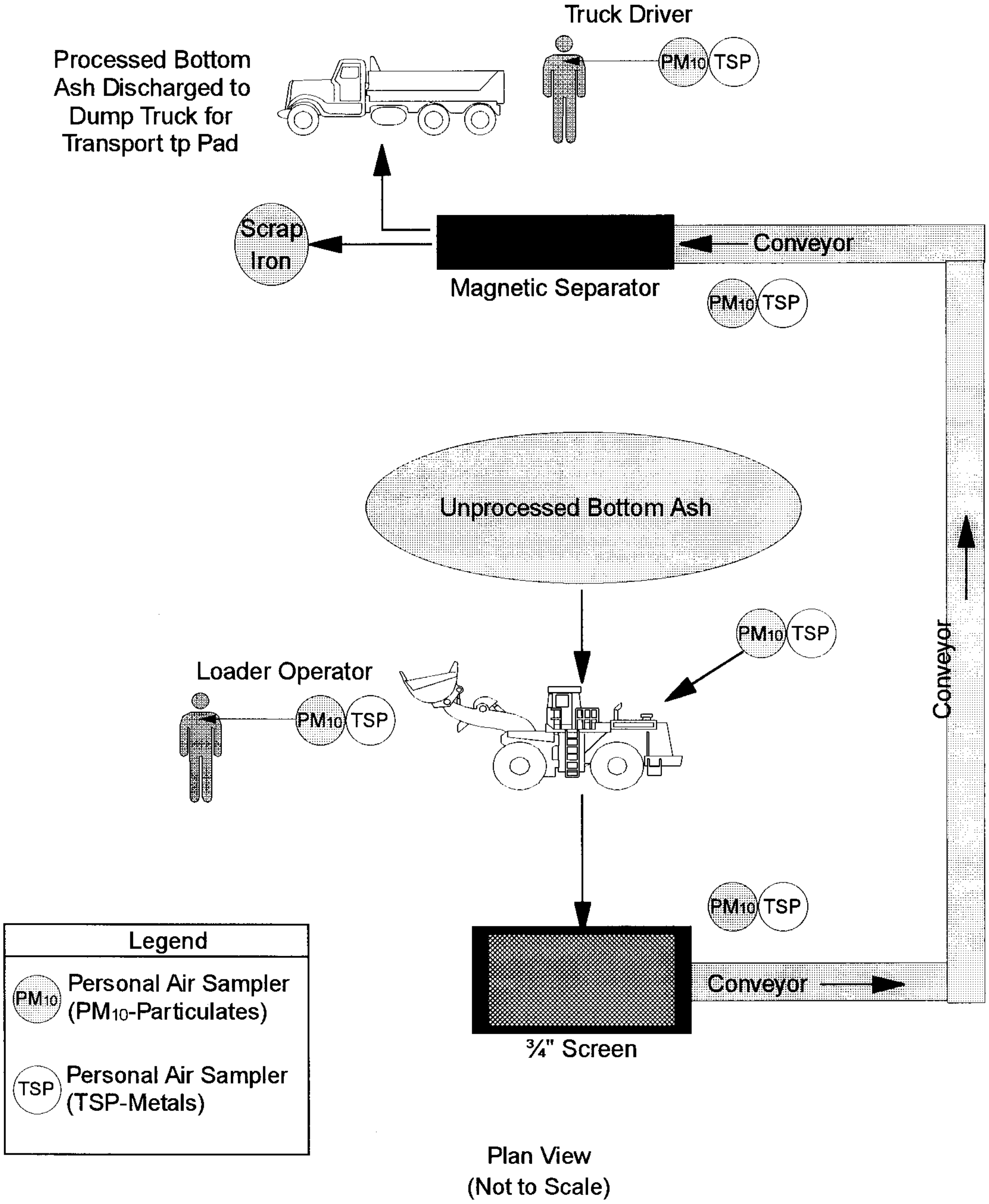
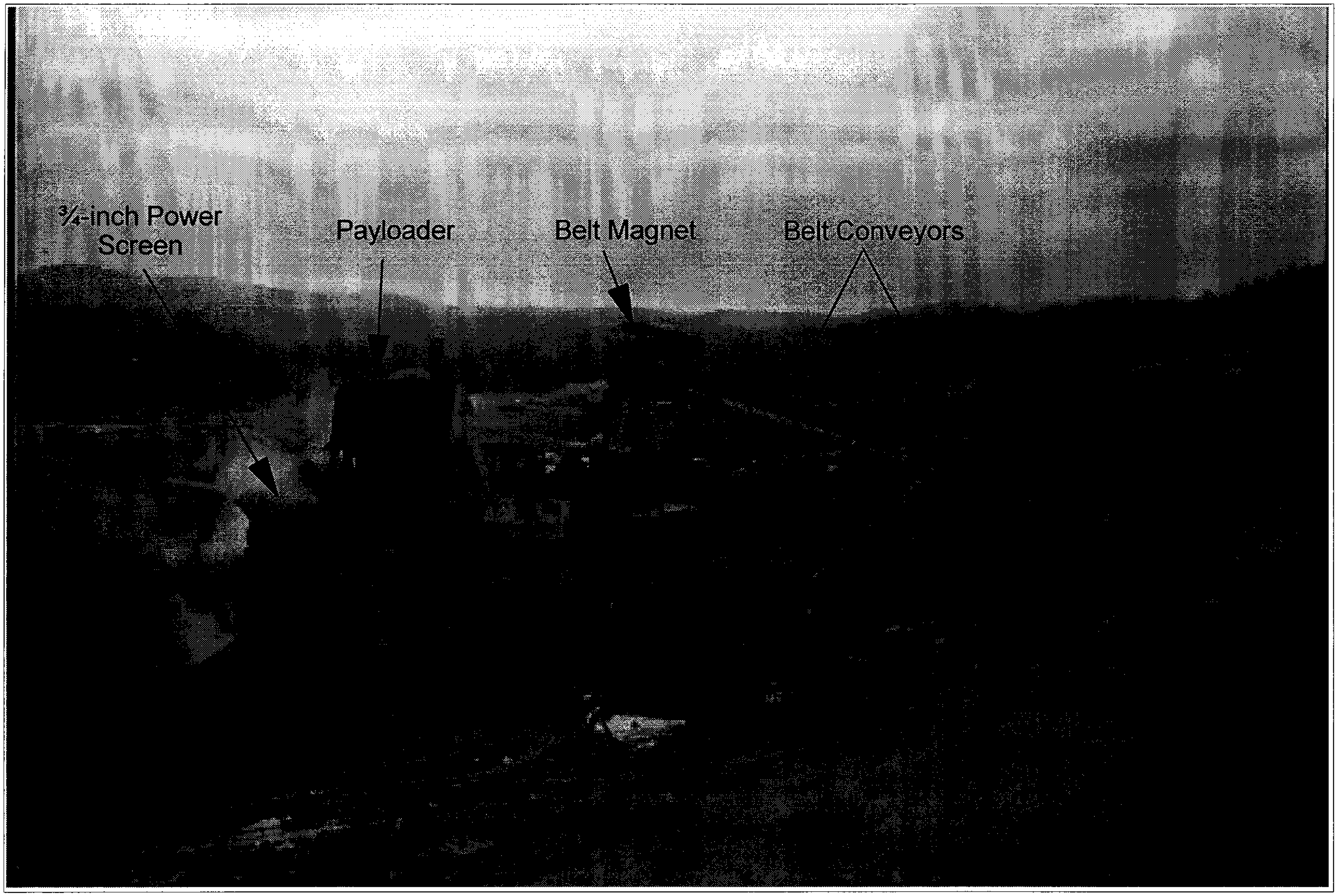


Figure 5-1

ASH PROCESSING EQUIPMENT LAYOUT AND AIR MONITORING LOCATIONS



Photograph 5-1
ASH PROCESSING EQUIPMENT

airborne, can remain in the air for some time; can settle onto the skin or into the eyes, causing irritations; or can be inhaled (i.e., PM_{10}) and deposited along the respiratory tract.

Personal air samplers (PAS) are small portable, battery operated air samplers that are typically used in an occupational environment to monitor dust levels and the potential for particulate matter inhalation by workers. They can be located directly on a human subject (i.e., within the breathing zone) or mounted onto equipment. PASs draw air through a filter, capturing the airborne particulates, which are subsequently weighed and analyzed for contaminants. PAS pumps draw air in at a known rate over a given time period. As a result, average air concentrations can be calculated for the monitoring period.

PASs were installed during the processing test period at the following locations:

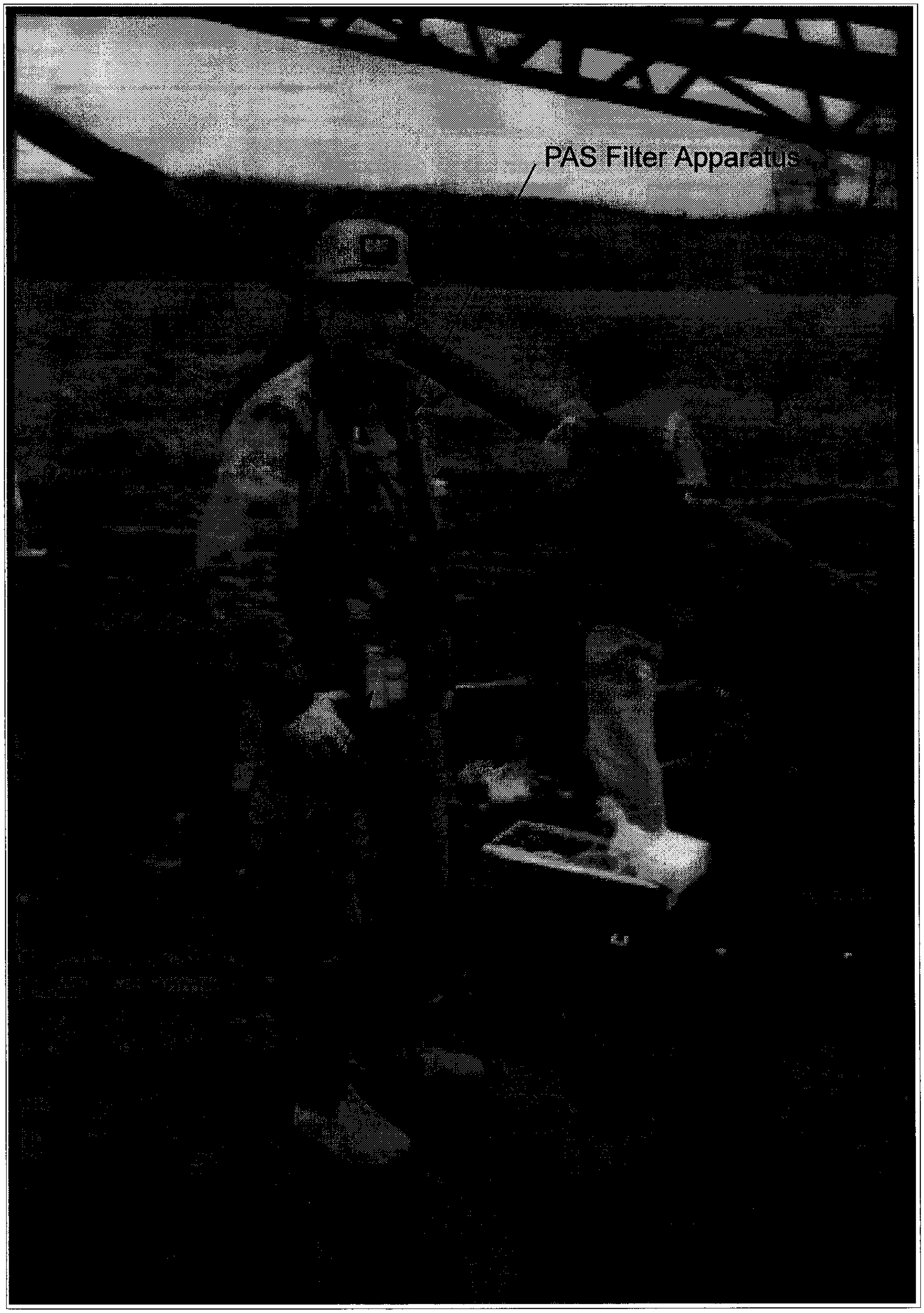
- the front end loader operator's breathing zone (see Photograph 5-2),
- the truck operator's breathing zone,
- alongside the power screen, and
- alongside the truck loading area (see Photograph 5-3).

Figure 5-1 identifies all TSP and PM_{10} monitoring locations (i.e., PAS samplers) at the BA processing site. Direct mercury vapor monitoring was also performed on the ash at the processing site. This was accomplished with the use of a Jerome Sampler. The Jerome Sampler can take direct spot readings of mercury or it can take long-term readings of mercury using a special filter called a dosimeter. The Jerome Sampler was used to take direct spot readings during the BA processing period. Photograph 5-4 shows NJDEP personnel taking a direct spot mercury reading with a Jerome Sampler.

5.1.2 Static Periods

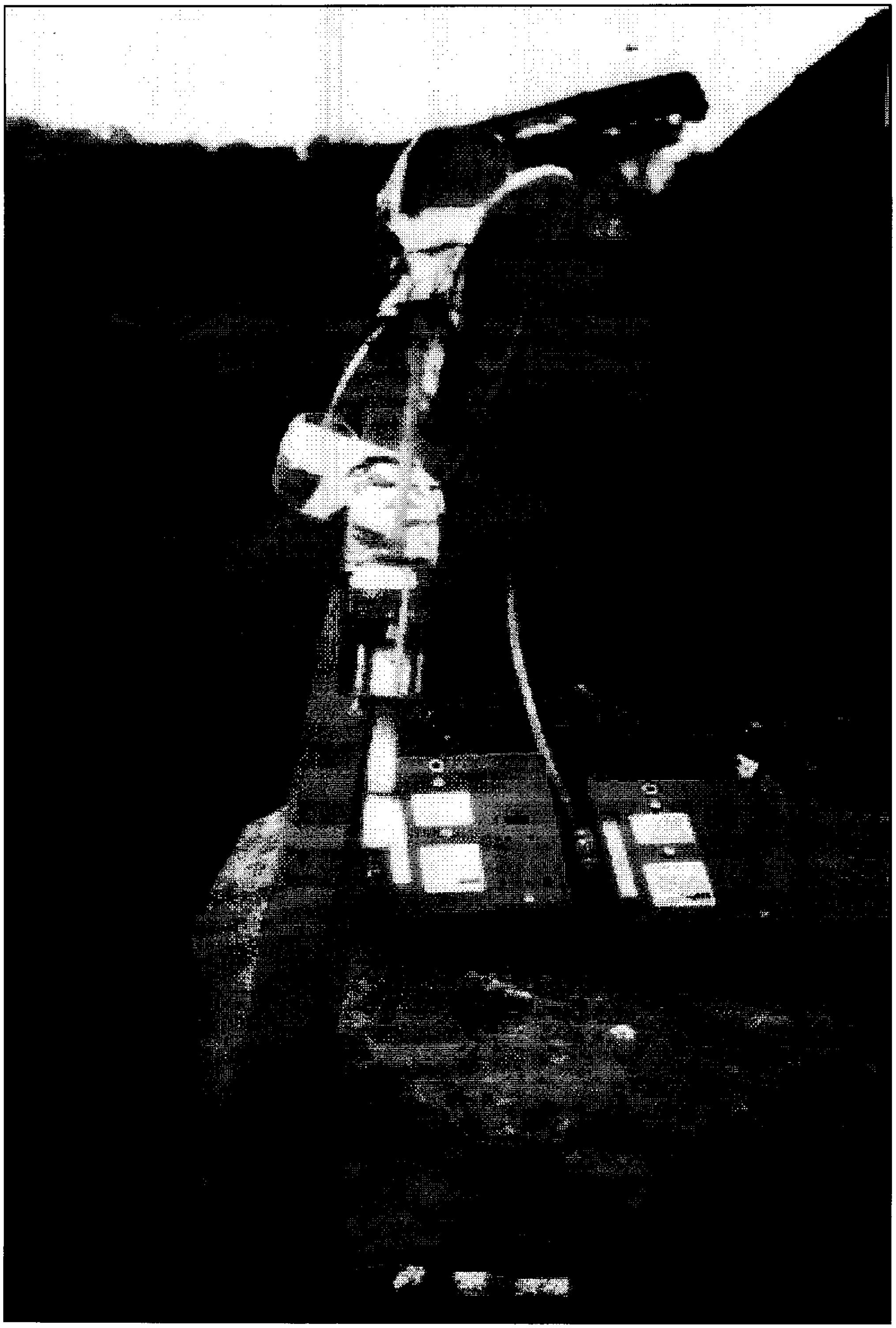
The static periods consisted of those periods during which the stockpile was undisturbed by human activity, but was exposed to natural weathering conditions (e.g., wind and rain). During these periods, seven high volume air samplers with vacuum motors and two static samplers were used to measure fugitive dust released by wind erosion from the undisturbed bottom ash stockpile. The high volume sampler consists of a vacuum motor enclosed in a housing unit that draws air through a filter at a measured rate. The filter, placed over the air inlet of the vacuum motor, collects dust particles that are subsequently weighed and analyzed for contaminants. Average air concentrations of particulates and contaminants can be calculated if total operational time and the volume of air passing through the filter are known. Photograph 5-5 presents a picture of a high volume sampler used in the air monitoring effort.

Of the five high volume samplers, four were placed downwind and one upwind. Two static (non-motorized) samplers were also used, one located to the north and the other to the southwest of the stockpile. Figure 5-2 shows the location of these samplers relative to the location of the stockpile. The four downwind high



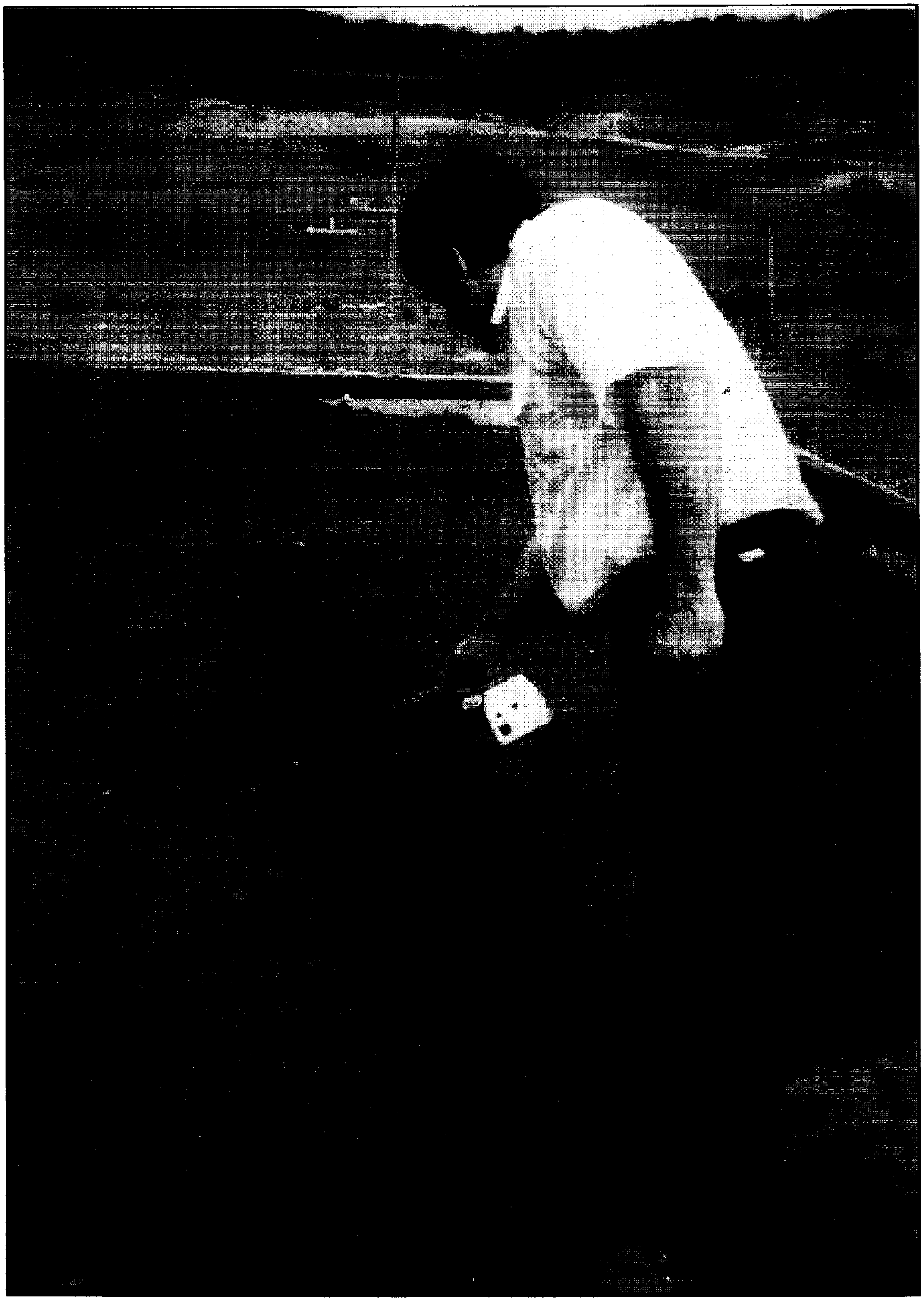
Photograph 5-2

LOADER OPERATOR AND PERSONAL AIR SAMPLER



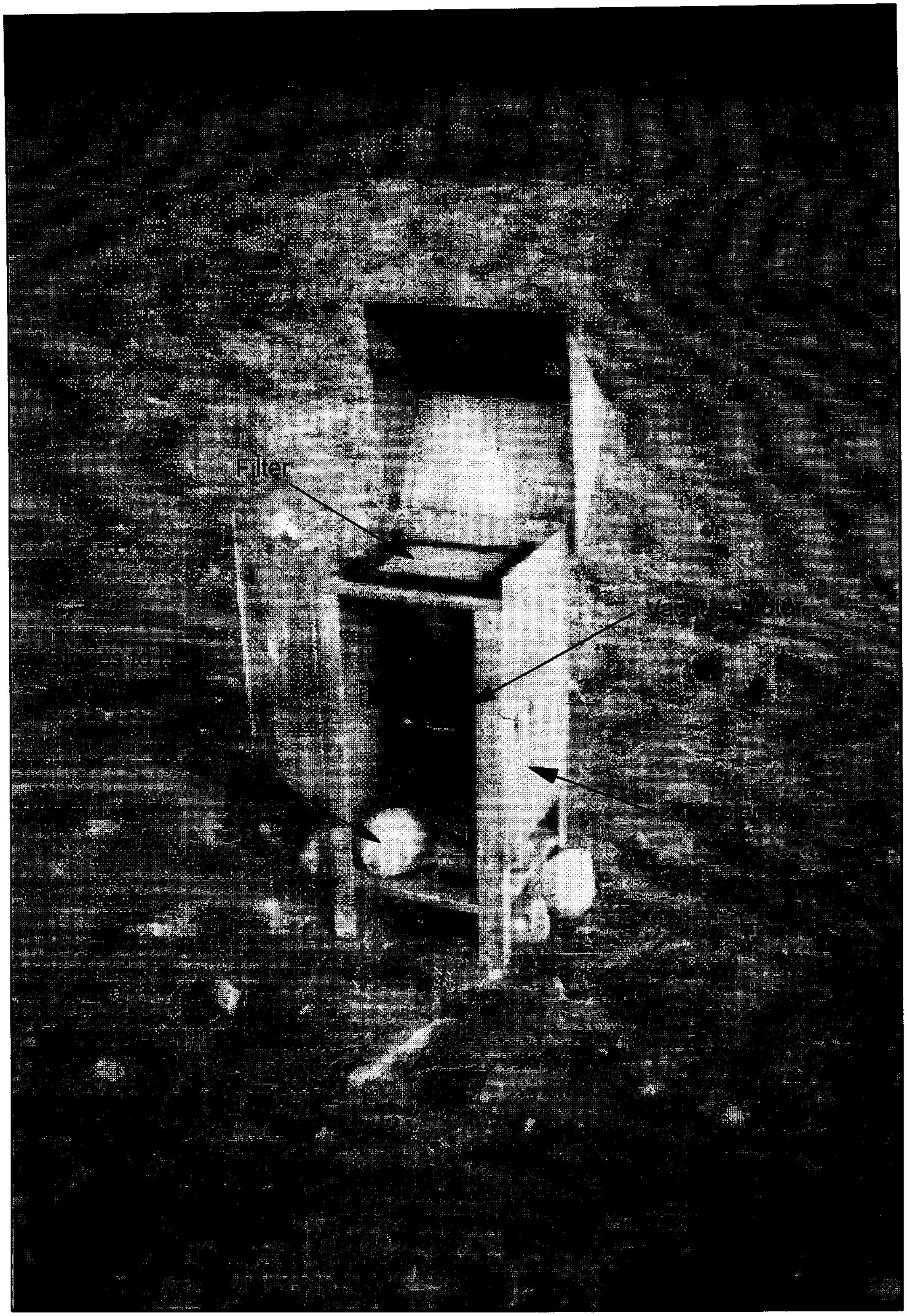
Photograph 5-3

PROCESSING AREA PERSONAL AIR SAMPLER
PUMPS AND FILTER APPARATUS SETUP



Photograph 5-4

JEROME SAMPLER MERCURY ANALYZER



Photograph 5-5

HIGH VOLUME AIR SAMPLER APPARATUS

volume air samplers were designated as HV-1 through HV-4; the upwind high volume air sampler was designated HV-5. The static samplers were designated S1 and S2.

Static samplers were used to correct for particulates that could collect on the filters when the vacuum motor was not in operation. Previous studies have shown that over a six day period during which a high volume sampler is operational for only one day, material collected during the non-operational times can account for an average of 13% of the total material collected on the filter (Blanchard and Romano, 1978). This increment can be attributed in part to the deposition from settleable and wind borne particulates. Consequently, two static filters were employed: one alongside the upwind high volume air sampler (S2) and one in the midst of the array of downwind samplers (S1). The static sampler values (weights) were used as blank samples and subtracted from the high volume air sampler values to account for particulates that may have settled on the filters during non-operational times.

An electronic weather station (EWS) supplied by Climatronics of Bohemia, NY, was installed on the site to monitor and record meteorological conditions and to control the on-off operation of high volume air samplers HV-1 through HV-5 (see Figure 5-2). The EWS recorded 15-minute averages of wind velocity and wind direction; calculated the standard deviation of wind direction; and recorded temperature, humidity, and total rainfall over the 15-minute period. Recorded averages were written to a storage module that was periodically downloaded to collect the data. The controls of the on-off operation of samplers HV-1 through HV-5 were set so that the samplers were activated during meteorological conditions in which HV-5 represented the upwind sampler, and HV-1 through HV-4 represented the downwind samplers (i.e., wind direction from the south). The on-off operations were programmed to respond to both wind direction and wind speed as follows:

1. <u>Conditions for turning the samplers on:</u>
    - A. Five minute average wind speed greater than one meter per second (m/s) or 2.24 miles per hour (mph),
    - B. Wind direction from 135 to 225 degrees true north for a minimum of five minutes, and
    - C. Samplers off for a minimum time period of 15 minutes.
2. <u>Conditions for turning the samplers off:</u>
    - A. Samplers on for a minimum of 15 minutes.
    - B. Five minute average wind speed below one m/s.
    - C. No wind from the specified range for five minutes.
    - D. Total accumulated operational time 24-hours.

Figure 5-3 provides a flow chart of the EWS high volume operational protocol. High volume sampler operational times were written to the EWS storage module, which, as previously indicated, was periodically downloaded to collect the data for analysis.

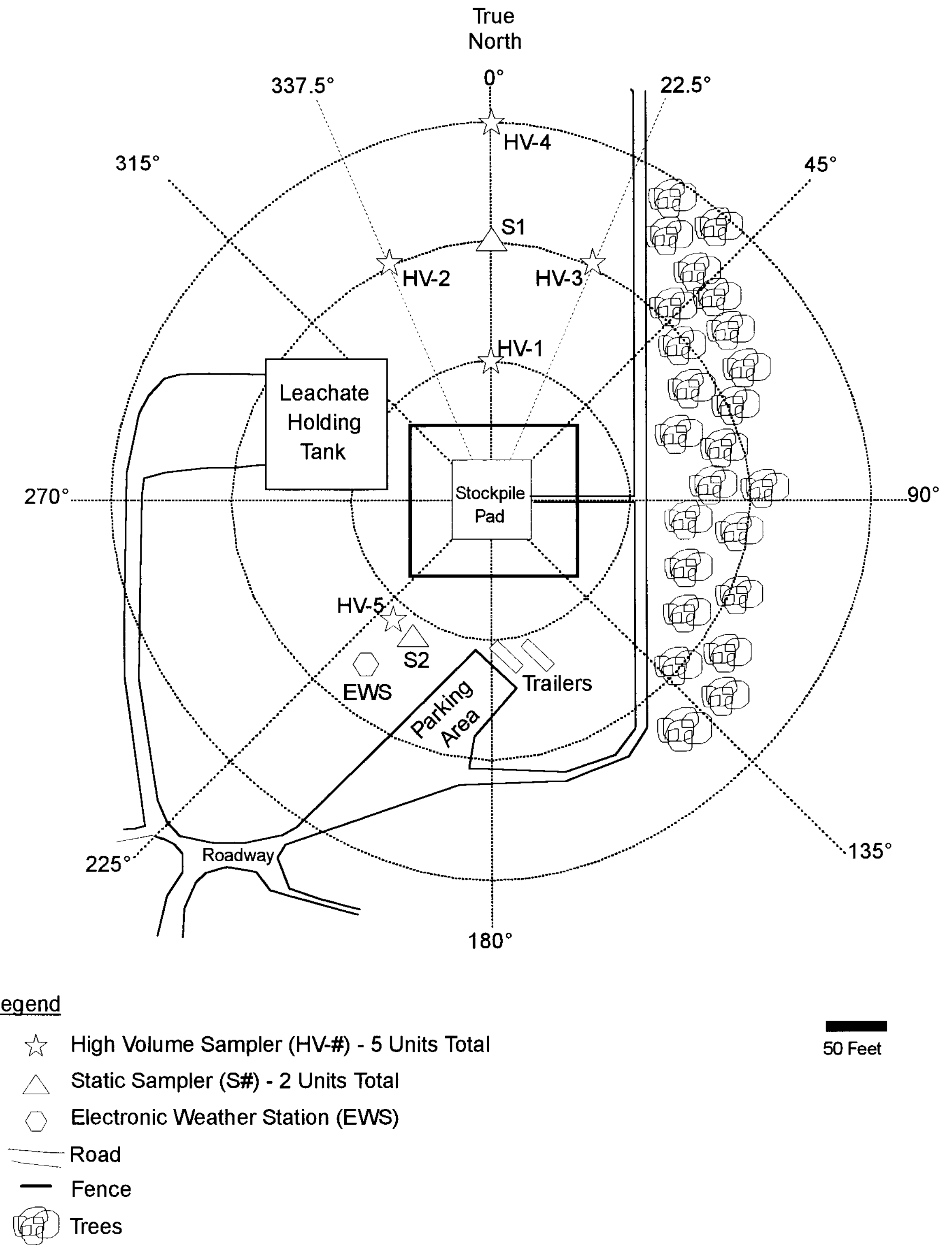


Figure 5-2

LOCATION OF STOCKPILE AIR AND WEATHER MONITORS

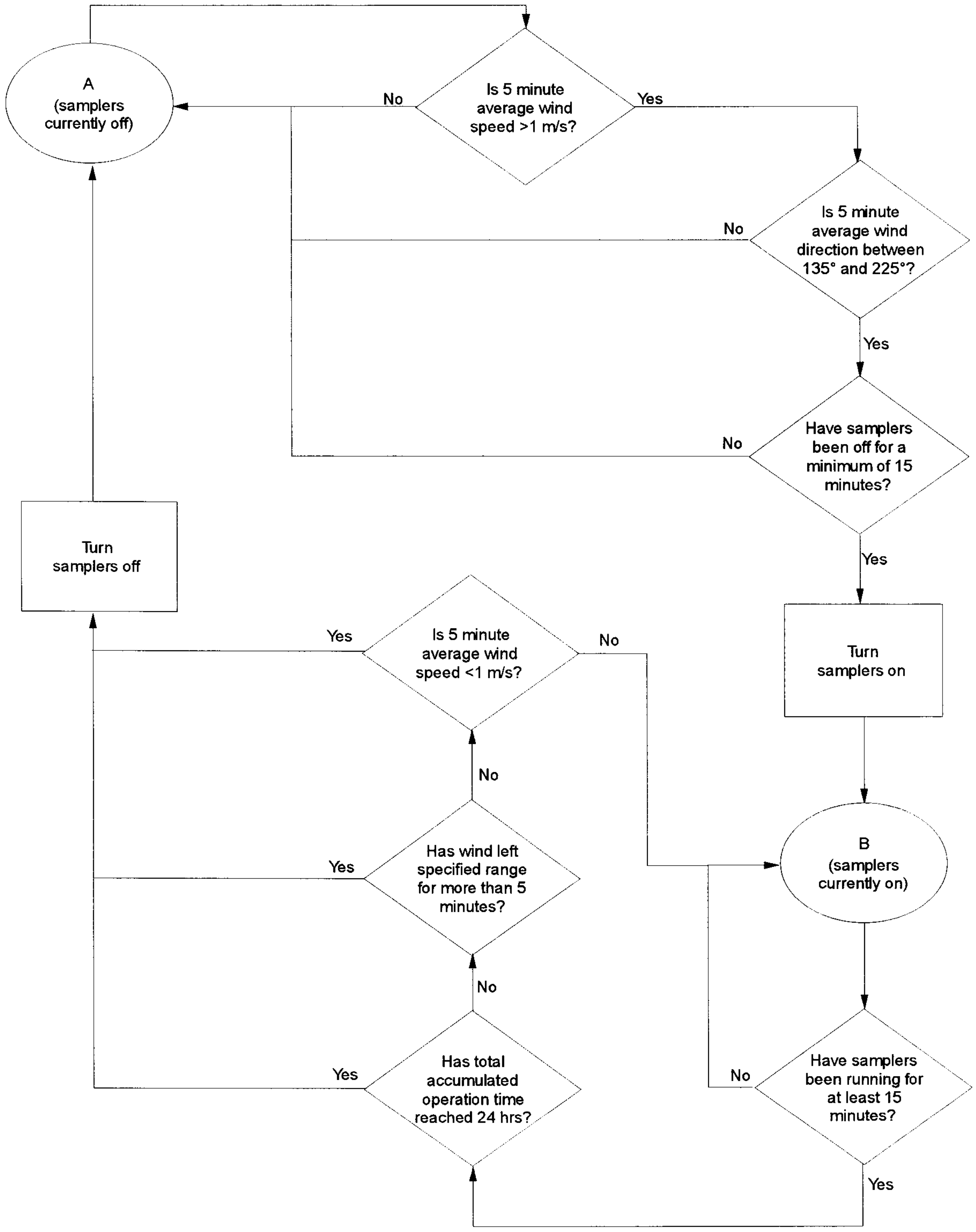


Figure 5-3

ELECTRONIC WEATHER STATION OPERATIONAL FLOW CHART

5.1.3 Turnover Periods

During stockpile turnover periods , the stockpile was turned by means of a front-end loader (Caterpillar 936) for approximately six hours to simulate ash loading and unloading operations that would be expected at an ash-aggregate storage facility. Turning of the stockpile involved using the loader bucket to move the stockpiled ash from one side of the stockpile pad to the opposite side, and involved loader movement as well as lifting and dropping of the ash. Nine turnover events were monitored over the course of the evaluation program.

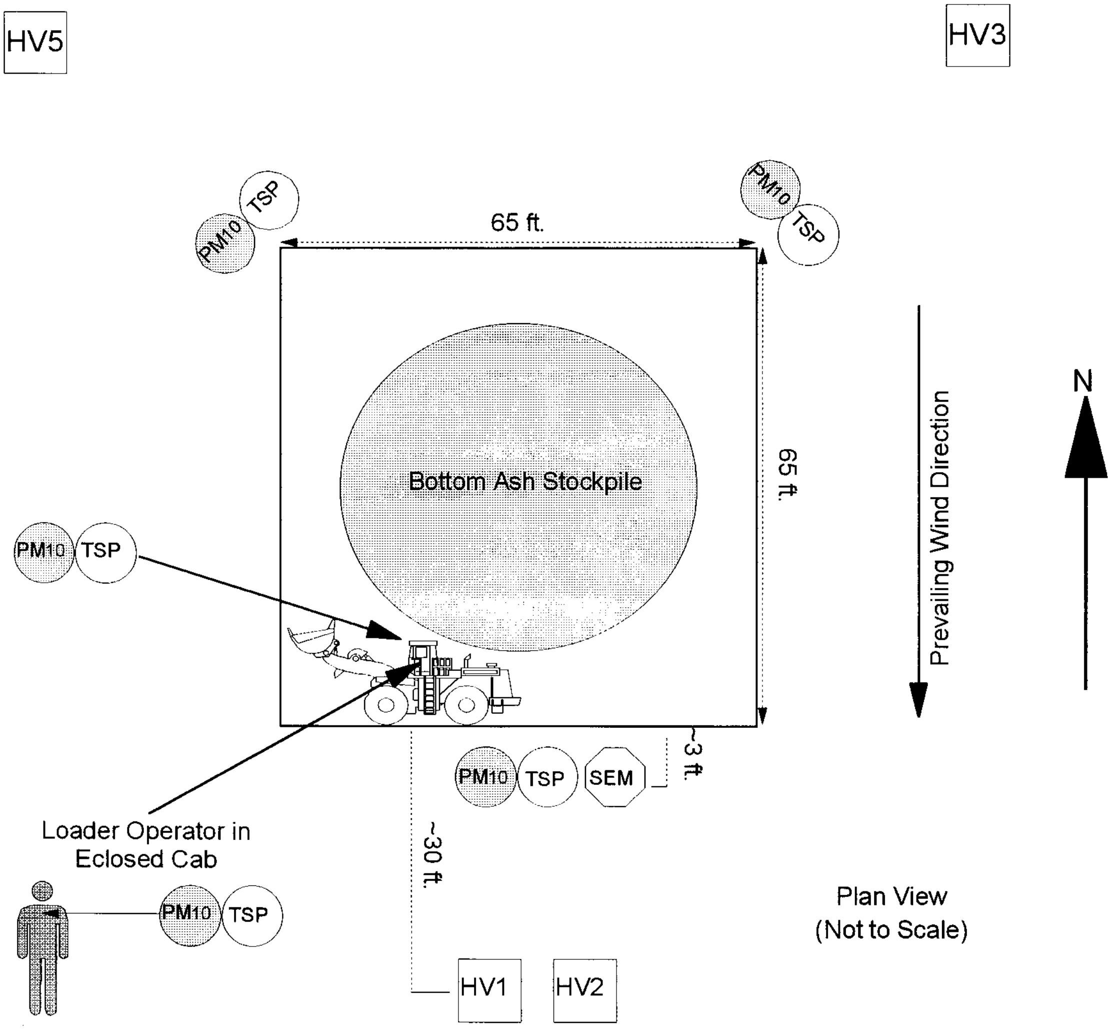
Figure 5-4 provides a schematic depicting the location of each sampler relative to the prevailing wind direction during turnover periods. The actual location of each sampler varied somewhat during each event, depending on the prevailing wind direction; however, the general arrangement shown in Figure 5-4 was the same. During these turnover periods, four of the five high volume air samplers used during the static monitoring period described in Section 5.1.2 (HV-1, HV-2, HV-3 and HV-5) were relocated to monitor fugitive dust emissions in the more immediate vicinity of the stockpile. HV-4 remained in the field to provide background samples.

During initial turnover periods more fugitive dust emissions appeared to occur during the first hour of the turnover activity, when the front end loader first penetrated the surface of the pile, than during the latter period (i.e., latter five hours) of the event. This was attributed to the fact that the surface of the stockpile was visibly drier at the beginning of a turnover period and, therefore, more prone to dispersion. During the latter portion of the turnover period, the damp interior of the pile was brought to the surface, apparently reducing visible fugitive dust.

To attempt to distinguish between the fugitive dust monitored by the downwind high volume samplers during the first hour of operation and the fugitive dust monitored during the last five hours, one of the filters from the two downwind samplers was replaced after one-hour of stockpile mixing. Measuring the dust collected on the original and replacement filters in this duplicate sampler permitted a comparison of the filter loading during the first hour with the filter loading during the remaining five hours.

PASs were also positioned around the stockpile and on the front end loader and loader operator to monitor TSP metals and PM_{10} particulates. Six PASs were located around the stockpile (three to monitor TSP and three to monitor PM_{10}). In addition, two PASs were mounted on the front-end loader (one to monitor TSP and one to monitor PM_{10}) and two were attached to the front-end loader's operator (one to monitor TSP and one to monitor PM_{10}).

During four of the turnover periods (turnover periods six through nine), one or two additional PAS samples were collected for scanning electron micrograph (SEM) analysis of particle size distribution. SEM sample collectors were placed on the downwind side of the stockpile (see Figure 5-4). One TSP sample was collected during each event for SEM analysis during events six through nine. One PM_{10} sample was also collected for SEM analysis during event six.



Legend	
PM10	Personal Air Sampler (PM_{10}-Particulates)
TSP	Personal Air Sampler (TSP-Metals)
HV#	High Volume Samplers
SEM	S.E.M. Samplers

NOTE: Positioning of air samplers is approximate. Actual positioning differed depending on the prevailing wind direction during the sampling event. Personal air samplers adjacent to pad were placed approximately 3 ft. from the pad. High volume samplers were placed approximately 30 ft. from the pad.

Figure 5-4

TURNOVER PERIOD SAMPLER LOCATIONS

Mercury vapor analysis was conducted using the Jerome direct reading analyzer during event one. During events two through nine a dosimeter was utilized, since mercury vapor concentrations were below the detection limits of the direct reading analyzer. See Appendix B1 for additional discussion of the Jerome Sampler operation.

5.2 ANALYTICAL METHODS

Table 5-1 lists the air monitoring methods, the analytical tests that were performed on samples collected, and the laboratories responsible for the respective tests. See Appendix B1 for a more detailed description of the high volume air sampler, personal air sampler, mercury analyzer and scanning electron microscopy procedures.

Table 5-1

AIR MONITORING ANALYTICAL METHODS AND TESTS

Air Monitor	Test	Lab	Method
High Volume Samplers	Total Particulates Elemental Characterization[1]	NYSDOH NJDEP	- USEPA, EPA 600/4-77-027a
Personal Air Samplers	Total Particulates[2] Elemental Characterization[1,3,4] SEM. Size Gradation[5]	NJDEP NJDEP SUNY	NIOSH 0600 NIOSH 7900/OSHA ID-121/OSHA ID-125G JOEL 5300 SEM
Jerome 411	Mercury Vapor	NJDEP	-

1. AA or ICP used for metals analysis of As, Ba, Be, Cd, Cr, Pb, Mn, Ni and Zn.
2. Measured on respirable particulates only. Samples were collected during ash processing and for all turnover events.
3. Measured on TSP samples only. Samples were collected during ash processing and for all turnover events.
4. Mercury analyzed using a Jerome 411 direct reading mercury vapor analyzer during the ash processing event and turnover event #1. During all other turnover events a Jerome 411 sampler was used in conjunction with a dosimeter.
5. Samples for scanning electron microscope (SEM) analyses were collected during turnover events.

5.3 STOCKPILE AIR MONITORING RESULTS

Section 5.3 presents the results of the ambient air stockpile monitoring program. Results for the fugitive dust monitoring, ambient air trace metal monitoring, and scanning electron microscope (SEM) analyses are presented for the BA processing, static, and turnover periods.

5.3.1 BA Processing Period Results

5.3.1.1 TSP Trace Metal Results

During the BA processing period, TSP samples were analyzed for trace metal content. Table 5-2 presents the results of these analyses. Table 5-2 also lists Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). PELs are allowable time weighted eight-hour exposure limits expressed in terms of micrograms per cubic meter. The results show that all measured levels of TSP metal were several orders of magnitude below the OSHA PELs. All measurements for this monitoring project were less than eight hours and were not adjusted to 8-hour time weighted average. This provides a conservative comparison of recorded concentrations to the OSHA PEL.[1]

Table 5-2

TRACE METAL CONCENTRATIONS IN SUSPENDED PARTICULATE MATTER COLLECTED DURING BA PROCESSING ($\mu g/m^3$)

Parameter	Location[1]				OSHA PEL
	Loader Operator	Truck Operator	Screening Location	Truck Loading	
As	<0.038	<0.038	<0.035	<0.038	10
Ba	0.41	0.28	0.13	0.14	500
Be	<0.14	<0.14	<0.13	<0.14	2
Cd	<0.14	0.14	<0.13	<0.14	5
Cr	0.14	0.14	0.13	<0.14	1000
Pb	0.27	<0.14	<0.13	<0.14	50
Mn	0.27	0.28	0.38	<0.14	-
Ni	0.14	<0.14	<0.13	<0.14	1000
Zn	1.5	0.07	1.4	<0.14	-

1. Location refers to the point of sample collection. Sampler locations are depicted in Figure 5-1.

5.3.1.2 PM_{10} Results

Measured PM_{10} dust concentrations are presented in Table 5-3. The PM_{10} results were all one to two orders of magnitude below the PM_{10} OSHA PEL.

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[1] Since all measurements were less than eight hours, calculating an eight-hour time weighted average would result in a reported decrease in trace metal values (i.e., if a monitoring period was 6 hours, trace metals would be multiplied by 6/8).

Table 5-3

PM_{10} CONCENTRATIONS MEASURED DURING BA PROCESSING (µg/m3)

Location	PM_{10}
Loader Operator	130
Truck Operator	36
Screening Location	290
Truck Loading	32
OSHA PEL	5000

1. Location refers to the point of sample collection. Sampler locations are depicted in Figure 5-1.

5.3.1.3 Mercury Vapor Results

Instantaneous mercury vapor readings were recorded with the Jerome sampler at four locations; the unprocessed bottom ash pile, screening location, scrap iron pile and a background location several hundred feet from the processing operations. All mercury vapor samples were collected using the direct sampling mode. Table 5-4 presents mercury reading results. Mercury vapor concentrations were below detection limits (3 $\mu g/m^3$) at the unprocessed bottom ash and background location site. Two samples collected at the screening location were above detection limits (see Table 5-4) with direct reading values showing 10 and 20 $\mu g/m^3$. Two readings measured at the scrap iron pile also were above detection limits, with values of 10 $\mu g/m^3$. All recorded values, however, were below the 100 $\mu g/m^3$ OSHA PEL for mercury.

Table 5-4

BOTTOM ASH PROCESSING DIRECT MERCURY VAPOR READINGS (µg/m3)

Location	Discrete Sample Readings					
Unprocessed Bottom Ash Stockpile	<3	<3	<3	-	-	-
Screening Location	<3	<3	<3	20	10	<3
Scrap Iron Pile	<3	<3	10	10	-	-
Background	<3	-	-	-	-	-
OSHA PEL	100					

5.3.2 Static Period Results

5.3.2.1 Total Suspended Particulate Results

Table 5-5 presents the average total suspended particul, ate (TSP) concentrations measured during 30 static stockpile monitoring periods. Appendix C2, Table C2-2, presents a listing of TSP concentrations for each static monitoring period and Table C2-3 presents a listing of wind speed, temperature, humidity and total rainfall recorded during each event. For benchmark reference purposes, Table 5-5 also includes a listing of TSP measurements recorded in 1991 at other locations in the State of New Jersey. Data presented in Table 5-5 suggest that there were no measurable differences between the upwind and downwind TSP dust concentrations measured at the stockpile site during monitoring periods. The TSP concentrations at the stockpile site were also similar to those concentrations reported at other locations in New Jersey (NJDEP/Bureau of Air Monitoring, 1992). Both the average downwind and the average upwind ambient air concentrations measured at the stockpile were below the average annual New Jersey TSP criteria of 75 μg/m^3.

Table 5-5

AVERAGE TOTAL SUSPENDED PARTICULATE CONCENTRATIONS DURING STATIC STOCKPILE PERIODS
$(\mu g/m^3)$

Location		Average Concentration
Stockpile Site	Downwind[2]	62
	Upwind[1,3]	70
Other New Jersey Locations[4]	Atlantic City	58
	Camden-Rutgers	26
	Newark	60
	Jersey City	59
	New Brunswick	80
	Clifton	40
	Paterson	55
N. J. Annual Average Criteria		75

1. Does not include concentrations from 10/25/93 and 10/6/93 due to excessively high TSP upwind levels caused by local truck traffic (see Appendix C2).
2. Represents the average of the four downwind high volume samplers over 30 sampling events.
3. Represents the average of one upwind high volume sampler over 28 events.
4. Values taken from NJDEP, Bureau of Air Monitoring, July 1992.

5.3.2.2 TSP Trace Metal Results

Appendix C2, Table C2-1, presents a detailed listing of the results of the trace metal content testing of the TSP dust samples collected by the high volume samplers during the static monitoring periods. Table 5-6 provides an abbreviated version of the trace metal data in terms of downwind to upwind ratios for each high volume sampler. Ratios less than one indicate that the downwind concentrations were less than upwind concentrations and ratios greater than one indicate that the downwind concentrations were greater than the upwind values. The ratios presented in Table 5-6 indicate that the measured downwind TSP trace metal concentrations were similar to measured upwind TSP trace metal concentrations.

Table 5-6

AVERAGE TRACE METALS
DOWNWIND TO UPWIND CONCENTRATION RATIO RECORDED DURING STATIC STOCKPILE AIR MONITORING PERIODS[1]
(µg/m3)

Trace Metal	Downwind to Upwind Ratio[2]				Avg.[3]
	HV-1	HV-2	HV-3	HV-4	
As	0.87	1.4	1.1	0.93	1.1
Ba	0.89	0.90	1.2	0.84	0.95
Be	1.0	1.0	1.2	1.1	1.1
Cd	1.0	1.0	1.2	1.0	1.1
Cr	1.0	1.0	1.3	1.0	1.1
Pb	0.88	1.0	1.1	0.87	1.0
Mn	0.77	0.68	1.2	0.67	0.82
Ni	1.0	1.0	1.3	1.0	1.1
Zn	3.7	1.1	1.1	1.0	1.7

1. A complete listing of trace metal results is presented in Appendix C2.
2. Downwind to upwind ratio was calculated by dividing the trace metal concentration at the downwind (HV-1, HV-2, HV-3 or HV-4) sampler by the concentration at the upwind sampler (HV-5).
3. Avg. represents the average ratio for HV-1, HV-2, HV-3 and HV-4.

5.3.3 Turnover Period Results

5.3.3.1 Total Suspended Particulate Results

Table 5-7 presents average TSP concentrations recorded during each of the nine stockpile turnover event monitoring periods. The overall average concentration for all nine monitoring events combined is also presented. Table 5-7 lists TSP dust concentrations measured using high volume air samplers located around the stockpile periphery at a distance of approximately 30 feet from the stockpile edge (see Figure 5-4). The table presents the results for the background sampler (HV-4), as well as those for the first hour of active

Table 5-7

**HIGH VOLUME SAMPLER TSP DUST RESULTS
RECORDED DURING STOCKPILE TURNOVER PERIODS
(µg/m3)**

Turnover Event			Average Concentration[1]	First Hour[2]	After First Hour[3]	Background[4]
#	Date	Months				
1	05/18/93	6	161	146	137	104
2	06/22/93	7	69	101	156	39
3	06/23/93	7	65	160	216	45
4	727/93	8	88	109	93	64
5	07/28/93	8	112	164	157	46
6	08/23/93	9	206	118	145	87
7	08/24/93	9	392	374	456	212
8	10/05/93	10	160	253	300	27
9	10/06/93	10	148	55	153	47
Average			156	167	201	74
OSHA (PELS)			15000	15000	15000	15000

1. Represents average of three high volume samplers placed approximately 30-feet from the stockpile pad (for example HV-1, HV-3, HV-5 as shown in Figure 5-4). The data were not included from the duplicate sampler used for separately collecting dust during the first hour and the remaining sampling period.
2. Represents the concentration collected at the downwind sampler during the first hour of the active event.
3. Represents the concentration collected at the downwind sampler after the first hour of the turnover event (i.e., latter five hours of event).
4. Represents the concentration collected at HV-4 which was left in its static sampling position to collect background dust concentrations.

operations and for the operational period after the first hour (see Section 5.1.3). A listing of Occupational Safety and Health Administration (OSHA) eight hour time weighted average limits (PELs) has been included to permit comparison of OSHA criteria with the monitored results. Although there was a measurable increase in TSP ambient air concentrations during the respective turnover periods, the TSP concentrations were all at least two orders of magnitude below OSHA TSP criteria. The results did not suggest any major differences between the first hour of turnover activity and the subsequent five-hour activity.

5.3.3.2 PM_{10} Results

Table 5-8 presents PM_{10} dust concentration results for PAS samplers that were located on the person of the operator, on the exterior of the front-end loader and in the area around the periphery of the stockpile at approximately five feet from the stockpile edge (see Figure 5-4). All PM_{10} concentrations were one to two orders of magnitude below PM_{10} OSHA criteria.

Table 5-8

PERSONAL AIR SAMPLER PM$_{10}$ DUST RESULTS RECORDED DURING STOCKPILE TURNOVER PERIODS

$(\mu g/m)^3$

Turnover Event			PAS PM$_{10}$ Dust Measurement Locations[1]		
#	Date	Month[2]	Loader Operator	Loader	Adjacent to Pad
1	05/18/93	6	21	80	17
2	06/22/93	7	17	360	28
3	06/23/93	7	20	17	38
4	727/93	8	21	350	27
5	07/28/93	8	18	620	52
6	08/23/93	9	88	770	110
7	08/24/93	9	200	330	73
8	10/05/93	10	220	710	67
9	10/06/93	10	140	440	91
Average			83	409	56
OSHA PEL			5000	5000	5000

1. Sample locations are depicted in Figure 5-4.
2. Represents number of months after stockpile construction.

5.3.3.3 TSP Trace Metal Results

Table 5-9 lists the average TSP trace metal concentrations measured using PAS samplers during the nine turnover events. Trace metals were also measured at three locations: the front-end loader operator, the exterior of the front-end loader and around the stockpile periphery (see Figure 5-4). Table 5-9 also lists relevant OSHA eight hour time weighted average trace metal PELS. The trace metal concentrations presented in Table 5-9 are all several orders of magnitude below the OSHA PELS.

Table 5-10 presents the results of TSP trace metal testing using the high volume samplers in a format that facilitates comparison of measured trace metal concentrations obtained from the samplers located in the vicinity of the stockpile (see Figure 5-4) to those obtained from the background sampler (HV-4). The table also presents values for the first hour of operational time at a downwind sampler as well as values for the remainder of the turnover period. The values presented inTable 5-10 are only for trace metals which were detected above the method detection limit which include As, Ba, Pb, Mn and Zn (see Appendix C3).

The results indicate that during the first hour of operations trace metal concentrations ranged from approximately 3 to 10 times higher than the background concentrations. Zinc concentrations exhibited the

Table 5-9

PERSONAL AIR SAMPLER TSP TRACE METAL CONCENTRATIONS RECORDED DURING STOCKPILE TURNOVER PERIOD

(μg/m3)

Parameter	PAS TSP Measurement Locations[1]			OSHA PEL
	Loader Operator	Loader	Adjacent to Pad	
As	0.093	0.30	<0.17	10
Ba	2.1	6.2	<2.2	500
Be	<0.26	<0.65	<0.27	2
Cd	<0.25	0.65	<0.27	5
Cr	1.0	1.5	<1.0	1000
Pb	0.072	0.09	0.083	50
Mn	0.90	3.0	0.76	50
Hg	0.34	1.4	<0.44	5000
Ni	0.29	0.78	0.36	1000
Zn	1.3	7.8	2.2	15000

1. Sampler locations are depicted in Figure 5-4.

Table 5-10

RATIO OF MONITORED AVERAGE TSP METAL CONCENTRATIONS TO BACKGROUND AVERAGE TSP TRACE METALS DURING TURNOVER PERIODS

Parameter	Average Concentration Ratio[1,4]	First Hour[2,4]	After First Hour[3,4]
As	1.1	2.6	1.4
Ba	3.0	6.7	5.3
Be	ND	ND	ND
Cd	ND	ND	ND
Cr	ND	ND	ND
Pb	2.8	7.9	8.2
Mn	1.9	2.7	2.9
Ni	ND	ND	ND
Zn	4.6	10	7.7

1. Represents average of three high volume samplers placed approximately 30-feet from the stockpile pad (for example HV-1, HV-3, HV-5 as shown in Figure 5-4). The data were not included from the duplicate sampler used for separately collecting dust during the first hour and the remaining sampling period.
2. Represents the concentration collected at the downwind sampler during the first hour of the turnover period (i.e., latter five hours).
3. Represents the concentration collected at the downwind sampler after the first hour of the turnover period.
4. ND values not detected above the method detection limit.

highest increase. After the first hour, trace metal concentrations ranged from approximately 1.4 to 7.7 times the background concentrations. Again, zinc concentrations were the most elevated of all the trace metals. The results do not suggest any differences between the first hour and post first hour periods. The average increase in trace metal concentrations over the entire turnover period ranged from 1.0 to 4.6 times the background concentration, with zinc exhibiting the highest increase.

5.3.3.4 Scanning Electron Microscopy Particle Size Distribution Results

During the course of stockpile turnover periods six, seven, eight, and nine, fugitive dust air samples (i.e., TSP and PM_{10}) were collected for SEM analyses to assist in characterizing particle size distribution. Two PM_{10} dust samples were collected for SEM analysis during turnover events six and seven. Sampler placement and collection methodology are described in Section 5.1.3 (see Figure 5-4).

Figure 5-5 provides a graphic representation of the TSP and PM_{10} SEM size distribution analyses. Analysis of the SEM TSP data shows particles collected ranged from 1 to approximately 20 μm, with the majority (55 to 95 percent) of the particles in the PM_{10} range. Analysis of the PM_{10} particle size data shows particles collected ranged from 1 to 11 μm, with sizes distributed throughout the range from 1 to 11 μm. See Appendix C4 for more detailed SEM results.

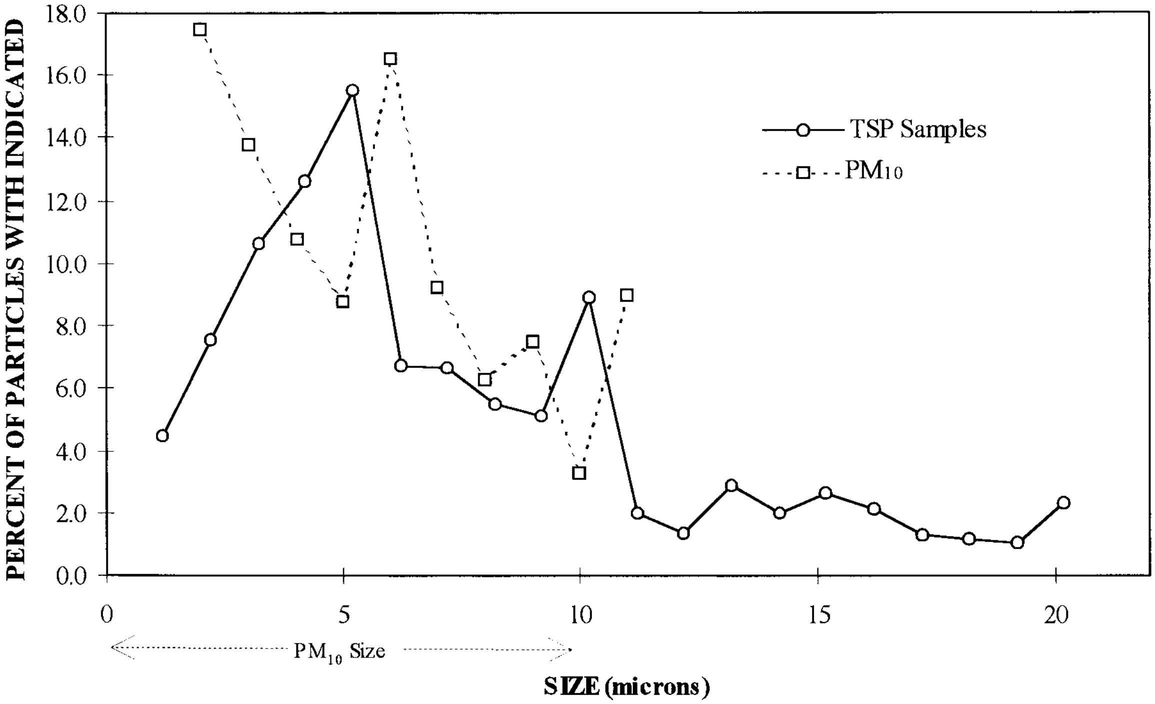

Figure 5-5

SEM SIZE DISTRIBUTION RESULTS

Section 6

SOIL QUALITY TESTING

Section 6 describes the soil quality sampling and testing effort that was undertaken as part of the stockpile evaluation program and the results of this effort. Section 6 is divided into three subsections. Section 6.1 outlines the soil sampling schedule and sampling locations. Section 6.2 presents a description of the sampling methods and analytical test procedures, and Section 6.3 presents a description of the test results.

6.1 SOIL QUALITY SAMPLING SCHEDULE AND SAMPLING LOCATIONS

Soil samples were collected in the vicinity of the stockpile on two separate occasions during the demonstration project: on June 21, 1993 and November 30, 1993. These two sampling events correspond to approximately six months ($t = 6$), and 11 months ($t = 11$) after the construction of the stockpile. In the interim between the first and second soil sampling events, the stockpile was turned over eight times.

During each event a total of 24 samples were collected from 12 predefined locations or sectors around the stockpile and from two depths at each sampling location: the upper surface (i.e., top 2 inches) and the subsurface (i.e., 4-6 inches below the surface).

The 12 sectors from which samples were collected were defined by dividing the area around the stockpile into four quadrants: north, south, east and west (see Figure 6-1). The north quadrant was bounded by the true compass headings of 315 to 45 degrees. The east quadrant was bounded by the true compass headings of 45 to 135 degrees. The south quadrant was bounded by the true compass headings of 135 and 225 degrees, and the west quadrant was bounded by the true compass headings of 225 and 315 degrees.

Each of the quadrants was further subdivided into three sectors, bounded by radial distances from the center of the stockpile. The first sector in each quadrant consisted of the area between the edge of the stockpile pad and a radial distance of 50 feet from the center of the stockpile (50 foot radial). The second sector consisted of the area between the 50 foot radial and the 75 foot radial; and the third sector, the area between the 75 foot radial and the 100 foot radial. Table 6-1 lists the 12 sampling sectors and their boundaries, defined in terms of polar coordinates.

6.2 SAMPLING METHODS AND ANALYTICAL TESTS

Using a hand trowel, surficial and subsurface samples were randomly collected from five locations within each sector. Approximately 1000 grams of soil were removed from the surface (i.e., 0 - 2 inch depth) and subsurface (i.e., 4 - 6 inch depth) from each of five discrete locations within a sector. The discrete surficial samples collected within a sector, and the discrete subsurface samples collected within each sector were separately

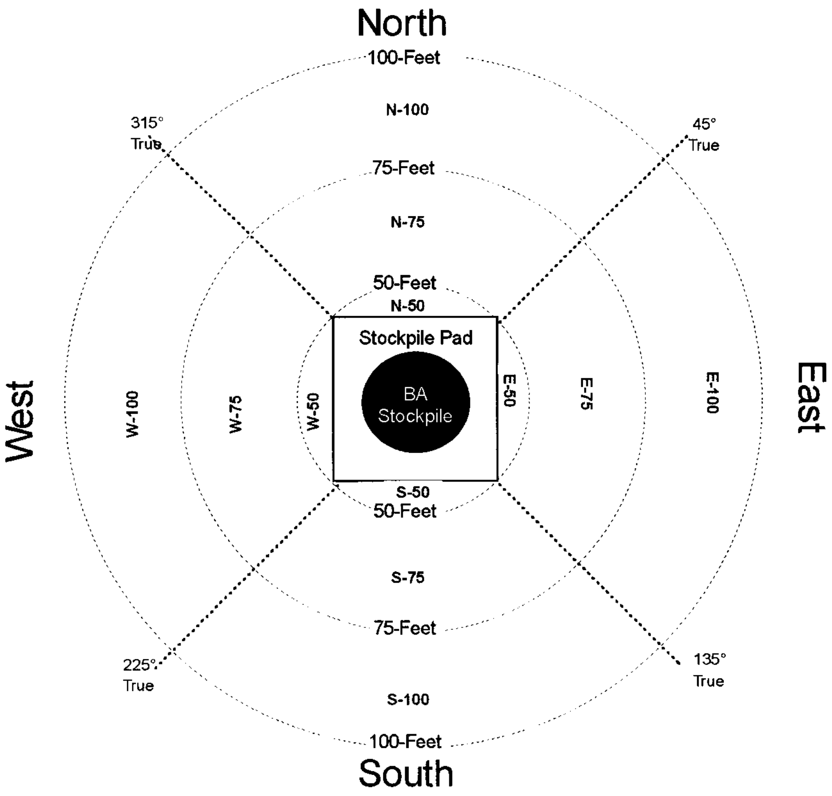

Figure 6-1

SOIL SAMPLE COLLECTION QUADRANTS AND SECTORS

Table 6-1

SOIL SAMPLE COLLECTION LOCATION QUADRANTS REPRESENTED BY POLAR COORDINATE BOUNDARIES

Quadrant	Sector	r[1]	⊖[2]
North	N-50	0 - 50	315 - 45
	N-75	50 - 75	315 - 45
	N-100	75 - 100	315 - 45
East	E-50	0 - 50	45 - 135
	E-75	50 - 75	45 - 135
	E - 100	75 - 100	45 - 135
South	S-50	0 - 50	135 - 225
	S-75	50 - 75	135 - 225
	S-100	75 - 100	135 - 225
West	W-50	0 - 50	225 - 315
	W-75	50 - 75	225 - 315
	W-100	75 - 100	225 - 315

1. r = radial distance in feet from stockpile center.
2. ⊖ = angle in degrees, where true north is 0° and 360°.

composited (i.e., two composite samples -- surface and subsurface) prior to transport to NJDEP laboratories in Trenton for trace metals analysis. Samples were analyzed for As, Ba, Be, Cd, Cr, Cu, Pb, Mn, Hg, Ni, and Zn using USEPA Method SW-846. One set of trace metal analyses was run on each composited sample.

6.3 SOIL QUALITY TESTING PROGRAM RESULTS

Tables 6-2 and 6-3 present the soil quality results for the first and second soil sampling events, respectively. The tables list soil trace metal contents in terms of micrograms per gram (μg/g) for each of the four sampled sectors, and for each depth sampled within each respective sector.

The average surface and subsurface soil trace metal concentrations measured in terms of micrograms per gram (μg/g) during the first and second sampling events were compared with typical soil trace metal concentrations previously reported in New Jersey soils (NJDEP, 1994). The results of this comparison, presented in Table 6-4, indicate that the trace metals concentrations detected in the soils in the vicinity of the stockpile site were not measurably different from the trace metal concentrations typically found in New Jersey soils.

Table 6-5 presents a listing of average trace metal concentrations in the stockpiled BA compared to the average trace metal concentrations found in the soils adjacent to the stockpile. The data indicate that copper, lead, zinc and cadmium are all present in significantly higher concentrations in the ash compared to soils adjacent to the stockpile site.

Given the above, it would generally be expected that increases in soil trace metal concentrations of these four metals would be the most likely indicators of deposition in soils adjacent to the stockpile. Trace metal concentrations found in bottom ash were compared to those found in soils to determine which of the trace metals were likely to be found in increased concentrations in soils exposed to bottom ash. The results of this comparison, presented in Table 6-5, suggest that Cu, Pb, Zn and Cd, in descending order, are the trace metals with concentrations ranging from 109 to 60 times the levels found in the soils adjacent to the stockpile.

A comparison was therefore made between Cu, Pb, Zn and Cd concentrations measured during the first and second events. To facilitate this comparison trace metal concentration recorded during the first event was compared to that of the second event by dividing the respective concentrations to yield a concedntration ratio. Table 6-6 provides a list of these ratios. A value greater than one indicates that the trace metal content recorded for the second event sample was higher than that for the first event sample, while a value less than one indicates that the second event trace metal content was lower than that recorded for the first event. A higher value in the second event would suggest a trend toward increasing trace metal soil concentrations. The results failed to indicate a consistent trend in either surficial or subsurface samples for any sector. The data suggest that transport of ash particles, if any, was occurring at a rate that was too slow to detect within the six month sampling period.

During the turnover periods, it became apparent that front end loader activity provided sufficient movement of the stockpile through spillage and wheel tracking to spread observable quantities of ash around the

Table 6-2

TRACE METAL SOIL CONCENTRATIONS
(June 21, 1993: First Soil Sampling Event)
(μg/g)

Trace Metal	Depth (inches)	Quadrant											
		N-50	N-75	N-100	E-50	E-75	E-100	S-50	S-75	S-100	W-50	W-75	W-100
As	0-2	7.7	6.9	8.4	6.3	6.0	7.8	8.0	8.4	7.8	6.0	8.0	6.9
	4-6	6.3	6.8	7.0	5.9	6.5	5.6	9.5	9.2	9.0	5.9	6.3	8.3
Ba	0-2	52	58	59	49	44	52	55	51	66	47	54	68
	4-6	63	57	67	42	51	49	53	53	70	68	43	54
Be	0-2	<1.5											
	4-6	<1.5											
Cd	0-2	0.5	0.5	0.5	1.0	1.0	0.5	1.0	1.0	0.5	1.0	0.5	0.5
	4-6	0.5	0.5	0.5	0.5	1.0	0.5	1.0	0.5	0.5	1.0	0.5	0.5
Cr	0-2	16	18	20	15	14	18	16	15	18	14	18	17
	4-6	16	18	21	13	16	22	18	16	17	12	14	17
Cu	0-2	20	19	21	25	19	19	19	18	20	18	18	19
	4-6	18	29	20	18	18	18	17	19	19	19	18	17
Pb	0-2	21	19	19	29	20	18	22	20	23	18	22	23
	4-6	20	20	23	18	19	17	19	19	22	21	19	20
Mn	0-2	455	535	589	426	430	525	557	555	570	415	535	715
	4-6	660	545	607	450	490	475	433	532	629	609	50	615
Hg	0-2	<0.0005											
	4-6	<0.0005											
Ni	0-2	18	19	22	18	16	19	18	19	19	18	18	20
	4-6	18	20	22	16	17	20	17	19	21	18	17	18
Zn	0-2	92	64	79	83	60	78	65	70	78	60	65	85
	4-6	60	69	75	64	70	75	60	57	74	60	58	65

perimeter within 50 feet of the stockpile. This was particularly noticeable in the N-50 and E-50 sectors. Although the ratios listed in Table 6-6 show somewhat higher values in the N-50 and E-50 sectors, the available data were not deemed sufficient to suggest any definitive trend. Additional longer term monitoring, perhaps for several years, would be required to detect any significant trend toward trace metal accumulation or increasing concentrations in local soils.

Table 6-3

TRACE METAL SOIL CONCENTRATIONS

(November 30, 1993: Second Soil Sampling Event)

(μg/g)

Trace Metal	**Depth (inches)**	**Quadrant**											
		N-50	**N-75**	**N-100**	**E-50**	**E-75**	**E-100**	**S-50**	**S-75**	**S-100**	**W-50**	**W-75**	**W-100**
As	0-2	9.3	7.3	8.0	6.0	6.1	6.0	7.6	5.3	7.3	7.0	6.6	6.3
	4-6	6.7	7.9	7.7	7.6	6.6	7.5	6.3	6.0	7.0	6.3	6.3	7.0
Ba	0-2	43	56	63	54	47	51	59	45	51	49	54	60
	4-6	43	51	46	59	43	49	58	50	58	35	56	49
Be	0-2	<1.5											
	4-6	<1.5											
Cd	0-2	1.0	1.0	0.5	1.0	0.5	0.5	1.0	1.0	1.0	0.5	0.5	0.5
	4-6	1.0	1.0	0.5	1.0	0.5	0.5	1.5	1.0	0.5	0.5	0.5	0.5
Cr	0-2	14	16	19	13	20	21	16	13	16	12	19	24
	4-6	15	17	20	17	15	31	16	13	18	11	17	19
Cu	0-2	21	19	17	36	18	17	21	16	15	16	20	16
	4-6	13	20	18	33	18	19	16	20	16	13	17	18
Pb	0-2	25	23	21	31	19	18	24	17	19	14	19	19
	4-6	15	22	23	30	18	16	20	18	21	16	19	18
Mn	0-2	388	510	697	443	600	415	505	435	568	395	572	668
	4-6	413	515	562	460	425	415	567	493	706	348	465	495
Hg	0-2	<0.0005											
	4-6	<0.0005											
Ni	0-2	14.9	18.3	18.9	17.2	18.5	17.0	18.3	18.3	18.1	16.0	20.9	20.3
	4-6	14.9	18.5	20.4	18.0	17.5	20.5	19.9	21.4	18.6	14.4	16.5	18.1
Zn	0-2	70	64	80	108	50	105	64	50	88	49	65	69
	4-6	52	60	70	95	55	65	55	50	69	41	60	64

Table 6-4

COMPARISON OF AVERAGE TRACE METAL SOIL CONCENTRATIONS AT STOCKPILE SITE WITH NEW JERSEY SOILS

($\mu g/g$)

Parameter	Average Stockpile Site Soils				New Jersey Soil Concentrations[1]
	Event 1		Event 2		
	0-2"	4-6"	0-2"	4-6"	
Cu	19	18	19	18	2-50
Pb	21	20	21	20	1-45
Zn	73	66	72	61	25 - 150
Cd	0.70	0.60	0.70	0.70	1.5 - 4
Ba	55	56	53	50	-
Cr	16	17	17	17	5 - 50
Ni	19	18	18	18	10 - 80
Hg	<0.0005	<0.0005	<0.0005	<0.0005	0.05 - 0.5
Mn	526	508	516	489	50 - 1500
As	7.3	7.2	6.9	6.9	1 - 15

1. Ranges reported.

Table 6-5

COMPARISON OF TRACE METAL CONCENTRATIONS IN ASH AND STOCKPILE SITE SOILS

Parameter	Stockpiled[1] Bottom Ash (μg/g)	Stockpile[2] Site Soils (μg/g)	Ratio of Ash to Soil
Cu	2,188	20	109
Pb	1,758	20	88
Zn	5,080	75	68
Cd	30	0.5	60
Ba	716	52	14
Cr	123	18	7
Ni	125	19	7
Hg	0.81	0.2	4
Mn	1,114	500	2
As	13	7.5	2

1. See Table 3-3.
2. Based on median observed values (see Tables 6-2 and 6-3).

Table 6-6

RATIO OF Cd, Cu, Pb and Zn SOILS CONCENTRATIONS BETWEEN THE FIRST AND SECOND SAMPLING EVENTS[1]

Trace Metal	Depth (inches)	Quadrant											
		N-50	N-75	N-100	E-50	E-75	E-100	S-50	S-75	S-100	W-50	W-75	W-100
Cd	0-2	2.0	2.0	1.0	1.0	0.50	1.0	1.0	1.0	2.0	0.52	1.0	1.0
	4-6	2.0	2.0	1.0	2.0	0.50	1.0	1.5	2.0	1.0	0.51	1.0	1.0
Cu	0-2	1.1	1.0	0.84	1.4	0.95	0.92	1.1	0.90	0.77	0.84	1.1	0.86
	4-6	0.74	1.0	0.92	1.8	1.0	1.0	0.94	1.0	0.81	0.71	0.94	1.0
Pb	0-2	1.2	1.2	1.1	1.0	0.94	1.0	1.1	0.84	0.85	0.79	0.86	0.82
	4-6	0.77	1.1	1.0	1.6	0.92	0.94	1.1	0.92	1.0	0.75	1.0	0.90
Zn	0-2	0.76	1.0	1.0	1.3	0.83	1.4	1.0	0.71	1.1	0.82	1.0	0.82
	4-6	0.87	0.87	0.93	1.5	0.79	0.87	0.92	0.87	0.92	0.69	1.0	1.0

1. Ratio = Second Event Concentration ÷ First Event Concentration.

Section 7

GROUNDWATER, SURFACE WATER AND SEDIMENT/SOIL QUALITY IMPACT ASSESSMENT

Section 7 describes the methods used to evaluate potential groundwater and surface water quality impacts that could result from the stockpiling of screened, ferrous-free municipal waste combustor bottom ash and the results of the evaluation. Section 7 is divided into five subsections. Section 7.1 summarizes the general evaluation methodology. Section 7.2 describes the general approach used to develop the stockpile discharge (source) parameters used in the assessment. Section 7.3 outlines the groundwater simulation approach and the results of the groundwater analysis. Section 7.4 reviews the surface water quality simulation and the results of the surface water analysis and Section 7.5 examines the potential impacts of stockpile runoff on sediment quality.

7.1 GENERAL EVALUATION METHODOLOGY

A stockpile runoff and mass discharge model (source model) was developed and subsequently used to assess the stockpile runoff impacts on groundwater, surface water and soil or sediment environments. This source model was prepared using field runoff flow rates and elemental concentrations recorded during the monitored rainfall events throughout the one-year stockpile monitoring program.

Impacts on the groundwater environment were evaluated using a three-dimensional groundwater model to project increases in total dissolved solids and trace metal groundwater concentrations resulting from stockpile runoff. New Jersey Department of Environmental Protection (NJDEP) groundwater quality criteria (NJDEP, 1993) were used as reference concentrations in assessing the magnitude of potential groundwater quality impacts.

Surface water impacts were evaluated using mass discharge calculations to estimate the potential Dilution Attenuation Factor (DAF) that would be needed to reduce unattenuated elemental stockpile runoff loadings to levels below those of Chronic National Ambient Water Quality Criteria (NWQC) (USEPA, 1986). Chronic water quality criteria are designed to assure the protection of the aquatic biota from damage caused by pollutant discharges. Further analysis was undertaken to determine the percentage of gaged stream locations in New Jersey that would have adequate DAFs during mean annual seven consecutive day, ten year (MA7CD10) low flow conditions to reduce unattenuated stockpile runoff loadings to NWQC levels. This latter analysis provided an indication of the relative number of locations in New Jersey where surface water flow might not be sufficient to attenuate anticipated stockpile runoff loadings.

Sediment and soil impacts were evaluated using mass discharge calculations of total and soluble stockpile runoff trace metal loadings, respectively, to assess the potential impact of these loadings on sediment and soil quality. NJDEP soil quality cleanup standards (NJDEP, 1994) were used as the reference concentrations in estimating the relative effect of these loadings on sediment and soil quality.

7.2 BOTTOM ASH STOCKPILE RUNOFF SOURCE MODEL

Section 7.2 describes the approach used to develop the bottom ash (BA) stockpile runoff source model.

The mass discharge of any constituent (e.g., trace metal, TDS) from an ash stockpile can be represented by the product of the runoff volume and the concentration of the constituent of interest. This relationship can be defined by the following equation:

$$M = V \times C$$

where[1],

M = mass released (M/T)

V = runoff volume (L^3/T), and

C = concentration (M/L^3).

As a result, defining the value of both V and C is required to determine the mass released from a stockpile. Rainfall, runoff and concentration data collected during the one year stockpile sampling program were used to develop input parameters to assist in defining values of V and C for input into a bottom ash stockpile source model.

7.2.1 Runoff Volume (V)

The volume of runoff from a stockpile during a given storm event can be represented by the following equation:

$$V = K_R I A$$

where,

V = runoff volume (L^3)

K_R = stockpile runoff coefficient (dimensionless)

I = rainfall (L), and

A = area (L^2).

The stockpile runoff coefficient (K_R) represents the relative quantity of runoff expressed as a fraction of the rainfall.

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[1] Note: M, L and T represent the units of mass, length and time. (L denotes length and L^3 volumetric unit for this equation only. In other parts of the report L denotes liters.)

An analysis of the rainfall and runoff data recorded during the bottom ash stockpile monitoring period suggested a relationship between runoff at the stockpile and rainfall intensity, expressed in terms of inches per hour (in/h). Figure 7-1 illustrates this relationship in a graphical format. It includes data from 17 rainfall events for which both runoff flow rates and rainfall intensities were accurately measured. The calculated values for K_R are presented in Table 7-1 along with relevant rainfall and runoff data.

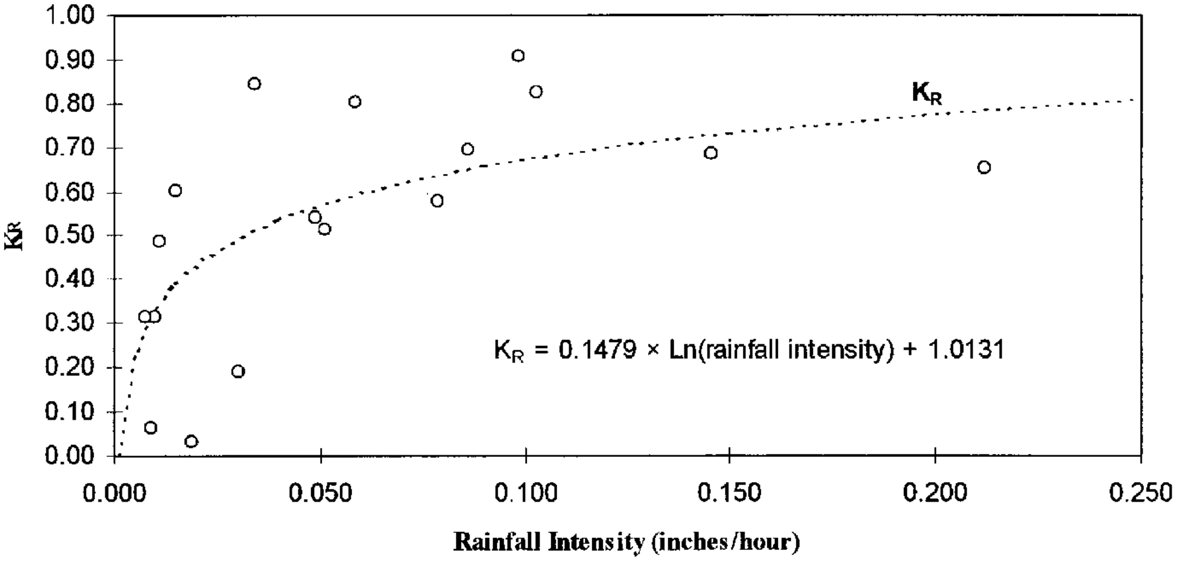


Figure 7-1

RUNOFF COEFFICIENT (K_R) AS A FUNCTION OF RAINFALL INTENSITY

Values for K_R are presented in Figure 7-1 along with a logarithmic regression curve and the regression curve equation, both of which were computer generated to fit the observed data. The figure illustrates the relationship between increasing rainfall intensity and increasing runoff coefficients. Values for K_R in Figure 7-1 range from a low of 0.06 to a high of 0.91.

Although there is considerable scatter among the data, it is logical that rainfall intensity would prove to be an important variable in predicting runoff from a bottom ash stockpile. The bottom ash is a highly absorptive material, and as a result, low intensity rainfalls would be expected to yield correspondingly low runoff coefficients, since much of the initial rainfall would be absorbed by the ash pile. Larger intensity storm events would be expected to saturate the pile more quickly. The expected result would be a larger fraction of runoff (i.e., a higher value of K_R).

Table 7-1

RAINFALL-RUNOFF DATA USED TO CALCULATE STOCKPILE RUNOFF COEFFICIENTS (K_R)

Event Date	Event Duration (h)	Total Rain (in)	Rain Intensity (in/h)	Total Runoff (in)	Runoff Intensity (in/h)	Runoff Coefficient
Variable	-	I	i	-	-	K_R
12/10/92	22	0.23	0.011	0.11	0.0052	0.49
12/28/92	27	0.24	0.0088	0.015	0.00056	0.06
02/13/93	1.8	0.15	0.086	0.10	0.060	0.70
03/04/93	3.5	0.18	0.051	0.093	0.026	0.52
04/16/93	1.7	0.24	0.15	0.16	0.10	0.69
04/21/93	15	0.87	0.058	0.70	0.047	0.81
04/26/93	11	1.1	0.10	0.93	0.085	0.83
06/04/93	2.0	0.060	0.030	0.011	0.0057	0.19
06/05/93	6.3	0.060	0.010	0.019	0.0030	0.32
06/09/93	12	0.23	0.019	0.0076	0.00062	0.03
06/20/93	17	0.84	0.049	0.46	0.026	0.54
09/27/93	6.6	1.4	0.21	0.91	0.14	0.65
10/03/93	5.1	0.40	0.078	0.23	0.045	0.58
10/19/93	34	0.50	0.015	0.30	0.0090	0.60
10/21/93	15	0.11	0.0073	0.035	0.0023	0.31
10/30/93	35	1.2	0.034	1.0	0.028	0.85
11/27/93	11	1.1	0.098	0.95	0.089	0.91

It is reasonable to expect that the degree of absorption or the stockpile absorption coefficient ($K_T = 1-K_R$) for a single storm event will be dependent on the moisture content and the degree of saturation of the stockpile prior to that event, which in turn will be dependent on the ambient air temperature, humidity and total rainfall prior to the subject storm. Given the highly variable nature of these meteorological parameters, the scatter observed in Figure 7-1 for a random set of storm events is understandable. The rainfall-runoff relationship depicted in Figure 7-1 was considered a reasonable approximation of average runoff coefficients that could be expected for meteorological conditions in the State of New Jersey.

The relationship presented in Figure 7-1 was used to estimate an expected annual runoff distribution by month from a bottom ash stockpile. This distribution, presented in Figure 7-2, was developed using five years of daily rainfall data collected at John F. Kennedy International Airport from 1989 through 1993. Average monthly rainfall quantities and total rainfall durations for each month provided the data for the calculation of mean monthly rainfall intensities. The monthly rainfall intensities were used in conjunction with the relationship presented in Figure 7-1 to project average monthly runoff coefficients (K_R). These average monthly runoff coefficients along with average monthly rainfall values were used to calculate average monthly stockpile runoff quantities. See Appendix D1 for a more detailed description and tabulation of the data used in this analysis.

The runoff distribution presented in Figure 7-2 facilitated estimation of the total average monthly volumetric loading from the monitored bottom ash stockpile. An examination of Figure 7-2 shows that higher values of K_R and hence greater runoff loadings can be expected to occur during the spring and summer season, when high intensity rainfall events are most frequent.

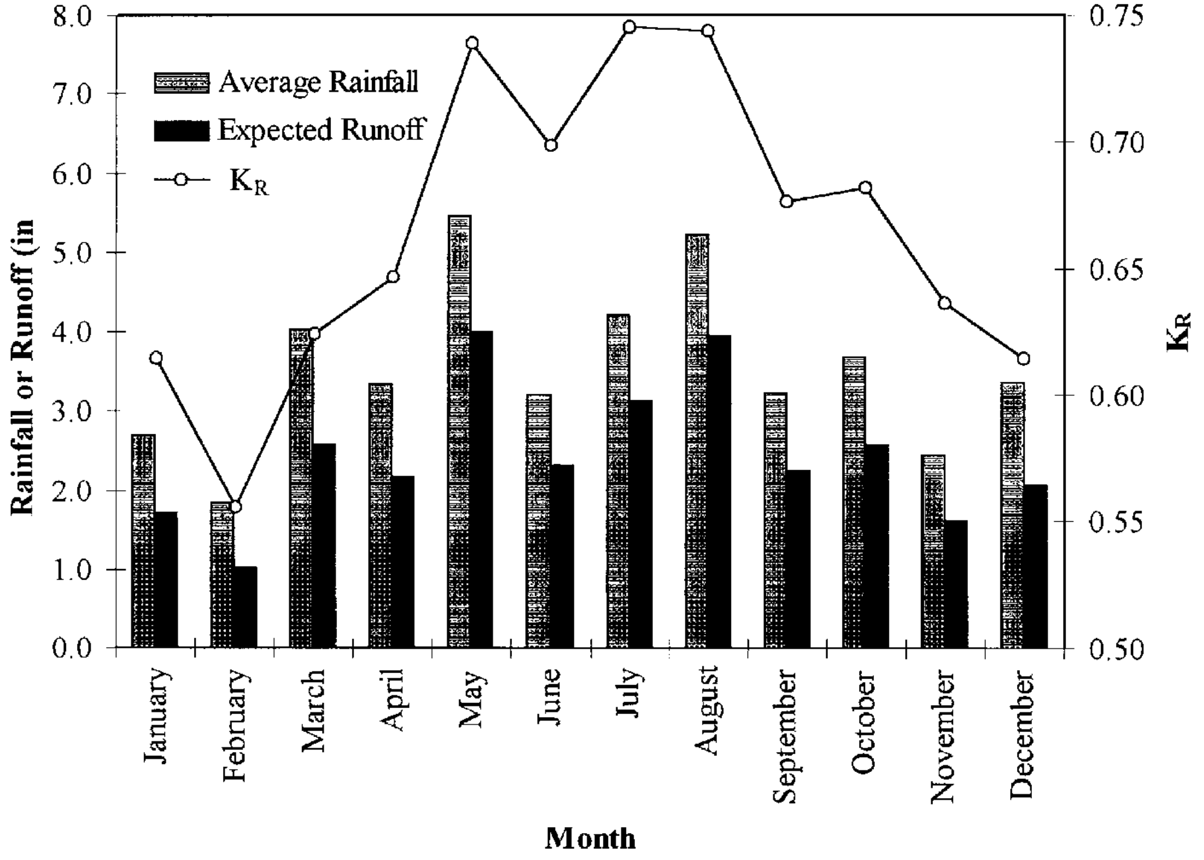


Figure 7-2

**EXPECTED BOTTOM ASH STOCKPILE
MONTHLY RUNOFF DISTRIBUTION**

7.2.2 Discharge Concentrations (C) - Soluble

During the course of the stockpile sampling program, runoff samples were collected for the soluble trace metals (Ag, Al, As, Ba, Be, Ca, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Se, Si, and Zn), total dissolved solids (TDS), alkalinity and pH analyses. The results of these analyses were presented in Section 4.5.

An evaluation of measured concentrations of the test parameters was undertaken to see whether any quantifiable relationship between elemental concentration data and first flush (initial runoff volume during a given rainfall event), rainfall intensity, rainfall duration or total rainfall could be identified. Such a relationship would have permitted the development of an annual concentration distribution, similar to the volumetric runoff distribution presented in Section 7.2.1. However, no consistent quantifiable relationship between concentration data and first flush, rainfall intensity, duration or total rainfall was observed.

Since no clear relationship between runoff concentration and rainfall could be identified, it was determined that average recorded runoff concentration data represented the current best estimate of expected elemental runoff concentrations from a bottom ash stockpile. Table 7-2 lists average runoff concentration data for all monitored events during the sampling program. It also indicates the upper 90 percent confidence limit (C_{90}) of the recorded data for each parameter, as well as the reference concentrations used in the groundwater and surface water assessments presented in Sections 7.3 and 7.4, respectively. To provide for a conservative projection of expected runoff concentrations, the soluble concentrations, represented by the upper 90 percent confidence limit (C_{90}) for each parameter, were used in the calculation of soluble mass discharge estimates from a bottom ash stockpile. Appendix D2 presents a graphical and tabular analysis of concentration data and C_{90} data as a function of rainfall.

7.2.3 Mass (Soluble) Source Discharge Loading (M)

Utilizing the calculations presented in Sections 7.2.1 and 7.2.2, it is possible to project the mass discharge of soluble metals or TDS from a bottom ash stockpile using the following relationship:

$$M = K_R IA \cdot C \cdot U$$

where,

M = mass discharge (g)

K_R = 0.1479 Ln (i) + 1.0131

i = average rainfall intensity (in/h)

I = rainfall (in)

A = area (m^2)

U = unit conversion factor, m/in = 0.0254, and

C = upper 90% confidence limit (C_{90}) soluble concentration (mg/L).

Using the volumetric runoff distribution presented in Figure 7-2 and the C_{90} concentrations presented in Table 7-2, a projected monthly mass loading distribution for each test parameter was calculated. Table 7-3 lists the estimated monthly loadings expressed in terms of grams released. These mass loading values (soluble)

Table 7-2

BOTTOM ASH STOCKPILE AVERAGE AND UPPER 90% CONFIDENCE LIMIT RUNOFF CONCENTRATIONS (mg/L)

Elements	Soluble		Total[1]		NJ GWQC[3]	Chronic NWQC[4]
	Avg	C90[2]	Avg	C90[2]		
Ag	0.010	0.010	0.010	0.010	-	0.0001
Al	0.17	0.28	2.1	3.0	0.20	0.75
As	0.0010	0.0010	0.0029	0.0038	0.01	0.19
Ba	0.065	0.076	0.087	0.105	2.0	-
Be	0.0028[5]	0.0038[5]	0.0031	0.0041	0.020	0.0053
Ca	172	194	241	327	-	-
Cd	0.0052[5]	0.0059[5]	0.0066	0.0084	0.004	0.0011
Cr	0.026[5]	0.029[5]	0.026	0.029	0.10	0.011
Cu	0.10	0.13	0.30	0.41	1.0	0.01
Fe	0.041[5]	0.049	0.48	0.67	0.30	-
Hg	0.001	0.001	0.001	0.001	0.002	0.000012
K	129	154	135	161	-	-
Mg	36	48	37	49	-	-
Mn	0.12	0.16	0.17	0.22	0.05	-
Na	386	459	392	469	50	-
Ni	0.049[5]	0.050[5]	0.053	0.056	0.10	0.160
Pb	0.056[5]	0.060	0.24	0.32	0.010	0.0032
Se	0.0015	0.0019	0.0021	0.0029	0.05	-
Si	1.0	1.2	1.9	2.5	-	-
Zn	0.11	0.14	1	1	5.0	0.110
Solids	2397	2759	3480	3911	500	-
Cl	664	771	-	-	250	-
SO_4	744	863	-	-	250	-

1. Total equals sum of the soluble and particulate fractions.
2. Represents the upper 90% confidence limit of the data (see Appendix D2).
3. NJ GWQC represents New Jersey Ground Water Quality Criteria (NJDEP, 1993).
4. Chronic NWQC represents chronic (3 year, 4 day) National Water Quality Criteria for the protection of freshwater aquatic organisms (USEPA, 1995).
5. Over 80% of the values used to calculate the average concentration were method detection limit values.

were used as source loadings for the groundwater and surface water impact evaluations presented in Sections 7.3 and 7.4, respectively.

