



US Army Corps
of Engineers
Construction Engineering
Research Laboratories

USACERL TR-98/10
November 1997

CONSTRUCTION PRODUCTIVITY ADVANCEMENT RESEARCH (CPAR) PROGRAM

Modified Abrasive Blast/Chemical Stabilizer
Admixtures for Deleading Immersed Steel
Structures Coated With Lead-Based Paint

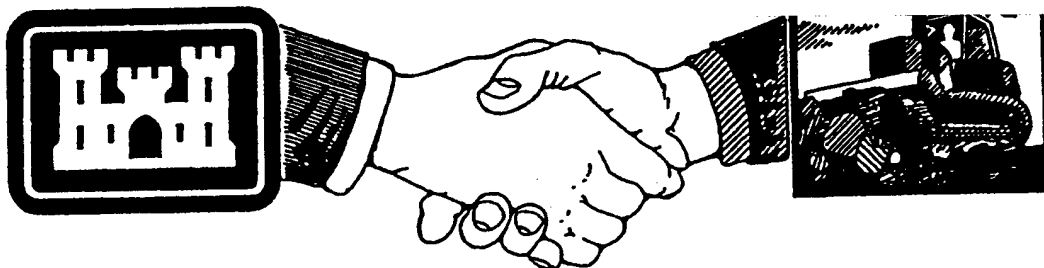
by

Curt Gustafson and Vincent F. Hock

Approved for public release; distribution is unlimited

DTIC QUALITY INSPECTED 2

19980109 096



*A Corps/Industry Partnership To Advance
Construction Productivity and Reduce Costs*

The contents of this report are not to be used for advertising, publication or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED

DO NOT RETURN IT TO THE ORIGINATOR

USER EVALUATION OF REPORT

REFERENCE: USACERL Technical Report 97/144, *Modified Abrasive Blast/Chemical Stabilizer Admixtures for Deleading Immersed-Steel Structures Coated With Lead-Based Paint*

Please take a few minutes to answer the questions below, tear out this sheet, and return it to USACERL. As user of this report, your customer comments will provide USACERL with information essential for improving future reports.

1. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which report will be used.)

2. How, specifically, is the report being used? (Information source, design data or procedure, management procedure, source of ideas, etc.)

3. Has the information in this report led to any quantitative savings as far as manhours/contract dollars saved, operating costs avoided, efficiencies achieved, etc.? If so, please elaborate.

4. What is your evaluation of this report in the following areas?

a. Presentation: _____

b. Completeness: _____

c. Easy to Understand: _____

d. Easy to Implement: _____

e. Adequate Reference Material: _____

f. Relates to Area of Interest: _____

g. Did the report meet your expectations? _____

h. Does the report raise unanswered questions? _____

i. General Comments. (Indicate what you think should be changed to make this report and future reports of this type more responsive to your needs, more usable, improve readability, etc.)

5. If you would like to be contacted by the personnel who prepared this report to raise specific questions or discuss the topic, please fill in the following information.

Name: _____

Telephone Number: _____

Organization Address: _____

6. Please mail the completed form to:

Department of the Army
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES
ATTN: CECER-TR-I
P.O. Box 9005
Champaign, IL 61826-9005

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE November 1997	3. REPORT TYPE AND DATES COVERED Final	
4. TITLE AND SUBTITLE Modified Abrasive Blast/Chemical Stabilizer Admixtures for Deleading Immersed-Steel Structures Coated With Lead-Based Paint		5. FUNDING NUMBERS CPAR LZ4	
6. AUTHOR(S) Curt Gustafson and Vincent F. Hock			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Construction Engineering Research Laboratories (USACERL) P.O. Box 9005 Champaign, IL 61826-9005		8. PERFORMING ORGANIZATION REPORT NUMBER TR 98/10	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Headquarters, U.S. Army Corps of Engineers (HQUSACE) ATTN: CECW 20 Massachusetts Ave., NW. Washington, DC 20314-1000		10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) While the use of lead-based paint (LBP) has been broadly banned, old LBP remains on many structures, creating problems as these structures require maintenance and repainting. Tight environmental regulations control paint removal operations that involve LBP to ensure that the surrounding air, land, and water environments are not contaminated. In this study, USACERL modified existing chemical stabilizer/ abrasive blast admixtures to enable removal of LBP from immersed structural steel and concrete surfaces. The modified abrasive blasting admixture effectively stabilizes the heavy metal paint waste during the removal process. This project produced and demonstrated: (1) industry specifications and user guidance for the removal of hazardous paints from immersed surfaces, (2) formulations for chemical stabilizers added to abrasive blast media, (3) an engineering and environmental assessment of effects on subsequent coating life, (4) methods for dust control and facility containment during blasting, (5) tests to verify the long-term stability of the hazardous heavy metal paint waste in a landfill, and (6) possible recycling options for the abrasive blast residue.			
14. SUBJECT TERMS Construction Productivity Advancement Research (CPAR) Program paint removal hazardous waste management		15. NUMBER OF PAGES 82	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT SAR

Foreword

This study was conducted for the Directorate of Research and Development, Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Construction Productivity Advancement Research Work Unit LZ4, "Abrasive Blasting of Lead Using Hazardous Waste Stabilizers." The technical monitors were John Gilson, CECW-EE, D. Chen, CEMP-ET, and C. Harris, CEMP-CE.

The work was performed by the Materials Science and Technology Division (FL-M) of the Facilities Technology Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Vincent F. Hock. Curt Gustafson was the industry-partner author of this report, and was associated with The TDJ Group, Inc., Cary, IL. Dr. Ilker R. Adiguzel is Acting Chief, CECER-FL-M; Larry M. Windingland is Acting Operations Chief, CECER-FL; and Dr. Alan W. Moore is the responsible Technical Director, CECER-FL. The USACERL technical editor was William J. Wolfe, Technical Resources.

COL James A. Walter is Commander and Dr. Michael J. O'Connor is Director of USACERL.

Contents

SF 298	1
Foreword	2
List of Figures and Tables	5
1 Introduction	7
Background	7
Objective	8
Approach	8
Cited Manufacturers	9
Industry Approval/Promotion of Blastox	10
2 Discussion of Technology	12
Abrasive Blasting	12
Leachability of Lead	13
Chemical Stabilization of Lead	13
The Engineered Abrasive	15
3 Impacts of USEPA Regulations	17
Solid Waste Regulations	17
OSHA Lead-in-Air Construction Regulations	18
4 Results of Laboratory Research	20
Blasting Admixture Development	20
Abrasive Cutting Characteristics	21
Limits Lead Leachability	21
Worker Safety Issues	22
Admixture Operating Performance	22
Coating Tests	23
Field Evaluation of Coating Systems	24
Discussion of Laboratory Results	25
5 Discussion of Field Demonstration	26
6 Results of Demonstration	32

Area Air Monitoring.....	32
Personal Air Monitoring.....	32
Personal Exposure Level Time Weight Averages	33
Surface and Inspection Results	34
Surface Profile Measurements.....	34
Adhesion of Prime Coat	35
Thickness Measurements.....	35
TCLP Data	36
Coating Inspection After 19 Months in Service	36
Cost and Benefit Analysis	38
7 Conclusions, Recommendations, and Commercialization/Technology Transfer	40
Transfer	40
Conclusions	40
Recommendations	42
Commercialization/Technology Transfer	42
Appendix A: Toxicity Characteristic Leaching Procedure.....	44
Appendix B: Blastox® Technical Data.....	47
Appendix C: Material Safety Data Sheet (OSHA 29 CFR 1910.1200), Blastox®	49
Appendix D: Exterior Environmental Exposure to Lead Monitoring Results	53
Appendix E: TDJ Recycling Program	73
Appendix F: List of Blastox® Suppliers.....	77
Appendix G: Recommended Chemical Stabilizer Specifications for Incorporation into COE Civil Works Guide Specification 09940	79
Distribution	

List of Figures and Tables

Figures

1	Leachability of metallic hydroxides.....	14
2	Dexter Dam site.	27
3	Gate No. 1 at Dexter Dam.....	28
4	Test areas on Gate No. 1 at Dexter Dam.	29
5	View of containment structure from dry face of the dam gate.....	30
6	Operation of the slurry blast system.....	31

Tables

1	XRF analysis of Blastox® and Type I cement.	15
2	Exterior lead air monitoring results.....	33
3	Personal exposure lead levels.	33
4	Lead time weight average lead analysis results.....	34
5	Surface profile measurements.	34
6	Prime coat adhesion results (psi).....	35
7	Dry film thickness.	35
8	TCLP results of waste.	36
9	Savings in real present value dollars on steel substrates.	39

1 Introduction

Background

The U.S. Government maintains a large inventory of structures (buildings, equipment, bridges, dam gates, etc.) that contain lead-based paints (LBP) on their surfaces. LBP was conventionally used in the construction industry due to its excellent corrosion protection capabilities. The use of LBP paint has been banned for residential structures and consumer products, and industrial use is rapidly declining. However, old LBP remains on the surfaces of many structures and continues to be a problem as these structures require maintenance and repainting. Due to the toxicity of lead, tight environmental regulations control paint removal operations that involve LBP to ensure that the surrounding air, land, and water environments are not contaminated.

The U.S. Environmental Protection Agency (USEPA) regulates the disposal of the waste generated from LBP abatement projects, and the type of containment necessary to protect the surrounding environment. Complete rules can be found in 40 CFR 261.3 and 261.24. The rules dictate that environmental controls of containment must be used to ensure the operations have no negative impact on the environment. The amount of airborne lead is regulated, as is the amount of acceptable leachable lead from the waste. USEPA regulations are discussed in more detail later.

Extensive research has been performed to find methods to remove LBP from structures without harming the environment, workers, or surrounding communities. USACERL evaluated one method involving the abrasive blasting of a properly enclosed structure using an engineered abrasive.* In response to this research, the USEPA approved the processing of Blastox® treated LBP waste

*Hock, Vincent F., Curt M. Gustafson, and Susan A. Drozd, *Demonstration of Lead-Based Paint Removal and Chemical Stabilization Using Blastox®*, Technical Report (TR) 96/20/ADA319807 (U.S. Army Construction Engineering Research Laboratories [USACERL], October 1996). Note: Blastox® is a product of the TDJ Group, Inc., 760-A Industrial Dr., Cary, IL 60013, tel. 847/639-1113.

that passes the Toxicity Characteristic Leaching Procedure (TCLP) as nonhazardous. (Appendix A outlines the TCLP.) The Steel Structures Painting Council (SSPC) has also approved the use of Blastox® to stabilize leachable lead (*SSPC News* May 1996). Since the use of engineered abrasives for LBP removal is broadly applicable to steel, concrete, and wood structures, they promise to play an important role in LBP abatement throughout the spectrum of Government or industry-owned structures in the United States.

Objective

The objective of this work unit was to modify existing chemical stabilizer/abrasive blast admixtures to enable removal of LBP from immersed structural steel and concrete surfaces such as Corps of Engineers (COE) lock and dam gates, water storage tanks, and bridge decks.* The modified abrasive blasting admixture would effectively stabilize the heavy metal paint waste (e.g., form an insoluble metallic silicate complex) during the removal process. The end products would be: (1) industry specifications and user guidance for the removal of hazardous paints from immersed surfaces, (2) chemical stabilizers added to abrasive blast media (e.g., coal slag), (3) an engineering and environmental assessment of any effects on subsequent coating life, (4) dust control and containment of facility during blasting, (5) long-term stability of the hazardous heavy metal paint waste in a landfill, and (6) possible recycling options for the abrasive blast residue.

Approach

This project planned to develop and evaluate the blast media admixture. This was to involve optimizing the blend ratios of the chemical stabilizer (e.g., calcium silicate complexes) with different abrasive blast media.

The engineered abrasives were used to blast test panels. These panels were then recoated with typical primer/topcoat paint systems and placed in accelerated weathering tests, salt fog, humidity, and deionized water to

*Note that Blastox® was the only commercially available stabilizer at the time of this study. "Different admixtures" refers to the mixture of varying concentrations of Blastox® with various abrasive substrates.

determine if there were any coating performance problems associated with the blast media mixtures.

Based on the blast media and coatings tests, a field demonstration was conducted on a dam gate in Portland District. LBP was removed using the engineered abrasives. TCLP tests were performed on the waste. USEPA and Occupational Safety and Health Administration (OSHA) site and worker air-monitoring and blood tests were conducted to evaluate the impact of the process on the environment and workers. After the field demonstration, the lead leachability and reuse options of the non-hazardous wastes were evaluated. Because the waste demonstrated long-term chemical stability, the option of using the spent blast media as raw material for another industrial application was shown to be a viable option.

The field demonstration and the project were concluded by USACERL and Portland District personnel visiting the dam gates after a year of immersion service to evaluate the performance of the coating system applied after blasting with the engineered abrasive. The condition of the coating was compared to that of a surface prepared with traditional blast media and blasting methods.

Cited Manufacturers

The following list of manufacturers referenced in this report is included for informational purposes only. Any discussion of specific manufacturers or products, or any views or opinions expressed herein are solely those of the authors; they do not represent either the views or policies of any agency of the federal government, including the U.S. Army Corps of Engineers, or the U.S. Army Construction Engineering Research Laboratories.

3M Product Information Center 3M Center, Bldg 515-3N-06 St. Paul, MN 55144-1000 (612) 737-6501	RCI Environmental, Inc. 17772 Preston Road, Suite 202 Dallas, TX 75252 (214) 250-6606
Abhe-Svaboda, Inc. Contact information to be provided	S.G. Pinney & Associates PO Box 9220-T Port St. Lucie, FL 34985 (561) 337-3080
American Electrical Power Contact information to be provided	Tnemec Co., Inc. PO Box 411749 Kansas City, MO 64141 (816) 483-3400

Bullard Abrasive Products, Inc. 50-T Hopkinton Rd Westboro, MA 01581 (508) 366-4488	TORBO / Keizer Technologies Americas, Inc. 10720 Tube Dr., Suite 16 Fort Worth, TX 76053 (817) 685-7090
P.E.A.T. Power Environmental Abatement Technologies, Inc. 3556 Lake Shore Road, Suite 740 Buffalo, NY 14219	

Industry Approval/Promotion of Blastox

Blastox has been specified on thousands of projects since 1991. A partial annotated list of companies and government entities that specify Blastox® on a wide variety of structures follows:

American Electric Power	(a large utility with operating plants in several Midwestern states) has specified Blastox® for their lead abatement work on multiple projects since 1993.
Norfolk Southern	specifies Blastox® on all lead abatement bridge work. Projects have been completed in Kentucky, Virginia, West Virginia, Alabama, Michigan, Pennsylvania, and other locations.
Carolina Power and Light	has added Blastox® to their specification list for lead abatement.
KLM Engineering	is an engineering firm working in water systems, storage, and distribution, who specifies Blastox® for use on municipal and industrial water towers and ground storage tanks.
Exxon	refinery in Baytown, TX has specified Blastox® and coal slag for their lead abatement work. Their first storage tank was successfully lead-abated with all nonhazardous results.
Ashland Oil	performed a demonstration project with Blastox® and wet abrasive blasting, and now specifies Blastox® and wet abrasive blasting on lead abatement projects.
Marathon Oil	has specified Blastox for their lead-abatement work since 1995, and has successfully completed projects in several states.
Chevron	has evaluated Blastox® in 1996 and will use it on lead projects.
Shell Oil	has specified Blastox® for use on several projects, including offshore platforms, refinery structures, and onsite water towers.
AEC Engineering	is a consulting engineering firm working in water systems and distribution field. They have specified Blastox on hundreds of municipal water towers since 1993.
Union Electric	electric utility and power plant operator serving the St. Louis metropolitan area, has specified Blastox® for all lead abatement projects since 1993.
UNOCOL	Pipeline division, Chicago, specifies Blastox®, and has used it on at least one project per year since 1994.
Bunge Corp.	is a food processing company that manufactures vegetable oils with plants throughout the country. Bunge is in the midst of a multi-year project to lead-abate all tank farms and facilities, and is using Blastox® on all these projects.

