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16 Abstract (Limit: 200 words)

Estimates the costs, economic impacts, and benefits of the Phase IV LDR rule on newly identified mineral processing wastes. Addresses regulatory options. Defines the universe and estimates waste volumes. Provides methodology used to assess cost, economic impacts, and benefits of this rule. Appendices include analysis of options under alternative baselines, methodology for identifying hazardous waste streams, mineral processing waste stream status changes since December 1995, mineral processing waste treatment and disposal costs, development of costing functions, explanation of cost modeling calculations, mineral processing cost model example calculation for the titanium and titanium dioxide sector, derivation of value of shipments and value added for mineral processing sectors, risk and benefits assessment for the storage of recycled materials, constituent concentration data for recycled materials, and data summaries for high-risk mineral processing facilities.

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MINERAL PROCESSING WASTES FORMERLY EXEMPT UNDER THE BEVILL AMENDMENT

This regulatory impact analysis (RIA) estimates the costs, economic impacts, and benefits of the final rule applying Phase IV Land Disposal Restrictions (LDRs) to newly identified hazardous mineral processing wastes.

In today's rule, EPA is promulgating standards for mineral processing wastes no longer exempt from Subtitle C requirements under the Bevill exemption. Under the provisions of today's proposal, previously exempt Bevill mineral processing wastes destined for disposal need to be treated to meet RCRA Universal Treatment Standards (UTS) before management or disposal in a land-based unit. At the same time, however, operators can reclaim hazardous mineral processing residues and store them in non-land based units prior to reclamation without complying with full Subtitle C requirements, under a new conditional exclusion.

Background

This component of the Phase IV Land Disposal Restrictions rule is one in a series of regulations that restricts the continued land disposal of hazardous wastes. EPA has developed these regulations pursuant to the 1984 Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA). At the time HSWA was enacted, EPA was required to promulgate treatment and disposal standards by May 8, 1990 for wastes already identified or listed as hazardous; EPA completed development of treatment standards and waste management practices for these wastes in 1990. EPA also is required to develop treatment standards for wastes subsequently identified or listed as hazardous. EPA is addressing these "newly identified" wastes in several "phases." EPA has finalized rules for three phases and proposed the Phase IV rule in two parts in August 1995 and January 1996. Subsequently, EPA finalized a portion of the Phase IV rule on May 12, 1997 and modified parts of the earlier proposals in a 'second supplemental' proposal, also issued on May 12, 1997. Today's rule finalizes the portions of the Phase IV rule not promulgated earlier.

Under the provisions of the RCRA Mining Waste Exclusion, solid waste from the extraction, beneficiation, and processing of ores and minerals is exempt from regulation as hazardous waste under Subtitle C of RCRA, as amended. The Mining Waste Exclusion was established in response to the so-called "Bevill Amendment," which was added in the 1980 Solid Waste Disposal Act Amendments. The Bevill Amendment precluded EPA from regulating these wastes until the Agency performed a study and submitted a Report to Congress. Following a process of litigation and rulemakings that took place over several years, the Agency promulgated final rules on September 1, 1989 (54 FR 36592) and January 23, 1990 (55 FR 2322) establishing that only 20 specific mineral processing wastes fulfilled the newly promulgated special wastes criteria; all other mineral processing wastes were removed from the Mining Waste Exclusion.

These newly identified non-exempt wastes have the same regulatory status as any other industrial solid waste. Thus, if they exhibit characteristics of hazardous waste or are listed as hazardous wastes, they must be managed in accordance with RCRA Subtitle C or equivalent state standards. Existing waste characterization data suggest that many of these wastes may exhibit the characteristic of toxicity for metals (waste codes D004-D011), corrosivity (D002), and/or reactivity (D003).

EPA considers these wastes to be "newly identified" because they were brought into the RCRA Subtitle C system after the date of enactment of the HSWA on November 8, 1984. EPA did not include the newly identified wastes within the scope of the LDRs for Subtitle C characteristic hazardous wastes published in June 1990, deciding instead to promulgate additional treatment standards (Best Demonstrated Available Technology, or BDAT) in several phases. At the time, EPA had not performed the technical analyses necessary to determine whether the treatment standards being promulgated for characteristic hazardous wastes were feasible for the newly non-exempt mineral processing wastes. In addition, the list of non-exempt wastes was not yet final, because the regulatory determination for the 20 wastes studied in the 1990 Report to Congress had not yet been promulgated. The boundaries of the Exclusion have now been firmly established, and the Agency is ready to characterize and establish treatment standards for all newly identified hazardous mineral processing wastes.

Today's rule contains elements that are related to non-HSWA provisions of the statute (e.g., the conditional exclusion from the definition of solid waste for storage of mineral processing residues) as well as elements that are related to HSWA provisions (the proposed universal treatment standards for land disposed mineral processing wastes). The definition of solid waste provisions of this rule are not being promulgated pursuant to HSWA. Thus, these federal requirements will take effect only in states that do not have final RCRA authorization. In contrast, the universal treatment standards for land disposed mineral processing wastes are being promulgated pursuant to HSWA. Therefore, these treatment standard provisions will take effect in all states upon the effective date of the rule regardless of final state authorization status.

1. **REGULATORY OPTIONS**

This section presents the final option that EPA is finalizing in today's rule, which applies LDR standards to newly identified hazardous mineral processing wastes. In addition, this RIA also includes an analysis of an industry-proposed option. EPA's option is described as Option 1 and the industry option is described as Option 2. Section 1.1 summarizes the key features of each option. Section 1.2 discusses their operational implications.

1.1 Specific Options

Summarized below are the two options that EPA has analyzed in this RIA. In addition to the option-specific details outlined below, both of the options share the following common features:

- Mineral processing wastes being disposed must be treated to UTS levels prior to land disposal in either Subtitle C or Subtitle D disposal units;
 - Operators of facilities that generate and manage hazardous mineral processing wastes must comply with simplified recordkeeping and reporting requirements;
 - Secondary mineral processing materials destined for legitimate recycling may be stored for up to one year; and
 - Recycling of non-mineral processing materials outside of RCRA Subtitle C jurisdiction is prohibited, i.e., the conditional exclusions for certain activities (as described below) are available <u>only</u> for mineral processing residues; and

Hazardous mineral processing residues can be legitimately recycled to primary beneficiation operations/units without risk to the Bevill status of any beneficiation wastes generated by such units. That is, these operations would not become regulated Subtitle C units and resulting wastes from these units would not lose their Bevill status when mineral processing residues are mixed with ores, minerals, or beneficiated ores or minerals, provided that at least 50 percent of the materials entering the operations are ores, minerals, or beneficiated ores or minerals.

Option 1 -- **Conditional Exemption from RCRA Jurisdiction**

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Option 1 represents an attempt to both (1) stimulate greater resource recovery in the minerals industry by not classifying recoverable mineral processing residuals as wastes if they are not managed in land-based units, and (2) ensure that appropriate waste treatment standards and technologies are applied to hazardous mineral processing wastes destined for land disposal, thereby protecting human health and the environment.

In this option, a conditional exclusion from the definition of solid waste would apply to a nonexempt mineral processing residue if the following conditions were met:

- 1) The material contains recoverable amounts of minerals, acids, cyanide, water, or other values;
- 2) The material is legitimately recycled (as defined at 261.2(f));
- 3) The material is not accumulated speculatively (as defined at 261.1(c)(8));
- 4) The material is stored in tanks, containers, or buildings meeting minimum integrity standards; and
- 5) The owner or operator provides a one-time notification to the EPA Regional Administrator or State.

Alternatively, facility operators could obtain a determination from an authorized State or from the Regional Administrator that solid secondary materials may be placed on pads instead of in tanks, containers, or buildings. These pads must meet minimum design requirements so that the unit provides effective containment and will not become part of the waste disposal problem through discard.

Option 2 -- Unconditional Exclusion from RCRA Jurisdiction

This option is based on approaches advanced by the mineral processing industry and would maximize the ability of industry to recycle secondary materials without triggering *any* additional requirements. In this option all outputs from mineral processing facilities would be unconditionally excluded from RCRA jurisdiction regardless of how the materials are stored. Consequently, there would be no special requirements for any type of unit storing secondary materials.

1.2 Discussion of Options and Implications for the Regulatory Impact Analysis

The Agency has performed a detailed analysis of both of these options, assuming each of three alternative baselines. The baseline discussed in the remainder of this RIA is the one the Agency believes

best reflects actual operator behavior. EPA refers to this baseline as the "modified prior treatment" baseline (because it is a variation on the "prior treatment baseline," one of the two baselines modeled in the December 1995 RIA). A description of the assumptions underlying the alternative baselines (prior treatment and no prior treatment), and the resulting estimated costs and impacts can be found in Appendix A.

The modified prior treatment baseline assumes that all generators of hazardous mineral processing wastes currently dispose those wastes in compliance with Subtitle C treatment standards (except for LDRs). The least-cost method for attaining compliance for most operators would be to lime neutralize and/or cement-stabilize their waste(s) to remove the hazardous characteristic(s).¹ Because these methods routinely reduce contaminant concentrations to below UTS levels, there would be essentially no new treatment required upon promulgation of the LDRs, and hence, no costs or benefits associated with the LDR portion of the rule.² The baseline also allows for consideration of apparent confusion within the regulated community as to requirements that currently apply to their mineral processing operations. Operators are assumed to temporarily store characteristic spent materials in unlined land-based units prior to reinsertion into a mineral processing production unit. This alternative reflects the Agency's belief that some operators do not clearly understand the Subtitle C regulations that apply to their secondary materials, i.e., that spent materials intended for recycling are not currently excluded from Subtitle C regulation.

Option 1 requires that if secondary materials are stored prior to reinsertion into the production process, that they must be stored in tanks, containers, or buildings, or in limited cases, on approved pads.³ The Agency believes that although Option 1 may impose a slight disincentive to recycling, it is protective of the environment, without interfering excessively with resource recovery. The requirement that secondary materials be stored off the ground provides higher potential benefits in terms of environmental protection than Option 2.

Option 2 would impose no additional requirements for management of secondary materials to be recycled, regardless of how they are stored. Consequently, this option represents the least cost approach for industry and may provide greater incentives for materials reuse than the EPA's options. At the same time, this option does little to ensure that recycling is legitimate and also does not impose any standard to ensure that land-based storage of materials prior to reinsertion into the production process does not result in releases that contribute to the "waste management problem." This option, therefore, could be expected to result in greater releases of hazardous constituents to the environment and greater human exposure to those constituents.

² As described in more detail in Section 3.1.1, EPA based the final UTS levels on analytical data from commercial treatment facilities showing that treatment to remove toxicity characteristic metals routinely achieves the final UTS levels. (Letter from Michael Fusco, Rollins Environmental Inc. to Anita Cummings, U.S. EPA Office of Solid Waste, December 19, 1996.)

³ These tanks, containers and buildings do not, however, have to meet 40 CFR Part 265 Subpart I, J or DD standards.

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¹ As discussed in Section 2 below, the vast majority of hazardous mineral processing wastes exhibit the characteristics of corrosivity and/or toxicity. EPA has shown that cement stabilization (in some cases preceded by neutralization), which is the basis for the UTS standards, is an effective treatment technology for removing these hazardous waste characteristics.

2. DEFINING THE UNIVERSE AND ESTIMATING WASTE VOLUMES

EPA developed a step-wisc methodology for both defining the universe of mineral processing sectors, facilities, and waste streams potentially affected by the Phase IV Land Disposal Restrictions and estimating the volumes of wastes potentially affected under the various implementation options being considered by the Agency. The Agency's methodology began with the broadest possible scope of inquiry in order to ensure that EPA captured all of the potentially affected mineral commodity sectors and waste streams. The Agency then narrowed the focus of its data gathering and analysis as it completed each subsequent step. Appendix B describes this six-step methodology in detail and provides a summary of the affected secondary materials. Appendix C lists the mineral processing facilities affected by this rulemaking.

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The Agency's data sets and underlying Technical Background Document *Identification and Description of Mineral Processing Sectors and Waste Streams* were made available to the regulated community during the comment period following the January 1996 proposal. In some cases, reviewers supplied the Agency with additional or more current information about a particular commodity sector. In addition, some commenters provided subsequent information in public comment submitted following the May 1997 supplemental proposal. Where appropriate, EPA revised the sector reports in the Technical Background Document and incorporated new information into its analysis. Further, since the rule was proposed in January 1996, EPA has obtained other information that it has used to update some of the sector reports. This information also has been incorporated into the analysis presented in this RIA.⁴

EPA has developed a bounded cost analysis, providing an expected cost (expected value case), as well as a lower bound cost (minimum value case), and an upper bound cost (maximum value case) for each of the options considered. EPA used two factors, uncertainty about generation rate and uncertainty about hazardous characteristics, to develop these three cost cases. All other steps in the cost modeling process are applied consistently across the three cost cases.

As in the previous RIAs, EPA began with the three estimates of generation rates potentially affected by this rulemaking for every waste stream: a minimum generation rate, an expected generation rate, and a maximum generation rate. In some cases, there is no variation in the three estimates because the generation rate of the stream is known (e.g., it was reported in literature). For a number of these waste streams, EPA also lacked data about hazardous characteristics. To address these uncertainties, EPA weighted the volume estimates for each waste stream to account for the degree of certainty that the particular waste stream exhibited one or more of the RCRA hazardous waste characteristics. As shown in Exhibit 2-1, 100 percent of each waste stream known to be hazardous was included in the minimum, expected, and maximum value scenarios. For streams that were only suspected of being hazardous, however, 0 percent, 50 percent, and 100 percent of the generation rate is each of the cost scenarios was multiplied by the percentage considered to be hazardous in this analysis, based on the certainty that the waste stream is hazardous. The remaining "nonhazardous" portion drops out of the analysis. Exhibit 2-2 presents the average facility levels of waste assumed to be "hazardous" in each sector, for the minimum, expected, and maximum value cases.

⁴ Appendix D provides a comparison of waste streams included in the January 1996 RIA, April 1997 RIA, and this RIA.

Exhibit 2-1 Portion of Waste Stream Considered to Be Hazardous (in Percent)

	Hazard Characteristic(s)			
Costing Scenario	Y	Y?		
Minimum	100	0		
Expected	100	50		
Maximum	100	100		

Notes:

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Y means that EPA has actual analytical data demonstrating that the waste exhibits one or more of the RCRA hazardous waste characteristics.

Y? means that EPA, based on professional judgment, believes that the waste may exhibit one or more of the RCRA hazardous waste characteristics.

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		Minimum C	lost Scenario		Expected Cost Scenario			Maximum Cost Scenario				
Commodity	Number of Facilities	Waste Water (mt/yr)	1 - 10% Solids (mt/yr)	Solids (mt/yr)	Number of Facilities	Waste Water (mt/yr)	1 - 10% Solids (mt/yr)	Solids (mt/yr)	Number of Facilities	Waste Water (mt/yr)	l - 10% Solids (mt/yr)	, Solids (mt/yr)
Alumina and Aluminum	23	• .	-	3,330	23	-	-	3.330	23	-	•	3,330
Antimony	6	53		3,532	6	4.500	-	3,532	6	9,000		3,532
Beryllium	2	27.600		100	2	77.500	-	23,000	2	1,027,500	-	45,000
Bismuth	i	200	200	3,300	l	12,300	12,200	10,020	l	24,200	24,000	25,200
Cadmium	2	285	190	570	<u>э</u>	2.850	1,900	5,700	2	28.500	19,000	57,000
Calcium	t	-		40	1	-	•	40	1	•		4(
Chromium and Ferrochromium				3,030	1	-	-	3,300	1		-	6.00
Coal Gas	-	-	-		-	-		-	1	-	65,000	
Соррег	10	-	530,000	900	10	-	530,000	900	10	-	530,000	900
Elemental Phosphorus	2	560,000	500,000	2.30	2	560,000	500,000	230	2	560,000	500,000	230
Fluorspar and Hydrofluoric Acid	-	-		-	3	5.000	-	-	3	15,000	•	
Germanium	4	200		10	4	1.100	-	161	4	2,000		30
Lead	3	870,000		7,660	3	870.000	•	30,460	3	870,000		60,46
Magnesium and Magnesia from Brines	2			13,038	2	-	, -	13,380	2		-	16,80
Mercury	7	9,000	-	12	7	11,000	-	12	7	60,000	-	1
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	11	91	-	100	1)	91	-	23,000	11	91		45.00
Platinum Group Metals	3	200	••	2	3	1,140	•	15	3	2,000	-	1.5
Rare Earths	1	21,200	·	170	<u> </u>	1,021,000	•	3,000	1	2,021,000	-	11,50
Rhenium	2			44,000	2	50	-	44,000	2	100	-	44,00
Scandium	. 7	200			7	1,120	-	-	7	2,000	-	
Sclenium	3	22,000		68	3	22,000		680	3	22,000	-	6,80
Synthetic Rutile	1	.30,000		75,000	<u> </u>	30,000	· ·	75,000	<u> </u>	30,000		75,00
Tantalum, Columbium, and Ferrocolumbium	2		75,000	1,500	2	-	75,000	1,500	2	-	75.000	1,50
Tellurium	2	200	· ·	200	2	11,000		2,000	2	30,000		9,00
Titanium and Titanium Dioxide	7	55,289		65,114	7	75,876		68,243	7	96,289		71,67
Tungsten	6	370		-	6	730	-		6	5,000	•	
Uranium	17	300	-	100	17	1,250	-	650	17	2,200	-	1,20
Zine	3	3,243,417	-	16,600	3	3,243,417	•	16,600	3	3,243,417		16,60
Zirconium and Hatnium	2	17,100			2	521,000			2	2,256,000		

E E	xhibit 2-2		
Average Facility	Waste Type	Input	Data

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3. COST AND ECONOMIC IMPACTS OF THE RULE

This section presents the methodology and results of EPA's analysis of the cost and economic impacts arising from today's proposed rule. Section 3.1 begins by describing the methods employed to determine the costs of complying with the two options described above and to compute the screening-level economic impact measures employed in this analysis. Section 3.2 presents and describes the results of the analysis. Section 3.3 discusses potential impacts on small entities. Section 3.4 addresses media contaminated with manufactured gas plant (MGP) waste. Finally, Section 3.5 discusses facilities operating underground injection control (UIC) wells.

3.1 Methods

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This section describes the methodology used to calculate the costs and screening-level economic impacts of managing the affected mineral processing wastes under each of the two regulatory options. The basic analytical construct used throughout this analysis is that facility operators will choose the least-cost option that complies with the law. For today's final rule the Agency has conducted a *dynamic* analysis of shifts in recycling that simulates shifts in types or quantities of mineral processing residues between treatment/disposal and storage/recycling/reclamation. For Option 1 the analysis examines shifts that may diminish recycling, while for Option 2 the analysis assumes no change in recycling.

To analyze each option, EPA employed a number of steps and assumptions, some of which exert a major influence on the results obtained. The following sub-sections discuss these major analytical steps.

3.1.1 Waste Management Assumptions

The costs imposed by a particular regulatory option are measured as the difference in cost between the current, or baseline, management practices and the lowest-cost alternative practice allowed under the option. In this analysis, therefore, EPA identified what it believes to be the current management practices that are applied to the waste streams of interest and then determined the costs of these practices. These baseline costs are then subtracted from the costs of complying with the least-cost management practice allowed under each of the options. Exhibit 3-1 summarizes the pre- and post-rule behavior that is discussed in more detail below.

Baseline or Option	Wasted Portion	Recycled Secondary Materials
Baseline	Treated to TC levels, disposed	Stored in unlined land-based units
Option 1	Treated to UTS levels, disposed	Stored in tanks, containers, and buildings
Option 2	Treated to UTS levels, disposed	Stored in unlined land-based units

	Exhibit 3-1	
Assumed	Management	Practices

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Pre-LDR Behavior (Baseline)

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In the baseline, operators are assumed to be in full compliance with RCRA Subtitle C requirements (but not LDRs) for managing waste materials. The baseline assumes that the operator has chosen the least-cost option for compliance with these requirements: corrosive and/or TC toxic wastewaters and slurries are treated (generally with lime) in tanks; and TC toxic solids, sludges, and other materials are cement stabilized within 90 days of being generated, and disposed (generally on site) in a Subtitle D unit.⁵ Fundamentally, these assumptions are based upon the feasibility of mineral processing residue treatment by lime neutralization for wastewaters and slurries and cement stabilization for sludges and solids. These methods, along with high temperature metals recovery (HTMR), are part of the basis for the UTS standards.

A point of further interest and critical importance to the analysis presented below is the fact that the very same technologies can be used to treat wastes to the point of removing the hazardous characteristic(s) and to meet the UTS standards; the difference between achieving removal of the hazardous characteristic and the UTS standards is simply one of degree. Since the January 1996 supplemental proposed rule, EPA received numerous comments on the use of existing UTS levels for mineral processing wastes. These comments suggested that some of the existing UTS levels were inappropriate for mineral processing wastes. In response to these comments, the Agency analyzed additional stabilization data provided by the commenters and, in light of this new information, is promulgating revised UTS levels for mineral processing wastes.⁶ Exhibit 3-2 presents the TC levels, existing UTS levels, and final UTS levels. Based on the final levels, EPA believes that mineral processing facility operators treating wastes using cement stabilization will not incur any additional costs in order to achieve UTS levels.

In the baseline, all secondary materials destined for recycling, including spent materials, are assumed to be stored in unlined, land-based units for some period of time prior to reinsertion into the process. This assumption reflects apparent confusion in the regulated community concerning the status of spent materials, and the proper methods for storing them prior to disposal or reuse.⁷ (Because sludges and by-products that are reclaimed are not solid wastes, and hence, not hazardous wastes, there are currently no standards regulating storage units for sludges and by-products.)

⁷ Spent materials destined for recycling, if stored, must be stored in tanks, containers, or buildings for less than 90 days prior to recycling, unless they are stored at a RCRA permitted treatment, storage, or disposal facility.

⁵ To comply with current regulations, facility operators also could dispose of these wastes in a Subtitle C permitted landfill. Appendix E presents a break-even analysis showing that treatment and Subtitle D disposal is less expensive than Subtitle C disposal without treatment, in most cases. EPA has assumed that , facility operators will opt to treat their waste prior to disposal in all cases, however, based on data from the biennial reporting system indicating that mineral processing wastes are generally not disposed of in Subtitle C landfills.

⁶ Letter from Michael Fusco, Rollins Environmental, Inc. to Anita Cummings, U.S. EPA Office of Solid Waste, December 19, 1996.

Exhibit 3-2 Existing and Final UTS Levels (Nonwastewater Metals)

Waste Code	Constituent	TC Level (mg/l)	Existing UTS level (mg/l TCLP)	Final UTS Level (mg/l TCLP)
D004	Arsenic	5.0	5.0	5.0
D005	Barium	100.	7.6	21
D006	Cadmium	1.0	0.19	0.11
D007	Chromium	5.0	0.86	0.60
D008	Lead	5.0	0.37	0.75
D009	Mercury	.2	0.025	.025
D010	Selenium	1.0	0.16	5.7
D011	Silver	5.0	0.30	0.14
	Antimony		2.1	1.15
	Beryllium		0.014	1.22
	Nickel		5.0	11
	Thallium		0.078	0.20
	Vanadium		0.23	1.6
	Zinc		5.3	4.3

Post-Rule Compliance Behavior

To determine the incremental impact of the Phase IV LDR standards, EPA first predicted costminimizing behavior by affected facility operators that would be in compliance with the provisions of each option analyzed.

Under Option 1, facility operators are expected to move material destined for recycling from unlined land-based storage units to non-RCRA TCBs. These materials could be stored in TCBs for up to one year in the absence of a RCRA Subtitle C permit.⁸ Facility operators would continue treating the wasted portion using cement stabilization or neutralization and dewatering.

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⁸ Note that for purposes of the cost model, although storage for up to one year is possible under this option, the Agency assumed that facilities only have capacity to store solids for 90 days and liquids for 30 days. In addition, storage is allowed on approved pads in limited circumstances. To be conservative, EPA has not modeled storage on approved pads.

Under Option 2, facility operators are expected to continue storing material destined for recycling in unlined land-based storage units. These materials could be stored for up to one year in the absence of a RCRA Subtitle C permit.⁹ Facility operators would continue treating the wasted portion using cement stabilization or neutralization and dewatering.

Dynamic Shifts

The Agency has used a dynamic analysis to model changes in the management of newly-identified mineral processing wastes that might be induced by the new LDR requirements. Specifically, the dynamic analysis accounts for shifts in the amount of material that is recycled rather than being treated and disposed. For instance, Option 1 might create a minor disincentive for recycling newly-identified mineral processing wastes, because of the additional storage unit requirements. Option 2, which does not impose any new storage requirements, would neither increase nor decrease the amount of materials recycled (which are assumed to be stored in land based units without restriction in the baseline).

3.1.2 Cost Modeling Assumptions

EPA estimated the implementation costs of the options for hazardous waste streams from mineral processing by calculating the difference between the estimated pre- and post-LDR costs. Because of data limitations, EPA used sector-wide averages and totals for estimating the impacts of the rule. Sector-wide estimates were developed on an average facility basis, however, so as to correctly address facility-level economies of scale. Detailed cost model calculations and results are bound in a separate document.

Cost Functions

To calculate the costs of managing the affected wastes under the baseline and the two options, EPA developed and applied cost-estimating functions for treatment and disposal, as well as storage prior to recycling. Appendix F provides a detailed discussion of these cost functions. The cost functions address the capital and O&M costs associated with each technology, as well as decommissioning costs for on-site tank treatment and stabilization. These costing equations are expressed as a function of the waste generation rate (in metric tons/year). In addition, the costing functions provide a means of estimating the break-even point between off-site and on-site land disposal costs.

The application of new technologies for treating wastes often involves the procurement and installation of new capital equipment, as well as changes in periodic operating costs. Because this new equipment is used over an extended period of time (i.e., not consumed), it is necessary to allocate its procurement and installation costs over its useful operating life. EPA addressed this issue by annualizing the initial capital costs over the operating life of the durable equipment, and then adding the discounted value of the annualized initial capital costs to the annual (recurring) capital, operating, and maintenance costs associated with the technology, in order to obtain a total annualized cost. This yields a measure of cost impact that can be compared directly with data reflecting the ability of the affected firms to bear this incremental cost (e.g., sales, earnings).

The costing functions incorporate the following general assumptions:

- *Operating Life.* The analysis assumes a 20-year operating life for waste management units and facilities. With a positive and even moderately significant discount rate, extending the operating life beyond this period adds complexity but little tangible difference in estimated costs.
- *Tax Rate.* Costs are estimated on a before-tax basis to facilitate comparisons with available data related to predicting ultimate economic impacts.
- Discount Rate. The analysis uses a discount rate of seven percent, in keeping with current Office of Management and Budget (OMB) guidance.¹⁰
- *Inflation Rate.* The analysis is conducted in real terms and, consequently, assumes an inflation rate of zero.

General Approach to Developing Waste Management Costs

Based on the assumed incentives and/or disincentives for increase recycling, as well as each stream's certainty of recycling, EPA estimated the percentage of hazardous material sent to treatment and disposal for each baseline and option. The remaining hazardous material is considered to be recycled.¹¹ The dynamic analysis results from the shifts in management in each baseline-option combination. Exhibit 3-3 presents the percentages of hazardous mineral processing waste streams that are sent to treatment and disposal, in both the baseline and post-rule options. Exhibit 3-4 presents the percentages of hazardous mineral processing wastes that are recycled.

EPA then aggregated the non-reclaimed hazardous streams by solids content, based on the assumption that a facility would not build a separate stabilization facility and on-site landfill for each individual waste stream but would instead handle all wastes requiring neutralization, dewatering, stabilization, and disposal in common treatment and disposal units. That is, the facility operator would take advantage of scale economies and co-manage similar waste types. Therefore, EPA calculated the "model facility" generation rate by *mineral processing sector* (e.g., lead, copper) for hazardous waste streams containing 1 to 10 percent solids (i.e., slurries), hazardous waste streams having greater than 10 percent solids, and hazardous wastewaters.¹²

¹⁰ OMB, 1992. Circular A-94.

¹¹ EPA developed the recycling assumptions (percentages) using limited empirical data on the recycling of two listed wastes, K061 (emission control dust from electric arc steel furnaces) and F006 (wastewater treatment sludge from electroplating operations). More information on the derivation of the percentages in the tables can be found in Appendix A.

¹² EPA added the total sector generation rate of each type of waste and divided these totals by the maximum number of facilities in the sector generating waste requiring treatment. More information on this totaling process can be found in Appendix G. An example of the cost model calculations for a single sector can be found in Appendix H.

	Percent Disposed Certainty of Recycling						
Baseline or Option	Y	Y?	YS	YS?	N		
Baseline	0	15	25	80	100		
Option 1	0	25	35	85	100		
Option 2	0	15	25	80	100		

Exhibit 3-3 Proportions of Waste Streams Sent to Treatment and Disposal (in percent)

Exhibit 3-4 Proportions of Waste Streams Stored Prior to Recycling (in percent)

		Percent Recycled						
		Cert	ainty of R	ecycling				
Baseline or Option	Y	Y?	YS	YS?	Ν			
Baseline	100	85	75	20	0			
Option 1	100	75	65	15	0			
Option 2	100	85	75	20	0			

Notes for Exhibits 3-3 and 3-4:

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Y	means that EPA has information indicating that the waste stream is fully recycled.
Y?	means that EPA, based on professional judgment, believes that the waste stream could be fully recycled.
YS	means that EPA has information indicating that a portion of the waste stream is fully recycled.
YS?	means that EPA, based on professional judgment, believes that a portion of the waste stream could be fully recycled.
N	means that EPA does not believe the stream is or could be recycled.

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In contrast, quantities of residues destined for recycling were assumed to require segregation, so as to promote efficient resource recovery. EPA made the conservative assumption that each material to be recovered would require storage prior to reclamation and, therefore, that each would require its own storage unit. Consequently, for each recycled stream, EPA divided the total sector quantity stored prior to recycling by the number of facilities generating that waste stream to determine the "average facility" quantity recycled. The significant difference in the calculation of the "model facility" totals for treatment and disposal and "average facility" quantities of materials stored prior to recycling are due to the difference in management assumption, i.e., streams to be treated are co-mingled while streams to be recycled are not.

Having derived the "model facility" quantity of each type of waste (wastewaters, 1-10 percent solids, and more than 10 percent solids) going to treatment and disposal, and the "average facility" quantities of individual streams going to storage prior to recycling in each sector, EPA calculated the cost associated with each of these activities.

Development of Treatment Costs

In the analysis, the Agency made the following assumptions about waste treatment and disposal practices:

Management of hazardous mineral processing wastes containing more than 10 percent solids involves non-permitted treatment followed by disposal of the stabilized mass in a Subtitle D unit. Treatment consists of cement stabilization, which increases the mass of waste destined for disposal to 146 percent of the mass entering stabilization.

Management of hazardous mineral processing wastewaters and wastes containing 1 to 10 percent solids involves non-permitted treatment followed by disposal of the stabilized residue in a Subtitle D unit. Treatment consists of neutralization, followed by dewatering of the precipitated solids, and cement stabilization of the dewatered sludge. The precipitated mass from neutralization is 15 percent of the original waste stream, while the dewatered mass is 15 percent of the precipitated mass (or 2.25 percent of the original waste stream). Stabilization increases the mass of the dewatered sludge to 146 percent of the mass entering stabilization.

These assumptions and their factual basis are documented in Appendix F and Appendix G.

The Agency has assumed that both pre- and post-LDR management of treated residues would occur in (primarily) on-site Subtitle D waste disposal piles, because under the baseline, affected operators would have constructed such units to be in compliance with (i.e., avoid) pre-LDR Subtitle C waste management requirements. For low volume wastes (less than or equal to 3,163 metric tons solids/year or 350 metric tons liquids/year), EPA has assumed that the operator would send the waste to an off-site Subtitle C facility for treatment (stabilization) and ultimate disposal in a Subtitle D unit. The Agency did not include non-hazardous waste streams in the analysis because the treatment standards in the Phase IV LDR rule will not affect those wastes.

The first step in determining the cost of treatment was to compute the quantity of waste requiring each *type* of treatment at a "model facility" in each sector, because each treatment technology generates a residue which must either be further treated or disposed. For example, both wastewaters and wastes with a 1 to 10 percent solids content are assumed to be neutralized and dewatered in the same units, while the sludge (residue) generated from dewatering is mixed with waste with more than 10 percent solids, stabilized in a single stabilization unit, and disposed in a single Subtitle D waste pile. Once EPA determined the quantities of waste going to each treatment unit (accounting for volume changes brought about by each treatment step), the Agency used costing equations (described in detail in Appendix F) to determine the capital, operating and maintenance, and closure costs of each of the treatment and disposal units. These costs were then annualized and totaled. In some sectors, there was not enough waste to justify on-site treatment and disposal, so the Agency used a unit cost to reflect shipping the waste off-site for treatment and disposal. The "model facility" treatment cost was multiplied by the number of facilities treating and disposing waste to get the total sector treatment cost.

Development of Storage Costs

To determine the costs associated with storing wastes prior to recycling, EPA assumed that wastes to be recycled are stored for 30 days or less in drums or tanks if they are liquid and for less than 90 days in drums, roll-off containers, or buildings if they have a solids content of more than 10 percent.¹³ To estimate the impacts of the material reclamation practices outlined above, the Agency used unit cost functions (described in detail in Appendix F) to calculate the costs associated with storing wastes in piles, surface impoundments, RCRA TCBs, and non-RCRA TCBs. Again, and in contrast to waste <u>treatment</u> operations, EPA determined recycling costs on a per waste stream basis, rather than a per facility basis, because it is important in many cases that the wastes to be recycled <u>not</u> be commingled. To determine the total sector storage cost, EPA multiplied the cost of storage for each stream by the number of facilities generating that stream and summed these total sector stream costs.

Development of Administrative Costs

To determine the costs of complying with the administrative requirements of this rule, EPA assumed that each facility recycling a waste stream would incur a one time notification cost of \$100, and that each facility disposing of a waste would incur a one time waste analysis plan cost of \$935 as well as an annual sampling cost of \$470.¹⁴ If a facility is partially recycling a waste stream and partially disposing of it, the facility would incur all three of these costs. EPA annualized the one-time costs for each waste stream and added the annual sampling costs to determine the total sector administrative costs.

Development of Total Costs

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EPA then calculated incremental treatment and disposal costs by subtracting total sector pre-LDR treatment and disposal costs from total sector post-LDR treatment and disposal costs. EPA calculated total sector incremental storage costs in a similar manner. EPA calculated the total sector costs by adding the total sector incremental treatment costs, the total sector incremental storage costs, and the total sector

¹³ Both options allow a longer period of storage; because, however, facility operators would have to build larger and more expensive storage units to take advantage of these longer periods of storage, EPA has assumed that they would attempt to minimize storage time.

¹⁴ Costs derived from Supporting Statement for EPA Information Collection Request 1442.15 Land Disposal Restrictions - Phase IV: Treatment Standards for Wastes from Toxicity Characteristic Metals, Mineral Processing Secondary Materials, and the Exclusion of Recycled Wood Preserving Wastewaters, April 1998.

administrative costs. EPA divided this total sector cost by the number of facilities in the sector to determine the average facility costs.

3.1.3 Economic Impact Analysis

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To evaluate the significance of increased waste management costs on affected facilities and industry sectors, EPA employed simple ratio analyses to yield first-order economic impact estimates. The Agency compared sector-wide estimated regulatory compliance costs for each option with four different measures of economic activity.

First, EPA calculated the ratio of total annualized compliance costs as a percentage of *firm-specific* sales for each affected mineral processing firm.¹⁵ To do this, EPA first identified the facilities and firms that may be affected by the rule based on information contained in the technical background document Identification and Description of Mineral Processing Sectors and Waste Streams, U.S. EPA Office of Solid Waste, April 1998, and on information obtained from public comments on the proposed rule. Where uncertainty existed regarding whether certain facilities currently generate hazardous mineral processing waste, EPA included the facilities estimated in the cost model). EPA then researched the total sales for each business owning one or more facilities using a variety of public and commercial data sources. For seven of the 126 facilities in the analysis, EPA could not obtain estimated sales data for the direct owner and instead calculated the ratio of total annualized compliance costs as a percentage of sales for each firm and compared it to the threshold value for significant impacts of three percent (and, for sensitivity purposes, to the alternative threshold of one percent).

Second, EPA compared regulatory costs for each sector to the estimated *sector-specific value of shipments* from the facilities in that sector. This provides a rough measure of the extent to which gross margins for each sector overall would be reduced by the increased waste management costs, or alternatively, the amount by which the affected commodity price would need to increase to maintain existing margins. Value of shipments data were derived by multiplying each sector's total production by the price of the commodity produced. EPA calculated the ratio of annualized incremental cost to the value of shipments for each option and defined the screening level threshold for significant impact as three percent.

Third, for 16 industry sectors where data were available, EPA compared estimated regulatory costs for each sector to the estimated *value added* by that sector. A ratio of regulatory costs to value added may be more useful in assessing regulatory impacts than a ratio of regulatory costs to shipments. In particular, a mineral processing sector (such as the primary copper industry) generally incurs substantial costs to purchase or produce the raw materials (such as copper concentrate) used in mineral processing activities. The total dollar value of shipments for a mineral processing industry thus includes not only the costs of production and profit, but also the costs of raw materials. In contrast, the value added in manufacturing measures the sales revenue minus the cost of raw materials. Thus, it presents a clearer picture of the extent of economic activity at the regulated operation, and the basis on which the firm may make profits attributable to that operation. EPA obtained value added data for copper and aluminum from a Census

¹⁵ Although it would be preferable to analyze facility-specific impacts (e.g., plant closures) rather than firm-specific impacts, available data do not support facility-specific analyses.

Bureau publication.¹⁶ The Agency obtained value added data for 14 industry sectors categorized as "primary nonferrous metals, not elsewhere classified" from the same publication, and apportioned the total value added to each of the 14 sectors according to that sector's proportion of the total value of shipments for the 14 sectors.¹⁷ For this analysis, EPA used a screening level of 10 percent for significant impact.

Fourth, EPA compared estimated regulatory costs to the *firm-specific earnings* of affected mineral processing firm. This ratio analysis permits a direct comparison of regulatory costs to earnings and indicates the maximum extent to which the regulation will reduce earnings if a company cannot pass on any of the regulatory costs to customers. EPA obtained earnings data for 18 firms that collectively own 39 of the 126 facilities (31 percent) identified as potentially affected by the rule. For an additional 53 facilities (42 percent), EPA was able to obtain estimated earnings data for a higher-tier owner (i.e., a corporate parent). EPA then calculated the ratio of total annualized compliance costs as a percentage of carnings for each of the firms owning affected facilities (and, separately, for the higher-tier owners of affected facilities where necessary).

Finally, EPA also considered the extent to which the affected entities might be able to pass on to their customers the costs of regulation. Mineral processing firms face significant competition from international competitors. For most affected sectors, U.S. production represents only a fraction of worldwide production. Consequently, it may be difficult or impossible for U.S. firms to pass on any incremental regulatory costs to their customers (i.e., because most producers are unaffected by U.S. regulations).

3.2 Results

This section presents EPA's estimates of the cost and screening-level economic impacts of Options 1 and 2. These estimates are discussed for each option, followed by a brief comparison between options. Note that the detailed discussion of cost and economic results presented in Sections 3.2.1 and 3.2.2 focuses on the expected value case. Exhibit 3-5 highlights the differences between the minimum, expected, and maximum value cases.

	Minimum	Expected	Maximum
Option 1	\$7,200,000	\$10,000,000	\$14,000,000
Option 2	\$41,000	\$230,000	\$230,000

Exhibit 3-5 Summary of Cost Results

EPA's use of the dynamic analysis contributes to some counter-intuitive results such as savings in some sectors where costs are expected. The unexpected consequences result from relative economies of scale and a low-volume wastewater treatment unit cost gap. Both are discussed further.

• The dynamic shift and relative economies of scale. The overall cost for an option will depend on the amount and type of material moving from treatment and disposal to recycling, the storage requirements, and the relative unit costs. For both options, at any given generation rate storage prior to recycling is less

¹⁶ Bureau of the Census, U.S. Department of Commerce, 1995 Survey of Manufactures.

¹⁷ EPA's background calculations are provided in Appendix I.

expensive than treatment and disposal. However, because quantities to be treated and disposed are aggregated, while quantities to be recycled need to be stored in dedicated units, moving small quantities of materials from treatment and disposal to recycling may not produce a cost savings due to relative scale economies. For example, if a facility were treating and disposing two wastewater streams in the baseline, one generated at 100,000 mt/yr and one at 150 mt/yr, these two streams would be commingled and the unit cost of treatment in the baseline would be based on treating 100,150 mt/yr. If after the rule went into effect the smaller stream was then fully recycled, the *unit cost* of storing 150 mt/yr in a dedicated unit might be higher than the *unit cost* of treating those 150 mt/yr in the baseline (when the unit cost was based on treating 100,150 mt/yr).

Low-volume wastewater treatment unit cost gap. In addition to the problem of relative scale economies, there is a low volume wastewater treatment unit cost gap. That is, using available information on pertinent treatment technologies, the smallest treatment system that can reasonably be built on-site has a capacity of 350 mt/yr, resulting in an annualized cost of about \$100 per metric ton, while off-site treatment and disposal costs \$175 per metric ton. Therefore, for facilities treating and disposing small quantities of wastewater in the baseline, a slight increase in the quantity treated and disposed (and, therefore, a slight decrease in the quantity recycled) may shift treatment from off-site to on-site. Because off-site treatment is significantly more expensive, the result of this shift is a decreased cost, rather than an increase (as would be expected).

3.2.1 Cost Analysis Results

Option 1

Under Option 1, the total expected incremental cost is \$10,000,000. These impacts are distributed by sector as shown in Exhibit 3-6. Twenty-seven of the industry's twenty-nine sectors (93 percent) are projected to experience increased costs, one sector (three percent) is expected to have no additional costs, and one (three percent) is anticipated to realize cost savings. On a sector basis, incremental costs range from an expected savings of \$96,000 (scandium) to an increase of \$3,800,000 (zinc). EPA expects two sectors (7 percent) to experience total incremental costs greater than \$1,000,000 (copper and zinc) and an additional three sectors (10 percent) to have total costs of more than \$700,000 (alumina/aluminum, elemental phosphorous, and lead). The one sector with no expected costs is coal gas. Finally, EPA expects that the only sector to experience cost savings will be the scandium sector (\$96,000).

On a per facility basis, average incremental expected costs range from a savings of \$14,000 (scandium) to an increase of \$1,300,000 (zinc). Facilities in three other industry sectors (10 percent) are expected to have cost increases between \$100,000 and \$500,000 (copper, elemental phosphorus, and lead). Facilities in the remainder of the sectors (83 percent) are expected to have cost increases of less than \$100,000, except that coal gas facilities are not expected to incur any impacts.

Option 2

Under Option 2, the total expected incremental cost to industry is \$230,000, significantly lower than for Option 1. These impacts are distributed as shown in Exhibit 3-7. Twenty-eight sectors are projected to experience increased costs, with one sector experiencing no change in costs. Expected incremental costs per sector range from zero (coal gas) to \$38,000 (uranium). Seven additional sectors

under this option are expected to experience costs of \$10,000 or more (alumina/aluminum, cadmium, copper, germanium, mercury, titanium/titanium dioxide, and zinc).

On a per facility basis, average incremental expected costs range from zero (coal gas) to \$6,200 (cadmium). Costs are low under this option because the only costs that the Agency estimates will be incurred by industry under this option are recordkeeping and reporting requirements. No other cost impacts are estimated for any of the sectors because the Agency expects that under this option, management practices will not change, relative to the baseline. That is, facility operators will continue to store materials to be recycled in unlined land-based units and will continue to treat materials using stabilization. Therefore, no new costs attributable to storage are expected.

1	Option 11 Minimum	Value Case		Value Case	Maximum	Value Case
	Total	Avg. Fac.	Total	Avg. Fac.	Total	Avg. Fac.
	Incremental	Incremental	Incremental	Incremental	Incremental	Incremental
Commodity	Cost (\$/yr)	Cost (\$/yr)	Cost (\$/yr)	Cost (\$/yr)	Cost (\$/yr)	Cost (\$/yr)
Alumina and Aluminum	280,000	12,000	760.000	33.000	1,400,000	61,000
Antimony			24,000	4.000	36,000	6,000
Beryllium	58,000	58.000	55.000	27.000	340,000	170,000
Bismuth	-		14.000	14,000	25.000	25,000
Cadmium	-		74,000	37.000	460.000	230,000
Calcium	-	-	9	9	9	9
Chromium and Ferrochromium	57,000	57,000	57,000	57,000	64.000	64,000
Coa! Gas	-	-	-	-	66.000	66,000
Copper	2,700,000	270,000	2,500.000	250.000	2,500.000	250,000
Elemental Phosphorus	900,000	450.000	900.000	450.000	900.000	450,000
Eluorspar and Hydrofluoric Acid	-	-	49.000	16.000	81.000	27,000
Germanium		-	22,000	5,600	24,000	6,100
Lead	29,000	9,700	830,000	280.000	1,500.000	500,000
Magnesium and Magnesia from Brines	1,100	560	2,600	1,300	44,000	22,000
Mercury		-	190,000	27,000	510,000	73,000
Molybdenum, Ferromolybdenum, and Ammonum Molybdate	•	-	7,300	660	7.300	660
Platinum Group Metals	-	•	5,400	1,800	11.000	3,800
Rare Earths	4,800	4,800	92,000	92,000	310.000	310,000
Rhenium	-	-	3,100	1,500	5,600	2,800
Scandium		-	(96,000)	(14,000)	42,000	6,000
Selenium	28,000	14,000	46,000	15,000	130,000	42,000
Synthetic Rutile			73,000	73.000	130,000	130.000
Tantalum, Columbium, and Ferrocolumbium	170.000	84,000	170,000	85,000	170.000	85.000
Tellurium -		-	17,000	8,700	38.000	19,000
Titanium and Titanium Dioxide	74,000	37,000	230,000	33,000	370.000	52,000
Tungsten	-	•	25,000	4,200	34.000	5,700
Uranium		-	60,000	3,500	120.000	6,800
Zinc	2,900,000	960,000	3,800,000	1,300,000	4,000.000	1,300,000
Zirconium and Hafnium	-	-	99,000	49,000	320.000	160,000
Total / Average	7,200,000		10,000,000		14,000.000	

Exhibit 3-6 Option 1 Incremental Costs

Exhibit 3-7 Option 2 Incremental Costs

	Minimum	Value Case	Expected	Value Case	Maximum Value Case		
Commodity	Total Incremental Cost (\$/yr)	Avg. Fac. Incremental Cost (\$/yr)	Total Incremental Cost (\$/yr)	Avg. Fac. Incremental Cost (\$/yr)	Total Incremental Cost (\$/yr)	Avg. Fac. Incremental Cost (\$/yr)	
Alumina and Aluminum	13,000	570	26,000	1,100	26,000	1,100	
Antimony	-	-	6,800	1,100	6,800	1,100	
Beryllium	570	570	2,800	1,400	2,800	1.400	
Bismuth	-	-	5,600	5,600	5,600	5,600	
Cadmium	-		12,000	6,200	12,000	6,200	
Calcium	-		9	9	9	9	
Chromium and Ferrochromium	570	570	580	580	580	580	
Coal Gas	-	-	· -	-	570	570	
Copper	5,700	570	17,000	1,700	17,000	1,700	
Elemental Phosphorus	4,500	2,300	4,500	2,300	4,500	2,300	
Fluorspar and Hydrofluoric Acid	-	-	1,700	570	1,700	. 570	
Germanium	-	-	13,000	3,200	13,000	3,200	
Lead	3,400	1,100	6,900	2,300	6,900	2,300	
Magnesium and Magnesia from Brines	1,100	560	1,700	840	1,700	840	
Mercury	-	-	12.000	1,700	12,000	1,700	
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-		7,300	660	7,300	660	
Platinum Group Metals	•	-	5,100	I,700	5,100	1,700	
Rare Earths	I,100	1,100	2.800	2,800	2,800	2,800	
Rhenium	•	-	2,300	1,100	2,300	1,100	
Scandium	-		7,900	1.100	7,900	1,100	
Selenium	1.100	570	7,900	2.600	7,900	2,600	
Synthetic Rutile	-	-	590	590	590	590	
Tantalum, Columbium, and Ferrocolumbium	1.100	570	3,400	1,700	3,400	1.700	
Tellarium	-	-	3,400	1,700	3,400	1,700	
Titanium and Titanium Dioxide	3.400	1,700	17,000	2,500	17,000	2.500	
Tungsten	-	-	6,800	1,100	6,800	1,100	
Uranium		-	38,000	2,300	38,000	2,300	
Zinc	5,100	1,700	10,000	3,400	10,000	3,400	
Zirconium and Hafnium	-	-	4,500	2,300	4,500	2,300	
Total / Average	41,000		230,000		230,000		

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3.2.2 Economic Impact Analysis Results

As described above, EPA conducted four ratio analyses comparing regulatory costs to the following four financial indicators: (1) firm-specific sales, (2) sector-specific value of shipments, (3) sector-specific value added, and (4) firm-specific earnings. This section presents the results of these analyses.

Approximately 75 businesses owning approximately 126 facilities may be affected by the rule. These facilities fall into the following sectors: alumina/aluminum, antimony, beryllium, bismuth, cadmium, calcium, chromium/ferrochromium, coal gas, copper, elemental phosphorous, germanium, fluorspar/ hydrofluoric acid, lead, magnesium and magnesia from brines, mercury, molybdenum/ferromolybdenum/ ammonium molybdate, platinum group metals, rare carths, rhenium, scandium, selenium, synthetic rutile, tantalum/columbium/ferrocolumbium, tellurium, titanium/titanium dioxide, tungsten, uranium, zinc, and/or zirconium/hafnium. Firms in these sectors face significant competition from international competitors. For most sectors, U.S. production represents only a fraction of world-wide production. Consequently, it may be difficult or impossible for U.S. firms to pass on any incremental regulatory costs to their customers (i.e., because most producers are unaffected by U.S. regulations).

Ratio of Regulatory Costs to Sales

The first measure considered is the ratio of total annualized compliance costs as a percentage of firm-specific sales for each affected mineral processing firm. For seven of the 126 facilities in the analysis, EPA could not obtain estimated sales data for the direct owner and instead calculated the ratio on the basis of the sales of a higher-tier owner (i.e., a corporate parent). The calculated ratios are compared to the threshold value for significant impacts of three percent and, for sensitivity purposes, to the alternative threshold of one percent.

EPA's analysis finds that neither Option 1 nor Option 2 would result in a significant impact on any mineral processing firm under the three percent threshold. Under the alternative threshold of one percent, two firms (one that processes copper and one that processes both cadmium and zinc) would incur an impact. Several possible - but unlikely - exceptions to this finding arise as a result of data limitations. Because this analysis was unable to obtain sales data for certain businesses, the analysis could not directly estimate impacts on these companies:

- One company processing hydrofluoric acid is expected to incur annual costs of only \$16,000 under Option 1 or \$570 under Option 2. Therefore, this company will not incur significant impacts under Option 1 unless it has sales of less than \$533,333 (i.e., \$16,000/0.03) or, using the alternate threshold of one percent, sales of less than \$1,600,000 (i.e., \$16,000/0.01). Under Option 2, the company will not incur significant impacts unless it has sales of less than \$19,000 (or \$57,000 using the alternate threshold of one percent).
- Similarly, the analysis does not address businesses that own the 17 facilities in the uranium sector. The average annual cost to such facilities is \$3,500 under Option 1 and \$2,300 under Option 2. Thus, significant impacts would arise under Option 1 only for those concerns with sales of less than \$116,667 or, using the alternate threshold of one percent, less than \$350,000 (i.e., \$3,500/0.01).¹⁸ Under

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¹⁸ This assumes that only one uranium processing facility is owned per business.

Option 2, significant impacts would arise only for those concerns with sales of less than \$76,667 or, using the alternate threshold of one percent, less than \$230,000.

The sales levels required for these companies to avoid significant cost-to-sales impacts are relatively low in comparison to those of firms for which data are available. For example, the *lowest* sales figure that was available for an affected mineral processing firm (excluding small businesses) exceeds \$10,000,000. Even among small businesses (see Section 3.3) the average sales figure exceeds \$90,000,000. Therefore, EPA believes that significant cost-to-sales impacts are unlikely.

Ratio of Regulatory Costs to Value of Shipments

Economic impacts expressed as a ratio of regulatory costs to the value of shipments arc shown in Exhibit 3-8 for Option 1, and in Exhibit 3-9 for Option 2. Option 1 imposes significant cost impacts (defined as 3 percent of the value of shipments for the sake of this analysis) on three of the 29 industrial sectors (10 percent of the affected sectors) in the expected value case. EPA projects significantly affected sectors to include mercury (36 percent impact), tungsten (6 percent), and fluorspar/hydrofluoric acid (4 percent). Two other sectors are expected to incur impacts of between 1-3 percent (cadmium and selenium). The remaining 24 sectors (83 percent of all affected sectors) are expected to experience economic impacts of less than one percent.

Option 2 would not impose significant burdens on any of the 29 sectors. Two sectors are expected to incur impacts of between 1-3 percent (mercury and tungsten) under this option.

The severity of predicted economic impacts does not in all cases reflect the magnitude of increased waste treatment costs estimated in this analysis. Facilities in several sectors are projected to experience significant cost increases but are not expected to suffer serious economic impact, because of high production rates and/or because the commodities that they produce have a high unit market price. Examples include alumina and aluminum, copper, elemental phosphorous, lead, titanium, and zinc. Plants in other sectors are projected to experience low impacts because estimated incremental waste treatment costs are relatively modest.

In contrast, the sectors that are projected to experience the most significant impacts have both moderate incremental waste management costs and low commodity production rates, a low commodity price, or both. Prominent examples in this category include cadmium and selenium. It is worthy of note, however, that several such commodities are co-products. That is, their principal or sole source of production is another, generally much larger mineral production operation. Consequently, while new waste management controls (and their costs) might threaten the economic viability of production of these commodities, they would generally not threaten the viability of the larger operation. This phenomenon is critically important to evaluating potential impacts on a number of sectors projected to experience significant cost/economic impacts in this analysis. Exhibit 3-10 displays the relationships between some of these sectors and their larger associated commodity production operation(s).

	Production	Price	Value of Shipments	Incremental Sector Cost \$		Economic Impact (percent of Value of Shipments)			
Sector	MT	\$/MT	s	Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,600,000	1.543	5.554.800,000	280.000	750,000	1,400,000	0.01	0.01	0.03
Antimony	20,100	3 351	67.355,100	-	24,000	36,000	0.00	0.04	0.05
Beryllium	217	352.640	76,522,880	58,000	55,000	340,000	. 0.08	0 07	0.44
Bismuth *	1,100	7 937	8 730 700		14,000	25,000	0.00	0 16	0.29
Cadmium	1,450	2.756	3,996,200	-	74,000	460,000	0.00	1 85	11-51
Calcium	1,100	4.480	4,928,000	-	9	9	0.00	0.00	0.00
Chromium and Ferrochromium			39.000,000	57,000	57,000	64,000	0.15	0.15	0.16
Coal Gas			186.000,000	-	-	66,000	0.00	0.00	0.04
Copper	2,000,000	2,249	4,498.000,000	2.700,000	2,500,000	2,500,000	0.06	0.06	0.06
Elemental Phosphorus	311,000	2,756	857.116.000	900,000	900.000	900,000	0.11	011	0.11
Fluorspar and Hydrofluoric Acid	8,200	162	1,328,400		49,000	81,000	0.00	3 69	6.10
Germanium	18	2,000.000	36.000,000	-	22,000	24,000	- 0.00	0.06	0.07
Lead	340,000	1.076	365.840,000	29,000	830,000	1,500,000	0.01	0.23	0.41
Magnesium and Magnesia from Brines	143,000	3.858	551,694,000	1,100	2,600	-14,000	0.00	0.00	0.01
Mercury	70	7,542	527,940	•	190,000	510,000	0.00	35,99	96.60
Molybdenum, Ferromolybdenum and Ammonium Molybdate			427.500,000		7,300	7,300	. 0.00	0.00	0.00
Platinum Group Metals			42.792,580	-	5,400	11.000	0.00	0.01	0.03
Rare Earths	20.000	2,870	\$7,400,000	4,800	92,000	310,000	0.01	0.16	0.54
Rhenium	19	1,100,000	20.900,000		3,100	5,600	0.00	0.01	0.03
Scandium	25	1.400.000	35.000,000	-	(96,000)	42,000	0.00	-0 27	0.12
Selenium	350	7.055	2.469,250	28,000	46,000	130,000	1.13	1.86	5.26
Synthetic Rutile	140,000	650	91.000,000	-	73.000	130.000	0.00	0.08	0,14
Tantalum, Columbium, and Ferrocelumbium			95.727,210	170,000	170,000	170,000	0.18	0.18	0.18
Tellurium	60	46,287	2.777.220	-	17.000	38,000	0.00	061	1 37
Titanium and Titanium Dioxide			3,203,707,220	74,000	230,000	370,000	0.00	0.01	0.01
Tungsten	8,449	49	414,001	-	25,000	34,000	0.00	6.04	8 21
Uranium	2,132	31.130	66.369,160	-	60,000	120,000	0.00	0 09	0.18
Zinc	620,000	1.124	696,880,000	2,900,000	3,800,000	4,000.000	0.42	0.55	0.57
Zirconium and Hafnium			165.814,000	-	99,000	320,000	0.00	0.03	0.09
Total				7.200,000	10,000,000	14,000,000			

Exhibit 3-8 Option 1 Impacts (Value of Shipments Analysis)

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1	Production	Price	Value of Sector Cost F				Economic Impact of Value of Shipments)		
Sector	МТ	\$/MT	\$	Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,600,000	1,543	5,554,800,000	13,000	26,000	26,000	0.00	0.00	0.0
Antimony	20,100	3,351	67,355,100	-	6,800	6,800	0.00	0.01	0.0
Beryllium	217	352,640	76,522,880	570	2,800	2,800	0.00	0.00	0.0
Bismuth	1.100	7,937	8,730,700	-	5,600	5,600	0.00	0.06	0.0
Cadmium	L.450	2,756	3,996,200	-	12,000	12,000	0.00	0.30	0.3
Calcium	1,100	4,480	4,928,000	-	9	. 9	0.00	0.00	0.00
Chromium and Ferrochromium			39,000,000	570	580	580	0.00	0.00	0.00
Coal Gas			186,000,000	-	-	570	0.00	0.00	0.0
Copper	2,000,000	2,249	4,498,000,000	5,700	17,000	17,000	0.00	0.00	0.0
Elemental Phosphorus	311,000	2,756	857,116,000	4,500	. 4,500	4,500	0.00	0.00	0.0
Fluorspar and Hydrofluoric Acid	8.200	162	1,328,400	-	1,700	1,700	0.00	0.13	0.1
Germanium	18	2,000,000	36,000,000	-	13,000	13.000	0.00	0.04	0.0
Lead	340.000	1,076	365,840,000	3,400	6.900	6,900	0.00	0.00	0.0
Magnesium and Magnesia from Brines	143.000	3,858	551,694,000	1,100	1.700	1,700	0.00	0.00	0.0
Mercury	70	7.542	527,940	-	12,000	12,000	0.00	. 2.27	2.2
Molybdenum, Ferromolybdenum and Ammonium Molybdate			427,500,000	-	7,300	7,300	0.00	0.0 0	0.0
Platinum Group Metals			42,792,580	-	5,100	5,100	0.00	0.01	0.0
Rare Earths	20.000	2,870	57,400.000	1,100	2,800	2,800	0.00	0.00	0.0
Rhenium	19	1,100.000	20,900,000	-	2,300	2,300	0.00	0.01	0.0
Scandium	25	1,400.000	35,000,000	-	7,900	7,900	0.00	0.02	0.0
Selenium	350	7.055	2,469,250	1,100	7,900	7,900	0.04	0.32	0.3
Synthetic Rutile	140,000	650	91,000.000		590	590	0.00	0.00	0.0
Tantalum, Columbium, and Ferrocolumbium			95,727,210	. 1,100	3,400	3,400	0.00	0.00	0.0
Tellurium	60	46.287	2,777,220	-	3,400	3,400	0.00	0.12	0.1
Titanium and Titanium Dioxide			3,203,707,220	3,400	17,000	17,000	0.00	0.00	0.0
Tungsten	8,449	49	414,001	-	6,800	6,800	0.00	1.64	1.6
Uranium	2,132	31,130	66,369,160	-	38,000	38.000	0.00	0.06	0.0
Zinc	620.000	1,124	696,880,000	5,100	10,000	10,000	0.00	0.00	0.0
Zirconium and Hafnium			365,814,000	-	4,500	4,500	0.00	0.00	0.0
Total				41,000	230.000	230,000			

Exhibit 3-9 Option 2 Impacts (Value of Shipments Analysis)

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Affected Commodity Sector	Primary Associated Commodity
Cadmium	Zinc
Mercury	Gold
Selenium	Copper
Antimony	Lead, silver/copper
Bismuth	Lead, copper/lead
Rhenium	Molybdenum
Tellurium	Copper

Exhibit 3-10 Relationships Among Mineral Commodity Production Operations

Ratio of Regulatory Costs to Value Added

Because value added is less than value of shipments, the ratio of regulatory costs to value added will be higher than the ratio of regulatory costs to shipments. EPA obtained data on value added for 16 mineral industry sectors. Detailed results of the value-added impact analysis are presented in Exhibit 3-11. For purposes of this analysis, EPA defined significant economic impacts as greater than 10 percent.

For Option 1, EPA anticipates that two of the 16 industry sectors (13 percent of the sectors included in this analysis) will be significantly affected (cadmium and selenium). Cadmium is a co-product of zinc production and selenium is a co-product of copper production; hence, these economic impacts are expected primarily to affect the production of these co-products and the reclamation of their residuals rather than the mineral processing operation as a whole. Because recovery is generally less expensive for these co-product residuals than treatment and disposal, EPA believes that the costs for these residuals will not significantly decrease their recovery (although the storage costs could add to the expense). Under Option 2, none of the 16 sectors are expected to be significantly affected.

Ratio of Regulatory Costs to Earnings

Comparing regulatory costs to earnings allows one to estimate how the costs of regulations will affect a company's bottom line. Incremental costs that exceed a company's or industry's earnings over an extended period will result in facility closures and exit from the industry in question. EPA obtained earnings data for 18 firms that collectively own 39 of the 126 facilities (31 percent) affected by the rule. For an additional 53 facilities (42 percent), EPA was able to obtain estimated earnings data for a higher-tier owner (i.e., a corporate parent). EPA then calculated the ratio of total annualized compliance costs as a percentage of earnings for each of the firms owning affected facilities (and, separately, for the higher-tier owners of affected facilities where necessary).

None of the firms analyzed are expected to incur severe impacts based on the cost-to-earnings ratio. Under Option 1, only three firms are expected to incur costs in excess of even one percent of earnings, and none of these is expected to exceed three percent of earnings. Under Option 2, no firms are expected to incur costs of even one percent of earnings.

Alumina and Aluminum2,874,500,000760,00026,0000.0%0.0%Antimony7,384,05224,0006,8000.3%0.14Beryllium8.389,10455,0002,8000.7%0.0%Bismuth943,50814,0005,6001.5%0.66Cadmium438,09874,00012,00016.9%2.7%Copper1,845,200,0002,500,00017,0000.1%0.0%Germanium3,946,63322,00013,0000.6%0.3%Lead40,106,565830,0006,9002.1%0.0%Magnesium and Magnesia from Brines60,481,4982,6001,7000.1%0.1%Rhenium2,291,2403,1002,3000.1%0.1%Selenium2,70,70146,0007,90017.0%2.9%Tellurium304,46317,0003,4005.6%1.1%Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	· · · · ·	Estimated				Economic Impact (Percent of Value Added)		
Antimony7,384,05224,0006,8000.3%0.16Beryllium8,389,10455,0002,8000.7%0.09Bismuth943,50814,0005,6001.5%0.66Cadmium438,09874,00012,00016.9%2.7%Copper1,845,200,0002,500,00017,0000.1%0.09Germanium3,946,63322,00013,0000.6%0.3%Lead40,106,565830,0006,9002.1%0.0%Magnesium and Magnesia from Brines60,481,4982,6001,7000.1%0.16Platinum Group Metals4,691,2955,4005,1000.1%0.1%Rhenium2,291,2403,1002,3000.1%0.16Selenium304,46317,0003,4005.6%1.16Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Sector		Option 1	Option 2	Option 1	Option 2		
Antimony7,384,05224,0006,8000.3%0.16Beryllium8,389,10455,0002,8000.7%0.09Bismuth943,50814,0005,6001.5%0.66Cadmium438,09874,00012,00016.9%2.7%Copper1,845,200,0002,500,00017,0000.1%0.09Germanium3,946,63322,00013,0000.6%0.3%Lead40,106,565830,0006,9002.1%0.0%Magnesium and Magnesia from Brines60,481,4982,6001,7000.1%0.16Platinum Group Metals4,691,2955,4005,1000.1%0.1%Rhenium2,291,2403,1002,3000.1%0.16Selenium304,46317,0003,4005.6%1.16Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Alumina and Aluminum	2.874.500.000	760.000	26.000	0.0%	0.0%		
Bismuth943.50814,0005,6001.5%0.66Cadmium438,09874,00012,00016.9%2.74Copper1,845,200,0002,500,00017,0000.1%0.06Germanium3,946,63322,00013,0000.6%0.34Lead40,106,565830,0006,9002.1%0.06Magnesium and Magnesia from Brines60,481,4982,6001,7000.0%0.06Platinum Group Metals4,691,2955,4005,1000.1%0.14Sclenium2,291,2403,1002,3000.1%0.14Sclenium304,46317,0003,4005.6%1.14Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.06Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%								
Cadmium438,09874,00012,00016.9%2.77Copper1,845,200,0002,500,00017,0000.1%0.09Germanium3,946,63322,00013,0000.6%0.37Lead40,106,565830,0006,9002.1%0.09Magnesium and Magnesia from Brines60,481,4982,6001,7000.0%0.09Platinum Group Metals4,691,2955,4005,1000.1%0.14Rhenium2,291,2403,1002,3000.1%0.14Selenium270,70146,0007,90017.0%2.99Tellurium304,46317,0003,4005.6%1.14Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.09Zinc76,398,0523,800,00010,0005.0%0.09Zirconium and Hafnium40,103,71599,0004,5000.2%0.09	Bervllium	8.389,104	55,000	2,800	0.7%	0.0%		
Copper Germanium1,845,200,0002,500,00017,0000.1%0.00Germanium3,946.63322,00013,0000.6%0.3%Lead40,106.565830,0006,9002.1%0.0%Magnesium and Magnesia from Brines60,481,4982,6001,7000.0%0.0%Platinum Group Metals4,691,2955,4005,1000.1%0.1%0.1%Rhenium2,291,2403,1002,3000.1%0.1%0.1%Selenium270,70146,0007,90017.0%2.9%Tellurium304,46317,0003,4005.6%1.1%Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Bismuth	943,508	14,000	5,600	1.5%	0.6%		
Germanium3,946.63322,00013,0000.6%0.3%Lead40,106.565830,0006,9002.1%0.0%Magnesium and Magnesia from Brines60,481,4982,6001,7000.0%0.0%Platinum Group Metals4,691,2955,4005,1000.1%0.1%Rhenium2,291,2403,1002,3000.1%0.1%Selenium270,70146,0007,90017.0%2.9%Tellurium304,46317,0003,4005.6%1.1%Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Cadmium	438,098	74,000	12,000	16.9%	2.7%		
Lead40,106.565830,0006,9002.1%0.0%Magnesium and Magnesia from Brines60,481,4982,6001,7000.0%0.0%Platinum Group Metals4,691,2955,4005,1000.1%0.1%Rhenium2,291,2403,1002,3000.1%0.1%Selenium270,70146,0007,90017.0%2.9%Tellurium304,46317,0003,4005.6%1.1%Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Copper	1,845,200.000	2,500,000	17,000	0.1%	0.0%		
Magnesium and Magnesia from Brines60,481,4982,6001,7000.0%0.0%Platinum Group Metals4,691,2955,4005,1000.1%0.1%Rhenium2,291,2403,1002,3000.1%0.1%Selenium270,70146,0007,90017.0%2.9%Tellurium304,46317,0003,4005.6%1.1%Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Germanium	3,946.633	22,000	13,000	0.6%	0.3%		
Platinum Group Metals 4,691,295 5,400 5,100 0.1% 0.16 Rhenium 2,291,240 3,100 2,300 0.1% 0.16 Selenium 270,701 46,000 7,900 17.0% 2.99 Tellurium 304,463 17,000 3,400 5.6% 1.16 Titanium and Titanium Dioxide 351,218,272 230,000 17,000 0.1% 0.0% Zinc 76,398,052 3,800,000 10,000 5.0% 0.0% Zirconium and Hafnium 40,103,715 99,000 4,500 0.2% 0.0%	Lead	40,106.565	830,000	6,900	2.1%	0.0%		
Rhenium2,291,2403,1002,3000.1%0.16Selenium270,70146,0007,90017.0%2.99Tellurium304,46317,0003,4005.6%1.16Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Magnesium and Magnesia from Brines	60,481,498	2,600	1,700	0.0%	0.0%		
Rhenium2,291,2403,1002,3000.1%0.16Selenium270,70146,0007,90017.0%2.99Tellurium304,46317,0003,4005.6%1.16Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Platinum Group Metals	4,691,295	5,400	5,100	0.1%	0.1%		
Tellurium304,46317,0003,4005.6%1.16Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%		2,291,240	3,100	2,300	0.1%	0.1%		
Titanium and Titanium Dioxide351,218,272230,00017,0000.1%0.0%Zinc76,398,0523,800,00010,0005.0%0.0%Zirconium and Hafnium40,103,71599,0004,5000.2%0.0%	Selenium	270,701	46,000	7,900	17.0%	2.9%		
Zinc76,398,0523,800,00010,0005.0%0.09Zirconium and Hafnium40,103,71599,0004,5000.2%0.09	Tellurium	304,463	17,000	3,400	5.6%	1.1%		
Zirconium and Hafnium 40,103,715 99,000 4,500 0.2% 0.04	Titanium and Titanium Dioxide	351,218,272	230,000	17,000	0.1%	0.0%		
	Zinc	76,398,052	3,800,000	10,000	5.0%	0.0%		
Total 5,316,667,197 8,482,100 142,000 0.2% 0.0%	Zirconium and Hafnium	40,103,715	99,000	4,500	0.2%	0.0%		
	Total	5,316,667.197	8,482,100	142,000	0.2%	0.0%		

Exhibit 3-11 Option 1 and 2 Impacts (Value Added Analysis)

Summary of Economic Impacts

EPA conducted four ratio analyses comparing regulatory costs to the following four financial indicators: (1) firm-specific sales, (2) sector-specific value of shipments, (3) sector-specific value added, and (4) firm-specific earnings. The results of this analysis are summarized in Exhibit 3-12 and discussed below:

Option 1

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- Based on the two firm-specific ratios (cost/sales and cost/earnings), no significant economic impacts are expected to result from Option 1.
- Based on cost as a percentage of value of shipments, three of the 29 sectors (10 percent sectors) are expected to incur significant impacts under Option 1. Significantly affected sectors are projected to include mercury (36 percent impact), tungsten (6 percent), and fluorspar/hydrofluoric acid (4 percent).

Exhibit 3-12

Summary of Economic Impact Screening Results:

	Percent of Firms or Sectors w/ Significant Impacts					
Impact Measure	Option 1	Option 2				
Cost/Sales	0% of firms	0% of firms				
Cost/Earnings	0% of firms	0% of firms				
Cost/Value of Shipments	10% of sectors	0% of sectors				
Cost/Value Added	13% of sectors	0% of sectors				

• Based on cost as a percentage of value added, two of the 16 sectors (13 percent) are expected to be significantly affected under Option 1 (cadmium and selenium).

Option 2

Option 2 is not expected to result in significant impacts under any of the four measures.

The divergence between the Option 1 results based on the firm-specific measures (particularly cost/sales) and those based on the sector-specific measures could result from diversified operations of affected firms. In this case, it is possible that significant impacts might occur at the facility level even if they do not lead to significant impacts at the firm level (i.e., due to the firm's additional operations besides those in affected mineral processing sectors).

3.3 Regulatory Flexibility Analysis

This section describes EPA's initial assessment of the small business impacts expected to be incurred by mineral processing firms as a result of the Phase IV Land Disposal Restrictions (LDRs). Approximately 20 small businesses owning approximately 22 facilities may be affected by the rule. The first subsection describes the methodology used in conducting the analysis. The second subsection presents the results of the analysis. In brief, the analysis concludes that no significant small business impacts are anticipated as a result of either option and, therefore, preparation of a formal Regulatory Flexibility Analysis is unnecessary.

3.3.1 Methodology

An initial assessment of small business impacts involves four major tasks: (1) defining "small entities" for the rule being analyzed, (2) determining what number constitutes a "substantial number" of these entities, (3) determining how "significant impacts" will be measured, and (4) completing a screening analysis. If the initial assessment determines that a substantial number of small entities may face significant impacts as a result of the rule being analyzed, then a formal Regulatory Flexibility Analysis may be required.

Defining "Small Entities" Affected by the Rule

The Phase IV LDRs will affect those mineral processing entities that currently (i.e., prior to the rule) generate hazardous waste. For purposes of this analysis, "small entity" refers to any such mineral processing business concern that has 750 or fewer employees including itself and all of its domestic and foreign affiliates (1000 or fewer employees for entities in the copper and aluminum sectors). This definition is consistent with the size standards established by the Small Business Administration (SBA) in 13 CFR Sections 121.103 and 121.201 on January 31, 1996 and as reprinted by SBA on January 7, 1998 (63 Federal Register 902). EPA does not believe that other types of small entities, such as non-profit organizations or local governments, will be affected by the application of Phase IV LDRs to mineral processing activities.

Determining What Number Constitutes a Substantial Number

This initial assessment applies a figure corresponding to 20 percent of small entities in determining whether a "substantial number" of small entities are likely to be impacted by the rule. For sensitivity analysis purposes, EPA has also applied an alternate figure corresponding to five percent of small entities.

Measuring "Significant Impacts"

To evaluate the impact that a small entity is expected to incur as a result of the rule, this analysis calculates the entity's ratio of annualized compliance costs as a percentage of sales. Entities are classified as facing potentially "significant" impacts if this ratio exceeds three percent. For sensitivity analysis purposes, EPA has also applied an alternate figure of one percent.

Conducting the Screening Analysis

The final task of the initial assessment is to conduct the screening analysis and determine whether, using the criteria established above, the rule is expected to result in significant impacts on a substantial number of small entities. The screening analysis involves four steps:

(1) Identify Facilities Generating Hazardous Mineral Processing Waste. EPA compiled a list of the facilities generating hazardous mineral processing waste based on information contained in the technical background document Identification and Description of Mineral Processing Sectors and Waste Streams, U.S. EPA Office of Solid Waste, December 1997, and on information obtained from public comments on the proposed rule. Where uncertainty existed regarding whether certain facilities currently generate hazardous mineral processing waste. EPA included the facility in this analysis to avoid understating impacts (even if doing so meant exceeding the number of facilities estimated in the cost model).

- (2) Obtain Employee And Sales Data For The Business Concerns Owning Each Facility. Using the list of facilities developed in the preceding step, EPA researched the number of employees and total sales for each business concern owning one or more facility. (As noted earlier, a "business concern" includes not only the company owning a given facility, but all of its domestic and foreign affiliates.) The Agency obtained data from a variety of public and commercial sources. Based on these data, approximately 20 small businesses owning approximately 22 facilities may be affected by the rulemaking.
- (3) Obtain Compliance Cost Data For Each Small Business Concern. For each facility owned by a small business concern, EPA applied its most current estimate for the "average" sector-specific facility cost, in the expected value case, of complying with Option 1 and Option 2 under the assumed modified prior treatment baseline. In the few cases where a small business concern owns multiple facilities, EPA added the compliance costs for the individual facilities to obtain a total compliance cost for the small business owner. For example, if one company owns two facilities, the costs of these facilities are added together to determine the total compliance cost to the company.
- (4) <u>Compute Small Business Impacts</u>. Finally, using the data obtained in the preceding steps, EPA calculated each small business concern's ratio of total annualized compliance costs as a percentage of sales. EPA then compared the ratios to the threshold value for significant impacts of three percent, and to the sensitivity threshold of one percent.

3.3.2 Results

As described above, EPA examined the potential for small business impacts by comparing, for each small business, the total annualized compliance costs as a percentage of sales. Approximately 20 small businesses owning approximately 22 facilities may be affected by the rule. These facilities fall into the following sectors: alumina/aluminum, antimony, cadmium, chromium, coal gas, germanium, fluorspar/hydrofluoric acid, molybdenum/ferromolybdenum/ammonium molybdate, platinum group metals, scandium, tungsten, and/or zinc. EPA's analysis finds that neither Option 1 nor Option 2 would result in a significant impact on a substantial number of small mineral processing entities. In fact the options are unlikely to result in a significant impact on *any* small mineral processing entities, and some small business owners would incur cost savings under Option 1. Two possible - but unlikely - exceptions to this finding arise as a result of data limitations. Because this analysis was unable to obtain sales data for certain small businesses, the analysis could not directly estimate impacts on these companies. Nevertheless, significant impacts on these businesses are unlikely, as discussed below:

> One company processing hydrofluoric acid is expected to incur annual costs of only \$16,000 under Option 1 or \$570 under Option 2. Therefore, this company will not incur significant impacts under Option 1 unless it has sales of less than \$533,333 (i.e., \$16,000/0.03) or, using the alternate threshold of one percent, sales of less than \$1,600,000 (i.e., \$16,000/0.01). Under Option 2, the company will not incur significant impacts unless it has sales of less than \$19,000 (or \$57,000 using the alternate threshold of one percent). Because higher sales can

be expected of a sustained business venture conducting mineral processing,¹⁹ EPA believes that this small business will not incur significant impacts.

Similarly, the analysis does not address small business concerns that may own one or more of the 17 facilities in the uranium sector. The average annual cost to such facilities is \$3,500 under Option 1 and \$2,300 under Option 2. Thus, if any of the 17 facilities are owned by small business concerns, significant small business impacts would arise under Option 1 only for those concerns with sales of less than \$116,667 (i.e., \$3,500/0.03) or, using the alternate threshold of one percent, less than \$350,000 (i.e., \$3,500/0.01).²⁰ Under Option 2, significant impacts would arise only for those concerns with sales of less than \$76,667 or, using the alternate threshold of one percent, less than \$230,000. Assuming the total sales of a small business owning a uranium processing facility are at all close to the average sales figure (over \$90 million) for all other small businesses in the analysis, then no impacts arise in the uranium sector under either option or threshold.

Even in the unlikely event that any company incurs significant impacts under the scenarios described above, the rule would not generate significant impacts on a *substantial number* of small businesses unless 20 percent or more of small mineral processing firms (five percent or more under the alternative threshold for "substantial number") incur significant impacts. This corresponds to four entities (one under the alternative threshold), and seems highly unlikely.

It is worth noting that actual impacts may be even less than estimated above because the facilities owned by small business concerns may incur smaller than average compliance costs. This could reasonably occur if small business concerns tend to own smaller than average facilities.

3.4 Media Contaminated with Manufactured Gas Plant Wastes

In addition to the newly identified mineral processing wastes, today's rule will also affect the remediation of media contaminated with manufactured gas plant (MGP) waste. MGPs produced gasified coal for lighting prior to the development of natural gas pipelines, and closed in response to natural gas pipelines in the 1950's. During MGP operation, soils, sediments, and groundwater often became contaminated from coal tars generated during the gasification process. Despite relatively high concentrations of hazardous constituents in the tars, EPA estimates that only about 15 percent of the contaminated media fail the TC for benzene. The media also commonly contains elevated levels of volatile organics, monocyclic aromatic hydrocarbons and polycyclic aromatic hydrocarbons.

Today's rule establishes treatment standards for media contaminated with MGP waste because MGP waste is a newly identified mineral processing waste. Therefore, hazardous contaminated media must meet UTS levels both for constituents present in concentrations at or greater than TC levels and for underlying hazardous constituents (UHCs).²¹ However, today's rule includes a provision ("the alternative

²¹ UHCs are hazardous constituents present in concentrations higher than UTS, but below TC levels.

¹⁹ For example, the average sales figure among all other small businesses in the analysis exceeds \$90 million.

²⁰ This assumes that only one uranium processing facility is owned per small business concern.

treatment standard") that will allow contaminated media to be treated to either a 90 percent reduction of initial concentration or 10 times the UTS, whichever is greater, provided the media is not used in a manner constituting disposal. As a result, there are two practical ways that remediation of contaminated media could be affected by today's rule: (1) cases where the baseline treatment method does not lower contaminant concentrations below applicable treatment levels, or (2) if baseline treatment consists of decharacterizing the media using dilution, which is prohibited by general LDR requirements.²² EPA analyzed the costs of today's rulemaking on media contaminated with MGP waste, and believes that only the second category will be affected. The remainder of this section summarizes the methodology used to determine the MGP-related costs of today's rulemaking and presents the results of this analysis.²³

EPA began the process of estimating the MGP-related costs of today's rule by estimating the number of sites where remediation will occur (or is presently occurring) and the total quantity of hazardous media to be remediated. The Agency then calculated the quantity and cost of hazardous media being treated in the baseline for each of four treatment categories: (1) co-burning; (2) ex-situ thermal treatment/bioremediation; (3) use constituting disposal; and (4) in-situ stabilization/treatment. Next, the Agency determined that the only affected treatment category is the use constituting disposal category because the other treatment categories reduce contaminant concentrations by at least 90 percent, and do not involve dilution. Consequently, EPA modeled shifts from this category to other treatment methods as well as to a "no cleanup" option in order to arrive at post-rule treatment quantities and total costs. EPA then subtracted the baseline costs from the post-rule costs to obtain a total incremental cost. Finally, EPA calculated the total annual incremental cost, assuming that it will take one year to clean up any given site, 20 years to complete all cleanups, and an equal number of sites will be cleaned up each year.

For purposes of this analysis, the Agency has grouped potentially affected former manufactured gas plant sites into two broad categories: commercial sites and captive sites. Commercial sites are those sites where historic utility companies manufactured gas for use in lighting and heating applications in cities and towns. Many of these sites are owned by present-day utility companies. The Agency estimates that there are 2,500 potentially affected commercial MGP sites in the United States. Captive sites comprise a larger universe of former manufactured gas plant operations used at rail yards, military outposts, institutions, large residences, coke works, and tar distilleries. EPA estimates that there are 28,700 potentially affected captive former MGP sites in the United States. Industry representatives estimate that between 500-5,000 tons of RCRA hazardous contaminated media are likely to be found at former MGP sites. This analysis assumes that commercial sites (which are, in general, larger than captive sites) contain 5,000 tons of hazardous contaminated media, while captive sites contain 500 tons of hazardous contaminated media, while captive sites contain 500 tons of hazardous contaminated media, while captive sites contain former and the still affected facilities, EPA estimates that 12,500,000 tons (2,500 sites x 5,000 tons) of hazardous contaminated media will be remediated at commercial sites, and 14,350,000 tons (28,700 sites x 500 tons) of hazardous contaminated media will be remediated at captive sites.

Contamination at former MGP sites is generally remediated using a combination of treatment methods. Through a review of available literature and personal communication with utility industry representatives, the Agency has concluded that, in general, ex-situ remediation is more common than in-

²² "Co-burning," which consists of blending (i.e., diluting) hazardous media with other suitable combustible media followed by burning in a utility boiler, is not affected by these LDRs.

²³ A detailed presentation of the underlying data and methodology used to arrive at these conclusions is outlined in a memorandum to Paul Borst, EPA, from ICF Incorporated, entitled *Cost of the Phase IV* Land Disposal Restrictions on Manufactured Gas Plant Wastes, dated January 28, 1998.

situ remediation. Therefore, this analysis assumes that 75 percent of the total quantity of hazardous contaminated media will be remediated using ex-situ remediation methods, and 25 percent of the total quantity will be remediated using in-situ remediation methods. The analysis further divides the ex-situ remediation quantities into three treatment categories:

- Co-Burning of Wastes in Utility Boilers (Co-Burning);
- Ex-Situ Thermal Treatment/Bioremediation (Ex-Situ TB); and
- Use Constituting Disposal (UCD).

The relative percentages and quantities for which each treatment category is used in full scale remediation efforts are estimated as follows:

- Co-Burning: 40 percent (10,740,000 tons)
 Ex-Situ TB: 30 percent (8,055,000 tons)
 UCD: 5 percent (1,342,500 tons)
 In-Situ ST: 25 percent (6,712,500 tons)
- EPA has determined that the only treatment category affected by today's rulemaking is the use constituting disposal (UCD) category.²⁴ Therefore, the Agency estimated shifts in treatment category for the quantity of waste originally (i.e., in the baseline) treated using UCD (five percent of the total volume). Site managers may choose to switch to another treatment category or may opt not to clean up at all. Because most former MGP sites are cleaned up on a voluntary basis, this analysis has estimated that only 10 percent of the baseline UCD quantity will not be cleaned up.²⁵ The Agency believes that no quantity of material will shift from UCD to co-burning post-rule because a site manager would have likely chosen the co-burning option in the baseline if that option were available. Therefore, the Agency split the remaining 90 percent of the baseline UCD quantity between Ex-Situ TB and In-Situ ST based on the overall 75/25 split between ex-situ and in-situ remediation methods. The post-rule shifts from UCD are summarized as follows:
 - Quantity not cleaned up: $1,342,500 \text{ tons } x \ 0.10 = 134,250 \text{ tons}$
 - Quantity shifted to Ex-Situ TB: 1,342,500 tons x 0.75(0.90) = 906,188 tons
 - Quantity shifted to In-Situ ST: 1,342,500 tons x 0.25(0.90) = 302,062 tons

Given these shifts and the relative use percentages outlined above, EPA calculated quantities of hazardous contaminated media treated in the baseline and post-rule for each treatment category. Exhibit 3-13 summarizes this information.

²⁵ Most MGP sites are remediated voluntarily, because a facility owner is selling the property or wishes to lower risk levels, although some clean-ups occur under federal or state mandate.

²⁴ Uses constituting disposal include asphalt, brick, and cement manufacturing. Because asphalt, brick, and some cement manufacturers are not RCRA-permitted facilities, baseline practice is assumed to consist of diluting the media to remove the characteristic and then using the decharacterized media in the production of asphalt, brick, or cement. After the effective date of the Phase IV LDRs, dilution will be prohibited and, as a result, these uses constituting disposal will be discontinued. RCRA hazardous contaminated media sent directly to a RCRA-permitted cement manufacturer without decharacterization will be unaffected, however, and is not counted in the UCD category of this analysis.

		II	Haz.	Dascuile		Post-Rule							
Facility Category	No. of Sites	Haz. Waste Tons/Site	Waste Total Tons	Tons UCD	Tons Not Rem.	Tons Ex-Situ	Tons In-Situ						
Commercial	2,500	5,000	12,500,000	630,000	63,000	420,000	140,000						
Captive	28,700	500	14,350,000	720,000	72,000	480,000	160,000						

Exhibit 3-13 Baseline and Post-Rule Treatment Quantities

The Agency also collected information on the unit treatment costs of each treatment method and calculated an average treatment cost for each treatment category. The average treatment cost for each treatment category are as follows:

•	Co-Burning:	\$135/ton
•	Ex-Situ TB:	\$235/ton
•	UCD:	\$80/ton
•	In-Situ ST:	\$61/ton

Using these average treatment costs, the Agency calculated total baseline and post-rule costs. Total baseline UCD costs and post-rule costs shifted to ex-situ and in-situ remediation are shown in Exhibit 3-14.

		Tons/Site Total Tons) 5,000 12,500,00		Baseline	Post-Rule							
Facility Category	No. of Sites	Waste	Haz. Waste Total Tons	\$ UCD	\$ Not Rem.	\$ In-Situ						
Commercial	2,500	5,000	12,500,000	50,000,000	-	99,000,000	8,500,000					
Captive	28,700	500	14,350,000	58,000,000	-	114,000,000	9,800,000					

Exhibit 3-14 Baseline and Post-Rule Treatment Costs

To determine the incremental cost associated with today's rulemaking, EPA subtracted the baseline UCD cost from the post-rule cost to arrive at a total incremental cost of \$58,000,000 for commercial sites, and \$66,000,000 for captive sites.

The analysis assumes that it takes approximately one year to clean up any given site where media contaminated with manufactured gas plant wastes exists, that it will take approximately 20 years to clean up all of the sites in the U.S., and that an equal number of sites are cleaned up each year. Therefore, the total annual incremental cost of today's rulemaking is assumed constant over a period of 20 years. EPA divided the total incremental costs of today's rulemaking by the number of commercial and captive facilities to arrive at an incremental cost per facility. Because of uncertainty regarding how the media used

in a manner constituting disposal is distributed among the 31,200 sites, EPA modeled two scenarios to determine the highest and lowest possible incremental costs and impacts. Scenario 1 assumes that five percent of the contaminated media at all sites would be affected. In other words, the total amount of hazardous media used in a manner constituting disposal is assumed to be evenly distributed across all potentially affected sites but makes up only a small percentage of contaminated media at each site. Scenario 2 assumes that the total amount of hazardous media used in a manner constituting disposal is assumed to be evenly distributed across all potentially affected sites but makes up only a small percentage of contaminated media at each site. Scenario 2 assumes that the total amount of hazardous media used in a manner constituting disposal is distributed across only five percent of MGP sites or, in other words, that only a small percentage of sites are affected, but all contaminated media at these sites is used in a manner constituting disposal. Exhibit 3-15 shows these incremental costs.

	Total	Sce	enario 1	Scenario 2					
MGP Sites	SP Sites Incremental Affected Cost Sites		Incremental Cost per Site	Affected Sites	Incremental Cost per Site				
Commercial	\$58,000,000	2,500	\$23,200	125	\$464,000				
Captive	\$66,000,000	28,700	\$2,300	1,435	\$46,000				
Total	\$124,000,000	31,200		1,560					

Exhibit 3-15 Incremental Costs of Today's Rulemaking for Sites with Media Contaminated with MGP Wastes

To evaluate the potential impacts of these costs, EPA researched the sector-specific annual revenue or value of shipments and the number of firms for the various SIC codes comprising commercial sites and three of the four categories of captive sites (excluding domestic and residential gas machines, which are discussed later). Figures for revenue or value of shipments per sector were then divided by the number of firms in the sector to calculate the average annual revenue or value of shipments per site, as shown in Exhibit 3-16.

For these categories, the Agency assessed the impacts of the costs by evaluating the ratio of annual compliance costs as a percentage of revenue or value added. The resulting impacts, under both Scenario One and Scenario Two, are estimated to be below EPA's three percent threshold level for all SIC categories, as shown in Exhibit 3-17. Impacts on owners of domestic and residential gas machines (believed to be located mansions and other large homes) were assessed indirectly. Under Scenario One, this class of captive owner will incur significant impacts only if household income is less than \$76,667 (i.e., \$2,300/0.03). This figure corresponds approximately to the 80th percentile for U.S. household income. Because mansions and other large homes with domestic or residential gas machines are likely to be owned by only the very highest-income households, significant impacts are unlikely for this category as well. Under Scenario Two, however, impacts on owners of residential gas machines are avoided only to the extent that household income exceeds \$1,527,767 (i.e., \$45,833/0.03). Data addressing household incomes at this level are not readily available. Therefore, it is possible (and perhaps likely) that some mansions and other large homes are owned by households having household incomes lower than \$1,527,767. Because cleanups for these entities are likely to be voluntary, however, owners are unlikely to conduct the cleanups if doing so would result in significant impacts. Consequently, any impact due to today's rule is unlikely, even for owners of domestic and residential gas machines under Scenario Two.

Exhibit 3-16 Revenues and Value of Shipments by SIC Code

MGP Sites	SIC Code	Number of Firms	Total Annual Revenue or Value of Shipments	Average Revenue or Value of Shipments
Commercial				
Utilities (Revenues) ²⁶				
Electric and Gas Services	491, 2, 3	11,156	\$292,030,897,000	\$26,177.026
Captive				
institutional Gas Machines (Revenues)27				· · · · ·
Hotels and Motels	7011	41,684	\$67,192,806,000	\$1,611,957
Hospitals	8062, 9063, 8069	1,403	\$28,812,975,000	\$20,536,689
Gas Producers ²⁸				
Paper and allied products	26	4,264	\$133,200,700,000	\$31,238,438
Chemicals and allied products	28	8,312	\$305,420,100,000	\$36,744,478
Petroleum and coal products	29	1,109	\$149,423,800,000	\$134,737,421
Rubber and Miscellaneous plastic products	30	13,142	\$113,592,800,000	\$8,643,494
Primary Metal Products	33	5,294	\$138,287,000,000	\$26,121,458
Fabricated Metal Products	34	32.959	\$166,532,000,000	\$5,052,702
Industrial Machinery and Equipments	35	50.911	\$258,661,400,000	\$5,080,658
Transportation equipment	37	9,878	\$399,269,300,000	\$40,420.055
Misc. manufacturing industries	39	16,564	\$39,498,300,000	\$2,384,587
Beehive Coke Works ²⁹				
Petroleum and Coal Products	2999	69	\$843,100,000	\$12.218.841

²⁶ Revenue data from U.S. Department of Commerce, Bureau of Census. 1992 Census of Transportation and Public Utilities. <u>Summary Statistics for the United States and States</u>. Table 1, p.8.

²⁷ Revenue data from U.S. Department of Commerce, Bureau of Census. 1992 Census of Services. <u>Major Sources of Receipts From Customers for the United States and States</u>. Table 2 and 47.

²⁸ Value of shipments data from U.S. Department of Commerce, Bureau of Census. 1992 Census of Manufacturing. <u>Summary of Findings: Selected Statistics with Major Groups Ranked by Value Added</u>. Table A.

²⁹ Value of shipments data from U.S. Department of Commerce, Bureau of Census. 1992 Census of Manufacturing. <u>Statistics for Industry Groups and Industries: 1992 and Earlier</u>, Table 1-1b.

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Exhibit 3-17 Impacts of Rule on Categories

MGP Sites	SIC	Average Revenue or	Scena	rio 1	Scena	rio 2
	Code	Value of Shipments	Avg Cost / Category	Economic Impact	Avg Cost / Category	Economic Impact
Commercial	•					
Utilities						
Electric and Gas Services	491, 2, 3	\$26,177,026	\$23,200	0.09%	\$464,000	1.877%
Captive						
Institutional Gas Machines					-	
Hotels and Motels	7011	\$1,611,957	\$2,300	. 0.14%	\$46,000	2.85%
Hospitals	8062, 9063, 8069	\$20,536,689	\$2,300	0.01%	\$46,000	0.22%
Gas Producers						
Paper and allied products	26	\$31,238,438	\$2,300	0.01%	\$46,000	0.15%
Chemicals and allied products	28	\$36,744,478	\$2,300	0.01%	\$46,000	0.13%
Petroleum and coal products	29	\$134,737,421	\$2,300	0.00%	\$46,000	0.03%
Rubber and Miscellaneous plastic products	30	\$8,643,494	\$2,300	0.03%	\$46,000	0.53%
Primary Metal Products	33	\$26,121,458	\$2,300	0.01%	\$46,000	0.18%
Fabricated Metal Products	34	\$5,052,702	\$2,300	0.05%	\$46,000	0.91%
Industrial Machinery and Equipments	35	\$5,080,658	\$2,300	0.05%	\$46,000	0.91%
Transportation equipment	37	\$40,420,055	\$2,300	0.01%	\$46,000	0.11%
Misc. manufacturing industries	39	\$2,384,587	\$2,300	0.10%	\$46,000	1.93%
Bechive Coke Works						
Petroleum and Coal Products	2999	\$12,218,841	\$2,300	0.02%	\$46,000	0.38% ·

3.5 Class I UIC Wells

Results of the capacity analysis (conducted under a different work assignment) indicate that there are only two facilities injecting newly identified mineral processing wastes into Class I UIC wells that might be affected by the Phase IV LDRs. Both of these facilities are owned by the same firm.

Other facilities inject newly identified mineral processing waste but are unaffected either because the facility has an approved no migration petition for its well or because the facility's waste has been decharacterized and meets the requirements of the Land Disposal Program Flexibility Act.

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One of the two potentially affected facilities is in the process of building a treatment plant to comply with a consent order to cease injecting in its wells by July 1998.³⁰ The cost of the treatment system is a result of the consent order, and therefore, is not attributable to the Phase IV LDRs.

The firms other facility has submitted a no migration petition to continue injecting its waste without treatment. It is unclear whether the petition will be approved. If the petition is rejected, the company could attempt to modify and resubmit the petition or it could build a treatment system. As a result, EPA has developed three cost estimates:

- The minimum cost estimate assumes that the petition is approved and that there are no costs attributable to the rulemaking.
- The intermediate cost estimate assumes that the petition will be rejected initially and be resubmitted for approval. The revised petition is assumed to have an 86 percent chance of approval and a 14 percent chance of being rejected.³⁷ Thus, the intermediate cost equals the sum of the cost of modifying a no migration petition plus 14 percent of the cost of building a treatment system (i.e., the expected value cost).
- The maximum cost estimate assumes that the original petition would be rejected and the facility would incur the cost of building the treatment system on-site.

The analysis assumes the up-front cost of modifying a no migration petition is \$98,000,³² which is equivalent to an annualized cost of \$9,250 over 20 years, assuming a 7 percent interest rate. To calculate the cost of building a treatment system, the facility's reported flow rate in gallons per minute was converted to metric tons per year. EPA then applied the cost equations used earlier in this RIA to estimate the annualized treatment cost to build and operate a treatment system. Application of the assumptions outlined above results in an estimated minimum cost of \$0, an intermediate annualized cost of \$530,000, and a maximum annualized cost of \$3,700,000.

To determine if these additional costs would significantly impact the owner of the facility, these costs were then added to the other costs to the facility as previously estimated in this RIA. The Agency then calculated revised firm specific ratios (cost/sales and cost/carnings) for the minimum, intermediate, and maximum cost estimates, and compared these ratios to the threshold value for significant impacts of three percent. No significant impacts are expected under either indicator.

³⁰ It appears that the wells are screened into a drinking water source, which is impermissible under the UIC program. While the company disputes this finding, it signed a consent order to avoid litigation.

³⁴ Analysis of the Effects of EPA Restrictions on the Deep Well Injection of Hazardous Waste, US EPA, Office of Ground Water and Drinking Water, EPA 570/9-91-031, October 1991.

³² Regulatory Impact Analysis of Proposed Hazardous Waste Disposal Restrictions for Class I Injection of Phase III Wastes (p. 3-2).

4. BENEFITS ASSESSMENT

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The potential human health and ecological benefits of the proposed LDRs for mineral processing arise from reduced releases of toxic waste constituents to the environment as a result of regulatory controls. These reductions in release translate into reduced exposures and reduced risks to human health and ecological receptors. This section describes the approaches that have been taken to evaluating risks to human health and the environment associated with waste disposal and with storage of recycled materials. A conservative generic risks assessment methodology was first used to assess potential health risks associated with groundwater and non-groundwater exposure pathways, and to identify potential high-risk mineral processing waste streams and facilities. Reductions in potential risks that may be associated with improved controls on the storage of recycled mineral processing streams were also calculated. Finally, EPA gathered site-specific data regarding a group of facilities which generate and manage the potential high-risk streams, and identified specific concerns associated with land management units, exposed populations, potential exposure pathways, and documented instances of environmental contamination.

4.1 Risk and Benefits Assessments Methodologies

4.1.1 Overview of Risk and Benefits Assessment Activities

In developing this RIA, a number of efforts have been undertaken to evaluate the risks associated with mineral processing wastes disposal and storage and to assess the health benefits associated with changes in management practices under the proposed LDRs. These efforts have evolved in parallel with changes in the definitions of the baseline assumptions and with changes in the regulatory options that have occurred during the regulatory development process. Much of the work done early in the development of the rule analyzes baseline assumptions and regulatory options that are to some degree different from those currently being considered. Most significantly, the initial focus of the risk and benefit assessment was the no prior treatment baseline, and changes in risk associated with waste disposal. As the regulatory development process progressed, however, the focus shifted to measuring the benefits of changes in storage practices for recycled materials assuming the modified prior treatment baseline.

All of the quantitative risk methodologies described below employ conservative generic methodologies, and do not provide definitive information about population health risks or risk reduction benefits for actual exposed populations. The generic level methodologies are not site-specific, and they employ proxy assumptions about facility characteristics, exposure pathways, receptors, and receptor behavior as a substitute for site-specific data. Exposed populations living near actual mineral processing facilities were not at first identified or enumerated, and the applicability of the various exposure pathways that are evaluated to these populations was not verified. Cancer risks and noncancer hazards are calculated for hypothetical individuals under the generic exposure conditions. The specific assumptions used in the risk assessment have been derived by EPA in the course of numerous regulatory analyses under RCRA, and they are generally considered to provide conservative, but plausible estimates of individual exposures and risks.

In keeping with the most current regulatory guidance, the Agency has explored the possibility of performing site-specific quantitative risk analyses for those facilities identified as generating high-risk wastes. As will be discussed in Section 4.3, however, the Agency concluded that the available data could not support such an analysis, and qualitative descriptions of potential risks at these facilities were developed instead.