7.2.4 Mass (Total) Source Discharge Loading

Total solids and total metal (soluble plus particulate) loadings were projected using the same approach that was outlined in Section 7.2.3, except that total solids and total metal data were used instead of soluble data. Average and C_{90} concentrations for total discharge concentrations are presented in Table 7-2. Table 7-4 presents

Table 7-3

ESTIMATED MASS (SOLUBLE) SOURCE DISCHARGE LOADING DISTRIBUTION

	Mass Release (g)												Total
	January	February	March	April	May	June	July	August	September	October	November	December	(g/yr)
Ag	0.15	0.09	0.22	0.19	0.35	0.20	0.27	0.34	0.20	0.22	0.14	0.18	2.6
Al	4.0	2.4	6.1	5.1	9.4	5.4	7.4	9.3	5.3	6.0	3.8	4.9	69
As[1]	0.015	0.009	0.022	0.019	0.035	0.020	0.027	0.034	0.019	0.022	0.014	0.018	0.25
Ba	1.1	0.7	1.7	1.4	2.6	1.5	2.0	2.5	1.4	1.6	1.0	1.3	19
Be[1]	0.06	0.03	0.08	0.07	0.13	0.08	0.10	0.13	0.07	0.08	0.05	0.07	1.0
Ca	2,799	1,694	4,242	3,557	6,613	3,816	5,183	6,524	3,706	4,225	2,628	3,409	48,396
Cd[1]	0.08	0.05	0.13	0.11	0.20	0.12	0.16	0.20	0.11	0.13	0.08	0.10	1.5
Cr[1]	0.42	0.26	0.64	0.54	1.00	0.58	0.79	0.99	0.56	0.64	0.40	0.52	7.3
Cu	1.9	1.1	2.9	2.4	4.5	2.6	3.5	4.4	2.5	2.9	1.8	2.3	33
Fe[1]	0.7	0.4	1.1	0.9	1.7	1.0	1.3	1.6	0.9	1.1	0.7	0.9	12
Hg	0.014	0.009	0.022	0.018	0.034	0.020	0.027	0.034	0.019	0.022	0.014	0.018	0.25
K	2,216	1,341	3,359	2,816	5,236	3,021	4,104	5,165	2,934	3,345	2,080	2,699	38,315
Mg	694	420	1,052	882	1,640	946	1,285	1,618	919	1,048	652	846	12,002
Mn	2.3	1.4	3.5	2.9	5.4	3.1	4.3	5.4	3.0	3.5	2.2	2.8	40
Na	6,623	4,007	10,038	8,416	15,648	9,029	12,264	15,437	8,768	9,997	6,218	8,067	114,512
Ni[1]	0.7	0.4	1.1	0.9	1.7	1.0	1.3	1.7	1.0	1.1	0.7	0.9	12
Pb[1]	0.9	0.5	1.3	1.1	2.0	1.2	1.6	2.0	1.1	1.3	0.8	1.1	15
Se	0.028	0.017	0.043	0.036	0.066	0.038	0.052	0.066	0.037	0.042	0.026	0.034	0.49
Si	17	10	26	22	41	24	32	40	23	26	16	21	300
Zn	2.0	1.2	3.0	2.5	4.6	2.7	3.6	4.6	2.6	3.0	1.8	2.4	34
Solids	39,821	24,094	60,355	50,605	94,085	54,291	73,743	92,816	52,722	60,111	37,385	48,507	688,535
Cl	11,120	6,728	16,854	14,132	26,273	15,161	20,593	25,919	14,723	16,786	10,440	13,546	192,275
SO_4	12,456	7,536	18,879	15,829	29,429	16,982	23,066	29,032	16,491	18,803	11,694	15,173	215,370

1. Over 80% of the values used to calculate the average concentration were method detection limit values.

Table 7-4

ESTIMATED MASS (TOTAL) SOURCE DISCHARGE LOADING DISTRIBUTION

	Mass Release (g)												Yearly Total (g/yr)
	January	February	March	April	May	June	July	August	September	October	November	December	
Ag	0.15	0.09	0.23	0.19	0.35	0.20	0.28	0.35	0.20	0.23	0.14	0.18	2.6
Al	44	26	66	56	103	60	81	102	58	66	41	53	758
As	0.054	0.033	0.082	0.069	0.128	0.074	0.101	0.127	0.072	0.082	0.051	0.066	0.94
Ba	1.5	0.9	2.3	1.9	3.6	2.1	2.8	3.5	2.0	2.3	1.4	1.8	26
Be[1]	0.06	0.04	0.09	0.08	0.14	0.08	0.11	0.14	0.08	0.09	0.06	0.07	1.0
Ca	4,717	2,854	7,149	5,994	11,145	6,431	8,735	10,994	6,245	7,120	4,428	5,746	81,714
Cd[1]	0.12	0.07	0.18	0.15	0.29	0.17	0.22	0.28	0.16	0.18	0.11	0.15	2.1
Cr[1]	0.42	0.26	0.64	0.54	1.00	0.58	0.79	0.99	0.56	0.64	0.40	0.52	7.4
Cu	5.9	3.6	9.0	7.5	14	8.1	11	14	7.8	8.9	5.6	7.2	102
Fe	10	5.9	15	12	23	13	18	23	13	15	9.1	12	168
Hg	0.014	0.0087	0.022	0.018	0.034	0.020	0.027	0.034	0.019	0.022	0.014	0.018	0.25
K	2,323	1,405	3,520	2,952	5,488	3,167	4,301	5,414	3,075	3,506	2,181	2,829	40,271
Mg	711	430	1077	903	1679	969	1316	1656	941	1073	667	866	12313
Mn	3.1	1.9	4.7	4.0	7.4	4.3	5.8	7.3	4.1	4.7	2.9	3.8	54
Na	6763	4092	10250	8594	15978	9220	12523	15763	8953	10208	6349	8238	117246
Ni[1]	0.81	0.49	1.2	1.0	1.9	1.1	1.5	1.9	1.1	1.2	0.8	1.0	14
Pb	4.6	2.8	7.0	5.9	11.0	6.3	8.6	10.8	6.1	7.0	4.4	5.7	80.40
Se	0.042	0.025	0.063	0.053	0.099	0.057	0.077	0.097	0.055	0.063	0.039	0.051	0.722
Si	36	22	55	46	85	49	67	84	48	55	34	44	627
Zn	11	7	17	14	27	15	21	26	15	17	11	14	194
Solids	56,436	34,147	85,536	71,719	133,339	76,942	104,510	131,541	74,718	85,191	52,983	68,744	978,855

1. Over 80% of the values used to calculate the average concentration were method detection limit values.

the resultant monthly solids and trace metal loadings. These mass loading values (total) were used as source loadings for the sediment and soil quality impact assessment presented in Section 7.5.

7.2.5 Stockpile Source Scenarios

As part of the groundwater and surface water assessment, four stockpile source conditions were selected for analysis. These four conditions represent stockpile locations consisting of 9, 25, 64 and 100 360 ton stockpiles. The numbers of stockpiles were selected so as to permit an evaluation of potential groundwater quality impacts at ash storage sites that would have sufficient capacity for approximately three to four months of processed bottom ash (BA) storage, given the range of BA production that would be expected at municipal waste combustors located in the State of New Jersey.

In New Jersey there are five operating municipal solid waste combustors generating approximately 1,700 tons of ash per day. Table 7-5 lists the New Jersey municipal solid waste combustors, their solid waste throughput capacities and their respective ash generation rates. It also lists the assumptions used to estimate bottom ash-aggregate production rates, the total quantity of processed BA produced each month, and the approximate number of 360 ton stockpiles of processed BA represented by the monthly output of each New Jersey WTE facility.

Table 7-5

NEW JERSEY ASH PRODUCTION (1994)

N.J. Facility	MSW (TPD)	Ash[1] (TPD)	Processed BA[2] (TPD)	BA Monthly Tons	# of 360 ton BA piles generated per month[3]
Camden	1050	315	195	5,940	17
Essex	2250	675	419	12,729	35
Gloucester	575	172	107	3,244	9
Warren	400	120	74	2,263	6
Union	1400	420	260	7,921	22
Total	5675	1702	1055	30,372	84

1. Total ash estimated = MSW × 0.3.
2. Processed BA = Ash × 0.62 (where 0.17 of ash was assumed to be ferrous metal, 0.15 fly ash and 0.05 oversize reject materials).
3. Number of 360-ton piles needed for monthly storage.

To determine the quantity of BA that could be generated at each New Jersey facility and used as an aggregate substitute material in road paving applications, it was assumed that the separation of the BA and fly ash (FA) fractions and the processing of the BA to remove oversize (plus 3/4-inch) materials and ferrous metal would result in the production of a BA aggregate fraction equivalent to approximately 62 percent of the total quantity of combined ash generated. This assumption was based on the relative quantities of bottom ash, fly ash and ferrous metal produced at the Warren County Resource Recovery Facility.

Table 7-6 lists the number of 360 ton stockpiles required to accommodate two, three and four months of storage capacity for each New Jersey facility. The list indicates that Camden, Essex, Gloucester, Warren and Union would require approximately 51, 105, 27, 18 and 66 360-ton stockpiles, respectively, to provide for approximately three months of storage.

Table 7-6

NUMBER OF BOTTOM ASH STOCKPILES NEEDED FOR SELECTED STORAGE CAPACITY[1]

N.J. Facility	Two Months Storage	Three Months Storage	Four Months Storage
Camden	34	51	68
Essex	70	105	140
Gloucester	18	27	36
Warren	12	18	24
Union	44	66	88

1. Number of 360-ton BA stockpiles.

7.3 GROUNDWATER QUALITY IMPACTS

Section 7.3 presents a description of the procedures used to project potential groundwater quality impacts resulting from bottom ash stockpile runoff and the results of the analysis.

7.3.1 Mass Loading Estimates

The mass loading from the stockpiling of bottom ash was estimated using the soluble mass loading distribution, presented in Section 7.2.3, as the base loading from each 360 tons of stockpiled ash. It was assumed for purposes of analysis that storage sites in excess of 360 tons, would consist of multiples of 360-ton piles. As a result, expected loadings from these sites were assumed to be directly proportional to the unit, 360-ton stockpile site. For example, 720 tons of ash or two 360-ton stockpiles were assumed to have a mass loading twice that of a 360-ton stockpile. This approach was used because all recorded field runoff and concentration data were based on the 360-ton stockpile that was monitored during the demonstration program. Since it is likely that 720 tons of stockpiled ash would normally be placed in one pile, thus exposing less surface area to rainfall than two 360-

ton piles, the multiple 360-ton pile approach used in this assessment provides a conservative estimate of the loading to groundwater.

7.3.2 Groundwater Impact Simulation

The analysis of groundwater quality impacts was undertaken using a three-dimensional groundwater flow model by Gayla (1987) to predict concentrations downgradient from a continuous horizontal planar source (HPS).

The HPS model requires the following input parameters:

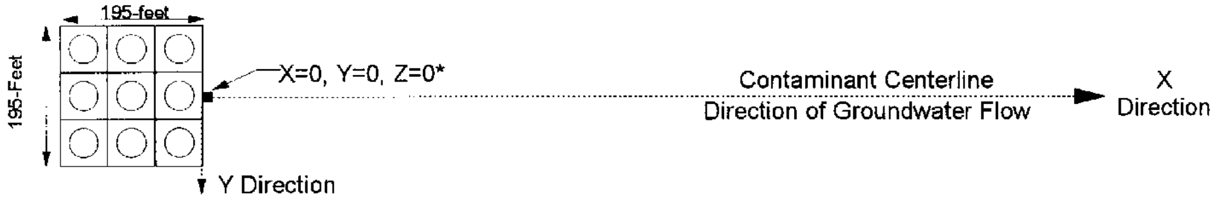
1. Source Parameters
    a. Number of sources
    b. Length, width and depth of source
    c. Contaminant release strength
2. Aquifer parameters
    a. Pore water velocity,
    b. Dispersivity,
    c. Pore space,
    d. Aquifer thickness
3. Contaminant properties
    a. Partition coefficient,
    b. Decay coefficient
4. Receptor locations, and
5. Time of estimation.

See Appendix D3 for additional discussions of the HPS model.

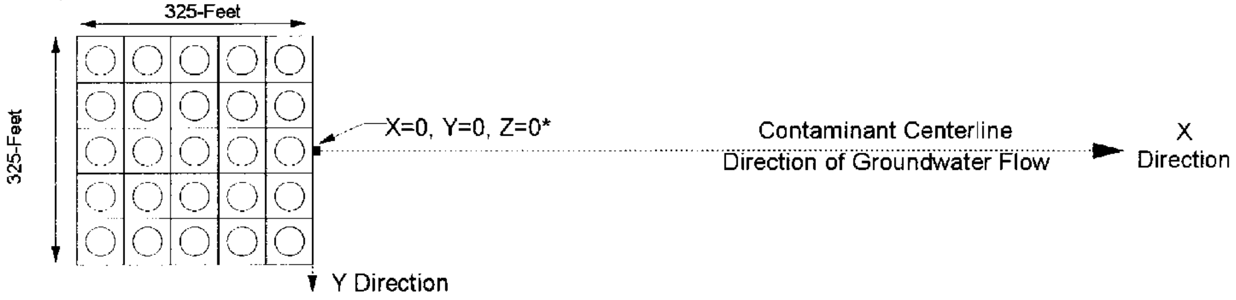
7.3.2.1 Source Parameters

As previously outlined, four different sized source areas containing 9, 25, 64 and 100 360-ton bottom ash stockpiles were modeled to estimate impacts of soluble trace metal and TDS release to groundwater. Each stockpile in the source areas was assumed to be of the same dimensions (i.e., encompassing a 65×65 square foot area) as the one monitored at the Warren County Landfill. Figure 7-3 illustrates the assumed areal arrangement of the four different source areas and the coordinate system used in each simulation. One side and center of the stockpile areal arrangement was modeled as the origin of the receptor grid (i.e., X = 0, Y = 0, and Z = 0, where X represents the longitudinal direction axis, Y represents the horizontal plane axis, and Z represents the vertical axis).

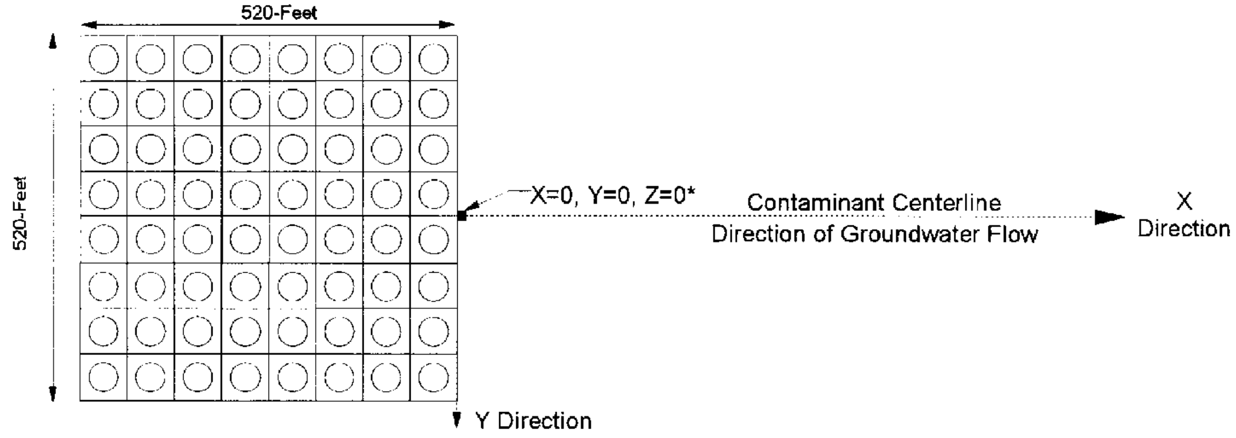
A) Nine 360 Ton Bottom Ash Stockpiles



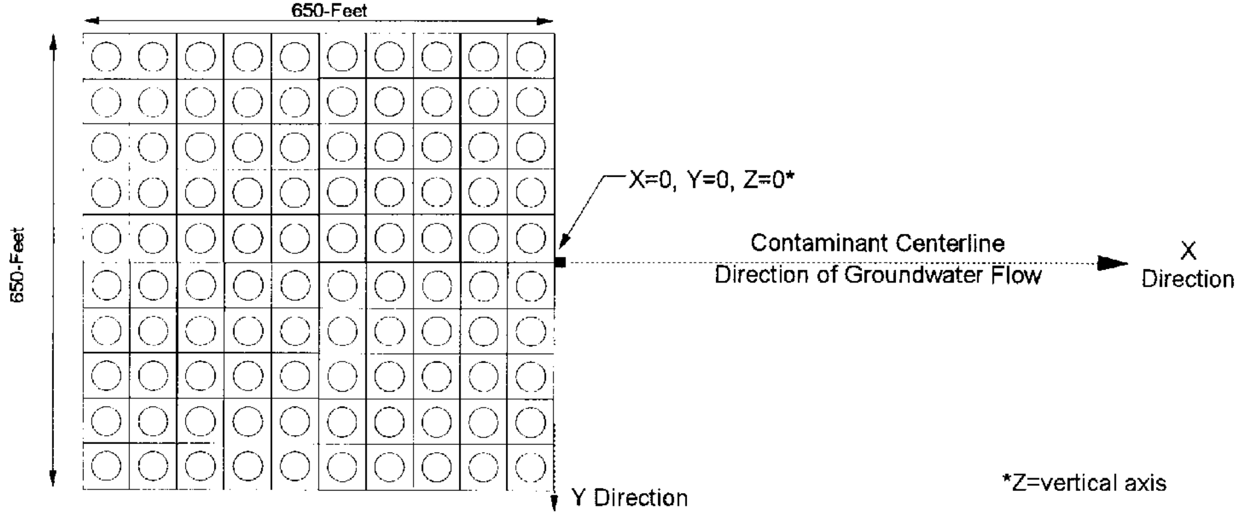
B) Twenty-five 360 Ton Bottom Ash Stockpiles



C) Sixty-four 360 Ton Bottom Ash Stockpiles



D) One Hundred 360 Ton Bottom Ash Stockpiles



*Z=vertical axis

Figure 7-3

GROUNDWATER IMPACT SIMULATION SOURCE CONFIGURATION

7.3.2.2 Aquifer Parameters

Aquifer parameters used in the assessment were obtained from two aquifer systems for which reported field data were available. These included systems in Warren County, New Jersey and Long Island, New York. The Warren County, New Jersey aquifer system parameters are typical of western New Jersey, with relatively low pore water velocities and correspondingly low dispersion coefficients. The Long Island aquifer parameters are typical of an upper glacial sandy aquifer, with relatively high pore water velocities in excess of 100 m/yr and correspondingly high dispersion coefficients. Table 7-7 lists the aquifer parameters used in the modeling effort. See Appendix D3 for a more detailed description of the data sources and derivation of the parameters.

Table 7-7

SUMMARY OF AQUIFER PARAMETERS

Parameter	Warren County, New Jersey	Long Island, New York
Pore Water Velocity (m/yr)	38	111
Porosity (decimal percent)	0.45	0.30
D_x(m^2/yr)	1,679	3,386
D_y(m^2/yr)	336	688
D_z(m^2/yr)	336	688
Aquifer Thickness (m)	15	30

NOTE: For a description of terms used in this table, see Appendix D3.

7.3.2.3 Contaminant Properties

Both retardation (contaminant partitioning) and decay were assumed to be equal to zero. The exclusion of potential soil partitioning effects of certain constituents (e.g., Pb) that are known to partition onto soil particles represents an extremely conservative assumption. However, use of this overly conservative assumption was considered justified since, to some extent, it may be representative of aquifer systems characterized by less favorable concentration-attenuating conditions (i.e., aquifer parameters) than those selected for use in this assessment.

7.3.2.4 Receptor Location and Time of Estimation

Receptors are the locations for which the model calculates groundwater contaminant concentrations. In order to assess potential groundwater impacts, receptors were located at 25 meter intervals from 25 to 2,000 meters from the source in the direction of the x axis. The time of estimation used in the analysis was 50 years, which was determined to be the time required to reach steady state conditions within 1000 meters of the source.

7.3.3 Groundwater Quality Simulation Results

The constituents of particular interest in this assessment were those for which the recorded source (stockpile) concentration exceeded New Jersey Groundwater Quality Criteria (see Table 7-2). This category included Al, Cd, Mn, Na, Pb, TDS, Cl and SO_4.

One modeling run using Warren County aquifer data and another using the Long Island aquifer data were undertaken in order to determine which aquifer system provided a more conservative aquifer scenario (i.e., resulted in higher downgradient contaminant concentrations). Due to the greater dispersion associated with the Long Island aquifer, the Warren County aquifer system simulation produced higher downgradient concentrations. See Appendix D4 for further discussion of these comparative modeling runs.

Figures 7-4 through 7-11 present the results of the Warren County aquifer groundwater modeling simulations for Al, Cd, Pb, Mn, Na, TDS, Cl and SO_4, respectively. Each figure includes the respective New Jersey groundwater quality standard. The results suggest that Pb, Na and TDS concentrations may warrant some concern. Lead (Pb) concentrations (see Figure 7-6) could possibly impact local groundwaters, particularly at large storage sites (i.e., 100 stockpiles). Sodium and TDS may be somewhat more problematic (see Figures 7-8 and 7-9). Bottom ash releases of Na could result in concentrations that exceed the New Jersey groundwater criterion at stockpile sites containing 25, 64 and 100 stockpile sites. The groundwater quality criterion for TDS is likely to be exceeded at large (i.e., 100 stockpile) sites.

7.4 SURFACE WATER IMPACT ASSESSMENT

Section 7.4 presents a description of the estimating procedures used to project the potential impacts of bottom ash stockpile runoff on surface water quality and the results of the analyses.

7.4.1 Mass Loading Estimates

Mass loading estimates used for the surface water assessment were the same as those used in the groundwater quality assessment, and were based on the mass (soluble) source discharge loading distribution from a 360-ton bottom ash stockpile (see Table 7-3). In the surface water assessment, however, it was further assumed that the critical surface water impact period would occur during a seven day, ten year low stream flow event that would most likely occur during the late summer to early fall period of August through October. Since the month of August represented the month with the second highest monthly mass release (see Table 7-3), an annual mass release based on the August release was assumed in the analysis (i.e., a mass release of 12 times the August mass release was used as the annual mass release).[1]

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[1] The highest monthly mass release occurred in May, which is only marginally higher than the calculated August release, but during a period (May) when a low stream flow is unlikely.

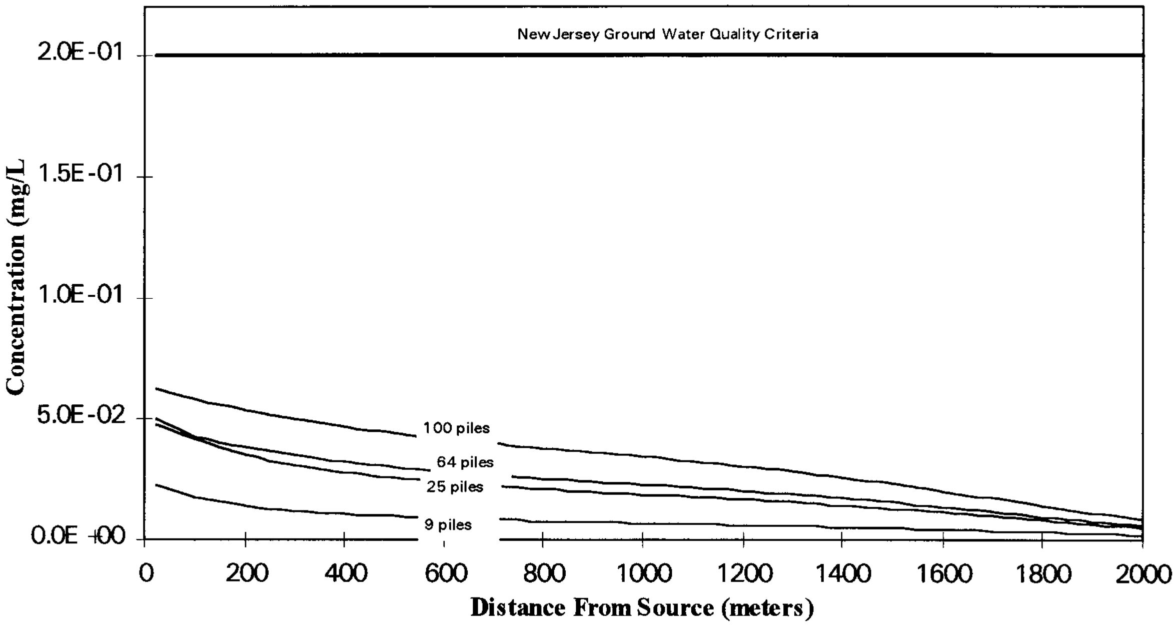

Figure 7-4
ALUMINUM GROUNDWATER MODELING RESULTS, WARREN COUNTY

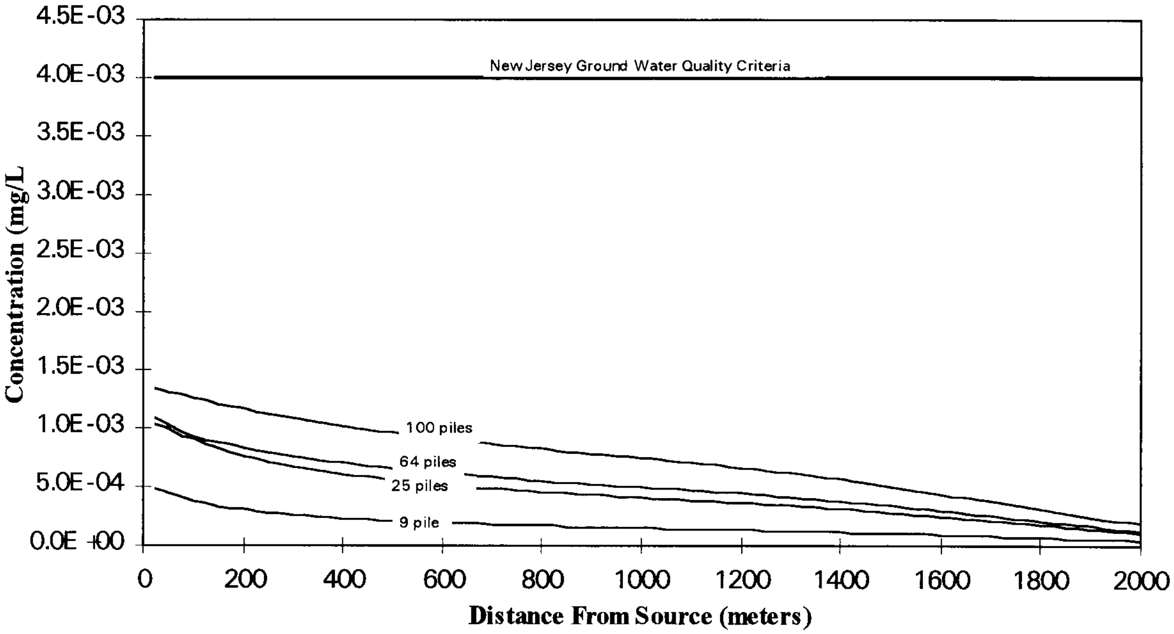

Figure 7-5
CADMIUM GROUNDWATER MODELING RESULTS, WARREN COUNTY

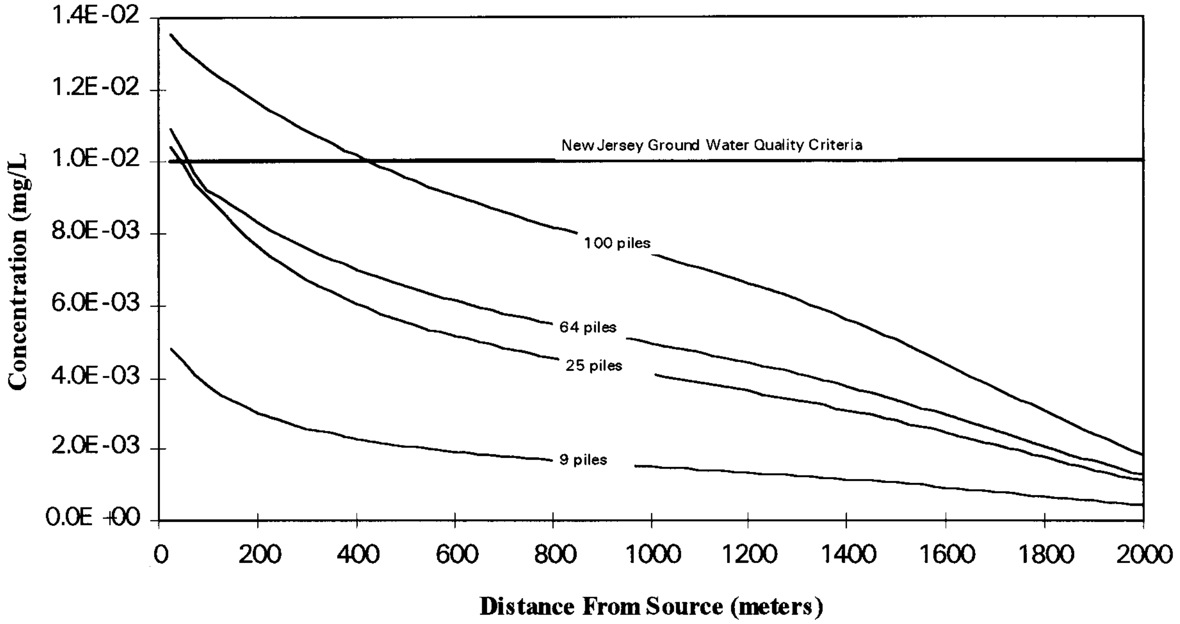

Figure 7-6
LEAD GROUNDWATER MODELING RESULTS
WARREN COUNTY

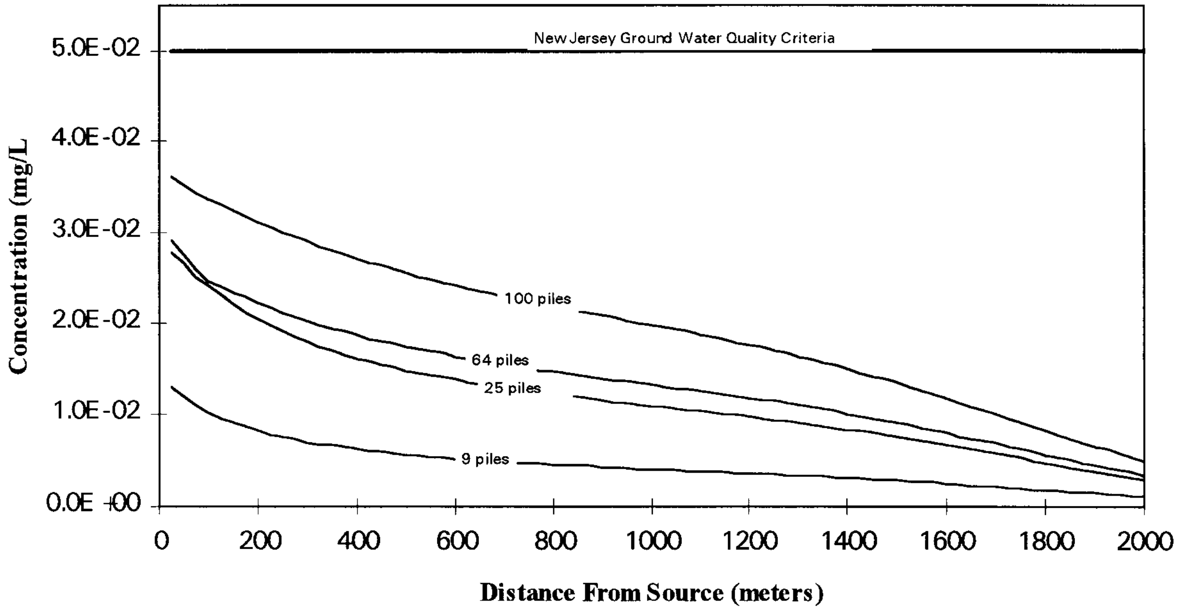

Figure 7-7
MANGANESE GROUNDWATER MODELING RESULTS
WARREN COUNTY

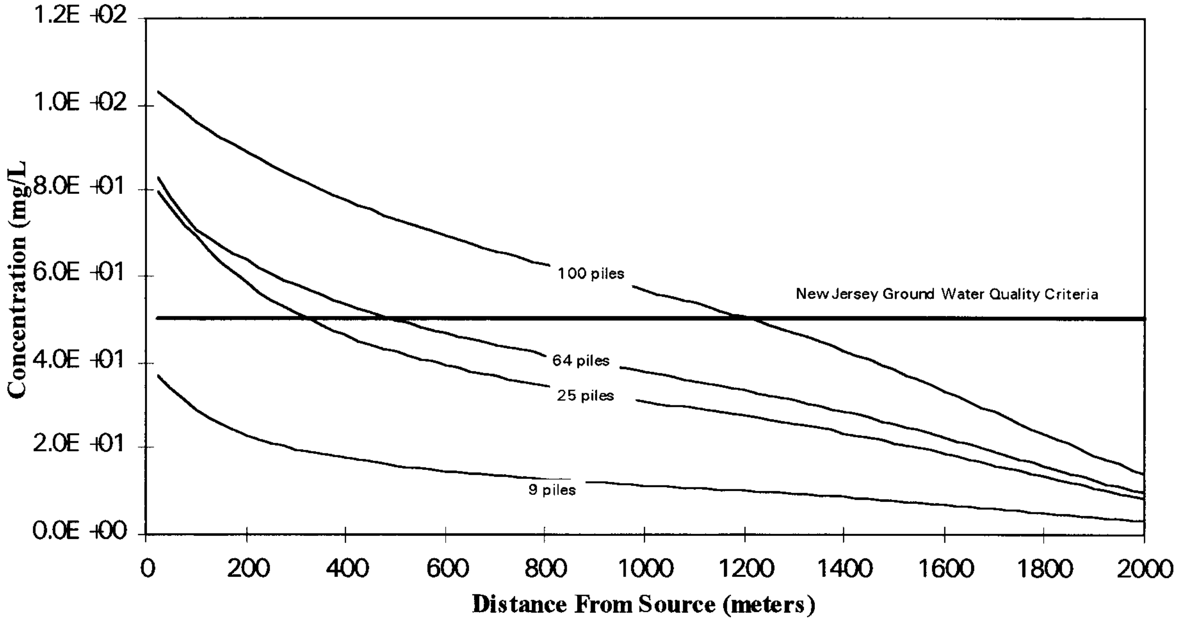

Figure 7-8
SODIUM GROUNDWATER MODELING RESULTS
WARREN COUNTY

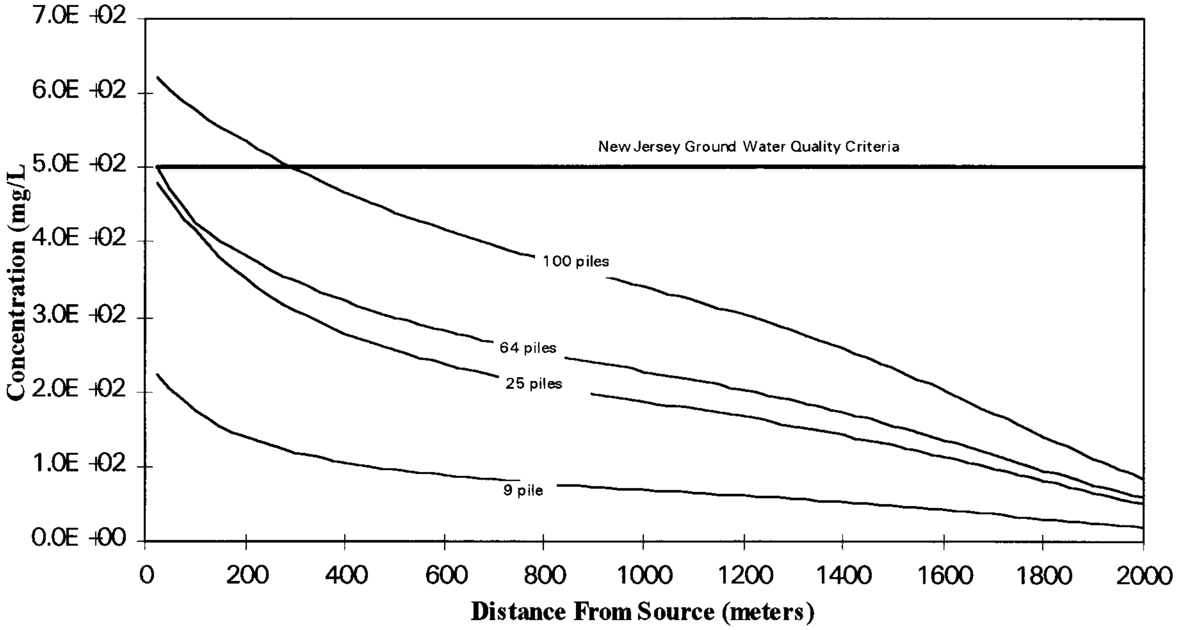

Figure 7-9
TDS GROUNDWATER MODELING RESULTS
WARREN COUNTY

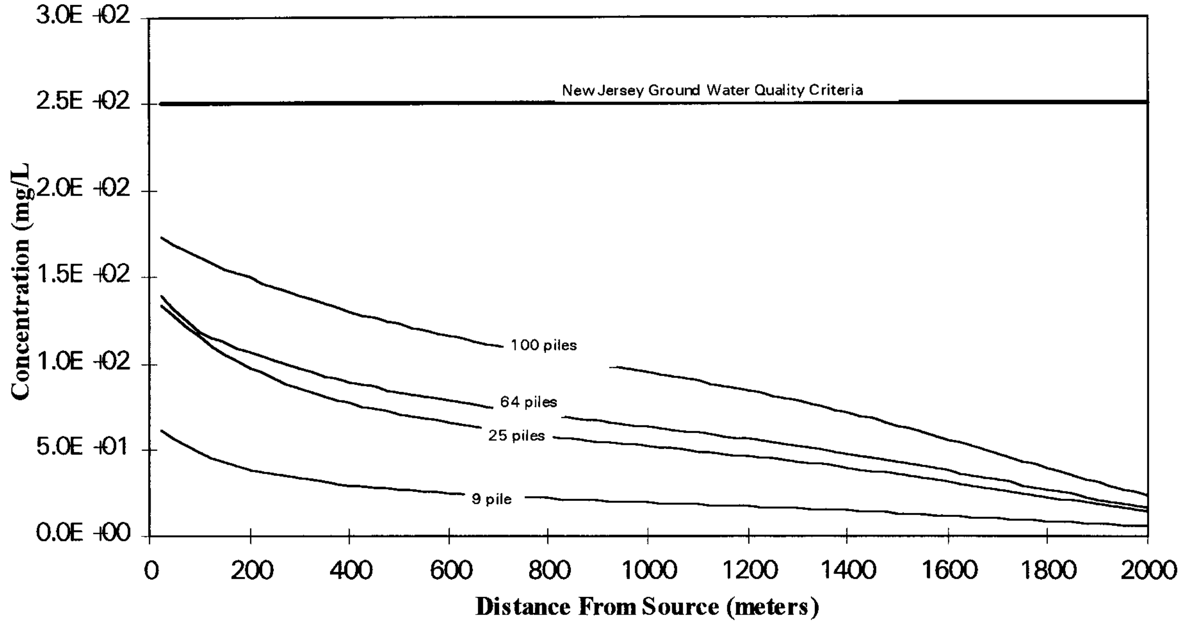

Figure 7-10
CHLORIDES GROUNDWATER MODELING RESULTS
WARREN COUNTY

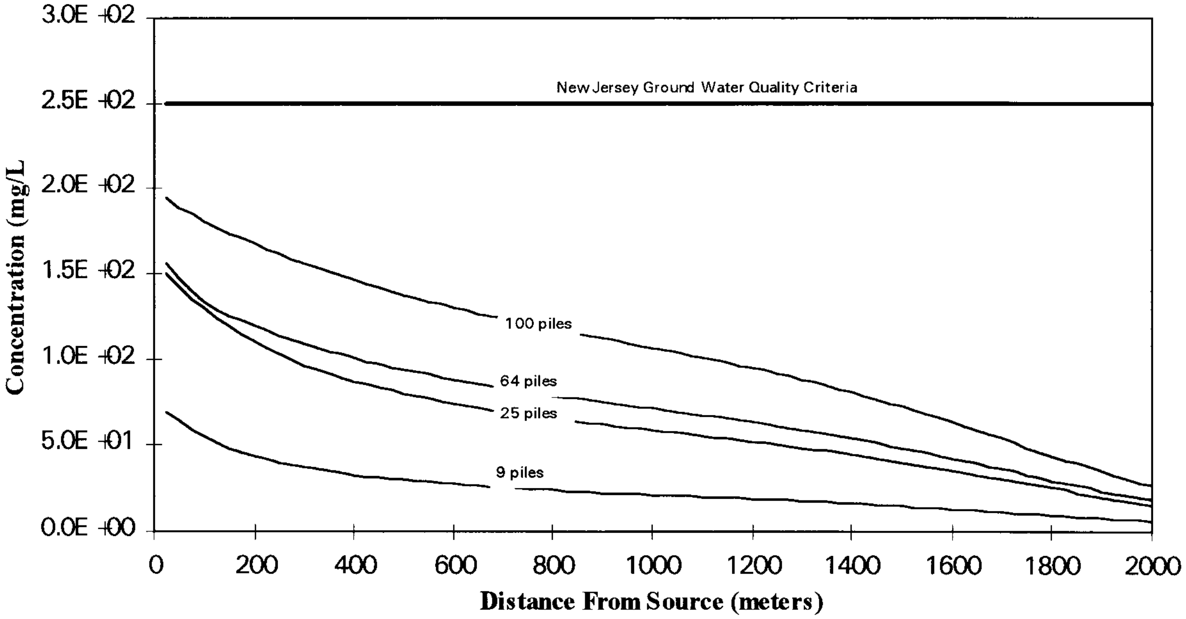

Figure 7-11
SULFATES GROUNDWATER MODELING RESULTS
WARREN COUNTY

7.4.2 Stockpile Source Scenarios

The multiple stockpile scenarios used for the surface water assessment were the same as those used in the groundwater assessment, presented in Section 7.3.2, and included storage areas containing 9, 25, 64 and 100 360-ton stockpiles.

7.4.3 Surface Water Impact Simulation

The USEPA (1988) suggests that impacts of point source pollutants on surface waters can be estimated by dividing the mass release per time for a given pollutant by the flow for the given surface water body as follows:

$$C = 1000\ M / (F_S + F_R)$$

where,

C = surface water pollutant concentration (mg/L),

M = mass release (g/yr),

F_S = surface water body flow (L/yr), and

F_R = source runoff flow (L/yr).

To facilitate the assessment of potential surface water quality impacts from the selected stockpile source areas, the suggested USEPA equation was rearranged and solved for stream flow required to reach a target reference concentration. This "reference" stream flow was calculated using the following relationship:

$$F_{SR} = (1000\ M/C_R) - F_R$$

where,

F_{SR} = reference stream flow (L/yr),

F_R = source runoff flow (L/yr),

M = mass release (g/yr), and

C_R = reference surface water concentration (mg/L),

Reference flows were calculated using the Chronic National Water Quality Criteria (NWQC) for fresh water aquatic organisms, as the reference concentration (C_R).

Table 7-2 provides a list of those bottom ash stockpile constituents of particular importance in the surface water impact analysis because of projected runoff concentrations in excess of NWQC. Included in this category were Cd, Cu, Cr, Pb, Hg and Ag. The relative importance of each of the listed trace metals was determined by calculating a reference Dilution Attenuation Factor (DAF), which was defined as follows:

$$DAF_R = F_{SR}/F_R.$$

The reference DAF as presented was used to project the relative quantity of stream flow to runoff required to achieve the reference flow rate. A low reference DAF implies the need for low dilution flow requirements for a receiving water relative to the stockpile runoff flow. A high DAF implies the need for high dilution receiving water flow requirements relative to the stockpile runoff flow (i.e., a more severe condition).

To further examine the potential severity of the impact of runoff from the bottom ash source areas, a review of low flow stream flow data in New Jersey, reported by the U.S. Geological Survey (USGS, 1982) for 407 gaging stations, was undertaken to determine the number of locations in New Jersey where the seven consecutive day, ten year low flow (MA7CD10) stream flow might be insufficient to reduce the concentration (C) of the stockpile runoff flow (F_R) to the reference surface water concentration flow (C_R). The NJDEP requires the use of MA7CD10 flow data to assess potential impacts associated with discharges to surface water streams (NJDEP, 1994). For a bottom ash stockpile source, the use of MA7CD10 low flow events as a sample stream flow rate is a highly conservative approach, since rainfall events are always associated with discharges from a stockpile source, and MA7CD10 low flow events during significant rainfall events are low probability events.

7.4.4 Surface Water Quality Simulation Results

Table 7-8 lists calculated reference flow (F_{SR}) values for each of the aforementioned elements and their respective DAFs. DAF values in Table 7-8 are the same for each stockpile source area, but reference stream flow requirements are higher for larger stockpile source areas. This is because the larger the source area the greater the runoff flow (F_R) and the greater the stream flow requirements (F_{SR}) to achieve the reference concentration.

The reference flow numbers and the DAF values presented in Table 7-8 seem to suggest that Hg and Ag would be the limiting elements with required DAFs of 62 and 84, respectively. Calculated reference flow and DAF values for Hg and Ag, however, were based on mass loadings that were projected by using minimum analytical detection levels (MDL) as respective source concentrations (i.e., Hg and Ag were not detected in the runoff samples at the MDL of the analytical procedure). As a result, it was determined that reference flows and DAFs associated with Hg and Ag cannot be regarded as good indicators of flow requirements.

More realistic reference flows and DAFs appear to be reflected in the Pb, Cu and Cd reference flows and DAF values, with Pb being the controlling parameter, having a DAF value of 15, and reference flow values ranging from 0.002 cubic meters per second (cms) for a nine stockpile source to 0.022 cms for a 100 stockpile source area.

Table 7-8

ESTIMATED REFERENCE FLOWS (F_{SR}) AND DILUTION ATTENUATION FACTORS (DAF) FOR BOTTOM ASH STOCKPILE RUNOFF RECEIVING WATERS

Parameter	STOCKPILES[1]				DAF[4]
	9	25	64	100	
	F_{SR} (cms)[2]				
Cd	0.00049	0.0014	0.0035	0.0054	3.6
Cu	0.0014	0.0038	0.010	0.015	10
Cr6	0.00017	0.0005	0.0012	0.0019	1.3
Pb	0.0020	0.0056	0.014	0.022	15
Hg[3]	0.0084	0.0234	0.060	0.094	62
Ag[3]	0.012	0.0320	0.082	0.13	84

1. Represents number of 360 ton bottom ash stockpiles.
2. F_{SR}=reference flows (see Section 7.4.3) cms=cubic meters per second.
3. Hg and Ag values are based on mass loadings projected by using minimum analytical detection limits as respective source concentrations.
4. DAF = Dilution Attenuation Factor (see Section 7.4.3).

Figure 7-12 depicts the frequency of occurrence of MA7CD10 low flows at 407 stream recording gage stations in New Jersey. Figure 7-12 also shows the range of reference flow rates (F_{SR}) for Pb from stockpile source areas ranging from nine stockpiles to 100 stockpiles. The graphical display indicates that 78 percent of the gaged sites in New Jersey would have MA7CD10 low flow rates sufficient to provide a DAF value of 15 or greater for a nine stockpile source area and 57 percent of the gaged sites, for a 100 stockpile source area.

These results suggest that although at the location of most gaged streams in New Jersey, MA7CD10 low flows would be sufficient to attenuate the projected stockpile source loadings, small drainage basins with low stream flows could potentially be susceptible to uncontrolled loadings from bottom ash stockpiles. As a result, consideration of site specific conditions at the stockpile source would be required to fully assess the magnitude of any potential receiving water body impact.

7.5 SEDIMENT/SOIL QUALITY IMPACTS

7.5.1 Mass Loading Estimates

Mass loading estimates used for the sediment quality assessment were based on the mass (total) source discharge unit loading distribution for a 360-ton bottom ash stockpile presented in Table 7-4. The use of total loadings (particulates plus soluble fraction), as presented in Table 7-4, represents a conservative approach when assessing the impact of the particulates on the environment, since it does not account for the inevitable loss of at least a portion of the soluble fraction of the particulate matter while in contact with the runoff.

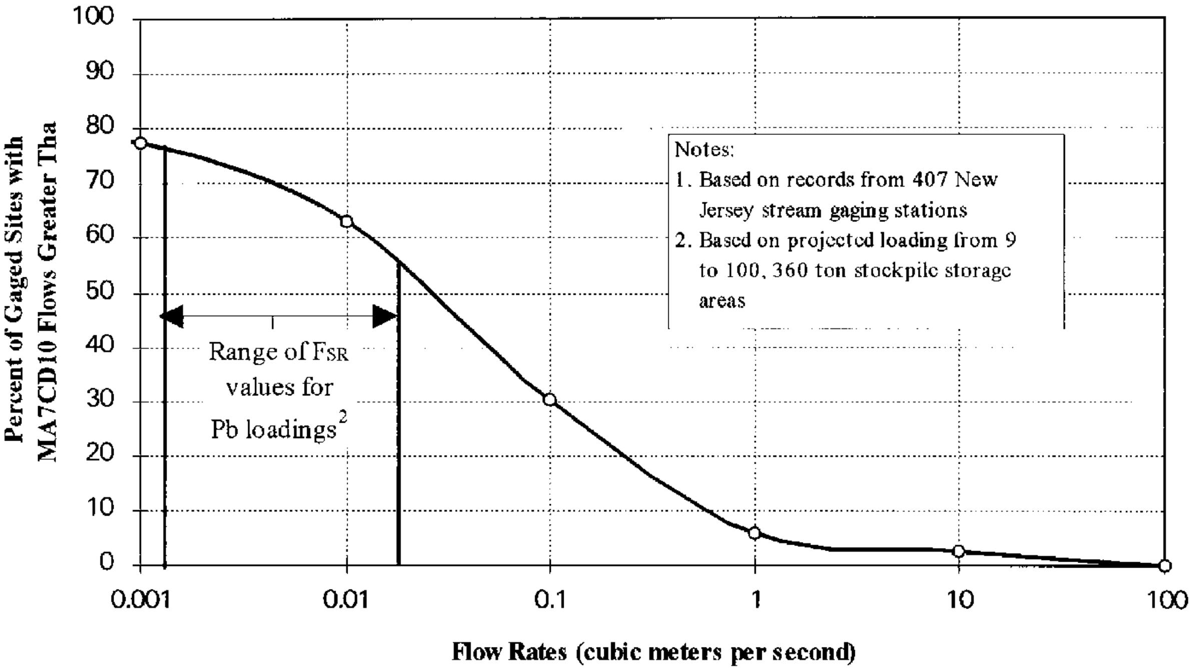

Figure 7-12

CUMULATIVE FREQUENCY DISTRIBUTION OF MA7CD10 LOW FLOW CONDITIONS IN NEW JERSEY[1]

7.5.2 Stockpile Source Scenarios

The scenarios used for the sediment impact assessment were the same as those used in the surface water assessment, presented in Section 7.4.2, which included storage areas containing 9, 25, 64 and 100 360-ton stockpiles. The scenario used for the soil quality assessment included soil quality impacts from the runoff of one 360 ton pile.

7.5.3 Sediment Quality Simulation

Particulate runoff from a bottom ash stockpile poses special assessment difficulties because of the site specific nature of projected loadings and the exposed environment. The distance a particle might be transported during any one rainfall event will depend on the size, shape and specific gravity of the particle, the intensity and duration of the rainfall event, and the geometry of the pile, the site and the topography of the surrounding terrain. The potential impacts associated with transported particles will depend on the interim and final locations at which these particles may be deposited. If they are transported directly to a receiving water body (e.g., stream or lake), then they could affect the quality of the sediment and the benthic ecosystem. With time, and depending on the nature of the benthic environment, particles may continue movement downgradient or may become buried by additional deposition. Trace elements present in the ash may also repartition back into the water column. If the particles do not reach a receiving water body, they may be transported to land environments adjacent to the stockpile storage site where they may accumulate and impact local soil quality.

The magnitude of potential sediment impacts resulting from the mass (total) loadings associated with the aforementioned scenarios was calculated using a simple mass balance model to determine the estimated annual trace metal increases in sediment trace metal concentrations in a selected control volume. This annual increase in sediment trace metal concentrations was compared to both New Jersey draft soil cleanup standards for residential and non-residential areas and New York sediment guidance criteria.

The selected control volume was assumed to be a 25 m by 25 m area. The selection of a control area of this approximate size assumes that all particulate matter would eventually deposit at this one, relatively small location with no post deposition scouring or subsequent burial of the ash particles by additional sediment from other sources. The particles were assumed to mix evenly within the top 2.54 cm (i.e., one inch) of soil or sediment. The following equation was used to calculate the annual sediment loading from the total mass release values:

$$C_T = 1{,}000{,}000M / \rho AD$$

where,

C_T = annual increase in sediment concentration (μg/g),

M = mass release of particulate constituents (g/yr),

ρ = density of sediment (1,600,000 g/m^3),

A = area of deposition (625 m^2), and

D = depth of sediment mixing (1 inch or 0.025 m).

Table 7-9 presents the results of this assessment for all constituents measured in the total runoff fraction generated from one 360-ton stockpile. The table also lists New Jersey soil cleanup standards for residential and non-residential soils (NJDEP, 1994) and New York State sediment quality guidance criteria (NYSDEC, 1992). Of the three sets of criteria listed in Table 7-9, the New Jersey residential soil standards are the most stringent and were therefore selected as the reference standard for the assessment. For purposes of analysis, a relative annual loading (RAL) was defined and calculated as follows:

$$RAL = C_T / \text{Reference Soil Standard.}$$

The RAL value provided a way to compare the relative significance of the potential sediment impact associated with each constituent analyzed and to select the controlling element. RAL values for each element for which New Jersey soil standards were available are presented in Table 7-9. On the basis of the data presented, Cd and Pb are the controlling elements with RAL values of 0.084 and 0.032, respectively.

Table 7-9

ESTIMATED ANNUAL INCREASE IN SEDIMENT ELEMENTAL CONCENTRATION FOR ONE STOCKPILE FOR SELECTED 25M BY 25M CONTROL AREA

Parameter	Total Mass Release[1] (g/yr)	Annual Increase in Sediment Concentration[2] (µg/g/yr)	Standards or Guidelines			Relative Annual Load (1/yr)
			NJ Soil Criteria		NY Soil/ Sediment (µg/g)	
			Res. (µg/g)	Non-Res. (µg/g)		
Ag	2.6	0.10	40	2000	200	0.0026
Al	758	30	-	-	-	-
As	0.94	0.038	-	-	-	-
Ba	26	1.0	600	26000	4000	0.0017
Be	1.0	0.041	2	2	0.16	0.021
Ca	81,714	3269	-	-	-	-
Cd	2.1	0.084	1	100	-	0.084
Cr	7.4	0.29	-	-	-	-
Cu	102	4.1	600	600	-	0.0068
Fe	168	6.7	-	-	-	-
Hg	0.25	0.010	14	260	20	0.00072
K	40,271	1,611	-	-	-	-
Mg	12,313	493	-	-	-	-
Mn	54	2.2	-	-	2000	0.0011
Na	117,246	4,690	-	-	-	-
Ni	14	0.57	250	2400	500	0.0023
Pb	80	3.2	100	600	-	0.032
Se	0.72	0.029	1	1	-	0.029
Si	627	25	-	-	-	-
Zn	194	7.8	1500	1500	-	0.0052
Solids	978,855	39,154	-	-	-	-

1. Values are upper 90% confidence limits (see Table 7-4).
2. Annual increase was calculated by assuming all particulates settled within a 25m by 25m area and were mixed in the top 1 inch of sediment. The sediment was assumed to have a density of 1,600,000 g/m^3.

It is of interest that the inverse of the RAL value (RAL^{-1}) represents the number of years that it would take for the selected control areas to reach the reference standard, based on the projected particulate loading. Given the RAL values for Cd and Pb, the Cd reference standard could be reached in approximately 12 years and the Pb reference standard could be reached in approximately 30 years.

Figure 7-13 provides a graphic representation of the influence of control volume size (i.e., deposition area dimensions) and stockpile source areas on RAL values and RAL^{-1} values using cadmium as the controlling element. An examination of the 25 m by 25 m control area curve presented in Figure 7-13 indicates that if particulate runoff from an ash stockpile source were permitted to accumulate in small control areas, then potential soil or sediment quality impacts could occur. This is a particular problem with increasing source area sizes. Larger control areas, however, as shown by the 100 m by 100 m curve are less susceptible to potential sediment quality impacts.

It is apparent that potential impacts from uncontrolled particulate runoff from a bottom ash stockpile site will be dependent on site specific conditions at both the source area and the receiving or deposition area, both of which will require consideration in the design of stockpile storage sites.

7.5.4 Soil Quality Simulation

If runoff from a bottom ash stockpile seeps into the ground, it is expected that a large fraction of some soluble trace metals present in runoff (e.g., lead and cadmium) will partition onto soil particles as the runoff percolates through the soil.

The magnitude of potential impacts to soil quality resulting from the partitioning of trace metals onto soils adjacent to a bottom ash stockpile was calculated by using a simple mass balance model, similar to the model used in the sediment quality assessment, to determine the estimated annual increase in trace metal concentrations in a selected control volume. This annual increase in trace metal concentration was compared to New Jersey draft soil cleanup standards for non-residential areas.

It was assumed in the assessment that 100 percent of the soluble trace metal loadings in the runoff would be absorbed onto soil particles present in the top 15.2 cm (i.e., 6 inches) of soil and that the exchange capacity of the soil is unlimited. This is a highly conservative assumption given the expected reduction in soil exchange capacity that is likely to occur with increasing trace metal concentrations. The selected control area was assumed to be an area represented by a distance of five meters from the circumference of a 360-ton stockpile, that has a diameter of 12 meters. The following equation was used to calculate the annual soluble metal loading to the top 15.2 cm of soil:

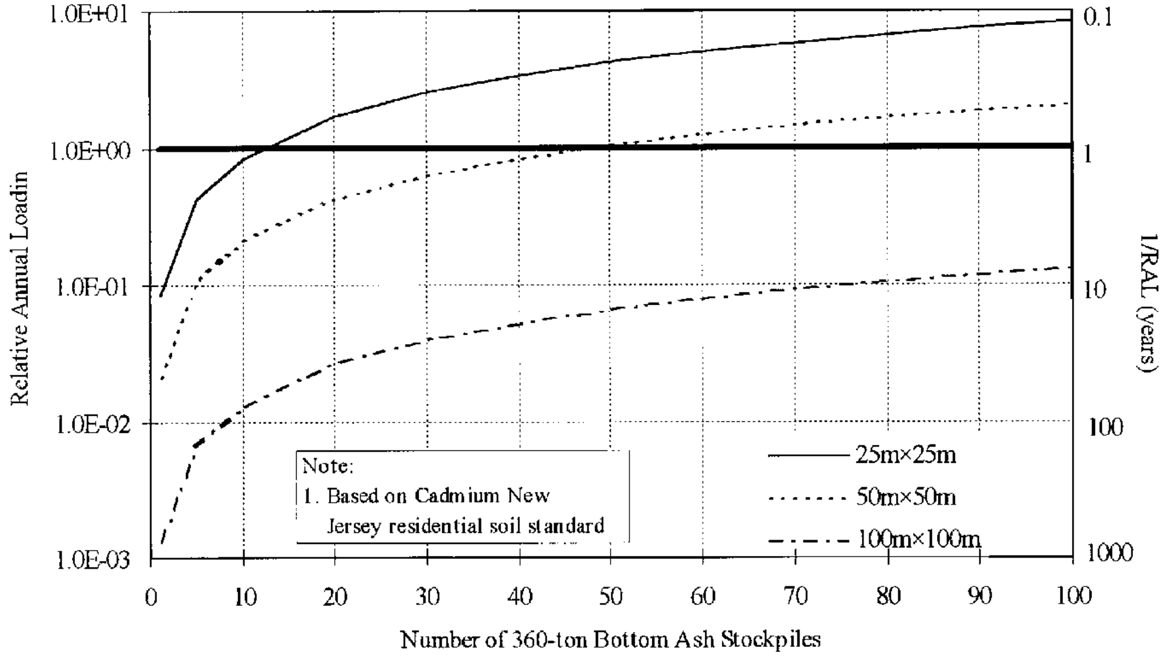

Figure 7-13

RELATIVE ANNUAL LOADING IN SEDIMENTS WITH SELECTED CONTROL AREAS AND STOCKPILE SOURCE AREA[1]

$$C_S = 1{,}000{,}000\ M_S/\rho AD$$

where,

C_S = annual increase in soil concentration (μg/g),

M_S = mass release of soluble constituents (g/yr),

ρ = density of soil (1,600,000 g/m^3),

A = area of seepage (267 m^2),

D = depth of soil impact (6 in or 0.15 m).

Table 7-10 presents the results of this assessment for all the constituents measured in the runoff, generated from one 360-ton stockpile. The results presented in Table 7-10 depict a RAL value (similar to that presented in Table 7-9 and explained in Section 7.5.3) where

$$RAL = C_S/\text{Reference Soil Standard}$$

On the basis of the data presented in Table 7-10, selenium (Se) and beryllium (Be) appear to be the controlling elements with RAL values of 0.0076 and 0.0075, respectively. Given the RAL values for Se and Be, the Se reference standard would be reached in approximately 132 years and the Be reference standard in approximately 134 years. It would take approximately 2500 and 4400 years, respectively, for lead and cadmium concentrations in the soil to reach the reference soil standards.

Given these results, it is unlikely that soil quality at a bottom ash stockpile site will be measurably impacted by trace metal partitioning when measured against non-residential soil cleanup standards. Given the much more stringent New Jersey residential cleanup standards (presented in Table 7-10), trace metal partitioning in residential soils could be a potential concern.

Table 7-10

ESTIMATED ANNUAL INCREASE IN SOIL ELEMENTAL CONCENTRATION FOR ONE STOCKPILE

Parameter	Total Mass Release[1] (g/yr)	Annual Increase in Soil Concentration[2] (μg/g/yr)	Standards or Guidelines			Relative Annual Load (1/yr)
			NJ Soil Criteria		NY Soil/ Sediment (μg/g)	
			Res. (μg/g)	Non-Res. (μg/g)		
Ag	2.6	0.04	40	2000	200	0.000020
Al	69	1.1	-	-	-	-
As	0.25	0.004	-	-	-	-
Ba	19	0.3	600	26000	4000	0.000011
Be	1.0	0.015	2	2	0.16	0.0075
Ca	48,396	756	-	-	-	-
Cd	1.5	0.02	1	100	-	0.00023
Cr	7.3	0.11	-	-	-	-
Cu	33	0.5	600	600	-	0.00085
Fe	12	0.2	-	-	-	-
Hg	0.25	0.004	14	260	20	0.000015
K	38,315	598	-	-	-	-
Mg	12,002	187	-	-	-	-
Mn	40	0.6	-	-	2000	0.00031
Na	114,512	1788	-	-	-	-
Ni	12	0.2	250	2400	500	0.000081
Pb	15	0.2	100	600	-	0.00039
Se	0.49	0.008	1	1	-	0.0076
Si	300	5	-	-	-	-
Zn	34	0.5	1500	1500	-	0.00035
Solids	688,535	10749	-	-	-	-
Cl	192,275	3002	-	-	-	-
SO4	215,370	3362	-	-	-	-

1. Values are upper 90% confidence limits (see Table 7-3)
2. Annual increases were calculated by assuming all dissolved runoff partitioned to the soil within 5 meters of the stockpile and was mixed in the top 1-inch of soil. The soil was assumed to have a density of 1,600,000 g/m^3.

Section 8

AMBIENT AIR QUALITY, SOIL QUALITY AND WORKER ENVIRONMENT ASSESSMENT

Section 8 describes the methods used to evaluate potential impacts associated with fugitive dust emissions from bottom ash stockpile sites. Section 8 is divided into five subsections. Section 8.1 summarizes the general evaluation methodology used in the assessment. Section 8.2 describes the stockpile emission (source) model selected and the procedures used to calibrate the model. Section 8.3 discusses the ambient air environment simulations and the results of the simulations; Section 8.4, the soil environment simulations and the results; and Section 8.5, the worker environment simulations and the results.

8.1 GENERAL EVALUATION METHODOLOGY

For the purpose of the evaluation, USEPA AP-42 fugitive dust emission factor equations (USEPA, 1985, 1988, 1991) were used to estimate fugitive dust emission rates from the bottom ash (BA) stockpile. The emission factor equations were used to predict potential total suspended particulate (TSP), and respirable or minus 10 micron particulate (PM_{10}) emissions from stockpile storage sites. Trace metal emissions were projected based on measured trace metal concentrations in minus 30 micron and minus 10 micron sized bottom ash particles.

Impacts to the ambient air and soil environments were evaluated using an USEPA ambient air dispersion model to project increases in TSP, PM_{10}, and trace metal ambient air concentrations, and trace metal soil concentrations. Estimates of trace metal soil concentrations were based on particle deposition and surface reflection rates available for use with the air dispersion model. Impacts to the worker environment were evaluated using a simplified worker area control volume model to calculate expected increases in TSP, PM_{10} and trace metal control volume concentrations.

To assess the significance of potential ambient air quality impacts, estimated increases in TSP, PM_{10} and trace metal concentrations were compared to USEPA (USEPA, 1991) and New Jersey Ambient Air Quality Standards (NJDEP, 1992). New Jersey non-residential soil quality cleanup standard concentrations (NJDEP, 1994) were used as reference concentrations in evaluating the significance of potential soil quality impacts. Occupational Safety and Health Administration (OSHA) standards (USEPA, 1988) were used to determine the relative magnitude of projected impacts on the worker environment.

8.2 BOTTOM ASH STOCKPILE DUST EMISSION SOURCE MODEL

The USEPA has developed dust emission factor equations for a number of unit operations associated with the handling, processing and storage of aggregate and sand-like materials (USEPA, 1985 and USEPA, 1988). Many of the unit operations for which equations have been defined are similar to unit operations associated with the stockpiling of bottom ash. These include dropping of aggregate from a payloader or conveyor, payloader and vehicular movement over unpaved roads, and aggregate-pile wind erosion. Section 8.2 discusses these unit operations, their respective emission factor equations, and the methods used to adjust these equations for use in the bottom ash source model.

8.2.1 Emission Factor Equations

Table 8-1 lists the relevant USEPA unit operation emission factor equations used to project dust emissions from a bottom ash stockpile site.

Equation 1, the Batch Drop Equation, expresses dust emissions in terms of kilograms per metric ton of material handled. Releases are expressed as a function of wind speed and moisture content. The Batch Drop equation was used in the emission source model to simulate unloading of bottom ash at the stockpile site (i.e., dropping from a truck), and loading of the bottom ash from the stockpile onto a truck for transport to its final point of use as construction aggregate.

Equation 2, the Unpaved Roadway Emission Equation, expresses particulate emissions from an unpaved roadway surface (assumed to be similar to an ash stockpile area) in terms of kilograms (Kg) per vehicle kilometers traveled (VKT). The emission rate is expressed as a function of percent silt content (i.e., minus 75 micron particles) on the roadway surface, mean vehicle speed, mean vehicle weight, mean number of wheels, and rainfall frequency. The Unpaved Roadway Emission Equation was used in the emission source model to simulate front end loader and truck movement on the stockpile site.

Equations 1 and 2 have provisions for estimating either a TSP (minus 30 micron particulate emissions) or PM_{10} emissions. This is accomplished by varying the function k, the aerodynamic particle size multiplier (USEPA, 1985 and USEPA, 1988). The aerodynamic particle size multiplier is a dimensionless constant that adjusts the emission factor for expected releases of particles within selected size ranges.

Equation 3, the TSP Wind Erosion Equation, expresses TSP dust (minus 30 micron diameter particulate emissions) in terms of pounds per acre per day and is presented as a function of the silt content (minus No. 200 or 75 micron sieve size), precipitation frequency, and wind speed.

Equation 4, the PM_{10} Wind Erosion Emission Equation, expresses PM_{10} (minus 10 micron diameter particulate emissions) in terms of grams per square meter per hour and is presented as a function of the fraction of pile exposed, an annual average wind speed, a threshold wind speed (particulate suspension threshold speed) and dimensionless parameters that are dependent on the particle size of the bottom ash (USEPA, 1985).

Table 8-1
USEPA AP-42 EMISSION FACTOR EQUATIONS

1. Batch Drop Equation (USEPA, 1985)

$$E = k(0.0016)(U \div 2.2)^{1.3} \div (M \div 2)^{1.4}$$

where;

E= Emissions (Kg/Mg)
k= Particle size multiplier
U= Mean wind speed (m/s)
M= Moisture content (%)

2. Unpaved Roadway Equation (USEPA, 1985)

$$E = k(1.7)(S \div 12)(V \div 48)(W \div 2.7)^{0.7}(N \div 4)\left(\frac{D - P}{D}\right)$$

where;

E= Emissions (Kg/vehicle kilometer traveled)
k= Particle size multiplier
S= Silt content (%)
V= Mean vehicle velocity (m/s)
W= Mean vehicle weight (Mg)
N= Mean number of wheels
D= Days in Analysis
P= Days in Analysis with rainfall >0.54mm

3. TSP Wind Erosion Equation (USEPA, 1985)

$$E = k(1.7)(S \div 1.5)(F \div 15)\left(\frac{365 - P}{235}\right)$$

where;

E= Emissions (lb/ac/day)
k= Particle size multiplier
S= Silt content (%)
P= Days per year with rainfall >0.54mm
F= Time wind exceeds 12 mph (%)

4. PM_{10} Wind Erosion Equation (USEPA, 1991)

$$E = 0.036(1 - V)(U_M \div U_T)^3 0.18(8x^3 + 12x)e^{-x^2}$$

where;

E= Emissions ($g/m^2/h$)
U_M= Mean wind velocity (m/s)
U_T= Threshold wind velocity (m/s)
V= Vegetative cover (%)
X= 0.886(UT÷UM)

Both Wind Erosion Emission equations (Equations 3 and 4) were used in the emission source model to simulate wind erosion effects during bottom ash storage.

The following is a detailed description of the procedure used to calculate expected emissions using Equations 1 through 4, presented in Table 1.

Batch Drop Equation

The total qualtity of emissions, expressed in terms of grams, was calculated by multiplying the Equation 1 emission factor (E) by the total metric tons of material handled. The total quantity of material handled was based on the stockpile source scenario modeled (see Section 8.2.3). The emissions were then converted to grams per second by dividing the total emissions in grams by the seconds in an 8 hour work day (28,800 seconds/8 hours).

Unpaved Roadway Equation

The total quantity of emissions, expressed in terms of grams, was calculated by multiplying the Equation 2 emission factor (E) by the total vehicle kilometers traveled. Travel distance was based on the specific stockpile source scenario modeled (see Section 8.2.3). Total vehicle kilometers traveled in one day was based on the number of trips necessary for a 3 ton front end loader to carry the quantity of ash processed in a single day, multiplied by the length of one side of the square stockpile area (see Table 8-2).

TSP Wind Erosion Equation

The total quantity of emissions, expressed in terms of grams per second, was calculated by multiplying the Equation 3 emission factor (E) by the exposed surface area of the stockpiles and by dividing by the number of seconds in one day; and by converting the units of pounds to grams. The area of the stockpile used in the calculation was based on the stockpile source scenario modeled (see Section 8.2.3).

PM_{10} Wind Erosion Equation

The total quantity of emissions, expressed in terms of grams per second, was calculated by multiplying the Equation 4 emission factor (E) by the exposed surface area of the stockpiles and dividing by the seconds in one hour. The area of the stockpile used in the calculation was based on the stockpile source scenario modeled (see Section 8.2.3).

8.2.2 Moisture Content Adjustment Factors

USEPA AP-42 emission factor equations were developed from data obtained using sand-like materials with a moisture content of approximately three percent (USEPA, 1985, 1988). Of the four emission factor equations presented in Table 8-1, only Equation 1 provides an adjustment for moisture content, where dust emissions are shown to be inversely related to the moisture content to a power of 1.4. In Equations 2, 3 and 4 moisture content is not directly included as a variable. In Equation 2 moisture content is indirectly addressed by the term for frequency of rainfall. Equation 2, the unpaved road emission factor, provides a term [(D-P)/D] that reduces the annual average release of emissions as a function of the frequency of precipitation, where D is the number of days of emissions and P is the number of days of emissions with rainfall greater than 0.01 inch. This term provides a mechanism for reducing average long term emissions by eliminating emissions from unpaved roadways (or in this case, payloader and truck traffic on the stockpile site) during rainfall periods. The equation, however, does not provide the means for adjusting emissions during periods without rainfall for materials such as bottom ash, that normally exhibit a moisture content significantly higher than the three percent moisture content associated with sand and gravel.

Based on field observations during the stockpile monitoring period, it was determined that the moisture content of the bottom ash was the most sensitive independent variable affecting visible dust emissions. During stockpile turnover events, the release of visible dust into the ambient air environment was almost exclusively associated with the handling and agitation of ash during periods when the ash appeared to be drier than normal. For example, during the initial period of a stockpile ash turnover event when the surface of the pile was noticeably drier than the interior of the pile, dust was observed; and during warm and dry periods when the ash particles were spread in a thin layer on the stockpile pad and particles were susceptible to rapid drying from the heat of the sun, front end loader wheel contact resulted in visible dust.

Inasmuch as Equation 2 was unable to account adequately for the moisture content of the ash, a moisture adjustment factor (MAF) was introduced into Equation 2. USEPA has previously introduced an adjustment or dust suppression factor to account for moisture (USEPA, 1994) as have others (Wells, 1988) in projecting fugitive dust emissions using these equations.

The moisture adjustment factor used in this assessment was calculated based on the relationship of emissions and moisture presented in Equation 1, where moisture content (M) was shown to be inversely related to emissions by a factor of moisture to the 1.4 power. The moisture content adjustment factor (MAF) was applied as follows:

$$E_a = E \times MAF$$

where,

E_a = Emissions adjusted for moisture,

E = Emissions unadjusted for moisture, and

MAF = moisture adjustment factor.

The MAF was defined as follows:

$$MAF = 1 / (M_a/3)^{1.4}$$

where,

MAF = moisture adjustment factor,

M_a = moisture content of bottom ash (%), and

3 = moisture content of natural sand and gravel material (%).

The effect of this moisture adjustment term on fugitive dust emissions is depicted in Figure 8-1.

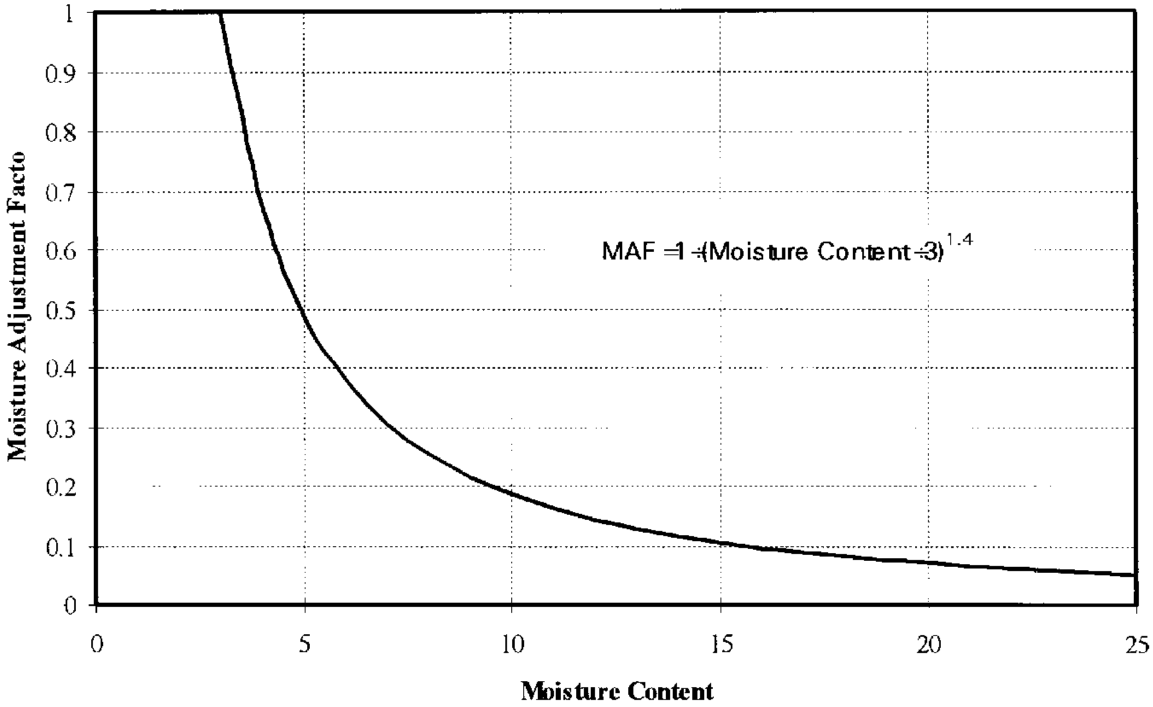

Figure 8-1

MOISTURE ADJUSTMENT FACTOR

The moisture content of the bottom ash (M_a) used to calculate the MAF for Equation 2 was based on the moisture content data obtained during the field monitoring program discussed in Section 3.

During the field monitoring program, moisture content at the surface of the stockpile varied seasonally, with higher moisture content observed during cooler periods (winter season) and lower moisture content observed during warmer periods (summer season). Data from the stockpile area indicating the seasonal variability in bottom ash moisture were used along with the MAF to project expected monthly emissions, using Equations 1, 2, 3 and 4.

To account for the effects of moisture and seasonal effects on fugitive dust emissions, Equations 1, 2, 3 and 4 were adjusted as follows:

- Equation 1 -- Batch Drop Equation

  MAF =as per Equation 1

  where M_a = measured moisture content at 3 foot depth within pile
- Equation 2 -- Unpaved Roadway Emissions Equation

  MAF = $1 / (M_a/3)^{1.4}$ from October through May

  MAF = 1 during summer season (June, July, August)

  where M_a = measured surface moisture content
- Equation 3 -- TSP Wind Erosion Equation

  MAF = 1 (no moisture adjustment)
- Equation 4 -- PM_{10} Wind Erosion

  MAF = 1 (no moisture adjustment)

Equation 1, the Batch Drop Equation, was used directly as presented in Table 8-1 together with its moisture adjustment factor. The moisture content measured at three feet below the surface was used as the ash moisture content (M_a) in the MAF adjustment because, during loading and unloading activities, the moisture content of interior of the pile is the moisture content of primary interest.

In the case of Equation 2, the Unpaved Roadway Emissions Equation, two MAF adjustments, based on seasonal conditions, were used to calculate emissions. The first adjustment reflected surface moisture conditions recorded during the months of October through May. It was assumed that the moisture content of the ash on the surface of the pile approximated that of the ash alongside the stockpile during the cooler fall, winter and early spring periods. However, the ash was observed to dry rapidly when spread on the surface of the stockpile pad during the hot early spring and summer period (June, July, and August). Therefore, no moisture adjustment factor was introduced (MAF = 1) into the equation for this period.

No moisture adjustment factors (MAF =1) were introduced into the Wind Erosion Equations 3 and 4. Moisture adjustments were considered unnecessary because the downwind increase in TSP ambient air concentrations predicted by Equation 3 without moisture adjustment (MAF = 1) was comparable to the downwind increase in ambient air concentrations measured in the field during the static monitoring program. As a result, no moisture adjustment (i.e., MAF = 1) was used in projecting emissions with the Wind Erosion equations. See Appendix E1 for a more detailed description of this analysis.

8.2.3 Stockpile Source Scenarios

Four different stockpile source conditions comparable to those used in Section 7 for the groundwater quality simulation (see Section 7.2.6) were modeled. The number of stockpiles were selected so as to permit an evaluation of potential air quality impacts at bottom ash storage sites capable of handling several months' production of processed ash. It was assumed that bottom ash was stored at each site in multiple 360-ton stockpiles with each pile having a radius of 18 feet and a height of 15 feet. It was also assumed that the quantity of bottom ash stored at each stockpile site was equivalent to three months production of bottom ash from a facility and that the ash throughput capacity at the site was equivalent to one day of supply to the site (or 1/90th of the sites' capacity) as follows:

Site Throughput Rate (tons/day) = Number of Piles × 360 tons/pile / 90 days.

Table 8-2 lists the site area and throughput rates for each storage site used in the assessment. The storage area size was based on the assumption that each stockpile requires a 65 x 65 foot (393 m^2) area for ash storage. The daily ash throughput rate represents the amount of new material delivered to the site each day. The amount of material handled or processed on site daily was assumed to be equal to twice the daily throughput, since the amount of material removed from the site was assumed equal to the amount delivered. The total quantity processed is needed to predict emissions using Equation 1 and was also used to project site vehicular traffic for input to Equation 2.

Table 8-2

SOURCE MODEL STORAGE SITE AREA SIZE AND DAILY THROUGHPUT RATES

Number of Piles	Storage Area Size (m^2)	Daily Ash Processing (tpd)	Daily Ash Throughput (tpd)
9	3,537	72	36
25	9,826	200	100
64	25,154	512	256
100	39,303	800	400

8.2.4 Particulate Emissions

Table E2-1 in Appendix E2 lists the projected monthly particulate emission loadings from one 360-ton stockpile site as projected using Equations 1 through 4, presented in Table 8-1. The results are presented for emissions calculated with and without the MAF, as outlined in Section 8.2.2. The data, displayed in Figure 8-2, clearly indicate that the higher TSP emissions projected for the summer months are due primarily to higher unpaved road emissions.

Table E2-1 in Appendix E2 also presents PM_{10} emissions estimates. PM_{10} emissions were projected using the aerodynamic particle size multiplier in Equations 1 and 2 and Equation 4, the PM_{10} Wind Erosion Equation. The PM_{10} seasonal trends displayed in Figure 8-3, are similar to those for the TSP emissions

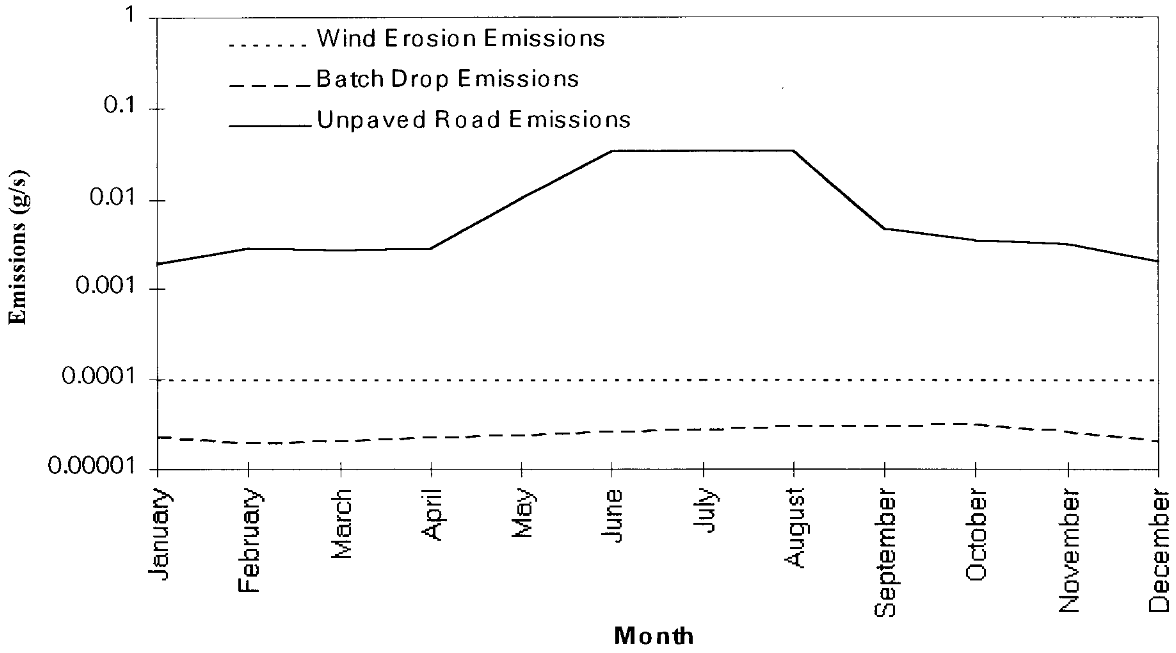

Figure 8-2

PROJECTED MONTHLY TSP EMISSION DISTRIBUTION

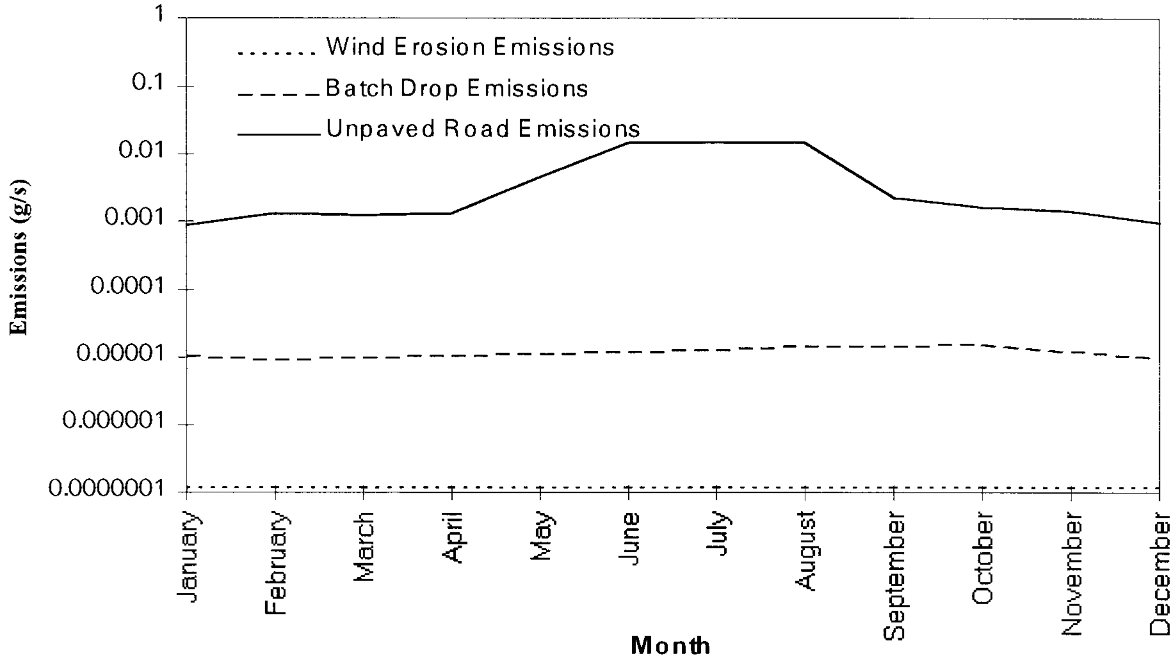

Figure 8-3

PROJECTED MONTHLY PM^{10} EMISSION DISTRIBUTION presented in Figure 8-2.

Table 8-3 lists all the variables in Equations 1, 2, 3 and 4 that were used to calculate PM_{10} and TSP emissions presented in Table E2-1 in Appendix E2 and Figures 8-2 and 8-3.

8.2.5 Trace Metal Emissions

Two trace metal emission estimates were made: TSP trace metals and PM_{10} trace metals. TSP trace metal emissions were calculated by multiplying projected TSP emissions presented in Table E2-1 in Appendix E2 by the trace metal concentrations that were reported in minus 30 micron Warren County bottom ash particles (LIRPB, 1992). PM_{10} trace metal emissions were calculated by multiplying the projected PM_{10} emissions by the trace metal concentrations reported in PM_{10} Warren County bottom ash particles (LIRPB, 1992). See Table E3-1 in Appendix E3 for TSP and PM_{10} trace metal concentration data.

8.3 STOCKPILE DUST AIR QUALITY IMPACTS

Section 8.3 describes the procedures used and the assessment of potential ambient air quality impacts resulting from stockpile dust emissions.

8.3.1 Emission Source Estimates

Fugitive dust loadings from the stockpiling of bottom ash were estimated from emissions data presented in Table E2-1 in Appendix E2 as a unit loading from each 360 tons of stockpiled ash. It was assumed for purposes of analysis that storage sites in excess of 360 tons would be constructed in multiples of 360-ton piles as was done in Section 7.3.

Ambient air trace metal concentrations were calculated by multiplying the PM_{10} dust emissions by trace metals concentrations found in Warren County bottom ash. Certain trace metals are enriched or depleted in the finer minus 10 micron ash fraction used in the ambient air trace metal analysis. Appendix E3, Table E3-1, presents trace metal concentrations for the minus 10 micron ash samples collected from the Warren County bottom ash (LIRPB, 1992).

To account for the enrichment or depletion in the minus 10 micron fraction, the minus 10 micron values presented in LIRPB (1992) were used to predict ambient air trace metal concentrations (see Appendix E3). If values were not available for trace metal concentrations on minus 10 micron particulates, average bottom ash trace metal values from Table 3-3 were used. Concentrations for hexavalent chromium (chromium (VI)) were not available, therefore chromium VI concentrations were assumed to be equal to 10% of total chromium concentrations.

Table 8-3
USEPA AP-42 EMISSION FACTOR EQUATION VARIABLES

1. Batch Drop Equation (USEPA, 1985)	
k_{30}= Particle size multiplier	0.74
k_{10}= Particle size multiplier	0.35
U= Mean wind speed (m/s)	5.5
M= Moisture content (%)	Varied[1]
2. Unpaved Roadway Emissions (USEPA, 1985)	
k_{30}= Particle size multiplier	0.8
k_{10}= Particle size multiplier	0.36
S= Silt content (%)	10
V= Mean vehicle velocity (m/s)	5
W= Mean vehicle weight (Mg)	32
N= Mean number of wheels	4
D= Days in analysis	365[2]
P= Days in analysis with rainfall >0.54mm	140[3]
3. TSP Wind Erosion Emissions (USEPA, 1985)	
S= Silt content (%)	10
P= Days per year with rainfall >0.54mm	140
F= Time wind exceeds 12 mph (%)	30
4. PM10 Wind Erosion Emissions (USEPA, 1991)	
U_M= Mean wind velocity (m/s)	5.5
U_T= Threshold wind velocity (m/s)	13
V= Vegetative cover (%)	0
$X= 0.886(U_T \div U_M)$	0.37

1. M was set to monthly values presented in Table E2-1
2. D was set to 1 for the worker health assessment
3. P was set to 0 for the worker health assessment

8.3.2 Ambient Air Impact Simulation

The Industrial Source Complex Short Term (ISCST2) air dispersion model was used to predict fugitive dust concentrations at downwind ambient air receptors. The ISCST2 model was chosen for the modeling analysis because it allows for use of actual meteorological data and it includes modeling options that permit incorporation of settling velocities for particles of different sizes. The ISCST2 Model uses a Gaussian plume model to predict the ambient air quality downwind from emission sources. See Appendix E4 for a more detailed discussion of the ISC Model.

The ISCST2 Model can incorporate particle reflection from the ground surface. The model was set to reflection values of one for ambient air calculations and zero for deposition calculations to provide for conservative results. The use of the ISCST2 Model required input data for the following parameters:

- Source parameters,
- Meteorological data, and
- Model receptors.

Additional discussion of the ISCST2 model is presented in Appendix E4.

8.3.2.1 Source Parameters

Four different sized source areas were modeled to estimate the impacts of dust emissions on ambient air quality. Stockpile dimensions and ash processing rates were as described in Section 8.2.3.

8.3.2.2 Meteorological Conditions

The ISCST2 Model was run using three years (1989, 1990 and 1991) of meteorological data collected from the Newark, New Jersey, and Atlantic City, New Jersey, National Weather Service Stations (NWS). Historical hourly wind speed, wind direction, temperature and atmospheric stability data for the years 1989, 1990 and 1991 were obtained from the Newark (Newark International Airport) NWS. Mixing height data were obtained from the Atlantic City, New Jersey NWS. The ambient air dust concentrations predicted by the ISCST2 Model for each of the three years were compared, and the highest concentrations projected were used in both the particulate and trace metal assessments.

8.3.2.3 Model Receptors

It was assumed that receptors would be located as close as 50 m from the edge of the stockpile area. Other studies (USEPA, 1994) have used points 100 m from an emission source as a hypothetical residential receptors. A 50 m distance provides for a somewhat more conservative assessment.

8.3.3 Air Assessment Criteria

The significance of the air quality impacts was determined by comparing increases in total suspended particulate (TSP), respirable dust (PM_{10}) and trace metal ambient air concentrations to existing USEPA and NJDEP ambient air quality standards or guidelines. USEPA respirable dust (PM_{10}) standards were used as the

PM_{10} reference concentration (USEPA, 1991). NJDEP TSP standards and ambient air trace metal guidelines were used as reference TSP and trace metal concentrations, respectively (NJDEP, 1992).

Ambient air trace metal criteria are divided into two categories. The first category is a direct reference concentration. This direct reference concentration is a 24 hour PM_{10} trace metal limitation. A Hazard Quotient (HQ) was used to assess the magnitude of potential trace metal impacts. The Hazard Quotient was calculated by dividing the predicted trace metal concentration by the reference concentration as follows:

$$\text{HQ} = \text{Predicted 24 hour } PM_{10} \text{ concentration } (\mu g/m^3) \text{ / Reference Concentration } (\mu g/m^3).$$

The trace metal concentrations were considered to be within acceptable levels if the calculated HQ was less than one.

The second category of ambient air trace metal criteria is presented in terms of carcinogenic risk and was calculated by multiplying the predicted trace metal concentration by a unit risk factor (URF) for each metal reported to exhibit carcinogenic risk as follows:

$$\text{Risk} = \text{URF } [\text{risk}/\mu g/m^3 \times \text{Predicted Annual } PM_{10} \text{ Concentration } (\mu g/m^3)].$$

NJDEP (1992) recommends the weighing of risks as follows

- A calculated risk less than 1×10^{-6} is considered acceptable.
- A calculated risk between 1×10^{-6} and 1×10^{-4} is considered of intermediate risk and acceptability must be determined by the NJDEP on a case-by-case basis.
- A calculated risk greater than 1×10^{-4} is considered unacceptable.

8.3.4 Ambient Air Assessment Results

In evaluating potential air quality impacts, two output averaging periods were considered: a 365-day average concentration, and the highest 24-hour concentration (or worst day of the year).

Figures 8-4, 8-5, 8-6 and 8-7 present the highest annual TSP, annual PM_{10}, 24-hour TSP and 24-hour PM_{10} ambient air concentrations calculated by the ISCST2 Model for receptors at a distance of 50 meters from the edge of the stockpile area for each of the stockpile scenarios. The data suggest that at this location, annual average TSP concentrations could exceed annual criteria at stockpile sites containing in excess of 100 stockpiles and maximum 24 hour criteria at stockpile sites containing in excess of 35 stockpiles. All annual and 24 hour PM_{10} concentrations would be below annual and maximum 24 hour criteria.