New Hampshire Department of Transportation (DOT)	has used Blastox® for bridge maintenance and as an option to their specifications for contractors to bid on production bridge work
Tennessee Valley Authority	has specified Blastox® and abrasives for their lead abatement since 1993.
The Iowa DOT	has successfully completed a study on Blastox® by an independent consultant.
North Dakota DOT	lists Blastox® as an option on specifications.
CAL TRANS	has allowed Blastox® for use on California bridges since 1995. Blastox® and copper slags have qualified for California Air Resource Board approval and for beneficial reuse under California/DTSC title 22. Even though California has a total metal standard, Blastox® is used with the beneficial reuse option through cement kilns rather than landfills.
South Dakota DOT	allowed a bridge to be done as a demonstration project. Based on this successful project, they have written specifications to include Blastox®.
Kansas DOT	allowed Blastox® to be used on a complete bridge project. After this successful project, they have written Blastox® into the specifications.
New York City DOT	will allow the use of allowed Blastox® to be used on a complete bridge project if submitted as an Engineering Change Order by a contractor.
Minnesota DOT	has used Blastox® since 1992. The Minnesota DOT is evaluating the use of Blastox® and wet blasting along with the State Air Quality Office (MN PCA) to allow revised specifications with less than 100 percent containment.
Georgia DOT	has approved the use of Blastox® with beneficial reuse on bridge work.
Pennsylvania DOT	approved Blastox® for use on several bridge projects between 1992 and 1996.
West Virginia DOT	has allowed Blastox® for use on several bridge projects since 1994.
Louisiana DOT	has approved Blastox® if submitted by a contractor.
Oklahoma DOT	has had Blastox® in their specifications since 1994, and has completed several bridge projects.
Michigan DOT	tested and approved Blastox® for use in 1993.
Washington DOT	has specified Blastox® for several bridge projects since 1993.
Oregon DOT	specified Blastox® for the historic St. John's bridge in Portland, OR. The Astoria bridge, spanning Oregon and Washington began in 1996 as a joint project with Washington State.
New York/New Jersey Port Authority	will allow the use of Blastox® if submitted as an Engineering Change Order by a contractor.
Triborough Bridge and Tunnel Authority (TBTA)	tested Blastox® on expansion joints along a section of the Triborough bridge. Independent laboratory testing produced nonhazardous results. TBTA will allow the use of Blastox® if submitted by a contractor.

2 Discussion of Technology

Abrasive Blasting

Abrasive blasting is a process in which abrasive particles such as sand, steel shot, plastic beads, or mineral slag, etc. are propelled by air at the structure's surface. As the particles strike the surface, they abrade the paint from the substrate. The debris is collected on ground tarps after blasting. Steel surfaces must be primed soon after blasting to prevent flash rusting.

The advantages of using traditional abrasive blasting processes to remove LBP are that:

1. It completely removes all the LBP from the surface.
2. It has a fast removal rate (about 100-150 sq ft/hour on steel surfaces).
3. The materials used for the process are inexpensive.

The disadvantages of using traditional abrasive blasting processes to remove LBP are that:

1. The process creates a large volume of waste.
2. The waste is usually classified as hazardous and must be disposed of accordingly (see note).
3. Containment structures are needed due to the significant amount of dust created (see note).
4. The initial capital costs can be significant due to the equipment requirement.
5. It may destroy soft substrates and damage even hard ones.

(Note: The use of a chemically engineered abrasive could eliminate disadvantage #2, and the use of the slurry blasting could minimize the disadvantage #3. These are the two biggest cost disadvantages of LBP removal via traditional dry abrasive blasting methods.)

Leachability of Lead

The leachability of lead is affected by two major factors: (1) the chemical form of the lead, and (2) the pH of the leachate. Some forms of lead, such as lead silicates, are chemically stable and will not leach into solutions, thus minimizing the threat. Due to the significant research performed on this topic, it will not be discussed in detail, but Hock, Gustafson, and Drozdz (1996) contain further information and references.

Lead solubility is amphoteric, meaning that lead is leachable at both low and high pHs, but is relatively insoluble at middle pHs. Figure 1 shows the solubility of metallic (including lead) hydroxides. By controlling the pH of the leaching solution, debris with lead could appear to be nonhazardous, but as soon as the pH buffering affect was overcome, the lead would again be free to leach.

Chemical Stabilization of Lead

To chemically stabilize lead, the leachability must be minimized by one of the two above techniques. Stabilizing lead leachability by pH alone is not an accepted industry practice. Therefore, chemically changing the form of lead is the best way to provide adequate long term stabilization of lead. Lead in paints is typically in the form of hydroxides, carbonates, and oxides, which are all soluble in both low and high pH solutions.

The USEPA has published a list of what it deems the best demonstrated available technologies (BDAT) for the stabilization of DOO8 and P+U Lead Wastes (which includes LBP). These BDAT stabilization technologies include "lime/fly ash mixtures, cement, concrete mixtures, or other proprietary or non-proprietary formulations prior to disposal." The additive, Blastox[®], is a silicate material very similar in composition to those specifically listed as BDAT materials.

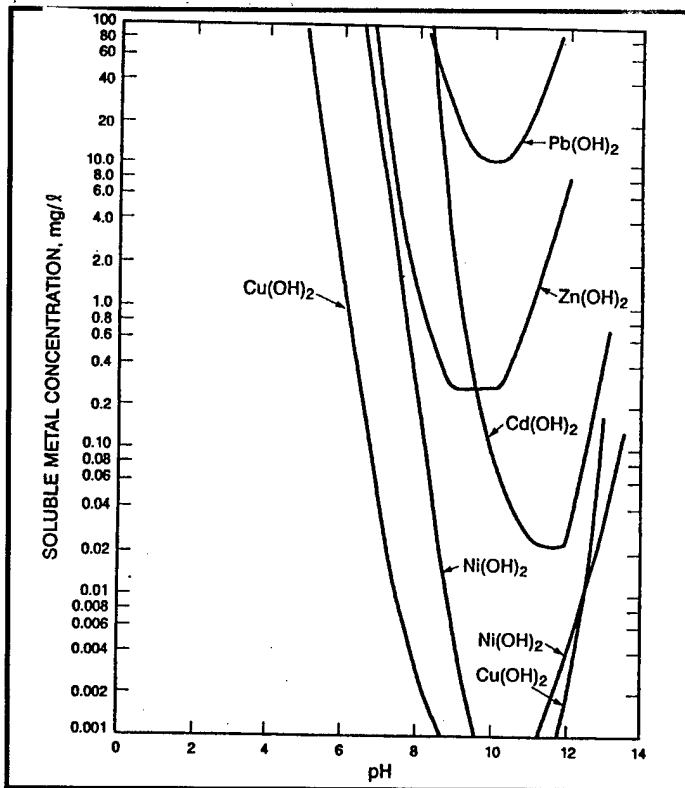


Figure 1. Leachability of metallic hydroxides.

Laboratory x-ray fluorescence analysis was used to conduct the compositional analysis of the material. The results show that Blastox[®] is a combination of tri- and di-calcium silicates. Table 1 lists the XRF results of Blastox[®] and Type I cement (high tri-calcium silicate and high tri-calcium aluminate cements). Appendix B contains additional technical data and specifications for the chemical stabilizer (BLASTOX[®]). Appendix C contains Material Safety Data Sheet information on Blastox[®].

Therefore, if the chemical form of lead can be converted from an oxide, hydroxide, or carbonate to a lead silicate, the solubility will be minimized across the pH spectrum. In fact, wastes that test hazardous for lead are typically sent to treatment facilities that mix the debris with a BDAT technology, and are then placed in a landfill.

Table 1. XRF analysis of Blastox® and Type I cement.

Compound	Blastox®	Type I Cement
CaO	65.52	63.57
SiO ₂	22.06	20.89
Al ₂ O ₃	4.58	4.72
MgO	3.55	2.77
Fe ₂ O ₃	2.07	2.25
MnO	0.44	—
K ₂ O	0.40	0.62
SO ₃	0.27	3.10
TiO ₂	0.18	0.18
P ₂ O ₅	0.11	—
Na ₂ O	0.07	0.01

The Engineered Abrasive

The engineered abrasive evaluated by USACERL contains reactive silicate compounds in a traditional abrasive blast medium (silica sand, coal/copper/nickel slag, etc.). The silicates can react with the lead to form an insoluble lead silicate. The debris will not be characterized as a hazardous waste when tested in accordance with the TCLP dictates (cf. Appendix A). USACERL evaluated a commercially available product, Blastox® (a calcium silicate material), and concluded that, when Blastox® was added in the proper amounts (20 weight percent for steel) to traditional abrasive media, the resultant debris from the lead abatement process were not hazardous according to the TCLP (Hock, Gustafson, and Drozd 1996).

It was determined that Blastox® and lead went through a series of cementitious, silicate reactions that resulted in a chemically stable lead silicate in a cementitious matrix. The waste passed TCLP tests, multiple back-to-back TCLP tests, and the Multiple Extraction Procedure (MEP), indicating long-term stability of the waste. This technology is currently being used by the Army, Navy, and Air Force.

New equipment is available (and currently being used by the Navy), which proposes to remove paint from surfaces using a combination of abrasives and water. This equipment uses water to pressurize abrasives in the blasting pot. The water/abrasives move together through the nozzle and the abrasives remove the paint, while the water controls the generation of dust. This equipment could reduce the amount of containment necessary to control lead dust generated during LBP removal operations.

Even though the earlier research proved the feasibility of the chemically engineered abrasive, further information was needed, such as: (1) performance of coatings applied after blasting with the engineered abrasive, (2) compatibility of additive with different abrasives, (3) removal rate of different types of abrasives, and (4) the compatibility of the abrasives with a new slurry blasting technique.

3 Impacts of USEPA Regulations

Solid Waste Regulations

Paint maintenance activities generate solid wastes that may be characterized as hazardous due primarily to the presence of heavy metals. The removal, proper collection, and ultimate disposal of these wastes are all governed by a full circle of environmental regulations that serve to reduce the threat to worker health/safety and protect the environment. The management of wastes generated from lead abatement activities is governed by the Resource Conservation and Recovery Act (RCRA) of 1976 and provisions contained in 40 Code of Federal Regulations (CFR) Parts 260-268.

The USEPA considers the LBP removal process to be the point of generation of the waste.* At this point of generation, the waste is classified as a solid waste, which must be further classified as either hazardous or nonhazardous. 40 CFR 261.3 states that a waste is hazardous if it exhibits one or more of the following characteristics: Ignitability, Corrosivity, Reactivity, or Toxicity. Contractors must use the Toxicity Characteristic Leaching Procedure (TCLP), EPA Test 1311 (Appendix A), to determine the hazardous nature of their waste. LBP removal operations usually generate a waste that is hazardous due to the toxicity caused by the high leachability of the lead.

Current TCLP guidelines for regulated heavy metals are found in 40 CFR 261.24. The most commonly encountered heavy metals in coating systems are lead and chromium; their respective regulatory leaching limits are each 5 mg/l. It is important to note that this is a leachability test, and *not* a total metals test. If the waste is characterized as hazardous, it must be handled, transported, and disposed of according to RCRA provisions.

*Letter to Kenneth Kastner from Michael Shapiro, Director, Office of Solid Waste, U.S. Environmental Protection Agency (3 June 1994).

OSHA Lead-in-Air Construction Regulations

29 CFR 1929.62 standards have changed the way the industry may approach lead abatement work. Contractors, waste generators, and consulting engineering firms have to learn new vocabulary and procedures. (Consultants and organizations such as the Steel Structures Painting Council [SSPC] and National Association of Corrosion Engineers [NACE] offer such training.) Several items introduced by this document have become standard practice for lead jobs:

1. *Contractors must provide a written compliance plan:* OSHA now requires that contractors submit a compliance plan before lead abatement work begins. The plan (usually prepared by an engineering firm) includes all phases of the project from containment design and setup, materials to be used, environmental compliance, and job teardown.
2. *The project must have a trained "competent person" on site:* A competent person is defined (in 29CFR 1929.62) as "one who is capable of identifying existing hazards in the surroundings or working conditions and who has authorization to take prompt corrective measures to eliminate them." The competent person shall make regular inspections of the job sites, materials and equipment.
3. *The Action Level was announced at 30 $\mu\text{g}/\text{m}^3$:* Therefore, if the lead-in-the-air is below 30 micrograms per cubic meter, no action is necessary. However, if readings are above 30 $\mu\text{g}/\text{m}^3$ (which is usually the case for dry blast abatement processes), then the contractor must provide protection for the workers to no greater than the Permissible Exposure Level (PEL) of 50 $\mu\text{g}/\text{m}^3$.
4. *Blood lead level monitoring was required for blasters and inspectors:* If the project is generating levels above the PEL, blood levels are monitored on a specific schedule. Some wet abrasive blast systems can control the lead in air to levels below the PEL and Action Level. This significantly reduces the amount of "engineering controls" necessary for a project.

The document outlined many new actions, but did not give the industry much help in determining how to comply with all of these changes. The only direction was to use engineering controls, e.g., the use of ventilation, to comply. Basically, if lead in the air levels were over the Action Level (30 $\mu\text{g}/\text{m}^3$), the people must be protected to the PEL (50 $\mu\text{g}/\text{m}^3$). New testing protocol was introduced as well, such as PM-10 and TSP. The PM-10 monitors checks particulate below 10 microns. TSP is a total suspended particulate monitor and records all sizes of

air contaminants. Consultants and laboratories found a strong business in providing these monitors and in conducting the testing and analysis.

While OSHA did not provide direction for containment, the SSPC, has set up standards and developed types of new containment to meet the intent of 1929.62. For example, lead projects may use engineering controls such as "negative air," or large dust collectors to help draw the lead in the air out of the containment and to make levels safer for workers.

4 Results of Laboratory Research

Blasting Admixture Development

Satisfaction of industry requirements determined the actual design of the admixture, as well as the markets where the technology was best applied. For an abrasive to be modified by the addition of a chemical agent, the "engineered abrasive" had to meet the following requirements:

- The technology must have abrasive cutting characteristics.
- The technology would have to limit the measured leachability of the lead in lead paint waste.
- The technology could not meaningfully increase worker safety concerns.
- The technology cannot have a material negative effect on coatings performance.
- The technology cannot impede normal paint removal operations (i.e., no excessive dusting, no unusual application requirements, etc.).

As noted above, silicate stabilization has been identified as a desirable approach. The challenge was to find an effective method for delivering the treatment to the problem. Normal blasting operations using dry blasting technologies require the abrasive to be dry and free flowing. The use of any liquid additive to abrasives would therefore require blending with or application to the abrasive, as well as drying before use.

The industry then looked at calcium silicate granules as a source of dry reagent addition. Sources of reagent were identified, and the most cost effective source for silicates were through cement production. In particular, cement clinker is a calcium silicate-rich material that is rock-like in consistency. TDJ, Inc. collected samples of clinker from various plants in the Midwest that produced No. 1 Portland cement. The material was reduced in size to a sand-like consistency (12-50 mesh), and was evaluated for hardness using the Mohs hardness scale.

This material had a Mohs hardness of between 6 and 7, which is harder than many sands, but is slightly softer than some mineral slags. In short, the material tested with sufficient hardness to qualify as an abrasive media.

Abrasive Cutting Characteristics

The material was then evaluated for general cutting characteristics. This evaluation involved the use of Blastox® to remove lead paint from sample test panels or to abrade the steel before the application of paint. (In this and all subsequent tests, TDJ used ground clinker with a particle size distribution similar to that of a 12-40 sized abrasive media.) The material was observed to exhibit good cutting characteristics, suggesting that the angularity and friability of the material was acceptable for general use. In addition, the media was reviewed for use under California Air Resource Board Standards (CARB). In those tests, CARB noted a slightly higher friability when compared to low dusting abrasives; application of the abrasive generated profile on a new steel plate used for the trial. After completion of that work, TDJ discussed the results of the analyses with S.G. Pinney representatives, and were informed that, in the opinion of senior engineers on staff, the material was suitable as an abrasive. They also stated that low levels of addition would not have a material influence on the performance of the abrasive media used. On the basis of that work, TDJ concluded that the material under review was sufficiently similar to commercial abrasive to classify it as an abrasive in its own right.

Limits Lead Leachability

As noted earlier in this report, the USEPA has identified silicates as a most desirable form of lead waste treatment. Cement clinker is rich in the silicates used for most cement-based stabilization processes. Through testing of leaded wastes with varying levels of contamination, TDJ observed that consistent success began to occur with an addition rate of about 12 percent clinker or cement. TDJ also observed that slightly lower levels of addition did not produce the same consistent success. TDJ also noted that mixing equipment will rarely provide a perfect mix of two dry materials, so all work with this technology (and all subsequent sales) would be based on a 15 percent minimum addition rate.

