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VOL VIII

FULL-SCALE INCINERATION SYSTEM DEMONSTRATION AT THE NAVAL BATTALION CONSTRUCTION CENTER, GULFPORT, MISSISSIPPI - VOL VIII: DELISTING

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This technical report is divided into eight volumes. This portion of the report comprises Volume VIII, Delisting. This volume documents the regulatory and technical lessons learned concerning disposition of soil that is considered hazardous after treatment. The report also documents the data collected in support of soil disposition. This demonstration project consisted of three phases: 1) demonstration of the effectiveness of the incinerator to process the soil, (2) demonstration of the ability of the incinerator to meet Resource Conservation and Recovery Act requirements (Destruction and Removal Efficiency of 99.999T), and (3) determination of the cost and reliability of using the incinerator on a long-term basis. The overall goal of the project was to determine the reliability and cost effectiveness of a 100 ton/day rotary kiln incinerator in processing soil contaminated with dioxins and other hazardous constituents of Herbicide Orange.

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EXECUTIVE SUMMARY

The Naval Construction Battalion Center Demonstration Project was conducted as part of the research, test, and evaluation phase of the U.S. Air Force Installation Restoration Program and was sponsored by the Air Force Engineering and Services Center (AFESC). The overall goal of the project was to determine the reliability and cost effectiveness of a 100 ton/day rotary kiln incinerator in processing soil contaminated with dioxins and other hazardous constituents of Herbicide Orange.

The demonstration project consisted of three phases. The first phase, the verification test burn, demonstrated the effectiveness of the 100 ton/day incinerator to process soil contaminated with constituents of Herbicide Orange, in particular 2,3,7,8-tetrachlorinated dibenzo dioxin.

The second phase demonstrated the ability of the incinerator to meet the requirements of the Resource Conservation and Recovery Act (RCRA), which specifies that the incinerator must meet or exceed a Destruction and Removal Efficiency of 99.9999%.

The third phase determined the cost and reliability of using the incinerator on a long-term basis.

This report is the last of eight volumes. Volume VIII documents the regulatory and technical lessons learned concerning disposition of soil after treatment. The report also documents the data collected in support of soil disposition.

Following the Section I introduction, Section II outlines the initial regulatory interaction for soil disposition between AFESC and the Environmental Protection Agency (EPA). It explains EPA's use of the Vertical Horizontal Spread/Organic Leachate Model (VHS/OLM) to show the health risk of a hazardous waste site. Comments and criticisms of VHS/OLM are presented.

Sections III and IV explain the field operations and subsequent analyses that were undertaken to support delisting of the soil, including the

verification test burn, a RCRA trial burn, and data collected during routine operations.

Section V presents conclusions that can be drawn from the delisting process. It examines problems with EPA's Practical Quantitation Limits and VHS/OLM, the cost and level of effort, the technical complexity, the required concentrations needed for delisting, and the Air Force response to EPA's implied delisting denial.

Section VI offers six recommendations to anyone considering submission of a delisting petition for a hazardous waste.

PREFACE

This report was prepared by EG&G Idaho, Inc., P. O. Box 1625, Idaho Falls, ID 83415, under Job Order Number (JON) 2103 9027, for the Air Force Engineering and Services Center, Engineering and Services Laboratory, Tyndall Air Force Base, Florida 32403-6001.

This report summarizes work done between September 1989 and February 1989 Major Terry Stoddart and Major Michael L. Shelley were the AFESC/RDVS Project Officers.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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LIST OF ABBREVIATIONS

AA	atomic absorption
AFESC	Air Force Engineering and Services Center
CLP	Contract Laboratory Program
DOD	Department of Defense
DRE	Destruction and Removal Efficiency
EC	electron capture
EP	Extraction Procedure
EPA	Environmental Protection Agency
GC	gas chromatograph
GFAA	gas flame/atomic absorption
HCE	hexachloroethane
HO	Herbicide Orange
HPLC	high performance liquid chromatography
HRGC	high resolution gas chromatography
HRMS	high resolution mass spectrometry
HxCDD	hexachlorodibenzodioxin
INEL	Idaho National Engineering Laboratory
ITAS	International Technologies Analytical Services
MDL	minimum detection limit
MS	mass spectrometry
NCBC	Naval Construction Battalion Center
OLM	Organic Leachate Model
OSW	EPA Office of Solid Waste
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PeCDD	pentachlorodibenzodioxin
PIC	product of incomplete combustion
POHC	principle organic hazardous constituent
ppb	parts per billion

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ppm	parts per million
ppq	parts per quadrillion
ppt	parts per trillion
PQL	practical quantitation limit
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development, and Demonstration
SAIC	Science Application International Corporation
SCC	secondary combustion chamber
SOW	statement of work
TCB	1,2,4-trichlorobenzene
TCDD	tetrachlorodibenzo-p-dioxin
TCLP	Toxicity Characteristic Leachate Procedure
UV	ultraviolet
VHS	Vertical Horizontal Spread
VOST	volatile organic sampling train

SECTION I
INTRODUCTION

A. OBJECTIVE

The purpose of the Full-Scale Incinerator System Demonstration Project was to show the reliability/maintainability and cost effectiveness of a mobile rotary kiln incinerator system for soil cleanup and restoration at a Herbicide Orange (HO)-contaminated site. The mobile waste incineration system, Model MWP-2000, manufactured and operated by Environmental Services Company (now known as ENSCO) of Little Rock, Arkansas, was selected for the project. The selected location was a former HO storage site at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi. This project was under the sponsorship of the Air Force Engineering and Services Center (AFESC), Tyndall Air Force Base, Florida.

The field demonstration of the program was organized in three phases to meet U.S. Environmental Protection Agency (EPA) requirements for a Research, Development, and Demonstration (RD&D) permit:

1. A preoperational test burn to verify technical performance and provide data for a range of soil feed rates.

2. A trial burn to ensure conditions of a Resource Conservation and Recovery Act (RCRA) permit can be met.

3. Continuous operation to provide reliability and maintainability data.

Additionally, a fourth phase, disposition of the process ash resulting from the test burns and continuous operation, was required by the EPA Office of Solid Waste (OSW) under RCRA regulations. This report discusses the activities associated with the fourth phase. The other phases are reported separately in References 1 through 7.

The objective of this report is to describe:

1. The regulatory process for disposition of incinerator residues.

2. The actions taken by the U.S. Air Force and its contractors to dispose of the process residues and the rationale for those actions.

3. The data collected to support incinerator residue disposition.

4. The conclusions, recommendations, and lessons learned from the disposition activities.

B. BACKGROUND

1. Former Use of Herbicide Orange (HO)

HO is primarily composed of two compounds, 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4-5-trichlorophenoxyacetic acid (2,4,5-T), and various esters of these two compounds. It was sprayed as a defoliant in Vietnam during the 1960s and at Eglin Air Force Base, Florida, between 1962 and 1970. NCBC served as a temporary storage site for the HO-filled drums while awaiting loading of those drums for ocean shipping to Vietnam. Early in 1970, the herbicide 2,4,5-T was reported to be a teratogen in mice and rats (Reference 8). More specifically, studies identified an unwanted by-product, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), which is contained in 2,4,5-T, as the reason for the teratogenic effects (Reference 9). The Department of Defense (DOD) discontinued the use of HO in 1970 (Reference 10). At that time, the remaining continental U.S. stockpile (850,000 gallons) was stored at NCBC, and the 1,370,000 gallons located in South Vietnam were shipped to Johnston Island in the central Pacific Ocean (Reference 11).

During the summer of 1977, the entire 2.2 million gallon HO stockpile was disposed of at sea by high temperature incineration (Project PACER HO, Reference 11). However, spills during the storage and handling of HO left the soil at the storage area contaminated with dioxin. The Air Force Logistics Command Plan and EPA permits for the disposal of bulk quantities of HO committed the Air Force to a followup storage site reclamation and environmental monitoring program (Reference 11). Immediately following the at-sea incineration, the U.S. Air Force Occupational and Environmental Health

Laboratory initiated site monitoring studies of chemical residues in nearby soil, drainage water, and drainage ditch sediment at the former NCBC HO storage site (References 11 and 12).

In 1984, AFESC requested the services of EG&G Idaho, Inc., at the Idaho National Engineering Laboratory (INEL) to characterize the extent of soil contamination (Reference 12). Subsequently, in 1985 EG&G Idaho managed two small-scale technology demonstration projects to determine the feasibility of decontaminating soil containing dioxins (References 13 and 14). Although those demonstrations were successful, the technologies were not sufficiently developed to process large quantities of soil. Therefore, AFESC continued with the technology demonstration using a full-scale rotary kiln incinerator. This demonstration was conducted under an RD&D permit granted by EPA Region IV.

The incinerator system was owned and operated by ENSCO and arrived onsite in September 1986. The verification test burn was performed in December 1986 (Reference 2) followed by a RCRA trial burn in May 1987 (Reference 7). Routine operations began in November 1987 and continued until November 1988. The incinerator was decontaminated and removed from the NCBC site in February 1989.

In November 1988 the Air Force submitted a petition to EPA requesting that the processed soil be excluded from the EPA's list of hazardous waste (Reference 15). That petition included data from the verification test burn, the RCRA trial burn, and operational data that was collected from the start of operations until July 1988. Subsequently, in March 1989 an addendum report was submitted that included operational data collected between August 1988 and the end of the routine operations in November 1988 (Reference 16).

At the time of this writing, EPA has not made a formal determination concerning the disposition of the processed ash.

2. Storage Site Location

NCBC is a fenced, limited-access military installation (see Figure 1). It is a land area of several square miles located approximately 2 miles from the Gulf of Mexico and is approximately 20 feet above sea level.

Approximately 18 acres at NCBC served as an HO storage site. During the temporary storage phase, the HO drums were stacked within three zones (A, B, and C), shown as shaded areas in Figure 2. The stacks in Zones B and C covered 40-foot-wide by 1200-foot-long strips along the indicated roadways (Figure 3). The storage of filled drums during 1970-1977 occurred only in Zone A. Because of the arrangement of the drums, approximately 31 acres of land were left unusable. The storage site within the perimeter of Zones A, B, and C is a restricted area and is not used. The soil processed during the one year of operation is stored entirely in Zone A.

C. SCOPE/APPROACH

The scope of this report is to document the regulatory and technical lessons learned concerning disposition of soil that is considered hazardous after treatment. This report also documents the data collected in support of soil disposition.

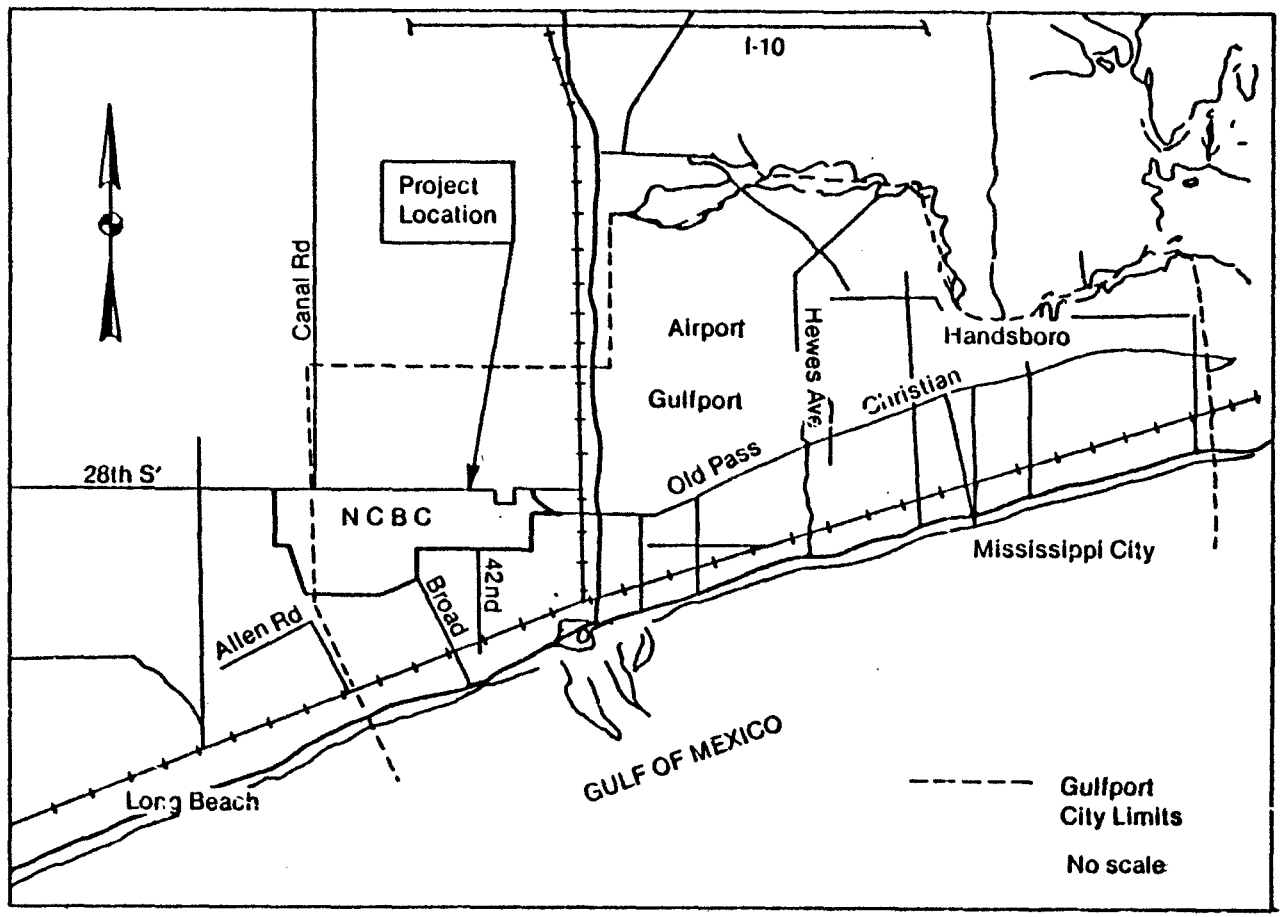

Figure 1. NCBC Vicinity Map.

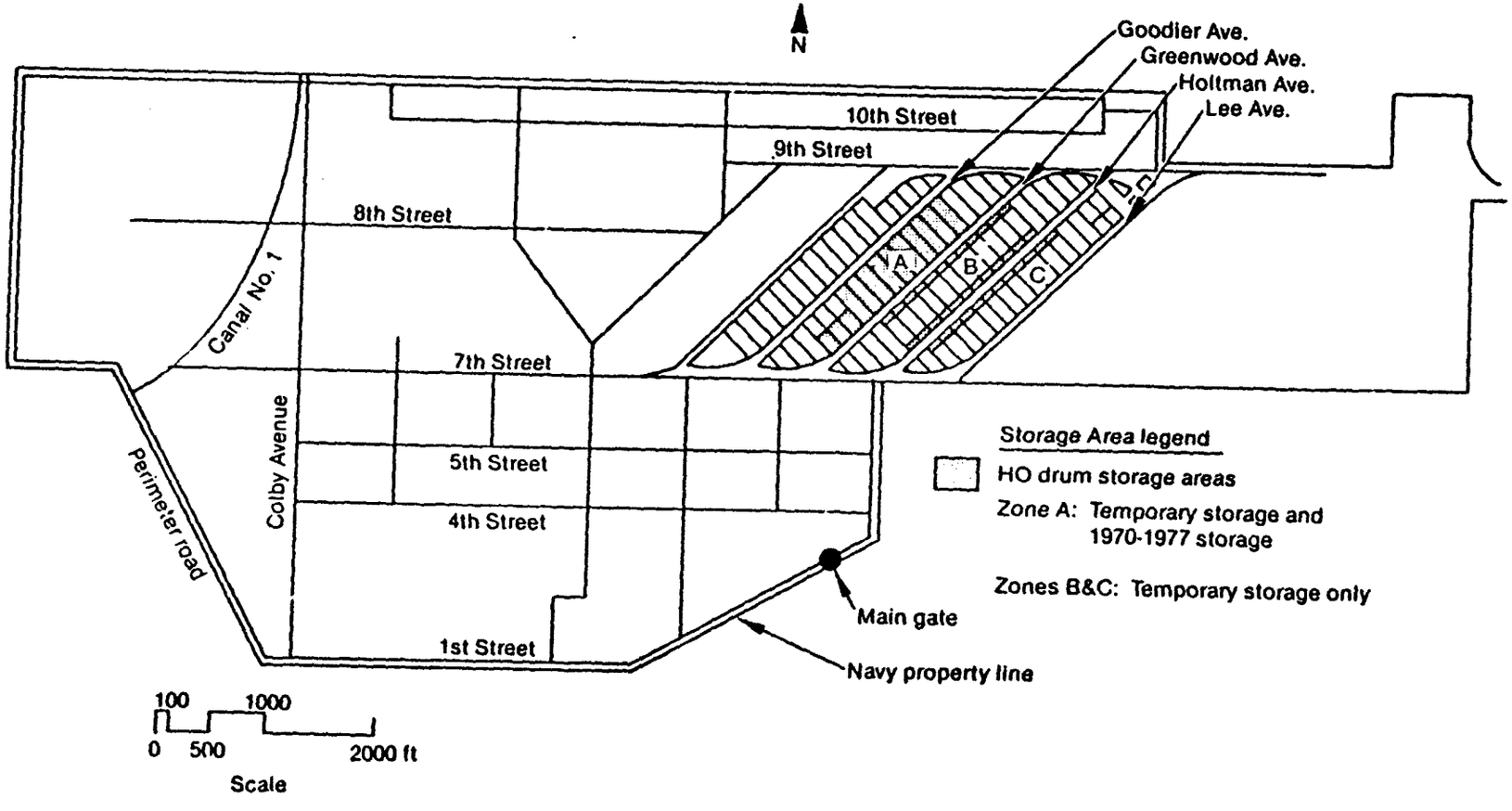

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Figure 2. NCBC and Location of Former Herbicide Orange Storage Site.