Tables 8-4 through 8-7 also present the highest ambient air and trace metal concentration calculations based on the three years modeled for each of the four stockpile scenarios. Annual average (i.e., 365-day)

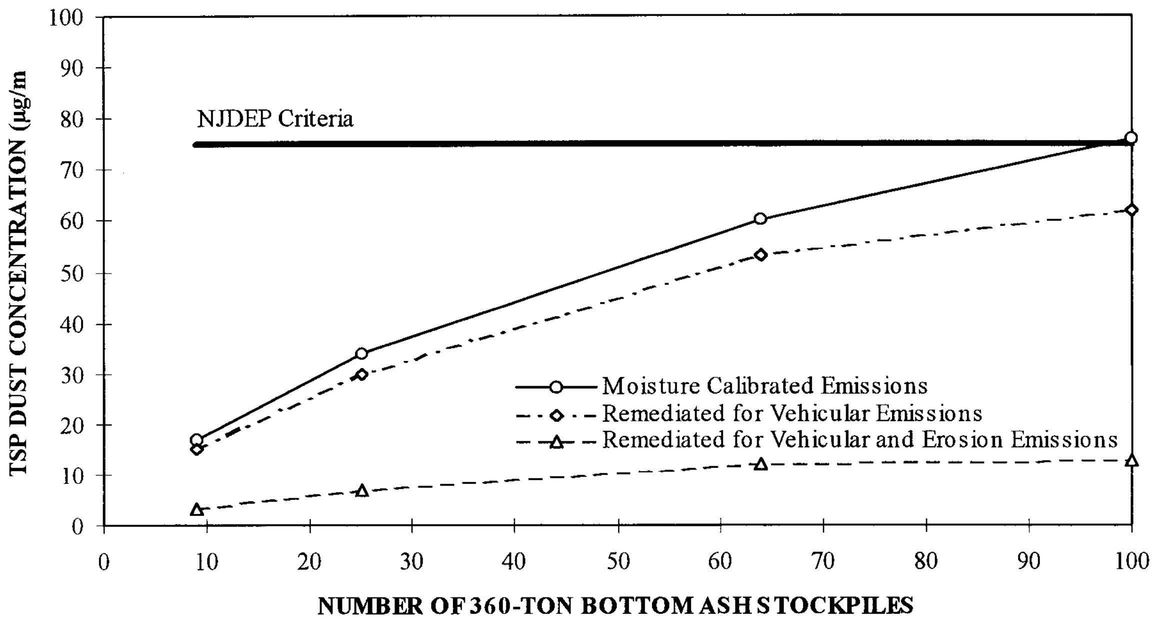

Figure 8-4

HIGHEST CALCULATED ANNUAL AVERAGE TSP DUST CONCENTRATIONS

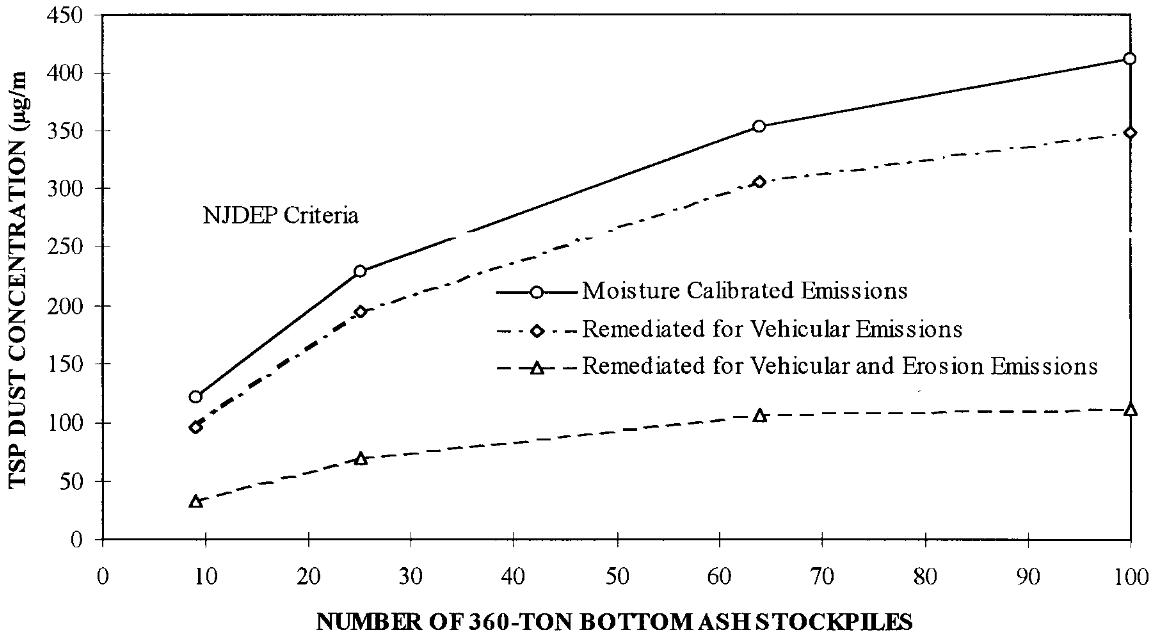

Figure 8-5

HIGHEST CALCULATED 24 HOUR AVERAGE TSP DUST CONCENTRATIONS

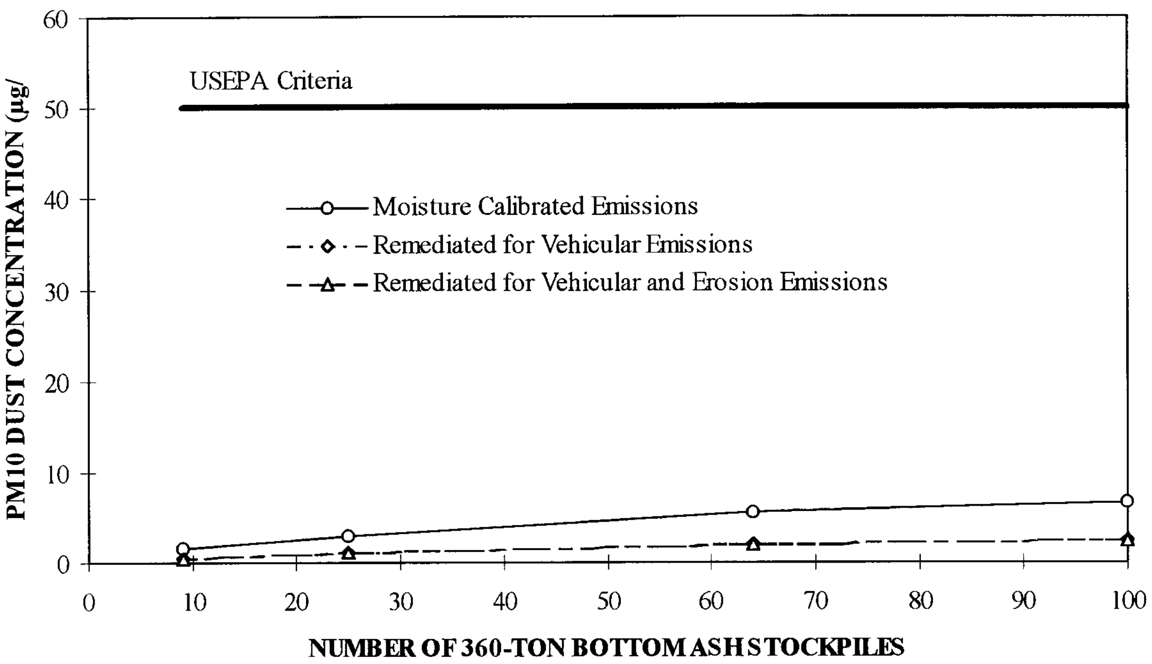

Figure 8-6
HIGHEST CALCULATED ANNUAL AVERAGE PM10 DUST CONCENTRATIONS

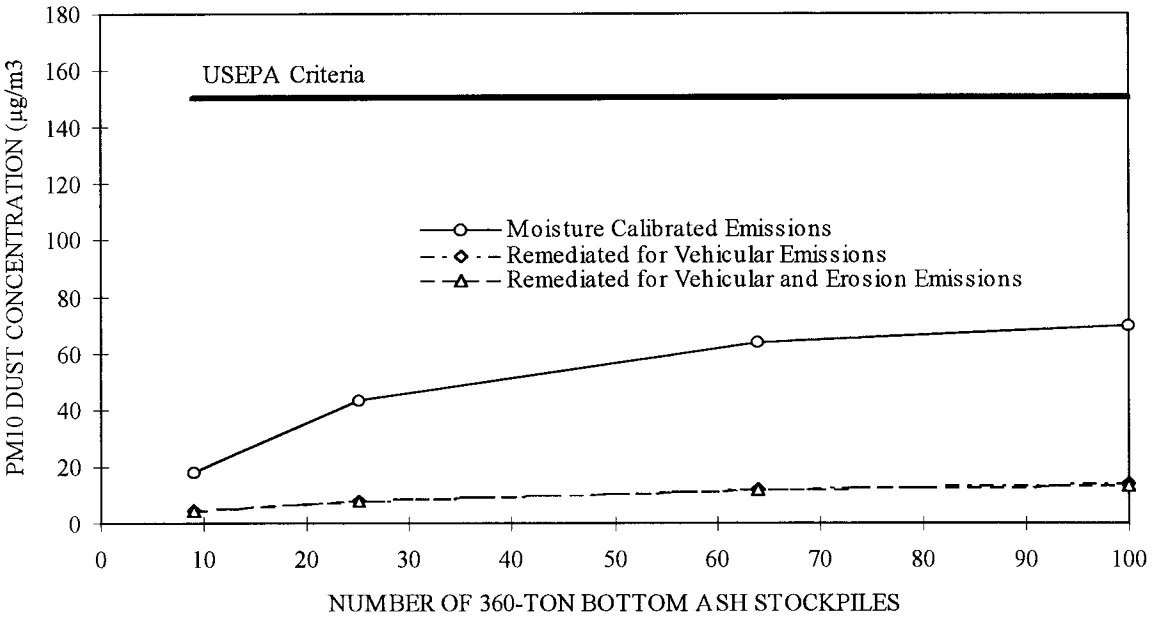

Figure 8-7
HIGHEST CALCULATED 24 HOUR AVERAGE PM_{10} DUST CONCENTRATIONS

concentrations presented in Tables 8-4 through 8-7 represent the highest calculated annual average concentrations based on meteorological conditions during the three years examined. Daily average (i.e., 24-hour) concentrations represent the highest three-year daily average concentrations. Where relevant and available, Hazard Quotients (HQ) and Cancer Risk Factors for the 9, 25, 64 and 100 stockpile sites have been included.

The ambient air trace metal assessment results suggest that total chromium levels could exceed allowable criteria for all stockpile scenarios, while lead and zinc appear to exceed New Jersey reference concentrations starting at 25 stockpiles. Copper concentrations are equivalent to New Jersey reference concentrations for the 100 stockpile scenario. Cadmium and chromium (VI) results indicate possible cancer risks in the 1×10^{-6} to 1×10^{-5} range for the 64 and 100 stockpile scenarios. Cancer risks in this range are usually assessed by the NJDEP on a case-by-case basis (see Section 8.3.2.5).

Many aggregate storage site managers commonly use dust suppression practices (e.g., water sprays) to reduce emissions. Additional analyses assessed the potential impacts if moist conditions were maintained at the stockpile site. Two remediation strategies were considered. The first strategy, the vehicular movement dust remediation strategy, assumed maintenance of a moisture content of at least 10 percent on just the stockpile site area in order to suppress emissions associated with traffic.

The second strategy, the stockpile and vehicular movement dust remediation strategy, assumes maintenance of a minimum of 10 percent moisture content on the surface of the site to suppress dust generated from vehicular traffic and on the stockpile surface. It was assumed that dust suppression remediation activities would only be implemented during the months of June, July and August when stockpile site surface moisture content was below the 10 percent remediation goal. Table E2-2 in Appendix E2 presents a listing of the moisture content data and revised emission loadings produced by these remediation strategies.

Figures 8-4 through 8-7 depict the results of the analyses with the proposed remediation strategies. Remediation of the vehicular emissions significantly reduces projected dust levels; however, predicted 24-hour TSP dust concentrations still exceed 24-hour TSP standards. Remediation of both vehicular emissions and wind erosion emissions reduce projected TSP levels below all criteria. Tables E5-1 to E5-8 in Appendix E5 present a detailed listing of calculated ambient air dust concentrations.

Figures 8-8 to 8-13 illustrate the effects of dust remediation strategies on ambient air trace metal levels. The figures present Hazard Quotients and calculated risks for those trace metals projected to exceed minimum acceptable levels. The data indicate that, with the exception of total chromium, all ambient air trace metal levels would be below criteria (HQ <1) or within acceptable risk levels (Risk $< 1 \times 10^{-6}$) using either remediation strategy. The figures indicate that even with vehicular and wind erosion remediation, total chromium levels could exceed acceptable criteria at 25 stockpiles. Tables E5-1 to E5-5 in Appendix E5 list calculated ambient air trace metal concentrations.

Table 8-4

AMBIENT AIR TRACE METAL CONCENTRATIONS AND IMPACT ASSESSMENT FOR 9 PILES

(µg/m^3)

Parameter	Average Period	Air Concentration (µg/m^3)	NJDEP Stds		Risk Analysis	
			RFC[1] (µg/m^3)	URF[2] (risk/µg/m^3)	Hazard[3] Quotient	Cancer[4] Risk
TSP	365 day	17.0	260	-	6.5E-02	-
	24 hour	121	75	-	1.6E+00	-
PM$_{10}$	365 day	1.5	150	-	1.0E-02	-
	24 hour	18	50	-	3.6E-01	-
Ag	24 hour	1.8E-04	-	-	-	-
Al	24 hour	8.2E-01	-	-	-	-
As	365 day	1.1E-04	4.3E-03	-	2.6E-02	-
Ba	24 hour	1.3E-02	5.0E-01	-	2.6E-02	-
Be	365 day	1.5E-06	-	2.4E-03	-	3.6E-09
Ca	24 hour	8.5E-01	-	-	-	-
Cd	365 day	1.2E-04	-	3.5E-03	-	4.1E-07
Cr (total)	24 hour	4.3E-03	2.0E-03	-	2.2E+00	-
Cr (VI)[5]	365 day	3.6E-05	-	1.2E-02	-	4.3E-07
Cu	24 hour	3.5E-02	1.3E-01	-	2.7E-01	-
Fe	24 hour	1.1E+00	-	-	-	-
Hg	24 hour	9.0E-06	3.0E-01	-	3.0E-05	-
K	24 hour	8.5E-02	-	-	-	-
Mg	24 hour	1.5E-01	-	-	-	-
Mn	24 hour	2.2E-02	4.0E-01	-	5.5E-02	-
Na	24 hour	2.6E-01	-	-	-	-
Ni	365 day	2.2E-04	-	2.4E-04	-	5.3E-08
Pb	24 hour	4.5E-02	1.0E-01	-	4.5E-01	-
Se	24 hour	1.8E-05	-	-	-	-
Si	24 hour	4.4E-03	-	-	-	-
Zn	24 hour	1.2E-01	2.0E-01	-	6.1E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = RFC × Air Concentration
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table 8-5

AMBIENT AIR TRACE METAL CONCENTRATIONS AND IMPACT ASSESSMENT FOR 25 PILES

($\mu g/m^3$)

		Air Concentration	NJDEP Stds		Risk Analysis	
Parameter	**Average Period**	**($\mu g/m^3$)**	**RFC[1] ($\mu g/m^3$)**	**URF[2] (risk/$\mu g/m^3$)**	**Hazard[3] Quotient**	**Cancer[4] Risk**
TSP	365 day	34	260	-	1.3E-01	-
	24 hour	229	75	-	3.1E+00	-
PM$_{10}$	365 day	2.9	150	-	1.9E-02	-
	24 hour	43	50	-	8.6E-01	
Ag	24 hour	4.3E-04	-	-	-	-
Al	24 hour	2.0E+00	-	-	-	-
As	365 day	2.2E-04	4.3E-03	-	5.1E-02	-
Ba	24 hour	3.1E-02	5.0E-01	-	6.3E-02	-
Be	365 day	2.9E-06	-	2.4E-03	-	7.0E-09
Ca	24 hour	2.0E+00	-	-	-	-
Cd	365 day	2.3E-04	-	3.5E-03	-	8.0E-07
Cr (total)	24 hour	1.0E-02	2.0E-03	-	5.2E+00	-
Cr (VI)[5]	365 day	7.0E-05	-	1.2E-02	-	8.4E-07
Cu	24 hour	8.3E-02	1.3E-01	-	6.4E-01	-
Fe	24 hour	2.6E+00	-	-	-	-
Hg	24 hour	2.1E-05	3.0E-01	-	7.1E-05	-
K	24 hour	2.0E-01	-	-	-	-
Mg	24 hour	3.5E-01	-	-	-	-
Mn	24 hour	5.2E-02	4.0E-01	-	1.3E-01	-
Na	24 hour	6.2E-01	-	-	-	-
Ni	365 day	4.3E-04	-	2.4E-04	-	1.0E-07
Pb	24 hour	1.1E-01	1.0E-01	-	1.1E+00	-
Se	24 hour	4.4E-05	-	-	-	-
Si	24 hour	1.0E-02	-	-	-	-
Zn	24 hour	2.9E-01	2.0E-01	-	1.4E+00	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = RFC × Air Concentration
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table 8-6

AMBIENT AIR TRACE METAL CONCENTRATIONS AND IMPACT ASSESSMENT FOR 64 PILES
($\mu g/m^3$)

			NJDEP Stds		Risk Analysis	
Parameter	Average Period	Air Concentration ($\mu g/m^3$)	RFC[1] ($\mu g/m^3$)	URF[2] (risk/$\mu g/m^3$)	Hazard[3] Quotient	Cancer[4] Risk
TSP	365 day	60	260	-	2.3E-01	-
	24 hour	353	75	-	4.7E+00	-
PM_{10}	365 day	5.5	150	-	3.7E-02	-
	24 hour	64	50	-	1.3E+00	-
Ag	24 hour	6.3E-04	-	-	-	-
Al	24 hour	2.9E+00	-	-	-	-
As	365 day	4.1E-04	4.3E-03	-	9.6E-02	-
Ba	24 hour	4.7E-02	5.0E-01	-	9.3E-02	-
Be	365 day	5.5E-06	-	2.4E-03	-	1.3E-08
Ca	24 hour	3.0E+00	-	-	-	-
Cd	365 day	4.3E-04	-	3.5E-03	-	1.5E-06
Cr (total)	24 hour	1.5E-02	2.0E-03	-	7.7E+00	-
Cr (VI)[5]	365 day	1.3E-04	-	1.2E-02	-	1.6E-06
Cu	24 hour	1.2E-01	1.3E-01	-	9.5E-01	-
Fe	24 hour	3.8E+00	-	-	-	-
Hg	24 hour	3.2E-05	3.0E-01	-	1.1E-04	-
K	24 hour	3.0E-01	-	-	-	-
Mg	24 hour	5.2E-01	-	-	-	-
Mn	24 hour	7.8E-02	4.0E-01	-	2.0E-01	-
Na	24 hour	9.2E-01	-	-	-	-
Ni	365 day	8.1E-04	-	2.4E-04	-	2.0E-07
Pb	24 hour	1.6E-01	1.0E-01	-	1.6E+00	-
Se	24 hour	6.5E-05	-	-	-	-
Si	24 hour	1.6E-02	-	-	-	-
Zn	24 hour	4.3E-01	2.0E-01	-	2.2E+00	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = RFC × Air Concentration
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table 8-7

AMBIENT AIR TRACE METAL CONCENTRATIONS AND IMPACT ASSESSMENT FOR 100 PILES

($\mu g/m^3$)

			NJDEP Stds		Risk Analysis	
Parameter	Average Period	Air Concentration ($\mu g/m^3$)	RFC[1] ($\mu g/m^3$)	URF[2] ($risk/\mu g/m^3$)	Hazard[3] Quotient	Cancer[4] Risk
TSP	365 day	76	260	-	2.9E-01	-
	24 hour	411	75	-	5.5E+00	-
PM_{10}	365 day	6.7	150	-	4.5E-02	-
	24 hour	70	50	-	1.4E+00	-
Ag	24 hour	6.9E-04	-	-	-	-
Al	24 hour	3.2E+00	-	-	-	-
As	365 day	5.0E-04	4.3E-03	-	1.2E-01	-
Ba	24 hour	5.1E-02	5.0E-01	-	1.0E-01	-
Be	365 day	6.7E-06	-	2.4E-03	-	1.6E-08
Ca	24 hour	3.3E+00	-	-	-	-
Cd	365 day	5.3E-04	-	3.5E-03	-	1.9E-06
Cr (total)	24 hour	1.7E-02	2.0E-03	-	8.4E+00	-
Cr (VI)[5]	365 day	1.6E-04	-	1.2E-02	-	1.9E-06
Cu	24 hour	1.3E-01	1.3E-01	-	1.0E+00	-
Fe	24 hour	4.2E+00	-	-	-	-
Hg	24 hour	3.5E-05	3.0E-01	-	1.2E-04	-
K	24 hour	3.3E-01	-	-	-	-
Mg	24 hour	5.7E-01	-	-	-	-
Mn	24 hour	8.5E-02	4.0E-01	-	2.1E-01	-
Na	24 hour	1.0E+00	-	-	-	-
Ni	365 day	9.9E-04	-	2.4E-04	-	2.4E-07
Pb	24 hour	1.7E-01	1.0E-01	-	1.7E+00	-
Se	24 hour	7.1E-05	-	-	-	-
Si	24 hour	1.7E-02	-	-	-	-
Zn	24 hour	4.7E-01	2.0E-01	-	2.4E+00	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = RFC × Air Concentration
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

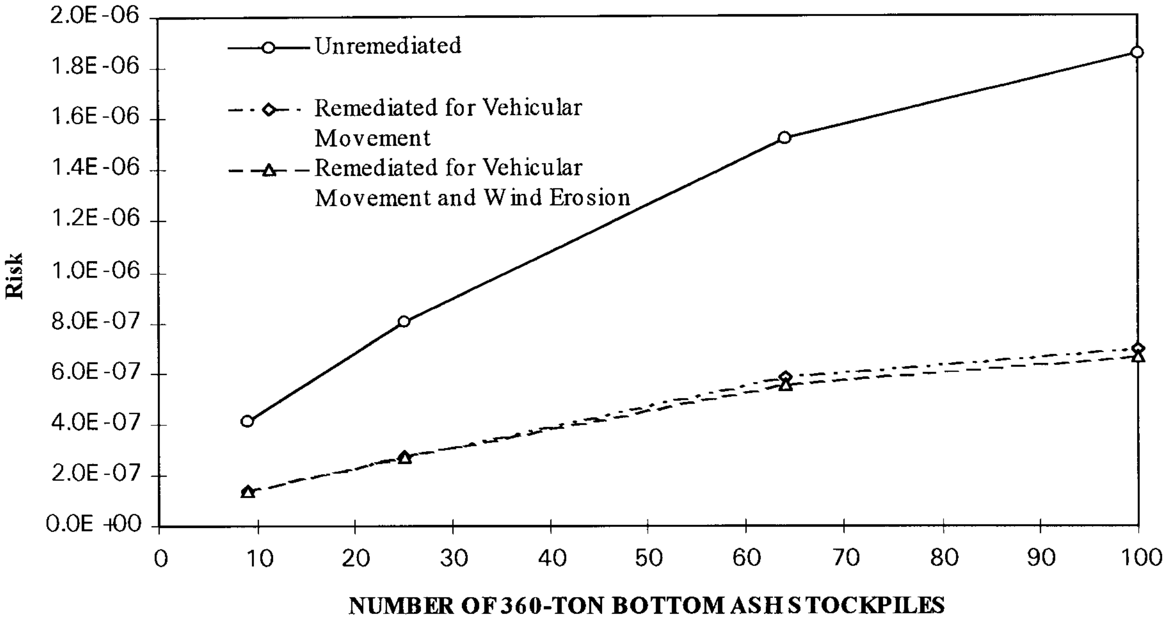

Figure 8-8

PROJECTED RISK ASSOCIATED WITH CADMIUM AMBIENT AIR TRACE METAL CONCENTRATION

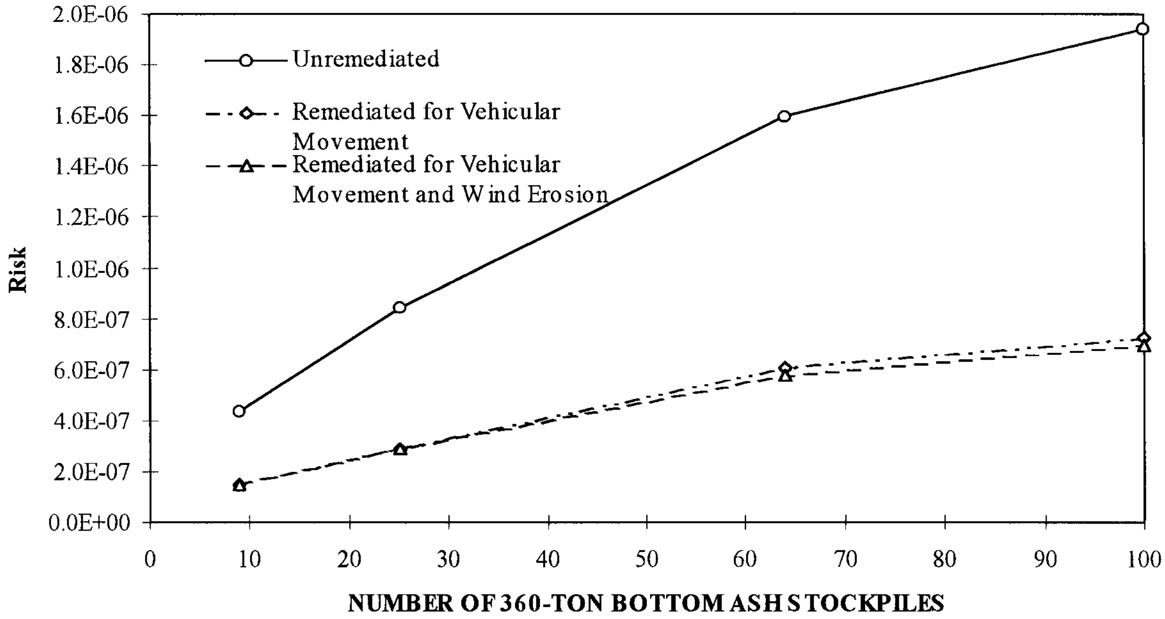

Figure 8-9

PROJECTED RISK ASSOCIATED WITH HEXAVALENT CHROMIUM AMBIENT AIR TRACE METAL CONCENTRATION

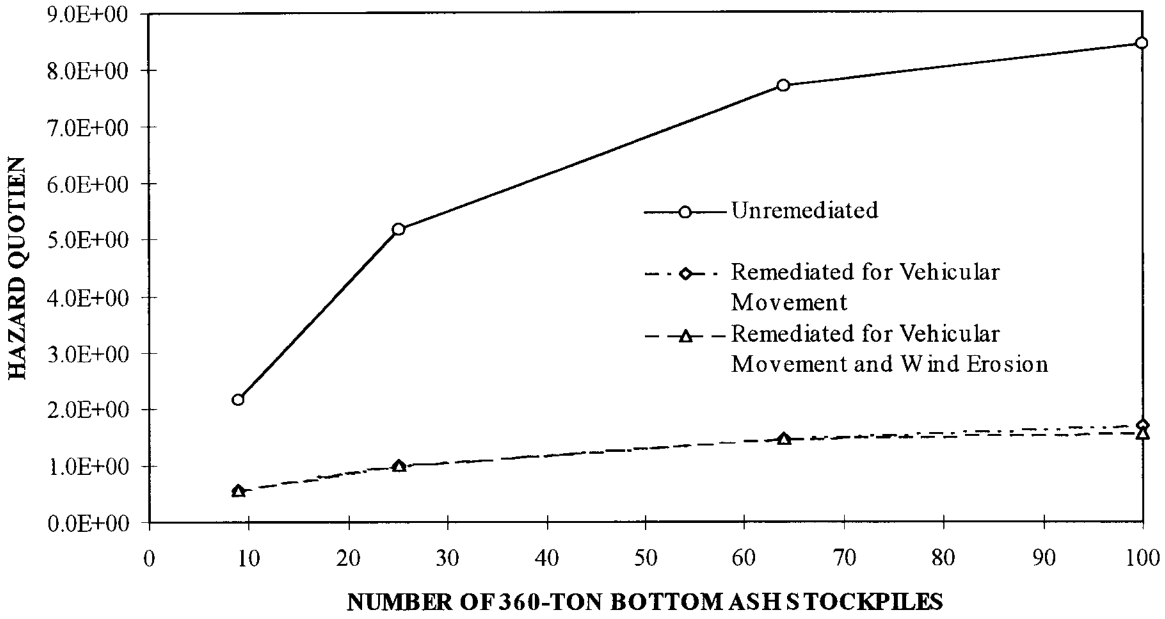

Figure 8-10

PROJECTED HAZARD QUOTIENT ASSOCIATED WITH TOTAL CHROMIUM AMBIENT AIR TRACE METAL CONCENTRATION

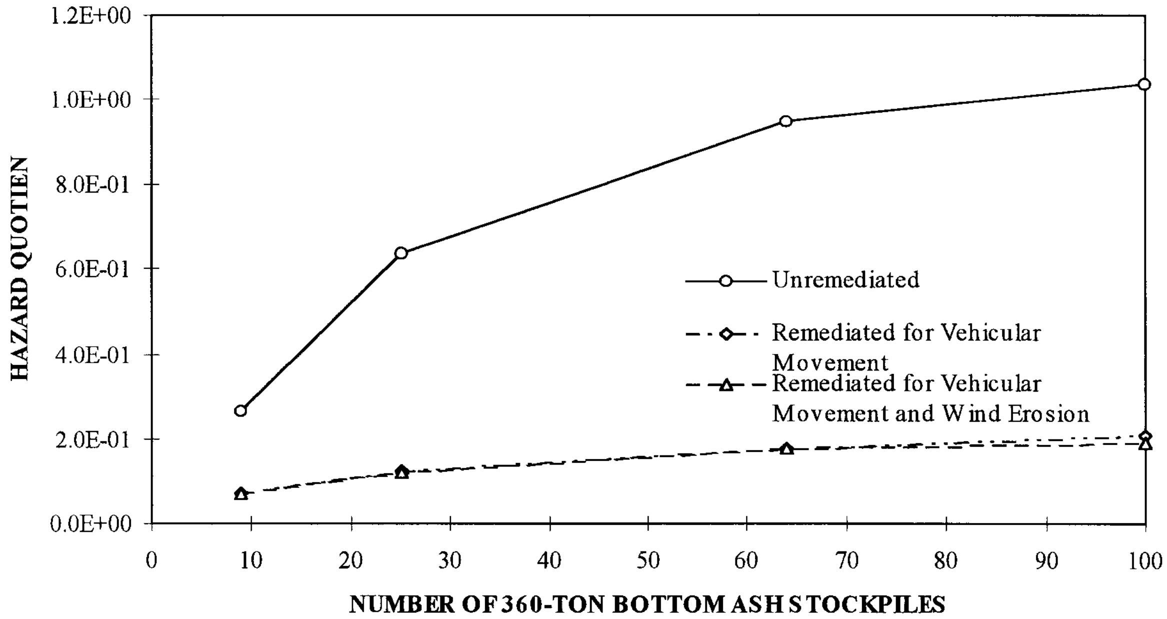

Figure 8-11

PROJECTED HAZARD QUOTIENT ASSOCIATED WITH COPPER AMBIENT AIR TRACE METAL CONCENTRATION

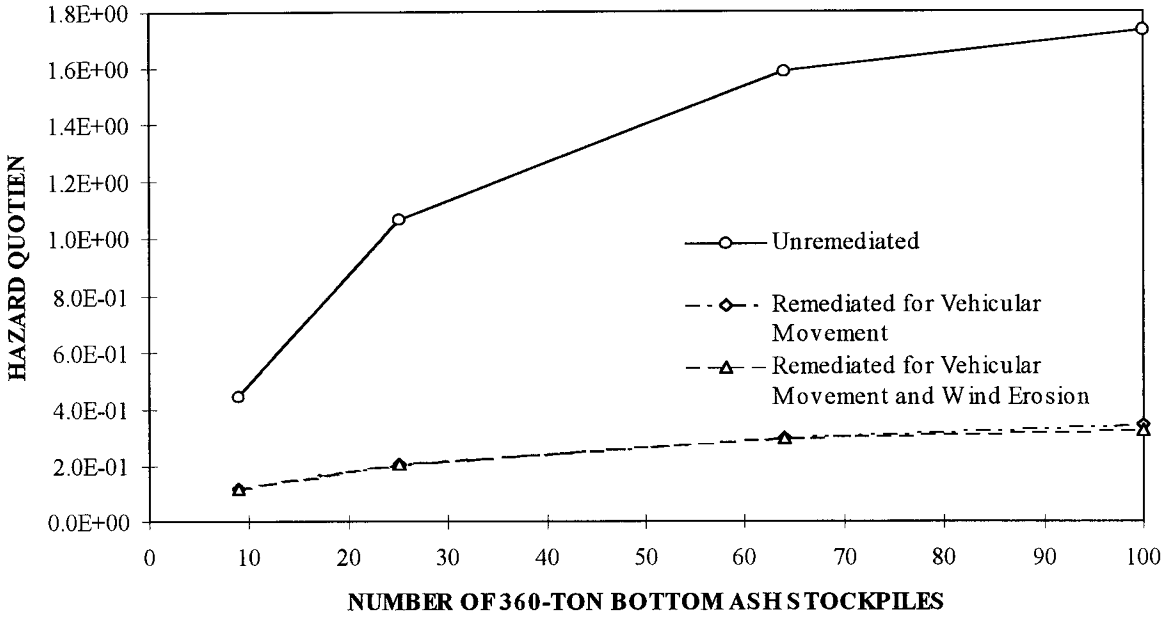

Figure 8-12

PROJECTED HAZARD QUOTIENT ASSOCIATED WITH LEAD AMBIENT AIR TRACE METAL CONCENTRATION

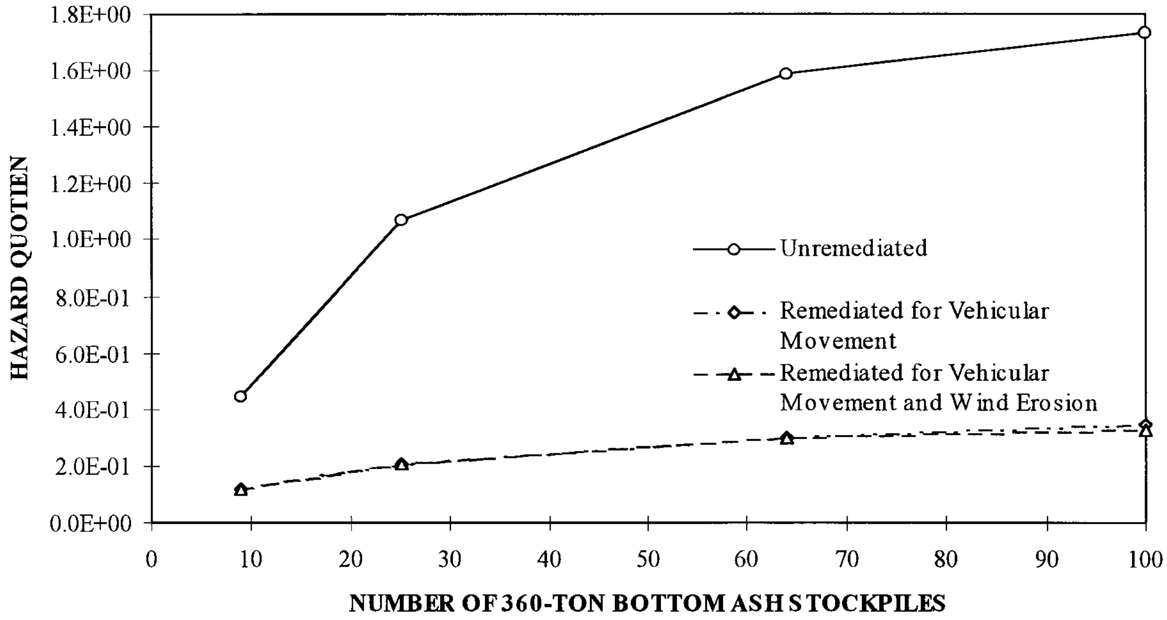

Figure 8-13

PROJECTED HAZARD QUOTIENT ASSOCIATED WITH ZINC AMBIENT AIR TRACE METAL CONCENTRATION

8.4 STOCKPILE DUST SOIL QUALITY IMPACT ASSESSMENT

Section 8.4 describes the procedures used and the assessment of potential soil quality impacts resulting from stockpile dust emissions.

8.4.1 Emission Source Estimates

Emission loadings used in the soil assessment were the same loadings presented in Section 8.3.1 and outlined in Table E2-1 in Appendix E2.

Trace metal soil concentrations were calculated by translating the TSP dust concentrations predicted by the ISCST2 Model to equivalent concentrations of the trace metals associated with the Warren County bottom ash. Certain trace metals (e.g., As, Cd, Cr, Pb, and Zn) are enriched while others, among them Cu, are depleted in the finer ($<30\mu$) ash fraction. Appendix E3, Table E3-1, presents trace metal concentrations for the $<30\mu$ ash samples collected from the Warren County bottom ash.

Trace metal concentrations measured in the <30 micron fraction of Warren County bottom ash were used to predict deposition trace metal concentrations (see Appendix E3). For those elements for which $<30\mu$ trace metal concentrations were not available, average trace metal values listed in Table 3-3 were used in the analysis.

8.4.2 Soil Quality Impact Simulation

Trace metal loadings to the soil were calculated by multiplying annual TSP deposition calculated by the ISCST2 Model by trace metal concentrations associated with the Warren County bottom ash. As in the ambient air quality assessment, the ISCST2 Model was run using three years (1989, 1990 and 1991) of meteorological data. Particulate deposition rates for each of the three years were compared, and the highest deposition rate was used in the assessment.

8.4.2.1 Source Parameters

As in the ambient air assessment, four different stockpile source conditions were used in the soil quality impact assessment. All site conditions were similar to the conditions outlined in Section 8.3.2.1 for the air quality assessment.

8.4.2.2 Meteorological Conditions

The ISCST2 Model was run as in the ambient air assessment described in Section 8.3.2.2.

8.4.2.3 Receptor Locations

It was assumed that receptors would be located as close as 50 m from the edge of the stockpile area. Other studies (USEPA, 1994) have used points 100 m from an emission source as a hypothetical residential receptor; however, a 50 m distance provides for a somewhat more conservative assessment.

8.4.3 Soil Assessment Criteria

New Jersey Department of Environmental Protection (NJDEP) Non-residential Soil Quality Cleanup Standards were used as the reference criteria (NJDEP, 1994). The NJDEP standards are based on a human health risk assessment in which both ingestion and inhalation exposure pathways for receptors at residential and non-residential locations are considered (NJDEP, 1992). The standards represent the maximum concentrations that can be present in the soil without potential adverse health effects from continuous long-term exposure.

The NJDEP soil standards are presented in terms of concentration ($\mu g/g$). To compare soil deposition values calculated by the ISCST2 Model to the reference criteria, it was necessary to convert each deposition value to a concentration. Deposition values were converted to concentrations by assuming that ash deposited on the soil surface was mixed into the top one inch of soil. It was also assumed that the soil density was 1.6 g/cm^3.

8.4.4 Soil Quality Assessment Results

The relative annual loading (RAL), introduced in Section 7.5.3, was used in the soil quality assessment. The RAL was previously defined as follows:

$$\text{RAL} = C_S \,/\, \text{Reference Standard}$$

where,

C_S = annual increase in trace metal soil concentration

The RAL values calculated in the soil quality assessment were used to identify the controlling trace metals with respect to soil quality impacts from dust emissions. The value RAL^{-1}, which represents the number of years it would take for concentration in the most highly impacted soil location to reach the reference standard (assuming an initial trace metal concentration of zero), was used to assess the potential significance of soil quality impacts.

Using the non-residential soil standards as the reference criteria, Tables 8-8, 8-9, 8-10 and 8-11 present RAL and RAL^{-1} values for the 9, 25, 64 and 100 stockpile sites, respectively.

Arsenic and zinc exhibit the highest relative annual loadings (RAL) of 0.0070 yr^{-1} and 0.0064 yr^{-1}, respectively, for the 100 stockpile scenario, with arsenic the controlling element. RAL and RAL^{-1} values for arsenic and zinc as a function of stockpile storage site size are presented in Figure 8-14. Based upon the results, it would take approximately 410 years of deposition from nine stockpiles and 140 years from 100 stockpiles before arsenic concentrations exceeded New Jersey non-residential criteria. The results also show that

Table 8-8

ESTIMATED SOIL TRACE METAL CONCENTRATIONS AND IMPACTS FOR NINE BOTTOM ASH STOCKPILES

Parameter	Deposition Rate (µg/m^2/yr)	Mixed in Top 1" of Soil (µg/g/yr)	NJDEP Stds Non-Residential (µg/g)	Relative Loading (1/yr)	Time to Exceed Std. (yrs)
TSP	20,000,000	500	-	-	-
Ag	2.0E+02	0.00495	2,000	2.5E-06	4.0E+05
Al	9.2E+05	22.9	-	-	-
As	2.0E+03	0.0490	20	2.5E-03	4.1E+02
Ba	1.5E+04	0.364	26,000	1.4E-05	7.1E+04
Be	2.0E+01	0.00050	2	2.5E-04	4.0E+03
Ca	9.5E+05	23.7	-	-	-
Cd	1.7E+03	0.0435	100	4.4E-04	2.3E+03
Cr	5.4E+03	0.135	-	-	-
Cu	3.4E+04	0.85	600	1.4E-03	7.0E+02
Fe	1.2E+06	29.9	-	-	-
Hg	1.0E+01	0.000249	-	-	-
K	9.5E+04	2.37	-	-	-
Mg	1.6E+05	4.06	-	-	-
Mn	2.4E+04	0.61	-	-	-
Na	2.9E+05	7.2	-	-	-
Ni	3.0E+03	0.074	2,400	3.1E-05	3.2E+04
Pb	4.9E+04	1.22	600	2.0E-03	4.9E+02
Se	2.0E+01	0.00051	1,000	5.1E-07	2.0E+06
Si	4.9E+03	0.122	-	-	-
Zn	1.3E+05	3.35	1,500	2.2E-03	4.5E+02

it would take approximately 450 years of deposition from nine stockpiles or 160 years of deposition from 100 stockpiles for zinc concentrations to exceed New Jersey non-residential criteria.

8.5 STOCKPILE DUST WORKER ENVIRONMENT IMPACTS

Section 8.5 presents a description of the procedures used and the assessment of potential impacts on the worker environment associated with stockpile dust emissions.

8.5.1 Emission Source Estimates

Emissions loadings used in the worker environment assessment were the same as those loadings presented in Table E2-1 in Appendix E2 and used in both the ambient air and soil quality

Table 8-9
ESTIMATED SOIL TRACE METAL CONCENTRATIONS AND IMPACTS FOR 25 BOTTOM ASH STOCKPILES

Parameter	Deposition Rate ($\mu g/m^2/yr$)	Mixed in Top 1" of Soil ($\mu g/g/yr$)	NJDEP Stds Non-Residential ($\mu g/g$)	Relative Loading (1/yr)	Time to Exceed Std. (yrs)
TSP	33,000,000	825	-	-	-
Ag	3.3E+02	0.00817	2,000	2.0E-04	4.9E+03
Al	1.5E+06	37.8	-	-	-
As	3.2E+03	0.0809	20	4.0E-03	2.5E+02
Ba	2.4E+04	0.601	26,000	1.0E-03	1.0E+03
Be	3.3E+01	0.00083	2	4.1E-04	2.4E+03
Ca	1.6E+06	39.1	-	-	-
Cd	2.9E+03	0.0718	100	7.2E-02	1.4E+02
Cr	8.9E+03	0.222	-	-	-
Cu	5.6E+04	1.41	600	2.3E-03	4.3E+02
Fe	2.0E+06	49.3	-	-	-
Hg	1.6E+01	0.000411	-	-	-
K	1.6E+05	3.91	-	-	-
Mg	2.7E+05	6.70	-	-	-
Mn	4.0E+04	1.01	-	-	-
Na	4.8E+05	11.9	-	-	-
Ni	4.9E+03	0.122	2,400	4.9E-04	2.0E+03
Pb	8.0E+04	2.01	600	2.0E-02	5.0E+01
Se	3.3E+01	0.00084	1,000	8.4E-07	1.2E+06
Si	8.1E+03	0.201	-	-	-
Zn	2.2E+05	5.53	1,500	3.7E-03	2.7E+02

assessments. Emission loadings during the month of August were used to project worker health impacts, since August data represented the highest monthly loadings.

In this assessment, emissions calculations from Equation 2, unpaved roadway emissions, were further adjusted to reflect the worst day of the year by setting the days in analysis (D) to 1 and days with rainfall >0.54 mm (P) to 0.

Worker environment trace metal concentrations were predicted by multiplying the projected TSP dust concentrations by the concentration of trace metals in the Warren County bottom ash (see Appendix E3, Table E3-1.)

8.5.2 Worker Environment Impact Simulation

The major concern associated with worker health and safety and the proposed demonstration activities is the potential for worker exposure to excessive concentrations of dust. To quantify particulate concentrations, emission factor equations 1 to 4 (see Table 8-1) were used to project the release of particulates into the worker

Table 8-10
ESTIMATED SOIL TRACE METAL CONCENTRATIONS AND IMPACTS FOR 64 BOTTOM ASH STOCKPILES

Parameter	Deposition Rate (µg/m^2/yr)	Mixed in Top 1" of Soil (µg/g/yr)	NJDEP Stds Non-Residential (µg/g)	Relative Loading (1/yr)	Time to Exceed Std. (yrs)
TSP	50,000,000	1,250	-	-	-
Ag	5.0E+02	0.0124	2,000	6.2E-06	1.6E+05
Al	2.3E+06	57.3	-	-	-
As	4.9E+03	0.1225	20	6.1E-03	1.6E+02
Ba	3.6E+04	0.91	26,000	3.5E-05	2.9E+04
Be	5.0E+01	0.00125	2	6.3E-04	1.6E+03
Ca	2.4E+06	59	-	-	-
Cd	4.4E+03	0.1088	100	1.1E-03	9.2E+02
Cr	1.3E+04	0.336	-	-	-
Cu	8.5E+04	2.13	600	3.6E-03	2.8E+02
Fe	3.0E+06	74.8	-	-	-
Hg	2.5E+01	0.00062	-	-	-
K	2.4E+05	5.9	-	-	-
Mg	4.1E+05	10.2	-	-	-
Mn	6.1E+04	1.53	-	-	-
Na	7.2E+05	18.0	-	-	-
Ni	7.4E+03	0.185	2,400	7.7E-05	1.3E+04
Pb	1.2E+05	3.04	600	5.1E-03	2.0E+02
Se	5.1E+01	0.00127	1,000	1.3E-06	7.9E+05
Si	1.2E+04	0.305	-	-	-
Zn	3.4E+05	8.38	1,500	5.6E-03	1.8E+02

environment. The worker environment was defined by a pre-selected control volume with a conservative air turnover rate.

The magnitude of the impact to worker health was assessed by projecting the particulate dust levels and corresponding trace metal concentrations in the worker environment and comparing estimated concentrations to Occupation Safety and Health Administration (OSHA) 8-hour permissible exposure levels (PELs).

Table 8-11
ESTIMATED SOIL TRACE METAL CONCENTRATIONS AND IMPACTS FOR 100 BOTTOM ASH STOCKPILES

Parameter	Deposition Rate (µg/m^2/yr)	Mixed in Top 1" of Soil (µg/g/yr)	NJDEP Stds Non-Residential (µg/g)	Relative Loading (1/yr)	Time to Exceed Std. (yrs)
TSP	57,000,000	1,425	-	-	-
Ag	5.6E+02	0.0141	2,000	7.1E-06	1.4E+05
Al	2.6E+06	65	-	-	-
As	5.6E+03	0.1397	20	7.0E-03	1.4E+02
Ba	4.1E+04	1.04	26,000	4.0E-05	2.5E+04
Be	5.7E+01	0.00143	2	7.1E-04	1.4E+03
Ca	2.7E+06	68	-	-	-
Cd	5.0E+03	0.1240	100	1.2E-03	8.1E+02
Cr	1.5E+04	0.383	-	-	-
Cu	9.7E+04	2.43	600	4.0E-03	2.5E+02
Fe	3.4E+06	85	-	-	-
Hg	2.8E+01	0.00071	-	-	-
K	2.7E+05	6.8	-	-	-
Mg	4.6E+05	11.6	-	-	-
Mn	7.0E+04	1.74	-	-	-
Na	8.2E+05	20.5	-	-	-
Ni	8.4E+03	0.211	2,400	8.8E-05	1.1E+04
Pb	1.4E+05	3.47	600	5.8E-03	1.7E+02
Se	5.8E+01	0.00144	1,000	1.4E-06	6.9E+05
Si	1.4E+04	0.348	-	-	-
Zn	3.8E+05	9.55	1,500	6.4E-03	1.6E+02

Control volume particulate or dust concentrations were calculated using the following equation:

$$C = \frac{E_T T}{V}$$

where

C = dust concentration (μg/m^3),
E_T = total particulate emission rate (grams/sec),
V = control volume (m^3), and
T = time for wind to travel across control volume

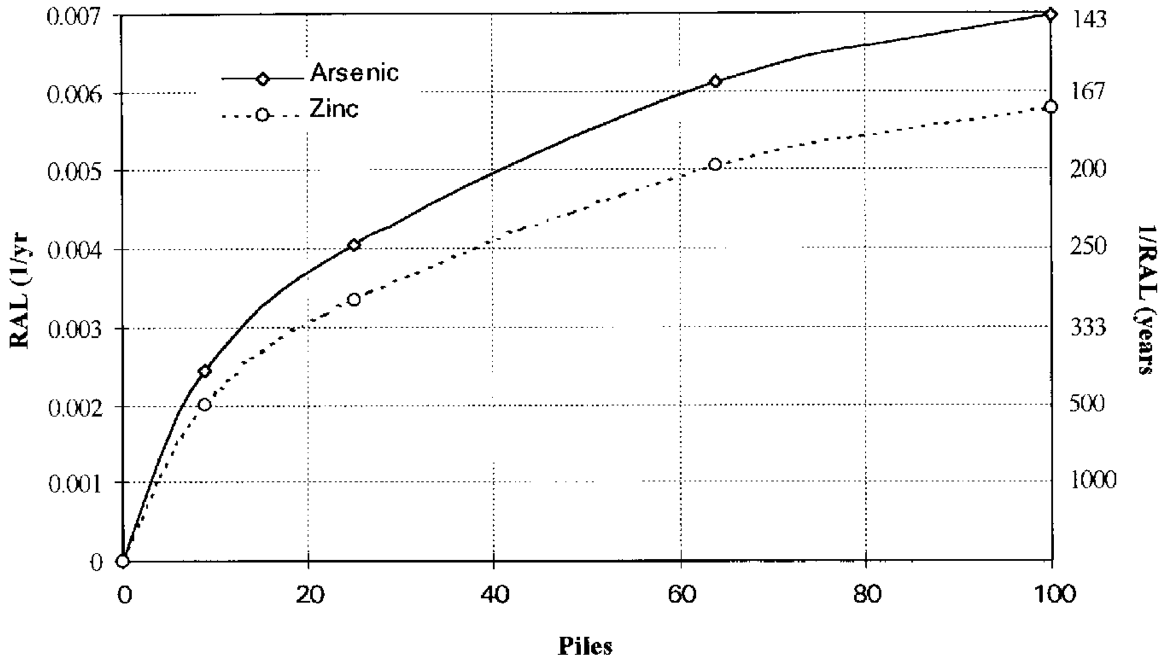

Figure 8-14

SOIL ASSESSMENT RESULTS
ARSENIC AND ZINC RELATIVE ANNUAL LOADING (RAL)

Impacts to the worker air environment were examined for the same four source conditions or storage scenarios used in the ambient air and soil impact assessment. Total emission source estimates (E_T) used were the same as those used for the air and soil assessments (see Table E2-1 in Appendix E2). Values for Control PM_{10} Volume (V) and turnover Time (T) are discussed below.

8.5.2.1 Source Parameters

Four different storage sites containing 9, 25, 64 and 100 stockpiles were used in the assessment. All site conditions were as outlined in the air quality assessment (Section 8.4.2.1).

8.5.2.2 Worker Environment Control Volume

A control volume was defined and used to assess the potential impacts of emissions on the worker environment. The control volume, or hypothetical work area, for each source scenario was assumed to be a square with the dimensions presented in Table 8-2, and a height equal to 15 feet, which is the height of the stockpile. Table 8-2 indicates the anticipated daily quantity of bottom ash processed at each storage facility. See Appendix E6 for a more detailed description of the worker control volume.

8.5.2.3 Meteorological Data

Control volume turnover rates were calculated by assuming that the air traveled diagonally across the square control volume. Two wind speeds were used in the turnover rate calculation. The first, 1 m/s (2.2 mph), as used as a conservative speed to represent calm conditions; the second, 2.3 m/s (5 mph), was used to represent average conditions (USEPA, 1991). See Appendix E6 for a more detailed description of control volume turnover rates.

8.5.3 Worker Environment Assessment Criteria

OSHA worker exposure criteria (USEPA, 1988) were used to assess the potential impacts of projected TSP and PM_{10} dust and trace metals on the worker environment. Trace metal criteria are based upon TSP dust levels and the expectation that potential impacts may occur from dermal contact as well as inhalation. The OSHA criteria are based upon an assumed 8-hour exposure period.

8.5.4 Worker Environment Assessment Results

Tables 8-12, 8-13, 8-14 and 8-15 present the results of the worker health assessment for the 9, 25, 64 and 100 stockpile areas, respectively. The tables present TSP and PM_{10} dust concentrations calculated for wind speeds equal to 1 m/s and 2.3 m/s. The tables also present calculated trace metal dust concentrations based upon the calculated 1 m/s TSP dust concentrations. The tables include Hazard Quotients along with each calculated dust or trace metal concentrations. The results for all stockpile runs were significantly lower than OSHA criteria.

Table 8-12
WORKER AIR TRACE METAL CONCENTRATIONS AND IMPACTS FOR 9 BOTTOM ASH STOCKPILES
(μg/m^3)

Parameter	Wind Speed (m/s)	Air Concentration (μg/m^3)	OSHA Standard (μg/m^3)	Hazard Quotient
TSP	1	1431	15000	9.5E-02
	2.3	622	15000	4.1E-02
PM$_{10}$	1	641	5000	1.3E-01
	2.3	279	5000	5.6E-02
Ag	1	1.4E-02	1.0E+01	1.4E-03
Al	1	6.6E+01	-	-
As	1	1.4E-01	1.0E+01	1.4E-02
Ba	1	1.0E+00	5.0E+02	2.1E-03
Be	1	1.4E-03	2.0E+00	7.2E-04
Ca	1	6.8E+01	-	-
Cd	1	1.2E-01	5.0E+00	2.5E-02
Cr (total)	1	3.8E-01	1.0E+03	3.8E-04
Cu	1	2.4E+00	1.0E+03	2.4E-03
Fe	1	8.6E+01	-	-
Hg	1	7.1E-04	5.0E+03	1.4E-07
K	1	6.8E+00	-	-
Mg	1	1.2E+01	-	-
Mn	1	1.7E+00	5.0E+01	3.5E-02
Na	1	2.1E+01	-	-
Ni	1	2.1E-01	1.0E+03	2.1E-04
Pb	1	3.5E+00	5.0E+01	7.0E-02
Se	1	1.5E-03	-	-
Si	1	3.5E-01	-	-
Zn	1	9.6E+00	1.5E+04	6.4E-04

Table 8-13

WORKER AIR TRACE METAL CONCENTRATIONS AND IMPACTS FOR 25 BOTTOM ASH STOCKPILES

(μg/m³)

Parameter	Wind Speed (m/s)	Air Concentration (μg/m³)	OSHA Standard (μg/m³)	Hazard Quotient
TSP	1	2385	15000	1.6E-01
	2.3	1037	15000	6.9E-02
PM_{10}	1	1068	5000	2.1E-01
	2.3	465	5000	9.3E-02
Ag	1	2.4E-02	1.0E+01	2.4E-03
Al	1	1.1E+02	-	-
As	1	2.3E-01	1.0E+01	2.3E-02
Ba	1	1.7E+00	5.0E+02	3.5E-03
Be	1	2.4E-03	2.0E+00	1.2E-03
Ca	1	1.1E+02	-	-
Cd	1	2.1E-01	5.0E+00	4.2E-02
Cr (total)	1	6.4E-01	1.0E+03	6.4E-04
Cu	1	4.1E+00	1.0E+03	4.1E-03
Fe	1	1.4E+02	-	-
Hg	1	1.2E-03	5.0E+03	2.4E-07
K	1	1.1E+01	-	-
Mg	1	1.9E+01	-	-
Mn	1	2.9E+00	5.0E+01	5.8E-02
Na	1	3.4E+01	-	-
Ni	1	3.5E-01	1.0E+03	3.5E-04
Pb	1	5.8E+00	5.0E+01	1.2E-01
Se	1	2.4E-03	-	-
Si	1	5.8E-01	-	-
Zn	1	1.6E+01	1.5E+04	1.1E-03

Table 8-14
WORKER AIR TRACE METAL CONCENTRATIONS AND IMPACTS FOR 64 BOTTOM ASH STOCKPILES
($\mu g/m^3$)

Parameter	Wind Speed (m/s)	Air Concentration ($\mu g/m^3$)	OSHA Standard ($\mu g/m^3$)	Hazard Quotient
TSP	1	3816	15000	2.5E-01
	2.3	1659	15000	1.1E-01
PM_{10}	1	1710	5000	3.4E-01
	2.3	743	5000	1.5E-01
Ag	1	3.8E-02	1.0E+01	3.8E-03
Al	1	1.7E+02	-	-
As	1	3.7E-01	1.0E+01	3.7E-02
Ba	1	2.8E+00	5.0E+02	5.6E-03
Be	1	3.8E-03	2.0E+00	1.9E-03
Ca	1	1.8E+02	-	-
Cd	1	3.3E-01	5.0E+00	6.6E-02
Cr (total)	1	1.0E+00	1.0E+03	1.0E-03
Cu	1	6.5E+00	1.0E+03	6.5E-03
Fe	1	2.3E+02	-	-
Hg	1	1.9E-03	5.0E+03	3.8E-07
K	1	1.8E+01	-	-
Mg	1	3.1E+01	-	-
Mn	1	4.7E+00	5.0E+01	9.3E-02
Na	1	5.5E+01	-	-
Ni	1	5.6E-01	1.0E+03	5.6E-04
Pb	1	9.3E+00	5.0E+01	1.9E-01
Se	1	3.9E-03	-	-
Si	1	9.3E-01	-	-
Zn	1	2.6E+01	1.5E+04	1.7E-03

Table 8-15
WORKER AIR TRACE METAL CONCENTRATIONS AND IMPACTS FOR 100 BOTTOM ASH STOCKPILES (μg/m^3)

Parameter	Wind Speed (m/s)	Air Concentration (μg/m^3)	OSHA Standard (μg/m^3)	Hazard Quotient
TSP	1	4770	15000	3.2E-01
	2.3	2074	15000	1.4E-01
PM_{10}	1	2137	5000	4.3E-01
	2.3	929	5000	1.9E-01
Ag	1	4.7E-02	1.0E+01	4.7E-03
Al	1	2.2E+02	-	-
As	1	4.7E-01	1.0E+01	4.7E-02
Ba	1	3.5E+00	5.0E+02	6.9E-03
Be	1	4.8E-03	2.0E+00	2.4E-03
Ca	1	2.3E+02	-	-
Cd	1	4.2E-01	5.0E+00	8.3E-02
Cr (total)	1	1.3E+00	1.0E+03	1.3E-03
Cu	1	8.1E+00	1.0E+03	8.1E-03
Fe	1	2.9E+02	-	-
Hg	1	2.4E-03	5.0E+03	4.8E-07
K	1	2.3E+01	-	-
Mg	1	3.9E+01	-	-
Mn	1	5.8E+00	5.0E+01	1.2E-01
Na	1	6.9E+01	-	-
Ni	1	7.1E-01	1.0E+03	7.1E-04
Pb	1	1.2E+01	5.0E+01	2.3E-01
Se	1	4.8E-03	-	-
Si	1	1.2E+00	-	-
Zn	1	3.2E+01	1.5E+04	2.1E-03

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PART III

TECHNICAL APPENDICES

Appendix A

BOTTOM ASH CHARACTERIZATION METHODS AND RESULTS

Appendix A presents bottom ash characterization analytical procedures and results for elemental, organic, and sequential chemical extraction testing. Appendix A is divided into four sections:

A1 Bottom Ash Characterization Analytical Procedures
A2 Bottom Ash Elemental Characterization Test Results
A3 Bottom Ash Organic Characterization Test Results
A4 Bottom Ash Sequential Chemical Extraction Test Results

A1

BOTTOM ASH CHARACTERIZATION
ANALYTICAL PROCEDURES

Appendix A1 describes the procedures used to test the stockpiled bottom ash for elemental characterization, moisture content, sequential chemical extraction, organic content and physical characteristics. A list of the analytical tests performed on the samples is presented in Table 3-1 in Section 3 and a list of the dates that samples were collected is presented in Table 3-2 in Section 3.

A1.1 Elemental Characterization

BA was delivered to the NJDEP laboratories (see Section 3, Table 3-2) where samples were prepared for chemical characterization analysis following Method 3050 from the USEPA SW-846 "Test Methods for Evaluating Solid Waste." All elements were analyzed using flame atomic adsorption or graphite furnace atomic adsorption except for silicon, which was analyzed using ICP; and mercury, which was analyzed using cold vapor atomic adsorption.

A1.2 Moisture Content

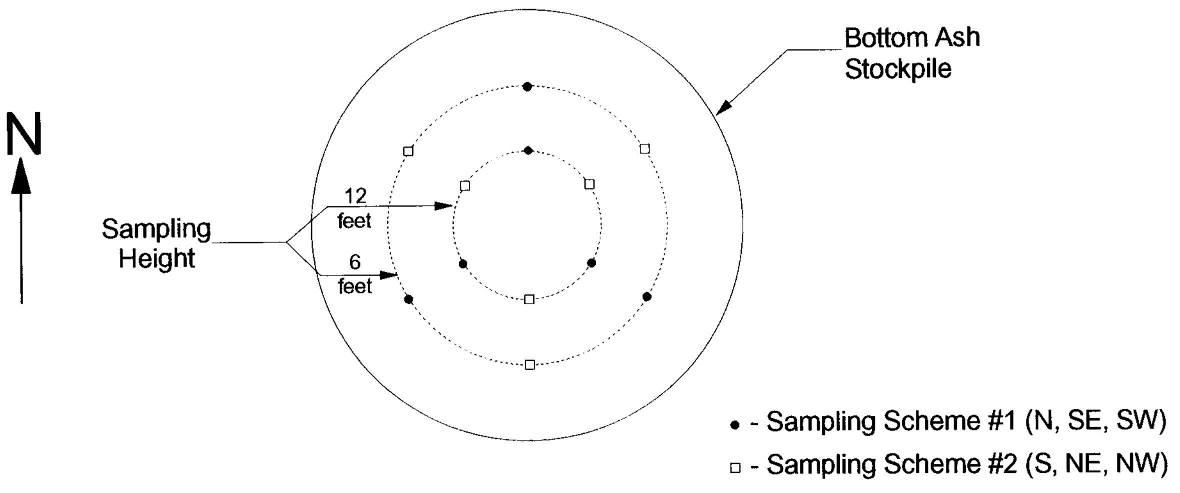
Figure A1-1 depicts the method for moisture sample collection from the bottom ash stockpile. Samples were collected by alternating between two sampling schemes. The first scheme involved taking samples from the pile's north, southeast and southwest sides. The second scheme involved taking samples from the pile's south, northeast and northwest sides. Moisture samples were always collected from the stockpile surface and from a depth of three feet into the pile at heights of six and 12 feet on the pile. Samples were placed in airtight containers and sent to the NJDEP laboratories in Trenton, New Jersey.

Moisture samples were weighed upon arrival at the NJDEP laboratories in Trenton, NJ, dried overnight at approximately 100°C, and weighed again. Percent moisture was calculated on a wet weight basis as follows:

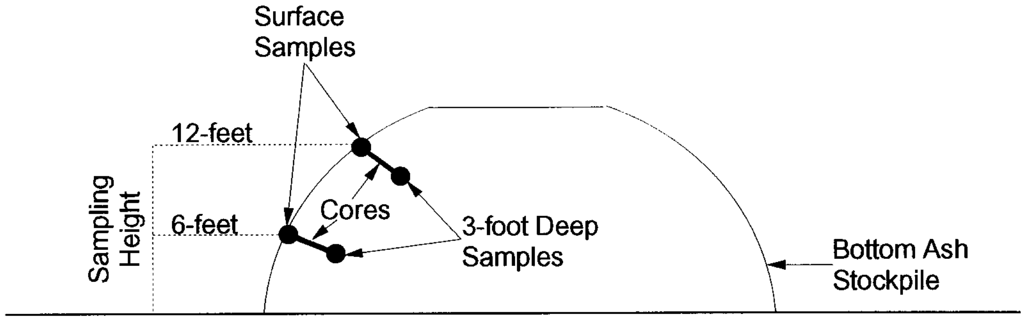
$$\%Moisture = \frac{weight_{wet} - weight_{dry}}{weight_{wet}} \times 100 \qquad (1)$$

A1.3 Sequential Chemical Extraction

Sequential Chemical Extraction tests were performed on the stockpiled bottom ash using procedures outlined by Tessier, A., P.G. Campbell and M. Bisson, "Sequential Chemical Extraction Procedure for the Speciation of Trace Metals," Analytical Chemistry Vol. 51, No. 7, June, 1979.



Stockpile Plan View



Stockpile Side View

Note:
Samples were collected by alternating between the two sampling schemes. Samples were collected from the stockpile at heights of 6-feet and 12-feet from the surface and at a 3-foot depth.

Figure A1-1
STOCKPILE MOISTURE COLLECTION PLAN

The Sequential Chemical Extraction method calls for five extractions per sample, each using a more aggressive extraction fluid than the previous one. Sequential chemical extractions were performed by the State University of New York on samples delivered to it following turnover events 1, 2, and 4 (t = 5, 6 and 7 months). Samples were also collected before the turnover events at t=0, 2 and 4 months and delivered to the State University of New York for Sequential Chemical Extraction testing.

In the first extraction, a one molar solution of magnesium chloride is used. Any trace metals dissolved in this fluid are regarded as an ion exchangeable fraction that is readily available for leaching. The second extraction (Extraction B) makes use of a one molar solution of sodium acetate. This extraction is designed to remove the carbonate bound trace metal fraction, which is considered available for leaching under somewhat acidic conditions. The third extraction (Extraction C) makes use of a 0.04 molar solution of hydroxlamine hydrochloric in a 25 percent solution of acetic acid. This solution is capable of dissolving iron and manganese oxide bound metals. The fourth extraction (Extraction D) makes use of a 0.02 molar solution of nitric acid in a 30 percent solution of hydrogen peroxide at a pH adjusted to 2. This solution is capable of dissolving metals bound as sulfides. The fifth extraction (Extraction E) makes use of 49 percent hydrofluoric acid which is intended to dissolve the remaining solid fraction. Metals dissolved in Fraction E are considered unavailable for leaching, even under extreme conditions.

A1.4 Organic Testing

Analyses for dioxins and furans and for priority pollutants were conducted by the New York State Department of Health on samples collected from the bottom ash stockpile after the first turnover event. Analyses for dioxins and furans were conducted following USEPA Method 8280 (USEPA, 1984).

Samples were prepared for priority pollutant analysis using USEPA Method 625 (USEPA, 1984). Samples were then analyzed for priority pollutants using the EPA 0LM01,0, CLP (Contract Laboratory Protocol) Organics SOW (Statement of Work) 3/90 method. Samples were analyzed on gas chromatograph and mass spectrometer.

A1.5 Physical Testing

Samples were collected from the bottom ash stockpile for analysis prior to the stockpile turnover events and following turnover events one and two. These include samples collected at T=0, 2 and 4 months (see Section 3, Table 3-2). Grain size analysis was determined using methods outlined in AASHTO T-27. Tests were conducted by the NJDOT.

Appendix A2

BOTTOM ASH ELEMENTAL CHARACTERIZATION TEST RESULTS

Appendix A2 presents the results of the stockpiled bottom ash elemental characterization as well as the results of an analysis to determine whether there was any change in the bottom ash elemental concentrations over the course of the monitoring period.

A2.1 Elemental Characterization Results

Table A2-1 lists the results of all replicates analyzed from the six bottom ash sampling events. The table presents the date of sample collection and the days and months from the construction date of the stockpile. It also includes the elemental concentration for each replicate.

A2.2 Elemental Characterization Time Analysis

An analysis was undertaken to determine if the stockpiled bottom ash elemental concentrations were changing over time. The analysis consisted of averaging elemental concentrations from each sampling event. The averages from each event were then normalized to a percent of the concentration measured from the first (t=0) sampling event. Figures A2-1 to A2-18 present the results of this analysis. Certain elements such as Cu and Fe appear to show an increase in concentration over time while Ca and Hg appear to show a decrease in concentration over time. Additional analyses were undertaken for those elements which showed a decrease in elemental concentrations over time compared to the initial t=0 elemental concentrations. The analyses consisted of comparing actual runoff concentrations for the elements being analyzed to predicted runoff concentrations which were based on rainfall and observed elemental loss. Predicted runoff concentrations were calculated by dividing the total elemental loss for each element for the entire stockpile by the total rainfall which fell on the stockpile pad. The results of these analyses are presented in Table A2-2. The results in the table indicate that the predicted runoff concentrations which were based on measured stockpile elemental concentrations are one to two orders of magnitude above the highest measured total runoff concentration (see Appendix B2). This suggests that observable trends in the data may be due to sample variance, rather than any definitive trend.

Table A2-1
STOCKPILE BOTTOM ASH ELEMENTAL CAHRACTERIZATION RESULTS
(μg/g)

	Sampling Event[1]																			
Mos.	0					6			7			8			9			10		
Days	0					165			201			235			262			305		
Date	12/4/92					5/18/93			6/23/93			7/27/93			8/23/93			10/5/93		
Al	45400	43000	44200	44100	44900	48500	44500	51500	47000	43100	45600	48300	47500	45300	43400	42800	46800	45400	43800	44400
As	11.9	11.5	17	11.5	11.4	19.1	18.3	17.3	18.1	18.5	21.1	17.6	17.6	18.5	16.8	17.5	17.5	14.7	14.3	16.2
Ba	679	706	712	749	735	806	806	820	735	664	663	801	760	692	692	695	664	716	693	725
Be	0.99	1	1	1	0.99	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cd	30.7	30	29	30	30.7	31.6	28.0	25.2	28.0	30.4	27.2	29.7	29.4	27.7	25.5	24.7	23.5	24.3	24.7	26.2
Ca	73100	74600	77600	75800	75400	50500	49500	45900	51500	49300	52400	50700	54400	47000	43400	44600	40200	44200	43600	42000
Cr	129	118	112	139	118	135	137	125	118	126	133	139	122	116	129	127	136	189	130	116
Cu	2460	2030	1870	2390	2190	2800	1730	3030	1250	1250	1240	1860	2230	1710	2790	2180	2650	4930	4280	5290
Fe	58000	58000	60000	55600	54700	56200	52300	49800	51800	59100	51700	59900	54200	63100	59100	61100	55100	73500	84400	68000
Pb	1640	1830	2010	1730	1580	1530	1250	1240	1460	1280	1180	1490	1450	1530	1530	1500	1470	1440	1280	1310
Mg	7430	7400	7200	7600	7620	8170	7750	7770	8250	8580	8980	8660	8820	8170	7840	7670	7350	7770	8410	7524
Mn	1170	1050	1070	1140	1140	2000	2250	1970	875	956	995	1040	956	1310	907	916	956	1020	1140	1040
Hg	0.82	0.85	0.79	0.75	0.82	0.44	0.41	0.43	0.60	0.49	0.53	0.48	0.48	0.51	0.55	0.53	0.55	0.49	0.50	0.47
Ni	118	112	124	151	122	150	135	143	125	142	117	144	165	161	183	174	165	143	158	129
K	4550	4500	4350	4700	4550	4750	4600	4660	4600	3920	4560	5150	5390	4950	4710	5650	4220	4370	4650	4370
Se	0.89	0.8	0.8	0.8	0.79	1.08	1.09	0.89	1.08	1.10	0.98	1.08	0.88	1.00	0.99	1.10	1.00	0.88	1.09	0.98
Ag	11.9	12	12	13	11.9	8.9	10.0	8.7	9.0	9.8	14.6	12.9	9.8	9.9	10.8	9.9	7.8	7.8	7.9	10.7
Na	8020	7800	7800	7900	8320	9410	9000	8980	8750	7840	8010	9160	95560	8910	8580	8660	8330	8250	8660	8010
Zn	4850	4700	5200	5400	5250	4450	4500	5340	3350	3090	3350	4950	4560	3860	4900	5100	4800	4130	3960	4320

1. Months represents the number of months since the stockpile was constructed.
Days represents the number of days since the stockpile was constructed.
The date represents the date when the sample was collected