TDJ has completed a series of tests that suggest that clinker fines (fines generated by abrasive reduction during the blasting process) do in fact act to effectively reduce the measured leachability of lead. Those tests have been

performed by a series of internal and independent studies, but those tests clearly suggest that clinker fines do limit lead leachability. The testing has revealed that:

- The addition of a minimum 15 percent by weight of clinker fines will allow abrasives contaminated with up to 35 percent lead paint to pass TCLP testing consistently.
- The same admixture and addition rates allow passage of MEP testing (eleven cycles of leaching) and multiple TCLP testing on the same sample.
- The same admixture and addition rates have allowed field samples of spent abrasives to consistently pass the synthetic precipitation leaching procedure (SPLP).

Worker Safety Issues

The silicate admixture will be used like an abrasive media, and the worst case use of that media will be dry blasting in a poorly ventilated containment. This will result in the suspension of some fine clinker dust in the air within containment, and the worker will be exposed to that dust. TDJ consulted with several manufacturers of clinker, and those parties reported that the clinker dust was classified by OSHA as a "nuisance dust," requiring only nominal respiratory protection (dust masks). The material can be an eye irritant, so some simple eye protection is also warranted. Beyond those simple precautions, no further protective action is required. A consideration of the lead abatement process reveals that the requirements for worker protection in a similar (dry blast) environment are significantly greater than those required for clinker dust. As a result, TDJ concluded that the use of this additive required no material change in worker protection during lead abatement projects, and the technology did not create a material threat to worker safety.

Admixture Operating Performance

The admixture was field applied in a series of projects. The first large scale applications were completed in concert with American Electrical Power. In general, dry blast applicators noted the generation of additional dust when slags were used, but noted no loss in cutting efficiency. All wastes tested passed TCLP requirements for nonhazardous waste classification. Workers reported no loss in productivity or difficulty in handling the abrasive when blended with additive.

Wastes were also applied with wet and slurry blast equipment. Trial projects included the use of slurry blast equipment and the blasting additive mixed with copper slag for use in the removal of lead primers from the nuclear missile submarine fleet. In general, there were no problems associated with the application of the technology and no problems with subsequent coatings performance. The U.S. Navy reports dramatic savings as a result of the trial. At the completion of these evaluations, TDJ concluded that the proposed admixture design appeared worthy of commercial application.

Coating Tests

One of the key limiting factors in the use of abrasive additives is the performance of the coatings system used to limit subsequent corrosion. The use of an additive may introduce a contaminant to the surface that will allow or encourage the formation of corrosion cells that will accelerate failure of the paint system. A significant failure of the system will force cleaning and repainting of the structure. Before any new abrasive, additive, or other chemistry is applied to the surface, laboratory and field analyses of coatings performance is advisable. In the case of Blastox[®], both methods of investigation were used.

As a first screening method, Blastox[®] treated metal surfaces were subjected to a series of accelerated weathering tests in a range of conditions by the Coatings Laboratory in Houston, TX. Virgin (unused and unpainted) steel panels were subjected to sand blasting through the use of a standard dry blast system. Black Beauty abrasive (12-40 material) was combined with a 12-50 Blastox[®] admixture at a ratio of 15 percent Blastox[®] (by weight) to 85 percent abrasive. The additive was uniformly mixed throughout the abrasive, and the blend was used to profile the steel. In addition, panels were subjected to the same abrasive treatment using an unblended 12-40 Black Beauty abrasive. In both cases, the steel was blasted until the surface profile was between 2.5 and 3.5 mm. Profiles were verified by direct surface measurement. Those surfaces were coated with the following paint systems:

- zinc rich epoxy
- polyamide epoxy
- titanium dioxide pigmented epoxy
- aluminum epoxy mastic.

Each coating system was applied to a Blastox[®] treated panel and a panel treated with standard abrasive. Each system was allowed to cure per the

manufacturers instructions. Once the coating systems were cured, they were subjected to fresh water immersion and salt fog chamber accelerated exposure tests. After 30-, 60-, and 90-day exposure periods, the paint systems were subjected to visual inspection and adhesion testing. As a result of that testing, the researchers concluded that all paint systems tested indicated acceptable laboratory performance with one exception: paint systems with a red iron oxide pigment. In that case, some loss in performance (for immersion service) was noted. The researchers determined that a sweep blast with standard abrasive was sufficient to remove the offending residue. No other problems were noted.

The above research was replicated by Tnemec Coatings Corporation. That company tested Blastox[®] against a wide range of manufactured steel coating systems, and concluded that Blastox[®] was acceptable and compatible with those coatings. Tnemec conducted long-term coatings testing in both atmospheric and immersion service. They announced in 1996 that all panels had passed 2 years in immersion service. May of 1997 will conclude 3 years of successful service. Tnemec now recommends Blastox[®] for use with any of their coatings for either service. The Tnemetch Technical Bulletin No. 96-01, dated May 1996 states:

Although the primers were tested using specific intermediate and/or topcoats, Tnemec feels that topcoats listed on the product data sheets will perform as expected when the substrate is prepared using Blastox[®] containing abrasive.

Field Evaluation of Coating Systems

The researchers noted that laboratory performance was not a fully reliable indicator of field performance. As a result, they recommended follow-up evaluations of coatings systems in a number of application environments. S.G. Pinney Associates were hired to visit a series of projects where Blastox[®] was used. The selected sites included immersion and nonimmersion service applications in a range of climates and with a range of paint systems. The coatings systems evaluated included Vinyl, Epoxy/Polyurethane, Inorganic Zinc, Zinc Rich Epoxies, and Polyurethane Primer/Silicon Alkyd topcoat. Project locations were throughout the United States and included bridge, tanks, piping, and a paper mill. The researchers visited each site, inspected the overall system performance, and subjected the systems to an on-site pull test. The coating systems exhibited no evidence of failure or accelerated weathering due to the use of Blastox[®]-treated abrasive.

Discussion of Laboratory Results

On the basis of lab and field results, representatives of S.G. Pinney, The Coatings Laboratory, Tnemec Coatings, and The TDJ Group concluded that Blastox[®] is appropriate for application on all surfaces to be painted, with the partial exception of red iron oxide pigmented systems, which require a sweep blast before use in immersion service. Subsequent field applications on steel over six winters have revealed no coatings failures related to the admixture.

5 Discussion of Field Demonstration

A field demonstration of the technologies was held at the Corps of Engineers, Portland District, Dexter Dam Site, Tainter Gate No. 1, which is located near Dexter, OR. (Figure 2 shows a map of the river and the location of the dam.). Gate No. 1 (Figure 3) was the demonstration site, where all demonstrations and tests were held. The LBP on the dam gates was removed by abrasive blasting with the chemically engineered abrasive. Abhe -Svaboda, Inc. was the COE (Portland District) contractor performing all lead paint abatement work; RCI Environmental performed all air and personnel air monitoring.

The CPAR Partner (TDJ Group, Inc.), supplied the necessary abrasive blast mixtures for each test section as part of the CPAR agreement. The abrasive blast mixture supplied were preblended (20 wt percent chemical stabilizer/abrasive media) and sent to the Dexter Dam site on or about 17 July 1995. The chemical stabilizer/abrasive blast media mixtures are: (1) chemical stabilizer (Blastox[®])/copper slag mixture, (2) chemical stabilizer (Blastox[®])/nickel slag mixture, (3) chemical stabilizer (Blastox[®])/coal slag mixture and (4) chemical stabilizer (Blastox[®])/silica sand mixture.

USACERL provided specifications to enable Portland District to make changes to COE contract DACW 57-94-C-0056 to allow the use of the chemical stabilizer admixtures by the COE contractor. In addition, USACERL contracted with RCI Environments to perform the area and personnel air monitoring. The operating parameters of the abatement technologies were also documented along with removal rates, surface profiles, waste analyses, and paint adhesion tests. TDJ also supplied labor, equipment, and materials to perform a demonstration of wet-abrasive blasting using the TORBO method or equivalent.

The work was completed between 18 and 21 July 1995. Four different blends of abrasives were used: silica sand, nickel slag, coal slag, and copper slag, each blended with 20 weight percent of the chemical additive. Dry and wet blasting were performed with the different abrasives. The dam gate was divided into eight sections such that two sections could be used for each type of abrasive- one section was dry blasted, and one section was slurry blasted. (Figure 4 shows the blasting pattern.)

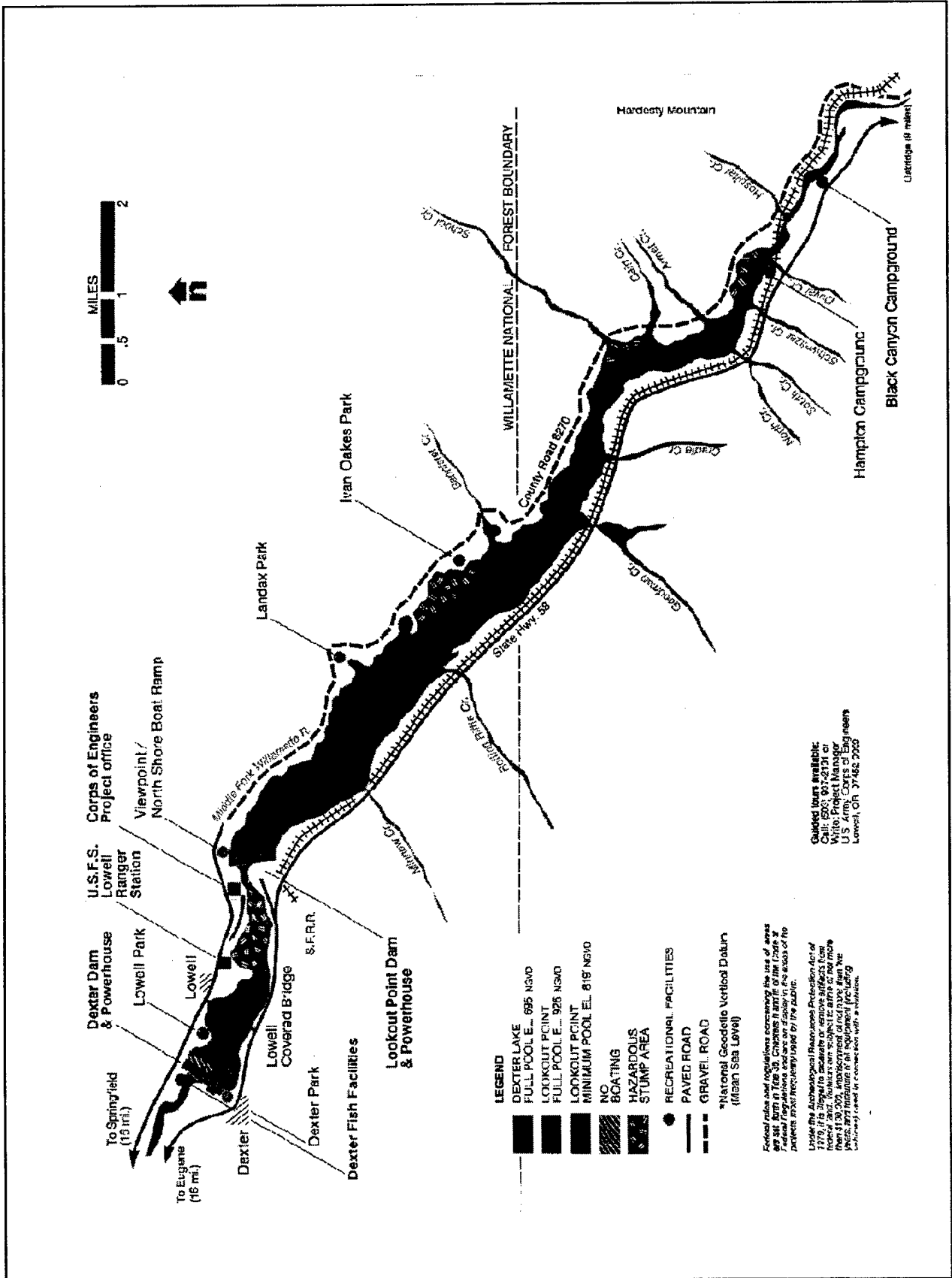


Figure 2. Dexter Dam site

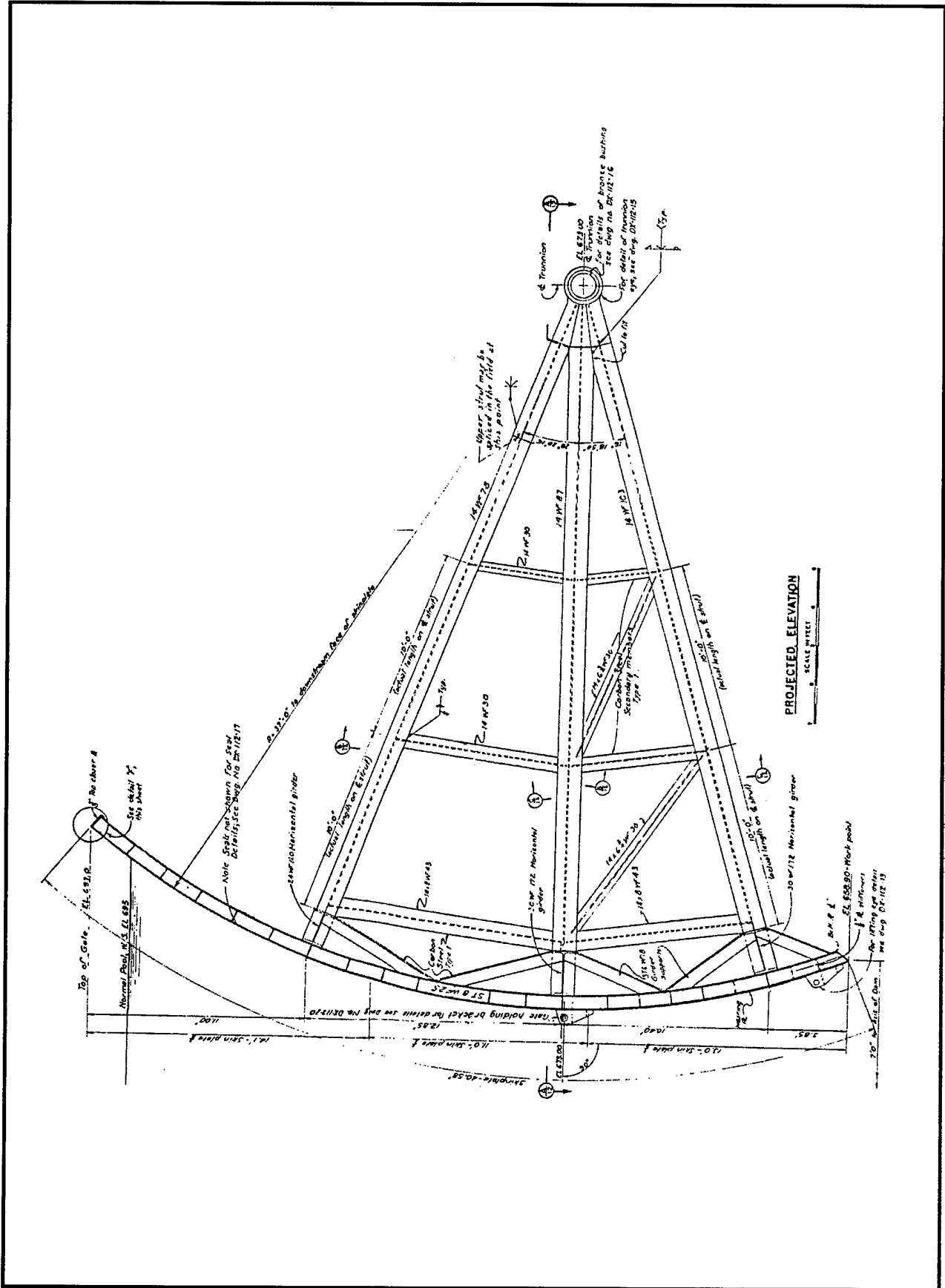


Figure 3. Gate No. 1 at Dexter Dam.

The dam gate was divided into four equally sized vertical sections, then each of these sections were divided into two unequal sections, equal to two thirds and one third of the vertical sections. The larger area of each vertical section was dry blasted with a different blend of abrasives. Likewise, the small areas of each vertical section were blasted using the slurry method with the same abrasive blend as the larger part of the vertical section. Therefore, two thirds of each of the four vertical sections were dry blasted and one third was slurry blasted, each with the same abrasive blend (Figure 4).

A simple containment system was constructed, since five of the six sides of the dam gate were protected by the structure itself (Figure 5). Therefore, the only containment necessary was on the top of the dam gate. Other structures such as water towers and bridge decks do not have this "in-place" containment system.