Generic Risk and Benefits Assessment for the Waste Disposal

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The initial risk assessment effort involved the development of risk and risk reduction estimates for the wasted (unrecycled) portions of the mineral processing waste streams, measured against the no prior treatment baseline. The assessment was limited to health risks arising from groundwater exposures. In this initial analysis, groundwater exposure concentrations were calculated using dilution-attenuation factor values (DAFs) derived by EPA for use in previous regulatory analyses. The DAFs were based solely on unit characteristics, and did not take into account the geochemical properties of the waste constituents. Risks were calculated using mean constituent concentrations estimated for each waste stream, and benefits were estimated in terms of "facility-waste stream combinations" the numbers of facilities at which given risk reductions would be achieved through imposition of the LDRs. The results of this assessment were summarized in the December 1995 Draft Mineral Processing LDRs RIA.

Subsequent to the October 1995 RIA, EPA conducted sensitivity analyses to better evaluate potential sources of uncertainty in the risk and benefits assessment for the RIA. As a result of this analysis, the risk and benefits assessment were revised, using constituent concentrations from individual waste samples, instead of mean values, to calculate risks. As in the previous effort, the benefits were calculated relative to the no prior treatment baseline. This analysis was also presented in the December 1995 Draft RIA.

For the final analysis of the potential risks associated with the disposal of mineral processing wastes, EPA employed DAF values that were derived specifically for waste management units from the mineral processing industry and which took into account differences in geochemical properties of the waste constituents. Except for this, this assessment was identical to that described in the previous paragraph, and evaluated benefits from changes in waste disposal relative to the no prior treatment baseline. The methods used and results are described in detail in Appendices A.2 and A.3 of this RIA.

Generic Risk Assessment for the Storage of Recycled Streams

As noted above, as the regulatory development process has progressed it has become clear that the major potential risk reduction for the regulatory options currently under consideration are those associated with improvements in the storage of recycled materials. The analysis described in Section 4.2 therefore focuses on the recycled streams, and on the risks associated with storage, rather than only with the disposal of the wasted portions of the streams. In this effort, EPA has assessed health risks both for groundwater exposure, as in the previous analysis, and for non-groundwater direct and indirect exposure pathways.

Risks are assessed for 14 waste streams that EPA has identified as being recycled and for which constituent concentration data were available. These 14 streams account for 40 percent of the total mineral processing waste generation, and for about 65 percent of the recycled volume. EPA derived groundwater DAF values specifically for land-based recycling units, and specifically for each waste constituent. EPA assessed non-groundwater risks associated with the storage of recycled materials using methods generally similar to those used to derive the proposed Exit Concentrations under the Hazardous Waste Identification Rule. These methods are described in detail in Appendix J.

No quantitative benefits assessment has been performed for the stored materials. This is because, under regulatory Option 1, recycled materials would be stored in tanks, containers, or buildings (TCBs) or in limited cases, on approved pads, and no data or satisfactory models are available which would allow the estimation of risks associated with these management units. Under Option 2, it is assumed that recycled materials would be stored in land-based units, and no health benefits from improved storage would be realized relative to the baseline.

Thus, for recycled materials management, EPA has estimated only potential baseline risks. These potential risks represent upper-bound estimates of the achievable health benefits if releases to the environment are completely abolished under the regulatory options under the modified prior treatment baseline.

4.1.2 Risk and Benefits Assessment Methods for the Storage of Recycled Materials

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As discussed in Section 4.1.1, a generic risk assessment has been performed for the storage of recycled materials under the modified prior treatment baseline. Under this baseline, (as under the no prior treatment baseline), all recycled streams are assumed to be stored in unlined land storage units prior to recycling. Streams were included in the analysis if EPA identified them as having non-zero recycled volumes under the "expected" cost scenario. Liquid waste streams were eliminated from the risk assessment if the estimated annual recycled volume was so low (less than 500 tons per year) that storage in land units would not be cost-effective. Based on these criteria, 14 streams were included in the risk assessment for stored materials, as shown in Exhibit 4-1. The waste constituent data used as inputs to this analysis are found in Appendix K.

Commodity	Recycled Stream
Aluminum and Alumina	Cast House Dust
Beryllium	Chip Treatment Wastewater
Beryllium	Spent Barren Filtrate
Copper	Acid Plant Blowdown
Elemental Phosphorus	Furnace Scrubber Blowdown
Rare Earths	Process Wastewater
Selenium	Plant Process Wastewater
Tantalum, Columbium, and Ferrocolumbium	Process Wastewater
Titanium and Titanium Oxide	Leach Liquor and Sponge Wastewater
Titanium and Titanium Oxide	Scrap Milling Scrubber Water
Zinc	Waste Ferrosilicon
Zinc	Spent Surface Impoundment Liquids
Zinc	Waste Water Treatment Plant Liquid Effluent
Zinc	Process Wastewater

Exhibit 4-1 Recycled Streams Included in the Storage Risk Analysis

All but two of these streams are wastewaters (WW) or liquid nonwastewaters (LNWW), for which the least-cost management unit is a surface impoundment. The remaining two streams (aluminum cast house dust and zinc waste ferrosilicon) are nonwastewaters (NWW), for which the least-cost management unit is a waste pile.

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Constituent concentration data were available from a total of 191 samples from the recycled materials, only three of which are of the two NWW streams, with the remainder representing WW and LNWW streams. Among these, 148 were bulk analytical results, and 42 were EP extraction analysis. Of the available samples, 138 had concentration data for constituents having toxicity criteria values that could be used in quantitative risk assessment. Again, three of the samples were from NWW streams. The data used to derive constituent-specific DAFs for stored recycled streams are summarized in Appendix K.

Although storage risks were calculated for only 14 of the 121 total mineral processing waste streams (due to a lack of constituents concentration data for the remaining streams), these streams represent a substantial proportion of the total generated wastes and an even higher proportion of the recycled wastes. Depending on which estimate of waste generation is used (minimum, expected, or maximum), the 14 recycled streams included in the risk analysis represent between approximately 32 and 42 percent of the total waste generation, and account for between 57 and 68 percent of the total recycled volume. This is because constituent concentration data are available for a substantial proportion of the high-volume waste streams. The extent of coverage of the storage risk assessment for the various commodity sectors is discussed in Appendix J.

To estimate groundwater exposure concentrations, bulk concentrations or adjusted EP constituent concentrations from each waste sample were divided by central tendency (CT) and high-end (HE) DAF values. The DAF values were derived specifically for the size and configuration of units (waste piles and surface impoundments) estimated in the cost and economic analysis as being necessary to contain recycled materials at representative size facilities in each commodity sector. DAF derivations were performed employing regionally representative ground-water transport parameters and climatological data for those facilities where these data were not available, or whose location was not known.

In evaluating potential risks, the 75th percentile constituent-specific DAFs were used to estimate central tendency (CT) groundwater concentrations. The rationale for using the 75th percentile DAFs rather than, for example, the 50th percentile value was that the EPACMTP model used to derive DAFs does not consider fractured or channeled flow or other facilitated transport mechanisms which may occur at some sites, resulting in higher groundwater concentrations than those predicted for homogeneous flow processes modeled by EPACMTP. The 95th percentile constituent-specific DAF values were used to estimate high-end (HE) groundwater concentrations, in keeping with the definition of a high-end receptor as someone exposed at levels between the 90th and 99th percentiles of all exposed individuals.

Risks for groundwater exposures were calculated assuming groundwater would be used as a drinking water supply by residents living near the management units for substantial proportions of their lives. Cancer risks were calculated for exposures to inorganic arsenic²⁸ using the Cancer Slope Factor (CSF) value from EPA's IRIS data base. For all other constituents, noncancer hazard quotients were calculated using EPA's chronic ingestion pathway Reference Doses (RfDs). The DAF values derived for mineral processing storage units, along with the exposure factor values and equations used to estimate groundwater pathway risks, are provided in Appendix J.1.

²⁸ Consistent with previous risk assessment efforts for mineral processing wastes, EPA chose not to model the potential ingestion pathway cancer risks associated with exposure to beryllium because, although beryllium has an approved Cancer Slope Factor in the IRIS data base, the value is currently under review, and there is a substantial degree of uncertainty surrounding the activity of beryllium as an ingestion pathway carcinogen.

Non-groundwater pathway risks for land storage of recycled materials were estimated using a variety of models, most of which generally follow the methods described in EPA's Technical Support Document for the proposed "HWIR-Waste" exit level derivation.²⁹ Exhibit 4-2 identifies the non-groundwater release events and exposure pathways for which risks were evaluated, and provides brief descriptions of the methods used to estimate exposures and risks. The release events that were evaluated for waste piles include air particulate generation by wind disturbance and materials handling, and surface run-off caused by rainfall. For surface impoundments, releases due to run-on and inlet/outlet control failure events were evaluated. Owing to the nature of the constituents being evaluated (all inorganics), volatilization release events were not considered.

The transport and exposure media which were evaluated included air, soils, home-grown vegetables, surface water, and game fish. Exposure pathways and exposure factor values were generally consistent with the child/adult resident, subsistence farmer, and subsistence fisher receptors used in the proposed HWIR-Waste exit level determination. Cancer risks and noncancer hazard quotients were calculated for all pathways using standard pathway models and ingestion and inhalation pathway toxicological parameters from IRIS. The methods used to estimate exposures and to evaluate risks from the storage of recycled materials through non-groundwater pathways are described in detail in Appendix J.2.

4.2 Generic Risk and Benefits Assessment Results

4.2.1 Risk Assessment Results for Recycled Materials Storage: Groundwater Pathway

Exhibit 4-3 summarizes the carcinogenic groundwater risk results for the 75 samples identified as containing arsenic, the sole ingestion pathway carcinogen among the waste constituents. Using the CT DAF values, the calculated cancer risks for 48 of these samples were less than 10^{-5} , the level of regulatory concern, and the risks for 27 of the samples exceeded this value. Cancer risks exceeded 10^{-5} for one or more samples from only five waste streams; beryllium spent barren filtrate, copper acid plant blowdown, elemental phosphorus furnace scrubber blowdown, tantalum, columbium, and ferrocolumbium process wastewater, and zine spent surface impoundment liquids. The highest cancer risks were associated with three samples of copper acid plant blowdown (10^{-3} to 10^{-2}). This waste stream accounted for 14 of the 16 samples with the highest CT cancer risks. The next highest risks (in the 10^{-4} to 10^{-3} range) were associated with one sample each from tantalum process wastewater and zine spent surface impoundment liquids.

²⁹ U.S. EPA, Technical Support Document for the Hazardous Waste Identification Rule: Risk Assessment for Human and Ecological Receptors, Office of Solid Waste, August 1995.

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Unit Type	Release Event/ Medium	Transport Medium I	Transport Medium II	Transport Medium III	Exposure Pathway	Receptors	Modeling Approaches
Waste Pile	Particulate Generation by Wind, Materials Handling	Air			Inhalation	Adult Resident	SCREEN3 (Emissions) ISCST3 (Deposition) HWIR (Exposure/Risk)
		Air	Soil (deposition)		Ingestion	Child/Adult Resident	HWIR-Waste (Exposure/Risk)
					Dermal	Child Resident	HWIR-Waste
		Air	Soil (deposition)	Crops	Ingestion	Subsistence Farmer	HWIR-Waste, modified for non- steady-state conditions (concentration in crops, vegetable intake, risk)
		Air	Soil/Water	Surface Water/Fish	Ingestion	Subsistence Fisher	Bounding analysis (100 percent deposition in water body)
Waste Pile	Runoff	Soil			Ingestion	Child Resident	Bounding analysis; 100 percent runoff to adjacent garden/yard, HWIR-Waste (exposure and risk)
		Soil			Dermal	Child Resident	Bounding analysis; 100 percent runoff to adjacent garden/yard, HWIR-Waste (exposure and risk)
		Soil	Сторѕ		Ingestion	Subsistence Farmer	Bounding Analysis; HWIR- Waste
		Soil		Surface Water/Fish	Ingestion	Subsistence Fisher	Bounding analysis (100 percent deposition in water body)
Surface Impoundment	Control/Berm Failure	Surface Water			Ingestion	Adult Resident	HWIR-Waste (Release algorithms, exposure, drinking water ingestion)
		Surface Water	Fish		Ingestion	Subsistence Fisher	HWIR-Waste (Releases, dilution, fish ingestion, risk)

Exhibit 4-2
Release and Exposure Pathway Modeling Summary for Mineral Processing Storage Risk Assessment

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		Number of Samples		Ce	ntral T	endenc	y		High End						
Commodity	Waste Stream	with Cancer Risk	<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1	<10-5	10-5 `to 10-4	10-4 to 10-3	to	to	>10-1	
Aluminum, Alumina	Cast house dust	2	2	0	0	0	0	0	2	0	0	0	0	0	
Beryllium	Chip treatment WW	1	1	0	0	0	0	0	1	0	0	0	0	0	
Beryllium	Spent Barren Filtrate	1	1	0	0	0	0	0	1	0	0	0	0	0	
Copper	Acid plant blowdown	30	9	7	8	3	3	0	5	3	5	8	5	4	
Elemental Phosphorus	Furnace scrubber blowdown	8	7	1	0	· 0	0	0	3	3	2	0	0	0	
Rare Earths	PWW	2	2	0	0	0	0	0	·0	2	0	0	0	0	
Selenium	Plant PWW	2	2	0	0	0	0	0	0	1	I	0	0	0	
Tantalum, ctc. ¹	PWW	13	10	2	1	0	0	0	7	3	0	3	0	0	
Fitanium and TiO2	Leach liquor & sponge wash water	2	2	0	0	0	0	0	0	1	1	0	0	0	
Titanium and TiO2	Scrap milling scrubber water	1	I	0	0	0	0	0	0	1	0	0	0	0	
Zinc	Waste ferrosilicon	0	0	0	0	0	0	0	0	0	0	0	0	0	
Zinc	Spent S.I. liquids	1	0	0	1	0	0	0	0	0	0	0	1	0	
Zinc	WWTP liquid effluent	0	0	0	0	0	0	0	0	0	0	0	0	0	
Zinc	Process wastewater	- 11	- 11	0	0	0	Ó	0	7	1	3	0	0	0	
		<u> </u>	[-					
Total		75	48	11	10	3	3	· 0	26	15	13	1İ	6	4	

Exhibit 4-3 RISK SUMMARY FOR STORAGE OF RECYCLED MATERIALS Distribution of Samples by Groundwater Risk Category: Cancer Risks

1. Tantalum, Columbium, and Ferrocolumbium

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Using the high-end (HE) DAF values, cancer risks calculated for the groundwater pathway exceeded 10^{-5} for 49 of the 75 samples. Under this set of assumptions, risks for at least one sample exceeded 10^{-5} for 11 of the 14 waste streams evaluated. The highest risks (25 of 30 samples > 10^{-5} , highest risk category > 10^{-1}) were again associated with copper acid plant blowdown, with the next highest risk (10^{-2} to 10^{-1}) being associated with the single sample of zinc spent surface impoundment liquids. Of the wastes whose CT cancer risks were below 10^{-5} for all samples, five (rare earths process wastewater, selenium plant wastewater, titanium/TiO₂ leach liquor and sponge wash water and scrap milling scrubber water, and zinc process wastewaters), had at least one sample with HE cancer risks above this level.

Cancer risks for most of the samples increased about two orders of magnitude from the CT to HE case. This is consistent with the difference between the CT and HE DAF values for arsenic managed in surface impoundments. In the case of the NWW waste streams managed in piles, both the CT and HE cancer risks for all samples were below 10⁻⁵. For aluminum/alumina cast house dust, this reflected the much higher CT and HE DAF values for arsenic managed in waste piles, compared to surface impoundments. Arsenic was not detected in the single sample of waste ferrosilicon from zinc production. Thus, no carcinogenic risks were calculated for this waste. The two other streams for which all HE sample-specific cancer risks were below 10⁻⁵ were beryllium chip treatment wastewater and zinc wastewater treatment plant liquid effluent.

Noncancer hazard quotient values for the groundwater pathway for the individual samples of recycled materials are summarized in Exhibit 4-4. Using the CT DAF values, hazard quotients exceeding 1.0 were calculated for 46 of 136 total samples from the 14 waste streams. As was the case for cancer risks, copper acid plant blowdown had the highest number of samples with noncancer hazard quotients above 1.0 (18 of 35 samples), and had the highest number of samples (4) in the highest-risk category (HQ from 100 to 1000). Samples from zinc production (11 of 22 for spent surface impoundment liquids and 8 of 16 for process wastewater) account for the bulk of the remaining hazard quotients above 1.0. The only other waste streams with CT hazard quotients above 1.0 included beryllium spent barren filtrate (three samples), beryllium chip treatment wastewater (one sample), elemental phosphorus furnace scrubber blowdown (one sample), tantalum process waste water (three samples), and zinc wastewater treatment plant liquid effluent (one sample).

When the HE DAF values are used to calculate exposures, hazard quotients exceed 1.0 for 102 of the 136 samples. As was the case for cancer risks, most of the hazard quotient values for individual samples are increased one to two orders of magnitude in the HE case compared to the CT case, reflecting the higher HE DAF values for the risk-driving constituents managed in surface impoundments. As for cancer risks, both the CT and HE DAF values for waste piles for all of the constituents are so high that no samples of either of the two streams stored in waste piles have hazard quotients exceeding 1.0 in either the CT or HE case. Hazard quotient values for one or more samples from four waste streams (rare earths process wastewater, selenium process wastewater, and titanium/TiO2 leach liquor and sponge wash water and scrap milling scrubber sludge) which were all below 1.0 in the CT case exceeded 1.0 in the HE case.

		Number of Samples with		. Ce	entral '	l`enden	cy				High	1 End		
Commodity	Waste Stream	Non- cancer Hazard	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k
Aluminum, Alumina	Cast house dust	2	2	0	0	0	0	0	2	0	0	0	0	0
Beryllium	Chip treatment WW	1	0	0	1	0	0	0	0	0	0	0	l	0
Beryllium	Spent Barren Filtrate	4	1	3	0	0	0	0	0	1	3	0	0	0
Copper	Acid plant blowdown	35	17	10	4	4	0	0	3	7	12	7	4	2
Elemental Phosphorus	Furnace scrubber blowdown	14	13	1	0	0	0	0	4	4	5	I	0	0
Rare Earths	PWW	4	4	0	0	0	0	0	2	2 ·	0	0	0	0
Selenium	Plant PWW	2	2	0	0	0	0	0	0	2	0	0	0	0
Tantalum, etc. 1	PWW	. 21	18	3	0	0	0	0	13	3	0	5	· 0	0
Titanium and TiO2	Leach liquor & sponge wash water	2	2	0	0	0	0	0	0	1	1	0	0	0
Titanium and TiO2	Scrap milling scrubber water	1	1	0	0	0	0	0	0	1	0	0	0	. 0
Zinc	Waste ferrosilicon	1	1	0	0	0	0	0	1	0	0	0	0	0
Zinc	Spent S.I. liquids	22	n	5	4	2	0	0	4	3	2	7	2	4
Zinc	WWTP liquid effluent	3	2	0	0	1	0	0	0	1	1	0	· 0	1
Zinc	Process wastewater	24	16	7	1	0	0	0	5	4	5	8	2	0
Totals		136	90	29	10	7	0	0	34	29	29	28	9	7

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Exhibit 4-4 RISK SUMMARY FOR STORAGE OF RECYCLED MATERIALS Distribution of Samples by Groundwater Hazard Category: Non-Cancer Hazards

1. Tantalum, Columbium, and Ferrocolumbium

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4.2.2 Potential Benefits From Control of Stored Materials: Groundwater Pathway

The cancer risk results for the individual samples, distributed across the numbers of facilities generating and storing the wastes, are summarized in Exhibit 4-5. Using the methods described in Section 4.1.2, EPA has estimated that CT screening level groundwater pathway cancer risks would exceed 10⁻⁵ at approximately 11 of the 56 facility-waste stream facilities.³⁰ All of these facility-waste stream combinations were managing copper acid plant blowdown (7 facility-waste stream combinations), zinc spent surface impoundment liquids (3 combinations), or beryllium spent barren filtrate (one combination). These results, of course, generally reflect the pattern of sample-specific risk results for the various commodity sectors. It should be noted, however, that for two waste streams, findings of one or more sample with greater than 10⁻⁵ risks did not translate into any facility-waste combinations above 10⁻⁵ risks. In the case of elemental phosphorus furnace scrubber blowdown, only one of eight samples had a cancer risk of just above 10⁵. Distributed across only two facilities estimated to be storing this waste, this result (one-seventh of the samples having risks above 10^{-5}) was rounded down to zero. Similarly, in the case of selenium plant process wastewater, a finding of hazard quotients greater than 1.0 at three of 13 facilities translates into zero of two facility-waste stream combinations. This occurrence is the almost inevitable result of having so few facilities in some of the commodity sectors, and the fact that non-integral numbers of waste-stream facility combinations are meaningless as risk or benefit indicators. It would be reasonable to interpret these results as indicating that either zero or one facility in these industries might have a CT cancer risk above 10^{-5} . Finally, the single facility managing beryllium chip treatment wastewater was placed in the 10^{-5} - 10^{-4} CT cancer risk category. Since there were only there were only two samples of this waste, one falling into this category, and one falling into the next lower risk category, the facility could also have been placed in the lower category.

When HE DAF values are used, the number of facility-waste stream combinations with cancer risks above 10⁻⁵ increases to 23 of 56 facilities. Under HE assumptions, most of the waste streams show one or more facilities at risk levels above 10⁻⁵. The exceptions include both the two NWW streams that would be stored in waste piles, as well as beryllium chip treatment wastewater and zinc wastewater treatment plant liquid effluent. As noted previously, arsenic is not reported as a constituent of the latter waste.

 30 Note that the totals in the risk categories do not sum exactly due to rounding. This is true for the following exhibit as well.

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		Waste St	Number of Waste Stream- Facility			Central Tendency							High End						
		Combina	Combinations		10-5	10-4	10-3	10-2			10-5	10-4	10-3	10-2					
Commodity	Waste Stream	Central Tendency	High End	<10-5	to <u>10-4</u>	to 10-3	to 10-2	to 10-1	>10-1	<10-5	to 10-4	to 10-3	to 10-2	to 10-1	>10-1				
Aluminum, Alumina	Cast house dust	23	23	23	0	0	U	0	0	23	0	0	0	0	0				
Beryllium	Chip treatment WW	2	2	2	0	0	0	0	0	2	0	0	0	0	0				
Beryllium	Spent Barren Filtrate	ļ	1	0	L	0	0	0	0	0	0	I	U	0	0				
Copper	Acid plant blowdown	10	10	3	2	3	i	I	0	2	1	2	2	2	2				
Elemental Phosphorus	Furnace scrubber blowdown	2	2	2	0	0	0	0	0	1	1	1	0	0	0				
Rare Earths	PWW	1	1	1	0	0	0	0	0	0	1	0	0	0	0				
Selenium	Plant PWW	2	2	2	0	0	0	υ	0	0	1	1	0	0	0				
Tantalum, etc. ¹	PWW	2	2	2	0	0	0	0	0	1	1	0	0	0	0				
Titanium and TiO2	Leach liquor & sponge wash water	2	2	2	0	0	0	0	0	0	I	I	0	0	0				
Titanium and TiO2	Scrap milling scrubber water	1	1	1	0	0	0	0	0	0	ł	0	0	0	0				
Zinc	Waste ferrosilicon	1	1	0	0	0	0	0	0	0	0	0	0	0	0				
Zinc	Spent S.I. liquids	3	3	0	0	3	0	0	0	0	0	0	0	3	0				
Zinc	WWTP liquid effluent	3	3	0	0	0	0	0	0	0	0	0	0	0	0				
Zinc	Process wastewater	3	3	3	0	0	U	0	0	2	0	1	0	0	0				
TOTAL 2		56	56	40	3	6	1	I	0	31	7	6	3	5	2				

Exhibit 4-5 RISK SUMMARY FOR STORAGE OF RECYCLED MATERIALS Distribution of Waste Stream/Facility Combinations by Groundwater Risk Category: Cancer Risks

1. Tantalum, Columbium, and Ferrocolumbium

2. Sums by risk category may not add to the number of central or high-end waste stream/facility combinations due to rounding.

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The distribution of facility-waste stream combinations by noncancer risk category is summarized in Exhibit 4-6. Using the CT DAF values, 12 facility-waste stream combinations are identified as having noncancer hazard quotients greater than 1.0. Five of these facilities are managing copper acid plant blowdown, two are managing beryllium chip treatment wastewater, and two of the facility-waste stream combinations are associated with the management of zinc spent surface impoundment liquids.

Using HE DAF values, 26 facility-waste stream combinations are identified as being associated with noncancer hazard quotients above 1.0. Again, four waste streams have no facility-waste stream combinations with hazard quotients above levels of concern: aluminum/alumina cast house dust, rare earth chip treatment wastewater, tantalum process wastewater, and zinc spent waste ferrosilicon.

As discussed previously, if regulatory options completely abolish groundwater releases from the mineral processing storage units, post-LDR risks for all of the waste stream-facility combinations would drop below levels of concern. Thus, the numbers of facilities above levels of concern in Exhibits 4-5 and 4-6 provide an upper-bound estimate of the regulatory benefits, in terms of groundwater risk reduction, that might be achieved by Option 1, under which all recycled materials would be stored in tanks, containers, and buildings.

The extent to which these benefits might actually be realized is difficult to predict without explicit modeling of releases from the tanks, containers, and buildings. These technologies would probably provide substantial risk reduction for most wastes, but EPA does not have sufficient data to estimate the level of risk reduction. Probably those streams with storage risks which just exceed levels of concern would be more likely to fall below levels of concern if managed in TCBs than those streams for which risks exceed levels of concern by many orders of magnitude, because a lower degree of control would be necessary to control these risks. EPA also believes that it will be easier to manage the low-volume recycled streams to achieve high levels of control than it will be to manage the higher volume streams.

4.2.3 Generic Risk Assessment Results for Storage of Recycled Materials: Non-Groundwater Pathways

The health risks associated with recycled materials storage that were calculated for most of the non-groundwater release events and exposure pathways under the modified prior treatment baseline were below levels of concern (lifetime cancer risk less than 10⁻⁵, hazard quotients less than 1.0). All risks under HE and CT assumptions were below these levels for the following release events/exposure pathway combinations:

- Inhalation of airborne particulate;
- Ingestion and dermal contact with soil contaminated by airborne particulate;
- Ingestion of crops grown in soil contaminated by airborne particulate;

		Number Waste Str			Ce	entral '	Fenden	cy				Hig	n End		
Commodity	Waste Stream	Facilit <u>Combina</u> Central Tendency	-	<1	1 to 10	10 to 100	100 to 1k	1 k to 10 k	>10k	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k
Aluminum, Alumina	Cast house dust	23	23	23	0	O	0	0	0	23	0	0	0	0	0
Beryllium	Chip treatment WW	2	2	0	0	2	0	0	0	0	0	0	0	2	0
Beryllium	Spent Barren Filtrate	1	L	0	I	0	0	0	0	0	0	1	0	0	0
Copper	Acid plant blowdown	10	10	4	3	1	1	0	0	ł	2	3	2	1	1
Elemental Phosphorus	Furnace scrubber blowdown	2	2	2	0	0	0	0	0	1	1	1	. 0	0	0
Rare Earths	PWW	1		1	0	0	0	0	0	1	0	0	0	0	0
Selenium	Plant PWW	2	2	2	0	0	0	0	0	0	2	0	0	0	0
Tantalum, etc. 1	PWW	2	2	2 2	0	0	0	0	0	1	0	0	0	0	0
Titanium and TiO2	Leach liquor & sponge wash water	2	2	2	0	0	0	0	0	0	1	I	0	0	0
Titanium and TiO2	Scrap milling scrubber water	1	1	1	0	0	0	0	. 0	0	I	0	0	0	0
Zinc	Waste ferrosilicon	1	1	1	0	0	0	0	0	1	0	0	0	0	0
Zinc	Spent S.I. liquids	3	3	2	0	1	1	0	. 0	0	0	0	1	0	1
Zinc	WWTP liquid effluent	3	3	2	0	0	1	0	0	0	1	I	0	0	1
Zine	Process wastewater	3	3	2	I	0	0	0	0	1	I.	1	1	0	0

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Exhibit 4-6 **RISK SUMMARY FOR STORAGE OF RECYCLED MATERIALS**

Tantalum, Columbium, and Ferrocolumbium
 Sums by hazard category may not add to the number of central or high-end waste stream/facility combinations due to rounding.

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- Ingestion and dermal contact with soil contaminated by surface run-off;
- Ingestion of crops grown on soil contaminated by surface run-off;
- Ingestion of surface water contaminated by airborne particulate and surface runoff and:
- Ingestion of game fish harvested from surface water contaminated by airborne particulate and surface run-off.

All of the pathways identified are complete only for waste piles. Thus, these findings indicate, as was the case for the groundwater pathway, that all non-groundwater risks for the two recycled streams stored in waste piles are less than levels of concern. In almost all cases, estimated cancer risks and noncancer hazard quotients were far below the defined levels of concern (usually by more than one order of magnitude). The only exception among all of these pathways was the HE inhalation pathway hazard quotient for barium inhalation from aluminum cast house dust, which was 0.19, or five times below the level of concern. Detailed risk results for these pathways are given in Appendix H.2.

The only pathways for which some risks exceeded levels of concern were ingestion of surface water contaminated by surface impoundment failure, and ingestion of fish harvested from waters contaminated by surface impoundment failures. Exhibit 4-7 summarizes the results of the comparison of surface water concentrations resulting from impoundment releases to HBLs for the water ingestion pathway.

Because there are multiple samples available for most of the waste streams managed in surface impoundments, the results of the comparison to HBLs are reported in terms of the numbers of samples and recycled streams for which the HE and CT surface water concentrations from impoundment releases exceed the HBLs, presented in order-of-magnitude categories.

Releases from surface impoundment failures were modeled as resulting in potential exceedances of HBLs for water ingestion for three constituents: arsenic, cadmium, and lead. Under high-end dilution assumptions, the arsenic concentrations in five samples (four bulk samples, one EP extraction) would exceed the drinking water HBL by up to one thousand-fold. (This is equivalent, in this case, to saying that the estimated cancer risks under HE assumptions would exceed the 10⁻⁵ level of concern by up to a factor of 1000.) All of these samples came from the copper acid plant blowdown stream, and under CT dilution assumptions the surface water concentration for arsenic exceeds the HBL for only one of the 40 total samples of this stream.

	СОМРА	RISON OF SURFACE	то н	EALTH	ATIONS I -BASED WATER P	LEVEL	.S ¹	CE IMPOU	NDMEN	T RELEAS	SES	
				Surfac Conce fron	h-End ce Water ntration 1 Bulk mples	Conc		ace Water from EP amples	Surfac Conce from	Tendency ce Water entration n Bulk mples	Surfac Concentr EP Ext	Tendency e Water ation from traction aples
				Exceed	mples ling HBL by:	Samp	oles Excee by:	ding HBL	Exceed	mples ling HBL by:	-	Exceeding L by:
Constituent	Commodity	Waste Stream	Total Samples	1-10x	10-100x	1-10x	10-100x	100-1000x	1-10x	10-100x	1-10x	10-100
Arsenic	Copper	Acid Plant blowdown	40	3	1.			l			l	
Cadmium	Zinc	Spent Surface Impoundment Liquids	24	I								
Lead	Copper	Acid Plant Blowdown	40	1								
•	Zinc	Spent Surface Impoundment Liquids	24	1	- 1					,		

Exhibit 4-7 RISK SUMMARY FOR STORAGE OF RECYCLED MATERIALS

1. The HBL for Arsenic corresponds to a 10-5 lifetime cancer risk. The HBL for cadmium corresponds to a noncancer hazard quotient of 1.0, and the HBL for lead is the MCL.

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The concentration of cadmium in one of 24 samples from the zinc spent surface impoundment liquid stream results in surface water concentrations exceeding the drinking water HBL under HE assumptions. The HBL is exceeded by a factor of ten or less. Under CT assumptions, there are no surface water exceedances for cadmium. For cadmium, an HBL exceedance corresponds to a hazard quotient value exceeding 1.0 for its critical toxic effect on kidney function. The lead concentrations in bulk samples from two waste streams result in estimated surface water concentrations exceeding the drinking water HBL. One sample of copper acid plant blowdown shows a concentration of lead such that the HE concentrations exceeds the HBL by a factor of less than ten. Under CT assumptions, this sample no longer exceeds the HBL. Two bulk samples of zinc spent surface impoundment liquids result in HE lead concentrations in surface water that exceed the HBL by a factor of up to 100. Again, under the CT dilution assumptions, the predicted lead concentrations in surface water are reduced to below the drinking water HBL. As noted previously, the HBL for lead is simply the Drinking Water MCL of 15 ug/l.

As shown in Exhibit 4-8, the predicted surface water concentrations of six contaminants released from surface impoundments also were such that HBLs derived for the ingestion of fish by subsistence fishers were exceeded. Six arsenic samples (again all from copper acid plant blowdown) resulted HE surface water concentrations exceeding the fish consumption HBLs by up to a factor of 1000. Four of these were bulk samples, and the remainder were EP extraction samples. Under CT assumptions, only one sample exceeded the arsenic fish ingestion HBL.

A total of 20 samples (one EP extraction, the rest bulk) contained cadmium concentrations which resulted in HE surface water concentrations exceeding the fish ingestion HBL by up to 1000-fold. These samples came from zinc spent surface impoundment liquids (10), zinc process wastewater (6), copper acid plant blowdown (2 samples), and one sample each from rare earths process wastewater and zinc wastewater treatment plant liquid effluent. Under CT dilution assumptions, the number of samples exceeding the HBL is reduced to 3 samples, and the maximum level of exceedance is reduce to less than 100-fold.

Under HE assumptions, five samples give mercury concentrations in high-end surface water exceeding the fish ingestion HBL. These samples come from copper acid plant blowdown (3) and zinc spent surface impoundment liquids (2), and under CT assumptions, none of these samples exceeds the fish HBL. In the case of mercury, an HBL exceedance is equivalent to a hazard quotient greater than 1.0 for reproductive effects.

A single sample result for selenium in copper acid plant blowdown results in surface water concentrations above the HBL, as do two thallium results (one each from titanium/TiO₂ leach liquor and sponge wash water and from copper acid plant blowdown). For all of these samples, no excedences occur under CT dilution assumptions. The same is true for the six analytical results for zinc (all from zinc commodity streams). All six of the samples exceed the fish ingestion HBL under HE but not under CT dilution assumptions.

			High-End Surface Water Concentration from Bulk Samples Samples Exceeding HBL			High-End Surface Water Concentration from EP Extraction Samples Samples Exceeding HBL			Central Tendency Surface Water Concentration from Bulk Samples Samples Exceeding		Central Tendency Surface Water Concentration from El Extraction Samples Samples Exceeding		
Constituent	Commodity	Waste Stream	Total No. Samples	1-10x	by:	100-1000x	1-10x	by:	100-1000x		IL by:	HB	L by:
Arsenic	Copper	Acid Plant Blowdown	40	2	2		1		l			ł	
		Acid Plant Blowdown	40	2	t			1					
		Process Wastewater	8		1		1	1					<u> </u>
Zine Zine	Zine	Process Wastewater	40	6				1					
	Spent Surface Impoundment Liquids	24	6	3					1	1			
	Zinc	WWTP Liquid Effluent	5			1					1		
Mercury	Copper	Acid Plant Blowdown	40	2			1						
	Zinc	Spent Surface Impoundment Liquids	24	L	1								
Selenium	Copper	Acid Plant Blowdown	40	1						_			
Fhallium	Titanium and TiO ₂	Leach liquid & sponge wash water	8	1		1							
	Copper	Acid Plant Blowdown	40				1						
Zinc	Zinc	Spent Surface Impoundment Liquids	2.4	5									
	Zine	WWTP Liquid Effluent	5	1				Ι					

Exhibit 4-8 RISK SUMMARY FOR STORAGE OF RECYCLED MATERIALS

1. The HBL for Arsenic corresponds to a 10-5 lifetime cancer risk. The HBL for the other constituents correspond to a noncancer hazard quotient of 1.0.

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Exhibit 4-9 summarizes the estimated numbers of facility-waste stream combinations which exceed HBLs for both surface water pathways under the modified prior treatment baseline. Under the ingestion pathway, the three facilities with HBL exceedances under HE assumptions drops to zero under CT assumptions, as do the two facilities storing zinc spent surface impoundment liquids. Similarly, when the fish ingestion pathway is considered, a large number of facilities storing six different waste streams show exceedances of the HBLs under HE assumptions, but only one facility (storing zinc spent surface impoundment liquids) exceeds an HBL under CT assumptions.

As was the case with the groundwater pathway, effective management of the recycled materials could reduce all of the estimated risks to below levels of concern. Again, however, there is no way to estimate how much risk reduction would be achieved without explicit modeling of the non-groundwater pathway releases from TCBs. Under Option 1, all of the streams could be managed in TCBs, and the degree of risk reduction and the magnitude of health benefits for storage are difficult to estimate. Because the magnitude of exceedances of the HBLs for most waste stream-facility combinations are rather low for the surface water pathways, it is likely that most of these risks would, in fact, be reduced below levels of concern under Option 1. In terms of reduced risks from the storage of recycled materials, Option 2 provides no benefits over the modified prior treatment baseline.

4.3 Qualitative Evaluation of Conditions at High-Risk Facilities

As noted in the preceding section, the screening level risk analyses identified a number of waste streams as posing potentially significant risks to human health through the groundwater and surface water pathways. To further evaluate these potential risks, the Agency has conducted a limited analysis of site-specific conditions at some facilities where these wastes are generated and recycled. The following sections summarizes the results of this analysis.

4.3.1 Identification of Potential High-Risk Streams and Facilities

Using the screening level analyses described in Section 4.2, the Agency has identified a group of wastes for which storage prior to recycling could pose high risks to human health. The criteria used to identify these streams was the estimation of central tendency individual cancer risks greater than 10^{-5} or noncancer hazard quotients above 1.0 for a large proportion of the waste sample data in the Agency's waste composition database associated with recycling operations for either groundwater or non-groundwater pathways. The streams which were identified and the exposure pathways of concern are identified in Exhibit 4-10.

The Agency then explored the possibility of refining the risk analysis for facilities at which these streams are recycled. Information from the Agency files and other sources (technical literature, EPA Regional and sfate regulators, public comments) related to recycling and management practices, regulatory status, environmental settings, and potential receptors, were examined for the facilities that generated the wastes. The intent was to explore the possibility of site-specific population risk assessments for these sites, to supplement the screening level assessments previously described.

DISTRIBU	JTION OF WASTE-STREAM FACIL MODIFI	ITY COMBINATI ED PRIOR TREA			IBL EXCEEI	DANCE UNDE	RTHE
		Sector Total Waste Stream-	Combi	of Waste Strea nations with H edances of HB	Waste Stream-Facility Combinations with Central Tendency Exceedances of HBLs by:		
Commodity	Waste Stream	Facility Combinations 1-10X		10-100X 100-1000X		1-10X	10-100X
I. Drinking Water							
Copper	Acid Blowdown	10	1			T	
Zine	Spent Surface Impoundment Liquids	3					
2. Fish Ingestion							
Copper	Acid Blowdown	10	2	1		1	
Rare Earths	Process Wastewater	I					
Titanium, TiO ₂	Leach Liquor and Sponge Wash Water	2					
Zinc	Process Wastewater	3					
Zinc	Spent Surface Impoundment Liquids	3	I	1			
Zinc	WWTP Liquid Effluent	3			I		1

Exhibit 4-9 RISK SUMMARY FOR STORAGE OF RECYCLED MATERIALS

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Exhibit 4-10
High-Risk Wastes and Exposure Pathways of Concern for Mineral Processing Wastes
Identified in the Screening Risk Assessment

		Grou	ndwater	Surface	e Water
Commodity Sector	Waste Stream	Cancer	Noncancer	Drinking Water	Fish Ingestion
Beryllium	Chip Treatment Wastewater		x		
Copper	Acid Plant Blowdown	x	X	x	x
Elemental Phosphorus	AFM Rinsate Furnace Scrubber Blowdown	X X	X X		
Selenium	Plant Process Wastewater	x	x		
Tantalum, Columbium, and Ferrocolumbium	Process Wastewater	x	x		
Titanium, Titanium Dioxide	Leach Liquor and Sponge Wash Water	x	x		x
Zinc	Spent Surface Impoundment	x	x	x	x
	Liquids Wastewater Treatment Plant Liquid Effluent		x		x
	Process Wastewater	x	x		

4.3.2 Land Management of Recycled Streams at Potential High-Risk Facilities

The first step in the evaluation of potential risks at these facilities was to confirm that land management of the high-risk materials has or is still occurring at these facilities and to characterize the nature of the land management units. The facilities generating and recycling the potentially high-risk materials were identified from a review of the Agency's database related to waste composition. Thus, specific waste composition data (waste volumes, constituent identities and concentrations) could be linked to specific facilities and locations, focusing the search for additional information. The nine facilities that were identified are shown in Exhibit 4-11.

Data from a number of sources were reviewed to locate information related to the current and past land management practices for the recycled wastes. The sources which were reviewed include past Agency evaluations of mineral processing waste management, computer data bases related to RCRA and CERCLA activity at facilities, NPDES and RCRA permit information, and documents related to RCRA corrective actions and closures and CERCLA remediation activities.³¹

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³¹ A complete list of the data sources may be found in "Data Gathering Results for Site-Specific Modeling of High-Risk Mineral Processing Waste Management", memorandum to Paul Borst, USEPA, from William Mendez, et. al., ICF Kaiser International, October 30, 1997.

Exhibit 4-11
Identification of Facilities Generating and Recycling Potential High-Risk Waste Streams

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Facility Number	Industry Sector	High-Risk Waste Stream	Location
1	Beryllium	spent barren filtrate*	Utah
2	Copper	acid plant blowdown*	Arizona
3	Elemental Phosphorous	furnace scrubber blowdown	Idaho
-4	Zinc	process wastewater*	Tennessee
5	Titanium and TiO2	waste acids (sulfate process)	Georgia
6	Copper	acid plant blowdown*, scrubber blowdown	Arizona
7	Titanium and TiO2	scrap milling scrubber water, waste acids (sulfate process)	Maryland
8	Zinc	spent surface impoundment liquids*, process wastewater*	Pennsylvania
9	Zinc	process wastewater*	Oklahoma

* Recycled stream

Information related to land management at the nine potential high risk facilities is summarized in the second column of Exhibit 4-12. It can be seen from these data that land management units were historically used in the management of the majority of the high-risk streams. At least five of the nine facilities, and possibly two others, appear to have managed such streams in surface impoundments at some point in the past. Since all of the potential high-risk wastes are wastewater or liquid nonwastewaters, management in waste piles or landfills was not encountered frequently, although one, or possible two, facilities may have co-disposed or "stored" small-volume liquid wastes in piles of non-liquid wastes (e.g., tailings piles).

There is also a pattern, however, of moving away from land management, possibly under the influence of RCRA and State regulatory initiatives, in the 1980s and 1990s. Post-1990, evidence was found that indicated only one facility (facility 2) continues to manage recycled streams in land units. It appears, however, that even these units are engineered structures (heap-leach piles and solar pads) with low-permeability liners used to recycle copper acid plant blowdown. Recent data suggest that another facility (facility_6) may no longer recycle copper acid plant blowdown, but treat it by mixing it with a large-volume tailings stream. Information related to potential releases from these management units are not available.

Facility Number (Sector, State)	Land Management Units	Receptors	Potential Groundwater Exposures	Potential Non- Groundwater Exposures	Incidents of Environmental Contamination/ Damage
I (Beryllium, Utah)	Conflicting information; barren filtrate is either recycled in process vessels or co- disposed with tailings	Approximately 1000 nearby residents; no aquatic ecological receptors	Local wells draw from deep aquifer; no evidence for contamination of this aquifer	There appear to be no significant water bodies nearby; no air releases	Some contamination of shallow aquifer, no evidence for contamination of deeper aquifer, documented acute release incidents do not appear to be related to recycling
2 (Copper, Arizona)	Historical recycling units are impoundments, recent data indicate blowdown is recycled to lined heap leach piles, solar pad	Approximately 3700 residents within one mile. No ecological receptors identified	Closest known wells appear to be outside of groundwater flow path from recycling units	Nearby down-gradient water bodies are intermittent, do not support fisheries, low potential for air releases	Extensive regional groundwater and surface water contamination; recycling may have contributed, but there are many potential sources other than recycling operations
3 (Elemental Phosphorous, Idaho)	Historical units are impoundments; these have been closed and treatment is currently in tanks	Spring-led water supply serves approximately 1100 people; Ecological receptors in nearby streams and river	No downgradient wells before discharge to surface water	Adjacent streams; Portneul river; springs fed by river used for drinking water	Groundwater contamination documented downgradient from historical recycling units; limited evidence of discharge to river
4 (Zinc, Tennessee)	Surface impoundments and tanks are in use for waste management; available data does not indicate which are used for recycling	Approximately 33,000 residents within three miles; facility surrounded by wetlands, near river	Potential nearby groundwater use	Nearby wetlands, lakes; no air releases	Metals contamination in sediments and soils beneath units; offsite exposures, damage not demonstrated

Exhibit 4-12 Summary of Site-specific Data for High-risk Mineral Processing Facilities

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Facility Number (Sector, State)	Land Management Units	Receptors	Potential Groundwater Exposures	Potential Non- Groundwater Exposures	Incidents of Environmental Contamination/ Damage
5 (Titanium and Titanium Oxide, Georgia)	Historical SWMUs (impoundments) are no longer used; treatment apparently in <u>tanks</u>	Approximately 25,000 within three miles; facility isolated near river	Groundwater discharges to river, with no wells	Discharge to adjacent Savannah River; dilution volume probably precludes adverse effect; no air releases	Low-level sediment and stream water contamination from past releases; unclear if related to recycling operations
6 (Copper, Arizona)	Historical recycling units (impoundments and piles) appear to be closed; facility treats blowdown by mixing with tailings	Fewer than 10 residents within 1 mile; no nearby ecological receptors identified	Nearby wells do not appear to be in groundwater flow path	Does not appear to be any discharge to nearby water bodies; low potential for air releases	Regional groundwater contamination from historical activities; a few instances of hazardous substances releases not known to be associated with recycling
7 (Titanium & TiO ₂ , Maryland)	Landfill in use for waste management, no information on recycling unit characteristics	Approximately 10,000 residents within three miles of facility ;ecological receptors in adjacent estuarine river	Discharge to river; no wells	River volume (Patapsco) may preclude adverse effects.	No data related to releases from recycling
8 (Zinc, Pennsylvania)	Historical nanagement units are surface impoundments, piles, no recent data on recycling units	approximately 2,5000 residents within ½ mile; nearby sensitive ecosystems in creek, river	Discharge to Raccoon Creek, Ohio River	River volume may preclude effects	No data related to releases from recycling
9 (Zinc, Oklahoma)	No data; production reported to have ceased in 1996	No data on ecological receptors	No data	No data	Metals contamination in soils, sediment, and surface water; link to recycling not established.

Exhibit 4-12 (continued) Summary of Site-specific Data for High-risk Mineral Processing Facilities

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In addition, data on land management units were absent or conflicting for several of the facilities. At facility 1 (a beryllium ore processor in Utah), information presented in public comments indicated both that spent barren filtrate was recycled in process vessels (tanks) or that it was not recycled, and instead disposed, along with other streams, in a large surface impoundment. At facilities 4 and 7, data were not available to indicate whether land management of recycled streams is still occurring, and at facility 9, the data gathering effort was curtailed when it was determined that the facility stopped production in 1996.

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4.3.3 Identification of Populations at Risk

EPA also reviewed information related to the human populations and ecological receptors potentially exposed to pollutants near the nine high-risk facilities, and regarding potential exposure pathways for site releases. Detailed summaries of this information for each of the nine facilities may be found in Appendix L, and these results are summarized in the third column of Exhibit 4-12.

It can seen that most of the potential high-risk facilities have substantial nearby resident populations. Seven of the eight facilities for which population data were developed have greater than 1,000 people living within three miles of the facility center coordinates, and the nearby resident populations were greater than 10,000 at three of the facilities. Only one facility (number 6, a copper smelter in Arizona), appears to be truly remote from significant populations; fewer than ten people reside within one mile of this facility.

These statistics may somewhat overstate the potential exposed populations, however. The population residing directly adjacent to most of the facilities is generally much smaller than the three-mile total, and at three facilities, the bulk of the nearby population is located across intervening water bodies that preclude groundwater exposure and reduce the potential for other exposures as well. In addition, as will be seen below, site characteristics are also present (low dependence on groundwater, etc.) that further reduce the potential for exposures.

Potential ecological receptors were also identified at the majority of the facilities. Five of the facilities are located adjacent to rivers, streams, or wetlands, into which releases may occur through groundwater discharge or surface runoff. At three other sites located in arid regions, there appear to be no perennial water bodies near the facilities and no aquatic biota receptors were identified. No information was developed on potential terrestrial receptors near these facilities. The other facility (number 9, a zinc smelter in Oklahoma) was determined to have ceased production operations in 1996, and no data were developed on receptors.

4.3.4 Potential Exposure Pathways at the High-Risk Facilities

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The fourth and fifth columns of Exhibit 4-12 summarize the information that was gathered related to potential exposure pathways at the nine high-risk facilities. One striking feature of these data is that there appears to be only one facility (number 4, a zinc smelter in Tennessee) where potential exposure through the groundwater pathway appears to be plausible. Even at this site, the possibility of groundwater exposures depends on whether significant releases actually occur, and it is unclear from the evidence in the record whether land management units (as opposed to tanks) are still in use at this facility to process or store recycled materials. At the other seven facilities where data are available, evidence suggests that groundwater exposures are unlikely, either because there are no wells located downgradient of the treatment units, because groundwater is drawn from a deep aquifer which is isolated from shallow groundwater contamination, or because the facilities are located adjacent to rivers into which groundwater discharge occurs without any intervening wells.

Significant surface water exposure (to biota or humans consuming biota) appears to be plausible at some of the facilities located near water bodies. The facilities where this appears to be most likely include facility 4 (again assuming releases occur), which is located adjacent to wetlands, and facilities 2 and 8, where groundwater discharges into relatively low-volume surface water bodies. At facility 3, the groundwater flow discharges to a small river near river-fed springs which are used as a drinking water supply at a large railyard and for approximately 30 residences. There is as yet, however, no evidence for significant groundwater discharge from this facility to the river. At facility 8 (a zine smelter in Pennsylvania), runoff releases are a plausible exposure mechanism in a creek adjacent to the site.

Discharges to surface water are also possible at other facilities, but the large volume of the receiving waters appears to reduce the potential significance of these exposures. This is the case at facility 5, which is adjacent to the Savannah River, and facility 7, which is on the shore of the Patapsco river in Maryland. At facility 8, groundwater discharge (and runoff to the creek) ultimately discharge to the Ohio River.

4.3.5 Documented Environmental Releases and Damages from the High-Risk Facilities

Several of the facilities have long histories of documented environmental contamination. However, in most cases, the connection between recycling operations and the observed releases cannot be confirmed. Facilities 2 and 6, for example, are located in an area of Arizona where there are many mining an mineral processing operations. Particularly near facility 2, there is severe regional groundwater contamination, associated with the combined releases from many mines, ore processing, and smelting operations. In addition, there is a large lake not far from the facility that is contaminated with copper, iron, and other metals at concentrations that cause the water to be visibly brown or blue-green, as well as toxic to aquatic organisms. This lake is located in the midst of several very large mining and ore processing operations.

It is difficult to attribute these instances of groundwater and surface water contamination to any single source. While it is possible that historical recycling operations have contributed to this problem, the magnitude of this contribution cannot easily be quantified. It is likely, however, that the releases from recycling, while not completely abolished, may have been substantially reduced by the move away from land management units.

At several other sites, instances of environmental contamination can be more plausibly linked to specific facilities and historic recycling, if not to current waste management operations. At facility 1, for example, there is documented contamination of shallow groundwater under the tailings impoundment that may have been used to co-dispose of the potentially recycled barren filtrate stream. At facility 3, well-defined plumes of groundwater contamination have been characterized downgradient of historic (now closed) units that were used to store recycled streams. At facilities 4 and 5, monitoring has shown the presence of sediment and groundwater contamination beneath and adjacent to waste management units, but the available data do not allow this contamination to be attributed to recycling operations. At the remaining facilities, no data related to past releases from recycling were identified. At a few sites, releases of hazardous materials have been reported, but no link can be established to recycling.

Damage to ecological receptors is poorly documented at the nine high-risk facilities. In some cases (the Arizona copper facilities) ecological damage has undoubtedly occurred due to widespread excavation and disturbance of natural habitats, and probably due to widespread surface and groundwater contamination from multiple mines, mills, and smelters. The contribution of recycling to this damage is not known, however.

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4.4 Uncertainties and Limitations in the Risk and Benefits Assessment for the Modified Prior Treatment Baseline

Given unlimited resources and data, the ideal way to estimate the benefits of the LDRs for mineral processing wastes would have been to conduct site-specific population risk assessments for each of the facilities and units where these wastes are managed. This was not possible for obvious practical reasons and because of limited data. Instead, the Agency has used generic screening level analyses to identify potentially high-risk streams and facilities and to see whether the number of facilities with high recycling risks would change in response to regulation. In addition, the Agency conducted limited reviews of site-specific data at facilities where the screening analysis predicted high risks in order to confirm the plausibility of the risk estimates and document whether environmental releases or damages had already occurred. The remainder of this section provides a brief discussion of the key assumptions and methods used in the screening level assessment and potential uncertainties and limitations of that assessment.

The generic multipathway risk assessment for the storage of mineral processing recycled materials relies on relatively simple, conservative models of contaminant releases, transport, exposures, and risks. Therefore, the risk assessment results cannot be used to estimate risk reduction benefits for actual exposed populations residing near the mineral processing facilities. Instead, they only provide plausible estimates of the potential health risks faced by hypothetical individuals under the defined exposure conditions.

The assessment also shares the limitation of all generic analyses that high levels of uncertainty and variability may not be adequately treated, since only a limited number of simple models and representative data are used to model risks from a wide range of units, wastes, and constituents. Many of these generic sources of uncertainty have been addressed in our previous work on mineral processing wastes, and the following discussion is focused on limitations specific to the multipathway analysis.

As noted previously, constituent concentration data are available for only 15 recycled waste streams, and for some wastes only small numbers of samples are available. It is interesting to note that two of the wastes for which estimated risks are the highest (copper acid plant blowdown and zinc spent surface impoundment liquids) also are those for which the largest number of samples are available. It is not possible to estimate which of the other wastes might also show risks above levels of concern if more data were available. As noted previously, the storage risk assessment covers waste streams representing about 40 percent of the total waste generated and about 65 percent of the recycled volume.

Limited data also are available concerning waste characteristics, including constituent speciation, solubility, and bioavailability. Throughout this analysis, we have assumed that all constituents would behave in such a manner as to maximize exposure potential. For example, we have assumed that none of the constituents would leach from soils after their initial deposition, and that all of the constituents would be bioavailable in the water column. Generally these assumptions increase the level of conservatism of the risk assessment.

In evaluating potential risks to human health, exposure through multiple release pathways (leaching to groundwater, particulate suspension, surface runoff, inlet/outlet failure for surface impoundments) were considered. In this analysis, it was assumed that all of the constituent mass placed in

the management units was available for release through all release pathways. This assumption may have resulted in the overestimation of risks for some pathways due to double counting of constituent mass. For example, if constituent mass is depleted over time due to leaching, then the mass of constituent available for release through other pathways (e.g. particulate suspension) is reduced.

Mass balance calculations were performed for the non-groundwater release pathways (see Appendix J.2.2.1), and it was found that the proportion of constituent mass released by all of these pathways was below one percent of the total mass present in the management units. Thus, the neglect of mass balance considerations for these pathways resulted in negligible bias in the risk assessment results. The mass balance calculations did not include the groundwater pathway, however, because the methodology used did not allow release masses (only release concentrations) to be calculated. It is therefore possible that substantial depletion of some soluble and mobile constituents could occur through groundwater leaching, and these constituents would not be available for release by other pathways. This possibility has little or no impact on the findings of the risk assessment for waste piles, since, even if it is assumed that all of the constituents are released through every pathway, all calculated risks are below levels of concern. While it is not possible to estimate the magnitude of the potential bias in the risk results for surface impoundments, it is likely to be low, because of the relatively high through-put which is assumed for the impoundments, relative to plausible leachate release volumes.

Releases to groundwater and groundwater fate and transport were evaluated using EPA's EPACMTP model. Leachate concentrations and constituent- and facility-specific DAFs were derived using the best available data, which, although limited, provided a reasonable basis for generic modeling of the representative facilities. High-end (95th percentile) and central tendency (75th percentile) DAFs were used to explore the levels of uncertainty and variability in groundwater fate and transport processes. Comparison of the HE and CT DAFs indicates that the probability distribution of the DAF values is quite broad, and that the level of uncertainty is quite high. As for the other pathways, exposure assumptions were used that provide a moderate degree of conservatism for the groundwater pathway risk estimates.

Release events and amounts for non-groundwater pathways were simulated mostly using the general methods adopted in HWIR-Waste. The one exception is air particulate generation, which was estimated using the SCREEN3 model, rather than the model recommended in HWIR-Waste. SCREEN3 is a widely-accepted screening level EPA model. We believe that it is appropriate for the types of release events that were modeled. The use of SCREEN3 is unlikely to have biased the results of the risk assessment significantly compared to other methods. However, no data were available concerning the particle size characteristics of the two wastes streams that were modeled, so EPA relied on data from an earlier study of mineral processing wastes stored in waste piles. Based on limited information, the Agency believes that the particle size distribution which was used may overstate the potential for particulate release of the more coarse-grained, high-density zinc waste ferrosilicon, while more accurately describing the potential for particulate releases of aluminum cast house dust.

Run-off releases were evaluated using the same model (the Universal Soil Loss Equation, USLE) applied in the HWIR-Waste risk analysis, with input parameters varied slightly to reflect the operating characteristics of the waste piles being simulated and the likely geographic distribution of the recycling facilities. We also assumed that no runoff controls would be used. The risk results are not particularly sensitive to these assumptions, as exposure concentrations in soil and surface water due to run-off events are very far below the levels of concern for all exposure pathways.

The ISCST3 model used to predict particulate air concentrations and deposition rates is a state-ofthe-art model that has been used in many regulatory proceedings by EPA. The input data that were used, the "worst-case" meteorological conditions, were somewhat more conservative than the meteorological data used in HWIR-Waste with a similar model. Thus, our estimates of air impacts are likely to be higher than those that would have been achieved had we replicated the HWIR-Waste approach. Again, however, all the estimated risks and exposure concentrations for air releases are far below levels of concern, despite this conservatism.

The modeling of releases from surface impoundments reproduced exactly the approach used in HWIR-Waste. This release model and its input parameters were derived based on data from management units in the pulp and paper industry, and just how reliably they predict releases from surface impoundments in the mineral processing industries is not known. This is clearly a major source of uncertainty in the risk assessment, as these release events are the only non-groundwater releases for which health risks are predicted to be above levels of concern.

Because of resource limitations and the specific characteristics of the facilities that we were evaluating, we developed simplified approaches to modeling the concentrations of waste constituents in surface soils and surface water to substitute for the much more elaborate methods used in HWIR-Waste. In the case of surface run-off, in the absence of site-specific data, we conservatively assumed that soil contamination would be limited to relatively small distances (50 or 100 meters) from the piles in arbitrarily defined circular plumes. This is only intended as a bounding analysis, and the finding that this pathway is not a major concern can be supported by the fact that, even with these relatively small exposure areas (and the resultant high soil concentrations), constituent concentrations due to run-off events were two or more orders of magnitude below levels of health concern.

Similarly, to be conservative, we assumed that all of the run-off and all of the particulate generated by the waste piles would be deposited on the watershed in such a way that all of these materials would rapidly find their way into surface water. This approach, while it resulted in surface water concentrations far below levels of health concern, may be less conservative than the approach taken for surface soils, because the CT and HE streams are both rather large, and the model does not take into account possible run-off or deposition into smaller streams, takes, or ponds where constituents may accumulate in surface water or sediment.

The approach taken in evaluating fish tissue concentrations was also somewhat more conservative than that taken in HWIR-Waste, in that the highest available BCF or BAF values were used, rather than representative values, in our calculations. For some constituents (arsenic, cadmium, mercury, thallium), this approach resulted in considerably higher tissue concentrations than would have been calculated had we used the HWIR-Waste values. This may be a major source of uncertainty in this screening level assessment, since the fish ingestion pathway resulted in the highest risks predicted for several of the constituents and waste streams.

5. OTHER REGULATORY ISSUES

This section discusses aspects of today's final rule that are not directly related to the application of LDR standards to newly identified hazardous mineral processing wastes, as well as certain other administrative requirements.

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5.1 Non-LDR Regulatory Issues

Today's final rule addresses several issues that relate to the definition and regulation of hazardous mineral processing wastes. The Agency is today taking final action in response to several Appeals Court remands of previous regulatory activity that relate to both particular waste categories and the identification of hazardous mineral processing wastes generally. These topics are discussed briefly below.

5.1.1 Use of the TCLP Test for Identifying Hazardous Mineral Processing Wastes

The Agency has decided to continue using the TCLP (SW-846 Test Method 1311) as the basis for determining whether mineral processing wastes and manufactured plant gas wastes are hazardous by the toxicity characteristic. The applicability of the TCLP to mineral processing wastes was challenged in *Edison Electric Institute v. EPA* (2 F.3d 438 (D.C. Cir. 1993)). In the *Edison* case, the Court held that EPA had not provided sufficient information in the record to establish a rational relationship between the TCLP's mismanagement scenario³² and management of mineral processing wastes. Specifically, the Court remanded use of the TCLP for identifying hazardous mineral processing wastes and directed EPA to demonstrate that disposal of mineral processing wastes in a municipal solid waste landfill is a "plausible" mismanagement scenario.

After further research and analysis, the Agency has compiled a substantial amount of evidence to suggest that mineral processing wastes may plausibly be mismanaged in a manner similar to that described in the TCLP mismanagement scenario. In particular, the Agency has identified a number of cases in which mineral processing wastes are likely to have been co-disposed with municipal solid waste. The specific details of these cases are discussed in the preamble to today's rule and in the supporting *TCLP Technical Background Document*, available in the public docket. As a consequence of this evidence, the Agency has concluded that the TCLP should continue to be used to determine whether mineral processing wastes are hazardous by the toxicity characteristic.

The Agency also has determined that a Regulatory Impact Analysis (RIA) is not necessary for this rule. Today's final rule does not change existing Agency regulations or policy; rather, it merely complies with the Court's ruling that the Agency provide more extensive evidence for an existing Agency position. It is, therefore, unlikely that there will be a significant additional impact associated with continuing application of the TCLP to mineral processing wastes.

5.1.2 Remanded Listed Mineral Processing Wastes

The Agency also is today revoking the current hazardous waste listings for five court-remanded smelting wastes. The Agency has determined not to re-list the wastes, but will instead regulate them, where appropriate, as characteristic wastes.

³² The mismanagement scenario assumes that wastes will be co-disposed with municipal solid waste and forms the basis for the TCLP.

In 1980, the Agency listed as hazardous eight wastes generated from primary metal smelters. Later that year, in response to enactment of the Bevill Amendment, the Agency withdrew the listings. In 1985, after further study of the wastes, the Agency proposed to relist six of the wastes, but did not finalize the listings and withdrew the proposal in October 1986. In response to a court order (*Environmental Defense Fund v. EPA*, 852 F. 2d 1316 (D.C. Cir. 1988)), EPA relisted the six wastes. This relisting was subsequently challenged by the American Mining Congress (*American Mining Congress v. EPA*, 907 F. 2d 1179 (D.C. Cir. 1990)). The Court upheld one of the listings (K088, spent polliners from primary aluminum reduction), but determined that the Agency's record for the five remaining waste streams did not adequately address certain issues raised by commenters during the rulemaking. These five listings are:

K064	Copper acid plant blowdown;
K065	Surface impoundment solids at primary lead smelters;
K066	Acid plant blowdown from primary zinc production;
K090	Emission control dust and sludge from ferrochromium-silicon production; and
K091	Emission control dust and sludge from ferrochromium production.

The Court did not vacate the listings, and therefore they remain in effect.

Upon further study, the Agency determined that current waste generation and management practices did not warrant the listing of these five wastes. Many of the wastes are no longer generated, and of the wastes that continue to be generated, many are recycled. As a consequence, the Agency has determined that these wastes may be best regulated by characteristic and not as listed wastes. A detailed description of current management of these wastes, along with a discussion of the Agency's specific rationale for its decision to withdraw the five waste listings, are provided in the *Five-Remanded Wastes Technical Background Document*, available in the public docket accompanying today's rule.

The Agency also has determined that a Regulatory Impact Analysis (RIA) is not necessary for this proposal. As discussed above, many of the wastes affected by the Agency's decision are no longer generated. In addition, a relatively small number of facilities generate the remaining wastes, and most of these remaining wastes are recycled. Consequently, the Agency does not anticipate that a significant impact will be incurred by the regulated community as a result of today's rule.

5.1.3 Titanium Tetrachloride Chloride-Ilmenite Wastes

Finally, the Agency has determined to classify titanium tetrachloride chloride-ilmenite wastes as mineral processing wastes not eligible for Bevill exemption. Waste acid from the production of titanium tetrachloride also was among the many wastes conditionally-exempted from Subtitle C regulation under the 1980 Bevill Amendment. In 1989, the Agency determined that the waste did not qualify for Bevill-exempt status because the Agency found that the waste is a mineral processing waste that did not meet the criteria for exemption for mineral processing wastes (high volume and low hazard).

One titanium tetrachloride producer, the DuPont Corporation, requested a determination that waste from its production process be classified as beneficiation waste, and therefore eligible for the Bevill Exemption. DuPont argued that its process differed from that used by other manufacturers and included a beneficiation step that generated the wastes in question. When the Agency determined that the wastes were generated as a result of mineral processing operations and not beneficiation activities, DuPont

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challenged the determination in court (*Solite Corporation v. EPA*, 952 F.2d 473 (D.C. Cir. 1991)). Based on the challenge, the Court remanded the Agency's determination for further consideration.

After a detailed analysis of DuPont's chloride-ilmenite production processes, the Agency has again concluded that the waste acid (ferric chloride) is a mineral processing waste and is not eligible for the Bevill exemption because it does not meet the criteria for exempting such wastes. The Agency's determination is based on a more detailed understanding of DuPont's production process that found no evidence to support DuPont's contention that some steps in the process, including the step generating the waste acid, can be classified as beneficiation. Details concerning DuPont's process, and the Agency's analysis of the process and its rationale for determining that the process does not include beneficiation operations, are provided in the preamble to today's rule.

The Agency also has determined that a Regulatory Impact Analysis (RIA) is not necessary for this rule. Today's proposal clarifies earlier Agency regulatory determinations and affects only one member of the regulated community. As a consequence, the Agency anticipates that there will be no significant impact on the regulated community as a result of this rule.

5.2 Other Administrative Requirements

This section describes the Agency's response to other rulemaking requirements established by statute and executive order, within the context of today's final rule.

5.2.1 Environmental Justice

EPA is committed to addressing environmental justice concerns and is assuming a leadership role in environmental justice initiatives to enhance environmental quality for all residents of the United States. The Agency's goals are to ensure that no segment of the population, regardless of race, color, national origin, or income bears disproportionately high and adverse human health and environmental impacts as a result of EPA's policies, programs, and activities, and that all people live in clean and sustainable communities. In response to Executive Order 12898 and to concerns voiced by many groups outside the Agency, EPA's Office of Solid Waste and Emergency Response formed an Environmental Justice Task Force to analyze the array of environmental justice issues specific to waste programs and to develop an overall strategy to identify and address these issues (OSWER Directive No. 9200.3-17).

Today's final rule covers wastes from mineral processing operations. The environmental problems addressed by this rule could disproportionately affect minority or low income communities, due to the location of some mineral processing and waste disposal facilities. Mineral processing sites are distributed throughout the country and many are located within highly populated areas. Mineral processing wastes have been disposed of in various states throughout the U.S., representing all geographic and climatic regions. In some cases, mineral processing waste is generated in one state and disposed of in another. In addition, mineral processing wastes are occasionally disposed of in municipal solid waste landfills.

Today's rule is intended to reduce risks from mineral processing wastes, and to benefit all populations. It is, therefore, not expected to result in any disproportionately negative impacts on low income or minority communities relative to affluent or non-minority communities.

5.2.2 Unfunded Mandates Reform Act

Under Section 202 of the Unfunded Mandates Reform Act of 1995, signed into law on March 22. 1995, EPA must prepare a statement to accompany any rule for which the estimated costs to state, local, or



tribal governments in the aggregate, or to the private sector, will be \$100 million or more in any one year. Under Section 205, EPA must select the most cost-effective and least burdensome alternative that achieves the objective of the rule and is consistent with statutory requirements. Section 203 requires EPA to establish a plan for informing and advising any small governments that may be significantly affected by the rule.

EPA has completed an analysis of the costs and benefits from today's final rule and has determined that this rule does not include a federal mandate that may result in estimated costs of \$100 million or more to either state, local, or tribal governments in the aggregate. The private sector is also not expected to incur costs exceeding \$100 million per year under either Option considered in this RIA.

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6. CONCLUSIONS

This section presents the Agency's preliminary conclusions regarding the regulatory impacts of implementing the options presented in today's notice. The chapter is organized around the central elements of the analyses provided in previous sections, namely characterizing the affected population of waste streams, facilities, and mineral industry sectors, analyzing the cost and economic impacts of implementing the options, and assessing the human health benefits of adopting these regulatory alternatives.

6.1 The Affected Universe

As described in depth in the preceding sections, EPA conducted intensive research in an attempt to identify and characterize all of the waste streams that might be affected by imposition of LDR requirements on non-exempt hazardous mineral processing wastes. This research has yielded a group of 121 potentially hazardous mineral processing residues that may be subject to Subtitle C controls and accordingly, to new LDR treatment standards.

This number is far smaller than the total population of mineral industry wastes, and reflects EPA's step-wise process of eliminating from the analysis wastes that are: (1) generated by extraction and beneficiation operations (these are Bevill-exempt), (2) the 20 exempt special mineral processing wastes, (3) wastes that are known or expected to be non-hazardous, and (4) wastes believed to be fully recycled and not stored on the land. The remaining waste streams have been included in the Agency's analyses, though in many cases substantial uncertainties regarding their generation rates, hazardous characteristics, and management practices have led EPA to develop several different estimates of these parameters, which in turn produce variable estimates of costs and benefits arising from new regulatory controls.

EPA recognizes the limitations that these data gaps and simplifying assumptions impose on the accuracy of the analyses presented above. EPA has provided detailed analyses of the potential cost and benefit impacts of the LDR options in the interests of providing interested parties with as much pertinent information as possible.

The analysis also examines the remediation of media contaminated with manufactured gas plant (MGP) waste. EPA estimates that there are approximately 2,500 potentially affected commercial MGP sites in the United States, and approximately 28,700 potentially affected captive MGP sites. Each contaminated site is believed to have between 500 and 5,000 tons of RCRA hazardous contaminated media. The total amount of hazardous contaminated media at all sites is estimated at over 26 million tons. Finally, this analysis examines the impact of today's rule on facilities operating Class I UIC wells, and finds that only two facilities are likely to be affected.

6.2 Cost and Economic Impacts of the Rule

Option 1 is estimated to result in annual costs to the regulated community of approximately \$10,000,000. In contrast, Option 2 is estimated to result in costs of only about \$230,000. These figures represent best estimates. Exhibit 6-1 highlights the differences between the minimum, expected, and maximum value cases.

Exhibit 6-1 Summary of Cost Analysis Results (\$/Year)

	Minimum	Expected	Maximum		
Option 1	\$7,200,000	\$10.000.000	\$14,000,000		
Option 2	\$41,000	\$230,000	\$230,000		

^a Options are described in detail in Section 1.

Option 1, although it is the higher cost option, results in relatively low costs due to the option's lack of prohibition in the recycling of secondary materials through beneficiation or Bevill process units. Option 2 results in relatively low net costs to industry because the option essentially allows facilities to continue operating as they currently operate. EPA assumes that in some cases, facility owners and operators, out of misunderstanding of current requirements, handle spent materials improperly. Option 2 would allow these owners and operators to continue to handle spent materials in this manner. The only costs incurred by facility owners under this option are relatively insignificant recordkeeping and reporting requirements.

Additional costs will be incurred due to the rule's effects on cleanups of contaminated media at manufactured gas plants. The incremental annual cost associated with these cleanups is estimated at approximately \$6,200,000 (which is in addition to the costs summarized in Exhibit 6-1). Finally, EPA estimates the cost of today's rule to facilities operating UIC wells to range from a minimum annualized cost of \$0, to an intermediate annualized cost of \$530,000, to a maximum annualized cost of \$3,700,000

Economic impacts on the mineral processing industry were estimated using four screening ratios. The results of this analysis are summarized in Exhibit 6-2 and discussed below:

Exhibit 6-2

Summary of Economic Impact Screening Results:

	Percent of Firms or Sectors w/ Significant Impacts				
Impact Measure	Option 1	Option 2			
Cost/Sales	0% of firms	0% of firms			
Cost/Earnings	0% of firms	0% of firms			
Cost/Value of Shipments	10% of sectors	0% of sectors			
Cost/Value Added	13% of sectors	0% of sectors			

Option 1

- Based on the two firm-specific ratios (cost/sales and cost/earnings), no significant economic impacts are expected to result from Option 1.
- Based on cost as a percentage of value of shipments, three of the 29 sectors (10 percent sectors) are expected to incur significant impacts under Option 1. Significantly affected sectors are projected to include mercury (36 percent impact), tungsten (6 percent), and fluorspar/hydrofluoric acid (4 percent).
- Based on cost as a percentage of value added, two of the 16 sectors (13 percent) are expected to be significantly affected under Option 1 (cadmium and selenium).

Option 2

 Option 2 is not expected to result in significant impacts under any of the four measures.

The divergence between the Option 1 results based on the firm-specific measures (particularly cost/sales) and those based on the sector-specific measures could result from diversified operations of affected firms. In this case, it is possible that significant impacts might occur at the facility level even if they do not lead to significant impacts at the firm level (i.e., due to the firm's additional operations besides those in affected mineral processing sectors).

Like the impacts on mineral processing firms, impacts on owners of MGP sites and UIC wells are not expected to be significant due to (1) the low costs per facility, and (2) the strong likelihood that MGP sites with relatively higher cleanup costs are owned by relatively large utilities.

6.3 Health Benefits of the Proposed LDRs

The benefits of the proposed LDRs for mineral processing wastes take the form of reduced risks to human health and the environment from improved management of the subject wastes. EPA has conducted analyses of the potential health risks associated with the disposal of mineral processing wastes and the storage of recycled streams and of the potential reductions in health risks that may be achieved under the proposed regulatory options. Potential risks and benefits have been evaluated for groundwater exposures to toxic waste constituents arising from waste disposal, and for groundwater and non-groundwater pathway exposures to constituents released during the storage of recycled streams. Detailed descriptions of the methods used to evaluate risks and benefits for waste disposal are found in Appendix A, and descriptions of the methods used for the risk assessment for waste storage are found in Appendix J of this RIA. In addition to these quantitative analyses, the Agency has conducted a limited evaluation of site-specific data at nine mineral processing facilities identified as managing potentially high-risk wastes. This evaluation examined current waste management practices, potential release and exposure pathways, identified potentially exposed populations, and reviewed the history of environmental releases and contamination at the facilities.

EPA estimates that the health benefits from improved waste disposal practices under either of the regulatory options would be quite low compared to the modified prior treatment baseline, considering only groundwater pathway exposures. For arsenic, which is a major risk-driving constituent for many wastes. risk reduction would not occur, since the TC regulatory level and UTS leachate concentration are identical. For other constituents, some exposure reduction could occur under these options, since the UTS

levels are lower than the TC leachate concentrations, and because some non-TC analytes may not be effectively immobilized by treatments designed to comply with the TC.

EPA's evaluation of the potential groundwater risks associated with the storage of recycled streams under the modified prior treatment baseline is described in Section 4.2. Estimated groundwater pathway cancer risks under high-end (HE) baseline assumptions exceeded 10⁻⁵ at 23 of 56 facilities storing recycled streams, while under central tendency (CT) assumptions, only 11 facilities exceed this level (Exhibit 4-5). The HE noncancer hazard quotients for groundwater exposures exceed 1.0 at 26 facilities storing recycled materials, and under CT assumptions baseline hazard quotients exceed 1.0 at 12 facilities (Exhibit 4-6). All of the facilities for which baseline cancer risks or noncancer hazard quotients exceed levels of concern manage wastewater and liquid nonwastewater streams in impoundments. Owing primarily to the low recycled volumes and small facility sizes, the baseline groundwater risks for the two nonwastewater streams managed in waste piles are below levels of concern under both CT and HE assumptions.

The analysis of non-groundwater pathway risks associated with waste storage under the modified prior treatment baseline indicated that, for the majority of the pathways evaluated, estimated baseline risks were far below levels of concern. As was the case for the groundwater pathway risk assessment, risks from the storage of the two nonwastewater streams in waste piles were less than levels of concern for all release events and exposure pathways.

Baseline risks greater than levels of concern were found for exposures to surface water contaminated by releases from surface impoundment failures of some waste streams, however. In the case of the direct ingestion pathway, one facility storing copper acid plant blowdown had an HE cancer risk exceeding 10⁻⁵. Under CT assumptions, the estimated cancer risk for this facility was below the level of concern. When exposure through fish consumption is considered, six facilities from three commodity sectors had HE risks from waste storage exceeding cancer or noncancer levels of concern. Under CT assumptions, risks from only two storage facilities exceeded levels of concern for the fish ingestion pathway. These results are summarized in Exhibit 4-9.

EPA did not quantitatively estimate the extent of risk reduction or the level of health benefits that could be brought about by the proposed LDRs' effects on recycled materials storage. This is because the available data and models do not allow the development of risk reduction estimates for tanks, containers, and buildings, which would be the required management units for most of the recycled streams under regulatory Option 1. If this option completely or substantially eliminates the release of recycled streams to groundwater and other media, the baseline risks discussed in the previous paragraphs could all be reduced to below levels of concern. Lesser degrees of control would result in less risk reduction and lower health benefits.

EPA evaluated site-specific conditions related to exposures and risk at nine facilities identified as generating and managing potentially high-risk recycled streams. The results of this analysis are summarized in Exhibit 4-12. The Agency found that, while management of these wastes in unlined land units was historically commonplace, there has been a marked tendency in recent years (since about 1980) to employ management techniques such as tanks or lined pads. In addition, while the resident populations near the majority of these facilities are quite large (greater than 10,000 at three facilities), direct groundwater exposures generally do not appear to be occurring, either because well locations are outside of groundwater flow patterns from recycling units, drinking water is obtained from deep aquifers isolated from shallow groundwater contamination, or groundwater discharges to surface water bodies adjacent to the facilities, and no wells are present. At only one of the nine sites does there appear to be the potential for human exposures through the consumption of groundwater contaminated by recycling operations, but no releases have been documented at that site. At three sites, groundwater discharge to surface water is

unlikely to pose significant risks due to the large dilution volume of the receiving waters, and the absence of nearby water intakes. At one facility, contaminated groundwater may discharge to a small river near a river-fed spring that is used as a drinking water supply. However, there is no evidence that contamination from the mineral processing operations has yet reached the surface water.

Significant regional groundwater and surface water contamination is present in the vicinity of the two copper smelting facilities in Arizona. However, this contamination cannot be attributed to current recycling operations, but rather is the combined result of the large number of mines, mills, and smelters that have operated in the area over the last century. At several of the facilities where sediment or groundwater contamination can be attributed to historical recycling operations (e.g., in surface impoundments), contamination is localized and no human health risk or damage to the environment has been documented.

ANALYSIS OF OPTIONS UNDER ALTERNATIVE BASELINES

This appendix presents the estimated costs, economic impacts, and benefits of regulatory options under two alternative baselines, the "no prior treatment" baseline and the "prior treatment" baseline, for mineral processing wastes under Phase IV LDRs. Under the no prior treatment baseline, wastes are assumed to be managed (i.e., stored or disposed of), untreated, in unlined surface impoundments and waste piles, i.e., the practices that were generally in place prior to removal of these wastes from the Bevill exclusion in 1989 and 1990. Under the prior treatment baseline, wastes are either treated to UTS levels and disposed in a Subtitle D unit or stored prior to recycling in tanks, containers, and buildings if they are spent materials or in unlined land based units if they are sludges or byproducts. The prior treatment baseline assumes facility operators clearly understand the Subtitle C regulations that apply to their secondary materials, i.e., that spent materials intended for recycling are not currently excluded from Subtitle C regulation.

Although the costs and economic impacts under the no prior treatment baseline were analyzed in the December 1995 RIA to the proposed rule, they are not analyzed in today's RIA because the costs of managing wastes with no prior treatment are not properly attributed to this rule. In addition, while the prior treatment baseline may more accurately assess the cost attributable to this rulemaking than the modified prior treatment baseline (i.e., the baseline used in the main analysis), EPA believes the modified prior treatment baseline more accurately reflects actual practice in the mineral processing industry. In both cases, however, EPA has elected to present the cost and benefits attributable to these other baselines in this Appendix.

The methodology for estimating the costs and economic impacts under these alternative baselines is the same as the methodology used in the primary analysis, which is discussed in Section 3.1. The estimated costs and economic impacts under these baselines are presented in Section A.1 of this Appendix. Section A.2 presents the results of the risk analysis for the no prior treatment baseline. Additional information supporting the risk analysis is included in Section A.3.

A.1 Costs and Impacts

In developing its estimates of the proposed rule's costs and economic impacts, EPA used a dynamic analysis to predict changes in the management of newly identified mineral processing wastes. The dynamic analysis accounts for a shift in the amount of material that is recycled rather than being treated and disposed due to incentives and disincentives for future recycling. EPA estimated the percentage of hazardous material sent to treatment and disposed for each baseline and option. The *remaining* hazardous material is considered to be recycled. The dynamic analysis reflects the shifts in management anticipated in each baseline/option combination.

Exhibit A.1-1 presents required changes in management practices as a result of the proposed Phase IV Land Disposal Restrictions for the wasted portion and the recycled portion of hazardous mineral processing secondary materials for the four regulatory options. Exhibit A.1-2 presents the predicted changes in recycling, given the required changes in management practices listed in Exhibit A.1-1. The information in Exhibit A.1-2 combines into an overall impact all incentives operating at a facility. For instance, under Option 1 assuming the modified prior treatment baseline, Exhibit A.1-1 suggested that there would be (1) no change in the amount recycled due to treatment requirements, and (2) a decrease in the amount recycled because of the stricter recycling unit standards. Because, however, the incremental cost of storing material in a tank, container, or building prior to recycling is usually less than the cost of moving that material to treatment and disposal, the <u>overall</u> predicted effect of this option-baseline

combination is a small decrease in the amount of material recycled. (That is, a facility operator in this option-baseline combination would usually pay the extra cost of storage rather than changing management practices.)

Baseline/Option	Affected Material	Required Change in Management	Implied Change In Recycling
NPT	Wasted	Disposal to UTS and Disposal	Increase
MPT/PT	Portion	TC to UTS	No Change
NPT/MPT to Option 1		Unlined Units to TCBs	Decrease
PT (SL/BP) to Option 1		Unlined Units to TCBs	Decrease
PT (SM) to Option 1	Recycled	TCBs to TCBs	No Change
NPT/MPT to Option 2	Portion	Unlined Units to Unlined Units	No Change
PT (SL/BP) to Option 2		Unlined Units to Unlined Units	No Change
PT (SM) to Option 2		TCBs to Unlined Units	No Change

Exhibit A.1-1 Changes in Management of Hazardous Mineral Processing Waste

NPT - No Prior Treatment Baseline MPT - Modified Prior Treatment Baseline PT - Prior Treatment Baseline SL - Material classified as a Sludge

BP - Material classified as a Byproduct

SM - Material classified as a Spent Material

Exhibit A.1-2 Overall Predicted Changes in Recycling

	Option 1	Option 2
No Prior Treatment	Increase	Big Increase
Modified Prior Treatment and Prior Treatment (SL/BP)	Small Decrease	No Change
Prior Treatment (SM)	No Change	Increase

Exhibit A.1-3 presents the percentages of the hazardous portion of mineral processing waste streams that are sent to treatment and disposal, in both the baseline and post-rule options, and Exhibit A.1-4 presents the percentages stored prior to recycling. Exhibits A.1-3 and A.1-4 are based on (1) the overall predicted changes in recycling listed in Exhibit A.1-2 and (2) empirical data, as described below. For option-baseline combinations that eliminate the differences in regulatory requirements for recycled sludges, by-products, and spent materials, the proportion of material recycled is the same for all three types of material after the rule goes into effect. Lastly, Exhibit A.1-5 shows the change in recycling percentage for each option-baseline combination. For option-baseline combinations that increase recycling, the largest shift is seen in Y? materials, and the smallest shift is seen in YS? materials.

The limited available data on the recycling of two listed wastes, K061 (emission control dust from electric arc steel furnaces) and F006 (wastewater treatment sludge from electroplating operations) were used to quantify the expected shift in recycling. These data were used due to the fact that an increase in the amount of K061 and F006 being recycled was observed after Land Disposal Restrictions (LDRs) for K061 and F006 were promulgated.¹ A 75 percent increase in K061 recycling was observed after the LDR for K061 was implemented, from an average of 15 percent recycled pre-LDR to 90 percent recycled post-LDR. Similarly, a 15-20 percent increase in the amount of F006 recycling was observed as a result of the F006 LDR, from 0 percent recycled pre-LDR to 15-20 percent recycled post-LDR.² Therefore, in the December 1995 RIA, the Agency modeled the 75 percent shift for Y? materials from the No Prior Treatment Baseline to Option 2 on K061, and the 15 percent shift for YS? materials from the No Prior Treatment Baseline to Option 2 on F006. Because Option 2 in the December 1995 RIA is no longer modeled, and Option 1 of today's proposal requires slightly more expensive storage units (tanks, containers, and buildings instead of lined land-based units, EPA adjusted these data slightly for use in Option 1 of today's RIA. The predicted shift in these two options for Y? material is 70 percent and the predicted shift for YS? materials is 10 percent. EPA used best professional judgement to estimate the shifts in the other option-baseline combinations.

		Percent Treated and Disposed				
Baseline or Option	Affected Material	Y	Certai Y?	nty of Rec YS	ycling YS?	N
Prior Treatment	SL/BP	0	15	25	80	100
Prior Treatment	SM	0	25	35	85	100
Modified Prior Treatment	All	0	15	25	80	100
No Prior Treatment	All	0	100	60	100	100
Option 1 from PT	All	0	25	35	85	100
Option 1 from MPT	All	0	25	35	85	100
Option 1 from NPT	All	0	30	40	90	100
Option 2 from PT	All	0	15	25	80	100
Option 2 from MPT	All	0	15	25	80	100
Option 2 from NPT	All	0	15	25	80	100

Exhibit A.1-3 Proportions of Waste Streams Treated and Disposed (in percent)

¹ 1990 Survey of Selected Firms in the Hazardous Waste Management Industry, Final Report, U.S. E.P.A. Office of Policy Analysis, (July 1992).

² Report to Congress on Metal Recovery, Environmental Regulation, & Hazardous Waste, U.S. E.P.A., Washington, D.C., (February 1994).

			Per	cent Recy	cled	
	Affected		ycling			
Baseline or Option	Material	Y	Y?	YS	YS?	Ν
Prior Treatment	SL/BP	100	85	75	20	0
Prior Treatment	SM	100	75	65	15	0
Modified Prior Treatment	All	100	85	75	20	0
No Prior Treatment	All	100	0	40	0	0
Option 1 from PT	All	100	75	65	15	0
Option 1 from MPT	All	100	75	65	15	0
Option 1 from NPT	All	100	70	60	10	0
Option 2 from PT	All	100	85	75	20	0
Option 2 from MPT	All	100	85	75	20	0
Option 2 from NPT	All	100	85	75	20	0

Exhibit A.1-4 Proportions of Waste Streams Stored Prior to Recycling (in percent)

Exhibit A.1-5 Change in Recycling Percentage for Affected Option-Baseline Combinations

		Increase	in Recycli	ng (percen	it)		
	Certainty of Recycling						
Baseline or Option	Y	Y?	YS	YS?	Ν		
Option 1 from NPT	0	70	20	10	0		
Option 1 from MPT & PT (SL/BP)	0	-10	-10	-5	0		
Option 1 from PT (SM)	0	0	0	0	0		
Option 2 from NPT	0	85	35	20	0		
Option 2 from MPT & PT (SL/BP)	0	0	0	0	0		
Option 2 from PT (SM)	0	10	10	5	0.00		

Notes for Exhibits A.1-3, A.1-4, and A.1-5:

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Bold type indicates shifts derived from empirical data

Y means that EPA has information indicating that the waste stream is fully recycled.

Y? means that EPA, based on professional judgment, believes that the waste stream could be fully recycled.

YS means that EPA has information indicating that a portion of the waste stream is fully recycled. YS? means that EPA, based on professional judgment, believes that a portion of the waste stream could be fully recycled.

SM - Spent material BP - Byproduct SL - Sludge

Cost results for all three baselines are summarized in Exhibit A.1-6. In general, the costs for the no prior treatment baseline are greater than for the modified prior treatment baseline (the baseline used in the main analysis) because facilities incur the full cost of waste treatment when coming into compliance

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from the no prior treatment baseline. Conversely, the costs in the prior treatment baseline are lower than the modified prior treatment baseline because recycled spent material are assumed to be already managed in tanks, containers, and buildings. The savings in the prior treatment baseline attributed to baseline management practices is most clearly seen under Option 2, which yields an overall savings. Sector specific cost results for Option 1 are presented in Exhibits A.1-7 and A.1-8, and cost results for Option 2 are presented in Exhibits A.1-9 and A.1-10. Value of shipment impact results for Option 1 and Option 2 are shown in Exhibits A.1-11 through A.1-14.