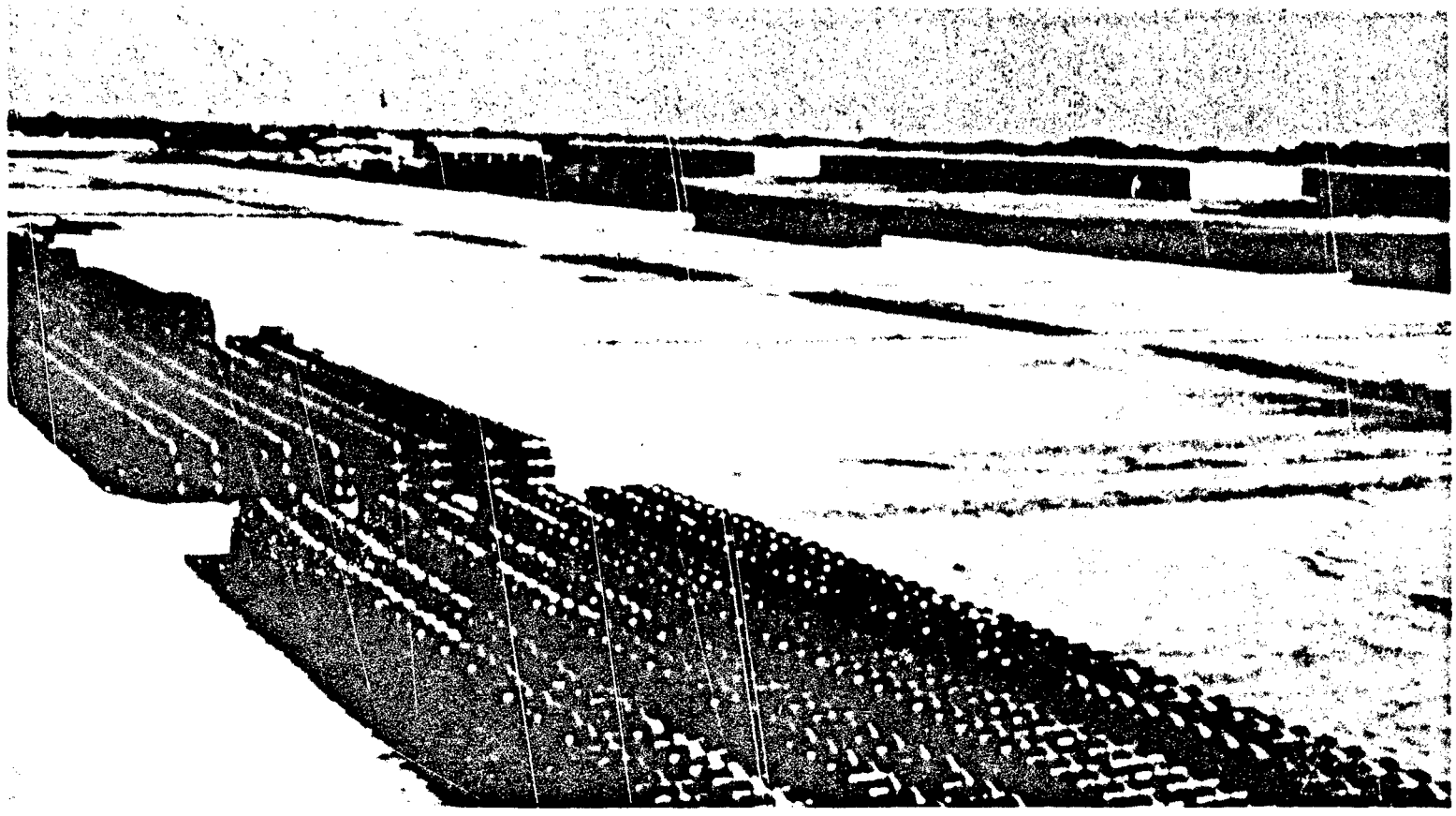

Figure 3. HO Drum Stacks in NCBC Storage Zones B and C.

SECTION II
INITIAL REGULATORY INTERACTION FOR SOIL DISPOSITION

A. LAND DISPOSAL RESTRICTIONS

According to EPA regulations described in 40 CFR 260.20, waste containing 2,3,7,8-TCDD or 2,3,7,8-tetrachlorinated dibenzofuran is classified as an F027 waste. On 7 November 1986, OSW promulgated regulations that effectively banned the land disposal of waste containing dioxins in excess of 1.0 parts per billion (ppb) (Reference 17). The regulations permitted disposal of dioxin-containing waste in approved landfills if the dioxin concentration was less than 1.0 ppb; however, at the time of project commencement, there were no approved landfills in the United States accepting any dioxin-contaminated waste. This effectively meant that disposal of dioxin-containing waste required processing. However, when such a waste is processed in an EPA-approved treatment device, the resulting waste is still considered hazardous and is defined as an F028 waste.

Because the F028 waste is still considered hazardous, it must either be disposed of as hazardous waste in an approved Subtitle C landfill or be excluded as a hazardous waste. The exclusion process is called "delisting." Delisting is a procedure by which a waste generator may petition EPA to review applicable data that could be used to determine if a waste meets the regulatory definitions of a hazardous waste. A petition mechanism to EPA is described in 40 CFR 260.20 and 260.22. That procedure allows persons to demonstrate that a specific waste from a particular site or generating facility should not be regulated as a hazardous waste under 40 CFR 261. To be excluded from regulation, petitioners must show that the waste does not meet any of the listing criteria, and must also demonstrate that the waste does not exhibit any of the hazardous waste characteristics and does not contain any other toxicants at hazardous levels (Reference 18). If EPA determines that the waste is no longer hazardous, it will remove that particular waste from its list of hazardous wastes, hence the name "delisting."

Once an F028 waste is delisted, it may be placed in a Subtitle D type landfill (e.g., a permitted municipal solid waste landfill), or with EPA permission it may be placed back upon the original site. The most economical option for the process ash appeared to be delisting followed by onsite disposal. Therefore, AFESC pursued the delisting option.

B. AFESC RESPONSE TO LAND DISPOSAL RESTRICTIONS

As with most regulatory petitions, the delisting process undergoes a very long and detailed review cycle. At the time of project initiation in early 1986, OSW expected the delisting process to take up to 2 years and it would not grant delisting of the waste prior to processing and analysis of the processed soil. Due to the unavailability of certified landfills that could accept F028-listed waste and the potential enormous costs of land disposal, AFESC was unwilling to commit to processing large quantities of contaminated soil without some assurances that delisting could be obtained. Therefore, prior to commencing routine soil processing, AFESC decided to perform a verification test burn.

The purpose of the verification test burn was to demonstrate that the MWP-2000 incinerator could process soil contaminated with polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and other constituents of HO and produce no hazardous effluents. AFESC project personnel were particularly concerned that the incinerator residue could meet the apparent EPA headquarters criteria for delisting, and that the incinerator would not produce any hazardous off-gases. EPA Region IV, which had permitting authority for this project, was particularly concerned about potential production of hazardous off-gases. Therefore, it required successful completion of a verification test burn prior to granting permission to commence routine soil processing and data gathering.

The delisting authority, which differs from the RD&D permitting authority, could influence the sampling and analysis planning for the verification test burns. Therefore, AFESC and EG&G Idaho project personnel obtained guidance early in the project from both OSW and EPA Region IV to improve the possibility of delisting petition approval when submitted later.

A draft delisting petition was submitted 22 January 1986 to OSW in Washington, D.C. Included was a list of constituents possibly present in the untreated soil at the former HO storage site. The recommended analytical methods and associated detection limits for each constituent were also listed. In response to a verbal request, additional NCBC sample data were submitted 14 April 1986. Because the revised RD&D application included a revised sampling and analysis matrix plan, a copy of this plan was also transmitted to OSW seeking verification that the revised plan was acceptable for the purpose of pursuing delisting. OSW did not respond during the period of the RD&D application review by EPA Region IV.

On 11 September 1980, OSW responded. The OSW letter:

1. Identified PCDD/PCDF congeners, chlorinated benzenes, and chlorinated phenols to be on the analysis list.

2. Recommended a list of only 9 metals; whereas, the EG&G Idaho list showed 14 metals.

3. Added three polycyclic aromatic hydrocarbons not on the submitted list.

4. Added 2,4-D and 2,4,5-T to the analysis list.

5. Deleted coal tar and creosote from the analysis list.

A meeting was held with OSW in Washington, D.C., 19 September 1986 to clarify certain details regarding the letter. A representative from Versar, Inc., the company performing the verification sampling for the project, also attended. Versar transmitted a modified sampling and analysis matrix plan to OSW on 15 October 1986. This plan included all analyses requested by OSW and several additional analyses to ensure that comprehensive analytical data would be available. The letter also included discussion about methods to achieve low detection limits for PCDDs/PCDFs and organics. On 12 December 1986, OSW confirmed that data collected in accordance with the modified sampling and analysis plan would be sufficient for the purposes of evaluating a delisting petition (i.e., OSW implicitly agreed not to request additional analyses after

the verification test burn was completed when additional data collection would have been impractical).

C. VERTICAL HORIZONTAL SPREAD (VHS) MODEL

On 27 November 1985, EPA proposed the Vertical Horizontal Spread (VHS) model in the Federal Register (Reference 19). The equation is a non-site-specific groundwater transport model that attempts to predict the fate of a given contaminant in a drinking water aquifer as it moves off of a hazardous waste site toward a drinking water well. Presumably, if the model showed that the health risk to nearby human receptors was within the range of acceptability, then EPA could grant delisting. If the model showed the risk to be unacceptable, then EPA would most likely deny delisting.

The model uses the following expression to determine a concentration of the contaminant in drinking water arbitrarily set 500 feet down gradient from a waste pit:

$$C_y = C_o \text{ erf} \left[\left(\frac{Y'}{4Y} \right) 0.5 \right] \text{ erf} \left[\frac{X}{4(\alpha_t y)\ 0.5} \right] \qquad (1)$$

where

C_y = Predicted groundwater concentration at a hypothetical receptor well located a distance Y down gradient (ppm)

C_o = Leachate concentration obtained from Extraction Procedure (EP) toxicity data or the Organic Leachate Model (ppm)

Y' = Width of hypothetical waste trench, fixed at 12.2 meters

Y = Distance to the receptor well, fixed at 152.4 meters

α_t = Transverse dispersivity, fixed at 2 meters

X = Length of the hypotnetical trench, in meters, calculated from the waste volume assuming a trench 12.2 meters (40 feet) wide and 2.4 meters (8 feet) deep.

The only variables in the equation that are not previously fixed by EPA are X, the length of the hypothetical trench, and the two concentrations C_y and C_o. If the volume of waste exceeds 6116 cubic meters (8000 cubic yards), where X would equal 206 meters, then the second error function in the equation approaches unity. Substituting the aforementioned values into Equation 1, one obtains:

$$C_y = C_o \times (0.1585) \ . \qquad (2)$$

Normally, C_o is determined through analysis using the EP Toxicity Test* or the Oily Waste EP Toxicity Test. For organics, however, EPA considered those tests inaccurate, therefore, at the time the VHS model was promulgated, EPA also proposed an empirical model for predicting C_o, the concentration of an organic in leachate as it enters the aquifer (Reference 20). Based on that proposed equation, EG&G Idaho ran the two models and determined that if the soil was processed and achieved a cleanup standard of less than 0.1 ppb, then delisting was plausible. Those calculations assumed a solubility of dioxin in water of 100 parts per trillion (ppt) and a pseudo-drinking water standard of 0.2 parts per quadrillion (ppq or parts per 10^{-15}).

Because there was no maximum concentration level for 2,3,7,8-TCDD in either the National Primary Drinking Water Standard or the National Secondary Drinking Water Standard, EPA adopted a pseudo-drinking water standard based on a cancer risk specific dose estimate of 6.4×10^{-12} mg/kg body weight-day (Reference 21). That risk estimate was based on a plausible upper-bound increased cancer risk of one in a million (10^{-6}) when exposed to the carcinogen at the dose rate for a lifetime; EPA assumed that a 70-kg person residing near the waste site consumed 2 liters of water per day from a

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* After 25 September 1990, the EP Toxicity Test was changed to the Toxicity Characteristic Leachate Procedure (TCLP). See Federal Register, 29 March 1990, p. 11798.

potentially contaminated drinking water well for 70 years. This resulted in a pseudo-drinking water standard of 0.2 ppq* (i.e., 2×10^{-4} ppt).

On 29 July 1986, EPA proposed a revised Organic Leachate Model (OLM) equation in the Federal Register (Reference 22). That model, which became final 13 November 1986 (Reference 23), is given by:

$$C_o = 0.00211\ C_w^{0.678}\ S^{0.373} \qquad (3)$$

where

C_o = leachate entering the aquifer (mg/L)

C_w = concentration of organic in the waste residue (mg/L)

S = the solubility of the organic (mg/L).

By combining Equations 2 and 3, one obtains

$$C_y = C_w^{.678}\ S^{.373}\ (0.0003344)\ . \qquad (4)$$

Rearranging and solving for C_w, one obtains

$$C_w = \left(\frac{C_y}{(S^{.373})(0.0003344)} \right)^{\frac{1}{0.678}}\ . \qquad (5)$$

It is interesting to note that the only volume-dependent term in Equation 1 is in the second err r function term. From this, it can be seen that the larger the waste volume, the lower the allowed concentration of organic contaminant in the waste. Equation 5 shows that if the drinking water standard is used for C_y and if the waste volume exceeds 6116 cubic

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* It is important to note that this pseudo-drinking water standard is more than two orders of magnitude below the best available analytical detection limits of 0.035 ppt observed for clean tap water during the verification test burn (Reference 2).

meters, such that the second error function in Equation 1 approaches unity, then the cleanup standard, C_w, remains fixed and independent of waste volume.

In 1986, both EG&G Idaho and EPA used 100 ppt for the solubility and 0.224 ppq for the compliance point concentration, C_y. This resulted in an allowed waste concentration, C_w, of 0.124 ppt. Because the analytical detection limits of the incinerator residue were projected to be approximately 5 ppt, the delistability of the incinerator residue became uncertain.

Closer examination of EPA's use of the OLM equation revealed that the 100 ppt solubility term, S, was based on pure 2,3,7,8-TCDD in pure deionized and distilled water. Additional research by the Monsanto Company revealed that the actual solubility of 2,3,7,8-TCDD in soil was 7.96×10^{-6} ppm (7.96 ppt), or two orders of magnitude lower than the previously used solubility (Reference 24). This correction to the solubility was submitted to EPA on 25 February 1987. Using this solubility and a pseudo-drinking water standard of 0.224 ppq (Reference 21), a delisting criteria, C_w, of 0.499 ppt of 2,3,7,8-TCDD in the soil was obtained. This level, however, is still below the best achievable detection limit using high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). Fortunately, EPA recognized this dilemma when it promulgated the OLM equation in 51 FR 41082-41100 (Reference 23); it stated: "Where hazardous constituents in a waste are determined to be nondetectable using appropriate analytical methods, the Agency will, as a matter of policy, not regulate the waste as hazardous." This simply meant that the waste analysis had to show nondetectable concentrations of 2,3,7,8-TCDD using HRGC/HRMS techniques to potentially obtain delisting. The verification test burn data clearly showed that neither 2,3,7,8-TCDD nor total TCDD was detected in the incinerator ash, thus delisting appeared probable.

D. CONTINUED USE OF VHS/OLM FOR DELISTING

Since promulgation of the VHS/OLM for evaluation of delisting, EPA has received an abundance of criticism. Most of the criticism has centered on the extraordinary conservatism of the model. Nevertheless, EPA believes the

VHS/OLM represents a "reasonable worst case" management scenario and therefore has continued to use the model.

On 2 June 1988, OSW answered many of the criticisms in response to public comment on a proposed delisting petition by Syntax Agribusiness, Inc., for certain solid wastes that were to be generated at the Denny Farm site in McDowell, Missouri, by the EPA mobile incinerator system (Reference 25). Some of the most significant comments are addressed below:

1. Conservativeness and Appropriateness of VHS/OLM

Several commentators expressed concern regarding the EPA's use of the OLM and VHS model as factors in setting the delisting levels; they criticized the conservative assumptions and parameters of the models. EPA responded by restating its need to maintain a "reasonable worst case" conservative approach to not incorrectly release a waste from the control of RCRA Subtitle C.

2. Site Specific Use of VHS/OLM

Other commentators criticized the choice of the VHS/OLM because its generic nature does not permit site specific factors to be considered. However, EPA believed that since the waste to be delisted would be removed from RCRA control and it could be put anywhere, it had to take a conservative approach and assume that it would be placed in any landfill. EPA apparently did not have the authority to specify the location of final waste disposal following delisting.

3. Use of Other Models

One commentator suggested that the model used by the Centers for Disease Control (Reference 26) be used instead of the VHS/OLM. However, that model only modeled the dermal and direct ingestion pathway and did not consider ingestion of groundwater as does the VHS/OLM. EPA considered use of other models that were under development by the EPA Office of Research and Development, however, those models were not sufficiently developed or peer reviewed for regulatory use.

4. Sorption Mechanisms

One commentator criticized the lack of attenuative mechanisms within the VHS/OLM that would significantly reduce the predicted concentration of highly attenuative compounds such as dioxin. EPA acknowledged that sorption effects can play an important part in the migration of contaminants through groundwater. However, it maintained that sorption effects are site specific and, therefore, chose to maintain a "reasonable worst case" position and not include them at all.

5. Data Basis for VHS/OLM

One commentator criticized the data on which the OLM was based. In particular, the commentator stated that the OLM is inappropriate for predicting the leaching capacity of highly insoluble compounds (such as dioxin) because highly insoluble compounds are not well represented in the data base on which the OLM was based. The commentator also stated that the insoluble compounds that are represented in the data base show a very poor correlation with the adopted model and that the actual leaching data from municipal incinerator ash show that the OLM overpredicts dioxin leaching by a factor of 100.

In response, EPA explained that the OLM was constructed by using a variety of soluble and insoluble organic compounds in a variety of matrices. EPA agreed that the variability of leaching data is partly responsible for the low correlation. Additionally, EPA stated that in general, any time a correlation is developed from a subset of data, the correlation will naturally be lower. Nevertheless, EPA continued to maintain a "reasonable worst case" position and did not permit the use of additional data from municipal incinerator ash from which to develop different correlation coefficients.

6. Receptor Water Consumption

One commentator criticized the highly conservative assumptions that the receptor lives only 500 feet down gradient from the disposal site and

that the receptor obtains all of his/her drinking water (2 liters per day) from that well for an entire lifetime. However, because the commentator did not submit supporting data, EPA rejected the commentator's suggestion that alternative assumptions would be appropriate.