All dry blasting was performed first. On 18 July, sections #1 and #2 were dry blasted with copper and coal slag respectively. Likewise, on 19 July, sections #3 and #4 were blasted with nickel slag and silica sand, respectively. On 20 July and 21 July, the four smaller sections were blasted using the slurry blast system (Figure 6). Sections #6 and #8 were blasted with the containment tarp off so the blasting could be viewed and videotaped. Sections #5 and #7 were blasted with the same containment structure as the dry blasting.

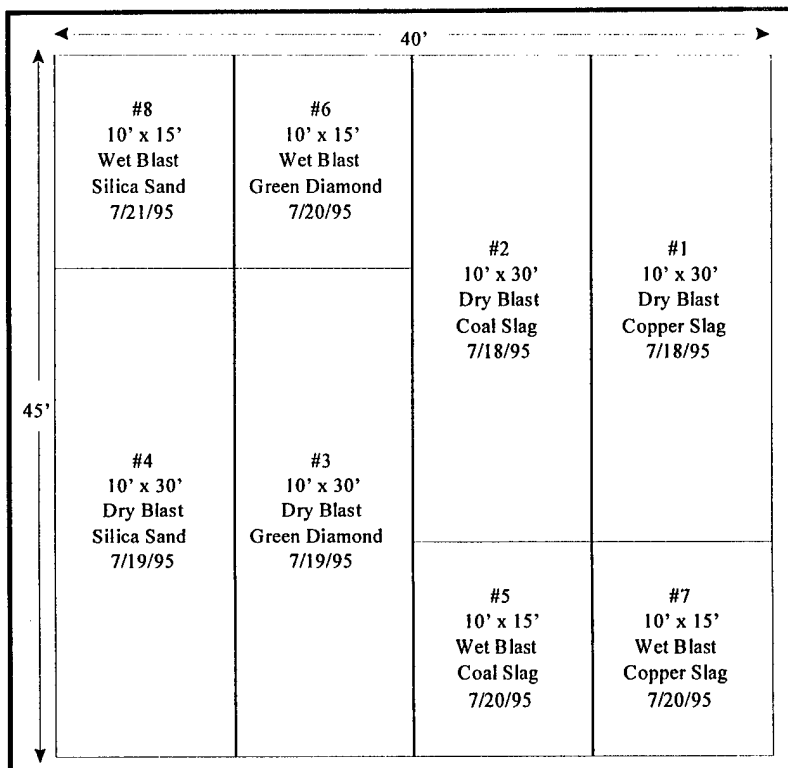


Figure 4. Test areas on Gate No. 1 at Dexter Dam.

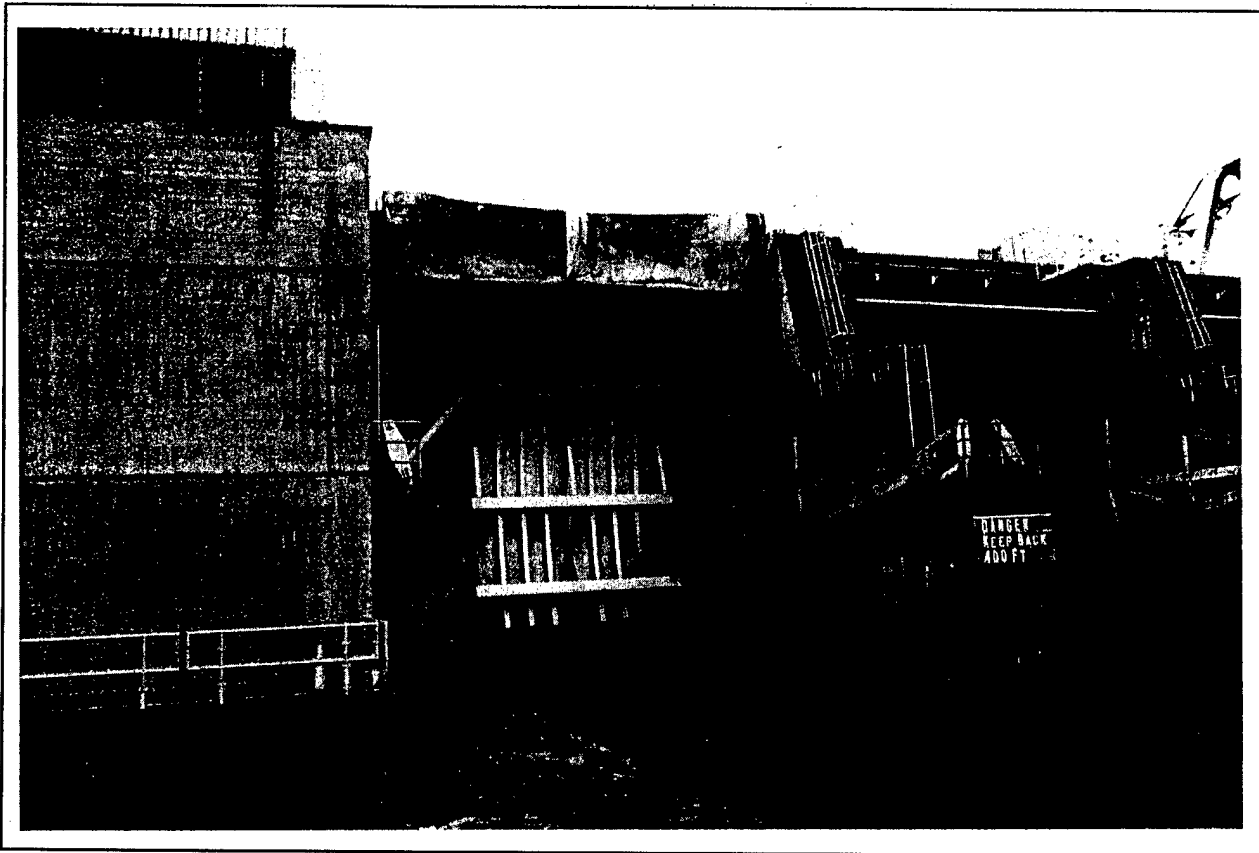


Figure 5. View of containment structure from dry face of the dam gate.

All air monitoring was performed by RCI Environmental. Daily measurements included:

1. Directing the monitoring and inspection of the lead-containing paint removal work on the job site to ensure that all requirements have been satisfied during the lead-containing paint removal operation.
2. Performing personal air-monitoring sampling on the employee anticipated to have the greatest risk of exposure as determined by the certified industrial hygienist (CIH).
3. Collecting environmental and PEL samples for analysis by an American Industrial Hygiene Association (AIHA)-certified laboratory for lead particles.
4. Taking a minimum of one (1) lead particle sample on each shift on the downwind side of the lead control area.



Figure 6. Operation of the slurry blast system.

6 Results of Demonstration

Area Air Monitoring

The laboratory analysis of the three air samples collected during dry blasting, with the containment structure in place revealed that the maximum lead-in-the-air reading was $1.5 \mu\text{g}/\text{m}^3$ of air quarterly mean as established in 40 CFR 50 or the established criteria of $30 \mu\text{g}/\text{m}^3$ (which is below the action level). During the slurry blasting, the top of the containment was pulled aside to visualize the operation. The debris from the dry blasting was cleaned up, but the inside of the containment tarps was still covered with the debris. A laboratory analysis was done of the three air samples collected during the slurry blasting with the top of the containment structure open. Results of the analysis revealed that there was environmental exposure to lead in violation of the $1.5 \mu\text{g}/\text{m}^3$ of air quarterly mean as established in 40 CFR 50 and the established criteria of $30 \mu\text{g}/\text{m}^3$ during the abatement of the lead paint from Gate No. 1 of Dexter Dam. The high level of airborne lead was probably due to the dry blast debris remaining on the tarp. This theory was justified by the fact that the results of the personnel air monitoring (shown in the next section) for the slurry blasting were very low. Table 2 and Appendix D give exterior environmental exposure to lead air monitoring sample laboratory analytical results.

Personal Air Monitoring

A laboratory analysis was done of the personal exposure level to lead air-monitoring samples that were collected during both wet and dry abatement of lead containing paint from Gate No. 1 at Dexter Dam. The results revealed that the abrasive blasting equipment operators in the containment structure during lead-containing paint abatement processes were not exposed to lead in excess of the PEL criteria of the respiratory protection equipment that were used for lead abatement personal protect as presented in 29 CFR1926.62(f)(2)(i). Table 3 lists the laboratory analytical results for the personal exposure level samples collected in the breathing zone of the blasting equipment operators.

Table 2. Exterior lead air monitoring results.

Sample Number	Sample Date	Sample Type	Sample Location	Air Volume Collected (L)	Analytical Results
DD-01	7/18/95	CEF closed	Containment entrance	956	<3.0 $\mu\text{g}/\text{m}^3$
DD-04	7/19/95	CEF closed	Containment entrance	688	<4.0 $\mu\text{g}/\text{m}^3$
6172940	7/20/95	GMW closed	North side downwind	19,832	<1.0 $\mu\text{g}/\text{m}^3$
6172939	7/20/95	GMW open	South side downwind	5,418	599 $\mu\text{g}/\text{m}^3$
6172937	7/20/95	GMW open	South side downwind	19,107	1150 $\mu\text{g}/\text{m}^3$
6172936	7/21/95	GMW open	South side downwind	1,032	1080 $\mu\text{g}/\text{m}^3$

Table 3. Personal exposure lead levels.

Sample Number	Sample Date	Sample Type	Air Volume (L)	Results
DD-02	7/18/95	Copper slag: dry	346	<8 $\mu\text{g}/\text{m}^3$
DD-03	7/18/95	Coal slag: dry	364	52 $\mu\text{g}/\text{m}^3$
DD-05	7/19/95	Nickel slag: dry	306	1130 $\mu\text{g}/\text{m}^3$
DD-06	7/19/95	Silica sand: dry	370	774 $\mu\text{g}/\text{m}^3$
DD-08	7/20/95	Coal slag: wet	310	35 $\mu\text{g}/\text{m}^3$
DD-09	7/20/95	Nickel slag: wet	296	46 $\mu\text{g}/\text{m}^3$
DD-10	7/20/95	Copper slag: wet	160	774 $\mu\text{g}/\text{m}^3$
DD-11	7/21/95	Silica sand: wet	176	45 $\mu\text{g}/\text{m}^3$

The review of the laboratory analytical results for the eight personal exposure level to lead samples appear to be inconsistent. The laboratory analytical results for the three breathing zone personal exposure level to lead air monitoring samples collected when Abhe-Svobada, Inc. was operating the wet blasting equipment appear to be almost identical. However, the laboratory analytical results for the breathing zone personal exposure level to lead air monitoring sample that was collected while P.E.A.T., Inc. was operating the wet media blasting equipment, revealed a personal exposure level to lead level that is approximately 18 times higher. The analytical results for personal exposure level to lead samples that were collected during the dry media abatement procedures also reveal a significant variance.

Personal Exposure Level Time Weight Averages

The laboratory analysis of the personal exposure level to lead air-monitoring samples revealed that blasting equipment operators in the containment structure during lead-containing paint abatement activities were not exposed to lead dust in excess of the 8-hour time weight average respiratory protection equipment criteria for LBP abatement personal protect as presented in 29 CFR 1926.62(f)(2)(i). Table 4 lists the personal exposure level to lead time weight average (TWA) calculations that are based on the laboratory analysis of the eight collected air samples.

Table 4. Lead time weight average lead analysis results.

Sample Number	Sample Date	Sample Type	Monitoring Time (min)	Analytical Results	Time Weighted Average
DD-02	7/18/95	Copper slag: dry	173	<8 µg/m ³	<.38 µg/m ³
DD-03	7/18/95	Coal slag: dry	182	52 µg/m ³	19.7 µg/m ³
DD-05	7/19/95	Nickel slag: dry	153	1130 µg/m ³	360.2 µg/m ³
DD-06	7/19/95	Silica sand: dry	183	774 µg/m ³	295.1 µg/m ³
DD-08	7/20/95	Coal slag: wet	155	35 µg/m ³	11.3 µg/m ³
DD-09	7/20/95	Nickel slag: wet	148	46 µg/m ³	14.2 µg/m ³
DD-10	7/20/95	Copper slag: wet	80	774 µg/m ³	129.0 µg/m ³
DD-11	7/21/95	Silica sand: wet	88	45 µg/m ³	8.3 µg/m ³

Surface and Inspection Results

A single applicator applied the primecoat each evening after the blasting had been completed using a Devilbiss 5-gal pressure pot comprised of a needle, a 0.070 in.* fluid tip, and a #30 air cap. The applicator indicated that the air pressure at the gun was between 50 and 55 psi, using fluid and air lines with an outside diameter of 3/8-in.

Surface Profile Measurements

Table 5 lists the surface profile measurements, taken according to ASTM D 4417 Method C (Replica Tape), for each of the different abrasives. Note that the blast was of poor quality, especially on the lower areas, which were less visible from the service bridge. While conducting these surface profile measurements, traces of the old red lead system remained on the blast. In most places a SSPC-SP5 white metal blast was not obtained.

Table 5. Surface profile measurements.

	Tape 1	Tape 2	Tape 3
Dry blast: coal slag	3.2	3.5	3.5
Dry blast: copper slag	3.0	3.2	3.7
Dry blast: silica sand	2.7	2.8	3.1
Dry blast: nickel slag	3.2	3.4	3.5
Wet blast: coal slag	3.4	3.5	3.3
Wet blast: copper slag	3.8	3.6	3.5
Wet blast: silica sand	3.7	3.5	3.5
Wet blast: nickel slag	3.5	4.1	3.9

*1 in. = 25.4 mm.

Adhesion of Prime Coat

The adhesion of the prime coat was measured using ASTM D 4541-85, "Pulled-Off Strength of Coatings using Portable Adhesion Testers." Circular aluminum test fixtures ("dollies") required for the test were affixed to the coating surfaces using 3M Scotch Weld 1838 epoxy cement. To promote adhesion of the dolly to the surface to be tested, the dollies were roughened on the contact side prior to applying the epoxy cement. The dollies were secured to the painted surfaces using magnetic C-clamps to apply firm pressure on both epoxy-cement contact surfaces while the adhesive cured for 24 hours. Finally, the dollies were loaded in tension and pulled from their coated substrates. All adhesion tests were run in triplicate; Table 6 shows the results, which indicate that the adhesion of the VZ 108d primecoat was average to good in all cases.

Thickness Measurements

Dry film thickness measurements of the primecoat were taken after the entire gate had been primed. Table 7 shows the results.

Table 6. Prime coat adhesion results (psi).

	Dolly 1	Dolly 2	Dolly 3
Dry blast: coal slag	1050	1075	1050
Dry blast: copper slag	1125	1000	1125
Dry blast: silica sand	1100	1025	1000
Dry blast: nickel slag	1200	1100	1075
Wet blast: coal slag	1200	1250	1275
Wet blast: copper slag	1100	1200	1250
Wet blast: silica sand	1275	1175	1150
Wet blast: nickel slag	1150	1100	1000

Table 7. Dry film thickness.

	Dry Film Thickness (mils)
Dry blast: coal slag	3.8
Dry blast: copper slag	3.5
Dry blast: silica sand	3.2
Dry blast: nickel slag	2.4
Wet blast: coal slag	2.6
Wet blast: copper slag	3.5
Wet blast: silica sand	3.5
Wet blast: nickel slag	2.7

Table 8. TCLP results of waste.

Sample	USACERL Results mg/L	Partner Results mg/L
Coal slag: dry	<0.05	0.13
Nickel slag: dry	<0.05	0.14
Silica sand: dry	<0.05	0.26
Copper slag: dry	<0.05	0.15
Combined: wet	NA	0.14
*Detection limits of the TCLP are 0.05 mg/L		

TCLP Data

The Toxicity Characteristic Leaching Procedure was performed on all wastes to ensure that the engineered abrasive adequately limited the leachability of the lead to handle the waste as nonhazardous. Two independent samples were taken from the site: one by USACERL and one by the Partner. Both samples were independently tested at separate laboratories. Table 8 shows the results of the leachability of lead only. The leachability of all Resource Conservation and Resource Act (RCRA) eight metals was tested, but only lead is reported since it was the only heavy metal present in the coating system. As stated earlier, if the lead leachability is above 5.0 mg/L, the waste is classified as hazardous, and must be treated as such. Note that only one sample from the wet blasting was obtained due to difficulty separating blast waste.

The total lead in the blast media ranged from 3,387 to 4,161 parts per million (ppm), indicating a relatively low amount of lead in the paint. According to the data, the chemically engineered abrasive controlled the leachability of the lead present, sufficiently so that the waste could be handled as nonhazardous. The results for both independent tests were similar, increasing the confidence of each test.