	Minimum	Expected	Maximum
Option 1 PT	3,400,000	4,400,000	6,100.000
Option 1 MPT	7,200,000	10,000,000	14,000.000
Option 1 NPT	30,000.000	81,000,000	160,000,000
Option 2 PT	(3,400,000)	(5,000,000)	(6,700,000)
Option 2 MPT	41.000	230,000	230,000
Option 2 NPT	23,000,000	70,000,000	140,000,000

Exhibit A.1-6 Summary of Cost Results for All Option-Baseline Combinations

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Exhibit A.1-7 Option 1 Incremental Costs Assuming No Prior Treatment

	Minimum	Value Case	Expected	Value Case	Maximum Value Case	
	Total	Avg. Fac.	Total	Avg. Fac.	Total	Avg. Fac.
	Incremental	Incremental	Incremental	Incremental	Incremental	Incrementa
Commodity	Cost (\$/yr)	Cost (S/yr)	Cost (\$/yr)	Cost (S/vr)	Cost (S/vr)	Cost (\$/vr
Alumina and Aluminum	1,100.000	49,000	3,200.000	140,000	4.800.000	210.00
Antimony	-		2,100.000	360,000	3,800,000	640.00
Beryllium	230.000	230,000	2,300.000	1,100.000	9,900.000	4,900.00
Bismuth			710,000	710,000	1.800.000	1,800.00
Cadmium			730,000	360.000	4,500.000	2,200,60
Calcium	•		9	9	9	
Chromium and Ferrochromium	190,000	190.000	190,000	190,000	200,000	200.00
Coal Gas	-	-		-	260.000	260,00
Copper	10,000.000	1,000,000	10,000.000	1,000,000	11,000.000	1,100.00
Elemental Phosphorus	2.700.000	1,300.000	2,700.000	1,300.000	2,700.000	1,300.00
Fluorspar and Hydrofluoric Acid	-	-	180.000	59.000	370,000	120,00
Germanium			210.000	52.000	470,000	120,00
Lead	\$4.000	28,000	5,100.000	1.700.000	9,900,000	3,300.00
Magnesium and Magnesia from Brines	2,000,000	990.000	2,000.000	1,000,000	2,100,000	1,100,00
Mercury	-	-	420.000	60,000	1.400,000	200,00
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	10,000.000	920,000	29,000,000	2.600,00
Platinum Group Metals		-	160,000	53,000	250,000	82,00
Rare Earths	220.000	220.000	1,700,000	1.700.000	5.000.000	5.000.00
Rhemum	-	-	2,900,000	1.400.000	5.100.000	2.500,00
Scandium	-	•	260.000	37,000	460,000	66.00
Selenium	530.000	270,000	720.000	240,000	2.400.000	790,0 0
Synthetic Rutile	-		1.400.000	1.400,000	2.400,000	2,400,00
Tantalum, Columbium, and Ferrocolumbium	460.000	230.000	680.000	340.000	920,000	460,00
Tellurium	-		390.000	200.000	1.900.000	930,00
Titanium and Titanium Dioxide	1,700.000	840.000	16.000.000	2,300,000	28.000.000	4,000,00
Tungsten			320,000	53,000	680,000	110,00
Uranium		•	830,000	49,000	1,500,000	90.00
Zinc	11,000,000	3.700.000	14.000.000	4,700,000	18.000.000	5.900.00
Zirconium and Hafnium		-	1.900.000	970,0 00	11.000.000	5,600.00
Total / Average	000,000,0F		81.000,000		160,000,000	

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Exhibit A.1-8 Option 1 Incremental Costs Assuming Prior Treatment

	Minimum	Value <u>Case</u>	Expected	Value Case	Maximum	Value Case _
1	Total	Avg. Fac.	Total	Avg. Fac.	Total	Avg. Fac.
	Incremental	Incremental	Incremental	Incremental	Incremental	Incremental
Commodity.	Cost (\$/yr)	Cost (\$/yr)	Cost (S/yr)	Cost (\$/yr)	Cost (\$/vr)	Cost (\$/yr)
Alumina and Aluminam	280.000	12,000	760.000	33.000	1,400.000	61.000
Antimony			6.800	1.100	6.800	1,100
Beryllium	570	570	2.800	1 400	2,800	1,400
Bismuth			5.600	<u>5</u> .600	6,200	6,200
Cadmium	-	-	67.000	34.000	430,000	220,000
Calcium			9	9	9	9
Chromium and Ferrochromium	57,000	57.000	57.000	57.000	64,000	64.000
Coal Gas		-		-	66,000	66,000
Copper	2,700,000	270.000	2,500.000	250.000	2.500,000	250.000
Elemental Phosphorus	290,000	140.000	290.000	140.000	290,000	140,000
Fluorspar and Hydrofluoric Acid			49,000	16.000	81,000	27,000
Germanium		· · ·	14,000	3,400	16,000	3,900
Lead	27,000	<u>9.</u> 000	89.000	30,000	120,000	40,000
Magnesium and Magnesia from Brines	1,100	560	2,600	1,300	44,000	22,000
Mercury	-	-	12,000	1,700	12,000	1,700
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	7,300	660	7.300	660
Platinum Group Metals	-		5,400	1,800	11.000	3,800
Rare Earths	1.100	1,100	90,000	90.000	310,000	310.000
Rhenium			3,100	1.500	5,600	2,800
Scandium		•	7,900	1.100	7,900	I.100
Selenium	1,100	570	17,000	5.600	110.000	35,000
Synthetic Rutile		-	64,000	64,000	120.000	120,000
Tantalum, Columbium, and Ferrocolumbium	1,100	570	3,400	1,700	3,400	1,700
Tellurium		•	10,000	5,200	15,000	7,600
Titanium and Titanium Dioxide	3.700	1,800	130,000	19,000	240,000	35,000
Tungsten	-		6,800	1,100	6,800	1.100
Uranium		•	56,000	3,300	110.000	6.700
Zinc	62,000	21,000	110,000	38,000	150.000	51.000
Zirconium and Hafnium			4,500	2.300	4,500	2.300
Total / Average	3,400,000		4,400,000		6,100.000	

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Exhibit A.1-9 Option 2 Incremental Costs Assuming No Prior Treatment

	Minimum	Value Case	Expected	Value Case	Maximum	Value Case
	Total	Avg. Fac.	Total	Avg. Fac.	Total	Avg. Fac.
	Incremental	Incremental	Incremental	Incremental	Incremental	Incremental
Commodity	Cost (\$/yr)	Cost (\$/yr)	Cost (\$/yr)	Cast (\$/yr)	Cost (\$/yr)	Cost (\$/vr)
Alumina and Aluminum	730.000	32,000	2,100,000	91.000	2,900,000	120.000
Antimony	· · .	-	2,100.000	350,000	3,800,000	630.000
Beryllium	160.000	160,000	2,200,000	L100,000	9,400,000	4.700.000
Bismuth	· · ·		710,000	710,000	1,800,000	1.800.000
Cadmium	· .		630,000	320,000	3,800,000	1.900.000
Calcium			9	9	9	9
Chromium and Ferrochromium	110.000	110.000	110.000	110,000	110,000	110.000
Coal Gas					180,000	180,000
Copper	7,400,000	740,000	7,500.000	750,000	7,700,000	770,000
Elemental Phosphorus	1.700.000	860,000	1,700,000	860,000	1,700.000	860.000
Fluorspar and Hydrofluoric Acid			110.000	38.000	260.000	87,000
Germanium			190,000	47,000	450.000	10.000
Lead	56,000	19,000	4,100,000	1,400,000	8,100,000	2.700.000
Magnesium and Magnesia from Brines	2,000,000	990,000	2,000,000	1,000.000	2,100.000	1,000.000
Mercury	-	•	190.000	27,000	800.000	110.000
Molybdenum, Ferromolybdenum, and Ammonium Molybdate		-	10,000.000	920.000	29,000.000	2,600.000
Platinum Group Metals	-		160.000	53.000	240.000	79.000
Rare Earths	210,000	210,000	1,600,000	1,600,000	4,600,000	4,600,000
Rhenium			2,900.000	1,400.000	5,100,000	2,500.000
Scandium	· ·	-	350.000	51.000	420,000	60,000
Selenium	490,000	240.000	660.000	220.000	2.200.000	750,000
Synthetic Rutile	-		1.300.000	1,300.000	2,200.000	2,200,000
Tantalum, Columbium, and Ferrocolumbium	260,000	130.000	480,000	240,000	720,000	360,000
Tellurium			370,000	190,000	1,800,000	900,000
Titanium and Titanium Dioxide	1.600.000	800.000	16,000,000	2,300,000	28.000,000	4,000,000
Tengsten			280,000	47,000	640.000	110.000
Uranium			800.000	47,000	1.400.000	84.000
Zinc	8,000,000	2,700.000	10.000,000	3,300,000	13.000.000	4,200,000
Zirconium and Hafnium			1.800,000	910.000	11.000,000	5 <u>,400.000</u>
Total / Average	23,000,000		70,000,000		140,000,000	

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Exhibit A.1-10
Option 2 Incremental Costs Assuming Prior Treatment

	Minimum	Value Case	Expected	Value Case	Maximum	Value Case
	Total	Avg. Fac.	Total	Avg. Fac.	Total	Avg. Fac.
	Incremental	Incremental	Incremental	Incremental	Incremental	Incremental
Commodity	Cost (\$/yr)	Cost (\$/yr)	Cost (\$/yr)	_Cost (\$/vr)	Cost (\$/vr)	Cost (\$/vr)
Alumina and Aluminum	13.000	570	26,000	1.100	26 000	1 100
Antimony	· ·		(10.000)	(1,700)	(19.000)	(3,100
Beryllium	(55,000)	(55,000)	(45,000)	(22.000)	(310.000)	(160.000)
Bismuth			(1,700)	(1.700)	(12,000)	(12.000
Cadmum			5.600	2.800	(16,000)	(8.100
Calcium		-	9	9	9	9
Chromium and Ferrochromium		570	580	580	580	580
Coal Gas				-	570	570
Copper	5,700	570	(3,900)	(390)	9,900	990
Elemental Phosphorus	(550,000)	(280,000)	(550.000)	(280,000)	(550.000)	(280,000
Fluorspar and Hydrofluoric Acid		-	1.700	570	1.700	570
Germanium			4.200	1.000	4,400	1,100
Lead	1,300	450	(670,000)	(220,000)	(1,200,000)	(410.000)
Magnesium and Magnesia from Brines	1,100	560	1,700	840	1,700	840
Mercury		-	(160,000)	(23,000)	(470.000)	(67.000)
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	7.300	660	7,300	660
Platinum Group Metals		-	5.100	1.700	5.100	1,700
Rare Earths	(1,900)	(1,900)	1.400	1.400	1,500	1,500
Rhenium	-		2,300	1,100	2,300	1,100
Scandium	-	-	110.000	16,000	(22,000)	(3,200
Selenium	(24,000)	(12.000)	(19.000)	(6,500)	(11,000)	(3.700)
Synthetic Rutile		-	(6.900)	(6,900)	(14,000)	(14.000
Tantalum, Columbium, and Ferrocolumbiam	(160.000)	(79,000)	(160.000)	(78,000)	(160,000)	(78.000
Tellurium	· · ·	-	(2.000)	(1,000)	(16,000)	(8,260)
Titanium and Titanium Dioxide	(62,000)	(31,000)	(75.000)	(11,000)	(95,000)	(14,000
Tungsten		•	(11,000)	(1,900)	(17,000)	(2,900)
Uranium		-	35,000	2,000	36,000	2,100
Zinc	(2,600,000)	(850.000)	(3,400.000)	(1,100,000)	(3,600,000)	(1,200,000)
Zirconium and Hafnium			(82,000)	(41,000)	(280,000)	(140,000
Total / Average	(3,400.000)		(5,000,000)		(6,700,000)	

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April 30, 1998

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			Value of		Incremental Sector Cost			Economic Im	pact
	Production	Price	Shipments		\$		(percen	t of Value of	Shipments)
Sector	MT	\$/MT	\$	Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,600,000	1,543	5,554,800,000	1,100,000	3,200,000	4,800,000	0.02	0.06	0.09
Antimony	20,100	3,351	67,355,100		2,100,000	3,800,000	0.00	3,12	5.64
Beryllium	217	352,640	76,522,880	230,000	2,300,000	9,900,000	0.30	3 01	12.94
Bismuth	1,100	7,937	8,730,700	-	710,000	1,800,000	0.00	8 13	20.62
Cadmium	1,450	2,756	3,996,200	-	730,000	4,500,000	0.00	18.27	112.61
Calcium	1,100	4,480	4,928,000		9	9	0.00	0.00	0.00
Chromium and Ferrochromium			39,000,000	190,000	190,000	200,000	0 49	0.49	0.51
Coal Gas			186,000,000		•	260,000	0.00	0.00	0.14
Copper	2,000,000	2,249	4,498,000,000	10,000,000	10,000,000	11,000,000	0 22	0.22	0.24
Elemental Phosphorus	311,000	2,756	857,116,000	2,700,000	2,700,000	2,700,000	0 3?	0 32	0 32
Eluorspar and Hydrofluoric Acid	8,200	162	1,328,400		180,000	370,0 00	0 00	13.55	27 85
Germanium	18	2,000,000	36,000,000		210,000	470,000	0.00	0.58	1.31
Lead	340,000	1,076	365,840,000	84,000	5,100,000	9,900,000	0.02	1 39	2.71
Magnesium and Magnesia from Brines	143,000	3,858	551,694,000	2,000,000	2,000,000	2,100,000	0 36	0.36	0.38
Mercury	70	7,542	527,940	-	420,000	1,400,000	0.00	79.55	265.18
Molybdenum, Ferromolybdenum and Ammonium Molybdate			427,500,000	-	10,000,000	29,000,000	0.00	2 34	6.78
Platinum Group Metals			42,792,580		160,000	250,000	0.00	0.37	0.58
Rare Earths	20,000	2,870	57,400,000	220,000	1,700,000	5,000,000	0 38	2.96	8.71
Rhenium	19	1,100,000	20,900,000		2,900,000	5,100,000	0 00	13.88	24.40
Scandium	25	1,400,000	35,000,000		260,000	460,000	0 00	0 74	1.31
Selenium	350	7,055	2,469,250	530,000	720,000	2,400,000	21.46	29 16	97 20
Synthetic Rutile	140,000	650	91,000,000	-	1,400,000	2,400,000	0.00	1 54	2.64
Tantalum, Columbium, and Ferrocolumbium			95,727,210	460,000	680,000	920,000	0.48	071	0.96
Tellunium	60	46,287	2,777,220		390,000	1,900,000	0.00	14 04	68.41
Titanium and Titanium Dioxide			3,203,707,220	1,700,000	16,000,000	28,000,000	0.05	0 50	0.87
Tungsten	8,449	49	414,001		320,000	680,000	0 00	77 29	164.25
Uranium	2,132	31,130	66,369,160		830,000	1,500,000	0.00	1 25	2 26
Zinc	620,000	1,124	696,880,000	11,000,000	14,000,000	18,000,000	1.58	2 01	2 58
Zirconium and Halnium			365,814,000		1,900,000	11,000,000	0 00	0.52	3.01
Total				30,000,000	81,000,000	160.000,000			

Exhibit A.1-11 Option 1 No Prior Treatment Baseline Impacts

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	Production	Price	Value of Shipments		Incremental Sector Cost \$		Economic Impact (percent of Value of Skipments)						
Sector	MT	\$/MT	s	Minimum	Expected	Maximum	Minimum	Expected	Maximum				
Alumina and Aluminum	3,600,000	1,543	5,554,800,000	280,000	760,000	1,400,000	0.01	0.01	0.03				
Antimony	20,100	3,351	67,355,100	-	6,800	6,800	Q .00	0.01	0.01				
Beryllium	217	352,640	76,522,880	570	2,800	2,800	0.00	0 00	0.00				
Bismuth	1,100	7,937	8,730,700		5,600	6,200	0.00	0 06	0 07				
Cadmium	1,450	2,756	3,996,200	•	67,000	430,000	0.00	1 68	10.76				
Calcium	1,100	4,480	4,928,000	-	9	9	0.00	0 00	0.00				
Chromium and Ferrochromium			39,000,000	57,000	57,000	64 000	0.15	0.15	0 16				
Coal Gas			186,000,000			66 000	0.00	0.00	0 04				
Copper	2,000,000	2,249	4,498,000,000	2,700,000	2,500,000	2,500,000	0.06	0.06	0 06				
Elemental Phosphorus	311,000	2,756	857,116,000	290,000	290,000	290,000	0.03	0.03	0.03				
Fluorspar and Hydrofluoric Acid	8,200	162	1,328,400		49,000	81,000	0.00	3.69	6.10				
Germanium	18	2,000,000	36,000,000	-	14,000	16,000	0.00	0.04	0.04				
Lead	340,000	1,076	365,840,000	27,000	89,000	120,000	0.01	0.02	0.03				
Magnesium and Magnesia from Brines	143,000	3,858	551,694,000	1,100	2,600	44,000	0.00	0.00	0.01				
Mercury	70	7,542	527,940		12,000	12,000	0.00	2 27	2 27				
Molybdenum, Ferromolybdenum and Ammonium Molybdate			427,500,000		7,300	7,300	0.00	0.00	0.00				
Platinum Group Metals			42,792,580		5,400	11,000	0.00	0.01	0.03				
Hare Earths	20,000	2,870	57,400,000	1,100	90,000	310,000	0.00	0.16	0.54				
Rhenium	19	1,100,000	20,900,000		3,100	5,600	0.00	0 0 1	0.03				
Scandium	25	1,400,000	35,000,000		7,900	7,900	0.00	0.02	0.02				
Selenium	350	7,055	2,469,250	1,100	17,000	110,000	0 ()4	0 69	4.45				
Synthetic Rutile	140,000	650	91,000,000		64,000	120,000	0 00	0.07	0.13				
Tantalum, Columbium, and Ferrocolumbium			95,727,210	1,100	3,400	3,400	0.00	0.00	0.00				
Tellunium	60	46,287	2,777,220	•	10,000	15,000	0.00	0.36	0.54				
Titanium and Titanium Dioxide			3,203,707,220	3,700	130,000	240,000	0 00	0.00	0.01				
Tungsten	8,449	49	414,001	-	6,800	6,800	0.00	1.64	1 64				
Uranium	2,132	31,130	66,369,160		56,000	110,000	0 00	0.08	0.17				
Zinc	620,000	1,124	696,880,000	62,000	110,000	150,000	0 01	0.02	0.02				
Zirconium and Hafnium			365,814,000		4,500	4,500	0.00	0.00	0.00				
Total				3,400,000	4,400,000	6,100,000							

Exhibit A.1-12 Option 1 Prior Treatment Baseline Impacts

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	Production	Price	Value of Shipments		Incremental Sector Cost \$			conomic Imp of Value of S	
Sector	MT	\$/MT	\$	Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,600,000	1,543	5,554,80 <u>0,000</u>	730,000	2,100,000	2,900,000	0.01	0.04	0 05
Antimony	20,100	3,351	67,355,100		2,100,000	3,800,000	0.00	3.12	5 64
Beryllium	217	352,640	76,522,880	160,000	2,200,000	9,400,000	0.21	2.87	12 28
Bismuth	1,100	7,937	8,730,700		710,000	1,800,000	0 00	8 13	20 62
Cadmium	1,450	2,756	3,996,200		630,000	3,800,000	0.00	15.76	95 09
Calcium	1,100	4,480	4,928,000	-	9	9	0 00	0 00	0.00
Chromium and Ferrochromium			39,000,000	110,000	110,000	110,000	0.28	0.28	0.28
Coal Gas			186,000,000	-		180,000	0.00	0.00	0.10
Copper	2,000,000	2,249	4,498,000,000	7,400,000	7,500,000	7,700,000	0 16	0.17	0.17
Elemental Phosphorus	311,000	2,756	857,116,000	1,700,000	1,700,000	1,700,000	0.20	0 20	0.20
Fluorspar and Hydrolluoric Acid	8,200	162	1,328,400		110,000	260,000	0.00	8 28	19.57
Germanium	18	2,000,000	36,000,000		190,000	450,000	0.00	0 53	1.25
Lead	340,000	1,076	365,840,000	56,000	4,100,000	8,100,000	0.02	1 12	2.21
Magnesium and Magnesia from Brines	143,000	3,858	551,694,000	2,000,000	2,000,000	2,100,000	0.36	0.36	0.38
Mercury	70	7,542	527,940		190,000	800,000	0.00	35 99	151.53
Molybdenum, Ferromolybdenum and Ammonium Molybdate			427,500,000		10,000,000	29,000,000	0.00	2 34	6.78
Platinum Group Metals			42,792,580		160,000	240,000	0.00	0.37	0 56
Rare Earths	20,000	2,870	57,400,000	210,000	1,600,000	4,600,000	0.37	2 79	8.01
Rhenium	19	1,100,000	20,900,000		2,900,000	5,100,000	0.00	13 88	24,40
Scandium	25	1,400,000	35,000,000		350,000	420,000	0.00	1.00	1 20
Selenium	350	7,055	2,469,250	490,000	660,000	2,200,000	19.84	26.73	89.10
Synthetic Rutile	140,000	650	91,000,000	-	1,300,000	2,200,000	0.00	1.43	2.42
Tantalum, Columbium, and Ferrocolumbium			95,727,210	260,000	480,000	720,000	0 27	0.50	0 75
Tellurium	60	46,287	2,777,220		370,000	1,800,000	0.00	13.32	64.81
Titanium and Titanium Dioxide			3,203,707,220	1,600,000	16,000,000	28,000,000	0.05	0.50	0.87
Tungsten	8,449	49	414,001	-	280,000	640,000	0.00	67.63	154.59
Uranium	2,132	31,130	66,369,160		800,000	1,400,000	0 00	1.21	2 11
Zinc	620,000	1,124	696,880,000	8,000,000	10,000,000	13,000,000	1.15	1.43	1.87
Zirconium and Hafnium			365,814,000		1,800,000	11,000,000	0 00	0 49	3.01
Total				23,000.000	70,000,000	140,000,000			

Exhibit A.1-13											
Option 2 No Prior Treatment	Baseline Impacts										

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1	Production	Price	Value of		Incremental Sector Cost			Economic Im	
Sector	MT	S/MT	Shipments S	Minimum	\$ Expected	Maximum	(percen Minimum	t of Value of Expected	Maximum
Alumina and Aluminum	3,600,000	1,543	5,554,800,000	13,000	26,000	26,000	0.00	U 00	0.00
Antimony	20,100	3,351	67 355 100	13,000	(10,000)	(19.000)	0.00	-0.01	-0.03
Beryllium	20,100	352,640	76,522,880	(55 000)	(45,000)	(310.000)	-0.07	-0.06	-0.03
Bismuth	1,100	7,937	8,730,700	(35,000)	(1,700)	(12,000)	0.00	-0.02	-0.14
Cadmium	1,450	2,756	3 996,200		5,600	(16 000)	0.00	0.14	-0.40
Calcium	1,100	4,480	4,928,000		9	9	0.00	0 00	0.00
Chromium and Ferrochromium		4,100	39,000,000		580	580	0.00	0.00	0.00
Coal Gas			186,000,000		-	570	0.00	0 00 0 C	0.00
Copper	2,000,000	2,249	4,498,000,000	5,700	(3,900)	9,900	0.00		0.00
Elemental Phosphorus	311,000	2,756	857,116,000	(550,000)	(550,000)	(550,000)	- 0.0 6	-0.06	-0.06
Fluorspar and Hydrofluoric Acid	8,200	162	1,328,400		1,700	1,700	0.00	0 13	0.13
Germanium	18	2,000,000	36,000,000		4,200	4,400	0.00	0.01	0.01
Lead	340,000	1,076	365,840,000	1,300	(670,000)	(1,200,000)	0.00	-0.18	-0.33
Magnesium and Magnesia from Brines	143,000	3,858	551,694,000	1,100	1,700	1,700	0.00	0 00	0.00
Mercury	70	7,542	527,940		(160,000)	(470,000)	0.00	30 31	-89.03
Molybdenum, Ferromolybdenum and Ammonium Molybdate			427,500,000		7,300	7,300	0.00	0.00	0.00
Platinum Group Metals			42,792,580	-	5,100	5,100	0.00	0.01	0.01
Rare Earths	20,000	2,870	57,400,000	(1,900)	1,400	1,500	0.00	0.00	0.00
Rhenium	19	1,100,000	20,900,000	_ ·	2,300	2,300	0.00	0.01	0 01
Scandium	25	1,400,000	35,000,000	-	110,000	(22,000)	0.00	0.31	0.06
Selenium	350	7,055	2,469,250	(24,000)	(19,000)	(11,000)	-0.97	-0.77	-0 45
Synthetic Rutile	140,000	65 0	91,000,000		(6,900)	(14,000)	0.00	-0.01	-0 02
Tantalum, Columbium, and Ferrocolumbium			95,727,210	(160,000)	(160,000)	(160,000)	0.17	-0.17	-0.17
Tellurium	60	46,287	2,777,220		(2,000)	(16,000)	0.00	-0.07	-0 58
Titanium and Titanium Dioxide			3,203,707,220	(62,000)	(75.000)	(95,000)	0.00	0.00	0 00
Tungsten	8,449	49	414,001		(11,000)	(17,000)	0.00	2.66	4.11
Uranium	2,132	31,130	66,369,160	-	35,000	36,000	0.00	0.05	0 05
Zinc	620,000	1,124	696,880,000	(2,600,000)	(3,400,000)	(3,600,000)	-0.37	-0.49	-0.52
Zirconium and Hatnium			365,814,000		(82,000)	(280,000)	0.00	0.02	-0 08
Total				(3,400,000)	(5,000,000)	(6,700,000)			

Exhibit A.1-14 Option 2 Prior Treatment Baseline Impacts

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A.2 Risk and Benefits Assessment Assumptions, Methods, and Results

A.2.1. Introduction

As discussed in Section 4.1, while EPA's current judgement is that the modified prior treatment baseline best represents current industry practice, the Agency has conducted a substantial amount of risk and benefits assessment work for the alternative baseline scenarios. This is particularly true for the no prior treatment baseline, which was regarded early in the regulatory development process as a prudently conservative characterization of current practice. EPA has also evaluated some potential risks and benefits assessment for the activities evaluated (disposal or storage) are applicable to more than one baseline, and to more than one regulatory option, because the behavioral assumptions made for that activity are the same under the various baselines and options. Thus they can be used to infer baseline risks and risk reduction benefits for other sets of baseline assumptions.

This appendix describes in detail the risk and benefits assessments that have been performed for the alternative baselines. The primary focus is on the work that EPA has done to evaluate groundwater pathway risks associated with waste disposal under the no prior treatment baseline. In addition, it discusses in less detail aspects of the risk and benefits assessments for the storage of recycled materials compared to the modified prior treatment baseline that are relevant to the alternative baselines. A.2.1.1 Groundwater Risk and Benefits Assessment for Waste Disposal

The bulk of this appendix is devoted to a description of the risk and benefits analysis for mineral processing waste disposal. As discussed in Section 4.1, EPA has performed quantitative risk and benefits analysis for the groundwater pathway risks associated with the disposal of these wastes. EPA analyzed risks for all 42 (later reduced to 34) of the spent materials, sludges, and byproduct streams from the mineral processing industry for which constituent concentration data were available. Pre-regulatory risks were analyzed under the no prior treatment baseline, which assumed final disposal of untreated materials in land units (waste piles and surface impoundment). Benefits were estimated for the three regulatory options under consideration at the time of the analysis. For all three options, it was assumed that the wastes would be treated to meet UTS levels for all constituents prior to disposal.

Since the modified prior treatment baseline assumes that all wastes would be treated to meet TC regulatory levels, the no prior treatment and modified prior treatment baseline risks are not the same, and the health benefits of moving from the baseline to the regulated environment are not equivalent. On the other hand, the post-regulatory requirements for treatment of all wastes to meet the UTS requirements remains a feature of the current regulatory options. Thus, the post-regulatory risks calculated for waste disposal are still relevant to the current options, as was discussed in Section 4.2.

A.2.1.2 Groundwater and Multipathway Risk Assessment for Recycled Materials

The methods used to evaluate risks associated with the storage of recycled materials are described in detail in Appendix H, and will not be discussed in detail here. Risks were assessed for waste storage under the modified prior treatment baseline, which assumes that the recycled materials would be stored in unlined land-based units (waste piles and surface impoundments). This assumption is the same as that made in the no prior treatment baseline. Therefore the risks associated with these two baselines are the same, and this provides the rationale for including a discussion of these results in this appendix.

Because suitable models and data are not available that would allow risk estimation for tanks, containers, and buildings, the risks associated with the storage of recycled materials under the prior

treatment baseline and under regulatory Options 1-3 have not been evaluated quantitatively. In section 4.2, the potential degrees of risk reduction associated with the various regulatory options are discussed qualitatively.

A.2.2 RISK AND BENEFITS ASSESSMENT METHODS

A.2.2.1 Risk Assessment Methods for Waste Disposal

A.2.2.1.1 Identification of Waste Streams for Quantitative Risk and Benefits Analysis

The procedures used to identify waste streams for inclusion in the risk and benefits assessments in the December 1995 RIA are described in Section 5.1.1.1 of that RIA.³ The number of waste streams that could be evaluated with regard to risks and benefits was limited by the lack of constituent concentration data to a small fraction of the wastes that were evaluated in the cost and economic analysis. To evaluate pre-LDR constituent concentrations, bulk concentration data were used for wastewaters (WW), and EP leachate data were used to estimate release concentrations for liquid nonwastewaters (LNWW) and nonwastewaters (NWW). Wastes for which these types of data were not available were excluded from the quantitative risk and benefits assessments.

The procedures used to identify waste streams for inclusion in the sample-specific risk and benefits were slightly different, as described in Section 5.5.1.1 of the December 1995 RIA. First, the data requirements for including a waste in the quantitative risk assessment were relaxed somewhat, allowing inclusion of LNWW and NWW wastes for which only bulk concentration data were available. Second, the assumed proportion of high-probability ("Y") recycled materials that would be disposed was reduced from 20 percent to zero. This resulted in the removal of the two recycled materials for which constituent concentration data were available from the quantitative risk assessment, making the risk and benefits analysis for Regulatory Options 1 and 2 the same, in terms of the waste streams that were included.

A total of 42 waste streams ultimately met the criteria for inclusion in the sample-specific risk and benefits assessments for changes in waste disposal practices under the proposed LDRs. These waste streams represent a relatively small proportion, in terms of numbers, of the waste streams included in the cost and economic analysis. However, as discussed in the December 1995 RIA Appendix J, the wastes that are included in the risk and benefits analysis for waste disposal account for between 71 and 92 percent of the estimated total waste volume covered by the cost and economic analysis, depending on which volume estimates are used.

These same 42 wastes were included in the preliminary risk and benefits calculations (ICF Incorporated 1996a). Since that time, as discussed above, a number of waste streams have been eliminated from the risk and benefits assessments, as summarized in Exhibit A.2-1. Two beryllium sector waste streams were removed because they are beneficiation wastes, and would not be addressed by LDRs. One waste stream in the copper commodity sector was removed from the waste disposal risk and benefits assessment because EPA believes that it is fully recycled. Another copper waste stream

³ Regulatory Impact Analysis of the Supplemental Proposed Rule Applying Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes, December 1995.

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Commodity	Waste Stream
Aluminum and Alumina	Cast house dust
Antimony	Autoclave filtrate
Beryllium	Spent barren filtrate streams
Bervllium	Bertrandite thickener slurry
Beryllium	Chip treatment wastewater
Beryllium	Spent raffinate
Copper	Acid plant blowdown (1)
Copper	Scrubber blowdown
Copper	Spent bleed electrolyte
Copper	Surface impoundment waste liquids
Elemental Phosphorous	AFM rinsate
Elemental Phosphorous	Furnace offgas solids
Elemental Phosphorous	Furnace scrubber blowdown
Elemental Phosphorous	Slag quenchwater
Germanium	Waste acid wash/rinse water
Germanium	Chlorinator wet air pollution control sludge
Germanium	Hydrolysis filtrate
Germanium	Waste still liquor
Lead	Process wastewater
Lead	Surface impoundment waste liquids
Magnesium and Magnesia (brine)	Smut
Molybdenum, Ferromolybdenum, Ammonium Molybdate	Liquid residues
Rare Earths	Spent ammonium nitrate processing solution (2)
Rare Earths	Process wastewater (2)
Selenium	Plant process wastewater
Tantalum, Columbium, and Ferrocolumbium.	Process wastewater
Titanium and Titanium Dioxide	Pickle liquor & wash water
Titanium and Titanium Dioxide	Leach liquor & sponge wash water
Titanium and Titanium Dioxide	Scrap milling scrubber water
Titanium and Titanium Dioxide	Spent surface impoundment liquids
Titanium and Titanium Dioxide	Spent surface impoundment solids
Titanium and Titanium Dioxide	Waste acids (Chloride process)
Titanium and Titanium Dioxide	Waste acids (Sulfate process)
Titanium and Titanium Dioxide	Wastewater treatment plant sludge/solids
Tungsten	Spent acid & rinse water
Zinc	Waste ferrosilicon
Zinc	Process wastewater
Zinc	Spent surface impoundment liquids (3)
Zinc	Spent surface impoundment solids (4)
Zinc	Spent synthetic gypsum (3)
Zinc	Wastewater treatment plant liquid effluent (3)
Zinc -	Zinc lean slag

Exhibit A.2-1 Commodity Waste Streams Included in Revised Benefits Analysis

Notes:

Strikethrough indicates streams that have been removed because they are fully recyled, no longer generated, or not disposed in land units.

(1) Number of facilities reduced from 9 to 7.

(2) Number of facilities reduced to 1.

(3) Number of facilities reduced from 4 to 3.

(4) Name changed to Wastewater treatment plant solids.

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was removed because it appears to be redundant with another stream. Two waste streams from lead production were removed, one because it is fully recycled, and another because it is no longer generated. Acid waste from titanium chloride production was removed from the analysis because EPA received information indicating that it is currently deep-well injected, and not land disposed. One waste stream from zinc production was removed because it is either recycled or not stored in land-based units. After removing these streams, 34 were left in the risk and benefits analysis for waste disposal. A zinc waste stream, "spent surface impoundment solids," was renamed to "waste water treatment plant solids," but remained in the analysis.

A.2.2.1.2 Waste Characterization Data and Release Concentration Estimates

The source of the mineral processing waste constituent concentration data used in the pre-LDR risk estimates is the same source as that used in the December 1995 RIA sample-specific risk assessment. These data are summarized in Appendix K of the December 1995 RIA. In this analysis a slightly different approach from that used in the RIA was adopted to enumerate samples of each waste type. In the December 1995 RIA, when both bulk analyses and EP leachate sample results were available for a LNWW or NWW stream, only the leachate data were used to estimate release concentrations. In the revised risk assessment presented below, both types of samples, when available, were used in the risk assessment to develop separate risk estimates. This approach makes the best possible use of the available data, and takes into account that, in many cases, it was not clear that the EP and bulk analyses for a given waste stream were from the same samples or batch of waste.

In adopting this approach, it was assumed that the observed differences in the release concentrations calculated from the two types of samples of the same wastes reflect real variability in waste stream constituent concentrations and in the leaching characteristics of the various constituents. In the December 1995 RIA, a total of 126 waste samples were evaluated for carcinogenic risks, and 217 samples were evaluated for noncarcinogenic risks. Using all of the available data in the revised risk assessment and excluding the wastes as described above. EPA calculated carcinogenic risks and noncarcinogenic hazard quotients for 115 samples and 190 samples, respectively. The number of samples evaluated for carcinogenic risks for beryllium (see below), and thus only streams containing detectable levels of arsenic were considered to pose carcinogenic risks.

For WW streams, the bulk concentration sample results were used directly as release concentration estimates. For LNWW and NWW streams, EP leachate concentrations were also used directly as release concentrations. For LNWW and WW bulk samples, release concentrations (mg/l) were conservatively estimated as being equal to the bulk constituent concentrations (mg/kg) divided by 20. This approach conservatively assumes that all waste constituents are completely leachable into the EP leachant.

For the post-LDR scenario, release concentrations for all constituents were estimated to be equal to one-half the landfill UTS concentrations for each constituent, or they were to be as being equal to the sample concentration, if that value was less than one-half the UTS concentration. The decision to use one-half the UTS concentration, instead of the UTS concentration itself, was based on EPA's assumption that waste managers required to comply with UTS would give themselves a conservative margin of safety and assume that all of the constituents are completely leachable. The basis for this judgment is discussed in Section 5.5.1.3 of the December 1995 RIA.

A.2.2.1.3 Exposure Assessment

Exposure concentrations of the waste constituents in ground water were estimated by dividing the release concentrations by the recently-developed constituent-specific DAF values derived for mineral processing wastes. Under the no-treatment baseline scenario, all NWW streams were assumed to be disposed in waste piles. Therefore, the 75th and 95th percentile wastepile DAF values were used to evaluate central tendency (CT) and high end (HE) exposure concentrations, respectively. All WW and LNWW wastes were assumed to be disposed in surface impoundments, and the 75th and 95th percentile impoundment DAFs were therefore used to calculate the CT and HE exposure concentrations for these wastes.

In evaluating risks, the 75th percentile constituent-specific DAFs were used to estimate central tendency (CT) groundwater concentrations. The rationale for using the 75th percentile DAFs rather than, for example, the 50th percentile value was that the EPACMTP model used to derive DAFs does not consider fractured or channeled flow or other facilitated transport mechanisms which may occur at some sites, resulting in higher groundwater concentrations than those predicted for homogeneous flow processes modeled by EPACMTP. The 95th percentile constituent-specific DAF values were used to estimate high-end (HE) groundwater concentrations, in keeping with the definition of a high-end receptor as someone exposed at levels between the 90th and 99th percentiles of all exposed individuals.

In the post-LDR case, all wastes (WW, LNWW, NWW) were assumed to be treated and disposed of in landfills. Since no data related to mineral processing waste disposal in landfills were available, DAFs values derived for waste piles were used for estimating all of the exposure concentrations in the post-LDR scenario.

As noted above, the DAF values used in this analysis differed from those used previously. The DAF values used here were derived based on data on constituent concentrations, facility and waste volumes, and locational data specifically for mineral processing wastes, rather than on generic values. In addition, the DAF values used in this assessments were calculated separately for pre- and post-LDR release concentration distributions. Thus, these values better reflect the expected fate and transport characteristics of the mineral processing industry waste constituents than did the values used previously. In particular, the revised DAFs account for the concentration-dependence of groundwater transport for each constituent and regional variations in precipitation and groundwater transport. These variations were not taken into account in the previous DAF derivations.

The constituent-specific DAF values used in the risk assessment for waste disposal are provided in Exhibit A.2-2. The surface impoundment DAFs, which are used in this analysis only for evaluating pre-LDR risks for liquid wastes, are summarized in the second and third columns of the Exhibit A.2-2. Most of the 75th percentile DAF (CT) values are lower than the CT value of 500 used in the RIA risk analysis. The values for antimony, arsenic, chromium, mercury, and thallium are only slightly lower (within about a factor of ten), while the values for barium, beryllium, cadmium, nickel, selenium, silver, and zinc are much lower (greater than a factor of ten) than the CT DAF values used in the December 1995 RIA. For these liquid waste stream constituents, the estimated pre-LDR constituent groundwater concentrations were greater than those estimated in the RIA. In contrast, the 75th percentile surface impoundment DAF value for lead and cyanide used in this analysis increased by several orders of magnitude over the CT DAFs used in the RIA, and thus the pre-LDR groundwater concentration estimates are lower for lead- and cyanidecontaining liquid waste streams than they were in previous analyses.

Exhibit A.2-2

Revised Constituent-Specific DAFs for the Mineral Processing Industry

	Surface Impo	undments (1)		Waste	Piles	
Constituent	Central Tendency (75th percentile) Pre-LDR	High End (95th percentile) Pre-LDR	Central Tendency (75th percentile) Pre-LDR	High End (95th percentile) Pre-LDR	Central Tendency (75th percentile) Post-LDR	High End (95th percentile)Post-LDR
Antimony	1.93E+02	2.28E+01	>10	8.36E+03	>10	98.36E+03
Arsenic	1.66E+02	1.71E+01	>10	2.56E+03	4.37E+09	2.56E+03
Barium	5.81E+00	1.17E+00	2.22E+03	1.38E+01	2.33E+03	1.46E+01
Beryllium	8.47E+00	1.24E+00	>10	4.87E+02	>10	° 5.54E+02
Cadmium	2.49E+01	1.40E+00	>10	2.67E+03	>10	° 3.26E+03
Chromium	9.82E+01	1.15E+01	2.21E+04	1.60E+02	2.21E+04	L60E+02
Cyanide	2.81E+10	4.20E+03	(2)	(2)	(2)	(2)
Lead	7.11E+05	4.98E+00	· >10	2.27E+05	>10	° 8.93E+08
Mercury	1.97E+02	8.05E+00	>10	4.29E+03	>10	⁹ 4.29E±03
Nickel	2.23E+01	1.51E+00	1.54E+06	1.41E+02	1.97E+06	1.46E+02
Selenium	· 2.70E+01	3.38E+00	1.18E+08	4.28E+02	1.19E+08	4.28E+02
Silver	1.11E+01	1.23E+00	>10	4.96E+02	>10	⁹ 4.87E+02
Thallium	2.97E+02	4.15E+01	>10	9.63E+04	>10	° 9.63E+04
Vanadium	5.67E+00	2.03E+00	>10	>109	>10°	>109
Zinc	1.23E+01	1.35E+00	>10	>10°	>109	>109

Source: U.S. EPA (1996)

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Notes:

(1) Post LDR DAFs for surface impoundments were not used in the risk calculations because it was assumed that all liquid wastes would be dewatered under LDRs.

(2) No DAFs were derived for cyanide disposed in waste piles because cyanide concentration data for non-liquid wastes were not available.

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The 95th percentile surface impoundment DAF values derived for this analysis are generally similar to the HE DAF values used in the 1995 RIA. The HE DAF values in the December 1995 RIA risk analysis ranged between 6 and 100. The constituent-specific DAFs used in this analysis range between 1.3 and 200 for all but one constituent. The sole outlier is the DAF for cyanide, which is 4200. For all constituents except cyanide, the 95th percentile surface impoundment DAFs used in this assessment result in pre-LDR estimated groundwater concentrations and health risks for liquid waste streams of generally similar magnitude to those calculated in the December 1995 RIA.

The constituent-specific waste pile DAF values derived for mineral processing wastes are shown in the last four columns of Exhibit A.2-2. These values were derived for both pre-LDR and post-LDR constituent concentrations. The former values were used to evaluate risks for all non-liquid waste streams pre-LDR, and the latter were used to evaluate risks post-LDR for all wastes, as explained above. The 75th percentile waste pile DAFs used in this analysis are, with few exceptions, many orders of magnitude greater than the CT DAF value (50) used in the December 1995 RIA. Thus, the predicted pre- and post-LDR risks for non-liquid waste streams containing these constituents are much lower than in the RIA. The lowest CT waste pile DAF value (about 2200), which was estimated for barium, is still about 40 times greater than the CT DAF value used in the RIA.

In comparison, most of the 95th percentile constituent-specific DAFs for the mineral processing wastes are somewhat closer to the range of HE values (12 to 100) used in the RIA. The pre-LDR HE waste pile DAFs are less than 10,000 for all but two contaminants, which are within two to three orders of magnitude of the RIA HE DAF range. Lead, vanadium, and thallium have HE DAFs that are higher than the values used in previous assessments. Post-LDR, the situation is similar. Most of the constituent-specific post-LDR DAF values for waste piles are less than 10,000, with the outliers again being lead and vanadium for which the DAF values are much higher. As with the 75th percentile DAFs, these revised 95th percentile DAF values result in the prediction of lower groundwater concentrations than those predicted in the previous assessments.

A.2.2.1.4 Risk Characterization

Lifetime cancer risks for the hypothetical receptor are calculated using the following equation:

$$Cancer Risk = \frac{EC * IR * EF * ED * CSF}{BW * 365 * AT}$$
(1)

Where:

EC	=	Exposure concentration of constituent in groundwater, mg/l
IR	=	Water ingestion rate (1.4 I/day)
EF _	=	Exposure frequency (350 days/year)
ED	=	Exposure duration (9 years)
CSF	=	Ingestion pathway Cancer Slope Factor (mg/kg-day) ¹
BW	=	Adult body weight (70 kg)
AT	=	Averaging time for dose estimation (70 years)

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Chronic noncancer hazard quotients for exposure to waste constituents in groundwater are calculated as follows:

$$Hazard \ Quotient = \frac{EC * IR * EF}{BW * 365 * RfD}$$
(2)

where the RfD is the EPA chronic ingestion pathway Reference Dose for the constituent,⁴ and the other variables have the same meaning as in Equation (1). The rationale for selecting the exposure factor values used in Equations (1) and (2) is discussed in Section 5.2.1.2 of the December 1995 RIA.

Two changes were made in the toxicological parameter values which were used to calculate risk results in this analysis. First, beryllium was no longer treated as an ingestion pathway carcinogen. While EPA has published an ingestion pathway cancer slope factor for beryllium, the Agency has not applied this value in several recent rulemakings, citing the great uncertainty surrounding the data supporting the cancer-causing potential of beryllium by the oral route. Thus, cancer risks are no longer calculated for beryllium-containing wastes, and arsenic is the sole carcinogenic constituent by the ingestion route included in the risk assessment. The other change in the toxicological parameter values was to use an updated IRIS RfD value for manganese, which had a very limited effect on the risk and benefits results.

A.2.2.2 Risk Assessment Methods for Storage of Recycled Materials

Risks associated with the storage recycled streams were assessed both for groundwater and nongroundwater pathways, as described in Appendix H. These methods will not be discussed in detail here.

A.2.2.3 Benefits Assessment Methods for Waste Disposal

A.2.2.3.1 Unit of Analysis for Benefits Assessment

Consistent with the December 1995 RIA, the unit of analysis of the benefits assessment is the "waste stream-facility combination." To calculate the benefits of improved management for a given waste stream, the number of facilities is first estimated, as described in Section A.2.2.3.2 of the RIA. Then, the numbers of facilities the imposition of the LDRs would result in changes in risk are calculated and categorized based on the order-of-magnitude change in risks pre- and post-LDR. The benefit measure is the number of facilities generating the waste (i.e., waste stream-facility combinations) that move from high-risk categories pre-LDR to lower-risk categories post-LDR. One feature of this approach is that a single facility that disposes of more than one waste stream will be counted in the benefits assessment as more than one waste stream-facility combination. Thus, the total number of waste stream-facility combinations in the benefits assessment exceeds the total number of facilities affected by the LDRs.

Another feature of this approach is that, as will be seen in Appendix A.2.2.3.3, not every exceedence of risk levels of concern pre-LDR results in an estimated benefit post-LDR. This is because if only a small number of samples from a given waste stream (one of 20, for example) give risk results above the level of concern, this may not translate into even one facility waste-stream combination if the number of facilities managing the waste is small (two or three). In this case, the estimated number of facilities with pre-LDR risks at levels of concern is zero. (Or more properly, it is less than one.)

⁴ Since there is currently no RfD value for lead, EPA calculated the hazard quotient for lead as the ratio of the exposure concentration to the MCL of 15 ug/l.

This approach does not provide an estimate of risk reduction for identifiable exposed individuals, nor does it allow calculations of population risk reduction. As explained in the December 1995 RIA, the lack of data regarding the number of individuals exposed to groundwater around mineral processing facilities precludes the development of population risk and benefit estimates.

A.2.2.3.2 Estimation of Numbers of Facilities Managing Mining Wastes

The total number of facilities managing specific wastes were estimated as described in Chapter 4 of the December 1995 RIA. For the HE benefits estimates, the total estimated numbers of facilities generating the various waste streams nation-wide were used in the benefits estimation. For the CT benefits estimates, a reduced number of facilities managing some of the waste streams was used. For all of the waste streams categorized "Y?" (i.e., low likelihood of being TC hazardous), the CT number of facilities was estimated as the total facilities generating the waste stream divided by two. Odd numbers of facilities were rounded up by one to generate an even number (e.g., an HE estimate of seven facilities resulted in a CT estimate of four facilities).

A.2.2.3.3 Attribution of Risks to Facility-Waste Stream Combinations

If there were always one and only one sample result per waste stream per facility, then the attribution of risks across waste streams and facilities would have been simple. (Each sample risk result would correspond to one facility-waste stream combination in the benefits analysis.) Unfortunately, the number of samples per waste stream and per facility varied considerably, necessitating the development of a method for distributing risk results from single samples and groups of samples across multiple facility-waste stream combinations. The approach used to distribute risks across facilities used in the revised benefits assessment is essentially identical to that described in detail in Section 5.5.2.4 of the December 1995 RIA, and can be summarized as follows:

- Where there is only one sample result for a waste stream, all of the facilities managing that waste are assigned the risk value associated with the pre- or post-LDR disposal of a waste having the same composition as the sample;
- Where there are multiple samples from a waste stream, the facilities disposing of that waste are assigned risk values in the same proportion as the risks are distributed across the samples. For example, if there are four waste samples and eight facilities disposing of the wastes, the risk results from each of the four waste samples are assigned to two facility-waste stream combinations;
- Where there are multiple samples from a single facility, the risk results for each sample at the facility are counted as separate risk estimates only if they are significantly different from one another.⁵ However, if multiple samples from a single facility result in risks that are very similar, the risks for all of those samples are averaged and counted as a single sample for purposes of the benefits analysis. The facility-waste stream combinations for a waste stream are then assigned to risk categories according the risk results from the individual samples from that waste stream, and from the combined

⁵ Risk from multiple samples are considered to be similar (homogeneous) if the same constituents account for the bulk of the risks, and if all of the sample-specific cancer risks or hazard quotients are within one to two orders of magnitude. (See the December 1995 RIA, p. 5-37.)

samples counted as a single sample. This approach avoids giving too great a weight to multiple samples from the same facility and the same batch of wastes.

The approach described above is rather complex, and requires a certain amount of professional judgment. However, as was the case for the sample-specific risk analysis in the December 1995 RIA, decisions about whether to combine samples within facilities had relatively little impact on either the pre-LDR or post LDR risk distributions, and the distribution of facility-wastes stream combinations across risk categories followed the distribution of the individual samples risk results quite closely.

A.2.2.4 Benefits Assessment Methods for Storage or Recycled Materials

As discussed in Section 4.2, a quantitative benefits assessment was not performed for recycled materials storage. Instead, the baseline risks are identified as an upper bound estimate of the risk reduction that could occur if all releases of toxic constituents were eliminated by storage in tanks containers, and buildings. This assumption also holds true for the no treatment baseline, since no treatment of stored materials is assumed under that baseline. The risk assessment for storage does not provide an estimate of the magnitude of the potential benefits associated with the prior treatment baseline. Analogous to the case for the disposal of treated wastes, it is likely that the benefits of improved storage under any of the regulatory options over the prior treatment baseline would be minimal.

A.2.3 RESULTS OF RISK AND BENEFITS ASSESSMENT FOR THE NO TREATMENT BASELINE

This section summarizes the results of the revised generic risk and benefits calculations that were completed using the constituent-specific DAFs, as described in Section A.2.2.1.

A.2.3.1 Risk and Benefits Assessment Results for Waste Disposal

The results of the risk assessment for mineral processing wastes are summarized in Exhibits A.2-3 and A.2-4. Exhibit A.2-3 provides the results of the pre- and post-LDR assessments of the individual cancer risks calculated for each sample, and Exhibit A.2-4 provides the results of the noncancer hazard quotient calculations for the samples.

The general pattern of waste disposal risks calculated in the December 1995 RIA is replicated in the risk calculations that use the newly-revised constituent-specific DAFs, but in a more extreme fashion. Waste streams move from higher risk categories pre-LDR to lower risk categories post-LDR. The most striking difference between the risk results presented here and those in the 1995 RIA is that all of the wastes with estimated health risks (both CT and HE) above levels of concern pre-LDR (greater than 10^{-5} cancer risk or hazard quotient > 1.0) move to below the levels of concern post-LDR.

Pre-LDR, CT cancer risks greater than 10^{-5} were predicted for 58 of 115 samples, with risk results distributed through all of the categories up to >10⁻¹. The pre-LDR HE cancer risks for 80 of 115 samples were greater than 10^{-5} , with the highest risks again reaching the highest risk category. These

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Exhibit A.2-3 Distribution of Samples by Groundwater Risk Category: Cancer Risks

Commodity V	,	Number																						i End						
Commodity	1				Pre-LDR						Post-LDR					Pre-LDR					Post-LDR									
Commodity		of Samples		10-5	10-4	10-3	10-2			10-5	10-4	10-3	10-2			10-5	10-4	10-3	10-2			10-5	10-4	10-3	10-2					
Commodity	· · · ·	with		lo	10	to	10			to	to	to	to			to	to	to	to			to	tu	tu	to					
	Waste Stream	Cancer Risk	<10-5	10-4	10-3	10-2	10-1	>10-1	<10-5	10-4	10-3	10-2	10-1	>10-1	<10-5	10-4	10-3	10-2	10-1	>10-1	<10-5	10-4	10-3	10-2	10-1	>10-1				
Al and Alumina C	Cast house dust	2	2	U	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	?	0	0	0	0	0				
Sb /	Autoclave filtrate	8	0	0	0	2	6	0	8	0	0	0	0	υ	υ	0	0	0	2	6	5	0	U	U)	0	υ				
Be	Spent barren filtrate streams	2 .	1	0	1	0	υ	υ	2	U	0	0	0	0	0	1	0	1	0	0	2	0	0	0	0	υ				
Be C	Chip treatment WW	1	1	0	υ	0	0	0	1	0	0	0	0	U	1	Û	0	0	0	0	1	0	0	0	υ	U				
Cu /	Acid plant blowdown	30	7	4	10	4	3	2	30	0	0	0	υ	0	1	6	4	10	4	5	- 30	0	Û	0	0	0				
Cu S	Scrubber blowdown	3	1	0	2	0	0	0	3	0	0	0	0	0	0	1	a	2	0	0	1	0	0	0	0	0				
Elemental Phosphorous	AFM rinsate	2	I 1	1	0	0	0	0	2	0	0	0	0	U.	0	1	L	υ	0	0	2	0	0	U	0	0				
Elemental Phosphorous	Furnace offgas solids	9	9	υ	υ	0	U	0	9	0	0	Û	0	0	9	0	0	υ	0	0	9	0	0	0	0	Û				
	Furnace scrubber blowdown	8	4	3	1	0	0	0	8	0	0	0	0	U	1	3	3	L	0	0	8	υ	0	υ	0	Ű				
	Slag quenchwater	1	0	1	0	0	υ	0	1	0	U	0	U	0	0	U	1	0	U	0	1	0	υ	Ū	Ű	ō				
	Waste acid wash/rinse water	1	l i	0	Ō	0	0	0	1	0	Ű	0	Ū.	0	0	1	0	0	Ű	0	i i	0	0	õ	õ	Ű				
	Chlorinator wet air poll, ctrl, sludge	1	і т	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	Г 1	0	0	ů	0	ō				
	Hydrolysis filtrate	1	1	0	0	0	0	0	1	0	0	0	o	0	1	0	0	υ	0	0	1 1	υ	0	Ð	u	0				
	Waste still liquor	1	1 1	0	0	0	υ	0	1	0	0	0	0	0	1	Û	0	0	0	0	1	ö	Ű	Ū.	ō	Ö				
	Smut	2	2	0	0	0	0	0	2	Û	0	0	0	Ű	2	0	0	0	0	0	2	0	0	0	Ő	ō				
	Liquid residues	1 1	0	0	0	1	U	0	1	0	0	0	0	υ	0	0	U	0	1	0	1	0	U	Ü	Ó	0				
	Spent anunon, nitrate proc. sol.	5	5	0	Ö	0	0	0	5	Ō	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	Ő				
	PWW	2	0	2	0	0	.0	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	Ű	0				
	Plant PWW	2	0	2	ο	0	0	0	2	υ	0	0	0	υ	0	0	2	0	0	0	2	υ	0	Ū	0	0				
	PWW	1 13	8	2	2	1	υ	0	13	0	0	0	0	υ	6	3	1	3	0	U	13	u	0	ů	Ű	ō				
feCol.															1									-		-				
	Pickle liquor & wash water	3	2	1	0	υ	0	0	3	0	0	0	0	0	0	2	1	0	0	0	3	υ	υ	0	υ	O				
	Leach liquor & sponge wash water	2	1	1	0	0	0	0	<u>-"</u>	0	0	0	0	0	0	L	1	0	υ	0	2	υ	0	0	Ű	Ő				
	Scrap nulling scrubber water	1	0	i	Ó	0	D	0	1	0	0	0	0	0	0	0	i	Ū	Ū	0	Ē	Ū.	0	0	0	Ű				
	Spent's i liquids	0	0	0	0	0	υ	0	0	Ö	0	ō	0	0	0	0	Ú	Ó	0	0	0	Ū.	Ű	õ	Ü	ō				
	Spent s.i. solids	ō	Ö	Ū	Ű	0	Ū	Ū	0	õ	Ō	Ō	Ō	0	0	0	ō	ō	Ó	0	ō	ō	ō	ŏ	ŏ	ŏ				
	Waste acids (Sulfate process)	4	1	3	Ó	0	Ū.	0	4	Ō	0	Ó	0	0	I 1	0	3	0	0	0	4	Ū.	Ö	Ŭ	0	ŏ				
	WWTP studge/solids	Ó	0	ò	Ő	ō	ō	ō	0	õ	Ō	0	0	υ	l o	U	0	0	0	0	0	Ű	Ď	Ŭ	Ŭ	ŏ				
	Spent acid & rinse water	2	1	0	1	0	0	0	2	ö	Ő	Ő	ō	0	0	1	ō	i	υ	0	2	Ö	ō	Ŭ	ŏ	õ				
	Waste terrosilicon	ō	0	ō	O	ō	ō	ō	ō	ŏ	ō	õ	Ö	ō	0	0	ō	Ó	ō	Ū	ō	Ű	Ŭ	ŏ	ŏ	ŏ				
	Spent s.i. liquids	l i	0	Ō	Ő	i	ō	ō	ī	ō	ō	Ō	ō	0	0	0	Ō	Ó	i i	0	i î	ō	Ö	ů	ő	õ				
	WWTP solids	l i	l î	Ō	0	0 0	Ō	ō	i	Ō	Ō	0	0	0	0	1	ò	0	0	0	i i	0	ō	ŏ	ő	ŏ				
	Spent synthetic gypsum	4	4	õ	ō	ō	ō	ō	4	ō	Ő	ō	0	U	2	Ū.	2	Ű	Ü	0	4	0	ŏ	ŏ	0	ŏ				
	WWTP liquid effluent	Ó	0	Ŭ	Ű	Ŭ	Ű	Ŭ	Ű	Ő	ö	Ő	0	Ű		ō	ō	Ŭ	Ŭ	ő	l i	0	Ŭ	ő	0 U	Ű				
	Zine lean slag	2	2	0	0	0	Ū	Ū	2	Ű	0	ō	0	0	2	0	0	Û	0	0	2	ŏ	ů	Ŭ	0	Ŭ				
		1	<u> </u>								_			·····		·	_			~										
Totals		115	57	21	17	9	9	2	115	o	0	υ	0	U	35	21	22	18	к	14	115	0	U	0	0	a				

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April 30, 1998

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Exhibit A.2-4 Distribution of Samples by Groundwater Hazard Category: Non-Cancer Hazards

	···		Central Tendency																End							
		Number of			P	re-LD	к				Pos	t-LDR					Р	re-LD	к				Past-	LDR		
	•	Samples with		1	10	100	1k			1	10	100	lk			1	10	100	lk			1	10	100	1 k	
Commodity	Waste Stream	Non-cancer Hazard	<1	to 10	to 100		to 10k	>10k	<1	ta 10				>10k	<1	to 10	to 100	to Ik	to 10k	>10k	<1	to 10	to 100	tu Ik	-to 10k >1	lok
															1							-		_		
	Cast house dust	2	2	0) () (2 1		0 () ()	•	2	0	0	0	0	0	2	0	0	0	0	0
Sb	Autoclave filtrate	8	0	0		•	4	0	1	5 1		0 0		-	- 0	0		2	2	-	8	0	0	0	0	0
Be	Spent barren filtrate streams	5	0	1		4 (•		5 (0 0		•	0	0		4	0	0	.5	0	Û	0	0	0
	Chip treatment WW	1 I	0	0	1	•	•	0		1 (,	0 0				0	0	0	U	1	- I	0	U	0	U	0
	Acid plant blowdown	35	6	8				0		5 1)	0 () 0	0	0	3	×	- 14	5	5	35	0	0	0	0	0
	Scrubber blowdown	3	0	1	:	2 () (1 (1	0 () ()	0	0	0	0	3	0	0	.3	υ	0	0	0	0
	AFM rinsate	2	0	2) (•		2 (0 0		· ·	0	0	- 0	2	0	0	2	0	0	0	υ	U
Elemental Phosphorous	Furnace offgas solids	14	14	Ú) (•	-) O		-14	0	0	0	0	0	14	0	U	0	0	U
Elemental Phosphorous	Furnace scrubber blowdown	14	5	6		2	I 0	0	1	4 (0	0 () ()	0	1	l	6	5	1	0	14	0	0	0	0	0
Elemental Phosphorous	Slag quenchwater	1	[1	0) () () (0	[1 ()	0 () ()	0	0	i i	U	0	0	0	Г I	0	0	0	0	0
	Waste acid wash/rinse water		I	0	•) () (0		1 4)	0 () ()	0	0	0	1	0	0	0	1	0	0	0	υ	0
Ge	Chlorinator wet air poll. ctrl. sludge	1	1	0	• •) () (0	1)	0 () U	0	1	0	0	0	0	0	1	0	0	0	0	0
Ge	Hydrolysis filtrate	1	1 1	0	• •) () (0		1	0	0 0	0 0	0	1	0	0	0	0	U	L	U	0	0	0	0
Ge	Waste still liquor	1) I	0) (0 () (0		1	D	0 0) ()	U	1	0	0	Ð	0	0	L	0	0	0	0	0
Mg and Magnesia (brine)	Smut	2	2	0) (0 () (0	ł	2	0	0 1) 0	0	1	1	U	0	0	0	2	0	0	0	0	0
Mo, FeMo, Amm. Mo	Liquid residues	1	0	0)) () ()	1	1 (0	0 0	0 0	0	0	0	0	- 1	0	0	1	0	0	0	υ	0
Rare harths	Spent ammon, nitrate proc. sol.	6	5	1	1) () () ()		6	0	0) (0	4	1	1	0	0	0	6	U	0	0	0	0
Rare Earths	PWW	4	2	2) () () U	1	4	U	0 () 0	0	1 1	1	1	1	U	0	4	0	υ	0	0	0
Se	Plant PWW	2	1	1) () () ()	1	2	0	0 0	5 0	0	0	U	1	1	0	0	2	0	0	0	0	0
Ta, Columbium, and FeCol	PWW	21	13	2		5 () 1	0	2	1	υ	0) ()	0	8	2	3	2	2	4	21	0	0	ō	ö	Ő
Titanium and TiO2	Pickle liquor & wash water	3	0	3	i 1) () () (3	υ	0 0) 0	0	0	0		0	0	0	3	0	υ	0	ø	ō
	Leach liquor & sponge wash water	2	l o	1		1 () () ()		2	0	0 0	0 0	0	0	0	2	0	υ	0	2	0	0	Ö	0	0
	Scrap milling scrubber water	ī	0	i	,	D () () 0	1	1	υ	0	D U	0	l ö	ü	- ī	0	Ū	Ű	Ī	ō	Ö	ö	ö	õ
	Spent s.a. liquids	· 10	10	C)	D () () 0	1 1	0 1	- 0	0 1	5 0	0	10	0	- 0	Ű	0	0	10	0	ō	õ	õ	ō
	Spent s 1 solids	6	6	č)	D () () 0			ΰ	-	0 0	, õ	3	3	Ű	õ	Ő	0	6	ŏ	0	ŏ	ő	Ű
	Waste acids (Sulfate process)	, ,	i o	ŏ) .	4 (1	4	•		Ďů			0	-	2	Ŭ	0	4	ö	ö	ő	ő	ŏ
	WWTP sludge/solids	2	2	õ		b (, ,		1	2	•	0 I			Ϊ	i i	0	0	ů	Ŭ	2	ő	ő	ő	ŏ	ö
	Spent acid & rinse water	4	3	ĩ		р р (1	4		0 I				i	0	i	ŏ	ů Ú	4	0	0	ŏ	ŏ	ΰ
	Waste ferrosilicon	l i	l í		}	u (1	•	ő.		jõ	-	1 7		័ត	ò	ő	ö	l í	ŏ	ő	ŏ	ŏ	Ű
Zn Zn	Spent s.r. liquids	22	1 1	t.		3			2	•	•	0 1		•	l i	Š	2	3	6	6	22	õ	ő	ŏ	ŏ	ő
Zn	WWTP solids	7	1 7	, a)	0 (-		-			•	n o			1	ī	0	ŏ	0	17	ŏ	ŏ	ŏ	ŏ	ö
Zn	Spent synthetic gypsum		د ا	0		õ i	· ·		1	•	•	•	5 0			,		0	ŭ	Ű		ő	ő	0	0	0 0
Zn	WWTP liquid effluent	i		1		1				•	~			•	Ū	ū	2	0 0	ŭ	ĩ	3	ő	ő	ŏ	0	0
Zn	Zine lean slag	3	Ĭ	0)	0			1				υ	-	3	ŭ	-	ŏ	0	ů.	3	ů	ŏ	ö	ů	ů ů
	<u> </u>	<u> </u>	<u> </u>						<u> </u>						<u> </u>	·	<u></u>									
Totals		197	95	35	5 3	6 1	5 13	1 2	19	7	D	0 0) (0	-58	26	35	41	16	21	197	0	0	0	υ	Ð

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proportions are not very different from those seen pre-LDR in both the December 1995 RIA. As noted above, estimated cancer risks for all of the waste samples post-LDR are below 10⁻⁵.

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The distribution of pre-LDR cancer risks across waste streams is generally the same as that seen in the previous risk assessments, with exception that several of the high-risk waste streams have been eliminated from the analysis, as described above. The majority of samples with risks above 10⁻⁵ pre-LDR were from antimony autoclave filtrate, copper acid plant blowdown, elemental phosphorous furnace scrubber blowdown, tantalum, columbium and ferrocolumbium process wastewater, and titanium/titanium oxide waste acids from the sulfate process. High-risk streams from the previous analysis which were eliminated in this analysis include beryllium spent raffinate, lead process wastewater, and zinc process wastewater.

As was the case for cancer risks, all of the wastes with pre-LDR noncancer hazard quotients above the level of concern drop below this level post-LDR, under both CT and HE assumptions (Exhibit A.2-4). Pre-LDR, the CT hazard quotients for 102 of 197 waste samples are above 1.0, while 139 of 197 samples had HE pre-LDR hazard quotients above 1.0. All of the same wastes having high pre-LDR cancer risks also had high pre-LDR hazard quotients. In addition, a substantial number of samples from zinc spent surface impoundment liquids and waste water treatment plant solids both had high noncancer hazard quotients pre-LDR. As was the case for cancer risks, the reduction in hazard quotients below the level of concern post-LDR is the result of the higher post-LDR DAF values that were derived using data for the mineral processing waste constituents.

The results of the benefits analysis for cancer risks and noncancer risks under the no prior treatment baseline are summarized in Exhibits A.2-5 and A.2-6, respectively. As discussed previously, the distribution of risks across facility-waste stream combinations closely follows that seen for the individual samples.

In the CT case, the number of facility-waste stream combinations with pre-LDR cancer risks greater than 10⁻⁵ is 33 out of an estimated 108 facilities.⁶ Post-LDR, all of the facility-waste stream combinations fall below the 10⁻⁵ CT risk level. In the HE case, 62 out of 133 facility-waste stream combination have pre-LDR cancer greater than 10⁻⁵. All of these waste stream-facility combinations fall into the risk category less than 10⁻⁵ post-LDR

The number of facility-waste stream combinations with pre-LDR CT hazard quotients greater than 1.0 is 39 out of 108. In the HE case, 70 of 133 facilities have pre-LDR hazard quotients greater than 1.0. Post-LDR, all of the waste stream-facility combinations fall below the level of concern. The changes in the distributions of facility-waste stream combinations across cancer risk and hazard quotient categories associated with the LDRs for mineral processing wastes are shown graphically in Exhibit A.2-7.

⁶ In reviewing Exhibits 5, the reader will note that the sums of the waste-stream-facility combinations in each risk category do not add up to the total number of facilities. This is because some of the facilities do not produce wastes with carcinogenic constituents (e.g., arsenic).

Exhibit A.2-5 Distribution of Waste Stream/Facility Combinations by Groundwater Risk Category: Cancer Risks

		Number of Central Tendency											High End														
		Waste Str Facilit				Pre-LI) <u>R</u>				Pa	<u>st-LD</u>	к					Pre-l.	<u>.br</u>					Post	LDR		
	1	Combinati	-		10-5	10-4		10.2		10	-5 1	0-4 1	10-3	10.2			10-5	10-4	10-3	10.3			10-5	10-4	10-3	10-1	
		Central	High		10-5 10		tu	to		10			tu	10-2 10			10-5 to	10-4 10	10-5	10-2			10-5 to	10-4	tu	10-2	-
Commodity	Waste Stream	Tendency	End	<10-5	10-4	10-3	0-2	10-1 >10	-1 <10	5 10	<u>-4 (</u>	0-3 1	0-2	10-1 >	10-1	<10-5	10-4	10-3	10-2	10-3	>10-1	<10-5	10-4	10-3	10-2	10-1	>10-1
Al and Alumina	Cast house dust	2.3	23	23	0	0	0	0	U	23	U	o	0	o	U	23	0	υ	0	υ	υ	2.	i 0	0	() (0 0
Sb	Autoclave filtrate	4	7	0	0	U	2	2	0	4	0	0	0	0	0	0	0	0	0	4	4		' U	0	() (0 0
Be	Spent barren filtrate streams	1	1	1	0	1	0	0	0	I.	0	0	0	0	0	0	I.	0	ι	0	0		0	Û	() (0 0
8e	Chip treatment WW	ι	2	1	0	0	0	0	0	1	0	0	0	0	- 0	?	0	0	0	0	0		2 0	0	()	0 0
	Acid plant blowdown	7	7	2	0	2	1	0	1	1	0	0	0	0	0	υ	1	0	2	i	I		' 0	0)	0 0
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	Furnace scrubber blowdown	2	2	i î	ĭ	ŏ	0	õ	ŏ	2	ŏ	õ	ő	õ	ő	ō	1	1	ň	ő	0			ő			õ õ
	Slag quenchwater	2	5	l á	;	ň	ň	õ	ŏ	2	ŏ	ŏ	ŏ	0	ŏ	ő	n	;	0	0	0			ü			0 0
	Waste acid wash/rinse water	2	â	,	. Â	ő	ň	ŏ	ň	2	õ	ő	0	ő	ŏ	ő	a	ō	ň	0	0			ő	Č	-	0 0
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	Hydrolysis filtrate	2		1 5	0	0	0	ő	Ň	2	ŏ	ő	υŬ	Ű	ň	4	ő	0	0	0				0	, r		0 0
		2	1 7	2	0	-		ő	Ň	2	~	ő	0	0	0		0	ň	0	0	0			0			0 0 0 0
	Waste still liquor	2		$\frac{2}{2}$	0	~	0	0	<u> </u>	2	0	0	0	0	0	2	0	0	0	0			. 0	0			
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	Liquid residues	1				•••	1	0			0	U	0		~ 1			-	0	2	0						0 0
	Spent anunon nitrate proc. sol				0	0	0	0			0	0	0	0	0	I	0	0	0	0	0		0	0	0	,	0 0
	PWW			0	1	0	0	0	0		0	0	0	0	0	0	0	1	0	0	•		0	0	(0 0
	Plant PWW	2	2	0	2		0	0	0	2	0	0	Û	0	0	0	0	2	0	U				U	(u o
	PWW	2	2		0	•	0	0	0	2	0	0	0	0	U	1	i	0	0				- "	Ð	(0 0
	Pickle liquor & wash water	2	3	1	1	0	0	0	0	2	0	0	0	0	0	0	2	2	0	0				0	(0 U
	Leach liquor & sponge wash water	1	2	1	1	0	0	0	0	I.	0	U	0	U	0	0	1	1	0	0			2 0	0)	0 0
	Scrap milling scrubber water	1 i	1	0	1	0	0	0	U	1	0	0	0	0	υ	0	0	1	0	0			1 0	Û)	0 0
	Spent s i, liquids	4	7	0	0	0	0	υ	U	o	0	0	0	0	0	0	O	0	0	0) ()	Û)	0 0
	Spent s.i. solids	4	7	0	0	0	0	0	0	0	0	0	0	0	0,	0	0	0	0	0	0			0	()	0 0
Litanium and TiO2	Waste acids (Sulfate process)	1	2	0	1	0	0	0	0	1	0	0	0	0	- 0	1	0	2	- 0	U	0		2 0	0)	υυ
Titamum and TiO2	WWTP sludge/solids	7	7	0	0	0	0	0	0	0	U	0	0	0	U	0	0	0	0	0	0	() 0	0	()	υ υ
W	Spent acid & rinse water	3	6	2	0	2	0	0	0	3	0	0	0	0	U	0	3	0	3	Û	0		i 0	0)	υ υ
Zu	Waste ferrosilicon	۱ I	1	0	0	0	0	0	0	0	0	0	0	U	0	0	0	0	0	0	0	() ()	0	()	0 0
	Spent s.i. liquids	3	3	0	0	i 0	3	0	0	3	0	0	0	0	0	0	0	0	0	4	0		6 0	0	()	0 0
	WWTP solids	3	3	3	0	0	0	0	0	3	0	0	Ð	0	U	0	3	0	0	0	0		5 0	U	()	0 0
	Spent synthetic gypsum	1 3	3	3	0	0	0	0	0	3	0	0	Ű	Ü	0	2	0	2	0	Ū	0		0	0	(5	õ õ
	WWTP liquid effluent	3		0	Ő	, o	ö	ő	0	ő	ő	õ	ŏ	õ	0	ō	0	0	ō		Ö	() 0	Ū.	i)	0 0
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TOTALS*		108	133	56		11	8	2	1	89	0	0	0	0	0	40	20	14	- 13	10	5	10	3 0	0)	υ ο

* Sums by risk category may not add to the number of central or high-end waste stream/facility combinations due to rounding

Includes waste stream/facility combinations with no cancer risk (but with an associated non-cancer hazard)

		Number o	Central Tendency											High End												
		Waste Strea	m/		P	re-LDI		Post-LDR								Pre-l	.DR		Post-LDR							
Commodity	•	Facility Combinations* Central High			t 1 o t					1	10 tu	100 ta	lk to			j tu	10 to	100 to	ik tu					10U 10	- Ik te	
	Waste Stream	Tendency	End	<1 1	0 10	N) 11	101	. >10k	<1	10	100	lk	10k	>10k	<1	10	100	1k.	10k	<u>>10k</u>	<1				10k	>10
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Be	Spent barren filtrate streams	1	i	0	0	1	0 1	0 0	1	ō	Ó	0	0	0	ō	0	0	ī	ā	ō	d i	0	ō	ŏ	ō	
	Chip treatment WW	i	2	ō	0	0	ö	1 0	1	0	0	0	0	0	0	0	0	0	Ü		;	0	ů.	0	ö	
	Acid plant blowdown	7	- 7	Ĩ)	•	ĩ	i o	7	ñ	0	0	ä	ő		Ť	ï	ž	ĭ		7	ŭ	ŏ	ŏ	ŏ	
Cu	Scrubber blowdown	10	10	i a	ĩ	7	0 1	n õ	10	õ	ŏ	ŏ	ő	ő		0	, o	10	, o	'n		ŏ	ő	ő	ŏ	
Elemental Phosphorous	AFM mosate	2		ŏ	2	0	•	0 U	2	ŏ	ŏ	ö	ŏ	ŏ		ő	ő	2	ŏ	ű		0	ő	ő	ő	
	Furnace offgas solids	2	2	2	0	õ	•	n 0	5	ň	ő	ŏ	ŏ	Ő		ő	ă	0	0	ő	~	ö	ö	0	ő	
	Furnace scrubber blowdown	2	5		ĩ	ő		0 0 0 0	5	ň	 	0	0	0		ŏ	, i	ÿ	ő	0		0	Ű	0	ö	
	Slag quenchwater	2	า้า	2	'n	ñ	-	0 0 1 0	15				· 0	0	•	2		- i	0	0		0	0	0	0	
	Waste acid wash/rinse water	2		5	0	ñ		0 0	5	Ő	0	0	0	0		õ	J	0	ů ů	0	- 1	0	0	0	0	
Ge	Chlorinator wet air poll ctrl sludge	2		2	0	0		0 0 0 0	1	ő		0	0	0		ő		ő	0	0		ΰ	ő	0	0	
	Hydrolysis filtrate	2		2	0	0	•	6 0 6 0	, í	ň	0	0	0	0		0	0	0	0			0	0		0	
	Waste still liquor			2	0	0		0 0	2	0	0	0	0	0	· ·		0	0	0	0		.,	-	0		
		4		$\frac{2}{2}$	ö	0	-	0 0	ź	0	0		0			ų.	0		0	U		0	0	0	0	
Mg and Magnesia (brine)	Smut	2	-		0				ź		0	0	0	0		0	0	0	0	0	2	0	0	0	0	
	Liquid residues		ź	0	0	1		0 0		0	0	0		0				-	-	0	-	0	0	0	0	
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Rare Earths	PWW	1			0	0	-	0 0		0	0	0	•	0		0	0	0	0	0		0	0	0	0	
Se	Plant PWW	2	2		1	0		0 0	2	0	0	0	0	0		0	1	1	0	0	-	0	0	0	0	
Ta, Columbium, and	PWW	2	2	יו	0	0	0	0 0	2	0	0	0	0	0	1	0	U	0	0	0	2	0	0	0	0	
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	Leach liquor & sponge wash water	1	2	0	1	1	-	0 0		0	0	0	0			0	2	0	0	0	2	Û	0	0	0	
Titamum and TiO2	Scrap nulling scrubber water	1		0	1	0	•	0 0	1	0	Û	0	••	-		0	1	0	0	0	1	0	0	0	0	
Titanium and TiO2	Spent s.i. liquids	4	7	4	0	0	-	0 0	4	0	0	0		-	· ·	0	0	0	0	U		U	0	U	0	
Titanium and TiO2	Spent s.i. solids	4	7	4	0	0	.,	0 0	4	0	0	0	0	0		2	0	0	0	0	7	0	Û	0	U	
Titanium and TiO2	Waste acids (Sulfate process)	1	2	0	0	1	-	0 0	1	0	0	0	0	0	-	0	1	l	0	0	2	0	U	U	U	
Titanium and TiO2	WWTP sludge/solids	7	7	7	Û	0	-	0 0	7	0	0	0	0	0		4	0	U	0	0	7	0	0	0	0	
W	Spent acid & rinse water	3	6	2	1	0	•	0 0	3	0	0	0	0	0		?	0	2	0	0	6	0	0	0	()	
Zn	Waste ferrosilicon	1	1	1	0	0	0	0 0	1 1	0	0	0	0	0		0	0	0	0	U		U	U	υ	0	
Zn	Spent s.i. liquids	3	3	0	1	1	0	1 (3	0	0	0	0	0		l	0	- 1	0	1	3	0	0	Û	0	
Zn	WWTP solids	1	- 3	3	0	0		0 0	3	0	0	0	•	-		L	1	0	0	0		0	0	0	0	
Zn	Spent synthetic gypsum	3	3	3	0	0.	0	0 0	3	0	0	0	0	0		2	0	0	Û	0	3	0	0	0	Û	
Za	WWTP liquid effluent	3	3	U	1	1	0	0 1	3	U	0	0	0	0	0	0	2	0	0	1	3	0	0	0	0	
Zn	Zine-lean slag	1	۱ I	1	0	0	0	0 0	1	Û	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	
TOTALS*		108	133	68		14		4 1	108	0	0	· o	0	0	Î	15	19	24	4		133	υ	0	0	0	

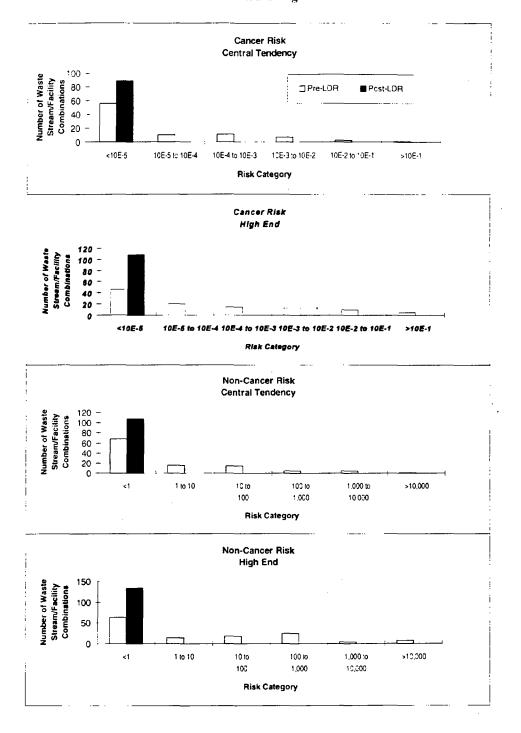
Exhibit A.2-6 Distribution of Waste Stream/Facility Combinations by Groundwater Hazard Category: Non-Cancer Hazards

• Sums by hazard category may not add to the number of central or high end waste stream/facility combinations due to rounding.

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Exhibit A.2-7 Distribution of Waste Stream/Facility Combinations by Groundwater Risk and Hazard Categories



April 30, 1998

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A.2.3.2 Risk and Benefits Assessment Results for Storage of Recycled Materials

EPA's evaluation of the potential groundwater risks associated with the storage of recycled streams under the modified prior treatment baseline is described in Section 4.2 of this RIA. These results will not be discussed further here.

A.2.4.0 LIMITATIONS AND UNCERTAINTIES OF THE GENERIC RISK AND BENEFITS ASSESSMENT FOR WASTE DISPOSAL

The section presents a brief discussion of the major uncertainties and limitations in the risk and benefits assessment for the no prior treatment baseline scenario. As stated in A.2.1, the discussion will be limited primarily to the sources of uncertainty specific to the revised analysis, and issues associated with previous risk and benefits work will only be mentioned briefly.

A.2.4.1 Major Uncertainties in the Risk Assessment for Waste Disposal

The major uncertainties associated with the risk assessment for mineral processing wastes are discussed in detail in Section 5.3.4 of December 1995 RIA, the major factors limiting the ability to quantify risks associated with the pre- and post-LDR disposal of mineral processing wastes include:

- Uncertainty about the identities, amounts, toxicity characteristics, elemental composition, and leaching behavior of wastes;
- Uncertainty about pre- and post-LDR waste amounts, waste management, recycling, and disposal practices;
- The use of the generic chemical release, groundwater transport, and exposure models instead of facility-specific data;
- The use of toxicity criteria derived primarily from animal studies; and
- The use of simplified models for predicting cancer risks and the potential for adverse noncancer affects.

This analysis represents EPA's attempt to address some of these uncertainties, continuing the process of refinement which began with the sensitivity analysis performed as part of the December 1995 RIA. In addition, EPA has incorporated information received from commenters on the RIA to further assure that the risk assessment is consistent with the most recent information available. The efforts taken to incorporate new data, and their affect on the risk results, are discussed below.

EPA received no substantial new information regarding the identities of additional waste streams or constituent concentrations that could be incorporated into the risk analysis. Based on public comments on the December 1995 RIA, a number of waste streams were removed from the risk and benefits analysis, either because they are no longer generated, or because EPA has determined that they are fully recycled and not disposed in land units. Removing these wastes from the analysis resulted in a reduction in the number of samples for which risks were calculated and in the number of facilities in the benefits analysis. The analysis is more accurate than the previous risk and benefits assessment in that it no longer includes waste streams that would not be covered by the LDRs. It should be remembered, however, that the risk and benefits assessment, while it still covers the majority of the estimated mineral processing waste volume, does not address the majority of waste streams that are included in the cost and economic impact analysis. Thus, it is likely that benefits from controls on waste disposal are underestimated, given that the risks for many wastes streams could not be calculated.

Several commenters on the December 1995 RIA noted the relatively limited amount of constituent concentration data that was used for the risk and benefits analysis, and criticized the assumptions used to characterize the leaching characteristics of wastes for which only bulk concentration data were used. In order to help address the shortage of data and to evaluate the impact of the leaching assumption, the both the EP and bulk analysis data were used in this analysis to develop separate risk estimates for NWW and LNWW waste streams when both are available, instead of using only the leachate data. This expansion of the analysis resulted in increases in the numbers of samples for which risk estimates were developed, as discussed in Section 4.1.2. This change in approach, which was adopted to make the fullest possible use of the available data, did not result in significant changes in the distribution of risks for the mineral processing waste samples as a whole, or for any of the individual waste streams. This also suggests that the particular leaching assumption that was used did not result in any significant bias in the risk assessment results.

The major change in the risk results from previous analyses of waste management practices is the dramatic reduction in estimated post-LDR groundwater pathway risks, to the extent that no waste samples had CT or HE post-LDR cancer risk or hazard quotients above levels of concern. This change is due to the changes in the method used to estimate groundwater concentrations. Like the previous analyses, the results presented in this assessment were derived using DAF values instead of site-specific modeling. In the original risk modeling, the DAFs were specific to the type of management unit, but were not constituent-specific, and they were derived for a nationally representative set of hydrogeological conditions. They, therefore, did not reflect (1) the inherent geochemical properties of the waste constituents, (2) the variations in transport that could be expected to occur as release concentrations varied, or (3) the specific hydrogeologic regimes at mineral processing facilities. In contrast, the DAF values used in this analysis take into account all of these factors. They were derived using constituent-specific geochemical concentrations, as well as hydrogeological variable values typical of the regional distribution of mineral processing facilities.

Thus, while the approach to groundwater transport modeling taken in this analysis is still not sitespecific, it has been carefully adjusted to incorporate all of the available data affecting potential releases and transport of waste constituents in groundwater. The degree of uncertainty associated with groundwater transport modeling, while still large, has thus been reduced substantially from previous analysis, and biases in the modeling resulting from failure to incorporate key variables has been greatly reduced.

The only major change in the toxicological parameter values that has been made since the previous risk analyses has been to eliminate consideration of beryllium as an ingestion pathway carcinogen. This change resulted in minimal impacts on the risk or benefits analysis, because beryllium was a risk driver for only a few waste streams. The impact of this change was reduced further because two of the waste streams from the beryllium industry were removed from the analysis for other reasons, as discussed in Section A.2.2.1.2.

A.2.4.2 Major Uncertainties in the Risk Assessment for Storage of Recycled Materials

The major limitations and sources of uncertainty in the multipathway risk assessment for the storage of recycled materials are discussed in detail in Appendix H, and will not be further addressed here.

A.2.5 REFERENCES CITED

ICF Incorporated (1996a). "Preliminary Results of Mineral Processing Wastes Risk and Benefits Assessments Using Constituent-Specific DAFs" technical memorandum submitted to the USEPA Office of Solid Waste, May 8, 1996.

ICF Incorporated (1996b), "Revised Results of Mineral Processing Wastes Risk and Benefits Assessments Using Constituent-Specific DAFs Derived for Mineral Processing Waste" technical memorandum submitted to the USEPA Office of Solid Waste, July 2, 1996.

ICF Incorporated (1995), "Regulatory Impact Analysis of the Supplemental Proposed Rules Applying Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes", submitted to the USEPA Office of Solid Waste, December 1995.

USEPA. Office of Solid Waste (1996), "Groundwater Pathway Analysis for Mineral Processing Wastes Background Document (Draft), July 1996.

A.3 Risk Characterization Spreadsheets

This section of Appendix A presents the data and calculations that were used to characterize risk changes for waste disposal pre- and post-LDR under the no prior treatment baseline scenario. Exhibit A.3-1 presents the list of wastes for which constituent-specific data were available. Exhibit A.3-2 presents the constituent-specific DAFs used to evaluate groundwater exposures. Exhibit A.3-3 presents the toxicity parameter values used in the risk analysis. Finally, Exhibit A.3-4 presents an example risk calculation for a single waste sample from concentration data to risk results.

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Exhibit A.3-1 List of Wastes for Which Constituent-Specific Data were Available

Commodity	Waste Stream
Aluminum and Alumina	Cast house dust
Antimony	Autoclave filtrate
Berryllium	Spent barren filtrate streams
Berryllium	Chip treatment wastewater
Copper	Acid plant blowdown
Copper	Scrubber blowdown
Elemental Phosphorous	AFM rinsate
Elemental Phosphorous	Furnace offgas solids
Elemental Phosphorous	Furnace scrubber blowdown
Elemental Phosphorous	Slag quenchwater
Germanium	Waste acid wash/rinse water
Germanium	Chlorinator wet air pollution control sludge
Germanium	Hydrolysis filtrate
Germanium	Waste still liquor
Magnesium and Magnesia (brine)	Smut
Molybdenum, Ferromolybdenum, Ammonium Molybdate	Liquid residues
Rare Earths	Spent ammonium nitrate processing solution
Rare Earths	Process wastewater
Selenium	Plant process wastewater
Tantalum, Columbium, and Ferrocolumbium	Process wastewater
Titanium and Titanium Dioxide	Pickle liquor & wash water
Titanium and Titanium Dioxide	Leach liquor & sponge wash water
Titanium and Titanium Dioxide	Scrap milling scrubber water
Titanium and Titanium Dioxide	Spent surface impoundment liquids
Titanium and Titanium Dioxide	Spent surface impoundment solids
Titanium and Titanium Dioxide	Waste acids (Sulfate process)
Titanium and Titanium Dioxide	Waste actus (Sunate process) Wastewater treatment plant sludge/solids
Tungsten	Spent acid & rinse water
Zinc	Waste ferrosilicon
Zinc	Spent surface impoundment liquids
Zinc	Wastewater treatment plant solids
Zinc	Spent synthetic gypsum
Zinc	Wastewater treatment plant liquid effluent
Zinc	Zinc lean slag
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	Central Tendency		Waste Piles							
Constituent	(75th percentile) Pre-LDR	High End (95th percentile) Pre-LDR	Central Tendency (75th percentile) Pre-LDR	High End (95th percentile) Pre-LDR	Central Tendency (75th percentile) Post-LDR	High End (95th percentile) Post-LDR				
Antimony	1.93E+02	2.28E+01	>10	8.36E+03	>10	°8.36E+03				
Arsenic	1.66E+02	1.71E+01	>10	2.56E+03	4.37E+09	2.56E+03				
Barium	5.81E+00	1.17E+00	2.22E+03	1.38E+01	2.33E+03	1.46E+01				
Beryllium	8.47E+00	1.24E+00	>10	4.87E+02	>10	°5.54E+02				
Cadmium	2.49E+01	1.40E+00	>10	2.67E+03	>10	⁹ 3.26E+03				
Chromium	9.82E+01	1.15E+01	2.21E+04	1.60E+02	2.21E+04	1.60E+02				
Cyanide	2.81E+10	4.20E+03								
Lead	7.11E+05	4.98E+00	>10	2.27E+05	>10	⁹ 8.93E+08				
Mercury	L97E+02	8.05E+00	>10	4.29E+03	>10	⁹ 4.29E+03				
Nickel	2.23E+01	1.51E+00	1.54E+06*	1.41E+02	1.97E+06	1.46E+02				
Selenium	2.70E+01	3.38E+00	1.18E+08	4.28E+02	1.19E+08	4.28E+02				
Silver	1.11E+01	1.23E+00	>10	4.96E+02	>10	°4.87E+02				
Thallium	2.97E+02	4.15E+01	>10	9.63E+04	>10	⁹ 9.63E+04				
Vanadium	5.67E+00	2.03E+00	>10	>109	>109	>109				
Zinc	1.23E+01	1.35E+00	>10	>109	>109	>109				

Exhibit A.3-2 Constituent-Specific DAFs Used to Evaluate Groundwater Exposures

Note: Central Tendency values are the 75th percentile of the distribution of DAF values and the High End values are the 95th percentile.

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Exhibit A.3-3 Toxicity Parameter Values Used in the Risk Analysis

Constituent	Oral Cancer Slope Factor (CSF) 1/(mg/kg-day)	Oral Reference Dose (RfD) mg/kg-day
Antimeny		0.0004
Arsenie	1.5	0.0003
Barium		0.07
Beryllium		0.005
Boron		0.09
Cadmium		0.0005
Chromium		0.005
Lead		0.0003
Manganese		0.047
Mercury		0.0003
Molybdenum		0.005
Nickel		0.02
Selenium		0.005
Silver		0.005
Thallium		0.00008
Vanadium		0.007
Zinc		0.3
Cyanide		0.02
Fluoride		0.06

Source: EPA IRIS (1996) and HEAST (1995)

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The Lead RfD is derived from the EPA action level of 0.015 mg/L. The RfD for Chromium is from Cr+6. The RfD for Thallium is from Thallium sulfate.

There were no toxicity values for the following constituents: Aluminum, Cobalt, Copper, Iron, Magnesium, Phosphate, Silica, Chloride, TSS, pH, Organics (TOC), Sulfide, or Sulfate.

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Waste Stream Data & Calculation	ons				<u>Çan</u>	cer		-	Non-Çancer				
		Sample		Central T	endency	High	End		Central T	Tendency		n End	
Commodity Waste Stream		Number		Pre-LDR	Post-LDR	Pre-LDR	Post-LDR		Pre-LDR	Post-LDR	Pre-LDR	Post-LD	
Pare Earths Spent ammonium nitral processing solution	te	7		5.57E-08	2.12E-12	5.41E-07	5.41E-07			4.47E-04			
Facility Identifier = Res. Chem, Phoeni State = AZ	ix			The cancer m The non-canc							t in a samp	ole.	
					Total								
		eatment Typ)e			EP Toxicity	Pre-LDI		Post-LD	R DAFS			
	Waste	1 10%	_		Analysis	Analysis	Central	High	Central	High			
•	Water	Solids	Solid	Constituents	(ppm)	(ppm)	Tendency	End	Tendency	End			
	1	0	0	Aluminum									
	1	0	0	Antimony						8.36E+03			
	1	0	0	Arsenic	0.0025					2.56E+03			
	1	0	0	Barium	0.05					1.46E+01			
	1	0	0	Beryllium			8.47E+00	1.24E+00	2.13E+15	5.54E+02			
	1	0	0	Boron	0.12								
	1	0	0	Cadmium	0.0025					3.26E+03			
	1	0	0	Chromium	0.01		9.82E+01	1.15E+01	2.21E+04	1.60E+02			
	1	0	0	Copper	0.005								
	1	0	0	Iron									
	1	0	0	Lead	0.011		7.11E+05	4.98E+00	1.00E+30	8.93E+08			
	1	0	0	Magnesium									
	1	0	0	Manganese	0.005								
	1	0	0	Mercury	0.0001		1.97E+02	8.05E+00	6.37E+12	4.29E+03			
	1	0	0	Molybdenum									
	1	0	0	Nickel						1.46E+02			
	1	0	0	Selenium	0.0025					4.28E+02			
	1	0	0	Silver	0.005					4.87E+02			
	1	0	0	Thallium						9.63E+04			
	1	0	0	Vanadium	0.005					1.00E+30			
	1	0	0 .	Zinc	· 0.005				1.34E+16	1.77E+03			
	1	0	0	Cyanide	0.005		2.81E+10	4.20E+03					
	1	0	0	Sulfide	0.025								
	1	0	0	Fluoride									

Exhibit A.3-4 - Example Risk Calculation for a Single Waste Sample from Concentration Data to Risk Results

April 30, 1998

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	+	ost-LDRs (UTS) - Centr	al Tendency			Post-LD	Hs (UTS) - I	High End	
	Groundwater	Cancer	Noncancer	Lifetime		Groundwater	Cancer	Noncancer	Lifetime	
	Conc	Dose	Dose	Excess	Hazard	Conc	Dose	Dose	Excess	Hazard
	(ppm=mg/L)	(mg/kg-d)	(mg/kg-d)	Cancer Risk	Quotient	(ppm=mg/L)	(mg/kg-d)	(mg/kg-d)	Cancer Hisk	Quotient
Aluminum										
Antimony Arsenic	5.72E-10	1.41E-12	1.10E-11	2.12E-12	3.66E-08	1.46E-04	3.60E-07	2.80E-06	5.41E-07	9.35E+03
Barium	1.63E-03	4.02E-06	3.13E-05	2.122-12	4.47E-04	4.27E-02	1.05E-04	8.20E-04	3.412-07	1.17E-02
Beryllium								0.202 01		
Boron										
Cadmium	1.55E-18	3.83E-21	2.98E-20		5.95E-17	2.91E-05	7.19E-08	5.59E-07		1.12E-03
Chromium	1.95E-05	4.80E-08	3.73E-07		7.46E-05	8.70E-04	2.14E-06	1.67E-05		3.34E-03
Copper										
Iron Lead	1.85E-31	4.56E-34	3.55E-33		1.18E-29	2.07E-10	5.11E-13	3.97E-12		1.32E-08
Magnesium	1.00E-31	4.30E-34	3.00E-33		1.102-29	2.0/2-10	5.11E-13	3.97E-12		1.325-00
Manganese										
Mercury	1.96E-15	4.84E-18	3.76E-17		1.25E-13	2.91E-06	7.18E-09	5.59E-08		1 86E-04
Molybdenum										
Nickel										
Selenium	6.72E-10 1.13E-11	1.66E-12 2.78E-14	1.29E-11 2.16E-13		2.58E-09 4.33E-11	1.87E-04 3.08E-04	4.61E-07 7.59E-07	3.58E-06 5.91E-06		7.17E-04 1.18E-03
Silver Thallium	1.132-11	2.700-14	2.102-13		4.335-11	3.062-04	7.596-07	0.91E-00		1.10E-03
Vanadium										
Zinc	1.98E-16	4.88E-19	3.79E-18		1.26E-17	1.50E-03	3.69E-06	2.87E-05		9.57E-05
Cyanide										
Sulfide										
Fluoride										
entration = pre-	LDR gw conce	entration -		-	centration is gre	ater than the treatme	nt level / D	AF); otherwi	se	
alues are return					dations					
previous page I	or an explanat	ion of the o	ose, nsk, and	i nazaru calci	Jiations.					

Exhibit A.3-4 (Continued) - Example Risk Calculation for a Single Waste Sample from Concentration Data to Risk Results

April 30, 1998

Groundwate Conce Noncancer Lifetime Groundwate Cancer Noncancer Lifetime Constituents (ppm=mg/L) (mg/kg-d) (mg/kg-d) (mg/kg-d) (mg/kg-d) (mg/kg-d) Cancer Risk Quotient (ppm=mg/L) Cancer Risk			Pre-LDF	s - Central T	endency			Pre-	LDRs - High	i End	
Construents (ppm=mg/L) (mg/kg-d) (mg/kg-d) Cancer Risk Quotient (ppm=mg/L) (mg/kg-d) (mg/kg-d) Cancer Risk Quotient Aluminum 8.61E-05 3.71E-08 2.89E-07 5.57E-08 9.63E-04 1.46E-04 3.60E-07 2.80E-06 5.41E-07 9.35E-03 Barjuium 8.61E-03 2.12E-05 1.65E-04 2.36E-03 1.79E-02 4.40E-06 3.42E-05 6.85E-02 Chromium 1.02E-04 2.51E-07 1.95E-06 3.91E-04 8.70E-04 2.14E-05 1.41E-01 Magnesium Magnesium 1.02E-04 2.51E-07 1.95E-06 3.25E-05 1.24E-05 3.66E-06 1.41E-01 Magnesium 9.26E-05 2.28E-07 1.78E-08 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.07E-04 1.02E-06 1.24E-05 2.84E-03 1.85E-02 1.82E-05 1.82E-05 1.82E-05 1.82E-05 1.82E-05<		Groundwate	Cancer	Noncancer	Lifetime		Groundwate	Cancer	Noncancer	Lifetime	
Aurimum							Conc	Dose	Dose	Excess	Hazard
Antimony Arisenic 1,51E-05 3,71E-08 2,89E-07 5,57E-08 9,63E-04 1,46E-04 3,60E-07 2,80E-06 5,41E-07 9,35E-03 Barilium 8,61E-03 2,12E-05 1,65E-04 2,36E-03 4,27E-02 1,05E-04 8,20E-04 1,17E-02 Beryllium Boron Cadmium 1,00E-04 2,48E-07 1,93E-06 3,85E-03 1,79E-03 4,40E-06 3,42E-05 6,85E-02 Chromum 1,02E-04 2,51E-07 1,93E-06 3,91E-04 8,70E-04 2,14E-06 1,67E-05 3,34E-03 Copper tron Lead 1,55E-08 3,81E-11 2,97E-10 9,89E-07 2,21E-03 5,45E-06 4,24E-05 1,41E-01 Magnesium Manganesie Mercury 5,08E-07 1,25E-09 9,74E-09 3,25E-05 1,24E-05 3,06E-08 2,38E-07 7,94E-04 Molybdenum Nickel Selenium 9,26E-05 2,28E-07 1,78E-06 3,55E-04 7,40E-04 1,82E-06 1,42E-05 2,84E-03 Silver 4,50E-04 1,11E-06 8,64E-06 1,72E-03 4,07E-03 1,00E-05 7,80E-06 2,84E-03 Silver 4,50E-04 1,00E-06 7,80E-06 2,60E-05 3,70E-03 9,13E-06 7,10E-05 2,37E-04 Zinc 4,07E-04 1,00E-06 7,80E-06 2,60E-05 3,70E-03 9,13E-06 7,10E-05 2,37E-04 Sulfide Fluoride 1,78E-13 4,39E-16 3,41E-15 1,71E-13 1,19E-06 2,94E-09 2,28E-08 1,11E-06 Sulfide Fluoride 10 DAF (for non-waste waters with an total constituent analysis concentration) concentration = total constituent analysis concentration / DAF (for solids with a total constituent analysis concentration) concentration = total constituent analysis concentration / DAF (for solids with a total constituent analysis concentration) concentration = total constituent analysis concentration / DAF (for solids with a total constituent analysis concentration) concentration = total constituent analysis concentration / DAF (for solids with a total constituent analysis concentration and no EP toxicity analysis concentration / DAF (for solids with a total constituent analysis concentration) provalues are returned for constituent analysis concentration / DAF (for solids with a total constituent analysis concentration and no EP toxicity analysis concentration water solid constituent analysis concentration / DAF (for solids with a total constituent analysis concentration and no EP toxicity analysis concentration water seq winta	Constituents	(ppm=mg/L)	(mg/kg-d)	(mg/kg-d)	Cancer Risk	Quotient	(ppm=mg/L)	(mg/kg-d)	(mg/kg-d)	Cancer Hisk	Quotient
Arsenic 1.51E-05 3.71E-08 2.89E-07 5.57E-08 9.63E-04 1.46E-04 3.60E-07 2.80E-06 5.41E-07 9.35E-03 Barium 8.61E-03 2.12E-05 1.65E-04 2.36E-03 4.27E-02 1.05E-04 8.20E-04 1.17E-02 Boron Cadmium 1.00E-04 2.48E-07 1.93E-06 3.85E-03 1.79E-03 4.40E-06 3.42E-05 6.65E-02 Chromlum 1.02E-04 2.51E-07 1.93E-06 3.85E-03 1.79E-03 4.40E-06 3.42E-05 3.34E-03 Copper iron 1.55E-08 3.81E-11 2.97E-10 9.89E-07 2.21E-03 5.45E-06 4.24E-05 1.41E-01 Magnesium Magnesium Magnesium 1.55E-09 9.74E-09 3.25E-05 1.24E-05 3.06E-08 2.36E 07 7.94E-04 Nickel Steindum 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-05 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-05 1.56E-02 Thali	Aluminum										
Barium 8.61E-03 2.12E-05 1.65E-04 2.36E-03 4.27E-02 1.05E-04 8.20E-04 1.17E-02 Beryllium Boron -<	Antimony										
Beryllium Boron Cadmium 1.00E-04 2.48E-07 1.93E-06 3.85E-03 1.79E-03 4.40E-06 3.42E-05 6.85E-02 Chromium 1.02E-04 2.51E-07 1.95E-06 3.91E-04 8.70E-04 2.14E-06 1.67E-05 3.34E-03 Copper iron 1.05E-08 3.81E-11 2.97E-10 9.89E-07 2.21E-03 5.45E-06 4.24E-05 1.41E-01 Magnesium Magnesium Magnesium Magnesium 4.40E-06 1.42E-05 3.06E-08 2.38E-07 7.94E-04 Molybdenum Nickel 9.26E-05 1.24E-05 3.06E-08 2.38E-07 7.94E-04 Nickel 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-02 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 </td <td></td> <td></td> <td></td> <td>2.89E-07</td> <td>5.57E-08</td> <td></td> <td></td> <td>3.60E-07</td> <td>2.80E-06</td> <td>5.41E-07</td> <td>9.35E-03</td>				2.89E-07	5.57E-08			3.60E-07	2.80E-06	5.41E-07	9.35E-03
Boron Cadmium 1.00E-04 2.48E-07 1.93E-06 3.85E-03 1.79E-03 4.40E-06 3.42E-05 6.85E-02 Chromium 1.02E-04 2.51E-07 1.95E-06 3.91E-04 8.70E-04 2.14E-06 1.67E-05 3.34E-03 Copper iron 1.02E-04 2.51E-07 1.95E-06 3.91E-04 8.70E-04 2.14E-06 1.67E-05 3.34E-03 Magnessum Magnessum 3.85E-07 2.21E-03 5.45E-06 4.24E-05 1.41E-01 Magnessum Silver 5.08E-07 1.25E-09 9.74E-09 3.25E-05 1.24E-05 3.06E-08 2.38E-07 7.94E-04 Molybdonum Nickel Silver 4.50E-04 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.01E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05 2.37E-04 Vanadium Zinc 4.07E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05<		8.61E-03	2.12E-05	1.65E-04		2.36E-03	4.27E-02	1.05E-04	8.20E-04		1.17E-02
Cadmium 1.00E-04 2.48E-07 1.93E-06 3.85E-03 1.79E-03 4.40E-06 3.42E-05 6.85E-02 Chromium 1.02E-04 2.51E-07 1.95E-06 3.91E-04 8.70E-04 2.14E-06 1.67E-05 3.34E-03 Copper tron 1.00E-04 2.51E-07 1.25E-08 3.81E-11 2.97E-10 9.89E-07 2.21E-03 5.45E-06 4.24E-05 1.41E-01 Magnesium Magnesium Magnesium 1.25E-09 9.74E-09 3.25E-05 1.24E-05 3.06E-08 2.38E-07 7.94E-04 Nickel	•										
Chromium 1.02E-04 2.51E-07 1.95E-06 3.91E-04 8.70E-04 2.14E-06 1.67E-05 3.34E-03 Copper Iron I Lead 1.55E-08 3.81E-11 2.97E-10 9.89E-07 2.21E-03 5.45E-06 4.24E-05 1.41E-01 Magnesium Manganose Mercury 5.08E-07 1.25E-09 9.74E-09 3.25E-05 1.24E-05 3.06E-08 2.38E-07 7.94E-04 Mickydonum Nickel 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-05 1.56E-02 Thallium Vanadium Zinc 4.07E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05 2.37E-04 Cyanide 1.78E-13 4.39E-16 3.41E-15 1.71E-13 1.19E-06 2.94E-03 2.28E-08 1.14E-06 Suffide Fluoride Vanadium Lotal constituent analysis concentration / 20 / DAF (for o	Boron										
Copper iron Copper iron <thcopper iron <thcopper iron</thcopper </thcopper 	Cadmium	1.00E-04	2.48E-07	1.93E-06		3.85E-03	1.79E-03	4.40E-06	3.42E-05		6.85E-02
Iron Lead 1.55E-08 3.81E-11 2.97E-10 9.89E-07 2.21E-03 5.45E-06 4.24E-05 1.41E-01 Magnesium Manganese Mercury 5.08E-07 1.25E-09 9.74E-09 3.25E-05 1.24E-05 3.06E-08 2.38E-07 7.94E-04 Molybdenum Nickel Selenium 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-05 1.56E-02 Thallium Vanadium Zinc 4.07E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05 2.37E-04 Cyanide 1.78E-13 4.39E-16 3.41E-15 1.71E-13 1.19E-06 2.94E-09 2.28E-08 1.14E-06 Sulfide Fluoride undwater (gw) concentration = total constituent analysis concentration / DAF (for waste waters with a total constituent analysis concentration) concentration = EP toxicity analysis concentration / DAF (for solids with a total constituent analysis concentration / DAF (for solids with a total constituent analysis concentration) concentration = EP toxicity analysis concentration / DAF (for solids with a total constituent analysis concentration / DAF (for 10% solids with a total constituent analysis concentration and no EP toxicity analysis concentration / DAF (for 10% solids with a total constituent analysis concentration and no EP toxicity analysis concentration / DAF (for 10% solids with a total constituent analysis concentration and no EP toxicity analysis concentration / DAF (for 10% solids with a total constituent analysis concentration and no EP toxicity analysis concentration / DAF (for 10% solids with a total constituent analysis concentration and no EP toxicity analysis concentration. cor dose = gw concentration x cancer gw intal Noncancer dose = gw concentration x noncancer averaging time 365 body weight) = 0.00247 L/kg-day. cancer gw intake = (gw intake*	Chromium	1.02E-04	2.51E-07	1.95E-06		3.91E-04	8.70E-04	2.14E-06	1.67E-05		3.34E-03
Magnesium Manganese Mercury Nickel 5.08E-07 1.25E-09 9.74E-09 3.25E-05 1.24E-05 3.06E-08 2.38E-07 7.94E-04 Selenium Nickel 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-05 1.56E-02 Thallium Vanadium Zinc 4.07E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05 2.37E-04 Cyanide Fluoride 1.78E-13 4.39E-16 3.41E-15 1.71E-13 1.19E-06 2.94E-09 2.28E-08 1.14E-06 sulfide Fluoride 1.78E-13 0.39E-16 3.41E-15 1.71E-13 1.19E-06 2.94E-09 2.28E-08 1.14E-06 soncentration = EP loxicity analysis concentration / DAF (for nom-waste waters with an EP toxicity analysis concentration) - - - - soncentration = total constituent analysis concentration / 20 / DAF (for solids with a total constituent analysis concentration and no EP toxicity analysis concentration waste waters with a total constituent analysis concentration and no EP toxicity analysis concentration wasto exertation / DAF or total constituent a	••						· .				
Manganose Mercury 5.08E-07 1.25E-09 9.74E-09 3.25E-05 1.24E-05 3.06E-08 2.38E-07 7.94E-04 Nickel Selenium 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-05 1.56E-02 Thallium Vanadium Zinc 4.07E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05 2.37E-04 Quaride 1.78E-13 4.39E-16 3.41E-15 1.71E-13 1.19E-06 2.94E-09 2.28E-08 1.14E-06 Sulfide Fluoride vanalysis concentration / DAF (for rom-waste waters with a Dal constituent analysis concentration) concentration = total constituent analysis concentration / DAF (for solids with a total constituent analysis concentration) concentration = total constituent analysis concentration / 20 / DAF (for solids with a total constituent analysis concentration) concentration = total constituent analysis concentration / 20 / DAF (for 30% solids with a total constituent analysis concentration and no EP toxicity analysis concentration woncentration = total constituent analysis concentration / 20 / DAF (for 30% solids with a total constituent analysi	Lead	1.55E-08	3.81E-11	2.97E-10		9.89E-07	2.21E-03	5.45E-06	4.24E-05		1.41E-01
Meroury 5.08E-07 1.25E-09 9.74E-09 3.25E-05 1.24E-05 3.06E-08 2.38E-07 7.94E-04 Nickel Selenium 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-05 1.56E-02 Thallium Vanadium Zinc 4.07E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05 2.37E-04 Cyanide 1.78E-13 4.39E-16 3.41E-15 1.71E-13 1.19E-06 2.94E-09 2.28E-08 1.14E-06 Sulfide Fluoride - - - - - - - undwater (gw) concentration = total constituent analysis concentration / DAF (for mon-waste waters with an EP toxicity analysis concentration) - - - concentration = total constituent analysis concentration / DAF (for solids with a total constituent analysis concentration and no EP toxicity analysis conc	Magnesium										
Molybdanum Nickel Selenium 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-05 1.56E-02 Thallium Vanadium Zinc 4.07E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05 2.37E-04 Cyanide 1.78E-13 4.39E-16 3.41E-15 1.71E-13 1.19E-06 2.94E-09 2.28E-08 1.14E-06 Sulfide Fluoride	Mangariese										
Nickel Selenium 9.26E-05 2.28E-07 1.78E-06 3.55E-04 7.40E-04 1.82E-06 1.42E-05 2.84E-03 Silver 4.50E-04 1.11E-06 8.64E-06 1.73E-03 4.07E-03 1.00E-05 7.80E-05 1.56E-02 Thallium Vanadium Zinc 4.07E-04 1.00E-06 7.80E-06 2.60E-05 3.70E-03 9.13E-06 7.10E-05 2.37E-04 Cyanide 1.78E-13 4.39E-16 3.41E-15 1.71E-13 1.19E-06 2.94E-09 2.28E-08 1.14E-06 Sullide Fluoride rundwater (gw) concentration = total constituent analysis concentration / DAF (for nom-waste waters with an EP toxicity analysis concentration) - - concentration = total constituent analysis concentration / DAF (for nom-waste waters with a total constituent analysis concentration) - - concentration = total constituent analysis concentration / DAF (for 10% solids with a total constituent analysis concentration) - concentration = total constituent analysis concentration / DAF (for 10% solids with a total constituent analysis concentration and no EP toxicity analysis concentration concentration = total constituent analysis concentration / DAF (for 10% solids with a total constituent analysis concentration and no EP toxicity anal	Mercury	5.08E-07	1.25E-09	9.74E-09		3.25E-05	1.24E-05	3.06E-08	2.38E-07		7.94E-04
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Exhibit A.3-4 (Continued) - Example Risk Calculation for a Single Waste Sample from Concentration Data to Risk Results

A-38

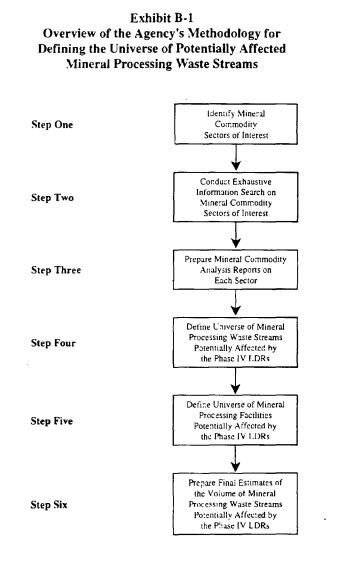
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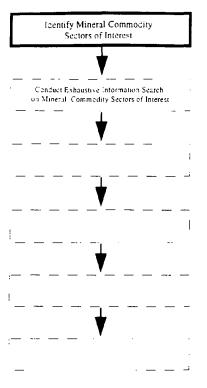
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METHODOLOGY

This appendix details EPA's step-wise methodology for defining the universe of mineral processing sectors, facilities, and waste streams potentially affected by the proposed Phase IV Land Disposal Restrictions. The Agency developed a step-wise methodology that began with the broadest possible scope of inquiry in order to assure that EPA captured all of the potentially affected mineral commodity sectors and waste streams. The Agency then narrowed the focus of its data gathering and analysis at each subsequent step. The specific steps and sources of data employed throughout this analysis are described below, and are summarized in Exhibit B-1.