Figure A2-1
BOTTOM ASH STOCKPILE ARSENIC CONCENTRATION

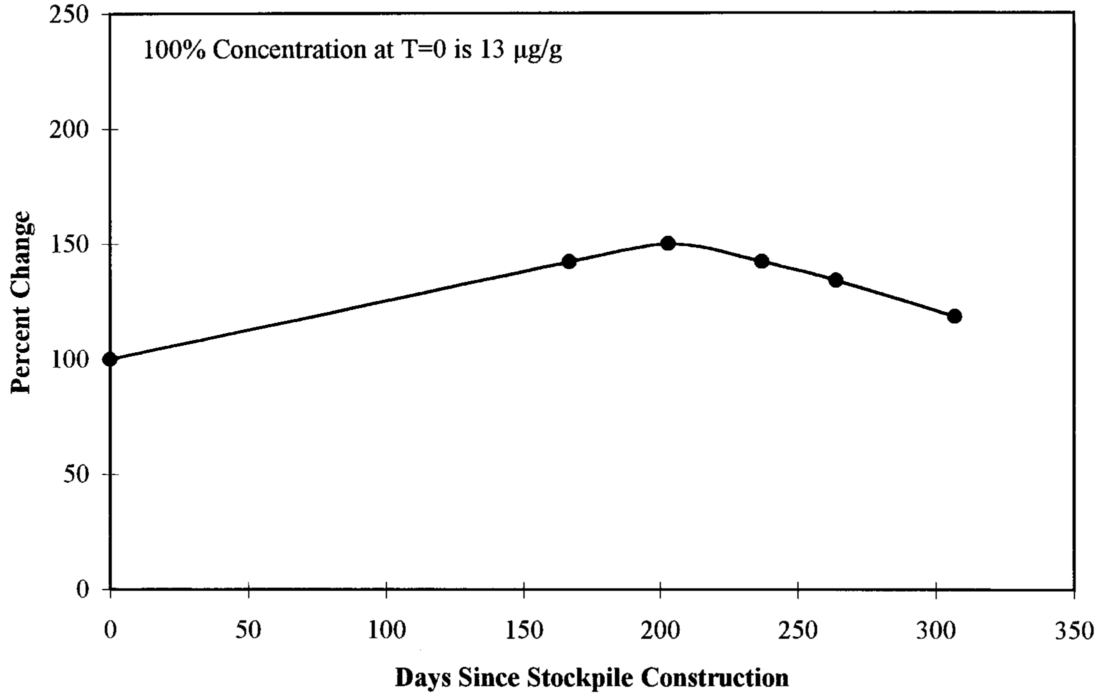


Figure A2-2
BOTTOM ASH STOCKPILE BARIUM CONCENTRATION

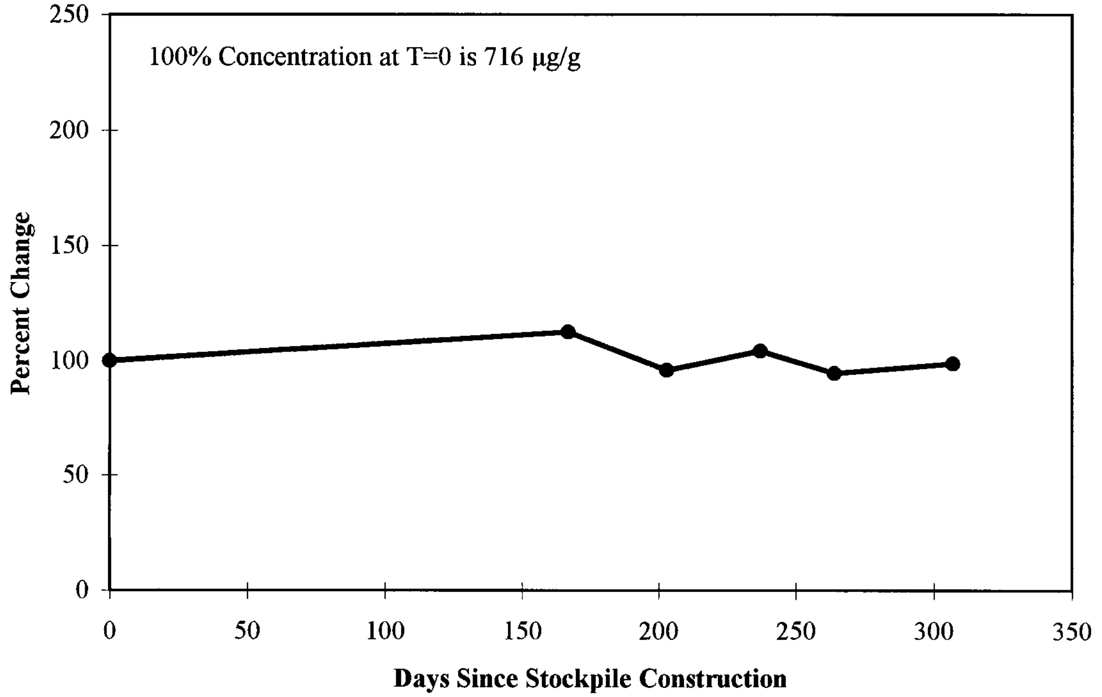


Figure A2-3
BOTTOM ASH STOCKPILE CADMIUM CONCENTRATION

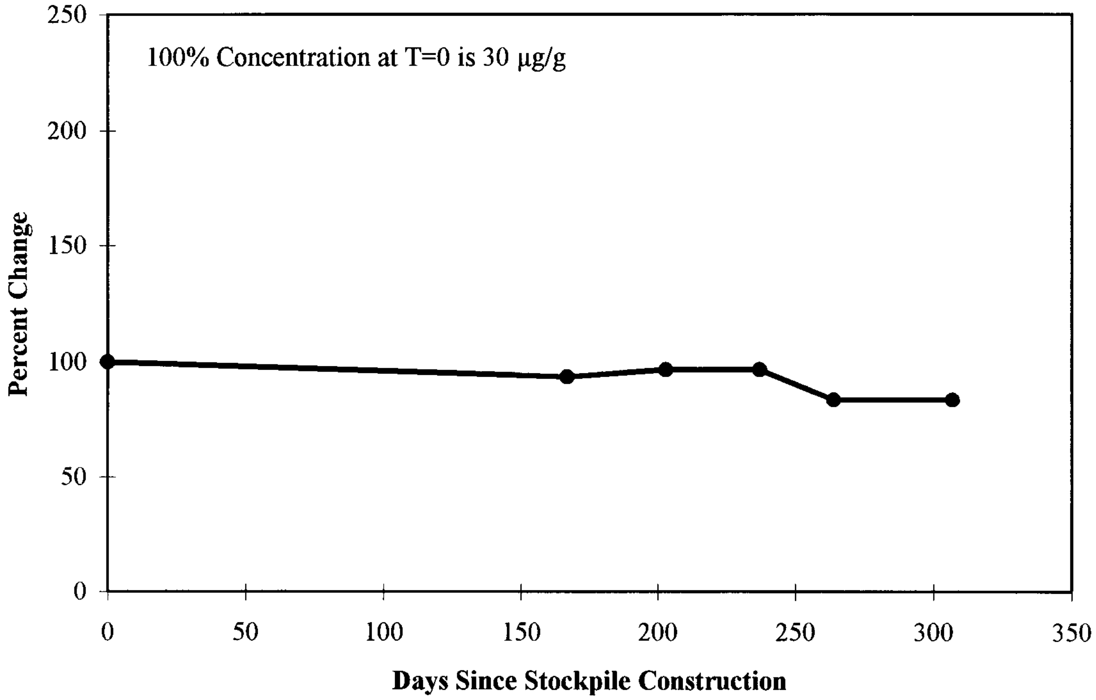


Figure A2-4
BOTTOM ASH STOCKPILE COPPER CONCENTRATION

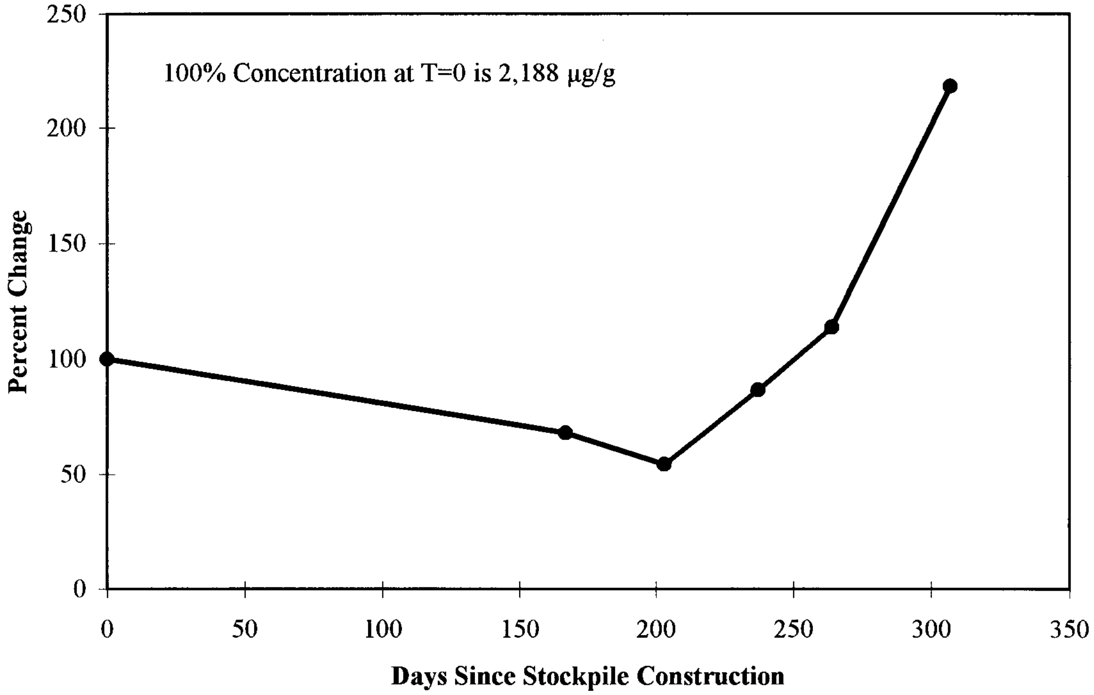


Figure A2-5
BOTTOM ASH STOCKPILE CHROMIUM CONCENTRATION

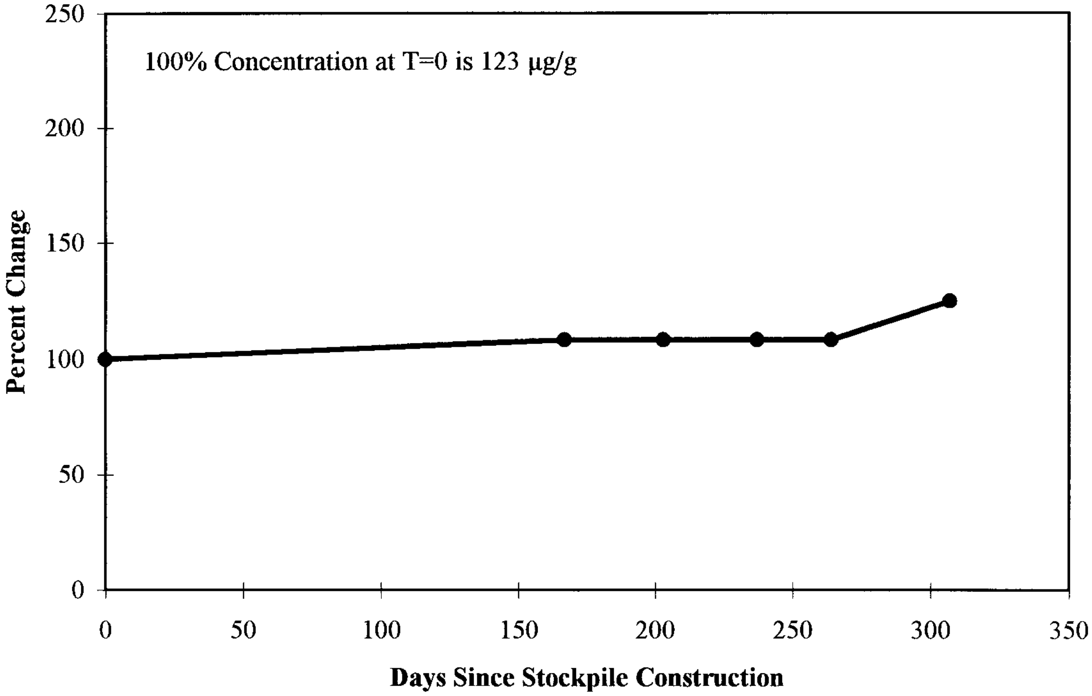


Figure A2-6
BOTTOM ASH STOCKPILE LEAD CONCENTRATION

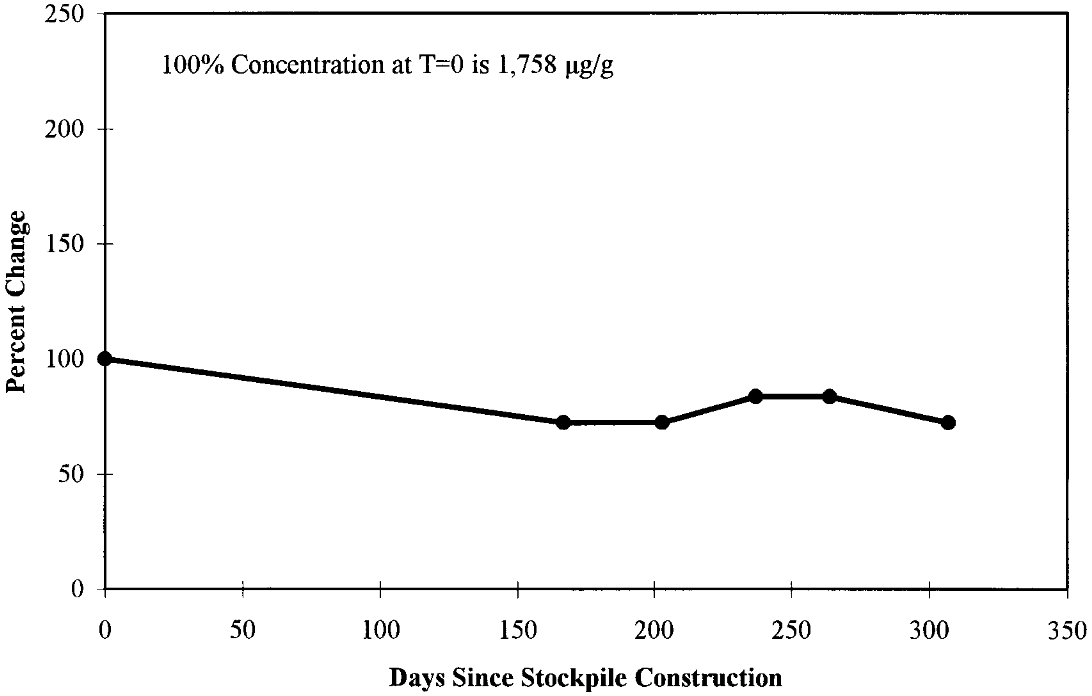


Figure A2-7
BOTTOM ASH STOCKPILE MERCURY CONCENTRATION

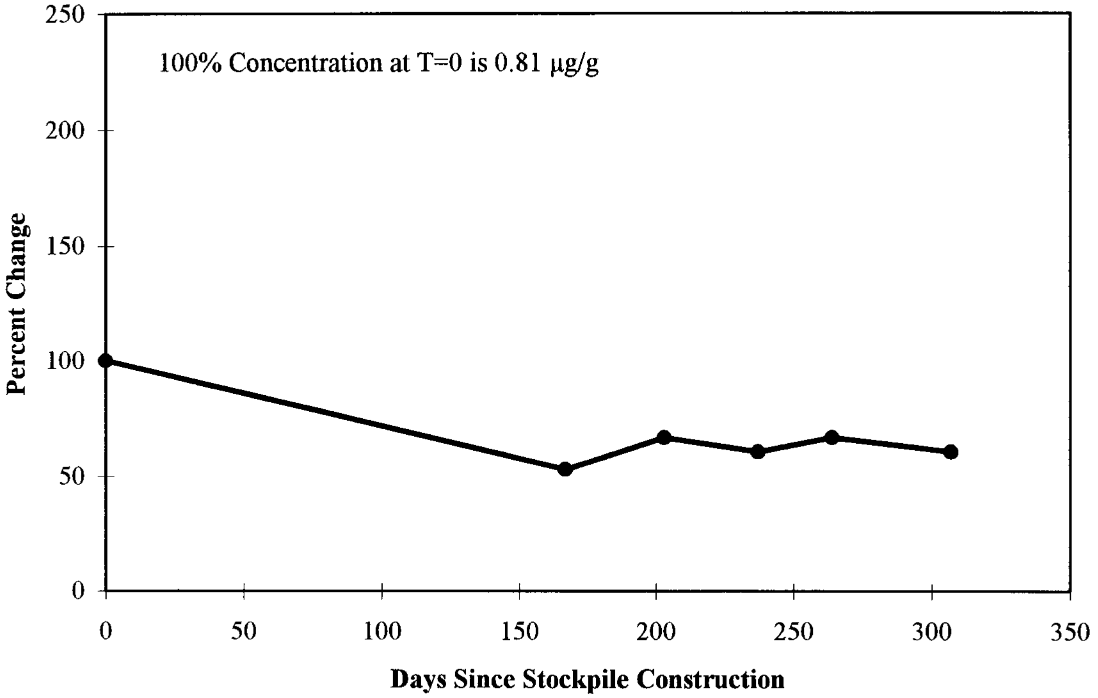


Figure A2-8
BOTTOM ASH STOCKPILE MANGANESE CONCENTRATION

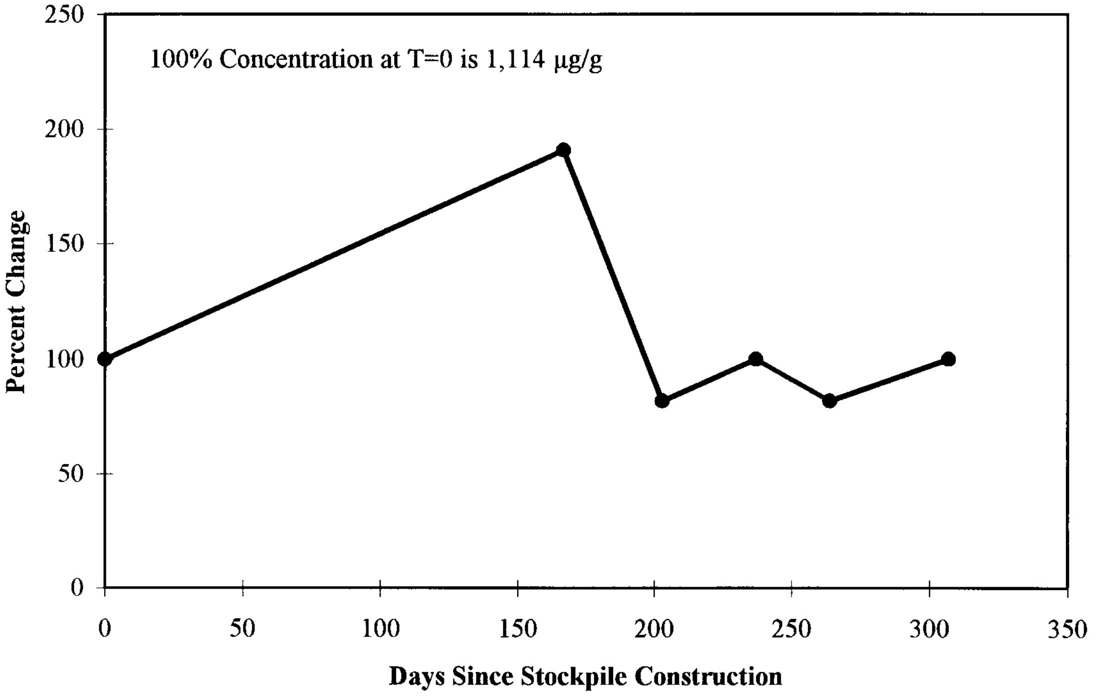


Figure A2-9
BOTTOM ASH STOCKPILE NICKEL CONCENTRATION

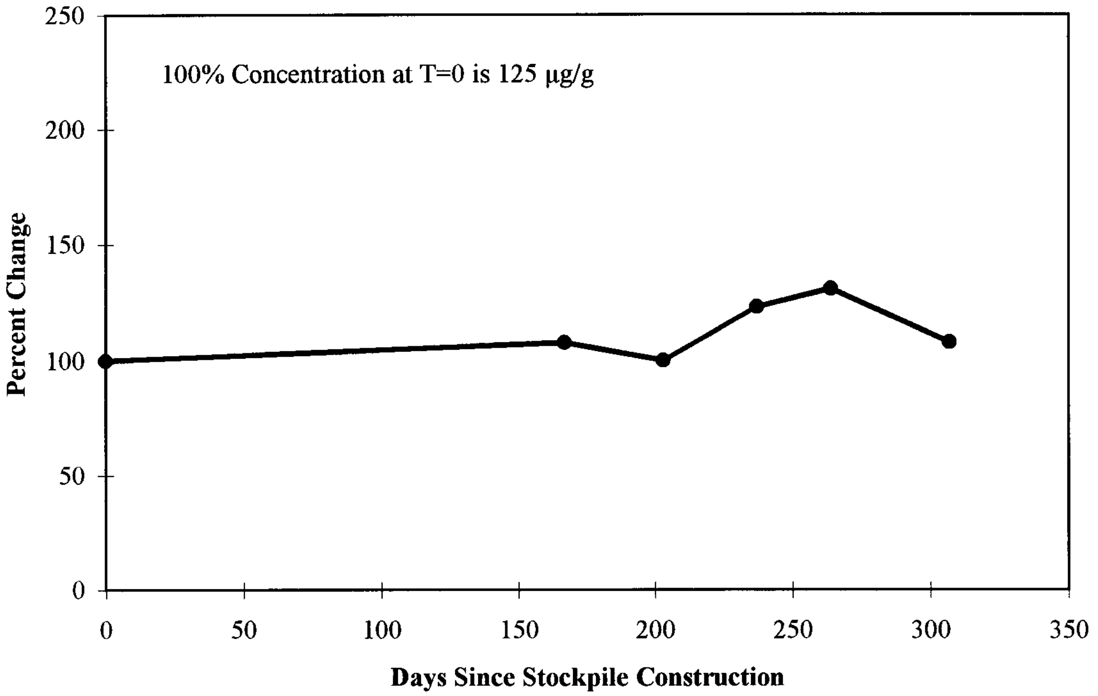


Figure A2-10
BOTTOM ASH STOCKPILE SILVER CONCENTRATION

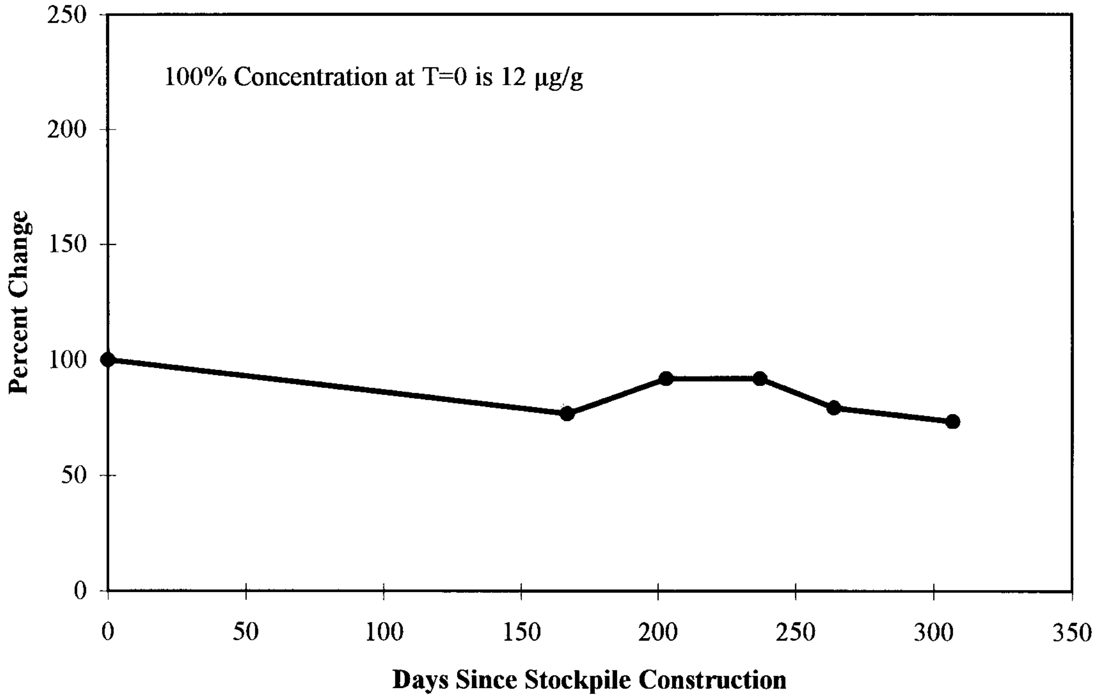


Figure A2-11
BOTTOM ASH STOCKPILE ZINC CONCENTRATION

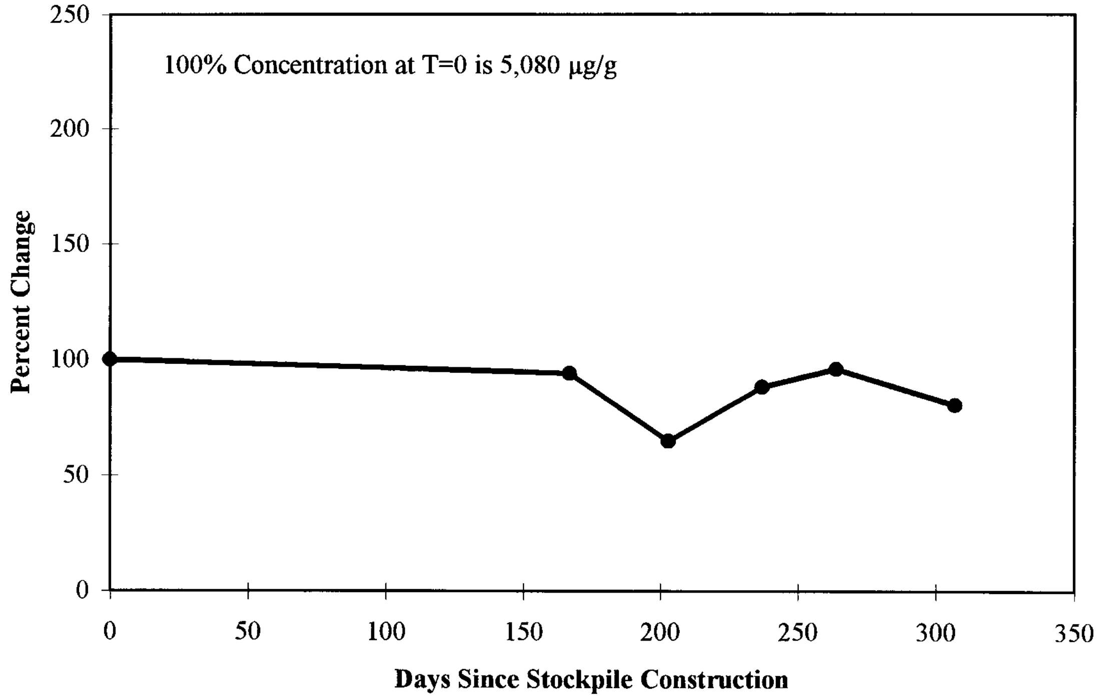


Figure A2-12
BOTTOM ASH STOCKPILE ALUMINIUM CONCENTRATION

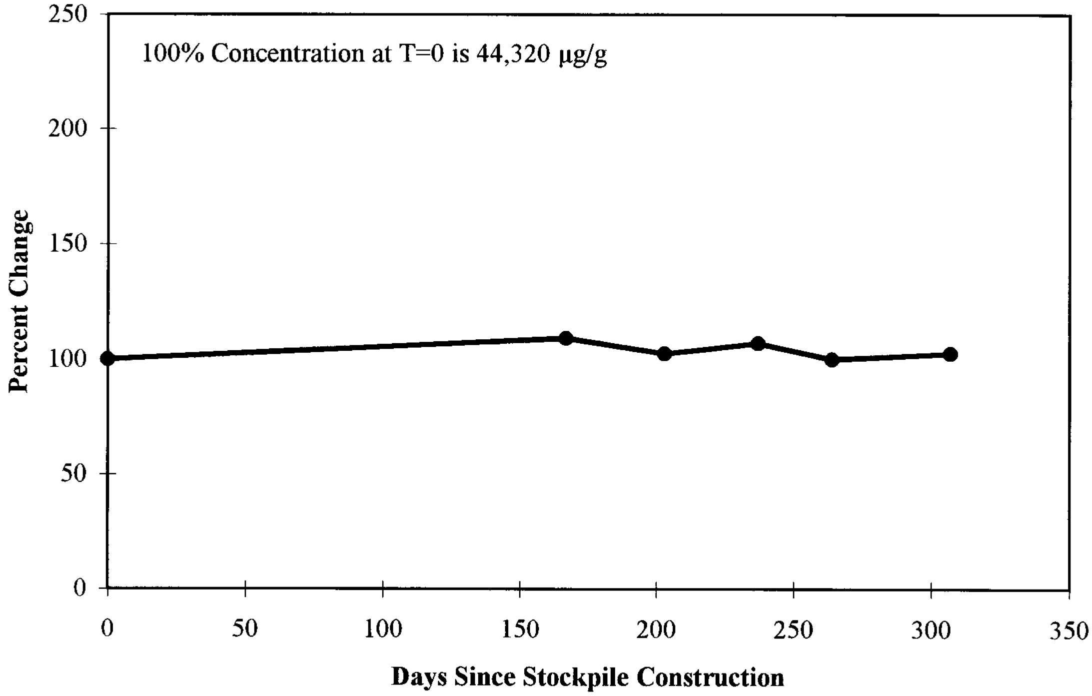


Figure A2-13
BOTTOM ASH STOCKPILE IRON CONCENTRATION

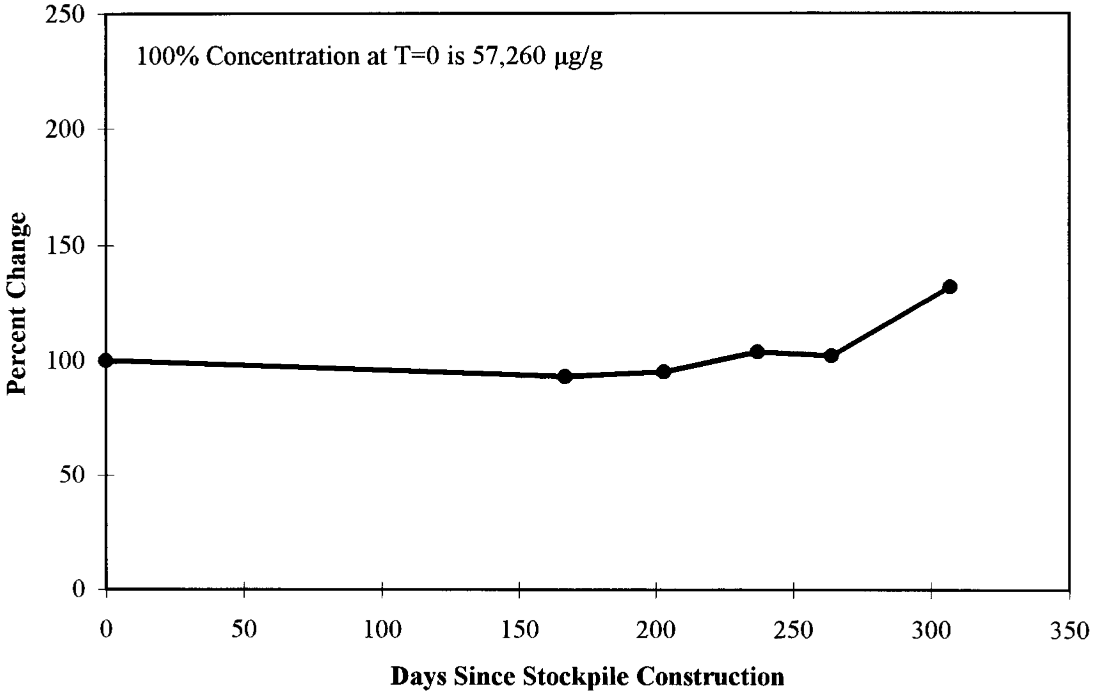


Figure A2-14
BOTTOM ASH STOCKPILE SELENIUM CONCENTRATION

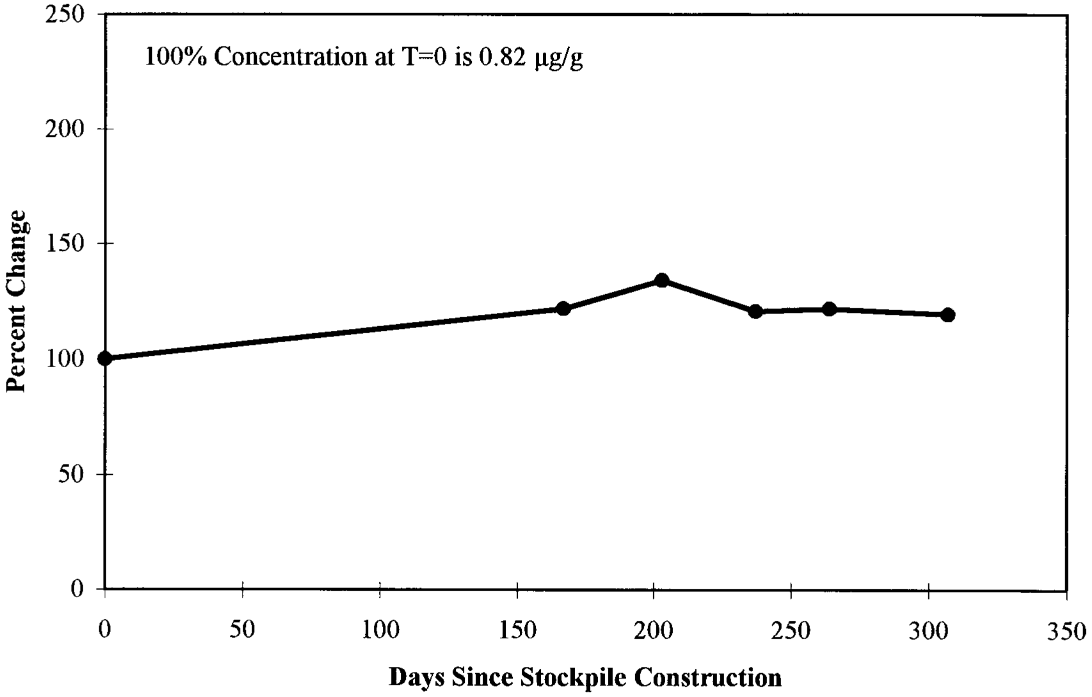


Figure A2-15
BOTTOM ASH STOCKPILE CALCIUM CONCENTRATION

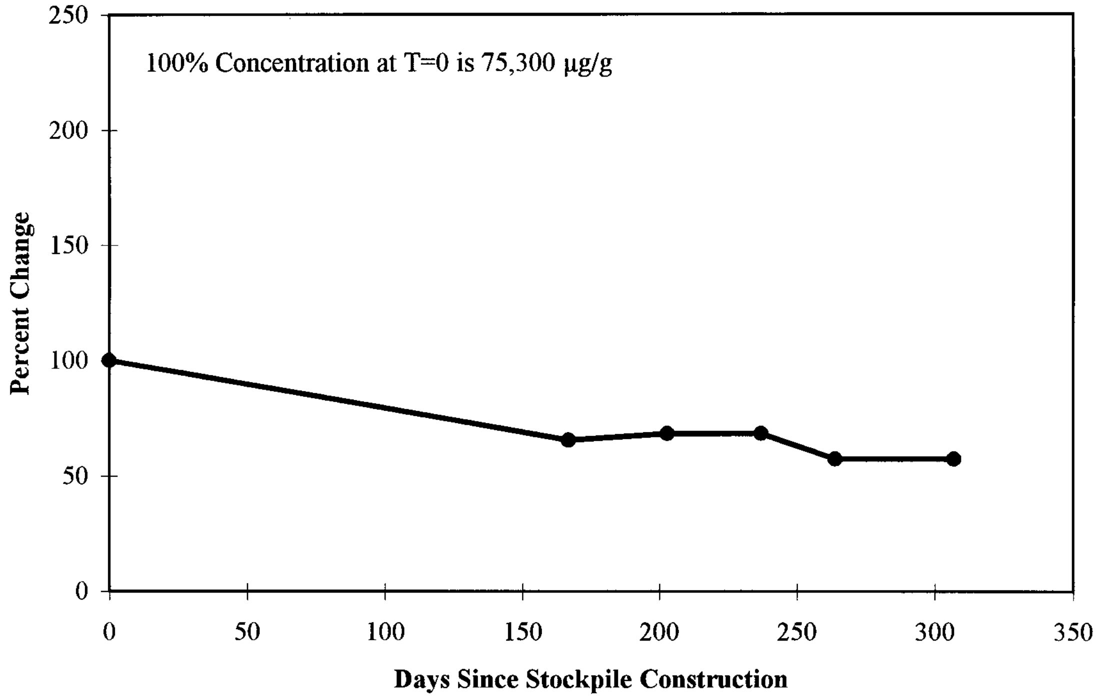


Figure A2-16
BOTTOM ASH STOCKPILE POTASSIUM CONCENTRATION

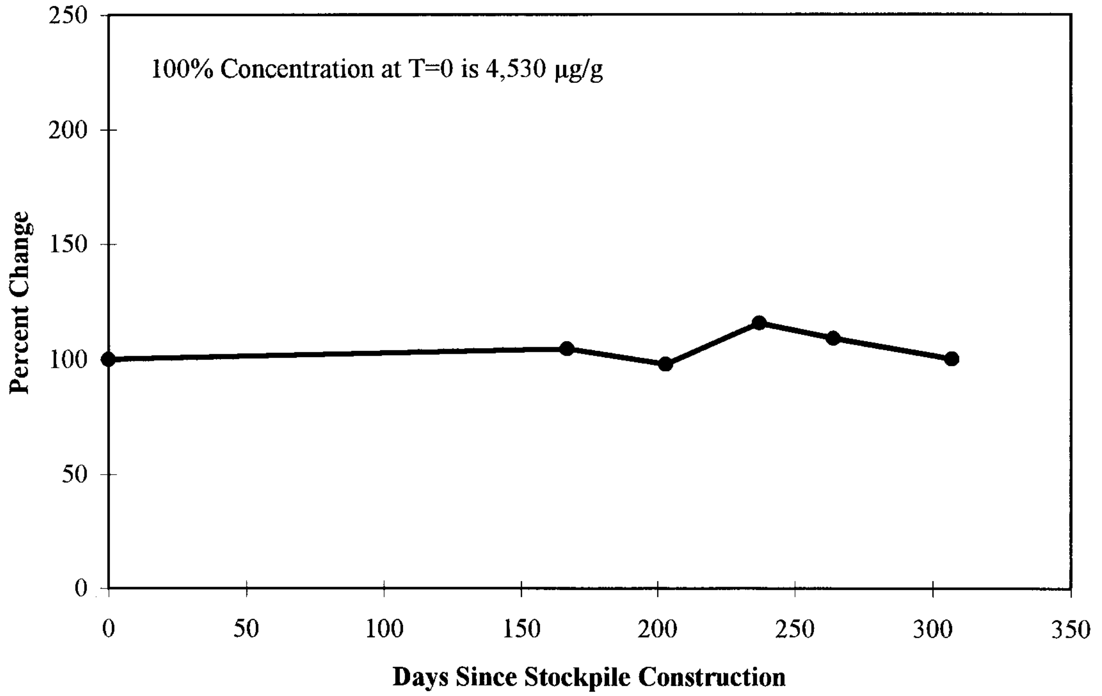


Figure A2-17
BOTTOM ASH STOCKPILE MAGNESIUM CONCENTRATION

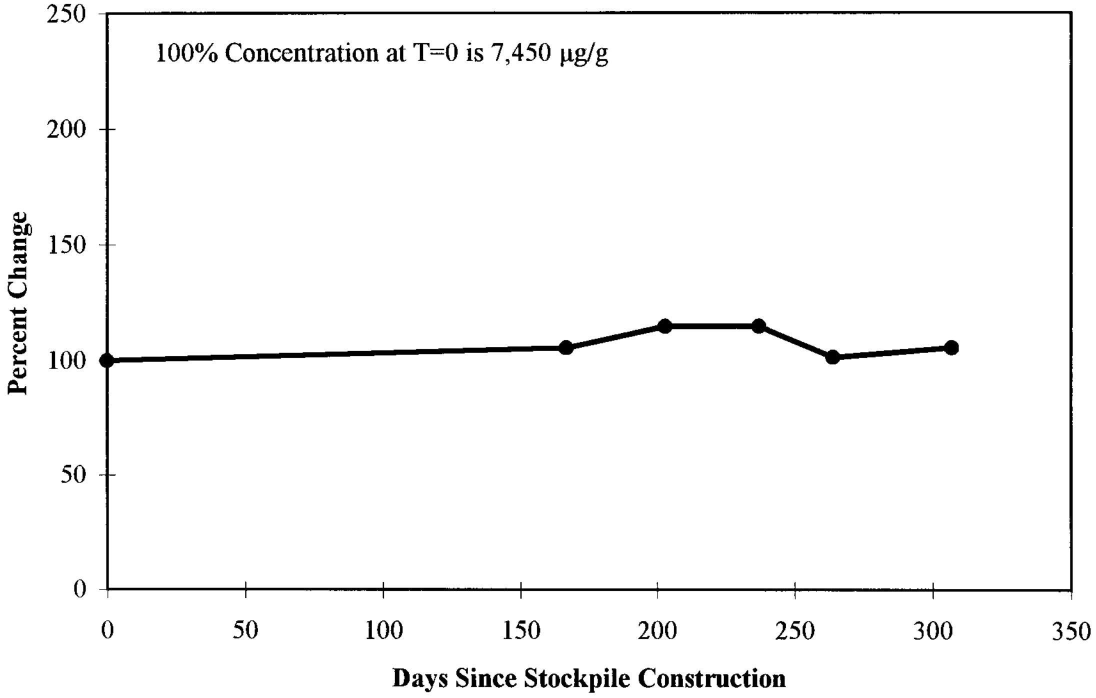


Figure A2-18
BOTTOM ASH STOCKPILE SODIUM CONCENTRATION

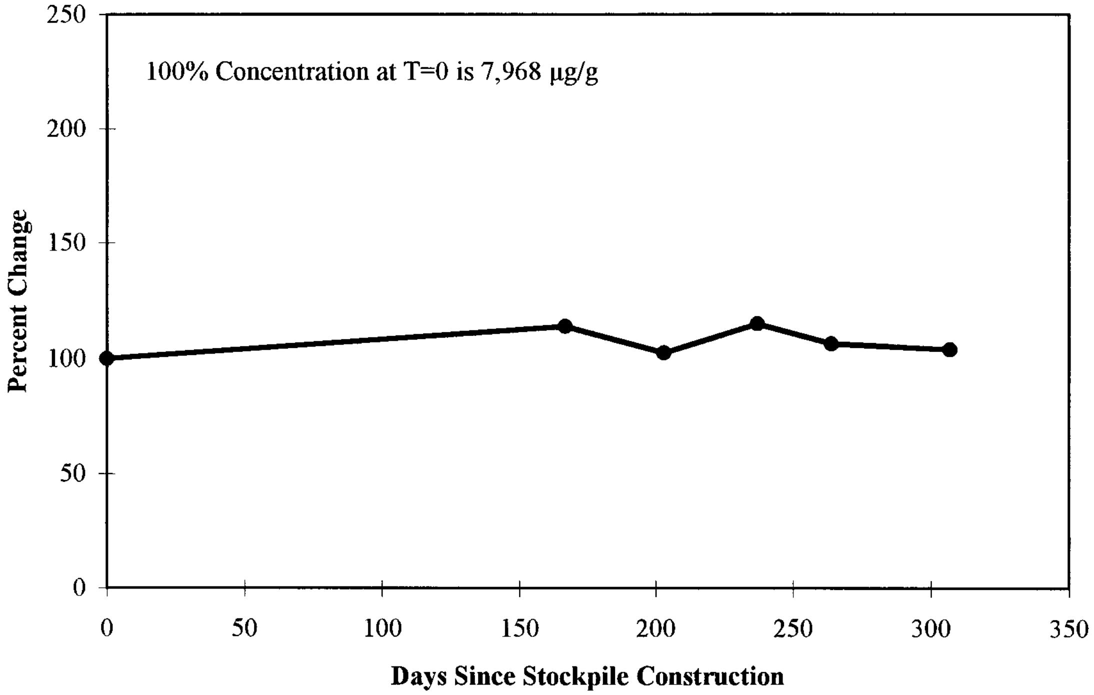


Table A2-2
STOCKPILED BOTTOM ASH ELEMENTAL LOSS CONCENTRATIONS COMPARED TO RUNOFF CONCENTRATIONS ESTIMATES

	Stockpile Elemental Concentrations[1]		Stockpile Total Elemental Loss[2]		Estimated Runoff	Highest Total Measured
	T=0 Months	T=10 Months		Total Rain[3]	Concentration[4]	Concentration[5]
Element	(μg/g)	(μg/g)	(mg)	(L)	(mg/L)	(mg/L)
Ba	720	710	3,500,000	411868	8.5	0.54
Cd	30	25	1,750,000	411868	4.2	0.05
Pb	1,800	1,300	175,000,000	411868	425	2.75
Hg	0.81	0.49	112,000	411868	0.27	0.001
Ag	12	8.8	1,120,000	411868	2.7	0.02
Zn	5,100	4,100	350,000,000	411868	850	6.4
Ca	75,000	43,000	11,200,000,000	411868	27193	2300

1. See Table A2-1
2. Loss in milligrams from total 360-ton BA Stockpile.
3. Total measured rainfall (41.6-inches) on 65-foot by 65-foot pad.
4. Calculated by diving total elemental loss (mg) by total rainfall (L).
5. Highest measured total elemental runoff concentration (see Appendix B2)

Appendix A3

BOTTOM ASH ORGANIC CHARACTERIZATION TEST RESULTS

Appendix A3 presents the results of the dioxin/furan and priority pollutant testing on the stockpiled bottom ash.

A3.1 Dioxin/Furan Test Results

Table A3-1 lists the results of the dioxin/furan testing performed on the stockpiled bottom ash sample collected on May 5, 1993. The table presents measured sample concentrations and the calculated toxic equivalents calculated using USEPA toxic equivalent factors. Results are presented for two ash replicates and a lab blank. The lab blank consisted of running an extraction on 15 grams of inert glass beads to detect any possible contamination in the reagents.

During analysis, measurements of concentrations of classes of dioxin or furan (i.e., TCDD, PCDD, etc.) compounds as well as specific compounds of concern within each class (i.e., 2,3,7,8-TCDD) were taken. USEPA provides toxic equivalent factors for the specific compounds of concern and for classes of compounds minus the specific compounds of concern.

Values in Table A3-1 are presented for measured specific compounds, measured total compounds, and calculated values for total compounds minus the concentrations of specific compounds.

A3.2 Priority Pollutants

Tables A3-2 and A3-3 present the results of the priority pollutant analysis of the stockpiled bottom ash sample collected May 5, 1993. The table presents individual results for four replicates.

Table A3-1
DIOXIN AND FURAN TEST RESULTS
STOCKPILE BOTTOM ASH
MAY 5, 1993
(ng/g)

	USEPA	*REPLICATE SAMPLES*				*Lab Blank*	
	TOXIC	*1*		*2*			*EPA*
DIOXIN / FURAN	*EQUIVALENT FACTOR*	*SAMPLE CONC*	*TOXIC EQUIV*	*SAMPLE CONC*	*TOXIC EQUIV*	*SAMPLE CONC*	*TOXIC EQUIV*
2378-TCDD	1.0	< 0.0018	0.0018	< 0.0014	0.0014	< 0.0002	0.0002
12378-PCDD	0.50	0.0037	0.0019	0.0044	0.0022	< 0.0002	0.0001
123478-HXCDD	0.040	0.0056	0.0002	0.0064	0.0003	< 0.0004	0.0000
123678-HXCDD	0.040	0.0032	0.0001	0.0041	0.0002	< 0.0004	0.0000
123789-HXCDD	0.040	0.0032	0.0001	0.0040	0.0002	< 0.0003	0.0000
1234678-HPCDD	0.0010	0.0800	0.0001	0.0760	0.0001	< 0.0006	0.0000
12346789-OCDD	0.0	0.3800	0.0000	0.3300	0.0000	< 0.0015	0.0000
2378-TCDF	0.10	0.0077	0.0008	0.0064	0.0006	< 0.0001	0.0000
12378-PCDF	0.10	0.0081	0.0008	0.0086	0.0009	< 0.0001	0.0000
23478-PCDF	0.10	0.0100	0.0010	0.0130	0.0013	< 0.0001	0.0000
123478-HXCDF	0.010	0.0110	0.0001	0.0097	0.0001	< 0.0002	0.0000
123678-HXCDF	0.010	0.0130	0.0001	0.0110	0.0001	< 0.0002	0.0000
234678-HXCDF	0.010	0.0130	0.0001	0.0120	0.0001	< 0.0002	0.0000
123789-HXCDF	0.010	< 0.0016	0.0000	0.0040	0.0000	< 0.0002	0.0000
1234678-HPCDF	0.0010	0.0480	0.0000	0.0480	0.0000	< 0.0005	0.0000
1234789-HPCDF	0.0010	0.0062	0.0000	0.0076	0.0000	< 0.0007	0.0000
12346789-OCDF	0.0	0.0030	0.0000	0.0370	0.0000	< 0.0008	0.0000
TOTAL-TCDD	0.010	0.0088	-	0.0130	-	< 0.0002	-
OTHER-TCDD	-	-	0.0001	-	0.0001	-	0.0000
TOTAL-PCDD	0.0050	0.0280	-	0.0360	-	< 0.0002	-
OTHER-PCDD	-	-	0.0001	-	0.0002	-	0.0000
TOTAL-HXCDD	0.00040	0.0680	-	0.0760	-	< 0.0004	-
OTHER-HXCDD	-	-	0.0000	-	0.0000	-	0.0000
TOTAL-HPCDD	0.000010	0.1400	-	0.1400	-	< 0.0006	-
OTHER-HPCDD	-	-	0.0000	-	0.0000	-	0.0000
TOTAL-TCDF	0.0010	0.1300	-	0.1700	-	< 0.0001	-
OTHER-TCDF	-	-	0.0001	-	0.0002	-	0.0000
TOTAL-PCDF	0.0010	0.0870	-	0.1000	-	< 0.0001	-
OTHER-PCDF	-	-	0.0001	-	0.0001	-	0.0000
TOTAL-HXCDF	0.00010	0.0710	-	0.0740	-	< 0.0002	-
OTHER-HXCDF	-	-	0.0000	-	0.0000	-	0.0000
TOTAL-HPCDF	0.000010	0.0700	-	0.0700	-	< 0.0005	-
OTHER-HPCDF	-	-	0.0000	-	0.0000	-	0.0000
Total Toxic Equivalents[1]			0.0076		0.0080		0.0003

1. Action Level for 2,3,7,8 TCDD in Soil = 4.5×10^{-3} ng/g. NYSDEC (November 30, 1992).

Table A3-2
PRIORITY POLLUTANTS (SEMI-VOLATILES)
STOCKPILE BOTTOM ASH
MAY 5, 1993
(pg/g)

SEMI-VOLATILES	*REPLICATE SAMPLES*			
	1	*2*	*3*	*4*
Phenol	< 3,900	< 3,900	< 3,700	< 4,200
Bis (2-Chloroethyl) Ether	< 3,900	< 3,900	< 3,700	< 4,200
2-Chlorophenol	< 3,900	< 3,900	< 3,700	< 4,200
1,3-Dichlorobenzene	< 3,900	< 3,900	< 3,700	< 4,200
1,4-Dichlorobenzene	< 3,900	< 3,900	< 3,700	< 4,200
1,2-Dichlorobenzene	< 3,900	< 3,900	< 3,700	< 4,200
2-Methyl Phenol	< 3,900	< 3,900	< 3,700	< 4,200
Bis (2-Chloroisopropyl) Ether	< 3,900	< 3,900	< 3,700	< 4,200
4-Methyl Phenol	< 3,900	< 3,900	< 3,700	< 4,200
N-Nitrosodi-N-Propylamine	< 3,900	780	< 3,700	< 4,200
Hexachloroethane	< 3,900	< 3,900	< 3,700	< 4,200
Nitrobenzene	< 3,900	< 3,900	< 3,700	< 4,200
Isophorone	< 3,900	< 3,900	< 3,700	< 4,200
2-Nitrophenol	< 3,900	< 3,900	< 3,700	< 4,200
2,4-Dimethylphenol	< 3,900	< 3,900	< 3,700	< 4,200
Bis (2-Chloroethoxy) Methane	< 3,900	< 3,900	< 3,700	< 4,200
2,4-Dichlorophenol	< 3,900	< 3,900	< 3,700	< 4,200
1,2,4-Trichlorobenzene	< 3,900	< 3,900	< 3,700	< 4,200
Naphthalene	49	77	81	< 4,200
4-Chloroaniline	< 3,900	< 3,900	< 3,700	< 4,200
Hexachlorobutadiene (C-46)	< 3,900	< 3,900	< 3,700	< 4,200
4-Chloro-3-Methylphenol	< 3,900	< 3,900	< 3,700	< 4,200
2-Methylnaphthalene	13	25	22	17
Hexachlorocyclopentadiene (C-56)	< 3,900	< 3,900	< 3,700	< 4,200
2,4,6-Trichlorophenol	< 3,900	< 3,900	< 3,700	< 4,200
2,4,5-Trichlorophenol	< 9,600	< 9,600	< 9,000	< 10,000
2-Chloronaphthalene	< 3,900	< 3,900	< 3,700	< 4,200
2-Nitroaniline	< 9,600	< 9,600	< 9,000	< 10,000
Dimethylphthalate	< 3,900	< 3,900	< 3,700	< 4,200
Acenaphthylene	15	27	25	16
2,6-Dinitrotoluene	< 3,900	< 3,900	< 3,700	< 4,200
3-Nitrotanaline	< 9,600	< 9,600	< 9,000	< 10,000

Table A3-3
PRIORITY POLLUTANTS (SEMI-VOLATILES)
STOCKPILE BOTTOM ASH
MAY 5, 1993
(pg/g)

	REPLICATE SAMPLES			
SEMI-VOLATILES	*1*	*2*	*3*	*4*
Acenaphthene	< 3,900	< 3,900	< 3,700	< 4,200
2,4-Dinitrophenol	< 9,600	< 9,600	< 9,000	< 10,000
4-Nitrophenol	< 9,600	< 9,600	< 9,000	< 10,000
Dibenzofuran	< 3,900	7.0	8.0	< 4,200
2,4-Dinitrotoluene	< 3,900	< 3,900	< 3,700	< 4,200
Diethylphthalate	< 3,900	17	20	23
4-Chlorophenyl Phenyl Ether	< 3,900	< 3,900	< 3,700	< 4,200
Fluorene	< 3,900	14	17	13
4-Nitroaniline	< 9,600	< 9,600	< 9,000	< 10,000
2-Methyl-4, 6-Dinitrophenol	< 9,600	< 9,600	< 9,000	< 10,000
N-Nitrosodiphenylamine	< 3,900	< 3,900	< 3,700	< 4,200
4-Bromophyl Phenyl Ether	< 3,900	< 3,900	< 3,700	< 4,200
Hexachlorobenzene	< 3,900	< 3,900	< 3,700	< 4,200
Pentachlorophenol	< 9,600	< 9,600	< 9,000	< 10,000
Phenanthrene	56	74	82	68
Anthracene	< 3,900	< 3,900	12	14
Carbazole	< 3,900	< 3,900	< 3,700	< 4,200
Di-N-Butyl Phthalate	140	100	98	69
Fluoranthene	27	40	40	27
Pyrene	28	46	43	29
Butyl Benzyl Phthalate	110	140	93	82
3,3'-Dichlorobenzidine	< 3,900	< 3,900	< 3,700	< 4,200
Benzo (a) Anthracene	< 3,900	< 3,900	< 3,700	< 4,200
Chrysene	< 3,900	< 3,900	< 3,700	< 4,200
Bis (2-Ethylhexyl) Phthalate	710	630	680	580
Di-N-Octyl Phthalate	46	65	49	52
Benzo (b) Fluoranthene	< 3,900	< 3,900	< 3,700	< 4,200
Benzo (k) Fluoroanthene	< 3,900	< 3,900	< 3,700	< 4,200
Benzo (a) Pyrene	< 3,900	< 3,900	< 3,700	< 4,200
Indeno (1,2,3-cd) Pyrene	< 3,900	< 3,900	< 3,700	< 4,200
Dibenzo (ah) Anthracene	< 3,900	< 3,900	< 3,700	< 4,200
Benzo (ghi) Perylene	< 3,900	< 3,900	< 3,700	< 4,200

Appendix A4

BOTTOM ASH SEQUENTIAL CHEMICAL EXTRACTION TEST RESULTS

Appendix A4 presents the results of the sequential chemical extraction testing performed on stockpiled bottom ash samples.

Table A4-1 presents the average and standard deviation for each fraction and for each time period tested as well as an overall average and standard deviation for each fraction.

Fraction A represents the most soluble fraction, while Fraction F represents the matrix Fraction material. A more detailed description of sequential chemical extraction fractions is presented in Appendix A1.

Table A4-1
SEQUENTIAL CHEMICAL EXTRACTION RESULTS
(µg/g)

		Fraction											
	Time	*A*		*B*		*C*		*D*		*E*			
	Months	avg	sd	avg	sd	avg	sd	avg	sd	avg	sd	Total	
Pb	0	<1.3	0.00	128	5	170	5	323	28	490	34	1111	72
	2	3.0	0.56	463	63	645	54	338	54	232	54	1681	226
	4	7.22	5.07	442	54	338	17	532	80	868	58	2187	214
	5	1.4	0.15	529	59	384	61	499	92	787	53	2201	265
	6	1.4	0.15	289	29	375	96	211	17	476	42	1353	184
	7	3.9	0.56	589	135	614	146	323	39	291	97	1820	418
	Avg	3.4	1.1	407	58	421	63	371	52	524	56	1726	230
Ag	0	<1.25	0	<1.25	0	<1.25	0	<1.25	0	<1.25	0	<6.25	0
	2	<1.25	0	<1.25	0	<1.25	0	<1.25	0	<1.25	0	<6.25	0
	4	<1.25	0	<1.25	0	<1.25	0	<1.25	0	<1.25	0	<6.25	0
	5	<1.25	0	<1.25	0	<1.25	0	<1.25	0	5.7	1.7	5.7	1.7
	6	<1.25	0	<1.25	0	<1.25	0	<1.25	0	3.9	1.7	3.9	1.7
	7	<1.25	0	<1.25	0	<1.25	0	<1.25	0	6.8	6.0	6.8	6.0
	Avg	<1.25	0.0	<1.25	0.0	<1.25	0.0	<1.25	0.0	3.4	1.6	5.5	1.6
Co	0	<0.18	0	0.98	0.56	2.7	0.19	0.84	0.23	9.3	1.1	14	2.1
	2	0.22	0.06	0.88	0.19	5.2	0.73	0.50	0.13	11	0.55	18	1.7
	4	<0.18	0	0.54	0.067	1.8	0.14	0.40	0.29	14	1.3	16	1.8
	5	<0.017	0	1.6	0.33	3.3	0.55	0.62	0.21	11	0.72	16	1.8
	6	<0.017	0	1.6	0.2	4.8	1.2	0.77	0.02	12	0.42	19	1.8
	7	<0.017	0	1.79	0.19	7	1.16	0.72	0.12	10.18	1.08	19	3
	Avg	0.22	0.01	1.2	0.26	4.1	0.7	0.64	0.17	11	0.86	17	2.0
Fe	0	7.8	2.7	263	17	8,907	299	852	66	27,233	2,260	37,263	2,645
	2	<6.25	0	69	17	11,940	6,151	742	77	36,367	2,016	49,118	8,261
	4	6.88	1.1	474	158	13,474	2,613	1,758	421	108,255	12,068	123,968	15,261
	5	<3.13	0	200	43	11,018	311	2,086	98	84,794	7,522	98,098	7,974
	6	<3.13	0	210	32	14,149	4,558	2,521	199	91,774	3,335	108,654	8,124
	7	<3.13	0	86.2	13.3	10,589	1,562	1,602	356	43,826	3,513	56,103	5,444
	Avg	7.3	0.6	217	47	11,680	2,582	1,594	203	65,375	5,119	78,867	7,952
Cr	0	2.9	0.18	3.6	0.64	21	0.41	6.3	0.16	81	8.8	115	10
	2	<0.28	0	3.0	0.26	6.7	2.1	6.4	0.71	248	10	264	13
	4	<0.28	0	2.7	0.20	31	0.87	4.1	0.39	239	3	276	4.5
	5	0.47	0.26	2.3	0.42	17	3.9	8.0	1.5	213	8	241	14
	6	0.44	0.14	2.7	0.64	15	0.43	4.9	1.2	231	10	254	12
	7	<0.28	0	2.54	0.79	35	6.79	6.62	1.66	120	4	164	13
	Avg	1.3	0.1	2.8	0.49	21	2.4	6.1	0.93	189	7.3	219	11
Zn	0	<2.5	0	1,170	273	2,047	303	165	12	944	19	4,326	607
	2	8.4	7.9	2,526	1,245	2,757	492	155	17	1,237	99	6,683	1,861
	4	3.1	1.0	891	41	503	84	114	10	1,006	46	2,517	182
	5	1.9	1.6	911	309	914	267	161	46	993	41	2,981	665
	6	1.3	0.72	568	116	857	54	11	6	813	32	2,250	208
	7	10.3	1.54	3,472	557	3,537	303	242	34	1,059	67	8,320	963
	Avg	5.0	2.1	1,590	424	1,769	251	141	21	1,009	51	4,513	748

Table A4-1 Continued

	Time	Fraction										Total	
		A		*B*		*C*		*D*		*E*			
	Months	**avg**	**sd**	**avg**	**sd**	**avg**	**sd**	**avg**	**sd**	**avg**	**sd**		
As	0	<0.55	0	2.55	0.62	4.96	0.34	5.76	0.5	6.73	2.6	20	4.06
	2	<0.55	0	0.84	0.38	2.36	0.09	7.03	0.62	16.2	2.7	26.4	3.79
	4	<0.55	0	0.65	0.11	1.06	0.22	1.85	0.21	19.9	1.7	23.5	2.24
	5	<0.55	0	0.61	0.1	0.97	0.29	3.23	0.27	33.7	3.5	38.5	4.16
	6	0.63	0.14	<0.55	0	0.97	0.14	2.75	0.38	11.4	1.5	15.7	2.16
	7	<0.55	0	<0.55	0	2	0.14	6.12	0.77	20.6	0.84	28	2
	Avg	0.6	0.0	1.2	0.20	2.0	0.20	4.5	0.46	18	2.1	25	3.0
Cd	0	<0.021	0	7.0	0.58	6.9	1.4	1.4	0.18	2.4	0.06	18	2.2
	2	4.0	0.51	15	2.6	34.3	12	1.7	0.27	2.5	0.35	58	16.1
	4	0.77	0.09	4.5	1.6	1.5	0.62	0.34	0.040	0.49	0.020	7.6	2.4
	5	1.5	0.27	9.6	1.6	3.8	1.2	0.71	0.10	2.3	0.14	18	3.3
	6	1.8	1.4	11	0.97	4.3	0.79	0.73	0.25	4.7	3.6	23	7.0
	7	4.2	0.22	22.04	3.9	13	0.48	0.7	0.21	5.7	1.7	46	7
	Avg	2.5	0.4	12	1.9	11	2.8	0.93	0.18	3.0	1.0	28	6.3
Ba	0	34	4.7	117	5.7	100	31	238	3	815	98	1,303	143
	2	11	0.64	17	4.4	55	7.8	251	34	222	39	555	86
	4	13	1.5	18	0.22	77	8.9	89	17	519	54	715	82
	5	13	2.3	31	8.1	64	4.2	158	22	638	93	904	130
	6	13	0.99	31	3.1	50	12	151	14	577	33	821	63
	7	5.7	0.4	35.7	3.2	28	6.7	289	31	175	42	533	83
	Avg	14.7	1.8	41	4.1	62	12	196	20	491	60	805	98
Cu	0	14	1.2	214	13	26	3.8	936	36	277	25	1,467	79
	2	15	1.5	232	35	429	310	1,081	104	493	25	2,250	476
	4	7.0	1.2	79	13	20	4.3	1,808	189	688	42	2,602	250
	5	5.8	1.5	361	67	70	28	800	80	751	108	1,987	285
	6	12	0.99	461	60	176	25	1,620	100	218	20	2,487	206
	7	10.6	1.5	519	94	475	35	1,090	130	420	26	2,515	287
	Avg	10.7	1.3	311	47	199	68	1,223	107	475	41	2,218	264
Ni	0	12	1.2	17	2.1	24	2.0	14	5.1	92	14	159	24
	2	8.8	2.1	12	1.5	41	4.5	11	1.2	90	3.3	163	13
	4	9.0	0.87	12	2.1	24	5.2	13	2.6	117	1.3	175	12
	5	7.9	2.1	16	2.8	27	2.6	21	3.8	102	91	174	102
	6	6.8	0.34	15	3.1	36	6.1	11	2.0	103	13	172	25
	7	5.6	0.34	23	1.6	71	8.5	22	5.4	102	25	224	41
	Avg	8.3	1.2	16	2.2	37	4.8	15	3.4	101	25	178	36
K	0	1,252	36	597	412	728	54	757	236	12,916	5,286	16,250	6,024
	2	521	181	236	38	1,961	810	379	73	9,066	1,210	12,163	2,312
	4	401	174	99	21	1,137	414	270	55	9,247	2,421	11,154	3,085
	5	609	98	401	110	515	241	323	167	8,373	691	10,221	1,307
	6	435	102	461	88	682	112	294	56	7,289	446	9,161	804
	7	785	92	751	78	1,143	254	478	48	6,506	665	9,663	1,137
	Avg	667	114	424	125	1,028	314	417	106	8,900	1,787	11,435	2,445

Table A4-1 Continued

		Fraction										**Total**	
	Time Months	*A*		*B*		*C*		*D*		*E*			
		avg	**sd**	**avg**	**sd**	**avg**	**sd**	**avg**	**sd**	**avg**	**sd**		
Ca	0	40,278	6,802	30,820	3,225	35,044	7,855	10,472	721	14,649	566	131,263	19,169
	2	11,580	3,090	29,656	3,695	50,877	10,531	6,034	1,575	3,975	1,476	102,122	20,367
	4	2,798	701	10,338	2,016	11,102	662	4,509	1,271	33,454	1,469	62,201	6,119
	5	5,036	1,453	25,322	10,010	30,694	2,620	6,264	505	25,215	1,834	92,531	16,422
	6	5,623	185	44,215	25,363	27,125	738	4,516	291	24,694	828	106,173	27,405
	7	11,388	1,158	44,713	5,741	29,217	2,034	7,721	1,335	2,787	2,782	95,826	13,050
	Avg	12,784	2,232	30,844	8,342	30,677	4,073	6,586	950	17,462	1,493	98,353	17,089

Appendix B

RUNOFF AND PRECIPITATION SAMPLING METHODS AND RESULTS

Appendix B presents a detailed description of runoff sample collection methods as well as runoff and precipitation test results. Appendix B is divided into four sections:

B1 Runoff Sample Collection Methods
B2 Runoff and Precipitation Elemental Characterization Test Results
B3 Runoff and Precipitation Organic Characterization Test Results
B4 Runoff and Precipitation Acidity/Alkalinity and pH Test Results

B1

RUNOFF SAMPLING COLLECTION METHODS

Appendix B1 presents a description of the runoff collection effort that was undertaken as part of the stockpile evaluation program. Two methods were used to collect stockpile runoff samples. Section B1.1 describes the sample collection method using the 300-gallon collection tank and Section B1.2 describes the sample collection method using the automatic sampler.

B1.1 300-GALLON TANK RUNOFF SAMPLE COLLECTION SYSTEM

The first method used to sample runoff involved the diversion of runoff from the stockpile pad into a 300-gallon sample collection tank during rainfall events. This 300-gallon tank diversion system was installed during the construction of the pad and drainage system in October 1992. Section 4 presents a detailed description of the stockpile pad and drainage system. This procedure was effective in collecting composite samples, but did not permit the effective collection of discrete runoff samples during storm events and was subsequently supplemented by an automatic sampler.

The sample collection drum used was a 300-gallon polyethylene tank with valved inlets that permitted the diversion of runoff into the drum or the leachate collection tank. Drain valves were provided at the bottom of the tank to either drain the tanks or collect samples; and vents were provided at the top of the tank to prevent a build-up of back-pressure that could prevent flow into the tank. Detailed specifications of the sampling drum design are presented elsewhere.[1]

During periods when the valve to the collection drum was closed, runoff flowed to the landfill leachate collection tank. When runoff sampling was planned, the valves were opened to permit the runoff flow into the drum.

The 300-gallon capacity of the drum was sufficient to contain approximately 0.1 inch of rainfall from the asphalt pad, assuming no absorption of rainfall by the ash. The drums were designed in such a manner that runoff that exceeded the capacity of the drum overflowed into the leachate collection tank.

Figure B1-1 presents an illustration of the method that was used to sample during an event in which runoff flow exceeded 300 gallons. Step 1 allowed the tank to fill. Samples were collected during Step 2. In Step 3 the tank was drained into the leachate collection tank with a calibrated pump while runoff was still permitted to flow into the tank. When the tank was drained, the pump was shut off and the tank was permitted to refill for another sample collection and volume measurement run. This method necessitated the use of a pump capable

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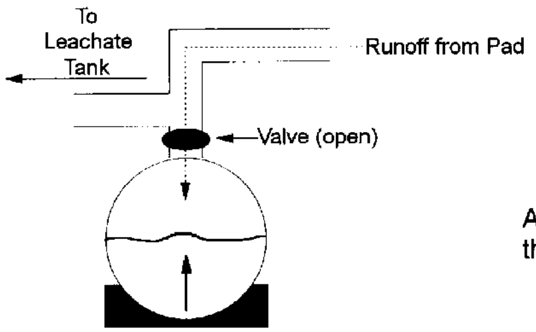
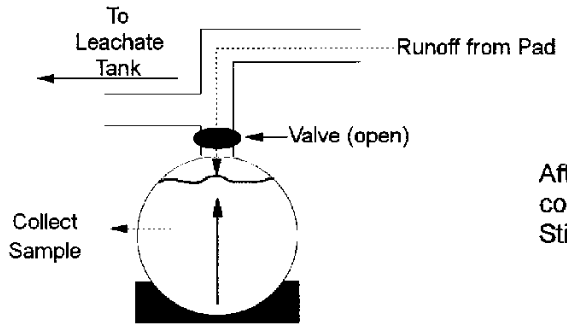
[1] See Pollution Control Financing Authority Construction Plan: Ash Storage-Stockpile Pad Project, Warren County District Landfill, February 1992.

1)



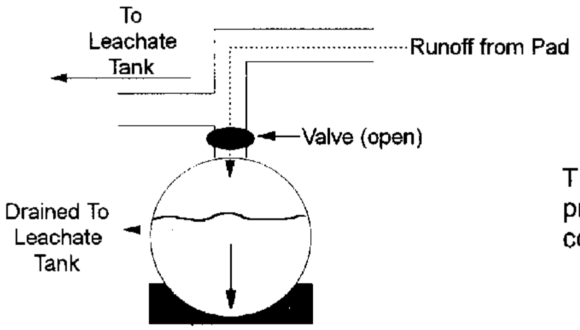
At the start of a runoff collection event, the flow from the pad was diverted into the 300-gallon collection tank

2)



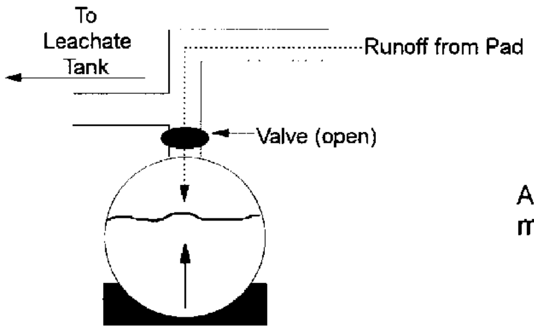
After the tank filled (during the storm event) the contents of the tank was stirred and a sample taken). Stirring was accomplished with a 3-foot plastic rod.

3)



The tank was subsequently drained using a pump at a precalibrated flow rate to determine the runoff collection volume.

4)



After the tank was emptied the collection tank was made ready for the collection of the next sample.

4) Steps 1 to 4 was repeated until the runoff event was completed.

Figure B1-1

MULTIPLE SAMPLE RUNOFF COLLECTION SCHEME USING THE 300-GALLON SAMPLE COLLECTION TANK

of draining the content of the sampling tank faster than the runoff drained from the stockpile pad. During high intensity rainfall events when the runoff was such that the tank could not be emptied in a timely fashion, grab samples of runoff were collected.

Volumetric measurements for multiple sampling events were calculated as follows:

$$TV=\sum_{1}^{n+1}(gpm \times t_n)+V_{n+1}$$

where:

TV = Total volume (gallons)

gpm = Rate of pumpage (gallons/minute)

t_n = Time to pump nth event (minutes)

V_{n+1} = Last sampling volume reading on tank (gallons).

B1.2 AUTOMATIC RUNOFF SAMPLE COLLECTION SYSTEM

In April 1993, an automatic sampling system was installed to facilitate the collection of discrete samples and to provide a means to monitor runoff flow more accurately. The location of the automatic sampler is described in detail in Section 4. This system included an ISCO model 3240 Variable Gate Flow Meter and an ISCO 3700 Automatic Sampler. The automatic sampling system permitted the collection of discrete runoff samples during rainfall and runoff events. Flow was monitored by a flow meter (positioned adjacent to the automatic sampler) using a gate valve located in the drainage pipe upstream of the 300-gallon tank (see Section 4).

The automatic sampler allowed for collection of discrete samples of runoff from the stockpile pad up to a total of 1,800 gallons of runoff. The flow meter and sampler were programmed to collect samples using the following protocol:

1. A 330 mL leachate sample was collected in a 1-L bottle for every 50 gallons of runoff,
2. A total of three (3) samples were collected and discharged into paired bottles (i.e., 150-gallons of runoff were collected),
3. Up to 12 different samples could be collected representing 1800 gallons of runoff.

B2

RUNOFF AND PRECIPITATION ELEMENTAL CHARACTERIZATION TEST RESULTS

Appendix B2 presents the elemental concentrations measured in the individual stockpile runoff and precipitation samples.

B2.1 RUNOFF SAMPLES

Tables B2-1 to B2-44 list the individual sample concentrations measured in the stockpile total and dissolved runoff samples. The tables also indicate the date and time of sample collection, amount of rain associated with the collected sample and the volume associated with the collected sample.

The samples were collected either in the 300-gallon sample tank or by the ISCO Automatic Sampler. Table 4-1 in Section 4 provides a breakdown of the type of collection method by sampling event.

B2.2 PRECIPITATION SAMPLE

Tables B2-45 and B2-46 list the individual sample elemental concentrations measured in the total precipitation samples. Total precipitation samples are samples where both wet precipitation (i.e., rainfall) and dry deposition (i.e., dust and particulates) were collected. Table B2-45 presents data for the total (particulate and dissolved) concentrations and Table B2-46 presents concentrations measured in the dissolved portion of the total precipitation. Elemental concentrations were not measured in the wet precipitation samples due to the limited volume collected (see Section 4).

Only one precipitation sample was collected per storm event, although several runoff samples were obtained. The sample collection method used to collect total precipitation samples provided only enough sample to analyze for metals in 10 out of the 35 sampling events.

Table B2-1

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
ALUMINUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	3.4
12/11/92 7:28	1.07	> 300	4.6
12/11/92 8:52	0.21	210	6.5
12/11/92 10:44	0.13	> 300	2.3
12/11/92 11:48	0.04	163	9.0
12/17/93 0:00	0.94	300	2.4
12/28/92 19:17	0.14	30	2.3
12/29/92 15:05	0.10	10	2.2
1/5/93 7:13	0.62	> 300	6.3
1/5/93 12:25	0.03	70	9.4
2/13/93 8:00	0.15	275	9.5
2/16/93 16:00	0.63	> 300	1.2
3/4/93 13:46	0.18	245	2.4
3/4/93 17:53	0.34	> 300	4.3
3/9/93 0:00	0.04	20	4.8
3/11/93 8:00	0.04	40	1.2
3/17/93 9:15	0.37	300	0.43
3/17/93 11:16	0.20	300	0.40
3/17/93 13:25	0.18	300	0.43
3/17/93 14:57	0.22	300	0.55
3/24/93 6:50	0.84	> 300	0.037
3/24/93 15:27	0.14	300	0.097
3/31/93 8:00	0.36	145	< 0.032
4/2/93 6:45	1.66	> 300	< 0.032
4/2/93 22:00	0.03	300	< 0.032
4/12/93 7:40	0.43	> 300	< 0.032
4/16/93 15:50	0.02	6	0.085
4/16/93 16:39	0.22	427	0.030
4/21/93 21:48	0.05	1	0.15
4/21/93 22:50	0.18	401	< 0.032
4/22/93 0:18	0.25	594	< 0.032
4/22/93 2:33	0.25	576	0.082
4/22/93 7:18	0.07	196	< 0.032
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.032
4/26/93 17:30	0.66	1324	0.047
4/26/93 23:44	0.07	551	0.099
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.056
6/4/93 0:00	0.06	30	0.074
6/5/93 0:00	0.06	50	< 0.032
6/9/93 0:00	0.23	20	0.070
6/10/93 0:00	0.23	255	0.062
6/20/93 21:01	0.42	314	0.062
6/20/93 22:51	0.38	836	0.10
6/21/93 0:31	0.04	50	0.11
6/21/93 0:00	1.15	300	0.56
7/2/93 0:00	0.40	300	0.10
7/6/93 0:00	0.32	275	< 0.032
7/14/93 0:00	0.39	> 300	2.5
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	1.9
9/27/93 17:45		224	0.98
9/27/93 18:21		181	0.62
9/27/93 19:00		143	0.45
9/27/93 19:35		109	0.38
9/27/93 20:14		117	0.33
9/27/93 20:59		167	0.32
9/27/93 21:43		170	0.45
9/27/93 22:29		161	0.28
9/27/93 23:10		255	0.63
9/27/93 23:46	1.40	124	0.44
9/28/93 0:22		105	0.40
10/3/93 1:07		179	1.2
10/3/93 1:44		148	1.3
10/3/93 2:43		171	0.83
10/3/93 6:13	0.40	112	0.30
10/12/93 9:02		150	8.2
10/12/93 9:47		300	11
10/12/93 10:25		450	6.3
10/12/93 11:01	1.03	600	4.8
10/20/93 0:19	0.21	237	0.78
10/20/93 2:12	0.08	159	1.0
10/20/93 4:49	0.07	191	1.3
10/20/93 14:35	0.04	63	0.64
10/21/93 5:16	0.10	146	0.43
10/21/93 20:28	0.11	91	2.0
10/30/93 12:49	0.15	143	3.6
10/30/93 14:54	0.09	192	2.4
10/30/93 16:30	0.08	182	1.6
10/30/93 17:04	0.04	190	2.4
10/30/93 17:42	0.09	258	2.8
10/30/93 18:43	0.17	466	3.6
10/30/93 20:43	0.12	331	1.2
10/31/93 0:23	0.03	126	0.28
10/31/93 10:56	0.07	119	0.28
10/31/93 19:54	0.12	183	0.83
10/31/93 21:17	0.10	196	3.7
10/31/93 21:51	0.13	263	3.7
11/28/93 3:21	0.19	297	16.00
11/28/93 3:57	0.08	178	4.20
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	5.20
11/28/93 5:59	0.15	515	26.90
11/28/93 6:32	0.10	182	11.50
11/28/93 7:07	0.08	201	15.50
11/28/93 7:41	0.22	653	21.60

Table B2-2

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
ALUMINUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.15
12/11/92 7:28	1.07	> 300	0.21
12/11/92 8:52	0.21	210	0.19
12/11/92 10:44	0.13	> 300	0.13
12/11/92 11:48	0.04	163	0.32
12/17/93 0:00	0.94	300	2.4
12/28/92 19:17	0.14	30	0.29
12/29/92 15:05	0.10	10	0.27
1/5/93 7:13	0.62	> 300	< 0.032
1/5/93 12:25	0.03	70	0.19
2/13/93 8:00	0.15	275	0.081
2/16/93 16:00	0.63	> 300	0.21
3/4/93 13:46	0.18	245	< 0.032
3/4/93 17:53	0.34	> 300	0.031
3/9/93 0:00	0.04	20	0.061
3/11/93 8:00	0.04	40	0.045
3/17/93 9:15	0.37	300	0.046
3/17/93 11:16	0.20	300	0.058
3/17/93 13:25	0.18	300	0.067
3/17/93 14:57	0.22	300	0.062
3/24/93 6:50	0.84	> 300	0.042
3/24/93 15:27	0.14	300	0.035
3/31/93 8:00	0.36	145	< 0.032
4/2/93 6:45	1.66	> 300	< 0.032
4/2/93 22:00	0.03	300	< 0.032
4/12/93 7:40	0.43	> 300	< 0.032
4/16/93 15:50	0.02	6	0.052
4/16/93 16:39	0.22	427	0.036
4/21/93 21:48	0.05	1	0.14
4/21/93 22:50	0.18	401	< 0.032
4/22/93 0:18	0.25	594	< 0.032
4/22/93 2:33	0.25	576	0.079
4/22/93 7:18	0.07	196	< 0.032
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.032
4/26/93 17:30	0.66	1324	< 0.032
4/26/93 23:44	0.07	551	0.067
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.041
6/4/93 0:00	0.06	30	0.077
6/5/93 0:00	0.06	50	< 0.032
6/9/93 0:00	0.23	20	< 0.032
6/10/93 0:00	0.23	255	0.042
6/20/93 21:01	0.42	314	0.044
6/20/93 22:51	0.38	836	< 0.032
6/21/93 0:31	0.04	50	0.11
6/21/93 0:00	1.15	300	0.22
7/2/93 0:00	0.40	300	< 0.032
7/6/93 0:00	0.32	275	< 0.032
7/14/93 0:00	0.39	> 300	< 0.032
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.10
9/27/93 17:45		224	0.23
9/27/93 18:21		181	0.19
9/27/93 19:00		143	0.21
9/27/93 19:35		109	0.24
9/27/93 20:14		117	0.20
9/27/93 20:59		167	0.27
9/27/93 21:43		170	0.19
9/27/93 22:29		161	0.20
9/27/93 23:10		255	0.21
9/27/93 23:46	1.40	124	0.15
9/28/93 0:22		105	0.23
10/3/93 1:07		179	< 0.10
10/3/93 1:44		148	< 0.10
10/3/93 2:43		171	< 0.10
10/3/93 6:13	0.40	112	0.13
10/12/93 9:02		150	< 0.10
10/12/93 9:47		300	0.17
10/12/93 10:25		450	0.17
10/12/93 11:01	1.03	600	0.19
10/20/93 0:19	0.21	237	< 0.10
10/20/93 2:12	0.08	159	0.15
10/20/93 4:49	0.07	191	0.21
10/20/93 14:35	0.04	63	0.14
10/21/93 5:16	0.10	146	< 0.10
10/21/93 20:28	0.11	91	0.22
10/30/93 12:49	0.15	143	0.18
10/30/93 14:54	0.09	192	0.20
10/30/93 16:30	0.08	182	0.17
10/30/93 17:04	0.04	190	0.24
10/30/93 17:42	0.09	258	0.25
10/30/93 18:43	0.17	466	0.31
10/30/93 20:43	0.12	331	0.29
10/31/93 0:23	0.03	126	0.19
10/31/93 10:56	0.07	119	0.13
10/31/93 19:54	0.12	183	0.16
10/31/93 21:17	0.10	196	0.34
10/31/93 21:51	0.13	263	0.27
11/28/93 3:21	0.19	297	0.250
11/28/93 3:57	0.08	178	0.310
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.270
11/28/93 5:59	0.15	515	0.440
11/28/93 6:32	0.10	182	0.390
11/28/93 7:07	0.08	201	0.340
11/28/93 7:41	0.22	653	0.390

Table B2-3

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
ARSENIC
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	< 0.0010
12/11/92 7:28	1.07	> 300	0.0010
12/11/92 8:52	0.21	210	< 0.0010
12/11/92 10:44	0.13	> 300	0.0010
12/11/92 11:48	0.04	163	0.0010
12/17/93 0:00	0.94	300	< 0.0010
12/28/92 19:17	0.14	30	< 0.0010
12/29/92 15:05	0.10	10	< 0.0010
1/5/93 7:13	0.62	> 300	< 0.0010
1/5/93 12:25	0.03	70	< 0.0010
2/13/93 8:00	0.15	275	0.012
2/16/93 16:00	0.63	> 300	0.0020
3/4/93 13:46	0.18	245	0.0030
3/4/93 17:53	0.34	> 300	0.0040
3/9/93 0:00	0.04	20	0.0040
3/11/93 8:00	0.04	40	< 0.0010
3/17/93 9:15	0.37	300	< 0.0010
3/17/93 11:16	0.20	300	< 0.0010
3/17/93 13:25	0.18	300	< 0.0010
3/17/93 14:57	0.22	300	< 0.0010
3/24/93 6:50	0.84	> 300	< 0.0010
3/24/93 15:27	0.14	300	< 0.0010
3/31/93 8:00	0.36	145	0.0010
4/2/93 6:45	1.66	> 300	0.0020
4/2/93 22:00	0.03	300	0.0020
4/12/93 7:40	0.43	> 300	0.0020
4/16/93 15:50	0.02	6	0.0030
4/16/93 16:39	0.22	427	0.0020
4/21/93 21:48	0.05	1	0.0020
4/21/93 22:50	0.18	401	0.0030
4/22/93 0:18	0.25	594	< 0.0020
4/22/93 2:33	0.25	576	0.0020
4/22/93 7:18	0.07	196	0.0010
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.0020
4/26/93 17:30	0.66	1324	0.0010
4/26/93 23:44	0.07	551	0.0020
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.0020
6/4/93 0:00	0.06	30	0.0020
6/5/93 0:00	0.06	50	0.0010
6/9/93 0:00	0.23	20	0.0010
6/10/93 0:00	0.23	255	< 0.0020
6/20/93 21:01	0.42	314	< 0.0020
6/20/93 22:51	0.38	836	< 0.0020
6/21/93 0:31	0.04	50	< 0.0020
6/21/93 0:00	1.15	300	< 0.0020
7/2/93 0:00	0.40	300	< 0.0020
7/6/93 0:00	0.32	275	< 0.0020
7/14/93 0:00	0.39	> 300	0.0010
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.0040
9/27/93 17:45		224	0.014
9/27/93 18:21		181	0.013
9/27/93 19:00		143	0.015
9/27/93 19:35		109	0.014
9/27/93 20:14		117	0.013
9/27/93 20:59		167	0.012
9/27/93 21:43		170	0.013
9/27/93 22:29		161	0.0070
9/27/93 23:10		255	0.0060
9/27/93 23:46	1.40	124	0.0080
9/28/93 0:22		105	0.0030
10/3/93 1:07		179	0.0010
10/3/93 1:44		148	0.0020
10/3/93 2:43		171	< 0.0010
10/3/93 6:13	0.40	112	< 0.0010
10/12/93 9:02		150	0.012
10/12/93 9:47		300	0.014
10/12/93 10:25		450	0.0090
10/12/93 11:01	1.03	600	0.0100
10/20/93 0:19	0.21	237	< 0.0010
10/20/93 2:12	0.08	159	< 0.0010
10/20/93 4:49	0.07	191	0.0010
10/20/93 14:35	0.04	63	0.0010
10/21/93 5:16	0.10	146	< 0.0010
10/21/93 20:28	0.11	91	0.0030
10/30/93 12:49	0.15	143	0.0050
10/30/93 14:54	0.09	192	0.0030
10/30/93 16:30	0.08	182	0.0010
10/30/93 17:04	0.04	190	0.0030
10/30/93 17:42	0.09	258	0.0030
10/30/93 18:43	0.17	466	0.0040
10/30/93 20:43	0.12	331	0.0010
10/31/93 0:23	0.03	126	< 0.0010
10/31/93 10:56	0.07	119	< 0.0010
10/31/93 19:54	0.12	183	< 0.0010
10/31/93 21:17	0.10	196	0.0030
10/31/93 21:51	0.13	263	0.0040
11/28/93 3:21	0.19	297	0.02
11/28/93 3:57	0.08	178	0.00
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.00
11/28/93 5:59	0.15	515	0.03
11/28/93 6:32	0.10	182	0.01
11/28/93 7:07	0.08	201	0.01
11/28/93 7:41	0.22	653	0.02

Table B2-4

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
ARSENIC
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	< 0.0010
12/11/92 7:28	1.07	> 300	< 0.0010
12/11/92 8:52	0.21	210	< 0.0010
12/11/92 10:44	0.13	> 300	< 0.0010
12/11/92 11:48	0.04	163	< 0.0010
12/17/93 0:00	0.94	300	< 0.0010
12/28/92 19:17	0.14	30	< 0.0010
12/29/92 15:05	0.10	10	< 0.0010
1/5/93 7:13	0.62	> 300	< 0.0010
1/5/93 12:25	0.03	70	< 0.0010
2/13/93 8:00	0.15	275	< 0.0010
2/16/93 16:00	0.63	> 300	< 0.0010
3/4/93 13:46	0.18	245	< 0.0010
3/4/93 17:53	0.34	> 300	< 0.0010
3/9/93 0:00	0.04	20	< 0.0010
3/11/93 8:00	0.04	40	< 0.0010
3/17/93 9:15	0.37	300	< 0.0010
3/17/93 11:16	0.20	300	< 0.0010
3/17/93 13:25	0.18	300	< 0.0010
3/17/93 14:57	0.22	300	< 0.0010
3/24/93 6:50	0.84	> 300	< 0.0010
3/24/93 15:27	0.14	300	< 0.0010
3/31/93 8:00	0.36	145	< 0.0010
4/2/93 6:45	1.66	> 300	< 0.0010
4/2/93 22:00	0.03	300	< 0.0010
4/12/93 7:40	0.43	> 300	< 0.0010
4/16/93 15:50	0.02	6	< 0.0010
4/16/93 16:39	0.22	427	< 0.0010
4/21/93 21:48	0.05	1	< 0.0010
4/21/93 22:50	0.18	401	< 0.0010
4/22/93 0:18	0.25	594	< 0.0010
4/22/93 2:33	0.25	576	0.0020
4/22/93 7:18	0.07	196	< 0.0010
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0010
4/26/93 17:30	0.66	1324	< 0.0010
4/26/93 23:44	0.07	551	< 0.0010
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
5/21/93 0:00	0.37	300	< 0.0010
6/4/93 0:00	0.06	30	0.0010
6/5/93 0:00	0.06	50	0.0010
6/9/93 0:00	0.23	20	< 0.0010
6/10/93 0:00	0.23	255	< 0.0010
6/20/93 21:01	0.42	314	< 0.0010
6/20/93 22:51	0.38	836	< 0.0010
6/21/93 0:31	0.04	50	< 0.0010
6/21/93 0:00	1.15	300	< 0.0010
7/2/93 0:00	0.40	300	< 0.0010
7/6/93 0:00	0.32	275	< 0.0010
7/14/93 0:00	0.39	> 300	< 0.0010
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.0010
9/27/93 17:45		224	< 0.0010
9/27/93 18:21		181	< 0.0010
9/27/93 19:00		143	< 0.0010
9/27/93 19:35		109	< 0.0010
9/27/93 20:14		117	< 0.0010
9/27/93 20:59		167	< 0.0010
9/27/93 21:43		170	< 0.0010
9/27/93 22:29		161	< 0.0010
9/27/93 23:10		255	< 0.0010
9/27/93 23:46	1.40	124	< 0.0010
9/28/93 0:22		105	< 0.0010
10/3/93 1:07		179	< 0.0010
10/3/93 1:44		148	< 0.0010
10/3/93 2:43		171	< 0.0010
10/3/93 6:13	0.40	112	< 0.0010
10/12/93 9:02		150	< 0.0010
10/12/93 9:47		300	< 0.0010
10/12/93 10:25		450	< 0.0010
10/12/93 11:01	1.03	600	< 0.0010
10/20/93 0:19	0.21	237	< 0.0010
10/20/93 2:12	0.08	159	< 0.0010
10/20/93 4:49	0.07	191	< 0.0010
10/20/93 14:35	0.04	63	< 0.0010
10/21/93 5:16	0.10	146	< 0.0010
10/21/93 20:28	0.11	91	< 0.0010

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
10/30/93 12:49	0.15	143	< 0.0010
10/30/93 14:54	0.09	192	< 0.0010
10/30/93 16:30	0.08	182	< 0.0010
10/30/93 17:04	0.04	190	< 0.0010
10/30/93 17:42	0.09	258	< 0.0010
10/30/93 18:43	0.17	466	< 0.0010
10/30/93 20:43	0.12	331	< 0.0010
10/31/93 0:23	0.03	126	< 0.0010
10/31/93 10:56	0.07	119	< 0.0010
10/31/93 19:54	0.12	183	< 0.0010
10/31/93 21:17	0.10	196	< 0.0010
10/31/93 21:51	0.13	263	< 0.0010
11/28/93 3:21	0.19	297	< 0.001
11/28/93 3:57	0.08	178	< 0.001
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.001
11/28/93 5:59	0.15	515	0.001
11/28/93 6:32	0.10	182	0.001
11/28/93 7:07	0.08	201	0.001
11/28/93 7:41	0.22	653	0.001

Table B2-5

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
BARIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.054
12/11/92 7:28	1.07	> 300	0.046
12/11/92 8:52	0.21	210	0.041
12/11/92 10:44	0.13	> 300	0.028
12/11/92 11:48	0.04	163	0.068
12/17/93 0:00	0.94	300	0.073
12/28/92 19:17	0.14	30	0.047
12/29/92 15:05	0.10	10	0.080
1/5/93 7:13	0.62	> 300	0.072
1/5/93 12:25	0.03	70	0.10
2/13/93 8:00	0.15	275	0.11
2/16/93 16:00	0.63	> 300	0.027
3/4/93 13:46	0.18	245	0.074
3/4/93 17:53	0.34	> 300	0.093
3/9/93 0:00	0.04	20	0.12
3/11/93 8:00	0.04	40	0.081
3/17/93 9:15	0.37	300	0.053
3/17/93 11:16	0.20	300	0.048
3/17/93 13:25	0.18	300	0.044
3/17/93 14:57	0.22	300	0.042
3/24/93 6:50	0.84	> 300	0.033
3/24/93 15:27	0.14	300	0.055
3/31/93 8:00	0.36	145	0.044
4/2/93 6:45	1.66	> 300	0.040
4/2/93 22:00	0.03	300	0.052
4/12/93 7:40	0.43	> 300	0.037
4/16/93 15:50	0.02	6	0.11
4/16/93 16:39	0.22	427	0.10
4/21/93 21:48	0.05	1	0.060
4/21/93 22:50	0.18	401	0.062
4/22/93 0:18	0.25	594	0.049
4/22/93 2:33	0.25	576	0.11
4/22/93 7:18	0.07	196	0.054
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.034
4/26/93 17:30	0.66	1324	0.032
4/26/93 23:44	0.07	551	0.064
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37		0.064
6/4/93 0:00	0.06	30	0.087
6/5/93 0:00	0.06	50	0.068
6/9/93 0:00	0.23	20	0.071
6/10/93 0:00	0.23	255	0.086
6/20/93 21:01	0.42	314	0.083
6/20/93 22:51	0.38	836	0.10
6/21/93 0:31	0.04	50	0.10
6/21/93 0:00	1.15	300	0.082
7/2/93 0:00	0.40	300	0.044
7/6/93 0:00	0.32	275	0.052
7/14/93 0:00	0.39	> 300	0.070
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.18
9/27/93 17:45		224	0.13
9/27/93 18:21		181	0.27
9/27/93 19:00		143	0.43
9/27/93 19:35		109	0.35
9/27/93 20:14		117	0.29
9/27/93 20:59		167	0.54
9/27/93 21:43		170	0.23
9/27/93 22:29		161	0.39
9/27/93 23:10		255	0.13
9/27/93 23:46	1.40	124	0.13
9/28/93 0:22		105	0.14
10/3/93 1:07		179	< 0.050
10/3/93 1:44		148	0.14
10/3/93 2:43		171	< 0.050
10/3/93 6:13	0.40	112	0.19
10/12/93 9:02		150	0.23
10/12/93 9:47		300	0.17
10/12/93 10:25		450	0.14
10/12/93 11:01	1.03	600	0.13
10/20/93 0:19	0.21	237	< 0.050
10/20/93 2:12	0.08	159	< 0.050
10/20/93 4:49	0.07	191	< 0.050
10/20/93 14:35	0.04	63	< 0.050
10/21/93 5:16	0.10	146	0.090
10/21/93 20:28	0.11	91	0.11
10/30/93 12:49	0.15	143	0.090
10/30/93 14:54	0.09	192	0.10
10/30/93 16:30	0.08	182	< 0.050
10/30/93 17:04	0.04	190	0.11
10/30/93 17:42	0.09	258	0.17
10/30/93 18:43	0.17	466	0.10
10/30/93 20:43	0.12	331	0.13
10/31/93 0:23	0.03	126	0.15
10/31/93 10:56	0.07	119	0.12
10/31/93 19:54	0.12	183	0.16
10/31/93 21:17	0.10	196	< 0.050
10/31/93 21:51	0.13	263	0.14
11/28/93 3:21	0.19	297	0.39
11/28/93 3:57	0.08	178	0.27
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.33
11/28/93 5:59	0.15	515	0.37
11/28/93 6:32	0.10	182	0.33
11/28/93 7:07	0.08	201	0.32
11/28/93 7:41	0.22	653	0.37

Table B2-6

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
BARIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.02
12/11/92 7:28	1.07	> 300	0.02
12/11/92 8:52	0.21	210	0.04
12/11/92 10:44	0.13	> 300	0.01
12/11/92 11:48	0.04	163	0.02
12/17/93 0:00	0.94	300	0.0
12/28/92 19:17	0.14	30	0.04
12/29/92 15:05	0.10	10	0.06
1/5/93 7:13	0.62	> 300	0.042
1/5/93 12:25	0.03	70	0.09
2/13/93 8:00	0.15	275	0.058
2/16/93 16:00	0.63	> 300	0.03
3/4/93 13:46	0.18	245	0.073
3/4/93 17:53	0.34	> 300	0.031
3/9/93 0:00	0.04	20	0.079
3/11/93 8:00	0.04	40	0.051
3/17/93 9:15	0.37	300	0.028
3/17/93 11:16	0.20	300	0.023
3/17/93 13:25	0.18	300	0.019
3/17/93 14:57	0.22	300	0.016
3/24/93 6:50	0.84	> 300	0.026
3/24/93 15:27	0.14	300	0.030
3/31/93 8:00	0.36	145	0.045
4/2/93 6:45	1.66	> 300	0.040
4/2/93 22:00	0.03	300	0.054
4/12/93 7:40	0.43	> 300	0.029
4/16/93 15:50	0.02	6	0.087
4/16/93 16:39	0.22	427	0.068
4/21/93 21:48	0.05	1	0.03
4/21/93 22:50	0.18	401	0.032
4/22/93 0:18	0.25	594	0.021
4/22/93 2:33	0.25	576	0.083
4/22/93 7:18	0.07	196	0.027
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.033
4/26/93 17:30	0.66	1324	0.030
4/26/93 23:44	0.07	551	0.057
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37		0.062
6/4/93 0:00	0.06	30	0.090
6/5/93 0:00	0.06	50	0.068
6/9/93 0:00	0.23	20	0.071
6/10/93 0:00	0.23	255	0.084
6/20/93 21:01	0.42	314	0.080
6/20/93 22:51	0.38	836	0.105
6/21/93 0:31	0.04	50	0.10
6/21/93 0:00	1.15	300	0.08
7/2/93 0:00	0.40	300	0.038
7/6/93 0:00	0.32	275	0.055
7/14/93 0:00	0.39	> 300	0.065
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.07
9/27/93 17:45		224	0.13
9/27/93 18:21		181	0.23
9/27/93 19:00		143	0.34
9/27/93 19:35		109	0.19
9/27/93 20:14		117	0.25
9/27/93 20:59		167	0.35
9/27/93 21:43		170	0.21
9/27/93 22:29		161	0.18
9/27/93 23:10		255	0.14
9/27/93 23:46	1.40	124	0.14
9/28/93 0:22		105	0.09
10/3/93 1:07		179	< 0.05
10/3/93 1:44		148	0.07
10/3/93 2:43		171	< 0.05
10/3/93 6:13	0.40	112	0.15
10/12/93 9:02		150	0.15
10/12/93 9:47		300	0.10
10/12/93 10:25		450	0.07
10/12/93 11:01	1.03	600	0.09
10/20/93 0:19	0.21	237	< 0.05
10/20/93 2:12	0.08	159	< 0.05
10/20/93 4:49	0.07	191	< 0.05
10/20/93 14:35	0.04	63	< 0.05
10/21/93 5:16	0.10	146	0.08
10/21/93 20:28	0.11	91	0.08
10/30/93 12:49	0.15	143	0.07
10/30/93 14:54	0.09	192	0.08
10/30/93 16:30	0.08	182	< 0.05
10/30/93 17:04	0.04	190	0.10
10/30/93 17:42	0.09	258	0.14
10/30/93 18:43	0.17	466	< 0.05
10/30/93 20:43	0.12	331	< 0.05
10/31/93 0:23	0.03	126	0.10
10/31/93 10:56	0.07	119	0.07
10/31/93 19:54	0.12	183	0.09
10/31/93 21:17	0.10	196	< 0.05
10/31/93 21:51	0.13	263	0.08
11/28/93 3:21	0.19	297	0.160
11/28/93 3:57	0.08	178	0.220
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.220
11/28/93 5:59	0.15	515	0.160
11/28/93 6:32	0.10	182	0.180
11/28/93 7:07	0.08	201	0.200
11/28/93 7:41	0.22	653	0.180

Table B2-7

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
BERYLLIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	< 0.0010
12/11/92 7:28	1.07	> 300	< 0.0010
12/11/92 8:52	0.21	210	< 0.0010
12/11/92 10:44	0.13	> 300	< 0.0010
12/11/92 11:48	0.04	163	< 0.0010
12/17/93 0:00	0.94	300	< 0.0010
12/28/92 19:17	0.14	30	< 0.0010
12/29/92 15:05	0.10	10	< 0.0010
1/5/93 7:13	0.62	> 300	< 0.0010
1/5/93 12:25	0.03	70	< 0.0010
2/13/93 8:00	0.15	275	< 0.0010
2/16/93 16:00	0.63	> 300	< 0.0010
3/4/93 13:46	0.18	245	0.0020
3/4/93 17:53	0.34	> 300	0.0020
3/9/93 0:00	0.04	20	0.0030
3/11/93 8:00	0.04	40	0.0030
3/17/93 9:15	0.37	300	0.0030
3/17/93 11:16	0.20	300	0.0030
3/17/93 13:25	0.18	300	0.0020
3/17/93 14:57	0.22	300	0.0030
3/24/93 6:50	0.84	> 300	0.0060
3/24/93 15:27	0.14	300	0.0030
3/31/93 8:00	0.36	145	< 0.0010
4/2/93 6:45	1.66	> 300	< 0.0010
4/2/93 22:00	0.03	300	0.0010
4/12/93 7:40	0.43	> 300	0.0020
4/16/93 15:50	0.02	6	< 0.0010
4/16/93 16:39	0.22	427	< 0.0010
4/21/93 21:48	0.05	1	< 0.0010
4/21/93 22:50	0.18	401	< 0.0010
4/22/93 0:18	0.25	594	< 0.0010
4/22/93 2:33	0.25	576	< 0.0010
4/22/93 7:18	0.07	196	< 0.0010
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0010
4/26/93 17:30	0.66	1324	< 0.0010
4/26/93 23:44	0.07	551	< 0.0010
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
5/21/93 0:00	0.37	300	< 0.0010
6/4/93 0:00	0.06	30	< 0.0010
6/5/93 0:00	0.06	50	< 0.0010
6/9/93 0:00	0.23	20	< 0.0010
6/10/93 0:00	0.23	255	< 0.0010
6/20/93 21:01	0.42	314	< 0.0010
6/20/93 22:51	0.38	836	< 0.0010
6/21/93 0:31	0.04	50	< 0.0010
6/21/93 0:00	1.15	300	< 0.0010
7/2/93 0:00	0.40	300	< 0.0010
7/6/93 0:00	0.32	275	< 0.0010
7/14/93 0:00	0.39	> 300	< 0.0010
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.010
9/27/93 17:45		224	< 0.010
9/27/93 18:21		181	< 0.010
9/27/93 19:00		143	< 0.010
9/27/93 19:35		109	< 0.010
9/27/93 20:14		117	< 0.010
9/27/93 20:59		167	< 0.010
9/27/93 21:43		170	< 0.010
9/27/93 22:29		161	< 0.010
9/27/93 23:10		255	< 0.010
9/27/93 23:46	1.40	124	< 0.010
9/28/93 0:22		105	< 0.010
10/3/93 1:07		179	< 0.010
10/3/93 1:44		148	< 0.010
10/3/93 2:43		171	< 0.010
10/3/93 6:13	0.40	112	< 0.010
10/12/93 9:02		150	< 0.010
10/12/93 9:47		300	< 0.010
10/12/93 10:25		450	< 0.010
10/12/93 11:01	1.03	600	< 0.010
10/20/93 0:19	0.21	237	< 0.010
10/20/93 2:12	0.08	159	< 0.010
10/20/93 4:49	0.07	191	< 0.010
10/20/93 14:35	0.04	63	< 0.010
10/21/93 5:16	0.10	146	< 0.010
10/21/93 20:28	0.11	91	< 0.010

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
10/30/93 12:49	0.15	143	< 0.010
10/30/93 14:54	0.09	192	< 0.010
10/30/93 16:30	0.08	182	< 0.010
10/30/93 17:04	0.04	190	< 0.010
10/30/93 17:42	0.09	258	< 0.010
10/30/93 18:43	0.17	466	< 0.010
10/30/93 20:43	0.12	331	< 0.010
10/31/93 0:23	0.03	126	< 0.010
10/31/93 10:56	0.07	119	< 0.010
10/31/93 19:54	0.12	183	< 0.010
10/31/93 21:17	0.10	196	< 0.010
10/31/93 21:51	0.13	263	< 0.010
11/28/93 3:21	0.19	297	< 0.01
11/28/93 3:57	0.08	178	< 0.01
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.01
11/28/93 5:59	0.15	515	< 0.01
11/28/93 6:32	0.10	182	< 0.01
11/28/93 7:07	0.08	201	< 0.01
11/28/93 7:41	0.22	653	< 0.01

Table B2-8

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
BERYLLIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	< 0.0010
12/11/92 7:28	1.07	> 300	< 0.0010
12/11/92 8:52	0.21	210	< 0.0010
12/11/92 10:44	0.13	> 300	< 0.0010
12/11/92 11:48	0.04	163	< 0.0010
12/17/93 0:00	0.94	300	< 0.0010
12/28/92 19:17	0.14	30	< 0.0010
12/29/92 15:05	0.10	10	< 0.0010
1/5/93 7:13	0.62	> 300	< 0.0010
1/5/93 12:25	0.03	70	< 0.0010
2/13/93 8:00	0.15	275	< 0.0010
2/16/93 16:00	0.63	> 300	< 0.0010
3/4/93 13:46	0.18	245	0.0020
3/4/93 17:53	0.34	> 300	< 0.0010
3/9/93 0:00	0.04	20	< 0.0010
3/11/93 8:00	0.04	40	< 0.0010
3/17/93 9:15	0.37	300	< 0.0010
3/17/93 11:16	0.20	300	< 0.0010
3/17/93 13:25	0.18	300	< 0.0010
3/17/93 14:57	0.22	300	< 0.0010
3/24/93 6:50	0.84	> 300	< 0.0010
3/24/93 15:27	0.14	300	< 0.0010
3/31/93 8:00	0.36	145	< 0.0010
4/2/93 6:45	1.66	> 300	< 0.0010
4/2/93 22:00	0.03	300	0.0010
4/12/93 7:40	0.43	> 300	< 0.0010
4/16/93 15:50	0.02	6	< 0.0010
4/16/93 16:39	0.22	427	< 0.0010
4/21/93 21:48	0.05	1	< 0.0010
4/21/93 22:50	0.18	401	< 0.0010
4/22/93 0:18	0.25	594	< 0.0010
4/22/93 2:33	0.25	576	< 0.0010
4/22/93 7:18	0.07	196	< 0.0010
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0010
4/26/93 17:30	0.66	1324	< 0.0010
4/26/93 23:44	0.07	551	< 0.0010
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
5/21/93 0:00	0.37	300	< 0.0010
6/4/93 0:00	0.06	30	< 0.0010
6/5/93 0:00	0.06	50	< 0.0010
6/9/93 0:00	0.23	20	< 0.0010
6/10/93 0:00	0.23	255	< 0.0010
6/20/93 21:01	0.42	314	< 0.0010
6/20/93 22:51	0.38	836	< 0.0010
6/21/93 0:31	0.04	50	< 0.0010
6/21/93 0:00	1.15	300	< 0.0010
7/2/93 0:00	0.40	300	< 0.0010
7/6/93 0:00	0.32	275	< 0.0010
7/14/93 0:00	0.39	> 300	< 0.0010
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.010
9/27/93 17:45		224	< 0.010
9/27/93 18:21		181	< 0.010
9/27/93 19:00		143	< 0.010
9/27/93 19:35		109	< 0.010
9/27/93 20:14		117	< 0.010
9/27/93 20:59		167	< 0.010
9/27/93 21:43		170	< 0.010
9/27/93 22:29		161	< 0.010
9/27/93 23:10		255	< 0.010
9/27/93 23:46	1.40	124	< 0.010
9/28/93 0:22		105	< 0.010
10/3/93 1:07		179	< 0.010
10/3/93 1:44		148	< 0.010
10/3/93 2:43		171	< 0.010
10/3/93 6:13	0.40	112	< 0.010
10/12/93 9:02		150	< 0.010
10/12/93 9:47		300	< 0.010
10/12/93 10:25		450	< 0.010
10/12/93 11:01	1.03	600	< 0.010
10/20/93 0:19	0.21	237	< 0.010
10/20/93 2:12	0.08	159	< 0.010
10/20/93 4:49	0.07	191	< 0.010
10/20/93 14:35	0.04	63	< 0.010
10/21/93 5:16	0.10	146	< 0.010
10/21/93 20:28	0.11	91	< 0.010

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
10/30/93 12:49	0.15	143	< 0.010
10/30/93 14:54	0.09	192	< 0.010
10/30/93 16:30	0.08	182	< 0.010
10/30/93 17:04	0.04	190	< 0.010
10/30/93 17:42	0.09	258	< 0.010
10/30/93 18:43	0.17	466	< 0.010
10/30/93 20:43	0.12	331	< 0.010
10/31/93 0:23	0.03	126	< 0.010
10/31/93 10:56	0.07	119	< 0.010
10/31/93 19:54	0.12	183	< 0.010
10/31/93 21:17	0.10	196	< 0.010
10/31/93 21:51	0.13	263	< 0.010
11/28/93 3:21	0.19	297	< 0.01
11/28/93 3:57	0.08	178	< 0.01
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.01
11/28/93 5:59	0.15	515	< 0.01
11/28/93 6:32	0.10	182	< 0.01
11/28/93 7:07	0.08	201	< 0.01
11/28/93 7:41	0.22	653	< 0.01

Table B2-9

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
CADMIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	< 0.0040
12/11/92 7:28	1.07	> 300	< 0.0040
12/11/92 8:52	0.21	210	< 0.0040
12/11/92 10:44	0.13	> 300	< 0.0040
12/11/92 11:48	0.04	163	< 0.0040
12/17/93 0:00	0.94	300	< 0.0040
12/28/92 19:17	0.14	30	< 0.0040
12/29/92 15:05	0.10	10	< 0.0040
1/5/93 7:13	0.62	> 300	< 0.0040
1/5/93 12:25	0.03	70	< 0.0040
2/13/93 8:00	0.15	275	< 0.0040
2/16/93 16:00	0.63	> 300	< 0.0040
3/4/93 13:46	0.18	245	< 0.0040
3/4/93 17:53	0.34	> 300	< 0.0040
3/9/93 0:00	0.04	20	< 0.0040
3/11/93 8:00	0.04	40	< 0.0040
3/17/93 9:15	0.37	300	< 0.0040
3/17/93 11:16	0.20	300	< 0.0040
3/17/93 13:25	0.18	300	< 0.0040
3/17/93 14:57	0.22	300	< 0.0040
3/24/93 6:50	0.84	> 300	< 0.0040
3/24/93 15:27	0.14	300	< 0.0040
3/31/93 8:00	0.36	145	< 0.0040
4/2/93 6:45	1.66	> 300	< 0.0040
4/2/93 22:00	0.03	300	< 0.0040
4/12/93 7:40	0.43	> 300	< 0.0040
4/16/93 15:50	0.02	6	< 0.0040
4/16/93 16:39	0.22	427	0.011
4/21/93 21:48	0.05	1	< 0.0040
4/21/93 22:50	0.18	401	< 0.0040
4/22/93 0:18	0.25	594	< 0.0040
4/22/93 2:33	0.25	576	< 0.0040
4/22/93 7:18	0.07	196	< 0.0040
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0040
4/26/93 17:30	0.66	1324	< 0.0040
4/26/93 23:44	0.07	551	< 0.0040
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
5/21/93 0:00	0.37	300	< 0.0040
6/4/93 0:00	0.06	30	< 0.0040
6/5/93 0:00	0.06	50	< 0.0040
6/9/93 0:00	0.23	20	< 0.0040
6/10/93 0:00	0.23	255	< 0.0040
6/20/93 21:01	0.42	314	< 0.0040
6/20/93 22:51	0.38	836	< 0.0040
6/21/93 0:31	0.04	50	< 0.0040
6/21/93 0:00	1.15	300	< 0.0040
7/2/93 0:00	0.40	300	< 0.0040
7/6/93 0:00	0.32	275	< 0.0040
7/14/93 0:00	0.39	> 300	< 0.0040
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.010
9/27/93 17:45		224	< 0.010
9/27/93 18:21		181	< 0.010
9/27/93 19:00		143	< 0.010
9/27/93 19:35		109	< 0.010
9/27/93 20:14		117	< 0.010
9/27/93 20:59		167	0.020
9/27/93 21:43		170	0.020
9/27/93 22:29		161	0.030
9/27/93 23:10		255	< 0.010
9/27/93 23:46	1.40	124	< 0.010
9/28/93 0:22		105	< 0.010
10/3/93 1:07		179	< 0.010
10/3/93 1:44		148	< 0.010
10/3/93 2:43		171	< 0.010
10/3/93 6:13	0.40	112	< 0.010
10/12/93 9:02		150	0.030
10/12/93 9:47		300	0.030
10/12/93 10:25		450	0.020
10/12/93 11:01	1.03	600	0.020
10/20/93 0:19	0.21	237	< 0.010
10/20/93 2:12	0.08	159	< 0.010
10/20/93 4:49	0.07	191	< 0.010
10/20/93 14:35	0.04	63	0.010
10/21/93 5:16	0.10	146	0.010
10/21/93 20:28	0.11	91	< 0.010

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
10/30/93 12:49	0.15	143	< 0.010
10/30/93 14:54	0.09	192	0.020
10/30/93 16:30	0.08	182	< 0.010
10/30/93 17:04	0.04	190	0.020
10/30/93 17:42	0.09	258	< 0.010
10/30/93 18:43	0.17	466	< 0.010
10/30/93 20:43	0.12	331	< 0.010
10/31/93 0:23	0.03	126	< 0.010
10/31/93 10:56	0.07	119	< 0.010
10/31/93 19:54	0.12	183	< 0.010
10/31/93 21:17	0.10	196	0.020
10/31/93 21:51	0.13	263	< 0.010
11/28/93 3:21	0.19	297	0.04
11/28/93 3:57	0.08	178	0.02
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.00
11/28/93 5:59	0.15	515	0.06
11/28/93 6:32	0.10	182	0.03
11/28/93 7:07	0.08	201	0.04
11/28/93 7:41	0.22	653	0.05

Table B2-10

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
CADMIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	< 0.0040
12/11/92 7:28	1.07	> 300	< 0.0040
12/11/92 8:52	0.21	210	< 0.0040
12/11/92 10:44	0.13	> 300	< 0.0040
12/11/92 11:48	0.04	163	< 0.0040
12/17/93 0:00	0.94	300	< 0.0040
12/28/92 19:17	0.14	30	< 0.0040
12/29/92 15:05	0.10	10	< 0.0040
1/5/93 7:13	0.62	> 300	< 0.0040
1/5/93 12:25	0.03	70	< 0.0040
2/13/93 8:00	0.15	275	< 0.0040
2/16/93 16:00	0.63	> 300	< 0.0040
3/4/93 13:46	0.18	245	< 0.0040
3/4/93 17:53	0.34	> 300	< 0.0040
3/9/93 0:00	0.04	20	< 0.0040
3/11/93 8:00	0.04	40	< 0.0040
3/17/93 9:15	0.37	300	< 0.0040
3/17/93 11:16	0.20	300	< 0.0040
3/17/93 13:25	0.18	300	< 0.0040
3/17/93 14:57	0.22	300	< 0.0040
3/24/93 6:50	0.84	> 300	< 0.0040
3/24/93 15:27	0.14	300	< 0.0040
3/31/93 8:00	0.36	145	< 0.0040
4/2/93 6:45	1.66	> 300	< 0.0040
4/2/93 22:00	0.03	300	< 0.0040
4/12/93 7:40	0.43	> 300	< 0.0040
4/16/93 15:50	0.02	6	< 0.0040
4/16/93 16:39	0.22	427	< 0.0040
4/21/93 21:48	0.05	1	< 0.0040
4/21/93 22:50	0.18	401	< 0.0040
4/22/93 0:18	0.25	594	< 0.0040
4/22/93 2:33	0.25	576	< 0.0040
4/22/93 7:18	0.07	196	< 0.0040
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0040
4/26/93 17:30	0.66	1324	< 0.0040
4/26/93 23:44	0.07	551	< 0.0040
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	< 0.0040
6/4/93 0:00	0.06	30	< 0.0040
6/5/93 0:00	0.06	50	< 0.0040
6/9/93 0:00	0.23	20	< 0.0040
6/10/93 0:00	0.23	255	< 0.0040
6/20/93 21:01	0.42	314	< 0.0040
6/20/93 22:51	0.38	836	< 0.0040
6/21/93 0:31	0.04	50	< 0.0040
6/21/93 0:00	1.15	300	< 0.0040
7/2/93 0:00	0.40	300	< 0.0040
7/6/93 0:00	0.32	275	< 0.0040
7/14/93 0:00	0.39	> 300	< 0.0040
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.010
9/27/93 17:45		224	< 0.010
9/27/93 18:21		181	< 0.010
9/27/93 19:00		143	< 0.010
9/27/93 19:35		109	< 0.010
9/27/93 20:14		117	< 0.010
9/27/93 20:59		167	0.020
9/27/93 21:43		170	0.020
9/27/93 22:29		161	0.030
9/27/93 23:10		255	< 0.010
9/27/93 23:46	1.40	124	< 0.010
9/28/93 0:22		105	< 0.010
10/3/93 1:07		179	< 0.010
10/3/93 1:44		148	< 0.010
10/3/93 2:43		171	< 0.010
10/3/93 6:13	0.40	112	< 0.010
10/12/93 9:02		150	0.010
10/12/93 9:47		300	< 0.010
10/12/93 10:25		450	< 0.010
10/12/93 11:01	1.03	600	< 0.010
10/20/93 0:19	0.21	237	< 0.010
10/20/93 2:12	0.08	159	< 0.010
10/20/93 4:49	0.07	191	< 0.010
10/20/93 14:35	0.04	63	0.010
10/21/93 5:16	0.10	146	0.010
10/21/93 20:28	0.11	91	< 0.010
10/30/93 12:49	0.15	143	< 0.010
10/30/93 14:54	0.09	192	0.010
10/30/93 16:30	0.08	182	< 0.010
10/30/93 17:04	0.04	190	< 0.010
10/30/93 17:42	0.09	258	< 0.010
10/30/93 18:43	0.17	466	< 0.010
10/30/93 20:43	0.12	331	< 0.010
10/31/93 0:23	0.03	126	< 0.010
10/31/93 10:56	0.07	119	< 0.010
10/31/93 19:54	0.12	183	< 0.010
10/31/93 21:17	0.10	196	0.010
10/31/93 21:51	0.13	263	< 0.010
11/28/93 3:21	0.19	297	0.010
11/28/93 3:57	0.08	178	0.010
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.004
11/28/93 5:59	0.15	515	< 0.004
11/28/93 6:32	0.10	182	< 0.004
11/28/93 7:07	0.08	201	< 0.004
11/28/93 7:41	0.22	653	< 0.004

Table B2-11

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
COPPER
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.93
12/11/92 7:28	1.07	> 300	1.0
12/11/92 8:52	0.21	210	0.29
12/11/92 10:44	0.13	> 300	0.56
12/11/92 11:48	0.04	163	0.71
12/17/93 0:00	0.94	300	0.52
12/28/92 19:17	0.14	30	0.48
12/29/92 15:05	0.10	10	0.52
1/5/93 7:13	0.62	> 300	0.27
1/5/93 12:25	0.03	70	0.30
2/13/93 8:00	0.15	275	0.39
2/16/93 16:00	0.63	> 300	0.015
3/4/93 13:46	0.18	245	0.19
3/4/93 17:53	0.34	> 300	0.34
3/9/93 0:00	0.04	20	0.43
3/11/93 8:00	0.04	40	0.28
3/17/93 9:15	0.37	300	0.11
3/17/93 11:16	0.20	300	0.12
3/17/93 13:25	0.18	300	0.12
3/17/93 14:57	0.22	300	0.12
3/24/93 6:50	0.84	> 300	< 0.0060
3/24/93 15:27	0.14	300	0.12
3/31/93 8:00	0.36	145	0.085
4/2/93 6:45	1.66	> 300	0.035
4/2/93 22:00	0.03	300	0.14
4/12/93 7:40	0.43	> 300	0.12
4/16/93 15:50	0.02	6	0.15
4/16/93 16:39	0.22	427	0.080
4/21/93 21:48	0.05	1	0.11
4/21/93 22:50	0.18	401	0.12
4/22/93 0:18	0.25	594	0.021
4/22/93 2:33	0.25	576	0.20
4/22/93 7:18	0.07	196	0.077
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.030
4/26/93 17:30	0.66	1324	0.028
4/26/93 23:44	0.07	551	0.15
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.11
6/4/93 0:00	0.06	30	0.11
6/5/93 0:00	0.06	50	0.086
6/9/93 0:00	0.23	20	0.085
6/10/93 0:00	0.23	255	0.065
6/20/93 21:01	0.42	314	0.072
6/20/93 22:51	0.38	836	0.059
6/21/93 0:31	0.04	50	0.059
6/21/93 0:00	1.15	300	< 0.0060
7/2/93 0:00	0.40	300	0.091
7/6/93 0:00	0.32	275	0.052
7/14/93 0:00	0.39	> 300	0.26
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.23
9/27/93 17:45		224	0.13
9/27/93 18:21		181	0.10
9/27/93 19:00		143	0.090
9/27/93 19:35		109	0.090
9/27/93 20:14		117	0.10
9/27/93 20:59		167	0.11
9/27/93 21:43		170	0.12
9/27/93 22:29		161	0.12
9/27/93 23:10		255	0.12
9/27/93 23:46	1.40	124	0.10
9/28/93 0:22		105	0.10
10/3/93 1:07		179	0.20
10/3/93 1:44		148	0.20
10/3/93 2:43		171	0.12
10/3/93 6:13	0.40	112	0.080
10/12/93 9:02		150	1.5
10/12/93 9:47		300	1.8
10/12/93 10:25		450	1.0
10/12/93 11:01	1.03	600	0.80
10/20/93 0:19	0.21	237	0.17
10/20/93 2:12	0.08	159	0.18
10/20/93 4:49	0.07	191	0.24
10/20/93 14:35	0.04	63	0.21
10/21/93 5:16	0.10	146	0.10
10/21/93 20:28	0.11	91	0.33
10/30/93 12:49	0.15	143	0.63
10/30/93 14:54	0.09	192	0.42
10/30/93 16:30	0.08	182	0.27
10/30/93 17:04	0.04	190	0.41
10/30/93 17:42	0.09	258	0.45
10/30/93 18:43	0.17	466	0.57
10/30/93 20:43	0.12	331	0.18
10/31/93 0:23	0.03	126	0.060
10/31/93 10:56	0.07	119	0.060
10/31/93 19:54	0.12	183	0.15
10/31/93 21:17	0.10	196	0.59
10/31/93 21:51	0.13	263	0.57
11/28/93 3:21	0.19	297	2.20
11/28/93 3:57	0.08	178	0.67
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.75
11/28/93 5:59	0.15	515	3.83
11/28/93 6:32	0.10	182	1.62
11/28/93 7:07	0.08	201	2.19
11/28/93 7:41	0.22	653	3.13