Coating Inspection After 19 Months in Service

Representatives from USACERL revisited the dam gate on 25-26 February 1997 to evaluate the coating after 19 months of service. Initial observation revealed a few localized spots of rust approximately 4 in. in diameter. The rust was caused by broken blisters and there was dense #4 blistering in the rusted areas. Once the small amount of paint on the rusted areas was removed, it was noted that a grinder had been used in these areas prior to painting. A description of the coating appearance by blasted area follows:

Area 1 had been dry blasted with copper slag. Adhesion was low (especially in the upper parts), and underfilm corrosion was present. Paint thickness was 11-12 mils* thick, except for along the weld line where thickness was 14-16 mils. There was blistering possibly where there had been some fill welding.

Area 2 had been dry blasted with coal slag. Poor adhesion was found in both locations tested in the upper areas of this section, but was better in the lower areas. Paint thickness was similar to that seen in Area 1.

Area 3 had been dry blasted with nickel slag. Thickness was only 9-13 mils and adhesion was low.

Area 4 had been dry blasted with silica sand and chemical additive. Paint was only 9-10 mils thick and #6 Dense blistering was present where the area was ground after blasting. Corrosion was present in broken blister and there was light underfilm corrosion, but not as bad as in Areas 1 and 2.

Area 5 had been wet blasted with coal slag. Underfilm corrosion and poor adhesion was found, both similar to other areas of dam gate. Paint thickness was mostly 10-11 mils, but occasionally ranged from 8-15 mils.

Area 6 had been wet blasted with nickel slag and additive. Adhesion about the same as area dry blasted with coal slag and maybe slightly better. Paint can be stripped from the substrate and spots of underfilm corrosion.

Area 7 had been wet blasted with copper slag and additive. Thickness ranged from 9-11 mils with apparent underfilm corrosion. A section of paint was removed exposing the old red lead primer. It was obvious that a White Metal Blast was not achieved in this area.

Area 8 had been wet blasted with silica sand and additive. Adhesion was excellent; it met the expectations for that paint system. No traces of underfilm corrosion were noted.

To summarize, Areas 1 and 2 had the poorest adhesion, Area 8 had the best adhesion, and the adhesion was about the same in all other areas. There were

*1 mil = 0.001 in. = 0.0254 mm.

remains of the red lead primer used in the paint system that was abated. Dense #4 and #6 blistering was present in areas that had been ground and welded. Some small areas of localized Underfilm corrosion were present except in area #8. Given the results of the coatings tests performed during the development of the admixture, these results were unexpected. Primer was added to the surfaces at the end of each day after blasting, but no topcoat was applied until the entire surface had been blasted, which was over 7 working days. This could indicate that the primer had allowed corrosion to initiate prior to the application of the topcoats. Noted that neither USACERL nor TDJ could control the COE contractor schedule completely. This allowed the contractor some flexibility in the repainting schedule. A White Metal Blast was specified for this project, but apparently had not been accomplished in all areas. It should be noted that the COE Guide Specification does not allow the application of topcoat to a ground area; it must be reblasted to achieve surface profile.

Cost and Benefit Analysis

A cost analysis of the use of Blastox[®] as an additive to blast media to stabilize LBP waste after removal was completed using field data from actual demonstration site (Table 9). Cost factors presented are based on actual contractor costs and are compared to actual government estimates. The term "capital facilities" refers to the capital investment in this technology (e.g., blast machines). The labor figure includes the personnel work expenditure. Consumables refers to the blast media additives, tarps, and covers and packaging required for disposal. Environmental testing refers to required tests such as air monitoring (both personal and site), XRF testing, and TCLP waste analyses.

The information in Table 9 shows that the use of Blastox[®] can yield an immediate and relevant savings for deleading steel structures such as COE dam gates. This is based on the significant savings in disposal costs of a nonhazardous waste. The savings are \$0.93-3.04/sq ft of abrasively blasted steel surface. The use of the TORBO wet blast system can increase the savings even further by reducing the level of containment required from 100 to 85 percent wind screen. This could the cost of actual confinement from \$6.40/sq ft to \$5.00-\$5.50/sq ft.

Table 9. Savings in real present value dollars on steel substrates.

Cost Factors	Blast Media Without Blastox [®]	With Blastox [®] Additive at \$0.25/lb (20% mixing)
Capital Facilities ¹	\$40.00/site hour	\$40.00/site hour
Labor ²	\$280.00/site hour	\$280.00/site hour
Consumables ³	\$70.00/site hour (containment) \$67.00/site hour (crane rental) \$137.00/site hour	\$102.00/site hour \$67.00/site hour \$169.00/site hour
Environmental Testing ⁴	\$151.00	\$151.00
Subtotal	\$608.00/site hour	\$640.00/site hour
Strip Rate ⁵	100 sq ft/hour (may be higher when not hampered by height and configuration)	100 sq ft/hour
Removal Cost	\$6.08/sq ft	\$6.40/sq ft
Disposal Cost ⁶	\$1.40 – \$3.60/sq ft (\$350 – \$900/ton)	\$0.15 – \$0.24/sq ft (\$35.21 – \$55.01/ton)
Total Cost	\$7.48 – \$9.68/sq ft	\$6.55 – \$6.64/sq ft
Savings		\$0.93 – \$3.04/sq ft
Notes:		
<ol style="list-style-type: none"> Capital rates of recovery are from actual contractor costs and DEH government cost estimate detail sheets. Costs for investment are amortized over 7 years for depreciation, and assume a 2000-hour site year. Labor is quoted from actual contractor costs or derived from government estimate sheets. Consumables are based on items used up in the job process. Blastox[®] is factored into this number based on its rate of application and percent of additive by weight. Abrasive blasting of steel required 8 lb of abrasive per sq ft. Environmental testing includes air monitoring (both personal and site), XRF, and TCLP tests. Strip rate varies depending on size of equipment and nature of the structure, i.e., wood buildings or 120-ft high elevated steel water or storage tank. Disposal costs for hazardous waste were supplied by the Marketing Department, Chemical Waste Management, Inc., Oakbrook, IL. Costs for nonhazardous waste reflect typical costs from 12 states (Solid Waste Digest, October 1993, Chartwell Information Publishers, Inc., Alexandria, VA), and supplementary information from four additional states. The higher end of the range of disposal costs reflects per unit costs of the disposal of small quantities of waste (less than 5 tons). Lower per-unit disposal costs reflect disposal of bulk wastes from larger projects. 		

7 Conclusions, Recommendations, and Commercialization/Technology Transfer

Conclusions

The demonstration successfully evaluated the composition, performance, and cost effectiveness of using an engineered abrasive containing Blastox[®] for LBP removal from a COE steel structure and stabilization of the LBP containing abrasive blast waste. The end products of the demonstration were:

1. Industry specifications and user guidance for the removal of hazardous paints from immersed surfaces. The composition of Blastox[®] is a di- and tri-calcium silicate based material similar in composition to type 1 cement. This was determined by X-ray fluorescence analyses. Appendix B gives the industry specifications.
2. Chemical engineering added to abrasive blast media (e.g., coal slag). The chemical stabilizer can be added (20 weight percent) to at least four abrasive blast media. Blastox[®] was preblended with coal slag, silica sand, copper and nickel slags, and was used to remove LBP from tainter gate No. 1 at Dexter Dam with no significant difference in performance.
3. An engineering and environmental assessment of any effects on subsequent coating life. There appears to be no long-term coating degradation due to the use of the chemical stabilizer admixture. There are some occurrences of poor workmanship on the part of the COE contractor such as performing grinding on the blasted steel surface and not reblasting. This causes underfilm corrosion and blistering. In addition to Dexter Dam, TDJ has documented two COE lock and dam gate projects in which Blastox[®] was used to remove and stabilize the lead paint waste. Gates were blasted in 1994 at the Port Allen Flood Locks in Port Allen, LA. The 3-A-Z, 5-E-Z zinc rich system was used. According to the COE project manager, no coating problems have been observed. Gates were also blasted in March 1996, at the Algiers Flood Locks, Algiers, LA. The 3-A-Z vinyl system was used and reported to be in excellent condition by the COE project manager.

4. Dust control and containment of the hazardous heavy metal paint waste in a landfill. The laboratory analysis of the three exterior air-monitoring samples collected with the containment structure in place did not reveal environmental exposure to lead at or in excess of the action level during the abatement of the lead-containing paint from Gate number 1 at Dexter Dam. However, it is believed that the lead-containing dust emission when the containment was opened resulted from dust being blown off the inside surfaces of the tarps. The dust was deposited on these surfaces during the dry blasting phase. This explanation is based on the personal exposure level data that shows, on average, lower lead exposure values for wet blast as compared to dry blast. The laboratory analysis of the personal exposure level to lead breathing zone monitoring samples that were collected in the containment structure during both the wet and dry abrasive media abatement of lead-containing paint revealed that there was no exposure to lead in excess of the time-weight average personal exposure levels that used respiratory protection for a lead paint abatement project as established by 29 CFR 1910.1026(f)(2)(i).
5. Long-term stability of the hazardous heavy metal paint waste in a landfill. The long-term stability of the LBP waste was documented by performing TCLP (EPA method 1311) analyses on the waste. The results show lead less than 1 PPM. In addition CERL and TDJ have performed multiple (five) TCLP analyses on stabilized lead paint waste and did not exceed 5 PPM at any time (Hock, Gustafson, and Drozd 1996).
6. Recycling options for the abrasive blast residue. TDJ has instituted a beneficial reuse program throughout the United States. The nonhazardous waste (TCLP tested) would be delivered to a central staging center or directly to a recycling center. There the waste is used as a feedstock for the cement industry. According to RCRA, most wastes that are used or reused as ingredients in an industrial process are excluded from the definition of a solid waste. Therefore if the spent abrasives are reused in another industrial process (i.e., the cement industry), they are no longer classified as solid waste. One of the major provisions under RCRA is to "reduce, reuse, and recycle." Appendix E contains the description of the TDJ beneficial reuse program and a list of recycling centers nation wide. In addition to the list of recycling centers, Appendix F contains a list of suppliers of the Chemical Stabilizer, including the state, city, product, company, and phone number of the supplier.

Recommendations

1. It is recommended that an engineering abrasive containing chemical stabilizer (Blastox®) or its equivalent be considered as a feasible alternative to other means of removal of LBP from COE steel structures such as lock and dam gates, or comparable industry structures such as bridges.
2. It is recommended that the chemical stabilizer be preblended (20 weight percent) with any of the abrasives documented in this demonstration.
3. It is recommended that the chemistry and technical specifications of the chemical stabilizer contained in this report be used for all COE LBP abatement specifications, and for specifications developed for industry and other Government agencies.
4. It is recommended that the testing of the chemical stabilized LBP waste be performed using only the TCLP (EPA method 1311) analysis.
5. Where applicable, the stabilized LBP abrasive blast should be recycled according to the guidelines developed by TDJ. Appendix F to this report lists suppliers and recycling centers.
6. Where applicable, the use of wet blast (TORBO) system in combination with the chemical stabilizer is recommended to further reduce the cost of LBP abatement.
7. It is recommended that the chemistry and technical specifications of the chemical stabilizer be incorporated into the COE Civil Works Guide Specification 09940.

Commercialization/Technology Transfer

TDJ has completed commercialization of the chemical stabilizer for addition to abrasive blast media and for LBP abatement on COE structures such as lock and dam gates. TDJ produces, manufactures, and markets the chemical stabilizer worldwide through a network of suppliers and distributors (Appendix F). The industry specifications and chemistry are contained in this report and in the Draft USACERL User Guide *User Guide and Specifications for Using Blastox® To Remove and Stabilize Lead-Based Paint*. In addition, TDJ has produced the MSDS contained in Appendix C.

TDJ has also developed a network of beneficial reuse or recycling centers across the United States. This allows the stabilized LBP to be reused under RCRA act.

A list of recycling centers and guidance for the beneficial reuse program is contained in Appendix E.

Appendix F contains the recommended chemistry and technical specifications of the chemical stabilizer to be incorporated into the COE Civil Works Guide Specification 09940.

Appendix A: Toxicity Characteristic Leaching Procedure

The Toxicity Characteristic Leaching Procedure (TCLP) (USEPA Method 1311) procedure used for all the tests is:

1. Each 100-g homogeneous sample was passed through a 9.5 mm standard sieve. Any portion of the sample that failed to pass through the sieve was crushed or milled to reduce its size until it would pass through the sieve.

2. A 5-g portion of the entire sample was tested to determine the extraction fluid to use:

- A 5-g sample was weighed into a 250-ml beaker.
- 96.5 ml of deionized water was added, stirred vigorously for 5 minutes, and the pH of the solution was determined. If the pH was <5.0 , then TCLP Extraction Fluid 1 (described below) was used.
- If the pH was >5.0 , then 3.5 ml of 1N HCL was added, and the solution was heated to 50 C and held for 10 minutes. The solution was then allowed to cool and the pH was remeasured. If the pH was <5.0 , then Extraction Fluid 1 was used, but if it was >5.0 , then Extraction Fluid 2 (described below) was used.

3. The procedure used to prepare the extraction fluids was:

- *Extraction Fluid 1:* 5.7 ml of glacial acetic acid and 2.572 grams of NaOH were added to 500 ml of deionized water. The volume was increased to 1000 ml. The pH was 4.93 ± 0.05 .
- *Extraction Fluid 2:* 5.7 ml of glacial acetic acid added to 500 ml of deionized water and the volume was increased to 1000 ml.

4. A 100-g sample was transferred to a 2-L, acid-washed polyethylene bottle. Then 2 L of the prescribed extraction fluid were added.

5. The lid was secured and the bottle was placed into the rotator. The motor was started and the bottle lids were checked to assure there were no leaks.
6. The sample was rotated for 18 ± 2 hours.
7. After the samples were finished rotating, the bottles were removed from the rotator. Then 100 ml of the extraction fluid was removed from the bottle and placed into a 150 ml, acid-washed beaker for digestion.

After extraction in accordance with USEPA Method 1311, the next step was digestion of the solution to prepare it for atomic absorption analysis. The procedure used to digest the samples is USEPA SW896 Method 3010A.

The last step in the TCLP test involved using atomic absorption to determine how much of the heavy metal leached from the solid waste into the extraction fluid in parts per million (ppm). A portion of the fluid was retained so that, if an error occurred during atomic absorption, or if the results were not conclusive, it could be reanalyzed. The solid portion was disposed either as a nonhazardous or hazardous waste depending on the results of the TCLP test (USEPA Method 1311).

Appendix B: Blastox[®] Technical Data

Technical Data

PRODUCT NAME

Blastox[®], a patented lead abatement blast additive.

PRODUCT DESCRIPTION

Blastox[®] is a granular, complex calcium silicate-based blasting abrasive additive.

USE: Typically used at a 15 percent weight ratio for stabilizing lead in lead-based paint blast removal operations, producing a non-hazardous waste suitable for disposal in a local subtitle D landfill. Use is compatible with standard dry or wet blast equipment.

CHEMICAL REACTIONS: Blastox[®] produces lead silicates through chemical conversion of the lead in the paint. It is intended solely as a lead stabilizing additive, reducing leachable lead in untreated spent abrasive wastes from up to 100 mg/l to less than 5.0 mg/l (RCRA limit for lead) according to the TCLP.

RESTRICTIONS: Material must be kept dry until preparations are made for field application. Wet or otherwise contaminated Blastox[®] does not carry a performance guarantee. For dry blasting operations, moisture separators are required and air dryers are recommended. Blastox[®] is designed with cementitious properties and may solidify in equipment, on substrates and around general work areas upon extended exposure to moisture. Care should be taken to avoid these situations or additional cleaning measures may be required.

APPLICATION TECHNIQUES

For dry blasting lead painted steel, six (6) to eight (8) pounds of a 15 percent weight ratio blended abrasive must be used per square foot of paint removed for adequate stabilization. For blasting lead painted wood substrates or for blast operations using less than six (6) pounds per square foot of paint removed, contact TDJ Group's Technical Service for specific recommendations.

*TYPICAL PROPERTIES

SPECIFIC GRAVITY: 3.15-3.22
 BULK DENSITY: 85-90 #/ft³
 HARDNESS: (Mohs) > 6.0
 SOLUBILITY: (Slight) .1%-1.0%

SCREEN ANALYSIS

Sieve Size	% Retained
16	28
20	24
30	20
40	16
50	10
<50	2

*These data are a result of historical production performance. TDJ does not imply that future production will exactly demonstrate these typical properties.

AVAILABILITY

Sold pre-blended with abrasives throughout the United States by licensed blenders and distributors. Contact TDJ's corporate office or your regional manager for a list of local suppliers.