7. Conservation of Mass

Because of its simplicity, the VHS/OLM assumes no conservation of mass. In essence, the model implicitly fixes the source term of the model as infinite with respect to time; there are no decay terms or terms that account for eventual depletion of the contamination source. This assumption, which has become one of the most discussed assumptions within the VHS/OLM, would most likely underestimate the dilution of a contaminant that may occur in an aquifer. Although EPA acknowledged this flaw and that models do not always predict factual values accurately, EPA believes that the VHS model provides a useful analytical tool for the evaluation of the hazards posed by hazardous wastes.

8. Toxicity Characteristic Leachate Procedure Modeling

The promulgation of the Toxicity Characteristic Leachate Procedure (TCLP) for organics and metals may cause some changes in EPA policy. In development of the TCLP, EPA used the Composite Model for Landfills (Reference 27). The model is considerably more sophisticated than the VHS/OLM and removes some of the overconservatism inherent in the VHS/OLM. At the time of this writing, OSW has not approved the use of Composite Model for Landfills for the purposes of delisting.

SECTION III
FIELD OPERATIONS TO SUPPORT DELISTING

A. VERIFICATION TEST BURN

The verification test burn was conducted to demonstrate the feasibility of obtaining delisting and to demonstrate to EPA Region IV that no hazardous effluents were being emitted as a result of the waste incineration. To achieve those goals, a series of incinerator performance tests was conducted in which native contaminated soil was processed while a variety of effluent and feedstock samples were collected. This section summarizes the results of those tests (see Reference 2 for additional detailed information).

1. Test Plan and Test Conditions

Six tests were conducted at different feed rates. The first was a clean soil test in which soil was fed to the incinerator at a 5 ton/hour rate for 8 consecutive hours. The purpose of this test was to ensure that all equipment was functional prior to processing contaminated soil; repairs or modifications would be more difficult to implement after the incinerator became potentially contaminated.

Five contaminated soil tests were run in December 1986. The feed rate ranged from 2.8 to 6.3 ton/hour. As indicated in Table 1, the thermal conditions for all tests were nearly the same; the kiln temperature ranged from 1355 to 1645°F and the secondary combustion chamber (SCC) temperature ranged from 2097 to 2174°F. The lowest kiln temperature was observed on Test 6 that also had the highest mass feed rate; therefore, Test 6 represents the most severe conditions observed during the verification test burn.

TABLE 1. SUMMARY OF INCINERATOR OPERATING CONDITIONS DURING VERIFICATION TEST BURNS.

Parameter	Test Burn[a] 1	2	3	5	6
Date	12/06/86	12/07/86	12/07/86	12/15/86	12/15/86
Start time		1339	0945	1455	09201145
Finish time		1455	1100	1605	10301255
Duration (min)	76	75	70	70	70
Average soil feed rate (ton/h)	2.82	3.64	3.71	5.22	6.31
Soil treated (ton)	3.6	4.6	4.3	6.1	7.4
Kiln max. temp. (°F)	1661	1449	1642	1624	1418
Kiln min. temp. (°F)	1630	1332	1440	1391	1315
Kiln avg. temp. (°F)	1645	1377	1552	1485	1355
Kiln min. pressure (in. H_2O)	-9.64[b]	-0.37	-0.44	-0.43	-0.39
Kiln max. pressure (in. H_2O)	-0.15	0	-0.14	-0.36	-0.23
Kiln avg. pressure (in. H_2O)	-2.1	-0.2	-0.25	-0.39	-0.33
SCC max. temp. (°F)	2184	2184	2187	2168	2118
SCC min. temp. (°F)	2161	2137	2140	2090	2081
SCC avg. temp. (°F)	2171	2159	2174	2113	2097
SCC min. pressure (in. H_2O)	-2.15	-2.27	-2.37	-2.70	-2.51
SCC max. pressure (in. H_2O)	-1.68	-1.62	-1.95	-2.36	-2.12
SCC avg. pressure (in. H_2O)	-2.00	-1.92	-2.09	-2.51	-2.26
Avg. stack oxygen concentration (%)	3.68	5.22	5.68	10.58	5.41
Avg. combustion efficiency $\frac{CO_2\ (\%)}{CO\ (\% + CO_2\ \%)}$	Invalid[c]	99.9584	99.9481	99.9585	99.9811

a. Test Burn 4 is not shown because of similarity to Test Burn 3 and the samples were not analyzed.

b. During the test burn the kiln pressure normally operated between zero and -1 inch of water except for two readings: -8.4 inches at 0715 and -9.64 inches at 0745, which were both ahead of the stack sampling period.

c. The combustion efficiency for Test 1 was invalid due to a CO_2 monitor failure. The instrument was repaired and subsequent tests are valid.

2. Sampling

Samples were collected from a variety of locations as shown in Figure 4. Most notably, the ash drag, kiln solids, and soil feedstock samples were collected every 15 to 20 minutes. The kiln solids were sampled because the ash drag cooling water had the potential of introducing contamination to the ash drag. The kiln solids samples were to be analyzed only if contamination was found in the ash drag samples. As discussed in Section IV (B), no contamination was found in the ash drag samples.

Stack gas samples were taken during each test burn. A volatile organic sampling train (VOST) was used to collect any volatile products of incomplete combustion (PICs). A Modified Method 5 sampling train was also used to sample the stack gas during each test to collect particulate and semivolatile compounds including PCDDs.

Soil residence time in the kiln was calculated to be approximately 20 minutes. Therefore, all sample collection began approximately 30 minutes after the contaminated soil feed to the incinerator started. This ensured that the collected samples represented the conditions that were anticipated during normal operations.

All samples collected were placed in their appropriate containers and preserved as required (with ice, if necessary) and were analyzed within the time constraints and according to procedures in Reference 28.

3. Sample Analysis

The methods used to analyze the samples collected during the verification test burn are summarized in Table 2. These methods were reviewed by OSW prior to the verification test burn and deemed appropriate for purposes of delisting the treated soil.

International Technologies Analytical Services (ITAS) performed all analyses for the verification test burn. ITAS used a VG/70-250F high resolution mass spectrometer for dioxin and furan analyses. The method used was an

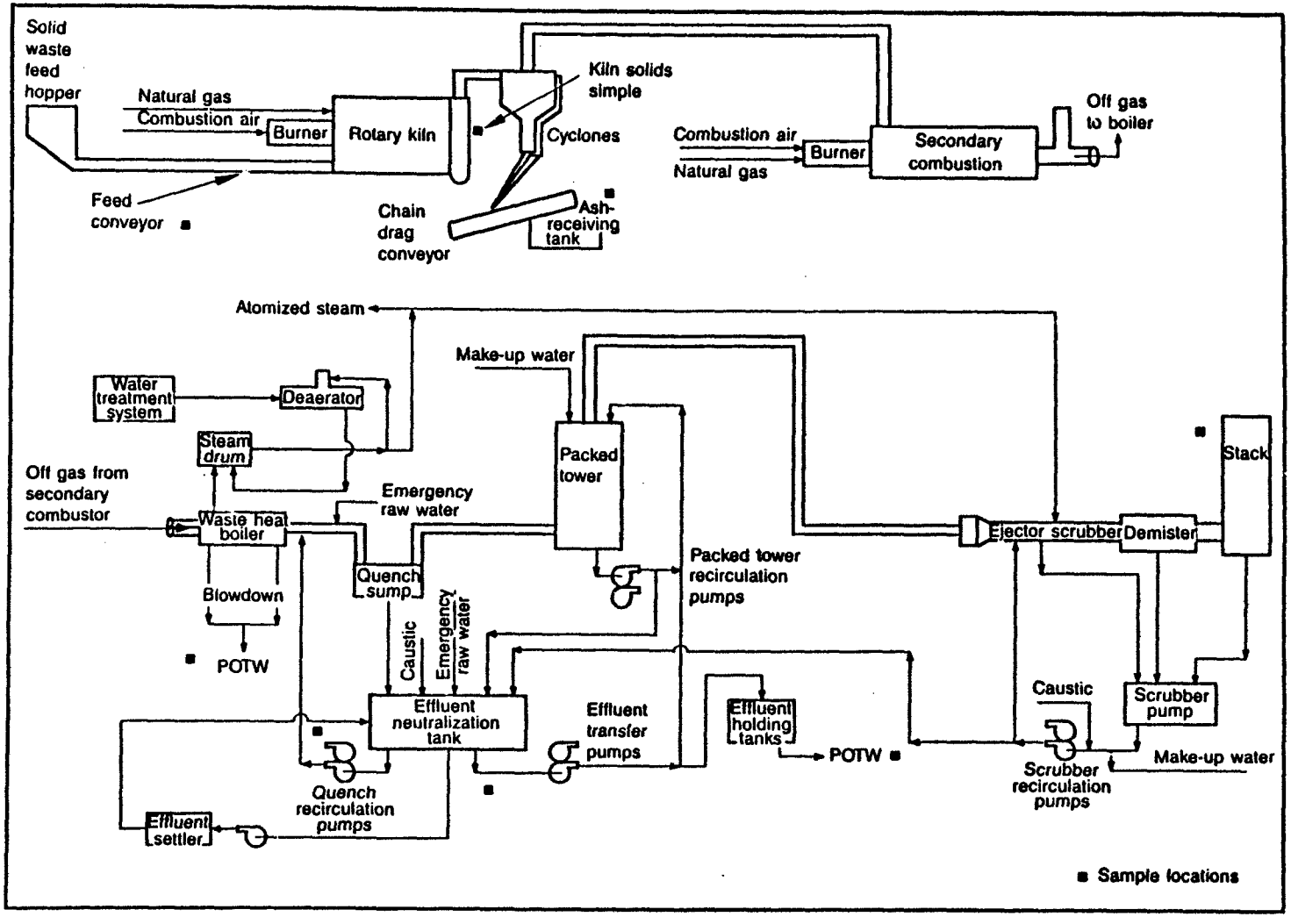

Figure 4. Sampling Locations During Verification Test Burn.

TABLE 2. VERIFICATION TEST BURN ANALYTICAL METHODS.

Analyte	Matrix	Method	Description
2,3,7,8-TCDD	Water	ITAS SOP[a]	U.S. EPA CLP[b] plus Method 8280[c] modified for HRGC/HRMS
	Soil	ITAS SOP[a]	U.S. EPA CLP[b] plus Method 8280[c] modified for HRGC/HRMS
	Stack gas	ITAS SOP[a]	U.S. EPA CLP[b] plus Method 8280[c] modified for HRGC/HRMS
PCDD/PCDF (total)	Water	ITAS SOP[a]	U.S. EPA CLP[b] plus Method 8280[c] modified for HRGC/HRMS
	Soil	ITAS SOP[a]	U.S. EPA CLP[b] plus Method 8280[c] modified for HRGC/HRMS
	Stack gas	ITAS SOP[a]	U.S. EPA CLP[b] plus Method 8280[c] modified for HRGC/HRMS
Extractable organics (acid and base/ neutral)	Water	U.S. EPA CLP SOW[d]	L/L extraction, GC/MS analysis
	Soil	U.S. EPA CLP SOW[d]	Sonification extraction, GC/MS analysis
	Stack gas	Methods 3510, 3540[c] U.S. EPA CLP SOW[d]	L/L and Soxhlet extraction, combine extracts and analyze per CLP
PAHs	Water	Method 8310[c]	L/L extraction, HPLC analysis
	Soil	Methods 3540, 3550 and 8310[c]	Soxhlet or sonification extraction, HPLC analysis
	Stack gas	Methods 3510, 3540 and 8310[c]	L/L and Soxhlet extraction, combine extracts, HPLC analysis
Toxaphene/PCBs	Water	U.S. EPA CLP SOW[d]	L/L extraction, GC/MS analysis
	Soil	U.S. EPA CLP SOW[d]	Sonification extraction, GC/MS analysis
	Stack gas	Methods 3510, 3540[c] U.S. EPA CLP SOW[d]	L/L and Soxhlet extraction, combine extracts and analyze per CLP
Herbicides	Water	Method 8150[c]	Extraction, methylation, GC/EC
	Soil	Method 8150[c]	Extraction, methylation, GC/EC
	Stack gas	Methods 3510, 3540 and 8150[c]	L/L and Soxhlet extraction, combine and methylate extracts, GC/EC
Metals	Water	U.S. EPA CLP SOW[e]	Digestion, AA or GFAA analysis
	Soil	U.S. EPA CLP SOW[e]	Digestion, AA or GFAA analysis
PICs	VOST	Method 3720	Thermal disorption, GC/MS
	MM5	Methods 3510, 3540[c] and U.S. EPA CLP SOW[d]	L/L and Soxhlet extraction, combine extracts and analyze per CLP

a. See Appendix R for ITAS SOPs.

b. See Appendix S for U.S. EPA CLP required detection limits.

c. Methods from EPA SW-846 (Reference 19).

d. Statement of Work, "Organic Analysis, Multi-Media, Multi-Concentration," July 1985 Revision.

e. Statement of Work, "Inorganic Analysis, Multi-Media, Multi-Concentration," SOW No. 785, July 1985.

adaptation of EPA SW-846 8280 (Reference 28); the adaptation provided for high resolution mass spectrometry (HRMS) analyses. The adapted method is nearly identical to the method that is now called EPA SW-846 8290 for high resolution analysis. During the preparation of the delisting petition, the ITAS method was informally reviewed and approved by Science Application International Corporation (SAIC) that was on contract to OSW as a delisting petition reviewer. SAIC concurred that the two methods are very similar and sufficient for purposes of delisting petition evaluation.

B. RCRA TRIAL BURN

1. Need for Trial Burn

A RCRA trial burn was performed in May 1987 to demonstrate compliance with EPA hazardous waste incinerator operating requirements (Reference 7). Specifically, the trial burn was designed to demonstrate that the MWP-2000 incinerator could process materials, called principle organic hazardous constituents (POHCs), that are considered more difficult to destroy than 2,3,7,8-TCDD with a Destruction and Removal Efficiency (DRE) of 99.9999% or greater as specified in 40 CFR 264.343. The trial burn was needed because the aforementioned verification test burns did not show compliance with the DRE standard; those tests were not designed to demonstrate DRE compliance.

The performance criteria specified in 40 CFR 264.343 were part of the RD&D permit for the MWP-2000 incinerator operation at NCBC. However, EPA Region IV had previously agreed that a RCRA trial burn to demonstrate 99.9999% DRE would not be necessary for the MWP-2000 unit located at NCBC. That agreement was predicated on the premise that an identical ENSCO-owned MWP-2000 incinerator located in El Dorado, Arkansas, had already demonstrated compliance with the 99.9999% DRE requirement. The verification test burns at NCBC in December 1986 were only intended to demonstrate to EPA that the MWP-2000 could process native NCBC soil without producing hazardous effluents.

The MWP-2000 incinerator located in El Dorado underwent a RCRA trial burn in the spring of 1986. In late autumn, shortly before the December 1986 verification test burn at NCBC, EPA Region VII notified ENSCO that the RCRA trial burn at El Dorado failed to demonstrate the required 99.9999% DRE. ENSCO did not

notify the Air Force, EG&G Idaho, or EPA Region IV of this shortcoming. As a result, the verification tests proceeded as planned and achieved the Air Force goal to demonstrate that the treated soil PCDD/PCDF congener sum (tetra, penta, and hexa) be less than 1.0 ppb. However, due to the low concentration of TCDD in the native soil, the DRE requirement could not be demonstrated even though HRMS was used to achieve the lowest possible detection levels. Additionally, the data results indicated that delisting was plausible.

After careful examination of all available data and extensive discussions with EPA Region IV, it was determined that the data were not sufficient to satisfy the POHC performance 99.9999% DRE requirement; a trial burn of the MWP-2000 incinerator system was required to demonstrate this capability before full-scale soil restoration could proceed at NCBC.

2. Relevance of Trial Burn to Delisting

The data collected from the RCRA trial burn did not have a direct or significant effect on EPA's delisting decision. The purpose of the trial burn was to demonstrate compliance with the DRE requirements specified in 40 CFR 264.343; the trial burn did not provide any data regarding the waste classification of the processed native NCBC soil. The trial burn did, however, add data to support the Air Force claim that difficult-to-incinerate waste could be processed without producing any additional hazardous waste. The trial burn is mentioned herein to provide the reader a generalized view of the testing efforts needed for incinerator demonstration. Additional information is found in Reference 7.

3. Surrogate Soil and POHC Selection

Because the concentrations of contaminating constituents were not sufficiently high in the native soil to achieve the desired analytical sensitivity, a surrogate POHC feed was necessary. Two POHCs were selected as surrogates for the HO-contaminated soil: hexachloroethane (HCE) and 1,2,4-trichlorobenzene (TCB). Those two compounds were selected because they were considered to be more difficult to destroy than 2,3,7,8-TCDD according to the heat of combustion ranking system (Reference 29). Additional rationale for their selection can be found in Reference 7.

EPA Region IV denied permission to use native NCBC soil for the trial burns. As a result, clean builders sand was selected as a surrogate for the native NCBC soil.

The trial burn was conducted in May 1987, and after extensive review by EPA Region IV, permission to operate was granted 25 November 1987. Routine operations began 27 November 1987 and continued until 19 November 1988.

C. DATA COLLECTION DURING ROUTINE OPERATIONS

1. Sample Collection

Once routine operations began in November 1987, routine sampling commenced to support the delisting petition. Each month, a 24-hour composite sample was collected and analyzed for a variety of Appendix VII compounds. Monthly samples included feedstock soil (untreated soil) and treated soil. Feedstock soil samples were obtained from the conveyor belt that transports the soil from the shredder to the feed hopper.

Between November 1987 and April 1988, treated soil samples were obtained as grab samples from the five to six roll-off boxes filled during a 24-hour period. The treated soil samples were taken by collecting six grab samples from different locations in each roll-off box (i.e., a total of 30 to 36 samples) and compositing all grab samples to form a composite sample. The 24-hour sampling episode was arbitrarily chosen to take place between the 14th and 17th of each month because the first sampling episode occurred 15 December 1987. The decision to collect samples on a monthly basis, rather than weekly or daily, for example, was somewhat arbitrary, but based partly on the need to collect sufficient data to support delisting while retaining control over analytical costs.

Beginning in April 1988, samples of treated soil were collected in a similar manner. Each hour, a 16-ounce sample jar was filled with treated soil collected as it fell from the ash drag conveyor into the ash drag bin. To facilitate collection, a sampling tool was used that held the sample jar so it could be positioned to collect the soil as it fell into the ash drag bin. After

all 24 samples had been collected, a composite sample was made by homogenizing the contents of all the jars in a large clean container. Precautions were also taken to perform the mixing in a "clean" area (one of the sample trailers located on the site) to minimize the chance of any cross-contamination since the analysis would look for concentrations in the low parts per trillion (ppt) range.