Step One



B.1 Identify Mineral Commodity Sectors of Interest

EPA reviewed the 36 industrial sectors (commodities) and 97 different general categories of wastes previously developed and published in the October 21, 1991 Advanced Notice of Proposed Rule Making (ANPRM). EPA also reviewed the U.S. Bureau of Mines's 1991 Minerals Yearbook, 1995 Mineral Commodities Summary, and the 1985 Mineral Facts and Problems. The Agency reviewed this comprehensive listing of all of the mineral commodity sectors and removed from further consideration all non-domestically produced mineral commodities; all inactive mineral commodities, such as nickel; and all mineral commodities generated from operations known not to employ operations that meet the Agency's definition of mineral processing.¹ As a result of this process, EPA identified a total of 62 mineral commodities that potentially generate "mineral processing" waste streams of interest. These mineral commodity sectors are listed below in Exhibit B-2.

The Agency notes that Exhibit B-2 represents EPA's best efforts at identifying mineral commodities which may generate mineral processing wastes. Omission or inclusion on this list does not relieve the generator from managing wastes that would be subject to RCRA Subtitle C requirements.

B.2 Conduct Exhaustive Information Search on Mineral Commodity Sectors of Interest

EPA researched and obtained information characterizing the mineral processing operations and wastes associated with the mineral commodities listed in Exhibit B-2. This information was used by EPA both to update existing data characterizing mineral processing wastes obtained through past Agency efforts and to obtain characterization information on newly identified waste streams not previously researched.

To provide the necessary foundation to develop a fully comprehensive inventory of mineral commodity sectors, facilities, and waste streams that might be affected by the Phase IV LDRs program, EPA embarked on an ambitious information collection program. Specifically, to capitalize on information collected through past efforts, as well as to collect more recent data, the Agency conducted the following activities:

¹ Sectors that employ operations that mill (e.g., grind, sort, wash), physically separate (e.g., magnetic, gravity, or electrostatic separation, froth flotation), concentrate using liquid separation (e.g., leaching followed by ion exchange), and/or calcine (i.e., heat to drive off water or carbon dioxide), and use no techniques that the Agency considers to be mineral processing operations (e.g., smelting or acid digestion) are unaffected by the Phase IV LDRs.

Exhibit B-2 Mineral Commodities Of Potential Interest

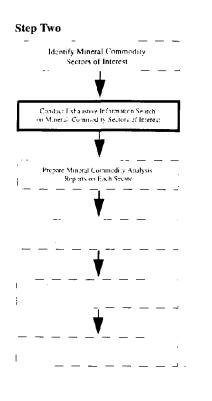
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30) Iron and Steel 61) Zinc				
31) Lead 62) Zirconium/Hafnit		Iron and Steel		
	1)	Lead	62)	Zirconium/Hafnium

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- Reviewed the National Survey of Solid Wastes From Mineral Processing Facilities (NSSWMPF) survey instruments and public comments (submitted in response to the 1991 ANPRM) for process-related information (e.g., process flow diagrams, waste characterization data, and waste management information).
- Reviewed numerous documents (e.g., Bureau of Mines publications, the Randol Mining Directory and other Industrial Directories, and various Agency contractor reports) for process-related information.
- Reviewed trip reports prepared both by EPA and its contractors from sampling visits and/or inspections conducted at approximately 50 mineral processing sites located through out the United States.
- Reviewed sampling data collected by EPA's Office of Research and Development (ORD), EPA's Office of Water (OW), and Agency survey data collected to support the preparation of the 1990 Report to Congress.
- Reviewed both the 1993, 1994, and 1995 "Mineral Commodity Summaries" prepared by the U.S. Bureau of Mines (BOM) for salient statistics on commodity production.
- Partially reviewed and summarized damage case information presented in the "Mining Sites on the National Priorities List, NPL Site Summary Reports" to support work on assessing the appropriateness of the Toxicity Characteristic Leaching Procedure (TCLP) for mineral processing wastes.
- Contacted the BOM Commodity Specialists associated with the commodity sectors of interest to (1) obtain current information on mining companies, processes, and waste streams. and (2) identify other potential sources of information.
- Retrieved applicable and relevant documents from the BOM's FAXBACK document retrieval system. Documents retrieved included monthly updates to salient statistics, bulletins, and technology review papers.
- Conducted an electronic query of the 1991 Biennial Reporting System (BRS) for waste generation and management information on 34 mineral processing-related Standard Industrial Classification (SIC) numbers.
- Conducted an electronic literature search for information related to mineral processing and waste treatment technologies contained in numerous technical on-line databases,

including: NTIS, Compendex Plus, METADEX, Aluminum Industry Abstracts, ENVIROLINE, Pollution Abstracts, Environmental Bibliography, and GEOREF.

EPA focused its search for relevant information (published since 1990) on the mineral commodities listed in Exhibit B-2. The Agency chose 1990 as the cutoff year so as not to duplicate past information collection activities conducted by EPA and its contractors, and to obtain information on mineral processes "retooled" since clarification of the Bevill Amendment to cover truly "high volume, low hazard" wastes. After an exhaustive search through both the publicly available and Agency-held information sources, EPA assembled and organized all of the collected information hy mineral commodity sector.

Step Three

Conduct I: chaustive Information Search on Mineral Commodity Sectors of Interest Propare Mineral Commodity Analysis Reports on Each Sector Define Lin Jerres: I Mineral Processing Waste Streams Patentially Affected by The Phase IV UDRs

B 3 Prepare Mineral Commodity Analysis Reports on Each of the Identified Sectors

As discussed above, EPA embarked on a very ambitious information collection program to collect current information on relevant mineral processes, salient statistics, waste characteristics, waste generation rates, and waste management information. All of the publicly available information was collected, evaluated for relevance (both applicability and age), and compiled to prepare 49 analyses covering 62 mineral commodities. Each mineral commodity analysis report consists of:

- A commodity summary describing the uses and salient statistics of the particular mineral commodity.
- A process description section with detailed, current process information and process flow diagram(s).
- A process waste stream section that identifies -- to the maximum extent practicable -- individual waste streams, sorted by the nature of the operation generating the waste stream (i.e., extraction/beneficiation or mineral processing).² Within this section, EPA also identified:

² EPA strongly cautions that the process information and identified waste streams presented in the commodity analysis reports should not be construed to be the authontative list of processes and waste streams. These reports represent a best effort, and are unlikely to include every potential process and waste stream. Furthermore, the omission of an actual waste stream (and thus its not being classified as either an extraction/beneficiation or mineral processing waste in this report) does not relieve a generator from the responsibility of correctly determining whether the particular waste is covered by the Mining Waste Exclusion. Neither are these descriptions intended as regulatory findings as to the application of Subtitle C of RCRA to any particular waste.

- waste stream sources and form (i.e., wastes with less than 1 percent solids and total organic content, wastes with 1 to 10 percent solids, and wastes with greater than 10 percent solids);
- Bevill-Exclusion status of the waste stream (i.e., extraction/beneficiation waste stream, mineral processing waste stream, or non-uniquely-associated waste stream).
 - waste stream characteristics (total constituent concentration data, and statements on whether the waste stream exhibited one of the RCRA hazardous waste characteristics of toxicity, ignitability, corrosivity, or reactivity):
- annual generation rates (reported or estimated);
- management practices (e.g., tank treatment and subsequent NPDES discharge, land disposal, or in-process recycling); and
- whether the waste stream was being (or could potentially be) recycled, and be classified as either as a sludge, by-product, or spent material.

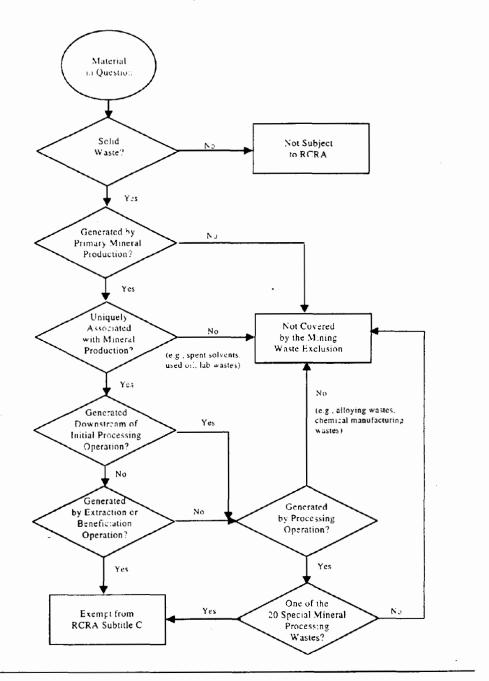
The collection and documentation of the commodity summary and process description sections of the mineral commodity analysis reports was relatively straight-forward and involved little interpretation on the part of EPA. However, the preparation of the process waste stream sections of the mineral commodity analysis reports required extensive analysis and substantive interpretation of the publicly available information by the Agency. The process used by EPA to develop descriptions of waste stream sources, form, characteristics, management, and recyclability is described below.

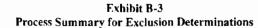
Waste Stream Sources and Form

EPA reviewed process descriptions and process flow diagrams obtained from numerous sources including. <u>Kirk-Othmer, EPA's Effluent Guideline Documents</u>, EPA survey instruments, and the literature. As one would expect, the available process descriptions and process flow diagrams varied considerably in both quality and detail, both by commodity and source of information. Therefore, EPA often needed to interpret the information to identify specific waste streams. For example, process descriptions and process flow charts found through the Agency's electronic literature search process often focused on the production process of the mineral product and omitted any description or identification of waste streams (including their point of generation). In such cases, the Agency used professional judgment to determine how and where wastes were generated.

Bevill-Exclusion Status

EPA used the Agency's established definitions and techniques for determining which operations and waste streams might be subject to LDR standards. EPA decisions concerning whether individual wastes are within the scope of the RCRA Mining Waste Exclusion were based upon a number of different factors. The Agency examined these factors in sequence, in such a way as to yield unambiguous and consistent decisions from sector to sector. The step-wise methodology used for this analysis is presented below and summarized in Exhibit B-3:





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- Ascertain whether the material is considered a solid waste under RCRA.
- Determine whether the waste is generated by a primary mineral production step, and, more generally, whether or not primary production occurs in the sector/within a process type.
- Establish whether the waste and the operation that generates it are uniquely associated with mineral production.
- Determine whether the waste is generated by a mineral extraction, beneficiation, or processing step.
- Check to see whether the waste, if a processing waste, is one of the 20 special wastes from mineral processing.

This analytical sequence results in one of three outcomes:

- (1) the material is not a solid waste and hence, not subject to RCRA;
- (2) the material is a solid waste but is exempt from RCRA Subtitle C because of the Mining Waste Exclusion; or
- (3) the material is a solid waste that is not exempt from RCRA Subtitle C and is subject to regulation as a hazardous waste if it is listed as a hazardous waste or it exhibits any of the characteristics of hazardous waste.³

Waste Stream Characteristics

EPA used waste stream characterization data obtained from numerous sources to document whether a particular waste stream exhibited one (or more) of the characteristics of a RCRA hazardous waste (i.e., toxicity, corrosivity, ignitability, and reactivity). In cases where actual data indicated that a waste did exhibit one of the characteristics of a hazardous waste, the specific characteristic(s) was designated with a **Y**. However, despite more than ten years of Agency research on mineral processing operations, EPA was unable to find waste characterization data for many waste streams. To present mineral commodity profiles that were as complete as possible, EPA used a step-wise methodology for estimating waste characteristics for individual waste streams when documented waste generation rates and analytical data were not available. Specifically, due to the paucity of waste characterization data (particularly, TCLP data), EPA used total constituent data (if available) or professional judgment to determine whether a particular waste exhibited one of the characteristics of a RCRA hazardous waste (i.e., toxicity, corrosivity, ignitability, and reactivity).

⁴ RCRA Subtitle C regulations define toxicity as one of the four characteristics of a hazardous waste. EPA uses the Toxicity Characteristic Leaching Procedure (TCLP) to assess whether a solid waste is a hazardous waste due to toxicity. The TCLP as applied to mineral processing wastes was recently remanded to the Agency, for further discussion, see the Applicability of TCLP Technical Background Document in the docket for the January 1996 Supplemental Proposed Rule.

To determine whether a waste might exhibit the characteristic of toxicity, EPA first compared 1/20th of the total constituent concentration of each TC metal to its respective TC level.⁴ In cases where total constituent data were not available, EPA then used professional judgment to evaluate whether the waste stream could potentially exhibit the toxicity characteristic for any of the TC metals. For example, if a particular waste stream resulted through the leaching of a desired metal from an incoming concentrated feed, the Agency assumed that the precipitated leach stream contained high total constituent (and therefore, high leachable) concentrations of non-desirable metals, such as arsenic. Continuing through the step-wise methodology, EPA relied on professional judgment to determine, based on its understanding of the nature of a particular processing step that generated the waste in question, whether the waste streams that EPA determined could potentially exhibit one or more of the characteristics of a RCRA hazardous waste were designated by **Y**?. The Agency acknowledges the inherent limitations of this conservative, step-wise methodology and notes that it is possible that EPA may have incorrectly assumed that a particular waste does (or does not) exhibit one or more of the RCRA hazardous waste characteristics.

The Agency stresses that the results and information presented in the individual commodity analysis reports are based on the review of publicly available information. The accuracy and representativeness of the collected information are only as good as the source documents. As a result of this limited data quality review, EPA notes that in some instances, Extraction Procedure (EP) leachate data reported by various sources are greater than $1/20^{th}$ of the total constituent concentration. Generally one would expect, based on the design of the EP testing procedure, the total constituent concentrations to be at least 20-times the EP concentrations. This apparent discrepancy, however, can potentially be explained if the EP results were obtained from total constituent analyses of liquid wastes (i.e., EP tests conducted on wastes that contain less than one-half of one percent solids content are actually total constituent analyses).

Waste Stream Generation Rates

As data were available, EPA used actual waste generation rates reported by facilities in various Agency survey instruments and background documents. However, due to the general lack of data for many of the mineral commodity sectors and waste streams, the Agency needed to develop a step-wise method for estimating mineral processing waste stream generation rates when actual data were unavailable.

Specifically, EPA developed an "expected value" estimate for each waste generation rate using draft industry profiles, supporting information, process flow diagrams, and professional judgment. From the "expected value" estimate, EPA developed upper and lower bound estimates, which reflect the degree of uncertainty in our data and understanding of a particular sector, process, and/or waste in question. For example, EPA obtained average or typical commodity production rates from published sources (e.g., BOM Mineral Commodity Summaries) and determined input material quantities or concentration ratios from published market specifications. In parallel with this activity, EPA reviewed process flow diagrams for information on flow rates, waste-to-product ratios, or material quantities. The Agency then calculated any additional waste generation rates and subtracted out known material flows, leaving a defined material flow, which was allocated among the remaining unknown waste streams using professional judgment. Finally, EPA assigned a minimum, expected, and maximum volume estimate for each waste stream.

⁴ Based on the assumption of a theoretical worst-case leaching of 100 percent and the design of the TCLP extraction test, where 100 grams of sample is diluted with two liters of extractant, the maximum possible TCLP concentration of any TC metal would be 1/20th of the total constituent concentration.

A key element in developing waste generation rates was the fact that by definition, average facility level generation rates of solids and sludges are less that 45,000 metric tons/year, and generation rates of wastewaters are less than 1,000,000 metric tons/year. Using this fact, in the absence of any supporting information, maximum values for solids and sludges were set at the highest waste generation rate found in the sector in question or 45,000 metric tons/year/facility, whichever was lower.

The precise methodology for determining waste generation rates varied depending on the quantity and quality of available information. The waste streams for which EPA had no published annual generation rate were divided into five groups and a methodology for each group was assigned as follows.

- Actual generation rates for the waste in question from one or more facilities were available. EPA extrapolated from the available data to the sector on the basis of waste-to-product ratios to develop the expected value, and used a value of plus or minus 20 percent of the expected value to define the upper and lower bounds.
- A typical waste-to-product ratio for the waste in question was available. EPA multiplied the waste-to-product ratio by sector production (actual or estimated) to yield a sector wide waste generation expected value, and used onehalf and twice this value for the lower and upper bounds, respectively.
- 3. No data on the waste in question were available, but generation rates for other generally comparable wastes in the sector were. EPA used the maximum and minimum waste generation rates as the upper and lower bounds, respectively, and defined the expected value as the midpoint between the two ends of the range. Adjustments were made using professional judgment if unreasonable estimates resulted from this approach.
- 4. No data were available for any analogous waste streams in the sector, or information for the sector generally was very limited. EPA drew from information on other sectors using analogous waste types and adjusting for differences in production rates/material throughput. The Agency used upper and lower bound estimates of one order of magnitude above and below the expected value derived using this approach. Results were modified using professional judgment if the results seemed unreasonable.
- 5. All EPA knew (or suspected) was the name of the waste. The Agency used the high value threshold (45,000 metric tons/year/facility or 1,000,000 metric tons/year/facility) as the maximum value, 0 or 100 metric tons per year as the minimum, and the midpoint as the expected value.

Waste Stream Management Practices

EPA reviewed process descriptions and process flow diagrams obtained from numerous sources including, <u>Kirk-Othmer</u>, <u>EPA's Effluent Guideline Documents</u>, EPA survey instruments, and the literature. As noted earlier, the available process descriptions and process flow diagrams varied considerably in both quality and detail, both by commodity and source of information. Therefore, EPA often needed to interpret the information to determine how specific waste streams were managed. For example, process descriptions and process flow charts found through the Agency's electronic literature search process often

focused on the production process of the mineral product and omitted any description or identification of how or where waste streams were managed. In such cases, the Agency used professional judgment to determine how and where specific waste streams were managed. For example, EPA considered (1) how similar waste streams were managed at mineral processing facilities for which the Agency had management information. (2) the waste form and whether it was amenable to tank treatment, (3) generation rates, and (4) proximity of the point of waste generation to the incoming raw materials, intermediates, and finished products to predict the most likely waste management practice.

Waste Stream Recyclability and Classification

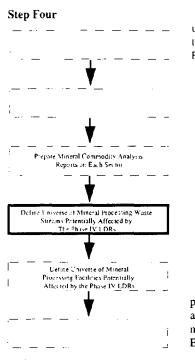
As was the case for the other types of waste stream-specific information discussed above, EPA was unable to locate published information showing that many of the identified mineral processing waste streams were being recycled. When information showing that a particular waste stream was being either fully or partially recycled was found, the recyclability of the waste stream was designated by Y and YS, respectively.

However, due to the paucity of data for many of the mineral commodity sectors and waste streams, the Agency developed a method for determining whether a particular mineral processing waste stream was expected to be either fully or partially recycled, designated by **Y**? and **YS**?, respectively. This method was designed to capture the various types of information that could allow one, when using professional judgment, to determine whether a particular waste stream could be recycled or if it contained material of value.

If EPA determined that the waste stream was or could be fully/partially recycled, it used the definitions provided in 40 CFR §§ 260.10 and 261.1 to categorize the waste stream as either a by-product, sludge, or spent material.

EPA, through the process of researching and preparing mineral commodity analysis reports for the mineral commodities listed in Exhibit B-2, identified a total of 533 waste streams that are believed to be generated at facilities involved in mineral production operations.

B.4 <u>Define the Universe of "Mineral Processing" Waste Streams Potentially Affected by the Phase IV</u> LDRs



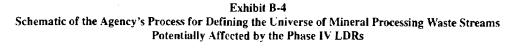
The Agency then evaluated each of the waste streams using the process outlined in Exhibit B-4, to remove waste streams that would not be affected by the Phase IV LDRs. Specifically, EPA removed:

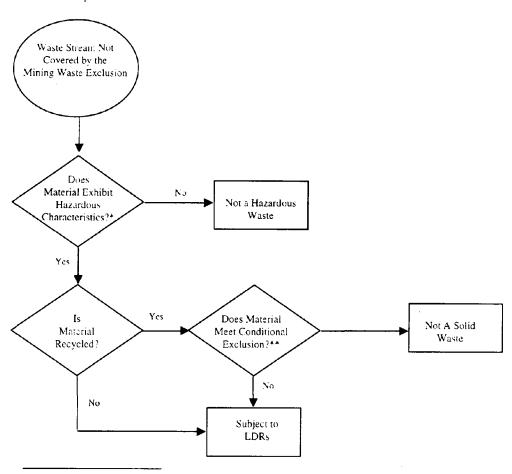
- All of the extraction and beneficiation waste streams;
- The "Special 20" Bevill-Exempt mineral processing waste streams;
- Waste streams that were known to be fully recycled in process; and
- All of the mineral processing waste streams that did not exhibit one or more of the RCRA characteristics of a hazardous waste (based on either actual analytical data or professional judgment).

As a result of this evaluation process, EPA narrowed the potential universe of waste streams that could potentially be affected by the proposed Phase IV LDRs to the 121 hazardous mineral processing waste streams presented below in Exhibit B-5.⁵

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⁵ EPA strongly cautions that the list of waste streams presented in Exhibit B-5 should not be construed to be the authoritative list of hazardous mineral processing waste streams. Exhibit B-5 represents EPA's best effort, and clearly does not include every potential waste stream. Furthermore, the omission of an actual waste stream (and thus its not being classified as a hazardous mineral processing waste does not relieve the generator from its responsibility of correctly determining whether the particular waste is subject to Subtitle C requirements.





* Listed hazardous waste are excluded from further analysis because they are already, subject to all relevant Subtitle C requirements.

** To meet the conditional exclusion, materials must be stored in tanks, containers, of buildings for less than one year, or have a site specific determination that sold material may be stored on a concrete or asphalt pad. (Other requirements can be found in 261.4(a)(15))

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Exhibit B-5 Potentially Hazardous Mineral Processing Waste Streams by Commodity Sector

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B-14

Alumina and Aluminum	Coal Gas
Cast house dust	Multiple effects evaporator concentrate
Electrolysis waste	Copper
Antimony	Acid plant blowdown
Autoelaye fütrate	WWTP sludge
Slag and furnace residue	Elemental Phosphorus
Stripped anolyte Solids	Andersen Filter Media
Beryllium	Precipitator slurry
Chip treatment wastewater	NOSAP slurry
Filtration discard	Phossy Water
Spent Barren Filtrate	Furnace building washdown
Bismuth	Furnace scrubber blowdown
Alloy residues	Fluorspar and Hydrofluoric Acid
Spent caustic soda	Off-spec fluosilicic acid
Electrolytic slimes	Germanium
Lead and zine chlorides	Waste acid wash and rinse water
Metal chloride residues	Chlorinator wet air pollution control
Slag	sludge
Spent electrolyte	Hydrolysis filtrate
Spent soda solution	Leach residues
Waste acid solutions	Spent acid/leachate
Waste acids	Waste still liquor
Cadmium	Lead
Caustic washwater	Acid plant sludge
Copper and lead sultate filter cakes	Baghouse incinerator ash
Copper removal filter cake	Sturried APC dust
Iron containing impunties	Solid residues
Spent leach solution	Spent furnace brick
Lead sulfate waste	Stockpiled miscellaneous plant waste
Post-leach filter cake	Wastewater treatment plant houid offluer
Spen: punfication solution	Magnesium and Magnesia from Brines
Scrubber wastewater	Cast house dust
Spent electrolyte	Smut
Zine precipitates	Mercury
Calcium	Dust
Dust with quick lime	Furnace residue
Chromium and Ferrochromium	Quench water
ESP Dus:	*
GCT Sludge	
e-	

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B-15

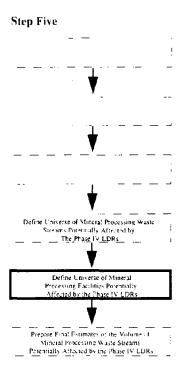
Exhibit B-5 (continued)

	m, Ferromolybdenum, and	Titanium and Titanium Dioxide
	1 Molybdate	Pickle liquor and wash water
	ue dust/gases	Scrap milling scrubber water
	quid residues	Smut from Mg recovery
Platinum G	Group Metals	Leach liquor and sponge wash water
SL	ag	Spent surface impoundment liquids
	bent acids	Spent surface impoundments solids
	bent solvents	Waste acids (Sulfate process)
Rare Earths	5	WWTP studge/solids
Sp	ent ammonium nitrate processing	Tungsten
	solution	Spent acid and rinse water
Ele	ectrolytic cell caustic wor APC	Process wastewater
	sludge	Uranium
Pr	ocess wastewater	Waste nitric acid from UO, production
	ent scrubber liquor	Vaporizer condensate
	lvent extraction crud	Superheater condensate
	astewater from caustic wet APC	Slag
Rhenium	astewate. Hom cuasite wet At e	Uranium chips from ingot production
	ent barren scrubber liquor	Zinc
	ent rhenium raffinate	Acid plant blowdown
Scandium	chi i i chi dhi i shinate	Waste ferrosilicon
	ent acids	Process wastewater
	ent solvents from solvent extraction	Discarded refractory brick
Selenium	ent solvents nom solvent extraction	Spent cloths, bags, and filters
	ent filter cake	Spent counts, bags, and millers Spent goethite and leach cake residues
	ant process wastewater	Spent surface impoundment liqds
Sli	•	Spent synthetic gypsum
	llurium slime wastes	TCA :ower blowdown
	aste solids	
Synthetic R		Wastewater treatment plant liquid efflue WWTP solids
		Zirconium and Hafnium
	ent iron oxide slurry	
	PC dust/sludges	Spent acid leachate from zirconium
	ent acid solution	alloy production
	Columbium, and Ferrocolumbium	Spent acid leachate from z conium
	gester sludge	metal productior.
	ocess wastewater	Leaching rinse water from zircontum
	ent_raffinate_solids	alloy production
Tell ur ium		Leaching rinse water from zircomum
Sla		metal production
	lid waste residues	
	aste electrolyte	
Wa	astewater	
Note:	EPA was unable to collect sufficient in	tormation to determine whether the production of
		and Lithium Carbonate, Soda Ash, Sodium Sulfate, and
	Stront:um produce mineral processing	
-	processing	

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B.5 Define the Universe of "Mineral Processing" Facilities Potentially Affected by the Phase IV LDRs



EPA then used the information contained in the individual sector analysis reports to identify the number of facilities, by commodity, that potentially generated the hazardous mineral processing wastes listed in Exhibit B-5. As discussed earlier, the individual sector analysis reports listed the facilities involved in the production of a particular mineral commodity. In addition, as the available information allowed, the Agency also (1) identified the specific processes used by each facility and (2) identified the specific waste streams generated by process. However, in cases where the Agency had insufficient information to determine which of the individual facilities generated a particular waste stream. EPA assumed that the waste stream was generated at all of the reported facilities known to be using the same process.

The Agency then used the individual sector analysis reports, various U.S. Bureau of Mines documents, the Randol Mining Directory, and the Mine Safety and Health Administration (MSHA) address/employment database to determine which of the mineral processing facilities were collocated with mining and/or extraction/beneficiation facilities.

Lastly, the Agency used the 1990 Report to Congress and the individual commodity sector analysis reports to identify the mineral processing facilities that also generate one (or more) of the special 20 Bevill-Exempt mineral processing wastes.

Appendix C presents a summary of the mineral processing facilities by mineral commodity sector that generate hazardous mineral processing wastes. Appendix C also indicates whether the mineral processing facilities are collocated and/or generate one (or more) of the "Special 20" waste streams.

B.6 Prepare Final Estimates of the Volume of Mineral Processing Waste Streams Potentially Affected by the Phase IV LDRs

The Agency compiled the information in the previous steps to arrive at the final data set. Exhibit B-6 presents for each potentially affected waste stream in all affected sectors, the reported and/or estimated generation rate, the hazardous characteristics, information about recycling status, RCRA waste type, and treatment type (physical form).

Exhibit B-6 Final Data Set

		Reported		Est./Report ration (100		Number	Average Facility Generation (int/yr)			
Commodity	Waste Stream	Generation (1000mt/yr)	Nin	Avg.	Max	of Facilities with Process	Minimum	Expected	Maximum	
Abirana and Abiranian	Cast house dust	19	19	19	19	23	830	830	820	
	Electrolysis waste	58	ńh	58	58	23	2 500	2 500	2,500	
Antimony	Autoclave filtrate	NA	0.32	27	-14	K:	53	4,500	9,000	
	Stripped anolyte solids	0.19	0.19	0.19	C.19	2	45	i)s	95	
	Stag and furnace residue	21	21	21	21	6	3,500	3,500	3,500	
Beryllium	Chip treatment wastewater	NA	0.2	100	2000	2	100	50,000	1,300,009	
	Spent barren filtrate	55	55	15	55	1	55,000	55,000	55,000	
	Filtration diseard	NA	0.2	45	90	2	100	23,000	45,000	
Bisrauth	Alloy residues	NA	01	3	6	1	100	3,000	6.000	
	Spent caustic so la	NA	0.1	61	12	1	100	6,100	12,000	
	Electrolyac shines	NA	U	0.02	0.2	1	0	20	2041	
	Lead and zine chlorides	NA	0:	3	6	I	109	3,000	6 (X04)	
	Metal chionde residues	3	3	3	3	1	3,000	3,000	3,000	
	Slug	NA	01	-	10	1	100	1,000	10,005)	
	Spent electrolyte	NA	01	61	12		. 100	6,100	12,000	
	Spent soda solution	NA	01	61	12	1	100	5,100	12,000	
	Waste actu solutions	NA	01	61	12	1	100	5,100	12,000	
	Waste acids	NA	υ	0.1	0.2	1	υ	100	200	
Cadmium	Curstic washwater	NA	0.19	19	19	2	95	950	9,500	
	Cupper and lead sulfate filter cakes	NA	0.19	19	19	2	95	950	9,500	
	Copper removal filter cake	NA	0.19	1.9	19	2	95	950	9,500	
	Iron containing impurities	N.A	0.19	1.9	- 19	2	95	950	9,500	
	Spent leach solution	NA	0.19	1.9	19	2	95	950	9,500	
	Lead sulfate waste	NA	0 19	19	19	2	95	950	9,500	
	Post-leach filter cake	NA	019	19	19	2		950	9,500	
	Syent purification solution	NA	019	1.9	19	2	95	950	9.500	
	Scrubber wastewater	NA	9.9	19	19	2	95	950	9.5.30	
	Spent electrolyte	NA	V. 0	1.9	19	2	95	950	9,500	
	Zine precipitales	NA	6,9	19	19	,	- 25	950	9,500	

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		Reported		ist./Report ation (100		Number	Average	Facility Genera	tion (mi/yr)
Commodity	Waste Stream	Generation (1000mt/yr)	Min	41g.	Max	of Facilities with Process	Minimum	Expected	Maximum
Calcium	Dust web quicklone	0.04	0.04	40.0	0.04	t,	40	40	-ku
Chromium and Ferrochronium	ESP dust	3	3	3	3	1	3,000	3,000	.1,000
	GCT sludge	NA	0.03	- 03	1		.30	300	3,000
Coal Gas	Multiple effects evaporator concentrate	NA	0	Û	65	1	U	0	65,000
Copper	Arid plant blowdown	5300	5300	5300	5200	10	\$10,000	530,000	* 30,0 0 0
	Spent furnace brick	3	3	4	3	· 10	300	300	300
	WWTP sludge	6	0	6	6	10	500	600	
Elemental Phosphorus	Andersen Filter Media	i) 46	0.46	0.16	U 46	Ŷ	230	230	230
	Precipitator slurry	160	160	160	160	2	80 (00)	50,000	80,000
	NOSAP simry	160	160	160	160	<u>.</u>	80.000	5 0 000	80.00
	Phossy Water	670	670	6/0	620	2	340.000	540 600	340,000
	Furnace scrubber blowdown	410	410	410	410	2	210 000	210 000	210,006
	Farnace Building Washdown	700	700	700	700	2	350 000		350,000
Fluorspar and Hydrofluoric Acid	Off-spee fluosificie acid	NA NA	0	15	-14		0	5 000	15,000
Gemanium	Waste acid wash and rinse water	NA	0.4	2 2	-4	4	:00	550	1.000
	Chlorinator wet air pollution control sludge	NA	0.01	0.21	04	4	ì	53	100
	Hydrolysis filmae	NA	0.01	0.21	04	-1	(53	100
	Leach residues	0.01	0.01	9.01	0.01	3	3	3	
	Spent ac:d/leachate	NA	0+	2.2	4	4	100	550	1,00
	Waste still liquor	NA	0 01	0.21	0.4	+	j.	53	100
Lata J	Acid plant sludge	14	- 4	14	14	3	4,700	4,700	4 700
	Bughouse memorator ash	NA	03	ר ז	30	3	100	1,000	.0,00
	Slurried APC Dust	7	7	7	7	1	2,700	2,300	2.30
	Solid residues	04	04	0.4	0.4	3	130	130	133
	Spent fornace brick	· · · ·	<u> </u>	<u> </u>	1	3	330	330	330
	Stockpiled miscellaneous plant waste	NA	03	67	130	3	100	22,000	43.00
	WWEP liquid efflicat	2600	2600	2600	2600	3	570,000	870.000	370,00
Magnesium and Magnesia from Brines	Case house dust	NA	0.076	0 76	7.6		76	760	7,60
	Sn.u:	26	20	26	26	2	13,000	13.000	13.00
Mercury	Dust	0.007	0.007	0,007	0.007			I	
	Qiench walei	NA	61	77	420	7	9,000	E) 000	50.00
	Funace residue	0.077	0.077	0.077	0 077	7	11		1

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		Reported		ist./Report ration (100		Number	Average Excility Generation (mt/yr)			
Commodity	Waste Stream	Generation (1000mt/yr)	Min	۸×g.	Max	of Facilities with Process	Minimum	Expected	Maximum	
Molybdeauni, Ferry-molybdenuic, and Animonium Molybdate	Hue dust/gases	NA	11	250	500	11	601	23,000	45,000	
1	Liquid residues	1	L	I	1	2	500	5(6)	500	
Platmum Group Metals	Slag	NA	0.0046	0 0 16	0 16	3	2	15	150	
	Spent acids	NA	03	1.7	1	3	100	570	1.000	
	Spent solvents	NA	0.3	17	3	3	100	570	1.000	
Rare Earths	Spent ammonium nitrate processing solution	14	14	14	14	i	14,000	14,660	14,05.0	
	Electrolytic cell caustic wet APC sludge	NA	0 07	0,7	7	1	7()	700	7 000	
	Process wastewater	1)	7	7	1	7,000	7,000	7.000	
	Spent scrubber liquor	NA	. 0.1	.500	1000	l	100	500 000	1,000,00,0	
	Solvent extraction crud	NA	0.1	23	45	ŀ	100	2 300	4 500	
	Wastewater from caustic wet APC	NA	01	500	10.00	1	1(X)	500,000	1.0003.000	
Rhenum	Spent barren serubber liquor	NA	9	01	0.2	2	0	50	IŬ	
	Spent then.um rattinate	88	85	88	58	2	44,000	44,000	-1-1,000	
Scandium	Spent acids	NA	0.7	39	7	7]+ X)	560	1.006	
	Spent solvents from solvent extraction	NΛ	0.7	39	7	7	100	560	1,000	
Seleaium	Spent lilter cake	NA	0.05	05	5	1	17	170	1,700	
	Plant process wastewater	66	66	66	66	2	33,000	33 000	33,000	
	Slag	NA	-0.05	0.5	5	4	17	170	1.70	
	Tellurium slime wastes	NA	0.05	05	5	٦	17	170	1,70	
	Waste solids	NA	0.05	05	5	1	17	170	1,70	
Synthetic Rutile	Spent iron oxide slurry	45	45	45	45	1	45,000	45,000	45,00	
	APC dust/sludges	30	.30	30	30	1	30.000	¹ 0,600	30,006	
	Spent acid solution	.30	30	.30	30	1	30 000	°0,000	30,600	
Taritalum, Columbium, and Ferrocolumbium	Digester sludge	1	L	ł	l	2	500	500	. 500	
	Process wastewater	150	150	150	150	2	75,000	i5,000	75,00	
	Spent raffinate solids	2	2	2	2	2	1,000	1,000	1,000	
Tellunium	Siag	NA	0 2	2	9	2	100	L'000	4,50	
	Solid waste residues	NA	0 2	2	9	2	100	1,000	4,50	
	Waste electrolyte	NA	0?	7	20	2	100	1,000	10,00	
	Wastewater	NA	02	20	-40	2	100	10,000	20,00	

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		Reported	Liner Liner	Est./Reported Generation (1000mt/yr)	ed Hint/yr }	Number	Антади	Average Facility Generation (mt/yr)	tion (mt/yr)
Commodity	Waste Stream	(lowhou/yr)	Nin	Avg.	Max	of Facilities	Minimum	Expected	Maximum
Titanum and firanium Dioxide	Puskie liquor ankl wash water	VZ	2.2	2.7	3.2	×	08.7	006	001'1
	Scrap nelling scrubber water	VN.	-	۰.	0	-	1.000	0.000	6.U(H)
	Smut from Mg recovery	VN.	0.1	22	45	<u>ا</u> د	ξu	000, 1	23.000
	Leach liquor and spunge wash water	ΥN.	380	480	5:0	\$	190.000	240,000	140.002
	Spent subscention important high-	ΥN	0.62	\$4	67	7	64	(Kit	(H)K)
:	sprins succurrendeur angene subdes	94	36	96	46	1.	001.2	5.100	5.101
	Wuste acids (builate process)	VN	70	66	11	2	1001	(XHI)()~	(i0) 68
	WWTP studge/solids	420	420	0ć†	071	4	000 09	00100	600.004
Tungstern	Spent acid and rinse water	N.N.	U	0	21	v	0	0	1 405 8
	Process workewater	VN	2.2	7	\$	\$	1/0	067	1.92.1
Uranum	Waste nitrie acid from L (32 products n	V.N	21	2.5	34	17	100	051	20.0
	Vaporizes condensate	VN	1.7	63	17	17	100	550	1.000
	Superficater condensate	NN	01	1.6	17	51	100	055	1,000
	skg	VN	0	85	17	121	0	500	1.000
,	Demissions choice ingot production	VN	1.1	2.5	Ŧ 1	1.1	1(K)	041	:07
Zink	u wobwedd muta hoor	130	051	130	130	-	130,000	130,000	000.001
	Waste terrostlicon	17	17	17	17	1	17,300	17,000	000121
	Jainmaist w svarold	0005	5000	5000	5000	5	1,700,000	1 201,003	1,700,100
	Descarded refractory tinck			1	-	1	1,000	1.(XX)	1.000
	Spent , holds, bays, and filters	0.15	0.15	015	0.15		50	50	8
	Spent goothite and leach cake residues	51	51	15	51	3	5,000	5,000	5,000
	Spent surface empoundment hejords	IN261	1930	1900	000-1	3	630,000	e.30,000	630,000
	WWTP Solids	0.75	0.75	0 75	0.75	ł.	2.60	250	9X c
	Spent synthetic gypsum	91	16	16	91	1	5,700	5, 3600	5,300
	TCA to see blowdown	0.25	0.25	0 25	62.0	-	. x 0	250	95
	Wastewater treatment plant liquid offlucin	5600	2600	2600	2600	3	870,000	870.000	870.000
Ziconium and Hatmum	Spent and leachate from Zr alloy prod	¥N.	0	0	350	61	0	Ξ	00011
	Spent acid leachate from Zr metal prod-	N A	0	0	1500	ſ	0	Ξ	800,000
	Leaching time water from Zr alloy prod	NN NN	t	42	- 15	2	0XM), T T	1000,12	26.000
	I maching tinse water from Zr metal grod.	٩Z	0.1	ICKN C	2:00	•	100	0001005	1.000.000

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																RA Waste	Type		[reatment]	Туре
Commodity	Waste Stream	As	Bu	Cd	UL UL	Metals Pb	Hg	Se	Δg	Corr	Ignit	Hety	Haz?	Current Recycle	By- Prod.	Spent Mat'i	Sludge	Waste Water	1-10% Solids	Soli
Aluntina and Aluntinian	Cast house dust			Ŷ			Y			N ^o	יא	N ⁹	1	¥?			1	0	0	
	Electrolysis waste					¥2				N?	N'	N2	0.5	¥2			:	u I	0	1
Antierony	Autoclave filtrate	Y?		۲٦	Î	۲Y (¥?			Yn	Ň7	N2	0.5	Y57				· · · · · ·	0	0
	Stripped anolyte solids	Y?								N)	N۶	N?	0.5	Y	ī			6	0	1
	Slag and furnace residue					Ÿ?				N	N۲	N ⁹	0.5	N				0	U	1
Beryllium	Chip treatment westewater				¥۴					NS	N.,	N?	0.5	YS?		1		I	U	U
	Spent barren filtrate							Y		N.:	N?	N.,	1	YS		1		1	0	0
	Lilitration discard					Y''				N'	- Nº	N''	0.5	N				(A. 19	0	1
Bischith	Alloy residues					<u> </u>				N?	N?	<u>N?</u>	0.5	N				i, i	0	1
	Spent caustic soda					Ϋ́				NC	N?	N?	0.5	Y [.] 7		1			- 1	0
	Electrolytic slimes					Y?				N.'	N''	N''	05	¥?	- 1				0	1
	Lead and zine chlorides					Y ?				N?	N?	N''	0.5	N				÷	0	1
	Metal chioride residues					Y 7				"N"	N.5	N ⁹	0.5	N				9	0	1
	Stag					Y ?				N°	N?	N?	05	N				C	U	1
	Spent electrolyte					Υ.				N?	N?	N۶	0.5	N				i.	- 1	()
	Spent soda solution					<u>Y</u> ?				۲?	N?	N?	0.5	Y ?		1		1	. 0	0
	Waste acid solutions									۲۶	N?	N'	05	N				1	0	0
	Waste acids							_		Y"	N7	N?	0.5	YS9				1	0	0
Cadmium	Caustic wishwater			Y"						۲٩	<u>N</u> ,	.Nº	0.5	۲'n				1	0	0
	Cogper and lead subtate filter dakes					Y''				N*	N	N?	0.5	Y"	'			0	0	· 1
	Copper removal filter cake			Y?						Nº	N'	N?	0.5	Ϋ́	1			Û	0	
	fron containing impurities			¥?						N'	N?	N?	0.5	N				0	U	۱ ۱
	Spent leach solution	Y''	L	Y?		Y''			 	۲°	N'	N2	05	Y''				0	<u> </u>	0
	Lead sulfate waste	ļ	L	Y2		۲°	⊢⊢	-		N?	N'	N?	0.5	Y"	- '			0	0	1
	Post-lea/h filter cake			¥2						N?	יא	N?	05	N				Û	0	'
	Spent purification solution			Ϋ́?						۲Ÿ	N٩	N?	0.5	N				1	0	0
	Scrubber wastewater			Y 7						¥?	N ^a	N? .	0.5	Y?			1	:	0	0
	Spent electrolyte			- Y ¹						Y,	N ²	N.3	0.5	N				0	H	0
	Zinc precipitates		I	Y ^{**}			1 T		I	N?	N''	N?	0.5	Y"				Ö	0	1

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																RCRA Waste Type	t'Type		놀	Type
Commercials	Waste Stream	NV.	83	B	25	TC Metals	He	Š	e V	(prt	-ni	Retv	C.eH	Current Recycle	19 19	Spent Mar'l	Sluctoe	Waste	1-10% Sulits	Solid
					;		•	:	ł		9	1								
Calcium	Dust with quickhme									ίλ	î	έN	0.5	۲				0	6	-
Стгопинт and Ferrochronum	18FP dS1				÷			۲.	-	âN	î.	ź	-	54			-	9	Ģ	-
	GCT shulpe 1		Ĺ	Γ	2			ſ		ž	ì	z	5 ()	\ \			-	c	¢	-
Coal Gas	Multiple effects evaporator concentrate	4						÷	[ź	ź	ź	-	۶X	-			c	-	=
Copper	Acid plant blowd.swn	ŕ		ŀ	Þ	2	Þ	ŀ	>	Y	ŝ	ż	-	X.S			ŀ	0	-	0.
	Spent lumace brick				ίλ	ſ				ż	ż	ź	0.5	4.4		-		c	0	-
	WWTP slikibe			۲?		۲۶	Γ	Π	Π	N.	ĉN	ź	0.5	۲S			-	0	0	-
Elementari Phosphorus	Aruler ven Filler Media			<u>,</u>						ź	îż	ź	-	z				c	0	-
	Precipitator slumy			τγ					Γ	ż.	`^		-	ΥS			-	0	_	0
	VOSAP slumy									۶.	ŝ	۲	-	z				0	-	c
	Phossy Water			ίÅ						N.	Å	Y	-	۶۸		-		0	-	0
	Furnace scrubber blowdown			۲						٢	٤N	ź	-	Å			-		0	0
	i urnace Buildage Wash.Jown			Y						î.	ż	ź		٨		-		-	0	0
Florispar and Hydroffueric Acid	Oil-spec fluosflicie acid									۲۶	ž	ź	50	S-A				-	u	0
Gemaniun	Waste acid wash and rir se water	<u>د ۲</u>		٠.λ	λ	ίλ		۲.:	(eð .	ź	ź	۲ C	۰SY		-		-	G	0
	Chlorinator wet air	1.1		τ.λ	۲. ۲	۰.۸		5	ŝ,	ìz	ź	ź	0.5	۲S?			-	5	a	-
	pollutaria control sludge																			
	Aydro.ysis filtrate	11		۲.۲	ιλ	ίλ		ί.λ	6.3	î.	ź	ŕ	0.5	z				0	2	-
	LeavE residnes			5.Å		۰.۰λ				î.	ź	ź	0.5	z				0	0	•••
	Spent and/kachate	1				٠uλ				۲۶	ŝ	ź	0.5	183		-		-	0	0
	Waste still liquor	1		Υ.γ	۲٦.	۲٦		۲.۲	1.5	ż	52	ź	0.5	z				0	0	-
l caJ	Acid ohnt sludge									6	î	ź	05	έ. 3			-	0	9	-
	ğaghouse incinctator asl			Y		Y				, z	ž	ź	-	z				0	0	-
	Shirried AFC Dust			Y		Y				î	ŝ	ź	-	۲			-	0	0	-
	Solid residues					έÅ				ź	ςN Ν	ŝ	0.5	i.A	-			0	0	-
	Spent turnace brack					Y				î	ŝ	ź	-	~		-		0	Ð	-
	Stockpiled nuscellancous plant waste			~		~				ź	2	ź	_	٢٤٧		-		0	-	-
	WWTF hquid effluent					ι.λ				ιλ	۶,N	ź	0.5	Y		-		-	c	0
Magnesiura and Magnesia from Brines	Cast house dust		ι.λ							ż	Ŷ	ż	50	с л			-	0 	9	-
			ľ	Ĺ					I	ź	2	ź	-	2	L			4	c	•

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Commodity	Waste Stream	As	Ba	Cd	- <u>G</u>	M <u>et</u> als Pb	Hg	Se	Ag	Corr	Ignit	Retv	Haz?	Current Recycle	By Prod.	Spent Mat'l	Sludge	Waste Water	1-10% Solids	Solid
Mercury	Dusi						- ¥?			N7	N?	N?	0.5	N				0	0	
	Quench wate:					¥2	¥7			N?	N?	N7	0.5	¥2				1	0	0
	Formace revidue						- γ?			N?	N?	N?	0.5	N				0	0	
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	Flue dust/gases					Υ'				<u>-</u>	N7	NT	0.5	N				0	0	:
	Liquid residues	Y ?		Y'		- 72		Υ"		N?	- N?	N?	0.5	N				1	0	0
Platinu:n Group Metals	Slag					- Y,		Y ?		N۶	Nº	N?	0.5	Ŷ	Т			0	0	·
	Spent acids					Υ?			¥?	Y?	N2	N?	0.5	N				1	0	0
	Spent solvents		· · · ·			Y?			Y?	N٦	۲r	N?	0.5	Ň				1	0	0
Rare Earths	Spear ammonium nurate processing solution						_			Ŷ	N ⁹	N?		N				- 1	0	
	Flectrolytic cell caustic wet APU sludge									Yi	N"	N?	0.5	Ŷ			1	U	0	
	Process wastewater	_				Ŷ				۲'n	N ^o	N?	<u>-</u> 1	YS?		1		1	0	υ
	Spent scrubber liquor									۲Ÿ	N7	٧?	05	¥82			1		0	0
	Solvest extraction crud	_								N ⁷	Y"	N7	05	N				Ū	0	
	Wastewater from caush : wet APC				۲,	Υ.,					N?	N?	05	¥S?			ì		0	ō
Ricco	Spent barren scrubber liquor							¥?		- Nº	V	N	0.5	¥?			1		0	0
	Spent rhenium raffinate					Y.'				N"	NC.	N?	0.5	N				0	0	l
Scanduam	Spent acids									Y?	N''	N?	0.5	N				1	0	0
	Spent solvents from solvent extraction									N	ΥÜ	N2	0.5	Ŷ?				I	0	0
Selenium	Spen: filter cake							Y		N.,	N°.	N?	0.5	Y?	T			0	0	
	Plant process wastewater					Ŷ				Ŷ	N°	N?	1	YS?		1		1	Ű	0
	Slag							¥?		N?	N?	N?	0.5	Y\$2	1			0	0	1
	Tellur um slime wastes	_						¥?		z	N?	N?	0.5	¥?	1			0	0	
	Waste solids							¥2		N?	N ⁹	N۶	0.5	N				0	0	I
Synthetic Rutile	Spen: iron oxide slurry			Y	Ϋ́γ					N:	N?	۳N	0.5	YS?	1			0	0	1
	APC dust/sludges			Y'	Y7					N7	N?	N ⁵	0.5	Y			1	U	U	1
	Spene acid schution			Y?	Y ''				<u> </u>	¥1	N?		0.5	Γ <u>Υ</u>			1		0	0

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									-	-	┞╴	╞	┢		RC.	RURA Waske Type	c Type		÷	Type
					ž	TC Metals	ļ	ŀ	Ţ					Current	B).	Spent		Waste		
Commodity	Waste Stream	Ŷ	Ŧ	۲.)	ڻ ت	ź	Ŧ	ð.	×	Corr	Han H	Reiv	Haz?	Recycle	Prod	Nati	Studge		Solids	Solid
Tantalum, Columbium, and Ferrocolumbium	Digester shudge									S	Ż	2	5: O	z				0	¢	-
	Process washebuter	5		• *	ίλ	·	ſ	íλ	$\left \right $	Y	ź.	Ż	-	6.5		-		c	-	c
	Spentraffinate solics						-			i,	ź.	ž	s: 0	z				0	0	
Telluriora	Slag							43	┢	î	2	È.	50	4 <u>8</u> 4				•	0	-
	Solid waste residues							17		ž	ż	ž	0.5	z				¢	o	_
	Waste electrulyte	Γ	Γ			S.		٢.		ź	ź	2	0.5	z				-	•	0
	Wastewater							۲.۲	-	ίÅ	ŝ	ź	5 0	7		-		-	c	e
Tranum and Frianum: Dioxide	Pickle fiquor and water			ίÅ	٨.	٨				 بہ	<u>2</u>	ź	50	ċS۸		-		-	0	0
	Scrap milling scrubber water			ιÅ	۲.γ	۲		۲.		ĩ	ž	۲,	05	λS?			-	-	0	0
	 Sinut 'rom Mg recovery 									ŝ	ź	7		λ3				=	с	-
	Leach liquot and sponge wash water				6.1	Å				7	ż	2	-	۲۶٬		-		-	0	υ
	Spent surface impoundment liqueix				۲.	λ7.				ź	ź	2	0.5	<i>4</i> 3		-		-	0	Ð
	Spent surface impoundments solids				۰.λ	ж.	 			ž	ž.	ż	0.5	z				0	0	-
	Waste acids (Sulfare process)	*			7			7	٨	7	z	z	-	z				-	0	0
	WWTP sludg:/solids				έ.Λ					z	z	z	0.5	z				0	0	-
Fungsiet:	Speni acid arid rinse water								\square		N:: N	ž	0.5	ίSΥ		-		-	0	ý.
	Process wastewater						٦			1.1	ŝ	ź	0.5	ΥS?		-		-	0	0
Uranium	Waste atric acid from UO2 production									۲،	ž	î.	0.5	۶۶		-		-	0	0
	Vapo: .zet condensate									έλ	ïż	î	0.5	z				-	0	C
	Superlicater condensate									14	ä	۶.	0.5	z				-	0	o
	Stag									ËZ	λ.	ĩ	0.5	Å	-			0	0	-
	Uramum chips from meet acoduction									ź	£	ź	0.5	۲.	-			•	¢	-

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															RC	RA Waste	Туре	1	reatment	Туре
						Metals								Current	Hy.	Spent		Waste	1-10%	
Commodity	Waste Stream	As	Ba	Cu	('r	Pb	Hg	Si	٨g	Corr	Ignit	Retv	Haz?	Recycle	Prod.	Mat'l	Sludge	Water	Solids	Sulid
Zinc	Acid plant blow.lown	Ŷ		Ŷ	Y	Υ?	- , ,	Y	Ŷ	Ŷ	N	N		Y				1	0	0
	Waste ferrosilicon					¥?				N?	N'	N ^o	0.5	Y?	:			0	0	
	Process wastewater	Y		Ŷ	Ŷ	Ŷ		Ϋ́	Y	Y	N?	N ²	· ·	¥?		1		- I	0	0
	Discarded refractory brick	۲ı		¥??	Υ <u>Υ</u> ?	¥?				N ²	N?	N''	0.5	N				U	0	1
	Spent cloths, bags and filters			¥2		٢٦	۲Ÿ	۲'n	¥?	Ň?	N?	Nn	0.5	Y		I		0	0	
	Speni goethite and feach cake residues	Ŷ		Ŷ	Ŷ	Ϋ́ν	۲'n	Ŷ	Ŷ	N''	N?	N .?	1	Y .		1		0	0	1
	Spent surface imponidment liquids			1.5						Ŷ	N7	N?	1	¥\$?		1		1	. 0	0
	WWTP Solus	Y'.		- Y 2		¥2	Y"	Y9	¥?	N'?	N'	N2	0.5	YS			1	0	0	1
	Sperit synthetic gypsum	¥.,		Y		ŶŤ				N?	Ν,	N2	1	N				0	0	Ĩ
	H A tower blowd swn			Υ ^γ		. Y.	Y ?	Ya		¥?	N ²	No	0.5	YS		1		1	0	0
	Wastewater treatment plant bigund offhien			۲"						N?	N"	N?	0.5	¥\$?		I		i	0	0
Zirconicm and Hafmum	Spent wid leachate from Zr allov prod.							_			N°	N?	0.5	N .					0	0
	Spent acid leachaie from Zr metal prod.									Y?	N.,	N?	0.5	N				1	· 0	0
	Leaching rinse water from Zr alloy prod									Y''	N?	N?	05	¥\$?		1		1	0	Ű
	Leaching tinse water from Zr meta- nrost									Y	N?	N?	0.5	¥\$?		1		1	0	0

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April 30, 1998

SUMMARY OF MINERAL PROCESSING FACILITIES PRODUCING HAZARDOUS WASTE STREAMS

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APPENDIX C

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Mineral Commodities	Facility Names	Facility Locations	Mining and MP Facility Collocated	Comments	Generates one of the Special 20 Wastes
Alumina & Aluminum	Alcan Aluminum Corp.	Henderson, KY	no	Processing	Nu
	ALCOA	Warrick, IN	no	Processing	No
	ALCOA	Massena, NY	nv	Processing	No
	ALCOA	Badin, NC	no	Processing	No
	ALCOA	Alcoa, TN	no	Processing	No
	ALCOA	Rockdale, TX	no	Processing	No
	ALCOA	Wenatchee, WA	no	Processing	No
	ALUMAX	Mt. Holly, SC	no	Processing	No
	Columbia Aluminam Corp.	Goldendale, WA	no	Processing	No
	Columbia Falls Aluminum Corp.	Columbia Falls, MT	no	Processing	Nu
	Eastico	Frederick, MD	no	Processing	No
	Intalco Aluminum Corp.	Ferndale, WA	no	Processing	No
	Kaiser Aluminum Corp.	Spokane, WA	no	Processing	No
	Kaiser Aluminum Corp.	Tacoma, WA	no	Processing	No
	National South Wire	Hawesville, KY	no	Processing	Νο
•	Noranda Aluminum	New Madrid, MO	no	Processing	No
	Northwest Alloys Inc.	The Dalles, OR	no	Processing	No
	Ormet	Hannibal, OH	по	Processing	No

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Mineral Commodities	Facility Names	Facility Locations	Mining and MP Facility Collocated	Comments	Generates one of the Special 20 Wastes
Aluminum (continued)	Ravenswood Aluminum Corp.	Ravenswood, WV	no	Processing	No
	Reynolds	Massena, NY	no	Processing	No
	Reynolds	Froutdale, OR	no	Processing	No
	Reynelds	Longview, WA	πο	Processing	Νσ
	Venalco	Vancouver, WA	no	Processing	No
Antimony	Amspec Chemical Corp	Glouchester, NJ	no	Processing	No
	Anzon. Inc.	Laredo, TX	no	Processing	No
	ASARCO Inc.	Omaha, NE	no	Processing	Nu
	Laurel Ind.	LaPorte, TX	πο	Processing	No
	Sunshine Mining Company	Kellogg, ID	yes	Processing	no
	US Antimony Corp	Thompson Falls, MT	no	Processing	no
Beryllium	Brush Wellman	Delta, UT	yes	mining, produces Be(OH);	no
	Brush Wellman	Elmore, OH	no	Secondary ore processing of Be Metal and Alloys	nu
	NGK Metals	Revere, PA	nu	Secondary ore processing of Be Metal	no
Bismuth	ASARCO	Omana, NE	no	Processing	yes
Cadmium	ASARCO	Denver, CO	nu	Processing	no
	Big River Zinc Corp.	Sauget, IL	no	Processing	no
	Jersey Miniere Zinc. Corp	Clarksville, TN	yes (Gordonsville)	Processing	no
	ZUA	Bartlesville, OK	nυ	Processing	no
Calcium Metal	Pfizer Chem (Quigley Company)	Canaan, CT	no	Processing	no
Chromium	Macalloy Corp	Charleston, SC	no	Processing	no

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Mineral Commodities	Facility Names	Facility Locations	Mining and MP Fucility Collocated	Comments	Generates one of the Special 20 Wastes
Coal gas	Great Plains Coal Gasification Plant, Dakota Gasification Co.	Beulah, ND	уся	Synthetic Gas produced	Yes. Gasifer Ash, Process Wastewater
Copper	ASARCO	El Paso, TX	по	Smelting	Yes. Slag, slag tailings and/or calcium sulfate sludge
	ASARCO	Amarillo, TX	no	Electrolytic Refining	Yes. Slag, slag tailings and/or calcium sulfate sludge
	ASARCO	Hayden, AZ	yes	Mining, Smelting and Electrowinning	Yes. Slag, slag tailings and/or calcium sulfate studge
	Copper Range	White Pine, MI	yes	Mining, Smelting & Refining	Yes. Slag, slag tailings and/or calcium sulfate sludge
	Cypr u s	Claypool, AZ	yes	Mining, Smelting, Refining, & Electrowinning	Yes. Slag, slag tailings and/or calcium sulfate sludge
	Kennecott	Garfield, UT	yes	Mining, Smelting and Refining	Yes. Slag, slag tailings and/or calcium sulfate studge
	Magma (BHP)	San Manuet, AZ	yes	Mining, Smelting, Refining, and Electrowinning	Yes. Slag, slug tailings and/or calcium sulfate sludge
	Phelps Dodge	Playas, NM	no	Smelting only	Yes. Stag, slag tailings and/or calcium sulfate sludge
	Phelps Dodge	El Paso, TX	no	Refining only	Yes. Slag, slag tailings and/or calcium sulfate sludge
	Phelps Dodge	Hurley, NM	yos	Mining, Smelting and Electrowinning (same as Chino Mines)	Yes. Slag, slag tailings and/or calcium sulfate sludge
Elemental Pho spo rous	FMC	Pocatello, ID	ycs	Processing	Yes. Slag
	Monsanio	Soda Springs, ID	yes	Processing	Yes. Slag
Germanium	Atomergic Chem	Plainview, NY	по	Processing	no
	Cubot	Reverc, PA	no	Processing	no
	Fagle-Pichet	Quapaw, OK	no	Processing	no

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Mineral Commodities	Facility Names	Facility Locations	Mining and MP Facility Collocated	Comments	Generates one of the Special 20 Wastes
Germanium (continued)	Musto Exploration (inactive)	St. George, UT	yes .	Mining and Refining	no
Fluorospar and Hydrofluoric Acid	Allied Signal	Geismar, LA	no	Processing	Yes. Fluorogypsum and process wastewater
	El. duPont	La Port, TX	Πυ	Processing	Yes. Fluorogypsum and process wastewater
	Attochemical, N.A.	Calvert City, KY	по	Processing	Yes. Fluorogypsum and process wastewater
Lead	ASARCO	East Helena, MT	yes	Smelter	Yes. Slag
	ASARCO	Glover, MO	yes	Smelter/Refinery	Yes. Slag
	Doe Run Co.	Herculaneum, MO	yes	Smelter/Refinery	Yes Slag
Magnesium	Dow Chemical Co.	Freeport, TX	yes	MgCl from seawater, Mg metal processing, magnesia processing	no
	Magnesium Corp. of America	Salt Lake City, UT	yes	Mg metal processing from lake brines	Yes. Process wastewater
	Northwest Alloys Inc.	Addy, WA	no	Mg metal processing	πο
Mercury	Barrick Meeur Gold Mines, Inc.	Toole. UT	yes	Mining and Retorting	no
	FMC Gold Co.	Humboldt, NV	yes	Mining	no
	FMC Gold Co.	Gabbs, NV	yes	Mining	no
	Homestake Mining Co.	Napa, CA	yes	Mining, leaching	no
	Independence Mining Co. Inc.	Elko, NV	ycs	Mining	no
	Newmont Gold Co.	Eureka, NV	yes	Mining	no
	Placer Dome U.S.	East Ely, NV	yes	Mining	no

April 30, 1998

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Mineral Commodities	Facility Names	Facility Locations	Mining and MP Facility Collocated	Comments	Generates one of the Special 20 Wastes
Molybdenum, Ferro molybdenum and	Cyprus-Climax- Henderson	Empire, CO	yes	Mining and Processing	no
Ammonium Molybdate	Cyprus-Climax	Fort Madison, 1A	no	Processing	no
-	Cyprus-Climax	Cold Water, MI	no	Processing, possibly phased out	no
	Cyprus-Climax- Green Valley	Tucson, AZ	no	Processing	no
	Kennecott	Bingham Canyon, UT	yes	Processing	copper slag, slag tailings, WWTP sludge
	Montana Resources Inc	Butte, MT	yes	Processing	no
	Phelps Dodge	Hurley, NM	yes	Processing	no
	San Manuel	San Manuel, AZ	yes	Processing	110
	San Manuel	Morenci, AZ	yes	Processing	no
	Thompson Creek	Challis, ID	yes	Processing	nu
	Thompson Creek	Langeloth, PA	no	Processing	no
Platinum Group Metals	ASARCO Inc.	Amarillo, TX	no	Processing	
	Kennecolt Corp.	Salt Lake City, UT	yes	Processing	
	Stillwater Mine	Nye, MT	yes	Mining and Smelting	no
Pyrobitumens, Mineral Waxes, and Natural Asphalts	American Gilsonite	Bonaza, UT Uintah County	ycs	Production of gilsonite (natural asphalt)	no
	Ziegler Chemical and Mineral Corp	Vernal, UT Uintah County,	yes	Production of gilsonite (natural asphalt)	πυ
Rare Earths	Molycorp	Mountain Pass, CA	yes	Mining of Bastnasite	no
Rhenium	Cyprus-Climax	Green Valley, AZ	yes	Recovers and refines rhenium	nu
	Cyprus-Chimax	Fort Madison, 1A	no	Rhenium recovery	no

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Mineral Commodities	Facility Names	Facility Locations	Mining and MP Facility Collocated	Comments	Generates one of the Special 20 Wastes
Scandium	Baldwin Metals Processing Co.	Phoenix, AZ	no	Processing	no
	Boulder Scientific Co.	Mead, CO	по	Refining	no
	Interpro (subsidiary of Concord Trading Corp.)	Golden, CO	. 10	Refining	no
	Materials Preparation Center	Ames, IA	по	Processing	no
	Rhone-Poulenc, inc.	Phoeniz, AZ	по	Processing	no
	APL Engineered Materials	Urbana, IL	no	Refining	no
	Sausville Chemical Co.	Garfield, NJ	no	Refining	no
Sclenium	ASARCO	Amarillo, TX	ло	Processing	no
	Kennecott	Garfield, UT	yes	Processing	yes
	Phelps Dodge	El Paso, TX	no	Processing	no
Synthetic Rutile	Kerr-McGee Chemical Corp.	Mobile, AL	no	Processing	no
Tantalum, Columbium and	Cabot Corp.	Boyertown, PA	nu	Cb and Ta pentoxide/metal, FeCb, Ta capacitor powder	ກບ
Ferrocolumbium	Shieldalloy Metallurgical Corp.	Newfield, NJ	no	FeCb	no
Tellurium	ASARCO	Amarillo, TX	Ott	Processing	no
	Kennecott Corp.	Gartield, UT	yes	Mining, Smelting and Refining	Yes. Slag, slag tailings and/or calcium sulfate sludge

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Mineral Commodities	Facility Names	Facility Locations	Mining and MP Facility Collocated	Comments	Generates one of th Special 20 Wastes
Titanium and Titanium Dioxide	E.I. duPont de Nemours & Co-Inc	Antioch, CA	no	TiO, Production	Yes. Chloride process w solids
	E.I., duPont	Edgemoor, DE	no	TiO ₂ Production	Yes. Chloride process w solids
	E.I. duPont	New Johnsonville, TN	no	TiO ₂ Production	Yes. Chloride process w solids
	E.I. duPont	Pass Christian, MS	no	TiO, Production	Yes. Chloride process v solids
	Kemira, Inc.	Savannah, GA	no	TiO ₂ Production	Yes. Chloride process v solids
	Kerr-McGee Chemical Corp.	Hamilton, MS	no	TiO ₂ Production	Yes. Chloride process v solids
	Kronos, Inc.	Lake Charles, LA	no	TiO, Production	Yes. Chloride process solids
	Millenium Chemicals, Inc.	Ashtabula, OH	no	TiO ₂ Production	Yes. Chloride process solids
	Millenium Chemicals, Inc.	Baltimore, MD	nu	TiO ₂ Production	Yes. Chloride process solids
Tungsten	Buffalo Tungsten	Depew, NY	no	Processing	ΝΟ
	General Electric	Euctid, OH	no	Processing	no
	OSRAM Sylvania, Inc.	Towanda, PA	· no	Processing	no
	Kennametal	Fallon, NV	100-150 miles to Humbold and Starlight mine	Processing	no
	Kennametal	LaTrobe, PA	no	Processing	no
	Teledyne Advance Materials	Huntsville, AL	no	Processing	no
Uranium	no facilities listed				

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Mineral Com nod ities	Facility Names	Facility Locations	Mining and MP Facility Collocated	Comments	Generates one of the Special 20 Wastes
Zinc	Big River Zine Corp.	Sauget, IL	по	Smelter (electrolytic)	no
	Savage Zinc	Clarksville, TN	yes	Smelter (electrolytic)	no
	Zinc Corp. of America	Monaco, PA	no	Smelter (pyrometallurgical)	Yes. Slag
Zirconium and	Teledyne	Albany, OR	110	Processing	no
Hafnium	Western Zirconium	Ogden, UT	no	Processing	no

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MINERAL PROCESSING WASTE STREAMS STATUS CHANGES SINCE DECEMBER 1995

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APPENDIX D

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Sector	Waste Stream	Waste Type	Action	Date	Reason
Antimony	Autoclave filtrate	Liquid	Number of facilities changed from seven to six	April 1997	McGean Chemical removed, inactive
Antimony	Stag and furnace residue	Solid	Number of facilities changed from seven to six	April 1997	McGean Chemical removed, inactive
Beryllium	Bertrandite thickener slurry	Liquid	Dropped Out of Analysis	April 1997	Public comment indicate previous agency decision on beneficiation processing line
Beryllium	Beryl thickener slurry	Liquid	Dropped Out of Analysis	April 1997	Public comment indicate previous agency decision on beneficiation processing line
Beryllium	Spent barren filtrate streams	Liquid	Dropped Out of Analysis	April 1997	Public comment indicate previous agency decision on beneficiation processing line
Beryllium	Spent barren filtrate streams	Liquid	Added to Analysis	April 1998	Further review indicated that this waste stream was a processing waste
Beryllium	Spent raffinate	Liquid	Dropped Out of Analysis	April 1997	Public comment indicate previous agency decision on beneficiation processing line
Boron	Waste liquor	Liquid	Dropped Out of Analysis	April 1997	Determined to be not- hazardous
Cadmium	Scrubber wastewater	Liquid	Former RCRA waste type changed from spent material to sludge	April 1997	Incorrectly characterized in original analysis

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Sector	Waste Stream	Waste Type	Action	Date	Reason
Chromium/Ferrochromium	ESP dust	Solid	Added to Analysis	April 1998	Waste was delisted, now subject to LDRs
Chromium/Ferrochromium	GCT sludge	Solid	Added to Analysis	April 1998	Waste was delisted, now subject to LDRs
Copper	Acid plant blowdown	Liquid	Increased number of facilities from nine to ten	April 1997	Changed to reflect potential double counting of scrubber blowdown
Copper	Acid plant blowdown	Liquid	Former RCRA waste type changed from by-product to sludge	April 1997	Incorrectly characterized in original analysis
Copper	APC dust/sludge	Solid	Dropped Out of Analysis	April 1997	Not land stored
Copper	Process wastewaters	Liquid	Dropped Out of Analysis	April 1997	Not land stored
Соррег	Serubber blowdown	Liquid	Dropped Out of Analysis	April 1997	Believed to be same as acid plant blowdown, removed to prevent double counting
Copper	Spent bleed electrolyte	Liquid	Dropped Out of Analysis	April 1997	Not land stored
Copper	Spent furnace brick	Solid	Added to Analysis	April 1998	New information indicates land stored prior to recycling
Соррст	Surface impoundment waste liquids	Liquid	Dropped Out of Analysis	April 1997	Double counted (same as process wastewaters)
Copper	Tankhouse slimes	Solid	Dropped Out of Analysis	April 1997	Not land stored
Соррег	Waste contact cooling water	Liquid	Dropped Out of Analysis	April 1997	Not land stored
Elemental Phosphorous	AFM rinsate	Liquid	Changed Generation Rate	April 1997	Commenter provided data
Elemental Phosphorous	AFM rinsate	Liquid	Current recycling status changed from N to Y	April 1997	Commenter provided data
Elemental Phosphorous	AFM rinsate	Liquid	Dropped Out of Analysis	April 1998	Commenter provided data
Elemental Phosphorous	Andersen Filter Media	Solid	Added to Analysis	April 1997	Commenter indicated this material is hazardous
Elemental Phosphorous	Dust	Solid	Dropped Out of Analysis	April 1997	Commenter provided data

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April 30, 1998

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Sector	Waste Stream	Waste Type	Action	Date	Reason
Elemental Phosphorous	Furnace Building Washdown	Liquid	Added to Analysis	April 1997	Commenter provided data
Elemental Phosphorous	Furnace offgas solids	Solid	Dropped Out of Analysis	April 1997	Commenter provided data
Elemental Phosphorous	Furnace scrubber blowdown	Liquid	Changed Generation Rate	April 1997	Commenter provided data
Elemental Phosphorous	Furnace scrubber blowdown	Liquid	Current recycling status changed from N to Y	April 1997	Commenter provided data
Elemental Phosphorous	Furnace scrubber blowdown	Liquid	Corrosivity changed from YS to Y	April 1997	Commenter provided data
Elemental Phosphorous	Precipitator slurry	Liquid	Added to Analysis	April 1998	New information indicates that waste stream is hazardous
Elemental Phosphorous	NOSAP slurty	Liquid	Added to Analysis	April 1998	New information indicates that waste stream is hazardous
Elemental Phosphorous	Phossy Water	Liquid	Added to Analysis	April 1998	New information indicates that waste stream is hazardous
Gold and Silver	Refining wastes	Solid	Dropped Out of Analysis	April 1997	Generated at secondary smelter only
Gold and Silver	Slag	Solid	Dropped Out of Analysis	April 1997	Not land stored
Gold and Silver	Spent Furnace Dust	Solid	Dropped Out of Analysis	April 1997	Not land stored
Gold and Silver	Wastewater	Liquid	Dropped Out of Analysis	April 1997	Generated at secondary smelter only
Gold and Silver	Wastewater treatment sludge	Solid	Dropped Out of Analysis	April 1997	Generated at secondary smelter only
Lead	Acid plant blowdown	Liquid	Dropped Out of Analysis	April 1997	Fully recycled, not land stored
Lead	Baghouse dust	Solid	Dropped Out of Analysis	April 1997	Fully recycled, not land stored
Lead	Process wastewater	Liquid	Dropped Out of Analysis	April 1997	Fully recycled, not land stored

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April 30, 1998

Sector	Waste Stream	Waste Type	Action	Date	Reason
Lead	Stockpiled miscellaneous plant waste	Solid	Number of facilities changed from four to three	April 1998	ASARCO, Oniaha NE facility removed - inactive
Lead	Surface impoundment waste liquids	Liquid	Dropped Out of Analysis	April 1997	No longer generated
Lead	WWTP liquid effluent	եւզաժ	Corrosivity changed from Y to Y?	April 1997	To reflect variability of stream at different facilities
Lead	WWTP liquid effluent	Liquid	Number of facilities changed from four to three	April 1998	ASARCO, Omaha NE facility removed - inactive
Lead	WWTP liquid effluent	Liquid	Former RCRA waste type changed from sludge to spent material	April 1997	Incorrectly characterized in original analysis
Lead	WWTP solids/sludge	Solid	Dropped Out of Analysis	April 1998	Fully recycled, not land stored
Magnesium and Magnesia from Brines	Smut	Solid	Current recycling status changed from Y? to N	April 1997	Review of recycling information yielded new conclusion
Mercury	Dust	Solid	Gurrent recycling status changed from YS? to N	April 1997	Review of recycling information yielded new conclusion
Мегенту	Dust	Solid	Number of facilities decreased from nine to seven	April 1997	Pinson Mining and Western Hog Ranch facilities no longer recovering mercury
Мегситу	Furnace residue	Solid	Number of facilities decreased from nine to seven	April 1997	Pinson Mining and Western Hog Ranch facilities no longer recovering mercury
Mercury	Quench Water	Liquid	Number of facilities decreased from nine to seven	April 1997	Pinson Mining and Western Hog Ranch facilities no longer recovering mercury

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April 30, 1998

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Sector	Waste Stream	Waste Type	Action	Date	Reason
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	Flue dust/gases	Sohd	Number of facilities decreased from twelve to eleven	April 1997	Cyprus Climax Bagdad facility removed - no processing mineral occurring
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	Molybdic oxide refining wastes	Solid	Dropped Out of Analysis	April 1997	No longer generated
Pyrobitumens, Mineral Waxes, and Natural Asphalts	Still bottoms	Solid	Dropped Out of Analysis	April 1998	Production facilities no longer in operation
Pyrobitumens, Mineral Waxes, and Natural Asphalts	Waste catalysts	Liquid	Dropped Out of Analysis	April 1998	Production facilities no longer in operation
Rare Earths	Solvent extraction crud	Solid	Number of facilities decreased from twenty to one	April 1997	Nincteen production facilities no longer in operation
Rare Earths	Solvent extraction crud	Solid	Current recycling status changed from YS? to N	April 1997	Review of recycling information yielded new conclusion
Rare Earths	Spent lead filter cake	Solid	Dropped Out of Analysis	April 1997	Fully recycled, not land stored
Rare Earths	Spent scrubber liquor	Liquid	Corrosivity changed from YS to Y?	April 1997	YS not an allowable entry
Rare Earths	Spent scrubber liquor	Liquid	Former RCRA waste type changed from spent material to sludge	April 1997	Incorrectly characterized in original analysis
Rare Earths	Waste solvent	Liquid	Dropped Out of Analysis	April 1997	Fully recycled, not land stored
Rare Earths	Waste zinc contaminated with mercury	Solid	Dropped Out of Analysis	April 1997	No longer generated

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Sector	Waste Stream	Waste Type	Action	Date	Reason	
Rare Earths Wastewater from caustic wet APC		Liquid	Former RCRA waste type changed from spent material to sludge	April 1997	Incorrectly characterized in original analysis	
Rhenium	Spent barren scrubber liquor	Liquid	Former RCRA waste type changed from spent material to sludge	April 1997	Incorrectly characterized in original analysis	
Selenium	Tellurium slime wastes	Solid	Current recycling status changed from YS? to Y?	April 1997	Review of recycling information yielded new conclusion	
Tantalum, Columbium, and Ferrocolumbium	Digester sludge	Solid	Corrosivity changed from Y to Y?	April 1997	Original source did not provide data, based on expert opinion	
Tantalum, Columbium, and Ferrocolumbium	Spent raffinate solids	Solid	Corrosivity changed from Y to Y?	April 1997	Original source did not provide data, based on expert opinion	
Tellurium	Slag	Solid	Number of facilities changed from one to two	April 1997	Kennecott facility added to analysis based on information in comment	
Tellurium	Solid waste residues	Solid	Number of facilities changed from one to two	April 1997	Kennecott facility added to analysis based on information in comment	
Tellurium	Waste electrolyte	Liquid	Number of facilities changed from one to two	April 1997	Kennecott facility added to analysis based on information in comment	
Tellurium	Wastewater	Liquid	Number of facilities changed from one to two	April 1997	Kennecott facility added to analysis based on information in comment	
Tellurium	Wastewater	Liquid	Corrosivity changed from Y to Y?	April 1997	No supporting data showing stream is definitely corrosive	
Titanium and Titanium Dioxide	Serap detergent wash water	Liquid	Dropped Out of Analysis	April 1997	Not hazardous	

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Sector	Waste Stream	Waste Type	Action	Date	Reason	
Titanium and Titanium Scrap milling scrubber Dioxide		Liquid	Former RCRA waste type changed from spent material to sludge	April 1997	Incorrectly characterized in original analysis	
Titanium and Titanium Dioxide	Spent surface impoundment liquids	Liquid	Waste treatment type changed from solid to wastewater	April 1997	Incorrectly characterized in original analysis	
Titanium and Titanium Dioxide	Waste acids (Chloride process)	Liquid	Dropped Out of Analysis	April 1997	Fully recycled/Treated, not land stored	
Titanium and Titanium Dioxide	Waste ferrie chloride	Liquid	Dropped Out of Analysis	April 1997	Same as Wastes acids (chloride process)	
Titanium and Titanium Dioxide	WWTP studge/solids	Solid	Chromium toxicity changed from Y to Y?	April 1997	No supporting data showing stream fails EP or TCLP test for chromium	
Tungsten	Process wastewater	Liquid	Number of facilities changed from five to six	April 1997	Produced at all facilities	
Zine	Acid plant blowdown	Liquid	Former RCRA waste type changed from spent material to sludge	April 1997	Incorrectly categorized in original analysis	
Zine	Process wastewater	Liquid	Number of facilities changed from four to three	April 1997	Zine Corporation of America-Bartlesville, Oklahoma facility no longer operational	
Zinc	Spent cloths, bags, and filters		Number of facilities changed from four to three	April 1997	Zinc Corporation of America-Bartlesville, Oklahoma facility no longer operational	
Zinc Spent surface impoundment solids		Solid	Number of facilities changed from four to three	April 1997	Zine Corporation of America-Bartlesville, Oklahoma facility no longer operational	
Zinc	Spent surface impoundment solids		Dropped Out of Analysis	April 1997	No longer generated	

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Sector	Waste Stream	Waste Type	Action	Date	Reason	
Zine	Spent synthetic gypsum	Solid	Number of facilities changed from four to three	April 1997	Zine Corporation of America-Bartlesville, Oklahoma facility no longer operational	
Zine	Zinc-lean slag	Solid	Dropped Out of Analysis	April 1997	This is a special waste	
Zinc	WWTP liquid effluent	Liquid	Number of facilities changed from four to three	April 1997	Zinc Corporation of America Bartlesville, Oklahoma facility no longer operational	
Zinc	WWTP solids	Solid	Added to Analysis	April 1997	New information on management practices	
Zine	WWTP solids	Solids	Number of facilities changed from four to three	April 1997	Zine Corporation of America-Bartlesville, Oklahoma facility no longer operational	
Zinc	WWTP solids	Solid	Current recycling status changed from N to YS	April 1997	Zine Corporation of America-Bartlesville, Oklahoma facility no longer operational	

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MINERAL PROCESSING WASTE TREATMENT AND DISPOSAL COSTS: LOW-COST ANALYSIS

APPENDIX E

This appendix comprises an analysis of the treatment and disposal options available to owners and/or operators of mineral processing facilities. The appendix presents the available technically feasible treatment and disposal options, a cost comparison of those options, and a determination of the lowest-cost alternative.

Under the current regulations governing the disposal of hazardous mineral processing waste, owners and/or operators of mineral processing facilities have several disposal options available, depending on the physical form of the waste(s) in question:

- Characteristic Solid wastes may be:
 - Disposed of in a Subtitle C landfill;
 - Treated, followed by disposal in a Subtitle C landfill; or
 - Treated, followed by disposal in a Subtitle D landfill.
- Characteristic Liquid wastes may be:
 - Treated, followed by disposal of solid residues in a Subtitle C landfill; or
 - Treated, followed by disposal of solid residues in a Subtitle D landfill.

With today's completion of this rulemaking, owners and/or operators of mineral processing facilities that generate characteristic hazardous waste (whether solid or liquid) must choose one of the following treatment and disposal options:

- Treated and disposed of in a Subtitle D landfill; or
- Treated and disposed of in a Subtitle C landfill.

Depending on the quantity of waste generated, owners and/or operators of mineral processing facilities may choose to send the waste off-site for treatment and disposal, or build a treatment system on-site.

E.1 Pre-Rule Lowest Cost Option

E.1.1 Analysis of Treatment and Disposal Costs

Using on-site cost functions and off-site unit prices from Appendix F, EPA has calculated prerule (or baseline) treatment and disposal costs over a range of waste generation rates (100 mt/yr - 175,000 mt/yr) for on- and off-site Subtitle C landfill disposal, and on- and off-site treatment followed by Subtitle D landfill disposal. Exhibit E-1 shows the total treatment and/or disposal cost plotted against a range of waste generation rates.¹ The total cost of disposing mineral processing wastes increases as the quantity of waste increases using all four alternatives.

¹ Because Subtitle C landfill disposal is more expensive than Subtitle D landfill disposal, EPA assumes that if facility operators treated their wastes, they would opt for treatment followed by Subtitle D disposal rather than treatment followed by Subtitle C disposal. Therefore, treatment followed by Subtitle C disposal is not included in Exhibit E-1.

Total treatment and/or disposal costs were divided by the waste generation rate to obtain unit costs. Exhibit E-2 shows the unit treatment and/or disposal cost plotted against a range of waste generation rates. Note that the unit cost of off-site treatment and disposal is constant, while the unit cost of on-site Subtitle C landfilling and treatment and disposal decreases as waste quantity increases.

\$1.600.000 \$1,400,000 \$1,200,000 \$1,000,000 Cost (\$/yr **\$8**00,000 \$600,000 \$400.000 \$200,000 1,000 2,000 3.**0**00 4.000 5,000 6,000 7,000 Naste Gen ration Rate (mt/yr) - - - O'f-Site Subtit e C On-Site Subtitle C Off-Site T&D - - · On-Sile T&D

Exhibit E-1 Total Cost of Treatment and/or Disposal Alternatives

E.1.2 Subtitle C Disposal vs. Treatment and Subtitle D Disposal

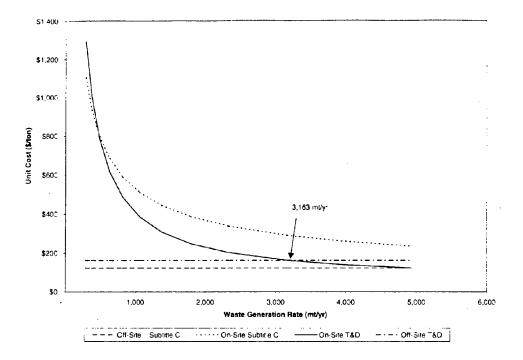
Exhibits E-1 and E-2 show that treatment followed by disposal in a Subtitle D landfill is less costly than Subtitle C landfilling for virtually the entire range of solid waste generation rates under consideration in this rulemaking. For small waste generation rates, however, off-site Subtitle C landfilling is actually a lower cost option than treatment and Subtitle D disposal. Likewise, for waste generated in excess of approximately 150,000 mt/yr (not shown in the exhibits), on-site Subtitle C landfilling is a lower cost option than treatment and Subtitle D disposal. However, data for the biennial reporting system indicate that few, if any, mineral processing facilities are currently sending waste off-site for Subtitle C disposal. Therefore, EPA believes that owners and/or operators of mineral processing facilities generating waste in excess of 150,000 mt/yr will opt to treat and dispose the waste in a Subtitle D landfill. As a result, EPA considers on- and off-site treatment and Subtitle D disposal to be the lowest-cost disposal options for managing hazardous wastes from mineral processing.

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Exhibit E-2 Unit Cost of Treatment and/or Disposal Alternatives

E-3



E.1.3 On-Site vs. Off-Site Treatment and Subtitle D Disposal

In addition to determining that treatment and disposal is the lowest-cost disposal option, EPA has identified a "break-even" point at which it is more economical to treat and dispose of waste on-site rather than send wastes off-site for treatment and disposal. Exhibit E-2 shows the "break-even" point between off-site treatment and disposal and on-site treatment and disposal. This "break-even" point occurs at approximately 3,163 mt/yr, and therefore waste that is generated in small quantities (0 mt/yr - 3,163 mt/yr) will be sent off-site for treatment and disposal rather than be treated and disposed on-site. Waste generated in excess of 3,163 mt/yr, however, will be treated and disposed on-site, assuming cost-minimizing behavior.

E.2 Post-Rule Lowest Cost Option

Because Subtitle C landfill disposal is more expensive than Subtitle D landfill disposal, EPA assumes that if facility operators treated their wastes, they would opt for treatment followed by Subtitle D disposal rather than treatment followed by Subtitle C disposal. Additionally, the above analysis shows that on-site treatment and disposal is less expensive than off-site treatment and disposal for waste

quantities above 3,163 mt/yr. Therefore, EPA assumes that the post-rule lowest-cost option is off-site treatment followed by Subtitle D disposal for wastes generated in quantities below 3,163 mt/yr, while onsite treatment followed by Subtitle D disposal is the lowest cost option for wastes generated in quantities in excess of 3,163 mt/yr.

E.3 Conclusion

EPA believes that Subtitle C disposal is generally more expensive than treatment followed by Subtitle D disposal. This assertion, coupled with data on current management practices, has led EPA to assume that owners and/or operators of mineral processing facilities will choose to treat waste to UTS levels and dispose of the treated waste in a Subtitle D landfill. Therefore, in both the pre-rule (baseline) and post-rule (option) scenarios, the mineral processing cost model reflects the assumption that for waste generated in quantities below 3,163 mt/yr, owners and/or operators will send the waste off-site for treatment and disposal, while owners/operators will build an on-site treatment system for waste generated in excess of 3,163 mt/yr.

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DEVELOPMENT OF COSTING FUNCTIONS

APPENDIX F

EPA's cost analysis is based on costing functions and/or unit costs for on- and off-site treatment and disposal costs and for on-site storage of recyclable materials. To develop the cost functions, EPA identified all of the treatment and disposal permutations that are available in the various baseline-option scenarios. Similarly, EPA identified all of the possible storage practices available under any of the assumed baseline practices and regulatory options considered. The costing functions were developed by estimating costs for facilities of different sizes and curve-fitting these individual facility costs. For some equipment associated with disposal and storage practices, the Agency has used rental costs rather than purchase costs, irrespective of the quantities of material involved. EPA recognizes the likelihood that mineral processing facilities actually own this equipment, such as front end loaders and dump trucks. To be conservative, however, the Agency included rental costs as a simple way to account for the use of this equipment.

The cost functions and associated assumptions are presented in the following six sections:

- 1. Annualization of Before-Tax Compliance Costs
- 2. On-site Treatment and Disposal Costs
- 3. Off-site Treatment and Disposal Costs
- 4. Storage of Solid Materials
- 5. Storage Of Liquid Materials
- 6. Curve-fit Cost Functions

F.1 Annualization of Before-Tax Compliance Costs

Under Executive Order 12866, EPA must determine whether a regulation constitutes a "significant regulatory action." One criterion for defining a significant regulatory action, as defined under the Executive Order, is if the rule has an annual effect on the conomy of \$100 million or more. To determine whether a rule is a significant regulatory action under this criterion, all costs are annualized on a before-tax basis assuming a seven percent real rate of return and a 20-year operating life. The savings attributable to corporate tax deductions or depreciation on capital expenditures for pollution control equipment are not considered in calculating before-tax costs.

Annual before-tax compliance costs were determined for on-site treatment, disposal, and storage. Before-tax compliance costs were used because they represent a resource cost of the rule, measured before any business expense tax deductions available to affected companies. Also, as described in section 3.1.2 of this R1A, screening level economic impacts are computed based upon other pre-tax indications of financial wherewithal, such as value of shipments and value added. Accordingly, computing management and compliance costs on a pre-tax basis provides a consistent measure of impacts on all affected facilities, and is the method used throughout this R1A. In reformulating the costs of compliance, EPA used a public sector discount rate of seven percent and assumed a 20-year operating life for annualizing capital costs.

The following formula was used to determine before-tax annualized costs:

Before-Tax Costs = (Capital Costs)(CRF) + (Annual Capital + O&M Costs) + (Closure Costs)(CRF)/(1.07⁻¹)

CRF	Ξ.	Capital recovided follows:	very factor based on a 7 percent real rate of return (i) as	
$(1 + i)^{n}(i)$	=	0.09439	where $n = 20$	

F.2 On-site Treatment and Disposal

 $(1 + i)^{n} - 1$

Where:

Treatment of Acidic and Caustic Liquid Wastes

Treatment of liquid waste involves neutralization, precipitation, and dewatering, resulting in a sludge requiring stabilization/solidification. Neutralization is the process of adjusting either acidic or caustic liquid waste streams to a pH of approximately seven. Many manufacturing and processing operations produce effluents that are acidic or alkaline (caustic) in nature. Neutralization of acidic or caustic waste streams is necessary in a variety of situations: (1) to prevent metal corrosion and/or damage to other construction materials; (2) as a preliminary treatment for optimum operation of subsequent waste treatment processes; and (3) to provide neutral water for recycling, either as process water or as boiler feed. Treatment to adjust pH also may be desirable to break emulsions, to precipitate certain chemical species, or to control chemical reaction rates (e.g., chlorination). Precipitation, which may occur as a result of the addition of neutralization reagents, or which may require additional reagents, is necessary to remove dissolved solids, such as toxicity characteristic metals from solutions. Corrosive waste streams are neutralized by the addition of an alkaline material, such as lime. Caustic waste streams are neutralized by the addition of an acidic material, such as sulfuric acid. Additional reagent will cause precipitation of dissolved metals. The precipitated metal sludge or slurry is then dewatered in preparation for stabilization. There is probably no lower limit on the solids content of sludges handled by cement solidification, although dewatering is advantageous as a volume reduction measure.

Cost estimates were prepared assuming 1.752 hours per year for waste flow rates of 35.130 metric tons per year (mt/yr) to 350,000 mt/yr, while batch runs were assumed for 3,510 mt/yr and 350 mt/yr, adjusting the operating hours per year to 876 and 88, respectively.

Neutralization

Capital Costs

The following assumptions were used in developing the direct capital cost equations for neutralization in Exhibit F-1:

- Stainless steel neutralization reactor (1) ½-hour retention time, 5% over design (based on waste and calcium hydroxide or sulfuric acid solution flows);
- Stainless steel mix tank (1) two-hour retention time, 5% over design (based on 10% calcium hydroxide or 20% sulfuric acid solution flows);
- Piping, electrical, and instrumentation; and

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EXHIBIT F-1

COST EQUATIONS FOR ON-SITE NEUTRALIZATION AND PRECIPITATION OF PHASE IV WASTES (1995 \$)

Neutralization

Capital Costs (350 \leq Q \leq 370,000 mt/yr) ¹	$Cost(\$) = 36,131 + 151.95 Q^{5}$
O&M Costs / Yr ($350 \le Q \le 370,000 \text{ mt/yr}$)	$Cost(\$) = -206,719 + 36,594 \ln Q$
Precipitation	
Capital Costs $(350 \le Q \le 370,000 \text{ mt/yr})^2$	$Cost(\$) = 3,613 + 15.195 Q^{-5}$
O&M Costs / Yr (350 $\leq Q \leq$ 370,000 mt/yr)	Cost(\$) = 0.3465 Q + 826.48
Closure	
Closure Costs (Q < 37,910 mt/yr)	Cost(\$) = 6,493
Closure Costs (37,910 ≤ Q ≤ 370,000 mt/yr)	.Cost(\$) = 6,361 + 3.0 x 10^{-3} Q

Note:

For quantities above the upper limit of the cost equations, a second system is required.

 1 Q = Annual quantity of acidic or caustic waste managed (mt/yr). Capital and O&M equations apply to either type of waste (similar costs due to use of high cost stainless steel reactor in both designs and roughly equal neutralizing material costs). Fifteen percent of the waste stream neutralized and precipitated will need to be dewatered and stabilized.

Neutralization is performed in a less than 90 day accumulation treatment tanks (40 CFR 262.34); therefore, a RCRA permit is not required.

Acidic Waste Only

- Carbon steel holding tank (1) two-hour retention time, 5% over design (based on 10% calcium hydroxide solution flow);
- Carbon steel centrifugal pumps (3) for the calcium hydroxide solution out of the mix tank and out of the holding tank, and for the waste flow into the reactor;
- Stainless steel centrifugal pump (1) for the waste flow into the reactor;

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- Cast iron agitators (2) for the mix tank and the holding tank; and
- Stainless steel agitator (1) for the reactor.

Caustic Waste Only

- Stainless steel pump (1) for sulfuric acid flow out of the mix tank;
- Carbon steel pumps (2) for the waste flow into and out of the neutralization reactor; and
- Stainless steel agitators (2) for the sulfuric acid mix tank and the neutralization reactor.

Capital costs are similar for either type of waste due to the use of a high cost stainless steel reactor in both designs.

Operation and Maintenance Costs

The following assumptions were used in development of the O&M cost equations for neutralization in Exhibit F-1:

- Operating hours 90 percent operating factor (i.e., 330 days/year);
- Labor one operator at 20 percent time for continuous systems, or ½ hour of labor per batch;
- Power electricity for pumps and agitators: and
- Materials waste pH was assumed to be 1.0 (acidic wastes) and 13.0 (caustic wastes) and waste specific gravity was assumed to be 1.03. Material quantities calculated from the stoichiometric addition of 0.033 gallon of 10% calcium hydroxide or 0.022 gallon of 20% sulfuric acid solution needed per gallon of waste.

O&M costs are similar for either acidic or alkaline waste due to roughly equal neutralizing material costs.

Performance Assumptions

The following performance goals were assumed for neutralization:

- Neutralized waste exits with a pH of approximately seven;
- Solid residuals are generated, with half of inlet total suspended solids (TSS) level of 3.0% assumed to settle and form a sludge with 10% solids content. Therefore, 15% of the original waste stream will leave the neutralization step as hazardous sludge, due to precipitation of a portion of the 500 ppm TC-metals assumed to be in the inlet waste stream--this sludge will require dewatering, stabilization, and disposal; and
- The quantity of calcium hydroxide or sulfuric acid solutions added to the waste streams results in minimal flow changes.

<u>Closure Costs</u>

Cost equations for closure of the neutralization tanks and associated equipment are listed in Exhibit F-1 and include the following components:

- Decontamination of tank interiors, pumps, and liners;
- Management and off-site disposal of decontamination residuals as hazardous waste;
- Testing rinsate to demonstrate tanks and equipment are successfully decontaminated; and
- Certification of closure by a professional engineer.

Precipitation

EPA has assumed that in some cases, precipitation will require more reagent than used for neutralization, though these reagents will be added to the same reactor vessel. To account for this possibility, the Agency has determined that the capital cost for precipitation will consist of the cost of a small reagent holding tank, assumed to be 10 percent of the capital cost equation. O & M costs will consist of doubling the original reagent cost. Cost equations for this additional precipitation step are included in Exhibit F-1.

Surge Capacity

EPA also has assumed that a seven day surge tank is needed. The cost of this tank was developed along with that of other storage tanks, and is presented below in section 5.

Dewatering

Capital Costs

The following assumptions were used in development of the direct capital cost equations for dewatering, which are presented in Exhibit F-2.

- The dewatering direct capital cost includes a scroll centrifuge;
- Installation charges were estimated at 15% of the equipment purchase costs;

Operation and Maintenance Costs

The following assumptions were used in the development of the O&M cost equations for dewatering in Exhibit F-2:

- Direct operation and maintenance costs consist of operating labor and electricity;
- Operating hours--90% operating factor (i.e., 330 days/year);
- The dewatered sludge has a solids content of 60 percent and a specific gravity of 1.03;

EXHIBIT F-2 COST EQUATIONS FOR ON-SITE DEWATERING OF PHASE IV WASTES (1995 \$)

Dewatering of 1-10% Solids-Containing Wastes

Capital Costs $(350 \le Q \le 370,000 \text{ mt/yr})^{1}$	

 $Cost($) = 95,354 + 664.48 Q^{5}$

O&M Costs / Yr (350 $\leq Q \leq$ 370,000 mt/yr)

 $Cost(\$) = 12,219 + 286.86 Q^{5}$

 1 Q = Annual quantity of waste managed (mt/yr), which equals 15 percent of the original waste volume

On-Site Stabilization of Solids and Dewatered Sludges

Chemical stabilization/fixation is used to immobilize toxic and hazardous constituents in waste sludges and soils. Chemical immobilization is accomplished though changing the soluble hazardous constituents into insoluble forms, and binding the constituents in an insoluble matrix. This process also limits surface exposure of the constituents to leaching agents. Cement stabilization, which consists of mixing the waste with cement to form a rock-like material that binds waste constituents in a solidified matrix, is used particularly with sludges and solids that contain heavy metals. This is because the high pH of the cement fixes the heavy metals in insoluble hydrated oxides, hydroxides, or carbonates. In addition to the chemical immobilization, cement stabilization improves the physical characteristics of the waste by increasing its strength and reducing the leachability of contaminants after the solidified waste is land disposed.

The equipment needed for cement stabilization includes a cement storage silo, an auger, a water tank, a pump, a pugmill, a waste feed hopper, and curing boxes. The cement is stored in a silo and transported to the pugmill via the auger. The waste, once deposited into the feed hopper by a front end loader, is conveyed by a belt conveyer to the mixer. Water is stored in a tank and pumped into the mixer. Depending on regulations and operator preference, the stabilized waste mixture can be put in curing boxes for seven to 28 days, or can be loaded directly into a truck for transport to a landfill where it will cure. EPA assumed that facilities would use curing boxes. The following data and assumptions were used to develop the cost for stabilization processes at eight different flow rates:

Assumptions:

The waste has a solids content of 60 percent.