Table B2-12

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
COPPER
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.45
12/11/92 7:28	1.07	> 300	0.29
12/11/92 8:52	0.21	210	0.09
12/11/92 10:44	0.13	> 300	0.20
12/11/92 11:48	0.04	163	0.32
12/17/93 0:00	0.94	300	0.29
12/28/92 19:17	0.14	30	0.47
12/29/92 15:05	0.10	10	0.53
1/5/93 7:13	0.62	> 300	0.041
1/5/93 12:25	0.03	70	0.13
2/13/93 8:00	0.15	275	0.081
2/16/93 16:00	0.63	> 300	< 0.0060
3/4/93 13:46	0.18	245	0.10
3/4/93 17:53	0.34	> 300	0.039
3/9/93 0:00	0.04	20	0.16
3/11/93 8:00	0.04	40	0.156
3/17/93 9:15	0.37	300	0.041
3/17/93 11:16	0.20	300	0.042
3/17/93 13:25	0.18	300	0.054
3/17/93 14:57	0.22	300	0.039
3/24/93 6:50	0.84	> 300	0.029
3/24/93 15:27	0.14	300	0.063
3/31/93 8:00	0.36	145	0.080
4/2/93 6:45	1.66	> 300	0.030
4/2/93 22:00	0.03	300	0.14
4/12/93 7:40	0.43	> 300	0.097
4/16/93 15:50	0.02	6	0.12
4/16/93 16:39	0.22	427	0.040
4/21/93 21:48	0.05	1	0.074
4/21/93 22:50	0.18	401	0.079
4/22/93 0:18	0.25	594	0.029
4/22/93 2:33	0.25	576	0.15
4/22/93 7:18	0.07	196	0.026
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.048
4/26/93 17:30	0.66	1324	0.015
4/26/93 23:44	0.07	551	0.14
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.080
6/4/93 0:00	0.06	30	0.11
6/5/93 0:00	0.06	50	0.084
6/9/93 0:00	0.23	20	0.076
6/10/93 0:00	0.23	255	0.056
6/20/93 21:01	0.42	314	0.064
6/20/93 22:51	0.38	836	0.057
6/21/93 0:31	0.04	50	0.060
6/21/93 0:00	1.15	300	< 0.0060
7/2/93 0:00	0.40	300	0.071
7/6/93 0:00	0.32	275	0.053
7/14/93 0:00	0.39	> 300	0.081
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.030
9/27/93 17:45		224	0.040
9/27/93 18:21		181	0.060
9/27/93 19:00		143	0.070
9/27/93 19:35		109	0.070
9/27/93 20:14		117	0.080
9/27/93 20:59		167	0.080
9/27/93 21:43		170	0.090
9/27/93 22:29		161	0.10
9/27/93 23:10		255	0.060
9/27/93 23:46	1.40	124	0.060
9/28/93 0:22		105	0.070
10/3/93 1:07		179	0.040
10/3/93 1:44		148	0.020
10/3/93 2:43		171	0.020
10/3/93 6:13	0.40	112	0.040
10/12/93 9:02		150	0.040
10/12/93 9:47		300	0.020
10/12/93 10:25		450	0.020
10/12/93 11:01	1.03	600	0.030
10/20/93 0:19	0.21	237	0.030
10/20/93 2:12	0.08	159	0.020
10/20/93 4:49	0.07	191	0.020
10/20/93 14:35	0.04	63	0.030
10/21/93 5:16	0.10	146	0.030
10/21/93 20:28	0.11	91	0.030
10/30/93 12:49	0.15	143	0.040
10/30/93 14:54	0.09	192	0.040
10/30/93 16:30	0.08	182	0.030
10/30/93 17:04	0.04	190	0.020
10/30/93 17:42	0.09	258	< 0.020
10/30/93 18:43	0.17	466	< 0.020
10/30/93 20:43	0.12	331	0.020
10/31/93 0:23	0.03	126	0.030
10/31/93 10:56	0.07	119	0.040
10/31/93 19:54	0.12	183	0.030
10/31/93 21:17	0.10	196	< 0.020
10/31/93 21:51	0.13	263	< 0.020
11/28/93 3:21	0.19	297	< 0.030
11/28/93 3:57	0.08	178	< 0.030
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.030
11/28/93 5:59	0.15	515	< 0.030
11/28/93 6:32	0.10	182	< 0.030
11/28/93 7:07	0.08	201	< 0.030
11/28/93 7:41	0.22	653	< 0.030

Table B2-13

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
CHROMIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	< 0.020
12/11/92 7:28	1.07	> 300	< 0.020
12/11/92 8:52	0.21	210	< 0.020
12/11/92 10:44	0.13	> 300	< 0.020
12/11/92 11:48	0.04	163	< 0.020
12/17/93 0:00	0.94	300	< 0.020
12/28/92 19:17	0.14	30	< 0.020
12/29/92 15:05	0.10	10	< 0.020
1/5/93 7:13	0.62	> 300	< 0.020
1/5/93 12:25	0.03	70	< 0.020
2/13/93 8:00	0.15	275	< 0.020
2/16/93 16:00	0.63	> 300	< 0.020
3/4/93 13:46	0.18	245	< 0.020
3/4/93 17:53	0.34	> 300	< 0.020
3/9/93 0:00	0.04	20	< 0.020
3/11/93 8:00	0.04	40	< 0.020
3/17/93 9:15	0.37	300	< 0.020
3/17/93 11:16	0.20	300	< 0.020
3/17/93 13:25	0.18	300	< 0.020
3/17/93 14:57	0.22	300	< 0.020
3/24/93 6:50	0.84	> 300	< 0.020
3/24/93 15:27	0.14	300	< 0.020
3/31/93 8:00	0.36	145	< 0.020
4/2/93 6:45	1.66	> 300	< 0.020
4/2/93 22:00	0.03	300	< 0.020
4/12/93 7:40	0.43	> 300	< 0.020
4/16/93 15:50	0.02	6	< 0.020
4/16/93 16:39	0.22	427	< 0.020
4/21/93 21:48	0.05	1	< 0.020
4/21/93 22:50	0.18	401	< 0.020
4/22/93 0:18	0.25	594	< 0.020
4/22/93 2:33	0.25	576	< 0.020
4/22/93 7:18	0.07	196	< 0.020
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.020
4/26/93 17:30	0.66	1324	< 0.020
4/26/93 23:44	0.07	551	< 0.020
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	< 0.020
6/4/93 0:00	0.06	30	< 0.020
6/5/93 0:00	0.06	50	< 0.020
6/9/93 0:00	0.23	20	< 0.020
6/10/93 0:00	0.23	255	< 0.020
6/20/93 21:01	0.42	314	< 0.020
6/20/93 22:51	0.38	836	< 0.020
6/21/93 0:31	0.04	50	< 0.020
6/21/93 0:00	1.15	300	< 0.020
7/2/93 0:00	0.40	300	< 0.020
7/6/93 0:00	0.32	275	< 0.020
7/14/93 0:00	0.39	> 300	< 0.020
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.050
9/27/93 17:45		224	< 0.050
9/27/93 18:21		181	< 0.050
9/27/93 19:00		143	< 0.050
9/27/93 19:35		109	< 0.050
9/27/93 20:14		117	< 0.050
9/27/93 20:59		167	< 0.050
9/27/93 21:43		170	< 0.050
9/27/93 22:29		161	< 0.050
9/27/93 23:10		255	< 0.050
9/27/93 23:46	1.40	124	< 0.050
9/28/93 0:22		105	< 0.050
10/3/93 1:07		179	< 0.050
10/3/93 1:44		148	< 0.050
10/3/93 2:43		171	< 0.050
10/3/93 6:13	0.40	112	< 0.050
10/12/93 9:02		150	< 0.050
10/12/93 9:47		300	< 0.050
10/12/93 10:25		450	< 0.050
10/12/93 11:01	1.03	600	< 0.050
10/20/93 0:19	0.21	237	< 0.050
10/20/93 2:12	0.08	159	< 0.050
10/20/93 4:49	0.07	191	< 0.050
10/20/93 14:35	0.04	63	< 0.050
10/21/93 5:16	0.10	146	< 0.050
10/21/93 20:28	0.11	91	< 0.050
10/30/93 12:49	0.15	143	< 0.050
10/30/93 14:54	0.09	192	< 0.050
10/30/93 16:30	0.08	182	< 0.050
10/30/93 17:04	0.04	190	< 0.050
10/30/93 17:42	0.09	258	< 0.050
10/30/93 18:43	0.17	466	< 0.050
10/30/93 20:43	0.12	331	< 0.050
10/31/93 0:23	0.03	126	< 0.050
10/31/93 10:56	0.07	119	< 0.050
10/31/93 19:54	0.12	183	< 0.050
10/31/93 21:17	0.10	196	< 0.050
10/31/93 21:51	0.13	263	< 0.050
11/28/93 3:21	0.19	297	< 0.050
11/28/93 3:57	0.08	178	< 0.050
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.050
11/28/93 5:59	0.15	515	< 0.050
11/28/93 6:32	0.10	182	< 0.050
11/28/93 7:07	0.08	201	< 0.050
11/28/93 7:41	0.22	653	< 0.050

Table B2-14

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
CHROMIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	< 0.020
12/11/92 7:28	1.07	> 300	< 0.020
12/11/92 8:52	0.21	210	< 0.020
12/11/92 10:44	0.13	> 300	< 0.020
12/11/92 11:48	0.04	163	< 0.020
12/17/93 0:00	0.94	300	< 0.020
12/28/92 19:17	0.14	30	< 0.020
12/29/92 15:05	0.10	10	< 0.020
1/5/93 7:13	0.62	> 300	< 0.020
1/5/93 12:25	0.03	70	< 0.020
2/13/93 8:00	0.15	275	< 0.020
2/16/93 16:00	0.63	> 300	< 0.020
3/4/93 13:46	0.18	245	< 0.020
3/4/93 17:53	0.34	> 300	< 0.020
3/9/93 0:00	0.04	20	< 0.020
3/11/93 8:00	0.04	40	< 0.020
3/17/93 9:15	0.37	300	< 0.020
3/17/93 11:16	0.20	300	< 0.020
3/17/93 13:25	0.18	300	< 0.020
3/17/93 14:57	0.22	300	< 0.020
3/24/93 6:50	0.84	> 300	< 0.020
3/24/93 15:27	0.14	300	< 0.020
3/31/93 8:00	0.36	145	< 0.020
4/2/93 6:45	1.66	> 300	< 0.020
4/2/93 22:00	0.03	300	< 0.020
4/12/93 7:40	0.43	> 300	< 0.020
4/16/93 15:50	0.02	6	< 0.020
4/16/93 16:39	0.22	427	< 0.020
4/21/93 21:48	0.05	1	< 0.020
4/21/93 22:50	0.18	401	< 0.020
4/22/93 0:18	0.25	594	< 0.020
4/22/93 2:33	0.25	576	< 0.020
4/22/93 7:18	0.07	196	< 0.020
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.020
4/26/93 17:30	0.66	1324	< 0.020
4/26/93 23:44	0.07	551	< 0.020
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	< 0.020
6/4/93 0:00	0.06	30	< 0.020
6/5/93 0:00	0.06	50	< 0.020
6/9/93 0:00	0.23	20	< 0.020
6/10/93 0:00	0.23	255	< 0.020
6/20/93 21:01	0.42	314	< 0.020
6/20/93 22:51	0.38	836	< 0.020
6/21/93 0:31	0.04	50	< 0.020
6/21/93 0:00	1.15	300	< 0.020
7/2/93 0:00	0.40	300	< 0.020
7/6/93 0:00	0.32	275	< 0.020
7/14/93 0:00	0.39	> 300	< 0.020
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.050
9/27/93 17:45		224	< 0.050
9/27/93 18:21		181	< 0.050
9/27/93 19:00		143	< 0.050
9/27/93 19:35		109	< 0.050
9/27/93 20:14		117	< 0.050
9/27/93 20:59		167	< 0.050
9/27/93 21:43		170	< 0.050
9/27/93 22:29		161	< 0.050
9/27/93 23:10		255	< 0.050
9/27/93 23:46	1.40	124	< 0.050
9/28/93 0:22		105	< 0.050
10/3/93 1:07		179	< 0.050
10/3/93 1:44		148	< 0.050
10/3/93 2:43		171	< 0.050
10/3/93 6:13	0.40	112	< 0.050
10/12/93 9:02		150	< 0.050
10/12/93 9:47		300	< 0.050
10/12/93 10:25		450	< 0.050
10/12/93 11:01	1.03	600	< 0.050
10/20/93 0:19	0.21	237	< 0.050
10/20/93 2:12	0.08	159	< 0.050
10/20/93 4:49	0.07	191	< 0.050
10/20/93 14:35	0.04	63	< 0.050
10/21/93 5:16	0.10	146	< 0.050
10/21/93 20:28	0.11	91	< 0.050
10/30/93 12:49	0.15	143	< 0.050
10/30/93 14:54	0.09	192	< 0.050
10/30/93 16:30	0.08	182	< 0.050
10/30/93 17:04	0.04	190	< 0.050
10/30/93 17:42	0.09	258	< 0.050
10/30/93 18:43	0.17	466	< 0.050
10/30/93 20:43	0.12	331	< 0.050
10/31/93 0:23	0.03	126	< 0.050
10/31/93 10:56	0.07	119	< 0.050
10/31/93 19:54	0.12	183	< 0.050
10/31/93 21:17	0.10	196	< 0.050
10/31/93 21:51	0.13	263	< 0.050
11/28/93 3:21	0.19	297	< 0.050
11/28/93 3:57	0.08	178	< 0.050
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.050
11/28/93 5:59	0.15	515	< 0.050
11/28/93 6:32	0.10	182	< 0.050
11/28/93 7:07	0.08	201	< 0.050
11/28/93 7:41	0.22	653	< 0.050

Table B2-15

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
IRON
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.57
12/11/92 7:28	1.07	> 300	0.50
12/11/92 8:52	0.21	210	< 0.023
12/11/92 10:44	0.13	> 300	0.45
12/11/92 11:48	0.04	163	0.84
12/17/93 0:00	0.94	300	1.1
12/28/92 19:17	0.14	30	0.38
12/29/92 15:05	0.10	10	0.86
1/5/93 7:13	0.62	> 300	1.1
1/5/93 12:25	0.03	70	2.1
2/13/93 8:00	0.15	275	2.8
2/16/93 16:00	0.63	> 300	0.55
3/4/93 13:46	0.18	245	0.47
3/4/93 17:53	0.34	> 300	0.88
3/9/93 0:00	0.04	20	2.0
3/11/93 8:00	0.04	40	1.0
3/17/93 9:15	0.37	300	0.14
3/17/93 11:16	0.20	300	0.12
3/17/93 13:25	0.18	300	0.10
3/17/93 14:57	0.22	300	0.13
3/24/93 6:50	0.84	> 300	< 0.023
3/24/93 15:27	0.14	300	0.030
3/31/93 8:00	0.36	145	< 0.023
4/2/93 6:45	1.66	> 300	< 0.023
4/2/93 22:00	0.03	300	< 0.023
4/12/93 7:40	0.43	> 300	< 0.023
4/16/93 15:50	0.02	6	< 0.023
4/16/93 16:39	0.22	427	< 0.023
4/21/93 21:48	0.05	1	0.076
4/21/93 22:50	0.18	401	< 0.023
4/22/93 0:18	0.25	594	< 0.023
4/22/93 2:33	0.25	576	0.041
4/22/93 7:18	0.07	196	< 0.023
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.023
4/26/93 17:30	0.66	1324	< 0.023
4/26/93 23:44	0.07	551	0.12
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	< 0.023
6/4/93 0:00	0.06	30	< 0.023
6/5/93 0:00	0.06	50	< 0.023
6/9/93 0:00	0.23	20	< 0.023
6/10/93 0:00	0.23	255	< 0.023
6/20/93 21:01	0.42	314	< 0.023
6/20/93 22:51	0.38	836	< 0.023
6/21/93 0:31	0.04	50	< 0.023
6/21/93 0:00	1.15	300	< 0.023
7/2/93 0:00	0.40	300	< 0.023
7/6/93 0:00	0.32	275	< 0.023
7/14/93 0:00	0.39	> 300	0.42
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.42
9/27/93 17:45		224	0.34
9/27/93 18:21		181	0.12
9/27/93 19:00		143	0.11
9/27/93 19:35		109	0.080
9/27/93 20:14		117	0.090
9/27/93 20:59		167	0.10
9/27/93 21:43		170	0.090
9/27/93 22:29		161	0.070
9/27/93 23:10		255	0.15
9/27/93 23:46	1.40	124	0.070
9/28/93 0:22		105	0.060
10/3/93 1:07		179	0.17
10/3/93 1:44		148	0.18
10/3/93 2:43		171	0.10
10/3/93 6:13	0.40	112	< 0.050
10/12/93 9:02		150	1.9
10/12/93 9:47		300	2.1
10/12/93 10:25		450	1.3
10/12/93 11:01	1.03	600	1.0
10/20/93 0:19	0.21	237	0.15
10/20/93 2:12	0.08	159	0.18
10/20/93 4:49	0.07	191	0.24
10/20/93 14:35	0.04	63	0.11
10/21/93 5:16	0.10	146	0.080
10/21/93 20:28	0.11	91	0.40
10/30/93 12:49	0.15	143	0.68
10/30/93 14:54	0.09	192	0.48
10/30/93 16:30	0.08	182	0.27
10/30/93 17:04	0.04	190	0.45
10/30/93 17:42	0.09	258	0.46
10/30/93 18:43	0.17	466	0.59
10/30/93 20:43	0.12	331	0.18
10/31/93 0:23	0.03	126	0.070
10/31/93 10:56	0.07	119	0.070
10/31/93 19:54	0.12	183	0.15
10/31/93 21:17	0.10	196	0.70
10/31/93 21:51	0.13	263	0.66
11/28/93 3:21	0.19	297	2.87
11/28/93 3:57	0.08	178	0.65
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.86
11/28/93 5:59	0.15	515	0.92
11/28/93 6:32	0.10	182	1.80
11/28/93 7:07	0.08	201	2.53
11/28/93 7:41	0.22	653	3.35

Table B2-16

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
IRON
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.10
12/11/92 7:28	1.07	> 300	0.10
12/11/92 8:52	0.21	210	< 0.23
12/11/92 10:44	0.13	> 300	0.082
12/11/92 11:48	0.04	163	0.090
12/17/93 0:00	0.94	300	0.12
12/28/92 19:17	0.14	30	0.061
12/29/92 15:05	0.10	10	0.11
1/5/93 7:13	0.62	> 300	0.031
1/5/93 12:25	0.03	70	0.13
2/13/93 8:00	0.15	275	< 0.023
2/16/93 16:00	0.63	> 300	0.029
3/4/93 13:46	0.18	245	< 0.023
3/4/93 17:53	0.34	> 300	< 0.023
3/9/93 0:00	0.04	20	< 0.023
3/11/93 8:00	0.04	40	< 0.023
3/17/93 9:15	0.37	300	< 0.023
3/17/93 11:16	0.20	300	< 0.023
3/17/93 13:25	0.18	300	< 0.023
3/17/93 14:57	0.22	300	< 0.023
3/24/93 6:50	0.84	> 300	< 0.023
3/24/93 15:27	0.14	300	< 0.023
3/31/93 8:00	0.36	145	< 0.023
4/2/93 6:45	1.66	> 300	< 0.023
4/2/93 22:00	0.03	300	< 0.023
4/12/93 7:40	0.43	> 300	< 0.023
4/16/93 15:50	0.02	6	< 0.023
4/16/93 16:39	0.22	427	< 0.023
4/21/93 21:48	0.05	1	< 0.023
4/21/93 22:50	0.18	401	< 0.023
4/22/93 0:18	0.25	594	< 0.023
4/22/93 2:33	0.25	576	0.034
4/22/93 7:18	0.07	196	< 0.023
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.023
4/26/93 17:30	0.66	1324	< 0.023
4/26/93 23:44	0.07	551	0.12
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	< 0.023
6/4/93 0:00	0.06	30	< 0.023
6/5/93 0:00	0.06	50	< 0.023
6/9/93 0:00	0.23	20	< 0.023
6/10/93 0:00	0.23	255	< 0.023
6/20/93 21:01	0.42	314	< 0.023
6/20/93 22:51	0.38	836	< 0.023
6/21/93 0:31	0.04	50	< 0.023
6/21/93 0:00	1.15	300	< 0.023
7/2/93 0:00	0.40	300	< 0.023
7/6/93 0:00	0.32	275	< 0.023
7/14/93 0:00	0.39	> 300	< 0.023
8/9/93 0:00	0.37	> 300	
9/27/93 17:09	1.40	652	< 0.050
9/27/93 17:45		224	< 0.050
9/27/93 18:21		181	< 0.050
9/27/93 19:00		143	0.050
9/27/93 19:35		109	< 0.050
9/27/93 20:14		117	0.050
9/27/93 20:59		167	0.060
9/27/93 21:43		170	0.050
9/27/93 22:29		161	0.060
9/27/93 23:10		255	0.060
9/27/93 23:46		124	< 0.050
9/28/93 0:22		105	< 0.050
10/3/93 1:07	0.40	179	< 0.050
10/3/93 1:44		148	< 0.050
10/3/93 2:43		171	< 0.050
10/3/93 6:13		112	< 0.050
10/12/93 9:02	1.03	150	< 0.050
10/12/93 9:47		300	< 0.050
10/12/93 10:25		450	< 0.050
10/12/93 11:01		600	< 0.050
10/20/93 0:19	0.21	237	< 0.050
10/20/93 2:12	0.08	159	< 0.050
10/20/93 4:49	0.07	191	< 0.050
10/20/93 14:35	0.04	63	< 0.050
10/21/93 5:16	0.10	146	< 0.050
10/21/93 20:28	0.11	91	< 0.050
10/30/93 12:49	0.15	143	< 0.050
10/30/93 14:54	0.09	192	< 0.050
10/30/93 16:30	0.08	182	< 0.050
10/30/93 17:04	0.04	190	< 0.050
10/30/93 17:42	0.09	258	< 0.050
10/30/93 18:43	0.17	466	< 0.050
10/30/93 20:43	0.12	331	< 0.050
10/31/93 0:23	0.03	126	< 0.050
10/31/93 10:56	0.07	119	< 0.050
10/31/93 19:54	0.12	183	< 0.050
10/31/93 21:17	0.10	196	< 0.050
10/31/93 21:51	0.13	263	< 0.050
11/28/93 3:21	0.19	297	< 0.050
11/28/93 3:57	0.08	178	< 0.050
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.050
11/28/93 5:59	0.15	515	< 0.050
11/28/93 6:32	0.10	182	< 0.050
11/28/93 7:07	0.08	201	< 0.050
11/28/93 7:41	0.22	653	< 0.050

Table B2-17

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
LEAD
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*	*TIME OF SAMPLE COLLECTION*	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*	*TIME OF SAMPLE COLLECTION*	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.21	5/21/93 0:00	0.37	300	0.080	10/30/93 12:49	0.15	143	0.43
12/11/92 7:28	1.07	> 300	0.22	6/4/93 0:00	0.06	30	< 0.050	10/30/93 14:54	0.09	192	0.30
12/11/92 8:52	0.21	210	0.070	6/5/93 0:00	0.06	50	< 0.050	10/30/93 16:30	0.08	182	0.21
12/11/92 10:44	0.13	> 300	0.12	6/9/936/10/93	0.23	20	0.060	10/30/93 17:04	0.04	190	0.31
12/11/92 11:48	0.04	163	0.050	6/10/93 0:00	0.23	255	< 0.050	10/30/93 17:42	0.09	258	0.31
12/17/93 0:00	0.94	300	0.48	6/20/93 21:01	0.42	314	< 0.050	10/30/93 18:43	0.17	466	0.39
12/28/92 19:17	0.14	30	0.17	6/20/93 22:51	0.38	836	< 0.050	10/30/93 20:43	0.12	331	0.17
12/29/92 15:05	0.10	10	0.23	6/21/93 0:31	0.04	50	< 0.050	10/31/93 0:23	0.03	126	< 0.050
1/5/93 7:13	0.62	> 300	0.50	6/21/93 0:00	1.15	300	< 0.0500	10/31/93 10:56	0.07	119	< 0.050
1/5/93 12:25	0.03	70	0.53	7/2/93 0:00	0.40	300	0.070	10/31/93 19:54	0.12	183	< 0.050
2/13/93 8:00	0.15	275	0.97	7/6/93 0:00	0.32	275	0.070	10/31/93 21:17	0.10	196	0.35
2/16/93 16:00	0.63	> 300	0.23	7/14/93 0:00	0.39	> 300	0.24	10/31/93 21:51	0.13	263	0.41
3/4/93 13:46	0.18	245	0.24	8/9/93 0:00	0.37	> 300		11/28/93 3:21	0.19	297	1.52
3/4/93 17:53	0.34	> 300	0.38	9/27/93 17:09		652	0.20	11/28/93 3:57	0.08	178	0.44
3/9/93 0:00	0.04	20	0.44	9/27/93 17:45		224	< 0.050	11/28/93 4:53	0.12	176	
3/11/93 8:00	0.04	40	0.13	9/27/93 18:21		181	< 0.050	11/28/93 5:26	0.11	309	0.53
3/17/93 9:15	0.37	300	< 0.050	9/27/93 19:00		143	< 0.050	11/28/93 5:59	0.15	515	2.75
3/17/93 11:16	0.20	300	< 0.050	9/27/93 19:35		109	0.13	11/28/93 6:32	0.10	182	1.12
3/17/93 13:25	0.18	300	< 0.050	9/27/93 20:14		117	< 0.050	11/28/93 7:07	0.08	201	1.59
3/17/93 14:57	0.22	300	< 0.050	9/27/93 20:59		167	0.15	11/28/93 7:41	0.22	653	2.17
3/24/93 6:50	0.84	> 300	< 0.050	9/27/93 21:43		170	0.18				
3/24/93 15:27	0.14	300	< 0.050	9/27/93 22:29		161	0.16				
3/31/93 8:00	0.36	145	0.20	9/27/93 23:10		255	0.17				
4/2/93 6:45	1.66	> 300	0.16	9/27/93 23:46	1.40	124	0.15				
4/2/93 22:00	0.03	300	0.21	9/28/93 0:22		105	0.16				
4/12/93 7:40	0.43	> 300	< 0.050	10/3/93 1:07		179	< 0.050				
4/16/93 15:50	0.02	6	0.10	10/3/93 1:44		148	0.15				
4/16/93 16:39	0.22	427	< 0.050	10/3/93 2:43		171	< 0.050				
4/21/93 21:48	0.05	1	0.09	10/3/93 6:13	0.40	112	< 0.050				
4/21/93 22:50	0.18	401	< 0.050	10/12/93 9:02		150	1.0				
4/22/93 0:18	0.25	594	< 0.050	10/12/93 9:47		300	1.3				
4/22/93 2:33	0.25	576	0.090	10/12/93 10:25		450	0.72				
4/22/93 7:18	0.07	196	0.070	10/12/93 11:01	1.03	600	0.56				
4/22/93 12:09	0.07	77		10/20/93 0:19	0.21	237	0.13				
4/26/93 14:48	0.40	542	< 0.050	10/20/93 2:12	0.08	159	0.13				
4/26/93 17:30	0.66	1324	0.070	10/20/93 4:49	0.07	191	0.17				
4/26/93 23:44	0.07	551	0.060	10/20/93 14:35	0.04	63	< 0.050				
4/27/93 2:52	0.00	39		10/21/93 5:16	0.10	146	< 0.050				
5/6/93 0:00	0.12	300		10/21/93 20:28	0.11	91	0.27				

Table B2-18

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
LEAD
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	< 0.050
12/11/92 7:28	1.07	> 300	< 0.050
12/11/92 8:52	0.21	210	< 0.050
12/11/92 10:44	0.13	> 300	< 0.050
12/11/92 11:48	0.04	163	< 0.050
12/17/93 0:00	0.94	300	< 0.050
12/28/92 19:17	0.14	30	0.070
12/29/92 15:05	0.10	10	0.15
1/5/93 7:13	0.62	> 300	< 0.050
1/5/93 12:25	0.03	70	< 0.050
2/13/93 8:00	0.15	275	< 0.050
2/16/93 16:00	0.63	> 300	< 0.050
3/4/93 13:46	0.18	245	< 0.050
3/4/93 17:53	0.34	> 300	< 0.050
3/9/93 0:00	0.04	20	0.090
3/11/93 8:00	0.04	40	< 0.050
3/17/93 9:15	0.37	300	< 0.050
3/17/93 11:16	0.20	300	< 0.050
3/17/93 13:25	0.18	300	< 0.050
3/17/93 14:57	0.22	300	< 0.050
3/24/93 6:50	0.84	> 300	< 0.050
3/24/93 15:27	0.14	300	< 0.050
3/31/93 8:00	0.36	145	< 0.05
4/2/93 6:45	1.66	> 300	< 0.050
4/2/93 22:00	0.03	300	0.090
4/12/93 7:40	0.43	> 300	< 0.050
4/16/93 15:50	0.02	6	0.090
4/16/93 16:39	0.22	427	< 0.050
4/21/93 21:48	0.05	1	< 0.050
4/21/93 22:50	0.18	401	< 0.050
4/22/93 0:18	0.25	594	< 0.050
4/22/93 2:33	0.25	576	0.090
4/22/93 7:18	0.07	196	< 0.050
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.050
4/26/93 17:30	0.66	1324	< 0.050
4/26/93 23:44	0.07	551	0.050
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
5/21/93 0:00	0.37	300	< 0.050
6/4/93 0:00	0.06	30	< 0.050
6/5/93 0:00	0.06	50	< 0.050
6/9/93 0:00	0.23	20	< 0.050
6/10/93 0:00	0.23	255	< 0.050
6/20/93 21:01	0.42	314	< 0.050
6/20/93 22:51	0.38	836	< 0.050
6/21/93 0:31	0.04	50	< 0.050
6/21/93 0:00	1.15	300	< 0.050
7/2/93 0:00	0.40	300	0.070
7/6/93 0:00	0.32	275	< 0.050
7/14/93 0:00	0.39	> 300	0.050
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.050
9/27/93 17:45		224	< 0.050
9/27/93 18:21		181	< 0.050
9/27/93 19:00		143	< 0.050
9/27/93 19:35		109	< 0.050
9/27/93 20:14		117	< 0.050
9/27/93 20:59		167	0.15
9/27/93 21:43		170	0.15
9/27/93 22:29		161	0.15
9/27/93 23:10		255	0.10
9/27/93 23:46	1.40	124	0.11
9/28/93 0:22		105	0.17
10/3/93 1:07		179	< 0.050
10/3/93 1:44		148	< 0.050
10/3/93 2:43		171	< 0.050
10/3/93 6:13	0.40	112	< 0.050
10/12/93 9:02		150	< 0.050
10/12/93 9:47		300	< 0.050
10/12/93 10:25		450	< 0.050
10/12/93 11:01	1.03	600	< 0.050
10/20/93 0:19	0.21	237	< 0.050
10/20/93 2:12	0.08	159	< 0.050
10/20/93 4:49	0.07	191	< 0.050
10/20/93 14:35	0.04	63	< 0.050
10/21/93 5:16	0.10	146	< 0.050
10/21/93 20:28	0.11	91	< 0.050

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
10/30/93 12:49	0.15	143	< 0.050
10/30/93 14:54	0.09	192	< 0.050
10/30/93 16:30	0.08	182	< 0.050
10/30/93 17:04	0.04	190	< 0.050
10/30/93 17:42	0.09	258	< 0.050
10/30/93 18:43	0.17	466	< 0.050
10/30/93 20:43	0.12	331	< 0.050
10/31/93 0:23	0.03	126	< 0.050
10/31/93 10:56	0.07	119	< 0.050
10/31/93 19:54	0.12	183	< 0.050
10/31/93 21:17	0.10	196	< 0.050
10/31/93 21:51	0.13	263	< 0.050
11/28/93 3:21	0.19	297	< 0.050
11/28/93 3:57	0.08	178	< 0.050
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.050
11/28/93 5:59	0.15	515	< 0.050
11/28/93 6:32	0.10	182	< 0.050
11/28/93 7:07	0.08	201	< 0.050
11/28/93 7:41	0.22	653	< 0.050

Table B2-19

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
MANGANESE
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.092
12/11/92 7:28	1.07	> 300	0.065
12/11/92 8:52	0.21	210	0.083
12/11/92 10:44	0.13	> 300	0.024
12/11/92 11:48	0.04	163	0.17
12/17/93 0:00	0.94	300	0.027
12/28/92 19:17	0.14	30	0.15
12/29/92 15:05	0.10	10	0.59
1/5/93 7:13	0.62	> 300	0.23
1/5/93 12:25	0.03	70	0.28
2/13/93 8:00	0.15	275	0.39
2/16/93 16:00	0.63	> 300	0.12
3/4/93 13:46	0.18	245	0.081
3/4/93 17:53	0.34	> 300	0.13
3/9/93 0:00	0.04	20	0.76
3/11/93 8:00	0.04	40	0.38
3/17/93 9:15	0.37	300	0.068
3/17/93 11:16	0.20	300	0.057
3/17/93 13:25	0.18	300	0.047
3/17/93 14:57	0.22	300	0.044
3/24/93 6:50	0.84	> 300	0.031
3/24/93 15:27	0.14	300	0.074
3/31/93 8:00	0.36	145	0.19
4/2/93 6:45	1.66	> 300	0.11
4/2/93 22:00	0.03	300	0.16
4/12/93 7:40	0.43	> 300	0.18
4/16/93 15:50	0.02	6	0.76
4/16/93 16:39	0.22	427	0.15
4/21/93 21:48	0.05	1	0.19
4/21/93 22:50	0.18	401	0.21
4/22/93 0:18	0.25	594	0.075
4/22/93 2:33	0.25	576	1.4
4/22/93 7:18	0.07	196	0.076
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.20
4/26/93 17:30	0.66	1324	0.087
4/26/93 23:44	0.07	551	0.41
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.16
6/4/93 0:00	0.06	30	0.059
6/5/93 0:00	0.06	50	0.070
6/9/93 0:00	0.23	20	0.015
6/10/93 0:00	0.23	255	0.078
6/20/93 21:01	0.42	314	0.040
6/20/93 22:51	0.38	836	0.10
6/21/93 0:31	0.04	50	0.026
6/21/93 0:00	1.15	300	< 0.0020
7/2/93 0:00	0.40	300	0.091
7/6/93 0:00	0.32	275	0.044
7/14/93 0:00	0.39	> 300	0.11
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.050
9/27/93 17:45		224	0.040
9/27/93 18:21		181	0.050
9/27/93 19:00		143	0.050
9/27/93 19:35		109	0.050
9/27/93 20:14		117	0.050
9/27/93 20:59		167	0.050
9/27/93 21:43		170	0.050
9/27/93 22:29		161	0.060
9/27/93 23:10		255	0.050
9/27/93 23:46	1.40	124	0.050
9/28/93 0:22		105	0.040
10/3/93 1:07		179	0.050
10/3/93 1:44		148	0.040
10/3/93 2:43		171	0.020
10/3/93 6:13	0.40	112	0.030
10/12/93 9:02		150	0.36
10/12/93 9:47		300	0.40
10/12/93 10:25		450	0.22
10/12/93 11:01	1.03	600	0.17
10/20/93 0:19	0.21	237	0.050
10/20/93 2:12	0.08	159	0.050
10/20/93 4:49	0.07	191	0.050
10/20/93 14:35	0.04	63	0.040
10/21/93 5:16	0.10	146	0.050
10/21/93 20:28	0.11	91	0.090
10/30/93 12:49	0.15	143	0.14
10/30/93 14:54	0.09	192	0.090
10/30/93 16:30	0.08	182	0.070
10/30/93 17:04	0.04	190	0.080
10/30/93 17:42	0.09	258	0.090
10/30/93 18:43	0.17	466	0.11
10/30/93 20:43	0.12	331	0.040
10/31/93 0:23	0.03	126	0.040
10/31/93 10:56	0.07	119	0.050
10/31/93 19:54	0.12	183	0.050
10/31/93 21:17	0.10	196	0.11
10/31/93 21:51	0.13	263	0.11
11/28/93 3:21	0.19	297	0.44
11/28/93 3:57	0.08	178	0.11
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.15
11/28/93 5:59	0.15	515	0.79
11/28/93 6:32	0.10	182	0.32
11/28/93 7:07	0.08	201	0.45
11/28/93 7:41	0.22	653	0.66

Table B2-20

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
MANGANESE
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.032
12/11/92 7:28	1.07	> 300	0.025
12/11/92 8:52	0.21	210	0.037
12/11/92 10:44	0.13	> 300	0.0070
12/11/92 11:48	0.04	163	0.079
12/17/93 0:00	0.94	300	0.013
12/28/92 19:17	0.14	30	0.15
12/29/92 15:05	0.10	10	0.58
1/5/93 7:13	0.62	> 300	0.17
1/5/93 12:25	0.03	70	0.22
2/13/93 8:00	0.15	275	0.057
2/16/93 16:00	0.63	> 300	0.060
3/4/93 13:46	0.18	245	0.080
3/4/93 17:53	0.34	> 300	0.042
3/9/93 0:00	0.04	20	0.66
3/11/93 8:00	0.04	40	0.34
3/17/93 9:15	0.37	300	0.054
3/17/93 11:16	0.20	300	0.044
3/17/93 13:25	0.18	300	0.036
3/17/93 14:57	0.22	300	0.029
3/24/93 6:50	0.84	> 300	0.035
3/24/93 15:27	0.14	300	0.063
3/31/93 8:00	0.36	145	0.19
4/2/93 6:45	1.66	> 300	0.093
4/2/93 22:00	0.03	300	0.16
4/12/93 7:40	0.43	> 300	0.18
4/16/93 15:50	0.02	6	0.76
4/16/93 16:39	0.22	427	0.15
4/21/93 21:48	0.05	1	0.17
4/21/93 22:50	0.18	401	0.18
4/22/93 0:18	0.25	594	0.071
4/22/93 2:33	0.25	576	1.2
4/22/93 7:18	0.07	196	0.076
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.19
4/26/93 17:30	0.66	1324	0.085
4/26/93 23:44	0.07	551	0.37
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.089
6/4/93 0:00	0.06	30	0.068
6/5/93 0:00	0.06	50	< 0.0020
6/9/93 0:00	0.23	20	< 0.0020
6/10/93 0:00	0.23	255	0.075
6/20/93 21:01	0.42	314	0.036
6/20/93 22:51	0.38	836	0.10
6/21/93 0:31	0.04	50	0.034
6/21/93 0:00	1.15	300	< 0.0020
7/2/93 0:00	0.40	300	0.083
7/6/93 0:00	0.32	275	0.043
7/14/93 0:00	0.39	> 300	0.071
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.010
9/27/93 17:45		224	0.030
9/27/93 18:21		181	0.040
9/27/93 19:00		143	0.040
9/27/93 19:35		109	0.040
9/27/93 20:14		117	0.040
9/27/93 20:59		167	0.050
9/27/93 21:43		170	0.050
9/27/93 22:29		161	0.060
9/27/93 23:10		255	0.050
9/27/93 23:46	1.40	124	0.040
9/28/93 0:22		105	0.040
10/3/93 1:07		179	0.030
10/3/93 1:44		148	0.020
10/3/93 2:43		171	0.020
10/3/93 6:13	0.40	112	0.020
10/12/93 9:02		150	0.060
10/12/93 9:47		300	0.040
10/12/93 10:25		450	0.040
10/12/93 11:01	1.03	600	0.040
10/20/93 0:19	0.21	237	0.040
10/20/93 2:12	0.08	159	0.030
10/20/93 4:49	0.07	191	0.030
10/20/93 14:35	0.04	63	0.040
10/21/93 5:16	0.10	146	0.040
10/21/93 20:28	0.11	91	0.050
10/30/93 12:49	0.15	143	0.050
10/30/93 14:54	0.09	192	0.040
10/30/93 16:30	0.08	182	0.030
10/30/93 17:04	0.04	190	0.030
10/30/93 17:42	0.09	258	0.020
10/30/93 18:43	0.17	466	0.020
10/30/93 20:43	0.12	331	0.030
10/31/93 0:23	0.03	126	0.040
10/31/93 10:56	0.07	119	0.040
10/31/93 19:54	0.12	183	0.040
10/31/93 21:17	0.10	196	0.030
10/31/93 21:51	0.13	263	0.020
11/28/93 3:21	0.19	297	0.030
11/28/93 3:57	0.08	178	0.030
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.030
11/28/93 5:59	0.15	515	0.020
11/28/93 6:32	0.10	182	0.020
11/28/93 7:07	0.08	201	0.020
11/28/93 7:41	0.22	653	0.010

Table B2-21

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
MERCURY
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	< 0.0010
12/11/92 7:28	1.07	> 300	< 0.0010
12/11/92 8:52	0.21	210	< 0.0010
12/11/92 10:44	0.13	> 300	< 0.0010
12/11/92 11:48	0.04	163	< 0.0010
12/17/93 0:00	0.94	300	< 0.0010
12/28/92 19:17	0.14	30	< 0.0010
12/29/92 15:05	0.10	10	< 0.0010
1/5/93 7:13	0.62	> 300	< 0.0010
1/5/93 12:25	0.03	70	< 0.0010
2/13/93 8:00	0.15	275	< 0.0010
2/16/93 16:00	0.63	> 300	< 0.0010
3/4/93 13:46	0.18	245	< 0.0010
3/4/93 17:53	0.34	> 300	< 0.0010
3/9/93 0:00	0.04	20	< 0.0010
3/11/93 8:00	0.04	40	< 0.0010
3/17/93 9:15	0.37	300	< 0.0010
3/17/93 11:16	0.20	300	< 0.0010
3/17/93 13:25	0.18	300	< 0.0010
3/17/93 14:57	0.22	300	< 0.0010
3/24/93 6:50	0.84	> 300	< 0.0010
3/24/93 15:27	0.14	300	< 0.0010
3/31/93 8:00	0.36	145	< 0.0010
4/2/93 6:45	1.66	> 300	< 0.0010
4/2/93 22:00	0.03	300	< 0.0010
4/12/93 7:40	0.43	> 300	< 0.0010
4/16/93 15:50	0.02	6	< 0.0010
4/16/93 16:39	0.22	427	< 0.0010
4/21/93 21:48	0.05	1	< 0.0010
4/21/93 22:50	0.18	401	< 0.0010
4/22/93 0:18	0.25	594	< 0.0010
4/22/93 2:33	0.25	576	< 0.0010
4/22/93 7:18	0.07	196	< 0.0010
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0010
4/26/93 17:30	0.66	1324	< 0.0010
4/26/93 23:44	0.07	551	< 0.0010
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	< 0.0010
6/4/93 0:00	0.06	30	< 0.0010
6/5/93 0:00	0.06	50	< 0.0010
6/9/93 0:00	0.23	20	< 0.0010
6/10/93 0:00	0.23	255	< 0.0010
6/20/93 21:01	0.42	314	< 0.0010
6/20/93 22:51	0.38	836	< 0.0010
6/21/93 0:31	0.04	50	< 0.0010
6/21/93 0:00	1.15	300	< 0.0010
7/2/93 0:00	0.40	300	< 0.0010
7/6/93 0:00	0.32	275	< 0.0010
7/14/93 0:00	0.39	> 300	< 0.0010
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.0010
9/27/93 17:45		224	< 0.0010
9/27/93 18:21		181	< 0.0010
9/27/93 19:00		143	< 0.0010
9/27/93 19:35		109	< 0.0010
9/27/93 20:14		117	< 0.0010
9/27/93 20:59		167	< 0.0010
9/27/93 21:43		170	< 0.0010
9/27/93 22:29		161	< 0.0010
9/27/93 23:10		255	< 0.0010
9/27/93 23:46	1.40	124	< 0.0010
9/28/93 0:22		105	< 0.0010
10/3/93 1:07		179	< 0.0010
10/3/93 1:44		148	< 0.0010
10/3/93 2:43		171	< 0.0010
10/3/93 6:13	0.40	112	< 0.0010
10/12/93 9:02		150	< 0.0010
10/12/93 9:47		300	< 0.0010
10/12/93 10:25		450	< 0.0010
10/12/93 11:01	1.03	600	< 0.0010
10/20/93 0:19	0.21	237	< 0.0010
10/20/93 2:12	0.08	159	< 0.0010
10/20/93 4:49	0.07	191	< 0.0010
10/20/93 14:35	0.04	63	< 0.0010
10/21/93 5:16	0.10	146	< 0.0010
10/21/93 20:28	0.11	91	< 0.0010
10/30/93 12:49	0.15	143	< 0.0010
10/30/93 14:54	0.09	192	< 0.0010
10/30/93 16:30	0.08	182	< 0.0010
10/30/93 17:04	0.04	190	< 0.0010
10/30/93 17:42	0.09	258	< 0.0010
10/30/93 18:43	0.17	466	< 0.0010
10/30/93 20:43	0.12	331	< 0.0010
10/31/93 0:23	0.03	126	< 0.0010
10/31/93 10:56	0.07	119	< 0.0010
10/31/93 19:54	0.12	183	< 0.0010
10/31/93 21:17	0.10	196	< 0.0010
10/31/93 21:51	0.13	263	< 0.0010
11/28/93 3:21	0.19	297	< 0.0010
11/28/93 3:57	0.08	178	< 0.0010
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.0010
11/28/93 5:59	0.15	515	< 0.0010
11/28/93 6:32	0.10	182	< 0.0010
11/28/93 7:07	0.08	201	< 0.0010
11/28/93 7:41	0.22	653	< 0.0010

Table B2-22

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
MERCURY
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	< 0.0010
12/11/92 7:28	1.07	> 300	< 0.0010
12/11/92 8:52	0.21	210	< 0.0010
12/11/92 10:44	0.13	> 300	< 0.0010
12/11/92 11:48	0.04	163	< 0.0010
12/17/93 0:00	0.94	300	< 0.0010
12/28/92 19:17	0.14	30	< 0.0010
12/29/92 15:05	0.10	10	< 0.0010
1/5/93 7:13	0.62	> 300	< 0.0010
1/5/93 12:25	0.03	70	< 0.0010
2/13/93 8:00	0.15	275	< 0.0010
2/16/93 16:00	0.63	> 300	< 0.0010
3/4/93 13:46	0.18	245	< 0.0010
3/4/93 17:53	0.34	> 300	< 0.0010
3/9/93 0:00	0.04	20	< 0.0010
3/11/93 8:00	0.04	40	< 0.0010
3/17/93 9:15	0.37	300	< 0.0010
3/17/93 11:16	0.20	300	< 0.0010
3/17/93 13:25	0.18	300	< 0.0010
3/17/93 14:57	0.22	300	< 0.0010
3/24/93 6:50	0.84	> 300	< 0.0010
3/24/93 15:27	0.14	300	< 0.0010
3/31/93 8:00	0.36	145	< 0.0010
4/2/93 6:45	1.66	> 300	< 0.0010
4/2/93 22:00	0.03	300	< 0.0010
4/12/93 7:40	0.43	> 300	< 0.0010
4/16/93 15:50	0.02	6	< 0.0010
4/16/93 16:39	0.22	427	< 0.0010
4/21/93 21:48	0.05	1	< 0.0010
4/21/93 22:50	0.18	401	< 0.0010
4/22/93 0:18	0.25	594	< 0.0010
4/22/93 2:33	0.25	576	< 0.0010
4/22/93 7:18	0.07	196	< 0.0010
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0010
4/26/93 17:30	0.66	1324	< 0.0010
4/26/93 23:44	0.07	551	< 0.0010
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	< 0.0010
6/4/93 0:00	0.06	30	< 0.0010
6/5/93 0:00	0.06	50	< 0.0010
6/9/93 0:00	0.23	20	< 0.0010
6/10/93 0:00	0.23	255	< 0.0010
6/20/93 21:01	0.42	314	< 0.0010
6/20/93 22:51	0.38	836	< 0.0010
6/21/93 0:31	0.04	50	< 0.0010
6/21/93 0:00	1.15	300	< 0.0010
7/2/93 0:00	0.40	300	< 0.0010
7/6/93 0:00	0.32	275	< 0.0010
7/14/93 0:00	0.39	> 300	< 0.0010
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	< 0.0010
9/27/93 17:45		224	< 0.0010
9/27/93 18:21		181	< 0.0010
9/27/93 19:00		143	< 0.0010
9/27/93 19:35		109	< 0.0010
9/27/93 20:14		117	< 0.0010
9/27/93 20:59		167	< 0.0010
9/27/93 21:43		170	< 0.0010
9/27/93 22:29		161	< 0.0010
9/27/93 23:10		255	< 0.0010
9/27/93 23:46	1.40	124	< 0.0010
9/28/93 0:22		105	< 0.0010
10/3/93 1:07		179	< 0.0010
10/3/93 1:44		148	< 0.0010
10/3/93 2:43		171	< 0.0010
10/3/93 6:13	0.40	112	< 0.0010
10/12/93 9:02		150	< 0.0010
10/12/93 9:47		300	< 0.0010
10/12/93 10:25		450	< 0.0010
10/12/93 11:01	1.03	600	< 0.0010
10/20/93 0:19	0.21	237	< 0.0010
10/20/93 2:12	0.08	159	< 0.0010
10/20/93 4:49	0.07	191	< 0.0010
10/20/93 14:35	0.04	63	< 0.0010
10/21/93 5:16	0.10	146	< 0.0010
10/21/93 20:28	0.11	91	< 0.0010
10/30/93 12:49	0.15	143	< 0.0010
10/30/93 14:54	0.09	192	< 0.0010
10/30/93 16:30	0.08	182	< 0.0010
10/30/93 17:04	0.04	190	< 0.0010
10/30/93 17:42	0.09	258	< 0.0010
10/30/93 18:43	0.17	466	< 0.0010
10/30/93 20:43	0.12	331	< 0.0010
10/31/93 0:23	0.03	126	< 0.0010
10/31/93 10:56	0.07	119	< 0.0010
10/31/93 19:54	0.12	183	< 0.0010
10/31/93 21:17	0.10	196	< 0.0010
10/31/93 21:51	0.13	263	< 0.0010
11/28/93 3:21	0.19	297	< 0.0010
11/28/93 3:57	0.08	178	< 0.0010
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.0010
11/28/93 5:59	0.15	515	< 0.0010
11/28/93 6:32	0.10	182	< 0.0010
11/28/93 7:07	0.08	201	< 0.0010
11/28/93 7:41	0.22	653	< 0.0010

Table B2-23

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
NICKEL
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	< 0.050
12/11/92 7:28	1.07	> 300	< 0.050
12/11/92 8:52	0.21	210	< 0.050
12/11/92 10:44	0.13	> 300	< 0.050
12/11/92 11:48	0.04	163	< 0.050
12/17/93 0:00	0.94	300	< 0.050
12/28/92 19:17	0.14	30	< 0.050
12/29/92 15:05	0.10	10	< 0.050
1/5/93 7:13	0.62	> 300	< 0.050
1/5/93 12:25	0.03	70	< 0.050
2/13/93 8:00	0.15	275	< 0.050
2/16/93 16:00	0.63	> 300	< 0.050
3/4/93 13:46	0.18	245	< 0.050
3/4/93 17:53	0.34	> 300	< 0.050
3/9/93 0:00	0.04	20	0.12
3/11/93 8:00	0.04	40	< 0.050
3/17/93 9:15	0.37	300	< 0.050
3/17/93 11:16	0.20	300	< 0.050
3/17/93 13:25	0.18	300	< 0.050
3/17/93 14:57	0.22	300	< 0.050
3/24/93 6:50	0.84	> 300	< 0.050
3/24/93 15:27	0.14	300	< 0.050
3/31/93 8:00	0.36	145	< 0.050
4/2/93 6:45	1.66	> 300	< 0.050
4/2/93 22:00	0.03	300	< 0.050
4/12/93 7:40	0.43	> 300	< 0.050
4/16/93 15:50	0.02	6	< 0.050
4/16/93 16:39	0.22	427	< 0.050
4/21/93 21:48	0.05	1	< 0.050
4/21/93 22:50	0.18	401	< 0.050
4/22/93 0:18	0.25	594	< 0.050
4/22/93 2:33	0.25	576	< 0.050
4/22/93 7:18	0.07	196	< 0.050
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.050
4/26/93 17:30	0.66	1324	< 0.050
4/26/93 23:44	0.07	551	< 0.050
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	< 0.050
6/4/93 0:00	0.06	30	< 0.050
6/5/93 0:00	0.06	50	< 0.050
6/9/93 0:00	0.23	20	< 0.050
6/10/93 0:00	0.23	255	< 0.050
6/20/93 21:01	0.42	314	< 0.050
6/20/93 22:51	0.38	836	< 0.050
6/21/93 0:31	0.04	50	< 0.050
6/21/93 0:00	1.15	300	< 0.050
7/2/93 0:00	0.40	300	< 0.050
7/6/93 0:00	0.32	275	< 0.050
7/14/93 0:00	0.39	> 300	< 0.050
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.050
9/27/93 17:45		224	< 0.040
9/27/93 18:21		181	< 0.040
9/27/93 19:00		143	0.060
9/27/93 19:35		109	0.060
9/27/93 20:14		117	0.080
9/27/93 20:59		167	0.10
9/27/93 21:43		170	0.090
9/27/93 22:29		161	0.090
9/27/93 23:10		255	< 0.040
9/27/93 23:46	1.40	124	< 0.040
9/28/93 0:22		105	0.080
10/3/93 1:07		179	< 0.040
10/3/93 1:44		148	< 0.040
10/3/93 2:43		171	< 0.040
10/3/93 6:13	0.40	112	< 0.040
10/12/93 9:02		150	0.080
10/12/93 9:47		300	0.080
10/12/93 10:25		450	< 0.040
10/12/93 11:01	1.03	600	0.060
10/20/93 0:19	0.21	237	< 0.040
10/20/93 2:12	0.08	159	< 0.040
10/20/93 4:49	0.07	191	< 0.040
10/20/93 14:35	0.04	63	< 0.040
10/21/93 5:16	0.10	146	< 0.040
10/21/93 20:28	0.11	91	< 0.040
10/30/93 12:49	0.15	143	< 0.040
10/30/93 14:54	0.09	192	< 0.040
10/30/93 16:30	0.08	182	< 0.040
10/30/93 17:04	0.04	190	< 0.040
10/30/93 17:42	0.09	258	< 0.040
10/30/93 18:43	0.17	466	< 0.040
10/30/93 20:43	0.12	331	< 0.040
10/31/93 0:23	0.03	126	< 0.040
10/31/93 10:56	0.07	119	< 0.040
10/31/93 19:54	0.12	183	< 0.040
10/31/93 21:17	0.10	196	< 0.040
10/31/93 21:51	0.13	263	< 0.040
11/28/93 3:21	0.19	297	0.11
11/28/93 3:57	0.08	178	< 0.04
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.04
11/28/93 5:59	0.15	515	0.12
11/28/93 6:32	0.10	182	0.05
11/28/93 7:07	0.08	201	0.10
11/28/93 7:41	0.22	653	0.11

Table B2-24

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
NICKEL
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	< 0.050
12/11/92 7:28	1.07	> 300	< 0.050
12/11/92 8:52	0.21	210	< 0.050
12/11/92 10:44	0.13	> 300	< 0.050
12/11/92 11:48	0.04	163	< 0.050
12/17/93 0:00	0.94	300	< 0.050
12/28/92 19:17	0.14	30	< 0.050
12/29/92 15:05	0.10	10	< 0.050
1/5/93 7:13	0.62	> 300	< 0.050
1/5/93 12:25	0.03	70	< 0.050
2/13/93 8:00	0.15	275	< 0.050
2/16/93 16:00	0.63	> 300	< 0.050
3/4/93 13:46	0.18	245	< 0.050
3/4/93 17:53	0.34	> 300	< 0.050
3/9/93 0:00	0.04	20	< 0.050
3/11/93 8:00	0.04	40	< 0.050
3/17/93 9:15	0.37	300	< 0.050
3/17/93 11:16	0.20	300	< 0.050
3/17/93 13:25	0.18	300	< 0.050
3/17/93 14:57	0.22	300	< 0.050
3/24/93 6:50	0.84	> 300	< 0.050
3/24/93 15:27	0.14	300	< 0.050
3/31/93 8:00	0.36	145	< 0.050
4/2/93 6:45	1.66	> 300	< 0.050
4/2/93 22:00	0.03	300	< 0.050
4/12/93 7:40	0.43	> 300	< 0.050
4/16/93 15:50	0.02	6	< 0.050
4/16/93 16:39	0.22	427	< 0.050
4/21/93 21:48	0.05	1	< 0.050
4/21/93 22:50	0.18	401	< 0.050
4/22/93 0:18	0.25	594	< 0.050
4/22/93 2:33	0.25	576	< 0.050
4/22/93 7:18	0.07	196	< 0.050
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.050
4/26/93 17:30	0.66	1324	< 0.050
4/26/93 23:44	0.07	551	< 0.050
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
5/21/93 0:00	0.37	300	< 0.050
6/4/93 0:00	0.06	30	< 0.050
6/5/93 0:00	0.06	50	< 0.050
6/9/93 0:00	0.23	20	< 0.050
6/10/93 0:00	0.23	255	< 0.050
6/20/93 21:01	0.42	314	< 0.050
6/20/93 22:51	0.38	836	< 0.050
6/21/93 0:31	0.04	50	< 0.050
6/21/93 0:00	1.15	300	< 0.050
7/2/93 0:00	0.40	300	< 0.050
7/6/93 0:00	0.32	275	< 0.050
7/14/93 0:00	0.39	> 300	< 0.050
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.050
9/27/93 17:45		224	< 0.040
9/27/93 18:21		181	< 0.040
9/27/93 19:00		143	0.060
9/27/93 19:35		109	0.060
9/27/93 20:14		117	0.080
9/27/93 20:59		167	0.090
9/27/93 21:43		170	0.090
9/27/93 22:29		161	0.090
9/27/93 23:10		255	< 0.040
9/27/93 23:46	1.40	124	< 0.040
9/28/93 0:22		105	0.080
10/3/93 1:07		179	< 0.040
10/3/93 1:44		148	< 0.040
10/3/93 2:43		171	< 0.040
10/3/93 6:13	0.40	112	< 0.040
10/12/93 9:02		150	< 0.040
10/12/93 9:47		300	< 0.040
10/12/93 10:25		450	< 0.040
10/12/93 11:01	1.03	600	< 0.040
10/20/93 0:19	0.21	237	< 0.040
10/20/93 2:12	0.08	159	< 0.040
10/20/93 4:49	0.07	191	< 0.040
10/20/93 14:35	0.04	63	< 0.040
10/21/93 5:16	0.10	146	< 0.040
10/21/93 20:28	0.11	91	< 0.040

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
10/30/93 12:49	0.15	143	< 0.040
10/30/93 14:54	0.09	192	< 0.040
10/30/93 16:30	0.08	182	< 0.040
10/30/93 17:04	0.04	190	< 0.040
10/30/93 17:42	0.09	258	< 0.040
10/30/93 18:43	0.17	466	< 0.040
10/30/93 20:43	0.12	331	< 0.040
10/31/93 0:23	0.03	126	< 0.040
10/31/93 10:56	0.07	119	< 0.040
10/31/93 19:54	0.12	183	< 0.040
10/31/93 21:17	0.10	196	< 0.040
10/31/93 21:51	0.13	263	< 0.040
11/28/93 3:21	0.19	297	< 0.040
11/28/93 3:57	0.08	178	< 0.040
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	< 0.040
11/28/93 5:59	0.15	515	< 0.040
11/28/93 6:32	0.10	182	< 0.040
11/28/93 7:07	0.08	201	< 0.040
11/28/93 7:41	0.22	653	< 0.040

Table B2-25

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SELENIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.0040
12/11/92 7:28	1.07	> 300	0.0030
12/11/92 8:52	0.21	210	0.0020
12/11/92 10:44	0.13	> 300	0.0010
12/11/92 11:48	0.04	163	0.0020
12/17/93 0:00	0.94	300	0.0030
12/28/92 19:17	0.14	30	0.0020
12/29/92 15:05	0.10	10	0.0020
1/5/93 7:13	0.62	> 300	< 0.0010
1/5/93 12:25	0.03	70	< 0.0010
2/13/93 8:00	0.15	275	0.0010
2/16/93 16:00	0.63	> 300	< 0.0010
3/4/93 13:46	0.18	245	< 0.0010
3/4/93 17:53	0.34	> 300	< 0.0010
3/9/93 0:00	0.04	20	< 0.0010
3/11/93 8:00	0.04	40	< 0.0010
3/17/93 9:15	0.37	300	< 0.0010
3/17/93 11:16	0.20	300	< 0.0010
3/17/93 13:25	0.18	300	< 0.0010
3/17/93 14:57	0.22	300	< 0.0010
3/24/93 6:50	0.84	> 300	< 0.0010
3/24/93 15:27	0.14	300	< 0.0010
3/31/93 8:00	0.36	145	< 0.0010
4/2/93 6:45	1.66	> 300	< 0.0010
4/2/93 22:00	0.03	300	< 0.0010
4/12/93 7:40	0.43	> 300	0.0010
4/16/93 15:50	0.02	6	0.0010
4/16/93 16:39	0.22	427	< 0.0010
4/21/93 21:48	0.05	1	< 0.0010
4/21/93 22:50	0.18	401	0.0020
4/22/93 0:18	0.25	594	0.0010
4/22/93 2:33	0.25	576	0.0020
4/22/93 7:18	0.07	196	< 0.0010
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0010
4/26/93 17:30	0.66	1324	0.0010
4/26/93 23:44	0.07	551	0.0010
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.0010
6/4/93 0:00	0.06	30	0.0020
6/5/93 0:00	0.06	50	0.0020
6/9/93 0:00	0.23	20	0.0010
6/10/93 0:00	0.23	255	0.0010
6/20/93 21:01	0.42	314	0.0030
6/20/93 22:51	0.38	836	0.0020
6/21/93 0:31	0.04	50	0.0020
6/21/93 0:00	1.15	300	0.0020
7/2/93 0:00	0.40	300	0.0020
7/6/93 0:00	0.32	275	0.0020
7/14/93 0:00	0.39	> 300	0.0020
8/9/93 0:00	0.37	> 300	
9/27/93 17:09	1.40	652	0.0010
9/27/93 17:45		224	0.0030
9/27/93 18:21		181	0.0020
9/27/93 19:00		143	0.0040
9/27/93 19:35		109	0.0320
9/27/93 20:14		117	0.0310
9/27/93 20:59		167	0.0390
9/27/93 21:43		170	0.0350
9/27/93 22:29		161	0.0420
9/27/93 23:10		255	0.0050
9/27/93 23:46		124	0.0060
9/28/93 0:22		105	0.0270
10/3/93 1:07	0.40	179	0.0020
10/3/93 1:44		148	0.0020
10/3/93 2:43		171	0.0010
10/3/93 6:13		112	0.0040
10/12/93 9:02	1.03	150	0.0010
10/12/93 9:47		300	0.0010
10/12/93 10:25		450	0.0010
10/12/93 11:01		600	0.0010
10/20/93 0:19	0.21	237	0.0010
10/20/93 2:12	0.08	159	0.0010
10/20/93 4:49	0.07	191	0.0010
10/20/93 14:35	0.04	63	0.0010
10/21/93 5:16	0.10	146	0.0010
10/21/93 20:28	0.11	91	0.0020
10/30/93 12:49	0.15	143	0.0010
10/30/93 14:54	0.09	192	0.0010
10/30/93 16:30	0.08	182	< 0.0010
10/30/93 17:04	0.04	190	0.0010
10/30/93 17:42	0.09	258	< 0.0010
10/30/93 18:43	0.17	466	< 0.0010
10/30/93 20:43	0.12	331	0.0020
10/31/93 0:23	0.03	126	0.0030
10/31/93 10:56	0.07	119	0.0030
10/31/93 19:54	0.12	183	0.0030
10/31/93 21:17	0.10	196	< 0.0010
10/31/93 21:51	0.13	263	< 0.0010
11/28/93 3:21	0.19	297	0.01
11/28/93 3:57	0.08	178	0.00
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.00
11/28/93 5:59	0.15	515	0.00
11/28/93 6:32	0.10	182	0.00
11/28/93 7:07	0.08	201	< 0.00
11/28/93 7:41	0.22	653	0.00

Table B2-26

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SELENIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	< 0.0010
12/11/92 7:28	1.07	> 300	0.0020
12/11/92 8:52	0.21	210	0.0010
12/11/92 10:44	0.13	> 300	< 0.0010
12/11/92 11:48	0.04	163	0.0010
12/17/93 0:00	0.94	300	0.0030
12/28/92 19:17	0.14	30	0.0020
12/29/92 15:05	0.10	10	< 0.0010
1/5/93 7:13	0.62	> 300	< 0.0010
1/5/93 12:25	0.03	70	< 0.0010
2/13/93 8:00	0.15	275	< 0.0010
2/16/93 16:00	0.63	> 300	< 0.0010
3/4/93 13:46	0.18	245	< 0.0010
3/4/93 17:53	0.34	> 300	< 0.0010
3/9/93 0:00	0.04	20	< 0.0010
3/11/93 8:00	0.04	40	< 0.0010
3/17/93 9:15	0.37	300	< 0.0010
3/17/93 11:16	0.20	300	< 0.0010
3/17/93 13:25	0.18	300	< 0.0010
3/17/93 14:57	0.22	300	< 0.0010
3/24/93 6:50	0.84	> 300	< 0.0010
3/24/93 15:27	0.14	300	< 0.0010
3/31/93 8:00	0.36	145	< 0.0010
4/2/93 6:45	1.66	> 300	< 0.0010
4/2/93 22:00	0.03	300	< 0.0010
4/12/93 7:40	0.43	> 300	0.0010
4/16/93 15:50	0.02	6	< 0.0010
4/16/93 16:39	0.22	427	< 0.0010
4/21/93 21:48	0.05	1	< 0.0010
4/21/93 22:50	0.18	401	< 0.0010
4/22/93 0:18	0.25	594	< 0.0010
4/22/93 2:33	0.25	576	0.0020
4/22/93 7:18	0.07	196	< 0.0010
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	< 0.0010
4/26/93 17:30	0.66	1324	< 0.0010
4/26/93 23:44	0.07	551	< 0.0010
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.0010
6/4/93 0:00	0.06	30	0.0020
6/5/93 0:00	0.06	50	0.0020
6/9/93 0:00	0.23	20	0.0010
6/10/93 0:00	0.23	255	0.0010
6/20/93 21:01	0.42	314	< 0.0010
6/20/93 22:51	0.38	836	0.0010
6/21/93 0:31	0.04	50	0.0020
6/21/93 0:00	1.15	300	0.0010
7/2/93 0:00	0.40	300	0.0020
7/6/93 0:00	0.32	275	0.0010
7/14/93 0:00	0.39	> 300	0.0020
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.0010
9/27/93 17:45		224	0.0030
9/27/93 18:21		181	0.0020
9/27/93 19:00		143	0.0040
9/27/93 19:35		109	0.0050
9/27/93 20:14		117	0.0180
9/27/93 20:59		167	0.0180
9/27/93 21:43		170	0.0140
9/27/93 22:29		161	0.0380
9/27/93 23:10		255	0.0050
9/27/93 23:46	1.40	124	0.0040
9/28/93 0:22		105	0.0110
10/3/93 1:07		179	0.0020
10/3/93 1:44		148	0.0020
10/3/93 2:43		171	0.0010
10/3/93 6:13	0.40	112	0.0030
10/12/93 9:02		150	0.0010
10/12/93 9:47		300	0.0010
10/12/93 10:25		450	0.0010
10/12/93 11:01	1.03	600	0.0010
10/20/93 0:19	0.21	237	< 0.0010
10/20/93 2:12	0.08	159	< 0.0010
10/20/93 4:49	0.07	191	< 0.0010
10/20/93 14:35	0.04	63	< 0.0010
10/21/93 5:16	0.10	146	< 0.0010
10/21/93 20:28	0.11	91	< 0.0010
10/30/93 12:49	0.15	143	< 0.0010
10/30/93 14:54	0.09	192	< 0.0010
10/30/93 16:30	0.08	182	< 0.0010
10/30/93 17:04	0.04	190	< 0.0010
10/30/93 17:42	0.09	258	< 0.0010
10/30/93 18:43	0.17	466	< 0.0010
10/30/93 20:43	0.12	331	< 0.0010
10/31/93 0:23	0.03	126	0.0010
10/31/93 10:56	0.07	119	0.0010
10/31/93 19:54	0.12	183	< 0.0010
10/31/93 21:17	0.10	196	< 0.0010
10/31/93 21:51	0.13	263	< 0.0010
11/28/93 3:21	0.19	297	0.002
11/28/93 3:57	0.08	178	0.001
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.001
11/28/93 5:59	0.15	515	< 0.0010
11/28/93 6:32	0.10	182	< 0.0010
11/28/93 7:07	0.08	201	< 0.0010
11/28/93 7:41	0.22	653	< 0.0010

Table B2-27

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SILVER
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	< 0.010
12/11/92 7:28	1.07	> 300	< 0.010
12/11/92 8:52	0.21	210	< 0.010
12/11/92 10:44	0.13	> 300	< 0.010
12/11/92 11:48	0.04	163	< 0.010
12/17/93 0:00	0.94	300	< 0.010
12/28/92 19:17	0.14	30	< 0.010
12/29/92 15:05	0.10	10	< 0.010
1/5/93 7:13	0.62	> 300	< 0.010
1/5/93 12:25	0.03	70	< 0.010
2/13/93 8:00	0.15	275	< 0.010
2/16/93 16:00	0.63	> 300	< 0.010
3/4/93 13:46	0.18	245	< 0.010
3/4/93 17:53	0.34	> 300	< 0.010
3/9/93 0:00	0.04	20	< 0.010
3/11/93 8:00	0.04	40	< 0.010
3/17/93 9:15	0.37	300	< 0.010
3/17/93 11:16	0.20	300	< 0.010
3/17/93 13:25	0.18	300	< 0.010
3/17/93 14:57	0.22	300	< 0.010
3/24/93 6:50	0.84	> 300	< 0.010
3/24/93 15:27	0.14	300	< 0.010
3/31/93 8:00	0.36	145	< 0.010
4/2/93 6:45	1.66	> 300	< 0.010
4/2/93 22:00	0.03	300	< 0.010
4/12/93 7:40	0.43	> 300	< 0.010
4/16/93 15:50	0.02	6	< 0.010
4/16/93 16:39	0.22	427	< 0.010
4/21/93 21:48	0.05	1	< 0.010
4/21/93 22:50	0.18	401	< 0.010
4/22/93 0:18	0.25	594	< 0.010
4/22/93 2:33	0.25	576	< 0.010
4/22/93 7:18	0.07	196	< 0.010
4/22/93 12:09	0.07	77	< 0.010
4/26/93 14:48	0.40	542	< 0.010
4/26/93 17:30	0.66	1324	< 0.010
4/26/93 23:44	0.07	551	< 0.010
4/27/93 2:52	0.00	39	< 0.010
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
5/21/93 0:00	0.37	300	< 0.010
6/4/93 0:00	0.06	30	< 0.010
6/5/93 0:00	0.06	50	< 0.010
6/9/93 0:00	0.23	20	< 0.010
6/10/93 0:00	0.23	255	< 0.010
6/20/93 21:01	0.42	314	< 0.010
6/20/93 22:51	0.38	836	< 0.010
6/21/93 0:31	0.04	50	< 0.010
6/21/93 0:00	1.15	300	< 0.010
7/2/93 0:00	0.40	300	< 0.010
7/6/93 0:00	0.32	275	< 0.010
7/14/93 0:00	0.39	> 300	< 0.010
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.010
9/27/93 17:45		224	0.010
9/27/93 18:21		181	0.010
9/27/93 19:00		143	0.010
9/27/93 19:35		109	0.020
9/27/93 20:14		117	0.020
9/27/93 20:59		167	0.020
9/27/93 21:43		170	0.020
9/27/93 22:29		161	0.020
9/27/93 23:10		255	0.010
9/27/93 23:46	1.40	124	0.010
9/28/93 0:22		105	0.020
10/3/93 1:07		179	0.010
10/3/93 1:44		148	< 0.010
10/3/93 2:43		171	< 0.010
10/3/93 6:13	0.40	112	0.010
10/12/93 9:02		150	0.010
10/12/93 9:47		300	0.010
10/12/93 10:25		450	0.010
10/12/93 11:01	1.03	600	0.010
10/20/93 0:19	0.21	237	0.010
10/20/93 2:12	0.08	159	< 0.010
10/20/93 4:49	0.07	191	0.010
10/20/93 14:35	0.04	63	0.010
10/21/93 5:16	0.10	146	0.010
10/21/93 20:28	0.11	91	0.010

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
10/30/93 12:49	0.15	143	0.010
10/30/93 14:54	0.09	192	0.010
10/30/93 16:30	0.08	182	< 0.010
10/30/93 17:04	0.04	190	0.010
10/30/93 17:42	0.09	258	0.010
10/30/93 18:43	0.17	466	< 0.010
10/30/93 20:43	0.12	331	< 0.010
10/31/93 0:23	0.03	126	0.010
10/31/93 10:56	0.07	119	0.010
10/31/93 19:54	0.12	183	0.010
10/31/93 21:17	0.10	196	< 0.010
10/31/93 21:51	0.13	263	0.010
11/28/93 3:21	0.19	297	0.01
11/28/93 3:57	0.08	178	0.01
11/28/93 4:53	0.12	176	0.01
11/28/93 5:26	0.11	309	0.01
11/28/93 5:59	0.15	515	0.01
11/28/93 6:32	0.10	182	0.01
11/28/93 7:07	0.08	201	0.01
11/28/93 7:41	0.22	653	0.01

Table B2-28

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SILVER
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*		*SAMPLE VOLUME (gal)*		*CONC. (mg/L)*
12/10/92 21:34	0.23		295	<	0.010
12/11/92 7:28	1.07	>	300	<	0.010
12/11/92 8:52	0.21		210	<	0.010
12/11/92 10:44	0.13	>	300	<	0.010
12/11/92 11:48	0.04		163	<	0.010
12/17/93 0:00	0.94		300	<	0.010
12/28/92 19:17	0.14		30	<	0.010
12/29/92 15:05	0.10		10	<	0.010
1/5/93 7:13	0.62	>	300	<	0.010
1/5/93 12:25	0.03		70	<	0.010
2/13/93 8:00	0.15		275	<	0.010
2/16/93 16:00	0.63	>	300	<	0.010
3/4/93 13:46	0.18		245	<	0.010
3/4/93 17:53	0.34	>	300	<	0.010
3/9/93 0:00	0.04		20	<	0.010
3/11/93 8:00	0.04		40	<	0.010
3/17/93 9:15	0.37		300	<	0.010
3/17/93 11:16	0.20		300	<	0.010
3/17/93 13:25	0.18		300	<	0.010
3/17/93 14:57	0.22		300	<	0.010
3/24/93 6:50	0.84	>	300	<	0.010
3/24/93 15:27	0.14		300	<	0.010
3/31/93 8:00	0.36		145	<	0.010
4/2/93 6:45	1.66	>	300	<	0.010
4/2/93 22:00	0.03		300	<	0.010
4/12/93 7:40	0.43	>	300	<	0.010
4/16/93 15:50	0.02		6	<	0.010
4/16/93 16:39	0.22		427	<	0.010
4/21/93 21:48	0.05		1	<	0.010
4/21/93 22:50	0.18		401	<	0.010
4/22/93 0:18	0.25		594	<	0.010
4/22/93 2:33	0.25		576	<	0.010
4/22/93 7:18	0.07		196	<	0.010
4/22/93 12:09	0.07		77		
4/26/93 14:48	0.40		542	<	0.010
4/26/93 17:30	0.66		1324	<	0.010
4/26/93 23:44	0.07		551	<	0.010
4/27/93 2:52	0.00		39		
5/6/93 0:00	0.12		300		
5/21/93 0:00	0.37		300	<	0.010
6/4/93 0:00	0.06		30	<	0.010
6/5/93 0:00	0.06		50	<	0.010
6/9/93 0:00	0.23		20	<	0.010
6/10/93 0:00	0.23		255	<	0.010
6/20/93 21:01	0.42		314	<	0.010
6/20/93 22:51	0.38		836	<	0.010
6/21/93 0:31	0.04		50	<	0.010
6/21/93 0:00	1.15		300	<	0.010
7/2/93 0:00	0.40		300	<	0.010
7/6/93 0:00	0.32		275	<	0.010
7/14/93 0:00	0.39	>	300	<	0.010
8/9/93 0:00	0.37	>	300		
9/27/93 17:09	1.40		652	<	0.010
9/27/93 17:45			224	<	0.010
9/27/93 18:21			181		0.010
9/27/93 19:00			143		0.010
9/27/93 19:35			109		0.010
9/27/93 20:14			117		0.010
9/27/93 20:59			167		0.020
9/27/93 21:43			170		0.020
9/27/93 22:29			161		0.020
9/27/93 23:10			255		0.010
9/27/93 23:46			124		0.010
9/28/93 0:22			105		0.020
10/3/93 1:07	0.40		179	<	0.010
10/3/93 1:44			148	<	0.010
10/3/93 2:43			171	<	0.010
10/3/93 6:13			112		0.010
10/12/93 9:02	1.03		150		0.010
10/12/93 9:47			300	<	0.010
10/12/93 10:25			450	<	0.010
10/12/93 11:01			600	<	0.010
10/20/93 0:19	0.21		237		0.010
10/20/93 2:12	0.08		159	<	0.010
10/20/93 4:49	0.07		191		0.010
10/20/93 14:35	0.04		63		0.010
10/21/93 5:16	0.10		146	<	0.010
10/21/93 20:28	0.11		91		0.010
10/30/93 12:49	0.15		143		0.010
10/30/93 14:54	0.09		192	<	0.010
10/30/93 16:30	0.08		182	<	0.010
10/30/93 17:04	0.04		190		0.010
10/30/93 17:42	0.09		258	<	0.010
10/30/93 18:43	0.17		466	<	0.010
10/30/93 20:43	0.12		331	<	0.010
10/31/93 0:23	0.03		126		0.010
10/31/93 10:56	0.07		119		0.010
10/31/93 19:54	0.12		183		0.010
10/31/93 21:17	0.10		196	<	0.010
10/31/93 21:51	0.13		263	<	0.010
11/28/93 3:21	0.19		297	<	0.010
11/28/93 3:57	0.08		178	<	0.010
11/28/93 4:53	0.12		176		
11/28/93 5:26	0.11		309	<	0.010
11/28/93 5:59	0.15		515	<	0.010
11/28/93 6:32	0.10		182	<	0.010
11/28/93 7:07	0.08		201	<	0.010
11/28/93 7:41	0.22		653	<	0.010

Table B2-29

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
ZINC
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.32
12/11/92 7:28	1.07	> 300	0.33
12/11/92 8:52	0.21	210	0.045
12/11/92 10:44	0.13	> 300	0.26
12/11/92 11:48	0.04	163	0.82
12/17/93 0:00	0.94	300	0.11
12/28/92 19:17	0.14	30	0.26
12/29/92 15:05	0.10	10	0.34
1/5/93 7:13	0.62	> 300	0.92
1/5/93 12:25	0.03	70	1.1
2/13/93 8:00	0.15	275	1.9
2/16/93 16:00	0.63	> 300	0.38
3/4/93 13:46	0.18	245	0.16
3/4/93 17:53	0.34	> 300	0.94
3/9/93 0:00	0.04	20	1.1
3/11/93 8:00	0.04	40	0.35
3/17/93 9:15	0.37	300	0.093
3/17/93 11:16	0.20	300	0.088
3/17/93 13:25	0.18	300	0.085
3/17/93 14:57	0.22	300	0.11
3/24/93 6:50	0.84	> 300	0.043
3/24/93 15:27	0.14	300	0.074
3/31/93 8:00	0.36	145	0.11
4/2/93 6:45	1.66	> 300	0.094
4/2/93 22:00	0.03	300	0.19
4/12/93 7:40	0.43	> 300	0.13
4/16/93 15:50	0.02	6	0.53
4/16/93 16:39	0.22	427	0.21
4/21/93 21:48	0.05	1	0.13
4/21/93 22:50	0.18	401	0.14
4/22/93 0:18	0.25	594	0.13
4/22/93 2:33	0.25	576	0.55
4/22/93 7:18	0.07	196	0.20
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.22
4/26/93 17:30	0.66	1324	0.19
4/26/93 23:44	0.07	551	0.23
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
5/21/93 0:00	0.37	300	0.10
6/4/93 0:00	0.06	30	0.13
6/5/93 0:00	0.06	50	0.18
6/9/93 0:00	0.23	20	0.10
6/10/93 0:00	0.23	255	0.11
6/20/93 21:01	0.42	314	0.095
6/20/93 22:51	0.38	836	0.13
6/21/93 0:31	0.04	50	0.087
6/21/93 0:00	1.15	300	0.039
7/2/93 0:00	0.40	300	0.15
7/6/93 0:00	0.32	275	0.072
7/14/93 0:00	0.39	> 300	0.61
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.58
9/27/93 17:45		224	0.24
9/27/93 18:21		181	0.13
9/27/93 19:00		143	0.10
9/27/93 19:35		109	0.080
9/27/93 20:14		117	0.090
9/27/93 20:59		167	0.090
9/27/93 21:43		170	0.080
9/27/93 22:29		161	0.070
9/27/93 23:10		255	0.25
9/27/93 23:46	1.40	124	0.13
9/28/93 0:22		105	0.12
10/3/93 1:07		179	0.44
10/3/93 1:44		148	0.47
10/3/93 2:43		171	0.26
10/3/93 6:13	0.40	112	0.090
10/12/93 9:02		150	3.4
10/12/93 9:47		300	4.0
10/12/93 10:25		450	2.5
10/12/93 11:01	1.03	600	2.0
10/20/93 0:19	0.21	237	0.32
10/20/93 2:12	0.08	159	0.36
10/20/93 4:49	0.07	191	0.53
10/20/93 14:35	0.04	63	0.28
10/21/93 5:16	0.10	146	0.19
10/21/93 20:28	0.11	91	0.78

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
10/30/93 12:49	0.15	143	1.4
10/30/93 14:54	0.09	192	0.97
10/30/93 16:30	0.08	182	0.60
10/30/93 17:04	0.04	190	0.93
10/30/93 17:42	0.09	258	1.0
10/30/93 18:43	0.17	466	1.4
10/30/93 20:43	0.12	331	0.40
10/31/93 0:23	0.03	126	0.080
10/31/93 10:56	0.07	119	0.11
10/31/93 19:54	0.12	183	0.29
10/31/93 21:17	0.10	196	1.5
10/31/93 21:51	0.13	263	1.5
11/28/93 3:21	0.19	297	4.90
11/28/93 3:57	0.08	178	1.60
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	1.80
11/28/93 5:59	0.15	515	6.40
11/28/93 6:32	0.10	182	3.80
11/28/93 7:07	0.08	201	4.80
11/28/93 7:41	0.22	653	5.80

Table B2-30

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
ZINC
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.13
12/11/92 7:28	1.07	> 300	0.14
12/11/92 8:52	0.21	210	0.040
12/11/92 10:44	0.13	> 300	0.10
12/11/92 11:48	0.04	163	0.26
12/17/93 0:00	0.94	300	0.047
12/28/92 19:17	0.14	30	0.11
12/29/92 15:05	0.10	10	0.32
1/5/93 7:13	0.62	> 300	0.14
1/5/93 12:25	0.03	70	0.090
2/13/93 8:00	0.15	275	0.057
2/16/93 16:00	0.63	> 300	0.077
3/4/93 13:46	0.18	245	0.15
3/4/93 17:53	0.34	> 300	0.099
3/9/93 0:00	0.04	20	0.30
3/11/93 8:00	0.04	40	0.18
3/17/93 9:15	0.37	300	0.051
3/17/93 11:16	0.20	300	0.036
3/17/93 13:25	0.18	300	0.035
3/17/93 14:57	0.22	300	0.029
3/24/93 6:50	0.84	> 300	0.052
3/24/93 15:27	0.14	300	0.057
3/31/93 8:00	0.36	145	0.11
4/2/93 6:45	1.66	> 300	0.095
4/2/93 22:00	0.03	300	0.19
4/12/93 7:40	0.43	> 300	0.13
4/16/93 15:50	0.02	6	0.51
4/16/93 16:39	0.22	427	0.21
4/21/93 21:48	0.05	1	0.13
4/21/93 22:50	0.18	401	0.14
4/22/93 0:18	0.25	594	0.13
4/22/93 2:33	0.25	576	0.45
4/22/93 7:18	0.07	196	0.15
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.22
4/26/93 17:30	0.66	1324	0.14
4/26/93 23:44	0.07	551	0.21
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.11
6/4/93 0:00	0.06	30	0.12
6/5/93 0:00	0.06	50	0.17
6/9/93 0:00	0.23	20	0.10
6/10/93 0:00	0.23	255	0.12
6/20/93 21:01	0.42	314	0.092
6/20/93 22:51	0.38	836	0.13
6/21/93 0:31	0.04	50	0.091
6/21/93 0:00	1.15	300	0.046
7/2/93 0:00	0.40	300	0.15
7/6/93 0:00	0.32	275	0.083
7/14/93 0:00	0.39	> 300	0.14
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.060
9/27/93 17:45		224	0.030
9/27/93 18:21		181	0.030
9/27/93 19:00		143	0.040
9/27/93 19:35		109	0.040
9/27/93 20:14		117	0.050
9/27/93 20:59		167	0.040
9/27/93 21:43		170	0.050
9/27/93 22:29		161	0.050
9/27/93 23:10		255	0.040
9/27/93 23:46	1.40	124	0.030
9/28/93 0:22		105	0.050
10/3/93 1:07		179	0.050
10/3/93 1:44		148	0.020
10/3/93 2:43		171	0.030
10/3/93 6:13	0.40	112	0.030
10/12/93 9:02		150	0.060
10/12/93 9:47		300	0.030
10/12/93 10:25		450	0.030
10/12/93 11:01	1.03	600	0.030
10/20/93 0:19	0.21	237	0.070
10/20/93 2:12	0.08	159	0.070
10/20/93 4:49	0.07	191	0.040
10/20/93 14:35	0.04	63	0.050
10/21/93 5:16	0.10	146	0.050
10/21/93 20:28	0.11	91	0.050
10/30/93 12:49	0.15	143	0.040
10/30/93 14:54	0.09	192	0.040
10/30/93 16:30	0.08	182	0.040
10/30/93 17:04	0.04	190	0.030
10/30/93 17:42	0.09	258	0.030
10/30/93 18:43	0.17	466	0.020
10/30/93 20:43	0.12	331	0.030
10/31/93 0:23	0.03	126	0.030
10/31/93 10:56	0.07	119	0.040
10/31/93 19:54	0.12	183	0.050
10/31/93 21:17	0.10	196	0.020
10/31/93 21:51	0.13	263	0.020
11/28/93 3:21	0.19	297	0.030
11/28/93 3:57	0.08	178	0.020
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.020
11/28/93 5:59	0.15	515	0.010
11/28/93 6:32	0.10	182	0.010
11/28/93 7:07	0.08	201	0.020
11/28/93 7:41	0.22	653	0.010

Table B2-31

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
CALCIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	220
12/11/92 7:28	1.07	> 300	170
12/11/92 8:52	0.21	210	100
12/11/92 10:44	0.13	> 300	120
12/11/92 11:48	0.04	163	110
12/17/93 0:00	0.94	300	180
12/28/92 19:17	0.14	30	240
12/29/92 15:05	0.10	10	330
1/5/93 7:13	0.62	> 300	190
1/5/93 12:25	0.03	70	300
2/13/93 8:00	0.15	275	110
2/16/93 16:00	0.63	> 300	69
3/4/93 13:46	0.18	245	120
3/4/93 17:53	0.34	> 300	120
3/9/93 0:00	0.04	20	210
3/11/93 8:00	0.04	40	190
3/17/93 9:15	0.37	300	88
3/17/93 11:16	0.20	300	90
3/17/93 13:25	0.18	300	93
3/17/93 14:57	0.22	300	83
3/24/93 6:50	0.84	> 300	60
3/24/93 15:27	0.14	300	120
3/31/93 8:00	0.36	145	1.0
4/2/93 6:45	1.66	> 300	1.0
4/2/93 22:00	0.03	300	1.0
4/12/93 7:40	0.43	> 300	180
4/16/93 15:50	0.02	6	2,300
4/16/93 16:39	0.22	427	1,500
4/21/93 21:48	0.05	1	170
4/21/93 22:50	0.18	401	180
4/22/93 0:18	0.25	594	120
4/22/93 2:33	0.25	576	300
4/22/93 7:18	0.07	196	110
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	130
4/26/93 17:30	0.66	1324	100
4/26/93 23:44	0.07	551	310
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	320
6/4/93 0:00	0.06	30	250
6/5/93 0:00	0.06	50	190
6/9/93 0:00	0.23	20	200
6/10/93 0:00	0.23	255	150
6/20/93 21:01	0.42	314	110
6/20/93 22:51	0.38	836	130
6/21/93 0:31	0.04	50	140
6/21/93 0:00	1.15	300	140
7/2/93 0:00	0.40	300	340
7/6/93 0:00	0.32	275	170
7/14/93 0:00	0.39	> 300	180
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	220
9/27/93 17:45		224	310
9/27/93 18:21		181	420
9/27/93 19:00		143	480
9/27/93 19:35		109	620
9/27/93 20:14		117	840
9/27/93 20:59		167	790
9/27/93 21:43		170	850
9/27/93 22:29		161	900
9/27/93 23:10		255	650
9/27/93 23:46	1.40	124	610
9/28/93 0:22		105	770
10/3/93 1:07		179	180
10/3/93 1:44		148	150
10/3/93 2:43		171	170
10/3/93 6:13	0.40	112	280
10/12/93 9:02		150	490
10/12/93 9:47		300	430
10/12/93 10:25		450	360
10/12/93 11:01	1.03	600	390
10/20/93 0:19	0.21	237	240
10/20/93 2:12	0.08	159	200
10/20/93 4:49	0.07	191	170
10/20/93 14:35	0.04	63	250
10/21/93 5:16	0.10	146	250
10/21/93 20:28	0.11	91	200
10/30/93 12:49	0.15	143	180
10/30/93 14:54	0.09	192	150
10/30/93 16:30	0.08	182	120
10/30/93 17:04	0.04	190	120
10/30/93 17:42	0.09	258	120
10/30/93 18:43	0.17	466	120
10/30/93 20:43	0.12	331	150
10/31/93 0:23	0.03	126	230
10/31/93 10:56	0.07	119	240
10/31/93 19:54	0.12	183	210
10/31/93 21:17	0.10	196	130
10/31/93 21:51	0.13	263	110
11/28/93 3:21	0.19	297	190
11/28/93 3:57	0.08	178	140
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	140
11/28/93 5:59	0.15	515	210
11/28/93 6:32	0.10	182	160
11/28/93 7:07	0.08	201	190
11/28/93 7:41	0.22	653	200

Table B2-32

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
CALCIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	210
12/11/92 7:28	1.07	> 300	170
12/11/92 8:52	0.21	210	100
12/11/92 10:44	0.13	> 300	130
12/11/92 11:48	0.04	163	110
12/17/93 0:00	0.94	300	180
12/28/92 19:17	0.14	30	170
12/29/92 15:05	0.10	10	210
1/5/93 7:13	0.62	> 300	170
1/5/93 12:25	0.03	70	290
2/13/93 8:00	0.15	275	90
2/16/93 16:00	0.63	> 300	70
3/4/93 13:46	0.18	245	120
3/4/93 17:53	0.34	> 300	60
3/9/93 0:00	0.04	20	210
3/11/93 8:00	0.04	40	180
3/17/93 9:15	0.37	300	80
3/17/93 11:16	0.20	300	90
3/17/93 13:25	0.18	300	90
3/17/93 14:57	0.22	300	80
3/24/93 6:50	0.84	> 300	90
3/24/93 15:27	0.14	300	120
3/31/93 8:00	0.36	145	1.2
4/2/93 6:45	1.66	> 300	1.1
4/2/93 22:00	0.03	300	1.2
4/12/93 7:40	0.43	> 300	170
4/16/93 15:50	0.02	6	240
4/16/93 16:39	0.22	427	140
4/21/93 21:48	0.05	1	170
4/21/93 22:50	0.18	401	180
4/22/93 0:18	0.25	594	110
4/22/93 2:33	0.25	576	300
4/22/93 7:18	0.07	196	110
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	120
4/26/93 17:30	0.66	1324	100
4/26/93 23:44	0.07	551	270
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
5/21/93 0:00	0.37	300	280
6/4/93 0:00	0.06	30	250
6/5/93 0:00	0.06	50	200
6/9/93 0:00	0.23	20	200
6/10/93 0:00	0.23	255	140
6/20/93 21:01	0.42	314	110
6/20/93 22:51	0.38	836	130
6/21/93 0:31	0.04	50	140
6/21/93 0:00	1.15	300	140
7/2/93 0:00	0.40	300	310
7/6/93 0:00	0.32	275	170
7/14/93 0:00	0.39	> 300	180
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	220
9/27/93 17:45		224	290
9/27/93 18:21		181	380
9/27/93 19:00		143	430
9/27/93 19:35		109	430
9/27/93 20:14		117	460
9/27/93 20:59		167	400
9/27/93 21:43		170	420
9/27/93 22:29		161	440
9/27/93 23:10		255	450
9/27/93 23:46	1.40	124	310
9/28/93 0:22		105	350
10/3/93 1:07		179	160
10/3/93 1:44		148	130
10/3/93 2:43		171	150
10/3/93 6:13	0.40	112	250
10/12/93 9:02		150	360
10/12/93 9:47		300	350
10/12/93 10:25		450	290
10/12/93 11:01	1.03	600	320
10/20/93 0:19	0.21	237	210
10/20/93 2:12	0.08	159	190
10/20/93 4:49	0.07	191	170
10/20/93 14:35	0.04	63	210
10/21/93 5:16	0.10	146	210
10/21/93 20:28	0.11	91	190

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
10/30/93 12:49	0.15	143	170
10/30/93 14:54	0.09	192	140
10/30/93 16:30	0.08	182	120
10/30/93 17:04	0.04	190	120
10/30/93 17:42	0.09	258	110
10/30/93 18:43	0.17	466	100
10/30/93 20:43	0.12	331	140
10/31/93 0:23	0.03	126	240
10/31/93 10:56	0.07	119	240
10/31/93 19:54	0.12	183	200
10/31/93 21:17	0.10	196	120
10/31/93 21:51	0.13	263	100
11/28/93 3:21	0.19	297	140
11/28/93 3:57	0.08	178	130
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	130
11/28/93 5:59	0.15	515	110
11/28/93 6:32	0.10	182	120
11/28/93 7:07	0.08	201	120
11/28/93 7:41	0.22	653	100

Table B2-33

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
MAGNESIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	14
12/11/92 7:28	1.07	> 300	10
12/11/92 8:52	0.21	210	10
12/11/92 10:44	0.13	> 300	5.2
12/11/92 11:48	0.04	163	11
12/17/93 0:00	0.94	300	4.4
12/28/92 19:17	0.14	30	21
12/29/92 15:05	0.10	10	38
1/5/93 7:13	0.62	> 300	16
1/5/93 12:25	0.03	70	29
2/13/93 8:00	0.15	275	19
2/16/93 16:00	0.63	> 300	11
3/4/93 13:46	0.18	245	7.0
3/4/93 17:53	0.34	> 300	7.9
3/9/93 0:00	0.04	20	68
3/11/93 8:00	0.04	40	44
3/17/93 9:15	0.37	300	3.3
3/17/93 11:16	0.20	300	2.1
3/17/93 13:25	0.18	300	4.1
3/17/93 14:57	0.22	300	2.7
3/24/93 6:50	0.84	> 300	< 0.0060
3/24/93 15:27	0.14	300	14
3/31/93 8:00	0.36	145	25
4/2/93 6:45	1.66	> 300	8.2
4/2/93 22:00	0.03	300	39
4/12/93 7:40	0.43	> 300	41
4/16/93 15:50	0.02	6	100
4/16/93 16:39	0.22	427	32
4/21/93 21:48	0.05	1	46
4/21/93 22:50	0.18	401	48
4/22/93 0:18	0.25	594	21
4/22/93 2:33	0.25	576	130
4/22/93 7:18	0.07	196	17
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	27
4/26/93 17:30	0.66	1324	15
4/26/93 23:44	0.07	551	84
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
5/21/93 0:00	0.37	300	37
6/4/93 0:00	0.06	30	34
6/5/93 0:00	0.06	50	24
6/9/93 0:00	0.23	20	21
6/10/93 0:00	0.23	255	8.5
6/20/93 21:01	0.42	314	6.1
6/20/93 22:51	0.38	836	6.9
6/21/93 0:31	0.04	50	13
6/21/93 0:00	1.15	300	30
7/2/93 0:00	0.40	300	35
7/6/93 0:00	0.32	275	17
7/14/93 0:00	0.39	> 300	21
8/9/93 0:00	0.37	> 300	
9/27/93 17:09	1.40	652	65
9/27/93 17:45		224	110
9/27/93 18:21		181	160
9/27/93 19:00		143	210
9/27/93 19:35		109	250
9/27/93 20:14		117	320
9/27/93 20:59		167	370
9/27/93 21:43		170	400
9/27/93 22:29		161	420
9/27/93 23:10		255	250
9/27/93 23:46		124	220
9/28/93 0:22		105	310
10/3/93 1:07	0.40	179	77
10/3/93 1:44		148	52
10/3/93 2:43		171	59
10/3/93 6:13		112	120
10/12/93 9:02	1.03	150	38
10/12/93 9:47		300	29
10/12/93 10:25		450	26
10/12/93 11:01		600	33
10/20/93 0:19	0.21	237	56
10/20/93 2:12	0.08	159	45
10/20/93 4:49	0.07	191	47
10/20/93 14:35	0.04	63	71
10/21/93 5:16	0.10	146	74
10/21/93 20:28	0.11	91	57