The changes to the sampling procedures in April 1988 were made because the ash collection system was modified to mitigate the possibility of cross-contamination due to intermittent high winds. The treated soil was being analyzed at detection limits near 1 ppt, and even very small amounts of cross-contamination could bias the results and contaminate the clean processed soil. For that reason, the ash collection system was completely enclosed in April 1988.

2. Sample Handling

Both the feedstock soil and treated soil samples were placed in I-Chem sample jars that had been certified as clean. All samples were shipped by Federal Express so analysis could be performed as quickly as possible and within the specified holding times. All sample containers were labeled with a specially coded sample number that indicated the date the sample was collected and the type of sample obtained (i.e., feedstock or treated soil sample). Each sample was tracked using a chain-of-custody form.

3. Sample Analysis During Routine Operations

The analyses of the routine operation samples were performed in accordance with the same or more stringent methodologies used for the verification test burn. The list of constituents was agreed upon by OSW.

The methods used to analyze the monthly samples for comprehensive analysis are summarized in Tables 3 and 4. Table 3 presents the analyte list for each sample collected while Table 4 presents the analytical method used for each analyte with respect to the laboratory employed.

Two laboratories were used for the monthly comprehensive samples. ITAS of Knoxville, Tennessee, performed the analyses of samples collected from November 1987 to March 1988. Beginning in April 1988, Twin Cities Testing in St. Paul,

Minnesota, was used. The switch in laboratories was primarily a cost-saving effort; additionally, it provided a second laboratory to act as a verification of the first laboratory. Both laboratories provided excellent services.

TABLE 3. PROCESS ASH AND FEEDSTOCK SAMPLE CROSS-REFERENCE LIST.

Sample Number	Description	Lab	Hi Res Dioxins & Furans	Metals	Cyanides Sulfides	Herbicides	Poly-Nuclear Aromatics	Pesticides & PCP	Semivolitiles (see notes)	Ammended EP Toxicity
SBCH121687A	Dec 16, '87 ash bin	IT	X	X	X	X	X	X	X	X
SBSH121687	Dec 16, '87 ash bin duplicate of SBCH121687	TC	X			X				
SBCL121687	Dec. 16, '87 ash bin	IT		X	X	X	X	X	X	
SBJH121687C	Dec 16, '87 ash drag EPA Collected	IT	X	X	X	X	X	X	X	X
SJSH121687	Dec 16, '88 ash drag duplicate of SBJH121687 EPA collected	TC	X			X				
SBCH011688	Jan 16, '88 ash bin	IT	X	X	X	X	X	X	X	X
SDCH011688TC	Jan 16, '88 ash bin duplicate of SBCH011688	TC					X			
SBCL011688B	Jan 16, '88 ash bin	IT		X	X	X	X	X	X	
SBCH021688	Feb 16, '88 ash bin	IT	X	X	X	X	X	X	X	X
SBCL021688	Feb 16, '88 ash bin	IT		X	X	X	X	X	X	X
SBCH031688	Mar 16, '88 ash bin	IT	X	X	X	X	X	X	X	X
SDCH031688TC	Mar 16, '88 ash bin duplicate of SBCH031688	TC					X			

TABLE 3. PROCESS ASH AND FEEDSTOCK SAMPLE CROSS-REFERENCE LIST (CONTINUED).

Sample Number	Description	Lab	Hi Res Dioxins & Furans	Metals	Cyanides Sulfides	Herbicides	Poly-Nuclear Aromatics	Pesticides & PCP	Semivolitiles (see notes)	Ammended EP Toxicity
SBCL031688	Mar 16, '88 ash bin	IT		X	X	X	X	X	X	X
SJSH041488	Apr 14, '88 ash drag	IT	X							X
SBCO041488TC	April 14, '88 ash bin duplicate of SBCL041488	TC					X			
SRCO042188	Apr 21, '88 kiln solids (Revised sample number)	TC	X			X				
SRC042188	Apr 21, '88 kiln solids	IT	X			X				
SJCO042888	Apr 28, '88 ash drag	TC	X			X				
SRCO042888	Apr 28, '88 kiln solids	TC	X			X				
SRC042888	Apr 28, '88 kiln solids	IT	X			X				
SJSH051388	May 13, '88 ash drag	TC	X			X				
SBCL061788TC	June 17, '88 ash bin	TC		X	X	X	X	X		
SBCL082688TC	Aug 26, '88 ash bin	TC		X	X	X	X	X	X	
SJSH082688TC	Aug 26, '88 ash drag	TC	X			X				
SJSH082688TC	Aug 26, '88 ash drag Duplicate	TC	X			X				
SBCL092288TC	Sept 22, '88 ash bin	TC		X	X	X	X	X	X	
SJSH092288TC	Sept 22, '88 ash drag	TC	X			X				

TABLE 3. PROCESS ASH AND FEEDSTOCK SAMPLE CROSS-REFERENCE LIST (CONTINUED).

Sample Number	Description	Lab	Hi Res Dioxins & Furans	Metals	Cyanides Sulfides	Herbicides	Poly-Nuclear Aromatics	Pesticides & PCP	Semivolitiles (see notes)	Ammended EP Toxicity
SBCL101988TC	Oct 19, '88 ash bin	TC		X	X	X	X	X	X	
SJSH101988TC	Oct 19, '88 ash drag	TC	X			X				
SBCL111688TC	Nov 16, '88 ash bin	TC		X	X	X	X	X	X	
SBCL111688TC	Nov 16, '88 ash bin Duplicate	TC				X		X		
SJSH111688TC	Nov 16, '88 ash drag	TC	X			X				
SJSH111688TC	Nov 16, '88 ash drag Duplicate	TC				X				

TABLE 3. PROCESS ASH AND FEEDSTOCK SAMPLE CROSS-REFERENCE LIST (CONCLUDED).

Sample Number	Description	Lab	Hi Res Dioxins & Furans	Metals	Cyanides Sulfides	Herbicides	Poly-Nuclear Aromatics	Pesticides & PCP	Semivolitiles (see notes)	Ammended EP Toxicity
FBCL082688TC	Aug 28, '88 feedstock	TC	X(1)			X				
FBCL092288TC	Sept 22, 88 feedstock	TC	X(1)			X				
FBCL101988TC	Oct 19, '88 feedstock Duplicate	TC	X(1)			X				
FBCL111688TC	Nov 11, '88 feedstock	TC	X(1)			X				
FBCL111688TC	Nov 11, '88 feedstock Duplicate	TC	X(1)			X				

Note: X indicates sample was analyzed for the category of constitutent indicated
IT indicates sample analyzed by International Technologies Analytical Services.
TC indicates sample analyzed by Twin Cities Testing, Inc.

TABLE 4. ANALYTICAL METHODOLOGIES USED.

Compound Name	Twin Cities Testing Methods	ITAS Test Methods
Semivolatiles:		
Phenol	Semivolatiles analyzed by EPA Contract Laboratory Protocol 8/87 revision, with methylene chloride/Saxhlet extraction	Semivolatiles analyzed by EPA Contract Laboratory Protocol 8/87 revision
Bis(2-chloroethyl)ether		
2-chlorophenol		
1,3-dichlorobenzene		
1,4-dichlorobenzene		
Benzyl alcohol		
1,2-dichlorobenzene		
2-methylphenol		
Bis(2-chloroisopropyl)ether		
4-methlyphenol		
N-nitroso-di-b-propylamine		
Hexachloroethane		
Nitrobenzene		
Isophorone		
2-nitrophenol		
2,4-dimethylphenol		
Benzoic acid		
Bis(2-chloroethoxy)methane		
2,4-dichologphenol*		
1,2,4-trichlorobenzene		
Napthalene		
4-chloroaniline		
Hexachlorobutadiene		
4-chloro-3-methylphenol		
2-methylnaphthalene		
Hexachlorocyclopentadiene		
2,4,6-trichlorophenol*		
2,4,5-trichlorophenol		
2-nitroaniline		
Dimethl phthalate*		
Acenaphthylene		
2,6-dinitrotoluene*		
3-nitroaniline		
Acenaphthene		
2,4-dinitrophenol		
4-nitrophenol		
Dibensofuran		
2,4-dinitrotoluene		
Diethylphthalate		
4-chlorophenyl-phenylether		
Fluorene		
4-nitroaniline		

TABLE 4. ANALYTICAL METHODOLOGIES USED (CONTINUED).

Compound Name	Twin Cities Testing Methods	ITAS Test Methods
Semivolatiles (continued):		
4,6-dinitro-2-methylpheno	Semivolatiles analyzed by EPA Contract Laboratory Protocol 8/87 revision, with methylene chloride/Soxhlet extraction	Semivolatiles analyzed by EPA Contract Laboratory Protocol 8/87 revision
N-nitrosodiphenylamine (1)		
4-bromophenyl-phenylether		
Hexachlorobenzene		
Pentachlorophenol		
Phenanthrene		
Anthracene		
Di-n-butylphthalate		
Fluoranthene		
Pyrene		
Butylbenzylphthalate		
3,3'-dichlorobenzidine		
Benzo(a)anthracene		
Chrysene		
bis(2-ethylhexyl)phthalate		
Di-n-octyl phthalate		
Benzo(b)Fluoranthene		
Benzo(k)fluoranthene		
Benzo(a)pyrene		
Indeno(1,2,3-cd)pyrene		
Dibenz(a,h)anthracene		
Benzo(g,h,i)pyrene		
2,6-dichlorophenol*		
2,5-dichlorophenol*		
1,2,3,5-tetrachlorobenzene and/or 1,2,4,5-tetrachlorobenzene*		
2,3,4,6-tetrachlorophenol and/or 2,3,4,5-tetrachlorophenol*		
M-cresol*		
Benzidine*		
Acetic acid, 1-methylethyl E*		
2-pentanone, 4-hydroxy-4-met*		
Heptane, 2,3-dimethyl-*		
2-pentanone, 4-hydroxy-4-met*		
Heptane, 2,3-dimethyl-*		
Octane, 4-methyl-*		
Undecane, 2,5-dimethyl-*		

TABLE 4. ANALYTICAL METHODOLOGIES USED (CONTINUED).

Compound Name	Twin Cities Testing Methods	ITAS Test Methods
Dioxin/Furan Analysis by High Resolution GC/Low Resolution MS		
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	SW846-8290	Modified SW846-8280
Total tetrachlorodibenzo-p-dioxins	SW846-8290	Modified SW846-8280
2,3,7,8-substituted pentachlorinated benzodioxins	SW846-8290	Modified SW846-8280
Total pentachlorodibenzo-p-dioxins	SW846-8290	Modified SW846-8280
2,3,7,8-substituted hexachlorodibenzo-p-dioxins	SW846-8290	Modified SW846-8280
Hexachlorodibenzo-p-dioxins	SW846-8290	Modified SW846-8280
2,3,7,8-substituted heptachlorinated dibenzodioxins		
Total heptachlorinated dibenzodioxins	SW846-8290	Modified SW846-8280
Total octachlorinated dibenzodioxins	SW846-8290	Modified SW846-8280
2,3,7,8-tetrachlorodibenzofuran	SW846-8290	Modified SW846-8280
Total tetrachlorodibenzofuran	SW846-8290	Modified SW846-8280
2,3,7,8-substituted pentachloro dibenzofurans	SW846-8290	Modified SW846-8280
Total pentachlorinated dibenzofurans	SW846-8290	Modified SW846-8280
2,3,7,8-substituted hexachlorodibenzofurans	SW846-8290	Modified SW846-8280
Total hexachlorodibenzofurans	SW846-8290	Modified SW846-8280
2,3,7,8-substituted heptachlorodibenzofurans		
Total heptachlorinated dibenzofurans	SW846-8290	Modified SW846-8280v
Total octachlorinated dibenzofurans	SW846-8290	Modified SW846-8280
Dioxin/Furan Analysis by High Resolution GC/Low Resolution MS		
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	Modified SW846-820	SW846-820
Total tetrachlorodibenzo-p-dioxins	Modified SW846-820	SW846-820
2,3,7,8-substituted pentachlorinated benzodioxins	Modified SW846-820	Not reported
Total pentachlorodibenzo-p-dioxins	Modified SW846-820	SW846-820
2,3,7,8-substituted hexachlorodibenzo-p-dioxins	Modified SW846-820	Not reported
Total hexachlorodibenzo-p-dioxins	Modified SW846-820	SW846-820
2,3,7,8-substituted heptachlorinated dibenzodioxins	Modified SW846-820	Not reported
Total heptachlorinated dibenzodioxins	Modified SW846-820	SW846-820
Total octachlorinated dibenzodioxins	Modified SW846-820	SW846-820
2,3,7,8-tetrachlorodibenzofuran	Modified SW846-820	SW846-820
Total tetrachlorodibenzofuran	Modified SW846-820	SW846-820
2,3,7,8-substituted pentachlorodibenzofurans	Modified SW846-820	Not reported
Total pentachlorinated dibenzofurans	Modified SW846-820	SW846-820
2,3,7,8-substituted hexachlorodibenzofurans	Modified SW846-820	Not reported
Total hexachlorodibenzofurans	Modified SW846-820	SW846-820
2,3,7,8-substituted heptachlorodibenzofurans	Modified SW846-820	Not reported
Total heptachlorinated dibenzofurans	Modified SW846-820	SW846-820
Total octachlorinated dibenzofurans	Modified SW846-820	SW846-820

TABLE 4. ANALYTICAL METHODOLOGIES USED (CONTINUED).

Compound Name	Twin Cities Testing Methods	ITAS Test Methods
Pesticides and PCBs		
Toxaphene		
Aroclor 1016		
Aroclor 1221	EPA-600/4-79-020	EP Contract
Aroclor 1232	Method 608,	Laboratory protocol
Aroclor 1242	March 1983	8/87
Aroclor 1248		
Aroclor 1254		
Aroclor 1260		
Herbicides		
2,4,5-trichlorophenoxyacetic acid (2,4,5-7)	SW846-8150	SW846-8150 modified
2,4-dichlorophenoxyacetic acid (2,4-D)	SW846-8150	to more closely
2,4,5-TP (Silvex)	SW846-8150	approximate the 7,87 CLP protocol for herbicides.
Cyanides and Sulfides		
EP toxicity extraction for cyanide analysis	Not analyzed	Fed. Register Vol 45, No. 98. p 33127
Total cyanide	SW846-9010	EPA CLP protocol 7/87 revision
pH	Not analyzed	SW846-9040
Total sulfide	SW846-9030 or EPA/CE-81-1, May 1981, Method 3-243	SW846-9030
Metals		
Antimony	SW846-7041	EPA CLP rev. 7/87 inductively coupled
Arsenic	SW846-7060	Argon plasma spectroscopy
Barium	SW846-6010	for all metals unless indicated below
Beryllium	SW846-6010	
Cadmium	SW846-7130 or 6010	
Chromium	SW846-7190 or 6010	
Hexavalent chromium	Sw846-7197	
Copper	Sw846-6010 or 7210	
Lead	SW846-6010 or 7420	
Magnesium	Not analyzed	

TABLE 4. ANALYTICAL METHODOLOGIES USED (CONCLUDED).

Compound Name	Twin Cities Testing Methods	ITAS Test Methods
Metals (continued)		
Mercury	SW846-7471	EPA CLP 7/87 cold vapor atomic absorption
Nickel	SW846-6010 or 7520	
Selenium	SW846-7740	
Silver	SW846-7760	
Thallium	SW846-7841	
Vanadium	SW846-6010	
Zinc	SW846-7950 or 6010	
Polynuclear Aromatic Hydrocarbons		
Fluoranthene		SW-8310
Benzo(a)anthracene	Analyzed as	SW-8310
Chrysene	semivolatiles	SW-8310
Benzo(b)fluoranthene		SW-8310
Benzo(a)fluoranthene		SW-8310
Dibenzo(a,h)anthracene		SW-8310
Indeno(1,2,3-cd)pyrene		SW-8310

* Indicates compound not reported by Twin Cities Testing.

SECTION IV
DATA PRESENTATION AND ANALYSIS

A. RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) TRIAL BURN

The RCRA trial burn successfully showed that the MWP-2000 incinerator can process highly refractory waste while meeting the requirements of 40 CFR 264.343. The DRE was demonstrated to be a minimum of 99.99997%. Additionally, POHC was not detected in any of the samples collected. Because the trial burn data does not directly influence the delistability of the process ash, they will not be discussed further (see Reference 7 for more information).

B. VERIFICATION TEST BURN AND MONTHLY COMPREHENSIVE SAMPLES

The results for the verification test burn are combined with the monthly comprehensive data for simplicity because the same analyte list was used for both. Only the ash drag results are presented herein because that waste stream is the only one that required delisting. Reference 2 contains data for the other waste streams.

1. Dioxins and Furans

The complete dioxin/furan analytical results for both the feedstock and the ash drag soils are presented in Tables 5 and 6, respectively. In certain cases, the 2,3,7,8-substituted homolog for a particular isomer was not analyzed. Those cases are indicated by an "NA" in the tables. In other cases, the total isomer and the 2,3,7,8-substituted homolog were both analyzed. The non-2,3,7,8-substituted homologs were then calculated by subtracting the 2,3,7,8-substituted homolog from the total isomer concentrations. The calculation assumes a zero value for any nondetectable concentrations. If the constituent was not detected, then an "ND" is indicated, followed by the observed method detection limit. The method detection limit specified is either 2.5 times the background noise observed on the chromatogram or the highest chromatogram peak observed at the appropriate retention time.