- The ratio of cement to waste to water is 36:100:10 by weight, based on information from the Portland Cement Association, McCutcheon Enterprises, and Rollins Environmental.¹
- Five days worth of water and cement would be stored.
- The density of cement is 85 lbs/ft² (which is the density of crushed furnace slag).
- The front end loader can move 20 shovelfuls per hour.
- The front end loader must be rented for full days.
- The number of operating days was calculated by assuming that the facility operator would only run the waste treatment equipment when enough waste was available for a full day's operation. This assumption maximizes use of equipment while ensuring that waste is treated within 90 days of generation.
- Freight and installation of major equipment would be approximately 30 percent of the purchase price, if not included in the price quotation.
- The amount of solidified waste disposed of in a landfill is 1.46 times the quantity, on a weight basis, of the waste being stabilized. The density of this stabilized waste is 110 lb/ft³.
- •. •
- Stabilization is performed in a less-than-90 day accumulation treatment tank (40 CFR 262.34), so that a RCRA permit is not required.

Cost Data:

- The cost of cement was assumed to be \$84.20 per short ton, which is the average of three price quotations: \$60/ton, \$74.50/ton and \$76/ton (Allentown Cement Company, Illinois Cement Company, and Kaiser Cement Company), plus 20 percent of this average to cover shipping.
- The cost of a 700 ft³ silo is \$13,340, the cost of a 9,000 ft³ silo is \$28,000, and the cost of a 19,000 ft³ silo is \$36,000 (Virginia Silo and Rock Systems Inc.).
- The cost of an auger for the cement is \$10,000 to \$15,000 per silo (Virginia Silo).

¹ This is a much lower ratio of cement to waste than had been assumed in the previous stabilization cost function. A representative of the Portland Cement Association suggested a ratio of 8 to 20 percent cement to waste (by weight) was sufficient, and that previous EPA estimates were high. A representative of McCutcheon Enterprises suggested a range of 10 to 36 percent cement to 100 percent waste by weight. Furthermore, Rollins Environmental Inc., a commercial treater, indicated that they added 20 to 25 percent Portland cement to waste. EPA chose 36 percent cement to waste to be conservative. (Personal communication between ICF Incorporated and Jack Miller. McCutcheon Enterprises, September 3, 1997; personal communication between ICF Incorporated and Chuck Wilk, Portland Cement Association, September 9, 1997; and Letter from Michael Fusco, Rollins Environmental Inc., to Anita Cummings. US EPA, Office of Solid Waste, December 19, 1996.)

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- The cost of renting a 7.5 yd³ capacity 375 horsepower front end loader is \$1,400/day (Means, 1995).
- The fuel and maintenance cost of the front end loader is \$56.15/hr (Mcans, 1995).
- The cost of a heavy equipment operator is \$28.70/hr (Engineering News Record, July 29, 1996, p. 63).
- The cost of a small equipment operator is S26.13/hr (Engineering News Record, July 29, 1996, p. 63).
- The cost of electricity is \$0.07/kWh (CKD Cost Model Documentation).
- The cost of a 10 gallon per minute 0.5 horsepower centrifugal pump is \$734, and the cost of a 100 gallon per minute 5 horsepower centrifugal pump is \$2,007 (Means Environmental Restoration Unit Cost Book, p. 8-356).
- The cost of a one cubic yard plywood box is \$48.59 (Means Environmental Restoration Unit Cost Book, p. 8-215).
- The cost of water is \$25 for 3,000 gallons (McCutcheon Enterprises).
- Cost for tanks of various sizes are as follows:
 - 500 gallon tank: \$450,
 - 1.000 gallon tank: \$1,246,
 - 2.000 gallon tank: \$1.681.
 - 8.000 gallon tank: \$4,593,
 - 15.000 gallon tank: \$6,876,
 - 20,000 gallon tank: \$8,332,
 - 25,000 gallon tank: \$9,405, and
 - 29,600 gallon tank: \$10.567.

In some cases multiple tanks are needed. (Availability and Costs of Storage Units Suitable for Mineral Processing Secondary Materials, Chem-tainer Price List Attachment, p.2, and Highland Tank Attachment, p.3).

- A 7.5 horsepower eight ton capacity waste hopper costs \$9,640 while a 10 horsepower 14 ton capacity waste hopper costs \$28,693 (Rock Systems, Inc.).
- A pugmill that processes three tons/hr costs \$20,000, a pugmill that processes 60 tons/hour costs \$45,000, and a pugmill that processes 187 tons/hour costs \$100,000 (Scott Equipment Manufacturing).

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Exhibit F-3 presents the cost data for the specific cost elements for each of the eight waste generation rates. Exhibit F-4 plots annualized cost as a function of waste generation rate. The curve fit cost function is also shown in Exhibit F-4. The equation for this cost function is:

$$Y = 49.177 (X) + 342,233$$

where Y is the annualized cost of cement stabilization in dollars per year, and X is the annual quantity of waste to be stabilized in metric tons per year.

On-site Subtitle C Landfill

Initial Capital Costs and Assumptions

The landfill design assumes a 20-year operating life with one new cell opened per year (20 cells for 20-year operating life). The following assumptions were used in the development of the initial capital cost equation for landfill operations in Exhibit F-5:

- Land, which includes 5 meters between cells, 15 meters between the cells and the edge of the active area, and a 46-meter buffer around the 20 cell area;
- Site preparation, which includes clearing the 20-cell area and 21 meters around the 20-cell area of vegetation;
- Gravel roads within the active area;
- A 50 foot x 35-foot concrete pad for unloading waste and truck cleaning;
- Warning, stop, and directional signs:
- A maintenance building for equipment repair:
- Utilities site work that includes the installation of electricity, a septic system, a domestic well, a gas line to propane tank, and a telephone at the site;
- An earthen berm around the 20-cell active area for surface water control;
- A package leachate treatment system;
- A groundwater monitoring system that includes six upgradient wells (three shallow wells to provide a horizontal profile of groundwater composition and one cluster of three wells at different depths near one another to provide a vertical profile of groundwater composition) and a minimum of nine downgradient wells (three three-well clusters with the wells in each cluster at different depths). For facilities with an active area side dimension greater than 300 ft, the unit would have the minimum three three-well cluster for the first 300 ft, plus one cluster of three wells for every additional 150 ft;

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Exhibit F-3 Annual Stabilization Cost of Solids and Dewatered Sludges

	A	в	С	D	E	F	G	н	Notes
Waste Quantities (mt/yr)	900	1,500	3,000	15,000	30,000	75,000	150,000	300,000	
Waste Quantities (mt/qtr)	225	375	750	3,750	7,500	18,750	37,500	75,000	
Operational Hours per day	8	8	B	8	. 8	8	8	8	
Operational days per quarter	15	26	51	13	26	63	41	81	3tph. 60tph, or 187 tph
Operational days per year	64	104	204	52	104	252	164	324	
Waste Quantities (mt/day)	14	14	15	288	283	298	915	926	
Waste Quantities (mt/hr)	2	2	2	36	36	37	114	116	
Reagent									
Cement (mt/day)	5.1	5.2	_5.3	104	104	107	329	333	36 % by weight
Cement (ft3/day)	131	135	_137	2,693	2,693	2,779	8,540	8,645	85/b/ft3
Horsepower - screw conveyer	7.5	7.5	7.5	10	10	10	28	28	
Capital Cost									
Silo	13,340	13,340	13,340	36,000	36,000	36,000	108,0 00	108,000	includes freight
Screw Conveyer	10,000	10,000	10,000	15,000	15,000	15,000	40,000	40,000	includes freight
O & M Cost									
Cement (\$)	30,071	50,119	100,238	501,190	1,002,381	2,505,952	5,011,905	10,023,810	\$84.2/short ton
Labor	14,694	23,878	46,838	11,939	23,878	57, 859	37,654	74,390	\$28.70/hr - heavy equip. oper
Electricity	200	326	639	217	434	1,052	1,883	3,721	
Maintenance	2,334	2,334	2,334	5,100	5,100	5,100	14,800	14,800	10% capital
Water Usage									
Water (mt/day)	1.4	1.4	1.5	28.8	28.8	29.8	91 .5	92.6	10% waste quantity
Water (gal/day)	372	381	389	7,624	7,624	7,866	24,173	24,471	
Horsepower - pump	0.5	C.5	0.5	. 5	5	5	5	5	
Capital Cost									
Tank	1,681	1,681	1,681	16,654	16,664	16,664	47,025	47,025	
Freight and Installation	504	504	504	4,999	4,999	4,999	14,108	14,108	30% of purchase price
Pump	734	734	734	2,007	2,007	2,007	2,007	2,007	10 GPM, 100 GPM
O & M Cost								-	
Water (\$)	198	330	660	3,302	6,605	16,511	33,023		\$25/3000gal
Labor	13,379	21,740	42,644	10,870	21,740	52,678	34,283	67,729	\$26.13/hr
Electricity	13	22	43	109	217	526	342	676	
Maintenance	242	242	242	1.867	1,867	1,867	4,903	4,903	10% capital

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	А	в	С	D	E	F	G	н	Notes
Waste Handling									
horsepower - waste hopper	7.5	7.5	7.5	10	10	10	20	20	
Capital Cost									
Waste Hopper	9.64C	9.640	9,640	28,693	28,693	28,693	57,386	57,386	
O & M Costs									
Front End Loader - Rental (\$/yr)	89,600	145,600	285,600	72,800	145,600	352,800	229,600	453,600	\$1400/day, 7.5yd3 bucket
FEL - Fuel and Maintenance	28,749	46,717	91,637	23,358	46,717	113,198	73,669	145,541	\$56.15/hr
Electricity	200	326	639	217	434	1,052	1,370	2,706	\$0.07/kWh
Labor	29,389	47,757	93,677	23,878	47,757	115,718	75,309	148,781	\$28 70/hr, 2 laborers
Maintenance	964	964	964	2,869	2,869	2,869	5,739	5,739	10% capital
Pugmili System	╉╍╌╴╉								
Mass Processed (mt/day)	21	21	21	421	421	435	1,335	1,352	
Horsepower - pugmill	15	15	15	75	75	75	150	150	
Capital Cost									
Pugmill	20,000	20,000	20,000	45,000	45,000	45,000	100,000	100,000	
Freight and Installation	6,000	6,000	6,000	13,500	13,500	13,500	30,000	30,000	30% of purchase price
O & M Costs									
Electricity	401	651	1,278	1,629	3,257	7,892	10,273	20,295	\$0.07/kWh
Labor	14,694	23,878	46,838	11,939	23,878	57,859	37,654	74,390	\$28.70/hr
Maintenance	_2,000	2,000	2,000	4,500	4,500	4,500	10,000	10,000	10% capital
Casting Equipment	+ $ +$								
Number of 1 cy forms required	244	406	813	4064	8128	20320	40640	81281	form used 4 times
O & M Costs									
Forms (\$/yr)	11,856	19,776	39,504	197,518	394,988	987,397	1,974,746	3,949,444	\$48.59/form
Total Capital Cost (\$)	61,899	61,899	61,899	161.863	161,863	161,863	398,526	398,526	
Annualized Capital Cost (\$/yr)	5,843	5,843	5,843	15,278	15,278	15,278	37,617	37,617	
O & M Cost (\$/yr)	238,985	386,660	755,775	873,304	1,732,224	4,284,834	7,557,153	15,066,570	
Total Annualized Cost (\$/yr)	244,828	392,503	761,617	888,583	1,747,502	4,300,112	7,594,769	15,104,187	
Unit Cost (\$/mt)	272.03	261.67	253.87	59.24	58,25	57.33	50.63	50.35	

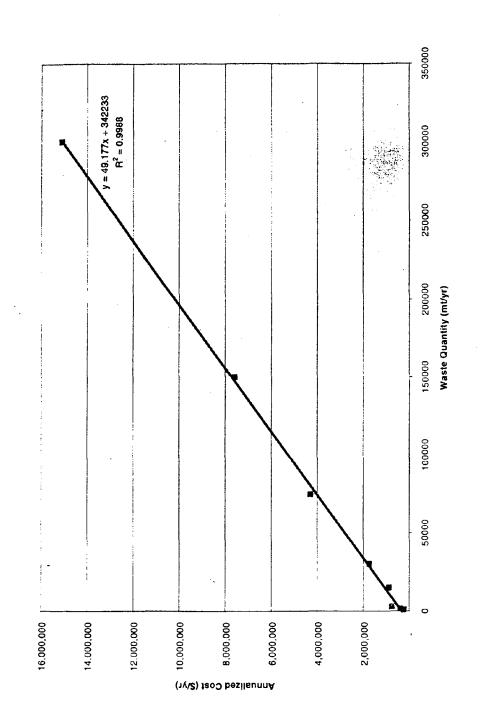
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Exhibit F-4 Annual On-site Stabilization Cost of Solids

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EXHIBIT F-5

COST EQUATIONS FOR ON-SITE SUBTITLE C LANDFILLS PHASE IV WASTES (1995 \$)

Capital Costs (Q ≥ 1,000 mt/yr)	$Cost(\$) = 83,378 + 23,422 Q^{0.5}$
Annual Capital Costs (Q > 1,000 mt/yr)	$Cost($) = 3,137 Q^{0.64}$
O&M Costs / Yr (Q > 1,000 mt/yr)	$Cost($) = 114,223 + 1,737 Q^{0.5}$
Closure Costs (Q ≥ 1,000 mt/yr)	$Cost(\$) = 1,829 Q^{0.57}$
Post-Closure Costs / Yr ($Q \ge 1,000 \text{ mt/yr}$)	$Cost(S) = 1,523 Q^{0.50}$
Cover Replacement Costs / Yr (Q > 1,000 mt/yr)	$Cost(\$) = 3,502 Q^{0.59}$

Note: Q = Annual quantity of waste managed (mt/yr) ranging from 1,000 to 150,000 MT/yr.

- Portable submersible pumps for cell dewatering and leachate removal if sump pump fails;
- Heavy equipment, which includes dozers, landfill compactors, scrapers, and utility trucks;
- Construction of the first cell with the following containment system design in descending order starting with the layer closest to the waste:
 - 0.3 meter protective soil layer;
 - geotextile filter fabric:
 - 0.3 meter sand layer;
 - 30 mil HDPE liner:

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- 0.3 meter sand layer;
- 30 mil HDPE liner; and
- 0.91 meter clay layer;
- Wet wells and pumps for the leachate collection system and the leachate detection system;

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- RCRA initial costs, which include the following items:
 - ID number;
 - waste analysis:
 - waste analysis plan:
 - inspection schedule;
 - personnel training;
 - alarm and spill equipment;
 - arrangement with local land authority;
 - contingency plan;
 - operating record:
 - groundwater monitoring plan;
 - background groundwater monitoring:
 - closure plan, closure cost estimate, post-closure plan, post-closure cost estimate;
 - closure/post-closure financial assurance (obtain mechanism excludes payments to mechanism);
 - liability insurance (obtain mechanism excludes payments to mechanism);
 - Part A permit application; and
 - Part B permit application; and
 - Fees, which include construction quality assurance (CQA), engineering, construction and inspection, construction and field expenses, contractor's overhead and profit, spare parts inventory, and contingency.

Annual Capital Costs and Assumptions

Annual capital costs include the construction of one new cell and closure (i.e., final cover) of the previously used cell each year for the operating life (i.e., 19 years). The following assumptions were used in the development of the annual capital cost equation for landfill operations in Exhibit F-5:

- Cell construction consisting of the same containment design as described in the initial capital cost assumptions;
- Construction of each cell's cover with the following cover system design in ascending order starting with the layer closest to the waste:
 - 0.6 meter clay layer;
 - 30 mil PVC liner;
 - 0.3 meter sand layer;
 - geotextile filter fabric;
 - 0.6 meter topsoil layer; and
 - vegetation;

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Fees which include CQA, engineering, construction and inspection, contractor's overhead and profit, and contingency.

Operation and Maintenance Costs and Assumptions

The following assumptions were used in the development of the O&M cost equation for landfill operations in Exhibit F-5:

- Labor for personnel to operate the landfill, which includes equipment operators, laborers, clerical staff, a technician, a manager, and an engineer:
- RCRA administrative costs, which include the following items:
 - review waste analysis and plan;
 - conduct and record inspections;
 - training program review for facility personnel;
 - review contingency plan;
 - maintain operating record;
 - review closure/post-closure plan;
 - update closure/post-closure cost estimate;
 - review closure/post-closure financial assurance mechanism;
 - review third party liability mechanism;
 - review corrective action schedule; and
 - permit renewal (Assumed the Part B permit is renewed every five years. Averaged the periodic costs out on an annual basis.);
- Maintenance labor and supplies;
- Leachate treatment;
- Groundwater monitoring semi-annually for the following parameters: pH; specific conductance; total organic carbon; total organic halogens: metals; and VOC's; and
- Utilities, which include fuel for heavy equipment, electricity for maintenance building and pumps, and heat for maintenance building.

Closure Costs and Assumptions

The following assumptions were used in the development of the closure cost equation for landfill operations in Exhibit F-5:

- Construction of the final cell's (cell 20) cover consisting of the same cover design described in the annual capital cost assumptions;
- Decontamination by steam cleaning of heavy equipment (dozers, scrapers, compactors, and trucks). Assumed residuals generated at 100 gal/hr and managed off-site as a hazardous waste (transportation 100 miles one-way and commercial hazardous waste treatment);
- Pumps and lines decontaminated with an alkaline solution. Assumed residuals generated at 500 gal/pump and managed off-site as a hazardous waste (transportation 100 miles one-way and commercial hazardous waste treatment):

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- Certification of closure by an independent registered professional engineer; and
- Fees, which include CQA, engineering, construction and inspection, contractor's overhead and profit, and contingency.

Post-Closure and Cover Replacement Costs and Assumptions

The following assumptions were used in the development of the post-closure and cover replacement cost equations for landfill operations in Exhibit F-5:

- Survey plat indicating location and dimension of cells to permanently surveyed benchmarks;
- Waste record submitted to local land authority;
- Note added to property deed stating previous land use;
- Final cover inspected semi-annually;
- Maintenance of final cover (i.e., mow semi-annually and fertilize annually);
- Reseed, fertilize, mulch, and water 1/6 of entire 20-cell area every five years:
- Conduct routine erosion damage repair of cover and ditch every five years:
- Exterminate for burrowing rodents every two years;
- Replace the cover on the first five cells during the last five years of post-closure:
- Leachate managed off-site as a hazardous waste (transportation 100 miles one-way and commercial hazardous waste treatment) for all landfill sizes;
- Pumps replaced annually;
- Groundwater monitoring semi-annually for the following parameters: pH; specific conductance; total organic carbon; total organic halogens; metals; and VOC's;
- Certification of post-closure by an independent registered professional engineer; and
- Fees, which include administration, CQA, engineering, construction inspection testing, construction and field expenses, contractor's overhead and profit on the cover replacement cost, and contingency.

Disposal of Solid Materials in On-site Subtitle D Piles

The waste pile disposal cost function includes land, a compacted soil base, and the costs of a dump truck to move the material to the pile.

EPA made the following assumptions in assembling these cost functions:

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- The purchase cost of land is \$2500/acre (from CKD Monofill Model Cost Documentation, 1995);
- The unit does not require a formal liner, though it is assumed that it will need at least a foot of compacted soil as a base;
- The cost of compacted soil is \$0.2325/ft³ (from CKD Monofill Model Cost Documentation, 1995);
- The unit must be sized for 20 years' accumulation of waste;
- The necessary land area is determined by assuming the material is stored in a conical pile with a maximum height of 100 ft, where the height of the pile is $\frac{1}{2}$ the radius and the volume of the pile is calculated using the following formula: $V = \frac{1}{3}\pi r^2 h$;
- The length of a side of the square plot for a single pile is the twice the radius plus a ten foot buffer zone around the edge of the pile to move equipment; therefore, the area of the pile is $[2^*(r+10)]^2$;
- The area of the square plot for multiple piles is calculated by assuming that the volume to be stored is equally divided by the number of piles, then adding the area of each individual pile with its buffer zone (to allow equipment to move between the piles);
- The density of solid materials is the same as crushed furnace slag (85 lb/ft³);
- The cost of purchasing a 25 short ton capacity dump truck is \$275,000 (vendor quote, 1996);
- The cost of renting a 25 short ton capacity dump truck is \$775/day (from Means, 1995):
- The fuel and maintenance cost of the truck is \$18.85/hr (from Means, 1995);
- The cost of labor to operate the truck is \$22.80/hr (Engineering News Record, 10/31/94, p. 49);
- It would take ½ hour to drive the dump truck to the waste pile, empty it, and return to the point of generation;
- There is no cost associated with a conveying system at the waste pile; and
- Below 50 mt/yr, facilities would not use a pile for disposal as it would be more
 economically attractive to send the material off-site for disposal, even for Subtitle C treatment and disposal.

The costs of disposing solid materials in on-site Subtitle D piles are shown in Exhibit F-6. Exhibit F-7 plots annualized cost as a function of waste generation rate, and displays the curve fit cost function.

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Disposal of Liquid Materials in Surface Impoundments (On-Site Subtitle D)

On-site disposal of liquids (for the no prior treatment baseline) poses some interesting problems, in that release of wastewater is regulated under the NPDES programs, which places limits on what "pollutants" can be released into the environment, including heat, turbidity, and percent solids, to name a few. Because EPA has assumed simple release of materials (for this baseline) under the RCRA program, but some treatment or settling is required under the NPDES programs, EPA has assumed that a facility operator will "treat" liquid waste in surface impoundments, by adding reagent in a tank basin before the waste enters the surface impoundment. Further, EPA has assumed that the facility will then hold the material in the surface impoundment for 15 days before release. Because, however, facility operators will have to treat these waste liquids to UTS levels in a tank system before release, EPA believes the cost of constructing the surface impoundment is a sunk cost, and should not be counted towards calculating the baseline cost.²

Equations were developed for the capital and O & M costs for on-site neutralization of acidic and caustic wastewaters subject to federal NPDES standards. The cost functions were developed by estimating the costs for different size facilities and curve fitting the results. These equations are presented in Exhibit F-8. Because the capital costs for acidic and caustic wastes are very close, EPA used the costs for acidic wastes for all waste streams in the cost model. The Agency based this decision on the assumption that the majority of corrosive mineral processing wastestreams were acidic rather than caustic.

F.3 Off-Site Treatment and Disposal

The cost of sending liquids off-site for treatment and disposal of residues is \$175/mt, which includes a cost of \$25/mt for transportation and a cost of \$150/mt for treatment. The cost of sending solid waste off-site for treatment is \$164/mt, which includes \$25/mt for transportation, \$88/mt for stabilization, and \$355/mt for disposal (which is adjusted to \$51/mt because stabilization increases the mass of waste to be disposed to 146 percent of the original mass). The price of off-site treatment of liquids was taken from the September 1994 document Estimating Costs for the Economic Benefit of RCRA Noncompliance. The cost of off-site Subtitle D disposal is taken from the Technical Background Document: Data and Analyses Addressing the Costs of CKD Management Alternatives. The commercial price for stabilization is estimated at \$88/mt, based on an \$80/short ton difference between off-site landfill and stabilization (\$170/short ton) and off-site landfill alone (\$90/short ton) reported in *El Digest*, November 1994.

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² EPA believes it is inappropriate to include sunk capital costs in the baseline, because the incremental costs of this rule are calculated as the difference between the post rule costs and the baseline costs. If EPA included these non recoverable costs in the baseline, the incremental cost of the rule would be understated.

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Exhibit F-6 Annual Disposal Cost of Solids in Waste Piles

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Waste Pile - Disposal	Unit Cost	A	8	_ C	D	E	F	G	н
Waste Quantilies (mt/yr)		50	500	5,000	50,000	75,000	100,000	250,000	500,
Waste Quantity (f13/yr)		1,297	12,968	129,682	1,295,824	1,945,235	2,593,647	6,484,118	12,968
Total Unit Waste Quantity (ft3)		25,936	259,365	7,593,647	25,936,471	38,904,706	51,872,941	129,682,353	259,364
Unit Construction									
Number of Piles		1	1	1	7	10	13	31	
Radius of Pile (ft)		47	59	180	202	205	207	210	
Height of Pile (ft)		18	40	85	96	98	98	100	
Unit size (ft?)		8,733	31,772	130,272	1,142,363	1,683,210	2,223,596	5,463,850	10,927
Unit size (acres)		0.20	1	3	26	39	51	125	
Annualized Lond (\$/yr)	\$2500/acre	47	172	706	6,188	9,118	12,046	29,599	50
Unit base (compacted soil)	\$0 2325/13	192	_697	2,859	25,070	36,939	48,798	119,908	239
Dump Truck									· · · · · · · · · · · · · · · · · · ·
Number of trips - Annual		3	23	221	2,205	3,307	4,410	11,023	22
Number of hours - annum		1.5	12	111	103	1,654	2,205	5,512	1
Annua Rental Cost	\$775/day	2,325	17,825						
Number of Original Trucks Needed		1	1	1	1	1	1	3	
Lifetime of Truck(s)		201	20	20	20	16	12	14	
Total Number of Trucks Needed		1	1	1	1	2	2	6	
Annualized Purchase cost	\$275,000	· · ·		25,957	25,957	34,915	37,646	107,762	19
Annual zed Labor Cost	\$22.80/hr		262	2,519	25,137	37,700	50,274	125,662	25
Ann. Fuel and Maintenance Cost	\$ <u>18</u> 85/hr	28	217	2,093	20,782	31,168	11,564	103,892	203
Total Annual Cost (\$/yr)		2,626	19,173	34,124	103,135	149,841	190,329	486,823	
Unit Cost (\$/mt)		52.53	38.35	6 82	2.05	2.00	1.90	1.95	

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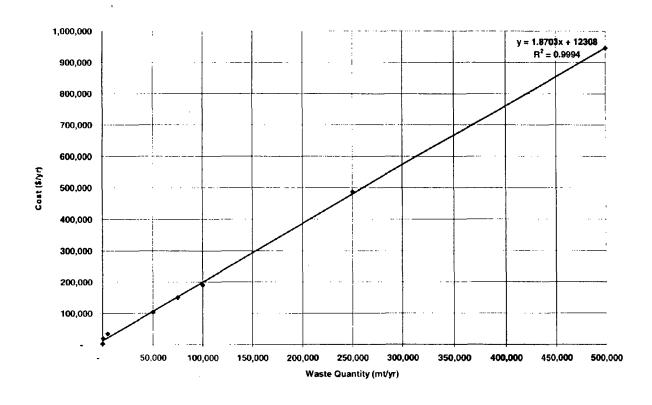
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Exhibit F-8 COST EQUATIONS FOR ON-SITE DISPOSAL OF WASTEWATERS (TO MEET NPDES STANDARDS ONLY - 1995 \$)

Capital Costs $(350 \le Q \le 350,000 \text{ mt/yr})^1 \text{Cost}(\$) = 16,777 + 75.08 \text{ Q}^5$

O&M Costs / Yr $(350 \le Q \le 350,000 \text{ mt/yr})$ Cost $(\$) = -113,989 + 19,114 \ln Q$

 1 Q = Annual quantity of waste managed (mt/yr)

F.4 Storage of Solid Materials

Storage of Solid Materials in Drums

The drum storage cost function for solids includes the capital cost of the drums, labor to open and close drums, and labor to move the drums either manually (using a handtruck) or using a pallet truck. The drum(s) would be filled by placing them under a hopper or chute, and would then be closed by a laborer. The drum would be moved to a storage area within the same area of the facility either on a handtruck (using manual labor) or on a pallet truck. Later, the drum would be moved to the point of reentry and opened. The normal feed handling equipment would be used to reinsert the material back into the process.

The Agency made the following assumptions in assembling these cost functions:

- The capital cost of a carbon steel drum is \$52 (from Non-RCRA Tanks, Containers, and Buildings, December 1996, p. 17. This price includes \$2 per drum for freight):
- 55 gallon drums have 50 gallons of usable capacity;
- The density of solid materials is the same as crushed furnace slag (85 lb/ft³);
- A laborer could close (or open) drums at the rate of 12 drums per hour;
- A laborer could move a drum from the point of generation to the storage area (or back from the storage area to the point of reentry) using a handtruck at a rate of 8 drums per hour;
- A laborer could move drums from point of generation to the storage area (or back from the storage area to the point of reentry) using a pallet truck at a rate of 32 drums per hour;
- The material to be stored is generated continuously, therefore, unless more than 90 drums are generated, the efficiencies of using a pallet truck would be lost and facilities would use manual labor to move drums rather than use the pallet truck:

- The cost of unskilled labor is \$19/hr (from CKD Monofill Model Cost Documentation, 1995):
- The cost of a small equipment operator is \$24.60/hr (Engineering News Record, 10/31/94, p. 49):
- The cost of a handtruck is \$209, and the cost of a pallet truck is \$3,020 (from Peters and Timmerhaus, 1990, updated to 1995 dollars);
- The cost of fuel and maintenance for the pallet truck is \$1.50/hr, which is estimated to be the same as the fuel and maintenance cost of a gasoline powered cart (from Means Building Construction Cost Data, 1995, p. 18);
- Once a drum had been returned to the point of reentry it would be handled by the normal processing equipment, and would not incur any further "storage" costs; and
- The upper limit of material being stored in drums is 200 mt/yr, because having more than 200 drums would both be impractical and impose opportunity costs that have not been fully accounted for (there is likely to be both a practical limit on the floor space available to store the drums, and a cost associated with using additional floor space).

The costs of storing solid materials in drums are shown in Exhibit F-9.

Storage of Solid Materials in Roll-off Containers

The roll-off container storage cost function includes the capital cost of the containers, and the rental of a truck to move full roll-offs first to the storage area and then to the point of re-entry. It also includes labor, fuel, and maintenance to operate the truck.

A roll-off container would be filled by parking it beneath a hopper or chute. It would then be driven across the site to a storage area by a truck designed to move roll off containers. The container would be "rolled off" the truck and set on the ground. Later the container would be picked up by the truck and driven back across the site to the point of re-entry and the contents dumped into a pile beside the normal feed materials, where the material would be picked up by the normal feed handling equipment.

The Agency made the following assumptions in assembling these cost functions:

- The purchase price of a 20 yd³ roll-off container is \$2670, a 30 yd³ container is \$3,045 and a 40 yd³ container is \$3,510 (from Non-RCRA Tanks, Containers, and Buildings, December, 1996, p.27);
- The cost of shipping is \$320 per container, based on a shipping cost of \$1.60 per mile and an assumed distance of 200 miles (from Non-RCRA Tanks, Containers, and Buildings, December, 1996, p.27);

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Exhibit F-9	
Annual Storage Cost Assuming Quarterly Storage of Solids in Drums	

Drum Storage Cost (Solids)	Unit Cost	A	В	c	D	E	F	G	н
Waste Quantilies (mt/yr)		0.5	4	10	50	75	100	150	_200
Waste Quantitios (mt/qtr)		0.125	1	2.5	12.5	18.75	25	37.5	50
Wasle Quantity (gal/gtr)		24.25	194 02	485.04	2425.22	3637 83	4850.44	7275.67	9700.89
Purchase of Drums									
Number of Drums per quarter		1	4	10	49	73	98	146	195
Annualized Cost of Drums	\$52/drum	4.91	19.63	49.08	240.51	358 .30	481.01	716.61	957 11
Labor to Open/Close Drums									
Number of Hours per year		0.67	2.67	6.67	32.67	48 67	65.33	97.33	130.00
Annual Labor Cost	\$19/hr	12.67	50.67	126.67	620.67	924.67	1241.33	1849.33	2470.00
Move Drums									
Ann. Handtruck Capital. Cost	\$209	19.73	19.73	19 73	0.00	0.00	0.00	0.00	0.00
Ann. pallet truck Cap. Cost	\$3020	0.00	0 00	0 00	285.06	285.06	285 06	285.06	285.06
Number of Hours - Annual		1	4	10	12 25	18.25	24.5	36.5	
Annual Labor Cost	see notes	19	76	190	301 35	448.95	602,7	897.9	1199.25
Annual Fuel and O & M Cost	\$1.50/hr	0	0	0	18.38	27.38	36.75	54.75	73 13
Total Annual Cost (\$/yr)		56.30	166.03	385.48	1465.96	2044.35	2646 85	3803.65	4984.55
Unit Cost (\$/mt)		112.60	41.51	38.55	29.32	27.26	26.47	25.36	24.92

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- The cost of a tarp is \$425 (from Non-RCRA Tanks, Containers, and Buildings, December, 1996, p.25);
- The density of solid materials is the same as crushed furnace slag (85 lb/ft²);
- It would take 2 hours to move a roll-off container from the point of generation to the storage area (or back from the storage area to the point of reentry);
- The roll-off truck must be rented in full day increments each time it is necessary to move a roll-off container;
- The cost of renting the roll-off truck is \$500/day or \$4,500/month (based on a vendor quote of \$4,500/month, and standard construction estimating practices that daily rental is a third of weekly rental, which is a third of monthly rental);
- The cost of labor to operate the roll-off truck is S22.80/hr (Engineering News Record, 10/31/94, p. 49);
- The fuel and maintenance cost of the roll-off truck is \$18.85/hr (which is the fuel and maintenance cost of a 25 ton off-road dump truck from Means, 1995); and
- Once the contents of a roll-off container had been emptied into a pile at the point of reentry they would be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing solid materials in roll-off containers are shown in Exhibit F-10.

Storage of Solid Materials in Buildings

The building storage cost function includes the capital cost of constructing a dome style building, such as those used by regional highway departments to store road chemicals. This cost function also includes rental of a dump truck to move material from the point of generation to the storage area and later to the point of re-entry, labor to operate the truck, truck fuel, and maintenance as well as the capital, operating, and maintenance costs of a front end loader to fill the truck at the storage building. The following is a brief description of how materials would be stored in buildings.

The dump truck would be filled by parking it under a hopper or chute, and would then be driven across the site to a storage building where it would dump the material onto the pad outside the entrance to the building. The front end loader would then push the material into a pile in the dome. Later the material would be picked up by a front end loader and put back into the dump truck, be driven across the site to the point of re-entry and dumped into a pile beside the normal feed materials, where it would be picked up by the normal feed handling equipment.

The Agency made the following assumptions in assembling these cost functions:

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Exhibit F-10
Annual Storage Cost Assuming Quarterly Storage of Solids in Roll-Off Containers

Rolloff Storage Cost	Unit Cost	A	в	c	D	E	F	G	н
Waste Quantities (mtyr)		50	75	100	50 0 ·	1,000	2,500	5.000	7,500
Waste Quantities (m/gt/)		2.5	19	25	125	250	625	1 250	1,875
Waste Quantity (yd:Vgtr)		-5.0	18	24	120	240	60C	1,201	1,801
Purchase of Roll-offs				·					
Number of 20 yd3 Roll-olfs		1		-	-				
Cost of Boll-offs	\$2670/R-uff	2,670	2,670	•					
Number of 30 yd3 Roll-offs			-	1	•	•	-		•
Cost of Roll-offs	\$3045/r-off		-	3,045	-	-			
Number of 30 yd3 Roll-offs			-		4	7	16	31	46
Cost of Roll-offs	\$3510/r off		-	-	14,040	24,570	56,160	108,810	161,460
lam	\$425 each	425	425	425	1,700	2,975	6,800	13,175	19,550
Shipping	\$320 Each		320	320	1,280	2,240	5,120	9,920	14,720
Annualized Cost of Roll-offs		322	322	358	1,607	2,811	6,426	12,451	18,475
Roll-off Truck									
Number of Linps - Annual		8	8	8	32	56	128	248	368
Number of Rental days		8	8	8	32	56	128	248	365
Annual Rental of Roll-off Truck	\$500/day	4,000	4,000	4,000	16,000	28,000			
Annual Bental of Boll-off Truck	\$4500/mo	0	0	0	0	0	54000	54000	54000
Number of Hours - Annual		16	16	16	64	112	256	496	736
Annual Labor Cost	\$22.80/hr	365	365	365	1,459	2,554	5,837	11,309	16,751
Ann Fuel and Maintenance Cost	\$18.85/hr	302	302	302	1,206	2,111	4,826	9,350	13,874
Total Annual Cost (\$/yr)		4,989	4,989	5,024	20,272	35,476	71,088	87,109	103,129
Unit Cost (\$/mt)		99.77	66.52	50.24	40.54	35.48	28.44	17.42	13.75

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- The capital cost of a building is based on the average price for dome buildings (see Tables 14, 15, and 16 of Non-RCRA Tanks, Containers, and Buildings, December, 1996, pp. 32-33);
- The capacity utilization of these buildings is assumed to be 80 percent, since a conveying system is not used;
- The dome will be built on an asphalt base pad that is a square with sides equal in length to the diameter of the building plus 20 feet;
- The cost of the asphalt pad is \$6.50/yd² (from Means Site Work 1994, p. 59);
- The density of solid materials is the same as crushed furnace slag (85 lb/ft³);
- The cost of purchasing a 25 short ton capacity dump truck is \$275.000. The expected lifetime of this equipment is 26,000 operating hours (vendor quote, 1996);
- The fuel and maintenance cost of the truck is \$18.85/hr (from Means, 1995);
- The cost of labor to operate the truck is \$22.80/hr (Engineering News Record, 10/31/94, p. 49);
- It would take ½ hour to drive the dump truck to the building, empty it, and return to the point of generation;
- It would take ½ hour to drive the truck back from the storage area to the point of reentry, and dump the contents on the ground;
- The cost of renting a 7.5 yd³ capacity 375 hp front end loader is \$1,400/day (from Means, 1995);
- The fuel and maintenance cost of the front end loader is \$56.15/hr (from Means, 1995):
- The cost of labor to operate the front end loader is \$26.90/hr (Engineering News Record, 10/31/94, p. 49);
- The front end loader can move 20 shovelfuls per hour;
- The front end loader must be rented for full days; and
- Once the contents of the dump truck had been emptied into a pile at the point of reentry they would be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing solid materials in buildings are shown in Exhibit F-11.

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	Annual Storage Cost Assuming Quarterly Storage of Solids in Dome Buildings									
Building Storage Cost	Unit Cost	A	<u> </u>		D	<u> </u>	F	G	н	
Waste Quantities (mt/yr)		1,380	2,048	2,660	15,800	17,952	28,448	42,072	50,704	
Waste Quantities (ml/qti)		345	5*2	665	3,950	4,488	7,112	10,518	12,691	
Waste Quantity (ft3rgtr)		8,948	13,279	17,248	102,449	116,403	184,460	272,800	329,160	
Waste Quantity (yd3/gtr)		331	492	639	3,794	4,311	6,832	10,104	12,191	
Capital Cost										
Number of Buildings		I	1	1	1	1	1	1	1	
Diameter of Building (ft)			40	50	100	100	124	150	150	
size of base pad (yd2)		400	400	544	1,600	1,600	2,304	3,211	3,211	
Asphalt Pad	6.50/yd2	2,600	2,600	3,539	10,400	10,400	14,976	20,872	20,872	
Total Cost of Building		50,500	62,500	72,000	121,000	134,000	190,000	343,000	381,500	
Annualized Cost of Building		5,012	6,145	7,130	12,403	13,630	19,318	34,346	37,980	
Dump Truck										
Number of trips - quarter		32	46	60	350	396	628	923	1,120	
Number of trips - annual		128	184	240	1,400	1,584	2,512	3,7*2	4,480	
Number of hours - annual		64	92	·20	700	792	1,256	1,855	2,24g	
Lifetime of Truck		20	20	20	20	20	20	14	12	
Annualizea Purchase cost	\$275,000	25,957	25,957	25,957	25,957	25,957	25,957	36,018	37,793	
Annual Labor Cost	\$22 80/hr	1.459	2,098	2,736	15,960	18, 058	28,637	42,317	51,072	
Ann. Fuel and Maintenance Cost	\$18.85/hr	1,206	1,734	2,262	13,195	14,929	23,676	34,985	42,224	
Front End Loader										
Number of Hours (annual)		9	.3	17	101	115	182	269	325	
Number of Days (annual)		4	4	4	12	12	20	28	36	
Annual Rental	\$1,400/day	5,600	5,600	5,600	16,800	16,800	28,000	39,200	50, 40 0	
Annual Labor Cost	\$26 90/hr	238	353	458	2,722	3,093	4,901	7,248	8,745	
Ann. Fuel and Maintenance Cost	\$ 50 15/h1	496	736	957	5,681	6,455	10,230	15,129	18,254	
Total Annual Cost (\$/yr)		39,969	42,623	45,100	92,718	98,922	140,748	209,243	246,469	
Unit Cost (\$/mt)		23 96	20.81	16.95	5.87	5.51	4.95	4.97	4.85	

Exhibit F-11

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Storage of Solid Materials in Unlined Waste Piles

The waste pile storage cost function includes land, the costs of a dump truck to move the material to the storage site and back, and a front end loader to move the material at the pile. The following is a brief description of how solid materials would be stored in waste piles.

A dump truck would be filled by parking it under a hopper or chute, and would then be driven across the site to a waste pile where it would dump the material (either on the lined site directly, or onto a conveyor system). Later, the material is picked up by a front end loader, put back into the dump truck, driven across the site to the point of re-entry, and dumped into a pile beside the normal feed materials, where it would be picked up by the normal feed handling equipment.

EPA made the following assumptions in assembling these cost functions:

- The purchase cost of land is \$2,500/acre (from CKD Monofill Model Cost Documentation, 1995);
- The cost of compacted soil is \$0.2325/ft³ (from CKD Monofill Model Cost Documentation, 1995);
- The necessary land area is determined by assuming the material is stored in a conical pile with a maximum height of 100 ft, where the height of the pile is $\frac{1}{2}$ the radius and the volume of the pile is calculated using the following formula: $V = \frac{1}{3}\pi r^{2}h$;
- The length of a side of the square plot for a single pile is the twice the radius plus a ten foot buffer zone around the edge of the pile to move equipment; therefore, the area of the pile is [2*(r+10)]²;
- The area of the square plot for multiple piles is calculated by assuming that the volume to be stored is equally divided by the number of piles, then adding the area of each individual pile with its buffer zone (to allow equipment to move between the piles);
- The density of solid materials is the same as crushed furnace slag (85 lb/ft³);
- The cost of purchasing a 25 short ton capacity dump truck is \$275,000. The expected lifetime of this equipment is 26,000 operating hours (vendor quote, 1996):
- The fuel and maintenance cost of the truck is \$18.85/hr (from Means, 1995);
- The cost of labor to operate the truck is \$22.80/hr (Engineering News Record, 10/31/94, p. 49);
- It would take ½ hour to drive the dump truck to the waste pile, empty it, and return to the point of generation;
- There is no cost associated with a conveying system at the waste pile:

- It would take ½ hour to drive the truck back from the storage area to the point of reentry, and dump the contents on the ground;
- The cost of renting a 7.5 yd³ capacity 375 hp front end loader is \$1,400/day (from Means, 1995);
- The fuel and maintenance cost of the front end loader is \$56.15/hr (from Means, 1995);
- The cost of labor to operate the front end loader is \$26.90/hr (Engineering News Record, 10/31/94, p. 49);
- The front end loader can move 20 shovelfuls per hour;
- The front end loader must be rented for full days; and
- Once the contents of the dump truck had been emptied into a pile at the point of reentry they would be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing solid materials with no free liquids in waste piles are shown in Exhibit F-12. EPA developed the costs of just the operation and maintenance costs of storing materials in unlined, unmonitored units for baseline-option combinations that induce a change of storage units from land based to non-land based units (i.e., storing sludges in the prior treatment baseline and in RCRA containment buildings in Option 1). The O & M costs of storing materials in unlined, unmonitored piles are shown in Exhibit F-13.

F.5 Storage of Liquid Materials

Storage of Liquid Materials in Drums or Mobile Mini-Bulk Tanks

Low volumes of liquid materials can be stored in either drums or mobile mini-bulk containers, which are small tanks that are designed to be moved by a pallet truck. The costs associated with storing hquid materials in drums are calculated in same manner as storing solid materials in drums, with the following exceptions:

- Liquid materials are stored for 30 days, while solid materials are stored for 90 days. Therefore, fewer drums are required;
- Because liquid materials are often corrosive, polyethylene drums and mini-bulk containers are used;
- The density of liquid materials is the same as water (62.4 lb/ft³);
- The capital cost of a 55-gallon polyethylene drum is \$127 (from Non-RCRA Tanks, Containers, and Building, December 1996, p. 17. This price includes \$2 per drum for freight);

Waste Pile - Free Liquids	Unit Cost	A	8	С	D	Ε	F	G	н
Waste Quantities (m//yr)		500	5,000	15,000	25,000	40,000	70,000	90,000	120,000
Waste Quantities (mt/gtr)		125	1,250	3,750	6,250	10,000	17,500	22,500	30,000
Waste Quantity (ft3/gtr)		3,242	32,421	97,262	162,103	259,365	453,888	583,571	778,094
Waste Quantity (yd3/qtr)		120	1,201	3,602	6,004	9,606	16,811	21,614	28,818
Unit Construction									
Unit size (ft2)		3,218	9,825	17,987	24,118	31,772	44,394	51,693	61,619
Annualized Land (\$/yr)	\$2500/acre	17	53	97	131	172	240	280	334
Unit base (compacted soil)	\$0.2325/113	71	216	395	529	697	974	1,134	1,352
Dump Truck									
Number of trips - guarter		12	112	332	552	882	1,544	1,986	2,646
Number of trips - annual		48	448	1,328	2,208	3,528	6,176	7,944	10,584
Number of hours - annual		24	224	664	1,104	1,764	3,088	3,972	5,292
Number of Original Trucks Needed		1	1	1	1	1	2	2	2
Lifetime of Truck(s)		20	20	20	20	15	17	13	10
Total Number of Trucks Needed		1		1	1	2	4	4	4
Annualized Purchase cost	\$275,000	25,957	25,957	25,957	25,957	35,533	68,529	73,324	78,617
Annualized Labor Cost	\$22.80/hr	547	5,107	15,139	25,171	40,219	70,406	90,562	120,658
Ann. Fuel and Maintenance Cost	\$18.85/hr	452	4,222	12,516	20,810	33,251	58,209	74,872	99,754
Front End Loader			·						
Number of Hours (annual)		3.20	32 02	96. 06	160.10	256.16	448.28	576.37	768.19
Number of Days (annual)		4	8	16	24	36	60	76	100
Annual Rental	\$1,400/day	5,600	11,200	22,400	33,600	50,400	84,000	106,400	140,000
Annual Labor Cost	\$26.90/hr	86	861	2,584	4,307	6,891	12,059	15,504	20,672
Ann. Fuel and Maintenance Cost	\$56.15/hr	180	1,798	5,394	8,990	14,384	25,171	32,363	43,151
Total Annual Cost (\$/yr)		32,911	49,415	84,483	119,495	181,547	319,589	394,439	504,538
Unit Cost (\$/mt)		65.82	9.88	5.63	4.78	4 54	4.57	4.38	4.20

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Exhibit F-12 Storage of Solid $\overline{}$

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Waste Pile - Free Liquids	Unit Cost	A	В	C	D	E	F	G	н
Waste Quantities (mt/yr)		500	5,000	15,000	25,000	40,000	70,000	90,000	120,000
Waste Quantities (mt/qtr)		125	1,250	3,750	6,250	10,000	17,500	22,500	30,000
Waşte Quantity (ft3/qtr)		3,242	32,421	97,262	162,103	259,365	453,888	583,571	778,094
Waste Quantity (yd3/qtr)		120	1,201	3,602	6,004	9,606	16,811	21,614	28,818
Unit Construction									
Unit size (ft?)		3,218	9,825	17,987	24,118	31,772	44,394	51,693	61,619
Annualized Land (\$/yr)	\$2500/acre								
Unit base (compacted soil)	\$0.2325/tt3								
Dump Truck									
Number of trips - guarter		12	112	332	552	882	1,544	1,986	2,646
Number of trips - annual		48	448	1,328	2,208	3,528	6,176	7,944	10,584
Number of hours - annual		24	224	664	1,104	1,764	3,088	3,972	5,292
Number of Original Trucks Needed		1	1	1	1	1	2	2	2
Lifetime of Truck(s)		20	20	20	20	15	17	13	10
Total Number of Trucks Needed		1	1	1	1	2	4	4	4
Annualized Purchase cost	\$275,000	25,957	25,957	25,957	25,957	35,533	68,529	73,324	78,617
Annualized Labor Cost	\$22.80/hr	547	5,107	15,139	25,171	40,219	70,406	90,562	120,658
Ann. Fuel and Maintenance Cost	\$18.85/hr	452	4,222	12,516	2 0,8 10	33,251	58,209	74,872	99,754
Front End Loader									·
Number of Hours (annuai)		3.20	32 02	96.06	160 .10	256.16	448.28	576.37	768.49
Number of Days (annual)		4	8	16	24	36	.60	76	100
Annual Rental	\$1,400/day	5,600	11,200	22,400	33,600	50,400	84,000	106,400	140,0 00
Annual Labor Cost	\$26.90/hr	86	861	2,584	4,307	6,891	12,059	15,504	20,672
Ann. Fuel and Maintenance Cost	\$56.15/hr	180	1,798	5,394	8,990	14,384	25,171	32,363	43,151
Total Annual Cost (S/yr)		32,823	49,146	83,991	118,835	180,678	318,374	393,025	502,852
Unit Cost (S/mt)		65.65	9.83	5.60	4.75	4.52	4.55	4.37	4.19

Exhibit F-13 Annual Storage Cost (O & M only) Assuming Quarterly Storage of Solids in Unlined, Unmonitored Waste Piles

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- F-32
- The capital cost of a 220-gallon polyethylene mini-bulk tank is \$285 (from Non-RCRA Tanks, Containers, and Building, December 1996, Appendix D); and
- A laborer could move mini-bulks from point of generation to the storage area (or back from the storage area to the point of reentry) using a pallet truck at a rate of 4 tanks per hour:

The costs of storing liquid materials in drums and mobile mini-bulk tanks are shown in Exhibit F-14.

Storage of Liquid Materials in Tanks

The tank storage cost function includes the capital cost of the tanks, as well as piping to move the liquids from the point of generation to the storage area and then back to the point of re-entry. Liquid materials would be piped from the point of generation to storage tanks. Prior to reuse, these materials would be piped back through the same pipes to the point of re-entry, where they would be handled by the normal feed dispersing equipment.

The Agency made the following assumptions in assembling the tank storage cost function:

- Liquids are stored for a maximum of 30 days;
- The density of liquid materials is the same as water (62.4 lb/ft³);
- Tank capital and O & M costs were developed following the method used by DPRA for the "Organic Dyes and Pigments Waste Listings Document," 1995, and include the minimal plumbing associated with the tank only:
- For tanks with a capacity of or less than 25,000 gallons, the base capital cost was updated using the price of a single walled vertical tank (from Non-RCRA Tanks, Containers, and Building, December 1996, p. 22.)
- For tanks greater than 25,000 gallons EPA used the cost from the "Organic Dyes and Pigments Waste Listings Document" (these costs were adjusted to use the correct discount rate and retention time);
- The distance from the point of generation to the storage tank, and from the storage tank back to the point of reentry are a function of the amount of material to be stored. Small volumes of liquid material to be stored do not require additional piping, while large volumes of material to be stored will need to be piped to storage areas further away;
- There is no cost associated with pumping the material to and from the tank; and
- Once the liquid has been returned to the point of reentry it will be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing liquid materials in tanks are shown in Exhibit F-15.

Drum Storage Cost (liquids)	Unit Cost	A	В	С	D	E	F	G	н
Waste Quantities (mt/yr)		0.5	10	50	75	100	150	200	_250
Waste Quantities (mt/mo)		0.042	0.833	4.167	6.250	8.333	12.500	16.667	20.833
Waste Quantity (gal/mo)		11.01	220.24	1101.20	1651.79	2202.39	3303.59	4404.78	5505.98
Purchase of Drums	· · · · · · · · · · · · · · · · · · ·								
Number of Drums		1	5	0		0	0	0	. с
Annualized Cost of Drums	\$127/drum	127.00	635.00	0 00	0.00	0.00	0.00	0.00	0.00
Number of 220-gallon Mini-bulks		0	0	6		11	16	21	26
Cost of Mini-bulk	\$285/tank	0.00	0.00	1881.00	2508.00	3448.50	5016.00	6583.50	81 <u>51.</u> 00
Annualized Capital Cost		11.99	59.94	177.55	236.73	325.50	473.46	<u>621.42</u>	769.37
Labor to Open/Close Drums									
Number of Hours per year		2	10	•	-	-			-
Annual Labor Cost	\$19/hr	38	190			· ·		<u> </u>	•
Move Drums									
Ann. Handtruck Capital. Cost	\$209	19.73	19.73	0.00	0.00	0.00	0.00	0.00	0.00
Ann. Pallet Truck Cap. Cost	\$3020	0	0	285 -	285	285	285	285	285
Number of Hours - Annual		1	5	12	16	22	32	42	52
Annual Labor Cost	\$19/hr	19	95	228	304	418	608	798	988
Ann. Fuel and Maintenance Cost	<u>\$1.5/hr</u>	0	0	18		33	48	63	78
Total Annual Cost (\$/yr)		88.72	364.67	708.61	849.79	1061.56	1414.52	1767.47	2120.43
Unit Cost (\$/mt)		177.43	36.47	14.17	11.33	10.62	9.43	8.84	8.48

Exhibit F-14 Annual Storage Cost Assuming 30 Day Storage of Liquids in Drum and Mini-Bulks

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Tank Storage Cost (Liquids) Unit (Cost A	В	C	D	E	F
Waste Quantities (mt/yr)	45.4	227.0	1,135.1	22,702.6	90,810.4	181,620.7
Waste Quantity (gal/yr)	12,000	60,000	300,000	6,000,000	24,000,000	48,000,000
Waste Quantity (gal/mo)	1,000	5,000	25,000	500,000	2,000,000	4,000,000
Waste Flow rate (gal/day)	33	167	833	16,667	66,667	133,333
Purchase of Tanks						
Number of Tanks	1	1	1	1	1	1
Cap. Cost of Double Walled Tanks	1,246	3,466	9,405			
Freight and Installation	374	1,040	2,822			
Indirect Capital	518	1,442	3,912			
Annualized Cost of Tanks	202	561	1,523	9,318	23,897	40,604
Annual O & M	141	393	1,065	6,515	16,710	28,392
Piping						
Length of additional pipe (ft)		-		500	1,000	1,000
Piping - Annualized Capital		•	-	425	821	821
Piping - Annual O & M			-	1,000	<u>1,</u> 000	1,000
Total Annual Cost (\$/yr)	343	954	2,589	17,258	42.428	70,817
Unit Cost (\$/mt)	7.55	4.20	2.28	0.76	0.47	0.39

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Exhibit F-15
Annual Storage Cost Assuming 30 Day Storage of Liquids in Tanks

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Storage of Liquid Materials in Unlined Surface Impoundments

The surface impoundment storage cost function includes the capital cost of land, site preparation, a liner, and piping of liquids to the surface impoundment. Liquid materials would be piped from the point of generation to the surface impoundment. When these materials are going to be reused they would be piped back through the same pipes to the point of reentry, where they would be handled by the normal feed equipment.

The Agency made the following assumptions in assembling the surface impoundment storage cost function:

- Liquid materials are stored for a maximum of 30 days;
- The density of liquid materials is the same as water (62.4 lb/ft²);
- The purchase cost of land is \$2500/acre (from CKD Monofill Model Cost Documentation, 1995);
- The cost of excavation is \$0.1077/ft³ (from CKD Monofill Model Cost Documentation, 1995);
- The area of the surface impoundment is calculated using the formulas described in section D.7 of the April 15, 1997 RIA;
- The distance from the point of generation to the surface impoundment, and from the surface impoundment back to the point of reentry, are a function of the amount of material to be stored, but the minimum distance is 500 feet. Larger quantities of material to be stored will need to be piped 1000 feet away:
- There is no cost associated with pumping the material to and from the surface impoundment; and
- Once the liquid has been returned to the point of reentry it will be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing liquid materials in unlined surface impoundments without groundwater monitoring are shown in Exhibit F-16. In addition, EPA developed the costs of just the operation and maintenance costs of storing materials in unlined, unmonitored units for baseline-option combinations that induce a change of storage units from land based to non-land based units (i.e., storing by-products in the prior treatment baseline and in RCRA tanks in Option 1). The O & M costs of storing materials in unlined, unmonitored surface impoundments are shown in Exhibit F-17.

Storage of Liquid Materials in Seven Day Surge Tank

The costs of storing liquid materials in a seven day surge tank are shown in Exhibit F-18 These costs are similar to the costs of storing liquid materials in a 30 day accumulation tank with one notable exception, the length of storage is seven days rather than 30.

F.6 Curve Fit Cost Functions

The Agency plotted and curve fit each set of cost results (from Exhibits F-9 through F-18) to transform the costs into cost functions. Exhibit F-19 presents these curve fit storage and disposal cost functions, along with the range for which these cost equations are valid. EPA determined the break-even points between the relevant storage methods for each Baseline or Option. Exhibit F-19 also presents the optimum management ranges allowed under each baseline and option. Cells in this exhibit which have been blacked out under a particular option or baseline are unallowable management methods. Finally, Exhibits F-20 through F-28 present graphs of the individual cost for our sample waste generation rates along with the resulting curve fit cost functions.

F-36

	age Cost Assu	ining .vi D	ay storage	or Enquites	in Omneu, c	mionitoreu	Surface impo	unuments	
Surface Impoundment	Unit Cost	<u>A</u>	8	C	D	E	F	G	<u> </u>
Waste Quantities (mt/yr)		5C0	5,000	25,000	50,000	100,000	500,000	1,000,000	2,000,000
Waste Quantities (mt/mo)		42	417	2,083	4,167	8,333	41,667	83,333	166,667
Waste Quantity (ft3/mo)		1,472	14,721	73,604	147,209	294,418	1,4/2,089	2,944,177	5,888,355
Waste Quantity (gal/mo)		11,012	110,120	550,598	1,101,196	2,202,392	11,011,959	22,023,919	44,047,837
Waste Quantity (gal/day)		367	3,671	18,353	36,707	73,413	367,065	734,131	1,468,261
Unit Construction									
Unit size (ft2)		4,061	6,410	15,688	26,478	47,192	204,364	395,890	774,557
Unit size (acres)		0.09	0.15	0.36	0.61	1.08	4.69	9.09	17.78
Annualized Land (\$/yr)	\$2500/acre	22	35	85	143	256	1,107	2,145	4,196
Annualized Excavation	\$0 17077/ft3	24	237	1,186	2,373	4 ,746	23,729	47,457	94,914
Material Handling									
Distance to Unit (ft)		500	500	500	500	1,000	1,000	1,000	1,000
Piping - annualized capital		425	425	425	425	821	985	1,120	1,390
Piping - annual O & M		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total Annual Cost (\$/yr)		1,470	1,697	2,696	3,941	6,823	26,820	51,722	101,500
Unit Cost (\$/mt)		2. 9 4	0.34	0.11	0.08	0.07	0.05	0.05	0.05

Exhibit F-16 Annual Storage Cost Assuming 30 Day Storage of Liquids in Unlined, Unmonitored Surface Impoundments

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Exhibit F-17
Annual Storage Cost (O & M only) Assuming 30 Day Storage of Liquids in Unlined, Unmonitored Surface Impoundment

Surface Impoundment	Unit Cost	Α	В	С	D	E	F	G	Н
Waste Quantities (mt/yr)		500	5,000	25,000	50,000	100,000	500,000	1,000,000	2,000,000
Waste Quantities (mt/mo)		42	417	2,083	4,167	8,333	41,667	83,333	166,667
Waste Quantity (ft3/mo)		1,472	14,721	/3,604	147,209	294,418	1,472,089	2,944,177	5,888,355
Waste Quantity (gal/mo)		11,012	110,120	550,598	1,101,196	2,202,392	11,011,959	22,023,919	44,047,837
Waste Quantity (gal/day)		367	3,671	18,353	36,707	73,413	367,065	7 34 ,131	1,468,261
Unit Construction			1						
Unit size (ft2)		4,061	6,410	15,688	26,478	47,192	204,364	395,890	774,557
Unit size (acres)		0.09	0.15	0.36	0.61	1.08	4.69	9.09	17.78
Annualized Land (\$/yr)	\$2500/acre						_		
Annualized Excavation	\$0.17077/ft3								
Material Handling									
Distance to Unit (ft)		500	500	500	500	1,000	1,000	1,000	1,000
Piping - annualized capital									
Piping - annual O & M		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total Annual Cost (\$/yr)		1,000	1.000	1,000	- 1,000	1,000	1,000	1,000	1,000
Unit Cost (\$/mt)		2.00	0.20	0.04	0.02	0.01	0.00	0.00	0.00

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Tank Storage Cost (Liquids)	Unit Cost	Α	B	С	D	E	F
Waste Quantities (mt/yr)		197	<u>9</u> 84	4,919	98,378	393,512	787,023
Waste Quantity (gal/yr)		52,000	260,000	1,300,000	26,000,000	104,000,000	208,000,000
Waste Quantity (gal/week)		1,000	5,000	25,000	500,000	2,000,000	4,000,000
Waste Flow rate (gal/day)		143	714	3,571	71,429	285,714	571,429
Purchase of Tanks							
Number of Tanks		1	1	1	1	1	1
Annualized Cost of Tanks		796	1,892	3,307	9,318	23,897	40,604
Annual O & M		556	1,323	2,313	6,515	16,710	28,392
Piping							
Length of additional pipe (ft)		-	_	-	500	1,000	1,000
Piping - Annualized Capital		•	•	-	425	821	821
Piping - Annual O & M				-	1,000	1,000	1,000
Total Annual Cost (\$/yr)		1,352	3,215	5,620	17,258	42,428	70,817
Unit Cost (\$/mt)		6.87	3.27	1.14	0.18	0.11	0.09

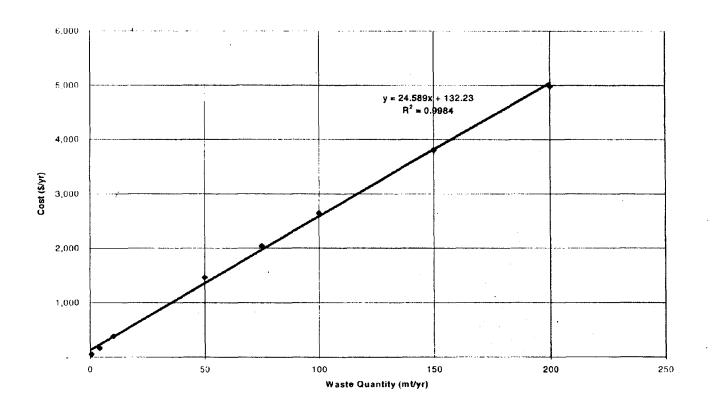
Exhibit F-18	
Annual Storage Cost Assuming 7 Day Storage of Liquids in Surge Tank	

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Relevant Ranges of Use for Curve Fit Cost Functions							
Solids	Equation	Range	NPT, MPT	PT SL/BP	PT SM	Opt. 1	Opt. 2
Drums - solid	y = 24.589x + 132.23	0.5 -200	0 - 200	0 - 200	0 - 200	0 - 200	0 - 200
Roll-off	y = - 0.0022x^2 + 29.272x +4840.9	50-7500	200 - 935	200 - 935	200 - 1343.1	200 - 1343.1	200 - 935
Building	y = 0.00002x^2 + 3.2395x + 35800	1300 - 51000			1343.1 ++	1343.1 ++	
Unlined Pile	y = 4.0335x + 26522	500 - 120,000	935 ++	935 + +			935 ++
Unlined Pile - O \$ M	y = 4.0207x + 26271	500 - 120,000	935 ++	935 ++			
Disposal Pile	y = 1.8703x + 12308	50 - 500000			<u></u>		
Liquids							
Drum	y = -0.0074x^2+9.4798x+189.34	0.5 - 250	0-220	0-220	0-220	0-220	0-220
Tanks	y = -9e 7x^2 + 0.55x + 1795.7	45 - 200000	220-500	220-500	220++,	220 - 1 millior	220-500
Unlined SI	y = 0.05x + 1565.9	500 - 2000000	500++_	500++			500++
Unlined SI (O & M)	y = 1000	500 - 2000000	500++	500++			500++

Exhibit F-19	
Relevant Ranges of Use for Curve Fit	Cost Functions

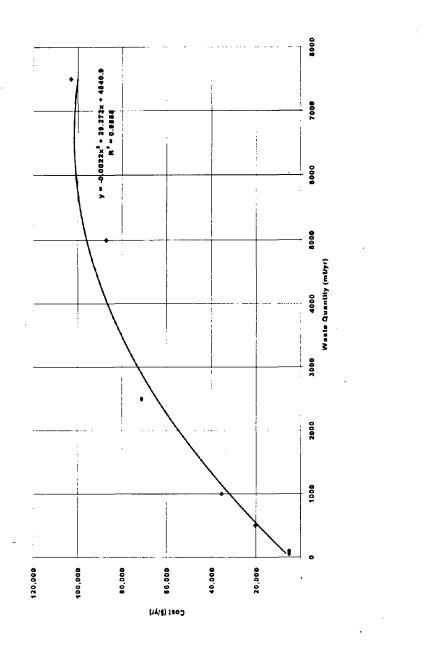




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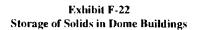


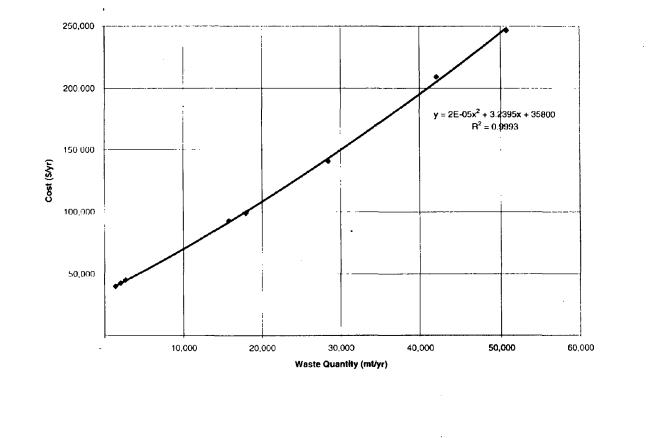


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Exhibit F-21 Storage of Solids in Roll-off

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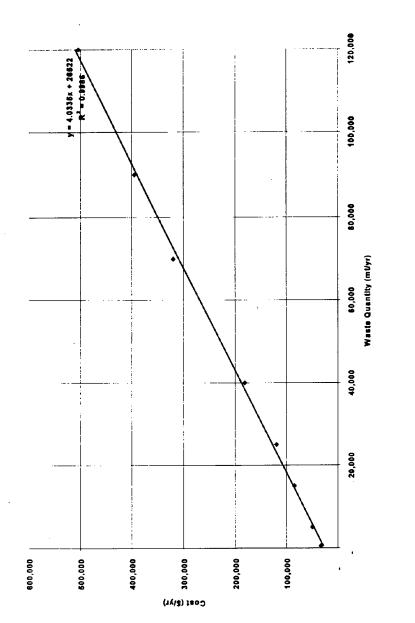


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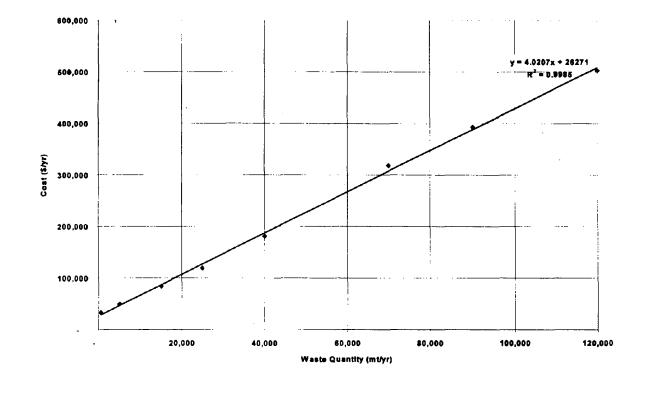


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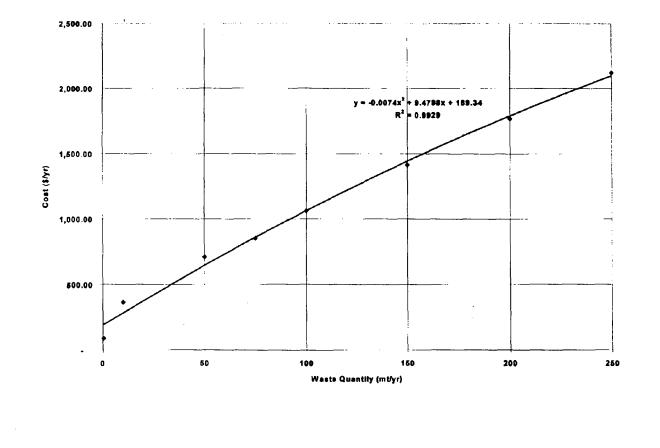




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Storage of Liquids in Drums/Mini-Bulks





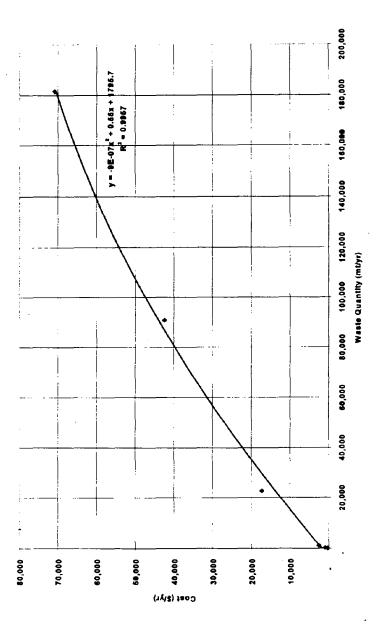
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Exhibit F-26

Storage in Tanks



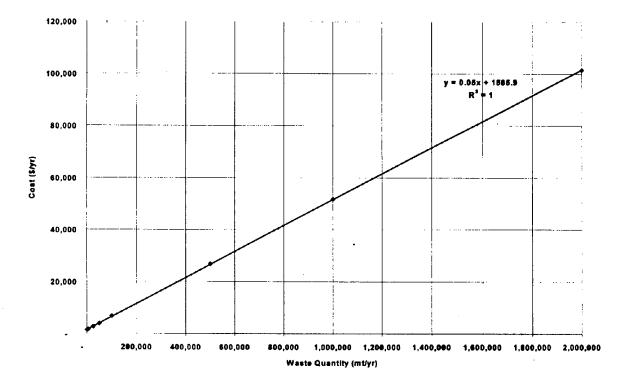
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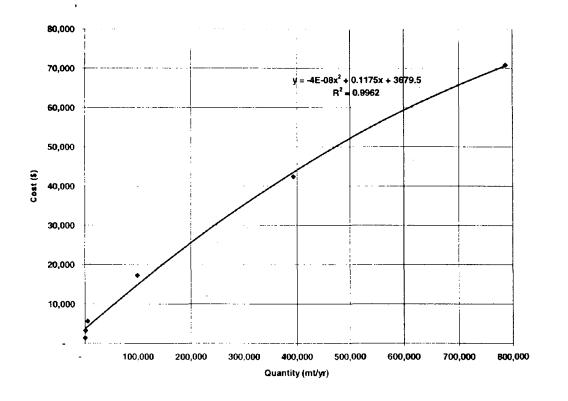
Storage of Liquids in Unlined Impoundments



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Exhibit F-28 Storage of Liquids in Seven Day Accumulation Tank



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EXPLANATION OF COST MODELING CALCULATIONS

APPENDIX G

This appendix describes the cost modeling assumptions and procedure used by EPA in developing cost estimates supporting the final RCRA Phase IV Land Disposal Restrictions (LDR) cost and economic impact analyses for mineral processing wastes. EPA performed the cost modeling was performed in six steps. First, EPA manipulated the input data to determine the portion of each waste stream that is considered to be hazardous. Second, EPA divided the hazardous portion of each waste stream into a portion of material sent to treatment and disposal, and a portion stored prior to recycling. Third, EPA used these portions of material to determine the average facility and total sector costs associated with treatment and disposal. In the fourth step, EPA calculated the average facility and total sector. Finally, the costs attributable to this rule were calculated by subtracting the cost of the baseline from the cost of each regulatory option. Appendix H presents a detailed example of the cost model calculations for the titanium and titanium dioxide sector.

Determine Portion of Waste Stream Considered to Be Hazardous

To account for the uncertainty in the data caused by the lack of documented information on both waste characteristics and recyclability. EPA developed a range consisting of minimum, expected, and maximum value estimates of waste volumes potentially affected by the various options. Then EPA weighted these volume estimates for each waste stream to account for the degree of certainty that the particular waste stream exhibited one or more of the RCRA hazardous waste characteristics.

As shown below in Exhibit G-1, EPA used a matrix to account for the uncertainty in waste characterization. Each waste stream was assigned a multiplier in each costing scenario (i.e., minimum, expected, and maximum) based on the whether the waste stream was known to be hazardous (Y) or only suspected to be hazardous (Y?). Therefore, in the expected value case, if a waste stream was only suspected to be hazardous, only half of it was counted in the analysis and the rest was assumed to be non-hazardous. In the minimum value scenario, the stream would drop out of the analysis, and in the maximum value case the entire stream would be analyzed as if it was known to be hazardous.

Determine Portion of Waste Stream Sent to Treatment and Disposal and the Amount Recycled

EPA also used a set of matrices to divide the hazardous portion of each waste stream into a component sent to treatment and disposal and a component stored prior to recycling. EPA used the tables in Exhibits G-2 and G-3 to determine each of these portions for the appropriate baseline or option. For example, in the modified prior treatment baseline, 15 percent of the hazardous portion of a waste believed to be fully recyclable (Y?) is assumed to be sent to treatment and disposal while 85 percent of the hazardous portion is assumed to require storage prior to recycling.

	Exhibit G-1	
Portion of Waste Stream	Considered	to Be Hazardous (Percent)

	Hazard Characteristic(s)					
Costing Scenario	Y	Y?				
Minimum	100	0				
Expected	100	50				
Maximum	100	100				

where:

Y means that EPA has data **demonstrating** that the waste exhibits one or more of the RCRA hazardous waste characteristics; and

Y? means that EPA, hased on professional judgment, believes that the waste may exhibit one or more of the RCRA hazardous waste characteristics.

Exhibit G-2						
Proportions of Waste Streams Treated and Disposed						
(in percent)						

Baseline or Option	Percent Recycled Certainty of Recycling						
	Y	Y?	YS	YS?	N		
Prior Treatment (SL/BP)	0	15	25	80	100		
Prior Treatment (SM)	0	25	35	85	100		
Modified Prior Treatment	0	15	25	80	100		
No Prior Treatment	0	100	60	100	100		
Option 1 from PT	0	25	35	85	100		
Option 2 from PT	0	15	25	80	100		
Option 1 from MPT	0	25	35	85	100		
Option 2 from MPT	0	15	25	80	100		
Option 1 from NPT	0	30	40	85	:00		
Option 2 from NPT	0	15	25	80	100		

Notes:

Y means that EPA has information indicating that the waste stream is fully recycled.

Y? means that EPA, based on professional judgment, believes that the waste stream could be fully recycled. YS means that EPA has information indicating that a portion of the waste stream is fully recycled.

YS? means that EPA, based on professional judgment, believes that a portion of the waste stream could be fully recycled.

PT -- Prior Treatment Baseline

MPT -- Modified Prior Treatment Baseline

NPT -- No Prior Treatment Baseline

SL -- RCRA Sludge

BP -- RCRA By-Product

SM -- RCRA Spent Material

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Baseline or Option	Percent Recycled						
	Certainty of Recycling						
	Y	<u>Y?</u>	YS	Y <u>S?</u>	<u>N</u>		
Prior Treatment (SL/BP)	100	85	75	20	0		
Prior Treatment (SM)	100	75	65	15	0		
Modified Prior Treatment	100	85	75	20	0		
No Prior Treatment	100	0	40	0	0		
Option 1 from PT	100	75	65	15	0		
Option 2 from PT	100	85	75	20	0		
Option 1 from MPT	100	75	65	15	0		
Option 2 from MPT	100	85	75	20	0		
Option 1 from NPT	100	70	60	10	0		

Exhibit G-3 Proportions of Waste Streams Stored Prior to Recycling (in percent)

Notes:

Option 2 from NPT

Y means that EPA has information indicating that the waste stream is fully recycled.

100

Y? means that EPA, based on professional judgment, believes that the waste stream could be fully recycled. YS means that EPA has information indicating that a portion of the waste stream is fully recycled.

85

YS? means that EPA, based on professional judgment, believes that a portion of the waste stream could be fully recycled:

75

20

0

PT -- Prior Treatment Baseline

MPT -- Modified Prior Treatment Baseline

NPT -- No Prior Treatment Baseline

SL -- RCRA Sludge

- BP -- RCRA By-Product
- SM -- RCRA Spent Material

Calculate Treatment Cost

"Model facility" generation rates of each type of waste sent to treatment (i.e., wastewaters, wastes with 1 to 10 percent solids, and wastes with more than 10 percent solids) were computed in each sector by summing the total sector quantities of each waste type sent to treatment and dividing by the maximum number of affected facilities in each costing scenario. These data can be found in the input data tables of the Cost Model. These "model facility" generation rates of each type of waste were used to first determine whether wastes would be treated on- or off-site and then to determine the cost associated with their treatment. EPA assumed that the most efficient means of treating a number of waste streams was to commingle these streams and build a single treatment facility on-site. This treatment system would sequentially treat each type of waste by first neutralizing liquid streams (wastewaters and wastes with 1 to 10 percent solids), precipitating the metals in these liquid streams, dewatering the residue from precipitation, stabilizing both the residue from dewatering and any solid wastes, and disposing of the stabilized mass. As indicated, each step in the process would generate a residue requiring further treatment or disposal. Therefore, EPA calculated the total quantity requiring neutralization and precipitation (100 percent of the liquid streams), the quantity being dewatered (15 percent of liquid streams), the quantity

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being stabilized (15 percent of the quantity being dewatered, which equals 2.25 percent of the total quantity of liquid streams, plus 100 percent of solid streams), and the quantity being disposed (146 percent of the quantity being stabilized, which equals 3.29 percent of the total quantity of liquid streams, plus 146 percent of the total quantity of solid streams). If the quantity requiring neutralization was below 350 mt/yr, EPA assumed that the waste would be sent off-site for treatment. If the quantity requiring stabilization was below 3,163 mt/yr, EPA assumed that the waste would be sent off-site for treatment and disposal. These quantities represent economic break-even points for on-site and off-site application of each management practice.

EPA then applied these estimated quantities to the treatment and disposal costing functions described in Appendix F to estimate "model facility" treatment costs for each baseline and option. The model facility cost was then multiplied by the maximum number of affected facilities in each sector, to determine the total sector cost. EPA calculated the incremental total sector treatment and disposal cost by subtracting the total sector baseline treatment and disposal cost from the total sector post-rule treatment and disposal cost.

Calculate Recycling Costs

Recycling costs are specific to each waste stream, based on the assumption that it is important not to commingle materials prior to reclamation. Quantities of individual streams destined for recovery were therefore not totaled.

EPA assumed that the only costs associated with recycling wastes are the costs of constructing and operating storage units. For each waste stream, EPA used the quantity (proportion) of each waste stream that is recycled to calculate storage costs for the three baselines and three options. EPA then multiplied the average facility recycling cost by the number of facilities generating that waste stream to calculate the total sector cost for each waste stream. The total sector costs were then added for each waste stream to determine the total sector recycling cost in each baseline and post-rule option. EPA then calculated the incremental total sector storage costs by subtracting the total sector baseline recycling storage costs from the total sector post-rule option recycling storage costs.

Calculate Administrative Costs

Administrative costs also are specific to each waste stream. For each waste that is known <u>not</u> to be recycled (N recycling status) and therefore requires treatment and disposal, there is a one-time cost of \$935 to develop a waste analysis plan, and an annual testing cost of \$470. For each waste that is known to be fully recycled (Y recycling status), there is a one-time notification cost of \$100.¹ Wastes that are partially recycled and partially treated/disposed (Y?, YS, and YS? recycling status) incur all three administrative costs. Note that in the minimum value case, wastes with Y? hazard certainty are assumed to not be hazardous. Therefore, in the minimum value case, wastes with Y? hazard certainty do not incur any administrative costs. EPA calculated a total administrative cost for each waste stream. Administrative costs for all waste streams in the sector were then summed to obtain a total sector administrative cost.

¹Costs derived from Supporting Statement for EPA Information Collection Request 1442.15 Land Disposal Restrictions - Phase IV: Treatment Standards for Wastes from Toxicity Characteristic Metals, Mineral Processing Secondary Materials, and the Exclusion of Recycled Wood Preserving Wastewaters, April 1998.

Calculate Total Sector Costs and Impacts

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Finally, EPA calculated the total sector costs by adding the total sector incremental treatment and disposal costs, total sector incremental recycling costs, and total sector administrative costs. EPA divided this total sector cost by the number of facilities to determine the average facility cost. EPA then divided the total sector costs by the value of shipments to determine the screening-level economic impact estimates in each sector.

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MINERAL PROCESSING COST MODEL EXAMPLE CALCULATION: TITANIUM AND TITANIUM DIOXIDE SECTOR APPENDIX H

This appendix presents a stepwise example of how the mineral processing cost model calculates the cost of this rulemaking for Option 1 assuming the Modified Prior Treatment baseline for the sector producing titanium and titanium dioxide.¹ The intermediate quantities and cost results presented in this appendix are calculated using the same methodology as used by the cost model. *These quantities and results differ slightly from those found in the cost model printouts due to rounding.*

The appendix is divided into six sections, each of which describes one important facet of the data or calculations used in the cost model. The first section reviews the input data required for cost calculations. The second section shows how the input data are manipulated for use in later cost calculations. The third section presents calculations of treatment costs. The fourth section presents calculations of storage costs. The fifth section presents calculations of administrative costs. Finally, in the sixth section, the incremental treatment and storage costs are combined, along with administrative costs, to obtain the total incremental sector cost.

H.1. Review of Input Data

This section reviews the five types of input data used to calculate the cost of this rulemaking to the titanium and titanium dioxide mineral processing sector:

- 1. Waste stream generation rates;
- 2. Hazardous characteristics;
- 3. Certainty of recycling;
- 4. Physical form (i.e. wastewater, waste with 1 to 10 percent solids, or solid); and
- 5. Former regulatory classification (i.e., by-product, spent material, or sludge).

These data are used to calculate sector costs as described in later sections of this appendix.

H.1.1 Waste Stream Generation Rate and Number of Waste-Generating Facilities

The titanium and titanium dioxide mineral processing sector generates eight waste streams. Exhibit H-1 shows the number of waste generating facilities and the total sector waste stream generation rates for each of these eight waste streams. The number of facilities generating each waste stream varies, ranging from one facility producing scrap milling scrubber water to seven facilities generating waste water treatment plant (WWTP) sludges or solids. EPA obtained data on the generation rate for two of the eight streams (spent surface impoundment solids and WWTP sludges or solids). For the six waste streams for which data were unavailable, EPA estimated a minimum generation rate, an expected generation rate, and a maximum generation rate.

¹ For the purpose of simplicity, this section only describes calculations for the Modified Prior Treatment baseline and Option 1. Calculations for all of the other baselines and the other option follow the same pattern as described below.

Titanium Waste Stream	Number of Facilities	Estimated or Reported Generation (mt/yr)				
	Facilities	Minimum	Expected	Maximum		
Pickle Liquor and Wash Water	3	2,200	2,700	3,200		
Scrap Milling Scrubber Water	1	4,000	5.000	6,000		
Smut from Mg Recovery	2	100	22,000	45,000		
Leach Liquor and Sponge Wash Water	2	380,000	480,000	580,000		
Spent Surface Impoundment Liquids	7	630	3,400	6,700		
Spent Surface Impoundment Solids	7	36,000	36,000	36,000		
Waste Acids (Sulfate Process)	2	200	39,000	77,000		
WWTP Sludges/Solids	7	420,000	420,000	420,000		

Exhibit H-1 Waste Stream Generation Rates

H.1.2 Hazardous Characteristics

Each waste stream in the data set is known or suspected to be hazardous for at least one of the four RCRA hazard characteristics:

- Toxicity (i.e., containing one or more of the eight TC metals);
- Corrosivity;
- Ignitability; and
- Reactivity.

Exhibit H-2 summarizes the status of each of the eight waste streams for the four hazardous characteristic categories, as well as each stream's overall hazard certainty. Three of the waste streams in the sector are known to be hazardous for at least one of the characteristics, as indicated in the far right column by a "Y" (yes) overall hazard certainty classification. The other five streams in the sector are only suspected to be hazardous and are assigned a "Y?" hazard certainty classification in the far right column. For example, leach liquor and sponge wash water is known to be hazardous because it is corrosive, even though the stream is only suspected to be hazardous for chromium and lead, and is not believed to be ignitable or reactive.

Exhibit H-2
Hazardous Characteristics

Titanium		TC Metals					Соп	Turnia	Rety	Overall		
Waste Stream	As	Ba	Cd	Cr	Pb	Hg	Sc	Ag	Con	Ignit	Retv	Haz?
Pickle Liquor and Wash Water			Y ?	Y ?	¥?				Y?	N?	N?	Y?
Scrap Milling Scrubber Water	T	—	Y?	Y ?	Y?		Y ?		N?	N?	N?	Y?
Smut from Mg Recovery	T		1						N?	N?	Y	Y
Leach Liquor and Sponge Wash Water			1	¥?	¥?				Ŷ	N?	N?	Y
Spent Surface Impoundment Liquids	T^{-}			Υ?	Y ?				N?	N?	N?	Y?
Spent Surface Impoundment Solids				Y ?	Y?				N ²	N?	N?	Y?
Waste Acids (Sulfate Process)	Y		Γ	Y			Ŷ	Y	Y	N	N	Y
WWTP Sludges/Solids				Y ?					N	N	N	Y?

Y = known to be hazardous, Y? = suspected to be hazardous

H.1.3 Recycling Status, RCRA Waste Type, and Waste Treatment Type

H-3

Exhibit H-3 depicts the recycling status, RCRA waste type, and physical form of each of the waste streams in the titanium sector. Of the eight waste streams in the sector, none are assigned a "Y" (yes) in Exhibit H-3 because none are known to be fully recycled. Two are believed to be fully recycled (Y?). None are assigned a "YS" (yes sometimes) because none are known to be partially recycled, but three are believed to be partially recycled (YS?). Three are assigned "N" (no) because they are known not to be recycled at all (N). Of the five streams that are recycled in some capacity, three were formerly classified as spent materials, one as a by-product, and one as a sludge. Five of the waste streams in the sector are wastewaters, and three waste streams are solids.

Titanium Waste Stream	Recycling Status	Former RCRA Waste Type	Physical Form
Pickle Liquor and Wash Water	YS?	Spent Mat'l	Wastewater
Scrap Milling Scrubber Water	YS?	Sludge	Wastewater
Smut from Mg Recovery	Y?	By-Product	Solid
Leach Liquor and Sponge Wash Water	YS?	Spent Mat'l	Wastewater
Spent Surface Impoundment Liquids	Y?	Spent Mat'l	Wastewater
Spent Surface Impoundment Solids	N	NA	Solid
Waste Acids (Sulfate Process)	N	NA	Wastewater
WWTP Sludges/Solids	N	NA	Solid

Exhibit H-3 Recycling Status

H.2. Manipulation of Input Data

This section shows how input data described in the previous section are manipulated so that treatment and storage costs can be calculated. The model combines uncertainty about hazard characteristics with uncertainty in generation rates to create a hounded cost analysis, i.e., an expected value case with minimum and maximum value cases providing estimated lower- and upper-bound costs. This section of the appendix helps set the stage for later calculation of expected value costs, upper bound costs, and lower bound costs by calculating the quantity of each waste stream that must be treated and disposed versus recycled in the expected value case, the upper bound case, and the lower bound case.

Manipulation of input data occurs in four steps which are listed here and described in detail later in this section:

- 1) The estimated or reported generation rate for each of the eight waste streams (from Exhibit H-1) is divided into a hazardous component and a non-hazardous component;
- 2) The hazardous portion of each waste stream is divided into a component that is treated and disposed, and a component that is stored prior to recycling:
- 3) "Model facility" totals are calculated for the treated and disposed waste; and
- 4) Average facility quantities are calculated for waste stored prior to recycling.

There is a critical difference between "model facility" totals for treated and disposed waste and average facility quantities for waste stored prior to recycling. "Model facility" totals, which are used to model treatment of all waste streams in a sector in a single treatment system at each facility, are calculated on a sector basis. In contrast, average facility quantities, which are used to calculate storage costs of individual waste streams that must not be commingled, are calculated on an individual waste stream basis.

H.2.1 Estimate Waste Stream Portion Assumed to be Hazardous

As indicated in Exhibit H-2 above, five of the waste streams in the titanium and titanium dioxide mineral processing sector are only suspected to be hazardous (Y?). To apportion this uncertainty over the minimum, expected, and maximum value cases, we multiply the overall waste stream generation rates (minimum, expected, and maximum) for each of the eight waste streams from Exhibit H-1 by the following percentages in Exhibit H-4, to calculate the minimum, expected, and maximum quantities of the waste stream estimated to be both generated and hazardous:

Costing Scenario	Hazard Certainty				
-	Y?	Y			
Minimum	()%	100%			
Expected	50%	100%			
Maximum	100%	100%			

Exhibit H-4 Hazard Certainty Multipliers

The resulting quantities of waste estimated to be hazardous for each waste stream in the titanium and titanium dioxide sector are shown in Exhibit H-5. The effect of this procedure is to bound the analysis, which is especially important for the five streams that are only suspected to be hazardous. For example, the quantity of pickle liquor and wash water (Y? hazard certainty) assumed to be hazardous in the minimum value case would be 0 mt/yr [i.e., 22,000 mt/yr generated (from Exhibit H-1) x 0% (from Exhibit H-4) = 0 mt/yr], while the expected value case hazardous portion would be 13,500 mt/yr [27,000 mt/yr generated (from Exhibit H-1) x 50% (from Exhibit H-4) = 13,500 mt/yr].² In the maximum value case, the entire quantity (32,000 mt/yr) is assumed to be hazardous. For the three titanium waste streams known to be hazardous (Y), the entire generated quantity of those wastes is included in the analysis.

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² Conversely, note that 22,000 mt/yr of the waste is considered non-hazardous in the minimum value case, while 13,500 mt/yr is considered non-hazardous in the expected value case. The portion of waste that is assumed non-hazardous drops out of the analysis from this point forward.

Titanium Waste Stream	Hazard Certainty	Portion of Waste that is Hazardous (mt/yr)					
waste Stream	Certainty	Minimum	Expected	Maximum			
Pickle Liquor and Wash Water	Y?	0	1,350	3.200			
Scrap Milling Scrubber Water	Y?	0	2,500	6.000			
Smut from Mg Recovery	Y	100	22,000	45.000			
Leach Liquor and Sponge Wash Water	Y	380,000	480,000	580,000			
Spent Surface Impoundment Liquids	Y?	0	1,700	6,700			
Spent Surface Impoundment Solids	Y?	0	18,000	36,000			
Waste Acids (Sulfate Process)	Ý	200	39,000	77,000			
WWTP Sludges/Solids	Y?	, 0	210,000	420.000			

Exhibit H-5 Portion of Waste Assumed to be Hazardous

H-5

H.2.2 Divide Hazardous Quantities Into Portion Treated/Disposed and Portion Stored Prior to Recycling

The hazardous portion of each waste stream (from Exhibit H-5) is then divided into a component of waste that is treated/disposed, and a component that is stored for recycling. To determine these portions, the model applies an appropriate multiplier, depending on its particular recycling status (as indicated in Exhibit H-3 above). The treatment/disposal multipliers are shown in Exhibit H-6, and the recycling multipliers are shown in Exhibit H-7. Note that in all cases the treatment and disposal multiplier in Exhibit H-6 and the recycling multiplier in Exhibit H-7 sum to 100 percent (i.e., all waste is assumed to be handled in accordance with EPA regulations and either treated and disposed, or stored prior to recycling). The multipliers are applied to the portion of material considered to be hazardous in the minimum, expected, and maximum value cases.

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Exhibit H-6
Proportions of Waste Streams Treated and Disposed (in percent)

	Percent Disposed Recycling Status								
Baseline or Option									
	Y	Y ?	YS	YS?	N				
No Prior Treatment	0	100	60	100	100				
Modified Prior Treatment	0	15	25	80	100				
Prior Treatment (SL/BP)	0	15	25	80	100				
Prior Treatment (SM)	0	25	35	85	100				
Option 1 from NPT	0	- 30	40	90	100				
Option 1 from MPT	0	25	35	85	100				
Option 1 from PT (SL/BP)	0	25	35	85	100				
Option 1 from PT (SM)	0	25	35	85	100				
Option 2 from NPT	0	15	25	80	100				
Option 2 from MPT	0	15	25	80	100				
Option 2 from PT (SL/BP)	0	15	25	80	100				
Option 2 from PT (SM)	0	15	25	80	100				

SL = Sludge, BP = By-Product, SM = Spent Material, PT = Prior Treatment, MPT = Modified Prior Treatment, NPT = No Prior Treatment

	Percent Recycled Recycling Status							
Baseline or Option								
	Y	Y ?	YS	YS?	Ν			
No Prior Treatment	100	0	40	0	Ŭ			
Modified Prior Treatment	100	85	75	20	0			
Prior Treatment (SL/BP)	100	85	75	20	0			
Prior Treatment (SM)	100	75	65	15	0			
Option 1 from NPT	100	70	60	10	0			
Option 1 from MPT	100	75	65	15	Ű			
Option 1 from PT (SL/BP)	100	75	65	15	0			
Option 1 from PT (SM)	100	75	65	15	0			
Option 2 from NPT	100	85	75	20	0			
Option 2 from MPT	100	85	75	20	0			
Option 2 from PT (SI JBP)	100	85	75	20	0			
Option 2 from PT (SM)	100	85	75	20	0			

Exhibit H-7 Proportions of Waste Streams Stored Prior to Recycling (in percent)

SL = Sludge, BP = By-Product, SM = Spent Material, PT = Prior Treatment, MPT = Modified Prior Treatment, NPT = No Prior Treatment

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The quantities of waste treated/disposed and the quantities of waste stored prior to recycling for each waste stream in the sector are shown in Exhibits H-8 and H-9, respectively. Quantities reported in Exhibits H-8 and H-9 are calculated by multiplying the portion of waste that is hazardous (Exhibit H-5) by the appropriate treatment/disposal or recycling multipliers (from Exhibits H-6 and H-7). For example, of the 1,350 mt/yr of pickle liquor and wash water assumed to be hazardous in the expected value case of the Modified Prior Treatment baseline, 80 percent of the waste, or approximately 1,080 mt/yr (1,350 mt/yr x 0.80), is sent to treatment/disposal, while 20 percent of the waste, or approximately 270 mt/yr (1,350 mt/yr x 0.20), is stored prior to recycling.

H.2.3 Calculate Total Quantity Treated and Disposed at a "Model Facility"

In performing cost modeling, EPA assumes that each facility operator generating waste in the titanium sector builds a single treatment plant to treat all wastes, rather than building a separate treatment plant for each waste stream. Therefore, to obtain the quantity of waste treated and disposed at a "model facility," the model sums the treated and disposed portion of all eight waste streams by physical form (i.e., wastewaters, wastes with one to ten percent solids, and wastes with more than ten percent solids) and divides by the maximum number of facilities generating waste in the sector, which in this sector example is two in the minimum value case, and seven in the expected and maximum value cases. The reason why there are only two facilities generating waste in the minimum value case is that there is uncertainty about the hazard characteristics (Y?) of several of the titanium waste streams (see Exhibit H-5). Recall that waste streams that have a Y? hazard certainty classification are considered not hazardous in the minimum value case, 50% hazardous in the expected value case, and 100% hazardous in the maximum value case (see Exhibit H-4). Therefore, the maximum number of facilities generating at least one hazardous titanium waste drops to two in the minimum value case, because all of the titanium waste streams generated by more than two facilities have a Y? hazard certainty classification (see Exhibit H-1). For purposes of EPA's calculations, it does not matter whether some types of waste are generated at fewer facilities, because the model assumes a single treatment system for all types of waste generated at all facilities. For example, the total wastewater treated/disposed for the pre-rule expected value case is 426,335 mt/yr (which is the sum of the wastewater streams in Exhibit H-10). Dividing by seven, the model facility wastewater treated/disposed for the expected value case is 60,905 mt/yr. Exhibit H-8 presents the model facility waste treated/disposed for the minimum, expected, and maximum value scenarios.

Waste Stream	Multipher	Portion of Waste Treated/Disposed (mt/yr)				
		Minimum	Expected	Maximum		
Pre-Rule (Modified Prior Treatment)						
Pickle Liquor and Wash Water	0.80	0	1,080	2,560		
Scrap Milling Scrubber Water	0.80	0	2,000	4,800		
Smut from Mg Recovery	0.15	15	3,300	6,750		
Leach Liquor and Sponge Wash Water	0.80	304,000	384,000	464,000		
Spent Surface Impoundment Liquids	0.15	0	255	1,005		
Spent Surface Impoundment Solids	1	0	18,000	36,000		
Waste Acids (Sulfate Process)	1	200	39,000	77.000		
WWTP Sludges/Solids	1	0	210,000	420,000		
Post-Rule (Option 1)						
Pickle Liquor and Wash Water	0.85	0	1,148	2.720		
Scrap Milling Scrubber Water	0.85	0	2.125	5,100		
Smut from Mg Recovery	0.25	25	5.500	11.250		
Leach Liquor and Sponge Wash Water	0.85	323,000	408,000	493.000		
Spent Surface Impoundment Liquids	0.25	0	425	1.675		
Spent Surface Impoundment Solids	1	0	18,000	36,000		
Waste Acids (Sulfate Process)	1	200	39,000	77,000		
WWTP Sludges/Solids	1	0	210.000	420,000		

Exhibit H-8 Portion of Hazardous Wastes Generated Treated and Disposed

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Waste Stream	Multiplier	Portion of Waste Stored Prior to Recycling (mt/yr)					
		Minimum	Expected	Maximum			
Pre-Rule (Modified Prior Treatment)							
Pickle Liquor and Wash Water	0.20	0	270	640			
Scrap Milling Scrubber Water	0.20	0	500	1,200			
Smut from Mg Recovery	0.85	85	18,700	38.250			
Leach Liquor and Sponge Wash Water	0.20	76,000	96,000	116,000			
Spent Surface Impoundment Liquids	0.85	0	1,445	5,695			
Spent Surface Impoundment Solids	0	0	0	0			
Waste Acids (Sulfate Process)	0	0	0	0			
WWTP Sludges/Solids	0	0	0	0			
Post-Rule (Option 1)							
Pickle Liquor and Wash Water	0.15	0	203	480			
Serap Milling Scrubber Water	0.15	0	375	900			
Smut from Mg Recovery	0.75	75	16,500	33,750			
Leach Liquor and Sponge Wash Water	0.15	57,000	72,000	87,000			
Spent Surface Impoundment Liquids	0.75	0	1,275	5,025			
Spent Surface Impoundment Solids	U	0	0	0			
Waste Acids (Sulfate Process)	0	U	0	0			
WWTP Sludges/Solids	0	0	0	0			

Exhibit H-9 Portion of Hazardous Wastes Generated that is Stored Prior to Recycling

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	Model Facility Waste Treated/Disposed (mt/yr)									
	1	Minimum			Expected		Maximum			
	Waste- waters	1-10% Solids	Solids	Waste- waters	t-10% Solids	Solids	Waste- waters	1-10% Solids	Solids	
Pre-Rule (MPT)	152,100	0	8	50.905	0	33,043	78.481	0	66,107	
Post Rule (Option 1)	161,100	e	13	54 <u>,</u> 385	Û	33.357	82.785	0	66.750	

Exhibit H-10 . Model Facility Quantity of Waste Treated/Disposed

H-10

H.2.4 Calculation of Average Quantity Recycled

Because recycling costs are specific to each waste stream in the sector, the cost model does not calculate model facility totals for recycling. Rather, it calculates an average facility total by dividing the portion of each waste stream that is stored prior to recycling (from Exhibit H-9) by the number of facilities that generate each waste (from Exhibit H-1). Exhibit H-11 shows the results of this calculation.

Waste Stream	Number of	Average Facility Waste Stored Prior to Recycling (mt/yr)		
	Facilities	Minimum	Expected	Maximum
Pre-Rule (Modified Prior Treatment)			•	
Pickle Liquor and Wash Water	3	0	90	213
Scrap Milling Scrubber Water	1	0	500	1.200
Smut from Mg Recovery	2	43	9.350	19,125
Leach Liquor and Sponge Wash Water	2	38,000	48,000	58.000
Spent Surface Impoundment Liquids	7	0	206	814
Spent Surface Impoundment Solids	7	υ	0	0
Waste Acids (Sulfate Process)	2	0	0	0
WWTP Sludges/Solids	7	0	0	0
Post-Rule (Option 1)				
Pickle Liquor and Wash Water	3	0	68	160
Scrap Milling Scrubber Water	1	0	375	900
Smut from Mg Recovery	2	38	8,250	16.875
Leach Liquor and Sponge Wash Water	2	28,500	36.000	43,500
Spent Surface Impoundment Liquids	7	0	182	718
Spent Surface Impoundment Solids	7	0	0	()
Waste Acids (Sulfate Process)	2	0	0	0
WWTP Sludges/Solids	7	0	0	0

Exhibit H-11 Average Facility Quantities Stored Prior to Recycling

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H.3. Treatment Cost Calculations

This section of the appendix explains how the cost model calculates the total incremental treatment cost incurred by the titanium and titanium dioxide mineral processing sector.

The model first determines if the treated and disposed waste quantities from Exhibit H-10 are large enough to warrant on-site treatment. Next the model calculates neutralization, dewatering, stabilization, and disposal costs. The model then annualizes capital and closure costs and calculates a total sector treatment cost. Finally, the model calculates the total titanium sector incremental treatment cost. All treatment and disposal calculations are performed using the "model facility" quantities calculated in Section H.2.3 of this document.