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
10/30/93 12:49	0.15	143	63
10/30/93 14:54	0.09	192	54
10/30/93 16:30	0.08	182	48
10/30/93 17:04	0.04	190	39
10/30/93 17:42	0.09	258	36
10/30/93 18:43	0.17	466	32
10/30/93 20:43	0.12	331	48
10/31/93 0:23	0.03	126	98
10/31/93 10:56	0.07	119	110
10/31/93 19:54	0.12	183	85
10/31/93 21:17	0.10	196	41
10/31/93 21:51	0.13	263	31
11/28/93 3:21	0.19	297	54
11/28/93 3:57	0.08	178	41
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	41
11/28/93 5:59	0.15	515	42
11/28/93 6:32	0.10	182	35
11/28/93 7:07	0.08	201	38
11/28/93 7:41	0.22	653	30

Table B2-34

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
MAGNESIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	13
12/11/92 7:28	1.07	> 300	8.9
12/11/92 8:52	0.21	210	7.4
12/11/92 10:44	0.13	> 300	4.9
12/11/92 11:48	0.04	163	11
12/17/93 0:00	0.94	300	4.2
12/28/92 19:17	0.14	30	15
12/29/92 15:05	0.10	10	33
1/5/93 7:13	0.62	> 300	15
1/5/93 12:25	0.03	70	29
2/13/93 8:00	0.15	275	3.5
2/16/93 16:00	0.63	> 300	1.3
3/4/93 13:46	0.18	245	6.9
3/4/93 17:53	0.34	> 300	4.3
3/9/93 0:00	0.04	20	77
3/11/93 8:00	0.04	40	49
3/17/93 9:15	0.37	300	12
3/17/93 11:16	0.20	300	11
3/17/93 13:25	0.18	300	13
3/17/93 14:57	0.22	300	11
3/24/93 6:50	0.84	> 300	11
3/24/93 15:27	0.14	300	22
3/31/93 8:00	0.36	145	25
4/2/93 6:45	1.66	> 300	8.2
4/2/93 22:00	0.03	300	38
4/12/93 7:40	0.43	> 300	35
4/16/93 15:50	0.02	6	87
4/16/93 16:39	0.22	427	26
4/21/93 21:48	0.05	1	38
4/21/93 22:50	0.18	401	39
4/22/93 0:18	0.25	594	17
4/22/93 2:33	0.25	576	110
4/22/93 7:18	0.07	196	15
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	26
4/26/93 17:30	0.66	1324	14
4/26/93 23:44	0.07	551	79
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	38
6/4/93 0:00	0.06	30	35
6/5/93 0:00	0.06	50	26
6/9/93 0:00	0.23	20	21
6/10/93 0:00	0.23	255	7.8
6/20/93 21:01	0.42	314	6.1
6/20/93 22:51	0.38	836	7.0
6/21/93 0:31	0.04	50	13
6/21/93 0:00	1.15	300	31
7/2/93 0:00	0.40	300	35
7/6/93 0:00	0.32	275	17
7/14/93 0:00	0.39	> 300	21
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	64
9/27/93 17:45		224	110
9/27/93 18:21		181	170
9/27/93 19:00		143	200
9/27/93 19:35		109	250
9/27/93 20:14		117	290
9/27/93 20:59		167	350
9/27/93 21:43		170	380
9/27/93 22:29		161	400
9/27/93 23:10		255	400
9/27/93 23:46	1.40	124	210
9/28/93 0:22		105	290
10/3/93 1:07		179	77
10/3/93 1:44		148	52
10/3/93 2:43		171	59
10/3/93 6:13	0.40	112	120
10/12/93 9:02		150	30
10/12/93 9:47		300	21
10/12/93 10:25		450	20
10/12/93 11:01	1.03	600	28
10/20/93 0:19	0.21	237	50
10/20/93 2:12	0.08	159	41
10/20/93 4:49	0.07	191	43
10/20/93 14:35	0.04	63	62
10/21/93 5:16	0.10	146	67
10/21/93 20:28	0.11	91	56
10/30/93 12:49	0.15	143	61
10/30/93 14:54	0.09	192	52
10/30/93 16:30	0.08	182	48
10/30/93 17:04	0.04	190	38
10/30/93 17:42	0.09	258	35
10/30/93 18:43	0.17	466	31
10/30/93 20:43	0.12	331	48
10/31/93 0:23	0.03	126	99
10/31/93 10:56	0.07	119	100
10/31/93 19:54	0.12	183	83
10/31/93 21:17	0.10	196	40
10/31/93 21:51	0.13	263	29
11/28/93 3:21	0.19	297	49
11/28/93 3:57	0.08	178	40
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	41
11/28/93 5:59	0.15	515	32
11/28/93 6:32	0.10	182	31
11/28/93 7:07	0.08	201	32
11/28/93 7:41	0.22	653	22

Table B2-35

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
POTASIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	140
12/11/92 7:28	1.07	> 300	140
12/11/92 8:52	0.21	210	180
12/11/92 10:44	0.13	> 300	110
12/11/92 11:48	0.04	163	180
12/17/93 0:00	0.94	300	94
12/28/92 19:17	0.14	30	250
12/29/92 15:05	0.10	10	380
1/5/93 7:13	0.62	> 300	150
1/5/93 12:25	0.03	70	240
2/13/93 8:00	0.15	275	110
2/16/93 16:00	0.63	> 300	58
3/4/93 13:46	0.18	245	100
3/4/93 17:53	0.34	> 300	91
3/9/93 0:00	0.04	20	220
3/11/93 8:00	0.04	40	200
3/17/93 9:15	0.37	300	70
3/17/93 11:16	0.20	300	74
3/17/93 13:25	0.18	300	70
3/17/93 14:57	0.22	300	63
3/24/93 6:50	0.84	> 300	34
3/24/93 15:27	0.14	300	100
3/31/93 8:00	0.36	145	99
4/2/93 6:45	1.66	> 300	32
4/2/93 22:00	0.03	300	140
4/12/93 7:40	0.43	> 300	220
4/16/93 15:50	0.02	6	390
4/16/93 16:39	0.22	427	170
4/21/93 21:48	0.05	1	190
4/21/93 22:50	0.18	401	180
4/22/93 0:18	0.25	594	110
4/22/93 2:33	0.25	576	370
4/22/93 7:18	0.07	196	100
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	150
4/26/93 17:30	0.66	1324	49
4/26/93 23:44	0.07	551	280
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
5/21/93 0:00	0.37	300	120
6/4/93 0:00	0.06	30	120
6/5/93 0:00	0.06	50	79
6/9/93 0:00	0.23	20	61
6/10/93 0:00	0.23	255	34
6/20/93 21:01	0.42	314	41
6/20/93 22:51	0.38	836	49
6/21/93 0:31	0.04	50	100
6/21/93 0:00	1.15	300	140
7/2/93 0:00	0.40	300	100
7/6/93 0:00	0.32	275	62
7/14/93 0:00	0.39	> 300	80
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	150
9/27/93 17:45		224	210
9/27/93 18:21		181	310
9/27/93 19:00		143	390
9/27/93 19:35		109	480
9/27/93 20:14		117	620
9/27/93 20:59		167	720
9/27/93 21:43		170	800
9/27/93 22:29		161	880
9/27/93 23:10		255	490
9/27/93 23:46	1.40	124	440
9/28/93 0:22		105	630
10/3/93 1:07		179	160
10/3/93 1:44		148	110
10/3/93 2:43		171	130
10/3/93 6:13	0.40	112	250
10/12/93 9:02		150	68
10/12/93 9:47		300	47
10/12/93 10:25		450	42
10/12/93 11:01	1.03	600	53
10/20/93 0:19	0.21	237	110
10/20/93 2:12	0.08	159	81
10/20/93 4:49	0.07	191	85
10/20/93 14:35	0.04	63	130
10/21/93 5:16	0.10	146	130
10/21/93 20:28	0.11	91	100

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
10/30/93 12:49	0.15	143	130
10/30/93 14:54	0.09	192	110
10/30/93 16:30	0.08	182	83
10/30/93 17:04	0.04	190	86
10/30/93 17:42	0.09	258	82
10/30/93 18:43	0.17	466	68
10/30/93 20:43	0.12	331	100
10/31/93 0:23	0.03	126	200
10/31/93 10:56	0.07	119	220
10/31/93 19:54	0.12	183	170
10/31/93 21:17	0.10	196	82
10/31/93 21:51	0.13	263	69
11/28/93 3:21	0.19	297	115
11/28/93 3:57	0.08	178	92
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	80
11/28/93 5:59	0.15	515	70
11/28/93 6:32	0.10	182	60
11/28/93 7:07	0.08	201	64
11/28/93 7:41	0.22	653	44

Table B2-36

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
POTASIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	130
12/11/92 7:28	1.07	> 300	140
12/11/92 8:52	0.21	210	170
12/11/92 10:44	0.13	> 300	110
12/11/92 11:48	0.04	163	180
12/17/93 0:00	0.94	300	170
12/28/92 19:17	0.14	30	250
12/29/92 15:05	0.10	10	360
1/5/93 7:13	0.62	> 300	150
1/5/93 12:25	0.03	70	240
2/13/93 8:00	0.15	275	91
2/16/93 16:00	0.63	> 300	58
3/4/93 13:46	0.18	245	92
3/4/93 17:53	0.34	> 300	35
3/9/93 0:00	0.04	20	220
3/11/93 8:00	0.04	40	190
3/17/93 9:15	0.37	300	65
3/17/93 11:16	0.20	300	71
3/17/93 13:25	0.18	300	67
3/17/93 14:57	0.22	300	55
3/24/93 6:50	0.84	> 300	56
3/24/93 15:27	0.14	300	93
3/31/93 8:00	0.36	145	98
4/2/93 6:45	1.66	> 300	30
4/2/93 22:00	0.03	300	14
4/12/93 7:40	0.43	> 300	220
4/16/93 15:50	0.02	6	360
4/16/93 16:39	0.22	427	170
4/21/93 21:48	0.05	1	180
4/21/93 22:50	0.18	401	180
4/22/93 0:18	0.25	594	100
4/22/93 2:33	0.25	576	340
4/22/93 7:18	0.07	196	100
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	150
4/26/93 17:30	0.66	1324	78
4/26/93 23:44	0.07	551	280
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
5/21/93 0:00	0.37	300	120
6/4/93 0:00	0.06	30	120
6/5/93 0:00	0.06	50	81
6/9/93 0:00	0.23	20	61
6/10/93 0:00	0.23	255	32
6/20/93 21:01	0.42	314	42
6/20/93 22:51	0.38	836	53
6/21/93 0:31	0.04	50	97
6/21/93 0:00	1.15	300	130
7/2/93 0:00	0.40	300	100
7/6/93 0:00	0.32	275	60
7/14/93 0:00	0.39	> 300	82
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	130
9/27/93 17:45		224	200
9/27/93 18:21		181	270
9/27/93 19:00		143	370
9/27/93 19:35		109	250
9/27/93 20:14		117	560
9/27/93 20:59		167	690
9/27/93 21:43		170	750
9/27/93 22:29		161	790
9/27/93 23:10		255	480
9/27/93 23:46	1.40	124	410
9/28/93 0:22		105	530
10/3/93 1:07		179	160
10/3/93 1:44		148	100
10/3/93 2:43		171	140
10/3/93 6:13	0.40	112	220
10/12/93 9:02		150	64
10/12/93 9:47		300	41
10/12/93 10:25		450	37
10/12/93 11:01	1.03	600	48
10/20/93 0:19	0.21	237	99
10/20/93 2:12	0.08	159	74
10/20/93 4:49	0.07	191	72
10/20/93 14:35	0.04	63	110
10/21/93 5:16	0.10	146	120
10/21/93 20:28	0.11	91	77

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
10/30/93 12:49	0.15	143	130
10/30/93 14:54	0.09	192	52
10/30/93 16:30	0.08	182	48
10/30/93 17:04	0.04	190	82
10/30/93 17:42	0.09	258	77
10/30/93 18:43	0.17	466	68
10/30/93 20:43	0.12	331	100
10/31/93 0:23	0.03	126	190
10/31/93 10:56	0.07	119	210
10/31/93 19:54	0.12	183	170
10/31/93 21:17	0.10	196	85
10/31/93 21:51	0.13	263	67
11/28/93 3:21	0.19	297	115
11/28/93 3:57	0.08	178	93
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	90
11/28/93 5:59	0.15	515	70
11/28/93 6:32	0.10	182	60
11/28/93 7:07	0.08	201	63
11/28/93 7:41	0.22	653	44

Table B2-37

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SILICA
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
12/10/92 21:34	0.23	295	1.5
12/11/92 7:28	1.07	> 300	1.3
12/11/92 8:52	0.21	210	0.31
12/11/92 10:44	0.13	> 300	0.46
12/11/92 11:48	0.04	163	2.8
12/17/93 0:00	0.94	300	0.53
12/28/92 19:17	0.14	30	0.53
12/29/92 15:05	0.10	10	1.6
1/5/93 7:13	0.62	> 300	2.7
1/5/93 12:25	0.03	70	4.6
2/13/93 8:00	0.15	275	6.8
2/16/93 16:00	0.63	> 300	1.4
3/4/93 13:46	0.18	245	1.6
3/4/93 17:53	0.34	> 300	2.4
3/9/93 0:00	0.04	20	4.5
3/11/93 8:00	0.04	40	1.6
3/17/93 9:15	0.37	300	0.51
3/17/93 11:16	0.20	300	0.41
3/17/93 13:25	0.18	300	0.36
3/17/93 14:57	0.22	300	0.42
3/24/93 6:50	0.84	> 300	0.20
3/24/93 15:27	0.14	300	0.38
3/31/93 8:00	0.36	145	0.94
4/2/93 6:45	1.66	> 300	0.84
4/2/93 22:00	0.03	300	0.79
4/12/93 7:40	0.43	> 300	0.84
4/16/93 15:50	0.02	6	2.2
4/16/93 16:39	0.22	427	2.0
4/21/93 21:48	0.05	1	0.72
4/21/93 22:50	0.18	401	0.80
4/22/93 0:18	0.25	594	0.60
4/22/93 2:33	0.25	576	2.6
4/22/93 7:18	0.07	196	0.80
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.99
4/26/93 17:30	0.66	1324	0.89
4/26/93 23:44	0.07	551	1.1
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
5/21/93 0:00	0.37	300	0.89
6/4/93 0:00	0.06	30	0.98
6/5/93 0:00	0.06	50	0.97
6/9/93 0:00	0.23	20	1.3
6/10/93 0:00	0.23	255	2.1
6/20/93 21:01	0.42	314	0.78
6/20/93 22:51	0.38	836	1.5
6/21/93 0:31	0.04	50	0.90
6/21/93 0:00	1.15	300	0.63
7/2/93 0:00	0.40	300	0.89
7/6/93 0:00	0.32	275	0.71
7/14/93 0:00	0.39	> 300	2.1
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	1.7
9/27/93 17:45		224	1.2
9/27/93 18:21		181	1.2
9/27/93 19:00		143	1.2
9/27/93 19:35		109	1.4
9/27/93 20:14		117	1.7
9/27/93 20:59		167	1.7
9/27/93 21:43		170	1.8
9/27/93 22:29		161	1.8
9/27/93 23:10		255	1.8
9/27/93 23:46	1.40	124	1.6
9/28/93 0:22		105	1.8
10/3/93 1:07		179	1.4
10/3/93 1:44		148	1.3
10/3/93 2:43		171	1.0
10/3/93 6:13	0.40	112	0.95
10/12/93 9:02		150	8.0
10/12/93 9:47		300	10
10/12/93 10:25		450	6.3
10/12/93 11:01	1.03	600	5.2
10/20/93 0:19	0.21	237	1.2
10/20/93 2:12	0.08	159	1.1
10/20/93 4:49	0.07	191	1.3
10/20/93 14:35	0.04	63	1.0
10/21/93 5:16	0.10	146	0.94
10/21/93 20:28	0.11	91	1.9

TIME OF SAMPLE COLLECTION	RAIN (in.)	SAMPLE VOLUME (gal)	CONC. (mg/L)
10/30/93 12:49	0.15	143	2.8
10/30/93 14:54	0.09	192	2.0
10/30/93 16:30	0.08	182	1.3
10/30/93 17:04	0.04	190	1.9
10/30/93 17:42	0.09	258	1.9
10/30/93 18:43	0.17	466	2.3
10/30/93 20:43	0.12	331	0.94
10/31/93 0:23	0.03	126	0.65
10/31/93 10:56	0.07	119	0.72
10/31/93 19:54	0.12	183	1.0
10/31/93 21:17	0.10	196	2.6
10/31/93 21:51	0.13	263	2.5
11/28/93 3:21	0.19	297	9.43
11/28/93 3:57	0.08	178	2.75
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	3.24
11/28/93 5:59	0.15	515	17.30
11/28/93 6:32	0.10	182	7.57
11/28/93 7:07	0.08	201	10.70
11/28/93 7:41	0.22	653	15.30

Table B2-38

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SILICA
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	0.43
12/11/92 7:28	1.07	> 300	0.75
12/11/92 8:52	0.21	210	0.10
12/11/92 10:44	0.13	> 300	0.19
12/11/92 11:48	0.04	163	0.51
12/17/93 0:00	0.94	300	
12/28/92 19:17	0.14	30	0.36
12/29/92 15:05	0.10	10	1.0
1/5/93 7:13	0.62	> 300	0.91
1/5/93 12:25	0.03	70	1.2
2/13/93 8:00	0.15	275	4.9
2/16/93 16:00	0.63	> 300	0.46
3/4/93 13:46	0.18	245	0.81
3/4/93 17:53	0.34	> 300	0.59
3/9/93 0:00	0.04	20	2.0
3/11/93 8:00	0.04	40	1.1
3/17/93 9:15	0.37	300	0.34
3/17/93 11:16	0.20	300	0.24
3/17/93 13:25	0.18	300	0.23
3/17/93 14:57	0.22	300	0.21
3/24/93 6:50	0.84	> 300	0.34
3/24/93 15:27	0.14	300	0.35
3/31/93 8:00	0.36	145	0.91
4/2/93 6:45	1.66	> 300	0.84
4/2/93 22:00	0.03	300	0.78
4/12/93 7:40	0.43	> 300	0.78
4/16/93 15:50	0.02	6	2.1
4/16/93 16:39	0.22	427	1.7
4/21/93 21:48	0.05	1	0.66
4/21/93 22:50	0.18	401	0.69
4/22/93 0:18	0.25	594	0.54
4/22/93 2:33	0.25	576	2.3
4/22/93 7:18	0.07	196	0.70
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	0.93
4/26/93 17:30	0.66	1324	0.79
4/26/93 23:44	0.07	551	0.96
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	0.85
6/4/93 0:00	0.06	30	0.97
6/5/93 0:00	0.06	50	0.98
6/9/93 0:00	0.23	20	1.3
6/10/93 0:00	0.23	255	2.0
6/20/93 21:01	0.42	314	0.74
6/20/93 22:51	0.38	836	1.5
6/21/93 0:31	0.04	50	0.89
6/21/93 0:00	1.15	300	0.63
7/2/93 0:00	0.40	300	0.81
7/6/93 0:00	0.32	275	0.71
7/14/93 0:00	0.39	> 300	1.0
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	0.62
9/27/93 17:45		224	0.73
9/27/93 18:21		181	1.0
9/27/93 19:00		143	1.1
9/27/93 19:35		109	1.2
9/27/93 20:14		117	1.8
9/27/93 20:59		167	1.2
9/27/93 21:43		170	1.3
9/27/93 22:29		161	1.3
9/27/93 23:10		255	1.6
9/27/93 23:46	1.40	124	0.98
9/28/93 0:22		105	1.1
10/3/93 1:07		179	0.66
10/3/93 1:44		148	0.62
10/3/93 2:43		171	0.59
10/3/93 6:13	0.40	112	0.73
10/12/93 9:02		150	0.86
10/12/93 9:47		300	0.98
10/12/93 10:25		450	0.89
10/12/93 11:01	1.03	600	0.97
10/20/93 0:19	0.21	237	0.63
10/20/93 2:12	0.08	159	0.57
10/20/93 4:49	0.07	191	0.57
10/20/93 14:35	0.04	63	0.56
10/21/93 5:16	0.10	146	0.63
10/21/93 20:28	0.11	91	0.74
10/30/93 12:49	0.15	143	0.65
10/30/93 14:54	0.09	192	0.58
10/30/93 16:30	0.08	182	0.51
10/30/93 17:04	0.04	190	0.52
10/30/93 17:42	0.09	258	0.49
10/30/93 18:43	0.17	466	0.47
10/30/93 20:43	0.12	331	0.48
10/31/93 0:23	0.03	126	0.59
10/31/93 10:56	0.07	119	0.62
10/31/93 19:54	0.12	183	0.66
10/31/93 21:17	0.10	196	0.57
10/31/93 21:51	0.13	263	0.52
11/28/93 3:21	0.19	297	0.61
11/28/93 3:57	0.08	178	0.47
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	0.46
11/28/93 5:59	0.15	515	0.54
11/28/93 6:32	0.10	182	0.53
11/28/93 7:07	0.08	201	0.57
11/28/93 7:41	0.22	653	0.60

Table B2-39

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SODIUM
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	340
12/11/92 7:28	1.07	> 300	340
12/11/92 8:52	0.21	210	220
12/11/92 10:44	0.13	> 300	290
12/11/92 11:48	0.04	163	270
12/17/93 0:00	0.94	300	350
12/28/92 19:17	0.14	30	630
12/29/92 15:05	0.10	10	970
1/5/93 7:13	0.62	> 300	370
1/5/93 12:25	0.03	70	480
2/13/93 8:00	0.15	275	240
2/16/93 16:00	0.63	> 300	160
3/4/93 13:46	0.18	245	250
3/4/93 17:53	0.34	> 300	240
3/9/93 0:00	0.04	20	600
3/11/93 8:00	0.04	40	540
3/17/93 9:15	0.37	300	180
3/17/93 11:16	0.20	300	190
3/17/93 13:25	0.18	300	170
3/17/93 14:57	0.22	300	150
3/24/93 6:50	0.84	> 300	100
3/24/93 15:27	0.14	300	270
3/31/93 8:00	0.36	145	290
4/2/93 6:45	1.66	> 300	78
4/2/93 22:00	0.03	300	61
4/12/93 7:40	0.43	> 300	620
4/16/93 15:50	0.02	6	1,200
4/16/93 16:39	0.22	427	480
4/21/93 21:48	0.05	1	520
4/21/93 22:50	0.18	401	520
4/22/93 0:18	0.25	594	300
4/22/93 2:33	0.25	576	1,000
4/22/93 7:18	0.07	196	290
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	400
4/26/93 17:30	0.66	1324	210
4/26/93 23:44	0.07	551	740
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	310
6/4/93 0:00	0.06	30	440
6/5/93 0:00	0.06	50	220
6/9/93 0:00	0.23	20	170
6/10/93 0:00	0.23	255	75
6/20/93 21:01	0.42	314	150
6/20/93 22:51	0.38	836	160
6/21/93 0:31	0.04	50	310
6/21/93 0:00	1.15	300	410
7/2/93 0:00	0.40	300	330
7/6/93 0:00	0.32	275	200
7/14/93 0:00	0.39	> 300	280
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	460
9/27/93 17:45		224	750
9/27/93 18:21		181	1,100
9/27/93 19:00		143	1,400
9/27/93 19:35		109	1,500
9/27/93 20:14		117	1,800
9/27/93 20:59		167	2,200
9/27/93 21:43		170	2,500
9/27/93 22:29		161	2,500
9/27/93 23:10		255	1,500
9/27/93 23:46	1.40	124	1,300
9/28/93 0:22		105	1,800
10/3/93 1:07		179	610
10/3/93 1:44		148	410
10/3/93 2:43		171	460
10/3/93 6:13	0.40	112	920
10/12/93 9:02		150	230
10/12/93 9:47		300	150
10/12/93 10:25		450	150
10/12/93 11:01	1.03	600	180
10/20/93 0:19	0.21	237	460
10/20/93 2:12	0.08	159	340
10/20/93 4:49	0.07	191	370
10/20/93 14:35	0.04	63	550
10/21/93 5:16	0.10	146	530
10/21/93 20:28	0.11	91	390
10/30/93 12:49	0.15	143	590
10/30/93 14:54	0.09	192	480
10/30/93 16:30	0.08	182	390
10/30/93 17:04	0.04	190	320
10/30/93 17:42	0.09	258	290
10/30/93 18:43	0.17	466	240
10/30/93 20:43	0.12	331	370
10/31/93 0:23	0.03	126	760
10/31/93 10:56	0.07	119	830
10/31/93 19:54	0.12	183	640
10/31/93 21:17	0.10	196	290
10/31/93 21:51	0.13	263	220
11/28/93 3:21	0.19	297	480
11/28/93 3:57	0.08	178	380
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	360
11/28/93 5:59	0.15	515	260
11/28/93 6:32	0.10	182	250
11/28/93 7:07	0.08	201	240
11/28/93 7:41	0.22	653	160

Table B2-40

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SODIUM
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	340
12/11/92 7:28	1.07	> 300	340
12/11/92 8:52	0.21	210	210
12/11/92 10:44	0.13	> 300	290
12/11/92 11:48	0.04	163	270
12/17/93 0:00	0.94	300	340
12/28/92 19:17	0.14	30	630
12/29/92 15:05	0.10	10	980
1/5/93 7:13	0.62	> 300	340
1/5/93 12:25	0.03	70	480
2/13/93 8:00	0.15	275	250
2/16/93 16:00	0.63	> 300	160
3/4/93 13:46	0.18	245	240
3/4/93 17:53	0.34	> 300	82
3/9/93 0:00	0.04	20	570
3/11/93 8:00	0.04	40	500
3/17/93 9:15	0.37	300	170
3/17/93 11:16	0.20	300	180
3/17/93 13:25	0.18	300	170
3/17/93 14:57	0.22	300	130
3/24/93 6:50	0.84	> 300	140
3/24/93 15:27	0.14	300	240
3/31/93 8:00	0.36	145	290
4/2/93 6:45	1.66	> 300	78
4/2/93 22:00	0.03	300	610
4/12/93 7:40	0.43	> 300	620
4/16/93 15:50	0.02	6	1,100
4/16/93 16:39	0.22	427	440
4/21/93 21:48	0.05	1	460
4/21/93 22:50	0.18	401	480
4/22/93 0:18	0.25	594	280
4/22/93 2:33	0.25	576	1,000
4/22/93 7:18	0.07	196	280
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	400
4/26/93 17:30	0.66	1324	210
4/26/93 23:44	0.07	551	710
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	310
6/4/93 0:00	0.06	30	450
6/5/93 0:00	0.06	50	220
6/9/93 0:00	0.23	20	170
6/10/93 0:00	0.23	255	70
6/20/93 21:01	0.42	314	120
6/20/93 22:51	0.38	836	160
6/21/93 0:31	0.04	50	310
6/21/93 0:00	1.15	300	420
7/2/93 0:00	0.40	300	290
7/6/93 0:00	0.32	275	200
7/14/93 0:00	0.39	> 300	280
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	460
9/27/93 17:45		224	620
9/27/93 18:21		181	960
9/27/93 19:00		143	1,300
9/27/93 19:35		109	1,500
9/27/93 20:14		117	1,800
9/27/93 20:59		167	2,200
9/27/93 21:43		170	2,500
9/27/93 22:29		161	2,500
9/27/93 23:10		255	1,300
9/27/93 23:46	1.40	124	1,300
9/28/93 0:22		105	1,800
10/3/93 1:07		179	550
10/3/93 1:44		148	400
10/3/93 2:43		171	450
10/3/93 6:13	0.40	112	760
10/12/93 9:02		150	220
10/12/93 9:47		300	130
10/12/93 10:25		450	130
10/12/93 11:01	1.03	600	180
10/20/93 0:19	0.21	237	420
10/20/93 2:12	0.08	159	320
10/20/93 4:49	0.07	191	340
10/20/93 14:35	0.04	63	500
10/21/93 5:16	0.10	146	490
10/21/93 20:28	0.11	91	390
10/30/93 12:49	0.15	143	580
10/30/93 14:54	0.09	192	470
10/30/93 16:30	0.08	182	380
10/30/93 17:04	0.04	190	320
10/30/93 17:42	0.09	258	290
10/30/93 18:43	0.17	466	250
10/30/93 20:43	0.12	331	360
10/31/93 0:23	0.03	126	760
10/31/93 10:56	0.07	119	840
10/31/93 19:54	0.12	183	620
10/31/93 21:17	0.10	196	290
10/31/93 21:51	0.13	263	210
11/28/93 3:21	0.19	297	480
11/28/93 3:57	0.08	178	390
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	360
11/28/93 5:59	0.15	515	260
11/28/93 6:32	0.10	182	250
11/28/93 7:07	0.08	201	240
11/28/93 7:41	0.22	653	160

Table B2-41

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SOLIDS
TOTAL CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	2,800
12/11/92 7:28	1.07	> 300	2,700
12/11/92 8:52	0.21	210	1,800
12/11/92 10:44	0.13	> 300	2,300
12/11/92 11:48	0.04	163	2,100
12/17/93 0:00	0.94	300	2,900
12/28/92 19:17	0.14	30	4,000
12/29/92 15:05	0.10	10	6,400
1/5/93 7:13	0.62	> 300	3,000
1/5/93 12:25	0.03	70	6,300
2/13/93 8:00	0.15	275	3,000
2/16/93 16:00	0.63	> 300	1,300
3/4/93 13:46	0.18	245	2,000
3/4/93 17:53	0.34	> 300	1,000
3/9/93 0:00	0.04	20	5,400
3/11/93 8:00	0.04	40	4,200
3/17/93 9:15	0.37	300	1,900
3/17/93 11:16	0.20	300	1,700
3/17/93 13:25	0.18	300	1,600
3/17/93 14:57	0.22	300	1,200
3/24/93 6:50	0.84	> 300	2,500
3/24/93 15:27	0.14	300	2,200
3/31/93 8:00	0.36	145	3,900
4/2/93 6:45	1.66	> 300	3,500
4/2/93 22:00	0.03	300	6,600
4/12/93 7:40	0.43	> 300	4,000
4/16/93 15:50	0.02	6	8,800
4/16/93 16:39	0.22	427	6,400
4/21/93 21:48	0.05	1	4,300
4/21/93 22:50	0.18	401	3,700
4/22/93 0:18	0.25	594	2,300
4/22/93 2:33	0.25	576	6,400
4/22/93 7:18	0.07	196	2,500
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	3,400
4/26/93 17:30	0.66	1324	1,800
4/26/93 23:44	0.07	551	5,300
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	3,600
6/4/93 0:00	0.06	30	3,300
6/5/93 0:00	0.06	50	2,700
6/9/93 0:00	0.23	20	3,000
6/10/93 0:00	0.23	255	2,100
6/20/93 21:01	0.42	314	1,400
6/20/93 22:51	0.38	836	4,300
6/21/93 0:31	0.04	50	3,200
6/21/93 0:00	1.15	300	3,500
7/2/93 0:00	0.40	300	3,300
7/6/93 0:00	0.32	275	2,000
7/14/93 0:00	0.39	> 300	2,300
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	3,200
9/27/93 17:45		224	4,700
9/27/93 18:21		181	6,100
9/27/93 19:00		143	8,600
9/27/93 19:35		109	10,000
9/27/93 20:14		117	10,600
9/27/93 20:59		167	11,500
9/27/93 21:43		170	13,300
9/27/93 22:29		161	14,500
9/27/93 23:10		255	8,400
9/27/93 23:46	1.40	124	8,200
9/28/93 0:22		105	6,500
10/3/93 1:07		179	3,900
10/3/93 1:44		148	2,700
10/3/93 2:43		171	3,300
10/3/93 6:13	0.40	112	5,800
10/12/93 9:02		150	3,200
10/12/93 9:47		300	2,600
10/12/93 10:25		450	2,400
10/12/93 11:01	1.03	600	2,900
10/20/93 0:19	0.21	237	3,300
10/20/93 2:12	0.08	159	2,400
10/20/93 4:49	0.07	191	2,300
10/20/93 14:35	0.04	63	3,400
10/21/93 5:16	0.10	146	3,700
10/21/93 20:28	0.11	91	3,600
10/30/93 12:49	0.15	143	3,700
10/30/93 14:54	0.09	192	3,600
10/30/93 16:30	0.08	182	3,100
10/30/93 17:04	0.04	190	2,600
10/30/93 17:42	0.09	258	2,500
10/30/93 18:43	0.17	466	1,900
10/30/93 20:43	0.12	331	3,000
10/31/93 0:23	0.03	126	5,200
10/31/93 10:56	0.07	119	5,700
10/31/93 19:54	0.12	183	4,500
10/31/93 21:17	0.10	196	2,300
10/31/93 21:51	0.13	263	2,600
11/28/93 3:21	0.19	297	3,100
11/28/93 3:57	0.08	178	2,600
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	2,400
11/28/93 5:59	0.15	515	2,300
11/28/93 6:32	0.10	182	2,300
11/28/93 7:07	0.08	201	2,600
11/28/93 7:41	0.22	653	2,300

Table B2-42

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SOLIDS
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	2,000
12/11/92 7:28	1.07	> 300	1,900
12/11/92 8:52	0.21	210	1,200
12/11/92 10:44	0.13	> 300	1,500
12/11/92 11:48	0.04	163	1,400
12/17/93 0:00	0.94	300	2,300
12/28/92 19:17	0.14	30	3,100
12/29/92 15:05	0.10	10	4,700
1/5/93 7:13	0.62	> 300	2,000
1/5/93 12:25	0.03	70	3,300
2/13/93 8:00	0.15	275	1,300
2/16/93 16:00	0.63	> 300	870
3/4/93 13:46	0.18	245	1,500
3/4/93 17:53	0.34	> 300	790
3/9/93 0:00	0.04	20	4,100
3/11/93 8:00	0.04	40	3,100
3/17/93 9:15	0.37	300	1,200
3/17/93 11:16	0.20	300	1,200
3/17/93 13:25	0.18	300	1,300
3/17/93 14:57	0.22	300	1,000
3/24/93 6:50	0.84	> 300	1,000
3/24/93 15:27	0.14	300	1,700
3/31/93 8:00	0.36	145	2,100
4/2/93 6:45	1.66	> 300	1,200
4/2/93 22:00	0.03	300	3,900
4/12/93 7:40	0.43	> 300	3,100
4/16/93 15:50	0.02	6	5,400
4/16/93 16:39	0.22	427	2,400
4/21/93 21:48	0.05	1	2,800
4/21/93 22:50	0.18	401	2,700
4/22/93 0:18	0.25	594	1,500
4/22/93 2:33	0.25	576	6,100
4/22/93 7:18	0.07	196	1,600
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	2,100
4/26/93 17:30	0.66	1324	1,200
4/26/93 23:44	0.07	551	4,300
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	2,900
6/4/93 0:00	0.06	30	2,700
6/5/93 0:00	0.06	50	1,600
6/9/93 0:00	0.23	20	1,600
6/10/93 0:00	0.23	255	1,000
6/20/93 21:01	0.42	314	1,000
6/20/93 22:51	0.38	836	1,300
6/21/93 0:31	0.04	50	1,900
6/21/93 0:00	1.15	300	2,300
7/2/93 0:00	0.40	300	2,900
7/6/93 0:00	0.32	275	1,500
7/14/93 0:00	0.39	> 300	1,800
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	2,600
9/27/93 17:45		224	4,200
9/27/93 18:21		181	5,500
9/27/93 19:00		143	7,900
9/27/93 19:35		109	8,700
9/27/93 20:14		117	9,900
9/27/93 20:59		167	11,000
9/27/93 21:43		170	13,000
9/27/93 22:29		161	14,000
9/27/93 23:10		255	7,900
9/27/93 23:46	1.40	124	7,300
9/28/93 0:22		105	5,700
10/3/93 1:07		179	2,800
10/3/93 1:44		148	1,700
10/3/93 2:43		171	2,200
10/3/93 6:13	0.40	112	4,100
10/12/93 9:02		150	2,200
10/12/93 9:47		300	1,700
10/12/93 10:25		450	1,400
10/12/93 11:01	1.03	600	1,700
10/20/93 0:19	0.21	237	2,400
10/20/93 2:12	0.08	159	2,100
10/20/93 4:49	0.07	191	2,000
10/20/93 14:35	0.04	63	2,900
10/21/93 5:16	0.10	146	2,900
10/21/93 20:28	0.11	91	2,600
10/30/93 12:49	0.15	143	3,000
10/30/93 14:54	0.09	192	2,400
10/30/93 16:30	0.08	182	2,000
10/30/93 17:04	0.04	190	1,900
10/30/93 17:42	0.09	258	1,800
10/30/93 18:43	0.17	466	1,400
10/30/93 20:43	0.12	331	2,700
10/31/93 0:23	0.03	126	4,100
10/31/93 10:56	0.07	119	4,300
10/31/93 19:54	0.12	183	3,300
10/31/93 21:17	0.10	196	1,700
10/31/93 21:51	0.13	263	1,400
11/28/93 3:21	0.19	297	2,200
11/28/93 3:57	0.08	178	1,800
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	1,900
11/28/93 5:59	0.15	515	1,300
11/28/93 6:32	0.10	182	1,200
11/28/93 7:07	0.08	201	1,300
11/28/93 7:41	0.22	653	900

Table B2-43

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
CHLORIDE
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	620
12/11/92 7:28	1.07	> 300	700
12/11/92 8:52	0.21	210	440
12/11/92 10:44	0.13	> 300	570
12/11/92 11:48	0.04	163	570
12/17/93 0:00	0.94	300	750
12/28/92 19:17	0.14	30	880
12/29/92 15:05	0.10	10	1,300
1/5/93 7:13	0.62	> 300	640
1/5/93 12:25	0.03	70	910
2/13/93 8:00	0.15	275	490
2/16/93 16:00	0.63	> 300	290
3/4/93 13:46	0.18	245	460
3/4/93 17:53	0.34	> 300	140
3/9/93 0:00	0.04	20	1,000
3/11/93 8:00	0.04	40	850
3/17/93 9:15	0.37	300	310
3/17/93 11:16	0.20	300	370
3/17/93 13:25	0.18	300	300
3/17/93 14:57	0.22	300	280
3/24/93 6:50	0.84	> 300	290
3/24/93 15:27	0.14	300	510
3/31/93 8:00	0.36	145	740
4/2/93 6:45	1.66	> 300	370
4/2/93 22:00	0.03	300	1,500
4/12/93 7:40	0.43	> 300	990
4/16/93 15:50	0.02	6	1,900
4/16/93 16:39	0.22	427	370
4/21/93 21:48	0.05	1	820
4/21/93 22:50	0.18	401	590
4/22/93 0:18	0.25	594	440
4/22/93 2:33	0.25	576	1,500
4/22/93 7:18	0.07	196	490
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	380
4/26/93 17:30	0.66	1324	360
4/26/93 23:44	0.07	551	1,400
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	500
6/4/93 0:00	0.06	30	780
6/5/93 0:00	0.06	50	480
6/9/93 0:00	0.23	20	270
6/10/93 0:00	0.23	255	84
6/20/93 21:01	0.42	314	200
6/20/93 22:51	0.38	836	290
6/21/93 0:31	0.04	50	570
6/21/93 0:00	1.15	300	690
7/2/93 0:00	0.40	300	630
7/6/93 0:00	0.32	275	380
7/14/93 0:00	0.39	> 300	560
8/9/93 0:00	0.37	> 300	
9/27/93 17:09		652	650
9/27/93 17:45		224	1,000
9/27/93 18:21		181	1,500
9/27/93 19:00		143	2,000
9/27/93 19:35		109	2,500
9/27/93 20:14		117	3,000
9/27/93 20:59		167	3,100
9/27/93 21:43		170	3,600
9/27/93 22:29		161	3,800
9/27/93 23:10		255	2,300
9/27/93 23:46	1.40	124	2,200
9/28/93 0:22		105	2,000
10/3/93 1:07		179	1,000
10/3/93 1:44		148	580
10/3/93 2:43		171	660
10/3/93 6:13	0.40	112	960
10/12/93 9:02		150	320
10/12/93 9:47		300	220
10/12/93 10:25		450	210
10/12/93 11:01	1.03	600	250
10/20/93 0:19	0.21	237	710
10/20/93 2:12	0.08	159	530
10/20/93 4:49	0.07	191	530
10/20/93 14:35	0.04	63	720
10/21/93 5:16	0.10	146	720
10/21/93 20:28	0.11	91	620
10/30/93 12:49	0.15	143	870
10/30/93 14:54	0.09	192	960
10/30/93 16:30	0.08	182	670
10/30/93 17:04	0.04	190	510
10/30/93 17:42	0.09	258	500
10/30/93 18:43	0.17	466	320
10/30/93 20:43	0.12	331	600
10/31/93 0:23	0.03	126	1,100
10/31/93 10:56	0.07	119	1,500
10/31/93 19:54	0.12	183	940
10/31/93 21:17	0.10	196	510
10/31/93 21:51	0.13	263	380
11/28/93 3:21	0.19	297	770
11/28/93 3:57	0.08	178	520
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	500
11/28/93 5:59	0.15	515	400
11/28/93 6:32	0.10	182	370
11/28/93 7:07	0.08	201	340
11/28/93 7:41	0.22	653	150

Table B2-44

STOCKPILE RUNOFF INDIVIDUAL SAMPLE
SULFATE
DISSOLVED CONCENTRATION
(mg/L)

TIME OF SAMPLE COLLECTION	*RAIN (in.)*	*SAMPLE VOLUME (gal)*	*CONC. (mg/L)*
12/10/92 21:34	0.23	295	590
12/11/92 7:28	1.07	> 300	480
12/11/92 8:52	0.21	210	300
12/11/92 10:44	0.13	> 300	370
12/11/92 11:48	0.04	163	330
12/17/93 0:00	0.94	300	530
12/28/92 19:17	0.14	30	770
12/29/92 15:05	0.10	10	1,200
1/5/93 7:13	0.62	> 300	570
1/5/93 12:25	0.03	70	990
2/13/93 8:00	0.15	275	320
2/16/93 16:00	0.63	> 300	240
3/4/93 13:46	0.18	245	440
3/4/93 17:53	0.34	> 300	170
3/9/93 0:00	0.04	20	1,200
3/11/93 8:00	0.04	40	860
3/17/93 9:15	0.37	300	300
3/17/93 11:16	0.20	300	350
3/17/93 13:25	0.18	300	350
3/17/93 14:57	0.22	300	290
3/24/93 6:50	0.84	> 300	320
3/24/93 15:27	0.14	300	490
3/31/93 8:00	0.36	145	670
4/2/93 6:45	1.66	> 300	340
4/2/93 22:00	0.03	300	1,300
4/12/93 7:40	0.43	> 300	810
4/16/93 15:50	0.02	6	1,300
4/16/93 16:39	0.22	427	210
4/21/93 21:48	0.05	1	790
4/21/93 22:50	0.18	401	530
4/22/93 0:18	0.25	594	430
4/22/93 2:33	0.25	576	1,600
4/22/93 7:18	0.07	196	420
4/22/93 12:09	0.07	77	
4/26/93 14:48	0.40	542	380
4/26/93 17:30	0.66	1324	360
4/26/93 23:44	0.07	551	1,400
4/27/93 2:52	0.00	39	
5/6/93 0:00	0.12	300	
5/21/93 0:00	0.37	300	1,200
6/4/93 0:00	0.06	30	870
6/5/93 0:00	0.06	50	680
6/9/93 0:00	0.23	20	560
6/10/93 0:00	0.23	255	320
6/20/93 21:01	0.42	314	270
6/20/93 22:51	0.38	836	280
6/21/93 0:31	0.04	50	410
6/21/93 0:00	1.15	300	590
7/2/93 0:00	0.40	300	1,200
7/6/93 0:00	0.32	275	570
7/14/93 0:00	0.39	> 300	630
8/9/93 0:00	0.37	> 300	
9/27/93 17:09	1.40	652	1,000
9/27/93 17:45		224	1,500
9/27/93 18:21		181	2,100
9/27/93 19:00		143	2,500
9/27/93 19:35		109	3,000
9/27/93 20:14		117	3,400
9/27/93 20:59		167	3,700
9/27/93 21:43		170	4,000
9/27/93 22:29		161	4,400
9/27/93 23:10		255	2,400
9/27/93 23:46		124	2,300
9/28/93 0:22		105	2,000
10/3/93 1:07	0.40	179	910
10/3/93 1:44		148	650
10/3/93 2:43		171	750
10/3/93 6:13		112	1,400
10/12/93 9:02	1.03	150	1,090
10/12/93 9:47		300	760
10/12/93 10:25		450	650
10/12/93 11:01		600	700
10/20/93 0:19	0.21	237	800
10/20/93 2:12	0.08	159	720
10/20/93 4:49	0.07	191	770
10/20/93 14:35	0.04	63	1,100
10/21/93 5:16	0.10	146	1,100
10/21/93 20:28	0.11	91	970
10/30/93 12:49	0.15	143	860
10/30/93 14:54	0.09	192	730
10/30/93 16:30	0.08	182	620
10/30/93 17:04	0.04	190	580
10/30/93 17:42	0.09	258	610
10/30/93 18:43	0.17	466	520
10/30/93 20:43	0.12	331	860
10/31/93 0:23	0.03	126	1,400
10/31/93 10:56	0.07	119	1,400
10/31/93 19:54	0.12	183	1,200
10/31/93 21:17	0.10	196	630
10/31/93 21:51	0.13	263	560
11/28/93 3:21	0.19	297	740
11/28/93 3:57	0.08	178	610
11/28/93 4:53	0.12	176	
11/28/93 5:26	0.11	309	600
11/28/93 5:59	0.15	515	500
11/28/93 6:32	0.10	182	500
11/28/93 7:07	0.08	201	490
11/28/93 7:41	0.22	653	340

Table B2-45
TOTAL PRECIPITATION INDIVIDUAL SAMPLE
TOTAL ELEMENTAL CONCENTRATIONS
(mg/L)

Event Date	Al	As	Ba	Be	Cd	Cu	Cr
1/5/93	< 0.032	< 0.0010	< 0.0010	< 0.0010	< 0.0040	< 0.0010	< 0.020
2/16/93	< 0.032	< 0.0010	< 0.0010	< 0.0010	< 0.0040	< 0.0010	< 0.020
3/4/93	0.11	< 0.0010	0.026	0.0020	< 0.0040	< 0.0010	< 0.020
3/17/93	< 0.032	< 0.0010	0.0260	0.0020	< 0.0040	< 0.0010	< 0.020
3/24/93	< 0.032	< 0.0010	0.024	0.0020	< 0.0040	< 0.0010	< 0.020
9/27/93	< 0.100	< 0.0010	< 0.0500	< 0.0100	< 0.0100	< 0.0200	< 0.050
10/3/93	< 0.10	< 0.0010	< 0.050	< 0.010	< 0.010	< 0.020	< 0.050
10/12/93	< 0.10	< 0.0010	< 0.050	< 0.010	< 0.010	< 0.020	< 0.050
10/20/93	< 0.10	< 0.0010	< 0.050	< 0.010	< 0.010	< 0.020	< 0.050
10/30/93	< 0.100	< 0.0010	< 0.050	< 0.0100	< 0.0100	< 0.0200	< 0.050

Event Date	Pb	Mn	Hg	Ni	Se	Ag	Zn
1/5/93	< 0.050	0.010	< 0.0010	< 0.050	< 0.0010	< 0.010	0.032
2/16/93	< 0.050	0.018	< 0.0010	< 0.050	< 0.0010	< 0.010	0.024
3/4/93	< 0.050	0.012	< 0.0010	< 0.050	< 0.0010	< 0.010	0.063
3/17/93	< 0.050	0.010	< 0.0010	< 0.050	< 0.0010	< 0.010	0.053
3/24/93	< 0.050	< 0.002	< 0.0010	< 0.050	< 0.0010	< 0.010	< 0.003
9/27/93	< 0.050	< 0.010	< 0.0010	< 0.040	< 0.0010	< 0.010	< 0.010
10/3/93	< 0.050	0.030	< 0.0010	< 0.040	< 0.0010	< 0.010	0.010
10/12/93	< 0.050	0.020	< 0.0010	< 0.040	< 0.0010	< 0.010	0.010
10/20/93	< 0.050	0.020	< 0.0010	< 0.040	< 0.0010	< 0.010	0.020
10/30/93	< 0.050	< 0.010	< 0.0010	< 0.040	< 0.0010	< 0.010	0.010

Event Date	Fe	Mg	K	Si	Na	Ca	Solids
1/5/93	< 0.023	0.052	0.36	< 0.050	9.0	5.3	38
2/16/93	0.026	0.631	0.17	< 0.050	13	5.6	62
3/4/93	0.088	< 0.006	2.1	< 0.050	10	6.0	120
3/17/93	0.055	< 0.006	2.0	< 0.050	11	5.6	51
3/24/93	0.031	< 0.006	0.10	< 0.050	4.1	1.8	210
9/27/93	< 0.050	< 0.0060	11	< 0.050	13	3.6	28
10/3/93	< 0.050	< 0.0060	2.4	< 0.050	6.2	2.7	81
10/12/93	< 0.050	< 0.0060	0.25	< 0.050	4.1	5.6	95
10/20/93	< 0.050	< 0.0060	0.27	< 0.050	3.3	1.7	42
10/30/93	< 0.050	< 0.0060	3.1	0.652	6.4	0.66	76

Table B2-46
TOTAL PRECIPITATION INDIVIDUAL SAMPLE
DISSOLVED ELEMENTAL CONCENTRATIONS
(mg/L)

Event Date	Al	As	Ba	Be	Cd	Cu	Cr	Fe
1/5/93	< 0.032	< 0.0010	< 0.0010	< 0.0010	< 0.0040	< 0.0010	< 0.020	< 0.023
2/16/93	< 0.032	< 0.0010	0.0230	< 0.0010	< 0.0040	< 0.0010	< 0.020	< 0.023
3/4/93	< 0.03	< 0.0010	< 0.001	< 0.0010	< 0.0040	< 0.0010	< 0.020	< 0.023
3/17/93	< 0.032	< 0.0010	< 0.0010	< 0.0010	< 0.0040	< 0.0010	< 0.020	< 0.023
3/24/93	< 0.032	< 0.0010	< 0.001	< 0.0010	< 0.0040	< 0.0010	< 0.020	< 0.023
9/27/93	0.180	< 0.0010	< 0.0500	< 0.0100	< 0.0100	< 0.0200	< 0.050	< 0.050
10/3/93	< 0.10	< 0.0010	< 0.050	< 0.010	< 0.010	< 0.020	< 0.050	< 0.050
10/12/93	< 0.10	< 0.0010	< 0.050	< 0.010	< 0.010	< 0.020	< 0.050	< 0.050
10/20/93	< 0.10	< 0.0010	< 0.050	< 0.010	< 0.010	< 0.020	< 0.050	< 0.050
10/30/93	< 0.100	< 0.0010	< 0.050	< 0.0100	< 0.0100	< 0.0200	< 0.050	< 0.050

Event Date	Pb	Mn	Hg	Ni	Se	Ag	Zn	Mg
1/5/93	< 0.050	< 0.002	< 0.0010	< 0.050	< 0.0010	< 0.010	0.037	0.490
2/16/93	< 0.050	0.009	< 0.0010	< 0.050	< 0.0010	< 0.010	0.028	0.601
3/4/93	< 0.050	< 0.002	< 0.0010	< 0.050	< 0.0010	< 0.010	0.027	< 0.006
3/17/93	< 0.050	< 0.002	< 0.0010	< 0.050	< 0.0010	< 0.010	0.012	< 0.006
3/24/93	< 0.050	< 0.002	< 0.0010	< 0.050	< 0.0010	< 0.010	< 0.003	< 0.006
9/27/93	< 0.050	< 0.010	< 0.0010	< 0.040	< 0.0010	< 0.010	< 0.010	< 0.006
10/3/93	< 0.050	0.020	< 0.0010	< 0.040	< 0.0010	< 0.010	0.010	< 0.006
10/12/93	< 0.050	0.020	< 0.0010	< 0.040	< 0.0010	< 0.010	0.010	< 0.006
10/20/93	< 0.050	0.020	< 0.0010	< 0.040	< 0.0010	< 0.010	0.020	< 0.006
10/30/93	< 0.050	< 0.010	< 0.0010	< 0.040	< 0.0010	< 0.010	< 0.010	< 0.006

Event Date	K	Si	Na	Ca	Cl	SO_4	Solids	
1/5/93	0.100	< 0.050	7.40	3.360	1.2	3.6	38	
2/16/93	0.140	< 0.050	13.20	5.430	1	4.3	21	
3/4/93	0.080	< 0.050	3.1	1.440	1	3.2	110	
3/17/93	0.510	< 0.050	8.6	3.920	2	2.0	22	
3/24/93	0.100	< 0.050	4.83	2.240	0.9	3.4	53	
9/27/93	< 0.040	< 0.0500	13	3.520	0	2.5	22	
10/3/93	2.280	< 0.0500	5.7	1.900	0.4	2.4	79	
10/12/93	0.240	< 0.0500	4.16	4.750	0.9	3.9	16	
10/20/93	0.270	< 0.0500	3.43	1.150	0.6	6.0	38	
10/30/93	3.060	0.0620	6.4	0.660	0.1	2.21	18	

B3

RUNOFF AND PRECIPITATION ORGANIC CHARACTERIZATION TEST RESULTS

Appendix B3 presents the individual results from the organic analysis of the stockpile runoff and rain samples collected on September 21, 1993.

B3.1 DIOXIN AND FURAN TEST RESULTS

Table B3-1 presents the dioxin and furan test results for the control pad runoff and bottom ash stockpile runoff. Concentrations of measured compounds were converted to USEPA toxic equivalents as described in Appendix A3. All concentrations measured in the stockpile runoff were below method detection limits, while all but two compounds in the control pad runoff were below detection limits.

B3.2 PRIORITY POLLUTANT TEST RESULTS

Table B3-2 presents the concentrations of volatile priority pollutants measured in two replicates of the stockpile runoff, two replicates of the control pad runoff, in the total precipitation sample and in the blank sample. All concentrations were below method detection limits with the exception of three compounds which were reported in similar concentrations in the control pad runoff, stockpile runoff and precipitation samples.

Table B3-3 presents the concentrations of semi-volatile priority pollutants measured in the control pad and stockpile runoff. Concentrations were below method detection limits with the exception of two compounds which were detected in the control pad runoff and stockpile runoff in similar concentrations.

Table B3-1
DIOXIN AND FURAN TEST RESULTS
RUNOFF
(ppb)

DIOXIN / FURAN	USEPA TOXIC EQUIVALENT FACTOR	CONTROL PAD		STOCKPILED BA	
		SAMPLE CONC	EPA TOXIC EQUIV	SAMPLE CONC	EPA TOXIC EQUIV
2378-TCDD	1.0	< 1.1E-06	1.1E-06	< 2.9E-06	2.9E-06
12378-PCDD	0.50	< 1.2E-06	6.0E-07	< 3.1E-06	1.6E-06
123478-HXCDD	0.040	< 1.8E-06	7.2E-08	< 4.6E-06	1.8E-07
123678-HXCDD	0.040	< 1.6E-06	6.4E-08	< 4.9E-06	2.0E-07
123789-HXCDD	0.040	< 1.5E-06	6.0E-08	< 4.2E-06	1.7E-07
1234678-HPCDD	0.0010	1.4E-05	1.4E-08	< 8.1E-06	8.1E-09
12346789-OCDD	0.0	4.3E-05	0.0E+00	< 1.2E-05	0.0E+00
2378-TCDF	0.10	< 9.5E-07	9.5E-08	< 2.2E-06	2.2E-07
12378-PCDF	0.10	< 6.3E-07	6.3E-08	< 1.9E-06	1.9E-07
23478-PCDF	0.10	< 9.5E-07	9.5E-08	< 2.2E-06	2.2E-07
123478-HXCDF	0.01	< 9.0E-07	9.0E-09	< 2.2E-06	2.2E-08
123678-HXCDF	0.010	< 9.0E-07	9.0E-09	< 2.3E-06	2.3E-08
234678-HXCDF	0.010	< 1.1E-06	1.1E-08	< 2.7E-06	2.7E-08
123789-HXCDF	0.010	< 1.2E-06	1.2E-08	< 2.2E-06	2.2E-08
1234678-HPCDF	0.0010	9.5E-06	9.5E-09	< 3.2E-06	3.2E-09
1234789-HPCDF	0.0010	< 2.3E-06	2.3E-09	< 4.0E-06	4.0E-09
12346789-OCDF	0.0	9.2E-06	0.0E+00	< 7.8E-06	0.0E+00
TOTAL-TCDD	0.010	< 1.1E-06		< 2.9E-06	
OTHER-TCDD			0.0E+00		0.0E+00
TOTAL-PCDD	0.0050	< 1.2E-06		< 3.1E-06	
OTHER-PCDD			0.0E+00		0.0E+00
TOTAL-HXCDD	0.00040	< 1.6E-06		< 4.9E-06	
OTHER-HXCDD			0.0E+00		0.0E+00
TOTAL-HPCDD	0.000010	2.5E-05		< 8.1E-06	
OTHER-HPCDD			1.1E-10		0.0E+00
TOTAL-TCDF	0.0010	< 9.5E-07		< 2.2E-06	
OTHER-TCDF			0.0E+00		0.0E+00
TOTAL-PCDF	0.0010	< 6.3E-07		< 1.9E-06	
OTHER-PCDF			0.0E+00		0.0E+00
TOTAL-HXCDF	0.00010	2.6E-06		< 2.2E-06	
OTHER-HXCDF			0.0E+00		0.0E+00
TOTAL-HPCDF	0.000010	9.5E-06		< 3.2E-06	
OTHER-HPCDF			0.0E+00		0.0E+00
Total Toxic Equivalents[1,2]			2.2E-06		5.7E-06

Table B3-2
PRIORITY POLLUTANTS (VOLATILES)
RUNOFF
(ppb)

VOLATILES	STOCKPILE RUNOFF		CONTROL PAD RUNOFF		TRIP BLANK[1]	TOTAL[2] PRECIP.
	REPLICATE-1[1]	REPLICATE-1[2]	REPLICATE-1[1]	REPLICATE-1[2]		
Benzene-d6 SURR		36		37		37
Fluorobenzene SURR		35		36		37
p-Bromofluorobenzene SURR		19		20		20
Dichlorodifluoromethane	< 0.50		< 0.50		< 0.50	
Chloromethane	< 0.50	< 0.77	< 0.50	< 0.77	< 0.50	< 0.77
Vinyl Chloride	< 0.50	< 0.41	< 0.50	< 0.41	< 0.50	< 0.41
Bromomethane	< 0.50	< 0.58	< 0.50	< 0.58	< 0.50	< 0.58
Chloroethane	< 0.50	< 1.4	< 0.50	< 1.43	< 0.50	< 1.4
Trichlorofluoromethane	< 0.50	< 0.45	< 0.50	< 0.45	< 0.50	< 0.45
1,1-Dichloroethene	< 0.50	< 0.27	< 0.50	< 0.27	< 0.50	< 0.27
Methylene Chloride	< 0.50	< 0.42	< 0.50	< 0.42	< 0.50	< 0.42
Trans-1,2-Dichloroethene	< 0.50	< 0.25	< 0.50	< 0.25	< 0.50	< 0.25
1,1-Dichloroethane	< 0.50	< 0.25	< 0.50	< 0.25	< 0.50	< 0.25
2,2-Dichloropropane	< 0.50		< 0.50		< 0.50	
Cis-1,2-Dichloroethane	< 0.50		< 0.50		< 0.50	
Chloroform	< 0.50	< 0.19	< 0.50	< 0.19	< 0.50	< 0.19
Bromochloromethane	< 0.50		< 0.50		< 0.50	
1,1,1-Trichloroethane	< 0.50	< 0.24	< 0.50	< 0.24	< 0.50	< 0.24
1,1-Dichloropropene	< 0.50		< 0.50		< 0.50	
Carbon Tetrachloride	< 0.50	< 0.24	< 0.50	< 0.24	< 0.50	< 0.24
1,2-Dichloroethane	< 0.50	< 0.27	< 0.50	< 0.27	< 0.50	< 0.27
Benzene	< 0.50	< 0.27	< 0.50	< 0.27	< 0.50	< 0.27
Trichloroethene	< 0.50	< 0.17	< 0.50	< 0.17	< 0.50	< 0.17
1,2-Dichloropropane	< 0.50	< 0.18	< 0.50	< 0.18	< 0.50	< 0.18
Bromodichlromethane	< 0.50	< 0.25	< 0.50	< 0.25	< 0.50	< 0.25
2-Chloroethylvinyl ether		< 5.3		< 5.3		< 5.3
Dibromomethane	< 0.50		< 0.50		< 0.50	
Cis-1,3-Dichloropropene	< 0.50	< 0.22	< 0.50	< 0.22	< 0.50	< 0.22
Toluene	< 0.50	< 0.23	< 0.50	< 0.23	< 0.50	< 0.23
Trans-1,3-Dichlopropene	< 0.50	< 0.32	< 0.50	< 0.32	< 0.50	< 0.32
1,1,2-Trichloroethane	< 0.50	< 0.41	< 0.50	< 0.41	< 0.50	< 0.41
1,3-Dichloropropane	< 0.50		< 0.50		< 0.50	

1. Analysis performed by the New York State Department of Health.

2. Analyses performed by the New Jersey Department of Environmental Protection

Table B3-2 (continued)

	STOCKPILE RUNOFF		CONTROL PAD RUNOFF		TRIP	TOTAL[2]
VOLATILES	REPLICATE-1[1]	REPLICATE-1[2]	REPLICATE-1[1]	REPLICATE-1[2]	BLANK[1]	PRECIP.
Tetrachloroethene	< 0.50	< 0.29	< 0.50	< 0.29	< 0.50	< 0.29
Dibromochloromethane	< 0.50	< 0.54	< 0.50	< 0.54	< 0.50	< 0.54
1,2-Dibromoethane (EDB)	< 0.50		< 0.50		< 0.50	
Chlorobenzene	< 0.50	< 0.20	< 0.50	< 0.20	< 0.50	< 0.20
1,1,1,2-Tetrachloroethane	< 0.50		< 0.50		< 0.50	
Ethylbenzene	< 0.50	< 0.31	< 0.50	< 0.31	< 0.50	< 0.31
M/P-Xylene	< 0.50		< 0.50		< 0.50	
O-Xylene	< 0.50		< 0.50		< 0.50	
Styrene	< 0.50		< 0.50		< 0.50	
Isopropylbenzene (Cumene)	< 0.50		< 0.50		< 0.50	
Bromoform	< 0.50	< 0.83	< 0.50	< 0.83	< 0.50	< 0.83
1,1,2,2-Tetrachloroethane	< 0.50	< 0.43	< 0.50	< 0.43	< 0.50	< 0.43
1,2,3-Trichloropropane	< 0.50		< 0.50		< 0.50	
N-Propylbenzene	< 0.50		< 0.50		< 0.50	
Bromobenzene	< 0.50		< 0.50		< 0.50	
1,3,5-Trimethylbenzene	< 0.50		< 0.50		< 0.50	
O-Chlorotoluene	< 0.50		< 0.50		< 0.50	
P-Chlorotoluene	< 0.50		< 0.50		< 0.50	
Tert-Butylbenzene	< 0.50		< 0.50		< 0.50	
1,2,4-Trimethylbenzene	< 0.50		< 0.50		< 0.50	
Sec-Butylbenzene	< 0.50		< 0.50		< 0.50	
4-Isopropyltoluene (p-Cymene)	< 0.50		< 0.50		< 0.50	
1,3-Dichlorobenzene	< 0.50	< 0.23	< 0.50	< 0.23	< 0.50	< 0.23
1,4-Dichlorobenzene	< 0.50	< 0.21	< 0.50	< 0.21	< 0.50	< 0.21
N-Butylbenzene	< 0.50		< 0.50		< 0.50	
1,2-Dichlorobenzene	< 0.50	< 0.19	< 0.50	< 0.19	< 0.50	< 0.19
1,2-Dibromo-3-Chloropropane	< 0.50		< 0.50		< 0.50	
1,2,4-Trichloropropane	< 0.50		< 0.50		< 0.50	
Hexachlorobutadiene (C-46)	< 0.50		< 0.50		< 0.50	
Naphthalene	< 0.50		< 0.50		< 0.50	
1,2,3-Trichlorobenzene	< 0.50		< 0.50		< 0.50	

1. Analysis performed by the New York State Department of Health.

2. Analyses performed by the New Jersey Department of Environmental Protection

Table B3-3
PRIORITY POLLUTANTS (SEMI-VOLATILES)
RUNOFF
(ppb)

SEMI-VOLATILES	CONTROL PAD RUNOFF	STOCKPILE RUNOFF
Phenol	< 11	< 11
Bis (2-Chloroethyl) Ether	< 11	< 11
2-Chlorophenol	< 11	< 11
2-Methyl Phenol	< 11	< 11
Bis (2-Chloroisopropyl) Ether	< 11	< 11
4-Methyl Phenol	< 11	< 11
N-Nitrosodi-N-Propylamine	< 11	< 11
Hexachloroethane	< 11	< 11
Nitrobenzene	< 11	< 11
Isophorone	< 11	< 11
2-Nitrophenol	< 11	< 11
2,4-Dimethylphenol	< 11	< 11
Bis (2-Chloroethoxy) Methane	< 11	< 11
2,4-Dichlorophenol	< 11	< 11
4-Dichloroaniline	< 11	< 11
4-Chloro-3-Methylphenol	< 11	< 11
2-Methylnaphthalene	< 11	< 11
Hexachlorocyclopentadiene (C-56)	< 11	< 11
2,4,6-Trichlorophenol	< 11	< 11
2,4,5-Trichlorophenol	< 27	< 27
2-Chloronaphthalene	< 11	< 11
2-Nitroaniline	< 27	< 27
Dimethylphthalate	< 11	< 11
Acenaphthylene	< 11	< 11
2,6-Dinitrotoluene	< 11	< 11
3-Nitrotanaline	< 27	< 27
Acenaphthene	< 11	< 11
2,4-Dinitrophenol	< 27	< 27
4-Nitrophenol	< 27	< 27

Table B3-3 (continued)

SEMI-VOLATILES	CONTROL PAD RUNOFF	STOCKPILE RUNOFF
Dibenzofuran	< 11	< 11
2,4-Dinitrotoluene	< 11	< 11
Diethylphthalate	< 11	< 11
4-Chlorophenyl Phenyl Ether	< 11	< 11
Fluorene	< 11	< 11
4-Nitroaniline	< 27	< 27
2-Methyl-4, 6-Dinitrophenol	< 27	< 27
N-Nitrosodiphenylamine	< 11	< 11
4-Bromophyl Phenyl Ether	< 11	< 11
Hexachlorobenzene	< 11	< 11
Pentachlorophenol	< 27	< 27
Phenanthrene	< 11	< 11
Anthracene	< 11	< 11
Carbazole	< 11	< 11
Di-N-Butyl Phthalate	0.30	0.50
Fluoranthene	< 11	< 11
Pyrene	< 11	< 11
Butyl Benzyl Phthalate	< 11	< 11
3,3'-Dichlorobenzidine	< 11	< 11
Benzo (a) Anthracene	< 11	< 11
Chrysene	< 11	< 11
Bis (2-Ethylhexyl) Phthalate	0.40	0.40
Di-N-Octyl Phthalate	< 11	< 11
Benzo (b) Fluoranthene	< 11	< 11
Benzo (k) Fluoroanthene	< 11	< 11
Benzo (a) Pyrene	< 11	< 11
Indeno (1,2,3-cd) Pyrene	< 11	< 11
Dibenzo (ah) Anthracene	< 11	< 11
Benzo (ghi) Perylene	< 11	< 11

B4

RUNOFF AND PRECIPITATION ACIDITY/ALKALINITY AND pH TEST RESULTS

Appendix B4 presents the acidity measurement results for total and wet precipitation and control pad runoff as well as stockpile pad alkalinity measurements. Results of pH measurements for all runoff and precipitation samples are also presented.

B4.1 RUNOFF AND PRECIPITATION ACIDITY/ALKALINITY TEST RESULTS

Table B4-1 presents the results of the alkalinity measurements made on the stockpile pad runoff. The results are expressed in terms of $CaCO_3$ (mg/L). Stockpile runoff alkalinity varied from 15 to 10 mg/L during the monitoring period.

Table B4-1 also presents acidity measurements for total and wet precipitation samples expressed as $CaCO_3$ (mg/L). The results for both precipitation samples were similar. The total precipitation sample had an average of 6.8 mg/L with a range from 3.2 to 19. The wet precipitation sample had an average of 6.5 mg/L with a range of results from 3.4 to 16 mg/L.

B4.2 RUNOFF AND PRECIPITATION pH TEST RESULTS

Table B4-2 presents results of pH measurements for stockpile runoff, total precipitation and wet precipitation. Stockpile pH results varied over the course of the monitoring program, ranging from 7.1 to 9.7, with an average of 8.6.

Total and wet precipitation samples exhibited similar results. Total precipitation sample average pH was 4.0 with values ranging from 3.3 to 5.8.

Table B4-1
ACIDITY / ALKALINITY RESULTS
(mg/L as $CaCO_3$)

EVENT DATE	STOCKPILE RUNOFF ALKALINITY	TOTAL PRECIPITATION ACIDITY	WET PRECIPITATION ACIDITY
12/10/92	37	8	-
12/17/92	54	-	-
12/28/92	62	-	-
1/5/93	65	6.7	5.7
2/12/93	22	-	
2/16/93	17	9.6	6.6
3/4/93	32	5.7	4.7
3/9/93	42	-	-
3/11/93	28	19	-
3/17/93	15	9	6.8
3/24/93	20	7.4	7.3
3/31/93	30	5.9	5.6
4/2/93	34	6.3	6.5
4/12/93	32	7.7	6.6
4/16/93	56	4.4	4.7
4/21/93	35	5.1	5.3
4/26/93	38	5.9	5.2
5/6/93	57	5.9	5.2
5/21/93	45	6.1	5.9
6/4/93	56	-	-
6/5/93	58	14	16
6/9/93	59	-	-
6/10/93	41	-	-
6/20/93	49	7.8	10
6/21/93	41	6.5	7
7/2/93	48	7.1	7
7/6/93	53	-	-
7/14/93	39	7.8	7.1
8/9/93	59	3.5	3.9
9/27/93	67	4.4	5.3
10/3/93	42	5.7	6.6
10/12/93	42	3.2	3.4
10/20/93	34	4.4	12
10/30/93	40	4	4.7
11/28/93	41	-	-
12/5/93	-	3.5	4.2
12/11/93	100	-	-
AVG	44	6.8	6.5
STD	17	3.3	2.7
MIN	15	3.2	3.4
MAX	100	19	16
N	37	37	36

Table B4-2
pH RESULTS

EVENT DATE	STOCKPILE RUNOFF	TOTAL PRECIP.	WET PRECIP.
10-Dec-92	9.4	4.6	-
17-Dec-92	9.6	-	-
28-Dec-92	9.7	-	-
5-Jan-93	9	5.5	-
12-Feb-93	8.9	-	5.4
16-Feb-93	7.7	5.2	-
4-Mar-93	-	5.8	5.8
16-Apr-93	7.1	5.6	5.2
6-May-93	8.6	-	-
21-May-93	9.4	4.9	4.6
4-Jun-93	8.6	-	-
5-Jun-93	8.6	3.8	3.8
9-Jun-93	8.4	-	-
10-Jun-93	8.4	-	-
20-Jun-93	8.4	3.5	3.4
21-Jun-93	8.6	3.4	3.4
2-Jul-93	8.5	3.5	3.5
6-Jul-93	8.4	-	-
14-Jul-93	9.5	3.5	3.4
9-Aug-93	8.6	5.4	5.5
27-Sep-93	8.1	3.6	3.5
3-Oct-93	8.1	3.5	3.3
12-Oct-93	8.1	3.5	3.4
20-Oct-93	8.1	3.4	3.3
30-Oct-93	8.4	3.5	3.4
28-Nov-93	8.4	-	-
12-Dec-93	8.5	-	3.3
AVERAGE	8.6	4.2	4.0
STD	0.6	0.9	0.9
MIN	7.1	3.4	3.3
MAX	9.7	5.8	5.8
N	26	17	16

Appendix C

AMBIENT AIR TEST METHODS AND RESULTS

Appendix C describes the methods used to collect TSP and PM_{10} particulates during static and active stockpile periods. This Appendix also presents a detailed listing of trace metal concentrations measured on filters during all events, as well as a listing of meteorological parameters measured by the electronic weather station.

Appendix C is divided into the following sections:

C1	Ambient Air Collection Methods
C2	Static Stockpile Period Ambient Air Trace Results
C3	Active Stockpile Period Ambient Air Trace Results
C4	Active Stockpile Period SEM Results

C1

AMBIENT AIR COLLECTION METHODS

Appendix C1 describes the methods used to record the amount and type of particulates (i.e., TSP and PM_{10}) and trace metals concentrations associated with the particulates collected on the high volume samplers and personal air sampler (PAS) filters.

C1.1 High Volume Air Samplers

The high volume air samplers used in the test program consisted of a vacuum motor manufactured by General Metal Works, Inc., Model Numbers BM2200 (120 volts, 8 amps, 60 cycle), installed in an aluminum enclosure. A filter mount on each vacuum motor provided a means of attaching the eight-inch by ten-inch glass fiber filters to the vacuum motor to ensure laminar air flow across the filter face. A rotimeter was used to measure vacuum pressure.

High volume samplers were used to collect total suspended particulates both during the static periods and during active events. All high volume filters were pre-weighed by the New York State Department of Health (NYSDOH) laboratories in Albany, New York, before use in the monitoring program. One filter was placed on each high volume sampler and the filter numbers were recorded along with date, time and vacuum pressure readings at the start of each event. At the end of an event the total operational time and pressure readings were recorded, and the filters were returned to the NYSDOH laboratories to be weighed again for TSP calculations. The vacuum pressure readings were used to calculate total volume of air filtered, based upon calibration curves generated for each meter by the NYSDOH prior to the test program. Ambient air dust concentrations were calculated by dividing the total mass of particulates on the filter by the total air volume filtered.

After the filters were weighed at the NYSDOH to determine total particulate, they were sent to the New Jersey Department of Environmental Protection (NJDEP) laboratories in Trenton, New Jersey, where metals analyses were performed.

Analyses were conducted using the technique outlined in "Reference Method for the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air" (USEPA). A strip was cut from each filter such that the strip area equaled 1/9 of the total filter area. The strip was then cold sonicated in an aqua-regia[1] solution and analyzed by flame Atomic Adsorption Spectrophotometry (AAS).

C1.2 Personal Air Samplers

Personal air samplers were used to collect TSP and respirable particulates (PM_{10}) during bottom ash

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[1] Aqua-regia solution = 334 mL 16N NHO_3 + 154 mL HCL +1512 mL distilled H_2O.

(BA) processing and stockpile turnover periods. Samples were collected on a 37 mm, 0.8 micron mixed cellulose ester fiber (MCEF) filter. Gillian Model HFS-513-A Personal Air Sampling Pumps were calibrated at maximum flow rates of 2.0 liters per minute. In addition, one blank sample per event was prepared and submitted for analysis.

TSP filters were sent to NATLSCO, an American Industrial Hygiene Association (AIHA) accredited laboratory in Long Grove, IL and analyzed for metals. Arsenic samples were analyzed by AAS using NIOSH method 7900. The remaining dust trace metals were analyzed by AAS using OSHA method ID-121. Due to limited sample volume obtained during extraction, some of these metals were analyzed by Inductively Coupled Plasma (ICP) using OSHA method ID-125G equivalent.

PM_{10} filters were also sent to NATLSCO and analyzed for weight gain utilizing NIOSH method 0600. One blank per event was prepared and submitted for analysis.

C1.3 Mercury Measurements

Mercury is a highly volatile metal that requires special measuring equipment. Instantaneous mercury readings were taken during the ash processing phase and first turnover event, while 8-hour continuous mercury readings were taken during the remaining turnover events.

All direct mercury field testing was performed by NJDEP Industrial Hygiene and Safety Unit personnel.

A Jerome 411 direct reading mercury vapor analyzer and 422 dosimeter controller unit were used to perform mercury vapor analyses. Using the approach described in this section, it was possible to take readings from the stockpile area or perform continuous sampling over the duration of the event being monitored.

To calibrate the Jerome 411, an operational test was performed before and after each sampling event. With the power off and a zero air filter inserted into the sampling port, the "film heat" switch was activated in order to purge residual mercury vapor from the sensor. Upon completion of the film heat cycle, the "bridge balance" was adjusted so that the sensor status read between 02 and 06. Complete functional testing of the instrument was performed at a frequency specified by the manufacturer.

Direct readings were collected by placing the Jerome 411 sampling port within a few centimeters of the BA stockpile and activating the unit. NJDEP personnel took direct mercury vapor readings at random intervals. During the ash processing, discrete mercury vapor readings were taken at the unprocessed bottom ash pile, at the screening location, and at the separated scrap iron pile. A background sample was taken 100 meters away from the processing activities. Discrete mercury vapor readings were also taken at random times at random locations around the stockpile during the first turnover event.

Continuous mercury samples were collected using a dosimeter in conjunction with the Jerome 411 sampler. Gold coil dosimeter tubes were heat purged immediately prior to sampling to drive off any residual background mercury contamination. Samples were collected by drawing a known volume of air through the

Jerome gold coil mercury vapor dosimeter tubes using air pumps similar to those used to collect PAS. One tube was collected for each sample using the Alpha-2 PAS pumps set at maximum flow rates of 50 cc/min. At the end of each sampling event mercury vapor readings were measured by heat purging the dosimeter into the Jerome 411 sampler. With a zero air filter in-line and the dosimeter inserted into the sampling port of the Jerome 411, leads from the 422 dosimeter controller unit were connected to the dosimeter electrodes. Direct readings were obtained from the Jerome 411 by simultaneous activation of the dosimeter controller unit and the Jerome 411 in the 10-second sample mode. Sample concentration and sensor status were recorded and the procedure immediately repeated to insure complete volatilization, and subsequent analysis, of mercury from the gold coil. Readings for each sample were added together to obtain a final concentration of elemental mercury vapor in milligrams per cubic meter. During turnover events mercury vapor dosimeters were placed along side of the personal air samplers on the front end loader operator, on the front end loader, and at all three sites located around the stockpile pad (see Section 5, Figure 5-5).

C1.4 Scanning Electron Microscope (SEM) Samplers

Samples for SEM analysis were collected using PAS filters and equipment. Both TSP and PM_{10} samples were collected.

The TSP and PM_{10} were delivered to the WMI and analyzed at the University Hospital Imaging Center at the State University of New York in Stony Brook, Long Island. Samples were analyzed on a JOEL 5300 Scanning Electron Microscope. A small rectangular section was cut from each filter and placed on a piece of double sided tape (the side with the particles was left exposed). The filter piece was then carbon coated in a sputter coater with carbon attachment.

Grain size analysis was performed by placing the rectangular section under an SEM and enlarging to 8-inches by 10-inches. A random selection of 50 particles were measured by hand with a ruler and their longest dimensions, shortest dimensions, and areas were recorded.

C2

STATIC STOCKPILE PERIOD AMBIENT AIR PARTICULATE AND TRACE METAL RESULTS

C2.1 Trace Metal Results

Table C2-1 presents results for the static stockpile period ambient air trace metal testing. The table presents trace metal results for each filter collected during all events that were monitored during the one-year program. The results are expressed in terms of ambient air concentrations ($\mu g/m^3$). The ambient air concentrations were calculated by multiplying the ambient air dust concentrations for a filter by the trace metal concentrations measured on the filter as follows:

$$M_A = M_F \times (P_A/1{,}000{,}000)$$

Where,

M_A = Ambient air trace metal concentration ($\mu g/m^3$)

M_F = Filter trace metal concentration ($\mu g/g$)

P_A = Ambient air dust concentration ($\mu g/m^3$)

The table lists the results for nine metals for each filter collected for each of 30 events with the exception of the events dated 8/27/93, 11/18/93 and 11/30/93. Several filters from each of these events were rendered useless due to field difficulties, such as vacuum motor burnout or destruction of the filter by insects.

C2.2 Total Suspended Particulates

Table C2-2 presents the rsults for the static stockpile period ambient air total suspended particulate testing. The table presents results for the four samples, HV-1 through HV-4, and the one upwind sampler, HV-5.

C2.3 Climatic Parameters

Table C2-3 presents the average climatic parameters for each of the static stockpile period events. Data is presented for wind speed, temperature, humidity and rainfall.

Table C2-1
STATIC STOCKPILE AIR SAMPLING
TRACE METAL CONCENTRATIONS
(µg/m^3)

	12/7/92				
	High Volume Filter				
	1	2	3	4	5
As	5.5E-05	2.0E-03	5.6E-05	5.6E-05	5.3E-05
Ba	8.2E-04	8.7E-04	7.8E-04	9.5E-04	8.0E-04
Be	< 5.5E-04	< 5.5E-04	< 5.6E-04	< 5.6E-04	< 5.3E-04
Cd	< 2.7E-03	< 2.7E-03	< 2.8E-03	< 2.8E-03	< 2.7E-03
Cr	< 2.7E-03	< 2.7E-03	< 2.8E-03	< 2.8E-03	< 2.7E-03
Pb	< 2.7E-03	1.2E-02	< 2.8E-03	< 2.8E-03	< 2.7E-03
Mn	2.2E-03	2.2E-03	1.7E-03	1.7E-03	1.1E-03
Ni	1.1E-03	2.2E-03	< 1.1E-03	< 1.1E-03	1.1E-03
Zn	6.0E-03	2.3E-02	5.0E-03	5.0E-03	9.1E-03

	12/2/92				
	High Volume Filter				
	1	2	3	4	5
As	5.4E-05	2.6E-04	2.2E-04	2.7E-04	5.3E-05
Ba	< 5.4E-04	< 5.2E-04	5.6E-04	6.6E-04	< 5.3E-04
Be	< 5.4E-04	< 5.2E-04	< 5.6E-04	< 5.5E-04	< 5.3E-04
Cd	< 2.7E-03	< 2.6E-03	< 2.8E-03	< 2.7E-03	< 2.6E-03
Cr	< 2.7E-03	< 2.6E-03	< 2.8E-03	< 2.7E-03	< 2.6E-03
Pb	< 2.7E-03	< 2.6E-03	< 2.8E-03	< 2.7E-03	2.6E-03
Mn	< 5.4E-04	1.0E-03	1.7E-03	2.2E-03	2.1E-03
Ni	< 1.1E-03	< 1.0E-03	< 1.1E-03	< 1.1E-03	1.1E-03
Zn	< 5.4E-04	2.6E-03	2.2E-03	5.5E-03	4.7E-03

	12/29/92				
	High Volume Filter				
	1	2	3	4	5
As	1.3E-04	1.2E-04	1.3E-04	8.5E-05	2.1E-04
Ba	4.3E-04	< 4.1E-04	5.1E-04	4.3E-04	4.6E-04
Be	< 4.3E-04	< 4.1E-04	< 4.3E-04	< 4.3E-04	< 4.2E-04
Cd	< 2.1E-03	< 2.0E-03	< 2.1E-03	< 2.1E-03	< 2.1E-03
Cr	< 2.1E-03	< 2.0E-03	< 2.1E-03	< 2.1E-03	< 2.1E-03
Pb	< 2.1E-03	< 2.0E-03	< 2.1E-03	< 2.1E-03	< 2.1E-03
Mn	8.5E-04	4.1E-04	1.3E-03	4.3E-04	8.3E-04
Ni	< 8.5E-04	< 8.2E-04	8.6E-04	< 8.5E-04	< 8.3E-04
Zn	2.1E-03	2.0E-03	2.6E-03	1.7E-03	2.5E-03

	4/16/93				
	High Volume Filter				
	1	2	3	4	5
As	< 1.1E-04	< 1.1E-04	< 1.1E-04	1.1E-04	1.1E-04
Ba	3.4E-04	3.4E-04	6.0E-04	3.3E-04	1.8E-04
Be	< 1.1E-04	< 1.1E-04	< 1.1E-04	< 1.1E-04	< 1.1E-04
Cd	< 1.1E-03	< 1.1E-03	< 1.1E-03	< 1.1E-03	< 1.1E-03
Cr	< 5.6E-03	< 5.6E-03	< 5.6E-03	< 5.7E-03	< 5.7E-03
Pb	< 5.6E-03	< 5.6E-03	< 5.6E-03	< 5.7E-03	< 5.7E-03
Mn	2.3E-03	2.3E-03	2.3E-03	2.3E-03	2.3E-03
Ni	< 4.5E-03	< 4.5E-03	< 4.5E-03	< 4.5E-03	< 4.5E-03
Zn	6.8E-03	6.8E-03	6.8E-03	5.7E-03	1.1E-02

	4/19/93				
	High Volume Filter				
	1	2	3	4	5
As	1.1E-04	1.1E-04	1.6E-04	1.1E-04	1.1E-04
Ba	4.8E-04	7.8E-04	9.0E-04	8.1E-04	1.1E-03
Be	< 5.4E-05	< 5.4E-05	< 5.4E-05	< 5.4E-05	< 5.6E-05
Cd	< 5.4E-04	< 5.4E-04	< 5.4E-04	< 5.4E-04	5.6E-04
Cr	< 2.7E-03	< 2.7E-03	< 2.7E-03	< 2.7E-03	< 2.8E-03
Pb	< 2.7E-03	< 2.7E-03	< 2.7E-03	< 2.7E-03	3.9E-03
Mn	4.8E-03	3.2E-03	4.3E-03	4.3E-03	6.7E-03
Ni	< 2.2E-03	< 2.2E-03	< 2.2E-03	< 2.2E-03	2.8E-03
Zn	5.4E-03	6.5E-03	7.0E-03	6.0E-03	7.2E-03

	4/21/93				
	High Volume Filter				
	1	2	3	4	5
As	9.1E-05	1.4E-04	1.4E-04	9.1E-05	1.4E-04
Ba	4.7E-04	4.5E-04	4.4E-04	4.4E-04	5.1E-04
Be	< 4.5E-05	< 4.5E-05	< 4.6E-05	< 4.6E-05	< 4.6E-05
Cd	< 4.5E-04	< 4.5E-04	< 4.6E-04	< 4.6E-04	< 4.6E-04
Cr	< 2.3E-03	< 2.3E-03	< 2.3E-03	< 2.3E-03	< 2.3E-03
Pb	< 2.3E-03	< 2.3E-03	< 2.3E-03	< 2.3E-03	< 2.3E-03
Mn	1.8E-03	1.8E-03	1.8E-03	1.4E-03	1.8E-03
Ni	< 1.8E-03	< 1.8E-03	< 1.8E-03	< 1.8E-03	2.3E-03
Zn	5.4E-03	5.0E-03	9.1E-03	7.3E-03	6.0E-03

	4/28/93				
	High Volume Filter				
	1	2	3	4	5
As	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04
Ba	8.7E-04	9.0E-04	1.1E-03	8.5E-04	1.0E-03
Be	< 3.8E-05	< 3.7E-05	< 3.8E-05	< 3.7E-05	< 3.7E-05
Cd	< 3.8E-04	< 3.7E-04	< 3.8E-04	< 3.7E-04	< 3.7E-04
Cr	< 1.9E-03	< 1.8E-03	< 1.9E-03	< 1.8E-03	< 1.9E-03
Pb	< 1.9E-03	< 1.8E-03	< 1.9E-03	< 1.8E-03	< 1.9E-03
Mn	2.3E-03	2.2E-03	5.3E-03	2.6E-03	3.4E-03
Ni	< 1.5E-03	< 1.5E-03	< 1.5E-03	< 1.5E-03	< 1.5E-03
Zn	4.5E-03	4.8E-03	5.0E-03	4.8E-03	6.0E-03

	5/4/93				
	High Volume Filter				
	1	2	3	4	5
As	9.7E-05	< 9.4E-05	9.7E-05	1.9E-04	< 9.6E-05
Ba	5.1E-04	4.9E-04	6.3E-04	3.9E-04	4.6E-04
Be	< 9.7E-05	< 9.4E-05	< 9.7E-05	< 9.4E-05	< 9.6E-05
Cd	< 9.7E-04	< 9.4E-04	< 9.7E-04	< 9.4E-04	< 9.6E-04
Cr	< 4.8E-03	< 4.7E-03	< 4.9E-03	< 4.7E-03	< 4.8E-03
Pb	< 4.8E-03	< 4.7E-03	< 4.9E-03	< 4.7E-03	< 4.8E-03
Mn	1.9E-03	9.4E-04	2.9E-03	9.4E-04	9.6E-04
Ni	< 3.9E-03	< 3.8E-03	< 3.9E-03	< 3.7E-03	< 3.8E-03
Zn	3.9E-03	4.7E-03	4.9E-03	3.7E-03	4.8E-03

Table C2-1 (continued)

	5/7/93				
	High Volume Filter				
	1	2	3	4	5
As	1.3E-04	1.2E-04	1.3E-04	1.3E-04	1.3E-04
Ba	9.6E-04	8.6E-04	1.3E-03	9.5E-04	1.2E-03
Be	< 6.3E-05	< 6.1E-05	< 6.3E-05	< 6.3E-05	< 6.3E-05
Cd	< 6.3E-04	< 6.1E-04	< 6.3E-04	< 6.3E-04	< 6.3E-04
Cr	< 3.2E-03	< 3.1E-03	< 3.2E-03	< 3.2E-03	< 3.1E-03
Pb	< 3.2E-03	< 3.1E-03	< 3.2E-03	< 3.2E-03	7.5E-03
Mn	3.2E-03	3.1E-03	7.0E-03	3.8E-03	3.1E-03
Ni	< 2.5E-03	< 2.5E-03	< 2.5E-03	< 2.5E-03	< 2.5E-03
Zn	5.0E-03	6.7E-03	6.3E-03	5.0E-03	1.1E-02

	5/11/93				
	High Volume Filter				
	1	2	3	4	5
As	1.7E-04	2.8E-04	2.8E-04	2.2E-04	2.7E-04
Ba	1.0E-03	1.2E-03	1.3E-03	1.0E-03	1.4E-03
Be	< 5.5E-05	< 5.5E-05	< 5.6E-05	< 5.5E-05	< 5.4E-05
Cd	< 5.5E-04	< 5.5E-04	< 5.6E-04	< 5.5E-04	< 5.4E-04
Cr	< 2.8E-03	< 2.8E-03	< 2.8E-03	< 2.7E-03	< 2.7E-03
Pb	< 2.8E-03	< 2.8E-03	< 2.8E-03	< 2.7E-03	< 2.7E-03
Mn	5.0E-03	6.1E-03	7.2E-03	4.9E-03	7.6E-03
Ni	< 2.2E-03	< 2.2E-03	< 2.2E-03	< 2.2E-03	< 2.2E-03
Zn	8.8E-03	8.3E-03	9.4E-03	8.8E-03	1.0E-02

	5/19/93				
	High Volume Filter				
	1	2	3	4	5
As	6.9E-05	6.7E-05	6.9E-05	6.9E-05	6.8E-05
Ba	5.7E-04	7.3E-04	7.8E-04	7.2E-04	7.7E-04
Be	< 6.9E-05	< 6.7E-05	< 6.9E-05	< 6.9E-05	< 6.8E-05
Cd	< 6.9E-04	< 6.7E-04	< 6.9E-04	< 6.9E-04	< 6.8E-04
Cr	< 3.4E-03	< 3.4E-03	< 3.4E-03	< 3.4E-03	< 3.4E-03
Pb	< 3.4E-03	< 3.4E-03	< 3.4E-03	< 3.4E-03	< 3.4E-03
Mn	2.1E-03	2.7E-03	2.7E-03	2.1E-03	3.4E-03
Ni	< 2.7E-03	< 2.7E-03	< 2.7E-03	< 2.8E-03	< 2.7E-03
Zn	3.4E-03	3.4E-03	1.6E-02	4.8E-03	5.4E-03

	5/28/93				
	High Volume Filter				
	1	2	3	4	5
As	2.1E-04	1.0E-04	< 1.0E-04	1.0E-04	1.0E-04
Ba	6.6E-04	8.5E-04	4.8E-04	8.1E-04	9.1E-04
Be	< 1.0E-04	< 1.0E-04	< 1.0E-04	< 1.0E-04	< 1.0E-04
Cd	< 1.0E-03	< 1.0E-03	< 1.0E-03	< 1.0E-03	< 1.0E-03
Cr	< 5.2E-03	< 5.0E-03	< 5.2E-03	< 5.2E-03	< 5.1E-03
Pb	< 5.2E-03	< 5.0E-03	< 5.2E-03	< 5.2E-03	< 5.1E-03
Mn	2.1E-03	3.0E-03	4.2E-03	3.1E-03	3.1E-03
Ni	< 4.2E-03	< 4.0E-03	< 4.2E-03	< 4.2E-03	< 4.1E-03
Zn	1.4E-02	3.3E-02	1.9E-02	1.0E-02	7.1E-03

	6/3/93				
	High Volume Filter				
	1	2	3	4	5
As	9.1E-05	1.3E-04	1.4E-04	9.2E-05	1.8E-04
Ba	5.3E-04	7.6E-04	1.1E-03	8.0E-04	8.9E-04
Be	< 4.6E-05	< 4.4E-05	< 4.6E-05	< 4.6E-05	< 4.5E-05
Cd	< 4.6E-04	< 4.4E-04	< 4.6E-04	< 4.6E-04	< 4.5E-04
Cr	< 2.3E-03	< 2.2E-03	< 2.3E-03	< 2.3E-03	< 2.3E-03
Pb	< 2.3E-03	< 2.2E-03	< 2.3E-03	< 2.3E-03	< 2.3E-03
Mn	1.8E-03	2.2E-03	5.5E-03	2.8E-03	3.2E-03
Ni	< 1.8E-03	< 1.7E-03	< 1.8E-03	< 1.8E-03	< 1.8E-03
Zn	9.1E-03	7.0E-03	5.9E-03	9.7E-03	1.0E-02

	6/10/93				
	High Volume Filter				
	1	2	3	4	5
As	4.4E-05	8.7E-05	1.3E-04	9.0E-05	8.8E-05
Ba	6.9E-04	8.9E-04	1.0E-03	8.8E-04	8.7E-04
Be	< 4.4E-05	< 4.3E-05	< 4.4E-05	< 4.5E-05	< 4.4E-05
Cd	< 4.4E-04	< 4.3E-04	< 4.4E-04	< 4.5E-04	< 4.4E-04
Cr	< 2.2E-03	< 2.2E-03	< 2.2E-03	< 2.3E-03	< 2.2E-03
Pb	< 2.2E-03	< 2.2E-03	< 2.2E-03	< 2.3E-03	< 2.2E-03
Mn	3.1E-03	3.5E-03	4.9E-03	3.2E-03	3.5E-03
Ni	< 1.8E-03	< 1.7E-03	< 1.8E-03	< 1.8E-03	< 1.8E-03
Zn	3.1E-03	3.5E-03	3.1E-03	4.1E-03	4.0E-03

	6/24/93				
	High Volume Filter				
	1	2	3	4	5
As	1.3E-04	8.7E-05	8.8E-05	8.5E-05	8.4E-05
Ba	1.2E-03	7.3E-04	8.8E-04	6.9E-04	8.5E-04
Be	< 4.4E-05	< 4.3E-05	< 4.4E-05	< 4.3E-05	< 4.2E-05
Cd	< 4.4E-04	< 4.3E-04	< 4.4E-04	< 4.3E-04	< 4.2E-04
Cr	< 2.2E-03	< 2.2E-03	< 2.2E-03	< 2.1E-03	< 2.1E-03
Pb	< 2.2E-03	< 2.2E-03	< 2.2E-03	< 2.1E-03	< 2.1E-03
Mn	4.0E-03	2.6E-03	3.1E-03	2.6E-03	3.8E-03
Ni	< 1.8E-03	< 1.7E-03	< 1.8E-03	< 1.7E-03	< 1.7E-03
Zn	8.9E-03	4.3E-03	5.3E-03	5.5E-03	5.5E-03