TABLE 5. MONTHLY FEEDSTOCK DIOXIN/FURAN AND HERBICIDE DATA. (units in ppb)

	DEC 16 '87	JAN 16 '88	FEB 16 '88	MAR 16 '88	APR 14 '88	APR 21 '88	APR 28 '88	MAY 13 '88	JUNE 17 '88
CONSTITUENT	FBCL121687A	FBOJ011688	FBOJ021688	FBOJ031688	FBCL041488	FBCL042188	FBCL042888	FBCL051388	FBCL061788TC
2378 TCDD	ND @ 0.089	7.3	1.9	11.46	1[illegible].90	11.2	4.2	14	1.3
TOTAL TCDD	0.63	8.6	1.96	10.3	16.00	11.4	4.5	15	6.8
2378 PeCDD	NM	NM	NM	NM	NM	NM	NM	ND @ 0.84	ND @ 0.11
TOTAL PeCDD	0.48	NM	NM	NM	ND @ 0.066	ND @ 0.098	ND @ 0.15	1.1	ND @ 0.11
2378 HxCDD	NM	NM	NM	NM	NM	NM	NM	ND @ 0.025	ND @ 0.034
TOTAL HxCDD	0.54	NM	NM	NM	ND @ 0.013	ND @ 0.10	ND @ 0.092	ND @ 0.025	ND @ 0.034
2378 TCDF	MISSING	NM	NM	NM	ND @ 0.17	0.28	0.17	0.26	0.018
TOTAL TCDF	3.7	ND @ 1.0	ND @ 1.0	ND @ 0.99	0.60	1.2	0.68	0.43	0.018
2378 PeCDF	NM	NM	NM	NM	NM	NM	NM	0.2	ND @ 0.046
TOTAL PeCDF	3.2	NM	NM	NM	0.57	1.1	0.64	0.7	ND @ 0.046
2378 HxCDF	NM	NM	NM	NM	NM	NM	NM	ND @ 0.048	ND @ 0.082
TOTAL HxCDF	2.4	NM	NM	NM	ND @ 0.035	ND @ 0.11	ND @ 0.10	0.024	ND @ 0.082
2,4-D	13000	NM	NM	NM	40000	54000	45000	290000	820000
2,4,5-T	3600	NM	NM	NM	81000.00	NR *	170000	410000	1900000
2,4,5-TP	ND @ 200.0	NM	NM	NM	ND @ 4600	NR *	ND @ 30.0	ND @ 40000	ND @ 4000

NOTE: NM INDICATES CONSTITUENT NOT MEASURED
NR INDICATES VALUE NOT REPORTED DUE TO ANALYTICAL INTERFERENCES

TABLE 5. MONTHLY FEEDSTOCK DIOXIN/FURAN AND HERBICIDE DATA (CONCLUDED).

	JULY 15 '88	Aug 26 '88	Sept 22 '88	Oct 19 '88	Nov 16, '88
CONSTITUENT	FBCL071588TC	FBCL082688	FBCL092288TC	FBCL101988TC	FBCL111688TC
2378 TCDD	2.34	3.5	3.2	1.4	0.55
TOTAL TCDD	2.34	3.5	3.3	1.4	0.55
2378 PeCDD	ND @ 0.021	ND @ 0.072	ND @ 0.130	ND @ 1.2	ND @ 0.017
TOTAL PeCDD	0.094	ND @ 0.072	ND @ 0.130	ND @ 1.2	ND @ 0.017
2378 HxCDD	ND @ 0.019	ND @ 0.061	ND @ 0.059	ND @ 0.044	ND @ 0.017
TOTAL HxCDD	ND @ 0.019	ND @ 0.061	ND @ 0.069	ND @ 0.044	ND @ 0.017
2378 TCDF	ND @ 0.047	ND @ 0.140	0.058	0.012	0.012
TOTAL TCDF	ND @ 0.047	ND @ 0.140	0.18	0.021	0.033
2378 PeCDF	ND @ 0.012	ND @ 0.053	ND @ 0.082	ND @ 0.021	ND @ 0.008
TOTAL PeCDF	ND @ 0.012	ND @ 0.053	ND @ 0.082	ND @ 0.021	0.0073
2378 HxCDF	ND @ 0.013	ND @ 0.043	ND @ 0.045	ND @ 0.016	ND @ 0.069
TOTAL HxCDF	ND @ 0.013	ND @ 0.043	ND @ 0.045	ND @ 0.016	ND @ 0.069
2,4-D	38000	7800	1900	4000	34000
2,4,5-T	38000	14000	32000	12000	38000
2,4,5-TP	ND @ 4.0	ND @ 4.0	ND @ 15.0	ND @ 15.0	ND @ 5.0

TABLE 6. HIGH RESOLUTION DIOXIN/FURAN DATA SUMMARY. (units in ppb)

Constituent	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	Verification Test 1	Verification Test 2	Verification Test 3	Verification Test 5	Verification Test 6	Dec 16 '87 Ash Bin	Dec 16 '87 Duplicate of SBCH121687A	Dec 16 '87 Ash Drag EPA Collected
			SAMPLE NUMBER:					SBCH121687A	SBSH121687	SBJH121687A
2378 TCDD	0.015	1.0	ND @ 0.0011	ND @ 0.0044	ND @ 0.0017	ND @ 0.0026	ND @ 0.0018	0.010	ND @ 0.0024	0.2
TOTAL TCDD			ND @ 0.00048	ND @ 0.0015	ND @ 0.00089	ND @ 0.0022	ND @ 0.0025	0.0099	ND @ 0.0024	0.16
NON 2378-TCDD *		0.01	0	0	0	0	0	0	0	0
2378 PeCDD	0.015	0.5	NM	NM	NM	NM	NM	NM	ND @ 0.0037	NM
TOTAL PeCDD			ND @ 0.00180	ND @ 0.0029	ND @ 0.00028	ND @ 0.00035	ND @ 0.00150	ND @ 0.0017	ND @ 0.0037	ND @ 0.0016
NON 2378-PeCDD *		0.005	0	0	0	0	0	0	0	0
2378 HxCDD	0.037	0.4	NM	NM	NM	NM	NM	NM	ND @ 0.0040	NM
TOTAL HxCDD			ND @ 0.00540	ND @ 0.00140	ND @ 0.00220	ND @ 0.00014	ND @ 0.00076	ND @ 0.014	ND @ 0.0040	0.012
NON 2378-HxCDD *		0.0004	0	0	0	0	0	0	0	0
2378 TCDF	0.015	0.1	ND @ 0.00220	0.0049	0.0054	0.0021	0.0038	ND @ 0.0058	ND @ 0.0017	ND @ 0.0088
TOTAL TCDF			ND @ 0.00085	0.0129	0.016	0.0067	0.0108	ND @ 0.0040	ND @ 0.0017	ND @ 0.013
NON 2378-TCDF *		0.001	0	0.008	0.0106	0.0046	0.007	0	0	0
2378 PeCDF	0.015	0.1	NM	NM	NM	NM	NM	NM	ND @ 0.0029	NM
TOTAL PeCDF			ND @ 0.00018	ND @ 0.00069	ND @ 0.00129	ND @ 0.00048	ND @ 0.00089	ND @ 0.0019	ND @ 0.0029	ND @ 0.0060
NON 2378-PeCDF *		0.001	0	0	0	0	0	0	0	0
2378 HxCDF	0.037	0.01	NM	NM	NM	NM	NM	NM	ND @ 0.0026	NM
TOTAL HxCDF			ND @ 0.00031	ND @ 0.00057	ND @ 0.00068	ND @ 0.00065	ND @ 0.00053	ND @ 0.0039	ND @ 0.0026	ND @ 0.0071
NON 2378-HxCDF *		0.0001	0	0	0	0	0	0	0	0

Note: * indicates a calculated value, see text

TABLE 6. HIGH RESOLUTION DIOXIN/FURAN DATA SUMMARY (CONTINUED).

Constituent	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	Dec 16 '87 Duplicate of SBJH121687	Early Dec '87 Ash Bin Composite	Late Dec '87 Ash Bin Composite	Jan 16 Ash Bin	Feb 16 Ash Bin	Feb 16 Ash Bin Duplicate	Early Feb '88 Ash Bin Composite	Late Feb '88 Ash Bin Composite
			SJSH121687	SSB0041488	SSAD041488	SBCH011688A	SBCH021688	SBSH021688TC	SSBF041488	SSAF041488
2378 TCDD	0.015	1.0	ND @ 0.0027	ND @ 0.0071	ND @ 0.0039	ND @ 0.013	ND @ 0.014	ND @ 0.00078	ND @ 0.0049	ND @ 0.0046
TOTAL TCDD			0.019	0.0068	0.0035	ND @ 0.0079	0.0049	ND @ 0.00078	0.0028	0.0064
NON 2378-TCDD *		0.01	0.019	0.0068	0.0035	0	0.0049	0	0.0028	0.0064
2378 PeCDD	0.015	0.5	ND @ 0.0033	NM	NM	NM	NM	ND @ 0.00095	NM	NM
TOTAL PeCDD			ND @ 0.0033	0.0084	0.0046	ND @ 0.0019	0.0039	ND @ 0.00095	0.0026	0.011
NON 2378-PeCDD *		0.005	0	0	0	0	0	0	0	0
2378 HxCDD	0.037	0.4	ND @ 0.0047	NM	NM	NM	0.014	ND @ 0.0029	NM	NM
TOTAL HxCDD			ND @ 0.0047	0.02	ND @ 0.020	0.032	0.048	ND @ 0.0029	0.015	0.017
NON 2378-HxCDD *		0.0004	0	0	0	0	0.034	0	0	0
2378 TCDF	0.015	0.1	ND @ 0.00094	ND @ 0.0039	ND @ 0.0060	ND @ 0.013	ND @ 0.013	ND @ 0.00055	ND @ 0.0089	ND @ 0.0052
TOTAL TCDF			ND @ 0.00094	0.004	0.0021	ND @ 0.0074	0.066	ND @ 0.00055	0.0022	0.00089
NON 2378-TCDF *		0.001	0	0.004	0.0021	0	0.066	0	0.0022	0.00089
2378 PeCDF	0.015	0.1	ND @ 0.0024	NM	NM	NM	NM	ND @ 0.0013	NM	NM
TOTAL PeCDF			ND @ 0.0024	ND @ 0.0011	ND @ 0.0020	ND @ 0.0010	0.0037	ND @ 0.0013	ND @ 0.00063	ND @ 0.00098
NON 2378-PeCDF *		0.001	0	0	0	0	0	0	0	0
2378 HxCDF	0.037	0.01	ND @ 0.0025	NM	NM	NM	NM	ND @ 0.0018	NM	NM
TOTAL HxCDF			ND @ 0.0025	ND @ 0.0018	ND @ 0.0019	ND @ 0.0015	0.004	ND @ 0.0018	ND @ 0.0017	ND @ 0.00069
NON 2378-HxCDF *		0.0001	0	0	0	0	0	0	0	0

Note: * indicates a calculated value, see text

TABLE 6. HIGH RESOLUTION DIOXIN/FURAN DATA SUMMARY (CONTINUED).

Constituent	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	March 16 Ash Bin	April 14 Ash Drag	April 14 Kiln Solids	April 21 Ash Drag	April 21 Kiln Solids TCT	April 21 Kiln Solids ITAS	April 28 Ash Drag	April 28 Ash Drag see note	April 28 Kiln Solids TCT
			SBCH031688	SJSH041488	SRC0041488	SJSH042188	SRC0042188-TC	SRC042188	SJSH042888	SJC0042888-TC	SRC0042888-TC
2378 TCDD	0.015	1.0	ND @ 0.010	ND @ 0.0074	ND @ 0.0041	ND @ 0.0033	ND @ 0.0017	ND @ 0.0028	ND @ 0.030	ND @ 0.0012	ND @ 0.001
TOTAL TCDD			ND @ 0.0056	0.004	ND @ 0.0024	ND @ 0.0020	ND @ 0.0017	ND @ 0.0027	ND @ 0.0074	ND @ 0.0012	ND @ 0.001
NON 2378-TCDD *		0.01	0	0.004	0	0	0	0	0	0	0
2378 PeCDD	0.015	0.5	NM	NM	NM	NM	ND @ 0.004	NM	NM	ND @ 0.0039	ND @ 0.0037
TOTAL PeCDD			ND @ 0.0040	0.0072	ND @ 0.0021	ND @ 0.0029	ND @ 0.004	ND @ 0.0047	ND @ 0.0042	ND @ 0.0039	ND @ 0.0037
NON 2378-PeCDD *		0.005	0	0	0	0	0	0	0	0	0
2378 HxCDD	0.037	0.4	NM	NM	ND @ 0.011	NM	ND @ 0.0094	NM	0.0049	ND @ 0.0074	ND @ 0.0083
TOTAL HxCDD			0.0094	0.026	0.056	0.029	ND @ 0.0094	0.017	0.038	ND @ 0.0074	ND @ 0.0083
NON 2378-HxCDD *		0.0004	0	0	0.056	0	0	0	0.0331	0	0
2378 TCDF	0.015	0.1	ND @ 0.010	ND @ 0.0057	ND @ 0.010	ND @ 0.0027	ND @ 0.0011	0.0039	0.0046	ND @ 0.0007	ND @ 0.0008
TOTAL TCDF			0.0035	0.008	ND @ 0.0045	0.0036	ND @ 0.0011	0.0064	0.0046	ND @ 0.0007	ND @ 0.0008
NON 2378-TCDF *		0.001	0.0035	0.008	0	0.0036	0	0.0025	0	0	0
2378 PeCDF	0.015	0.1	NM	NM	NM	NM	ND @ 0.0037	NM	NM	ND @ 0.0028	ND @ 0.0027
TOTAL PeCDF			ND @ 0.0017	ND @ 0.0032	ND @ 0.0037	ND @ 0.0029	ND @ 0.0037	ND @ 0.0031	ND @ 0.0012	ND @ 0.0028	ND @ 0.0027
NON 2378-PeCDF *		0.001	0	0	0	0	0	0	0	0	0
2378 HxCDF	0.037	0.01	NM	NM	NM	NM	ND @ 0.011	NM	NM	ND @ 0.0069	ND @ 0.0066
TOTAL HxCDF			ND @ 0.0016	ND @ 0.0040	ND @ 0.0036	0.016	ND @ 0.011	ND @ 0.0019	ND @ 0.0012	ND @ 0.0069	ND @ 0.0066
NON 2378-HxCDF *		0.0001	0	0	0	0	0	0	0	0	0

Notes: * indicates a calculated value, see text

TABLE 6. HIGH RESOLUTION DIOXIN/FURAN DATA SUMMARY (CONTINUED).

Constituent	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	April 28 Kiln Solids ITAS	May 13 Ash Drag	May 13 Kiln Solids	June 8 Ash Drag	June 9 Ash Drag	ASH DRAG Ash Drag	July 15 Ash Drag	August 26 Ash Drag
			SRC0042888	SJSH051388-TC	SRSH051388-TC	SJSH060888TC	SJSH060988TC	SJSH061788TC	SJSH071588TC	SJSH082688TC
2378 TCDD	0.015	1.0	ND @ 0.0019	ND @ 0.0045	ND @ 0.0033	ND @ 0.00071	ND @ 0.0011	ND @ 0.00013	ND @ 0.0083	ND @ 0.00029
TOTAL TCDD			ND @ 0.0017	0.006	ND @ 0.0033	ND @ 0.00071	ND @ 0.0011	ND @ 0.00013	ND @ 0.0083	ND @ 0.00029
NON 2378-TCDD *		0.01	0	0.006	0	0	0	0	0	0
2378 PeCDD	0.015	0.5	NM	ND @ 0.0031	ND @ 0.0056	ND @ 0.0026	ND @ 0.0020	ND @ 0.00021	ND @ 0.0041	ND @ 0.00022
TOTAL PeCDD			ND @ 0.0068	ND @ 0.0031	ND @ 0.0056	ND @ 0.0026	ND @ 0.0020	ND @ 0.00021	ND @ 0.0041	ND @ 0.00022
NON 2378-PeCDD *		0.005	0	0	0	0	0	0	0	0
2378 HxCDD	0.037	0.4	NM	ND @ 0.0098	ND @ 0.007	ND @ 0.0019	ND @ 0.0043	ND @ 0.00040	ND @ 0.0071	ND @ 0.00050
TOTAL HxCDD			ND @ 0.0097	ND @ 0.0098	ND @ 0.007	ND @ 0.0019	ND @ 0.0043	ND @ 0.00040	ND @ 0.0071	ND @ 0.00050
NON 2378-HxCDD *		0.0004	0	0	0	0	0	0	0	0
2378 TCDF	0.015	0.1	0.0029	ND @ 0.0021	ND @ 0.0018	ND @ 0.00036	ND @ 0.00097	ND @ 0.00022	ND @ 0.0031	ND @ 0.00009
TOTAL TCDF			0.005	ND @ 0.0021	ND @ 0.0018	ND @ 0.00036	ND @ 0.00097	ND @ 0.00022	ND @ 0.0031	ND @ 0.00009
NON 2378-TCDF *		0.001	0.0021	0	0	0	0	0	0	0
2378 PeCDF	0.015	0.1	NM	ND @ 0.0028	ND @ 0.0034	ND @ 0.0014	ND @ 0.0019	ND @ 0.00024	ND @ 0.0042	ND @ 0.00013
TOTAL PeCDF			ND @ 0.00085	ND @ 0.0028	ND @ 0.0034	ND @ 0.0014	ND @ 0.0019	ND @ 0.00024	ND @ 0.0042	ND @ 0.00013
NON 2378-PeCDF *		0.001	0	0	0	0	0	0	0	0
2378 HxCDF	0.037	0.01	NM	ND @ 0.0056	ND @ 0.006	ND @ 0.0016	ND @ 0.0025	ND @ 0.00031	ND @ 0.0040	ND @ 0.00017
TOTAL HxCDF			ND @ 0.0034	ND @ 0.0056	ND @ 0.006	ND @ 0.0016	ND @ 0.0025	ND @ 0.00031	ND @ 0.0040	ND @ 0.00017
NON 2378-HxCDF *		0.0001	0	0	0	0	0	0	0	0

Note: * indicates a calculated value, see text

TABLE 6. HIGH RESOLUTION DIOXIN/FURAN DATA SUMMARY (CONCLUDED).