H.3.1 Determination of On-Site versus Off-Site Treatment

The model assumes that low-volume wastes ($\leq 3.163 \text{ mt/yr}$ solids or $\leq 350 \text{ mt/yr}$ liquids) will be sent off-site for treatment and disposal. All wastes generated in the titanium sector are assumed to be treated on-site, because both wastewaters and solids are generated in quantities above the low-volume threshold in all three costing scenarios (see Exhibit H-10).

H.3.2 Neutralization and Precipitation Costs

Five of the eight titanium waste streams are wastewaters and therefore require neutralization, precipitation, dewatering, and stabilization prior to disposal. (The other three streams are solids, and do not require neutralization, precipitation, and dewatering.) The model uses four equations to determine the neutralization cost for wastewaters:³

•	Surge Tank Costs (S/yr)	=	$4 \times 10^{-6} Q_n^2 + 0.1175 Q_n + 3.680$
•	Capital Costs (\$)	=	$36,131 + 151.95 Q_n^{2.5}$
•	O&M Costs (S/yr)	=	-206,719 + 36,594 ln Q
•	Closure Costs (\$)	=	$6.361 + 10^{-3} Q_n$

In all four of the above equations, Q_n (the amount of waste requiring neutralization) equals the sum of wastewaters and waste streams with one to ten percent solids requiring treatment. Using the pre-rale expected value case as an example, the model facility quantity of wastewater requiring treatment is 60,905 mt/yr, and the quantity of wastes with one to ten percent solids content is 0 mt/yr (see Exhibit H-10). Therefore, neutralization surge tank storage costs equal \$10,985, neutralization capital costs equal \$73,631, neutralization O&M costs equal \$196,440 per year, and neutralization closure costs equal \$6,422. Exhibit H-12 shows the neutralization costs for the titanium and titanium dioxide sector.

³ Equations from Exhibit F-1, Appendix F.

H-11

Baseline/Option	Neutralization Costs			
Costs	Minimum	Expected	Max:mum	
Pre-Rule				
- Surge (\$/yr)	22.477	10.985	13,148	
- Cap:tal (S)	95.392	73.631	78,699	
- O&M (S/yr)	229.931	196,440	205,718	
- Closure (\$)	6,513	6,422	6.439	
Post-Rule				
- Surge (\$/yr)	23,713	11.411	13.681	
- Capital (\$)	97,214	74,687	79.851	
- O&M (\$/yr)	232,148	198.473	207.672	
- Closure (\$)	6,523	6.425	6,444	

Exhibit H-12 Neutralization Costs

The model uses two equations to determine the precipitation cost for wastewaters:⁴

•	Capital Costs (\$)	=	- 3,613 + 15.195 Q ₂ ²⁵
•	O&M Costs (\$/yr)	=	826.48 + 0.3465 Q

In the above equations, Q_p (the amount of waste requiring precipitation) equals the sum of wastewaters and waste streams with one to ten percent solids requiring treatment. Using the pre-rule expected value case as an example, the model facility quantity of wastewater requiring treatment is 60.905 mt/yr, and the quantity of wastes with one to ten percent solids content is 0 mt/yr (see Exhibit H-10). Therefore, precipitation capital costs equal \$7,363, and precipitation O&M costs equal \$21,930 per year. Exhibit H-13 shows the precipitation costs for the titanium and titanium dioxide sector.

Exhibit H-13 Precipitation Costs

Baseline/Option	Prec:pitation Costs			
Costs	Minimum Expected		Maximum	
Pre-Rule	•			
- Capital (\$)	9.539	7,363	7,870	
- O&M (\$/yr)	53,529	21,930	28.020	
Post Rule	•	•		
- Capital (\$)	9,721	7,469	7.985	
- O&M (\$/yr)	56.821	23,136	29,511	

⁴ EPA assumes that neutralization and precipitation occur within the same unit, therefore, precipitation closure costs are included in the neutralization closure cost equation.

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H.3.3 Dewatering and Stabilization Costs

Neutralization operations produce a slurry that must be dewatered, stabilized, and disposed of. About 15 percent of the quantity introduced into the neutralization operation leaves as this slurry. Therefore, in the following equations, Q_{dw} , the amount of material requiring dewatering, is 15 percent of the sum of the quantity of wastewaters and wastes with a solids content of 1 to 10 percent requiring treatment:³

•	Capital Costs (\$)	=	95,354 + 664.48 Q _{dw} ^{0.*}
•	O&M Costs (\$/yr)	=	$12,219 + 286.86 Q_{\rm in}^{0.5}$

For example, in the post-rule expected value case, Q_{dw} is equal to 9,658 mt/yr [(64,385 mt/yr wastewaters plus 0 mt/yr wastes with a solids content of 1 to 10 percent (from Exhibit H-10)) x 0.15]. Therefore, the capital cost associated with dewatering 9,658 mt/yr waste is \$160,655, and the O&M cost is \$40,410 per year.

Dewatering produces a sludge, which needs to be stabilized and disposed of. The dewatered sludge, equal to about 15 percent of the mass entering dewatering, is combined with the solid waste streams requiring stabilization and disposal in the following equation:⁶

Stabilization Costs (\$) = $49.177Q_s + 342,233$

In these equations, therefore, the quantity requiring stabilization, Q_x , is 2.25 percent⁷ of the sum of the original quantity of wastewaters and wastes with a solids content of 1 to 10 percent requiring treatment, added to the entire quantity of solid waste requiring treatment. For example, in the post-rule expected value case, Q_x is equal to 34,806 mJyr [1,449 mJyr wastewaters and wastes with 1 to 10 percent solids ((64,385 mJyr + 0 mJyr, from Exhibit H-10, * 0.0225) plus 33,357 mJyr solids (from Exhibit H-10)]. Therefore, the cost associated with stabilizing 34,806 mJyr waste is \$2,053,871. Exhibits H-14 and H-15 show the dewatering and stabilization costs, respectively, for the titanium and titanium dioxide sector.

⁵ Equations obtained from Exhibit F-2, Appendix F.

⁶ Equations obtained from page F-9, Appendix F.

² This is equal to 15 percent of the quantity entering dewatering, which is 15 percent of the original quantity requiring treatment.

H-14

Exhibit H-14 Dewatering and Stabilization Costs

Baseline/Option	Dewatering Costs		
Costs	Minimum	Expected	Maximum
Pre-Rule		-	
- Capital (\$)	195,721	158.366	167.450
O&M (\$/yr)	55,548	39.637	43.343
Post-Rule			
- Capital (\$)	198,808	160.655	169,400
- O&M (\$/yr)	56,881	40,410	44,185

Exhibit H-15 Stabilization Costs

Baseline/Option	Stabilization Costs			
Costs	Minimum	Expected	Maximum	
Pre-Rule	510,922	2,034,579	3,680.015	
Post-Rule	521,127	2,053,871	3,716.398	

II.3.4 Disposal Costs

After neutralization, precipitation, dewatering, and/or stabilization, stabilized residues from titanium sector wastes are disposed of in a pile. The cost of disposal in a pile is described by the following equation:⁸

• Pile Costs ($\frac{y}{y}$) = 1.8703 Q_{ds} + 12,308

In the above equation, Q_{dx} , the quantity being disposed of, is equal to 146 percent of the mass entering stabilization from dewatering added to 146 percent of the solid wastes entering stabilization. Alternatively, Q_{dx} is the sum of [1.46 x (0.0225 x (quantity of wastewaters and wastes with a 1 to 10 percent solids content requiring treatment)] and [1.46 x (quantity of solids requiring treatment)]. For example, in the expected value case of Option 3, Q_{dx} is equal to 50,817 mUyr [(1.449 mUyr x 1.46) plus (33,357 mUyr x 1.46)]. Therefore, the cost of disposal in a pile is equal to \$107,351. Exhibit H-16 depicts the disposal costs for the sector.

Exhibit H-16 Disposal Costs

Baseline/Option	Disposal Costs			
Costs	Minimum	Expected	Maximum	
Pre-Rule	21,675	106.278	197.566	
Post Rule	22.241	107,349	199.664	

⁵ Equation obtained from Exhibit F-18, Appendix F.

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H.3.5 Annualization of Costs and Calculation of Total Sector Treatment Costs

Because capital and closure costs are one-time costs, they are annualized so that total annualized titanium sector incremental treatment costs may be calculated. The model annualizes the titanium sector capital costs by multiplying them by a capital recovery factor (CRF) of 0.09439.⁵ Closure costs, which are assumed to be incurred after 20 years of operation (i.e., in year 21), are reduced to present value and then annualized using the CRF. The annualization process and the calculation of total neutralization, precipitation, dewatering, and stabilization costs are accomplished using the following formula:¹⁰

Annualized Cost = (Capital Costs)(CRF) + O&M Costs + (Closure Costs)(CRF)/(1.07²¹)

Using the above formula, the model combines the capital, O&M, and closure costs to obtain total annualized neutralization, precipitation, and dewatering costs for the titanium sector.¹¹ For example, the pre-rule expected value case annualized neutralization cost in the titanium and titanium dioxide sector equals $(\$73,631 \times 0.09439) + \$10.985 + \$196,440 + ((\$6,422 \times 0.09439) / 1.07^2)$, or \$214,521. The disposal and stabilization cost functions are already annualized. Exhibit H-17 presents the total annualized neutralization, precipitation, dewatering, stabilization, and disposal costs for the titanium sector.

Baseline/Option	Costing Scenario			
Costs (\$)	Minimum	Expected	Maximum	
Pre-Rule	<u> </u>			
- Neutralization	261,531	214.521	226,441	
- Precipitation	54,429	22.625	28.763	
- Dewatering	74.022	54.632	59.149	
- Stabilization	510,922	2.034,579	3,680,015	
Disposal	21,675	106,278	197.666	
Total	922,579	2,432,635	4,192,034	
Post-Rule				
- Neutralization	265.186	217,080	229.012	
- Precipitation	57.739	23,841	30,265	
- Dewatering	75.646	55,574	60,175	
- Stabilization	521.127	2,053.871	3.716.398	
- Disposal	22.241	107.349	199.664	
Total	941,939	2,457,715	4,235,514	

Exhibit H-17 Annualized Neutralization, Precipitation, Dewatering, Stabilization, and Disposal Costs (Modified Prior Treatment Baseline and Option 1)

^c Derivation of the CRF may be found on page F-2 of Appendix F.

¹⁰ For more information, see pages F-1 and F-2 of Appendix F.

¹⁷ Surge tank costs are also added to the annualized capital, O&M, and annualized closure costs in the calculation of the total annualized neutralization cost.

Total titanium sector pre- and post-rule treatment costs are calculated by summing the annualized neutralization, precipitation, dewatering, stabilization, and disposal costs from Exhibit II-17, and multiplying the sum by the maximum number of facilities in the titanium sector (two in the minimum value case, seven in the expected and maximum value cases). Therefore, the total titanium sector expected value case pre-rule treatment cost in this example is equal to $((\$214,521 + \$22,625 + \$54,632 + \$2,034,579 + \$106,278 = \$2,432,635) \times 7)$, or \$17,028,445. Similarly, the total titanium sector expected value case post-rule treatment cost in this example is equal to $((\$217,080 + \$23,841 + \$55,574 + \$2,053,871 + \$107,349 = \$2,399,311) \times 7)$, or \$17,204,005.

H.3.6 Total Sector Incremental Treatment Cost

The total titanium sector incremental treatment cost is calculated by subtracting the pre-rule total sector treatment cost from the post-rule total sector treatment cost. In this example, the total titanium sector incremental treatment cost is \$38,720 in the minimum value case, \$175,560 in the expected value case, and \$304,360 in the maximum value case.

H.4. Storage Cost Calculations

This section of the appendix calculates the total sector incremental storage cost incurred by the titanium and titanium dioxide mineral processing sector. This process involves four steps: (1) the appropriate storage unit for each waste stream is selected; (2) the average facility storage cost is calculated for each waste stream; (3) a total sector storage cost is calculated; and (4) a total sector incremental storage cost is calculated. Note that until the total sector storage cost is calculated at the end of this section, all calculations in this section are performed on an average facility basis.

H.4.1 Storage Unit and Cost Equation Determination

Depending on the quantity of recyclable waste generated and the physical form of the waste (liquid or solid), wastes that require storage prior to recycling can be stored in a variety of storage units. EPA developed individual cost equations for each type of storage unit and used these cost equations to determine, for any quantity being stored, the least cost storage unit available. Exhibit H-18 shows these cost functions for the various storage units available for use in the Modified Prior Treatment baseline and Option 1, as well as the range of quantities for which that unit would be employed.¹² In each of these equations, Q is the annual quantity requiring storage prior to recycling.

¹² For a full list of storage unit functions, refer to Exhibit F-18, Appendix F.

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		Modified Prior Trea	atment Baseline
Waste Type	Storage Unit	Quantity Range (mt/yr)	Cost Equation
Liquid	Drum	0 - 220	$Y = -0.0074 Q^2 + 9.4798 Q + 189.34$
	Tank	220 - 500	$Y = -9x10^{7} Q^{2} + 0.55 Q + 1.795.7$
	Unlined S.I.	≥ 500	Y = 1,000
Solid	Drum	0 - 200	Y = 24.589 Q + 132.23
	Roll-Off	200 - 935	$Y = -0.0022 Q^2 + 29.272 Q + 4.840.9$
	Unlined Pile	≥ 935	Y = 4.0207 Q + 26.271
		Option 1 (fro	m MPT)
Waste	Storage Unit	Quantity Range	Cost Equation
Type		(mt/yr)	
Liquid	Drum	0 - 220	$Y = -0.0074 Q^2 + 9.4798 Q + 189.34$
	Tank	220 - 1 million	$Y = -9x10^7 Q^2 + 0.55 Q + 1.795.7$
	Lined S.I.	> 1 million	Y = 0.0704 Q + 1.955.1
Solid	Drum	0 - 200	Y = 24.589 Q + 132.23
	Rell Off	200 1343.1	$Y = 0.0022 Q^2 + 29.272 Q + 4.840.9$
	Building	1343.1 - 45,000	$Y = 0.00002 Q^2 + 3.2395 Q + 35,800$
ſ	Lined Pile	> 45.000	Y = 4.0924 Q + 27,676

Exhibit H-18 Storage Cost Equations

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Exhibit H-19 shows the storage units used in the minimum, expected, and maximum value cases for the eight waste streams generated in the titanium sector. For example, scrap milling scrubber water is stored in an unlined surface impoundment in the pre-rule maximum value case because it is a liquid waste (i.e., a wastewater) and the quantity stored prior to recycling (i.e., 1,200 mt/yr) exceeds the threshold quantity of 500 mt/yr needed to store liquids in an unlined surface impoundment.

H.4.2 Storage Costs

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Exhibit H-20 shows the storage costs for each of the eight titanium waste streams. The quantities in Exhibit H-20 are created by putting the quantity of waste stored prior to recycling (Exhibit H-11) into the appropriate cost function from Exhibit H-18. For example, leach liquor and sponge wash water is stored in a tank in all three costing scenarios under Option 3. Therefore, the cost equation for the minimum, expected, and maximum value case is as follows:

Cest = $-9x10^{7}Q^{2} + 0.55Q + 1.795.7$

Inserting 28,500 mt/yr, 36,000 mt/yr, and 43,500 mt/yr into the minimum, expected, and maximum cost equations, respectively, yields a storage cost of \$16,740 in the minimum value case, \$20,429 in the expected value case, and \$24,018 in the maximum value case.

Titanium Waste Stream	Storage Unit			
	Minimum	Expected	Maximum	
Pre-Rule (Modified Prior Treatment)				
Pickle Liquor and Wash Water	Not Recycled	Drum	Drum	
Scrap Milling Scrubber Water	Not Recycled	Unlined S.I.	Unlined S.I.	
Smut from Mg Recovery	Drum	Unlined Pile	Unlined Pile	
Leach Liquor and Sponge Wash Water	Unlined S.I.	Unlined S.I.	Unlined S.I.	
Spent Surface Impoundment Liquids	Not Recycled	Drum	Unlined S.I.	
Spent Surface Impoundment Solids	Not Recycled	Not Recycled	Not Recycled	
Waste Acids (Sulfate Process)	Not Recycled	Not Recycled	Not Recycled	
WWTP Sludges/Solids	Not Recycled	Not Recycled	Not Recycled	
Post-Rule (Option 1)				
Pickle Liquor and Wash Water	Not Recycled	Drum	Drum	
Scrap Milling Scrubber Water	Not Recycled	Tank	Tank	
Smut from Mg Recovery	Drum	Building	Bu:lding	
Leach Liquor and Sponge Wash Water	Tank	Tank	Tank	
Spent Surface Impoundment Liquids	Not Recycled	Drun:	Tank	

Exhibit H-19	
Storage Units Used in the Modified Prior Treatment Baseline and C	option 1

Exhibit H-20 Average Facility Storage Costs

Not Recycled

Not Recycled

Nct Recycled

Spent Surface Impoundment Solids

Waste Acids (Sulfate Process) WWTP Sludges/Solids

Titanium Waste Stream	Average Facility Storage Cost (\$)			
	Minimum	Expected	Maximum	
Pre-Rule (Modified Prior Treatment)				
Pickle Liquor and Wash Water	Not Recycled	983	1,873	
Scrap Milling Scrubber Water	Not Recycled	1.000	1,000	
Smut from Mg Recovery	1,190	63,865	105.167	
Leach Liquer and Sponge Wash Water	1.000	1.000	1,000	
Spent Surface Impoundment Liquids	Not Recycled	1.828	1,000	
Spent Surface Impoundment Solids	Not Recycled	Not Recycled	Not Recycled	
Weste Acids (Sulfate Process)	Not Recycled	Not Recycled	Not Recycled	
WWTP Sludges/Solids	Not Recycled	Not Recycled	Not Recycled	
Post-Rule (Option 1)				
Pickle Liquor and Wash Water	Not Recycled	780	1,517	
Scrap Milling Scrubber Water	No: Recycled	2.002	2,290	
Smut from Mg Recovery	1.067	63.887	96.162	
Leach Liquor and Sponge Wash Water	:6.740	20.429	24,018	
Spent Surface Impoundment Liquids	Net Recycled	1,670	2,190	
Spent Surface Impoundment Solids	Not Recycled	Not Recycled	Not Recycled	
Waste Acids (Sulfate Process)	Not Recycled	Not Recycled	Not Recycled	
WWTP Sludges/Solids	Not Recycled	Not Recycled	Not Recycled	

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Not Recycled

Not Recycled

Not Recycled

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Not Recycled

Not Recycled

Not Recycled

H.4.3 Total Sector Storage Cost

To obtain a total sector storage cost, pre-rule (Modified Prior Treatment baseline) and post-rule (Option 1) total sector storage costs must be calculated under each scenario for each waste stream and summed. Total sector pre- and post-rule storage costs are calculated by multiplying the minimum. expected, and maximum average facility storage cost for each titanium waste stream (Exhibit H-20) by the number of facilities generating the waste stream. Using leach liquor and sponge wash water as an example, the post-rule total sector storage cost is \$42,792 (\$21,396 x 2 facilities) in the minimum value case, \$52,244 (\$26,122 x 2 facilities) in the expected value case, and \$60,916 (30,458 x 2 facilities) in the maximum value case. Exhibit H-21 shows the total sector storage cost for each waste stream and the total storage cost for the entire sector.

Provelies of Option	Number of	Storage Cost (\$)			
Baseline or Option	Facilities	Minimum	Expected	Maximum	
Pre-Rule (Modified Prior Treatment)			•	•	
Pickle Liquor and Wash Water	3	0	2.949	5.619	
Scrap Milling Scrubber Water	1	0	1.000	1.000	
Smut from Mg Recovery	2	2.330	127,730	206.334	
Leach Liquor and Sponge Wash Water	?	2.000	2,000	2.000	
Spent Surface Impoundment Liquids	7	0	12.796	7,000	
Spent Surface Impoundment Solids	7	0	0.	0	
Waste Acids (Sulfate Process)	2	0	0	0	
WWTP Sludges/Solids	7	- 0 ·	0	0	
Pre-Rule Total Sector		4,380	146,475	221,953	
Post-Rule (Option 1)			·		
Pickle Liquor and Wash Water	3	0	2,340	4.551	
Scrap Milling Scrubber Water	1	0	2,002	2,290	
Smut from Mg Recovery	2	2,134	127,774	192,324	
Leach Liquor and Sponge Wash Water	2	33,480	40,858	48.036	
Spent Surface Impoundment Liquids	7	0	11.690	15.330	
Spent Surface Impoundment Solids	7	0	0	0	
Waste Acids (Sulfate Process)	2		0	0	
WWTP Sludges/Selids	7	0	0	0	
Post-Rule Total Sector		35,614	184,664	262,531	

Exhibit H-21 Total Sector Storage Costs

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H.4.4 Total Sector Incremental Storage Cost

The total titanium sector incremental storage cost is calculated by subtracting the pre-rule total sector storage cost from the post-rule total sector storage cost. In this example (where the pre-rule scenario is the Modified Prior Treatment baseline, and the post-rule scenario is Option 1), the total titanium sector incremental storage cost is \$31,234 in the minimum value case. \$38,189 in the expected value case, and \$40,578 in the maximum value case.¹³

H.5. Administrative Cost Calculations

Administrative costs are specific to each waste stream generated in the titanium/titanium dioxide sector. For the three titanium wastes that are known <u>not</u> to be recycled (N recycling status--see Exhibit H-3) and therefore requires treatment and disposal, there is a one-time cost of \$935 to develop a waste analysis plan, and an annual testing cost of \$470. The remaining wastes the titanium/titanium dioxide sector are partially recycled and partially treated/disposed (Y?, YS, and YS? recycling status-- see Exhibit H-3) incur the \$935 waste analysis plan and \$470 annual testing costs, as well as a one time recycling notification cost of \$100. Recall from Exhibit H-2 that in the minimum value case, titanium/titanium dioxide wastes with Y? hazard certainty are assumed not to be hazardous. Therefore, in the minimum value case, wastes with Y? hazard certainty do not incur any administrative costs. Both the waste analysis plan cost and the recycling notification costs are one-time in nature, so they are annualized by multiplying by a CRF of 0.09439.¹⁴ Exhibit H-22 shows the administrative costs for the titanium/titanium dioxide sector.

EPA calculated a total administrative cost for each waste stream in the titanium/titanium dioxide sector by multiplying the appropriate administrative costs by the number of facilities generating the waste stream. Administrative costs for all of waste streams in the titanium/titanium dioxide sector were then summed to obtain a total sector administrative cost of \$3,408 in the minimum value case, and \$17,599 in the expected and maximum value cases.

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¹³ In the minimum value case, there is a savings in storage cost due to a slight decrease in the amount of material recycled.

¹⁴ Derivation of the CRF may be found on page F-2 of Appendix F.

Titanium Waste Stream	No. of	Waste Analysis Plan Cost		Annual Testing Cos:		Recycling Notification Cost		Waste Stream Administrative Cost	
	Fac.	M:n.	Exp./ Max.	Mir.	Exp./ Max	Min	Exp / Max.	Min.	Exp / Max
Pickle Liquor and Wash Water	3	0	264	0	1,410	0	28	0	1.702
Scrap Milling Scrubber Water		0	83	0	470	0	9	0	567
Smut from Mg Recovery	2	157	177	940	940	19	19	1,136	1136
Leach Liquor and Sponge Wash Water	2	177	177	940	940	19	19	1,136	1.136
Spent Surface Impoundment Liquids	7	0	618	0	3,290	0	66	0	3.974
Spent Surface Impoundment Solids	7	0	618	0	3,290	0	66	0	3,974
Waste Acids (Sulfate Process)	2	177	177	940	940	19	19	1,136	1.136
WWTP Sludges/Solids	7	0	613	C	3,290	0	66	0	3,974
Total Sector Administrative Cost								3.408	17,599

Exhibit H-22 Annualized Administrative Costs

H.6. Incremental Cost Calculations

This section of the appendix shows how the model calculates the total incremental cost of the rulemaking for the titanium sector. The total incremental cost is calculated by adding the total sector incremental treatment cost (calculated in Section H.3), the total sector incremental storage cost (calculated in Section H.4), and a total sector administrative cost (calculated in Section H.5). Thus, for the titanium and titanium dioxide sector, the incremental cost of this rulemaking is equal to \$73,362 (\$38,720 incremental treatment cost + \$31,234 incremental storage cost + \$3,408 total sector administrative cost) in the minimum value case of Option 1 from the Modified Prior Treatment baseline, \$231,348 (\$175,560 incremental treatment cost + \$38,189 incremental storage cost + \$17,599 total sector administrative cost) in the expected value case of Option 1 from the Modified Prior Treatment baseline, and \$362,537 (\$304.360 incremental treatment cost + \$40,578 incremental storage cost + \$17,599 total sector administrative cost administrative cost) in the maximum value case of Option 1 from the Modified Prior Treatment baseline.

The total cost incurred by an average facility in this sector is \$36,681 in the minimum value case, \$33,050 in the expected value case, and \$51,791 in the maximum value case. Average facility costs are calculated by dividing the total sector incremental cost by the maximum number of facilities in this sector. Note that in this example the *average* facility cost in the minimum value case (\$36,681) is larger than the average facility cost in the expected value case (\$33,050). This is due to the fact that there are only two facilities producing waste in the minimum value case, and seven facilities producing waste in the expected and maximum value case. This results in a higher average facility cost because the *total* sector incremental cost is divided by two rather than seven.

DERIVATION OF VALUE OF SHIPMENTS AND VALUE ADDED FOR MINERAL PROCESSING SECTORS

APPENDIX I

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In estimating the cost impacts of the Phase IV LDRs for mineral processing sectors generating hazardous waste, EPA gathered information on the current value of shipments from the 1997 Mineral Commodity Summaries¹ (1997 MCS), other literature sources, and conversations with Mineral Commodity specialists at the United States Geological Survey. In general, the Agency multiplied price data (\$/mt) with production data (mt) to determine the value of shipments, where sufficient information was available. Price and production data for the sectors listed below were taken or estimated from a number of sources. Details are provided below for each of these sectors, as are the raw price and production data for combined sectors. A concluding table shows the similar process used to derive value added estimates for 16 sectors.

ALUMINUM:	Mineral Commodity Summary 1997 (p18) Primary Production 1996: 3,600,000 mt
Production:	Mineral Commodity Summary 1997 (p18) Price 1996: ignot, average U.S. market (spot),
Price:	70.0 cents/pound (0.70 \$/pound * 2204.623 pounds/mt = 1543 \$/mt)
ANTIMONY:	Mineral Commodity Summary 1997 (p20) Production 1992: Primary Smelter 20,100 mt
Production:	Mineral Commodity Summary 1997 (p20) Price 1996: average 152 cents/pound (1.52
Price:	S/pound * 2204.623 pounds/mt = 3351 S/mt)
BERYLLIUM: Production: Price:	Mineral Commodity Summary 1997 (p31) Mine Production 1996: 217 mt Mineral Commodity Summary 1997 (p31) Price 1996: Domestic, beryllium-copper master alloy, contained beryllium 160 \$/pound. (160\$/pound * 2204.623 pounds/mt = 352.640 \$/mt)
BISMUTH:	Production capacity used in 1985 Mineral Facts and Problems (1983): 1,100 MT
Production:	Mineral Commodity Summary 1997 (p33) Price 1996: 3.60 \$/pound (3.60\$/pound *
Price:	2204.623 pounds/mt = 7936.64 \$/mt)
CADMIUM:	Mineral Commodity Summary 1997 (p39) Production 1996: refinery 1,450 mt.
Production:	Mineral Commodity Summary 1997 (p39) Price 1996: metal, 1.25 doliars/ pound (1.25
Price:	\$/pound * 2204.623 pounds/mt = 2,756 \$/mt)
CALCIUM: Production: · Price:	Mineral Commodity Specialists (USGS) Production: 1,000 tons (1,000 tons * 1.1 mt/tons = 1,100 mt) Mineral Commodity Specialists (USGS) 4.24 S/kg Russian, 4.72 \$/kg Chinese. The CIF price is what the cost of these imports would be in the US, which should be similar to the price of domestic calcium. Average the two to obtain 4.48 S/kg. (4.48 \$/kg * 1000 kg/mt = 4480 \$/mt)

¹ Mineral Commodity Summaries. United States Geological Service 1997.

CHROMIUM AND FERROCHROMIUM:

Sales from Macalloy Corporation dated Dec 11, 1997 were used as a proxy for the value of shipments in the ferrochromium sector. Dun and Bradstreet, 1997

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COAL GAS: Production:	Dakota Gasification Company Bulletin:
Price:	IEA Statistics, Energy Prices and Taxes. Fourth Quarter 1996 (p272) Natural Gas for Industry: 128.80 per 10E7 kilocalories GCV. (153 mmscf/day * 128.80 \$/10 ⁷ kcal * 9139 kcal/m ³ * 1m ³ /35.3107 ft ³ * 365 day/yr = \$186,000,000/year.)
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COPPER: Production:	Mineral Commodity Summary 1997 (p53) Production 1996: Refinery, Primary - 2.000.000 mt.
Price:	Mineral Commodity Summary 1997 (p53) Price 1996: Average London Metal Exchange, high grade - 102 cents/pound. (1.02 \$/pound * 2204.623 pounds/mt = 2,249 \$/int)
ELEMENTAL P	HOSPHORUS:
Production: Price:	1990 Report to Congress on Special Wastes from Mineral Processing: 311,000 mt. Mineral Commodity Specialist (USGS) - 1.25 \$/pound. (1.25 \$/pound *.2204.623 pounds/mt = 2,756 \$/mt)
FLOURSPAR AN	ND HYDROFLUORIC ACID:
Production:	Mineral Commodity Yearbook. 1996 Table 1: Production: Shipments United States: 8,200 mt
Price	Mineral Commodity Yearbook 1996 (p3), 142 - 152 \$/ton (Average = 147 S/ton * 1 ton/.9072 mt = 162 \$/mt).
GERMANIUM:	
Production:	Mineral Commodity Summary 1997, (p68) Production 1996: Refinery 18,000 kg (18,000 kg * 1 mt/1.000 kg = 18 mt)
Price:	Mineral Commodity Summary 1997, (p68) Price 1996 yearend: Zone refined - 2,000 \$/kg. (2,000 \$/kg * 1.000 kg/1 mt = 2,000,000 \$/mt)
LEAD:	
Production:	Mineral Commodity Summary 1997, (p94) Production 1996: Mine, lead in concentrates Primary refinery: From domestic ore- 340,000 mt.
Price:	Mineral Commodity Summary 1997 (p93) Price 1996 average,: US - 48.8 cents/pound. (.488 S/pound * 2204.623 pounds/mt = 1076 S/mt)
MAGNESIUM A	ND MAGNESIA FROM BRINES:
Production:	- Mineral Commodity Summary 1997 (p102) Production: Primary 1996- 143,000 mt. Mineral Commodity Summary 1997 (p102) Price 1996, yearend. Metals Week. US spot Western, average 1.75 \$/pound. (1.75 \$/pound * 2204.623 pounds/mt = 3,858 \$/mt)

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MERCURY: Production: Price:	Mineral Commodity Summary 1994 (p110) Production 1993: Mine- 70 mt Mineral Commodity Summary 1997 (109)Price 1996, average value 260 \$/flask. (260 \$/flask * 29.0082 flask/mt = 7542 \$/mt)
	1, FERROMOLYBDENUM, AND AMMONIUM MOLYBDATE:
Molybdenum Production: Price:	Mineral Commodity Summary 1997 (p114) Production: 1996 mine -57,000 mt Mineral Commodity Summary 1997 (p114) Price, 1996 average value 7.50 \$/kg. (7.50 dollars/kg ~ 1,000 kg/mt = 7.500 \$/mt)
Ferromolybder	um
Production: Price:	Mineral Commodity Specialist (USGS) -70 kg (70 kg * 1 mt/1000 kg = .07 mt) Mineral Commodity Specialists (USGS) - 15 \$/kg. (15 \$/kg * 1000 kg/1 mt = 15,000 \$/mt)
Ammonia Mol	ybdate
	No data were available, therefore the estimated value of shipments may be low.
PLATINUM GR	OUP METALS:
Platinum: Production :	Mineral Commodity Summary 1997, (p126) Mine Production 1996: Platinum 1,600 kg.
	(1.600 kg * 1 mt/1,000 kg = 1.6 mt)
Price	Mineral Commodity Summary 1997, Price 1996, average daily, New York, 410 S/troy ounce. (410 S/troy ounce * 32.1507 troy ounce/kg * 1,000 kg/mt = 13,181,787 \$/mt)
Palladium:	
Production:	Mineral Commodity Summary 1997,(p126)Mine Production 1996: Palladium 5,000 kg. (5.000kg * 1 mt/1,000kg = 5mt)
Price:	Mineral Commodity Summary 1996,(p126) Price 1996, average daily, New York.: 135 S/troy ounce. (135 \$/troy ounce * 32.107 troy ounce/kg * 1,000 kg/mt = 4,340,344 \$/mt)
RARE EARTHS	· · · ·
Production:	Mineral Commodity Summary 1997 (p135), Production 1996: Bastanite concentrates - 20.000 mt.
Price:	Mineral Commodity Summary 1997 (p135), Price 1996, yearend: Bastanite concentration, REO basis -2.87 \$/kg. (2.87 \$/kg * 1000 kg/mt = 2,870 \$/mt)
Monazite and ?	Mischmetal: . No data were available, therefore the estimated value of shipments may be low.
RHENIUM:	
Production:	Mineral Commodity Summary 1997 (p137). Production 1996: 18,500 kg. (18,500 kg * 1 mt/1000 kg = 19 mt
Price:	Mineral Commodity Summary 1997 (p137), Price 1996, average value, Metal powder, 99.99% pure - 1,100 \$/kg, (1,100 \$/kg * 1,000 kg/mt = 1,100,000 \$/mt)

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SCANDIUM: Production: Price:	Estimated based in engineering judgement: 25 mt Mineral Commodity Summary 1997, Price, 1996 yearend, oxide 99.9% purity 1,400 S/kg. (1,400 \$/kg * 1,000 kg/mt = 1,400,000 \$/mt)
SELENIUM: Production: Price:	Mineral Commodity Summary 1997, Production 1996, refinery: 350 mt Mineral Commodity Summary 1997, Price, dealers, average, 100 pound lots, refined: 3.20 \$/pound. (3.20 \$/pound * 2204.623 pounds/mt = 7,055 \$/mt)
SYNTHETIC R Production: Price:	UTILE: Mineral Commodity Specialist 1994: 140,000 mt Mineral Commodity Summary 1997 (p 140), Price, 1996 yearend: Bulk, f.o.b. Australian ports - 650 \$/mt.
· · ·	COLUMBIUM, AND FERROCOLUMBIUM:
Tantalum: Production :	Mineral Commodity Summary 1997 (p 170), consumption 1996: reported, raw material 490,000 kg. (490,000 kg * 1 mt/1000 kg = 490 mt)
Price:	Mineral Commodity Summary 1997(p 170): 27.75 \$/pound (27.75 \$/pound * 2204.623 pounds/mt = 61,178 \$/mt)
Columbium: Production: Price:	Mineral Commodity Summary 1997 (p51), Consumption, apparent 3,800,000 kg. (3,800,000 kg * 1 mt/1000 kg = 3.800 mt) Mineral Commodity Summary 1997 (p51), Price 1996: Columbite 3.00 \$/pound. (3.00
	S/pound * 2204.623 pounds/mt = 6613 S/mt)
Ferrocolumbiu Production:	im: Mineral Commodity Summary 1997 (p 51) Consumption 1996, reported: 2,800,000 kg. (2,800,000 kg * 1 mt/1,000 kg = 2,800 mt)
Price:	Mineral Commodity Summary 1997 (p 51) Price of steelmaking grade Ferrocolumbium 6.58 \$/pound. (6.58 \$/pound * 2204.623 pound/mt = 14,506 \$/mt)
TELLURIUM: Production:	Tellurium is primarily produced from copper tankhouse (or anode) slimes. The reported waste generation of these slimes was 4.000 mt/yr. We estimated that no more than 10 percent of this stream was tellurium, and hence, the generation rate of tellurium was 400 mt/yr.
Price:	mt/yr. Mineral Commodity Summary 1997 (p172) Price 1996, 99.7% minimum: 21 \$/pound. - (21 \$/pound * 2204.623 pounds/mt = 45,287 \$/mt)
,	D THANIUM DIOXIDE:
Titanium Diox Production: Price:	 Mineral Commodity Summary 1997, Titanium Dioxide -Production 1996-1,230,000 mt Mineral Commodity Summary 1997, Titanium Dioxide, 1996 Price, rutile. list, yearend: 1.09 \$/pound. (1.09 \$/pound * 2204.623 pound/int = 2403 \$/mt).

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Titanium Spor	
Production:	Mineral Commodity Summary 1994: 25,000 mt (estimated based upon 1989 and 1990 production levels).
Price:	Mineral Commodity Summary 1997, (p 181) Price 1996 yearend 4.50 \$/pound. (4.40 S/pound * 2204.623 pound/mt = 9920 S/mt)
TUNGSTEN:	
Production:	Mineral Commodity Specialist 1996: 8,449 mt.
Price	Mineral Commodity Summary 1997 Price 1996, concentrate average: US spot market, Metals Week - 67 \$/mtu W ² O: (67 \$/mtu * mtu/7.93 kg * 1000 kg/mt = 8449 \$/mt)
URANIUM:	
Production:	Energy Information Administration, Uranium Industry Annual 1997, April 1997 (p13) Production, 1997: 4,700,000 pounds. (4,700,000 pounds * mt/2204.623 pounds = 2132 mt)
Price:	Energy Information Administration, Uranium Industry Annual 1997, April 1997 (p12) Price 1997: 14.12 S/pound. (14.12 \$/pound * 2204.623 pounds/mt = 31,130 \$/mt)
ZINC:	
Production:	Mineral Commodity Summary 1997, (p190) Production 1996: Mine recoverable 620.000 mt.
Price	Mineral Commodity Summary 1997 (p190) Price 1996: average, Domestic producers - 51.0 cents/pound. (.51 \$/pound * 2204.623 pounds/mt = 1124 \$/mt)
ZIRCONIUM A	ND HAFNTUM:
Production:	Mineral Commodity Specialist 1993: 9,000 mt/yr
Price	Mineral Commodity Summary 1997, (p192) Price 1996: Zirconium Sponge 9-12 \$/pound (Average 9-12 \$/pound * 2204.623 \$/mt = 22,146 \$/mt)
Hafnium:	
Production:	Mineral Commodity Specialist 1993 - 900 mt/yr

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Mineral Commodity Summary 1997, (p192) Price 1996: Hafnium Sponge 165 - 210 S/kg (Average 165-210 S/kg * 1000 kg/mt = 185,000 \$/mt)

Price:

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Calculations for Value Added For Industry Sectors in SIC 3339

Value Added by Manufactures = 989,900,000							
Sector	Value of Shipments \$	Ratio of Sector/Total Shipments	Value Added (Ratio x Value Added) \$				
Antimony	67,355,100	0.0074594	7,384,05				
Beryllium	76,522,880	0.0084747	<u>8,389,10</u>				
Bismuth	8,606,400	0.0009531	943,50				
Cadmium	3,996,200	0.0004426	438,09				
Germanium	36,000,000	0.0039869	3,946,63				
Gold and Silver	3.584,214,601	0.3969419	392,932,80				
Lead	365,840,000	0.0405158	40,106,56				
Magnesium and Magnesia	551,694,000	0.0610986	60,481,49				
Platinum Group Metals	42.792.580	0.0047392	4,691,29				
Rhenium	20,900,000	0.0023146	2,291,24				
Selenium	2,469.250	0.0002735	270,70				
Tellurium	2,777.220	0.0003076	304,46				
Titanium and Titanium Dioxide	3,203,707,220	0.3548018	351,218,27				
Zinc	696,880,000	0.0771775	76,398,05				
Zirconium and Hafnium	365,814,000	0.0405129	40,103,71				
TOTAL VALUE	9,029,569,451	1.00	989,900,00				

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RISK AND BENEFITS ASSESSMENT FOR THE STORAGE OF RECYCLED MATERIALS

APPENDIX J

This appendix presents a brief summary of the groundwater (Section J.1) and the multipathway (Section J.2) risk assessment for the land storage of newly-identified mineral processing wastes under the modified prior treatment baseline. This effort builds on previous efforts on the identification of recycled waste streams, the estimation of recycled volumes, the identification of waste management strategies, and in the development of waste constituent concentration data, described in the December 1995¹ and August 1996² Draft RIAs for the Phase IV LDRs and in the Technical Memorandum reporting the Revised Risk Assessment Results for groundwater submitted to EPA in July, 1996.³

The analyses presented in this appendix differ from the previous risk assessments for mineral processing wastes, first, in that risks from land storage, rather than ultimate disposal, are evaluated. The assessment is limited to only those waste streams that have been identified as being recycled by the Agency. This effort also differs from previous risk assessments in that it only addresses risks under the modified prior treatment baseline, and does not quantitatively evaluate residual risks under any of the proposed regulatory alternatives. This is because, under three of the regulatory alternatives, requirements would be imposed requiring the storage of recycled materials in either buildings or tanks, rather than on the ground, and release and transport models appropriate to evaluating risks associated with these technologies are not available. Thus, the assessment presented below evaluates only "baseline" risks by identifying specific waste streams and constituents posing risks of regulatory concern under the modified prior treatment assumptions. These risks would be reduced under the proposed regulatory controls, but quantitative estimates of the benefits of these regulatory controls (e.g. the numbers of facilities going from high-risk to low-risk categories) are not developed. Under Option 4, no controls would be imposed on the storage of recycled materials, so there would be no health benefits.

Finally, the risk assessment described in this appendix differs from previous risk assessments for mineral processing wastes in that risks are evaluated for pathways other than groundwater ingestion. As in previous risk assessments, we evaluate leachate releases from land-based units to groundwater and subsequent groundwater ingestion. However, in Section J.2 we evaluate the risks associated with other release events, transport and exposure media, and exposure pathways. This multipathway analysis evaluates risks associated with air particulate and surface runoff releases from waste piles, and risks arising from surface impoundment runon events and inlet/outlet control failures. The transport and exposure media that are evaluated include air, soil and surface water, as well as home-grown crops and game fish.

³ ICF Incorporated. Revised Results of Mineral Processing Wastes Risk and Benefits Assessments Using Constituent-Specific DAFs Derived for Mineral Processing Waste, Submitted to the Office of Solid Waste, US Environmental Protection Agency, July 1, 1996.

¹ ICF Incorporated, Regulatory Impact Analysis of the Supplemental Proposed Rules Applying Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes, Submitted to the Office of Solid Waste, US Environmental Protection Agency, December 1995.

² ICF Incorporated, Regulatory Impact Analysis of the Application of Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes, Submitted to the Office of Solid Waste, US Environmental Protection Agency, August 1996.

J.1 RISK ASSESSMENT METHODS AND RESULTS FOR THE GROUNDWATER PATHWAY

This section of Appendix J presents a brief summary of the groundwater pathway risk assessment for the land storage of newly identified mineral processing wastes under the Modified Prior Treatment baseline. The analyses presented below employ very similar methods for estimating constituent releases, groundwater exposure concentrations, and health risks as were employed in the previous analyses. The only major differences from previous efforts are that groundwater DAFs have been derived using constituent concentration data for only those facilities and waste streams identified as being involved in recycling, and that the DAFs have been derived assuming a release duration of 20 years, corresponding the assumed life of the recycling storage facilities, instead of the much longer release period assumed for disposal facilities. This section addresses only those potential health risks arising from exposures through consumption of contaminated groundwater. Potential risks associated with other release, transport, and exposure pathways are evaluated in Section J.2.

J.1.1 Methods and Assumptions

J.1.1.1 Regulatory Scenarios

As noted previously, risks have been assessed for the modified prior treatment baseline. Under this baseline, it is assumed that recycled spent materials and sludges and byproducts from mineral processing will be stored land-based units prior to recycling. Nonwastewaters would be stored in unlined waste piles, and wastewater and liquid nonwastewater streams would be stored in unlined surface impoundments. Unlike the situation for disposal facilities, it is assumed that, where two or more recycled streams are generated at a facility, the streams would be stored in separate units prior to recycling, and that there would be no comanagement. Also, it has been assumed that the storage units would be sized to just accommodate the required amount of recycled material; three months' generation rates in the case of nonwastewaters, and one month's generation in the case of wastewaters and liquid nonwastewaters. The assumptions used to evaluate the size and configuration of storage facilities are described in detail in the December 1995 RIA and in Appendix D of this RIA.

J.1.1.2 Identification of Waste Streams

Under the modified prior treatment baseline, it is assumed that all recycled spent materials and recycled sludges and byproducts would be managed in land-based units. Thus, all of these waste streams were candidates for the storage risk assessment. Constituent concentration data were available for only some of these streams, however. Risks were therefore evaluated only for the 14 recycled waste streams listed in Exhibit J-1. Two of the waste streams (aluminum and alumina cast house dust and zinc waste ferrosilicon) are nonwastewaters, and the remainder are wastewaters or figurd nonwastewaters.

Although groundwater pathway risks were calculated for only 14 of the 117 total mineral processing waste streams, these streams represent substantial proportions of the total generated wastes and an even higher-proportion of the recycled wastes. Depending on which estimate of waste generation is used (minimum, expected, or maximum), the 14 recycled streams included in the risk analysis represent between 32 and 61 percent of the total waste generation, and account for between 60 and 89 percent of the total recycled volume. This is because constituent concentration data are available for a substantial proportion of the high-volume waste streams. The extent of coverage of the storage risk assessment for the various commodity sectors is summarized in Attachment J.A to this appendix.

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J.1.1.3 Waste Characterization Data and Release Concentration Estimates

The original source of constituent concentration data for the recycled materials used in the pre-LDR risk estimates is the same as that used in the RIA sample-specific risk assessment. These data are summarized in Appendix K of the December 1995 RIA. Consistent with the previous risk assessment, constituent concentration data from both bulk samples and EP extraction analysis were used in the risk assessment, when they were available, to develop separate risk estimates for the same waste streams. This was done in order to make the best possible use of the available data, and because in many cases we could not be sure that EP and bulk analyses from a given waste stream were from the same samples or batch of waste.

Commodity	Recycled Stream
Aluminum and Alumina	Cast House Dust
Beryllium	Spent Barren Filtrate Streams
Beryllium	Chip Treatment Wastewater
Copper	Acid Plant Blowdown
Elemental Phosphorus	Furnace Scrubber Blowdown
Rare Earths	Process Wastewater
Selenium	Plant Process Wastewater
Tantalum, Columbium, and Ferrocolumbium	Process Wastewater
Titanium and Titanium Oxide	Leach Liquor and Sponge Wastewater
Titanium and Titanium Oxide	Scrap Milling Scrubber Water
Zinc	Waste Ferrosilicon
Zinc	Spent Surface Impoundment Liquids
Zinc	Waste Water Treatment Plant Liquid Effluent
Zinc	Process Wastewater

Exhibit J-1 Recycled Streams Included in The Storage Risk Analysis

Constituent data from 187 waste samples were used to develop DAF values and to evaluate risks from land storage. Exhibit J-2 presents a breakdown of the samples by facility and types of analysis. It can be seen that the large majority of the data come from bulk samples, and the majority of the samples are from facilities whose identities and locations are unknown. Only three of the 187 samples are from nonwastewater streams managed in waste piles, with the remainder from wastewater and liquid nonwastewater streams managed in surface impoundments.

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Waste Type	Bulk Samples	EP Extraction Sample	Known Facilities	Unknown Facilities
Nonwastewater	2	1	0	ž
Wastewater	97	27	68	56
Liquid Nonwastewater	49	16	12	53

Exhibit J-2				
Distribution of Samples by Waste,	Sample, and Facility Type			

Arsenic concentration data were available for 75 of the waste samples, allowing the calculation of cancer risks for these samples. Noncarcinogen concentration data for constituents having DAF values and RfDs were available for 136 samples, which include all 75 of those with arsenic data. For WW streams, the bulk concentration sample results were used directly as release concentration estimates. For LNWW and NWW, EP leachate concentrations were also used directly as release concentrations. For LNWW and WW bulk samples, release concentrations (mg/l) were conservatively estimated as being equal to the bulk constituent concentrations (mg/kg) divided by 20. This approach conservatively assumes that all waste constituents are 100 percent leachable.

. All of the analytical results from every sample were used to evaluate risks, with one exception. A single bilk analytical result for selenium (100,000 mg/l) in zinc process wastewater was omitted from the risk analysis because this value far exceeds the maximum solubility of most naturally occurring selenium compounds, and is clearly spurious, based on the results for other samples from the same waste stream.

J.1.1.4 Exposure Assessment

Analogous to the procedures used in previous risk assessments, two sets exposure of exposure estimates were developed. Central tendency (CT) exposure concentrations were estimated by dividing the release concentrations of each constituent from each waste stream by the 75th percentile DAF value derived for that constituent. High-end (HE) exposure concentrations were estimating by dividing the release concentrations by the 95th percentile DAF values. The rationale for using the 75th percentile DAFs rather than, for example, the 50th percentile value was that the EPACMTP model used to derive DAFs does not consider fractured or channeled flow or other facilitated transport mechanisms which may occur at some sites, resulting in higher groundwater concentrations than those predicted for homogeneous flow processes modeled by EPACMTP. The 75th percentile of the DAF distribution was therefore judged by EPA to be more nearly representative of dilution conditions for the entire population of facilities than the 50th percentile. The 95th percentile constituent-specific DAF values were used to estimate high-end (HE) groundwater concentrations in keeping with the definition of a high-end receptor as someone exposed at levels between the 90th and 99th percentiles of all exposed individuals. Separate exposure and risk estimates were developed for each waste sample, analogous to the approach used for the analysis of disposal risks. DAF values were derived separately for waste piles and surface impoundments, and used to estimate exposure concentrations for nonwastewaters and liquid nonwastewaters/wastewaters, respectively. The DAF values derived by EPA for use in the mineral processing recycled materials storage risk assessment are shown in Exhibit J-3.

It can be seen from this exhibit that the DAF values (both the 75th and 95th percentile) derived for the management of recycled materials in waste piles are generally very much higher than those derived for

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surface impoundments. This is due primarily to the lower leachate volume generated by the waste piles than by surface impoundments. In the waste piles, leachate generation is limited by rainfall (and a large propertion of the facilities are in relatively dry areas), whereas surface impoundments provide their own leachate source to drive releases, in the form of the aqueous liquid wastes which they contain.

For all of the constituents, the CT DAF values for waste piles are greater than 10^{12} , implying, as will be seen below, such high dilutions of leachate that CT risks from all the constituents released from waste piles are well below levels of regulatory concern. The HE DAF value for waste piles are much lower for most constituents (in the range of 10^4 to 10^6), but still generally several orders of magnitude above even the corresponding HE values for surface impoundments. Thus, even the HE exposure concentrations associated with releases from waste piles result in relatively low risks.

The CT surface impoundment DAF values for all of the constituents but cyanide, lead, and mercury are all around 1000. The HE DAF values surface impoundments are mostly less than 100, with the exceptions being vanadium, cyanide and lead. As will be seen below, these lower DAF values imply higher risks for given constituent concentrations than do the DAF values for waste piles.

Constituent	Waste Pile DAF		Surface Impoundment DAF	
	75th Percentile	95th Percentile	75th Percentile	95th Percentile
Antimony	>101	2.0X10 ^r	2.7X10 ³	5.3X10 ²
Arsenic	>1012	1.8X10 ⁶	1.1X10*	3.37X10
Barium	>1012	1.2X10 ⁴	1.5X10 ²	2.9
Cadmium	>1012	2.4 X 10*	2.1 X 10 ³	1.3X10
Chromium (+6)	>10 ¹²	9.9X10 ⁴	6.3 X 10 ²	2.4X10'
Cyanide	NA*	NA	2.9 X 10 ⁹	1.8X10 ³
Lead	>1012	>10 ¹²	>10'2	1.2X10 ³
Mercury	>10 ⁻²	3.3X10°	1.5X10 ³	2.6X10'
Nickel	>10 ^{:2}	3 4X10°	1.6X10 ³	1.2X10 ¹
Selen.um	>10 ¹²	2 4X10 ⁴	1.9X10 ²	6.2
Silver	>10 ²	2.5X10 ⁴	4.3X10 ²	4.2
Thailium	NA	NA	3.5X10 ³	9.0X10 ¹
Vanadium	NA	NA	>10''	>10*
Zine	>10'`	5.8X10 ⁶	6.7X10 ²	3.9

Exhibit J-3 DAF Values Used in the Storage Risk Assessment

* DAFs were not derived for these constituents because no analytical data were reported for these constituents in any of the wastes disposed in waste piles.

J.1.1.5 Risk Characterization

Daily intakes of the waste constituents due to groundwater ingestion are estimated in precisely the same way as described in the July memorandum.² For arsenic, (the only constituent considered to be carcinogenic by ingestion), lifetime daily intake is calculated for a 70-kg adult drinking 1.4 liters per day of contaminated groundwater 350 days per year for nine years, assuming a 70-year life-span for averaging purposes. Daily intakes of noncarcinogens are calculated using the same assumptions, except that the dose is averaged over the period of exposure, rather than over a lifetime.

Lifetime cancer risks are calculated by multiplying the lifetime daily arsenic intake (from those waste streams having arsenic as a constituent) by the ingestion Cancer Slope Factor for arsenic of 1.5 (mg/kg-day)⁻¹. Noncancer hazard quotients for exposure to waste constituents are calculated by dividing the daily constituent intake of each constituent by its ingestion pathway Reference Dose (RfD). The toxicity values used in the assessment all come from EPA's IRIS database, and are current as of December 1996.

J.1.2 Estimation of Numbers of Facilities at Specific Risk Levels

In the previous risk and benefits assessments performed for the disposal of mineral processing wastes, the measure of the benefits of the regulatory alternatives was the reduction in the number of facilities at which waste management would results in risks above levels of regulatory concern. As noted previously, no risk assessment has been performed for the storage of recycled materials under any of the regulatory alternatives. Thus, a similar quantitative benefits assessment is not possible for waste storage under the various regulatory alternatives.

This risk assessment, however, does provide an estimate of the numbers of facilities in the various commodity sectors at which risks exceed levels of regulatory concern under the modified prior treatment baseline. This estimate presents an upper bound limit on the possible regulatory benefits; e.g., if regulation reduced releases of all waste constituents to zero, then all of the baseline risks greater than levels of regulatory concern would go to zero as well. Less than perfect control of releases would result in correspondingly smaller reductions in the number of facilities at high risk levels (yielding lower benefits), although the magnitude of risk reduction has not been quantified.

J.1.2.1 Estimation of the Numbers of Facilities Storing Recycled Materials

Risks have been assessed for all of the commodity sectors and waste stream which have been identified by the Agency as being involved in recycling under the modified prior treatment baseline, and for which constituent concentration data are available, as identified in Exhibit J-1. In this analysis, it has been assumed that all of the facilities in each commodity sector not only generate but store recycled sludges, byproducts, and spent materials. Thus, the numbers of facilities included in the assessment are simply equal the estimated numbers of facilities in the commodity sector, which is exactly analogous to the approach taken in the analysis of the risks associated with waste disposal.

In this analysis, it has been assumed that all of the facilities identified as generating the recycled streams also recycle them, under both CT and HE assumptions. Thus, the number of waste stream-facility combinations in each commodity sector is the same for the HE and CT risk estimates. Analogous to the previous analysis, where a single facility stores more than one waste stream, it is counted as more than one "waste stream-facility combination."

J.1.2.2 Attribution of Risks to Facility-Waste Stream Combinations

As was the case for the analysis of disposal risks, the number of risk estimates (one from each sample) does not always equal (in fact, rarely equals) the number of facilities storing the wastes. Thus, in estimating the distribution of risks across a commodity sector it is necessary to apportion the risks from individual samples to the CT and HE numbers of facilities.

The procedures used to do this are described in detail in Section 2.2.2 of the July memorandum. Basically, the approach involves distributing risk levels across the facilities in commodity sector in as close to the same proportions as they are distributed across the individual waste samples from the waste generated by that sector. For example, if there are two samples of a given waste stream in the data base, one with an estimated cancer risk of 10^{-6} and one with an estimated risk of 10^{-2} , half the facilities in the commodity sector would be placed in the " $<10^{-5}$ " category, and half would fall into the " 10^{-3} to 10^{-20} " category. One of the outcomes of using this approach is that not every risk result above a level of concern translates into a waste stream-facility combination. For example if there is only a very small proportion of samples (for example, one in 20) giving high risks, this may translate into zero waste stream facility combinations if there are, for example, only two or three total facilities in the industry. The July memo describes the approaches used for rounding the estimates of facilities in the various risk categories, where apportionment cannot be done evenly, and for combining risk estimates from multiple samples from a single facility so, so as not to give them undue weight across an entire industry.

J.1.3 Results of the Groundwater Risk Assessment

J.1.3.1 Risk Assessment Results by Sample

Exhibit J-4 summarizes the carcinogenic groundwater risk results for the 75 samples identified as containing arsenic, the sole ingestion pathway carcinogen among the waste constituents. Using the central tendency DAF values, the calculated cancer risks for 48 of these samples were less than 10^{-3} , the level of regulatory concern, and the risks for 27 of the samples exceeded this value. Cancer risks exceeded 10^{-5} for one or more samples from only four waste streams; copper acid plant blowdown, elemental phosphorous furnace scrubber blowdown, tantalum, columbium, and ferrocolumbium process wastewater, and zinc spent surface impoundment liquids. The highest risks cancer risks were associated with three samples of copper acid plant blowdown (10^{-3} to 10^{-2}). This waste stream accounted for 14 of the 16 samples with the highest CT cancer risks. The next highest risks (in the 10^{-4} to 10^{-3} range) were associated with one sample each from tantalum process wastewater and zinc spent surface impoundment liquids.

Using the high-end (CT) DAF values, cancer risks calculated for the groundwater pathway exceeded 10^{15} for 49 of the 75 samples. Under this set of assumptions, risks for at least one sample exceeded 10^{15} for 10 of the 14 waste streams evaluated. The highest risks (highest risk category >10-1) were again associated with copper acid plant blowdown (4 of its 30 samples), with the next highest risk $(10^{12} \text{ to } 10^{11})$ being associated with the single sample of zinc spent surface impoundment liquids. Of the wastes whose CT cancer risks were below 10^{15} for all samples, five (rare earths process wastewater, selenium plant wastewater, titanium/TiO₂ leach liquor and sponge wash water and scrap milling scrubber water, and zinc process wastewaters), had at least one sample with HE cancer risks above this level.

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				Ce	ntral	Tender	1C <u>y</u>				High	End		
		Number of Samples with		10-5 to	10-4 to	10-3 to	10-2 to			10-5 to	10-4 to	10-3 to	10-2 to	
Commodity	Waste Stream	Cancer Risk	<10-5	10-4	10-3	10-2	10-1	>10-1	<10-5	10-4	10-3	10-2	10-1	>10-1
Aluminum and Alumina	Cast house dust	2	2	0	0	0	0	0	2	0	0	0	0	0
Beryllium Beryllium	Spent barren filtrate streams Chip treatment WW		 	0	0 0	0 0	0 0	0 0	1	0 0	1 0	0 0	0 0	0 0
Copper	Acid plant blowdown	30	9	7	8	3	3	0	5	3	5	8	5	4
Elemental Phosphorus	Furnace scrubber blowdown	8	7	1	0	0	0	0	3	3	2	0	0	0
Rare Earths	PWW	2	2	0	0	0	0	0	0	2	0	0	0	0
Selenium	Plant PWW	2	2	0	0	U	0	0	0	I	I	0	0	0
Tantalum, Columbium, and Ferrocolumbium.	PWW	13	10	2	l	0	0	0	7	3	0	3	0	0
Titanium and TiO ₂	Leach liquor & sponge wash water	2	2	0	0	0	0	0	0	L	1	0	0	0
Titanium and TiO,	Scrap milling scrubber water	i i	1	0	0	0	0	0	0	I.	0	0	0	0
Zine	Waste ferrosilicon	0	0	0	0	0	0	0	0	0	0	0	0	0
Zinc	Spent s.i. liquids	1	U	0	1	0	0	0	0	0	0	0	1	0
Zine	WWTP liquid effluent	0	0	0	0	0	0	0	0	0	0	0	0	0
Zine	Process wastewator	11	11	0	0	0	0	0	7	I	3	0	0	0.
Totals		75	48	1)	10	3	3	0	26	15	13	11	6	4

Exhibit J-4 Distribution of Samples by Groundwater Risk Category: Cancer Risks

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Cancer risks for most of the samples increased about two orders of magnitude from the CT to HE case. This is consistent with the difference between the CT and HE DAF values for arsenic managed in surface impoundments. In the case of the NWW waste streams managed in piles, both the CT and HE cancer risks for all samples were below 10⁻⁵. For aluminum/alumina cast house dust, this reflected the much higher CT and HE DAF values for arsenic managed in waste piles, compared to surface impoundments, as well on the relatively small mass of arsenic present in the waste pile. Arsenic was not detected in the single sample of waste ferrosilicon from zinc production. Thus, no carcinogenic risks were calculated for this waste. The two other streams for which all HE sample-specific cancer risks were below 10⁻⁵ were beryllium chip treatment wastewater and zinc wastewater treatment plant liquid effluent.

Noncancer hazard quotient values for groundwater pathway for the individual samples of recycled materials are summarized in Exhibit J-5. Using the CT DAF values, hazard quotient values exceeding 1.0 were calculated for 46 of 136 total samples from the 14 waste streams. As was the case for cancer risks, copper acid plant blowdown had the highest number of samples with noncancer hazard quotients above 1.0 (18 of 35 samples), and had the highest number of samples (4) in the highest risk category (HQ = 100 to 1000). Samples from zinc production (11 of 22 for spent surface impoundment liquids and 8 of 16 for process wastewater) account for the bulk of the remaining hazard quotients above 1.0. The only other waste streams with CT hazard quotients above 1.0 included beryllium spent barren filtrate streams (three samples), beryllium chip treatment wastewater (one sample), elemental phosphorous furnace scrubber blowdown (one sample), tantalum, etc., process waste water (three samples), and zinc wastewater treatment plant liquid effluent (one sample).

When the HE DAF values are used to calculate exposures, hazard quotients exceed 1.0 for 102 of the 136 samples. As was the case for cancer risks, most of the hazard quotient values for individual samples are increased one to two orders of magnitude in the HE case compared to the CT case, reflecting the changes in the DAF values for the risk driving constituents managed in surface impoundments. As for cancer risks, both the CT and HE DAF values for waste piles for all of the constituents are so high, and the masses of constituents are so low, that no samples of the two waste streams managed in waste piles have hazard quotients exceeding 1.0 in either the CT or HE case. Hazard quotient values for four waste streams that were all below 1.0 in the CT case exceeded 1.0 in the HE case for at least one sample (rare earth process wastewater, selenium process wastewater, and titanium/TiO₂ leach liquor and sponge wash water and scrap milling scrubber sludge).

J.1.3.2 Risk Driving Constituents

For all of the cancer risk calculations, arsenic, being the only ingestion pathway carcinogen among the constituents evaluated, was always the risk driver. In the case of noncancer risks, many constituents drove risks (had the highest hazard quotients) for the samples evaluated. The noncancer risk driving constituents (constituents with the highest HE hazard quotients) for the various waste streams are identified in Exhibit J-6.

				Ce	entral Te	ndency					Hig	h End		
		Number of Samples with Non-cancer		1 to	10 to	100 to	1k to			1 to	10 tu	100 to	1k to	
Commodity	Waste Stream	Hazard	<1	10	100	1k	10k	>10k	<1	10	100	lk	10k	>10k
Aluminum and Alumina	Cast house dust	2	2	0	0	0	0	0	2	0	0	0	0	0
Beryllium	Spent barren filtrate streams	4	ł	3	0	0	0	0	0	I	3	0	0	0
Beryllium	Chip treatment WW	1	0	0	1	0	0	0	0	0	0	0	1	0
Copper	Acid plant blowdown	35	17	10	4	4	0	0	3	7	12	7	4	2
Elemental Phosphorus	Furnace scrubber blowdown	14	13	I.	0	0	0	0	4	4	5	1	0	0
Rare Earths	PWW	4	4	0	0	0	0	0	2	2	0	0	0	0
Selenium	Plant PWW	2	2	0	U	0	0	0	0	2	0	0	0	0
Tantalum, Columbium, and Ferrocolumbium	PWW	21	18	3	0	0	0	U	13	3	0	5	0	0
Titanium and TiO ₂	Leach liquor & sponge wash water	2	2	0	0	0	0	0	0	ì	I	0	0	0
Titanium and TiO_2	Scrap milling scrubber water	l	1	0	0	0	0	0	0	1	0	0	0	0
Zinc	Waste ferrosilicon	i i	1	0	0	0	0	0	1	0	0	0	0	0
Zine	Spent s.i. liquids	22	11	5	4	2	0	0	4	3	2	7	2	4
Zinc	WWTP liquid effluent	3	2	0	0	1	0	0	0	1	1	0	0	ł
Zinc	Process wastewater	24	16	7	1	0	0	0	5	4	5	8	2	0
Totals		136	90	29	10	7	0	0	34	29	29	28	9	7

Exhibit J-5 Distribution of Samples by Groundwater Hazard Category: Non-cancer Hazards

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Commodity	Waste Stream	Driving Constituent (number of samples)
Aluminum and Alumina	Cast house dust	2 samples total; no hazard quotients greater than 1
Beryllium	Spent barren filtrate streams	Beryllium (4/7), Thallium (1)
Beryllium	Chip treatment WW	Beryllium (1/1)
Copper	Acid plant blowdown	Arsenic (15/35), Cadmium (11), Chromium (1), Lead (1), Selenium (1), Thallium (1), Zinc (2)
Elemental Phosphorus	Furnace scrubber blowdown	Cadmium (8/14), Chromium (1), Thallium (1)
Rare Earths	PWW	Thallium (2/4)
Selenium	Plant PWW	Arsenic (1/2), Thallium (1)
Tantalum, Columbium, and Ferrocolumbium	PWW	Antimony (1/21), Cadmium (3), Chromium (4)
Titanium and TiO ₂	Leach liquor & sponge wash water	Thallium (2/2)
Titanium and TiO ₂	Scrap milling scrubber water	Thallium (1/1)
Zinc	Waste ferrosilicon	1 sample total; no hazard quotients greater than 1
Zinc	Spent s.i. liquids	Cadmium (12/22), Zinc (6)
Zinc	WWTP liquid effluent	Cadmum (2/3), Zinc (1)
Zinc	Process wastewater	Cadmum (12/21*), Zine (7)

Exhibit J-6 Constituents Driving Non-cancer Hazard Quotients in Recycled Streams

* A sample with a selemum concentration of 100,000 ppm was excluded from the analysis

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J.1.2.3 Risk Assessment Results by Facility

The cancer risk results for the individual samples, distributed across the numbers of facilities generating and storing the wastes, are summarized in Exhibit J-7. Using the methods described in Section J 1 1.2, it was estimated that CT groundwater pathway cancer risks would exceed 10⁻⁵ at 11 of the 56 waste stream-facility facilities⁴. All of these waste stream-facility combinations were managing either beryllium spent barren filtrate streams (1 facility-waste stream combinations), copper acid plant blowdown (7 facility-waste stream combinations), or zinc spent surface impoundment liquids (3 combinations). These results, of course generally reflect the pattern of sample-specific risk results for the various waste sectors. It will be noted, however, that for two waste streams, findings of one or more sample with greater than 10^{-5} risks did not translate into any facility-waste combinations above 10³ risks. In the case of elemental phosphorous furnace scrubber blowdown, only one of seven samples had a cancer risk of just above 10⁻⁵. Distributed across two facilities estimated to be storing this waste, this result (one-seventh of the samples having risks above 10⁻⁵) was rounded down to zero. Similarly, in the case of tantalum, etc., process wastewater, three of thirteen samples with risks above 10⁻⁵ was again rounded downward to zero of two facility-waste stream combinations. This occurrence is the almost inevitable result of having so few facilities in so many industries, and the fact that non-integral numbers of waste-stream facility combinations are meaningless as risk or benefit indicators. It would be reasonable to interpret these results as indicating that either zero or one facility in these industries might have CT cancer risk above 10⁵.

When HE DAF values are used, the number of facility-waste stream combinations with cancer risks above 10⁵ increases to 23 of 56 facilities. Under HE assumptions, most of the waste streams show one or more facilities at risk levels above 10⁵, the exceptions being the four low-risk waste streams identified in Exhibit J-4. These include both the two NWW streams that would be stored in waste piles, as well as beryllium chip treatment wastewater and zinc wastewater treatment plant liquid effluent. As noted previously, arsenic is not reported as a constituent of the latter waste.

The distribution of facility-waste stream combinations by noncancer risk category is summarized in Exhibit J-8. Using the CT DAF values, 12 waste stream-facility combinations are identified as having noncancer hazard quotients greater than 1.0. Five of these facilities are managing copper acid plant blowdown, two are managing beryllium chip treatment wastewater, and two of the facility-waste stream combinations are associated with the management of zinc spent surface impoundment liquids.

Using HE DAF values, 27 waste stream-facility combinations are identified as being associated with noncancer hazard quotients above 1.0. Again, four waste streams have no facility- waste stream combinations with hazard quotients above levels of concern: aluminum/alumina cast house dust, rare earth process wastewater, tantalum, etc., process wastewater, and zinc waste ferrosilicon.

 4 Note that the totals in the risk categories do not sum exactly due to rounding. This is true for the following exhibit as well.

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		Number of Waste Stream Facility	Waste Stream/		Central Tendency						High End				
		Combination	<u>15* #</u>		10-5	10-4	10-3	10-2			10-5	10-4	10-3	10-2	
		Central	High		to	to	to	to			to	to	to	to	
Commodity	Waste Stream	Tendency	End	<10-5	10-4	10-3	10-2	10-1	>10-1	<10-5	10-4	10-3	10-2	10-1	>10-1
Aluminum and Alumina	Cast house dust	23	23	23	0	0	0	0	0	23	0	0	0	0	0
Beryllium	Spent barren filtrate streams	1	1	0	1	0	0	0	0	0	0	1	U	0	0
Beryllium	Chip treatment WW	2	2	2	0	0	U	0	0	2	0	υ	0	0	U
Copper	Acid plant blowdown	10	10	3	2	3	ŧ.	1	0	2	I	2	2	2	2
Elemental Phosphorus	Furnace scrubber blowdown	2	2	2	0	0	0	0	0	1	l	i	0	0	0
Rare Earths	PWW	1	I	1	0	0	0	0	0	U	1	0	υ	0	0
Selenium	Plant PWW	2	2	2	0	0	Ø	0	0	0	1	1	0	0	0
Tantalum, Columbium, and Ferrocolumbium	PWW	2	2	2	0	0	0	0	0	1	1	0	0	0	0
Titanium and TiO ₂	Leach liquor & sponge wash water	2	2	2	0	0	0	0	0	0	1	1	0	0	0
Titanium and TiO ₂	Scrap milling scrubber water	i	1	1	0	0	0	0	0	0	1	0	0	0	0
Zinc	Waste ferrosilicon	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Zine	Spent s.i. liquids	3	3	0	0	3	0	0	0	0	0	0	0	3	0
Zine	WWTP liquid effluent	3	3	0	0	0	0	0	0	0	0	0	0	0	0
Zine	Process wastewater	3	3	3	0	0	0	0	0	2	0	1	0	0	0
TOTALS*		56	56	40	3	6		1	0	30	7	6	3	5	2

Exhibit J-7 Distribution of Waste Stream-Facility Combinations by Groundwater Risk Category: Cancer Risks

* Sums by risk category may not add to the number of central or high-end waste stream/facility combinations due to rounding.

Includes waste stream/facility combinations with no cancer risk (but with an associated non-cancer hazard)

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Exhibit J-8 Distribution of Waste Stream-facility Combinations by Groundwater Hazard Category: Non-cancer Hazards

	•	Number of Waste Stream		C	entral '	Tenden	cy				High	End			
		Facility Combinations*			1	10	100	1k			1	10	100	lk	
		Central	High	1	to	to	to	to			to	to	to	to	
Commodity	Waste Stream	Tendency	End	<1	10	100	1k	10k	>10k	<1	* 10	100	lk	10k	>10k
Aluminum and Alumina	Cast house dust	23	23	23	0	0	0	0	υ	23	0	0	0	0	0
Beryllium	Spent barren filtrate streams	1	1	0	1	0	0	0	0	0	0	1	0	0	0
Beryllium	Chip treatment WW	2	2	0	0	2	0	0	0	0	0	0	0	2	0
Copper	Acid plant blowdown	10	10	4	3	1	1	0	0	L	2	3	2	1	1
Elemental Phosphorus	Furnace scrubber blowdown	2	2	2	0	0	0	0	0	1	I.	1	0	0	0
Rare Earths	PWW	1	1	1	0	0	0	0	0	1	0	0	0	0	0
Selenium	Plant PWW	2	2	2	0	0	0	0	U	0	2	0	0	0	0
Tantalum, Columbium, and Ferrocolumbium	PWW	. 5	2	2	0	0	0	0	0	I	0	U	O	0	0
Titanium and TiO ₂	Leach liquor & sponge wash water	2	2	2	0	0	0	0	0	0	1	I.	0	0	0
Titanium and TiO ₂	Scrap milling scrubber water	1	1	1	0	0	0	0	0	0	1	0	0	0	0
Zinc	Waste ferrosilicon	1	1	1	0	0	0	0	0	1	0	0	0	0	0
Zinc	Spent s.i. liquids	3	3	2	0	1	ł	0	0	0	0	0	1	0	I
Zinc	WWTP liquid etfluent	3	3	2	0	0	1	0	0	0	1	I	0	0	1
Zine	Process wastewater	3	3	2	1	0	0	0	0	1	1	1	ι	0	0
TOTALS*		56	56	44	5	4	3	0	0	29	ÿ	8	4	4	2

* Sums by hazard category may not add to the number of central or high end waste stream facility combinations due to rounding.

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J.1.4 Summary of Groundwater Pathway Risk Results

The preceding analysis indicates that the storage of some mineral processing recycled materials in land-based units under modified prior treatment baseline assumptions may be associated with significant health risks due to groundwater consumption. Cancer risks greater than 10^{-5} and hazard quotients greater than 1.0 are predicted for the minority of waste streams and individual samples under CT exposure assumptions and for the majority of waste streams and samples under HE exposure assumptions. Estimated cancer risks range up to 10^{-1} for some samples under CT exposure assumptions and exceed 10^{-1} under HE assumptions. Hazard quotient values similarly approach 1,000 under CT assumptions and exceed 10,000 for a few waste streams using the HE DAF values.

Copper acid plant blowdown has the largest number of samples with high cancer risks, and the highest cancer risks for this recycled stream exceed those for the next highest stream by one to two orders of magnitude. This stream also has the largest number of samples with hazard quotients above 1.0, followed by zinc spent surface impoundment liquids and process wastewater.

Aluminum/alumina cast house dust and zinc waste ferrosilicon are the only two waste streams for which no samples exceed 10⁻⁵ cancer risk or noncancer hazard quotient value of 1.0 under either CT or HE assumptions. These are the only two nonwastewater streams evaluated, and the low risk results are primarily a function of the very high DAF values for waste piles compared to the values derived for surface impoundments. Two other waste streams (beryllium chip treatment wastewater and zinc wastewater treatment plant liquid effluent) have low cancer risks even under HE assumptions, but one or more samples of each of these wastes is associated with hazard quotients greatly exceeding 1.0, even under CT assumptions.

Aluminum and alumina cast house dust (23 facilities) and copper acid plant blowdown (10 facilities) account for almost half the facilities evaluated in the analysis. As noted above, risks for the former stream are all low, so cast house dust has no waste stream-facility combinations above risk levels of concern. The majority of the waste stream-facility combinations managing copper acid plant blowdown, in contrast, are placed into risk categories above levels of concern under both CT and HE assumptions, and this waste stream contributes the largest number of waste stream-facility combinations at high risk levels of any waste stream.

On a volume basis, two streams (copper acid plant blowdown and zinc process wastewater) account for approximately 86 percent of the total recycled materials volume for which constituent concentration data are available. As noted above, copper acid plant blowdown is one of the highest-risk waste streams. While the cancer risks estimated for zinc process wastewater generally fall into the low-risk categories, the noncancer hazard indices associated with this waste stream are generally quite high, especially under HE assumptions.

J.1.5 Uncertainties/Limitation of Analysis

Most of the major sources of uncertainty for this risk assessment of storage of mineral processing recycled materials are the same as those for the previous analyses of mineral processing waste disposal. These uncertainties are discussed in detail in the cited references. To summarize briefly, the major uncertainties include:

• Limitations in data concerning the identities, amounts, constituent concentrations, and leaching behavior of the recycled materials.

- Limitations in data concerning the amounts of the specific recycled streams generated at specific facilities and the management methods used during storage.
- Limitation in knowledge concerning the locations, climatic, and hydrogeological settings at mineral processing facilities.
- Uncertainties and variability in the methods used to model leaching and groundwater transport (DAFs) of the toxic constituents of recycled materials.
- Uncertainties in the methods used to identify exposed receptors, estimate human exposures, and in characterizing the toxicological impacts of exposure to toxic constituents of recycled materials.

All of these sources of uncertainty (and variability) apply at least as much to the evaluation of storage risks as they did to the evaluation of risks from waste disposal. As noted above, the number of samples used to derive DAFs, and for estimating risks for the recycled materials, is quite limited, even more so than in the case of the waste disposal risk assessment. This is especially true for the nonwastewaters managed in waste piles, for which only three samples from two waste streams (all from unknown facilities) were available.

J.2 RISK ASSESSMENT METHODS AND RESULTS FOR NON-GROUNDWATER PATHWAYS

This section presents a summary of the risk assessment for the land storage of newly-identified mineral wastes under the non-groundwater modified prior treatment baseline.

J.2.1 Methods and Assumptions

J.2.1.1 Overview of Risk Assessment Methods

The multimedia risk assessment for the storage of mineral processing wastes employs many of the methods and assumptions used by EPA to develop the proposed risk-based exit levels for the Hazardous Waste Identification Rule (HWIR-Waste). The HWIR-Waste Technical Support Document⁵ provides a detailed description of methods for evaluating releases, characterizing transport, and estimating exposures and risks associated with a number of non-hazardous waste management units. Individual algorithms and equations from HWIR-Waste are used to evaluate human exposures and risks associated with specific types of release events from land-based units (waste piles and landfills) that manage mineral processing recycled materials. In most cases, the HWIR-Waste methods are used without significant modification. However, in some instances, models were adjusted or simplified to reflect the specific characteristics of the facilities and constituents being modeled. For example, since none of the constituents addressed in this effort are appreciably volatile, the volatilization release and depletion equations from the HWIR-Waste models were not used and, since the recycling storage units were assumed to operate for only 20 years, the long-term steady-state assumptions employed in HWIR-Waste to estimate media concentrations were not valid, and time-dependent methods were substituted. Because of the shorter operating life spans of the storage units, compared to the assumptions made in HWIR-Waste, we also eliminated the soil depletion algorithms related to leaching and runoff. Thus, all soil contaminants were assumed to be fully conserved for the entire exposure period. Finally, particulate release and transport models were used which differed

⁵ USEPA. Technical Support Document for the Hazardous Waste Identification Rule: Risk Assessment for Human and Ecological Receptors, Office of Solid Waste, August 1995.

slightly from those used in HWIR-Waste, and generic climatic assumptions were used in the evaluation of air transport. These methods are described in detail in Attachment J-B.

The same general assumptions regarding receptors and receptor behavior were employed in this analysis as were used in HWIR-Waste. With a few exceptions, the same values for exposure frequency and duration and other exposure factors are used as were employed in HWIR-Waste. Most of the exposure factors corresponded either to the adult resident, child resident, subsistence farmer, or subsistence fisher receptors defined in HWIR-Waste, depending on whichever had the highest exposures and risks. The only major exception was again related to the characteristics of the facilities being evaluated, in that release and exposure durations were adjusted to 20 years for "direct" pathways, corresponding to the assumed life-span of the management units. A full 30 years high-end exposure assumption is employed, however, for exposures to persistent constituents in soils.

Input data for the release models come from the database of waste constituent concentrations developed in support of the RIA (see Section J.1.1.3). In this case, however, only those streams are included which EPA has identified as having non-zero recycled volumes in the expected cost scenario of the modified prior treatment baseline. Facility characteristics and sizes from the least-cost management strategies developed in the RIA are used, as discussed in Section 3.0 of this RIA.

The exposure and risk assessment algorithms are applied in a screening mode to identify those management units, release events, and exposure pathways that may be associated with risks exceeding regulatory levels of concern. In the screening mode, relatively conservative assumptions regarding releases, exposures, and the toxicity characteristics of the waste constituents are used to provide a high degree of assurance that exposures that could be associated with significant risks are not missed. For most of the release events, high-end (HE) assumptions are first used to identify the highest risks pathways and constituents. If HE assumptions indicate that all risks are below levels of concern for a given pathway, no further risk assessment is performed. If HE risks are above levels of concern, central tendency (CT) assumptions are used to determine whether risks are still of concern for particular waste management units, waste streams, and constituents, and to help characterize the variability in risks that is associated with changes in key variables.

The risk assessment presented below summarizes risks for single-release events and exposure pathways. Risks are not summed across exposure pathways, unless it clear that exposure through one pathway would reasonably be associated with exposure through another pathway for the same receptor (risks from the ingestion of home-grown root and above ground vegetables are summed, for example). The risk assessment has not been structured to consider detailed mass balances across release events or exposure media, although each release event is evaluated to determine if it would result in a substantial reduction of the amount of constituent available for release by other events. As will be seen in Section J.2.2, no individual events were found that release substantial portions of the annual recycled volumes from any of the management units.

J.2.1.2 Regulatory Scenarios

As for the groundwater pathway, risks have been assessed for the modified prior treatment baseline. Under this baseline, it is assumed that recycled spent materials, sludges, and byproducts from mineral processing will be stored in land-based units prior to recycling. Nonwastewaters would be stored in unlined waste piles, and wastewater and liquid nonwastewater streams would be stored in unlined surface impoundments. Unlike the situation for disposal facilities, it is assumed that where two or more recycled streams are generated at a facility, the streams would be stored in separate units prior to recycling, and that there would be no comanagement. Also, it has been assumed that the storage units would be sized to just accommodate the required amount of recycled material — three months' recycled volume in the case of nonwastewaters, and one month's recycled volume in the case of wastewaters and liquid nonwastewaters. The assumptions used to evaluate the size and configuration of storage facilities are described in detail in the August 1996 RIA.

J.2.1.3 Identification of Recycled Waste Streams

The same 14 waste streams were evaluated as in the groundwater pathway assessment. Since the April 1997 RIA, the beryllium spent barren filtrate waste stream was added to the list of recycled waste streams. This wastestream is however not listed further in this Appendix as it was evaluated and found not to be a significant contributer to risk. As noted previously, the 14 streams which are evaluated account for between approximately 32 and 61 percent of the total waste generated, and for between about 60 and 89 percent of the annual recycled volume, depending on which estimates are used, from the mineral processing industries that have been evaluated. The extent of coverage of waste streams from the individual industry sectors is summarized in Attachment J.A to this appendix.

J.2.1.4 Waste Characterization Data

The same data sources related to waste constituent concentration were used as described for the groundwater pathway assessment in Section J.1. No data were available related to the particulate characteristics of the two waste streams managed in waste piles. A reasonably conservative set of assumptions were therefore developed regarding waste silt content, particle size distribution, and particle size density, based partially on assumptions used in HWIR-Waste and on assumptions made by EPA as part of previous risk assessment efforts for similar mineral processing waste streams. These assumptions are described in more detail in Attachment J.B.

J.2.1.5 Facility Characterization Data

As noted above, facility size and configuration were determined for each recycled waste stream as part of the cost and economic impact analysis for the proposed Mineral Processing LDR. These methods are described in detail of Appendix E of the August 1996 RIA. Under the modified prior treatment scenario, it is assumed that all 14 recycled streams will be managed in unlined land-based units, nonwastewaters in waste piles and wastewaters and liquid nonwastewaters in surface impoundments. The management units were assumed to be sized to just meet the needs of the recycling units. Based on the Agency's evaluation of recycling practices, and considering the constraints on the duration of storage under existing regulations, it was assumed that all recycling storage piles would be sized to accommodate one quarter of the annual recycled volumes for typical facilities in the various commodity sectors, and that surface impoundments would be sized to accommodate one-twelfth of the annual recycled volumes of liquid streams. Thus, all units disposing of the same waste streams in any given commodity sector are assumed to be the same size. Further, it is assumed that no comanagement of multiple waste streams would occur in any management units.

For costing purposes, waste piles have been assumed to be conical, with side slopes of 2:1. Piles are assumed to be unlined and uncovered, with no special controls of runoff or particulate suspension. For purposes of emissions estimation, it is assumed that the piles are at full capacity at all times, and that the entire annual recycled volumes of the waste streams pass through the units each year, being added and removed at uniform rates on every day of operation throughout the year. It is assumed that, below a minimum recycled volume (500 mt/yr per facility) it is cheaper to store recycled materials in roll-off containers than in piles, and recycled streams with an annual recycled volume less than this amount were therefore not included in the risk assessment for waste piles. There was also an upper limit on the height

and area of a single pile, but none of the recycled nonwastewater streams were recycled in large enough volumes to reach this limit.

Surface impoundments used for recycling were assumed to be rectangular in shape, with a 2:1 length:width ratio and a rectangular prism-shaped bottom with a maximum depth of seven feet. Again, streams with annual recycled volumes of less than 500 mt/year per facility were assumed to be managed in tanks or containers, rather than impoundments. All of the recycled wastewater and liquid nonwastewater streams for which constituent data were available equaled or exceeded this volume, and thus all of them were included in the risk assessment.

The characteristics of the units used to store the recycled streams prior to recycling are summarized in Exhibit J-9. It can be seen that the two nonwastewater streams are both relatively low-volume, and the management units are correspondingly small. The sizes of the surface impoundments for the storage of liquid waste streams, on the other hand, span the range of the smallest possible facility size (42 cubic meters for titanium/Ti0₂ scrap milling scrubber water) to extremely large (99,167 cubic meters for zinc process wastewater).

J.2.1.6 Identification of Release Pathways

The screening-level risk assessment addressed non-groundwater release events from waste piles and surface impoundments managing mineral processing recycled streams. As an initial step in the risk assessment, release events and pathways were identified and screened to determine which would be the most likely to result in significant health risks to human receptors. The initial menu of events that were considered came from the HWIR-Waste Technical Background Document. The results of the screening are summarized in Exhibit J-10. As noted previously, many release events were screened out because of the characteristics of the units or the wastes involved. For example, volatilization release were eliminated for all management units and streams, because none of the toxic constituents, in the chemical forms that they are likely to be present, would be appreciably-volatile.

The release events that have been addressed include the generation of air particulates and runoff from waste piles, and the releases of liquid recycled streams from surface impoundments due to inlet/outlet failures and runon events during large storms. Groundwater releases from these units have been addressed previously and are not further evaluated here.

Commodity	Recycled Stream	Facility Type ⁱ	Facility Volume (m ³)	Facility Area (m ²)
Aluminum and Alumina	Cast House Dust	WP	107	108
Beryllium	Chip Treatment Wastewater	SI	417	558
Copper	Acid Plant Blowdown	SI	22,083	10.441
Elemental Phosphorous	Furnace Scrubber Blowdown	SI	17,500	8.429
Rare Earths	Process Wastewater	SI	117	385
Selenium	Plant Process Wastewater	SI	550	631
Tantalum. Columbium, and Ferrocolumbium	Process Wastewater	SI	4,375	2,517
Titanium and Titanium Oxide	Leach Liquor and Sponge Wastewater	SI	4,000	2,341
Titanium and Titanium Oxide	Scrap Milling Scrubber Water	SI	42	340
Zine	Waste Ferrosilicon	WP	1,093	509
Zinc	Spent Surface Impoundment Liquids	SI	10.500	5,319
Zinc	Waste Water Treatment Plant Liquid Effluent	SI	7.250	3.850
Zinc	Process Wastewater	SI	99.167	43.334

Exhibit J-9 Facility Sizes for the Recycled Waste Streams

Notes: 1. SI = Surface Impoundment, WP = Waste Pile

Exhibit J-10 Release Events Retained in the Mineral Processing Screening Risk Assessment

Management Unit	Release Events
Waste Pile	Particulate Generation by Wind
	Particulate Generation by Materials Handling
	Surface Runoff due to Rain Events
Surface Impoundments	Releases Due to Inlet/Outlet Failures
	Releases Due to Runon Events

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J.2.1.7 Transport and Exposure Pathways

After releases from the land storage units, waste constituents may be transported or appear as contaminants in various environmental media, depending on the characteristics of the release event, the facility characteristics, and the environmental fate and transport properties of the constituents. In HWIR-waste, a large number of transport and exposure pathways were identified for the various units and waste/constituent types, only a minority of which were evaluated in this risk assessment. Reasons for excluding transport and exposure pathways from the assessment included (1) the pathways were not relevant to the units and waste being evaluated, (2) pathway models were not adequately developed or were too complex to apply in the context of this screening level assessment, or (3) it became apparent that the transport and exposure routes were very unlikely to be associated with significant risks. In some cases, simple screening-level models were substituted for the more detailed transport and exposure models from HWIR-Waste. Exhibit J-11 summarizes the fate and transport pathways that were evaluated in this assessment and provides a general description of the exposure and risk modeling procedures used to evaluate them.

Probably the most significant transport pathway that was omitted from the assessment was the discharge of groundwater to surface water. This pathway was not considered because of the absence of applicable DAF values and groundwater discharge volume estimates that would have allowed EPA to estimate surface water exposure concentrations.

J.2.1.8 Release, Transport, and Exposure Modeling

J.2.1.8.1 Air Particulate Generation, Meteorological Modeling, and Deposition on Soils

Airborne particulates generation from waste piles storing the two nonwastewater streams was estimated using EPA's SCREEN3 model. Long-term concentrations of particulates in air and long-term particulate deposition rates were calculated using the more detailed ISCST3 model. Because the locations of the facilities managing these streams are not known (all the analytical data come from facilities without identifiers), it was not possible to use site-specific meteorological or elimatic data in the modeling of particulate generation and transport. Therefore, the models were run using a generic "worst-case" set of meteorological input data that is provided on part of ISCST3 for use in screening level analyses. High-End (HE) exposure concentrations (air and deposition values) were estimated for the point of maximal long-term impact (111 meters from the unit boundary in the case of aluminum cast house dust, and 248 meters in the case of zinc waste ferrosilicon), and the central tendency (CT) exposure estimates were deriving using the air concentrations and deposition rates averaged at every 100 meters from the unit boundary out to a distance of 2000 meters in the direction of maximal impact. The procedures and assumptions used in particulate generation and transport modeling are described in more detail in Attachment J-B.

Unit Type	Release Event/ Medium	Transport Medium I	Transport Medium II	Transport Medium III	Exposure Pathway	Receptors	Modeling Approaches
Waste Pile	Particulate Generation by Wind, Materials Handling	Air			Inhalation	Adult Resident	SCREEN3 (Emissions) ISCST3 (Deposition) HWIR (Exposure/Risk)
		Air	Soil (deposition)		Ingestion	Child/Adult Resident	HWIR-Waste (Exposure/Risk)
	[Dermal	Child Resident	HWIR-Waste
		Air	Soil (deposition)	Crops	Ingestion	Subsistence Farmer	HWIR-Waste, modified for non-steady-state conditions (concentration in crops, vegetable intake, risk)
		Air	Scil/Water	Surface Water/Fish	Ingestion	Subsistence Fisher	Bounding analysis (100 percent deposition in water body)
Waste Pile	Runoff	Soil			Ingestion	Child Resident	Bounding analysis; 100 percent runoff to adjacent garden/yard. HWIR-Waste (exposure and risk)
					Dermal	Child Resident	Bounding analysis; 100 percent runoff to adjucent garden/yard, HWIR-Waste (exposure and risk)
		Soil	Crops		Ingestion	Subsistence Farmer	Bounding Analysis; HWIR-Waste
		Soil		Surface Water/Fish	Ingestion	Subsistence Fisher	Bounding analysis: 100 percent deposition to surface water: HWIR- Waste
Surface Impoundment	Control/ Berm Failure	Surface Water			Ingestion	Adult Resident	HWIR-Waste (Release algorithms, exposure, drinking water ingestion)
		Surface Water	Fish		Ingestion	Subsistence Fisher	HWIR-Waste (Releases, dilution, fish ingestion, risk)

Exhibit J-11 Exposure Pathway Modeling Summary for Mineral Processing Storage Risk Assessment

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As was the case for the meteorological data, very little information was available related to the physical characteristics (fraction of particulate present in waste, particle size distribution, particle density) of the nonwastewater streams. Data developed by EPA in previous analyses of potential risks from similar mineral processing wastes⁶ known to be managed in piles were used in the absence of information specific to aluminum cast house dust and zinc waste ferrosilicon. These data are summarized in Exhibit J-11, along with the other parameter values used to estimate exposure concentrations in soil resulting from particulate deposition.

Accumulation of particulate materials in soils was assumed to occur for the entire 20-year lifespan of the waste piles. Exposure to the contaminated soil was assumed to begin at the end of the deposition period (when soil concentrations of deposited constituents would be the greatest), and it was assumed that the deposited constituents would not be depleted from the soil by leaching, runoff, or volatilization (ks = zero). This latter assumption adds a degree of conservatism to the estimation of soil concentrations, as some proportion of the deposited inorganics might, in the real world, be removed by runoff or leaching.

The soil concentrations from soil deposition were calculated using a variation of Equation 6-1 in the HWIR-Waste Technical Support Document. The equation was first rearranged to allow the calculation of soil concentrations from deposition rates, instead of vice-versa, and the exponential terms relating to the depletion of deposited material from the soil were eliminated from the equation. The result is a simple relationship describing the dilution of the deposited constituents uniformly in the mass of soil represented by the mixed layer. Consistent with HWIR-Waste, shallow mixing depths (1 and 2.5 cm) were used to calculate exposure concentrations for use in the soil ingestion and dermal contact pathways, and greater mixing depths (10 and 20 cm), corresponding to tilled depths, were used to calculate soil concentrations for the root vegetable consumption pathway. All other parameter values were the same as those to calculate soil concentration in the HWIR-Waste assessment.

J.2.1.8.2 Deposition of Airborne Particulates into Surface Water

The parameter values used in the estimation of particulate pathway emissions and transport modeling are summarized in Exhibit J-12. In HWIR-Waste, the relationship between airborne particulates and surface water contamination is modeled by a complex set of equations that simulate the both the direct deposition of particulates to surface water, and the deposition to soils onto a watershed, followed by overland transport to surface water bodies. Given the lack of knowledge about the locations of the storage piles relative to watersheds and surface water bodies, the relatively small size of the piles, and the relatively small mass of particulate that is generated, we have employed a much simpler screening approach to estimate the maximum long-term surface water concentrations that could result from the deposition of airborne particulates.

The methods simply assumes that, ultimately, all of the particulate emitted from the storage piles will end up in surface water. This is equivalent to making the conservative assumption that all of the particulates will either be directly deposited onto a surface water body, or that for that fraction of particulates that are initially deposited to soil, the sediment delivery ratio for the watershed will be equal to 1.0.

⁶ USEPA, Risk Screening Analysis of Mining Wastes, Appendix F: Development of Particulate Emission Factors, (Draft), Office of Solid Waste, October 25, 1987.

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Variable	Description	CT Value	HE Value	Units	Source
SC	Silt Content (both streams)	1.6	9.1	percent	Footnote 5
	Particulate Size Distribution	66 49 32 18	66 49 32 18	percent < 15 um percent < 10 um percent < 5 um percent < 2.5 um	Footnote 5
PD	Particle Density	2.65	2.65	gm/cc	Value for SiO, (sand)
Achd	Area of Waste Pile (Cast House Dust)	108	108	m ²	Waste data base, cost/economic impact methodology
Afesi	Area of Waste Pile (Ferrosilicon)	509	509	m²	Waste data base. cost/economic impact methodology
Z	Soil Mixing Depth (Dermal and Ingestion Exposures)	25	1	em	Typical values for untilled soils
Z	Soil Mixing Depth (Root Vegetable Ingestion)	20	10	cm	Typical tillage depths
BD	Soil Bulk Density	1.5	1.2	gm/cm ³	Typical for U.S. soils
ks	Soil Loss Constant	0	0	years	Assumes no soil depletion of deposited materials
t	Deposition Period	20	20	years	Assumes unit lifespan of 20 years
DV	Surface Water Dilution Volume	3.0X10 [*]	1.3X10 ⁷	m ¹ /ye ^{ar}	Third- and Fifth- Order Stream Flow, respectively, HWIR- Waste Equation 7-69

Exhibit J-12 Parameter Values Used in Particulate Pathway Emissions and Transport Modeling

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An additional simplifying assumption has been made regarding the behavior of deposited particulate in the surface water bodies, and regarding the speciation and solubility of particle-bound constituents. To estimate surface water concentrations, it is assumed that all of the constituents will be in the dissolved or suspended phase, and that none will remain bound to, or buried in, bottom sediment. This assumption probably overestimates the concentrations of some constituents in the water column, as some proportion of them would probably remain insoluble and bound to sediment.

Following the HWIR-Waste methodology, the airborne particulate matter is assumed to be deposited in either a "fifth order" or "third order" stream. These are streams or rivers of a given size and annual flow rate that have been selected (HWIR-Waste Technical Background Document Section 7.7.6.2) as the HE and CT surface water bodies, respectively. The long-term average concentration of constituents in surface water resulting from airborne particulate deposition is thus:

 $Csw (mg/l) = \frac{PG * Cwaste}{DV * 1000 L/m^3}$ (1)

where PG is the annual particulate generation rate (in kg) from the waste pile, and DV is the surface water annual dilution volume as defined in Exhibit J-12. Since deposition is assumed to occur continuously throughout the year into a continuously flowing stream, there is no need to multiply by the 20-year facility life span.

J.2.1.8.3 Runoff to Surface Soils

The amount of waste released to surrounding soils from waste piles through runoff events was calculated using the Universal Soil Loss Equation (USLE), in a manner very similar to that described for waste piles in Section 7-4 of the HWIR-Waste Technical Support Document. As in the case of particulate releases, some of the assumptions and parameter values that were used were changed to reflect the characteristics of the units and wastes being addressed, and to address the specific geometry of the delivery of sediment to the surrounding soils.

The parameter values used in the estimation of releases to soils from the waste piles and the resulting concentrations of constituents in soils and surface water are summarized in Exhibit J-13. In calculating runoff releases, in the absence of data related to the specific wastes and pile configurations being evaluated, we used the same values for soil crodability (k) and length-slope factors (LS) as were used for Subtitle D waste piles in HWIR-Wastes. The rainfall factor values (R) were changed slightly, however. The CT value used in the analysis was selected from the data in Table 7-42 of the HWIR-Waste Technical Support Document to reflect rainfall frequencies in the western US (where the majority of mineral processing waste, by volume, is managed), while the HE value was selected to be more representative of nationally-averaged conditions. In this analysis, the values for the USLE cover factor © and control practices factor were increased to 1.0 in both the CT and HE cases. These values reflect the likelihood that an active storage pile would not have any vegetative cover, and the conservative assumption (consistent with the cost and economic analysis) that there would be no special precautions taken to prevent runoff losses.

Variable	Description	CT Value	HE Value	Units	Source
Xe	Runoff loss from waste pile	calculated	calculated	kg/m²- ycar	HWIR-Waste equation 7-52
Achd	Area of Waste Pile (Cast House Dust)	108	108	m²	Waste data base. cost/cconomic impact methodology
Afesi	Area of Waste Pile (Ferrosilicon)	509	509	m²	Waste data base, cost/economic impact methodology
R	USLE Rainfall Factor	50	110	years''	CT= Typical of western US HE = US Median value
LS	Length-Slope Factor	1	3		HWIR-Waste value for Subtitle D ash piles
К	Soil Erodability Factor	0.25	0.25	unitless	HWIR-Waste value for Subtitle D ash piles
с	Cover Factor	1	1	unitless	Assumes no vegetative cover on waste piles
Р	Control Practices Factor	1	1	unitless	Assumes no measures to control runot[
ſ	Radius of area contaminated by runoff	5,000	10.000	cm	Contamination is assumed to be distributed uniformly in a circular area around the conical piles
DV	Surface Water Dilution Volume	3.0X10 ^t	1.3X10 ⁷	m ³ /ycar	Third- and Fifth-Order Stream Flow, respectively, HWIR-Waste Equation 7- 69

Exhibit J-13 Parameter Values Used in Runoff Release and Transport Modeling from Waste Piles

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A very simple sediment delivery model was used to estimate the concentrations of waste constituents in soils resulting from runoff. Currently, the sediment delivery model in the HWIR-Waste modeling system is under review, and final decisions about the configurations of waste management units, buffer zones, and receiving areas have not been made. In the absence of a definitive model, soil concentrations were simply calculated by assuming that the conical waste piles would generate circular "plumes" of runoff that would deposit evenly within defined distances from the center of the piles. For HE exposure estimates, the area of soil contaminated by runoff was assumed to be 100 meters in diameter, while for CT exposures, the area of contaminated soil was assumed to be 200 meters in diameter, or four times larger. This approach assumes that a storage pile would be located near the edge of a facility, that exposed receptors would reside directly adjacent to the facility boundary, and that there would be no preferred runoff path or deposition areas. As was the case for air particulate deposition, it was again assumed that deposition would occur for 20 years, and that the deposited constituents would not be further depleted by runoff or leaching after initial deposition.