	6/28/93				
	High Volume Filter				
	1	2	3	4	5
As	1.7E-04	1.7E-04	1.7E-04	1.7E-04	8.2E-05
Ba	1.4E-03	1.2E-03	2.0E-03	1.5E-03	1.2E-03
Be	< 8.3E-05	< 8.3E-05	< 8.4E-05	< 8.4E-05	< 8.2E-05
Cd	< 8.3E-04	< 8.3E-04	< 8.4E-04	< 8.4E-04	< 8.2E-04
Cr	< 4.2E-03	< 4.2E-03	< 4.2E-03	< 4.2E-03	< 4.1E-03
Pb	< 4.2E-03	< 4.2E-03	< 4.2E-03	< 4.2E-03	< 4.1E-03
Mn	1.0E-02	5.0E-03	1.8E-02	9.2E-03	6.6E-03
Ni	< 3.3E-03	< 3.3E-03	< 3.4E-03	< 3.3E-03	< 3.3E-03
Zn	1.7E-02	4.2E-03	7.6E-03	1.3E-02	4.9E-03

Table C2-1 (continued)

	7/1/93						7/12/93				
	High Volume Filter						High Volume Filter				
	1	2	3	4	5		1	2	3	4	5
As	1.3E-04	8.8E-05	1.4E-04	1.4E-04	8.8E-05	**As**	9.5E-05	9.4E-05	9.8E-05	9.8E-05	9.5E-05
Ba	1.4E-03	1.2E-03	1.5E-03	1.4E-03	1.3E-03	**Ba**	1.3E-03	2.1E-03	6.5E-04	1.1E-03	9.7E-04
Be	< 4.5E-05	< 4.4E-05	< 4.5E-05	< 4.5E-05	< 4.4E-05	**Be**	< 4.7E-05	< 4.7E-05	< 4.9E-05	< 4.9E-05	< 4.8E-05
Cd	< 4.5E-04	< 4.4E-04	< 4.5E-04	< 4.5E-04	< 4.4E-04	**Cd**	< 4.7E-04	< 4.7E-04	< 4.9E-04	< 4.9E-04	< 4.8E-04
Cr	< 2.2E-03	< 2.2E-03	< 2.3E-03	< 2.3E-03	< 2.2E-03	**Cr**	< 2.4E-03	< 2.3E-03	< 2.5E-03	< 2.5E-03	< 2.4E-03
Pb	3.1E-03	3.1E-03	< 2.3E-03	< 2.3E-03	< 2.2E-03	**Pb**	< 2.4E-03	< 2.3E-03	< 2.5E-03	< 2.5E-03	< 2.4E-03
Mn	4.5E-03	3.1E-03	5.4E-03	4.1E-03	4.0E-03	**Mn**	3.3E-03	3.8E-03	1.5E-03	2.9E-03	2.9E-03
Ni	< 1.8E-03	1.8E-03	< 1.8E-03	< 1.8E-03	< 1.8E-03	**Ni**	< 1.9E-03	< 1.9E-03	< 2.0E-03	< 2.0E-03	< 1.9E-03
Zn	7.1E-03	7.5E-03	7.7E-03	8.2E-03	7.5E-03	**Zn**	5.2E-03	1.3E-02	9.3E-03	7.8E-03	7.6E-03

	7/29/93						8/6/93				
	High Volume Filter						High Volume Filter				
	1	2	3	4	5		1	2	3	4	5
As	3.7E-04	3.2E-04	3.2E-04	2.7E-04	3.2E-04	**As**	1.9E-04	2.0E-04	2.0E-04	2.0E-04	1.9E-04
Ba	1.1E-03	1.0E-03	1.1E-03	9.9E-04	1.2E-03	**Ba**	1.3E-03	1.2E-03	1.3E-03	1.3E-03	1.1E-03
Be	< 5.3E-05	< 5.3E-05	< 5.4E-05	< 5.4E-05	< 5.4E-05	**Be**	< 9.6E-05	< 9.8E-05	< 9.9E-05	< 9.9E-05	< 9.3E-05
Cd	< 5.3E-04	< 5.3E-04	< 5.4E-04	< 5.4E-04	< 5.4E-04	**Cd**	< 9.6E-04	< 9.8E-04	< 9.9E-04	< 9.9E-04	< 9.3E-04
Cr	< 2.6E-03	< 2.7E-03	< 2.7E-03	< 2.7E-03	< 2.7E-03	**Cr**	< 4.8E-03	< 4.9E-03	< 4.9E-03	< 5.0E-03	< 4.7E-03
Pb	3.2E-03	3.2E-03	< 2.7E-03	< 2.7E-03	< 2.7E-03	**Pb**	< 4.8E-03	< 4.9E-03	< 4.9E-03	< 5.0E-03	< 4.7E-03
Mn	5.3E-03	4.3E-03	6.4E-03	5.4E-03	6.5E-03	**Mn**	2.9E-03	2.0E-03	3.0E-03	3.0E-03	2.8E-03
Ni	< 2.1E-03	< 2.1E-03	< 2.1E-03	< 2.2E-03	< 2.2E-03	**Ni**	< 3.9E-03	< 3.9E-03	< 3.9E-03	< 4.0E-03	< 3.7E-03
Zn	1.3E-02	7.4E-03	1.1E-02	1.3E-02	1.0E-02	**Zn**	1.2E-02	6.9E-03	1.2E-02	9.9E-03	1.0E-02

	8/10/93						8/27/93				
	High Volume Filter						High Volume Filter				
	1	2	3	4	5		1	2	3	4	5
As	8.8E-05	9.1E-05	1.3E-04	9.1E-05	8.7E-05	**As**		2.7E-04		2.0E-04	2.2E-04
Ba	7.5E-04	6.2E-04	7.0E-04	7.3E-04	6.1E-04	**Ba**		8.8E-04		7.1E-04	8.6E-04
Be	< 4.4E-05	< 4.6E-05	< 4.4E-05	< 4.5E-05	< 4.4E-05	**Be**		< 2.2E-05		< 2.2E-05	< 2.2E-05
Cd	< 4.4E-04	< 4.6E-04	< 4.4E-04	< 4.5E-04	< 4.4E-04	**Cd**		< 2.2E-04		< 2.2E-04	< 2.2E-04
Cr	< 2.2E-03	< 2.3E-03	< 2.2E-03	< 2.3E-03	< 2.2E-03	**Cr**		< 1.1E-03		< 1.1E-03	< 1.1E-03
Pb	4.0E-03	4.1E-03	4.4E-03	2.7E-03	< 2.2E-03	**Pb**		2.0E-03		1.8E-03	9.2E-03
Mn	2.2E-03	< 4.6E-04	1.8E-03	1.8E-03	1.7E-03	**Mn**		4.6E-03		3.1E-03	5.1E-03
Ni	< 1.8E-03	< 1.8E-03	< 1.8E-03	< 1.8E-03	1.7E-03	**Ni**		1.8E-03		1.5E-03	1.1E-03
Zn	7.5E-03	8.2E-03	6.2E-03	9.5E-03	7.4E-03	**Zn**		5.5E-03		5.5E-03	6.9E-03

	9/28/93						10/6/93				
	High Volume Filter						High Volume Filter				
	1	2	3	4	5		1	2	3	4	5
As	1.3E-04	1.6E-04	1.3E-04	1.8E-04	2.2E-04	**As**	1.9E-04	1.9E-04	2.0E-04	2.7E-04	2.6E-04
Ba	9.6E-04	1.0E-03	1.0E-03	9.2E-04	1.2E-03	**Ba**	1.7E-03	1.5E-03	2.2E-03	1.6E-03	2.3E-03
Be	< 4.3E-05	< 4.1E-05	< 4.4E-05	< 4.4E-05	< 4.3E-05	**Be**	< 6.4E-05	< 6.3E-05	< 6.5E-05	< 6.7E-05	< 6.4E-05
Cd	< 4.3E-04	< 4.1E-04	< 4.4E-04	< 4.4E-04	< 4.3E-04	**Cd**	< 6.4E-04	< 6.3E-04	< 6.5E-04	< 6.7E-04	< 6.4E-04
Cr	< 2.1E-03	< 2.0E-03	< 2.2E-03	< 2.2E-03	< 2.2E-03	**Cr**	< 3.2E-03	< 3.2E-03	< 3.3E-03	< 3.3E-03	< 3.2E-03
Pb	< 2.1E-03	< 2.0E-03	< 2.2E-03	< 2.2E-03	2.6E-03	**Pb**	< 3.2E-03	< 3.2E-03	4.6E-03	< 3.3E-03	5.8E-03
Mn	3.9E-03	4.5E-03	4.0E-03	3.1E-03	5.2E-03	**Mn**	7.7E-03	6.3E-03	1.6E-02	6.7E-03	1.3E-02
Ni	< 1.7E-03	< 1.6E-03	< 1.8E-03	< 1.8E-03	< 1.7E-03	**Ni**	< 2.6E-03	< 2.5E-03	< 2.6E-03	< 2.7E-03	< 2.6E-03
Zn	3.9E-03	7.0E-03	6.2E-03	1.1E-02	6.5E-03	**Zn**	7.1E-03	7.0E-03	5.9E-03	5.3E-03	8.4E-03

Table C2-1 (continued)

10/12/93					
	High Volume Filter				
	1	2	3	4	5
As	< 7.2E-05	< 7.2E-05	7.4E-05	7.4E-05	7.2E-05
Ba	6.3E-04	7.2E-04	4.9E-04	5.4E-04	8.5E-04
Be	< 7.2E-05	< 7.2E-05	< 7.4E-05	< 7.4E-05	< 7.2E-05
Cd	< 7.2E-04	< 7.2E-04	< 7.4E-04	< 7.4E-04	< 7.2E-04
Cr	< 3.6E-03	< 3.6E-03	< 3.7E-03	< 3.7E-03	< 3.6E-03
Pb	< 3.6E-03	< 3.6E-03	< 3.7E-03	< 3.7E-03	5.1E-03
Mn	2.9E-03	3.6E-03	2.2E-03	2.2E-03	5.1E-03
Ni	< 2.9E-03	< 2.9E-03	< 3.0E-03	< 3.0E-03	2.9E-03
Zn	8.7E-03	1.0E-02	5.2E-03	7.4E-03	4.3E-03

10/19/93					
	High Volume Filter				
	1	2	3	4	5
As	1.1E-04	1.1E-04	1.2E-04	1.2E-04	2.3E-04
Ba	1.2E-03	1.1E-03	1.3E-03	1.1E-03	1.5E-03
Be	< 1.1E-04	< 1.1E-04	< 1.2E-04	< 1.2E-04	< 1.1E-04
Cd	< 1.1E-03	< 1.1E-03	< 1.2E-03	< 1.2E-03	< 1.1E-03
Cr	< 5.6E-03	< 5.6E-03	< 5.8E-03	< 5.8E-03	< 5.7E-03
Pb	< 5.6E-03	< 5.6E-03	< 5.8E-03	< 5.8E-03	< 5.7E-03
Mn	3.4E-03	3.4E-03	3.5E-03	3.5E-03	6.9E-03
Ni	< 4.5E-03	< 4.5E-03	< 4.6E-03	< 4.7E-03	< 4.6E-03
Zn	1.1E-02	1.6E-02	5.8E-03	5.8E-03	8.0E-03

10/25/93					
	High Volume Filter				
	1	2	3	4	5
As	1.9E-04	1.9E-04	1.9E-04	< 4.9E-05	2.9E-04
Ba	1.5E-03	1.2E-03	1.4E-03	< 4.9E-05	2.2E-03
Be	< 4.8E-05	< 4.8E-05	< 4.9E-05	< 4.9E-05	< 4.9E-05
Cd	< 4.8E-04	< 4.8E-04	< 4.9E-04	< 4.9E-04	< 4.9E-04
Cr	< 2.4E-03	< 2.4E-03	< 2.4E-03	< 2.5E-03	< 2.4E-03
Pb	< 2.4E-03	< 2.4E-03	< 2.4E-03	< 2.5E-03	2.9E-03
Mn	8.1E-03	6.7E-03	6.8E-03	9.9E-04	1.5E-02
Ni	1.9E-03	1.9E-03	1.9E-03	< 2.0E-03	1.9E-03
Zn	1.1E-02	3.8E-03	4.4E-03	2.5E-03	1.0E-02

11/4/93					
	High Volume Filter				
	1	2	3	4	5
As	1.0E-04	1.0E-04	1.5E-04	1.0E-04	1.5E-04
Ba	1.1E-03	1.0E-03	1.0E-03	8.1E-04	1.7E-03
Be	< 5.0E-05	< 5.0E-05	< 5.1E-05	< 5.2E-05	< 5.1E-05
Cd	< 5.0E-04	< 5.0E-04	< 5.1E-04	< 5.2E-04	< 5.1E-04
Cr	< 2.5E-03	< 2.5E-03	< 2.6E-03	< 2.6E-03	< 2.5E-03
Pb	< 2.5E-03	< 2.5E-03	< 2.6E-03	< 2.6E-03	< 2.5E-03
Mn	7.0E-03	6.6E-03	6.2E-03	4.7E-03	1.2E-02
Ni	< 2.0E-03	2.5E-03	3.1E-03	3.1E-03	3.5E-03
Zn	1.1E-02	5.0E-03	7.2E-03	6.8E-03	1.2E-02

11/18/93					
	High Volume Filter				
	1	2	3	4	5
As	5.8E-05		< 4.7E-04	6.0E-05	5.8E-05
Ba	9.2E-04		6.7E-03	9.6E-04	9.5E-04
Be	< 5.8E-05		< 4.7E-04	< 6.0E-05	< 5.8E-05
Cd	< 5.8E-04		< 4.7E-03	< 6.0E-04	< 5.8E-04
Cr	< 2.9E-03		< 2.4E-02	< 3.0E-03	< 2.9E-03
Pb	< 2.9E-03		< 2.4E-02	< 3.0E-03	< 2.9E-03
Mn	3.5E-03		2.8E-02	3.6E-03	5.8E-03
Ni	< 2.3E-03		< 1.9E-02	< 2.4E-03	< 2.3E-03
Zn	4.6E-03		2.4E-02	3.6E-03	4.6E-03

11/30/93					
	High Volume Filter				
	1	2	3	4	5
As	7.2E-05	7.4E-05	7.3E-05		7.1E-05
Ba	6.0E-04	6.7E-04	6.1E-04		4.3E-04
Be	< 2.4E-05	< 2.5E-05	< 2.4E-05		< 2.4E-05
Cd	< 2.4E-04	< 2.5E-04	< 2.4E-04		< 2.4E-04
Cr	< 1.2E-03	< 1.2E-03	< 1.2E-03		< 1.2E-03
Pb	1.4E-03	1.7E-03	2.2E-03		1.6E-03
Mn	3.1E-03	2.7E-03	2.7E-03		2.8E-03
Ni	< 9.6E-04	< 9.8E-04	< 9.7E-04		< 9.4E-04
Zn	2.9E-03	3.2E-03	2.7E-03		3.8E-03

Table C2-2
STATIC STOCKPILE PERIOD MONITORING RESULTS
TOTAL SUSPENDED PARTICULATES

(μg/m3)

Event	Date	HV-1	HV-2	HV-3	HV-4	HV-5
1	12/7/92	41	39	41	40	38
2	12/22/92	3	24	27	34	29
3	12/29/92	19	17	19	18	18
4	4/16/93	15	17	31	19	22
5	4/19/93	88	83	80	78	107
6	4/21/93	38	36	39	36	38
7	4/28/93	56	45	98	47	59
8	5/4/93	33	30	64	27	34
9	5/7/93	73	67	112	77	73
10	5/11/93	85	82	96	71	121
11	5/19/93	53	58	60	65	70
12	5/29/93	51	53	59	58	64
13	6/3/93	45	46	83	53	63
14	6/10/93	54	57	77	55	68
15	6/24/93	79	68	70	55	64
16	6/28/93	129	94	248	129	93
17	7/1/93	83	69	90	81	76
18	7/12/93	49	62	56	50	57
19	7/29/93	75	60	94	0	101
20	8/6/93	0	0	53	61	46
21	8/10/93	0	36	48	49	41
22	8/27/93	-	76	-	67	122
23	9/29/93	60	72	65	57	100
24	10/6/93	123	99	266	105	221
25	10/12/93	51	55	52	47	86
26	10/19/93	51	47	65	274	124
27	10/25/93	112	94	101	73	261
28	11/4/93	79	74	74	65	109
29	11/15/93	40	0	294	40	57
30	11/30/93	35	33	34	0	36

Table C2-3
AVERAGE CLIMATIC PARAMETERS DURING STATIC STOCKPILE PERIOED MONITORING EVENTS

Date Filter Group Was Placed in Field	Average Wind Speed [1] (mph)	Average Temp [2] (°F)	Average Humidity [3] (%)	Total rain [4] (inches)
12/7/92	3.11	33.9	77	3.61
12/22/92	5.96	28.4	52	0.27
12/29/92	5.3	48.2	68	1.69
4/16/93	7	61.6	82	1.39
4/19/93	5.76	66.2	44	0
4/21/93	5.56	64.2	45	1.97
4/28/93	5.25	66.8	39	0
5/4/93	5.49	64.3	77	0.12
5/7/93	4.36	74.6	34	0
5/11/93	5.24	69.9	41	0
5/19/93	4.56	65.8	50	0.13
5/29/93	4.9	65.5	47	0.52
6/3/93	3.86	68	62	0.4
6/10/93	4.76	75	45	0.84
6/24/93	5.58	81.2	42	0.03
6/28/93	3.85	78.8	50	0.02
7/1/93	3.99	81.7	60	0.73
7/12/93	4.23	80.4	48	0.79
7/29/93	6.23	83.2	46	-
8/6/93	3.42	73.8	59	0.38
8/10/93	3.58	75.9	61	1.94
8/27/93	4.54	77.4	55	0
9/29/93	5.38	59.7	46	0
10/6/93	4.38	61.1	54	0
10/12/93	3.79	57.9	72	0
10/19/93	4.59	57.6	45	0.61
10/25/93	3.95	60	56	0.5
11/4/93	4.18	52	69	0.46
11/15/93	3.34	57	44	0.51
11/30/93	4.22	52	51	0.33

1. Average wind speed as measured by the EWS during fugitive dust collection periods
2. Average temperature measured by the EWS during period filters were in the filed
3. Average humidity measured by the EWS during period filters were in the filed
4. Total rain measured by the EWS which fell during period filters were in the filed

C3

ACTIVE STOCKPILE PERIOD AMBIENT AIR TRACE METAL RESULTS

C3.1 High Volume Sampler TSP Trace Metal

Table C3-1 presents results for the active stockpile period ambient air trace metal testing. The table presents results for nine trace metals for each high volume filter collected for each of the nine active stockpile monitoring events. The results are expressed in terms of ambient air concentrations ($\mu g/m^3$).

The table presents results for high volume samplers 1 to 5 (see Section 5.1.2). High volume samplers 1 to 3 and 5 were re-positioned around the stockpile during active events, while sampler 4 was used to collect background samples. To distinguish between the volume of dust generated during the first hour of a turnover period and that generated during the entire period, one downwind high volume sampler was replaced after the first hour of operation during each event. The results are listed in the table as 1st hr and post 1st hour samples.

C3.2 Personal Air Samplers TSP Trace Metals

Table C3-2 presents the results for the active stockpile period ambient air trace metal testing. The table presents results for trace metals for each area where a TSP PAS was placed for each of the nine active stockpile monitoring events.

The table presents results for TSP PAS samplers placed around the periphery of the stockpile, on the front end loader, and on the loader operator.

Table C3-1
ACTIVE STOCKPILE AIR SAMPLING
TRACE METAL CONCENTRATIONS
(µg/m^3)

EVENT-1						
	High Volume Sampler					
	1	**2**	**3 (1st hr.)**	**3 (post 1st hr.)**	**4**	**5**
As	< 1.6E-04	3.0E-04	< 1.1E-03	3.2E-04	1.6E-04	3.1E-04
Ba	2.4E-03	5.6E-03	1.4E-02	4.5E-03	2.1E-03	3.9E-03
Be	< 1.6E-04	< 1.5E-04	< 1.1E-03	< 1.6E-04	< 1.6E-04	< 1.6E-04
Cd	< 1.6E-03	< 1.5E-03	< 1.1E-02	< 1.6E-03	< 1.6E-03	< 1.6E-03
Cr	< 7.9E-03	< 7.6E-03	< 5.5E-02	< 8.0E-03	< 8.0E-03	< 7.8E-03
Pb	< 7.9E-03	1.2E-02	< 5.5E-02	1.4E-02	< 8.0E-03	1.1E-02
Mn	7.9E-03	1.1E-02	1.1E-02	9.6E-03	4.8E-03	1.4E-02
Ni	< 6.3E-03	< 6.1E-03	< 4.4E-02	< 6.4E-03	< 6.4E-03	< 6.2E-03
Zn	2.4E-02	5.0E-02	1.2E-01	3.8E-02	2.1E-02	3.4E-02

EVENT-2						
	High Volume Sampler					
	1	**2 (1st hr.)**	**2 (post 1st hr.)**	**3**	**4**	**5**
As	1.5E-04	< 1.3E-03	3.8E-04	1.6E-04	1.6E-04	< 1.6E-04
Ba	9.0E-04	7.5E-03	8.8E-03	3.8E-03	1.1E-03	1.3E-03
Be	< 1.5E-04	< 1.3E-03	< 1.9E-04	< 1.6E-04	< 1.6E-04	< 1.6E-04
Cd	< 1.5E-03	< 1.3E-02	< 1.9E-03	< 1.6E-03	< 1.6E-03	< 1.6E-03
Cr	< 7.6E-03	< 6.4E-02	< 9.5E-03	< 7.8E-03	< 7.8E-03	< 8.1E-03
Pb	< 7.6E-03	< 6.4E-02	1.5E-02	< 7.8E-03	< 7.8E-03	< 8.1E-03
Mn	4.6E-03	< 1.3E-02	1.1E-02	4.7E-03	1.6E-03	1.6E-03
Ni	< 6.1E-03	< 5.1E-02	< 7.6E-03	< 6.2E-03	< 6.2E-03	< 6.5E-03
Zn	2.6E-02	3.8E-02	7.8E-02	3.3E-02	4.7E-03	1.9E-02

EVENT-3						
	High Volume Sampler					
	1 (1st hr.)	**1 (post 1st hr.)**	**2**	**3**	**4**	**5**
As	< 8.7E-04	3.5E-04	1.4E-04	< 1.4E-04	< 1.4E-04	4.5E-04
Ba	1.2E-02	1.4E-02	1.0E-03	1.0E-03	1.1E-03	8.9E-03
Be	< 8.7E-04	< 1.7E-04	< 1.4E-04	< 1.4E-04	< 1.4E-04	< 1.5E-04
Cd	< 8.7E-03	< 1.7E-03	< 1.4E-03	< 1.4E-03	< 1.4E-03	< 1.5E-03
Cr	< 4.3E-02	< 8.7E-03	< 6.9E-03	< 7.1E-03	< 7.2E-03	< 7.4E-03
Pb	4.3E-02	4.5E-02	< 6.9E-03	< 7.1E-03	< 7.2E-03	2.2E-02
Mn	8.7E-03	1.9E-02	1.4E-03	1.4E-03	2.9E-03	1.3E-02
Ni	< 3.5E-02	8.7E-03	< 5.6E-03	< 5.7E-03	< 5.8E-03	< 5.9E-03
Zn	9.6E-02	1.4E-01	6.9E-03	8.5E-03	5.8E-03	8.5E-02

Table C3-1 (continued)

	EVENT-4					
	High Volume Sampler					
	1	2 (1st hr.)	2 (post 1st hr.)	3	4	5
As	1.6E-04	< 7.5E-04	2.0E-04	3.1E-04	< 1.6E-04	1.6E-04
Ba	1.7E-03	5.0E-03	1.8E-03	1.8E-03	1.5E-03	1.5E-03
Be	< 1.6E-04	< 7.5E-04	< 2.0E-04	< 1.6E-04	< 1.6E-04	< 1.6E-04
Cd	< 1.6E-03	< 7.5E-03	< 2.0E-03	< 1.6E-03	< 1.6E-03	< 1.6E-03
Cr	< 7.9E-03	< 3.8E-02	< 1.0E-02	< 7.8E-03	< 7.9E-03	< 8.0E-03
Pb	< 7.9E-03	< 3.8E-02	< 1.0E-02	< 7.8E-03	< 7.9E-03	< 8.0E-03
Mn	3.2E-03	7.5E-03	4.0E-03	4.7E-03	3.2E-03	3.2E-03
Ni	< 6.3E-03	< 3.0E-02	< 8.0E-03	< 6.2E-03	< 6.3E-03	< 6.4E-03
Zn	2.5E-02	3.0E-02	1.2E-02	3.6E-02	7.9E-03	9.6E-03

	EVENT-5					
	High Volume Sampler					
	1	2 (1st hr.)	2 (post 1st hr.)	3	4	5
As	1.5E-04	8.0E-04	3.5E-04	2.9E-04	< 1.5E-04	< 1.5E-04
Ba	5.8E-03	1.0E-02	7.0E-03	7.9E-03	1.0E-03	1.2E-03
Be	< 1.5E-04	< 8.0E-04	< 1.7E-04	< 1.4E-04	< 1.5E-04	< 1.5E-04
Cd	< 1.5E-03	< 8.0E-03	< 1.7E-03	< 1.4E-03	< 1.5E-03	< 1.5E-03
Cr	< 7.6E-03	< 4.0E-02	< 8.7E-03	< 7.2E-03	< 7.4E-03	< 7.3E-03
Pb	1.5E-02	< 4.0E-02	2.3E-02	2.3E-02	< 7.4E-03	< 7.3E-03
Mn	1.1E-02	< 8.0E-03	1.2E-02	1.4E-02	3.0E-03	2.9E-03
Ni	< 6.1E-03	< 3.2E-02	< 7.0E-03	< 5.8E-03	< 5.9E-03	< 5.8E-03
Zn	5.8E-02	1.0E-01	6.8E-02	7.4E-02	4.4E-03	1.3E-02

	EVENT-6					
	High Volume Sampler					
	1	2	3	4	5 (1st hr.)	5 (post 1st hr.)
As	3.0E-04	4.3E-04	2.9E-04	1.5E-04	< 7.9E-04	1.8E-04
Ba	2.8E-03	1.0E-02	2.5E-03	1.3E-03	4.2E-03	2.5E-03
Be	< 1.5E-04	< 1.4E-04	< 1.5E-04	< 1.5E-04	< 7.9E-04	< 1.8E-04
Cd	< 1.5E-03	< 1.4E-03	< 1.5E-03	< 1.5E-03	< 7.9E-03	< 1.8E-03
Cr	< 7.5E-03	< 7.2E-03	< 7.3E-03	< 7.3E-03	< 3.9E-02	< 9.1E-03
Pb	< 7.5E-03	2.0E-02	< 7.3E-03	< 7.3E-03	< 3.9E-02	< 9.1E-03
Mn	9.0E-03	1.9E-02	8.8E-03	2.9E-03	< 7.9E-03	7.3E-03
Ni	6.0E-03	5.8E-03	5.8E-03	< 5.8E-03	< 3.1E-02	< 7.3E-03
Zn	3.7E-02	1.0E-01	2.2E-02	4.4E-03	3.1E-02	1.6E-02

Table C3-1 (continued)

EVENT-7						
	High Volume Sampler					
	1 (1st hr.)	**1 (post 1st hr.)**	**2**	**3**	**4**	**5**
As	1.0E-03	7.3E-04	7.2E-04	5.6E-04	5.8E-04	4.3E-04
Ba	1.6E-02	8.4E-03	9.3E-03	8.1E-03	2.8E-03	3.0E-03
Be	< 1.0E-03	< 1.8E-04	< 1.4E-04	< 1.4E-04	< 1.5E-04	< 1.4E-04
Cd	< 1.0E-02	< 1.8E-03	< 1.4E-03	< 1.4E-03	< 1.5E-03	< 1.4E-03
Cr	< 5.2E-02	< 9.1E-03	< 7.2E-03	< 7.1E-03	< 7.3E-03	< 7.2E-03
Pb	< 5.2E-02	1.1E-02	2.2E-02	1.7E-02	< 7.3E-03	< 7.2E-03
Mn	3.1E-02	2.4E-02	2.8E-02	2.4E-02	1.3E-02	1.7E-02
Ni	< 4.2E-02	< 7.3E-03	< 5.8E-03	< 5.6E-03	< 5.8E-03	< 5.8E-03
Zn	1.3E-01	6.7E-02	7.7E-02	6.4E-02	1.3E-02	1.3E-02

EVENT-8						
	High Volume Sampler					
	1	**2**	**3**	**4**	**5 (1st hr.)**	**5 (post 1st hr.)**
As	< 1.4E-04	< 1.4E-04	5.7E-04	< 1.5E-04	< 7.1E-04	7.2E-04
Ba	4.6E-04	1.7E-03	1.6E-02	4.5E-04	1.6E-02	1.9E-02
Be	< 1.4E-04	< 1.4E-04	< 1.4E-04	< 1.5E-04	< 7.1E-04	< 1.8E-04
Cd	< 1.4E-03	< 1.4E-03	< 1.4E-03	< 1.5E-03	< 7.1E-03	< 1.8E-03
Cr	< 7.0E-03	< 7.2E-03	< 7.1E-03	< 7.3E-03	< 3.6E-02	< 9.0E-03
Pb	< 7.0E-03	< 7.2E-03	4.7E-02	< 7.3E-03	5.7E-02	5.9E-02
Mn	2.8E-03	4.3E-03	2.7E-02	2.9E-03	2.9E-02	3.2E-02
Ni	< 5.6E-03	< 5.7E-03	< 5.7E-03	< 5.8E-03	< 2.9E-02	< 7.2E-03
Zn	1.8E-02	2.1E-02	1.8E-01	1.6E-02	2.1E-01	2.1E-01

EVENT-9						
	High Volume Sampler					
	1	**2**	**3**	**4**	**5 (1st hr.)**	**5 (post 1st hr.)**
As	1.3E-04	5.3E-04	2.6E-04	2.7E-04	7.8E-04	3.3E-04
Ba	2.0E-03	9.4E-03	6.5E-03	2.3E-03	6.1E-03	5.8E-03
Be	< 1.3E-04	< 1.3E-04	< 1.3E-04	< 1.4E-04	< 7.8E-04	< 1.6E-04
Cd	< 1.3E-03	< 1.3E-03	< 1.3E-03	< 1.4E-03	< 7.8E-03	< 1.6E-03
Cr	< 6.5E-03	< 6.6E-03	< 6.6E-03	< 6.8E-03	< 3.9E-02	< 8.2E-03
Pb	7.8E-03	3.0E-02	2.1E-02	< 6.8E-03	< 3.9E-02	1.5E-02
Mn	6.5E-03	1.7E-02	1.3E-02	8.2E-03	7.8E-03	1.2E-02
Ni	< 5.2E-03	< 5.3E-03	< 5.3E-03	5.5E-03	< 3.1E-02	< 6.6E-03
Zn	2.3E-02	1.0E-01	6.8E-02	1.1E-02	1.2E-01	5.4E-02

Table C3-2
ACTIVE STOCKPILE PERSONAL AIR SAMPLER TRACE METAL CONCENTRATIONS
mg/m^3

EVENT-1					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	0.000043	< 0.00086	< 0.000043	< 0.000062	< 0.00014
Ba	< 0.0015	< 0.03	< 0.0015	< 0.0022	< 0.0048
Be	< 0.00015	< 0.003	< 0.00015	< 0.00022	< 0.00048
Cd	< 0.00015	< 0.003	< 0.00015	< 0.00022	< 0.00048
Cr	0.0003	< 0.003	< 0.00015	< 0.00022	< 0.00048
Hg	0.000155	0.000377	0.000357	0.00014	-
Pb	0.00045	< 0.003	0.00091	< 0.00022	0.00096
Mn	0.0003	< 0.003	< 0.00015	< 0.00022	< 0.00048
Ni	0.00015	0.003	< 0.00015	0.00022	< 0.00048
Zn	0.0013	< 0.003	< 0.00015	0.0011	< 0.00048

EVENT-2					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	< 0.000075	0.00076	< 0.000075	< 0.000076	< 0.00076
Ba	< 0.0042	< 0.0042	< 0.0042	< 0.0042	< 0.0042
Be	< 0.00042	< 0.00042	< 0.00042	< 0.00042	< 0.00042
Cd	< 0.00042	< 0.00042	0.00042	< 0.00042	< 0.00042
Cr	< 0.00042	< 0.00042	< 0.00042	0.00085	< 0.00042
Hg	0.000126	0.00010	0.000087	0.000037	-
Pb	< 0.00042	0.0017	0.00084	< 0.00042	0.00042
Mn	< 0.00042	0.00042	0.0046	< 0.00042	< 0.00042
Ni	< 0.00042	< 0.00042	< 0.00042	< 0.00042	< 0.00042
Zn	0.00042	0.0051	0.04	0.00085	< 0.00042

EVENT-3					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	< 0.000076	< 0.000074	< 0.000072	< 0.000074	< 0.00071
Ba	< 0.0043	< 0.0042	< 0.004	< 0.0041	< 0.004
Be	< 0.00043	< 0.00042	< 0.0004	< 0.00041	< 0.0004
Cd	< 0.00043	< 0.00042	< 0.0004	< 0.00041	< 0.0004
Cr	< 0.00043	< 0.00042	< 0.0004	< 0.00041	< 0.0004
Hg	0.000112	0.00011	0.000052	0.000201	-
Pb	0.0013	0.0012	< 0.0004	< 0.00041	< 0.0004
Mn	0.00043	0.00042	< 0.0004	< 0.00041	< 0.0004
Ni	0.00043	< 0.00042	< 0.0004	0.00041	< 0.0004
Zn	0.003	0.0037	0.0008	0.00083	0.0004

Table C3-2 (continued)

EVENT-4					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	< 0.00008	< 0.00008	< 0.000081	0.00011	< 0.00008
Ba	< 0.00017	0.0024	0.00034	0.00034	0.00017
Be	< 0.00017	< 0.00017	< 0.00017	< 0.00017	< 0.00017
Cd	< 0.00017	< 0.00017	< 0.00017	< 0.00017	< 0.00017
Cr	< 0.00017	0.00017	< 0.00017	< 0.00017	0.00017
Hg	0.000046	0.00005	0.00004	0.000079	-
Pb	< 0.00017	0.001	< 0.00017	< 0.00017	< 0.00017
Mn	< 0.00017	0.001	< 0.00017	< 0.00017	< 0.00017
Ni	< 0.00017	< 0.00017	< 0.00017	< 0.00017	< 0.00017
Zn	0.00034	0.0074	< 0.00017	< 0.00017	0.00052

EVENT-5					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	< 0.00007	0.00013	< 0.000072	< 0.000072	< 0.00007
Ba	0.00075	0.0045	0.00062	0.00046	0.0003
Be	< 0.00015	< 0.00015	< 0.00015	< 0.00015	< 0.00015
Cd	< 0.00015	< 0.00015	< 0.00015	< 0.00015	< 0.00015
Cr	< 0.00015	0.00015	< 0.00015	< 0.00015	< 0.00015
Hg	0.000041	0.00004	0.000031	0.000035	0.000035
Pb	< 0.00015	0.006	< 0.00015	< 0.00015	< 0.00015
Mn	0.0003	0.0034	< 0.00015	< 0.000153	< 0.00015
Ni	< 0.00015	0.0003	< 0.00015	< 0.00015	< 0.00015
Zn	0.0026	0.021	0.0012	0.00046	< 0.00015

EVENT-6					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	< 0.000071	< 0.000069	< 0.000069	< 0.000068	< 0.000067
Ba	0.00031	0.0017	0.00015	< 0.00015	0.00015
Be	< 0.00015	< 0.00015	< 0.00015	< 0.00015	< 0.00015
Cd	< 0.00015	< 0.00015	< 0.00015	< 0.00015	< 0.00015
Cr	0.00031	< 0.00015	0.00060	0.00015	0.00029
Hg	0.000051	< 0.00003	< 0.00003	< 0.000024	-
Pb	0.00093	0.0020	0.00075	0.00030	0.00044
Mn	0.00031	0.0011	0.00045	< 0.00015	< 0.00015
Ni	0.00015	0.00015	0.00030	< 0.00015	0.00015
Zn	0.0018	0.0058	0.0012	0.00030	0.00029

Table C3-2 (continued)

EVENT-7					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	< 0.000061	< 0.00038	< 0.000061	< 0.000063	< 0.00007
Ba	0.00027	0.0016	0.00027	< 0.00014	0.00015
Be	< 0.00013	< 0.00083	< 0.00013	< 0.00014	< 0.00015
Cd	< 0.00013	< 0.00083	< 0.00013	< 0.00014	< 0.00015
Cr	0.00013	0.0016	0.00013	0.00014	0.00015
Hg	-	-	-	-	-
Pb	0.0008	0.005	0.00054	< 0.00014	0.00061
Mn	0.0004	0.00083	0.00027	0.00014	0.00015
Ni	< 0.00013	< 0.00083	< 0.00013	0.00014	< 0.00015
Zn	0.0015	0.01	0.0017	< 0.00014	0.00015

EVENT-8					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	< 0.00019	< 0.00019	< 0.00019	< 0.00019	< 0.00019
Ba	< 0.0037	< 0.0036	< 0.0038	< 0.0038	< 0.0037
Be	< 0.00037	< 0.00036	< 0.00038	< 0.00038	< 0.00037
Cd	< 0.00037	< 0.00036	< 0.00038	< 0.00038	< 0.00037
Cr	< 0.0037	< 0.0036	< 0.00380	0.0038	< 0.0037
Hg	< 0.000023	< 0.00003	< 0.000022	< 0.000022	-
Pb	0.0022	0.0036	< 0.0019	0.00300	< 0.0019
Mn	< 0.00037	0.0018	< 0.00038	< 0.00038	< 0.00037
Ni	< 0.00037	< 0.00036	0.00038	0.00038	0.0011
Zn	< 0.00037	0.01	< 0.00038	< 0.00038	< 0.00037

EVENT-9					
	PAS Location				
Parameter	Operator	Loader	Adjacent to Pad		
As	< 0.00017	< 0.00018	0.00076	< 0.00018	< 0.00018
Ba	< 0.0034	< 0.0035	< 0.0033	< 0.0035	< 0.0034
Be	< 0.00034	< 0.00035	< 0.00033	< 0.00035	< 0.00034
Cd	0.00034	0.00035	< 0.00033	< 0.00035	< 0.00034
Cr	< 0.0034	< 0.0035	< 0.0033	< 0.0035	< 0.0034
Hg	0.00002	0.00002	0.000022	0.000021	-
Pb	< 0.0017	0.0038	< 0.0016	< 0.0017	< 0.0017
Mn	< 0.00034	0.00069	< 0.00033	< 0.00035	< 0.00034
Ni	0.00068	0.0014	0.00066	0.0010	0.0010
Zn	< 0.00034	0.0038	< 0.00033	< 0.00035	0.0048

C4

ACTIVE STOCKPILE PERIOD
SEM RESULTS

Appendix C4 presents the results of the SEM particle size analyses of samples collected during Stockpile Turnover Periods 6 through 9.

C4.1 Sample Collections

Samples for SEM size analysis were collected during four stockpile turnover periods (periods 6, 7, 8 and 9), using personal air samplers (PAS). TSP samples were collected during periods 6 through 9, while PM_{10} samples were collected only during periods 6 and 7 due to equipment limitations.

The PAS filters were sent to the State University of New York at Stony Brook for SEM analysis. Appendix C1.4 describes SEM particle size analysis methods in greater detail.

C4.2 SEM Particle Size Classification Results

Table C4-1 presents the results of the SEM size classifications for the samples collected using the TSP personal air sampler. Results, expressed in terms of percent of particles measured in the given size category, are presented for each of the four events.

Table C4-2 presents the results of the SEM size classification for the samples collected using the PM_{10} PAS. Results are expressed in terms of the percent of particles measured in the given size category. Results are presented for events 6 and 7.

Appendix D

STOCKPILE RUNOFF AND GROUNDWATER ASSESSMENT METHODS

Appendix D discusses the methods used to estimate runoff quantities and quality from the bottom ash stockpile. This appendix also describes the methods used in the groundwater modeling assessment, including the groundwater model and required parameters. The appendix consists of the following sections:

D1 Estimation of Expected Stockpile Runoff from Rainfall Data
D2 Runoff Trace Metal Concentration Estimating Procedures
D3 Groundwater Model Description
D4 Comparison of Groundwater Model Aquifer Parameters

D1

ESTIMATION OF EXPECTED STOCKPILE RUNOFF FROM RAINFALL DATA

Appendix D1 presents the data and calculations used to derive expected bottom ash stockpile runoff values from historical rainfall data.

D1.1 RAINFALL DATA

Hourly precipitation data was obtained from the National Climatic Data Center (NCDC) for the weather station located at JFK International Airport in New York. Precipitation values were obtained for the years 1989 through 1993. The data from JFK International Airport was used because rainfall was recorded to the nearest 0.01 inches. Hourly rainfall data included values for year, month, day, and hour.

D1.2 CALCULATION OF RAINFALL EVENTS

The hourly rainfall data was divided into discrete rainfall events, with specific rainfall amounts and durations. Average rainfall event intensity was then calculated for each event and the runoff coefficient was calculated using the equation developed in Section 7.1.

A rainfall event was defined by a continuous recording of hourly precipitation values. A break in the data for a one-hour interval was considered the end of an event. Rainfall event precipitation totals were calculated by summing all hourly precipitation readings for each event. Duration was calculated by summing the total number of hours in the rainfall event. It was assumed that, on the average, the event started and ended in the middle of the hour; therefore, one-half hour was subtracted to account for the starting time and one-half hour was subtracted to account for the ending time. If the event consisted of only one hourly reading, the event time was assumed to be one-half hour.

D1.3 MONTHLY RUNOFF ESTIMATES

Table D1-1 presents a list of monthly rainfall totals, total estimated time per month that it rained, average rainfall intensity, calculated runoff coefficient and calculated runoff. Values are presented for each month for the years 1989 through 1993. The table also presents the average values used to perform the assessments outlined in Section 7. Figures D1-1 to D1-5 depict the rainfall, runoff and runoff coefficient values in a graphical format.

Table D1-1
RAINFALL DATA AND CALCULATED RUNOFF

Year	Month	Total		Intensity (in./hr.)	Runoff Coeficient K_R	Runoff (inches)
		Rain (inches)	Time (hrs)			
1989	January	2.08	27.5	0.076	0.65	1.35
	February	2.64	46	0.057	0.61	1.61
	March	4.17	52	0.080	0.66	2.74
	April	3.71	61	0.061	0.62	2.29
	May	10.71	81	0.132	0.73	7.84
	June	8.07	53.5	0.151	0.75	6.06
	July	5.99	38	0.158	0.76	4.54
	August	4.35	29	0.150	0.75	3.26
	September	4.31	36.5	0.118	0.72	3.08
	October	6.58	61	0.108	0.70	4.62
	November	2.51	48.5	0.052	0.59	1.49
	December	0.61	9.5	0.064	0.62	0.38
1990	January	4.41	60	0.073	0.64	2.84
	February	1.17	35.5	0.033	0.53	0.62
	March	2.32	55.5	0.042	0.56	1.30
	April	4.64	56.5	0.082	0.66	3.07
	May	6.97	63	0.111	0.71	4.92
	June	2.37	20.5	0.116	0.71	1.69
	July	4.37	20	0.219	0.81	3.52
	August	6.68	41.5	0.161	0.76	5.08
	September	1.8	20.5	0.088	0.67	1.21
	October	5.03	32	0.157	0.76	3.81
	November	1.59	23	0.069	0.64	1.01
	December	3.89	62.5	0.062	0.62	2.41
1991	January	3.73	54.5	0.068	0.63	2.37
	February	1.58	56.5	0.028	0.50	0.79
	March	3.63	61	0.060	0.61	2.23
	April	3.9	58	0.067	0.63	2.46
	May	4.2	15	0.280	0.84	3.54
	June	1.9	22	0.086	0.67	1.27
	July	2.48	21.5	0.115	0.71	1.76
	August	7.59	32	0.237	0.82	6.21
	September	2.79	34	0.082	0.66	1.84
	October	1.52	16	0.095	0.68	1.04
	November	1.77	26	0.068	0.63	1.12
	December	3.64	63	0.058	0.61	2.22

Table D1-1 continued

Year	Month	Total		Intensity	Runoff Coeficient	Runoff
		Rain (inches)	Time (hrs)	(in./hr.)	K_R	(inches)
1992	January	1.34	33	0.041	0.56	0.75
	February	1.52	32.5	0.047	0.58	0.88
	March	3.23	53.5	0.060	0.62	1.99
	April	1.36	19.5	0.070	0.64	0.87
	May	3.49	38.5	0.091	0.68	2.36
	June	2.57	24	0.107	0.70	1.80
	July	5.75	47.5	0.121	0.72	4.13
	August	5.31	49.5	0.107	0.70	3.72
	September	1.78	31	0.057	0.61	1.08
	October	1.56	22.5	0.069	0.64	0.99
	November	5.53	57.5	0.096	0.68	3.79
	December	4.93	79.5	0.062	0.62	3.06
1993	January	2	40	0.050	0.59	1.18
	February	2.2	52	0.042	0.56	1.24
	March	6.83	77	0.089	0.67	4.59
	April	3.06	32	0.096	0.68	2.09
	May	1.88	13.5	0.139	0.74	1.39
	June	1.13	14	0.081	0.66	0.74
	July	2.39	18	0.133	0.73	1.75
	August	2.17	22	0.099	0.69	1.49
	September	5.55	44.5	0.125	0.72	4.01
	October	3.72	55.5	0.067	0.63	2.35
	November	0.88	13	0.068	0.63	0.56
	December	3.78	70	0.054	0.60	2.27
5-Yr Avg	January	2.7	43.0	0.1	0.61	1.7
	February	1.8	44.5	0.0	0.56	1.0
	March	4.0	59.8	0.1	0.62	2.6
	April	3.3	45.4	0.1	0.65	2.2
	May	5.5	42.2	0.2	0.74	4.0
	June	3.2	26.8	0.1	0.70	2.3
	July	4.2	29.0	0.1	0.75	3.1
	August	5.2	34.8	0.2	0.74	4.0
	September	3.2	33.3	0.1	0.68	2.2
	October	3.7	37.4	0.1	0.68	2.6
	November	2.5	33.6	0.1	0.64	1.6
	December	3.4	56.9	0.1	0.61	2.1

Figure D1-1
1989
Rainfall, Expected Runoff (K_R)

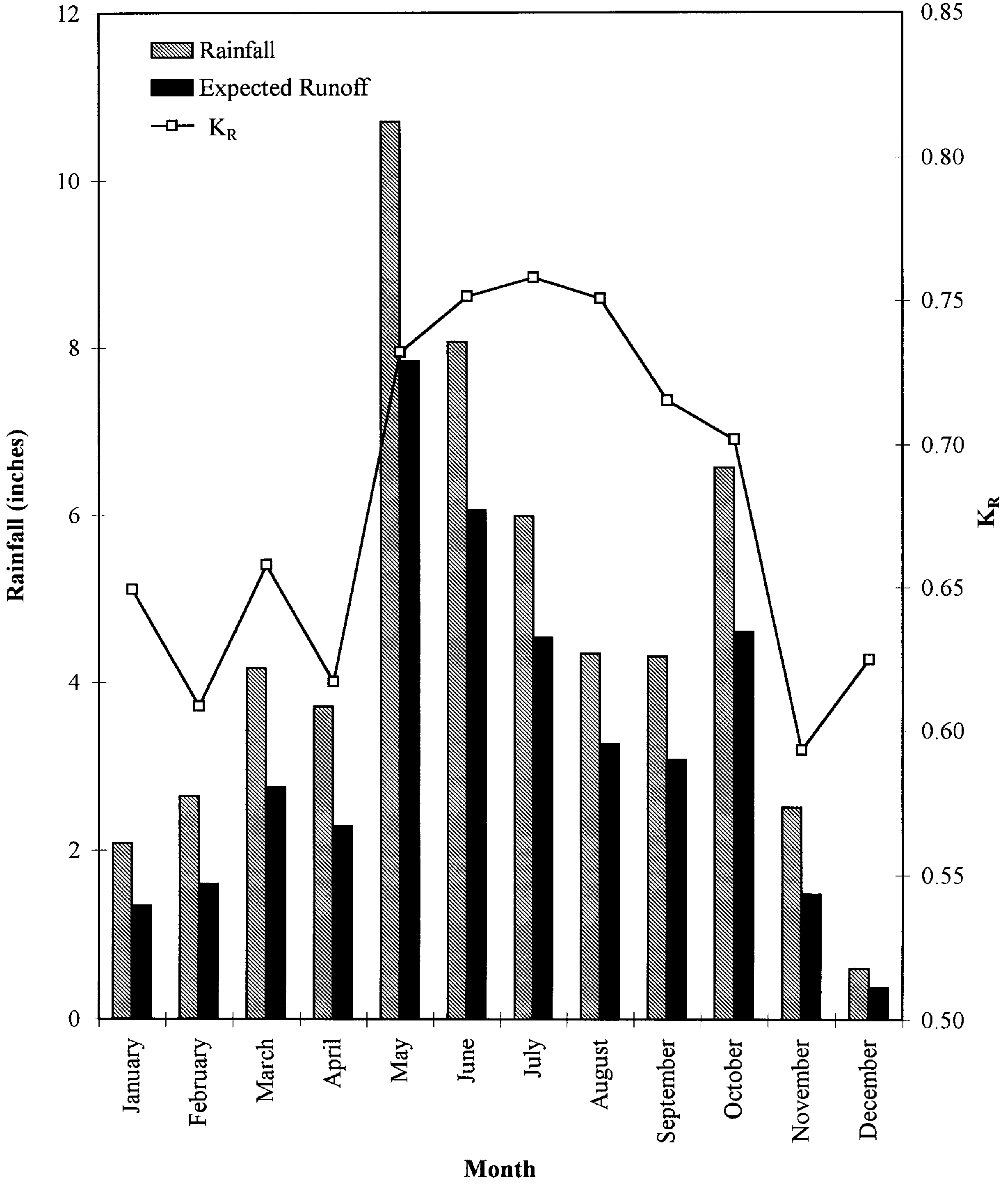


Figure D1-2
1990
Rainfall, Expected Runoff (K_R)

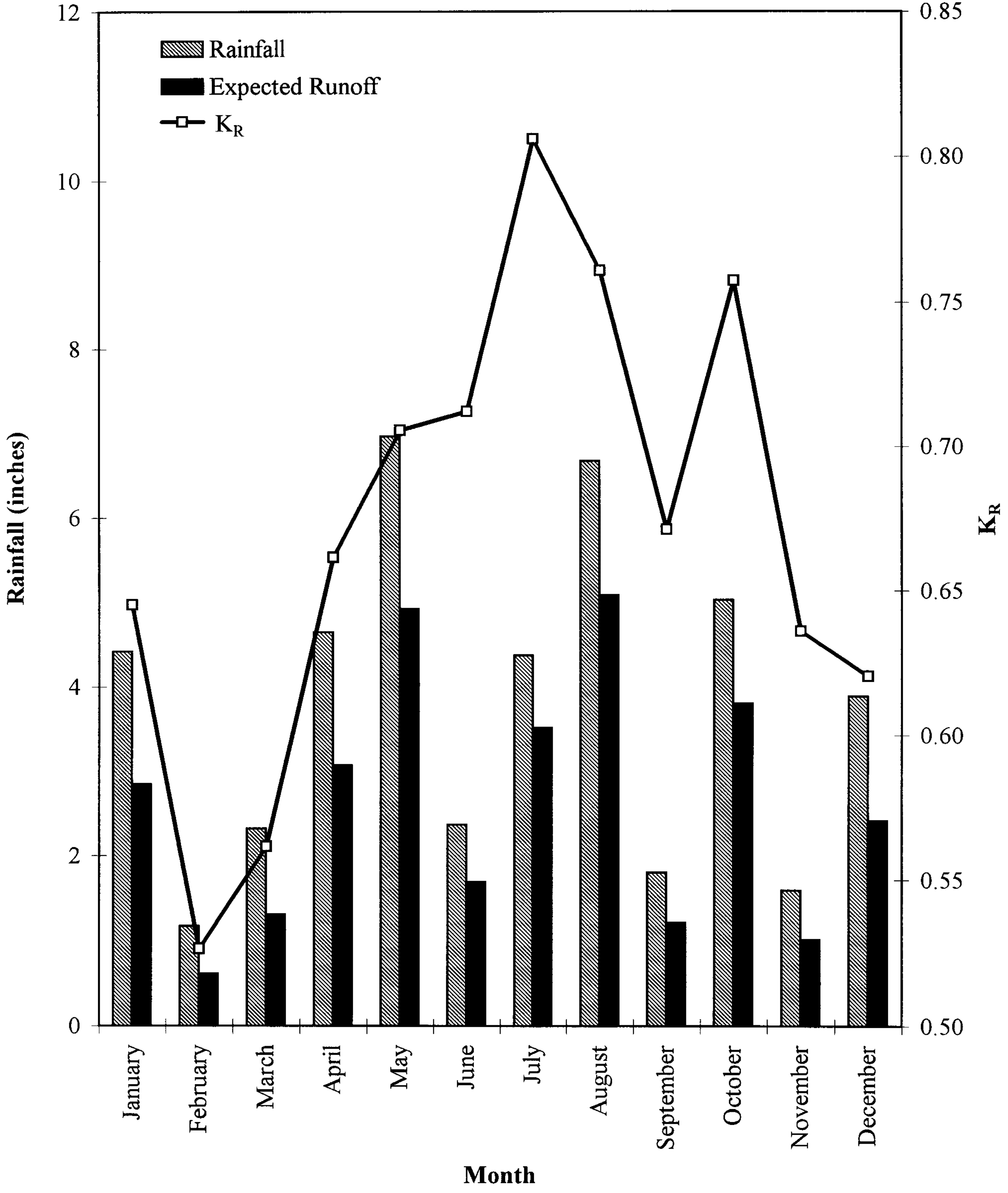


Figure D1-3
1991
Rainfall, Expected Runoff (K_R)

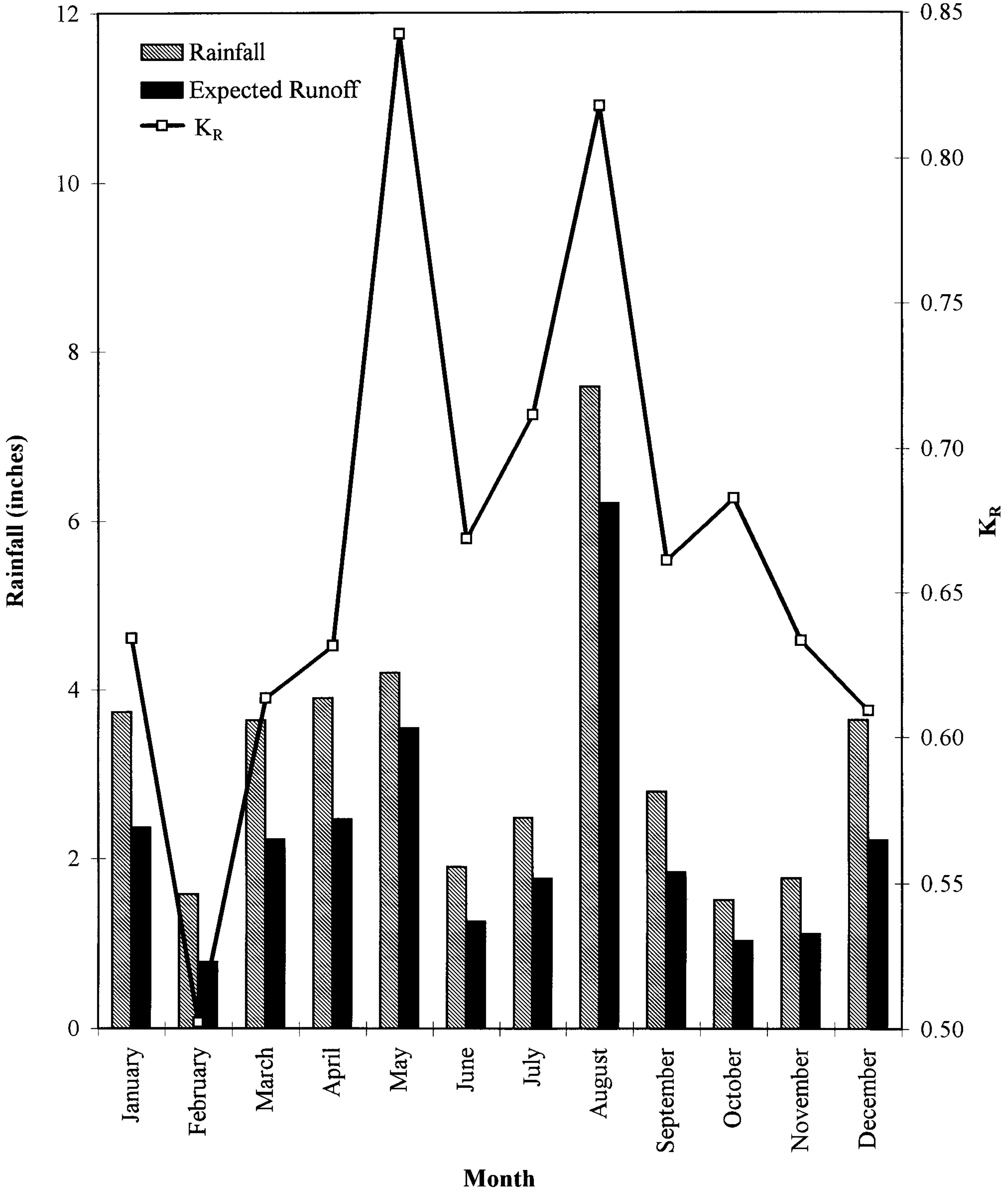


Figure D1-4
1992
Rainfall, Expected Runoff (K_R)

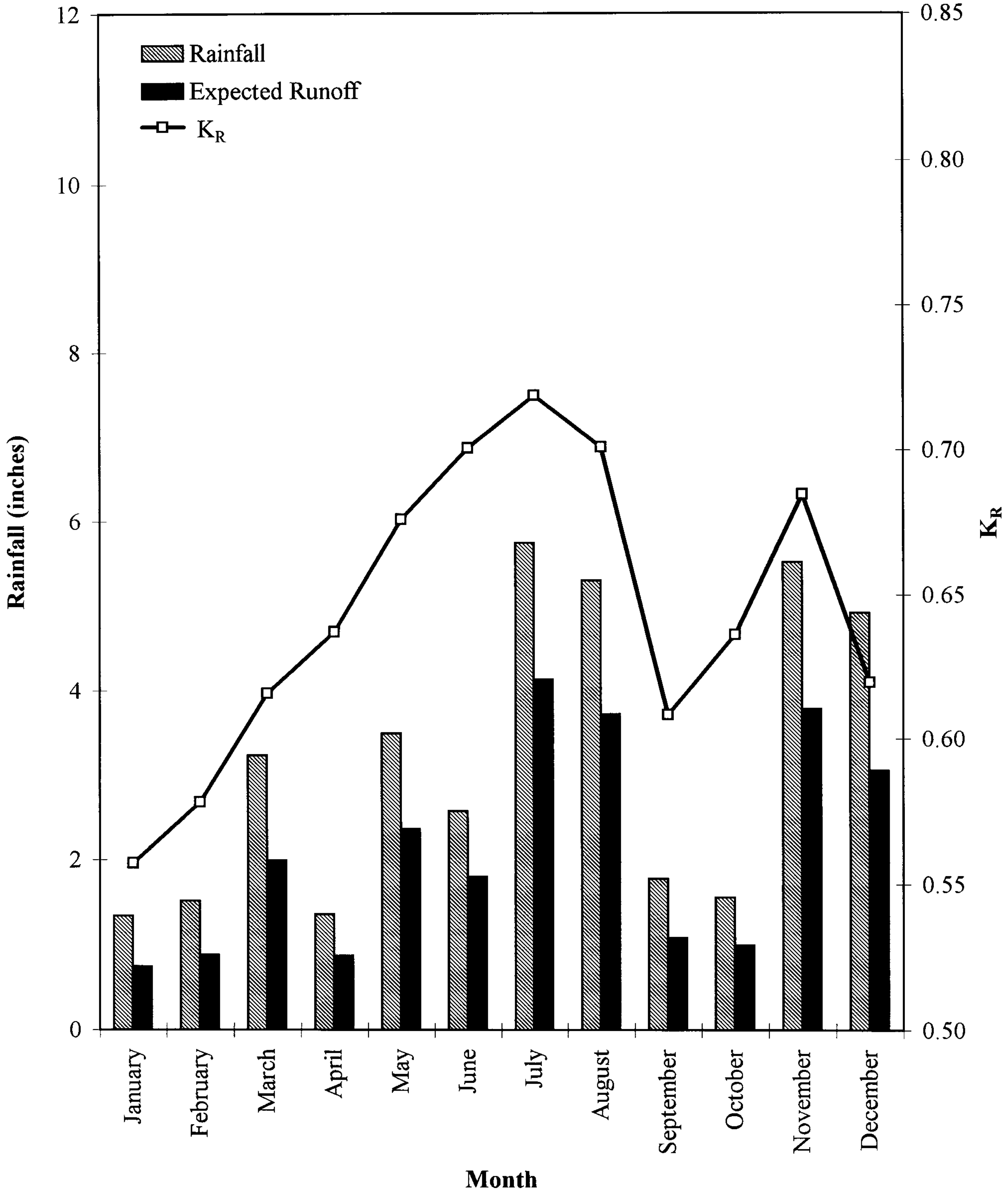
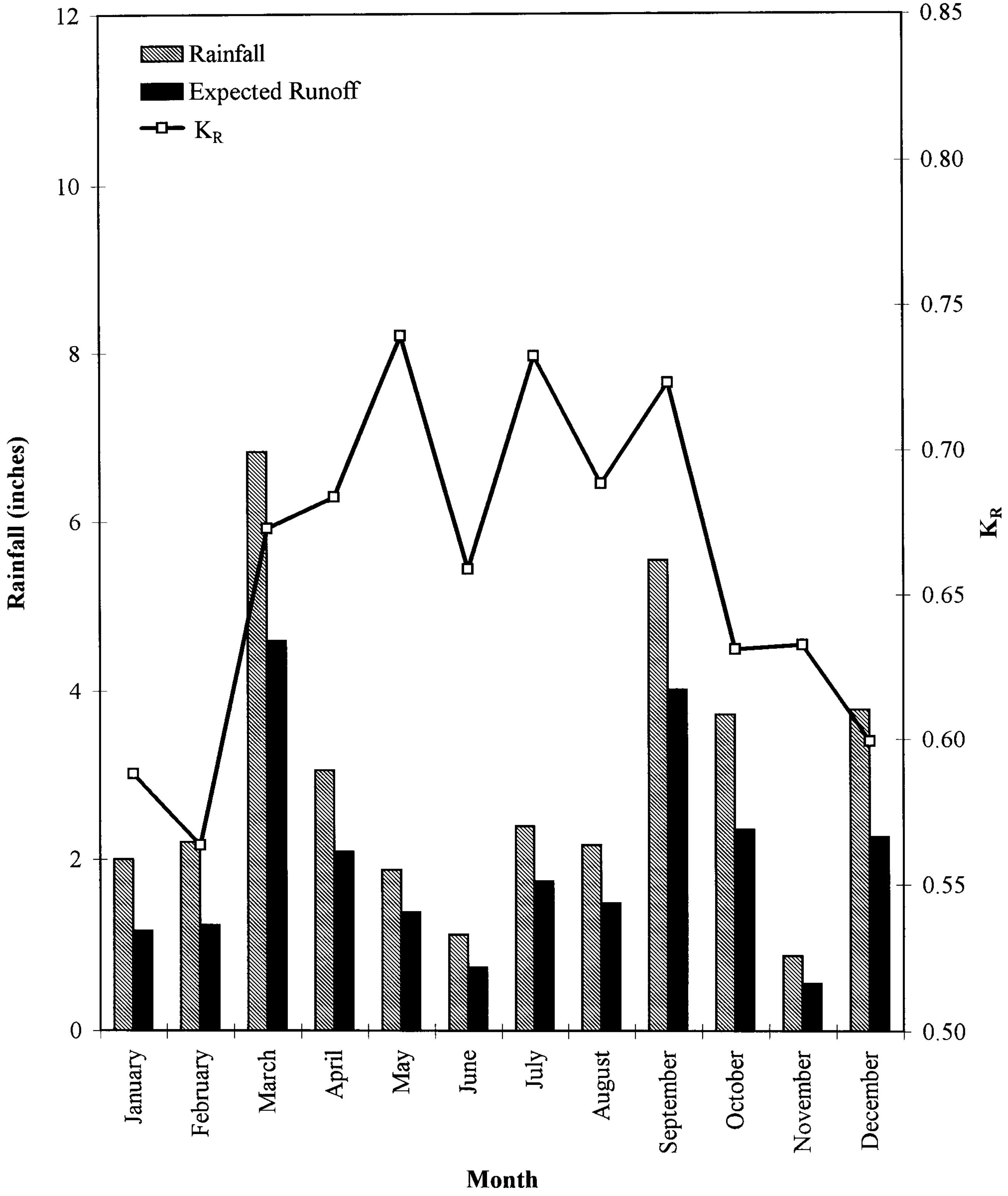


Figure D1-5
1993
Rainfall, Expected Runoff (K_R)



D2

RUNOFF TRACE METAL CONCENTRATION ESTIMATING PROCEDURES

Appendix D2 describes the procedures used to estimate rainfall intensity and runoff trace metal concentrations used in the groundwater, surface water and sediment impact assessments.

D2.1 AVERAGE RAINFALL INTENSITY

The average rainfall intensity used in the analysis was calculated using the total rainfall in a given event measured by the duration of the event. Both rainfall amount and duration were obtained from the Electronic Weather Station (EWS) records. The EWS was located adjacent to the stockpile pad (see Section 4 for more details).

D2.2 RUNOFF ELEMENTAL CONCENTRATION

Stockpile runoff samples were collected from December 1992 to December 1993 using two methods -- a 300-gallon sampling tank or an automatic sampler (see Appendix B1). Samples were analyzed for total and dissolved trace metals. Elemental concentrations used in this analysis were the dissolved trace metal concentrations. Data from the samples collected by both sampling methods were used as long as a complete rainfall record was available for the runoff sample.

D2.3 RAINFALL INTENSITY VERSUS RUNOFF TRACE METAL CONCENTRATIONS

Figures D2-1 to D2-22 show the relation between runoff concentrations and rainfall intensity for all trace metals measured over the course of the monitoring project, as well as for chlorides, sulfates and solids. The figures also indicate the value of the method detection limit for each trace metal.

The figures show no discernible correlation between runoff concentrations and average rainfall intensity. Based primarily on this analysis, the upper 90% confidence limit concentrations were selected for use as the average runoff trace metal concentrations in the groundwater and surface water quality assessments presented in Section 7. Figures D2-1 to D2-22 indicate average concentrations and upper 90% confidence values, and where relevant, the method detection limit.