Constituent	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	September 22 Ash Drag	October 19 Ash Drag	November 16 Ash Drag
			SJSH092288TC	SJSH101999TC	SJSH111688
2378 TCDD	0.015	1.0	ND @ 0.00029	ND @ 0.00098	ND @ 0.0020
TOTAL TCDD			ND @ 0.00029	0.0013	ND @ 0.0020
NON 2378-TCDD *		0.01	0	0.0013	0
2378 PeCDD	0.015	0.5	ND @ 0.0019	ND @ 0.00083	ND @ 0.00052
TOTAL PeCDD			ND @ 0.0019	ND @ 0.00083	ND @ 0.00052
NON 2378-PeCDD *		0.005	0	0	0
2378 HxCDD	0.037	0.4	ND @ 0.0021	ND @ 0.0014	ND @ 0.00058
TOTAL HxCDD			ND @ 0.0021	ND @ 0.0014	ND @ 0.00058
NON 2378-HxCDD *		0.0004	0	0	0
2378 TCDF	0.015	0.1	ND @ 0.00086	ND @ 0.00043	ND @ 0.0019
TOTAL TCDF			ND @ 0.00086	ND @ 0.00043	ND @ 0.0019
NON 2378-TCDF *		0.001	0	0	0
2378 PeCDF	0.015	0.1	ND @ 0.0011	ND @ 0.00052	ND @ 0.00020
TOTAL PeCDF			ND @ 0.0011	ND @ 0.00052	ND @ 0.00020
NON 2378-PeCDF *		0.001	0	0	0
2378 HxCDF	0.037	0.01	ND @ 0.0019	ND @ 0.00071	ND @ 0.00064
TOTAL HxCDF			ND @ 0.0019	ND @ 0.00071	ND @ 0.00064
NON 2378-HxCDF *		0.0001	0	0	0

One sample shown in Table 6 is higher in dioxin concentration than any other observed concentration. That sample was collected by an EPA Region IV subcontractor 16 December 1987 during the initial startup operational phase of the project. The EPA-collected sample (SBJH121687A) was obtained from the ash drag chute by compositing 24 hourly grab samples. During sample collection, the stainless steel bucket used for temporary storage and compositing was covered with aluminum foil and stored in the trunk of the sampler's automobile located adjacent to the incineration area. The EPA subcontractor split the sample with the ENSCO sampling crew which then submitted the sample to ITAS for analysis along with other samples collected on the same day.

The ENSCO collected sample (SBCH121687A) was collected during the same time period from the ash storage boxes located approximately 40 yards to the south of the ash drag chute. The sampling procedures described in Section III (C) were employed. Both sampling episodes were intended to characterize the same batch of treated soil.

One of the ENSCO-collected samples (SBCH121687A) and the EPA-collected sample (SBJH121687A) were analyzed using high resolution techniques while a second ENSCO-collected sample was analyzed using low resolution techniques. Neither of the ENSCO-collected samples showed contamination at the levels observed in the EPA-collected sample. The ENSCO-collected sample analyzed by low resolution GCMS showed no dioxins or furans, although that data are not included in this report.

In an effort to determine the potential source of contamination in the EPA-collected samples, split samples from the original EPA- and ENSCO-collected samples were removed from onsite archive storage and were reanalyzed by Twin Cities Testing. The results are also shown in Table 6 as sample numbers SJSH121687 and SBSH121687A, respectively. The analysis of the archived splits shows that no dioxins or furans were observed in the ENSCO-collected sample and only 19 ppt of non-2,3,7,8-TCDD substituted TCDD were detected in the EPA-collected sample. Because the EPA subcontractor also obtained a split sample of the feedstock, it is believed that the feedstock sample was mislabeled as the ash drag sample; the observed concentration of the feedstock was in the same range as the original EPA-collected ash drag sample.

To further characterize the potential for cross-contamination, a composite was made that consisted of equal portions of processed soil obtained from 8 days of operations before 16 December and 8 days after 16 December. The results of those samples are listed in Table 6 as samples SSBD041488 and SSAD041488, respectively. Those data indicated that the process ash dioxin/furan concentration is well below the practical quantitation limits. Those data also indicate the 200 ppt TCDD concentration observed in the 16 December EPA-collected sample was either a unique occurrence of cross-contamination of the ash drag sample with contaminated native NCBC soil, or, more likely, feedstock and treated soil samples that were mislabeled.

Because AFESC and its subcontractors had no quality control over the EPA-collected sample and because subsequent analysis shows the processed soil to be at least one order of magnitude below the original sample concentration, AFESC believes the data obtained from sample SBJH121687A and its archived sister sample SJSH121687 are in error.

2. Metals and EP Toxicity

Table 7 shows the data summary of the total metal analysis for the monthly comprehensive samples. Table 8 shows the EP toxicity analysis data for the same samples, in addition to some other samples collected for routine operation. Table 9 shows the predicted leachate concentration limits using the VHS equation assuming a waste soil volume of more than 8000 cubic yards and drinking water limits as indicated in the table. The EP toxicity data in Table 8 clearly show that the waste exceeds neither the limits specified in 40 CFR 261.24 nor the VHS-predicted leachate concentrations that are shown in Table 9. Therefore, the waste can be considered nonhazardous with respect to metals.

TABLE 7. TOTAL METAL ANALYSIS FOR MONTHLY COMPREHENSIVE AND VERIFICATION TEST BURN SAMPLES. (units in mg/kg, i.e., ppm)

Description	Sample #	Constituent														
		Sb	As	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Th	Vn	Zn
Verification Test #1			3.6	30.0 B		< 0.2	4.1		3.4	< 0.02	< 2.0	0.2	< 0.02			
Verification Test #2			2.7	24.0		< 0.2	4.9		4.2	< 0.02	1.8 B	0.2	< 0.02			
Verification Test #3			3.9	48.0		< 0.2	7.6		4.0	0.03	2.6 B	< 0.2	< 0.02			
Verification Test #5			3.6	27.0		< 0.2	5.8		4.5	< 0.02	2.0 B	< 0.2	< 0.02			
Verification Test #6			3.5	12.0 B		0.17	5.9		6.2	< 0.02	2.4 B	< 0.2	< 0.02			
Dec 16, '87 ash bin	SBCH121687C	< 6	13.20	24.4 B	0.2 B	< 1.0	5.60	2.4 B	< 6.0	< 0.02	< 4.0	< 12.0	< 1.0	< 6.0	11.40	5.90
Dec 16, '87 ash drag EPA Collected	SBJH121687C	< 6	13.80	26.5 B	0.3	< 1.0	6.00	3.3 B	< 6.0	< 0.02	< 4.0	< 12.0	< 1.0	< 6.0	12.90	7.10
Jan 16, '88 ash bin	SBCH011688C	< 6	6.30 B	24.0 B	0.3 B	< 1.0	5.20	2.7 B	< 6.0	< 0.02	< 4.0	< 12.0	1.80 B	< 6.0	9.20 B	6.90
Feb 16, '88 ash bin	SBCH021688	< 6	6.20	29.0 B	< 0.2	< 1.0	4.60	< 2.0	< 6.0	< 0.02	< 4.0	< 12.0	< 1.0	< 6.0	12.00	5.50
Mar 16, '88 ash bin	SBCH031688	< 6	< 6	21.6 B	< 0.2	< 1.0	4.00	< 2.0	< 6.0	< 0.02	< 4.0	< 12.0	< 1.0	< 6.0	9.00 B	10.00
Apr 14, '88 ash drag	SBCL041488	< 6	8.0	20.0 B	< 0.2	< 1.0	5.0	3.0 B	< 6.0	< 0.02	< 4.0	< 12.0	< 1.0	< 6.0	8.0 B	7.0
May 14, '88 ash drag	SBCL051388	< 0.1	3.0	34.0	< 0.1	1.0	9.4	5.4	30.0	<0.005	6.9	< 0.7	0.50	< 0.5	14.0	34.0
June 17, '88 ash bin	SBCL061788IC	< 0.2	2.0	45.0	0.6	<0.2	7.3	3.9	6.0	< 0.03	6.3	< 0.07	< 0.2	< 2.0	11.0	10.0
July 15, '88 ash bin	SBCL071588IC	< 0.2	2.5	31.0	0.6	2.0	10.0	8.0	9.0	< 0.03	4.0	< 0.3	< 1.0	< 3	10.0	15.0

TABLE 7. TOTAL METAL ANALYSIS FOR MONTHLY COMPREHENSIVE AND VERIFICATION TEST BURN SAMPLES (CONCLUDED).

Description	Sample #	Constituent														
		Sb	As	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Th	Vn	Zn
* Dec 16, '87 ash bin	SBCL121687	< 6.0	9.9	27.1 B	0.3 B	< 1.0	5.5	2.7 B	< 6.0	< 0.02	< 4.0	< 12.0	< 1.0	< 6.0	11.7	6.9
* Jan 16, '88 ash bin	SBCL0116888	< 6.0	< 6.0	26.3 B	0.4 B	< 1.0	6.3	2.8 B	< 6.0	< 0.020	< 4.0	< 12.0	< 1.0	< 6.0	9.7 B	7.7
* Feb 16, '88 ash bin	SBCL021688	< 6.0	< 6.0	27.0 B	0.2 B	< 1.0	4.2	2.2 B	< 6.0	< 0.02	< 4.0	< 12.0	< 1.0	< 6.0	11.0	4.8
* Mar 16, '88 ash bin	SBCL031688	< 6.0	< 6.0	19.5 B	< 0.2	< 1.0	4.0	< 2.0	< 6.0	< 0.02	< 4.0	< 12.0	< 1.0	< 6.0	8.0 B	8.0
Aug 26, '88 ash bin	SBCL082688IC	< 0.2	2.0	31.0	< 0.2	0.5	8.9	10.0	10.0	0.4	6.5	< 2.0	0.5	< 2.0	10.0	22.0
Sept 22, '88 ash bin	SBCL092288IC	< 0.2	5.6	34.0	0.4	0.55	8.4	6.0	16.0	< 0.03	5.0	< 2.0	0.65	< 2.0	15.0	23.0
Oct 19, '88 ash bin	SBCL101988IC	< 0.2	< 2.0	20.0	< 0.25	< 0.5	5.6	2.2	6.4	< 0.02	3.0	< 2.0	< 0.5	< 0.2	10.0	8.3
Nov 16, '88 ash bin	SBCL111688IC	< 0.2	1.4	21.0	< 0.25	< 0.5	6.3	4.8	0.5	< 0.03	6.0	< 0.2	< 0.5	< 2.0	11.0	9.9

NOTE: The value indicated for the "less than" values is the observed detection limit.
B - Detected. Value greater than the instrument detection level, but lower than the contract required detection level.

TABLE 8. EP TOXICITY DATA. (units in mg/L, i.e., ppm)

	Dec 16 '87 ash bin	Dec 16 '87 ash bin EPA collection	Jan 16 '88 ash bin	Feb 16 '88 ash bin	Feb 16 '88 ash bin	Mar 16 '88 ash bin	Mar 16 '88 ash bin	Apr 14 '88 ash drag
	SBCH121687A	SBJH121687B	SBCH0116888	SBCH021688	SBCL021688	SBCH031688	SBCL031688	SJSH041488
Arsenic	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Barium	0.12	0.15	0.17	0.14	0.17	0.14	0.12	0.11
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Silver	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Antimony	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Beryllium	0.002	0.002	0.003	0.002	0.003	0.003	0.003	0.003
Copper	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.01
Magnesium	1.8	2.5	3.4	1.8	2.0	2.8	3.0	2.6
Nickel	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Thallium	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Vanadium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.052	0.050	0.040	0.037	0.040	0.046	0.036	0.031
Lead	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03

< - Less than values indicate the observed detection limit.

TABLE 9. VHS-PREDICTED MAXIMUM ALLOWABLE METAL CONCENTRATIONS.

Constituent	Drinking Water Standard (mg/L)	VHS-Predicted Maximum Allowable Concentration in Leachate (mg/L)
Arsenic	0.05	0.32
Barium	1	6.31
Cadmium	0.01	0.06
Chromium	0.05	0.32
Lead	0.05	0.32
Mercury	0.002	0.01
Selenium	0.01	0.06
Silver	0.05	0.32

3. Reactivity

Table 10 shows the total weight and EP toxicity values for cyanides and sulfides. Because no detectable cyanides and low concentrations of sulfides were found in the samples, the data indicate that the waste is nonhazardous with respect to reactivity as specified in 40 CFR 261.23.

4. Herbicides, Pesticides, and Polynuclear Aromatics

Table 11 summarizes the concentrations of herbicides and pesticides found in the process ash while Table 12 summarizes the polynuclear aromatic hydrocarbons (PAHs) observed. Tables 11 and 12 also show the maximum allowed waste concentrations predicted by the VHS/OLM equation. That calculation uses the solubilities of the particular organic species and the drinking water standards (Reference 30) listed near the top of the table in addition to an assumed waste volume of more than 8000 cubic yards.

As indicated in Table 12, the analyses for several samples were determined to be invalid. EG&G Idaho Chemical Sciences Branch reexamined the raw analytical data and determined that certain PAH analyses of the ash samples exhibit poor reproducibility and poor recovery of the PAHs spiked to the samples. This is caused primarily by the analytical technique used, SW-846 8130. The extraction and subsequent analysis of PAHs and other compounds from ash matrices are notoriously difficult. Low level analysis for PAHs is typically done using high performance liquid chromatography (HPLC) with ultraviolet (UV) detection. These techniques (SW-846 8130) were used for the invalidated samples listed in Table 12. That procedure required that the samples be relatively free from interferences since HPLC is not as efficient as gas chromatography (GC). Because HPLC is not as efficient, chromatographic resolution is not as good and more selective detectors must be used, such as the UV detection. Detection by UV spectroscopy at a single wavelength also has considerable problems because most molecular absorption bands in the UV range are very broad. Additionally, many types of compounds such as many metals, metal complexes, some cations and anions, and most organic species with conjugated double bonds systems (such as the PAHs analyzed for the

TABLE 10. EP TOXICITY DATA AND TOTAL WEIGHT ANALYSIS FOR CYANIDES AND SULFIDES. (units in mg/kg, i.e., ppm)

		EP Toxicity - 3	Total Weight Analysis			
Description	Sample Number	Cyanide	Cyanide	Sulfide	Hexavalent Cr	pH
Verification Test #1		NA	<0.50	110	NA	11.55
Verification Test #2		NA	<0.50	93	NA	10.74
Verification Test #3		<0.01	1	70	NA	11.1
Verification Test #5		<0.01	0.7	110	NA	11.99
Verification Test #6		<0.01	0.7	34	NA	10.82
Dec. 16, '87 ash bin	SBCH121687C	<0.01	<0.6	45	<0.2	11.26
Dec 16, '87 ash drag EPA collected	SBJH121687C	<0.01	<0.6	74	<0.2	11.14
Jan 16, '88 ash bin	SBCH011688C	<0.01	<0.6	69	<0.2	12.34
Feb 16, '88 ash bin	SBCH021688	0.01	<0.6	<23	<0.2	12.83
Mar 16, '88 ash bin	SBCH031688	<0.01	<1.1	<22	<0.2	12.09
Apr 14, '88 ash drag	SBCL041488	< 0.02	<0.6	<22	<0.2	10.45
May 14, '88 ash bin	SBCL051388	NA	NA	4.3	NA	NA
June 17, '88 ash bin	SBCL061788TC	NA	< 2.50	< 2.15	NA	10.2
July 15, '88 ash bin	SBCL071588TC	NA	0.14	23	NA	10.5
Dec 16, '87 ash bin	SBCL121687	< 0.01	< 0.6	68	< 0.5	11.05
Jan 16, '88 ash bin	SBCL0116888	< 0.01	< 0.6	220	< 0.2	12.35
Feb 16, '88 ash bin	SBCL021688	< 0.01	< 0.6	360	< 0.2	12.77
Mar 16, '88 ash bin	SBCL031688	< 0.01	< 1.1	< 23	< 0.2	10.04

TABLE 10. EP TOXICITY DATA AND TOTAL WEIGHT ANALYSIS FOR CYANIDES AND SULFIDES (CONCLUDED).

		EP Toxicity - 3	Total Weight Analysis			
Description	Sample Number	Cyanide	Cyanide	Sulfide	Hexavalent Cr	pH
Aug 26, '88 ash bin	SBCL082688TC	NA	0.08	< 3.2	< 0.1	10.5
Sept 22, '88 ash bin	SBCL092288TC	NA	0.15	< 3.7	***	10.8
Oct 19, '88 ash bin	SBCL101988TC	NA	< 0.04	< 2.5	***	9.4
Nov 16, '88 ash bin	SBCL111688TC	NA	0.04	9.4	***	10.3

Note: 1. NA indicates that the constituent was not analyzed
2. Less than values indicate the observed detection limits.
3. Concentration observed in extract

TABLE 11. HERBICIDE AND PESTICIDE DATA SUMMARY WITH VHS/OLM CALCULATION. (units in ppm)

Description	Sample Number	Herbicides			Pesticide
		2,4-D	2,4,5-T	2,4,5T-P	Toxaphene
Solubility (ppm):		890	238	140	(See note 3
Drinking Water Limit (ppm)		0.10	0.01	0.01	
VHS Predicted Waste Limit (ppm)		106.9	7.4	9.9	(See note 3
Apr 14, '88 ash drag	SBCL041488	0.29	< 0.080	0.054	< 0.180
Apr 14, '88 ash drag	SJSH041488	< 0.06	< 0.008	< 0.001	NA
Apr 21, '88 kiln solids	SRC0042188 (TCT)	< 0.024	< 0.004	< 0.004	NA
Apr 21, '88 kiln solids	SRC0042188 (IT)	< 0.002	< 0.001	< 0.001	NA
Apr 28, '88 ash drag	SJC0042888 (TCT)	< 0.024	< 0.004	< 0.004	NA
Apr 28, '88 kiln solids	SRC042888 (TCT)	< 0.024	< 0.004	< 0.004	NA
Apr 28, '88 kiln solids	SRC042888 (IT)	< 0.002	< 0.001	< 0.001	NA
May 13, '88 ash bin	SBCL051388	< 0.240	< 0.034	< 0.040	< 0.020
May 13, '88 ash drag	SJSH051388	0.46	0.5	< 0.040	NA
June 17, '88 ash bin	SBCL061788TC	< 0.024	< 0.004	< 0.004	< 0.020
July 15, '88 ash bin	SBCL071588TC	< 0.024	< 0.004	< 0.004	< 0.020
Aug 26, '88 ash bin	SBCL082688TC	< 0.024	< 0.004	< 0.004	< 0.030
Aug 26, '88 ash drag	SJSH082688TC	< 0.024	< 0.004	< 0.004	NA
Aug 26, '88 ash drag	SJSH082688TC- DUP	< 0.024	< 0.004	< 0.004	NA
Sept 22, '88 ash bin	SBCL092288TC	< 0.060	< 0.015	< 0.015	< 0.040
Sept 22, '88 ash drag	SJSH092288TC	< 0.060	< 0.015	< 0.015	NA
Oct 19, '88 ash bin	SBCL101988TC	< 0.024	< 0.004	< 0 004	< 0.010

TABLE 11. HERBICIDE AND PESTICIDE DATA SUMMARY WITH VHS/OLM CALCULATION (CONTINUED).