The soil concentration resulting from surface runoff from waste piles was thus calculated using the following equation:

$$Csoil (mg/kg) = \frac{Xe (kg/m^2-year) * Achd (or Afesi)(m^2) * Cwaste (mg/kg) * t (years)}{BD (gm cm^3) * Z (cm) * X ~ r^2 (cm^2) * 0.001 kg/gm}$$
(2)

where the variable definitions and values are given in Exhibit J-13.

This approach to estimating soil concentrations from waste pile runoff greatly simplifies the potentially complex processes that would, in the real world, govern the generation and distribution of runoff contamination. It is intended only as a conservative screening tool to provide indications of the relative risks associated with the various waste and constituents, and to provide a high degree of assurance in ruling out wastes and constituents that pose no significant risks through this pathway.

J.2.1.8.4 Runoff To Surface Water

The deposition of runoff to surface water bodies was evaluated using a screening approach analogous to that used to evaluate the impacts of airborne particulate deposition on surface water quality. Again, it was assumed that 100 percent of the runoff-borne constituents would eventually find their way into the CT or IIE streams. Thus, the equation used to estimate the concentration of runoff-borne constituents in surface water during the operation of the storage piles is:

$$Csw (mg!) = \frac{Xe (kg/m^2-year) * Achd (or Afesi)(m^2) * Cwaste (mg!kg)}{DV (m^3/year) * 1000 L/m^3}$$
(3)

The annual average runoff from the piles is again released to surface water and diluted in the CT or HE stream dilution volume (DV, see Exhibit J-13) to provide a long-term average water concentration. Again, it is assumed that none of the runoff materials would become buried in bottom sediment.

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J.2.1.8.5 Surface Impoundment Releases to Surface Water

To evaluate surface water concentrations associated with releases from surface impoundments, we used precisely the same method as used in HWIR-Waste (Equation 7-70). Again, the release model has been simplified by removal of all of the equations related to volatilization.

The equation from HWIR-Waste estimates releases to surface water from runon events (overtopping due to unusually high rainfall) and from inlet-outlet control failures. It does not include releases due to berm failure or leakage. The model is probabilistic, estimating long-term average releases of impoundment contents as a function of annual event probabilities. As was the case for air deposition and runoff from waste piles, the average surface water concentrations during facility operations are calculated assuming that the annual waste releases due to the two types of events (summed) are diluted into the annual flow of the CT and HE streams, without partitioning to sediment. The major variables used to estimate surface water concentrations of constituents from impoundment failure are summarized in Exhibit J-14.

Variable	Description	CT Value	HE Value	Units	Source
RV	Release volume (annual average)	Calculated	Calculated	m³/year	HWIR-Waste, equation 7- 70
Prunon	Probability of runon event	2X10-4	2 X 10 ⁻⁴	years ⁻¹	DPRA. 1991 (sec text)
Tflood	Duration of Flooding	21,600	21.600	seconds	DPRA, 1991
Vrunon	Runon velocity	0.5	0.5	m/sec	DPRA. 1991
-h	Difference in height between flood and berm	0.0127	0.0127	m	DPRA, 1991
A	Arca of surface impoundment	Waste- specific	Waste- specific	m²	Mineral Processing data base, cost/economic analysis
Pio	Probability of inlet/outlet control event	0.0107	0.0107	years '	DPRA, 1991
h	Berm height	0.457	0.457	m	DPRA, 1991

Exhibit J-14 Parameters Used in The Estimation of Surface Impoundment Releases to Surface Water And Soils

The uncertainty associated with release and exposure estimates from this pathway must be regarded as very high. The model was originally intended to estimate long-term average releases from rare acute events occurring over the course of very many years. Thus, it may not be appropriate for estimating releases from rather short-lived storage impoundments (20 years) being evaluated in this assessment. In addition, the model does not capture the effects of the single acute releases on water quality in the short-term. Finally, the model and the parameter values used to estimate releases were originally derived by EPA based on data from a sample of surface impoundments in the pulp and paper industry.⁷ It is likely that the designs, sizes and operating parameters for impoundments in the mineral processing industry are substantially different, and the expected releases could also be different. One feature of the model that tends to result in conservatism in the exposure estimates from this pathway is that no dilution of recycled materials by runon events is assumed. In an actual extreme runon event, dilution of the wastes could be substantial, lowering the concentration of released materials.

J.2.1.9 Exposure and Risk Characterization

J.2.1.9.1 Toxicological Criteria

With a single exception, quantitative risk estimates have been developed using toxicity criteria values obtained from USEPA's IRIS data base or the HEAST tables and updates. To calculate inhalation pathway cancer risks and noncancer hazard quotients, inhalation Unit Risk and chronic inhalation pathway Reference Concentration (RfC) values are used. For the ingestion pathways, Cancer Slope Factors (CSFs) and chronic Reference Doses (RfDs) are used. The IRIS values are current as of December 1996. These values are summarized in Exhibit J-15.

Ingestion pathway RfD values are available for all of the constituents except lead (see below). Arsenic is the only constituent that is considered to be an ingestion pathway carcinogen in this assessment, so it is the only constituent with an ingestion pathway CSF. Inhalation pathway RfCs were available for only two of the constituents (barium and mercury), so inhalation pathway hazard quotients could be calculated only for these elements. Inhalation cancer Unit Risk values are available for five constituents considered to be inhalation pathway carcinogens, however.

Inorganic lead was the only constituent for which a different approach to risk characterization was employed. Since there is no RfD or RfC value for lead, the toxicity criterion that was used to evaluate potential noncancer risks associated with lead exposure was the Clean Water Act MCL of 15 ug/L. This value was used to evaluate concentrations in surface water arising from particulate deposition and runoff. assuming, in effect, that the water body would be used as a drinking water supply. Risks associated with lead exposure through other pathways were not evaluated because of the lack of acceptable toxicity criteria tor these pathways.

⁷ DPRA. Surface Water Control Berms for Pulp and Paper Mill Sludge Landfills and Surface Impoundments, Memo to Priscilla Halloran, OSW, July 18 1991.

Constituent	Ingestion Pathway Cancer Slope Factor (mg-kg-day) ⁻¹	Inhalation Pathway Unit Risk (ug/m ³) ⁻¹	Chronic Ingestion Pathway Reference Dose (mg/kg-day)	Chronic Inhalation Pathway Reference Concentration (mg/m ³)
Antimony			4X10 ⁻⁴	
Arsenic	1.5	4.3x10 ⁻³		
Barium			7X10 ²	5X104
Beryllium	4.3	2.4X10 ⁻³	5X10-3	
Cadmium		1.8X10 ⁻³	5X104	
Chremium (VI)		1.2X10 ^{-:}	5X10 ⁻³	
Lead			0.015 mg/L ²	
Mercury			3X10 ⁻⁴	3X10 ⁻⁴
Nickel		4.8X10 ⁻⁴	2X10 ⁻⁷	
Selenium			5X10 ⁻³	
Silver			5X10-3	
Thallium			8X10-5	
Vanadium			7X10-3	
Zinc			3X10-1	

Exhibit J-15 Toxicity Criteria Values Used in the Mineral Processing Storage Risk Assessment

Notes:

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Not used in risk assessment because of low weight of evidence
 Based on the Safe Drinking Water Act MCL for inorganic lead.

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For purposes of the assessment, it was assumed that all of the chromium present in the stored waste streams would be in the more toxic hexavalent form. This assumption will overstate risks when (as in most cases) the bulk of the chromium is in lower oxidation states.

J.2.1.9.2 Inhalation

Risks associated with inhalation pathway exposure to particulates released from waste piles are calculated directly from the estimated particulate concentrations in air generated by the ISCST3 model. Lifetime cancer risks associated with exposure to airborne particulates are calculated as:

Risk =
$$C_{\text{part}} (ug/m^3) * C_{\text{masse}} (mg/kg) * 10^6 kg/mg * UR (ug/m^3)^{-1}$$
 (4)

where C_{part} is the particulate concentration from the ISCST model, C_{waste} is the concentration of arsenic in the waste sample, and UR is the unit risk value constituent.

Inhalation noncancer hazard quotients are calculated as:

$$HQ = \frac{C_{part} (ug/m^3) * C_{waste} (mg/kg) * 10^{.6} kg/mg * 10^{.3} mg/ug}{RfC (mg/m^3)}$$
(5)

In both cases, the receptor is an adult resident, residing at either the point of maximum long-term air concentration (HE estimate), or at the point of average concentration within 2000 m of the facility (CT estimate). For screening purposes, exposure is assumed to be continuous for 365 days per year, and for carcinogenic constituents, the exposure duration is assumed to be the 20-year operating lifespan of the facility. As will be seen in Section J.2.1, in both the CT and HE cases, cancer risks were all below 10⁵ and inhalation hazard quotients were all below 1.0 under these very conservative screening assumptions, so more refined modeling scenarios were not developed for this pathway.

J.2.1.9.3 Soil Ingestion and Dermal Contact

Cancer and chronic noncancer risks were evaluated for dermal and incidental ingestion exposures to soil contaminated by particulate deposition (Section J.2.1.9.3) and by deposition of surface runoff (Section J.2.1.9.4). For each pathway, the soil concentrations after 20 years of deposition were used as inputs to the risk assessment, assuming no depletion of deposited materials from soils by volatilization, leaching, or runoff. For both the dermal and ingestion pathways, the shallower soil mixing depths (1.0 and 2.5 cm) were used to estimate soil concentrations of constituents consistent with the assumption of no tillage or soil disturbance.

Risks associated with soil ingestion were calculated using Equation 5-6 from the HWIR-Waste Technical Support Document, adapted to calculate risk as a function of concentration, instead of vice versa, and with the soil constituent depletion terms removed. Cancer risks were calculated for lifetime exposures to a child/adult resident, consistent with the HWIR-Waste approach, and noncancer hazard quotients were calculated for the child resident receptors, who receive the highest dose per body weight by this pathway. The exposure parameter values used to calculate contaminant intake and risks from soil ingestion are summarized in Exhibit J-16.

Variable	Description	CT Value	HE Value	Units	Source
AT	Averaging time (carcinogens)	70	70	years	Assumed full life span
EF	Exposure frequency	350	350	days/year	Worst-case assumption of year-round residency
IRc	Soil ingestion rate (child)	200	200	mg/day	HWIR-Waste Equation 5-6
IRa	Soil Ingestion rate (adult)	100	100	mg/day	HWIR-Waste Equation 5-6
BWc	Body weight (child)	15	15	kg	HWIR-Waste Equation 5-6
BWa	Body weight (adult)	70	70	kg	HWIR-Waste Equation 5-6
EDc	Exposure duration (child)	6	6	years	HWIR-Waste Equation 5-6
EDa	Exposure duration (adult)	3	24	years	Assumes 30 years' total residential tenure, six as a child, remainder as an adult
Kpw	Skin permeability constant for water	0.001	0.001	cm/hr	HWIR-Waste Equation 5-14
Y	Soil particle density	2.65	2.65	gm/cc	HWIR-Waste Equation 5-14
ΛF	Adherence factor	0.2	1.0	gm/cm ²	HWIR-Waste Equation 5-23
Tevent	Event Duration	5	12	hours	HWIR-Waste Equation 5-23

Exhibit J-16 Exposure Factor Values for Soil Ingestion and Dermal Contact Pathways

For the most part, these are standard values used in Agency rulemaking and risk assessments for contaminated sites. Differences from the HWIR-Waste assumptions include more frequent exposures (350 days/year) for adults and children, and a slightly shorter HE exposure duration (30 years, as opposed to 40 years in HWIR-Waste).

Risks from dermal exposures to contaminated soils were likewise calculated using equations based on the HWIR-Waste methodology. Specifically, equations 5-14 and 5-20 through 5-23 (adjusted as for the ingestion pathway) were used to calculate dermal contact rates with soil, dermal permeability constants, dermal absorbed doses, and risks from dermal exposures.

The soil concentration inputs were again the concentrations resulting from 20 years of contamination by runoff or air particulate deposition. As was the case for soil ingestion, exposure factor values were essentially the same as those used in the HWIR-Waste methodology. These values are summarized in the bottom rows of Exhibit J-16. All of the values for body weights, exposure duration, and exposure frequency are the same as those used for the ingestion pathway.

J.2.1.9.3 Ingestion of Home-Grown Vegetable

Crops grown near waste piles may become contaminated either from being grown in contaminated soil or from the deposition of particulates directly on the above-ground portions of the vegetables. In this analysis, risks were calculated for vegetable consumption by a subsistence farmer on soils contaminated either by particulate deposition or runoff. In each case, the methods used to calculate the intake of toxic constituents and risks were the same as those used in Equations 5-58, 5-59, 6-48, and 6-49 in the HWIR-Waste Technical Support Document.

Soil concentrations used to calculate root vegetable constituent concentrations were calculated as described previously. In the case of the root vegetable pathway, the soil mixing depths were either 20 cm (CT) or 10 cm (HE) instead of the shallower values used for the ingestion and dermal contact pathways. The exposure factor values used to estimate intake and risks for this pathway are summarized in Exhibit J-17. These values are essentially the same as those used on HWIR-Waste, the primary exception being the use of an HE exposure duration of 20 years, corresponding to the assumed life of the storage units, rather than the 40-year value used in HWIR-Waste.

J.2.1.9.4 Ingestion of Surface Water

Releases to surface water from surface impoundment failures and runoff from waste piles have been modeled. For both types of releases, the methods used to estimates constituent intakes and health risk are the same, and consistent with that used in the HWIR-Waste methodology.

As described previously, releases to surface water are assumed to be diluted into either a typical third-order (CT) or fifth-order (HE) stream. In this analysis, it is assumed that the surface water body in question would be used as a drinking water source, without further treatment to reduce exposure concentrations. Adult residents would then ingest either 1.4 liters (CT) or 2.0 liters (HE) of surface water for 350 days per year for 20 years. Lifetime doses of carcinogens are calculated based on an assumed lifespan (averaging time) of 70 years as for the other pathways, with residential exposure durations of either 9 (CT) or 30 (HE) years. Cancer risks are calculated as follows:

 $Risk = C_{water} (\underline{mg/l}) * WI (\underline{l/day}) * EF (\underline{days/year}) * ED (\underline{years}) * CSF (\underline{mg/kg} - \underline{day})^{-1}$ (6) BW (kg) * AT (years) * 365 (days/year) (6)

where WI is the daily water intake, in liters. Noncancer hazard quotients are calculated as:

Hazard Quotient =
$$\frac{C_{water}(mg/l) * WI (l/day) * EF (days/year)}{BW (kg) * 365 (days/year) * RfD (mg/kg-day)}$$
(7)

In the actual risk assessment, these equations were used, similar to the approach taken in HWIR-Waste, to calculate water concentrations of the constituents that would result in lifetime cancer risks of 10⁻⁵ or hazard quotients of 1.0 under CT and HE assumptions. These health-based levels (HBLs) were then used as a screening tool to determine which, if any, waste samples or constituents exceeded cancer risks or hazard quotient values of concern under either the CT or HE assumptions, so that more detailed analysis could be confined only to those wastes posing significant risks.

Variable	Description	CT Value	HE Value	Units	Source		
ι	Deposition period	20	20	years	20 years = facility life span		
kd	Soil-Water Dissociation Constant	constituent- specific	E.		HWIR-Waste data base		
RCF	Root Concentration Factor	constituent- specific	constituent- specific	mg/kg (veg.) mg/kg (soil)	HWIR-Waste data base		
Vg	Surface correction factor for volatiles	1	1	unitless	All constituents are inorganic		
Br	Plant-Soil BCF	constituent- specific	constituent- specific	ug/kg (veg.) ug/kg (soil)	HWIR-Waste data base		
Rp	Interception fraction	0.05	0.05	unitless	HWIR-Waste Equation 6-48		
kp	Plant surface loss coefficient	18	18	years"	HWIR-Waste Equation 6-48		
tp	Plant exposure to deposition	0.16	0.16	years	HWIR-Waste Equation 6-48		
Yp	Crop yield	1.7	1.7	kg/m^2 (DW)	HWIR-Waste Equation 6-48		
BWa	Adult Body Weight	70	70	kg	Standard Assumption		
F	Fraction from contaminated soil	0.4	0.9	unitless	HWIR-Waste Subsistence Farmer		
Cra	Consumption of above-ground vegetables	19.7	19.7	gm/day	HWIR-Waste Subsistence Farmer		
Crr	Consumption of root vegetables	28	28	gm/day	HWIR-Waste Subsistence Farmer		
EF	Exposure Frequency	350	350	days/year	HWIR-Waste Subsistence Farmer		
ED	Exposure duration	9	20	years	HWIR-Waste (CT), = deposition period (HE)		
AT	Averaging time	70	70	years	full life span		

Exhibit J-17 Exposure Factor Values Used for Crop Ingestion Pathway

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J.2.1.9.5 Ingestion of Fish from Contaminated Surface Water Bodies

In addition to being screened for potential risks associated with ingestion, the estimated surface water concentrations resulting from air particulate deposition, runoff, and surface impoundment failure were also screened to determine the potential risks associated with ingestion of fish from the contaminated surface water bodies. The primary inputs to this analysis were the surface water concentrations resulting from the various release pathways. The concentrations of toxic constituents in fish tissue were calculated as follows:

$C_{\text{fish}} (\text{mg/kg}) = C_{\text{water}} (\text{mg/l}) * \max (\text{BCF, BAF}) (l/kg)$

To calculate fish tissue concentrations, the estimated surface water concentrations were multiplied by the higher of either the fish bioconcentration factor (BCF) or fish bioaccumulation factor (BAF) values for the constituents. The primary source of these values was the chemical-specific data base from HWIR-Waste, but the values from that source were supplemented by values from other literature sources, as summarized in Attachment J-C. Where both a BCF and a BAF value were available for a constituent, the higher of the two values was chosen. Where multiple BCF values were found, we generally took what we considered to be the highest reliable value from either HWIR or the literature. Since the values in HWIR were intended to be representative, rather than conservative, this procedure resulted in our using higher BCF values for a number of constituents than were used in HWIR-Waste risk calculations, and the resultant hazard-based levels (HBLs) for this pathway were thus lower than those derived in HWIR-Waste for some constituents.

Constituent intakes and risks from fish ingestion were calculated using equations 5-67 and 5-68 from HWIR-Waste. Consistent with the HWIR-Waste approach, health-based levels (HBLs) were calculated for surface water exposures through fish ingestion for the adult subsistence fisher who is assumed to consume 60 gms (CT) or 130 gms (HE) of fish per day for 350 days per year, using a target cancer risk level of 10⁻⁵ and a target hazard quotient value of 1.0. These HBLs were then used to screen the surface water concentrations resulting from air deposition, runoff, and surface impoundment failures.

J.2.2 Results of Multipathway Risk Assessment

This section presents the results of the multimedia risk assessment for the storage of mineral processing recycled streams. It begins with a review of the release modeling from the point of view of mass balance considerations, and then presents discussions of the risk results for each of the release events, exposure media, and pathways.

J.2.2.1 Mass Balance for Release Pathways

As noted above, the risks associated with releases from for mineral processing facilities presented in this analysis have been evaluated separately. In other words, it has been assumed that releases occur independently of one another, and that all of the materials in the storage units are available for release by all release pathways. In this section, we review whether this assumption is valid by comparing the amounts of materials released from the storage units by the different release events.

The masses of recycled materials released from the various storage units are summarized in Exhibit J-18. It can be seen that only a very small proportion of the total annual recycled volume of all of the waste streams are released from waste piles. In the case of the two nonwastewater streams managed in piles, the annual release volumes from the two types of release events (particulate generation and runoff) are both far below one percent of the total annual recycled volume. Thus, depletion of material by these pathways will not seriously affect the total mass of material remaining in the piles, and thus the release estimates for runoff and particulate generation do not bias each other significantly. Similarly, releases from these pathways do not deplete the amount of materials available for leaching to groundwater.

Likewise, the estimated annual releases from surface impoundments also represent very small proportions of the total impoundment capacities and the annual recycled volumes. Thus, releases due to these events will not in the long run seriously deplete the amount of materials available for release by other pathways. For surface impoundments, the only other significant release pathway is infiltration to groundwater, since particulate generation and runoff are not important. The issue of whether leaching to groundwater might reduce the concentration of some constituents in the storage units has not been specifically addressed. EPA does not believe that, given the short operation life of these units and their continual replenishment with recycled materials, leaching to groundwater would seriously deplete any of the constituents.

J.2.2.2 Risk Results for Inhalation of Particulate

The estimated health risks associated with inhalation of particulates released from storage waste piles are quite low, as summarized in Exhibit J-19. Because of the lack of inhalation toxicity criteria, cancer risks could only be calculated for four constituents, and noncancer hazard quotients could be calculated for only two constituents. Since no inhalation toxicity criteria were available for the only two constituents analyzed for in zinc waste ferrosilicon (lead and zinc), no inhalation pathway risks could be calculated for that waste.

In the case of aluminum cast house dust, the highest cancer risks were associated with exposures to chromium (VI), followed by arsenic, nickel, and cadmium exposures. The HE cancer risk estimates for these constituents ranged from 10^{12} to 10^{10} , far below the 10^{-5} cancer risk level of regulatory concern, and the CT risks were even lower. As noted previously, the assumption that all of the chromium present would by hexavalent is very conservative, and risks for chromium exposures are likely to substantially overestimated for this reason.

The estimated inhalation hazard quotient values for aluminum cast house dust are also below levels that indicate the potential for significant adverse effects. The highest HE hazard quotient value (for barium) is 0.2, while for mercury the HE hazard quotient is less than 10^{-5} . Both of these values are below the 1.0 value, which indicates the potential for adverse effects, although the HE hazard quotient for barium approaches the level of concern.

Commodity	Unit Recycled Volume (kg/year)		HE Amount Released (kg/year)	Proportion of Annual Volume		
Aluminum and Alumina	Cast House Dust	Cast House Dust Waste Pile 581,000 Air Particulate Generation			324	0.06%
				Runoff	5,416	0.93%
Zinc	Waste Ferrosilicon	Waste Pile	5,950,000	Air Particulate Generation	1,520	0.03%
				Runoff	25,527	0.43%
Beryllium	Chip Treatment Wastewater	Surface Impoundment	2,500,000	Runon, Inlet/Outlet Control Failure	2,012	0.08%
Copper	Acid Plant Blowdown	Surface Impoundment	265,000,000	Runon. Inlet/Outlet Control Failurc	28,330	0.01%
Elemental Phosphorous	Furnace Scrubber Blowdown	Surface Impoundment	210,000,000	Runon. Inlet/Outlet Control Failure	23,127	0.01%
Rare Earths	Process Wastewater	Surface Impoundment	700,000	Runen, Inlet/Outlet Control Failure	1,480	0.21%
Selemum	Plant Process Wastewater	Surface Impoundment	3,300.000	Runon. Inlet/Outlet Control Failure	2,232	0.07%
Tantalum, Columbium, Ferrocolumbium	Process Wastewater	Surface Impoundment	37.500.000	Runon, Inlet/Outlet Control Failure	7,530	0.02%
Titanium, TiO <u>,</u>	Leach Liquor, Sponge Wash Water	Surface Impoundment	24,000,000	Runon, Inlet/Outlet Control Failure	7,050	0.03%
Titanium, TiO ₂	Serap Milling Serubber Water	Surface Impoundment	5,00,000	Runon, Inlet/Outlet Control Failure	1,337	0.27%
Zine	Spent Surface Impoundment Liquids	Surface Impoundment	63,000,000	Runon. Inlet/Outlet Centrol Failure	15.005	0.02%
Zinc	Wastewater Treatment Plant Liquid Effluents	Surface Impoundment	43,500,000	Runon, Inlet/Outlet Control Failure	11,115	0.03%
Zine -	Process Wastewater	Surface Impoundment	850.000,000	Runon, Inlet/Outlet Control Failure	111.784	0.0177

Exhibit J-18 Masses and Proportions of Recycled Streams Released by Specific Release Events

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Exhibit J-19	Exh	ibi	t J	-19
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		Estimated Inh	alation Pathwa	y Risks for								
Aluminum Cast House Dust												
			CANCE	R RISK	HAZARD QUOTIENT							
Constituent	CT Constituent Concentration in Air (ug/m3)	HE Constituent Concentration in Air (ug/m3)	СТ	HE	СТ	HE						
Antimony	1 73E-05	2.42E-04										
Arsenic	7.36E-05	1.03E-03	3.90E-13	1.22E-11								
Barium	2.30E-05	3.23E-04			1.92E-01	1.92E-01						
Cadmium	1.66E-05	2.33E-04	3.67E-14	1.15E-12								
Chromium(VI)	2.53E-04	3.55E-03	3.74E-12	1.17E-10								
Lead	3.91E-05	5.49E-04										
Mercury	2.30E-10	3.23E-09			3.20E-06	3.20E-06						
Nickel	5 98E-04	8.40E-03	3.54E-13	1.10E-11								
Selenium	2.12E-06	2.97E-05										
Silver	4 37E-06	6.14E-05										
Zinc .	2 76E-04	3.88E-03										

J.2.2.3 Risk Results for Soil Particulate Deposition

Particulate matter generated from waste piles may also be deposited onto soils and crops, resulting in direct exposure to contaminated soils and through the consumption of home-grown vegetables. In addition, impacts of particulate deposition to surface water have also been modeled. The risk results for these pathways are discussed in the following sections.

J.2.2.3.1 Incidental Ingestion and Dermal Contact Pathways

Risk results for the incidental ingestion and dermal contact pathways for soils contaminated by particulate deposition are summarized in Exhibit J-20. As was the case for the inhalation pathway, estimated cancer risks and hazard quotients for all of the constituents in both nonwastewater streams are below levels of concern for exposure by both pathways. The cancer risks and hazard quotients for the two pathways are generally within about one order of magnitude of each other, with higher risks for the ingestion pathways in some cases and higher risks for dermal contact in others.

The HE lifetime cancer risk associated with soil ingestion exposures to arsenic in aluminum cast house dust is $7X10^2$, while the CT value is $4X10^3$. In comparison, the HE and CT cancer risk estimates for dermal exposures are $1X10^6$ and $1X10^8$, respectively. The highest HE hazard quotient for ingestion exposures (again associated with exposures to arsenic) is $1X10^2$, while the highest HE hazard quotient for dermal exposures is $4X10^2$ (for arsenic). Hazard quotients for the remaining constituents range downward by many orders of magnitude from these values.

Exhibit	J-20
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				In	gestion			Dermal (Contact			
		·			CANCI	R RISK	HAZARD QUOTIENT		CANCER RISK		HAZARD QUOTIEN	
Constituent	CT Soil Concentration at 20 Years (mg/kg)	HE Soil Concentration at 20 Years (mg/kg)	СТ	HE	СТ	HE	ст	НЕ	СТ	HE		
Aluminum Cast	House Dust											
Antimony	5.26E-03	7.12E-02			1 75E-04	2.37E-03			2.98E-04	2.01E-02		
Arsenic	2.24E-02	3.04E-01	3.88E-08	7.13E-07	9.97E-04	1.35E-02	1.34E-08	1.44E-06	9.79E-04	3.89E-02		
Barium	7.01E-03	9.49E-02			L33E-06	1.81E-05			1.05E-07	3.44E-06		
Cadmium	5.05E-03	6.83E-02			1.35E-04	1.82E-03			3.31E-05	1.12E-03		
Chromium(VI)	7.71E-02	1.04E+00			2/06E-04	2.78E-03			2.62E-04	1.15E-02		
Lead	1.19E-02	1.61E-01										
Mercury	7.01E-08	9.49E-07			3.11E-09	4.22E-08			1.39E-12	4 53E-11		
Nickel	1.82E 01	2.47E+00			1 21E-04	1.64E-03			5.43E-05	1.90E-03		
Selenium	6.45E-04	8.73E-03			1.72E-06	2.33E-05			2.91E-06	1.86E-04		
Silver	1.33E 03	1.80E 02			3.55E-(16	4.81E-05			6.04E-06	4.09E-04		
Zinc	8.41E-02	1.14E+00			3.74E-06	5.06E-05			2.95E-06	L12E-04		
Zinc Waste Ferrosilicon												
Lead	3.50E+00	4.75E+01					l		L			
Zine	2.80E+01	3.80E+02	1		1.25E-03	1.69E-02			9.84E-04	3.72E-02		

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Zinc is the only constituent in zinc waste ferrosilicon for which a toxicity value is available for the ingestion and dermal pathway. Hazard quotient values for ingestion and dermal exposures to zinc from this stream are on the order of 10^{-4} to 10^{-2} , which is similar to the values for aluminum cast house dust.

While there is no ingestion pathway toxicity parameter for lead, it should be noted that the predicted HE soil concentration (48 mg/kg) is about ten times lower than EPA's recommended risk-based cleanup standard for lead in residential soils of 500 mg/kg.

These values in and of themselves are, as noted above, below the levels of concern. In fact, the values are low enough so that simultaneous exposures to all of the contaminants through both pathways results in a summed cancer risk less than 10^{-5} and a combined hazard index of less than 1. Given the conservative methods used to derive these values, and the small size of the units being evaluated, these results provide a high degree of assurance that risks for actual receptors would be below levels of concern.

J.2.2.3.2 Ingestion of Home-Grown Crops

The risk results for exposures to particulates deposited on soils and crops are summarized in Exhibit J-21. The HE estimated cancer risks associated with exposures to arsenic in aluminum cast house dust $(7X10^{-7})$ is very close to that for the ingestion pathway. The CT cancer risk for this pathway is $3X10^{-8}$. The highest HE noncancer hazard quotient for this pathway is $6X10^{-3}$, again associated with arsenic exposures, and the CT value for arsenic is one order of magnitude lower $(5X10^{-4})$. Hazard quotient values for the other constituents through the ingestion of home-grown crops are all much lower than the corresponding values for arsenic.

J.2.2.3.5 Particulate Deposition to Surface Water

Because the releases to air are so small and the surface water dilution volumes are so high, risks associated with surface water deposition are evaluated using a screening approach not unlike that used in the HWIR-Waste Technical Background Document to establish media concentrations corresponding to risk levels of concern. In this analysis, the methods and assumptions described in Section J.2.1 were used to calculate concentrations in surface water that corresponded to calculated cancer risk levels of 1X10⁻⁵ and hazard quotients of 1.0. HE exposure assumptions were used to evaluate exposures through the drinking water and fish ingestion pathways. These HE health-based levels were then used as a basis for comparison with the results of the concentration modeling for particulate deposition to surface water, as shown in Exhibit J-22.

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		Home-C	Frown Crop Ingestio	n Pathway Risk Ass	essment Results for	Particulate Depos	ition		·	
							CANCER RISK		HAZARD QUOTIENT	
Constituent	CT Soil Concentration at 20 Years (mg/kg)	HE Soil Concentration at 20 Years (mg/kg)			CT Concentration in Root Vegetables (mg/kg)	HE Concentration in Root Vegetables (mg/kg)	СТ	HE	СТ	HE
Aluminum Ca	st <u>House Dust</u>									
Antimony	6.57E-04	7.12E-03	4.35E-04	2.74E 03	9.86E-06	1.07E-04			1.26E-04	1.83E-03
Arsenic	2.80E 03	3.04E-02	1.40E-03	6.71E-03	7.73E-07	8.38E-06	2.91E 08	7.00E-07	5.25E-04	5.67E-03
Barium	8.76E-04	9.49E-03	5.36E-04	3.18E-03	2.48E-08	2.69E-07			8.63E-07	1.15E-05
Cadmium	6.31E-04	6.83E-03	5.19E-04	3.72E-03	2 52E-07	2.73E 06			1.17E-04	1.89E-03
Chromium(VI)	9.64E-03	1.04E-01	4.53E-03	2:01E-02	2.41E-06	2.61E-05			1.02E-04	1.02E-03
Lead	1.49E-03	1.61E-02	6.89E-04	2.98E-03	4 79E-11	5.19E-10				
Mercury	8.76E-09	9.49E 08	4.12E-09	1.83E-08	1 29E-15	1.40E-14			1.55E-09	1.55E-08
Nickel	2.28E-02	2 47E-01	1.13E-02	5.35E-02	2.22E-06	2.41E 05			6 34E-05	6 78E-04
Selenium	8.06E-05	8.73E 04	3.86E-05	1.75E-04	4 12E-07	4.47E-06			8.81E-07	9.21E-06
Silver	L66E-04	1.80E-03	1.44E 04	1.05E-03	4 16E-05	4.51E-04			4.56E-06	8.59E-05
Zinc	1.05E 02	1 14E 01	7 49E-03	4.95E-02	1.16E-05	1.25E-04			2.82E 06	4.20E-05
<u>Zinc Waste</u> Ferrosilicon Lead	4.38E-01	4 75E+00	2.03E-01	8.78E-01	1.41E-08	1.53E 07				
Zinc	3.50E+00	3.80E+01	2.50E+00	1.65E+01	3 85E-03	4.18E-02			9.39E-04	1.40E-02

			Screenin	g Results for Part	ticulate Depositio	n to Surface Wa	iter			_
Constituent	Concentrations Resulting from Releases of Aluminum Cast House Dust			Concentrations Resulting from Releases of Zinc Waste fermisilicon			Surface Water HBL Concentrations (mg/L) ¹			
	Maximum Concentration in Waste (mg/kg)	CT Water Concentration (mg/L)	HE Water Concentration (mg/L)	Maximum Concentration in Waste (mg/kg)	CT Water Concentration (mg/L)	HE Water Concentration (mg/L)	Fish - Noncancer	Fish - Cancer	Drinking Water - Noncancer	Drinking Water - Cancer
Antimony	7.5	8.10E-09	8.77E-07						1.40E-02	
Arsenic	32	3.46E-08	3.7415-06					7.40E-04		8.40E-04
Barium	10	1.08E-08	1.17E-06				3.77E-01		2.45E+00	
Beryllium							2.84E-02		1.75E-01	
Cadmium	7.2	7.78E-09	8.42E-07				7.35E-05		3.50E-02	
Chromium(V1)	110	1.19E-07	1.29E-05				9.00E-01		1.75E-01	
Lead	17	1.84E-08	1.99E-06	5000	5.40E-06	5.85E-04			1.50E-02	_
Mercury	0.0001	1.08E-13	1.17E-11						1.05E-02	
Nickel	260	2.81E-07	3.04E-05				1.02E-01		7.00E-01	
Selenium	0.92	9.94E-10	1.08E-07				8,40E-03		1.75E-01	
Silver	1.9	2.05E-09	2.22E-07				1.80E-02		1.75E-01	
Thallium							3.02E-05		2.80E-03	
Vanadium				•					2.45E-01	
Zinc	120	L30E-07	1.40E-05	40000	4.32E-05	4.68E-03	3.12E-01		1.05E+01	Γ

Exhibit J-22

¹HBLs correspond to an estimated lower risk of 10°, a noncancer hazard quotient of 1.0, or for lead, the MCL.

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As can be seen from the exhibit, the predicted surface water concentrations of the toxic waste constituents associated with air particulate deposition are all many orders of magnitude below the HBLs for drinking water or fish ingestion (corresponding to 10⁻⁵ cancer risk and hazard quotient equal to 1.0). Cadmium, with an HE predicted concentration of about two orders of magnitude below the HBL for fish ingestion, and chromium (VI), with an HE concentration of about four orders of magnitude below the HBL for fish ingestion, come the closest to any of the HBLs among the constituents of aluminum cast house dust. In the case of zinc waste ferrosilicon, the HE surface water concentration of zinc is about two orders of magnitude below the HBL for fish ingestion, and the HBL for fish ingestion, and the HBL for fish ingestion of lead is about thirty-fold below the drinking water HBL, which is based on the Clean Waster Act MCL. All of these results indicate little cause for concern for adverse health effects through this pathway, especially considering the conservativeness of the exposure assumptions (e.g., 100 percent of the particulate is deposited in surface water).

J.2.2.4 Risk Results for Runoff Releases to Surface Soils

The screening methods used to estimate constituent concentrations in surface soils due to runoff release from waste piles are summarized in Section J.2.1.8.3. Risks from this pathway were again evaluated by comparison of the resultant concentrations to HBLs. In this case, however, the HBLs were soil concentrations derived for the incidental ingestion and dermal contact pathways, and for the ingestion of contaminated root vegetables. The results of this analysis are summarized in Exhibit J-23.

As was the case for the air deposition pathway, the concentrations of toxic constituents in soils resulting from runoff releases are all below levels that would be associated with concern for adverse health effects. Both in the case of the ingestion and dermal exposure pathways, where shallow mixing depths were used, and in the case of the root vegetable ingestion pathway, where greater mixing depths were used, the estimated HE and CT concentrations of toxic constituents in soils are generally several orders of magnitude below the levels that might be associated with significant adverse health effects. (In the case of arsenic, the HBLs correspond to soil concentrations that would be associated with an HE cancer risk of 10⁻⁵. For the other constituents, the HBLs correspond to soil concentrations resulting in HE noncancer hazard quotient values of 1.0.)

These results hold true both for aluminum cast house dust and zinc waste ferrosilicon, even though, in the latter case, the predicted HE concentration of zinc is quite high (4,000 mg/kg). This finding is a result of zinc's relatively low human toxicity. The predicted HE concentration of lead (497 mg/kg) is just below EPA's recommended risk-based cleanup standard for lead in residential soils.

J.2.2.5 Risk Results for Runoff Deposition to Surface Water

Runoff from the waste piles may also be deposited into surface water. Long-term concentrations of waste constituents in surface water resulting from runoff loading were calculated for both waste streams, as described previously, and the resulting concentrations were compared to HBLs for surface water in the same fashion as was done for deposition of airborne particulates.

Exhibit J-23

					Aluminum Cas		RELEASES TO 1		Zinc Waste F	arrosilicon	
Constituent	Soil Ingestion Health- Based Level (mg/kg)	Contact Health-	Home-Grown Vegetable Consumption Health-Based Level (mg/kg)		HE Soil Concentration (Ingestion and Dermal Contact) (mg/kg)	CT Soil Concentration (Ingestion of Home-Grown Vegetables) (mg/kg)	HE Soil Concentration (Ingestion of Home-Grown Vegetables) (mg/kg)	CT Soil Concentration (Ingestion and Dermal) (mg/kg)	HE Soil Concentration	CT Soil	HE Soit Concentration (Ingestion of Home-Grown Vegetables) (mg/kg)
Antimony	30	3.54	74.1	1.92E-03	1.58E-01	2.39E-04	1.58E-02				
Arsenic	4.26	2.11	24.5	8.17E-03	6.74E-01	1.02E-03	6.74E-02				
Barium	525	27,600	>1,000,000	2.55E-03	2.11E-01	3.19E-04	2.11E-02				
Beryllium	NA	NA	NA								
Cadmium	37.5	61.1	3470	1.84E-03	1.52E-01	2.30E-04	1.52E-02				
Chromium	375	90.7	55600	2.81E-02	2.32E+00	3.51E-03	2.32E-01				
Cyanide	NA	NA	NA								
Lcad	NA	NA	NA	4.34E-03	3.58E-01	5.43E-04	3.58E-02	6.02E+00	4.97E+02	7.52E-01	4.97E+0
Mercury	22.5	21,000	>1,000,000	2.55E-08	2.11E-06	3.19E-09	2.11E-07				
Nickel	1,500	1,300	569,000	6.64E-02	5.48E+00	8.30E-03	5.48E-01				
Selenium	375	47	2,710	2.35E-04	1.94E-02	2.94E-05	1.94E-03			r — —	
Silver	375	44.1	55.6	4.85E 04	4.00E-02	6.07E-05	4.00E-03				
Thallium	NA	NΛ	NA								
Vanadium	NA	NA	· NA								
Zinc	22,500	10,200	758,000	3.07E-02	2.53E+00	3.83E-03	2.53E-01	4.82E+01	3.97E+03	6.02E+00	3.97E+02

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The results of that analysis are summarized in Exhibit J-24. As might be expected, since the amounts of materials released through surface runoff are roughly comparable to the amounts of air particulate generated, the results of the screening surface water risk analysis for this pathway are similar to those for air particulate deposition, in that all of the calculated concentrations of constituents in the surface water bodies are far below the HBLs for either surface water ingestion or the ingestion of fish.

	Zinc Waste	Ferrosilicon				
Constituent	Drinking Water Health- Based Level (mg/l) ¹	Fish Ingestion Health-Based Level (mg/l)	Maximum High-End Surface Water Concentration, Bulk Samples (mg/l)	Maximum Central Tendency Surface Water Concentration, Bulk Samples (mg/l)	Maximum High-End Surface Water Concentration, Bulk Samples (mg/l)	Maximum Central Tendency Surface Water Concentration, Bulk Samples (mg/l)
Antimony	0.014	NA	7.52E-09	1.15E-06		
Arsenic	0.00084	0.00074	3.21E-08	4.89E-06		
Barium	2.45	0.377	1.00E-08	1.53E-06		
Beryllium	0.175	0.0284				
Cadmium	0.035	0.0000735	7.22E-09	1.10E-06		
Chromium	0.175	0.9	1.10E-07	1.68E-05		
Cyanide	0.7	36.5				
Lead	0.015	NA	1.71E-08	2.60E-06	2.36E-05	3.60E-03
Mercury	0.0105	0.00000125	1.00E-13	1.53E-11		
Nickel	0.7	0.102	2.61E-07	3.97E-05		
Selenium	0.175	0.0084	9.23E-10	1.41E-07		
Silver	0.175	0.018	1.91E-09	2.90E-07		
Thallium	0.0028	0.0000302				
Vanadium	0.245	NA				
Zinc	10.5	0.312	1.20E-07	1.83E-05	1.89E-04	2.88E-02

Exhibit J-24

¹ HBLs correspond to a lower risk of 10⁻⁵, a noncancer hazard quotient of 1.0, or, for lead, the MCL value.

For aluminum cast house dust, the highest HE surface water concentrations (of antimony, arsenic, chromium, lead, and nickel) associated with runoff releases were all in the range of 10^{-6} to 10^{-5} mg/l, all of which were lower than the corresponding HBLs. In the case of zinc waste ferrosilicon, the estimated HE concentrations of lead and zinc, the two constituents for which concentration data were available, are both about ten-fold lower than the lowest HBLs. These results indicate that runoff releases to surface water are unlikely to be associated with significant risks to human health.

J.2.2.6 Risk Results for Surface Impoundment Releases to Surface Water

The surface water concentrations of toxic constituents resulting from surface impoundment releases were also compared to surface water HBLs. Unlike the other pathways evaluated, the screening comparison indicates the potential for adverse effects on human health above levels of concern for a few constituents from some samples from several waste streams. These results are summarized below.

J.2.2.6.1 Ingestion of Surface Water

Exhibit J-25 summarizes the results of the comparison of surface water concentrations from impoundment releases to HBLs. Because there are multiple samples available for most of the waste streams managed in surface impoundments, the results of the comparison to HBLs are reported in terms of the numbers of samples and recycled streams for which the HE and CT surface water concentrations from impoundment releases exceed the HBLs, presented in order-of-magnitude categories.

Releases from surface impoundment failures were modeled as resulting in potential exceedences of HBLs for water ingestion for three constituents: arsenic, cadmium, and lead. Under high-end dilution assumptions, the arsenic concentrations in five samples (four bulk samples, one EP extraction) would exceed the drinking water HBL by up to one thousand-fold. (This is equivalent, in this case, to saying that the estimated cancer risks under HE assumptions would exceed the 10⁻⁵ level of concern by up to a factor of 1000.) All of these samples came from the copper acid plant blowdown stream, and under CT dilution assumptions the surface water concentration for arsenic exceeds the HBL for only one of the 40 total samples from this stream.

The concentration of cadmium in one of 24 samples from the zinc spent surface impoundment liquid stream results in surface water concentrations exceeding the drinking water HBL under HE assumptions. The HBL is exceeded by a factor of ten or less. Under CT assumptions, there are no HBL exceedences for cadmium. For cadmium, an HBL exceedence corresponds to a hazard quotient value exceeding 1.0 for its critical toxic effect on kidney function.

The lead concentrations in bulk samples from two waste streams result in calculated surface water concentrations exceeding the drinking water HBL. One sample of copper acid plant blowdown shows a concentration of lead such that the HE concentrations exceeds the HBL by a factor of less than ten. Under CT assumptions, this sample no longer exceeds the HBL. Two bulk samples of zinc spent surface impoundment liquids result in HE lead concentrations in surface water that exceed the HBL by a factor of up to 100. Again, under the CT dilution assumptions, the predicted lead concentrations in surface water are reduced to below the drinking water HBL. As noted previously, the HBL for lead is simply the Drinking Water MCL of 15 ug/l.

СОМРАБ	RISON OF SI	URFACE WATER CO	NCENTRA	DRI	NKING WA	TER	<u></u>					
		Surfac Concentr	n High-End ee Water ation, Bulk nples	1	iximum H Surface V ntration, 1	-	Surfac Concentr	Tendency ee Water ation, Bulk nples	Central Tendency Surface Water Concentration, EP Samples			
			Compared to HBL ¹		Compared to HBL			Compared to HBL		Compared to HBL		
Constituent	Commodity	Wastestream	Total No. Samples	1-10x	10-100x	1-10x	10-100x	100-1000x	1-10x	10-100x	1-10x	10-100x
Arsenic	Copper	Acid plant blowdown	40	3	1			1			1	
Cadmium	Zinc	Spent surface impoundment liquids	24	1								
Lead	Copper	Acid plant blowdown	40	I								
	Zinc	Spent surface impoundment liquids	24	1	1							

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1. HBLs correspond to a lower risk of 10⁻⁵, a noncancer hazard quotient of 1.0, or, for lead, the MCL value.

2. EP samples are adjusted (i.e., have been multiplied by 1.95) to extrapolate to bulk concentrations.

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J.2.2.6.2 Ingestion of Contaminated Fish

The predicted surface water concentrations of six contaminants released from surface impoundments also were such that HBLs derived for the ingestion of fish by subsistence fishers were exceeded. The results are presented in Exhibit J-26. Six arsenic samples (again all from copper acid plant blowdown) were associated with HE surface water concentrations exceeding the fish consumption HBLs by up to a factor of 1000. Four of these were bulk samples, and the remainder were EP extraction samples. Under CT assumptions, only one sample exceeded the arsenic fish ingestion HBL.

A total of 20 samples (one EP extraction, the rest bulk) contained cadmium concentrations which resulted in surface water concentrations exceeding the fish ingestion HBL by a up to 1000-fold. These samples came from zinc spent surface impoundment liquids (10), zinc process wastewater (6), copper acid plant blowdown (2 samples), and one sample each from rare earths process wastewater and zinc wastewater treatment plant liquid effluent. Under CT dilution assumptions, the number of samples exceeding the cadmium HBL is reduced to 3 samples, and the maximum level of exceedence is reduce to less than 100-fold.

Under HE assumptions, five samples give mercury concentrations in surface water exceeding the fish ingestion HBL. These samples come from copper acid plant blowdown (3) and zinc spent surface impoundment liquids (2), and under CT assumptions, none of these samples exceeds the fish HBL. In the case of mercury, an HBL exceedence is equivalent to a hazard quotient greater than 1.0 for reproductive effects.

A single sample result for selenium in copper acid plant blowdown results in surface water concentrations above the HBL, as do two thallium results (one each from titanium/TiO₂ leach liquor and sponge wash water and from copper acid plant blowdown). For all of these samples, no exceedences occur under CT dilution assumptions. The same is true for the six analytical results for zinc (all from zinc commodity streams); all six samples exceed the fish ingestion HBL under HE but not under CT dilution assumptions.

J.2.2.7 Summary of Non-Groundwater Pathway Risk Assessment Results

The findings of this analysis parallel the results of the groundwater risk assessment for the storage of mineral processing wastes, which found generally very low risks for the nonwastewater streams disposed in waste piles, and higher risks (exceeding 10⁻⁵ cancer risk and hazard quotients of 1.0 in some instances) for the wastewaters and liquid nonwastewater streams disposed in surface impoundments.

In the groundwater analysis, the major reasons for the relatively low estimated risks were the generally low DAF values for waste piles, and the relatively low masses of toxic constituents in the relatively small piles. In this analysis, the small size of the waste piles (corresponding to the low recycled volumes of these streams) is again decisive in determining the generally low risks for the nonwastewater streams. None of the release events and exposure pathways that were evaluated for waste piles resulted in risks greater than the previously-noted levels of concern under either CT or HE assumptions. Estimated releases from both runoff and air particulate generation were low (in the range of a few hundred to a few thousand kilograms per year total mass), and even moderate dilution in exposure media was enough to reduce exposure concentrations below levels of concern with regard to adverse health effects.

Exhibit J-26

			um High-Ei · Concentrat Samples	ion, Bulk	Surfac Concent	Tendency e Water ration, Samples	Water C	m High-F oncentrati EP Sampl		Central Tendency Surface Water Concentration, EP Samples ²			
					ompared to		Compar	ed to HBL	Compared to HBL			Compared to HBL	
Constituent	Commodity	Wastestream	Total No. Samples	1-10x	10-100x	1 00-1 000x	1-10x	10-100x	1-10x	10-100x	100-1000x	1-10x	10-100x
Arsenic	Copper	Acid plant blowdown	40	2	2				1		1	1	
Cadmium	Copper	Acid plant blowdown	40	2									
	Rare Earths	Process wastewater	8						1				
	Zinc	Process wastewater	4()	6				「					
	Zine	Spent surface impoundment liquids	24	6	3	1	1	1					
	Zinc	WWTP liquid effluent	5			1		1					
Mercury	Copper	Acid plant blowdown	40	2				[1				
	Zinc	Spent surface impoundment liquids	24	ł	1			[
Selenium	Copper	Acid plant blowdown	40	I									
Thallium	Titanium and Titanium Dioxide	Leach liquid & sponge wash water	8	I									
	Copper	Acid plant blowdown	40						1				
Zinc	Zinc	Spent surface impoundment liquids	24	5									
	Zinc	WWTP liquid effluent	5	1									

NOTES:

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1. HBL = health-based level derived for fish ingestion based on worst-cast subsistence fisher.

2. EP samples are adjusted (i.e., have been multiplied by 1.95) to extrapolate to bulk concentrations.

The comparatively higher risks associated with waste managed in surface impoundments was primarily a function of the larger volumes of waste being managed and correspondingly larger release volumes. Even though the proportions of the recycled materials released from impoundments were relatively low, there was still enough mass present in the impoundments to result in surface water concentrations exceeding HBLs. It should be noted, however, that even for these high-volume wastes, exceedences of HBLs were limited to only a small minority of the constituents, samples and waste streams, and the greatest numbers of exceedences were for the fish ingestion pathway, where the HBLs for several constituents have been derived quite conservatively. Under HE assumptions, only nine samples (out of

135 having analytical data) resulted in exceedences of the drinking water HBL, and this number dropped to one under CT assumptions. Under HE assumptions, a total of 40 samples exceeded the far more

stringent fish ingestion HBLs, and this number dropped to 4 under CT assumptions.

Two of the twelve wastewater and liquid nonwastewater streams evaluated in the analysis accounted for the bulk of the HBL exceedences. Under HE assumptions, samples from copper acid plant blowdown accounted for six of the nine exceedences of the drinking water HBL, and zinc spent surface impoundment liquids accounted for the remaining three. Between them, these two streams also accounted for 34 of the 40 HE exceedences of the fish ingestion HBLs (copper acid plant blowdown 13, zinc spent surface impoundment liquids 21). Two other streams from the zinc commodity sector (six samples from process wastewater and two samples from waste water treatment plant liquid effluent) also accounted for one or more exceedences of the fish consumption HBL. Beyond that, only two other commodity sectors (rare earths and titanium/TiO₃) had any exceedences (one each, only under HE assumptions).

Thus, this analysis clearly identifies two commodity sectors and four waste streams as dominant in driving potential risks from the storage of mineral processing wastes, at least among the streams for which analytical data are available. Whether there are other streams and commodities for which non-groundwater risks might also exceed levels of concern cannot be determined without additional data concerning waste characteristics and composition.

J.2.2.8 Uncertainties/Limitations of the Analysis

As discussed in Section J.2.1, the multipathway risk assessment for the storage of mineral processing recycled materials relies on relatively simple, generic models of contaminant releases, transport, exposures, and risks. As such, this screening level analysis shares the general limitations of all generic analyses in that high levels of uncertainty and variability may not be adequately treated, since only a limited number of generally applicable models and generally representative data are used to model risks from a wide range of units, wastes, and constituents. Many of these generic sources of uncertainty have been addressed in our previous work on mineral processing wastes, and the following discussion is limited to limitations specific to the multipathway analysis

Constituent concentration data are available for only 14 recycled waste streams, and for some wastes only small numbers of samples are available. It is interesting to note that two of the wastes for which estimated risks are the highest (copper acid plant blowdown and zinc spent surface impoundment liquids) also are those for which the largest number of samples are available. It is not possible to estimate which of the other wastes might also show risks above levels of concern if more data were available.

Limited data are also available concerning waste characteristics, including constituent speciation, solubility, and bioavailability. Throughout this analysis, we have assumed that all constituents would behave in such a manner as to maximize exposure potential. For example, we have assumed that none of the constituents would leach from soils after their initial deposition, and that all of the constituents would be bioavailable in the water column. Generally these assumptions increase the level of conservatism in the risk assessment.

Release events and amounts were simulated mostly using the general methods adopted in HWIR-Waste. The one exception is air particulate generation, which was estimated using the SCREEN3 model, rather than the model recommended in HWIR-Waste. SCREEN3 is a widely-accepted screening level EPA model, however, and EPA believes that it is appropriate for the types of release events that were modeled. The use of SCREEN3 is unlikely to have biased the results of the risk assessment significantly compared to other methods. However, as noted previously, no data were available concerning the particle size characteristics of the two wastes streams that were modeled, so we relied on data from an earlier study of mineral processing wastes stored in waste piles. Based on limited information, we believe that the particle size distribution that was used may overstate the potential for particulate release of the more coarse-grained, high-density zinc waste ferrosilicon, while more accurately describing the potential for particulate releases of aluminum cast house dust.

Runoff releases were evaluated using the same model (USLE) applied in HWIR-Waste, with input parameters varied slightly to reflect the operating characteristics of the waste piles being simulated and the likely geographic distribution of the recycling facilities. The risk results are not particularly sensitive to these changes, as exposure concentrations for runoff events are below the levels of concern for all of the runoff exposure pathways.

The ISCST3 model used to predict particulate air concentrations and deposition rates is a state-ofthe-art model that has been used in many regulatory proceedings by EPA. The input data that were used, the "worst-case" meteorological conditions that are supplied with ISCST3 specifically for use in screening level assessments, were somewhat more conservative than the meteorological data used in HWIR-Waste with a similar model. Thus, our estimates of air impacts are likely to be higher than those that would have been achieved had we replicated the HWIR-Waste approach. Again, however, all risks associated with this pathway were far below levels of concern.

The modeling of releases from surface impoundments reproduced exactly the approach used in HWIR-Waste. This release model and its input parameters were derived based on data from management units in the pulp and paper industry, and just how reliably they predict releases from surface impoundments in the mineral processing industries is not known. This is clearly a major source of uncertainty in the risk assessment, as these release events are the only non-groundwater releases for which health risks are predicted to be above levels of concern.

Because of resource limitations and the specific characteristics of the facilities that were evaluated, simplified approaches were developed to estimate the concentrations of waste constituents in surface soils and surface water to substitute for the much more elaborate methods used in HWIR-Waste. In the case of surface runoff, in the absence of site-specific data, we conservatively assume that soil contamination would be limited to relatively small distances (50 or 100 meters) from the piles in arbitrarily defined circular plumes. This is only intended as a bounding analysis, and the finding that this pathway is not a major concern can be supported by the fact that, even with these relatively small exposure areas (and the resultant high soil concentrations), constituent concentrations due to runoff events were below levels of health concern.

Similarly, to be conservative, we assumed that all of the runoff and all of the particulate generated by the waste piles would be deposited on the watershed in such a way that all of these materials would rapidly find their way into surface water. This approach, while it resulted in surface water concentrations far below levels of health concern, may be less conservative than the approach taken for surface soils, in that the CT and HE streams are both rather large, and the model does not take into account possible runoff or deposition into smaller streams, lakes, or ponds where constituents may accumulate in surface water or sediment.

The approach we took in evaluating fish tissue concentrations was also somewhat more conservative than that taken in HWIR-Waste, in that we used the highest reliable BCF or BAF values, rather than representative values, in our calculations. For some constituents (arsenic, cadmium, mercury, thallium), this approach resulted in considerably higher tissue concentrations than would have been calculated had we used the HWIR-Waste values, and considerably lower HBLs. This may be a major source of uncertainty in this analysis, since the fish ingestion pathway resulted in the highest risks for several of the constituents.

ATTACHMENT J.A

Proportion of Mineral Processing Wastes Covered by the Storage Risk Assessment

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London Cathoun Out 16.227 16.227 16.227 10.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 24.92% Setter 15.220 41.250 41.250 41.250 41.250 100.00%			T	otal Recycled Vol	ume	Recycled Volume	Percent Analyzed in Risk Assessment			
Summan Carthour Dust 15.227 16.227 16.227 100.00%										
Summer Car House Dust 16.227 16.227 10.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 24.2430 48.87	Commodity	Weste Stream	Min.	Ave.	Max.	Expect.	Exp./Min.	Expect/Ave.	Exp./Max	
Electrogram Warden Part 2428 44.875 Part 2420 100.00% 24.937 Part 2420 100.00% 24.937 24.937 Senter 5001, Barron Fritzle Siteart 41.250 41.250 41.250 41.250 100.00% 100.00% 100.00% 25.937 25.917 Berler 51.252 51.252 51.252 112.20 51.252 112.20 110.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% <td< td=""><td>A uminum,</td><td>Cast House Dust</td><td>16.227</td><td>16.227</td><td>16.227</td><td>16.227</td><td>100.00%</td><td>100.00%</td><td>100.00%</td></td<>	A uminum,	Cast House Dust	16.227	16.227	16.227	16.227	100.00%	100.00%	100.00%	
Sector 19.227 90.657 95.12 19.227 100.000 29.000 29.900 Sign Sum Figure Figure Streams 41.250 41.250 41.250 41.250 100.000	Alumina									
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Sector 91/20 <t< td=""><td>Servii um</td><td></td><td>41.200</td><td></td><td>1</td><td>1</td><td>100.0078</td><td>T</td><td></td></t<>	Servii um		41.200		1	1	100.0078	T		
Image: Acd Plant Blowdown 3.375 000 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00% 1.000 00%			41.250				124 24%			
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Process Construction										
Funge Butlerg Washown 700,000 700,000 700,000 700,000 720,000 </td <td>lemental Phosphorus</td> <td>Furnace Scrubber Biowdown</td> <td>420,000</td> <td>420.000</td> <td>420.000</td> <td>420,000</td> <td>100 00%</td> <td>100.00%</td> <td>100 50%</td>	lemental Phosphorus	Furnace Scrubber Biowdown	420,000	420.000	420.000	420,000	100 00%	100.00%	100 50%	
Sector 1,122.000 1,122.000 1,22.000 1,22.000 1,22.000 1,20.000 1,20.000 1,20.000 1,20.000 1,20.000 1,20.000 1,20.000 1,20.000 1,20.000 1,20.000 1,20.000 1,000		Furnace Building Washcown	700.000	700,000	700,000					
Image: Sector Image: S			1,120,000	1,120,000	120,000	420.00C	37.50%	37.50%	<u>37.50%</u>	
Stud										
Spent Soubber Liquo: 20 100.000 230.000 200.001 Wastewater from APC SC 000 200.001 1.400 95.55% 9.62% 9.32%	Pare Earths			350	7,000					
Wastewater from APC 55.000 200.001 Image: constraint of the sector Image: consector Image: consector Image:		Process Wastewater	1.400	1,400	1.400	1.400	100 00%	100.00%	100.00%	
Sector 1.420 151.750 458.402 1.400 95.5% 9.92% 0.34% Beanum Spent Filter Cake 2.17 4.335		Spent Scrubber Liquor	20	100,000	200.000					
Spent Filter Cake 217 4.335 218 217 4.335 Plant Process Wastewater 13.200 13.200 13.200 100.00%		Wastewater from APC		50.000	200,000					
Bart Process Wastewater 13,200 13,200 13,200 13,200 13,200 100,00%		Sector	1.420	151,750	408,400	1.400	<u>95 59%</u>	<u>0 92%</u>	<u>0.34%</u>	
Blag 5' 1,020 Image: Constraint of the second s	Seie≏ium	Spent Filter Cake		217	4,335	<u> <u>†</u></u>	_			
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Instrum, encodum, um etc. Process Wastewater 127,500 127,500 127,500 127,500 127,500 100,00%		Teliur um Silme Wastes		217	4,335		<u> </u>			
errosolum- um etc. Sector 127.500 127.500 127.500 127.500 127.500 120.00% 100.00%		Sector	13,200	13.685	22,690	13,200	100.00%	95.46%	<u>57 67%</u>	
Sector 127,500 127,500 127,500 127,500 127,500 120,00% 100,00% <th< td=""><td>antalum, errocolum-</td><td>Process Wastewaler</td><td>127,500</td><td>127,500</td><td>127.500</td><td>127.500</td><td>100.00%</td><td>100.00%</td><td>100.00%</td></th<>	antalum, errocolum-	Process Wastewaler	127,500	127,500	127.500	127.500	100.00%	100.00%	100.00%	
Itanum Ox do		Sector	<u>*27,500</u>	*27,500	·27 500	127,500	100 00%	<u>100.00%</u>	<u>. 00 00%</u>	
Itanum Ox do						<u> </u>				
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Snut from Mg Recovery B5 18 70C 39,10C Image: Control of the second seco		Scrap Milling Scrubber Water		500	1.200	500		•00.00%	41.67%	
Spent Surface impoundment: Liquids 1,456 5.712 126.83* 82.53* 59.32* Sector 76,085 116.928 162.672 96.500 126.83* 82.53* 59.32* inc Acid Plant Blowdown 130.000 130.000 130.000 130.000 100.00* <td></td> <td>Snut from Mg Recovery</td> <td>85</td> <td>18.700</td> <td>39,100</td> <td></td> <td>-</td> <td></td> <td></td>		Snut from Mg Recovery	85	18.700	39,100		-			
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Sector 76,085 116,928 162,672 96,500 126,83% 82,53% 59,32% inc Acid Plant Blowdown 130,000 130,000 130,000 130,000 130,000 130,000 130,000 130,000 100,00% 50,00% 50,00% 50,00% 50,00% 50,00% 100,00				1,458	5,712			l I		
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Waste Ferristicon 7.225 14 45C 7.225 100 00% 50 00% Process Wastewater 4.335 000 4.335 000 4.335 000 4.335 000 100 00% 50 00% 378 000 378 000 378 000 378 000 378 000 378 000 378 000 378 000 378 000 100 00% 100 00% 100 00% 100 00% 100 00% 100 00% 100 00% 50 00% 38 000 38 000 <td></td> <td></td> <td></td> <td></td> <td></td> <td>↓</td> <td></td> <td> </td> <td></td>						↓				
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Spen: Goeth te: Leach Cake Residues 15,000 15,000 15 000 15 000 100 00% 50 00% 100 00% 50 00% 100 00% 50 00% <th< td=""><td></td><td>· · · · · · · · · · · · · · · · · · ·</td><td>9.335.000</td><td></td><td></td><td>4,335,000</td><td>1000%</td><td>100.00%</td><td>100.00%</td></th<>		· · · · · · · · · · · · · · · · · · ·	9.335.000			4,335,000	1000%	100.00%	100.00%	
Residues Control Spent Surface Impoundment 378,000 378,000 378,000 100,00% 50,00% 300,0		Spent Goeth tel Leach Cake	15.000			┟───┼				
Liguids Image: Constraint of the second		Residues				378,000	100 00%	100.00%	100.00%	
TAC Tower Blowdown 94 188 WW TP Liquid Effluent 261.020 522.020 261.000 100.00% 50.00% Sector 4.858,000 5.126.675 5.395.351 4.981,225 102.54% 97.16% 92.32%		Liquids								
WW TP Liquid Effluent 261.020 522.020 261.000 100.00% 50.00% Sector 4.858,020 5.126.675 5.395,351 4.381,225 102.54% 97.16% 92.32%			-			┟────┤		ļ		
Sector 4.858,000 5.126,675 5.395,351 4.981,225 102 54% 97.16% 92 32%						╞╍╴───┤		 		
								1	50 00%	
		Sector	4,858,000	5.126.675	<u>5,395,351</u>	4,981,225	102 54%	97,16%	<u>92 32%</u>	

ATTACHMENT J.A-1

Notes

Proportion of streams covered = 14/72 = 19.4 percent

Commodities not covered = Antimony, Bismuth, Calcium, Coal Gas, Fluorspar and Hydrofluoric Acid, Germanium, Lead, Magnesium and

Nagnesia, Mercury, Platinum Group Metals, Pyrobitumens, Rhenium, Scandium, Synthetic Rutile, Tellunum, Tungster, Uranium, Zirconium and Hafnum

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ATTACHMENT J.A-2

		MINERAL PROCESSING WASTE STREAMS ADDRESSED						ALS STORAGE			
			Generation Rate			Accycled Volume			Percent Recycled		
Commodity	Waste Stream	Min	Ave.	Max.	Min.	Expect.	Max	Min/Min.	Expect.'Ave.	Max Alax	
Vuminum Numina	Cast Huuse Dust	19,200	19 000	19 600	16 227	16 227	16.227	85 41%	85 41%	85 41%	
	Fiertrolysis Waste	58	58	_58							
	Sector	19,058	19.058	19 058	16 227	16.227	16 227	95 15%	<u>85 15%</u>	85 15%	
				_							
Reryl rum	Spent Barren F-trate Streams	55 300	55 000	55 200	41 250	41 250	41 250	/5 00 %	75 00%	75 00*;	
	Chip Treatment Wastewater	200	100 000	2 000 000		1C 000	400 000	<u> </u>	•0 00*•	20 00*5	
	Ethration Discard	200	450	∋C 300		L					
	Sector	55,400	153.450	2,145,000	41.250	51.220	441,250	74 45%	32 37 22	20 57 2	
			 		ļ	L		l			
Copper	Acid Plant Blowdown	5 300 000	5 200 000	5 300 000	3 975 000	3 975 00C	3 975 00C	75 00*1	75.00%	75 00*•	
	WWTP Sludge	6 000	6 000	6 000							
	Sector	5.306,000	5.306.000	5.306.000	2.975.000	3,975,000	3,975,000	74.92%	74.92%	74.92%	
lemental	Anderson Filler Mocia	460	460	460		<u>├──</u> ──					
hesphorus											
	Fumace Scrupber Blowdown	410 000	4 ° 0 000	410 000	420.000	429.000	420 000	102 44 %	102 44*	102 44%	
·····	Furnace Bulling Washdown	700.000	700 000	700 000	420.000	120.000	420.000	17.004	27.924	17 019/	
	Sector	1.1.0,4%	1,1:0,460	1.1/450	420.00C	420,000	420.000	37 82**	37 82%	37 82*5	
are Earths	Spart NH,NO, Solutor	14 000	14 300	14 300	†	<u> </u>	<u> </u>	<u> </u>	├─── ┤		
	Electrol: Cell Caustic Wet APC Stud	70	70	700							
	Process Wastewater	1 000	1 000	7 000	· 400	1 400	1 400	20.00%	20 00*%	20 00*•	
	Spent Scrubber Liquor	100	500 00C	1.000.000							
	Solven: Extraction Crud	100	2 300	4 500							
	Wastewater Irom APC	100	500.00C	1,000.000							
	Sector	21.370	1.023.370	2.026,200	<u>· 400</u>	<u>1.400</u>	1_40C	6 55%	<u>C 14*.</u>	0.07%	
sieneum	Spent Filter Cake	50	500	\$ 000							
	Flant Process Wastewater	66 000	66,000	56 000	13,200	13 200	13 200	20.00%	20.00%	20 00**	
	Slag	50	500	5 000							
	Tellurum Sime Wastes	50	500	\$ 000							
	Waste So ids	50	500	5 000							
	Sector	66,200	58,000	96,000	13,200	13,200	<u>13,200</u>	12 94%	1941%	<u>15.35°</u> ,	
antalum, arrocolum-oxum	Disjester Sludge	1 000	1 000	1 000					1		
c											
	Process Wastewater	150.000	150 000	153 000	127 500	27 500	127 500	85 00%	85 00%	85 00%	
	Spent Raffinare Solids	2 000	2 000	5 00C							
	Sector	153.000	153.000	153,000	127,500	127,500	127,500	83 33*	<u>83 33%</u>	<u>83 33°.</u>	
									ł		
lanium, Ttanium. ode	Pickel Liquor and Wash Water	2 200	2 700	3.200							
	Scrap Villing Scrubber Water	4 000	5 000	6 000		500	1 200	0 CO*%	PC0 01	20 00*•	
	Smut from Mg Recovery	100	22.000	45 COO							
	Leach Liguer Sponge Wash Water	380 000	480.000	580 000	76.000	96.000	116.000	20.00%	20.00%	20.00%	
	Spent Surface Impoundment Liguids	630	3 400	6,700							
	Waste Acids (Sulfale Process)	200	39 000	77 000							
	WWTP Sludgas Solids	420.000	420 000	420,000							
	Sector	807,130	972,100	137,300	76,000	96,500	117,200	9 42*%	9 93*4	10 30°s	
nc .	Acid Plant Blowdown	130,000	· 30 000	135,000						<u> </u>	
	Waste Fernsticon	17.000	17 000	17 000)	7 225	14 450	0.00 %	42 50*%	85.00%	
	Process Wastewater	5 000.000	\$ 000.000	5 000 000	4 335 000	4 335 000	4,335 300	36 70*4	35 7C°%	85 70%	
	Oscarded Refractory Brick	1 000	1 000	1,000		├ ────			├		
	Spent Clothes, Bags, and Filters	150	150	150							
	Spont Goethite, Leach Cake Residues	15 000	15 000	15 000		<u>├</u>		<u> </u>	<u> </u>		
	Spent Surface Impoundment Liquids	900.000	1 900,000	1 900,000	378,000	378 000	378 000	19 89*6	19 39%	19 86%	
	wwTF Soids	750	750	750	l	<u> </u>			┝───╉		
	Spent Synthetic Gypsum	16 000	16 000	16 000	<u> </u>				┝━━━╉		
	TAC Tower Blowcown	250	250	250					- <u></u> +	20.000	
	WWTP Liquid Effluent	2 600 000	2 600 000	2 600 000	0	251 000	522 000	0.00%	10 04%	20 08**	
	Sector	9 680,150	9,680,150	9,680,150	4 713,000	1,981,225	5.249.450	48.69%	51.46%	54.23%	
						1 1			1		

Notas

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Proportion of streams covered = 14/117 - 12.0 percent

Commonities on: onverse = Antenony Bomuth, Cadmum, Cascium, Coal Gas, Fluoroper and Hydrof upro Acid, Germanium, Lead, Magnessei, Mercury

Mulybdenum: Ferromolybdenum: and Ammonium Molybdate. Pyrobitumens, Rhenum, Scandium: Synthetic Rutile, Tellurum, Tungsten, Uranium

ATTACHMENT J.B

Summary of Particulate Generation, Air Transport, and Deposition Modeling

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ATTACHMENT J.B. Air Quality Modeling in Support of Mineral Processing Storage Analysis

Model Selection and Options

The Industrial Source Complex Short Term (ISC3ST- version 96113) was used to model the impacts of fugitive emissions from materials handling and wind erosion at the mineral processing facilities. The ISC3ST model is the model recommended by EPA in the Guideline On Air Quality Models (Revised), EPA-450/2-78-027R, Appendix W of 40 CFR Part 51 and Part 52. As stated in the guidance document:

"Fugitive emissions are usually defined as emissions that come from an industrial source complex. They include the emissions resulting from the industrial process that are not captured and vented through a stack but may be released from various locations within the complex. Where such fugitive emissions can be properly specified, the ISC model, with consideration of gravitational settling and dry deposition, is the recommended model."

The ISC3ST model was set-up to run using the following regulatory default options:

- Final plume rise
- Stack-tip downwash
- Buoyancy-induced dispersion
- Calms processing
- Default wind profile exponents
- Default vertical potential temperature gradients
- No exponential decay.

However, since the only sources included were fugitive area sources, the options applicable to stack point sources (e.g. stack-tip downwash) were not applied.

Emission Estimates

Emissions associated with the storage of mineral processing waste (aluminum/alumina cast house dust and ferrosilicon waste from zinc production) were estimated to occur from the aggregate handling of the waste materials and from the wind erosion of the waste piles. Emissions from the aggregate handling of the waste piles vary in proportion to the mean wind speed and the moisture content of the waste. Emissions generated by wind erosion of the waste piles were related to threshold friction velocity and the wind gusts of the highest magnitude routinely measured as the fastest mile. Because the lack of data, we made a few assumptions in estimating these emissions:

a) The material in the storage piles has a moisture content of 4.8 percent

b) The threshold friction velocity for the waste piles is the same as the threshold friction velocity for fine coal dust stored on a concrete pad. This assumption would overestimate emissions for the waste piles since fine coal dust on concrete pad has a greater crosion potential than the waste piles.

c) The fastest mile, (i.e., the wind gusts of the highest magnitude) occurs during period between disturbances to the piles.

d) The surface area of the storage pile which is disturbed during each work day is equal to 25 percent of the total pile surface area.

e) Data for the annual mean wind speed and for the fastest mile were taken for Kansas City which has an average values of the cities surveyed in "Extreme Wind Speed at 129 Stations in the Contiguous United States".

Emissions from handling of the waste materials and from the wind erosion of the waste piles were estimated using equations from EPA's AP-42, Compilation of Air Pollution Emission Factors, Volume I: Stationary Point and Area Sources. As previously stated, these equations relate parameters such as exposed surface area, moisture content, mean wind speed, threshold friction velocity, fastest mile to total TSP and PM₁₀ emissions.

Meteorological Assumptions

In addition to the meteorological assumptions needed to estimate emissions from mineral processing waste piles, meteorological data was required to complete the air quality dispersion modeling analysis using ISC3ST. To conservatively predict the impacts of the emission sources, worst-case meteorological data was used in ISC3ST.

The worst-case meteorological data is similar to that incorporated in the EPA model, SCREEN3. The worst-case meteorological data set contains an array of all possible combinations of wind speed, wind direction and stability class that could exist in an actual location. The data set of meteorological conditions consisted of:

- Mixing heights of 1000 meters
- Ambient temperatures of 298 DegK
- Wind directions varying from 10 to 360 degrees
- Wind speeds (varying from 1.0 m/sec to 20.0 m/sec) assigned to stability classes A through F

A few additional parameters are required to estimate deposition using the ISC3ST model. Those parameters include: The variables are: friction velocity at the application site (m/s), Monin-Obukhov length at the application site (m) and roughness length at the application site (m). The EPA model RAMMET, version 95227 was used to estimate these parameters. RAMMET requires data on surface roughness length at application site, noon time albedo and Bowen ratio, which vary by season and land-use type. Values by season and land-use type (10% urban, deciduous forest, coniferous forest, grassland and desert shrubland share the 90%, i.e., 22.5% each) were estimated. The appropriate fraction velocity, Monin-Obukhov length and roughness length values were extracted from the RAMMET output and added to worst case meteorological data for the deposition calculations.

Location of Maximum and Area-Average Concentrations and Concentrations

As with many Gaussian dispersion models, ISC3ST results are accurate no closer than 100 meters from each source. Thus to calculate impacts of the two sets of storage piles, both piles were placed in a prototypical facility with property boundaries located approximately 100 meters from the edge of each storage pile. Two sets of receptor grids were used to determine maximum peak 24 hour and annual average concentration and deposition values at points located around the property boundary. To pinpoint the maximum values, a grid of receptor points, with receptors located from 100 meters to 250 meters in each direction, with a resolution of 50 meters was input to ISC3ST. An array of polar receptors, at 45 degree intervals, from 200 to 3,000 meters was used to estimate area average concentrations.

Results

The maximum predicted 24 hour and annual average concentration (ug/m^3) and deposition (g/m^2) values are listed in Table 1. These maximum concentration were predicted to occur 180 meters from the Al cast house dust storage pile and 104 meters from the Ferrosilicon storage pile. Area average values were estimated over the entire polar receptor grid.

Pollutant		TSP	PM_{10}			
	24 Hour	Annual Average	24 hour	Annual Average		
Max. Concentration	258.4	64.6	192.2	32.3		
Area Average	18.5	4.6	9.2	2.3		
Max Deposition	2.6e-3	6.5e-4	5.4e-4	1.3e-4		
Area Ave. Dep.	5.9e-4	1.5e-4	1.1e-4	2.9e-5		

Table 1- Modeling Results

ATTACHMENT J.C

Fish Bioconcentration and Bioaccumulation Factor Values and Data Sources

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Chemical		BAF fish (L/kg body weight) (total)	Source	BCF fish (L/kg) (dissolved)	Source	RfD (mg/kg/day)	Source	Oral CSF (mg/kg/day)-1	Source	RfC (mg/m3)	Source	Inhal URF (og/m3)-1	Source
Antiinony	7440-36-0	NA		U	Barrows et. al 1980 (in EPA 1988)*	4 00E-04	IRIS	NA		NA		NA	
Arsenic	7440-38-2	NA		4	Barrows et al. 1978*	3 00E-04	IRIS	1.50E+00	IRIS	NA		4.30E-03	IRIS
Barium	7440-39-3	NA		100	Schroeder 1970*	7 00E-02	IRIS	NA		5 00E-04	HEAST	NA	
Berylhum	7440-41-7	NA		19	Barrows et al. 1978*	5.00E-03	IRIS	4 30E+00	IRIS	NA		2 40E-03	IRIS
Cadmium	7440-43-9	NA	•	3-7,440	Benoit et al. 1976 (in EPA 1985a)*; Giesy et al. 1977 (in Eisler 1985)*	5.00E-04	IRIS	NA		NA		1.80E-03	IRIS
Chromium (VI)	18540 29-9	NA		3	ЕРА 19855	5.00E-03	IRIS	NA		NA		1.20E-02	IRIS
Cyanide	57-12-5			0.3	Kenaga 1980 (KCN)*	2.00E 02	IRIS	NA		NA		NA	
Lead	7439-92-1	8		1-726	Maddock and Taylor 1980 (in Eisler 1988)*; Wong et al. 1981 (in Eisler 1988)*		NA	NA		NA		NA	
Mercury	7439-97-6	6.00E+04	ЕРА 1993b	129-10,000 (mercury(II)); 10,000 85,700 (methylmercury)	Various refs. in EPA 19850*	3.00E-04	IRIS (HgCl2)	NA		3.00E-04	IRIS	NA	
Nickel	7440-02-0	NA		47-106	Lind et al. manuscript (in EPA 1986)*	2.00E-02	IRIS (soluble salts)	NA		NA		NA	
Selenium	7482-49-2	0.5 1.0	Cleveland et. al 1993	5-322	Cleveland et. al 1993*; Ingersoll et. al 1990*	5.00E-03	IRIS	NA		NA		NA	
Silver	7440-22-4	NA		11-150	EPA 1987	5.00E 03	IRIS	NA		NA		NA	
Thallium	7440-28-0	NA		27-1430	Zitko et al. 1975; Barrows et al. 1978*	8.00E-05	IRIS (TI2Ch2 O3,TICI, or TI2H2S O4)			NA		NA	
Vanadium	7440-62-2	NA		NA		7.00E-03	HEAST	NA		NA		NA	
Zinc	7440-66-6	4.4		275-519	Xu and Pascoe 1993*	3.00E-01	IRIS	NA		NA		NA	

Attachment J.C Fish BCF, and Toxicity Values

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ATTACHMENT J.D

Risk Characterization and Screening Spreadsheets

- J.D-1 Inhalation Pathway
- J.D-2 Particulate Depostion Soil Ingestion and Dermal Contact
- J.D-3 Particulate Deposition to Surface Water Risk Screening Results
- J.D-4 Runoff Deposition to Soils Screening Results
- J.D-5 Runoff Deposition to Surface Water Screening Results
- J.D-6 Surface Impoundment Releases to Surface Soils Screening Results

ATTACHMENT J.D-1 Inhalation Pathway

Exposure and Risk Calculations for Particulate Deposition

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COMMODITY:	Alumina and Aluminum
WASTE STRE AM :	Cast house dust
CT PM 10 Concentration	2.3 ug/m3
HE PM10 Concentration	32.3 ug/m3

Constituent	RfC (mg/m3)	Unit Risk (ug/m3)-1	Maximum Concentration in Waste (mg/kg)	CT Constituent Concentration in Particulate (ug/m3)	HE Constituent Concentration in Particulate (ug/m3)	CT Cancer Risk	HE Cancer Risk	CT Noncancer Hazard Quotient	HE Noncancer Hazard Quotient
Antimony			7.5	1.73E-05	2 42E-04	0.00E+00	0.00E+00		
Arsenic		4.30E-03	32	7.36E-05	1.03E-03	3.90E-13	1.22E-11		
Barium	5.00E-04		10	2.30E-05	3.23E-04	0.00E+00	0.00E+00	1.92E-01	1.92E-01
Beryllium		2.40E-03	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00		
Cadmium		1 80E-03	7.2	1.66E-05	2.33E-04	3.67E-14	1.15E-12		
Chromium(VI)		1 20E-02	110	2.53E-04	3.55E-03	3.74E-12	1.17E-10		
Lead			17	3.91E-05	5.49E-04	0.00E+00	0.00E+00		
Mercury	3.00E-04		0.0001	2.30E-10	3.23E-09	0.00E+00	0.00E+00	3.20E-06	3.20E 06
Nickel		4.80E-04	260	5 98E-04	8.40E-03	3 54E-13	1.10E-11		
Selenium			0.92	2 12E-06	2.97E-05	0.00E+00	0.00E+00		
Silver			1.9	4.37E-06	6.14E-05	0.00E+00	0.00E+00		
Thallium			0	0.00E+00	0.00E+00	0.00E+00	0.00E+00		
Vanadium			0	0.00E+00	0.00E+00	0.00E+00	0.00E+00		
Zinc			120	2.76E-04	3.88E-03	0.00E+00	0 00E+00		
Exposure Variables		ст	HE	Units					
EF	Exposure Frequency	350	350	days/year					
EDa	Exposure Duration (Adult)	9	20	years					

Cancer Risk = U.R. * PM10 * Max Conc.* 10^-6* (EF/365) * (ED/70) Hazard Quotient = (EF/365) * (Max. Conc.* 10^-6) / RIC

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ATTACHMENT J.D-2 Particulate Deposition - Soil Ingestion and Dermal Contact

Expensive and Rinks Calculations for Particulate Deposition

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ATTACHMENT J.D-2 (Continued) Particulate Deposition - Vegetable Ingestion

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t sposure and Rab Calculations for Particulate Deposition	COMMODITY:	WAGTE GTRCAM

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												-	1	Ground Convention	2		28 3775160	
														Para Hardy	5	•		
													5	f sposule Frequency	ŝ	3	150 Derryme	
													g	É aprovine Diseatorn	•	8	1 8	
													Aſ	and putant	6	92	10 percent	

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ATTACHMENT J.D-3 Air Emissions to Surface Water - Risk Screening Results

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Exposure and Risk Calculations for Air Emissions

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COMMODITY:	ı	Alumina and Aluminum			
WASTE STREAM:		Cast house dust		Flow Rate	
CT Long-Term Emissions		3.24E+08	mg/year	3.00E+11	L/year
HE Long-Term Emis s ions		1.52E+09	mg/year	1.30E+10	L/year

					Surface Water HBL	Concentrations (mg	<u>(L)</u>
Constituent	Maximum Concentration in Waste (mg/kg)	CT Water Concentration (mg/L)	HE Water Concentration (mg/L)	Fish - Noncancer	Fish - Cancer	Drinking Water - Noncancer	Drinking Water - Cancer
Antimony	7.5	8.10E-09	8.77E-07	NA	NA	1.40E-02	NA
Arsenic	32	3.46E-08	3.74E-06	NA	7.40E-04	NA	8.40E-04
Barium	10	1 08E-08	1.17E-06	3.77E-01	NA	2.45E+00	NA
Beryllium	0	0.00E+00	0.00E+00	2.84E-02	NA	1.75E-01	NA
Cadmium	7.2	7.78E-09	8.42E-07	7.35E-05	NA	3.50E-02	NA
Chromium(VI)	110	1.19E-07	1.29E-05	9.00E-01	NA	1.75E-01	NA
Lead	17	1.84E-08	1.99E-06	NA	NA	1.50E-02	NA
Mercury	0.0001	1.08E-13	1.17E-11	• NA	NA	1.05E-02	NA
Nickel	260	2.81E-07	3.04E-05	1.02E-01	NA	7.00E-01	NA
Selenium	0.92	9.94E-10	1.08E-07	8.40E-03	NA	1.75E-01	NA
Silver	1.9	2.05E-09	2.22E-07	1.80E-02	NA	1.75E-01	NA
Thallium	0	0.00E+00	0.00E+00	3.02E-05	NA	2.80E-03	NA
Vanadium	0	0.00E+00	0.00E+00	NA	NA	2.45E-01	NA
Zinc	120	1.30E-07	1.40E-05	3.12E-01	NA	1.05E+01	NA

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ATTACHMENT J.D-4 **Runoff Deposition to Soils Screening Results**

Release, Exposure Risk Calculations for Waste Piles

1. Aluminum Cast House Dust

Constituent	Ingestion Pathway Carber Slobe Factor (mg:kg-dayi-1	Ingestion Pathway RfD (mg/kg-day)	Maximum Bulk Concentration in Waste (mg/kg)	CT Sol: Concentration (Ingestion and Dermal) (mg/kg)	HE Soil Concentration (Ingestion and Dermai Contact) (mg/kg;	CT Soil Concentration (Ingestion of Home- Grown Vegetables) (rng/kg)	HE Soil Concentration (Ingestion of Home- Grown Vegetables) (mg/kg)
Antimony		0.0004	75	1 925-03	1 58E-01	2 39E-04	1.58E-02
Arsenic	15	0.0003	32	8.17E-03	6.74E-01	1.02E-03	6 74E-02
Barium		0 07	10	2.55E-03	2.1 E-01	3.19E-04	2.11E-02
Beryllium		0.07					
Cadmium		0 0005	7.2	1.84E-03	1.52E-01	2.30E-04	1 52E-02
Chromum(VI)		0.005	:10	2.81E-02	2.32E+00	3 51E-03	2.32E-01
Lead			17	4.34E-03	3.58E-0*	5 43E-04	3.58E-02
Mercury		0.0003	0.0001	2 55E-C8	2.11E-06	3 19E-09	2.11E-07
Nicke		0.02	260	6.64E-02	5.48E+00	8 30E-03	5.48E-01
Selenium		0 005	0 92	2.35E-04	1.94E-02	2 94E-05	1.94E-03
S-lver		0 005	. 9	4.85E-04	4.00E-02	6 07E-05	4.0CE-03
Thailium		0 00008					
Vanadium		0 009					
Zinc		0.3	120	3.07E-02	2.53E+00	3 83E-03	2 53E-01
Pathway Variable	8		CT	HE	Units		
USLE Reiease Mo	od eling (7-52)						
AWPd	Area of Waste Pile (Du	ust)	108	108	m2		
AWPf	Area of Waste Pile (Fe	erros licon)	509	509	m2		
R	Rainta I factor		50	110	1/year		
к	Son Erodability Factor		. 0.25	0.25	Vy o ar		
LS	Length-Slope Factor		1	3	unitless		
С	Cover Factor		1	1	unitiess		

Control Practices Factor 1 unitless 1 Total Soil Loss (Dust) 301 1986 kg/year 9360 kg/year Total Soil Loss (Ferrosilicon) 14.8

5000 cm

Sod Delivery

Р

SL

SL

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r	Radius of contaminated area	10000	

Soil Concentration due to Deposition: Dermal and Ingestion (6-1)

Z	Mixing Depth	2.5	1 cm
8D	Soil Bulk Density	1.5	t.2 gm/cc
ks	Soil Loss Constant	0	0 1/years
t	Deposition Period	20	20 years
SM	Mixed Soil Mass (Dermal and Ingestion)	1 18E+06	9.42E+04 kg

Soil Concentration due to Deposition: Root Vegetables (6-58)

Z	Muang Depth	20	10 cm
8D	Soil Bulk Density	1.5	1.2 gm/cc
ks	Soil Loss Constant	0	0 1/years
t	Deposition Period	20	20 years
SM	Vixed Soil Mass (Root Vegetables)	9.42E+06	9.42 E+ 05 kg

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ATTACHMENT J.D-4 (Continued) Runoff Deposition to Soils Screening Results

Release, Exposure Risk Calculations for Waste Piles

2. Zinc Waste Ferrosilicon

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Ant.mony 0 0004 Arsenic 1 5 0 0003 Barum 0 007 Genyllium 0 0005 Chrom um(VI) 0 0003 Lead 5000 6 018874429 436.557:404 0.752359304 49.655714 Mercury 0 0003 Nickel 0 02 581eur 0.005 Stleur 0.005 5100 48.557:404 0.752359304 49.655714 Nickel 0 02 581eur 0.005 5100 5000 48.55099543 3972.457123 6 018874429 397.2457123 Zinc 0.3 40000 48.15099543 3972.457123 6 018874429 397.2457123 Zinc 0.3 40000 108.15099543 3972.457123 6 018874429 397.2457123	9- 5)
Arsanic 15 0.0003 Barum 0.07 Reyllium 0.07 Cadm um 0.005 Chrom um(VI) 0.003 Nickel 0.002 Selenium 0.002 Selenium 0.005 Silver 0.005 Silver 0.005 Zirc 0.009 Zirc 0.3 Avalum 0.009 Zirc 0.3 Varabium 0.009 Zirc 0.3 Varabium 0.009 Zirc 0.3 VSLE Polaase Modeling (7-52) AWPt Area of Waste Pile (Dust) Yea 'CB AWPt Area of Waste Pile (Dust) Yea 509 AWPt Area of Waste Pile (Dust) So Elecidability 0.25 Q25 0.25 V/ear R Raintallactor So Elecidability 0.25 Gottrol Practoes 1 LS Length-Sope Factor 1 LS Length-Sope Factor <td></td>	
Barum 0.07 Reyllium 0.07 Cadm um 0.005 Chrom um(VI) 0.0003 Lead 500 6.018874429 436.557:404 0.752359304 49.655714 Metcury 0.0003 0.02 5.000 5.000 5.000 1.00000 Selenum 0.0005 0.02 5.000 7.52359304 49.655714 1.00000 Selenum 0.0005 0.02 5.000 6.018874429 436.557:404 0.752359304 49.655714 Selenum 0.0003 0.02 5.000 5.000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.0000000 1.000000 1.0000000 1.00000000 1.00000000 1.0000000000 1.000000000000000000000000000000000000	
Cam um 0 0005 Chrom um(VI) 0.005 Lead 5000 6 0 18874429 436 557 : 404 0.752359304 49 6557 14 Mercury 0 002 3 0.005 5000 6 0 18874429 436 557 : 404 0.752359304 49 6557 14 Mercury 0 002 0.005 5100 5000 6 0 18874429 436 557 : 404 0.752359304 49 6557 14 Siteer 0.005 0.005 5100 5000 5100	
Chrom um(VI) 0.005 Lead 500 6 018874429 436 557:404 0.752359304 49.655714 Mercury 0 0003 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.752359304 49.655714 0 752359304 49.655714 0 752359304 49.655714 0 752359304 49.655714 0 752359304 49.655714 0 752359304 49.655714 752359304 49.655714 752359304 49.655714 752359304 49.655714 752359304 752359304 752359304 49.655714 752359304	
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Mercury 0.0003 Nickel 0.02 Selenium C.005 Silver C.005 Thallium C.00008 Variadium C.00008 Zinc 0.3 Pathway Variables CT HE Units Zinc 0.3 4000 48.*5099543 3972.457123 6.018874429 397.245713 Pathway Variables CT HE Units CT HE Units VSLE Poloase Modeling (7-52) 108 108 m2 108 108 108 AWP0 Area of Waste P le (Dust) 108 108 108 108 108 AWP1 Area of Waste P le (Ferrositicon) 509 509 10<	
Mercury 0.0003 Nickel 0.02 Selenium C.005 Silver 3.005 Thallium C.00008 Varadium C.0009 Zinc 0.3 40000 Pathway Variables CT HE Units VSLE Palaase Modeling (7-52) CT HE Units AWP5 Area of Waste Pie (Dust) 108 108 m2 AWP5 Area of Waste Pie (Dust) 509 509 m2 R Painfail factor 50 110 1/year K So 1E codability Factor 0.25 0.25 t/year LS Length-Sope Factor 1 3 unitiess C Cover Factor 1 1 unitiess P Covinol Practices Factor 1 1 unitiess	34
Nickel 0.02 Selenium C.005 Silver C.005 Thallium C.00008 Variadium C.0009 Zine 0.3 40000 48.*5099543 3972.457123 6.018874429 397.245712 Pathway Variables CT HE Units Units Units USLE Poloase Mcdeling (7-52) CT HE Units 1	
Selenium 0.005 Silver 0.005 Thallium 0.0008 Varadium 0.009 Zino 0.3 Varlables CT MVP3 Area of Waste Pile (Dust) CT NE USLE Poloase Modeling (7-52) AWP3 Area of Waste Pile (Dust) AWP4 Area of Waste Pile (Dust) AWP5 Area of Waste Pile (Errositicon) SC9 509 m2 R Paindell factor So I E-odability 0.25 Factor 1 LS Length-Sope Factor 1 ILS Length-Sope Factor 1 P Control Practices 1 P Control Practices 1 P Control Practices 1	
Thallium C.00008 Vanadium 0.009 Zinc 3.3 40000 48.15099543 3572.457123 6.018874429 397.245713 Pathway Variables CT HE Units Units 1000000000000000000000000000000000000	
Vanadium 0.009 Zinc 0.3 40000 48.15099543 397.457123 6.018874429 397.245713 Pathway Variables CT HE Units Un	
Zinc 0.3 40000 48:15099543 3972457123 6.018874429 397245713 Pathway Variables CT HE Units Un	
Pathway VariablesCTHEUnitsUSLE Poloase Modeling (7-52)AWPdArea of Waste P le (Dust)1°C8108 m2AWPtArea of Waste P le (Ferrosificon)5C9509 m2RPainfall factor50110 "/yearKSo I E-odability0.250.25 VyearFactor13 unitessCCover Factor11 unitessPControl Practices11 unitess	
USLE Peloase Modeling (7-52) AWPd Area of Wasta Pile (Dust) 108 108 m2 AWPt Area of Wasta Pile (Ferrosil-con) 509 509 m2 R Painfall factor 50 110 '/year K Sol Erodability 0.25 0.25 t/year LS Length-Sope Factor 1 3 unitiess C Cover Factor 1 1 unitiess P Control Practices ' unit ess	23
USLE Peloase Modeling (7-52) AWPd Area of Wasta Pile (Dust) 108 108 m2 AWPt Area of Wasta Pile (Ferrosil-con) 509 509 m2 R Painfall factor 50 110 '/year K Sol Erodability 0.25 0.25 t/year LS Length-Sope Factor 1 3 unitiess C Cover Factor 1 1 unitiess P Control Practices ' unit ess	
AWPdArea of Waste Pile (Dust)108108 m2AWPfArea of Waste Pile (Ferrosil-con)509509 m2RPainfall factor50110 1/yearKSol E-codability0.250.25 t/yearFactor13 unitiessCCover Factor11 unitiessPControl Practices11 unitiess	
AWPI Area of Waste Pile (Ferrositicon) 509 509 m2 R Rainfall factor 50 110 "/year K So I Erodability 0.25 0.25 Vyear LS Length-S ope Factor 1 3 unitiess C Cover Factor 1 1 unitiess P Control Practices Factor 1 1 unitiess	
AWPI Area of Waste Pile (Ferrositicon) 509 509 m2 R Rainfall factor 50 110 "/year K So I Erodability 0.25 0.25 Vyear LS Length-S ope Factor 1 3 unitiess C Cover Factor 1 1 unitiess P Control Practices Factor 1 1 unitiess	
R Painfail factor 50 110 Vyear K So I Endability Factor 0.25 0.25 Vyear LS Length-Sope Factor 1 3 unitiess C Cover Factor 1 1 unitiess P Control Practices Factor 1 unitiess	
K So I E-odability Factor 0.25 0.25 Vyear LS Length-Sope Factor 1 3 unitiess C Cover Factor 1 1 unitiess P Control Practices Factor 1 1 unitiess	
LS Length-Slope Factor 1 3 unitiess C Cover Factor 1 1 unitiess P Control Practices 1 unitiess Factor	
C Cover Factor 1 1 unitiess P Control Practices 1 unitiess Factor	
P Control Practices * t unitiess Factor	
SL Total Soil Loss 30° 1986 kg/year (Dust)	
SL Totat Soi Loss (Ferros licon) 1418 9360 kg/year	
Sci Deivery	
r Rad-us of contaminated area 10000 5000 cm	
Soil Concentration due to Deposition: Dermal and Ingestion (6- 1;	
Z Mixing Depth 2.5 I cm	
2 Mixing Deprin 2.5 Form BD Soil Bulk Density 1.5 1.2 gm/cc	
ks Soil Loss Constant 0 0 1/years	
t: Deposition Period 20 Z0 years	
SM Mixed Soii Mass (Dermal and Ingestion) 1 18E+06 9.42E+04 kg	
Scil Concentration due to Deposition: Root Vegetables (6-58)	
Z Vixang Depih 20 10 cm	
BO Soil Bulk Density 1.5 12 gm/cc	
s Soil Loss Constant 0 0 1/years	
t Deposition Period 20 20 years	
SM Mixed Soil Mass (Root Vegetables) 9.42E+06 9.42E+05 kg	

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ATTACHMENT J.D-5 Runoff Deposition to Surface Water Screening Results

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Release, Exposure Risk Calculations for Waste Piles

1. Aluminum Cast House Dust

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Constituent	Ingesticn Pathway Cancer Slope Factor (mg-kg-day)-1	ingestion Pathway BfD (mg/kg-day)	Maximum Bulk Concentration in Waste (mg/kg)	CT Waterbody Concentration (mg/l)	HE Waterbody Concentration (mg/l)
Antimony		0.0004	7.5	7.52E-09	1.15E-06
Arsenic	1.5	0.0003	32	3.21E-08	4.89E-06
Barium		0.07	10	1.00E-08	1.53E-06
Beryllium		0.07			
Cadmium		0.0005	7.2	7.22E-09	1.10E-06
Chromium(VI)		0.005	110	1.10E-07	1.68E-05
Lead			17	1.71E-08	2.60E-06
Mercury		0.0003	0.0001	1.00E-13	1.53E-11
Nickel		0.02	260	2.61E-07	3.97E-05
Selenium		0.005	0.92	9.23E-10	1.41E-07
Silver		0.005	1.9	1.91E-09	2.90E-07
Thallium		0.00008			
Vanadium		0.009			
Zinc		0.3	120	1.20E-07	1.83E-05
Pathway Variable s			СТ	HE	Units
USLE Release Mo	deling (7-52)				
AWPd	Area of Waste Pile (D	ust)	108	108 г	m2
AWPf	Area of Waste Pile (Fe		509	509 r	m2
R	Rainfall factor	•	50	110	t/year
к	Soil Erodability Factor		0.25	0.25 1	/year
LS	Length-Slope Factor		1	3 1	unitless
С	Cover Factor		1	1.	unitless
Р	Control Practices Factor		1	1.0	unitless
SL	Total Soil Loss (Dust)		301	1986	kg/year
SL	Total Soil Loss (Ferros	silicon)	1418	9360 1	kg/year
Surface Water Cha	aracteristics				
	Flow Rate		3.00E+11	1.30E+10 I	iter/year

ATTACHMENT J.D-5 (Continued) Runoff Deposition to Surface Water Screening Results

Release. Exposure Risk Calculations for Waste Piles

2. Zinc Waste Ferrosilicon

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Constituent	Ingestion Pathway Cancer Sicpe Factor (mg-kg-day)-1	Ingestion Pathway RfD (mg/kg-day)	Maximum Bulk Concentration in Waste (mg/kg)	CT Waterbody Concentration (mg/l)	HE Waterbody Concentration (mg/l)
Antimony		0.0004			
Arsenic	1.5	0.0003			
Barium		0.07			
Beryllium		0.07			
Cadmium		0.0005			
Chromium(VI)		0.005			
Lead			5000	2.36361E-05	0.003599954
Mercury		0 0003			
Nickel		0.02			
Selenium		0.005			
Silver		0.005			
Thallium		0.00008			
Vanadium		0.009			
Zinc		0.3	40000	0.000189089	0.028799636
Pathway Variables			СТ	HE	Units
USLE Release Mo	deling (7-52)				
AWPd	Area of Waste Pile (D	ust)	108	108 r	m2
AWPf	Area of Waste Pile (Fe	errosilicon)	509	509 (m2
R	Rainfall factor		50	110	1/year
к	Soil Erodability Factor		0.25	0.25 t	/year
LS	Length-Slope Factor		1	3 (unitless
С	Cover Factor		1	1 ເ	unitless
Ρ	Control Practices Factor		1	1 ι	unitless
SL	Total Soil Loss (Dust)		301	1986	kg/year
SL	Total Soil Loss (Ferros	silicon)	1418	9360	kg/year
Surface Water Cha	aracteristics				
	Flow Rate		3.00E+11	1.30E+10 I	iter/year

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FISH INGEST	ON										1	1		ł
·		1				Water Conce	gh-End Surface entration, Bulk mples	Water Concer	ency Surface Intration, Bulk	Maximur	n High-End Sur entration, EP S		Central Ten Water Conc	ency Surface entration, EP
						Compar	ed to HBL	Compare	d to HBL		Compared to H	BL	Compar	od to HBL
Constituent	Hazard-Based Level (mg/l)	Commodity	Wastestream	Facility	State	1-10x	10-100x	1-10x	10-100x	1-10x	10-100x	100-1000x	1-10x	10-100x
Arsenic	0.00084	Copper	Acid plant blowdown	Unknown	Unknown		<u> </u>							
		Соррег	Acid plant blowdown	Unknown	Unknown	×	ļ							
		Copper	Acid plant blowdown	Unknown	Unknown	×								
		Copper	Acid plant blowdown	Unknown	Unknown	×	ļ							
· ·		Copper	Acid plant blowdown	Magma, San Manuel	AZ							×	×	-
Cadmium	0.035	Zinc	Spent surface impoundment liquids	Zinc Corp of America, Monaca	PA	×		· · · · · ·						
Lead	0.015	Zinc	Spent surface impoundment liquids	Zinc Corp of America, Monaca	PA		x					-		
		Copper	Acid plant blowdown	Unknown	Unknown	×								
		Zinc	Spent surface impoundment liquids	Big River Zinc	IL	×		•						

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ATTACHMENT J.D-6 Surface Impoundment Releases to Surface Water Screening Results

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ATTACHMENT J.D-6 (Continued) Surface Impoundment Releases to Surface Water Screening Results

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FISH INGEST	ION		R C <u>ONCENTR</u>			1	i i	1	1 1							
	Hazard-			· .	· · · · · · · · · · · · · · · · · · ·	j			d Surlace Water Bulk Samples	Surfac Concentra	l Tendency e Water ation, Bulk nples		l um High-E r Concenti Sample		Surfa Concent	L Tendenc ce Water tration, E mples
	Based					1		Compare	d to HBL	Compan	d to HBL	C c	ompared t	o HBL	Compa	red to HB.
Constituent	(mg/l)	Source	Commodity	Wastestreem	Facility	State	1-10x	10-100x	100-1000x	1-10x	10-100x		10-100x		1-10x	10-100
Visenic	0.00074		Copper	Acid plant blowdown	Unknown	Unknown		-							1-104	10-100
430,110	0.00074		Copper	Acid plant blowdown	Unknown	Unknown	1	x x				ł	· · · ·			
·· · ····			Copper	Acid plant blowdown	Unknown	Unknown		<u> </u>			1	<u> </u>	-		<u>↓</u>	1
				· · · · · · · · · · · · · · · · · · ·			· * ·						i			
	i	····-	Copper	Acid plant blowdown	Unknown	Unknown	<u> </u>					ł				
	·											<u> </u>	-		ł —	-
			Copper	Acid plant blowdown	Magma, San Manuel	AZ	+ ·	· · ····			ļ		·	<u>x</u>	×	
· ·	· · · · · · · · · · · · · · · · · · ·		Copper	Acid plant blowdown	СВІ	СВІ	· · ·				· • · · · · · · · · · · · · · · · · · ·	×	·		·	· • · · ·
Cadmium	0.0000735	HBL	Zinc	Spent surface impoundment liquids		PA	Į	·}	×		×	——	-			+
			Zinc	WWTP liquid offluent	Zinc Corp of America	ок	1 i	1	····×		<u>×</u>				ļ	.
			Zinc		Big River Zinc	IL	I	X		<u>×</u>		<u> </u>	ļ			
			Zinc	Spent surface impoundment liquids	Zine Corp of America, Monaca			x		······			I		Į	
		<u> </u>	Zinc	Spent surface impoundment liquids	Zinc Corp of America, Monaca	PA	Į					1	ļ		l.	
			Соррег	Acid plant blowdown	Unknown	Unknown	×	L								
			Zinc	Spent surface impoundment liquids	Big River Zinc	<u>IL</u>	x	_								
			Zinc	Process wastewater	Zinc Corp, Bartlesville	ок	×			_	I	1		1		1
			Zinc	Process wastewater	Unknown	Unknown	×								I	
			Copper	Acid plant blowdown	Unknown	Unknown	L x				ľ				r	
			Zinc	Process wastewater	Unknown	Unknown	×	1					1		F	
	· · · · · · · · · · · · · · · · · · ·		Zinc	Spent surface impoundment liquids	Zinc Corp of America	ок	x				1		1	· ·	1	1
			Zinc	Process wastewater	Zinc Corp, Monaca	PA	×	1								1
			Zinc	Spent surface impoundment liquids		ок	x				1	<u> </u>	1		· ·	1
			Zinc	Process wastewater	Unknown	Unknown	x				1	<u> </u>	1	<u> </u>	[
			Zinc	Spent surface impoundment liquids	· · · · · · · · · · · · · · · · · · ·	OK	×				+	<u> </u>	· · · · ·		·	· † ·
··	+··		Zinc	Spent surface impoundment liquids		OK	<u> </u>	<u> </u>	· · · · · · · · · · · · · · · · · · ·			ł	+ · ·	· · · · ·	1	·
	· · · ·		t ····	· · · · · · · · · · · · · · · · · · ·	Zinc Corp of America		<u>+ .≓</u>	i	i	· = · - · · ·	f	·{	· {		f	+
	···		Zinc	Process wastewater	Unknown	Unknown	× .	i			·····		ł		┢	+
	·		Zinc	Spent surface impoundment liquids		OK	×					ł	I		-	ł
	————		Rare Earths	Process wastewater	Unknown	Unknown	ł	<u> </u>				<u>+×</u>			i	
Mercury	0.0000125	HBL	Zinc	Spent surface impoundment liquids		<u>n</u>	ł	. ×	· ··—···							+ ·
		ļ	Zinc		Big River Zinc	IL	×				· · · ·	ł			. .	
	↓─		Copper	Acid plant blowdown	Unknown	Unknown	x				ļ	┣──			ļ	-
	·		Copper	Acid plant blowdown	Unknown	Unknown	<u>×</u>				1		₽			
			Copper	Acid plant blowdown	СВІ	CBI	-			·	· · · · · ·	×			l	·
Selenium	0.0084	HBL	Copper	Acid plant blowdown	Unknown	Unknown	×	<u> </u>					l		L	
Challium	0 0000302	HBL	Titanium and Titanium Dioxide	Leach liquid & sponge wash water	Timet, Henderson	NV	×									
			Copper	Acid plant blowdown	Cyprus, Clay Pooi	AZ						*	1		1	1
Zinc	0 312	HBL	Zinc	Spent surface impoundment liquids		t ·	×					<u> </u>		·	1	+
	1		Zinc	Spent surface impoundment liquids	Zinc Corp of America, Monaca		x i	1			+ · · ·	1	1	j	1 -	
<u> </u>			Zinc	Spent surface impoundment liquids		11	×	t —			·		1	<u> </u>	t	
	+	·	Zinc	Spent surface impoundment liquids		1		† · ·			-	<u> </u>	<u> </u>	<u> </u>	† — · –	+
	<u>+</u>	· · · ·	Zinc	WWTP liquid effluent	Zinc Corp of America	OK	t	<u>├</u> ──	· · · ·			ţ	i			†
	<u>↓</u>	•	Zinc -	Spent surface impoundment liquids			×	t	——— ——			ł	<u>↓</u>	·	·	ł



CONSTITUENT CONCENTRATION DATA FOR RECYCLED MATERIALS

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APPENDIX K

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SUMMARY OF BULK AND EP ANALYSIS RESULTS FOR MINERAL PROCESSING WASTE (RECYCLED PORTION)

November, 1996

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Bulk Samples. Nonwastewaters.