TECHNICAL SERVICE

Complete technical bulletins and information are available from TDJ Group's corporate office. Technical assistance for specific applications is also available.

WARRANTY

If Blastox[®] blended abrasives are blended, used, sampled and tested properly, and spent abrasive material tests hazardous for lead, TDJ will refund the cost of the Blastox[®] additive, plus additional blending fees associated with the use of Blastox[®]. TDJ makes no other warranties, expressed or implied. For other heavy metals which may be present in coating systems or unique applications, please contact TDJ Group's Technical Service.



The TDJ Group, Inc.

760 - A Industrial Drive
 Cary, Illinois 60013

e mail tdj@blastox.com phone (847) 639-1113 fax (847) 639-0499

Appendix C: Material Safety Data Sheet (OSHA 29 CFR 1910.1200), Blastox[®]

SECTION I—IDENTITY

Supplier's Name and Address: The TDJ Group, Inc., 760-A Industrial Drive,
Cary, Illinois 60013

Information Telephone Number: (847) 693-1113 phone: (847) 639-0499 fax

Date of Preparation: May 1, 1997

SECTION II—INGREDIENTS / IDENTITY INFORMATION

Common Name: Blastox[®]

Abrasive Blasting Additive Ingredients:

- Ca_3SiO_5 TriCalcium Silicate (CAS# 12168-85-3)
- Ca_2SiO_4 Di Calcium Silicate (CAS# 10034-77-2)
- $\text{Ca}_3\text{Al}_2\text{O}_3$ TriCalcium Aluminate (CAS# 12042-78-3)
- $\text{Ca}_4\text{Al}_2\text{Fe}_2\text{O}_{10}$ Calcium Alumino Ferrite (CAS# 12068-35-8)
- Trace amounts of CaO, and MgO may also be present

SECTION III—PHYSICAL / CHEMICAL CHARACTERISTICS

Solubility in water - Slight (0.1-1.0 %)

Specific gravity - 3.15-3.22

Appearance & Odor - Dark Gray with no odor

The following properties are not applicable as the Blastox[®] is a solid granular form:

Boiling point, Melting point, Vapor pressure, Vapor Density, Evaporation rate

SECTION IV—FIRE AND EXPLOSION HAZARD DATA

Blastox[®] is not flammable nor explosive.

SECTION V—REACTIVITY DATA

Blastox[®] is stable and hazardous polymerization will not occur.

Keep Blastox[®] dry until used.

SECTION VI—HEALTH HAZARD DATA

Routes of Entry: Inhalation? Yes Skin? No Absorption/Ingestion? Yes

ACGIH Threshold Limit Value (1988-1989):

Total dust containing no asbestos and less than 1 percent silica-10 mg/m³.

OSHA PEL (Transitional):

Total dust 50 million particles per cubic foot.

OSHA PEL (Final):

Total dust 10 mg/m³, Respirable dust 5 mg/m³.

Effects of Overexposure:

Acute : This material contains calcium silicates and calcium aluminates, is

alkaline and can dry the skin and may cause caustic burns. Direct contact with the eyes can cause irritation. Inhalation can irritate the upper respiratory system.

Chronic : Abrasive dusts can cause inflammation of the lining tissue of the nose and inflammation of the cornea. Hypersensitive individuals may develop an allergic dermatitis. Signs and Symptoms of Redness to skin, minor irritation to eyes, nose, and throat.

Exposure:

- **Emergency** Irrigate (flood) eyes immediately and repeatedly with clean water.
- **First Aid** Wash exposed skin areas with soap and water. Apply sterile dressings.

Procedures : Remove from further exposure those individuals who develop signs or symptoms. Consult a physician immediately.

SECTION VII—PRECAUTIONS FOR SAFE HANDLING AND USE

If Blastox[®] is spilled it can be cleaned up by using normal dry methods. Use protective clothing to prevent skin exposure. Rubber boots, rubber gloves, tight fitting goggles and OSHA, MSHA, or NIOSH approved respirators should be used. Emergency procedures are not required.

Blastox[®] can be treated as a common waste for disposal or returned to the container for later use if it is not contaminated or wet.

SECTION VIII—CONTROL MEASURES

Observe ANSI standard Z88.2-1980 "Practices for Respiratory Protection," and standard Z9.4-19804 "Ventilation and Safe Practices of Abrasive Blasting Operations."

Local exhaust can be used to control airborne dust levels.

Use protective clothing to prevent skin exposure. Rubber boots, rubber gloves, tight fitting goggles and OSHA, MSHA, or NIOSH approved respirators should be used.

Following work with Blastox[®] workers should wash with soap and water

Appendix D: Exterior Environmental Exposure to Lead Monitoring Results

**MONITORING AIRBORNE LEAD PARTICLES
ASSOCIATED WITH THE
ABATEMENT OF LEAD-CONTAINING PAINT**

**REQUISITION NUMBER: W52EU25-5200-9119
PURCHASE ORDER NUMBER: DACW88-95-M-0566
PROJECT NAME: DEXTER DAM
PROJECT ADDRESS: DEXTER, OREGON 97431**

Prepared for:

**U.S. ARMY CORPS OF ENGINEERS
CONSTRUCTION ENGINEERING RESEARCH LABORATORY
2902 FARBER DRIVE
CHAMPAIGN, ILLINOIS 61821**

Prepared by:

**RCI ENVIRONMENTAL, INC.
1772 PRESTON ROAD
SUITE 202
DALLAS, TEXAS 75252**

AUGUST, 1995

MONITORING AIRBORNE LEAD PARTICLES
ASSOCIATED WITH THE
ABATEMENT OF LEAD-CONTAINING PAINT
DEXTER DAM, DEXTER OREGON 97431

TOPIC	TABLE OF CONTENTS	PAGE
SECTION 1.0	INTRODUCTION	1
SECTION 2.0	PERSONNEL AND EQUIPMENT	5
SECTION 3.0	SAMPLE COLLECTION	7
SECTION 4.0	LABORATORY ANALYSIS	12
SECTION 5.0	ANALYTICAL RESULTS	12
	5.1 AMBIENT AIR MONITORING SAMPLES	12
	5.2 PERSONAL AIR MONITORING SAMPLES	13
	5.3 PEL TIME WEIGHT AVERAGES	15
SECTION 6.0	CONCLUSIONS	16
SECTION 7.0	APPENDICES	
	7.1 DAILY PROJECT LOGS	
	7.2 CHAIN OF CUSTODY	
	7.3 ANALYTICAL RESULTS	
	7.4 CERTIFICATIONS	

SECTION 1.0 INTRODUCTION

The United States Army Corps of Engineers Construction Engineering Research Laboratory located at 2902 Farber Drive, in Champaign, Illinois 61821 requested on July 11, 1995, that RCI Environmental, Inc. located at 17772 Preston Road, Suite 202, Dallas, Texas 75252 provide the environmental consulting services to "Monitor Airborne Lead Particles Associated with the Abrasive Abatement of Lead-Containing Paint" from Gate Number 1, Dexter Dam from July 17th through July 21st, 1995. Dexter Dam is situated on the Middle Fork Willamette River near Dexter, Oregon.

The Scope of Work requested by the US Army Corps of Engineers Construction Engineering Research Laboratory to perform the consulting services for monitoring exterior and personal lead particle exposure levels associated with emissions from the abrasive removal of lead-containing paint required the RCI Environmental, Inc. representatives to comprehend and perform the following services

1. **INTRODUCTION:** Lead is toxic to humans causing irreversible damage to the central nervous system. Adults are known to be at risk from occupational exposure to lead. Monitoring will determine the exposure levels in the community at large and personal exposure limits (PEL's) for abatement workers.

2. **OBJECTIVE:** The objective of this work is to collect and measure airborne particles associated with the removal of vinyl covered lead-containing paint from Gate Number 1 at Dexter Dam during dry and wet lead paint abatement procedures utilizing four abrasive medias.

3. **MAJOR REQUIREMENTS:** In order to accomplish the scope of work, it was necessary for RCI Environmental to perform the following tasks:

- a. **Task 1:** Perform daily breathing zone air sampling at the abatement project work site during the period of abatement activities to establish personal exposure levels (PEL's) of abatement workers to lead particles. The air monitoring was performed per OSHA 29 CFR 1926, Final Rules, Tuesday May 4, 1993.
- b. **Task 2:** Utilize a Certified Industrial Hygienist (CIH) or an Industrial Hygienist (IH) Technician under CIH direct supervision to collect all samples.
- c. **Task 3:** Monitor airborne concentrations of lead particles in accordance with 29 CFR 1910.1025. The air monitoring, testing and reporting was performed an

IH technician under the direction of the CIH.

- d. Task 4: The daily monitoring procedure shall consist of the following:
1. Direct the monitoring and inspection of the lead-containing paint removal work on the job site to ensure all requirements have been satisfied during the lead-containing paint removal operation.
 2. The performance of personal air monitoring sampling on the employee anticipated to have the greatest risk of exposure as determined by the CIH.
 3. The environmental and personal exposure limit (PEL) samples were collected for analysis by an AIHA certified laboratory for lead particles.
 4. A minimum of one (1) lead particle sample on each shift was taken on the down wind side of the lead control area.

RCI Environmental developed the following lead-based paint abatement project profile to facilitate the implementation of the scope of work for monitoring the airborne lead particles associated with the abrasive abatement of the lead-containing paint from Gate Number 1 of Dexter Dam per the requirement of the U.S. Army Corps of Engineering Construction Engineering Research Laboratory.

SCOPE OF WORK

1. Review physical set-up of the contractor's containment area and safety barriers initially and daily to ensure compliance with the requirements as set forth in the U.S. Army Corps of Engineers guidelines for lead-based paint removal.
2. Collect exposure air samples, both area and personal.
 - A. Personal monitoring for the most at-risk population, abatement worker, to include 25% of the work force per abatement shift. The established criteria is 30 ug/M3 (micrograms per cubic meter), the OSHA Action Level for lead.
 - B. Environmental exposure monitoring down wind from the containment structure. A minimum of one sample was to be collected per shift. The criteria is 30 ug/M3 of lead outside of the containment area. Should the

analytical results reveal exposure above the criteria immediate notice and correction are required.

3. Visually inspect the outside of the containment structure during the abatement of the lead-based paint to identify fugitive releases or areas of suspected release of lead dust and lead paint residue into the environment.
4. Notify the U.S. Army Corps of Engineers in writing at the conclusion of the lead paint abatement process whether or not the analytical results obtained from air monitoring conducted outside of the containment structure were less than the required 30 ug/M3, and whether the respiratory protection worn by the abatement workers was adequate for the personal exposures levels that were recorded through the collection of samples in the containment structure.
5. Prepare a written report for the Army Corps of Engineers including all Certified Industrial Hygienists (CIH) and IH representative logs of operations, sampling efforts, sample analytical results and abatement worker personal exposure records.

DAILY ROUTINE

1. Record all daily activities in the on-site activity log.
2. Review the abatement company's "Lead Containing Paint Removal/Abatement Plan", "Worker Protection Plan", and "Waste Collection Plan". Provide the appropriate verbal comments on these actions plans to the abatement project supervisor. Occupational Safety and Health Administration (OSHA) Respiratory protection (29 CFR 1910.134), OSHA Construction Lead standard (29 CFR 1926.62), OSHA General Industry Lead standard (29 CFR 1910.1025), Environmental Protection Agency (EPA), and U.S. Army Corps of Engineers rules and regulations apply. Special Attention should be paid to the PPE for protection from abrasive blast media and safety features for protection from abrasive blast equipment such as "deadman" switches, automatic cut-offs, etc. 29 CFR 1910.94 (a)(6), (a)(3), (a)(2), and .244(b) shall apply. If supplied air type respiratory protection is utilized, the equipment and air shall be suitable for that used (grade D breathing air or breathing air type compressor).
3. Calibrate daily the fully charged air sampling vacuum pumps, the calibrator must be capable of $\pm 5\%$ accuracy and precision. If the calibration is not by a primary calibration source, the infield calibration source must be calibrated by a primary source. Record the sampling

pump calibrations in the daily log. All sampling pumps will be calibrated before and after sampling efforts. Periodic daily pump checks shall be performed to ensure that the pumps are operational and that the air flow is within $\pm 5\%$ of the initial air flow rate.

4. Place pumps and note placement in the daily log book. On personal samples capture the name, firm/company, firm's address, job title, respiratory protection and all PPE worn (including protection from abrasive materials and equipment, social security number of individuals and pump time on/off (total volume across sampling media), sample ID/media, and pump ID/flow rate (in liter per minute).

Pump placement should include:

- a. Downwind of the abatement containment structure;
 - b. On at least one operations personnel or 25% of the work force, whichever is greater.
5. Inspect all operations periodically and note inspections in the daily log. Abnormal observations should be noted and reported to the on-site operator and Army Corps of Engineers Representative for immediate corrective action. Of prime importance is the potential for lead escaping the containment, report immediately and close down the operation if area monitoring reveals releases over the quarterly mean action level of 1.5 ug/M3.
 6. Determine the activities scheduled for the day. Post (communicate) daily air sampling activities with the on-site operator and Army Corps of Engineers Representative.
 7. Prepare air sampling media for immediate, over-night transportation to Armstrong Forensic Laboratory in Arlington, Texas, for lead analysis. Send collected samples to Armstrong Forensic Laboratory on a daily basis and log the shipments.
 8. After the first day air sampling activities, results will be sent by the project CIH in Arlington, Texas, to the subject project site. These air sampling results and any notations by the CIH should be reviewed with the on-site operator and the Army Corps of Engineers Representative and noted in the log book. Personal air sample results should be compared to the respiratory Protection Factors to ensure adequate protection from lead and blast media is being supplied to the operators.

Maximum airborne lead values for a half-face, negative

pressure cartridge respirator or half-face supplied air respirator operated in negative pressure demand mode is 500 ug/M3 (0.50 mg/M3); for a loose fitting hood or helmet or a loose fitting PAPR or any continuous flow type CE abrasive blast respirator is 1,250 ug/M3 (1.25 mg/M3); for a full-face, negative pressure cartridge respirator or a tight fitting PAPR is 2,500 ug/M3 (2.5 mg/M3); for a half-face supplied air respirator operated in pressure demand mode is 50,000 ug/M3 (50 mg/M3); and for a full-face, supplied air respirator operated in pressure demand mode is 100,000 ug/M3 (100 mg/M3). The respiratory protection criteria are taken from 29 CFR 1926.62(f)(2)(i), Table 1, and not from 29 CFR 1910.1025.

9. Air sampling pumps shall be observed periodically to ensure that they are functioning. Pumps and sampling media (cassettes) shall be removed from the operator if he/she leaves the lead containment area for a period of time greater than ten minutes. In no case shall any individual personal sampling cassette be run longer than four hours on the personal sampling pump. Sampling pump air flow rates shall be checked prior to replacing cassettes. Log all activities and times.
10. Exterior monitoring samples (downwind) may be run full shift provided that the cassettes and pumps are inspected periodically and the pressure drop across the filter is not excessive nor is there visual evidence of build up of excessive material on the filter. Log all activities and times.
11. All logs, sample results, and communications become part of the final report to the Army corps of Engineers.

SECTION 2.0 PERSONNEL AND EQUIPMENT

Mr. Greg L. Upah, Industrial Hygiene Technician, under the supervision of Mr. Stevan Pierce, Certified Industrial Hygienist (ABIH), 1976; Registered Professional Engineer (PE), California, 1977; and Certified Safety Professional (CSP), BCSP, 1978; inspected the subject work site before the commencement of the lead-containing paint abatement project to ensure that all the requirements had been satisfied for the lead-containing paint abatement operation, reviewed the operators "Lead Containing Paint Removal/Abatement Plan", "Worker Protection Plan", and "Waste Collection Plan", discussed the lead containing abrasive waste transportation and storage plan with the abatement contractor's supervisor, certified that the respiratory protection for the employee's

was adequate for protecting the workers from lead dust during the abatement work, selected the abatement contractor workers who were deemed to have the greatest risk of exposure during the abatement project for personal air monitoring, supervised the collection of all air monitoring samples, and reviewed the laboratory analytical results obtained from the on-site air monitoring on a daily basis. Mr. Bill Garrelts, the Abhe and Svobada, Inc. abrasive blast equipment operator in the containment area had received respiratory equipment training and fitness testing according to the records of Mr. Henry Byran, Industrial Hygienist for Abhe and Svobada, Inc.