Description	Sample Number	Herbicides			Pesticide
		2,4-D	2,4,5-T	2,4,5T-P	Toxaphene
Solubility (ppm):		890	238	140	(See note 3
Drinking Water Limit (ppm)		0.10	0.01	0.01	
VHS Predicted Waste Limit (ppm)		106.9	7.4	9.9	(See note 3
Verification Test #1		< 0.020	< 0.002	NA	< 200
Verification Test #2		< 0.020	< 0.002	NA	< 210
Verification Test #3		< 0.020	< 0.002	NA	< 210
Verification Test #5		< 0.020	< 0.002	NA	< 210
Verification Test #6		< 0.020	< 0.002	NA	< 210
Dec. 16, '87 ash bin	SBCH121687C	< 0.02	0.022	< 0.02	< 0.180
Dec. 16, '87 ash bin	SBCL121687	< 0.02	< 0.02	< 0.02	< 0.180
Dec 16, '87 ash drag EPA Collected	SBJH121687C	< 0.02	< 0.02	< 0.02	< 0.200
Dec 16, '88 ash bin (duplicate of SBCH121687)	SBSH121687	< 0.024	< 0.004	< 0.004	NA
Dec 16, '88 ash drag (duplicate of SBJH121687 EPA collected)	SJSH121687	< 0.024	< 0.004	< 0.004	NA
Jan 16, '88 ash bin	SBCH011688C	< 0.02	< 0.02	< 0.02	< 0.180
Jan 16, '88 ash bin	SBCL011688	< 0.02	< 0.035	< 0.02	< 0.180
Feb 16, '88 ash bin	SBCH021688	< 0.02	< 0.01	< 0.01	< 0.180
Feb 16, '88 ash bin	SBCL021688	< 0.02	< 0.01	< 0.01	< 0.181
Mar 16, '88 ash bin	SBCH031688	< 0.004	0.002	< 0.001	< 0.180
Mar 16, '88 ash bin	SBCL031688	< 0.004	< 0.001	< 0.001	< 0.180

TABLE 11. HERBICIDE AND PESTICIDE DATA SUMMARY WITH VHS/OLM CALCULATION (CONCLUDED).

Description	Sample Number	Herbicides			Pesticide
		2,4-D	2,4,5-T	2,4,5T-P	Toxaphene
Solubility (ppm):		890	238	140	(See note 3
Drinking Water Limit (ppm)		0.10	0.01	0.01	
VHS Predicted Waste Limit (ppm)		106.9	7.4	9.9	(See note 3
Oct 19, '88 ash drag	SJSH101988TC	< 0.024	0.0044	< 0.004	NA
Nov 16, '88 ash bin	SBCL111688TC	< 0.025	< 0.005	< 0.005	< 0.010
Nov 16, '88 ash bin	SBCL111688TC -DUP	< 0.025	< 0.005	< 0.005	NA
Nov 16, '88 ash drag	SJSH111688TC	< 0.025	< 0.005	< 0.005	NA
Nov 16, '88 ash drag	SJSH111688TC -DUP	< 0.025	< 0.005	< 0.005	NA

Notes: 1. NA indicates that the constituent was not analyzed
2. Less than values indicate the observed detection limits.
3. Solubility data for toxaphene was not available.

TABLE 12. POLYNUCLEAR AROMATIC HYDROCARBON DATA SUMMARY WITH VHS/OLM CALCULATION. (units in ppm)

Description	Sample Number	Fluoranthene	Benzo(a)-anthracene	Chrysene	Benzo(b)-fluoranthene	Benzo(a)pyrene	Dibenzo(ah)-anthracene	Indeno(123-cd) pyrene
Solubility (ppm):		2.65E-01	5.70E-03	1.80E-03	1.40E-02	1.20E-03	5.00E-04	5.30E-04
Drinking Water Limit (ppm)		0.2	1.10E-05	2.00E-04	2.00E-05	3.00E-06	7.10E-07	2.00E-03
VHS Predicted Waste Limit (ppm)		25871.5	0.112	15.16	0.164	0.039	0.0075	886.7
Verification Test #1		0.0023 #	< 0.002	0.0017	< 0.002	< 0.002	< 0.003	< 0.003
Verification Test #2		0.0027 #	< 0.002	< 0.001	< 0.002	< 0.002	0.0076	< 0.003
Verification Test #3		0.0021	< 0.002	0.0021	< 0.002	< 0.002	0.0069	< 0.003
Verification Test #5		0.0037	< 0.002	< 0.001	< 0.001	< 0.001	0.0021	< 0.001
Verification Test #6		0.0063	0.0012	< 0.001	< 0.001	< 0.001	0.0034	< 0.001
Dec. 16, '87 ash bin	SBCH121687C	0.0089	0.016	0.03	0.0017	0.0097	invalid	0.0018
Dec 16, '87 ash drag EPA Collected	SBJH121687C	0.016	0.014	0.032	0.0011	0.0047	invalid	0.082
Dec. 16, '87 ash bin	SBCL121687	0.0046	0.089	0.058	0.0019	0.0066	invalid	0.00076
Jan 16, '88 ash bin	SBCH011688C	0.011	0.014	0.023	0.0042	0.0012	invalid	0.0014
Jan 16, '88 ash bin	SBCL011688B	0.011	0.014	0.025	0.0009	0.005	invalid	0.00081
Jan 16, '88 ash bin duplicate of SBCH011688	SDCH011688TC	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200

TABLE 12. POLYNUCLEAR AROMATIC HYDROCARBON DATA SUMMARY WITH VHS/OLM CALCULATION (CONTINUED).

Description	Sample Number	Fluoranthene	Benzo(a)-anthracene	Chrysene	Benzo(b)-fluoranthene	Benzo(a)pyrene	Dibenzo(ah)-anthracene	Indeno(123-cd) pyrene
Solubility (ppm):		2.65E-01	5.70E-03	1.80E-03	1.40E-02	1.20E-03	5.00E-04	5.30E-04
Drinking Water Limit (ppm)		0.2	1.10E-05	2.00E-04	2.00E-05	3.00E-06	7.10E-07	2.00E-03
VHS Predicted Waste Limit (ppm)		25871.5	0.112	15.16	0.164	0.039	0.0075	886.7
Feb 16, '88 ash bin	SBCH021688	0.014	0.019	0.028	0.0024	0.0083	0.0072	0.0013
Feb 16, '88 ash bin	SBCL021688	0.014	0.013	0.029	0.036	0.013	< 0.0018	< 0.00072
Mar 16, '88 ash bin	SBCH031688	0.01	0.02	0.032	0.00064	0.0025	invalid	0.00072
Mar 16, '88 ash bin	SBCL031688	0.0046	0.023	0.043	0.00097	0.002	< 0.0018	< 0.00079
Mar 16, '88 ash bin duplicate of SBCH031688	SDCH031688TC	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190
Apr 14, '88 ash drag	SBCL041488	invalid	invalid	invalid	invalid	invalid	invalid	invalid
Apr 14, '88 ash drag	SJSH041488	NA	NA	NA	NA	NA	NA	NA
April 14, '88 ash bin duplicate of SBCL041488	SBCO041488TC	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130
May 14, '88 ash drag	SBCL051388	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170
June 17, '88 ash bin	SBCL061788TC	< 0.160	< 0.160	< 0.160	< 0.160	< 0.160	< 0.160	< 0.160

TABLE 12. POLYNUCLEAR AROMATIC HYDROCARBON DATA SUMMARY WITH VHS/OLM CALCULATION (CONCLUDED).

Description	Sample Number	Fluoranthene	Benzo(a)-anthracene	Chrysene	Benzo(b)-fluoranthene	Benzo(a)pyrene	Dibenzo(ah)-anthracene	Indeno(123-cd) pyrene
Solubility (ppm):		2.65E-01	5.70E-03	1.80E-03	1.40E-02	1.20E-03	5.00E-04	5.30E-04
Drinking Water Limit (ppm)		0.2	1.10E-05	2.00E-04	2.00E-05	3.00E-06	7.10E-07	2.00E-03
VHS Predicted Waste Limit (ppm)		25871.5	0.112	15.16	0.164	0.039	0.0075	886.7
July 15, '88 ash bin	SBCL071588TC	< 0.160	< 0.160	< 0.160	< 0.160	< 0.160	< 0.160	< 0.160
Aug 26, '88 ash bin	SBCL082688TC	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290
Sept 22, '88 ash bin	SBCL092288TC	< 0.180	< 0.180	< 0.180	< 0.180	< 0.180	< 0.180	< 0.180
Oct 19, '88 ash bin	SBCL101988TC	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140	< 0.140
Nov 16, '88 ash bin	SBCL111688TC	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200

Notes: 1. NA indicates that the constituent was not analyzed
2. Less than values indicate the observed detection limits.

delisting petition) will absorb the UV light in the detector. Many of the compounds that cause interferences are soluble in the typical solvents used for extraction and elution from the HPLC with the possible exceptions of the metals, cations, and anions.

Very poor recovery of the PAHs and poor reproducibility were particularly apparent for sample SBCL041488 where matrix spike and matrix spike duplicate samples showed PAH concentrations for dibenzo-(ah)-anthracene that were 610 ppb in the original sample, 6.4 ppb in the matrix spike, and nondetectable at 1.8 ppb in the matrix spike duplicate. Similar results were obtained for all other PAHs in this analysis.

Several possibilities exist that may explain these results including: (a) the sample was very inhomogeneous or inhomogeneously contaminated explaining the very high original result, (b) the original sample was contaminated or mislabeled during the analysis procedure, or (c) an incorrect dilution factor was used to calculate the results of the original sample. The latter possibility was determined not to be the case; ITAS recalculated the results from the original laboratory data and obtained similar results. Difficulty with extracting from the soil/ash matrix was also apparent since the matrix spike duplicate was reported as a nondetectable. Similar results were obtained for the matrix spike. Matrix spike duplicate analyses are reported with samples SBCH121687B and SBJH121687B, SBCL011688B and SBCH011688B, and SBCL021688 and SBCH021688.

Overlapping interfering peaks were also apparent on many chromatograms [e.g., SBCH121687B and SBJH121687B have significant overlapping peak for dibenzo-(ah)-anthracene]. Overlapping interference may have caused the reported concentration for this analyte to be significantly overestimated. Two questions arise when overlapping interferences occur in a chromatogram: (1) Can the peak of the analyte of interest be positively identified? and (2) Where should a base line be drawn to most accurately quantitate the analyte if it can be tenably identified?

The analyses performed by Twin Cities Testing used the standard Contract Laboratory Program (CLP) protocols (August 1987 revision). Those

analyses have a significantly higher detection limit than the detection limits allegedly provided by the HPLC method described above.

Both PAH analyses employed have problems. HPLC is unreliable while CLP analyses does not provide sufficiently low detection limits to confirm compliance with the VHS/OLM equation.

5. PCBs

Each sample was analyzed for Arochlors 1016, 1221, 1232, 1242, 1248, 1254, and 1260, but none were detected. There is no record of PCB storage at the former HO storage area at NCBC.

6. Semivolatiles

The semivolatile compounds listed in Table 4 were routinely analyzed. However, as expected from high temperature incineration, none were found in any sample analyzed.

7. Toxicity Characteristic Leachate Procedure (TCLP) Data

In an effort to demonstrate that the process ash waste can be considered nonhazardous, several samples were split and extracted in accordance with the TCLP protocol proposed in the 7 November 1986 Federal Register (40 CFR 260). The resulting extractant was then analyzed using the same high resolution GC/MS techniques (proposed EPA Method 8290) as were used on the other soil samples. The resulting data are presented in Table 13. The extractant contained no dioxins or furans at detection levels approaching the low part per quadrillion range. This indicates an extremely low potential for any dioxins or furans to migrate into a groundwater aquifer.

TABLE 13. HIGH RESOLUTION TOXICITY CHARACTERISTIC LEACHATE PROCEDURE (TCLP) DATA.

CONSTITUENT	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	APRIL 14 ASH DRAG TCLP EXTRACTION SJTC011488	APRIL 21 ASH DRAG TCLP EXTRACTION SJTC042188	JUNE 17 ASH DRAG TCLP EXTRACTION SJTC061788TC	JULY 15 ASH DRAG TCLP SJTC071588TC
2378 TCDD	0.015	1.0	ND @ 0.000066	ND @ 0.000021	ND @ 0.0000047	ND @ 0.000036
TOTAL TCDD			ND @ 0.000025	ND @ 0.000028	ND @ 0.0000047	ND @ 0.000036
NON 2378-TCDD *		0.01	0	0	0	0
2378 PeCDD	0.015	0.5	NM	NM	ND @ 0.0000095	ND @ 0.000042
TOTAL PeCDD			ND @ 0.000022	ND @ 0.000012	ND @ 0.0000095	ND @ 0.000042
NON 2378-PeCDD *		0.005	0	0	0	0
2378 HxCDD	0.037	0.4	NM	NM	ND @ 0.000027	ND @ 0.000032
TOTAL HxCDD			ND @ 0.000016	ND @ 0.000008	ND @ 0.000027	ND @ 0.000032
NON 2378-HxCDD *		0.0004	0	0	0	0
2378 TCDF	0.015	0.1	ND @ 0.000042	ND @ 0.000015	ND @ 0.0000025	0.000024
TOTAL TCDF			ND @ 0.000022	ND @ 0.000012	ND @ 0.0000025	0.000024
NON 2378-TCDF *		0.001	0	0	0	0
2378 PeCDF	0.015	0.1	NM	NM	ND @ 0.0000048	0.0001
TOTAL PeCDF			ND @ 0.0000075	ND @ 0.000008	ND @ 0.0000048	0.00035
NON 2378-PeCDF *		0.001	0	0	0	0.00025
2378 HxCDF	0.037	0.01	NM	NM	ND @ 0.0000083	0.00034
TOTAL HxCDF			ND @ 0.000016	ND @ 0.000016	ND @ 0.0000083	0.0004
NON 2378-HxCDF *		0.0001	0	0	0	0.00006

At the time of publication of this report, EPA did not recognize the TCLP data in lieu of the VHS/OLM. Therefore, as a cost savings effort, only four samples were extracted and analyzed using the TCLP protocols.

C. VHS/OLM EQUATION AND APPLICATION TO NCBC PROCESS ASH

The VHS and OLM equations were presented previously in Section II (C) as Equations 3 and 4.

1. Application of VHS Equation to Metals Data

The drinking water standards for metals are listed in Table 9. By using those standards for C_y and solving for C_o in Equation 3, one can obtain the maximum VHS-predicted concentration of metals in the initial waste leachate; those predicted leachate concentrations are also listed in Table 9. By comparing the observed EP toxicity data given in Table 8 with the VHS-predicted maximum, one can see that no samples exceeded the maximum VHS-predicted leachate concentration.

2. Application of VHS/OLM Equations to Herbicide and PAH Data

For organics, C_o in Equation 3 is given by the OLM equation (Equation 4) and is presented again below:

$$C_y = C_w^{0.678}\, S^{0.373}\, 0.0003344 \quad . \qquad (4)$$

The drinking water standards as listed in Tables 11 and 12 for herbicides and PAHs were then substituted into Equation 4 for C_y. The equation was then solved for C_w which is also shown in those tables.

The observed concentrations of herbicides and PAHs were below the VHS-predicted waste limits for all valid samples; therefore, the waste can be considered nonhazardous with respect to herbicides and PAHs.

3. Application of VHS/OLM Equation to Dioxin/Furan Data

For dioxins and furans, a solubility of 7.96×10^{-6} ppm and a pseudo-drinking water standard of 0.224 ppq were used to calculate the VHS-predicted 2,3,7,8-TCDD equivalent waste limit of 0.499 ppt.

The solubility for TCDD is given in Reference 30. The pseudo-drinking water standard was calculated based on a dioxin potency factor for dioxin of 1.56×10^{5} kg-day/mg. The dioxin potency factor is the slope of the dose response curve for dioxin. Based on a 1×10^{-6} risk factor, the risk specific dose is:

$$(1 \times 10^{-6})(1.56 \times 10^{5} \text{ kg-day/mg}) = 6.41 \times 10^{-12} \text{ mg/kg-day} . \quad (6)$$

The pseudo drinking-water standard is then calculated by assuming that a 70-kg human ingests 2 liters of water per day, or

$$(6.41 \times 10^{-12} \text{ mg/kg-day}) \times (70 \text{ kg})/(2 \text{ liters/day}) = 0.224 \text{ ppq} . \quad (7)$$

To determine the compliance of the observed samples with the VHS-predicted limit, one must first calculate the 2,3,7,8-TCDD equivalent for each sample. Because of the varying toxicity between the different dioxin and furan isomers, each isomer is given a weighing value by EPA to normalize it with respect to the most toxic dioxin homolog, 2,3,7,8-TCDD.

Table 14 shows a spreadsheet that calculates the 2,3,7,8-TCDD equivalent concentration for the tetra, penta, and hexa isomers of dioxin and furans. As mentioned previously, the 2,3,7,8-homolog concentrations were not always analyzed. When the 2,3,7,8-homolog concentration was analyzed, the non-2,3,7,8-homolog concentration was calculated by subtracting the 2,3,7,8-homolog concentration from the total isomer concentration. Then the analyzed 2,3,7,8-homolog concentration and the calculated non-2,3,7,8-homolog concentration were evaluated against the appropriate practical quantitation limits (PQLs) that were presented by EPA in the 11 March 1988 Federal

TABLE 14. HIGH RESOLUTION DIOXIN/FURAN EQUIVALENT CALCULATION DATA SUMMARY (Units in ppm)

CONSTITUENT	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	VERIFICATION TEST 1	VERIFICATION TEST 2	VERIFICATION TEST 3	VERIFICATION TEST 5	VERIFICATION TEST 6	DEC. 16, '87 ASH BIN	DEC 16, '87 ASH BIN DUPLICATE OF SBCH121687A	DEC. 16, '87 ASH DRAG COLLECTED BY EPA
			SAMPLE NUMBER:					SBCH121687A	SBSH121687	SBJH121687A
2378 TCDD	0.015	1.0	0	0	0	0	0	< PQL	0	0.2
TOTAL TCDD										
NON 2378-TCDD *		0.01	0	0	0	0	0	0	0	0
2378 PeCDD	0.015	0.5							0	
TOTAL PeCDD			0	0	0	0	0	0		0
NON 2378-PeCDD *		0.005							0	
2378 HxCDD	0.037	0.4							0	
TOTAL HxCDD			0	0	0	0	0	0		< PQL
NON 2378-HxCDD *		0.0004							0	
2378 TCDF	0.015	0.1	0	< PQL	< PQL	< PQL	< PQL	0	0	0
TOTAL TCDF										
NON 2378-TCDF *		0.001	0	< PQL	< PQL	< PQL	< PQL	0	0	0
2378 PeCDF	0.015	0.1							0	
TOTAL PeCDF			0	0	0	0	0	0		0
NON 2378-PeCDF *		0.001							0	
2378 HxCDF	0.037	0.01							0	
TOTAL HxCDF			0	0	0	0	0	0		0
NON 2378-HxCDF *		0.0001							0	
Total 2,3,7,8-TCDD equivalent (ppt)			0	0	0	0	0	0	0	200

TABLE 14. HIGH RESOLUTION DIOXIN/FURAN EQUIVALENT CALCULATION DATA SUMMARY (CONTINUED).