Figure D2-1
RAINFALL INTENSITY VERSUS SILVER DISSOLVED RUNOFF CONCENTRATION

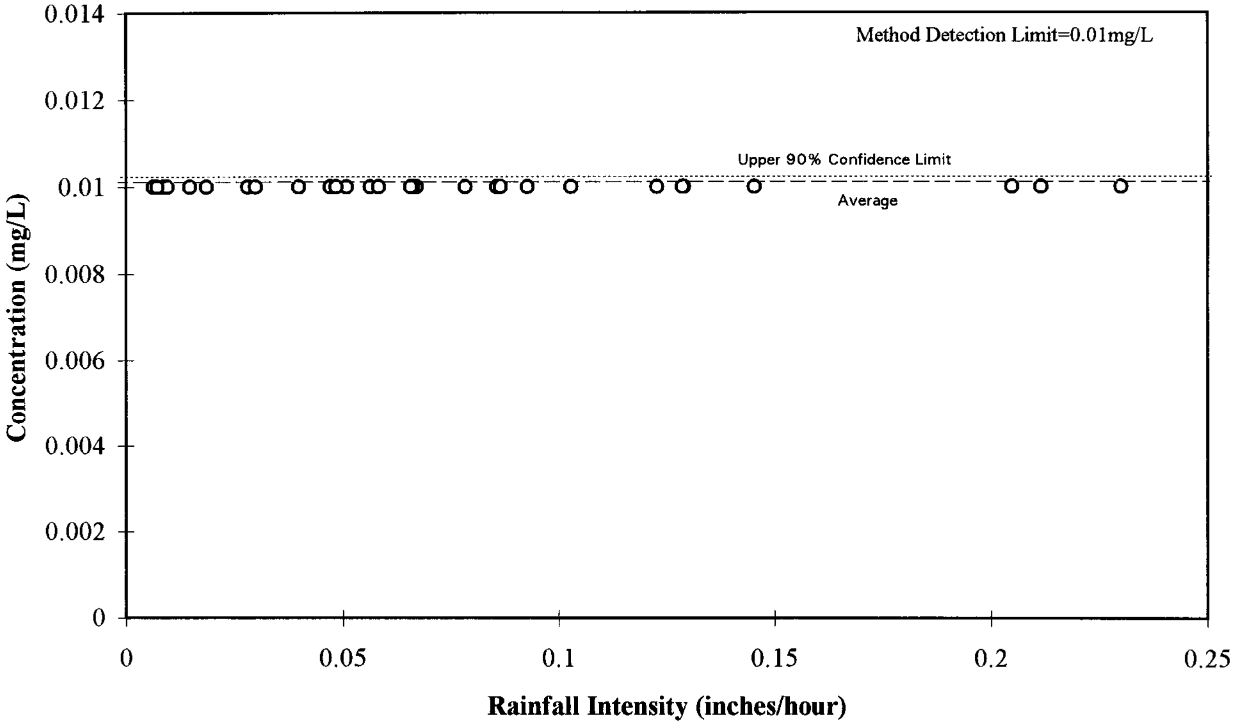


Figure D2-2
RAINFALL INTENSITY VERSUS ALUMINUM DISSOLVED RUNOFF CONCENTRATION

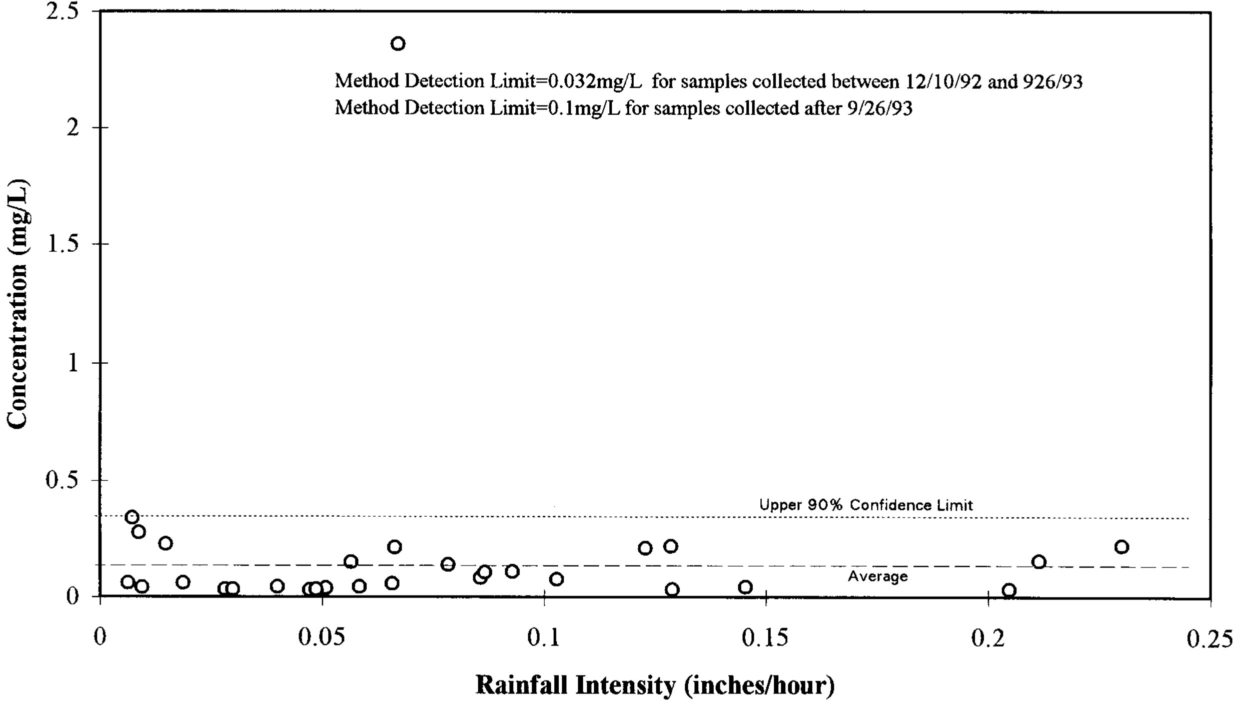


Figure D2-3
RAINFALL INTENSITY VERSUS ARSENIC DISSOLVED RUNOFF CONCENTRATION

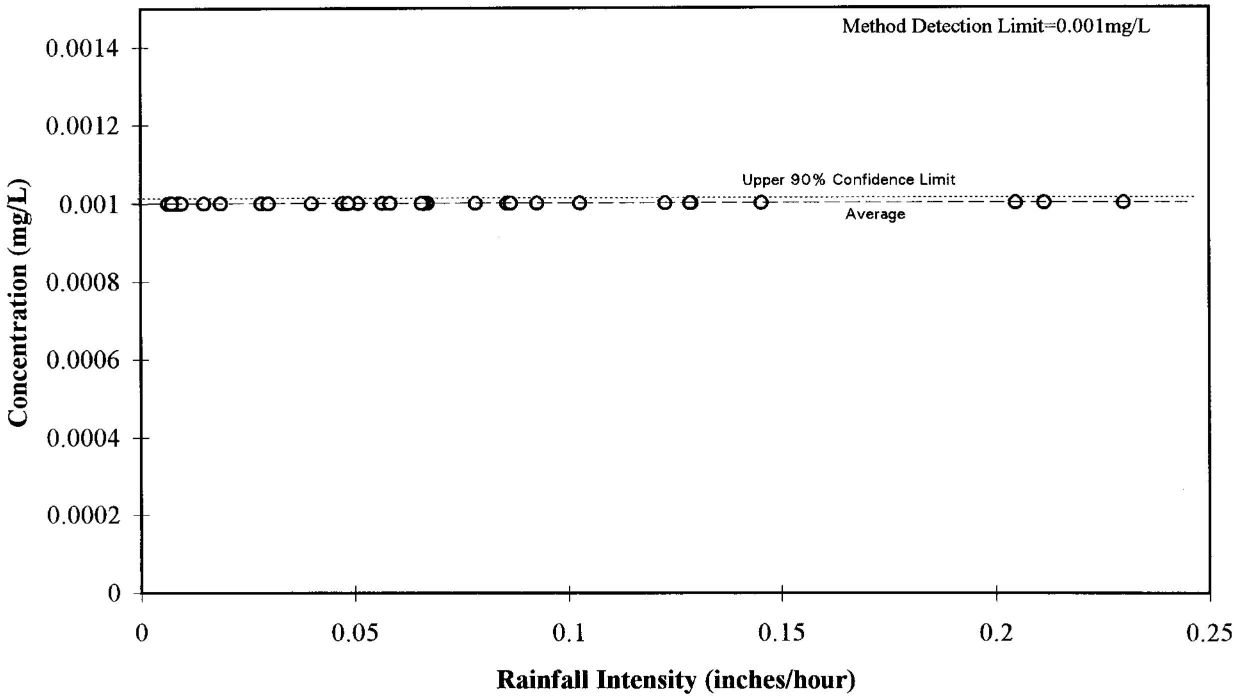


Figure D2-4
RAINFALL INTENSITY VERSUS BARIUM DISSOLVED RUNOFF CONCENTRATION

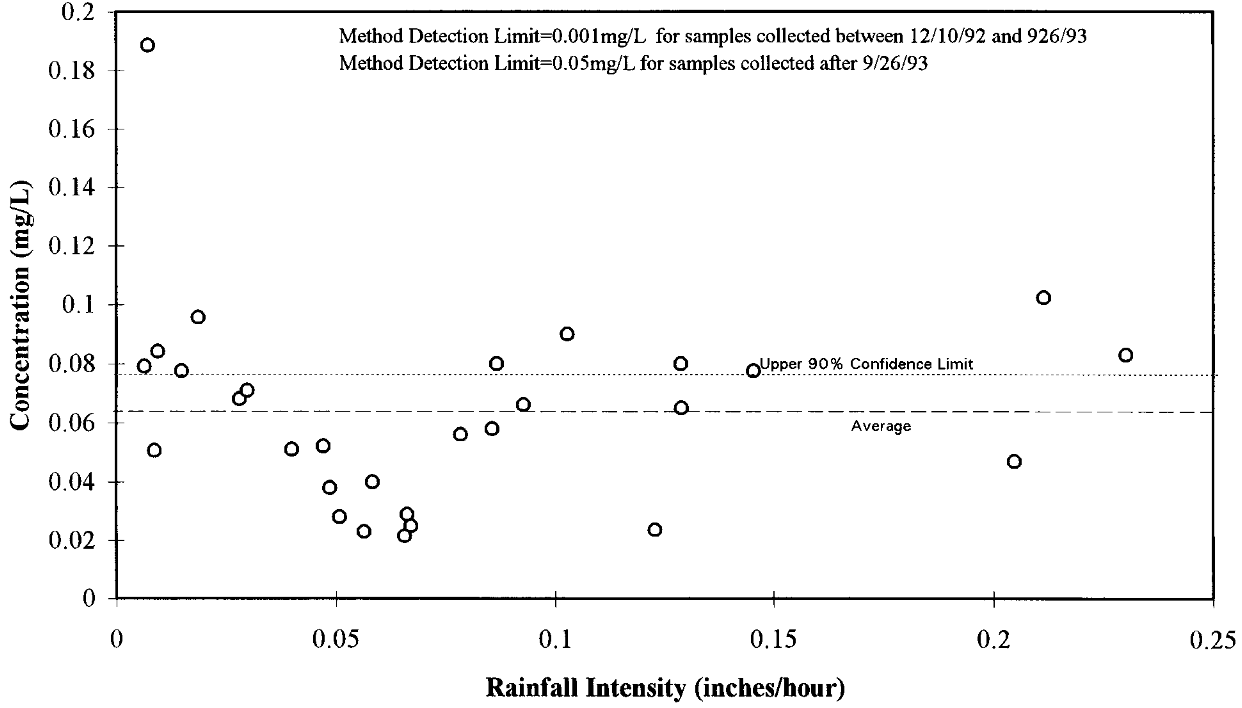


Figure D2-5
RAINFALL INTENSITY VERSUS BERYLLIUM DISSOLVED RUNOFF CONCENTRATION

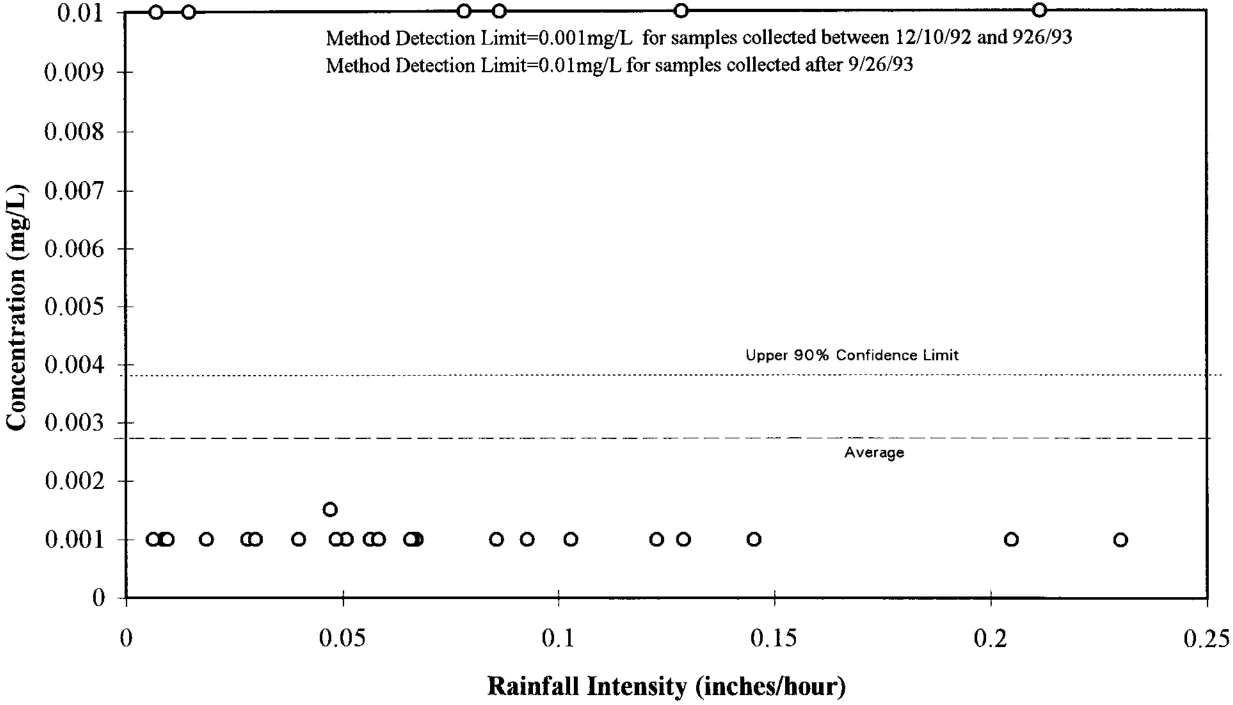


Figure D2-6
RAINFALL INTENSITY VERSUS CALCIUM DISSOLVED RUNOFF CONCENTRATION

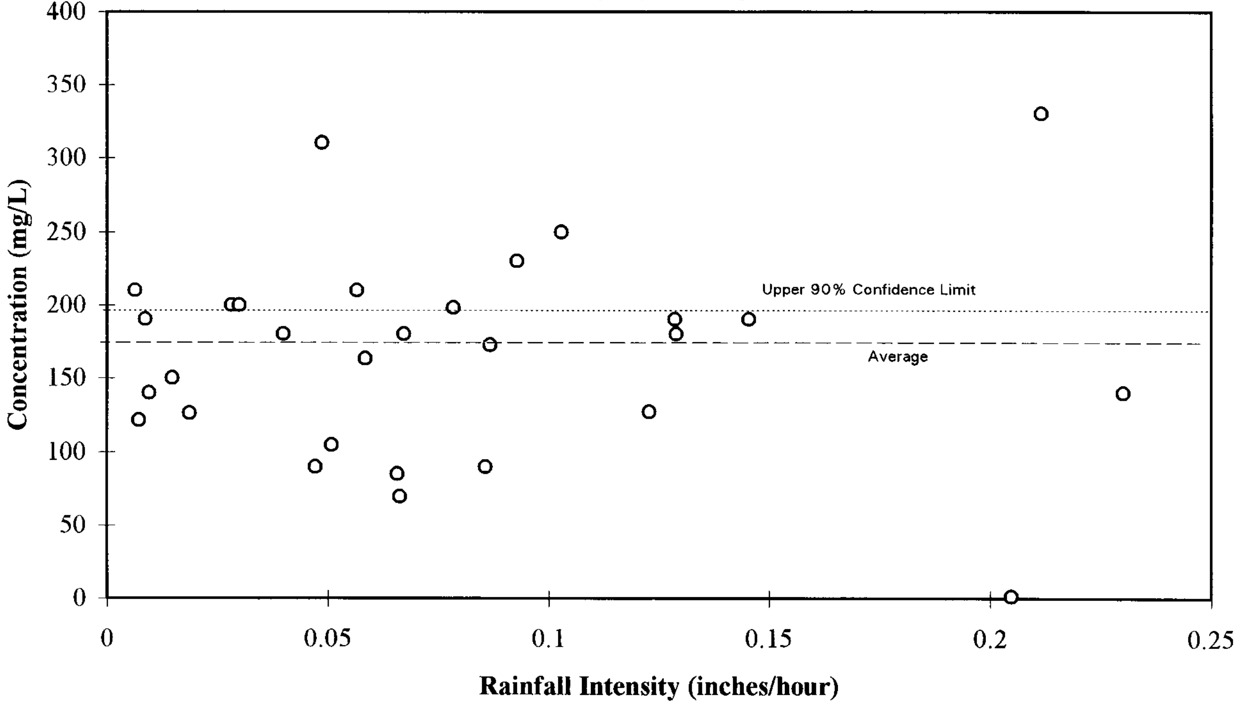


Figure D2-7

RAINFALL INTENSITY VERSUS CADMIUM DISSOLVED RUNOFF CONCENTRATION

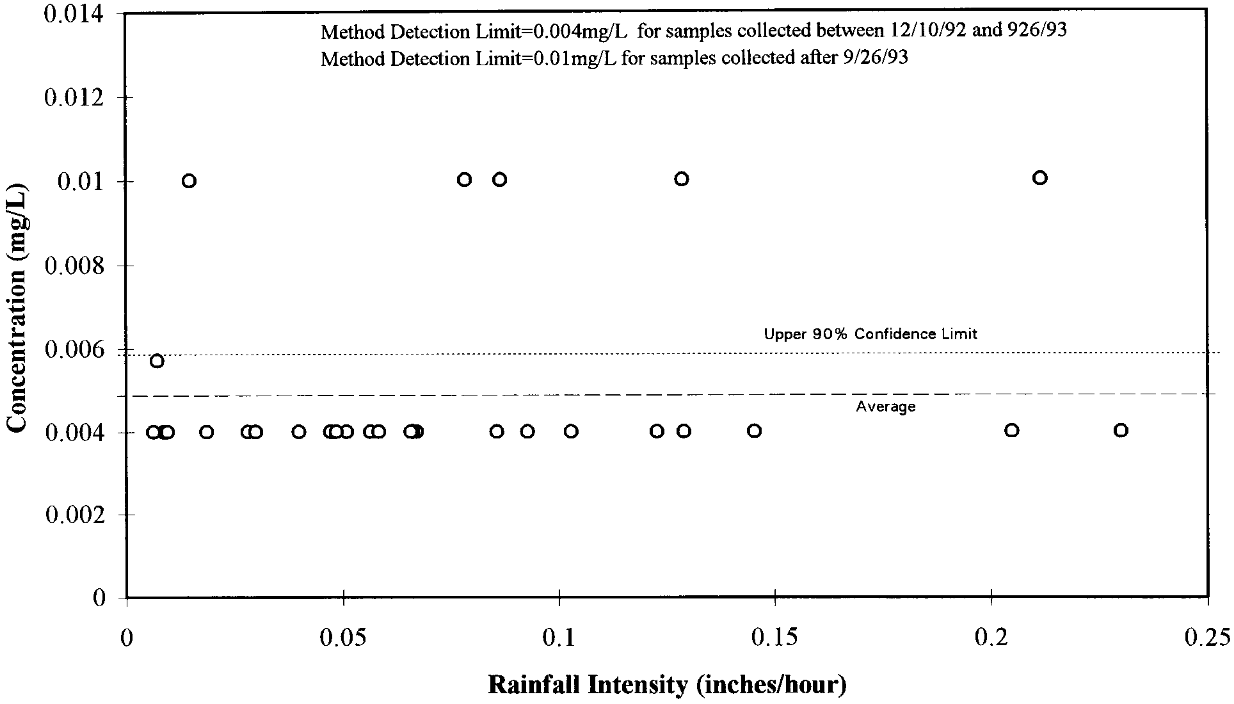


Figure D2-8

RAINFALL INTENSITY VERSUS CHROMIUM DISSOLVED RUNOFF CONCENTRATION

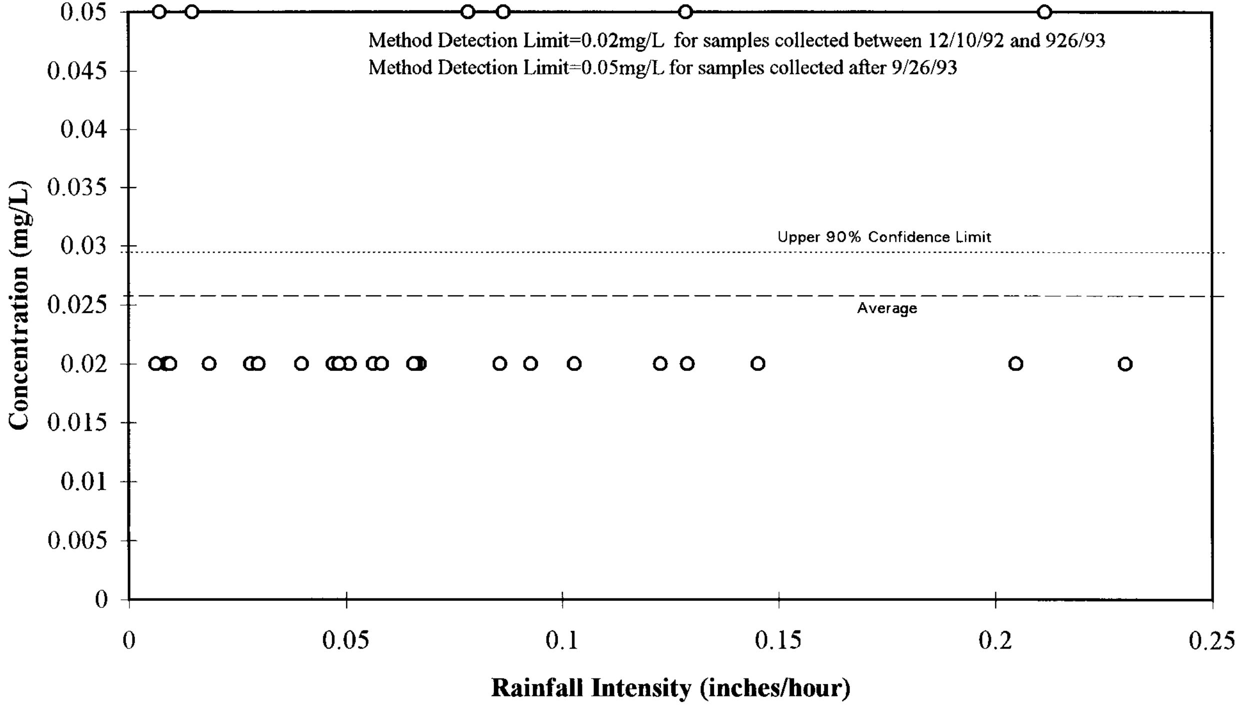


Figure D2-9
RAINFALL INTENSITY VERSUS COPPER DISSOLVED RUNOFF CONCENTRATION

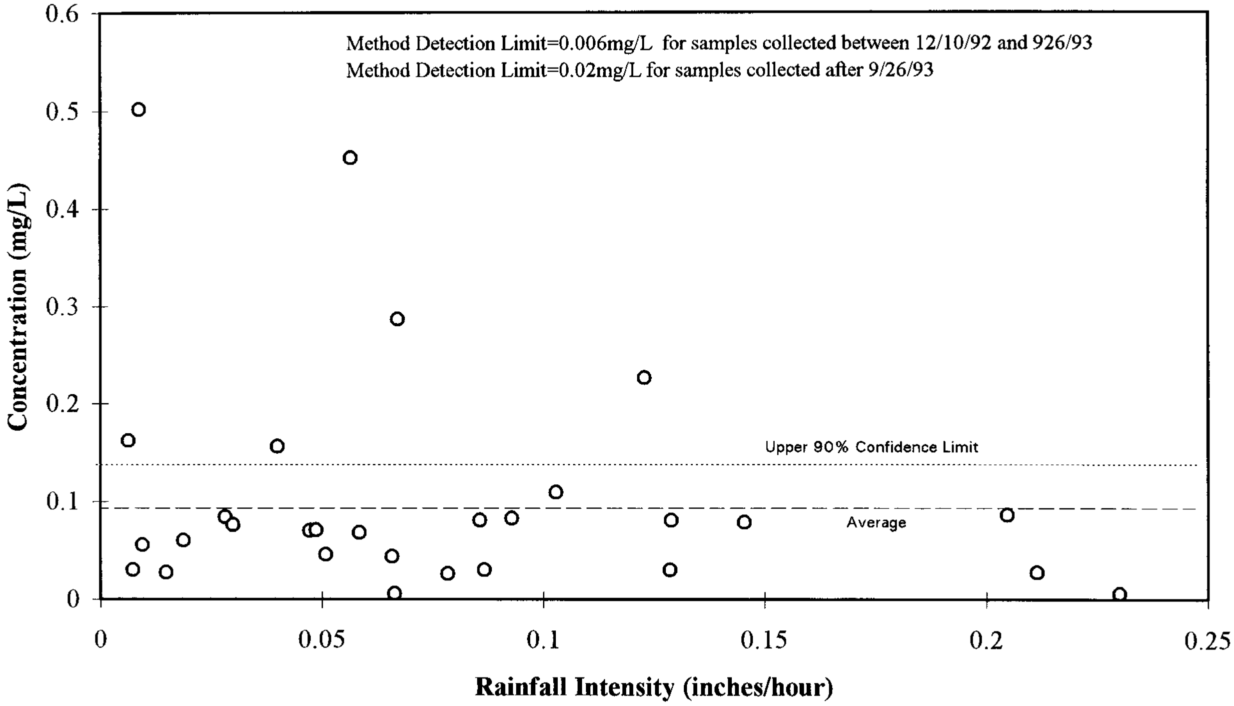


Figure D2-10
RAINFALL INTENSITY VERSUS IRON DISSOLVED RUNOFF CONCENTRATION

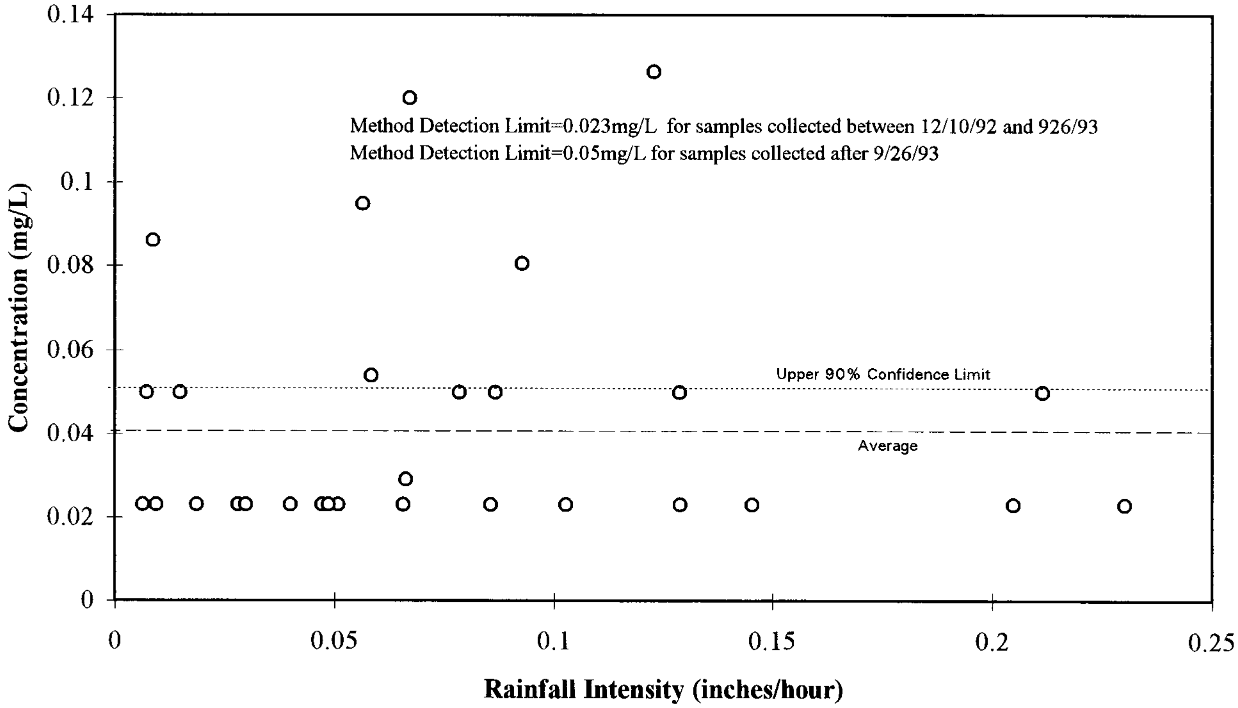


Figure D2-11
RAINFALL INTENSITY VERSUS POTASSIUM DISSOLVED RUNOFF CONCENTRATION

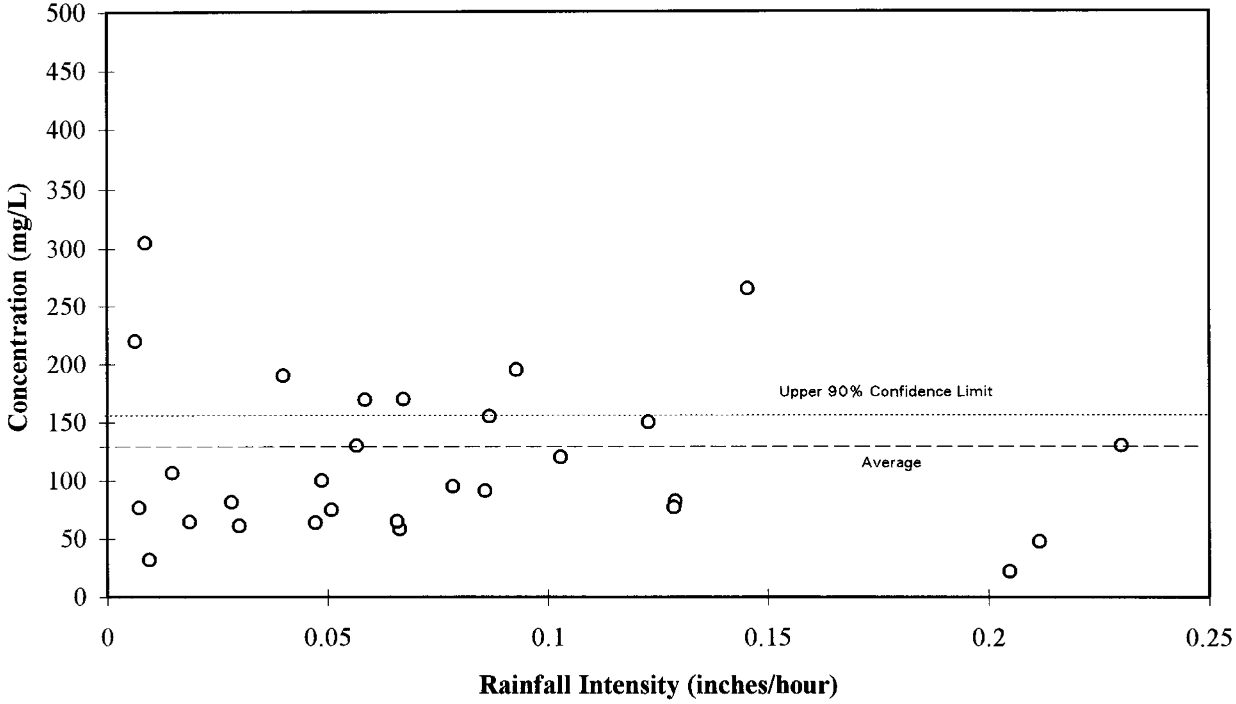


Figure D2-12
RAINFALL INTENSITY VERSUS MAGNESIUM DISSOLVED RUNOFF CONCENTRATION

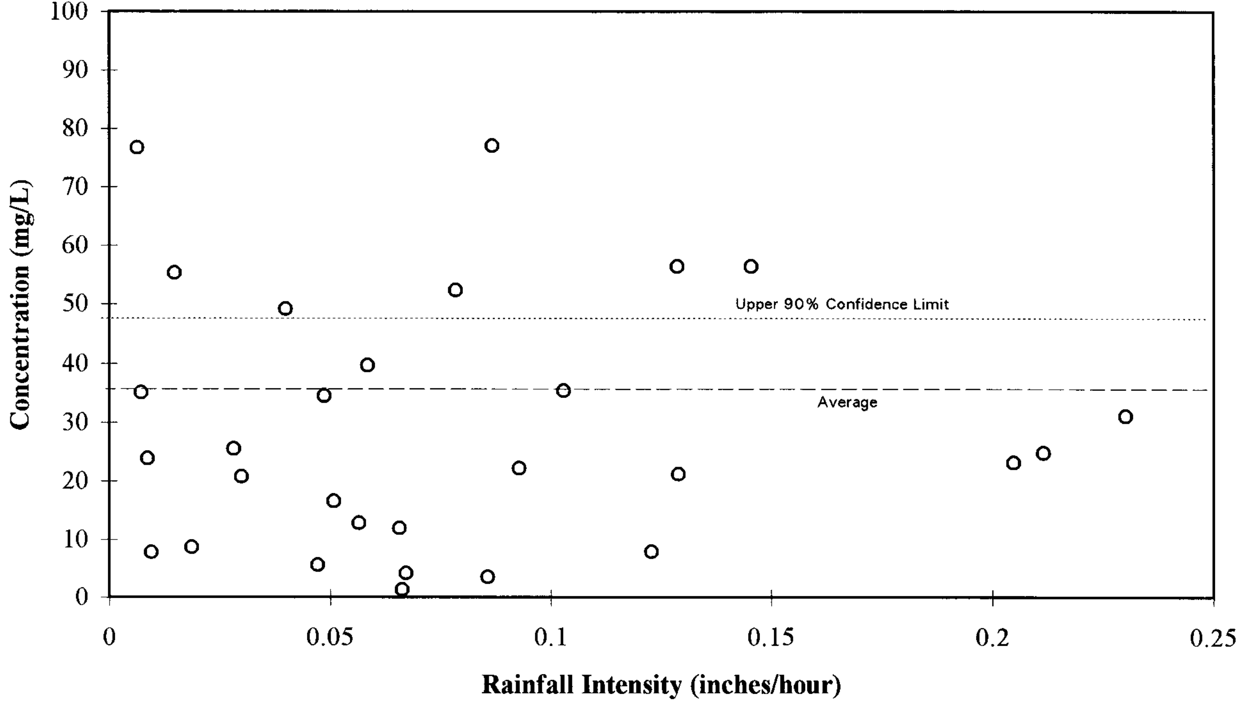


Figure D2-13
RAINFALL INTENSITY VERSUS MANGANESE DISSOLVED RUNOFF CONCENTRATION

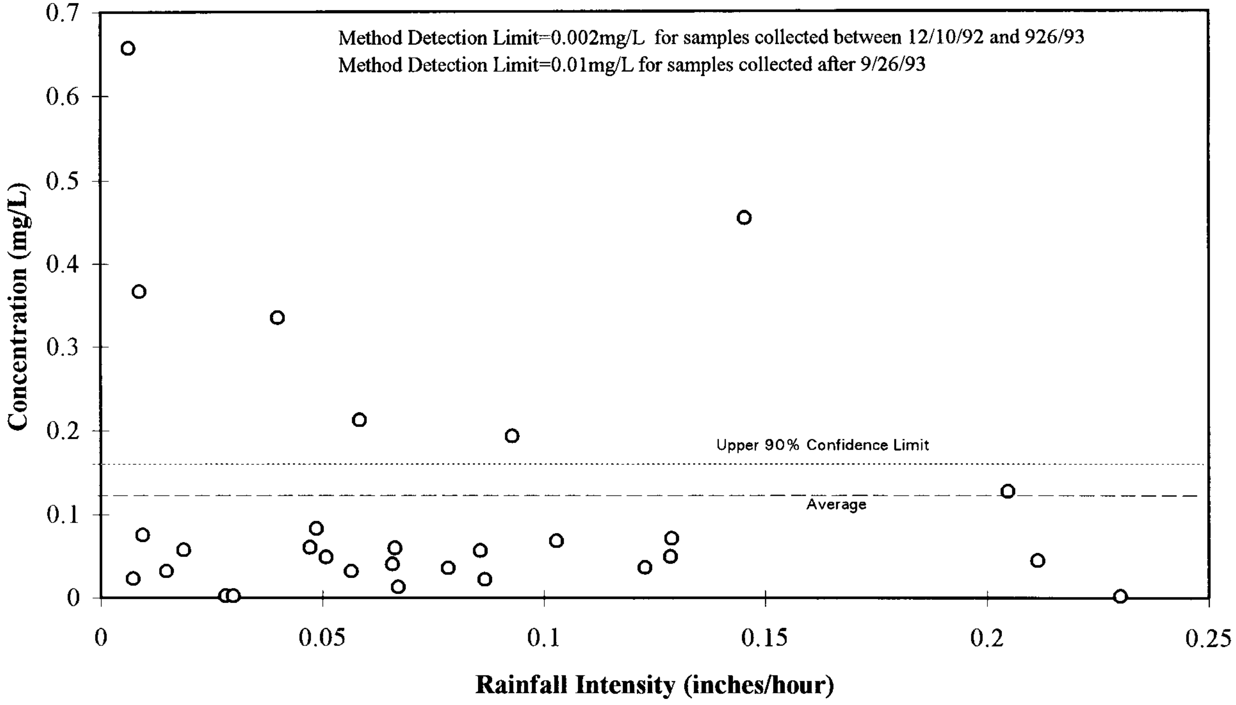


Figure D2-14
RAINFALL INTENSITY VERSUS SODIUM DISSOLVED RUNOFF CONCENTRATION

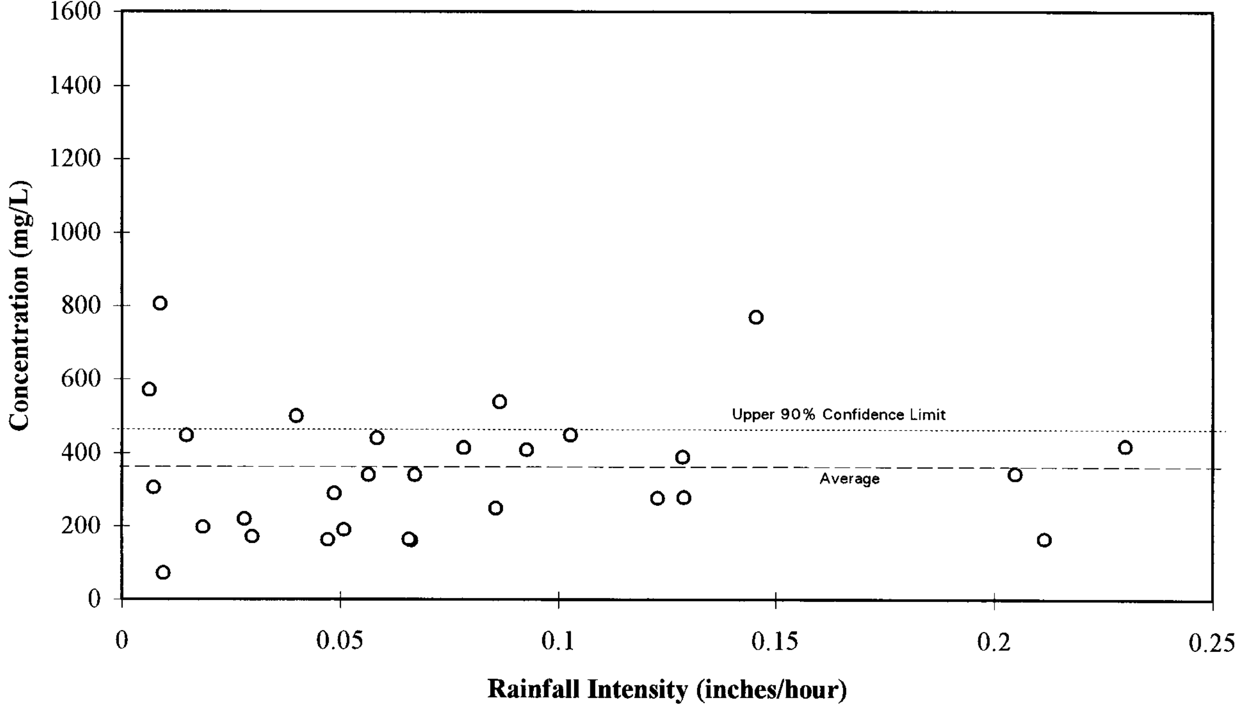


Figure D2-15
RAINFALL INTENSITY VERSUS NICKEL DISSOLVED RUNOFF CONCENTRATION

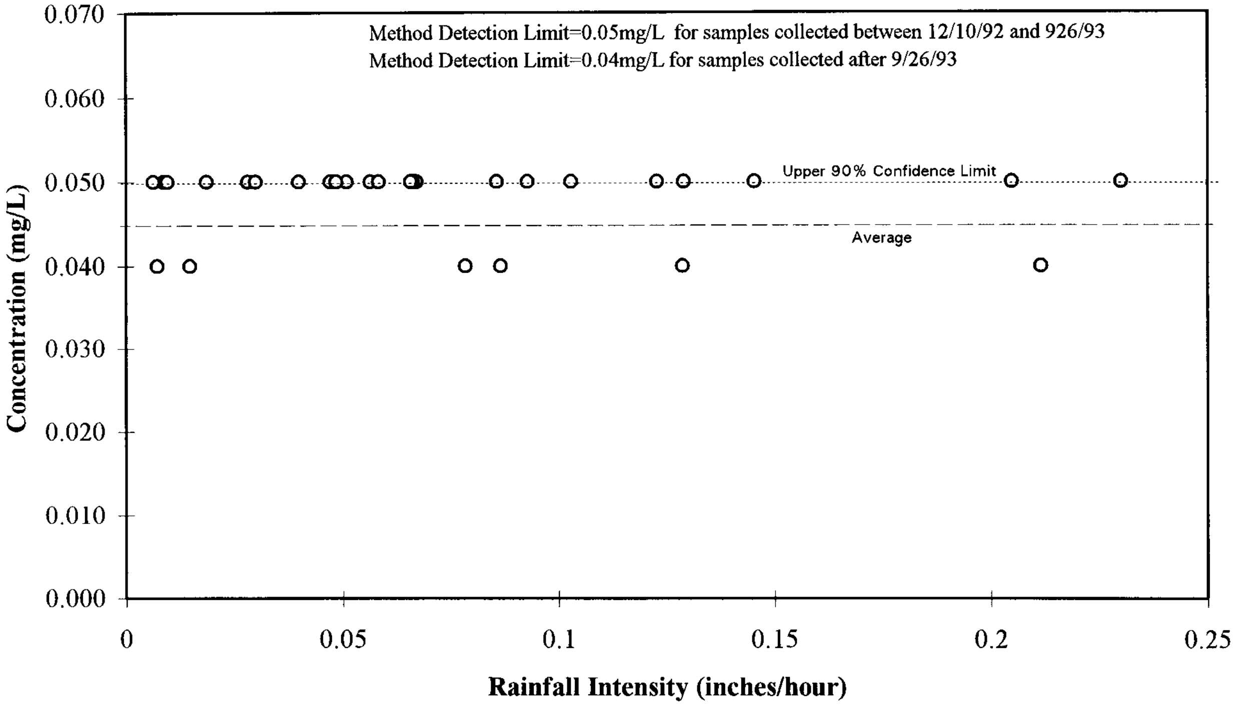


Figure D2-16
RAINFALL INTENSITY VERSUS LEAD DISSOLVED RUNOFF CONCENTRATION

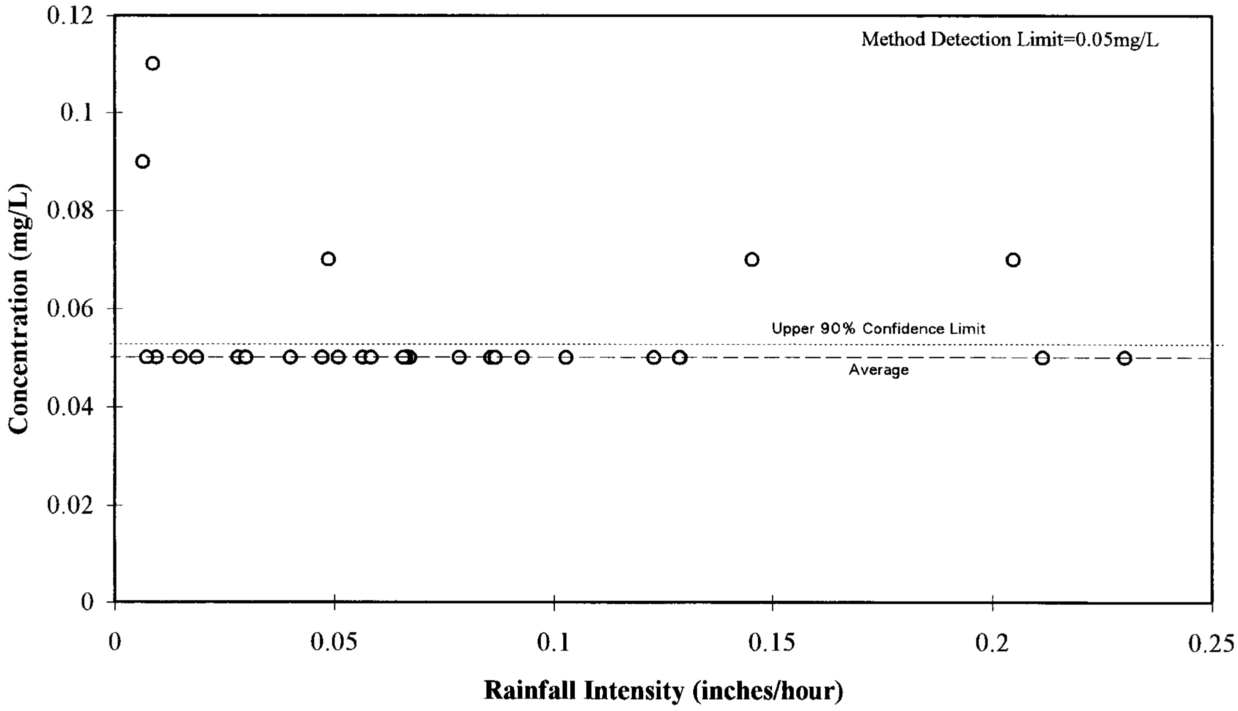


Figure D2-17
RAINFALL INTENSITY VERSUS SELENIUM DISSOLVED RUNOFF CONCENTRATION

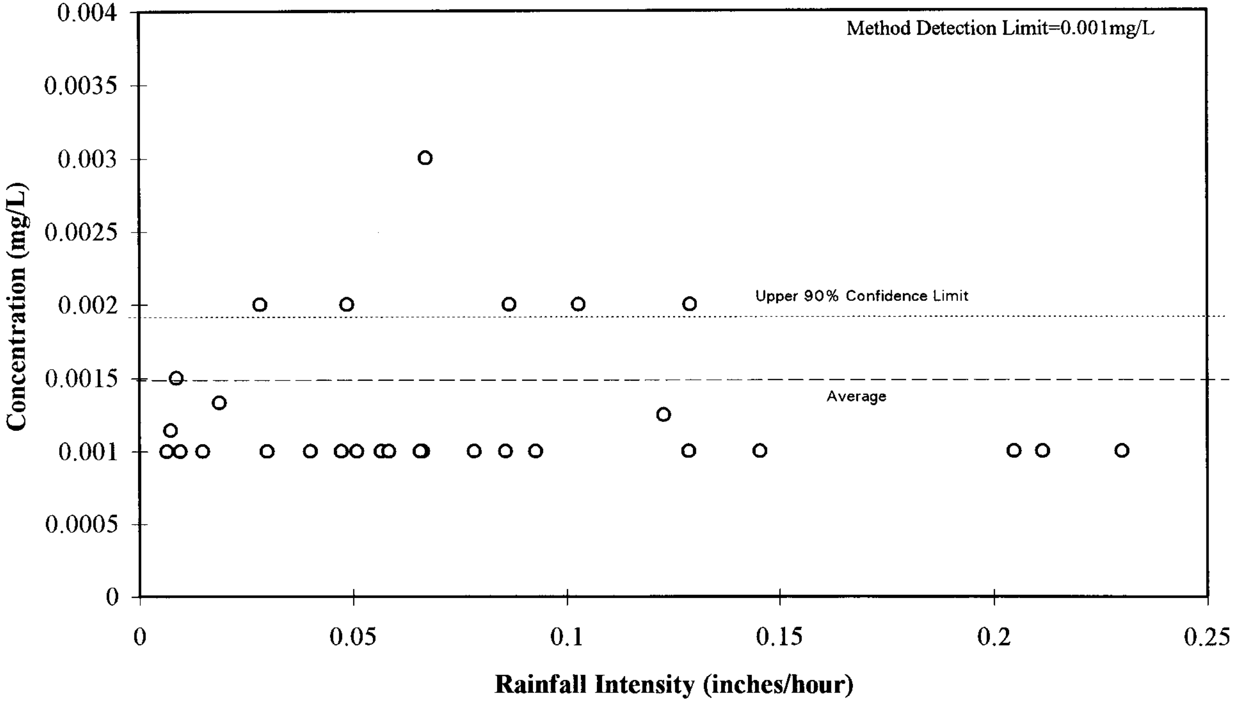


Figure D2-18
RAINFALL INTENSITY VERSUS SILICON DISSOLVED RUNOFF CONCENTRATION

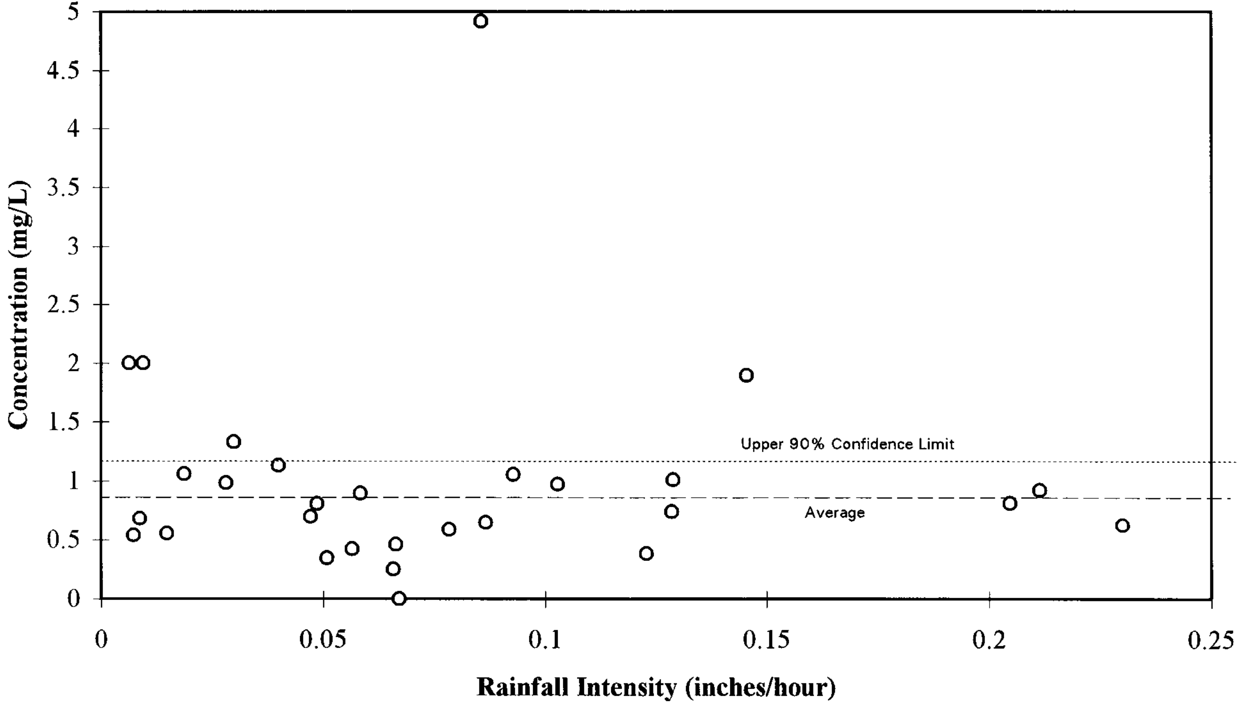


Figure D2-19
RAINFALL INTENSITY VERSUS ZINC DISSOLVED RUNOFF CONCENTRATION

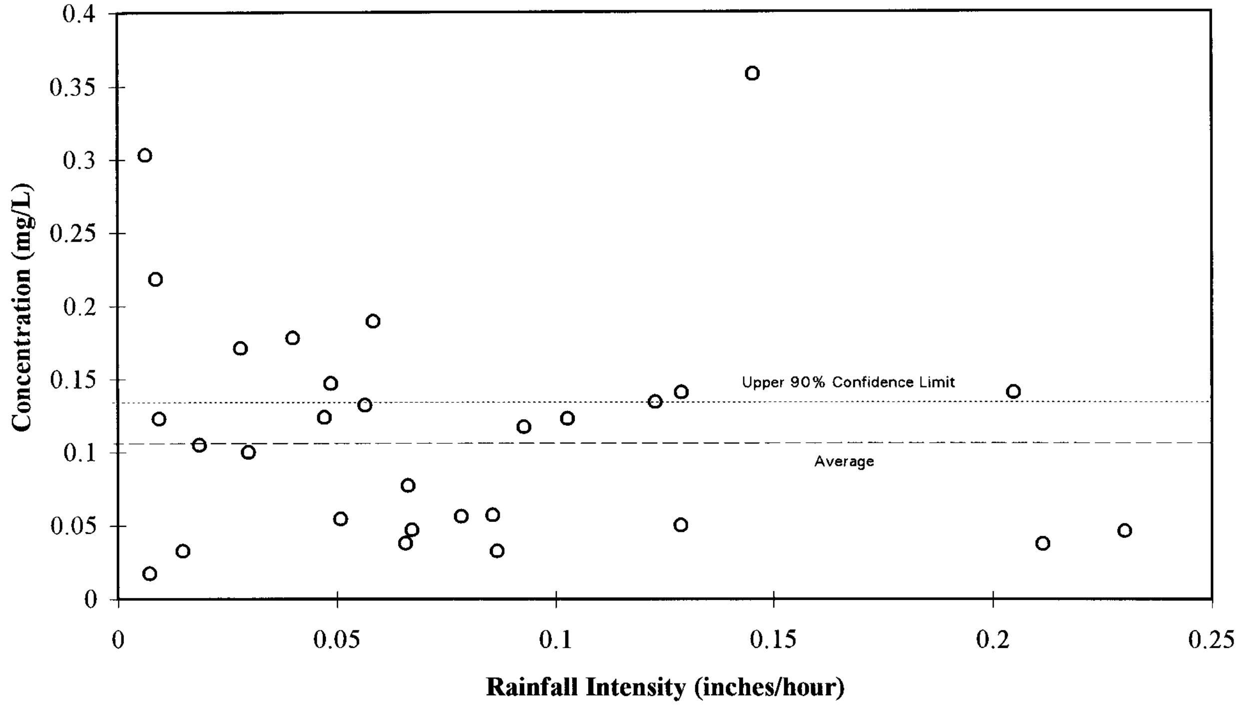


Figure D2-20
RAINFALL INTENSITY VERSUS SOLIDS DISSOLVED RUNOFF CONCENTRATION

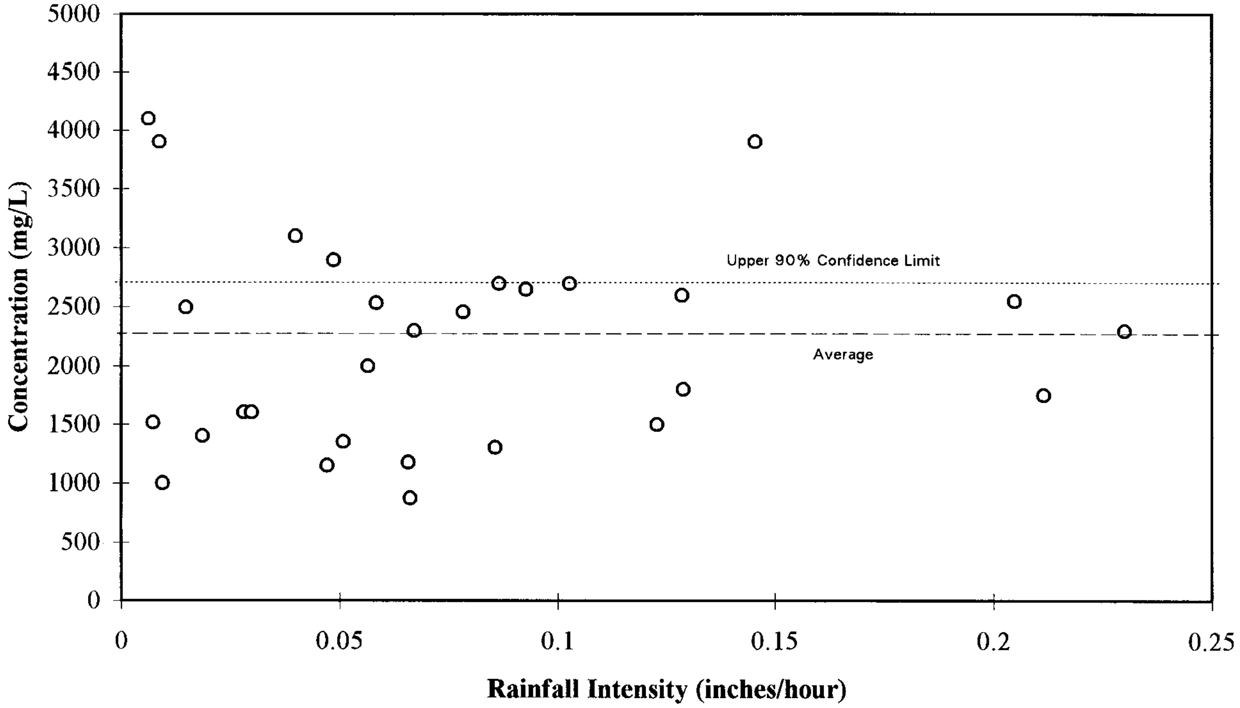


Figure D2-21
RAINFALL INTENSITY VERSUS CHLORIDE DISSOLVED RUNOFF CONCENTRATION

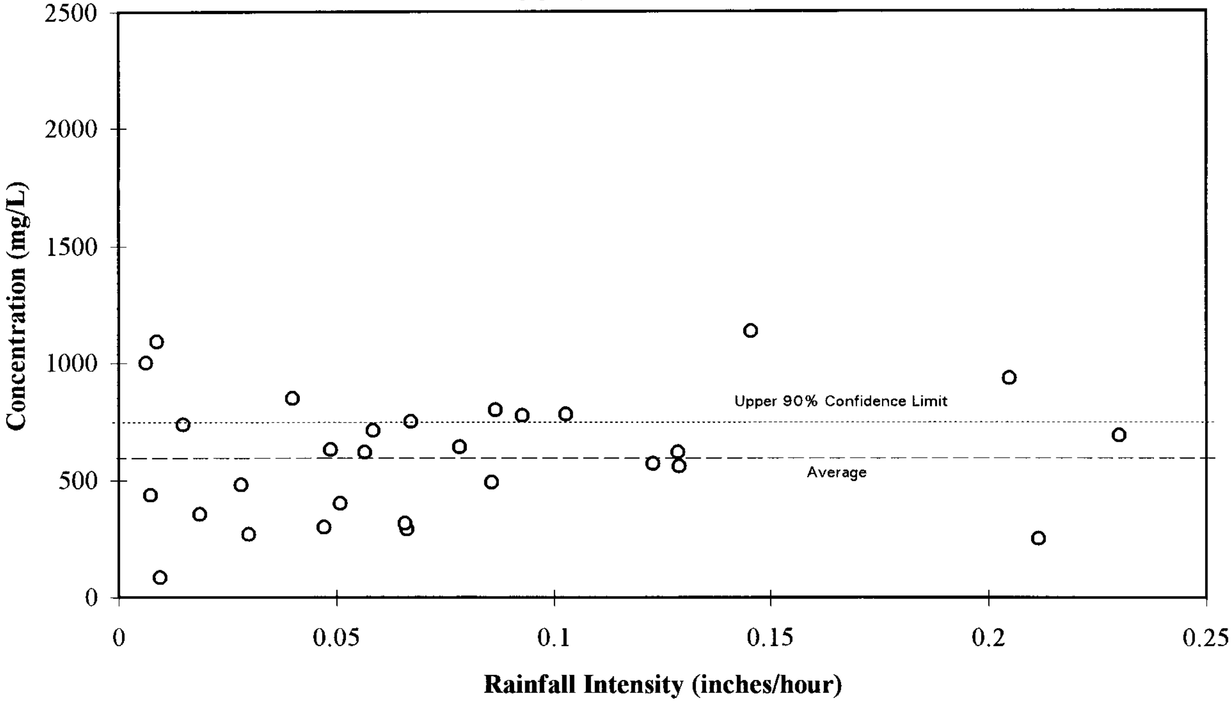
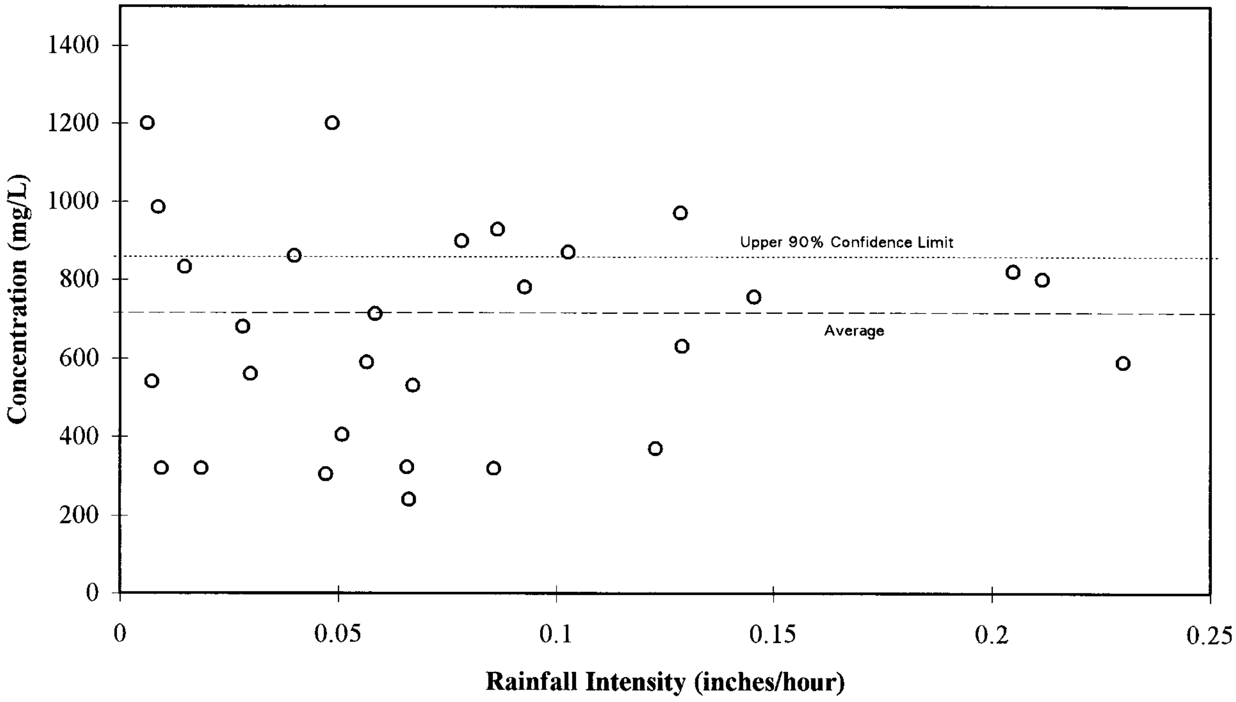


Figure D2-22
RAINFALL INTENSITY VERSUS SULFATES DISSOLVED RUNOFF CONCENTRATION



D3

GROUNDWATER MODEL DESCRIPTION

The groundwater model used in the runoff assessments simulates three-dimensional contaminant transport from a horizontal planar source. Appropriate uses of the model include simulations of contaminant transport from landfills, lagoons, and other applications where point source modeling is less accurate (Gayla, 1987).

The model requires parameters to define the source, aquifer and contaminant properties. The remainder of this appendix presents a description of the parameters required as model input.

D3.1 SOURCE PARAMETERS

The source parameters required for modeling (number of sources, source length, source width, source depth and contaminant release strength) are discussed in detail in Section 7.3.2.

D3.2 AQUIFER PARAMETERS

Two aquifers were used in the modeling assessments. The first aquifer used represents typical properties of the aquifer found at the Warren County Landfill site. The second aquifer modeled represents average values for a Long Island aquifer system.

Warren County, New Jersey

The hydrological properties used to determine the parameters necessary to run the model for the Warren County aquifer were obtained from the Warren County landfill groundwater impact assessment (Warren County, 1987). This report, which was prepared by Metcalf and Eddy Engineers and was part of the landfill environmental impact statement, contains site specific geological and hydrological data relevant to the subject assessment.

Seepage velocity was calculated using the following equation:

$V = -k/p(H/L)$,

where:

$V =$ seepage velocity (m/yr),
$H =$ hydraulic head (cm) = 7,320,
$L =$ distance (cm) = 122,000,
$p =$ porosity = 45%,
$k =$ hydraulic conductivity (m/yr) = 3.34.

The seepage velocity was determined to be 38 m/yr. The values for porosity and hydraulic conductivity used to calculate the seepage velocity were taken from the dolomite geological unit as presented in the groundwater impact modeling report (Warren County, 1987). This unit was chosen since it appears to give the most conservative results.

The dispersivity in the X and Y directions were calculated using the following equations:

$D_x = A_x V$,

$D_y = A_y V$,

where:

D_x = dispersivity in the direction of flow (m^2/yr),

D_y = dispersivity in the direction perpendicular to flow (m^2/yr),

A_x = dispersion coefficient in the direction of flow (m) = 46,

A_y = dispersion coefficient perpendicular to the flow (m) = 9.2,

V = seepage velocity (m/yr) =38.

The dispersivity in the direction of flow was determined to be 1,679 m^2/yr and the dispersivity perpendicular to the flow was determined to be 336 m^2/yr. No value was given for dispersivity in the Z direction, therefore, D_z was assumed to equal D_y.

The aquifer thickness was assumed to be 50 ft. (15 m). The modeled aquifer presented in the Warren County groundwater impact report ranged from approximately 30 meters to several hundred meters in thickness. To be conservative, half of the smallest value was chosen.

Long Island, New York

Local Long Island hydrological data reported by the U.S. Geologic Survey (Wexler, 1988; Franke, 1972) were used in the assessment. Wexler (1988) reports a range of seepage velocities between 0.3 ft/day to 5.8 ft/day. Lubke (1964) reports a range of 0.8 ft/day to 1.1 ft/day for pleistocene deposits, which are the major component of the upper glacial aquifer. A value of 1 ft/day (111 m/yr) was used in this assessment. Wexler (1988) reports a maximum upper glacial aquifer depth of 750 ft. while Franke (1972) reports a maximum depth of 400 ft. A conservative value of 100 ft. (30 m) was used in this assessment. The value for porosity, 0.30, was based upon Long Island's glacial aquifer and was taken from Wexler.

The dispersivity in the X and Y directions were calculated using the following equations:

$D_x = A_x V$,

$D_y = A_y V$,

where:

D_x = dispersivity in the direction of flow (m^2/yr),

D_y = dispersivity in the direction perpendicular to flow (m^2/yr),

A_x = dispersion coefficient in the direction of flow (m) = 0.5,

A_y dispersion coefficient perpendicular to the flow (m) = 6.2,

V = seepage velocity (m/yr) = 111.

The dispersion coefficients were taken from Wexler (1988). The dispersivity in the direction of flow was determined to be 3,386 m^2/yr and the dispersivity perpendicular to the flow was determined to be 688 m^2/yr. No value was given for dispersivity in the Z direction, therefore, D_z was assumed to equal D_y.

D3.3 CONTAMINANT PROPERTIES

The two contaminant properties required to use the model are the contaminant decay coefficient and the retardation factor. The decay coefficient represents the degree to which a contaminant is expected to decay over a given time, while the retardation factor is the degree to which precipitation/dissolution and adsorption/desorption processes slow down or speed up the movement of a contaminant through aquifers.

The decay coefficient was set to zero (no decay) for all modeling runs since no decay of trace metals was expected.

Retardation of certain trace metals may actually be a fairly significant factor in groundwater modeling. It is known that as leachate travels through soil above and in the aquifer, the metals contained within the leachate are subject to precipitation/dissolution and adsorption/desorption processes.

Precipitation/dissolution processes are those which influence the solubility of a metal and the likelihood that it will precipitate out of solution or dissolve into solution. Adsorption/desorption processes are those processes that affect the accumulation of ions at the boundary region of the liquid to solid interface (USEPA, 1985) Adsorption/desorption processes can greatly reduce the concentration of even a moderately adsorbed metal with distance from the original source. There are several factors that can affect the above processes in soil. These include

- Type of soil (i.e., clay, sand),
- Cation exchange capacity of the soil,
- Eh,
- pH,
- Alkalinity,
- Acidity,
- Organic content,
- Concentration of pollutant, and
- Concentration of competing ions.

The effect of these factors and others on adsorption/desorption and precipitation/dissolution processes can be fairly complex and can change with the specific environment, making exact predictions difficult. Retardation or soil attenuation coefficients are generally described in terms of a distribution coefficient. The distribution coefficient, k_d, is an empirical coefficient for a specific constituent under a particular set of conditions that is used to express the amount of the constituent adsorbed onto the subject soil compared to the concentration of the constituent in solution. The higher the k_d, the higher the concentration adsorbed onto the soil and the lower the concentration in solution.

The retardation coefficient (R) used in the model is related to k_d as follows:

$$R = \frac{k_d S}{P}$$

where,

R = retardation coefficient

k_d = distribution coefficient

S = soil density

p = soil porosity

As the distribution coefficient increases (i.e., greater soil adsorption and less of the specified constituent in solution), the retardation factor increases.

The behavior of two elements, cadmium and lead, is of particular relevance in the case of combustor ash.

The following is a brief overview of factors affecting retardation of Cd and Pb in soils.

Cadmium (EPRI, 1984)

Cadmium concentrations in soils can be controlled by both precipitation/dissolution reactions and by adsorption/desorption reactions.

Researchers have shown that Cd concentrations in calcareous soils (alkaline soils) are controlled by the solubility of $CdCO_3$. It has been suggested that precipitation is a major factor in the removal of Cd in landfill leachates at a pH >6.

Adsorption/desorption of Cd is controlled by the CED (cation exchange capacity) of the soil, while the presence of organic matter has been shown to have little effect. When cadmium is at low concentrations, adsorption to calcite and Al and Fe oxides may be the single most important adsorptive mechanism for cadmium.

Reported k_d values for cadmium range from 0.5 to 900.

Lead (EPRI, 1984)

Lead concentrations in soils can be controlled by both precipitation/dissolution reactions and by adsorptive/desorptive reactions.

The precipitation/dissolution reactions of lead in soils are primarily controlled by the solubility of lead phosphates in noncalcareous soils and $PbCO_3$ in calcareous and alkaline soils.

The adsorption of lead is highly pH dependent. Researchers have noted that adsorption increases with increasing pH (LIRPB, 1993). Lead is strongly retained by soils due to ion exchange and specific adsorption by clays and organic matter. Values of k_d were estimated to be in the range of 1,000 to 20,000.[1]

To provide for the most conservative assessment scenario, a value of 1 (no retardation) was used for all contaminants in this assessment.

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[1] 1600 g per liter was used as the basis for estimating k_d.

D4

COMPARISON OF GROUNDWATER MODEL AQUIFER SYSTEM

Appendix D4 presents a brief comparison of the two aquifer systems used in the groundwater impact assessment presented in Section 7. A more detailed description of the aquifer parameters used in the assessment is presented in Appendix D3.

D3.1 AQUIFER DESCRIPTIONS

The parameters used to describe an average Long Island aquifer are typical of a sandy aquifer with a high dispersion and relatively fast groundwater velocity. In comparison, the average parameters used to describe the Warren County, New Jersey, aquifer are typical of an aquifer system with lower dispersion and slower groundwater movement. The differences between the two aquifer systems produce two widely different sets of groundwater modeling results. Figures D4-1 and D4-2 present the expected concentration of a hypothetical contaminant released from one 360-ton bottom ash stockpile. Figure D4-1 presents predicted concentrations in the direction of groundwater flow along the contaminant plume centerline. Figure D4-2 presents the predicted concentration perpendicular to the groundwater flow at a distance of zero meters from the source. The results indicate that the stockpile would produce higher predicted groundwater concentrations within several kilometers of the source in the Warren County aquifer system than in the Long Island aquifer system.

The higher dispersion and groundwater velocity associated with the Long Island aquifer serves to move the contaminant faster, dispersing the contaminant plume faster than could be expected given the parameters used to model the Warren County aquifer. The rapid movement in the Long Island aquifer serves to decrease the predicted concentrations close to the source, but also to move the contaminant over a wider area. Therefore, contaminant concentrations would be higher in the Warren County aquifer than in the Long Island aquifer. Figure D4-1 shows that the predicted concentration in the Warren County aquifer falls below that of the Long Island aquifer at approximately 4.25 kilometers.

D4.1 AQUIFER WITH GREATEST IMPACT

The Warren County aquifer was used to project groundwater assessment impact results in Section 7 since it produced the highest predicted concentrations overall.

Figure D4-1
CONTAMINANT CONCENTRATION IN THE DIRECTION OF GROUNDWATER FLOW

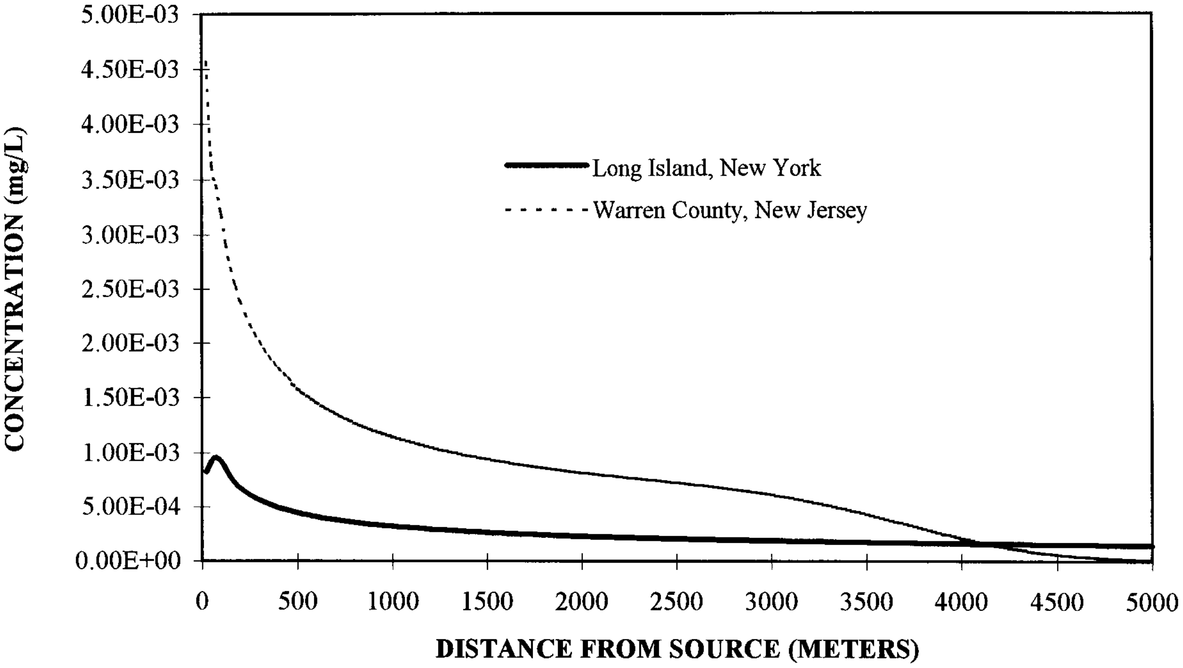
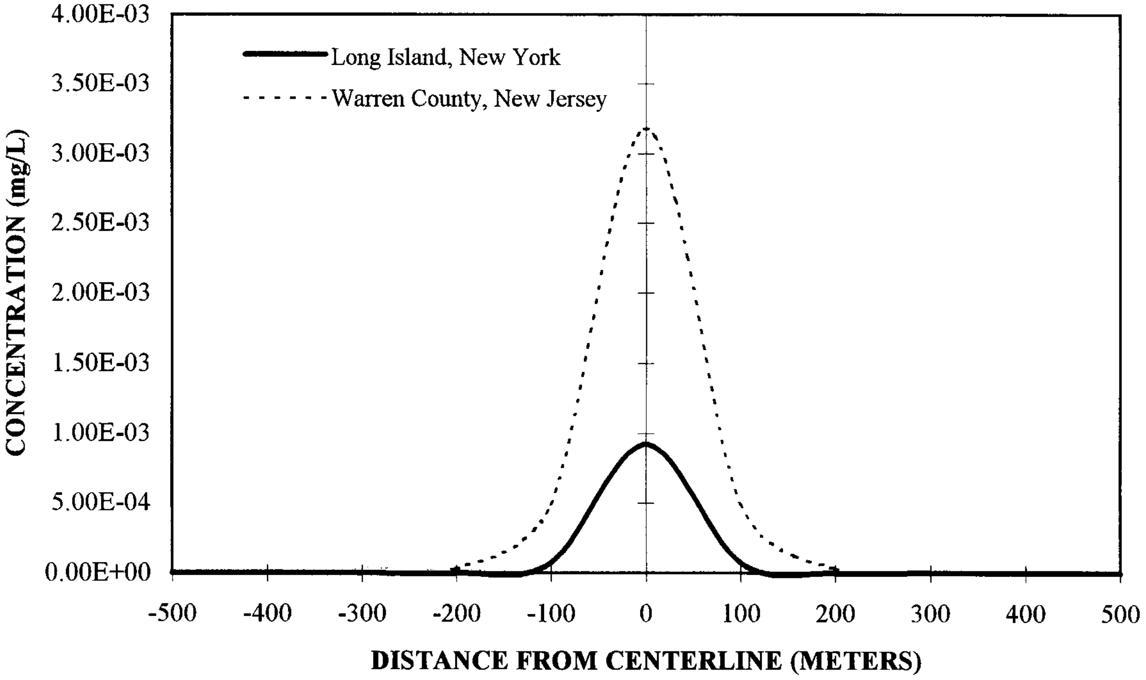


Figure D4-2
CONTAMINANT CONCENTRATION IN DIRECTION PERDENDICULAR TO DIRECTION OF FLOW



Appendix E

AMBIENT AIR ASSESSMENT METHODS AND RESULTS

Appendix E presents the methods and results for the ambient air, soil and worker health environmental assessments. Appendix E is divided into the following sections:

E1	Comparison of Measured Static Stockpile Period Ambient Air Dust to Predicted Concentrations
E2	Projected Ambient Air Particulate Emissions
E3	Bottom Ash Trace Metals used in Ambient Air, Soil and Worker Environment Assessments
E4	Industrial Source Complex Short Term Version 2 (ISCST2) Model Description
E5	Predicted Ambient Air Dust and Trace Metal Results for Remediated Dust Emissions
E6	Worker Environment Control Volume and Turnover Rate

E1

COMPARISON OF MEASURED STATIC STOCKPILE PERIOD AMBIENT AIR DUST TO PREDICTED CONCENTRATIONS

Appendix E1 presents a discussion concerning the use of a moisture adjustment factor to the USEPA AP-42 emission equations used in the ambient air assessments.

Four emission factor equations were used to predict fugitive dust emissions in the ambient air assessment. The equations are presented in detail in Section 8. The only equation to directly incorporate a moisture term for the material being handled is the batch drop equation. The TSP wind erosion and vehicular movement equation includes a term to reduce annual average emissions based upon the number of days per year with rainfall greater than 0.01". This term does not take into account the moisture content of the material.

Visual observations made over the course of the monitoring program revealed that the moisture content of the bottom ash had a significant impact on the amount of fugitive dust released when the front end loader traveled over ash which had fallen on the stockpile pad. Therefore, a moisture adjustment term similar to that in the loader batch drop was included in the vehicular movement equation. No observable stockpile wind erosion emissions during the static stockpile period were made, therefore, no moisture adjustments were made.

Comparisons were made between measured TSP ambient air concentrations and projected concentrations using non-moisture adjusted wind erosion emission equations. Projected levels were calculated using the ISCST2 dispersion model, actual meteorological data collected during the monitoring program at receptor locations equivalent to the placement of high volume samplers in the field. Table E1-1 lists the actual measured TSP ambient air concentrations and those obtained using the USEPA AP-42 emission equation unadjusted for moisture. Since the results were similar, it was determined that there was no basis to include a moisture adjustment term in the wind erosion emission equations.

Table E1-1
STATIC STOCKPILE AMBIENT AIR DUST MEASURED VERSUS PREDICTED
($\mu g/m^3$)

Event Date	Measured[1,3]				Predicted[2,3]			
	HV-1	*HV-2*	*HV-3*	*HV-4*	*HV-1*	*HV-2*	*HV-3*	*HV-4*
12/7/92	0	0	1	0	0	0	0	0
12/22/92	0	3	6	12	0.45	0.089	0.22	0.062
12/29/92	3	0	3	2	0.68	0.31	0.41	0.12
4/16/93	0	0	11	0	0.42	0.55	0.52	0.38
4/19/93	4	0	0	0	0	0	0	0
4/21/93	1	0	2	0	0	0	0	0
4/28/93	0	0	37	0	0	0	0	0
5/4/93	0	0	23	0	0	0	0	0
5/7/93	0	0	29	0	0	0	0	0
5/11/93	0	0	4	0	0.14	0.11	0.12	0.018
5/19/93	0	0	0	2	0.24	0.062	0.061	0.061
5/29/93	0	0	0	0	0	0	0	0
6/3/93	0	0	24	0	0	0	0	0
6/10/93	0	0	12	0	0	0	0	0
6/24/93	10	0	1	0	0	0	0	0
6/28/93	0	0	99	0	0	0	0	0
7/1/93	0	0	8	0	0	0	0	0
7/12/93	0	6	1	0	0	0	0	0
7/29/93	0	0	5	0	0	0	0	0
8/6/93	0	0	24	32	0	0	0	0
8/10/93	0	0	2	2	0	0	0	0
8/27/93	-	0	-	0	0	0	0	0
9/29/93	0	3	0	0	0	0	0	0
10/6/93	0	0	104	0	0.023	0.031	0.0052	0.0031
10/12/93	0	0	0	0	0	0	0	0
10/19/93	0	0	0	158	0	0	0	0
10/25/93	5	0	0	0	0	0	0	0
11/4/93	0	0	0	0	0	0	0	0
11/15/93	0	0	172	0	0	0	0	0
11/30/93	1	0	1	0	0	0	0	0

1. Measured concentrations were calculated by taking concentrations measured on the indicated high volume filter and subtracting the measured background filter concentration (HV-5). Values which were calculated as less than zero were set to zero.
2. Predicted concentration were predicted using the ISCST2 model, USEPA AP-42 emission equations, and actual field measured meteorological data.
3. HV-# indicates the high volume sampler (see Section 5).

E2

PROJECTED AMBIENT AIR PARTICULATE EMISSIONS

Appendix E2 presents a detailed listing of the projected particulate emissions from the bottom ash stockpile.

E2.1 UNREMEDIATED EMISSIONS

Table E2-1 presents the projected unremediated particulate emissions from the bottom ash stockpile and stockpile activities used in the ambient air assessment.

The table presents emissions for wind erosion, loader batch drop, and vehicular movement for TSP and PM_{10} particulates. The tables present unadjusted emissions, wind erosion and vehicular movement which are emissions which do not take into account the bottom ash moisture content. The loader batch drop equation includes a moisture term to account for stockpile moisture.

The adjusted emissions are emissions based upon the introduction of a moisture adjustment factor using the moisture content listed in the table. The surface moisture content represents the surface moisture of the bottom ash stockpile and was used to adjust the vehicular movement emissions except during the summer months when it was assumed to not reflect the moisture content of dry ash laying on the stockpile pad. Therefore, vehicular emissions were unadjusted for moisture for the months of June, July and August. See Appendix E1 for an explanation of the moisture correction term applied to the vehicular movement emissions.

The inner moisture content represents the moisture content of the bottom ash stockpile measured at a depth of three feet below the stockpile surface. The inner moisture content was used to adjust the batch drop emissions. No moisture adjustments were made to the wind erosion emissions since neither equation incorporated a moisture adjustment factor (see Appendix E1.)

E2.2 REMEDIATED EMISSIONS

Table E2-2 presents the projected remediated particulate emissions from the bottom ash stockpile and stockpile activities. The remediation strategy used in the assessment was set up to keep the stockpile surface and roadway moisture at a minimum of 10 percent. Table E2-2 presents data similar to that in Table E2-1 with adjustment to the moisture content used in the vehicular movement and wind erosion emission equations.

Analyses were run assuming two remediation strategies. The first assumed only vehicular movement emissions were remediated. This strategy used unadjusted wind erosion emissions, vehicular movement emissions adjusted to the remediated surface moisture content ($\geq 10\%$), and batch drop emissions using the stockpile inner moisture content. The second remediation strategy was assumed to be the same as the first strategy with the exception of the wind erosion emissions. Wind erosion emissions of TSP and PM_{10} particulates

Table E2-1
PROJECTED UNREMEDIATED PARTICULATE EMISSIONS FROM BOTTOM ASH STOCKPILE
(g/s)

		Moisture (%)		TSP Emissions			PM_{10} Emissions		
	Time Period	Surface	Inner	Wind[3] Erosion	Batch Drop	Vehicular Movement	Wind[3] Erosion	Batch Drop	Vehicular Movement
Unadjusted[1]	All	-	-	1.0E-04	6.1E-04	3.3E-02	1.2E-07	2.9E-04	1.5E-02
Adjusted[2]	January	23	21	-	2.3E-05	1.9E-03	-	1.1E-05	8.7E-04
	February	17	23	-	2.0E-05	2.9E-03	-	9.6E-06	1.3E-03
	March	18	22	-	2.1E-05	2.7E-03	-	1.0E-05	1.2E-03
	April	17	21	-	2.3E-05	2.9E-03	-	1.1E-05	1.3E-03
	May	7	20	-	2.4E-05	1.0E-02	-	1.2E-05	4.6E-03
	June	7	19	-	2.6E-05	3.3E-02	-	1.2E-05	1.5E-02
	July	7	18	-	2.8E-05	3.3E-02	-	1.3E-05	1.5E-02
	August	8.5	17	-	3.1E-05	3.3E-02	-	1.4E-05	1.5E-02
	September	12	17	-	3.1E-05	4.8E-03	-	1.4E-05	2.2E-03
	October	15	16	-	3.3E-05	3.5E-03	-	1.6E-05	1.6E-03
	November	16	19	-	2.6E-05	3.2E-03	-	1.2E-05	1.4E-03
	December	22	22	-	2.1E-05	2.0E-03	-	1.0E-05	9.1E-04

1. Unadjusted emissions - MAF=1 for equations 2,3 and 4
2. Adjusted emissions - Monthly MAF adjustment used (see Section 8.2.2)
3. No MAF included for wind erosion

Table E2-2
PROJECTED REMEDIATED PARTICULATE EMISSIONS FROM BOTTOM ASH STOCKPILE
(g/s)

		Remediated[3] Moisture (%)		TSP Emissions			PM_{10} Emissions		
	Time Period	Surface	Inner	Wind Erosion	Batch Drop	Vehicular Movement	Wind Erosion	Batch Drop	Vehicular Movement
Unadjusted[1]	All	-	-	1.0E-04	6.1E-04	3.3E-02	1.2E-07	2.9E-04	1.5E-02
Adjusted[2]	January	23	21	6.0E-06	2.3E-05	1.9E-03	7.0E-09	1.1E-05	8.7E-04
	February	17	23	9.1E-06	2.0E-05	2.9E-03	1.1E-08	9.6E-06	1.3E-03
	March	18	22	8.3E-06	2.1E-05	2.7E-03	9.7E-09	1.0E-05	1.2E-03
	April	17	21	9.1E-06	2.3E-05	2.9E-03	1.1E-08	1.1E-05	1.3E-03
	May	10	20	1.9E-05	2.4E-05	6.2E-03	2.2E-08	1.2E-05	2.8E-03
	June	10	19	1.9E-05	2.6E-05	6.2E-03	2.2E-08	1.2E-05	2.8E-03
	July	10	18	1.9E-05	2.8E-05	6.2E-03	2.2E-08	1.3E-05	2.8E-03
	August	10	17	1.9E-05	3.1E-05	6.2E-03	2.2E-08	1.4E-05	2.8E-03
	September	12	17	1.5E-05	3.1E-05	4.8E-03	1.7E-08	1.4E-05	2.2E-03
	October	15	16	1.1E-05	3.3E-05	3.5E-03	1.3E-08	1.6E-05	1.6E-03
	November	16	19	9.9E-06	2.6E-05	3.2E-03	1.2E-08	1.2E-05	1.4E-03
	December	22	22	6.3E-06	2.1E-05	2.0E-03	7.3E-09	1.0E-05	9.1E-04

1. Unadjusted emissions - MAF=1 for equations 2,3 and 4
2. Adjusted emissions - Monthly MAF adjustment used (see Section 8.2.2)
3. Moisture content was set to a minimum value of 10%.

were adjusted to the remediated surface moisture using the moisture adjustment factor defined in Section 8.

E3

BOTTOM ASH TRACE METALS USED IN AMBIENT AIR SOIL AND WATER ENVIRONMENT ASSESSMENTS

Appendix E3 presents the trace metal concentrations used in the ambient air, soil and water environment assessments presented in Section 8.

E3.1 AMBIENT AIR TRACE METAL CONCENTRATIONS

Studies have indicated that trace metals may be enriched or depleted in the finer size fraction of combustor residues when compared to a total characterization. Several studies on coal ash (Coles, 1979, Kaakinen, 1975, Davison, 1974, Martiewski, 1985) have shown differences in the finely sized ash fraction when compared to a total ash characterization. Several studies on MSW ash have shown similar findings (USEPA 1991, LIRPB, 1992, Stein, 1993).

To account for this difference in the finer sized ash fraction, elemental characterization data performed on <10μ particulates of the Warren County bottom ash was used to determine ambient air trace concentrations in the ambient air assessment. The data was gathered as part of the ash characterization study for the Warren County Resource Recovery Facility bottom ash (LIRPB, 1992).

Table E3-1 lists the elemental concentrations measured in the bottom ash stockpile and elemental concentrations measured in Warren County bottom ash <30μ (TSP) size fraction and <10μ (PM_{10}) size fraction.

Ambient air assessment trace metal levels were projected using PM_{10} particulates. The bottom ash stockpile elemental data was used in the ambient air trace metal analysis for metals that were not characterized for PM_{10} trace metals.

E3.2 SOIL ASSESSMENT TRACE METAL CONCENTRATIONS

The soil trace metal assessment was based upon deposition of TSP particulates on the stockpile site soils. The Warren County bottom ash <30μ elemental characterization concentrations were used to project trace metal loadings to soils. The bottom ash stockpile elemental data were used to project trace metal soil loadings for metals that were not characterized in the <30μ fraction of the Warren County bottom ash.

Table E3-1
TRACE METAL CONCENTRATIONS MEASURED IN: STOCKPILE BOTTOM ASH AND WCRRF <30µ AND <10µ BOTTOM ASH SAMPLES
(µg/g)

Parameter	Average Stockpile Concentration	WCRRF <30µ Concentration	WCRRF <10µ Concentration
Al	45800	-	-
As	17	98	75
Ba	728	-	-
Be	1.0	-	-
Cd	27	87	79
Ca	47400	-	-
Cr	134	269	241
Cu	2380	1705	1925
Fe	59800	-	-
Pb	1380	2433	2480
Mg	8120	-	-
Mn	1220	-	-
Hg	0.50	-	-
Ni	148	-	-
K	4740	-	-
Se	1.0	-	-
Ag	9.9	-	-
Na	8660	-	-
Zn	4320	6700	6740

E3.3 WORKER ENVIRONMENT TRACE METAL CONCENTRATIONS

The worker environment trace metal assessment was based upon TSP particulates in the worker air environment. The Warren County bottom ash $<30\mu$ elemental characterization concentrations were used to project trace metal loadings to the worker environment. The bottom ash stockpile elemental data were used to project trace metal worker environment loadings for metals that were not characterized in the $<30\mu$ fraction of the Warren County bottom ash.

E4

INDUSTRIAL SOURCE COMPLEX SHORT TERM VERSION 2 (ISCST2) DISPERSION MODEL DESCRIPTION

Appendix E4 presents a description of the estimating procedures used to project the magnitude of the potential ambient air impacts resulting from stockpile assessments.

Estimates were made of the ambient air concentrations downwind of potential dust generating activities by using the USEPA short-term version of the Industrial Source Complex (ISCST2) Model, Version 2. The Industrial Source Complex Model was selected for use because it is one of the most versatile of the EPA models for analyzing ambient air concentrations as well as particulate soil loadings, both of which are relevant to the subject assessment. The model also has the capability to utilize actual historical meteorological data, to cumulatively handle the impacts of multiple sources, and to calculate the ambient air quality at any desired receptor location.

The ISCST2 Model uses a Gaussian plume model to predict the ambient air quality downwind from emission sources. Dispersion is calculated as a function of atmospheric stability which in turn is an indicator of atmospheric turbulence. Relative turbulence is defined by stability categories which are a function of meteorological conditions. There are four modes -- one rural and three urban. The urban modes use urban mixing heights and redefine the stability class. The data generated for this report used the rural mode. Estimates of ground level concentrations were made by using emission factor equations (see Section 8) as input emission rates into the air dispersion model. The model can accept the following source types: Stack, area and volume. For purposes of the assessment undertaken in this report, all sources were converted to area sources.

For plumes consisting of particulates with appreciable gravitational settling velocities, the ISCST2 Model can account for the effects of gravitational settling on ambient particulate concentrations. The ISCST2 Model can also be used to calculate dry deposition. This feature was used to estimate the potential impacts to surrounding soils.

The model can be set up to calculate average ambient air concentration or deposition values for time periods ranging from one hour to one year. The model can use either hourly historical meteorological data or hypothetical data as input meteorological conditions.

The locations for which particulate concentrations are calculated by the model are called receptors. The ISCST2 uses either a polar or a Cartesian receptor grid. The model can also account for variations in terrain height over the receptor grid.

The ISCST2 Model also has a feature that allows it to address calm conditions (i.e., one meter per second or less). This assists in the simulation of wind-induced emissions (e.g., stockpile) by setting the concentration to zero at all receptors. Calm condition is defined as a wind speed of 1.0 meter per second or less. This wind speed is well below threshold wind velocities that are typically required to erode particulate matter from stockpiles (USEPA, 1985). The ISCST2 Model was set to calculate ambient air concentrations using the following options:

- Concentration mode,
- Rural dispersion,
- Regulatory default options,
  - Final plume rise,
  - Stack-tip downwash,
  - Buoyancy induced dispersion,
  - Calm processing,
  - Default wind profile,
  - Default temperature gradients,
  - No exponential decay for rural mode.

E5

PREDICTED AMBIENT AIR DUST AND TRACE METAL RESULTS FOR REMEDIATED DUST EMISSIONS

Appendix E5 presents a detailed listing of the projected ambient air dust and trace metal results calculated using the remediated particulate emission values as outlined in Appendix E2. Results are presented for two remediation strategies. Remediation strategy one assumed that emissions associated with vehicular movement would be reduced by the application of moisture to the stockpile site area. The second strategy assumed that the application of moisture to the stockpile as well as the site area would reduce vehicular movement and wind erosion emissions.

E5.1 AMBIENT AIR DUST AND TRACE METAL RESULTS BASED ON REMEDIATED VEHICULAR MOVEMENT EMISSIONS

Tables E5-1 to E5-4 present the projected ambient dust and trace metal results using non-moisture adjusted wind erosion emissions, loader batch drop emissions, and remediated vehicular movement emissions presented in Table E2-1 (see Appendix E2).

The results indicate that projected dust and trace metal levels are reduced when compared to unremediated emissions (see Section 8), but 24-hour TSP levels and total chromium levels exceed criteria at approximately 9 and 24 stockpiles, respectively.

E5.2 AMBIENT AIR DUST AND TRACE METAL RESULTS BASED UPON REMEDIATED VEHICULAR MOVEMENT AND WIND EROSION EMISSIONS

Tables E5-5 to E5-8 present the ambient air and trace metal concentrations projected using loader batch drop emissions, remediated vehicular movement and remediated wind erosion emissions presented in Table E2-2 (see Appendix E2).

The results presented in these tables indicate that projected ambient air dust and trace metals concentrations using remediated vehicular movement and wind erosion emissions are significantly reduced, but 24-hour TSP levels and total chromium levels still exceed criteria by approximately 50 percent, starting at approximately 64 stockpiles.

Table E5-1
AMBIENT AIR TRACE METAL CONCENTRATIONS BASED ON VEHICULAR MOVEMENT REMEDIATED EMISSIONS FOR 9 STOCKPILES
(μg/m^3)

		Air	NJDEP Stds		Risk Analysis	
Parameter	Average Period	Concentration (μg/m^3)	RFC[1] (μg/m^3)	URF[2] risk/μg/m^3	Hazard[3] Quotent	Cancer[4] Risk
TSP	365 day	15	260	-	5.8E-02	-
	24 hour	96	75	-	1.3E+00	-
PM10	365 day	0.52	150	-	3.5E-03	-
	24 hour	4.8	50	-	9.6E-02	-
Ag	24 hour	4.8E-05	-	-	-	-
Al	24 hour	2.2E-01	-	-	-	-
As	365 day	3.9E-05	4.3E-03	-	9.1E-03	-
Ba	24 hour	3.5E-03	5.0E-01	-	7.0E-03	-
Be	365 day	5.2E-07	-	2.4E-03	-	1.2E-09
Ca	24 hour	2.3E-01	-	-	-	-
Cd	365 day	4.1E-05	-	3.5E-03	-	1.4E-07
Cr (total)	24 hour	1.2E-03	2.0E-03	-	5.8E-01	-
Cr (VI)[5]	365 day	1.3E-05	-	1.2E-02	-	1.5E-07
Cu	24 hour	9.2E-03	1.3E-01	-	7.1E-02	-
Fe	24 hour	2.9E-01	-	-	-	-
Hg	24 hour	2.4E-06	3.0E-01	-	8.0E-06	-
K	24 hour	2.3E-02	-	-	-	-
Mg	24 hour	3.9E-02	-	-	-	-
Mn	24 hour	5.9E-03	4.0E-01	-	1.5E-02	-
Na	24 hour	6.9E-02	-	-	-	-
Ni	365 day	7.7E-05	-	2.4E-04	-	1.8E-08
Pb	24 hour	1.2E-02	1.0E-01	-	1.2E-01	-
Se	24 hour	4.9E-06	-	-	-	-
Si	24 hour	1.2E-03	-	-	-	-
Zn	24 hour	3.2E-02	2.0E-01	-	1.6E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = Air Concentration ÷ RFC
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table E5-5
AMBIENT AIR TRACE METAL CONCENTRATIONS BASED ON VEHICULAR MOVEMENT AND WIND EROSION REMEDIATED EMISSIONS FOR 9 STOCKPILES

($\mu g/m^3$)

		Air	NJDEP Stds		Risk Analysis	
Parameter	Average Period	Concentration ($\mu g/m^3$)	RFC[1] ($\mu g/m^3$)	URF[2] risk/$\mu g/m^3$	Hazard[3] Quotent	Cancer[4] Risk
TSP	365 day	3	260	-	1.3E-02	-
	24 hour	33	75	-	4.4E-01	-
PM10	365 day	0.51	150	-	3.4E-03	-
	24 hour	4.7	50	-	9.4E-02	-
Ag	24 hour	4.7E-05	-	-	-	-
Al	24 hour	2.2E-01	-	-	-	-
As	365 day	3.8E-05	4.3E-03	-	8.9E-03	-
Ba	24 hour	3.4E-03	5.0E-01	-	6.8E-03	-
Be	365 day	5.1E-07	-	2.4E-03	-	1.2E-09
Ca	24 hour	2.2E-01	-	-	-	-
Cd	365 day	4.0E-05	-	3.5E-03	-	1.4E-07
Cr (total)	24 hour	1.1E-03	2.0E-03	-	5.7E-01	-
Cr (VI)[5]	365 day	1.2E-05	-	1.2E-02	-	1.5E-07
Cu	24 hour	9.0E-03	1.3E-01	-	7.0E-02	-
Fe	24 hour	2.8E-01	-	-	-	-
Hg	24 hour	2.3E-06	3.0E-01	-	7.8E-06	-
K	24 hour	2.2E-02	-	-	-	-
Mg	24 hour	3.8E-02	-	-	-	-
Mn	24 hour	5.7E-03	4.0E-01	-	1.4E-02	-
Na	24 hour	6.8E-02	-	-	-	-
Ni	365 day	7.5E-05	-	2.4E-04	-	1.8E-08
Pb	24 hour	1.2E-02	1.0E-01	-	1.2E-01	-
Se	24 hour	4.8E-06	-	-	-	-
Si	24 hour	1.1E-03	-	-	-	-
Zn	24 hour	3.2E-02	2.0E-01	-	1.6E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = Air Concentration ÷ RFC
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table E5-2
AMBIENT AIR TRACE METAL CONCENTRATIONS BASED ON VEHICULAR MOVEMENT REMEDIATED EMISSIONS FOR 25 STOCKPILES

($\mu g/m^3$)

Parameter	Average Period	Air Concentration ($\mu g/m^3$)	NJDEP Stds		Risk Analysis	
			RFC[1] ($\mu g/m^3$)	URF[2] risk/$\mu g/m^3$	Hazard[3] Quotent	Cancer[4] Risk
TSP	365 day	30	260	-	1.2E-01	-
	24 hour	194	75	-	2.6E+00	-
PM10	365 day	1	150	-	6.7E-03	-
	24 hour	8.3	50	-	1.7E-01	-
Ag	24 hour	8.2E-05	-	-	-	-
Al	24 hour	3.8E-01	-	-	-	-
As	365 day	7.5E-05	4.3E-03	-	1.7E-02	-
Ba	24 hour	6.0E-03	5.0E-01	-	1.2E-02	-
Be	365 day	1.0E-06	-	2.4E-03	-	2.4E-09
Ca	24 hour	3.9E-01	-	-	-	-
Cd	365 day	7.9E-05	-	3.5E-03	-	2.8E-07
Cr (total)	24 hour	2.0E-03	2.0E-03	-	1.0E+00	-
Cr (VI)[5]	365 day	2.4E-05	-	1.2E-02	-	2.9E-07
Cu	24 hour	1.6E-02	1.3E-01	-	1.2E-01	-
Fe	24 hour	5.0E-01	-	-	-	-
Hg	24 hour	4.1E-06	3.0E-01	-	1.4E-05	-
K	24 hour	3.9E-02	-	-	-	-
Mg	24 hour	6.7E-02	-	-	-	-
Mn	24 hour	1.0E-02	4.0E-01	-	2.5E-02	-
Na	24 hour	1.2E-01	-	-	-	-
Ni	365 day	1.5E-04	-	2.4E-04	-	3.6E-08
Pb	24 hour	2.1E-02	1.0E-01	-	2.1E-01	-
Se	24 hour	8.4E-06	-	-	-	-
Si	24 hour	2.0E-03	-	-	-	-
Zn	24 hour	5.6E-02	2.0E-01	-	2.8E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = Air Concentration ÷ RFC
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table E5-6
AMBIENT AIR TRACE METAL CONCENTRATIONS BASED ON VEHICULAR MOVEMENT AND WIND EROSION REMEDIATED EMISSIONS FOR 25 STOCKPILES

($\mu g/m^3$)

		Air	NJDEP Stds		Risk Analysis	
Parameter	Average Period	Concentration ($\mu g/m^3$)	RFC[1] ($\mu g/m^3$)	URF[2] risk/$\mu g/m^3$	Hazard[3] Quotent	Cancer[4] Risk
TSP	365 day	7	260	-	2.7E-02	-
	24 hour	69	75	-	9.2E-01	-
PM10	365 day	1	150	-	6.7E-03	-
	24 hour	8.2	50	-	1.6E-01	-
Ag	24 hour	8.1E-05	-	-	-	-
Al	24 hour	3.8E-01	-	-	-	-
As	365 day	7.5E-05	4.3E-03	-	1.7E-02	-
Ba	24 hour	6.0E-03	5.0E-01	-	1.2E-02	-
Be	365 day	1.0E-06	-	2.4E-03	-	2.4E-09
Ca	24 hour	3.9E-01	-	-	-	-
Cd	365 day	7.9E-05	-	3.5E-03	-	2.8E-07
Cr (total)	24 hour	2.0E-03	2.0E-03	-	9.9E-01	-
Cr (VI)[5]	365 day	2.4E-05	-	1.2E-02	-	2.9E-07
Cu	24 hour	1.6E-02	1.3E-01	-	1.2E-01	-
Fe	24 hour	4.9E-01	-	-	-	-
Hg	24 hour	4.1E-06	3.0E-01	-	1.4E-05	-
K	24 hour	3.9E-02	-	-	-	-
Mg	24 hour	6.7E-02	-	-	-	-
Mn	24 hour	1.0E-02	4.0E-01	-	2.5E-02	-
Na	24 hour	1.2E-01	-	-	-	-
Ni	365 day	1.5E-04	-	2.4E-04	-	3.6E-08
Pb	24 hour	2.0E-02	1.0E-01	-	2.0E-01	-
Se	24 hour	8.3E-06	-	-	-	-
Si	24 hour	2.0E-03	-	-	-	-
Zn	24 hour	5.5E-02	2.0E-01	-	2.8E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = Air Concentration ÷ RFC
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table E5-3
AMBIENT AIR TRACE METAL CONCENTRATIONS BASED ON VEHICULAR MOVEMENT REMEDIATED EMISSIONS FOR 64 STOCKPILES

$(\mu g/m^3)$

		Air	NJDEP Stds		Risk Analysis	
Parameter	Average Period	Concentration $(\mu g/m^3)$	RFC[1] $(\mu g/m^3)$	URF[2] risk/$\mu g/m^3$	Hazard[3] Quotent	Cancer[4] Risk
TSP	365 day	53	260	-	2.0E-01	-
	24 hour	306	75	-	4.1E+00	-
PM10	365 day	2.1	150	-	1.4E-02	-
	24 hour	12	50	-	2.4E-01	-
Ag	24 hour	1.2E-04	-	-	-	-
Al	24 hour	5.5E-01	-	-	-	-
As	365 day	1.6E-04	4.3E-03	-	3.7E-02	-
Ba	24 hour	8.7E-03	5.0E-01	-	1.7E-02	-
Be	365 day	2.1E-06	-	2.4E-03	-	5.0E-09
Ca	24 hour	5.7E-01	-	-	-	-
Cd	365 day	1.7E-04	-	3.5E-03	-	5.8E-07
Cr (total)	24 hour	2.9E-03	2.0E-03	-	1.4E+00	-
Cr (VI)[5]	365 day	5.1E-05	-	1.2E-02	-	6.1E-07
Cu	24 hour	2.3E-02	1.3E-01	-	1.8E-01	-
Fe	24 hour	7.2E-01	-	-	-	-
Hg	24 hour	6.0E-06	3.0E-01	-	2.0E-05	-
K	24 hour	5.7E-02	-	-	-	-
Mg	24 hour	9.7E-02	-	-	-	-
Mn	24 hour	1.5E-02	4.0E-01	-	3.7E-02	-
Na	24 hour	1.7E-01	-	-	-	-
Ni	365 day	3.1E-04	-	2.4E-04	-	7.5E-08
Pb	24 hour	3.0E-02	1.0E-01	-	3.0E-01	-
Se	24 hour	1.2E-05	-	-	-	-
Si	24 hour	2.9E-03	-	-	-	-
Zn	24 hour	8.1E-02	2.0E-01	-	4.0E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = Air Concentration ÷ RFC
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table E5-7
AMBIENT AIR TRACE METAL CONCENTRATIONS BASED ON VEHICULAR MOVEMENT AND WIND EROSION REMEDIATED EMISSIONS FOR 25 STOCKPILES
($\mu g/m^3$)

Parameter	Average Period	Air Concentration ($\mu g/m^3$)	NJDEP Stds RFC[1] ($\mu g/m^3$)	NJDEP Stds URF[2] risk/$\mu g/m^3$	Risk Analysis Hazard[3] Quotent	Risk Analysis Cancer[4] Risk
TSP	365 day	12	260	-	4.6E-02	-
	24 hour	106	75	-	1.4E+00	-
PM10	365 day	2	150	-	1.3E-02	-
	24 hour	12	50	-	2.4E-01	-
Ag	24 hour	1.2E-04	-	-	-	-
Al	24 hour	5.5E-01	-	-	-	-
As	365 day	1.5E-04	4.3E-03	-	3.5E-02	-
Ba	24 hour	8.7E-03	5.0E-01	-	1.7E-02	-
Be	365 day	2.0E-06	-	2.4E-03	-	4.8E-09
Ca	24 hour	5.7E-01	-	-	-	-
Cd	365 day	1.6E-04	-	3.5E-03	-	5.5E-07
Cr (total)	24 hour	2.9E-03	2.0E-03	-	1.4E+00	-
Cr (VI)[5]	365 day	4.8E-05	-	1.2E-02	-	5.8E-07
Cu	24 hour	2.3E-02	1.3E-01	-	1.8E-01	-
Fe	24 hour	7.2E-01	-	-	-	-
Hg	24 hour	6.0E-06	3.0E-01	-	2.0E-05	-
K	24 hour	5.7E-02	-	-	-	-
Mg	24 hour	9.7E-02	-	-	-	-
Mn	24 hour	1.5E-02	4.0E-01	-	3.7E-02	-
Na	24 hour	1.7E-01	-	-	-	-
Ni	365 day	3.0E-04	-	2.4E-04	-	7.1E-08
Pb	24 hour	3.0E-02	1.0E-01	-	3.0E-01	-
Se	24 hour	1.2E-05	-	-	-	-
Si	24 hour	2.9E-03	-	-	-	-
Zn	24 hour	8.1E-02	2.0E-01	-	4.0E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = Air Concentration ÷ RFC
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table E5-4
AMBIENT AIR TRACE METAL CONCENTRATIONS BASED ON VEHICULAR MOVEMENT REMEDIATED EMISSIONS FOR 100 STOCKPILES

(µg/m^3)

Parameter	Average Period	Air Concentration (µg/m^3)	NJDEP Stds		Risk Analysis	
			RFC[1] (µg/m^3)	URF[2] risk/µg/m^3	Hazard[3] Quotent	Cancer[4] Risk
TSP	365 day	62	260	-	2.4E-01	-
	24 hour	348	75	-	4.6E+00	-
PM10	365 day	2.5	150	-	1.7E-02	-
	24 hour	14	50	-	2.8E-01	-
Ag	24 hour	1.4E-04	-	-	-	-
Al	24 hour	6.4E-01	-	-	-	-
As	365 day	1.9E-04	4.3E-03	-	4.4E-02	-
Ba	24 hour	1.0E-02	5.0E-01	-	2.0E-02	-
Be	365 day	2.5E-06	-	2.4E-03	-	6.0E-09
Ca	24 hour	6.6E-01	-	-	-	-
Cd	365 day	2.0E-04	-	3.5E-03	-	6.9E-07
Cr (total)	24 hour	3.4E-03	2.0E-03	-	1.7E+00	-
Cr (VI)[5]	365 day	6.0E-05	-	1.2E-02	-	7.2E-07
Cu	24 hour	2.7E-02	1.3E-01	-	2.1E-01	-
Fe	24 hour	8.4E-01	-	-	-	-
Hg	24 hour	7.0E-06	3.0E-01	-	2.3E-05	-
K	24 hour	6.6E-02	-	-	-	-
Mg	24 hour	1.1E-01	-	-	-	-
Mn	24 hour	1.7E-02	4.0E-01	-	4.3E-02	-
Na	24 hour	2.0E-01	-	-	-	-
Ni	365 day	3.7E-04	-	2.4E-04	-	8.9E-08
Pb	24 hour	3.5E-02	1.0E-01	-	3.5E-01	-
Se	24 hour	1.4E-05	-	-	-	-
Si	24 hour	3.4E-03	-	-	-	-
Zn	24 hour	9.4E-02	2.0E-01	-	4.7E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = RFC × Air Concentration
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

Table E5-8
AMBIENT AIR TRACE METAL CONCENTRATIONS BASED ON VEHICULAR MOVEMENT AND WIND EROSION REMEDIATED EMISSIONS FOR 100 STOCKPILES

($\mu g/m^3$)

		Air	NJDEP Stds		Risk Analysis	
Parameter	Average Period	Concentration ($\mu g/m^3$)	RFC[1] ($\mu g/m^3$)	URF[2] risk/$\mu g/m^3$	Hazard[3] Quotent	Cancer[4] Risk
TSP	365 day	13	260	-	5.0E-02	-
	24 hour	112	75	-	1.5E+00	-
PM10	365 day	2.4	150	-	1.6E-02	-
	24 hour	13	50	-	2.6E-01	-
Ag	24 hour	1.3E-04	-	-	-	-
Al	24 hour	6.0E-01	-	-	-	-
As	365 day	1.8E-04	4.3E-03	-	4.2E-02	-
Ba	24 hour	9.5E-03	5.0E-01	-	1.9E-02	-
Be	365 day	2.4E-06	-	2.4E-03	-	5.8E-09
Ca	24 hour	6.2E-01	-	-	-	-
Cd	365 day	1.9E-04	-	3.5E-03	-	6.6E-07
Cr (total)	24 hour	3.1E-03	2.0E-03	-	1.6E+00	-
Cr (VI)[5]	365 day	5.8E-05	-	1.2E-02	-	6.9E-07
Cu	24 hour	2.5E-02	1.3E-01	-	1.9E-01	-
Fe	24 hour	7.8E-01	-	-	-	-
Hg	24 hour	6.5E-06	3.0E-01	-	2.2E-05	-
K	24 hour	6.2E-02	-	-	-	-
Mg	24 hour	1.1E-01	-	-	-	-
Mn	24 hour	1.6E-02	4.0E-01	-	4.0E-02	-
Na	24 hour	1.9E-01	-	-	-	-
Ni	365 day	3.6E-04	-	2.4E-04	-	8.5E-08
Pb	24 hour	3.2E-02	1.0E-01	-	3.2E-01	-
Se	24 hour	1.3E-05	-	-	-	-
Si	24 hour	3.2E-03	-	-	-	-
Zn	24 hour	8.8E-02	2.0E-01	-	4.4E-01	-

1. RFC - NJDEP Reference Concentration (NJDEP, 1992)
2. URF - NJDEP Unit Risk Factor (NJDEP, 1992)
3. Hazard Quotient = RFC × Air Concentration
4. Cancer Risk = URF × Air Concentration
5. Cr (VI) was assumed to equal 10% of total chromium

E6

WORKER ENVIRONMENT CONTROL VOLUME AND TURNOVER RATE

Appendix E6 presents a description of the procedures used to estimate potential impacts to the worker environment. The magnitude of the impact to worker health was assessed by projecting the particulate dust levels and corresponding trace metal concentrations in the worker environment and comparing estimated concentrations to Occupational Safety and Health Administration (OSHA) permissible exposure levels (PELs).

E6.1 CONTROL VOLUME DUST CONCENTRATIONS

Control volume particulate or dust concentrations were calculated by means of the following equation:

$$C = \frac{E \cdot 10^6}{V \cdot (v/l)}$$

where

C = dust concentration (μg/m^3),
E = particulate emission rate (grams/sec),
V = control volume (m^3),
v = wind velocity (meters/sec), and
l = longest length of control volume (m)

Total dust (TSP) and respirable particles (PM_{10}) emissions from all activities were calculated from the emission factors presented in Appendix E2, Table E2-1 for the month of August. Emissions for the month of August represent the highest total monthly emissions and were used in the assessment to provide a conservative estimate of emissions.

Different control volumes (V) were set for each of the four stockpile scenarios examined. Dimensions of each area are presented in Section 8, and listed in Table E6-1. All control volume heights were set at 5 m. Control volume areas were assumed to be the area of all the stockpile pads in the given scenario.

Air turnover exchange rates within a control volume were assumed to be a function of the wind speed and direction. A constant wind speed during relatively calm conditions of one meter per second was used in the assessment. This results in an exchange of the air within a 920 m length control volume (100 stockpile storage site) in approximately 4-1/2 minutes. This represents 13 turnovers per hour. The wind was assumed to travel diagonally over the control volume. Figure E6-1 presents a schematic of a 100, 360-ton stockpile storage area.

Calm conditions (i.e., wind speed $\leq$ 1 m/s) will rarely occur over an extended period. Wind speeds in the Northeast portion of the U.S. average approximately five mph (2.3 m/s). As a result, outdoor turnover rates associated with a one meter per second wind velocity are extremely conservative. Turnover rates approximately

Table E6-1
CONTROL VOLUME DIMENSIONS

Number of Stockpiles	Length[1] (m)	Height[2] (m)	Loingest Distance[3] (m)	Area[4] (m^2)	Volume[5] (m^3)
9	59	5	84	3,537	17,686
25	99	5	140	9,826	49,129
64	159	5	224	25,154	125,770
100	198	5	280	39,303	196,515

1. The length of the side of the stockpile storage area
2. The height of the side of the stockpile storage area
3. The longest length was calculated as the diagonal distance accross the control volume
4. Area = Length × Length
5. Volume = Area × Height

Table E6-2
WORKER ENVIRONMENT PARTICULATE CONCENTRATIONS

		Particulate Emissions (g/s)[1]				1 m/s wind speed		2.3 m/s wind speed	
Particulate	Stockpiles	Wind Erosion	Loader Batch Drop	Vehicular Movement	Total	Air Turnover Rate[2] (seconds)	Dust[3] Concentration (μg/m^3)	Air Turnover Rate[2] (seconds)	Dust[3] Concentration (μg/m^3)
TSP	9	9.3E-04	2.8E-04	3.0E-01	3.0E-01	84	1431	37	622
	25	2.6E-03	7.6E-04	8.3E-01	3.0E-01	140	2385	61	1037
	64	6.6E-03	2.0E-03	2.1E+00	6.0E-01	224	3816	98	1659
	100	1.0E-02	3.1E-03	3.3E+00	1.2E+00	280	4770	122	2074
PM_{10}	9	1.1E-06	1.3E-04	1.3E-01	1.3E-01	84	641	37	279
	25	3.0E-06	3.6E-04	3.7E-01	3.7E-01	140	1068	61	465
	64	7.7E-06	9.3E-04	9.6E-01	9.6E-01	224	1710	98	743
	100	1.2E-05	1.4E-03	1.5E+00	1.5E+00	280	2137	122	929

1. Particulate emissions are based on the emssions from the worst month as presented in Table E2-1 Appendix E2
2. Air turnover rate was calculated by dividing the longest distance traveled (see Table E6-1) by the wind spped.
3. Dust Concentration was calculated by multiplying the total emissions by the air turnover rate

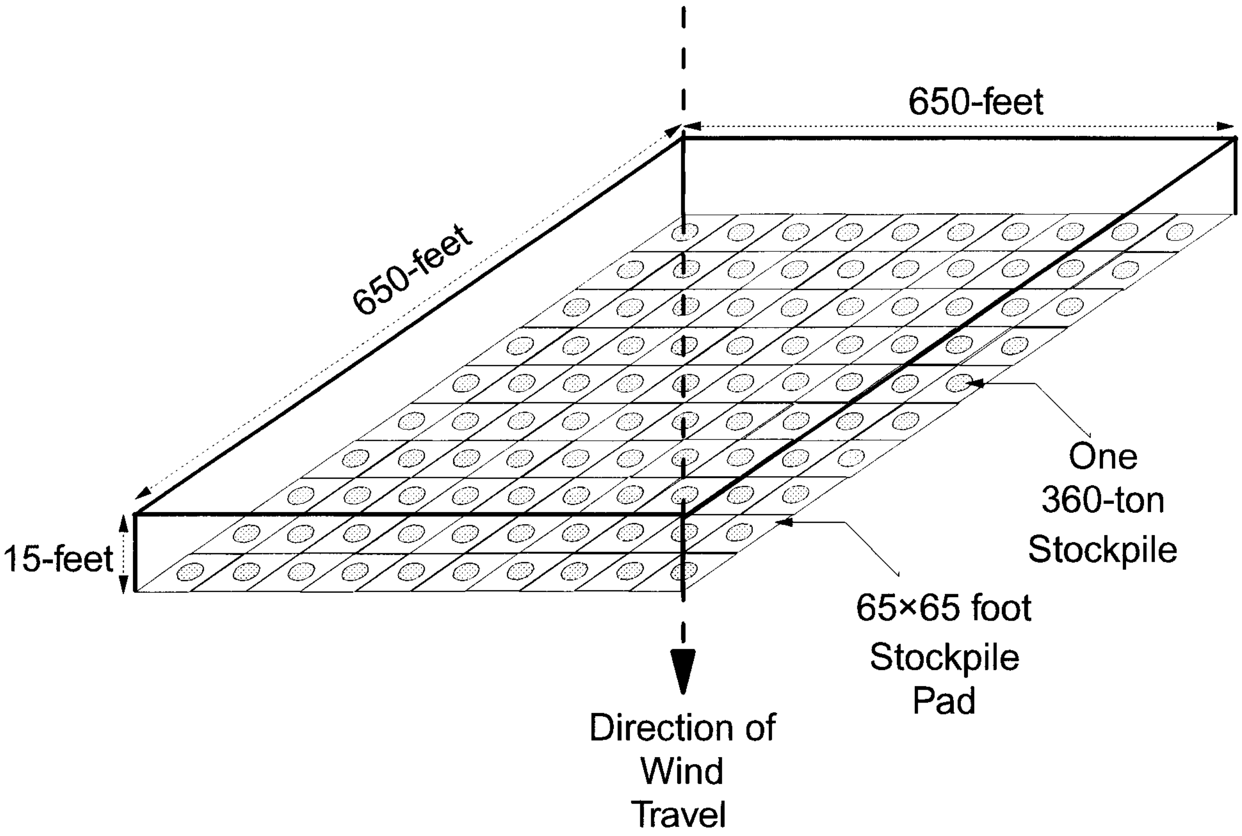


Figure E6-1
WORKER HEALTH ASSESSMENT 100 360-TON BOTTOM ASH STOCKPILE CONTROL VOLUME

2-1/2 times this amount are more likely.

Table E6-2 presents sample calculations and the resulting projected control volume turnover rates and dust concentrations for all four stockpile storage site scenarios.

E6.2 CONTROL VOLUME TRACE METAL CONCENTRATIONS

Table E6-3 presents a sample calculation used to project the trace metal concentrations in the storage and blending site control volume at a wind speed of one meter per second. The table presents values for the nine stockpile storage site scenarios. The table includes the bottom ash trace metal content used in the ambient trace metal calculations, which are based upon stockpile elemental characterization and Warren County Resource Recovery Facility <30μ bottom ash data (see Appendix E3).

Table E6-3
WORKER ENVIRONMENT TRACE METAL CONCENTRATIONS FOR 9 STOCKPILES

Trace Metal	Bottom Ash[1] Trace Metal Content (µg/g)	Dust[2] Concentration ($\mu g/m^3$)	Trace[3] Metal Concentration ($\mu g/m^3$)
Ag	10	1431	1.4E-02
Al	45,800	1431	6.6E+01
As	98	1431	1.4E-01
Ba	728	1431	1.0E+00
Be	1	1431	1.4E-03
Ca	47,400	1431	6.8E+01
Cd	87	1431	1.2E-01
Cr	269	1431	3.8E-01
Cu	1,705	1431	2.4E+00
Fe	59,800	1431	8.6E+01
Hg	0	1431	7.1E-04
K	4,740	1431	6.8E+00
Mg	8,120	1431	1.2E+01
Mn	1,220	1431	1.7E+00
Na	14,420	1431	2.1E+01
Ni	148	1431	2.1E-01
Pb	2,433	1431	3.5E+00
Se	1	1431	1.5E-03
Si	244	1431	3.5E-01
Zn	6,700	1431	9.6E+00

1. Trace metal content of Warren County Bottom Ash based on stockpile analysis or Warrren County <30µ particulates (see Appendix E3)
2. Based on 9 stockpiles and 1 m/s air speed (See Table E6-2).
3. Trace metal concentration calculated as follows:
   [Dust Concentration ($\mu g/m^3$) ÷ 1000000 (µg/g)] × Trace metal Content (µg/g)

REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE

May 1997

3. REPORT TYPE AND DATES COVERED

NREL Subcontract Report

4. TITLE AND SUBTITLE

Municipal Solid Waste Combustor
Bottom Ash Stockpile Runoff and
Dust Emissions Evaluation

5. FUNDING NUMBERS

Task #: IT632020

Subcontract #: AAE-3-13278

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

The Long Island Regional
Planning Board
Hauppauge, New York

8. PERFORMING ORGANIZATION REPORT NUMBER

DE97000246

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401-3393

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

NREL/SR-430-22847

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

12b. DISTRIBUTION CODE

UC-600

13. ABSTRACT *(Maximum 200 words)* Residues from municipal waste combustors in the US are currently managed by disposal, usually as combined ash in permitte monofills. In Europe it is a common practice in many locales to separate the bottom ash produced in municipal solid waste combustors from the fly ash. The bottom ash is processed and used as a substitute aggregate material in road construction and the fly ash is disposed of, sometimes with treatment, in secure landfills. If residues are to be recycled in the US, it will most likely require the separation of the bottom ash and fly ash streams. A major precondition for using bottom ash as an aggregate substitute material in the US is the identification of and, if needed, the mitigation of all potential environmental impacts associated with the use of bottom ash in construction applications.

14. SUBJECT TERMS

municipal solid waste, fly ash, bottom ash, aggregate substitute

15. NUMBER OF PAGES
200

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102