RCI Environmental representative Greg L. Upah was present at the abrasive abatement of lead-containing paint work site to perform the tasks outlined in the USACERL scope of work. Mr. Upah, AHERA and EPA/NEHA Certified Air Quality Specialist, was the Industrial Hygienist (IH) Technician that collected the exposure monitoring samples under the supervision of Mr. Stevan Pierce, CIH, and monitored the containment area during abatement activities for fugitive releases of lead.

Personal exposure levels (PEL's) to lead dust samples were collected on to analytical laboratory supplied pre-weighted three stage clear styrene acrylonitrile (SAN) 37 millimeter cassettes containing 0.8 micron (um) mixed cellulose-ester filters. Gilliam battery operated sampling pumps were used with the cassettes to collect the personal breathing zone samples at an air flow rate of two liters per minute. A Gast electric powered air sampling pump was utilized with the cassettes to collect exterior environmental samples at the containment entrance during the periods of lead abatement air monitoring.

A Graseby/GMW high volume air sampler, model number GMWT-2200 Tripod Hi Vol Sampler, with manometer was utilized to collect the environmental exposure air samples on the downwind side of the lead based paint abatement structure.

The respiratory protection for abrasive abatement equipment operator Mr. Bill Garrelts, Social Security Number 543-88-7685, of the abatement contractor Abhe and Svobada, Inc. was provided by full facepiece positive pressure demand hood with HEPA/Organic cartridge filters, Part Number 1091-00, approved by the U.S. Department of Labor/NIOSH (National Institute for Occupational Safety and Health) Approval Number TC-23C-452 and MSHA (Mine Safety and Health Administration) approved for respiratory protection against Organic Vapors, Dust, Fumes, Mists, Radon Daughters, Particulate, Radonuclides, Pesticides and Paints. The airborne lead dust respiratory protection factor for the full facepiece positive pressure demand hood and cartridge respirators is 100,000 ug/M3 (100 mg/M3).

The respiratory protection for abrasive abatement equipment operator Mr. Steve Sosnowski, Social Security Number 118-48-9957, of the abatement contractor Professional Environmental Abatement Technologies, Inc. was provided by a full facepiece negative pressure respirator with HEPA cartridge filters. The airborne lead dust respiratory protection factor for a full facepiece negative pressure cartridge respirator is 2,500 ug/M3 (2.5 mg/M3).

SECTION 3.0 SAMPLE COLLECTION

Personal air monitoring samples were to be collected during each time period that the four types of wet and dry abrasive media were utilized. The four types of blast media that were used to remove the vinyl covered lead based paint from Gate Number 1 at Dexter Dam were copper slag, coal slag, nickel slag, and silica sand. Each of the four types of wet and dry blast medias were pre-blended with twenty (20) percent, by weight, chemical stabilizer (Blastox) by the TDJ Group, Inc. The wet abrasive abatement of the lead containing paint was performed by Torbo Wet Abrasive Blasting Systems distributed by Keizer Technologies Americas, Inc.

Each of the four dry media abrasive abatement demonstration was to encompass the removal of thirty feet by ten feet, three hundred square feet, of vinyl covered lead-containing paint from steel Gate Number 1. The four wet media abrasive abatement demonstrations were to include the removal of a ten feet by fifteen feet, one hundred square feet, area of vinyl covered lead containing paint from steel Gate Number 1.

Air monitoring sample collection at the abrasive abatement of lead-containing paint site at Dexter Dam was accomplished through the utilization of electric sample collection pumps and battery operated breathing zone sample collection pumps connected to pre-loaded and pre-weighted clear styrene acrylonitrile (SAN) 37 millimeter cassettes. The cassettes contained 0.8 micron (um) mixed cellulose-ester filters for the collection of lead dust. A Graseby/GMW model GMWT-2200 Tripod Hi Vol Samples with manometer was used to collect environmental exposure air samples on the downwind side of the lead based paint abatement structure.

JULY 18, 1995

On July 18, 1995 RCI Environmental representative Greg Upah collected one exterior air monitoring sample at the entrance to the containment structure during the dry abrasive removal of lead containing paint from Gate Number 1 at Dexter Dam.

An electric sampling pump was calibrated to an flow rate of two liters of air per minute prior to the commencement of the collection of the exterior lead exposure level sample. The collection of sample number DD-01 commenced at 8:32 am and was completed without interruption at 4:30 pm. A total of nine hundred fifty-six liters of air were sampled during the four hundred seventy-eight minute air monitoring period. A fugitive release from the containment structure was noted during the sample collection period.

A fully charged battery operated sampling pump was calibrated to an air flow rate of two liters per minute prior to the collection of the breathing zone personal exposure level to lead sample for the abrasive blast equipment operator in the containment structure during the use of the dry copper slag media. The collection of air sample number DD-02 commenced at 8:31 am and was completed at 11:24 am. Three hundred forty-six liters of air were sampled during one hundred seventy-three minutes of air monitoring. Sample Number DD-02 appeared to be very clean after the sampling period.

Two thousand pounds of copper slag were utilized to remove three hundred square feet of lead containing paint in one hundred sixty minutes during the time period of the personal exposure level monitoring.

A fully charged battery operated sampling pump was calibrated to an air flow rate of two liters per minute prior to the collection of the breathing zone personal exposure level to lead sample for the abrasive blast equipment operator in the containment structure during the utilization of dry coal slag media. A cyclone was connected to the 37 millimeter cassette based on previous experience with cassette filter overload caused by coal slag debris during the abatement procedures. The collection of sample number DD-03 commenced at 1:20 pm and was completed at 4:22 pm. Three hundred sixty-four (364) liters of air were sampled during the one hundred eighty-two (192) minute air monitoring period. Air Sample Number DD-03 visually appeared to contain dust after the sampling period.

Two thousand three hundred pounds of coal slag were utilized to remove three hundred square feet of lead containing paint in one hundred fifty-seven minutes during the time period of the personal exposure level monitoring.

JULY 19, 1995

On July 19, 1995 RCI Environmental representative Greg Upah collected one exterior air monitoring sample at the entrance to the containment structure during the dry abrasive removal of lead containing paint from Gate Number 1 at Dexter Dam.

An electric sampling pump was calibrated to an flow rate of two liters of air per minute prior to the start of the collection of the lead exposure level sample. The collection of sample number DD-04 started at 8:11 am but was interrupted at 11:40 am due to the lack of abrasive blasting media. The collection of the air sample resumed at 2:00 pm and was completed at 5:15 pm. A total of six hundred eight-eight liters of air were sampled during the three hundred forty-four minute air monitoring period.

A fully charged battery operated samling pump was calibrated to an air flow rate of two liters per minute prior to the collection of the breathing zone personal exposure level to lead sample for the abrasive blast equipment operator in the containment structure during the utilization of dry nickel slag media. The collection of air sample number DD-05 commenced at 8:12 am and was completed at 10:45 am. A total of three hundred six liters of air were sampled during the one hundred fifty-three minute air monitoring period. Air Sample Number DD-05 visually appeared to be contain dust after the air sampling period.

One thousand five hundred pounds of nickel slag were utilized to remove three hundred square feet of lead containing paint in one hundred twenty-three minutes during the time period of the personal exposure level monitoring period.

A fully charged battery operated sampling pump was calibrated to an air flow rate of two liters per minute prior to the collection of the breathing zone personal exposure level to lead sample for the abrasive blast equipment operator in the containment structure during the utilization of dry silica sand media. The collection of sample number DD-06 commenced at 2:00 pm and was completed at 5:05 pm. A total of three hundred seventy liters of air were sampled during the one hundred eighty-five minute air monitoring period. Sample Number DD-06 visually appeared to contain dust after the air monitoring period.

One thousand five hundred pounds of silica sand were utilized to remove three hundred square feet of lead containing paint in one hundred seventy-one minutes during the time period of the personal exposure level monitoring period.

JULY 20, 1995

On July 20, 1995 RCI Environmental representative Greg Upah collected one exterior air monitoring sample at the down wind side of the containment structure during the wet abrasive media removal of lead containing paint from Gate Number 1 at Dexter Dam with the containment structure in place.

Two exterior air monitoring samples were collected at the downwind side of the containment structure during the wet abrasive removal of lead containing paint from Gate Number 1 at Dexter Dam with the top of the containment structure open.

A Graseby/GMW high volume air sampler, model number GMWT-2200 Tripod Hi Vol Sampler, with manometer was utilized to collect the environmental exposure air samples on the downwind side of the lead containing paint abatement structure.

The collection of sample number 6172940 commenced at 11:32 am with the containment structure in place during wet abrasive media blasting. The collection of the air monitoring sample was completed at 2:00 pm. A total of nineteen thousand eight hundred thirty-two liters of air were sampled during the one hundred forty-eight minute air monitoring period.

The collection of sample number 6172939 commenced at 2:30 pm with the containment structure top open during wet abrasive media blasting. The collection of the air monitoring sample was discontinued at 3:13 pm. A total of five thousand four hundred eighteen liters of air were sampled during the forty-three minute air monitoring period. Fugitive dust releases from the top of the containment structure were noted during the abatement process.

The collection of sample number 6172937 commenced at 3:19 pm with the containment structure top open during wet abrasive media blasting. The collection of the air monitoring sample was discontinued at 6:32 pm. A total of nineteen thousand one hundred seven liters of air were sampled during the one hundred ninety-three minute air monitoring period. Fugitive dust releases from the top of the containment structure were noted during the abatement process.

A fully charged battery operated sampling pump was calibrated to an air flow rate of two liters per minute prior to the collection of the breathing zone personal exposure level to lead sample for the abrasive blast equipment operator in the containment structure during the use of wet coal slag media with the containment structure in place. The collection of sample number DD-08 commenced at 11:15 am and was completed at 1:50 pm. A estimated three hundred ten liters of air were probable sampled during the one hundred fifty-five minute air monitoring period. The cassette line was disconnected from the personal air sampling pump when the blasting equipment operator emerged from the containment structure at 12:40 pm. The length of time that the air sampling equipment was not monitoring the breathing zone personal exposure level to lead is unknown. Air Sample Number DD-08 did visually appeared to contain dust after the air sampling period.

Six hundred pounds of coal slag were utilized to remove one hundred fifty square feet of lead containing paint in one hundred thirty-five minutes during the time period of the personal exposure level monitoring period.

A fully charged battery operated sampling pump was calibrated to an air flow rate of two liters per minute prior to the collection of the breathing zone personal exposure level to lead sample for the abrasive blast equipment operator in the containment structure during the utilization of wet nickel slag media with the top of the containment structure open. Collection of sample number DD-09 commenced at 2:25 pm and was completed at 4:53 pm. A total of two hundred ninety-six liters of air were sampled during the one hundred forty-eight minute air monitoring period. Sample Number DD-09 visually appeared to contain dust after the air sampling period.

A fully charged battery operated sampling pump was calibrated to an air flow rate of two liters per minute prior to the collection of the breathing zone personal exposure level to lead sample for abrasive blast equipment operator Mr. Steve Sosnowski (P.E.A.T.) in the containment structure during the use of wet copper slag media with the top of the containment structure open. Collection of sample number DD-10 commenced at 5:10 pm and was completed at 6:30 pm. A total of one hundred sixty liters of breathing zone air were sampled during the eighty minute monitoring period. Sample Number DD-09 did visually appeared to contain dust after the air sampling period.

JULY 21, 1995

On July 21, 1995 RCI Environmental representative Greg Upah collected one exterior air monitoring sample at the downwind side of the containment structure during the wet abrasive media removal of lead containing paint from Gate Number 1 at Dexter Dam with the top of the containment structure open. A Graseby/GMW high volume air sampler, model number GMWT-2200 Tripod Hi Vol Sampler, with manometer was utilized to collect the environmental exposure sample during the lead containing paint abatement structure.

The collection of sample number 6172936 commenced at 7:45 am with the top of the containment structure open during wet abrasive media blasting. The collection of the environmental air monitoring sample was completed at 9:00 am. A total of eight thousand nine hundred twenty-five liters of air were sampled during the seventy minute air monitoring period.

A fully charged battery operated sampling pump was calibrated to an air flow rate of two liters per minute prior to the

collection of the breathing zone personal exposure level to lead sample for the abrasive blast equipment operator in the containment structure during the utilization of wet silica sand media with the top of the containment structure open. The collection of sample number DD-11 commenced at 7:40 am and was completed at 9:08 am. A total of one hundred seventy-six liters of air were sampled during the eighty-eight minute air monitoring period. Air Sample Number DD-11 did visually appeared to contain dust after the air sampling period.

SECTION 4.0 LABORATORY ANALYSIS

The environmental and personal exposure level air monitoring samples that were collected at the Dexter Dam lead-containing paint abatement project site were transported to Armstrong Forensic Laboratory, Inc. located at 330 Loch'n Green Trail, Arlington, Texas 76012. Armstrong Forensic Laboratory has obtained AIHA (American Industrial Hygiene Association) Accreditation Number 363.

The environmental and the personal exposure level to lead air monitoring samples that were collected at the Dexter Dam work site were analyzed by NIOSH Method 7082.

SECTION 5.0 ANALYTICAL RESULTS

SECTION 5.1 ENVIRONMENTAL AIR MONITORING SAMPLES

The laboratory analysis of the three air samples collected with the containment structure in place revealed that there was not exposure to lead at or in excess of the action level of 1.5 micrograms per cubic meter (ug/M3) of air quarterly mean as established in 40 CFR 50 or the established criteria of 30 ug/M3 during the abatement of the lead paint from Gate Number 1 of Dexter Dam.

The laboratory analysis of the three air samples collected with the top of the containment structure open revealed that there was environmental exposure to lead in violation of the of 1.5 micrograms per cubic meter (ug/M3) of air quarterly mean as established in 40 CFR 50 and the established criteria of 30 ug/M3 during the abatement of the lead paint from Gate Number 1 of Dexter Dam.

The exterior environmental exposure to lead air monitoring sample laboratory analytical results are presented on the following page.

TABLE 1: EXTERIOR LEAD AIR MONITORING SAMPLE ANALYSIS RESULTS

SAMPLE NUMBER	SAMPLE DATE	SAMPLE TYPE	SAMPLE LOCATION	AIR VOLUME COLLECTED	ANALYTICAL RESULTS
DD-01	7/18/95	CEF Closed	Containment Entrance	956 Liters	<0.003 mg/M3 <3.0 ug/M3
DD-04	7/19/95	CEF Closed	Containment Entrance	688 Liters	<0.004 mg/M3 <4.0 ug/M3
6172940	7/20/95	GMW Closed	North Side Downwind	19,832 Liters	<0.001 mg/M3 <1.0 ug/M3
6172939	7/20/95	GMW Open	South Side Downwind	5,418 Liters	0.599 mg/M3 599 ug/M3
6172937	7/20/95	GMW Open	South Side Downwind	19,107 Liters	1.15 mg/M3 1150 ug/M3
6172936	7/21/95	GMW Open	South Side Downwind	1032 Liters	1.08 mg/M3 1080 ug/M3

The laboratory analysis of the air samples collected with the top of the containment structure open revealed that there was environmental exposure to lead in violation of the action level as established by 29 CFR 1910.1025 during the abatement of the lead paint from Gate Number 1.

SECTION 5.2 PERSONAL AIR MONITORING SAMPLES

The laboratory analysis of the personal exposure level to lead air monitoring samples that were collected during both the wet and dry abatement of lead containing paint from Gate Number 1 at Dexter Dam revealed that the abrasive blasting equipment operators in the containment structure during lead-containing paint abatement processes were not exposed to lead in excess of the personal exposure level (PEL) criteria of the respiratory protection equipment that was utilized for lead abatement personal protect as is presented in 29 CFR 1926.62(f)(2)(i).

The laboratory analytical results for the personal exposure level samples collected in the breathing zone of the blasting equipment operators are present on the following page.