CONSTITUENT	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	DEC. 16, '87 ASH DRAG DUPLICATE OF SBJH121687	EARLY DEC '87 ASH BIN COMPOSITE	LATE DEC '87 ASH BIN COMPOSITE	JAN 16 ASH BIN	FEB 16 ASH BIN	FEB 16 ASH BIN DUPLICATE	EARLY FEB '88 ASH BIN COMPOSITE	LATE FEB '88 ASH BIN COMPOSITE
			SJSH121687	SSBD041488	SSAD041488	SBCH011688A	SBCH021588	SBSH021688TC	SSBF041488	SSAF041488
2378 TCDD	0.015	1.0	0	0	0	0	0	0	0	0
TOTAL TCDD										
NON 2378-TCDD *		0.01	0.00019	< PQL	< PQL	0	< PQL	0	< PQL	< PQL
2378 PeCDD	0.015	0.5	0					0		
TOTAL PeCDD				< PQL	< PQL	0	< PQL		< PQL	< PQL
NON 2378-PeCDD *		0.005	0					0		
2378 HxCDD	0.037	0.4	0				< PQL	0		
TOTAL HxCDD				< PQL	0	< PQL			< PQL	< PQL
NON 2378-HxCDD *		0.0004	0				0.0000136	0		
2378 TCDF	0.015	0.1	0	0	0	0	0	0	0	0
TOTAL TCDF										
NON 2378-TCDF *		0.001	0	< PQL	< PQL	0	0.000066	0	< PQL	< PQL
2378 PeCDF	0.015	0.1	0					0		
TOTAL PeCDF				0	0	0	< PQL		0	0
NON 2378-PeCDF *		0.001	0					0		
2378 HxCDF	0.037	0.01	0					0		
TOTAL HxCDF				0	0	0	< PQL		0	0
NON 2378-HxCDF *		0.0001	0					0		
Total 2,3,7,8-TCDD equivalent (ppt)			0.19	0	0	0	0.0796	0	0	0

TABLE 14. HIGH RESOLUTION DIOXIN/FURAN EQUIVALENT CALCULATION DATA SUMMARY (CONTINUED).

CONSTITUENT	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	MAR 16 ASH BIN	APRIL 14 ASH DRAG	APRIL 14 KILN SOLIDS	APRIL 21 ASH DRAG	APRIL 21 KILN SOLIDS TCT	APRIL 21 KILN SOLIDS ITAS	APRIL 28 ASH DRAG	APRIL 28 ASH DRAG see note	APRIL 28 KILN SOLIDS
			SBCH031688	SJSH041488	SRC0041488	SJSH042188	SRC0042188-TC	SRC042188	SJSH042888	SJC0042888-TC	SRC0042888-TC
2378 TCDD	0.015	1.0	0	0	0	0	0	0	0	0	0
TOTAL TCDD											
NON 2378-TCDD *		0.01	0	< PQL	0	0	0	0	0	0	0
2378 PeCDD	0.015	0.5					0			0	0
TOTAL PeCDD			0	< PQL	0	0		0	0		
NON 2378-PeCDD *		0.005					0			0	0
2378 HxCDD	0.037	0.4			0		0		< PQL	0	0
TOTAL HxCDD			< PQL	< PQL		< PQL		< PQL			
NON 2378-HxCDD *		0.0006			0.0000224		0		< PQL	0	0
2378 TCDF	0.015	0.1	0	0	0	0	0	< PQL	< PQL	0	0
TOTAL TCDF											
NON 2378-TCDF *		0.001	< PQL	< PQL	0	< PQL	0	< PQL	0	0	0
2378 PeCDF	0.015	0.1					0			0	0
TOTAL PeCDF			0	0	0	0		0	0		
NON 2378-PeCDF *		0.001					0			0	0
2378 HxCDF	0.037	0.01					0			0	0
TOTAL HxCDF			0	0	0	< PQL		0	0		
NON 2378-HxCDF *		0.0001					0			0	0
Total 2,3,7,8-TCDD equivalent (ppt)			0	0	0.0224	0	0	0	0	0	0

TABLE 14. HIGH RESOLUTION DIOXIN/FURAN EQUIVALENT CALCULATION DATA SUMMARY (CONTINUED).

CONSTITUENT	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	APRIL 28 KILN SOLIDS ITAS	MAY 13 ASH DRAG	MAY 13 KILN SOLIDS	JUNE 8 ASH DRAG	JUNE 9 ASH DRAG	JUNE 17 ASH DRAG	JULY 15 ASH DRAG	AUGUST 26 ASH DRAG
			SRC0042888	SJSH051388-TC	SRSH051388-TC	SJSH060888TC	SJSH060988TC	SJSH061788TC	SJSH071588TC	SJSH082688TC
2378 TCDD	0.015	1.0	0	0	0	0	0	0	0	0
TOTAL TCDD										
NON 2378-TCDD *		0.01	0	< PQL	0	0	0	0	0	0
2378 PeCDD	0.015	0.5		0	0	0	0	0	0	0
TOTAL PeCDD			0							
NON 2378-PeCDD *		0.005		0	0	0	0	0	0	0
2378 HxCDD	0.037	0.4		0	0	0	0	0	0	0
TOTAL HxCDD			0							
NON 2378-HxCDD *		0.0004		0	0	0	0	0	0	0
2378 TCDF	0.015	0.1	< PQL	0	0	0	0	0	0	0
TOTAL TCDF										
NON 2378-TCDF *		0.001	< PQL	0	0	0	0	0	0	0
2378 PeCDF	0.015	0.1		0	0	0	0	0	0	0
TOTAL PeCDF			0							
NON 2378-PeCDF *		0.001		0	0	0	0	0	0	0
2378 HxCDF	0.037	0.01		0	0	0	0	0	0	0
TOTAL HxCDF			0							
NON 2378-HxCDF *		0.0001		0	0	0	0	0	0	0
Total 2,3,7,8-TCDD equivalent (ppt)			0	0	0	0	0	0	0	0

TABLE 14. HIGH RESOLUTION DIOXIN/FURAN EQUIVALENT CALCULATION DATA SUMMARY (CONCLUDED).

CONSTITUENT	Practical Quantitation Limit (PQL) ppb	2378 TCDD equivalence factor	SEPTEMBER 22 ASH DRAG SJSH092288TC	OCTOBER 19 ASH DRAG SJSH101999TC	NOVEMBER 16 ASH DRAG SJSH111688
2378 TCDD	0.015	1.0	0	0	0
TOTAL TCDD					
NON 2378-TCDD *		0.01	0	< PQL	0
2378 PeCDD	0.015	0.5	0	0	0
TOTAL PeCDD					
NON 2378-PeCDD *		0.005	0	0	0
2378 HxCDD	0.037	0.4	0	0	0
TOTAL HxCDD					
NON 2378-HxCDD *		0.0004	0	0	0
2378 TCDF	0.015	0.1	0	0	0
TOTAL TCDF					
NON 2378-TCDF *		0.001	0	0	0
2378 PeCDF	0.015	0.1	0	0	0
TOTAL PeCDF					
NON 2378-PeCDF *		0.001	0	0	0
2378 HxCDF	0.037	0.01	0	0	0
TOTAL HxCDF					
NON 2378-HxCDF *		0.0001	0	0	0
Total 2,3,7,8-TCDD equivalent (ppt)			0	0	0

Register. If either of the two homologs exceeded the PQL, the spreadsheet multiplied the observed concentration by the appropriate equivalence factor. The result of those calculations is shown in Table 14.

When the 2,3,7,8-homolog was not analyzed, the spreadsheet assumes that all of the measured total isomers are 2,3,7,8 substituted and thus uses the higher dioxin equivalence factor.

PQLs represent the upper bound of acceptable detection limits and are 10 times the minimum detection limit (MDL). PQLs are used in this calculation because they provide a greater degree of certainty that true values are represented than do false negatives or false positives. The concept of PQLs has been successfully used in other dioxin delisting petitions (Reference 31).

For the initial sample obtained 16 February 1988 (Sample SBCH021688) a conservative adjustment was made to the 2,3,7,8-TCDD equivalent calculation. When the 2,3,7,8-hexachlorodibenzodioxin (HxCDD) homolog is subtracted from the total HxCDD isomer concentrations, both the 2,3,7,8-HxCDD and the total HxCDD concentrations fall below the PQL. The calculation would normally assume that the concentrations were equivalent to a nondetectable concentration. To err on the conservative side, the calculation assumes that the total HxCDD concentration is greater than the 37 ppt PQL, is not-2,3,7,8-substituted, and calculates the 2,3,7,8-TCDD equivalence accordingly. The February sample is the only case in which an observed concentration bordered on the PQL such that an additional data interpretation was necessary. Nevertheless, the resulting equivalent calculations falls far below the 0.499 requirement.

By examining Table 14, one can see that the highest 2,3,7,8-TCDD equivalence of 0.0796 ppt was observed 16 February 1988.* Only one other valid sample showed a nonzero 2,3,7,8-TCDD equivalence; that sample had an observed 2,3,7,8-TCDD equivalence of 0.022 ppt and was collected on April 14

* Sample SBJH121687 and its duplicate SJSH121687A were invalidated [see Section IV(B)(1)].

from the kiln exit just upstream of the ash drag. No other valid ash sample showed any detectable 2,3,7,8-TCDD equivalent. Therefore, the dioxin and furan data clearly show that the waste does not meet the criteria that cause it to be listed as a hazardous waste. Additionally, the 2,3,7,8-TCDD equivalent calculations show that the waste does not exceed the allowable waste levels predicted by the VHS/OLM equation and therefore is not a hazard to a hypothetical drinking water aquifer. It can therefore be considered nonhazardous.

SECTION V
CONCLUSIONS

The task of characterizing a waste stream so it can be removed from the EPA list of hazardous waste is complex, costly, and time-consuming. Delisting of the NCBC process ash was pursued because, at the beginning of the project, it was the only viable disposal option. Following the verification test burn, the Air Force made a decision to continue the research project based on data that clearly showed the MWP-2000 incinerator could decontaminate F027 waste to a level that passed the models used by EPA.

In 1986, at the time of project commencement, EPA would not evaluate a delisting petition that contained only the verification test burn data. EPA specifically requested that the characterization data for the processed soil be included in the petition.*

A. PRACTICAL QUANTITATION LIMITS

At the time of publication of this report, EPA had not made a final decision regarding the fate of the NCBC processed soil. Despite the detailed planning, testing, and analysis, and the extraordinary low levels of contaminants, the probability of obtaining delisting for the NCBC process ash appears to be very low. The petition was submitted on 9 November 1988 (Reference 15), and amended on 27 March 1989 (Reference 16). EPA contacted the Air Force in the autumn of 1989 and verbally requested that the Air Force withdraw the petition. EPA implied that the dioxin concentration was unsatisfactorily high. EPA considers that any dioxin concentration above the practical quantitation limits (PQLs) to be unacceptable. EPA indicated that the use of the 15 part per trillion (ppt) PQL for TCDD and pentachlorodibenzodioxin (PeCDD) and 37 ppt for HxCDD was inappropriate for the Air Force petition.

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* Since that time, however, EPA has modified its position to allow for upfront testing followed by testing of each batch of soil processed. If the batch of soil processed is analyzed and determined to be free of contamination, then it may be delisted.

PQLs used for the Air Force delisting petition were the same ones used for a petition submitted by EPA for the Denny Farm site in McDowell, Missouri (Reference 32). Rather than using those PQLs, EPA instead desired to have PQLs for the Air Force petition based upon the quality assurance data that were submitted with the NCBC delisting petition.

By examining the data shown in Table 13, one can see that there are numerous samples that contained dioxin at concentrations just below the PQLs shown in the table. The Air Force maintains that those data are more likely to be false positive data rather than true dioxin concentrations.

Individual PQLs based upon the quality assurance data would probably have been lower than the ones used in Table 13; typically the sample specific PQLs were in the range of 10 ppt. Delisting of the NCBC process ash would not have been possible if individual PQLs were used in lieu of the EPA PQLs because many of the samples collected would have had dioxin concentrations slightly greater than the individual PQLs. Nevertheless, the Air Force maintains that PQLs established for the EPA petition are appropriate for the NCBC petition because of the precedent set by EPA and because of the inexact nature of analytical chemistry when detection levels in the low part per trillion range are attempted.

B. VHS/OLM

The VHS/OLM is an extraordinarily conservative groundwater model that does not truly represent the flow of contaminants in the groundwater. EPA has continued to use the model because it is the only one that has been peer reviewed. Although EPA has received much criticism for its use, until another model is peer reviewed and adopted, EPA is likely to continue its conservative stance.

The data in the NCBC delisting petition pass the VHS/OLM criteria if one uses the higher PQLs as described above. If lower PQLs are used, the criteria are met for approximately half of the samples collected; the remaining half are just slightly above the criteria. If the VHS/OLM is replaced with a less conservative model, then it is very likely that the criteria would be met, despite which PQLs are used.

On 29 March 1990, EPA stated that it would begin using a different groundwater transport model for the delisting program (Reference 32). That model was less conservative than the VHS/OLM and is the same model used for promulgation of the Toxic Characteristic Leachate Procedures (TCLPs). Nevertheless, EPA continues to use the VHS/OLM for delisting petitions; EPA finalized a delisting ruling for Allegan Metal Finishing Company on 17 September 1990, which used the VHS/OLM as a primary tool for petition evaluation (Reference 33). No explanation was given for not using the model described in Reference 32 for the TCLP. Similarly, a second delisting petition was to be evaluated using the VHS/OLM (Reference 34); again, no explanation was given for the continued use of that model.

C. COST AND LEVEL OF EFFORT

The technical complexity of sampling and analysis required for developing a delisting petition is extraordinary. The NCBC petition involved the services of numerous managers, technicians, chemists, statisticians, computer modelers, and environmental regulatory experts. The overall cost for collecting, analyzing, and reporting the data exceeded $1 million. Nevertheless, this cost was significantly lower than the estimated $5 million needed for disposal of the process ash in a hazardous waste landfill. Therefore, the attempt to delist was justified. If, however, EPA denies the delisting petition and requires the incinerator ash to be disposed in a hazardous waste landfill, then the cost of delisting will be to no avail.

D. TECHNICAL COMPLEXITY

The technical complexity of producing a delisting petition required services from a variety of disciplines. Chemical analysts who were subcontracted performed the actual analysis of the samples. EG&G Idaho employed one Ph.D. chemist and several other chemists with B.S. and M.S. degrees to validate the data received from the analytical laboratories and to interpret any unusual results. Two hazardous waste engineers with advanced degrees coordinated the collection of data, interpretation of the regulations, and wrote the petition. EG&G Idaho also utilized the services of numerous clerical and data-tracking personnel. The preparation of this delisting petition would not have been possible without such resources.

E. REQUIRED CONCENTRATIONS FOR DELISTING

The TCDD equivalent concentration needed for obtaining delisting as calculated by the VHS/OLM is 0.499 ppt. This concentration is below the currently available detection limit; therefore, EPA allows the use of PQLs. Samples with TCDD equivalent concentration in excess of the PQL are deemed to be unacceptable. If the measured concentration is below the PQL, then delisting is possible. As described in Part A above, the PQL for TCDD is in the range of 10 to 15 ppt.

To truly appreciate the minute concentrations required to obtain delisting for the volume of process ash at NCBC, one must compare the required concentrations to more common human experiences. The required concentration for delisting--0.499 ppt--is comparable to the thickness of a penny in a stack of pennies that extends from New York City to Los Angeles, California, and back 533 times! Additionally, if one conservatively assumed that the entire 15,000 cubic yards of process ash was contaminated to a level of 10 ppt, then the total inventory of TCDD in the process ash would be only 0.20 grams of TCDD equivalent.

F. AIR FORCE RESPONSE TO EPA'S IMPLIED DELISTING DENIAL

At the time of this report's publication, there was at least one hazardous waste disposal site that could accept the NCBC process ash. The cost for transportation disposal of the ash, however, would be in excess of $5 million. Due to the extremely low concentrations of TCDD equivalent in the processed soil and the enormous cost for disposal in a hazardous waste site, the Air Force denied the EPA request to withdraw the petition. The Air Force appropriately contends that delisting is not only a more appropriate use of limited Government funding, but is also protective of the environment and human health.

SECTION VI
RECOMMENDATIONS

Listed below are several recommendations to anyone who is considering submission of a delisting petition for a hazardous waste:

1. Be certain that you consider all alternative disposal options. A detailed cost estimate should be prepared for each option. Because the delisting option is costly, alternative options may ultimately be more advantageous.

2. If you choose to pursue delisting, be certain you understand the application of the models that EPA will use to evaluate the waste stream. If the EPA continues to use the VHS/OLM, then the petitioner should be prepared for very conservative delisting limits. The VHS/OLM has the advantage of simplicity; the delisting limits can usually be easily determined through the use of a hand-held calculator within a few hours. The proposed new model is considerably more complex and requires the use of a personal computer and someone capable of learning and running the model.

3. Obtain all of the pertinent guidance documents necessary to prepare the petition. The list of references to this report provides a good starting point; Reference 18 is particularly valuable. The references within Reference 18 should also be consulted.

4. Establish communication with an authority within OSW early in the delisting process. There is no substitute for personal face-to-face communications to determine the exact requirements for delisting. The EPA relies heavily upon subcontractors for review of delisting petitions. Therefore, the petitioner should also establish direct contact with the subcontractor to obtain technical guidance. Policy decisions should always be left to responsible persons within the EPA itself.

5. The delisting process can be a very long one; if disposition is needed quickly for the waste stream, then alternatives to delisting should be sought.

6. Many petitions are rejected by EPA because insufficient information was provided or because the information was poorly communicated. Therefore, when writing the delisting petition, be certain to provide all of the information requested. Take extra care in presenting the information so that the reviewers can easily find and understand the information. It is incumbent upon the petitioner to make the review of the petition as easy as possible.

SECTION VII
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