TABLE 2: PERSONAL EXPOSURE LEVEL LEAD SAMPLE ANALYSIS RESULTS

SAMPLE NUMBER	SAMPLE DATE	SAMPLE TYPE	AIR VOLUME COLLECTED	ANALYTICAL RESULTS
DD-02	7/18/95	Copper Slag Dry Process	346.0 Liters	<0.008 mg/M3 <8.0 ug/M3
DD-03	7/18/95	Coal Slag Dry Process	364.0 Liters	0.052 mg/M3 52 ug/M3
DD-05	7/19/95	Nickel Slag Dry Process	306.0 Liters	1.13 mg/M3 1130 ug/M3
DD-06	7/19/95	Silica Sand Dry Process	370.0 Liters	0.774 mg/M3 774 ug/M3
DD-08	7/20/95	Coal Slag Wet Process	310.0 Liters	0.035 mg/M3 35 ug/M3
DD-09	7/20/95	Nickel Slag Wet Process	296.0 Liters	0.046 mg/M3 46 ug/M3
DD-10	7/20/95	Copper Slag Wet Process	160.0 Liters	0.774 mg/M3 774 ug/M3
DD-11	7/21/95	Silica Sand Wet Process	176.0 Liters	0.045 mg/M3 45 ug/M3

The review of the laboratory analytical results for the eight personal exposure level to lead samples that were collected in the lead containing paint containment structure at Dexter Dam do not appear to be consistent. The laboratory analytical results for the three breathing zone personal exposure level to lead air monitoring samples collected when Bill Garrelts of Abhe and Svobada, Inc. was operating the wet blasting equipment appear to be almost identical; while the laboratory analytical results for the breathing zone personal exposure level to lead air monitoring sample that was collected while Steve Sosnowski of P.E.A.T., Inc. was operating the wet media blasting equipment revealed a personal exposure level to lead level that is approximately eighteen times higher.

The analytical results for personal exposure level to lead samples that were collected during the dry media abatement procedures also reveal a significant variance. Disconnected personal air monitoring equipment was noted during dry media abatement procedures.

SECTION 5.3 PERSONAL EXPOSURE LEVEL TIME WEIGHT AVERAGES

The laboratory analysis of the personal exposure level to lead air monitoring samples revealed that blasting equipment operators in the containment structure during lead-containing paint abatement activities were not exposed to lead dust in excess of the eight hour time weight average respiratory protection equipment criteria for lead-based paint abatement personal protect as presented in 29 CFR 1926.62(f)(2)(i).

The personal exposure level to lead time weight average (TWA) calculations that are based on the laboratory analysis of the eight collected air samples are presented in Table 3.

TABLE 5: LEAD TIME WEIGHT AVERAGE LEAD ANALYSIS RESULTS

SAMPLE NUMBER	SAMPLE DATE	SAMPLE TYPE	MONITORING TIME SPAN	ANALYTICAL RESULTS	TIME WEIGHT AVERAGE
DD-02	7/18/95	Copper Dry	173 Minutes		<8.0 ug/M3
			and		
DD-03	7/18/95	Coal Dry	182 Minutes	52 ug/M3	<22.6 ug/M3
DD-05	7/19/95	Nickel Dry	153 Minutes		1130 ug/M3
			and		
DD-06	7/19/95	Silica Dry	183 Minutes	774 ug/M3	655 ug/M3
DD-08	7/20/95	Coal Wet	155 Minutes		35 ug/M3
			and		
DD-09	7/20/95	Nickel Wet	148 Minutes	46 ug/M3	25.5 ug/M3
DD-10	7/20/95	Copper Wet	80 Minutes	774 ug/M3	129 ug/M3
DD-11	7/21/95	Silica Wet	88 Minutes	45 ug/M3	8.25 ug/M3

SECTION 6.0 CONCLUSIONS

The laboratory analysis of the three exterior air monitoring samples collected with the containment structure in place did

not revealed that there was environmental exposure to lead at or in excess of the action level during the abatement of the lead-containing paint from Gate Number 1 at Dexter Dam.

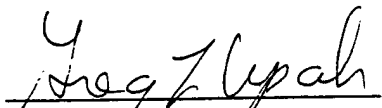
The laboratory analysis of the three exterior air monitoring samples that were collected with the top of the containment structure open did revealed that there was environmental exposure to lead in violation of the action level during the abatement of the lead-containing paint from Gate Number 1 at Dexter Dam.


The laboratory analysis of the personal exposure level to lead breathing zone monitoring samples that were collected in the containment structure during both the wet and the dry abrasive media abatement of lead-containing paint revealed that there was not exposure to lead in excess of the time weight average personal exposure levels for the utilized respiratory protection for a lead paint abatement project as established by 29 CFR 1910.1026(f)(2)(i).

LIMITATIONS:

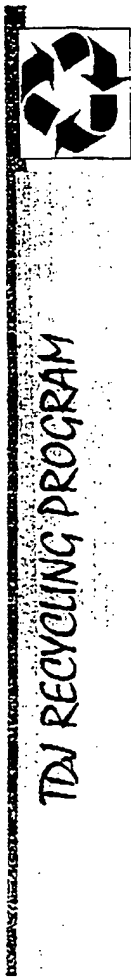
The RCI Environmental, Inc., professional Airborne Particle Monitoring service has been performed, our findings obtained and our conclusions prepared in accordance with customary principles and practices in the field of environmental science. This warranty is in lieu of all other warranties either expressed or implied. This company is not responsible for the conclusions, opinions, or recommendations made by others based on the information presented in this report.

RCI ENVIRONMENTAL, INC.


Greg L. Upah, President


Stevan W. Pierce, CIH

Appendix E: TDJ Recycling Program



WHAT DO THE U.S. EPA AND THE INDIVIDUAL STATES THINK OF BENEFICIAL REUSE?

Under the Resource Conservation and Recovery Act, most "wastes that are reused or reused as ingredients in an industrial process" are "excluded from the definition of a solid waste". Therefore, if the spent abrasives are reused in another industrial process, i.e. the cement industry, they are not classified as a solid waste. One of the major provisions under RCRA, is to "reduce, reuse, recycle".

Many state regulatory agencies, such as California, Virginia, and Illinois have the same regulations as the U.S. EPA. Currently, TDJ Recycling has letters from 25 states approving this reuse option. Typically all states support this program. For specifics on your state, or for a copy of the approval letter from your state, please contact us.

Direct Questions to:
 Curt Gustafson / James Lively
 TDJ Corp., Inc.
 760-A Industrial Drive
 Cary, Illinois
 847-639-1113 phone
 847-639-0499 fax

WHAT HAPPENS TO MY WASTE IF I BENEFICIALLY REUSE IT?

Your non-hazardous waste will be delivered to a central staging center or directly to a recycling center. There, your wastes will be combined with thousands of tons of other materials and used as a feedstock for the cement industry. In the production of cement, high temperatures are used to chemically transform the raw materials into another product. During this transformation, the spent abrasive waste loses its identity. Once the new product is formed, it will be used in the construction of roads, bridges, buildings, sidewalks, etc..

Upon consumption, the ownership of the waste will change, which also helps minimize your liability that is typically involved with disposal. A certification of reuse will be issued for your records detailing the date, facility name, and location which has consumed your waste. Meanwhile, every ton of waste you reuse will save a ton of raw materials, and over one cubic yard of landfill space.

WHY SHOULD I BENEFICIALLY REUSE MY WASTE?

Beneficial reuse of wastes minimizes the waste owner's liability, decreases disposal costs, saves landfill space and virgin raw materials. Wastes, such as non-hazardous spent abrasives, being placed in landfills everyday. Meanwhile, raw materials, with identical or similar composition, are being mined and used by the cement industry. In most cases, these 'wastes' can be beneficially reused as a raw material. "One man's garbage is another's raw material."

WHICH WASTES QUALIFY FOR BENEFICIAL REUSE?

The cement industry uses calcium oxide, iron oxide, alumina, and silica every day for the production of Portland cement and concrete products. Silica sand and slag abrasives contain enough silica, alumina, and iron to be reused as a raw material in the cement industry. Blastox® renders wastes non-hazardous such that they qualify for beneficial reuse, and adds calcium oxide and silica to the abrasives. Typically all spent abrasives, with and without Blastox®, qualify for reuse as long as the wastes are non-hazardous according to the TCLP test. Also, it is important to keep the spent abrasives free of foreign debris, such as gloves, plastic, etc. which are incompatible with the manufacturing process.

***WHAT MUST I DO TO
BENEFICIALLY REUSE MY
WASTES?***

1. Contact TDJ Recycling or your TDJ Regional Sales Manger two weeks before blasting begins.
 - a. We will inform you of the current status of the recycling program in your area.
 - b. We will supply you with a rough quote and work on the final quote for all reuse costs.
2. Once blasting begins, test the waste by the TCLP and Total Metals tests for all RCRA 8 metals.
3. If necessary send TDJ Recycling a spent sample for additional testing.
4. Keep TDJ informed of project status so that we can arrange transportation (if necessary) and dropoff schedules.
5. Direct inquiries to
Curt Gustafson or
James Lively
TDJ Recycling
760-A Industrial Drive
Cary, IL 60013
847-639-1113 phone
847-639-0499 fax

TDJ Recycling Program

**BENEFICIAL REUSE
CENTERS**

**WHAT MUST I DO TO BENEFICIALLY
REUSE MY WASTES?**

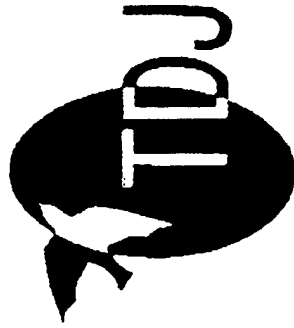
Contact TDJ Recycling or your Regional Sales Manger two weeks before blasting begins. Upon notification we will inform you of the current status of the recycling program in your area and supply you with a rough quote and begin work on the final quote for all reuse costs.

Test the waste by the TCLP and Total Metals tests for all RCRA 8 metals.

If necessary send TDJ Recycling a spent sample for additional testing.

Keep TDJ informed of project status so that we can arrange transportation (if necessary) and drop off schedules.

State	City	Material	Time frame
Al	Birmingham Mobile	Slag Sand & Slag	Active Pending
Ca	Colton Hayward	Sand & Slag Sand & Slag	Active Active
GA	Atlanta	Sand & Slag	Active
FL	Tampa	Slag	June 96
IL	LaSalle	Slag	Pending
IN	Speed	Sand & Slag	Pending
IA	Mason City	Sand & Slag	April
LA	Harvey	Sand & Slag	Active
MO	St. Louis	Sand & Slag	Pending
OH	Ironton	Sand & Slag	Active
OK	Tulsa	Slag	Active
OR	Portland	Sand & Slag	Active
PA	Pittsburgh	Sand & Slag	Pending
SC	Harleyville	Slags	Active
TN	Knoxville	Sands and Slag	Active
TX	Galveston Brownsville	Sand & Slag Sand & Slag	Active Pending
WA	Seattle	Sand & Slag	Active



**RECYCLING
PROGRAM**



TDJ GROUP, INC.
760-A INDUSTRIAL DRIVE
CARY, ILLINOIS 60013
847-639-1113

Appendix F: List of Blastox[®] Suppliers

State	City	Product	Company	Phone
Alabama	Mobile	Slags	Mobile Abrasive Products	334-694-0023
Alabama	** Birmingham	Slags	F & S Abrasives	205-323-8363
Alaska	** Anchorage	Slags	Polar Supply	907-5635000
Arizona	Phoenix	Slags	Air Blast Abrasives	602-258-9186
California	Compton	Sands & Slags	Gordon Sand	800-333-7930
California	Hayward	Slags	Kleen Blast	510-831-9800
Colorado	Denver	Sands & Slags	United Western Supply	303-388-1224
Florida	Davenport	Sands & Slags	Standard Sand & Silica	800-475-7263
Florida	Jacksonville	Sands & Slags	Standard Sand & Silica	904-355-0516
Florida	Miami	Sands & Slags	Standard Sand & Silica	305-593-1430
Florida	Tampa	Slags	Reed Minerals	813-677-9168
Georgia	Valdosta	Sands & Slags	The Scruggs Co.	800-230-7263
Georgia	** Atlanta	Slags	Abrasives & Equip. of Atlanta	404-691-0758
Indiana	Gary	Slags	Reed Minerals	219-944-6250
Kansas	LaCygne	Slags	Reed Minerals	913-757-4561
Louisiana	Harvey	Slags	Stan Blast Abrasives	800-783-1777
Louisiana	Houma	Sands	Custom Aggregates	800-627-2167
Michigan	** Flat Rock	Slags	Flat Rock Bagging	313-782-2073
Minnesota	Woodbury	Slags	Abrasive Technologies, Inc.	800-343-0117
Mississippi	Picayune	Sands	Custom Aggregates	800-326-2295
Missouri	St. Louis	Sands & Slags	Simpson Materials	800-736-4944
New Hampshire	Bow	Slags	Reed Minerals	603-224-4021
North Carolina	Hoffman	Sands	Southern Products & Silica	800-572-6348
North Carolina	Wadesboro	Sands	Lisk Sand	800-438-7711
North Dakota	Elgin	Sands & Slags	Abrasives, Inc.	701-584-3422
Ohio	Gallapolis	Slags	Reed Minerals	614-967-7322
Oklahoma	Tulsa	Sands & Slags	Mohawk Rock & Sand	918-584-2707
Oregon	Portland	Slags	Kleen Blast	800-634-8499
Pennsylvania	Wampum	Sands & Slags	Esco Sand	800-875-4302
South Carolina	Columbia	Sands & Slags	Foster-Dixiana	803-791-3129
South Carolina	Hardeeville	Sands & Slags	Foster-Dixiana	803-784-2139
South Dakota	Souix Falls	Slags	Stan Houston Equipment	605-336-3727
Tennessee	Memphis	Slags	Reed Minerals	901-789-0700
Tennessee	** Chattanooga	Slags	Porter Warner Industries	423-266-4735
Texas	Corpus Christi	Slags	Corpus Christi Equip. Co.	512-884-2981
Texas	Rockdale	Slags	Reed Minerals	512-446-8505
Texas	Galveston	Slags	Stan Blast Abrasives	409-740-3355
Texas	El Paso	Slags	Air Blast Abrasives	713-928-8441
Texas	** Corpus Christi	Slags	Clemtex	512-882-8282
Texas	** Dallas	Slags	Clemtex, Inc.	214-631-0584
Texas	** Houston	Slags	Clemtex, Inc.	713-672-8251
Texas	** Houston	Sands & Slags	T-TEX	713-991-7070
Virginia	Norfolk	Slags	Virginia Materials	757-855-0155
Washington	Tacoma	Slags	Kleen Blast	800-228-4786
Washington	Seattle	Sands & Slags	United Western Supply	206-767-9880
West Virginia	Moundsville	Slags	Reed Minerals	304-845-0211
Wisconsin	Taylor	Sands	Badger Mining	800-932-7263
Wisconsin	Waupaca	Slags	Waupaca Materials	715-258-8566

** DENOTES DISTRIBUTOR

**Appendix G: Recommended Chemical
Stabilizer Specifications for
Incorporation into COE Civil Works
Guide Specification 09940**

The following chemical stabilizer shall meet the following requirements.

Composition and Characteristics

The stabilizer is a tri-calcium silicate based material, the approximate composition of which is as follows:

Compound	Weight % ($\pm 5\%$)
CaO	65.52
SiO ₂	22.06
Al ₂ O ₃	4.58
MgO	3.55
Fe ₂ O ₃	2.07
MnO	0.44
K ₂ O	0.4
SO ₃	0.27
TiO ₂	0.18
P ₂ O ₅	0.11
Na ₂ O	0.07

Solubility in Water - Slight (0.1 - 1.0 %)

Specific Gravity - 3.15 - 3.22

Bulk Density 80 to 100 lb/cu ft

Color - Black

Odor - None

Noncombustible

Not Explosive

Mesh size - 95% greater than 60, but less than 12.

Hardness - greater than 6.0 on the Mohs scale

Intended Use: For removal of lead-based paint from steel surfaces, the chemical stabilizer shall be incorporated into the abrasive blast medium (coal slag, copper slag, silica sand, or other traditional abrasive media) at a rate of 20 %, by weight.

USACERL DISTRIBUTION

Chief of Engineers

ATTN: CEHEC-IM-LH (2)
ATTN: CEHEC-IM-LP (2)
ATTN: CECG
ATTN: CECC-P
ATTN: CECC-R
ATTN: CECW
ATTN: CECW-EE
ATTN: CECW-O
ATTN: CECW-P
ATTN: CECW-PR
ATTN: CEMP
ATTN: CEMP-E
ATTN: CEMP-C
ATTN: CEMP-M
ATTN: CEMP-R
ATTN: CERD-C
ATTN: CERD-ZA
ATTN: CERD-L
ATTN: CERD-M
ATTN: CERM
ATTN: DAEN-ZC
ATTN: DAIM-FDP

US Army Engr District

ATTN: Library (40)

US Army Engr Division

ATTN: Library (11)

CEWES 39180

ATTN: Library

CECRL 03755

ATTN: Library

Naval Facilities Engr Command

ATTN: Naval Facilities Engr Service Center 93043-4328

Nat'l Institute of Standards & Tech

ATTN: Library 20899

Defense Tech Info Center 22060-6218

ATTN: DTIC-O (2)

Tennessee Valley Authority

Federal Highway Administration

US Bureau of Reclamation