Constituents	Number of Detections	• Commodity	Waste Stream	Facility identifier	State	Constituent Concentration in Waste (mg/kg)	Volume of Waste Pile (m ³) (*)	Constituent Massiber Waste Pile (kg) (2)	Area of Waste Pile (m²)
Actimony	1	Alumina and Aluminum	Cast nouse dust	Urknown	Unkrown	7.5	107	1 08938	108
Arsen c	1	Alumina and Aluminum	Cast house dust	Unknown	Unknown	32	107	4 648	108
Banum	1	Alumina and Aluminum	Cast house dust	Unknown	Unknown	. 10	107	1 4525	·08
Cadmium	t	Atumina and Aluminum	Cast house dust	Unknown	Unknown	7.2	107	1 0458	108
Chromium	t	Alumina and Aluminum	Cast house dust	Unknown	Unknown	110	107	15 3775	*C8
Lead	2	Alumina and Aluminum	Cast house dust	Unknown	Unkrown	17	107	2.46925	108
Lead		Zinc	Waste ferrosil con	Unknown	Unknown	5000	.093	7437 5	509
Mercury	1	Alumina and Aluminum	Cast house dust	Unknown	Unknown	0.0001	107	0 00001	• 08
N ckel	1	Alumina and Aluminum	Cast house dust	Urknown	Unknown	260	107	37 765	108
Selenium	1	Alumina and Aluminum	Cast house dust	Urknown	Unknown	0.32	107	0 13363	:08
Silver	1	Alumina and Aluminum	Cast house dust	Unknown	Unknown	1.9	107	0 27538	108
Zinc	2	Alumina and Aluminum	Cast house dust	Urknown	Unknown	120	107	17 43	108
Zinc		Zinc	Waste ferrosil con	Unknown	Unkrown	40000	1093	59500	509

Bulk Samples. Wastewasters and Liquid Nonwastewaters

								Constituent	
						Constituent	Volume of	Mass in	Area of
						Concentration	Surface	Surface	Surface
	Number of	• ···				in Waste	Impoundment	Impoundment	Impoundment
Constituents	Detections	Commodity	Waste Stream	Facility dentifier	State	(mg/l)	(m [*]) (3)	(kg) (4)	(m²)
Antimony	31	Beryllium	Chip treatment wastewater	One Unnamed Facility	Unknown	0.003	417	0.00125	558
Antimony		Copper	Acid plant blowdown	Unknown	Unknown	140	22083	3091 66667	10441
Antimony		Copper	Acid plant blowdown	Unknown	Unknown	5	22083	110 41667	.044.
Antimony		Copper	Acid plant blowdown	Unknown	Unknown	0.5	22083	11 04167	.044.
Antimony		Copper · Eiemental Phosphorus	Acid plant blowdown	Unknown	Unknown	0.263	22083	5 80792	•0441
Antimony		Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant Unknown American Plant	Unknown Unknown	48 24	17500 17500	84 42.	8429 8429
Antimony Antimony		Elemental Phosphorus	Furnace scrubber blowdown	FMC Pocatello	Unknown ID	24	17500	42. 35.	8429 8429
Antimony		Elemental Phosphorus	Fumace scrubber blowdown	FMC Pocatello	1D	1.16	17500	20 3	8429 9429
Antimony		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.05	17500	0875	8429
Antimony		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Mt Pleasant	TN	0.05	17500	0 875	3429
Antmony		Elemental Phosphorus	Fumace scrubber blowdown	Unknown American Plant	Unknown	0 016	17500	0.28	3429
Antimony		Elemental Phosphorus	Furnace scrubber blowdcwn	Unknown American Plant	Unknown	0 016	17500	0.28	3429
Antimony		Bare Earths	Process wastewater	Molycorp. Louviers	co	0.5	117	0 05833	385
Antimony		Rare Earths	Process wastewater	Molycorp. Louviers	со	05	117	0 05933	385
Antimony		Selenium	Plant process wastewaters	AMAX, Fort Madison	1A	0 5	550	0 275	63*
Antimony		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unnamed Facility	Unknown	01	4375	0 4375	2517
Antimony		Ttanium and Ttanium Dioxide	Leach liquid & sponge wash water	Timet, Henderson	NV	25	4000	* 3.	2341
Antimony		Ttanium and Titanium Dioxide	Leach liquid & sponge wash water	Unnamed Plant	Unknown	0.074	4000	0 296	234*
Ant mony		Titanium and Titanium Dioxide	Scrap milling scrubber water	SCM, Baltmore	MD	05	42	0 02083	340
Antimony		Zinc	Process wastewater	Zinc Corp. Bart esville	OK	0.933	99167	92.5225	43394
Antimony		Zinc	Process wastewater	Zinc Corp, Bart'esville	OK	0.5	99167	49.58333	43384
Antimony		Zinc	Process wastewater	Zinc Corp, Monaca	PA	1	99167 99167	49 58333 49 58333	43384 43384
Antimony Antimony		Zinci Zinci	Process wastewater Process wastewater	Unknown Unknown	Unknown Unknown	0.5	39167	49.58333	43354
Anterna		Zinc	Process waslewater	Zinc Corp, Monaca	PA	0.155	99167	15.37083	43354
Anteriony		Zinc	Process wastewater	Zinc Corp, Monaca	PA	0.05	99167	4 95833	43354
Antimony		Znc	Process wastewater	Zinc Corp, Monaca	PA	2.05	99167	4 95833	43384
Antimony		Zno	Process wastewater	Zinc Corp, Bartlesville	OK	2.05	99167	4.95833	43384
Antimony		Znc	Process wastewater	Zinc Corp, Bartlesville	OK	2.05	99167	4 95833	43384
Antimony		Z.nc	Process wastewater	Zinc Corp, Bartlesville	OK	0.05	99167	4 95833	43384
Arsenic	43	Beryllium	Chip treatment wastewater	One Unnamed Facility	Unknown	0.003	417	0.00125	558
Arsenic		Copper	Acid plant blowdown	Unknown	Unknown	5800	22083	128083 33333	10441
Arsenic		Copper	Acid plant blowdown	Unknown	Unknawn	3400	22083	75083.33333	10441
Arsenic		Copper	Acid plant blowdown	Unknown	Unknown	2410	22083	53220.83333	10441
Arsenic		Copper	Acid plant blowdown	Unknown	Unknown	700	22083	15458 33333	10441
Arsenic		Copper	Acid plant blowdcwn	Unknown	Unknown	334	22083	7375.93333	10441
Arsenic		Copper	Acid plant blowdown	Unknown	Unknown	116	22083	2561.66667	10441
Arsenic		Copper -	Acid plant blowdown	Unknown	Unknown	32.9	22083	726 54167	10441
Arsenic		Copper	Ac d plant blowdown	Unknown	Unknown	30	22083	662 5	10441
Arsenic		Copper	Acid plant blowdown	Unknown	Unknown	5.41	22083	119.47083	10441 10441
Arsenic		Cooper	Acd plant blowdown	Unknown	Unknown	3 3	22083 22083	66.25 66.25	10441
Arsenic		Copper	Acid plant blowdown Acid plant blowdown	Unkhown Unkhown	Unknown Unknown	J 1.5	22083	33.125	10441
Arsenic Arsenic		Copper Copper	Acid plant blowdown	Unknown	Unknown	0.5	22083	11 04167	10441
Arsenic		Cooper	Ac.d plant blowdown	Unknown	Unknown	0.05	22083	1.104 7	10441
Arsenic		Cooper	Ac d plant blowdown	Unknown	Unknown	0.05	22083	1,104 7	10441
Arsenic		Elemental Phosphorus	Fumace scrubber blowdown	Unknown American Plant	Unknown	8.7	17500	152 25	8429
Arsenic		Elemental Phosphorus	Fumace scrubber blowdown	Unknown	Unknown	1	17500	17 5	8429
Arsanic		Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	0.501	17500	8 7575	8429
Arsenic		Elemental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	ID	0.5	17500	8.75	8429
Arsenic		Elemental Phosphorus	Fumace scrubber blowdown	Unknown American Plant	Unknown	0.4	17500	7.	8429
Arsenic		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.05	17500	C.875	8429
Arsenic		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Mt. Pleasant	ŤN	0 05	17500	0.875	8429
 Arsenic 			Furnace scrubber blowdown	Unknown American Plant	Unknown	0.016	17500	0 28	8423
Arsenic		Rare Earths	Process wastewater	Molycorp, Louviers	co	0.5	117	0.05833	385
Arsenic		Rare Earths	Process wastewater	Molycorp, Louviers	co	0.5	117	0.05833	385

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Ars	eric		Selenum	Plant process wastewaters	Climax Molyb.	IA	2.4	550	1 32	631
	enic		Selenium	Plant process wastewaters	AMAX, Fort Madison	IA	C 5	550	0 275	631
Ars	enic		Titan um and Titan um Dioxide	Leach liquic & sponge wash water	Timet, Henderson	NV	2.5	4000	10	2341
	enic		Titan um and Titan um Dioxide	Leach liquid & sponge wash water		Unknown	0.1	4000	C.4	2341
	enic		Titan um and Titanium Dioxide	Scrap milling scrubber water Process wastewater	SCM, Baltimore Zind Corp, Bartlesville	MÐ OK	05	42	02083	340
	enic enic		Zinci Zinci	Process wastewater Process wastewater	Zind Corp, Bartiesville Zind Corp, Monada	PA	2.54	99157 99167	251.88333	43384
	enic		Zec	Process wastewater	Unknown	Urknown	1.1	99*67	136 85 109 08333	43384 43384
	enic		Zho	Process wastewater	Zinc Corp, Banlesville	OK OK	3.5	99.67	49 58333	43384
	enic		Zinc	Process wastewater	Zinc Corp, Monaca	PA	0.05	99157	4.95833	43384
A-5	enic		Zinc	Process wastewater	Zind Corp, Monada	PA	0 05	99:57	4 95833	43384
Ars	enic		Zinc	Process wastewater	Zind Corp, Monada	P4	0 05	99167	4.95833	43384
	eniç		Zinc	Process wastewater	Zinc Corp. Bartlesville	ОК ОК	0.05	99*67	4 95833	43384
	enic		Zina Zina	Process wastewater Process wastewater	Zind Corp, Bartlesville	OK OK	0.05	99' 67	4 95833	43384
	enic enic		Z10 Zno	Process wastewater	Zind Corp, Bartlesville Unknown	Urknown	0 002 0 002	99°67 99'67	0.19833 0.19833	43384 43384
Arsi			Zrs	Spent surface impoundment liquids		IL	214	10500	2247	5319
Ear		35	Copper	Acid plant blowdown	Joknown	Urknown	59	22093	130 29167	10441
Ba~	rum -		Copper	Acid plant blowdown	Joknown	Urknown	5.8	22083	128.08333	10441
Bar			Copper	Acid plant blowdown	Jakaowa	Urknown	14	22083	30.91667	10441
Bar Bar			Copper Copper	Acid plant blowdown	Unknown	Urknown	1.2	22083	26.5	10441
Ear			Copper	Acid plant blowdown Acid plant blowdown	Unknown Unknown	Urknown Urknown	1	22083 22083	22.08333 1 04167	10441 10441
Bar			Copper	Acid plant blowcown	Unknown	Urknown	0.25	22053	5 52083	10441
Ban			Copper	Acid plant blowdown	Unknown	Urknown	0.2	22053	4.41667	10441
. Ban	rum		Copper	Acid plant blowdown	Unknown	Unknown	0 126	22083	2.7825	10441
8ar			Copper	Acic plant blowdown	Unknown	Urknown	0.05	22083	1 10417	10441
Bar			Copper	Acid plant blowdown	Unknown	Urknown	0.05	22083	1.10417	10441
Bar			Copper	Acid plant blowdown	Unknown	Unknown	0.05	22093	1.10417	10441
Bar Bar			Elemental Phosphorus Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant Unknown American Plant	Unknown Unknown	280	17500	4900	8429
Bar			Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	- Unknown	12 0.71	17500 17500	210. 12 425	8429 8429
Bar			Elemental Phosphorus	Fumace scrubber blowdown	FMC, Pocatel o	ID	0.5	17500	8 75	8429
Bar			Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	0.26	17500	4 55	8429
Ban	u m		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.05	17500	0 875	8429
Bar			Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.05	17500	0.875	8429
Bar			Rare Earths	Process wastewater	Molycorp, Louviers	co	0.5	117	0.05833	385
Ban Ban			Rare Earths Selen:um	Process wastewater Plant process wastewaters	Molycorp, Louviers AMAX, Fort Madison	CO IA	0.5 0.5	117 550	0.05833 0.275	385
Ban			Titan um and Titan:um Dioxide	Leach I guid & sponge wash water	Timet, Henderson	NV	2.5	4000	10.	631 2341
Ban			Titan um and Titan:um Dioxide	Scrap milling scrubber water	SCM Baltimore	MD	0.5	42	0.02033	340
Barr	um		Zinc	Process wastewater	Zinc Corp, Bartlesvi le	CK	05	99167	49 58333	43384
Ban			Zinc	Process wastewater	Zinc Corp, Monaca	PA	1	99167	49.58333	43384
Bar			Zinc	Process wastewater	Unknown	Unknown	0.5	99167	49.58333	43384
· Bari Bari			Zinc Zinc	Process wastewater Process wastewater	Zinc Corp, Bartlesville Unknown	CK	0 223	99167	22.11417	43384
Bar			Zinc	Process wastewater	Zinc Corp, Bartlesville	Unknown CK	0.2	99167 99167	19 83333 7 33833	43384 43384
Bar			Zind	Process wastewater	Zinc Corp, Monaca	PA	0.05	99167	4 95833	43384
Ban	um		Zinc	Process wastewater	Zinc Corp, Monaca	PA	0.05	99167	4 95833	43384
Barn	um		Zind	Process wastewater	Zinc Coro, Monaca	PA	0.05	99167	4 95833	43384
Bari			Zind	Process wastewater	Zinc Corp, Bartlesville	СК	0.05	99167	4 95833	43384
Bari		26	Zinc	Process wastewater	Zinc Coro, Bartlesville	CK	0.05	99167 417	4.95833	43384
	/lium /lium	20	Beryllium Copper	Chip Ireatment wastewater Acid plant blowdown	One Unnamed Facility Unknown	Unknown Unknown	3300 0.125	22083	1375 2.75042	558 10441
Bery			Copper	Acid plant blowdown	Unknown	Unknown	0 005	22083	0.11042	10441
Bery			Elemental Phosphorus	Fumace scrucber blowdown	Unknown American Plant	Unknown	0.93	17500	16.275	8429
Be-	rlium		Elemental Phosoborus	Furnace scrubber blowdown	Unknown American Plant	Unknown	0.16	17500	2.8	8429
Bery			Elemental Phosphorus	Furnace scrubber blowdown	FMC Pocatello	ID	0.05	17500	0.875	8429
Bery			Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	0 01 1	17500	0.1925	8429
Bery			Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Mt. Pleasant	TN .	0.005	17500	0.0875	8429
Bery Bery			Elemental Phosphorus Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	Stauffer, Mt. Pleasant Unknown American Plant	TN Unknown	0 005 0 002	17500 17500	0.0875 0.035	8429 8429
Bery			Rare Earths	Process wastewater	Molycorp, Louviers	CO	C.05	117	0.035	385
Bery			Rare Earths	Process wastewater	Molycorp, Louviers	co	0.05	117	0 00583	385
Beγ	rlium		Selen um	Plant process wastewaters	AMAX, Fort Madison	IA	0.05	550	0.0275	6,31
8ery			Titanium and Titanium Dioxide		Timet, Henderson	NV	0.25	4000	1	2341
Bery			Titanium and Titanium Dioxide	Leach I quid & sponge wash water		Unknown	0.0002	4000	8000.0	2341
Bery Bery			T tanium and Titanium Dioxide Zinc	Scrap milling scrubber water Process wastewater	SCM, Baltimore Zinc Corp, Bartlesville	OK	0.152 0.05	42 39167	0 00633 4 95833	340 43384
Be~			Znc		Zinc Corp, Monaca	PA	0	39167	4 95833	43384
Bery			Znc		Unknown	Unknown	0.01	99167	0 99157	43384
8e-y			Zinc		Unknown	Unknown	0.01	99167	0 99167	43334
Be~y			Znc		Zinc Corp, Monaca	PA	0.005	99167	0 49583	43384
Be~y			2.02		Zinc Corp, Monaca	. PA	0.005	99167	0 49583	43394
Bery			Zinc		Zinc Corp, Monaca	PA	0.005	99167 99167	0.49583	43394 43384
Bery Bery			Zinc Zinc		Zinc Corp, Bartlesville Zinc Corp, Bartlesville	OK OK	0.005	99167	0.49583 0.49583	43384
Bery			Zno		Zinc Corp, Bartlesville	OK OK	0.005	99167	0.49583	43384
Cadr		75	Beryflum		One Unnamed Facility	Unknown	0.063	417	0 02625	558
Cadr			Copper		Unknown	Unknown	620	22083	13691.66667	10441
Cadr			Copper		Urknown	Unknown	290	22083	6404.16667	10441
Cadr			Cooper		Unknown	Unknown	25.1	22083	554 29167	10441
Cadr			Copper		Unknown	Unknown	19	22083	419.58333	10441
Cadr Cadr			Cooper		Unknown	Unknown	11	22083	242.91667 238 5	10441 10 441
Cadr			Copper Copper		Unkhown Unkhown	Unknown Unknown	10.8 *0	22083 22083	238.5	10441
Cadr			Copper		Unknown	Unknown	6	22083	132.5	10441
Cadr			Copper		Unknown	Unknown	5.4	22083	119.25	10441
Cadr	กบาว		Copper		Unknown	Unknown	5	22083	110.41567	10441
Cadr			Copper		Unknown	Unknown	1.3	22083	28.70833	10441
Cadr			Copper		Unknown	Unknown	1.18	22083	26.05833	10441
Cadr			Copper		Unknown	Unknown	1	22083	22.08333	10441 10441
Cadr Cadr			Copper Copper		Unknown Unknown	Unknown Unknown	0 52 0 43	22083 22083	11 48333 9.49583	10441
200	-						0.0			

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Cadmium		Copcer	Acid plant blowdown	Unknown	Urknown	0.2	22093	4 4 1667	10441
Cadmum		Elemental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	ID	9.6	17500	158	8429
Caomum		E emental Phosphorus	Furnace scrubber blowdown	FMC. Pocate lo	1D	4 75	17500	83 125	8429
Cadmium Cadmium		Elemental Phosphorus Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	Unknown FMC, Pocate lo	Urknown ID	4 3.7	175CO 17500	70 54 75	8429 8429
Cadmium		E emental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Urknown	3.7	•7500	52 5	8423
Cadmium		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer Silver Bow	MT	2 86	. 75:00	50 05	8429
Cadmium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	19	17500	33 25	8429
Cadmium		Elemental Phosphorus Elemental Phosphorus	Furnace scrubber blowdown	FMC, Posatello Unknown American Plant	ID Unknown	1.3	*7500	22 75	8429
Cadmium Cadmium		Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	FMC, Pocate to	ID	0 6675 0 593	17500 17500	11.58125 10 3775	8429 8429
Cadmium		Elemental Phosphorus	Furnace scrubber blowdown	Stauller, Mt. Pleasant	TN	0 024	17500	0 42	8429
Cadmium		Elemental Phosphon.is	Furnace scrubber blowdown	Staulter Mt. Pleasant	TN	0.005	1/500	0.0375	8429
Cadmium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	0.001	17500	0.0175	8429
Cadmium Cadmium		Rere Earths Rere Earths	Process wastewater Process wastewater	D S. Chemical, Chattanooga Molycom, Louviers	TN CO	0.05	117 117	0.0063	385 385
Cadmium		Rare Earths	Process wastewater	Molycorp, Louviers	cõ	0.05	117	0.00593	385
Cadmum		Rare Earths	Process wastewater	D.S. Chemical, Chattanooga	TN	0 0005	117	0.0006	385
Cadmium		Selenium	Plant process wastewaters	AVAX, Fort Madison	IA	0.05	550	0.0275	531
Cadmsum Cadmsum		Selenium Fantalum, Columbium, and Ferrocolumbium	Plant process wastewaters Process wastewater	Climax Molyb. Unnamed Facility	lA Unknown	0.017	550 4375	0.00935 0.375	631 2517
Cadmum		Titanium and Titanium Dioxide	Leach liquid & sponge wash water	Timet, Henderson	NV	0.25	4000	0 3/3 t.	2341
Cadmium		Titanium and Titanium Dioxide	Leach liquid & sponge wash water	Unnamed Plant	Unknown	0.6	4000	0.64	2341
Cadmium		Titanium and Titanium Dioxide	Scrap miting scrucber water	SCM, Baltimore	MD	0.05	42	0 00208	340
Cadmium		Zinc	Process wastewater	Zinc Corp, Bartlesville	OK	555	99167	55037 5	43384
Cadmium Cadmium		Zine Zine	Process wastewater Process wastewater	Unknown Unknown	Unknown Unknown	410 160	99°67 99°67	40658.33333 15866 66667	43384 43384
Casmum		Zinc .	Process wastewater	Zinc Corp, Monaca	PA	113	99:67	11205.83333	43384
Cadmium		Zinc	Process wastewater	Unknown	Unknown	93	99*67	9222 5	43384
Cadmium		Zinc	Process wastewater	Unknown	Unknown	71.3	99167	7070.58333	43384
Cadmum		Zinc	Process wastewater	Jersey Miniere, Clarksville	TN	62.5	99157	6197.31567	43384
Cadmum		Zinc	Process wastewater	Zinc Corp, Bartlesville	ок С	44	99157	4363 33333	43384
Cadmium Cadmium		Zinc Zinc	Process wastewater Process wastewater	Zinc Corp. Bartlesville Jersey Miniere: Clarksville	OK TN	38.4 25	99167 99157	3808. 2479.16667	43384 43384
Cadmum		Zinc	Process wastewate	Unknown	Urknown	4	99167	396 56567	43384
Cadmum		Zinc	Process wastewater	Zine Corp, Monaca	PA	3 09	99.67	306.425	43384
Cadmium		Zinc	Process wastewater	Zinc Corp, Monaca	PA	2.71	93167	263./4167	43384
Cadmium		Zin¢	Process wastewater	Zinc Corp. Bartlesville	OK .	0 454	99167	45 02167	43384
Cadmum Cadmum		Zinc Zinc	Process wastewater Process wastewater	Zinc Corp, Monaca Zinc Corp, Bartlesville	PA OK	0.0562 0.0185	99167 99167	5.57317 1 83458	43384 43384
Cadmum		Zinc	Process wastewater	Unknown	Urknown	0.003	99157	0.2975	43384
Çadmum		Zinc	Spent surface impoundment liquids	Zinc Corp of America, Monaca	PA	40000	10500	42:000	53.3
Cadmium		Zinc	Scent surface impoundment liquids		IL.	5492	10500	57666	53'9
Cadmum		Zinć	Spent surface impoundment liquids			870	10500	9135	53.3
Cadmium Cadmium		Zinc Zinc	Spent surface impoundment liquids Spent surface impoundment liquids		IL	650 . 600	10500	5825 5300	5319 5319
Cadmium		Zinc	Spent surface impoundment liquids		ÖK .	160	10500	1680.	53.9
Cadmium		Z:nc	Scent surface impoundment liquids		OK .	100	10500	1050	5313
Cadmum		Zinc	Spent surface impoundment liquids		OK .	93	10500	976 5	5319
Cadmum		Zinc	Spent surface impoundment liquids		OK	90	10500	945	5319
Cadmium Cadmium		Zinc Zinc	Spent surface impoundment Equids Spent surface impoundment Equids		OK TN	70 45	10500	735 472 S	5319 5319
Cadmum		Zinc	Spent surface impoundment I guids		IL I	5.2	10500	54 6	5319
Cadmium		Zinc	Spent surface impoundment I guids		оĸ	1.3	10500	13 65	53.3
Cadmum		Zinc	Spent surface impoundment Equics		ж	13	10500	13 65	5319
Cadmum			Spent surface impoundment I guids		PA	0.3	10500	3 15	5319
Cadmium Cadmium		Zinc Zinc	Spent surface impoundment liquids WWTP liquid effluent	Zind Corp of America. Monaca	DK DK	0.2 24200	10500 7250	2.1 175450	5319 3850
Cadmium			WWTP liquid effluent	Zinc Corp of America	OK	24200	7250	7 25	3650
Chromium	44	Beryllium	Chip treatment wastewater	One Unnamed Facility	Unknown	7.4	417	3 08333	558
Chromium			Acid plant blowdown		Unknown	2*	22083	453.75	10441
Chromium			Acid plant blowdown	Unknown	Unknown	19 2 37	22083 22083	419.58333	10441
Chromium Chromium			Acid plant blowdown Acid plant blowdown	Unknown Unknown	Unknown Unknown	1.8	22083	52.3375 39.75	10441 10441
Chromium			Acid plant blowdown		Unknown	1.4	22083	30.91667	10441
Chromium		Copper	Acid plant blowdown	Unknown	Unknown	12	22083	26.5	10441
Chromum		Copper	Acid plant blowdown		Unknown	1.05	22083	23 1875	10441
Chromium		Copper Copper	Acid plant blowdown Acid plant blowdown		Unknown Unknown	0.78	22083 22083	22.08333 17.225	10441 104 4 1
Chromium			Acid plant blowdown	Unknown	Unknown	0.4	22083	8 83333	10441
Chromium			Acid plant blowdown	Jaknowa	Unknown	0.259	22083	5.71958	10441
Chromium			Acid plant blowdown		Unknown	0.16	22083	3 53333	10441
Chromium			Acid plant blowcown	Unknown	Unknown	0.13	22083	2 87033	10441 10441
Chromium			Acid plant blowdown Furnade scrubber blowdown		Unknown Unknown	0.1 940	22083 17500	2.20833 16450	8429
Chromum		•	Fumace scrubber blowdown	Unknown American Plant	Unknown	41	17500	717 5	3429
Chromum			Fumace scrubber blowdown	Unknown	Unknown	2	17500	35.	3429
Chromium			Furnace scrubber blowdown		Unkr.own	16	17500	28.	3429
Chromium			Furnace scrubber blowdown		1D	1.53	17500	26 775	3429
Chromium Chromium			Furnace scrubber blowdown Furnace scrubber blowdown		ID MT	1 2 0.07	17500 17500	21. 1 225	8429 8429
Chromum			Fumace scrubber blowdown		TN	C.05	17500	0 875	3429
Chromium			Furnace scrubber blowdown		TN	0.05	17500	0.875	8429
Chromium		Elemental Phosphorus	Fumace scrubber blowdown	Unknown American Plant	Unknown	0.0005	17500	0.00875	8429
Chromium					co	0.5	117	0 05833	335
Chromium Chromium					CO TN	0.5 0.041	117 117	0 05833 0.00478	385 385
Chromium			Process wastewater Process wastewater		TN	0.0005	117	0.00478	355
Chromium			Plant process wastewaters		IA	0.5	55C	0.275	631
Chromium			Leach liquid & sponge wash water		NV	2.5	4000	10.	2341
Chromium					Unknown	1.2	4000	48	2341
Chromium Chromium			Scrap milling scrubber water		MD	0.5	42 99167	0.02083 49.58333	340 43384
Chromium					OK PA	0.5 1	99167 99167	49.58333	43384 43384

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	Chromum		Zinc	Process wastewater	Zinc Corp. Bartlesville	ж	0.386	99167	38.27833	43384
	Chromium		Zinc	Process wastewater	Unknown	Unknown	0.06	99167	5 95	43384
	Chromium		7.nc	Process wastewater	Zinc Corp, Monaca	PA	0.05	99167	4 95833	43384
	Chromum		Zinc	Process wastewater	Zinc Corp, Monaca	PA	0 05	99167	4 95833	43384
	Chromium		Zinc	Process wastewater	Zinc Corp, Monaca	PA OK	0.05	99167	4.95833	43384
	Chromium Chromium		Zinc * Zinc	Process wastewater Process wastewater	Zinc Corp. Bartlesville Zinc Corp. Bartlesville	ож	0 05 0 05	99167 99167	4 95833 4 95833	43384 43384
	Chromum		Zinc	Process wastewater	Zinc Corp Bartlesville	ок ок	0 045	99167	4 4625	43384
	Chromum		Zinc	Process wastewater	Unknown	U~known	0.001	99167	0 09917	43384
	Cyanide	з	Elemental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	ID	0.3	17500	15 75	8429
	Cyanide		Tanta um, Columbium, and Ferrocolumpium		Unnamed Facility	Unknown	0.009	4375	0.03938	2517
	Cyan de	e e	Zine	Process wastewater	Zinc Corp. Bartlesville	OK	0.005	99167 417	0 49583	43384
	Lead Lead	56	Barysum Copper	Chip treatment wastewater Acid plant blowdown	One Unnamed Facility Unknown	Unknown Unknown	0 2 17900	22083	0.08333 395291 56667	558 10441
	Lead		Conper	Acid plant blowdown	Unknown	Unknown	7.0	22083	15679 16667	10441
	Lead		Cooper	Acid plant blowdown	Unknown	Unknown	70C	22083	15458.33333	10441
	Leac		Cooper	Acid plant blowdown	Unknown	Unknown	64C	22083	14133.33333	10441
	Lead		Copper	Acid plant blowcown	Unknown	Unknown	100	22083	2208.33333	10441
	Lead Lead		Capper Capper	Acid plant blowdown Acid plant blowdown	Unknown Unknown	Unknown Unknown	42.5 19	22083 22083	938 54167 419 58333	10441 10441
	Lead		Copper	Acid plant blowdown	Unknown	Urknown	9 87	22083	217 9625	10441
	Lead		Capper	Acid plant blowdown	Unknown	Unknown	3	22083	176 56567	10441
	Lead		Copper	Acid plant blow down	Unknown	Urknown	6 2 3	22083	137.57917	10441
	Lead			Acid plant blowdown	Unknown	Unknown	5.6	22083	123.66667	10441
	Lead Lead			Acid plant blowdown Acid plant blowdown	Unknown Unknown	Urknown Urknown	5 4.9	22083 22083	110 41667 108 20833	10441 10441
	lead			Acid plant b owcown	Unknown	Urknown	4.5	22083	88 33333	10441
	Leac			Acid plant blowcown	Unknown	Unknown	3 15	22083	69 5625	10441
1	Leas		Copper	Acid plant blowcown	Unknown	Unknown	2.8	22083	61 83333	10441
	Lead			Acid plant blowcown	Linknown	Ucknown	2.5	22083	55.20833	10441
	Lead			Acid plant blowdown	Unknown	Unknown	0.53	22083	1.704 7	1044 t
	Lead			Acid plant blowcown	Unknown:	Unknown	25	22083	4 4 667	10441
	Lead Lead			Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant Unknown American Plant	Urknown Urknown	150 52	• 7500 • 7500	2625. 910.	8429 8429
	Lead			Furnace scrubber blowdown	Stauffer, Mt. Pleasant	TN	1.4	17500	24 5	8429
	Lead			Fumace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.955	· 7500	16 7125	8429
	Lead			Furnace scrubber blowdown	FMC, Pocatello	ID	0.6	*7500	10.5	8429
	Lead			Furnace scrubber blowdown	FMC, Pocatello	ID	0.523	17500	9 1525	8429
	Lead Lead			Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant Unknown American Plant	Unknown Unknown	0.037 0.004	17500	0 6475 0 07	8429 8429
	Leas			Process wastewater	Molycorp, Louviers	CO	8.45	17	0.98583	385
	Lead			Process wastewater	Molycorp, Louviers	co	1 23	17	0 1435	385
ι	Lead			Process wastewater	D.S. Chemical, Chattanocga	TN	0.33	17	0.0385	385
	Lead			Process wastewater	DS Chemical Ohattanooga	TN	0.0005	117	0.00006	385
	Lead Lead			Plant process wastewaters Plant process wastewaters	AMAX, Fort Madison Climax Molyb.	IA IA	16.9 1.42	550 550	9.295 C 781	531 531
	Leas			Leach liquid & sponge wash water	Unnamed Plant	Unknown	2.8	4000	1.2	2341
	Leac			Leach liquid & sponge wash water	Timet, Henderson	NV	1 25	4000	5.	2341
t	Lead		Titan um and Titan um Dioxide	Scrap milling scrubber water	SCM, Baltimore	MD	0.25	42	01042	340
	Lead .			Process wastewater	Unknown	Unknown	300	99167	29750	43384
	Lead			Process wastewater	Zinc Corp, Monaca	PA	17	99167	1636.25	43384
	Lead Lead			Process wastewater Process wastewater	Zinc Corp, Bartlesville Zinc Corp, Bartlesville	OK OK	10.9 9.6	99167 99167	1080.91667 952	43384 43384
	Lead			Process wastewater	Zinc Corp. Bartlesville	OK	8.3	99167	823.08333	43384
	.ead			Process wastewater	Zine Coro, Menaca	PA	6 58	99167	652.51667	43384
	Lead			Process wastewater	Unknown	Unknown	5.8	99167	. 575 16667	43384
	Lead			Process wastewater	Zinc Corp. Monaca	PA CK	0.348	99167	34.51	43384
	Lead			Process wastewater Process wastewater	Zind Corp, Bantesville Zind Corp, Monaca	PA	0.0577 0.025	99167 99167	5.72192 2.47917	43384 43384
	Lead			Process wastewater	Zinc Corp. Bartlesville	сж.	0 025	99167	2.47917	43384
	ead			Process wastewater	Unknown	Unknown	0.0005	99167	0.04958	43384
	_ead			Spent surface impoundment liquids			200000	10500	2100000	5319
	ead			Spent surface impoundment liquids Spent surface impoundment liquids		IL .	13950	10500	146475	5319 5319
	_ead _ead			Spent surface impoundment liquids			7000 5000	10500 10500	73500. 52500.	5319
	ead		-	Spent surface impoundment liquids			2500	10500	26250	5313
	_ead			Spent surface impoundment liquids		PA	07	10500	7 35	5319
_	ead				Zinc Corp of America	OK	6100	7250	44225.	3850
	Mercury Mercury	42		Chip treatment wastewater Acid plant blowdown	One Unnamed Facility Unknown	Unknown	0 0002	417 22083	0 00008 33 125	558
	Mercury			Acid plant clewdown	Urknown	Unknown	15	22083	33 . 25	10441
	Mercury			Acid plant blowdown	Usknown	Unknown	0.36	22083	7.95	.044.
	Mercury			Acid plant blowdown	Urknown	Unknown	0 062	22083	36917	10441
	Mercury			Acid plant blowdown	Unknown	Unknown	C.0428	22083	0 94517 0 27604	10441
	Mercury Mercury			Acid plant blowdown Acid plant blowdown	Unknown Unknown	Unknown Unknown	0.0125	22083 22083	0 11042	10441
	dercury			Acid plant elevidown	Urknown	Unknown •	0.005	22083	0 11042	12441
	Mercury			Acid plant blewdown	Unknown	Unknown	0.0046	22083	0 10158	10441
	Mercury			Acid plant blowdown	Urkhown	Unknown	0.0022	22083	0 04858	10441
	Mercury			Acid plant blowdown	Unknown	Unknown	0.0018	22083	0 03975	10441
	dercury dercury			Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant Unknown American Plant	Unknown Unknown	0.1 0.05	1750C 1750C	1.75 0 875	8429 8429
	dercury dercury			Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant	Unknown	0.0002	17500	C 0035	8429
	dercury			Fumace scrubber blowdown		Unknown	0.00015	17500	0.00263	8429
	dercury		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Silver Bow	VT	0.00012	17500	0.0021	8429
	vercury			Furnace scrubber blowdown	FMC, Pocatello	D	0.0001	17500	0 00175	8429
	fercury			Furnace scrubber blowdown		TN TN	0.0001 0.0001	17500 17500	0.00175 0.00175	8429 8429
	dercury dercury			Furnace scrubber blowdown Process wastewater		TN CO	0.0001	1/500	0.00175	8429 385
	dercury				Molycorp, Louviers	co	0.0001	117	0.00001	385
	fercury			Plant process wastewaters	AMAX, Fort Madison	IA	0 00072	550	0 0004	631
	dercury		Titanium and Titanium Dioxide	Leach liquid & sponge wash water	Timet, Henderson	NV	0 00 16	4000	0 0064	2341
	fercury				Unnamed Plant	Unknown	0.0002	4000	8000.0	2341
``	fercury		Tranum and Titanium Dioxide	Scrap milling scrubber water	SCM, Baltimore	MD	0 0001	42	<u>_</u> 0	340

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Mercury		Zinc	Process wastewater	Zinc Corp. Monaca	PA	0	99167	34 51	43384
Mercury		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK	0 0274	99167	2 71717	43384
Mercury		Zinc	Process wastewater	Unknown	Unknown	0.018	99167	1.785	43384
Mercury		Zind	Process wastewater	Zinc Corp. Bart'esville	0K	0.00999	99167	0 99068	43384
Mercury		Zinc	Process wastewater	Zine Corp, Monaca	PA	0065	99167	0 54458	43354
Mercury		Zinc	Process wastewater	Zinc Corp, Monaca Zinc Corp, Bert equille	₽ à OK	0.0031	99167	0 30742	43384
Mercury More of		Zind	Process wastewater Process wastewater	Zind Corp, Bart esville Zind Corp, Bart esville	OK	0.0019 0.00075	09167 99167	0 18842 0 07438	43384 43394
Mercury Mercury		Zinci Zinci	Process wastewater	Zinc Corp, Monaca	PA	0.0001	99167	0 00992	43384
Mercury		Zinc	Process wastewater	Zinc Corp, Bart esville	OK	3.0001	39167	0 00992	43364
Mercury		Zinc	Process wastewater	Urknown	Unknown	0.0001	39167	0 00992	43394
Mercury		Zinc	Spent surface impour dment liquids	s Big River Zinc	IL.	23 8	10500	249 9	5319
Mercury		Zinc	Spent surface impoundment liquids		IL I	3 538	10500	37 149	5319
Mercury		Zina	Spent surface impoundment liquids		TN	1	10500	10 5	5319
Mercury More: Pr		Z-nc Zinc	Spent surface impoundment liquids		IL IL	2.17	10500	10 5	5319
Mercury Nickel	43	Ziric Berylkum	Spent surface impoundment liquids Chip treatment wastewater	One Unnamed Facility	Unknown	0 17 0 78	10500 417	1 785 0 325	5319 558
Nickel		Copper	Acid plant blowdown	Urknown	Unknown	1450	22083	32020 83333	10441
Nickel		Copper	Acid plant blowdown	Urknown	Jinknown	940	22083	20758 33333	10441
Nickel		Copper	Acid plant blowdown	Urknown	Unknown	20	22083	44 66667	10441
Nickel		Copper	Acid plant blowdown	Unknown	Jnknown	16	22083	353 33333	10441
Nickel		Copper	Acid plan' blowdown	Unknown	Unknown	2	22083	44 16667	10441
Nickel		Copper	Acid plant blowdown Acid plant blowdown	Unknown Unknown	Unknown	1.95	22083	43.0625	10441
Nickel Nickel		Copper Copper	Acid plant blowdown	Unknown	Unknown Unknown	18	22083 22083	39.75 26.5	10441
Nickel		Copper	Acid plant blowdown	Unknown	Unknown	· 2	22083	26.5	10441
Nickel		Copper	Acid plant blowdown	Unknown	Unknown	0 481	22083	10 62208	10441
Nickel		Copper	Acid plant blowdown	Unkrown	Unknown	0.005	22083	0.11042	10441
Nickel		Elementa Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	530	17500	9275.	9429
Nickel		Elementa Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	19	17500	332 5	8429
Nickel		Elementa Prosphorus	Furnace scrubber blowdown	Unknown Amencan Plant	Unknown	1.3	17500	22.75	8429
Nickel		Elementa: Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	ID	05	17500	8 75	8429
Nickel		Elemental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	:D	0.2	17500	35	8429
Nickel		Elementa: Phosphorus	Furnace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.05	17500	0 875	8429
Nickel Nickel		Elementa: Phosphorus Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	Stauffer, Mt. Pleasant Unknown American Plant	TN Unknown	0.05	1750G 1750C	0.875	8429
Nickel		Rare Earths	Process wastewater	D.S. Chemical, Chattanooca	TN	4	117	0.1575 0.46667	8429 365
Nickel		Rare Earths	Process wastewater	Molycorp, Louviers	co	0.5	117	0.05833	355
Nickel		Aare Earths	Process wastewater	Molycorp, Louviers	co	0.5	117	0 05833	365
Nickel		Rare Earths	Process wastewater	D.S. Chemical, Chattanooga	TN	80C.0	117	0.00093	385
Nickel		Seenum	Plant process wastewaters	AMAX Fort Madison	IA	0.5	550	0.275	631
Nickel		Seenum	Plant process wastewaters	Ci max Molyb.	IA	0.1	550	0 055	601
Nickel		Tantalum Columbium, and Ferrocolumbium		Unnamed Facility	Unknown	1	4375	4.375	2517
Nickel Nickel		Trianium and Titanium Dioxide Titanium and Titanium Dioxide	Leach iquid & sponge wash water Leach iquid & sponge wash water	Unnamed Plant Timet, Henderson	Urknown NV	7 2.5	4000 4000	28. 10.	2341
NICKE		Titanium and Titanium Dioxide	Scrap milling scrubber water	SCM, Baltimore	MD	0.5	40.00	0 02083	340
Nickel		Zirc	Process wastewater	Znc Corp. Monaca	PA	11	99167	1041 25	43384
Nickel		Zinc	Process wastewater	Zinc Corp, Bartlesville	ок	8 12	99167	905 23333	43384
Nickel		Zinc	Process wastewater	Unknown	Unknown	6.3	99167	624 75	43384
Nickel		Zind	Process wastewater	Zinc Corp. Bartlesville	OK	1.6	99167	158.66667	43384
Nickel		Zinc	Process wastewater	Zinc Corp Bartlesville	ок	0.5	99' 67	49 58333	43384
Nickel		Zinc	Process wastewater	Zinc Corp. Monaca	PA	0.05	99' 67	4 95833	43384
Nickel		Zinc	Process wastewater	Zinc Corp. Monaca	PA	0.05	99167	4 95833	43384
Nickel Nickel		Zina Zina	Process wastewater Process wastewater	Zinc Corp, Monaca Zinc Corp, Bartlesville	PA OK	0.05	99*67 99*67	4 95833 4 95833	43384 43384
Nickel		Zirc	Process wastewater	Zinc Corp, Bartlesville	OK OK	0.05	99.67	4.95833	43384
Nickel		Zirc	Process wastewater	Unknown	Unknown	0.03	99.67	2.975	43384
Nickel		Zirc	Scent surface impoundment liquids	Big River Zinc	IL.	257	·0500	2698.5	5319
Nickel		Zinc	WWTP I guid effluent	Zinc Corp of Amerca	ок	410	7250	2972 5	3850
Selenium	42	Beryllium	Chip treatment wastewater	One Unnamed Fac lity	Unknown	0.003	417	0.00125	55a
Selenum		Copper	Acid plant blowdown	Unknown	Urknown	1000	22033	22083 33333	10441
Selen um Selen um		Copper	Acid plant blowdown	Unknown Unknown	Urknown Urknown	1.9 91	22083 22083	262 79167 200.95833	10441 10441
Selenum		Copper Copper	Acid plant blowdown Acid plant blowdown	Unknown	Unknown	2.1	22083	46.375	10441
Selen um		Copper	Acid plant blowdown	Unknown	Unknown	2	22083	44.16667	10441
Selen um		Copper	Acid plant blowdown	Unknown	Unknown	0.761	22083	16 80542	10441
Selen:um		Copper	Acid plant blowdown	Unknown	Unknown	0.5	22093	11.04167	10441
Selenium		Copper	Acid plant blowcown	Unknown	Unknown	0 12	22083	2.65	10441
Selen um		Copper	Acid plant blowcown	Unknown	Unknown	0.1	22083	2 20833	10441
Selen um		Copper	Acid plant blowdown	Unknown	Unknown	0.005	22093	2.11042	10441 10441
Selenum		Copper Copper	Acid plant blowdown Acid plant blowdown	Unknown Unknown	Unknown Unknown	0.005	22083 22083	0.11042 0.11042	10441
Selenum		Copper	Acid plant blowdown	Unknown	Unknown	0.002	22083	0 04417	10441
Selen.um		E emental Phosphorus	Fumace scrubber blowdown	Unknown	Unknown	1	17500	175	8429
Selenium		E emental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	ID	0.5	17500	8.75	8429
Selenium		Elemental Phosphorus	Furnace scrutber blowdown	Stauffer, Mt. Pleasant	TN	0.05	17500	0 875	8429
Selenium		E emental Phosphorus	Fumace scrubber blowdown	Stauffer, Mt Pleasant	TN	0.05	17500	0 875	8429
Selenium		E emental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant	Unknown	0 045 0.045	17500 17500	0.7875 0 7875	8429 8429
Selenium Selenium		Elemental Phosphorus Elemental Phosphorus	Fumace scrubber blowdown Fumace scrubber blowdown	Stauffer, Silver Bow Unknown Amencan Plant	MT Unknown	0.045	17500	0 04375	8429
Selenium .		Rare Earths	Process wastewater	Molycorp, Louviers	CO	0.5025	17300	0.05833	385
Selenium		Rare Earths	Process wastewater	Molycorp, Louviers	co	0.5	117	0 05833	385
Selenium		Selen um	Plant process wastewaters	Climax Molyb	IA	3.6	550	1.98	631
Selenium		Selenum	Plant process wastewaters	AMAX, Fort Madison	IA	05	550	0 275	63!
Selenrum		Tantalum, Columbium, and Ferrocolumbium		Unnamed Facility	Unknown	0.01	4375	0 04375	2517
Selenium		Titan um and Titan um Dioxide	Leach liquid & sponge wash water	Timet, Henderson	NV	2.5	4000	10.	234*
Selenium		Titanium and Titanium Dioxide Titanium and Titanium Dioxide	Leach liquid & sponge wash water	Unnamed Plant SCM Bait more	Unknown MD	0.014	4000	0.056	234 · 340
Selenium Selenium		I tanium and Titanium Dioxide Zinc	Scrap milling scrubber water Process wastewater	Unknown	Unknown	100000		9916656 66667	43384
Selenium		Zinc	Process wastewater	Zinc Corp, Bartlesville	OK	0.5	99167	49.58333	43384
Selenium		Znc	Process wastewater	Zinc Corp, Monaca	PA	1	99167	49 58333	43384
Selenium		Znc	Process wastewater	Unknown	Unknown	C.39	99167	38 575	43384
Selenium		Znc	Process wastewater	Zinc Corp, Monaca	PA	C.05	99167	4 95833	43384
Selenium		Znc	Process waslewater	Zinc Corp, Monaca	PA ·	0 05	99167	4.95833	43384

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Se enium		Zinc	Process wastewater	Zinc Corp, Monaca	PA	0.05	99167	4 95833	43384
Se enium		Zinc	Process wastewater	Zinc Corp. Banlesville	OK	0 05	99167	4 95833	43384
Selenium		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK	0 05	99157	4 95833	43384
se enium		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK	0.05	93167	4.95833	43384
Selenium		Zind	Process wastewater	Zinc Corp, Bartlesville	ок	0 01	99167	0 99167	43384
Selenium		Zinc	Process wastewater	Unknown	Urknown	0 0025	99157	0 24792	43384
eenum		Zinc	Spent surface impoundment liquid.	s Big River Zinc	IL.	11	*0500	115.5	53*3
Siver .	38	Beryl'ium +	Chip treatment wastewater	One Unnamed Facility	Unknown	0 04	417	001667	558
Siver		Copper	Acid plant blowdown	Unknown	Unknown	124	22083	2738 33333	10441
dilver		Copper	Acid plant blowdown	Unknown	Urknown	1	22083	22.08333	10441
Silver		Copper	Acid plant blowdown	Unknown	Unknown	1	22083	22.08333	10441
lvar		Copper	Acro plant blowdown	Unknown	Urknown	05	22083	1 24167	10441
dver		Copper	Acid plant blowdown	Unknown	Urknown	0.05	22083	1 104 7	10441
ilver		Copper	Acid plant blowdown	Unknown	Urknown	0.04	22083	0.88333	10441
liver		Copper	Acid plant o dwidown	Unknown	Urknown	0 03	22083	0.6625	10441
ilver		Copper	Acid plant b owdown	Unknown	Urknown	0 022	22003	0 48583	10441
siver Siver		Capaer	Acid plant blowdown	Unknown	Urknown	0 02	22083	0.44167	10441
iver		Copper	Acid plant blowdown	Unknown	Urknown	0.01	22083	0.22083	10441
vər		Copper	Acid plant blowdown	Unknown	Urknown	0 0025	22083	0.22083	10441
ver		Elemental Phosphorus		Unknown American Plant	Urknown	16	175:00	28	8429
iver		E'emental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	FMC, Pocatello	10	1.03	.75:0	18.025	8429
					-				
vər		Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant Stauffer Mt Pleasant	Urknown TN	0.6 0.05	• 75:0	*0.5	8429
ver		E emental Phosphorus			TN		17500 17500	0 875	8429
er		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer Mt. Pleasant		0.05		2875	8429
vor		Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Urknown	0.001	*7500	0 01 75	8429
ver		E emental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Urknown	C 001	•7530	0 0175	8423
ver		Bare Earths	Process wastewater	Molycorp, Louviers	co	0.5	17	0.05833	385
ver		Rare Earths	Process wastewater	Malycora, Louviers	co	0.5	:17	0.05833	385
ver		Selen um	Plant process wastewaters	AMAX, Fort Madison	IA	0.5	550	0 275	631
ver		Titan um and Titanium Dioxide	Leach liquid & sponge wash water		NV	2.5	4000	10	2341
ver		Titan um and Titan um Dioxide	Leach liquid & sponge wash water	Unnamed Plant	Unknown	0.034	4000	2.136	2341
ver		Titan um and Titanium Dioxide	Scrap milling scrubber water	SCM, Baltimore	MÐ	0.5	42	0.02083	340
ver		Zinc	Process wastewater	Zinc Corp. Banlesville	CK	C.5	99*67	49 58333	43384
ver		Zinc	Process wastewater	Zine Corp. Menaca	PA	1	99.67	49 58333	43384
var		Zinc	Process wastewater	Zine Corp, Menaca	PA	0.05	99.67	4 95833	43384
vər		Zinc	Process wastewater	Zine Corp, Menaca	PA	0.05	99167	4.95833	43384
iver		Zinc	Process wastewater	Zinc Corp, Monaca	PA	0.05	99157	4 95833	43384
iver		Zinc	Process wastewater	Zinc Corp, Bartlesville	CK	0 05	99167	4 95833	43384
ver		Zinc	Process wastewater	Zinc Corp, Bartlesville	CK	0.05	99167	4 95833	43384
ver		Zinc	Process wastewater	Zinc Corp. Baniesville	OK	0.05	99167	4.95833	43384
ver		Zinc .	Process wastewater	Unknown	Unknown	0.01	99167	0 99167	43384
ver		Zinc	Process wastewater	Zinc Corp, Bartlesville	OK	0.0025	99167	0 24792	43384
ver		Zinc	Process wastewater	Unknown	Unknown	0.0015	99167	0.14875	43384
4 VOF		Zinc	Spent surface impoundment liquids		IL.	185.2	10500	1944.6	53.7
iver		Zinc	WWTP liquid effluent	Zinc Corp of America	ÖK	58 296	7250	422.5735	3850
hallum	28		Chip treatment wastewater	One Unnamed Facility	Unknown	0.002	417	0 00083	558
hallium	20	Beryllium			Unknown	2.5	22083	55.20833	10441
		Copper	Acid plant blowcown	Unknown		0.25	22083		10441
hallium		Copper	Acid plant blowcown	Unknown	Unknown			5.52083	
hallium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	45 · 45	17500	78 75	8429 8429
allium		Elemental Phosphonus	Furnace scrubber blowdown	Unknown American Plant	Unknown ID		17500	78.75 43.75	8429
allium		Elemental Phosphorus	Fumace scrubber blowdown	FMC, Pocatello		2.5	17500		
allium		Elemental Phosphorus	Fumace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0 25	17500	4,375	8429
allium		Elemental Phosphonus	Fumace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.25	17500	4 375	8429
allum		Elemental Phosphon.s	Furnace scrubber blowdown	Unknown American Plant	Unknown	0.0455	17500	0.79625	8429
allium		Elemental Phosphorus	Fumace scrubber blowdown	Unknown American Plant	Unknown	0 045	17500	0.7875	9429
allur		Elemental Phosphorus	Fumace scrubber blowdown	FMC, Pocatello	D	0.04	17500	07	8429
allium		Rare Earths	Process wastewater	Molycorp, Louviers	co	2.5	117	0 29167	385
hatlium		Rare Earths	Process wastewater	Melycorp, Louviers	co	25	117	0.29167	385
allium		Selenium	Plant process wastewaters	AMAX, Fort Madison	IA	2.5	550	1 375	631
allium		Titan um and Titanium Dioxide	Leach liquid & sponge wash water	Timet, Henderson	NV	12.5	4000	50.	2341
allium		Fitan um and Titanium Dioxide	Leach liquid & sponge wash water		Unknown	2.4	4000	9.6	2341
altium		Titan um and Titan um Dioxide	Scrap milling scrubber water	SCM. Baltimore	MD	2.5	42	0 10417	340
allium		Zinc	Process wastewater	Zinc Corp, Bartlesville	OK	3.59	99167	355 00833	43384
allium		Zinc	Process wastewater	Zinc Corp, Bartlesville	CK	2.5	99167	247.91667	43384
'allium		Zinc	Process wastewater	Zine Corp, Monaca	PA	3	99167	247 91667	43384
hallium		Zinc	Process wastewater	Zinc Corp, Monaca	PA	0.25	99167	24.79.67	43384
nallium		Zinc	Process wastewater	Zine Corp, Monaca	PA	0.25	99167	24.79.57	43384
hallum		Zinc	Process wastewater	Zinc Corp, Monaca	PA	0.25	99167	24 79 67	43384
allium		Zinc	Process wastewater	Zinc Corp. Bartlesville	ČK.	0.25	99167	24.79.67	43384
		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK OK	0.25	99167	24.79 67	43384
hallium						0.17	99167	16.85833	43384
hailium		Zinc	Process wastewater	Unknown	Unknown				43384
rallium		Zinc	Process wastewater	Unknown Zine Com, Bankowilla	Unknown	0.05	99167 00167	4 95833	
allum		Zinc	Process wastewater	Zinc Corp, Bartlesville	OK	0 024	99167	2.38	43384
anadium	27	Copper	Acid plant blowdown	Unknown	Unknown	2 72	22083	60 08667	10441
anadium		Copper	Acid plant blowdown	Unknown	Unknown	C.05	22083	10417	10441
inadium		E emental Phosphorus	Fumace scruober elowdown	Unknown American Plant	Unknown	710	17500	12425.	8429
ahadium		E emental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	35	17500	612 5	8429
nadium		Elemental Phosphorus	Furnace scrubber blowdown	Urknown American Plant	Unknown	1 5	17500	26 25	3429
inadum		E emental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	ID	1.27	17500	22 225	8429
anadium		Elemental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	ID	08	17500	'4 .	3429
anadium		Elemental Phosphorus	Fumace scrubber blowdown	Stauffer, Silver Bow	мт	0.53	17500	9 275	3429
anadium		Elemental Phosphorus	Furnace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.05	17500	0 875	8429
nadium		Elemental Phosphorus	Fumace scrubber blowdown	Stauffer, Mt. Pleasant	TN	0.05	17500	0 875	8429
anadium		E emental Phosphorus	Fumace scrubber blowdown	Unknown American Plant	Unknown	0.015	17500	0 2625	3429
inadium		Rare Earths	Process wastewater	Molycorp. Louviers	CO	0.5	1.2	0 05833	385
					co	0.5	117	0.05833	385
anadium and um		Rare Earths	Process wastewater	Molycorp. Louviers		0.5	550	0.05833	631
inadium		Selen um	Plant process wastewaters	AMAX, Fort Madison					2341
anadium		Titanium and Titanium D oxide	Leach liquid & sponge wash water	Timet, Henderson	NV	2.5	4000	10.	
aradium		Titanium and Titanium Dioxide	Scrap milling scrubber water	SCM, Baltimore	MD	1.51	42	0 06292	340
		Zinc	Process wastewater	Zinc Corp, Bartlesvil e	ОK	05	99167	49 58333	42384
anadium			Breeze westworten	Zinc Corp, Monaca	PA	1	99167	49.58333	43384
		Zinc	Process wastewater						
anadium anadium anadium		Zinc	Process wastewater Process wastewater	Zinc Corp. Monaca	PA	0.05	99167	4 95833	43384
anadium						0.05 0.05 0.05			

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Vanad um		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK	0 05	99167	4.95833	43384
Vanadum		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK OK	0.05	99*67	4 95833	43384
Vanadium		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK	0 05	99*67 99167	4 95833	43384 43384
Vanadum		Zinc	Process wastewater Process wastewater	Zinc Corp. Bartlesville Unknown	Urknown	0 03 0 005	99.67 99167	2.975 0.49583	43384
Vanadium Vanadium		Zinc Zinc	Process wastewater	Unknown	Unknown	0.005	99*67	0.49583	43384
Zinc	32	Becylium	Chip treatment wastewater	One Urnamed Facility	Unknown	7.2	417	3.	553
Zinc	.72	Copper	Acid plant blowdown	Unknown	Unknown	10000	22083	220833.33333	10441
Zinc		Capper	Acid plant blowdown	Unknown	Unknown	9200	22083	203166 66567	10441
Znc		Copper	Acid clant blowdown	Un <now*< td=""><td>Unknown</td><td>2030</td><td>22083</td><td>44829.16567</td><td>10441</td></now*<>	Unknown	2030	22083	44829.16567	10441
Z.nc		Copper	Apid plant blowdown	Unknown	Unknown	956	22083	18903.33333	10441
Zinc		Copper	Apid plant blowdown	Unknown	Unknown	1.2	22083	2539.58333	10441
Zinc		Copper	Acid plant blowdown	Unknown	Jaknown	100	22083	2208.33333	10441
Zro		Copper	Acid plant biowdown	Unknown	Joknown	91 13	22083	2012 45417	10441
Zro		Copper	Acid clant blowdown	Unknown	Unknown	73.2	22083	1616 5	10441
Zind		Copper	Acid plant blowdown Acid clant blowdown	Unknown Unknown	Unknown Unknown	51 48 2	22083 22083	1126 25 1064 41667	10441
Zinci Zinci		Cupper Copper	Acid plant blowdown	Unkrown	Unknown	7 79	22083	172.02917	10441
Zho		Copper	Acid plant blowdown	Unkrown	Unknown	5.7	22083	125.875	10441
Zno		Copper	Acid plant blowdown	Unkrown	Unknown	5.1	22083	112.625	10441
Zno		Elemental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	ID OI	2.1	17500	3692 5	8429
Zinc		Elemental Phosphorus	Furnace scrubber blowdown	FMC, Pocatelio	IQ.	196	17500	3430.	8429
Zinc		Elemental Phosphorus	Furnace scrubber blowdown	FMC, Pocatello	Ð	160	17500	2800	8429
. Zno		Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	130	17500	2275	8429
Zinc		Elemental Phosphonus	Furnace scrubber blowdown	Unknown American Plant	Unknown	77	17500	1347 5	8429
Zinc		Elemental Phosphorus	Furnace scrubber blowdown	Unknown American Plant	Unknown	69	17500	1207 5	8429
Zinc		Elemental Phosphorus	Furnace scrubber blowcown	FMC, Pocatello	1D	50	17500	875.	8429
Zinc		Elemental Phosphorus	Furnace scrubber blowcown	Monsanto, Soda Springs	ID .	47	17500	822.5	8429
Zinc		Elemental Phosphorus	Furnace scrubber blowcown	Stauffer, Mt. Pleasant	TN	3.94	17500	68 95	8429
Zinc		Elemental Phosphorus	Furnace scrubber blowcown	Stauffer, Silver Bow Stauffer, Mt. Pleasant	MT TN	3.94 1.38	17500 17500	68 95 24.15	8429 8429
Zinc		Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown	Unknown American Plant	Unknown	0.023	17500	0.4025	8429
Zinc		Elemental Phosphorus Base Faithe	Process wastewater	Nolycorp, Louviers	CO	14.2	17500	1.65667	365
Zinc Zinc		Rare Earths Rare Earths	Process wastewater	Molycom, Louviers	co	1 98	117	0.231	385
Zinc		Selenium	Plant process wastewaters	AMAX, Fort Madison	IA	0.5	550	0.275	631
Zinc		Titanium and Titanium Dioxide	Leach icuid & sponge wash water		NV	2.5	4000	10.	2341
Zinc		Titanium and Titanium Dioxide	Leach icu d & sponge wash water		Unknown	0.54	4000	2.15	2341
Zinc		Titanium and Titanium Dioxide	Scrap milling scrubber water	SCM, 5a timore	MD	05	42	0 02083	340
Z:nc		Zinc	Process wastewater	Unknown	Unknown	60000	99167	5950000	43384
Zinc		Zinc	Process wastewater	Unknown	Unknown	25000		2479166.56567	43384
Zinc		Zind	Process wastewater	Zinc Corp. Bartlesville	OK	20100	99'67	1993250.	43384
Zinc		Zinc	Process wastewater	Unknown	Unknown PA	11000	99167 99167	1090833.33333 1011500.	43384 43384
Zinc		Zinc	Process wastewater	Zinc Corp, Monaca Jersey Miniere, Clarksville	TN	6000	99167	595000.	43384
Zinc		Zinc Zinc	Process wastewater Process wastewater	Unknown	Unknown	4900	99167	485916.66667	43384
Zinc Zinc		Zirc	Process wastewater	Jersey Miniere, Clansville	TN	2840	99167	291633 33333	43384
Zinc		Zinc	Process wastewater	Unknown	Unknown	2430	99°67	240975.	43384
Z:nc		Zind	Process wastewater	Zinc Corp Bartlesville	OK	1600	99.67	158566 66667	43384
Znc		Zinc	Process wastewater	Unknown	Unknown	1130	99°67	12058 33333	43384
Zinc		Zinc	Process wastewater	Unknown	Unknown	64C	99*67	53466.66667	43384
Zinc		Zine	Process wastewater	Zinc Corp Bartlesville	OK	410	99*67	40658.33333	43384
Zinc		Zinc	Process wastewater	Unknown	Unknown	144 2	99*67	14299.83333	43384
Zinc		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK	91.8	99167	9103 5	43384
Zinc		Zinc	Process wastewater	Unknown	Unknown	87	99167 00167	8627.5 4958 33333	43384 43384
Zinc		Zinc	Process wastewater	Unknown Unknown	Unknown Unknown	50 50	99167 99167	4958 33333	43384
Zno		Zinc	Process wastewater Process wastewater	Unknown	Unknown	50	99.67	4958.33333	43384
Zinc Zinc		Zinc Zinc	Process wastewater	Zinc Corp. Monaca	PA	31.9	99.67	3163.4 567	43384
Zinc		Zinc	Process wastewater	Big R ver Zinc	IL	20	99167	*983.33333	43384
Zinc		Zinc	Process wastewater	Zinc Corp, Monaca	PA	14.4	99167	1428	43384
Zinc		Zinc	Process wastewater	Zinc Corp, Monaca	PA	10.9	99.67	1080.31567	43384
Zinc		Zinc	Process wastewater	Zinc Corp. Bartlesville	OK	6.37	99.67	631.69167	43384
Zinc		Zind	Process wastewater	Unknown	Unknown	3	99167	297.5	43384
Zinc		Zinc	Spent surface impoundment 'iquid			800000	10500	8400000.	5319
Zinc		Zinc	Spent surface impoundment iquid:			650000	10500 10500	6825000. 6184500.	53°9 53'9
Zinc		Zinc	Spent surface impoundment iquid			589000 500000	10500	5250000.	53.9
Zinc		Zinc	 Spent surface impoundment, iquid Spent surface impoundment, iquid 			300000	10500	3150000.	53*9
Zinc Zinc		Zinc Zinc	Spent surface impoundment iquid		iL	52000	10500	546000.	53.9
Zinc		Zinc	Spent surface impoundment iquid			10000	10500	105000	5319
Zinc		Zinc	Spent surface impoundment iquid		TN	6100	10500	64050	53.9
Zinc		Zinc	Spent surface impoundment iquid		TN	3400	10500	35700.	53.8
Zinc		Zirc	Spent surface impoundment liquid		ок	2430	10500	25515.	5319
Zinc		Zinc	Spent surface impoundment liquid:	s Zinc Corp of America	ок	1400	10500	14700.	53.3
Zinc		Zinc	Spent surface impoundment liquid	s Zinc Corp of America	OK	1400	10500	14700.	53.3
Zinc		Zing T	Spent surface impoundment iquid		ж	1130	10500	1865.	5319
Zinc		Zinc	Spent surface impoundment liquid:		OK	890	10500	9345.	5319
Zinc		Zinc	Spent surface impoundment liquid:		IL 	712	10500	7476.	5319 5319
Zinc		Zinc	Spent surface impoundment liquid		1	200	10500	2100.	5319 5319
Zinc		Zinc	Spent surface impoundment liquida	s Zinc Corp of America, Monaca	PA DA	50 50	10500	525 525	5319
Zinc		Zinc	Spent surface impoundment liquid		OK	19.3	10500	202 65	53*9
Zind		Zinc	Spent surface impoundment liquid: Spent surface impoundment liquid:		OK	19.3	10500	202 65	53.3
Zinc		Zinc	Spent surface imcoundment liquid:		PA	19.3	10500	105	53:9
Zinc		Zinc Zinc	Spent surface impoundment liquid: Spent surface impoundment liquid:		PA	C.8	10500	84	53*9
Zinc Zinc		Zinc	WWTP liquid effluent	Zinc Corp of America, wohaca Zinc Corp of America	ÖK .	450000	7250	3262500	3850
Zinc		Zinc	wwTP liquid effluent	Jersey Miniere	TN	2000	7250	14500	3850
Zinc		Zinc	WWTP liquid effluent	Zinc Corp of America	ок –	20	7250	145	3850



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EP Analysis Samples. Nonwastewaters.

	Number of					Constituent Concentration in Leachate	Volume of Waste Pile	Leachable Constituent Massiper Waste Pile	Area of Waste Pile
Constituents	Detections	Commodity	Waste Stream	Facility Identifier	State	(ng/l)	(ო ³) (1)	(kg) (5)	(m²)
Antimony	1	Aumina and Aluminum	Cast house dust	Facilities Surveyed	Urknown	0 42	107	1 21 984	108
Arsenic	3	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Urknown	0.001	107	0.0029	108
Arsenic		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Urknown	0 65	1671	29 56381	676
Arsenic		Machasium and Magnesia from Brines	Smut	Unknown American Plant	Urknown	0.1	1671	4 54905	676
Barum	3	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Urknown	0.25	107	0 3.353	108
Barum		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Urknown	149	1671	6778 08037	676
Barum		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Urknown	.4 3	1671	677 30304	676
Cadmium	3	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Urknown	35	107	10 16537	108
Cadmium		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	0.027	1671	1.22324	676
Cacmium		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	0.01	1671	0 4543	676
Chromium	3	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Unknown	0.085	·07	0 24978	108
Chromium		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	054	1671	2 45649	5/6
Chromium		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	0.023	1671	1 04628	676
Leac	з	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Unknown	0.024	· 07	0 06971	108
Leac		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	3 64	1671	165.58532	676
Leac		Machesium and Magnesia from Brines	Smut '	Unknown American Plant	Unknown	0 043	1671	1 95509	676
Mercury	3	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Unknown	0.84	:07	2,43969	108
Mercury		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unkhown	0.001	1671	0.04549	676
Mercury		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unkhown	0 0008	167 '	C 03639	676
Nickel	t	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Unknown	0.74	107	2,14925	108
Selenium	з	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Unknown	0.001	127	0 0029	108
Selenium		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	0.016	167*	0.72785	676
Selenium		Magnesium and Magnesia from Snnes	Smut	Unknown American Plant	Unknown	0.013	1671	0.59138	676
Silver	3	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Unknown	0.15	107	0.43565	108
Silver	•	Magnesium and Magnesia from Sinnes	Smut	Unknown American Plant	Unknown	0.14	1671	6 36867	676
Silver		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	0.05	167	2 27452	676
Zinc	з	Alumina and Aluminum	Cast house dust	Facilities Surveyed	Unknown	0.58	107	1 68455	108
Zine	-	Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	0.69	1671	31 38843	575
Zinc		Magnesium and Magnesia from Brines	Smut	Unknown American Plant	Unknown	0.02	1671	0 90981	676

EP Analysis Samples. Wastewaters and Liquid Nonwastewaters.

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Constituents	Number of Detections	Commo diy	Waste Stream	Faculty dentifier	State	Constituent Concentration n Leachate (mg/l)	Volume of Surface Impoundment (m ³)	Leachable Constituent Mass in Surface Impoundment (kg)	Area of Surface Impoundment Im ² 1
				· _ · · · · · · · · · · · · · · · · · ·			(3)	(6)	
Antimony	24	Copper	Acid plant blowdown	Cyprus, Clay Poci	AZ	5	22083	215 3125	10441
Antimony		Copper	Acid plant blowdown	Kennecott, Bingham Canyon	υT	0 168	22083	7 2345	10441
Antimony		Elemental Phosphorus	Furnace scrubber blowdown	Urknown	Unknown	• 6	17500	54 6	8429
Ant mony		Elemental Phosphorus	Furnace scrubber blowdown	Urknown	Unknown	1,17	17500	39 92625	8429
Antimony		Elemental Phosphorus	Furnace scrubber blowdown	Urknown	Unknown	0.47	17500	16 03875	8429
Antimony		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	J 16	17500	5.46	8429
Antimony		Elemental Phosphorus	Furnace scrubber blowdown	Urknown	Unknown	D.16	17500	5 46	8429
Antimony		Elemental Phosphorus	Fumace scrubber blowdown	Unknown	Unknown	0.05	17500	1 70625	8429
Antimony		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.05	17500	1 70625	8429
Antmony		Rare Earths	Process wastewater	Unknown	Unknown	05	1*7	0 11375	385
Antmony		Pare Earths	Process wastewater	Unknown	Unknown	0.5	117	0 11375	385
Antimony		Pare Earths	Process wastewater	Unknown	Unknown	0.5	117	0 11375	385
Antimony		Pare Farths	Process wastewater	Urknown	Unknown	05	117	0 11375	385
Antimony		Rare Earths	Process wastewater	Urknown	Unknown	0.5	1.2	0 11375	385
Antimony		Fare Earths	Process wastewater	Ursknown	Unknown	0.5	117	0.11375	385
Antimony		Selenium	Plant process wastewaters	Unknown	Unknown	0.5	55C	0 53625	631
Antimony		Selenum	Plant process wastewaters	Unknown	Unknown	05	560	0 53625	631
Ant:mony		Selenium	Plant process wastewaters	Zinc Corp of America, Monaca	PA	05	55C	0 53625	631
Ant mony		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.224	4375	1.911	2517
Antmory		Tantaium, Columbium, and Ferrocolumb um		Unknown	Ünknown	0 05	4375	0.42656	2517
Antmony		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.05	4375	0 42656	2517
Antmony		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.05	4375	0.42656	2517
Ant mony		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unkrown	Unknown	0.05	4375	0.42656	2517
Antmony		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0 05	4375	0.42556	2517
Arsenic	48	Copper	Ac d plant blowdown	Magma, San Manuel	AZ	12900	22083	551200.	10441
Arsenic		Copper _	Acid plant blowdown	CBI	CBI	193	22083	8311 0625	· 10441
Arsenic		Copper	Acid plant blowdown	CBI	CBI	126	22083	5425.875	10441
Arsenic		Copper	Acid plant blowdown	Kennecott, Bingham Canyon	UT	32.5	22083	1412 45	10441
Arsenic		Copper	Acid plant blowdown	Kennecott, Bingham Canyon	υτ	31,1	22083	1339.24375	10441
Arsenic		Copper	Acid plant blowdown	Magma, San Manuel	AZ	29 9	22083	1287.56875	10441
Arsenic		Copper	Acid plan; blowdown	CBI	CBI	21.6	22083	930 15	10441
Arsenic		Copper	Acid plant blowdown	CBI	CBI	14.1	22083	607.18125	10441
Arsenic		Copper	Acid plant blowdown	Magma, San Manuel	AZ	112	22083	482.3	10441
Arsen.c		Copper	Acid plant biowdown	Cyprus, Clay Pool	AZ	5	22083	215 3125	10441
Arsen c		Copper	Acid plant blowdown	CBI	CBI	0 19	22083	3.18188	10441
Arsen c		Copper	Acid clant b owdown	CBI	CBI	0 18	22033	7.75125	10441
Arsen c		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.05	22083	2.15313	10441
Arsen c		Copper	Acid plant browdown	Magma, San Manuel	AZ	0.05	22083	2.15313	10441
Arsenic		Copper	Acid clant blowdown	Magma, San Maruel	AZ	0.04	22083	1.7225	10441
Arsenic			Furnace scrubber blowdown	Unknown	Unknown	0.543	17500	18 52988	8429
Arsenic			Furnace scrubber blowdown	Unknown	Unknown	0.15	17500	5.1875	8429
Arsenic			Furnace scrubber blowdown	Unknown	Unknown	0.0619	17500	2.1234	8429
Arsenic			Fumace scrubber blowdown	Unknown	Unknown	0.05	17500	1 70625	8429
Arsenic			Fumace scrubber blowdown	Unknown	Unknown	0.05	17500	1.70625	8429
Arsenic			Furnace scrubber blowdown	Unknown	Unknown	0.00125	17500	0 04266	8429
				0.11.00					
			Apri	1 30, 1998					

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			D	A. A					
Arsenic		Rare Earths Rare Earths	Process wastewater Process wastewater	Unknown Unknown	Unknown Unknown	4.97	117	1.13068	385
Arsenic		Rare Earths	Process wastewater	Unknown	Unknown	1.1 0.945	117	0 25025 0 21499	385 385
Arsenic		Rare Earths	Process wastewater	Unknown	Unknown	0.945	117	0.11375	385
Arsenic		Rare Earths	Process wastewater	Unknown	Unknown	05	117	0 1375	385
Arsenic		Bare Earths	Process wastewater	Unknown	Unknown	05	117	0.11375	385
Arsenic		Selenium	Plant process wastewaters	Unknown	Unknown	05	550	0.53625	631
Arsenic		Selenium	Plant process wastewaters	Unknown	Unknown	05	550	0 53625	631
Arsenic		Tantaium, Columbium, and Ferrocolumbium		Unknown	Unknown	Q.5	4375	4 26563	25.7
Arsenic		Tantalum, Columbium, and Ferrocolumbium		Zinc Corp of America, Monaca		0.5	4375	4 26563	25.7
Arsenic		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0 15	4375	1 27969	25.7
Arsenic Arsenic		Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown Unknown	0.132	4375	1 12613	25.7
Arsenic		Tantalum, Columbium, and Ferrocolumbium		Unknown Unknown	Unknown	0.05	4375 4375	0.42656 0 42656	25°7 25°7
Arsenic		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.05	4375	0.42656	25.7
Arsanic		Tantalum, Columpium, and Ferrocolumbium		Unknown	Unknown	0.05	43/5	0.42656	25.7
Arsenic		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.05	4375	0.42656	25.7
Arsenic		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.05	4375	0 42656	2517
Arsenic		Tantalum, Columbium, and Ferrocolumbium		AMAX, East St. Louis	iL	0.05	4375	0 42656	25.7
Arsenic		Tantalum, Columbium, and Ferrocolumbium		Unnamed Plant	Unkrown	0.027	4375	0 23034	2517
Arsenic		Etanium and Etanium Dioxide	Leach I quid & sponge wash water	Unknown	Unknown	0.01	4000	0.078	2341
Arsenic Arsenic		Titanium and Titanium Dioxide	Leach liquid & sponge wash water	Unknown Linnemed Blant	Unknown	0.01	4000	0.078	2341
Arsenic		Titanium and Titanium Dioxice Eitanium and Titanium Dioxice	Leach liquid & sponge wash water Leach liquid & sponge wash water	Unnamed Plant Unnamed Plant	Unknown Unknown	0.005	4000 4000	0.039 0.0234	2341 2341
Arsenic				Unknown	Unknown	0.002	4000	0.0156	2341
Arsenic		Ttanium and Titanium Dioxide	Scrap milling scrubber water	Unknown	Unknown	0.02	42	0.00163	340
Arsenic		Titanium and Titanium Dioxide	Scrap milling scrubber water	Unknown	Unknown	0.0*25	42	0 00 02	340
Barum	50	Copper	Acid plant blowdown	CBI	CBI	10.9	22083	469 38 25	10441
Barum		Copper	Acid plant blowdown	CBI	CBI	9.6	22083	413.4	10441
Earum		Cooper	Acid plant blowdown	Cycrus, Clay Pool	AZ	5	22083	215 3125	10441
Earum		Copper	Acid plant blowdown	Magma, San Manuel	AZ	5	22083	215 3125	10441
Banum		Cooper	Acid plant blowdown	Magma, San Manuel	AZ	5	22083	215 3125	10441
Barum		Copper	Acid plant blowdown	CBI	CBI	0.8	22083	34 45	10441
Barum		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.4	22083	17 225	10441
Barum			Acid plant blowdown Acid plant blowdown	CBI CBI	CBI	0.4	22083	17 225	10441
Barum Barum			Acid plant blowdown Acid plant blowdown	Magma San Manuel	CBI AZ	0.3 0.2	22083	12.91875	10441
Banum			Acid plant blowdown	CBI	CBI	0.2	22083 22083	8.6125 8.6125	10441 10441
Barum			Acid plant blowdown	Kennecott, Bingham Canyon	UT.	0.136	22083	5.8565	10441
Bahum			Acid plant blowdown	Vagma, San Manuel	AZ	0.1	22083	4.30625	10441
Bahum			Acid plant blowdown	Kennecott Bingham Cariyon	UT .	0.25	22083	2.15313	10441
Banum		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.05	22083	2 *5313	10441
Banum			Furnace scrubber clowdown	Unknown	Unknown	1.2	17500	40.95	8429
Barum			Furnace scrubber blowdown	Unknown	Unknown	1	17500	34 125	8423
Barum			Furnace scrubber clowdown	Unknown	Unknown	0.81	17500	27 64125	8423
Barum			Fumace scrubber blowdown	Unknown	Unknown	0.25	17500	8 53125	8423
Barum Barum			Furnace scrubber blowdown	Unknown	Unknown	0.2	17500	6 825	8423
Barum			Furnace scrubber blowdown Furnace scrubber blowdown	Unknown Unknown	Unknown Unknown	0.05	17500 17500	* 70625 * 70625	8429 8429
Barum			Process wastewater	Unknown	Unknown	10	11300	2 275	385
Barum			Process wastewater	Unnamed Plant	Unknown	6	1.7	· 365	385
Barum			Process wastewater	Unknown	Unknown	5	1.7	1 * 375	385
Banum		Rare Earths	Process wastewater	Unnamed Plant	Unknown	3.7	1.2	0 84175	385
Bacum		Rare Earths	Process wastewater	Unknown	Unknown	12	1'7	0 273	385
Barum			Process wastewater	Unknown	Unknown	1	1.2	0 2275	385
Barum			Plant process wastewaters	Unknown	Unknown	0.965	550	03496	631
Barum			Plant process wastewaters	Unknown	Unknown	0.93	550	0 99743 0 99743	631
Barum Barum		Selenium Tantalum, Columbium, and Ferrocolumbium	Plant process wastewaters	Unknown Unnamed Plant	Unknown Unknown	093 08	550 4375	6 825	631 2517
Banum		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.5	4375	4 26563	2517
Sarum		Tantalum, Columbium, and Ferrocolumbium		Urknown	Unknown	05	4375	4 26563	2517
Barum		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.5	4375	4 26563	2517
Earum		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	05	4375	4 26563	2517
Earum		Fantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.5	4375	4 26563	2517
Barum		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	05	4375	4 26563	2517
Barum		Tantalum, Columbium, and Ferrocolumbium		AMAX, East St. Louis	<u>ال</u>	05	4375	4 26563	2517
Barum Barum		Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium	• · · · ·	Zinc Corp of America, Monaca Unknown	PA Unknown	05 0218	4375 4375	4 26563 1 85981	2517 2517
Barum		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.083	4375	0 70809	2517
Barum		Tantalum, Columbium, and Ferrocolumbium		Urknown	Unknown	0.056	4375	0.47775	2517
Barum		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.05	4375	0.42656	2517
Banum		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Urknown	Unknown	0.05	4375	0 42656	2517
Barum		Tantalum, Columbium, and Ferrocolumb-um	Process wastewater	Unknown	Unknown	0.05	4375	0 42656	2517
Sarum		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.05	4375	0.42656	2517
Barum Dooloo		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0 05	4375	0.42656	2517
Barum Dan m		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown Unknown	0.05	4375	0 42656	2517 2517
Barum Reryllium	22	Tantalum, Columbium, and Ferrocolumbium Cooper		Unknown Cyprus, Clay Pool	AZ	0.006 0.5	4375 22083	0.05119 21.53125	10441
Berytkum					UT	0.005	22083	0 21531	10441
Berythum			•	Unknown	Unknown	0.025	17500	0.85313	8429
Servilium				Unknown	Unknown	0.011	17500	0.37538	8429
Beryllium		Elemental Phosphorus		Unknown	Unknown	0.005	17500	0 17063	8429
Beryllium				Unkrown	Unknown	0.005	• 7500	0.17063	6429
Berylkum				Unknown	Unknown	0 0025	17500	0.08531	8429
Beryllium				Unkrown	Unknown	0.0025	*7500	0.08531	8429
Beryllium Genellium				Unknown	Unknown	0.05	· 17	0.01138	365
Seryllium Beryllium				Unknown Unknown	Unknown Unknown	0 05 0 05	117	0.01138 0.01138	385 385
Beryllium				Unknown	Urknown	0 05	:17	2.01138	385
Beryllium				Zinc Corp of America, Monaca		0.05	117	2.01138	385
Beryllium				Unknown	Unknown	0.025	117	0.00569	385
Beryllium				Unknown	Unknown	0.025	550	Ç 02681	631
Seryllium		Selenium	Plant process wastewaters	Unknown	Unknown	0.005	550	0.00536	631
Beryllium		Se enium	Plant process wastewaters	Unknown	Unknown	0.005	550	0.00536	631

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Berythum		Tanta um, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.005	4375	0.24266	25.17
		Tanta um, Columbium, and Ferrocolumbium		Unknown	Urknown				2517
Beryllium						0.005	4375	0.04266	2517
Berytlium		Tania um, Columbium, and Ferrocolumbium		Unknown	Uhknown	0.005	4375	0 04266	2517
Beryllum		Tania um, Columbium, and Ferrocolumbiun	r Process wastewater	Unknown	Unknown	0.005	4375	0.04265	2517
Berythum:		Tanta um, Columbium, and Ferrocolumbium	n Process wastewater	Unknown	Unknown	0 005	4375	0.04266	2517
Cadmium	48	Copper	Acid plant blowdown	CBI	CBI	24.5	22083	1055 03125	104-1
Gadmium		Copper	Acid plant blowdown	CBI	CBI	19.3	22083		10441
								856.94375	
Cadmium		Copper	Acid plant blowdown	Magma, San Manuel	AZ	5	22083	258 375	10441
Cadmium		Copper	Acid plant blowdown	Magma, San Maruel	AZ	4.5	22083	193.78125	10441
Cadmium		Copper	Acid plant blowdown	Magma, San Manuel	AZ	2 24	22083	96.46	*0441
Cadmium		Copper	Acid plant blowdown	CBI	CBI	1 4 9	22083	64 16313	12441
				CBI	CBI				
Cadmum		Copper	Acid plant blowdown			1.46	22083	62.87125	10441
Qadm um		Copper	Acid plant browdown	Kennecott, Bingham Canyon	UT	1.24	22083	53.3975	* 3441
Cadm um		Copper	Acid plant blowdown	Kennecott, Bingham Canyon	UT	1 08	22083	46 5075	10441
Cadmium		Cooper	Acid plant blowdown	Magma, San Maruel	AZ	0.52	22083	22.3925	·0441
Cadmium		Copper	Acid plant browdown	Cyprus, Clay Pool	A2	0.5	22083	21.53125	10441
Cadmium		Copper	Acid plant blowdown	СВІ	CBI	0 31	22083	13 34938	10441
Cadmium		Copper	Acid plant browcown	Magma, San Manuel	AZ	0 23	22083	9 90438	
Cadmum									10441
		Copper	Acid plant blowdown	CBI	CBI	015	22083	6.89	10441
Cadmium		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0 05	22083	2.153*3	10441
Cadmium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	2 07	*7500	70.63375	8429
Çadmum		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	1 42	*7500	48.4575	8429
Cadmium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.3	7500	10 2375	8429
Cadmium		E emental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0 0194	7500	0.56203	8429
Cadmium		Elemental Phosphorus	Fumace scrubber blowdown	Unknewn	Urknown	0 01	17500	0 34125	8429
Cadmium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0 01	:7500	0.34125	8429
Cadmium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Urknown	0 005	17500	0.17063	5429
Cadmium		Rare Earths	Process wastewater	Unknown	Unknown	35.4	17	8 0535	385
Cadmium		Rare Earths	Process wastewater	Unknown	Urknown	15	117	3.64	385
Cadmium		Rare Eachs	Process wastewater	Unnamed Plant	Ucknown	111	117	2.52525	385
Cadmium		Rare Earths	Process wastewater	Unknown	Ur.known.	2 79	117	0.63245	385
Cadmium		Selenum	Plant process wastewaters	Unnamed Plant	Unknown	0 52	550	0 5577	631
Cadmium		Selenum	Plant process wastewaters	Unknown	Unknown	05	550	0 53625	
				Unknown					631
Cadmium		Tantaium, Columbium, and Ferrocolumbium			Unknown	0.23	4375	1.962 9	2517
Cadmium		Tanta-um, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.198	4375	1.58313	2517
Cadmium		Tantaium, Columbium, and Ferrocolumbium	Process wastewater	Unnamed Plant	Unknown	0 18	4375	1.53563	2517
Cadmium		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	AMAX, East St. Louis	IL.	0.07	4375	0 59719	2517
Cadmium		Tantaium, Columbium, and Ferrocolumbium		Unknown	Unknown	0.05	4375	0.42656	2517
Cadmium		Tanta um, Columbium, and Ferrocolumbium		Unknown					
					Unknown	0.05	4375	0 42656	2517
Cadmium		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0 05	4375	0 42656	2517
Cadmium		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.05	4375	0 42656	2517
Cadmium		Tantatum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.05	4375	C 42656	2517
Cadmium		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Zind Corp of America, Monaca	PA	0.05	4375	0 42656	2517
Cadmium		Tanta'um, Columbium, and Ferrocolumbium		Unknown	Unknown	0 0499	4375	3 42571	2517
Cadmium									
		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.0432	4375	0 36855	2517
Cadmium		Titan um and Titan um Dioxide	Leach I quid & sponge wasn water	Unknown	Unknown	0.025	4000	0.195	2341
Cadmium		Titanium and Titanium Dioxide	Leach I quid & sponge wash water	Unknown	Unkhown	0 023	4000	0 1794	2341
Cadmium		Titanium and Titanium Dioxide	Leach I quid & sponge wash water	Unknown	Unknown	0.018	4000	0 1404	2341
Cadmium		T tanium and Titanium D oxide	Leach I quid & sponge wash water	Unknown	Unknown	0 007	4000	0 05 46	2341
Cadmium		T tanium and Titanium Dioxide	Leach I quid & sponge wash water		Unknown	0.005	4000		
								0.039	2341
Cadmium		Titanium and Titanium Dioxide	Leach liquid & sponge wash water		Unknown	0.003	4000	0.0234	2341
Cadmium		Titanium and Titanium Dioxide	Scrap milling scrubber water	Unknown	Unkhown	0.03	42	0.00244	34C
Cadmium		F tanium and Titanium Dioxide	Scrap milling scrubber water	Unknown	Unknown	0.025	42	0.00203	340
Chromium	47	Copper	Acid plant blowdown	Cyprus, Clay Pocl	AZ	5	22083	215 3125	10441
Chromium		Copper	Acid plant blowdown		ίπ	0.254	22083	10 93788	10441
Chromium		Copper	Acid plant blowdown	Magma San Manuel	AZ	0.25			
							22093	10.76563	10441
Chromium		Copper	Acid plant blowdown		υT	0.241	22083	10 37806	10441
Chromium		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.*71	22083	7.36369	10441
Chromium		Copper	Acid plant blowdown	Magma San Manuel	AZ	0.1	22083	4.30625	10441
Chromium		Copper	Acid plant blowdown		CBI	0 029	22063	1.24881	10441
Chromium			Acid p ant blowdown		AZ	0.029	22083	1.24881	10441
		Соррег							
Chromium		Copper	Acid p-ant blewdown		CBI	0.024	22083	1 0335	10441
Chromium		Copper	Acid plant blowdown		ÇBI	0 008	22083	0 3445	10441
Chromium		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.005	22083	0 21531	10441
Chromium		Copper	Acid plant blowdown		AZ	0.005	22083	0.21531	10441
Chromium		Copper	Acid plant blowdown		CBI	0 005	22083	0.21531	10441
Chromium		Copper	Acid plant blowdown		CBI	0.005	22083	0 21531	10441
Chromium		Copper	Acid plant blowdown	CBI	CBI	0 003	22083	0.12919	10441
Chromium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	_0.9	17500	30.7*25	8429
Chromium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.841	17500	28.69913	8429
Chromium		Elemental Phosphorus	Furnace scrubber blowdown		Unknown	0.5	17500	17.0625	8429
Chromium		Elemental Phosphorus	Fumace scrubber blowdown		Unknown	0.22	17500	7.5075	8429
		Elemental Phosohorus							
Chromium			Fumace scrubber blowdown		Unknown	0.05	17500	1.70625	8429
Chromium		Elemental Phosphorus	Furnace scrubber blowdown		Unknown	0.05	17500	1 70625	8429
Chromium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0 005	17500	0.17063	8429
Chromium		Bare Earths	Process wastewater	Urknown	Unknown	6 45	117	1 46738	385
Chromium		Rare Earths	Process wastewater		Unknown	05	117	0 11375	385
							117		385
Chromium		Pare Earths	Process wastewater		Unknown	05		0.11375	
Chromium		Pare Earths	Process wastewater		Unknown	05	1.2	0.11375	385
Chironi nu m		Seienium	Plant process wastewaters	Unknown	Unknown	0.5	550	0 53625	631
Chrom um		Selenium	Plant process wastewaters	Unknown	Unknown	0.5	550	0 53625	631
Chromium		Seienium	Plant process wastewaters		Unknown	05	550	0 53625	631
Chromum		Tantalum, Columbium, and Ferrocolumbium			PA	05	4375	4 26553	2517
							4375	0 94697	2517
Chrom um		Tantalum, Columbium, and Ferrocolumbium			Unknown	0.111			
C ^m rom um		Tantalum, Columbium, and Ferrocolumbium			Unknown	0.0 8	4375	0.6825	2517
Chromium		Tantalum, Columbium, and Ferrocolumbium			Unknown	3.08	4375	0.6825	2517
Chromium		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.079	4375	0.67397	2517
Chromium		Tantalum, Columbium, and Ferrocolumbium			Unknown	0.05	4375	0.42656	2517
Chromum							4375	0.42656	2517
		Tantalum, Columbium, and Ferrocolumbium			Unknown	0.05			
Chromium		Tantalum, Columbium, and Ferrocolumbium			Unknown	0.05	4375	0.42656	2517
Chrom:um		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.05	4375	0.42656	2517
Chromium		Tantalum, Columbium, and Ferrocolumbium			Unknown	0.05	4375	0.42556	2517
Chromium		Tantalum, Columbium, and Ferrocolumbium			Unknown	0.039	4375	0 33272	2517
Chromium						0.03	4375	0.25594	2517
Garomun		Tantalum, Columbium, and Ferrocolumbium	FIOLASS MESIGMET	Unknown	Unknown	0.03	43/3	0.20034	2317

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Chromium		Titanium and Titanium Dioxide	Leach iquid & sponge wash water	Unnamed Plant	Unknown	0.012	4000	0.0936	234*
Chromium		Titanium and Titanium Dioxde	Leach icu d & sponge wash water		Unknown	0.005	4000	0.039	2341
Chromium		Titan um and Titanium Dioxde	Leach icu d & sponge wash water		Unknown	0.001	4000	0.0078	234
Chromium		Titanium and Titanium Dioxide	Leach icu di& sponge wash water	Unnamed Plant	Unknown	0.001	4000	0.0078	2341
Chromium		Titanium and Titanium Dioxde	Scrap milling scrubber water	Unknown	Unknown	0.027	42	0.00219	340
Chromium		Titan um and Titanium Dioxide	Scrap milling scrubber water	AMAX East St. Louis	iL.	0.025	42	0 00203	340
Lead	43	Copper	Acid plant blowdown	Kennecott, Bingham Canyon	UT	6.74	22083	230 24 25	`044*
Lead		Copper	Acid clant blowdown	Kennecott, Bingham Canyon	UT	5.47	22083	278 614 38	°044°
Leac		Copper	Acid clant blowdown	Magma, San Manuel	AZ	5.71	22083	245 89698	1044
Lead		Copper	Acid plant blowdown	Magma, San Manuel	AZ	38	22083	163.6375	10447
Lead		Cupper	Acid plant blowdown	Macma, San Manuel	AZ	3.73	22083	·60 62313	10441
Lead		Copper	Acid plant blowdown	CBI	CBI	2.89	22083	24.45063	10441
Lead		Copper	Acid plant blowdown	CBI	CBI	2 55	22083	09.80938	10441
Leac		Copper	Acid plant blowdown	Cyprus C ay Pool	AZ	2 5	22083	07 65625	10441
Lead		Copper	Acid clan; blowdown	Magma, San Manuel	AZ	25	22083	107 65625	1044
Lead		Copper Copper	Acid clant blowdown	CBI CBI	CBI CBI	2 49 1.74	22083 22083	107 22563 74 92875	10441
Lead Lead		Copper	Acid plant blowdown Acid plant blowdown	CBI	CBI	0.896	22083	38 5 5 4	0441
Lead		Copper	Acid slant blowdown	Magma, San Manuel	AZ.	0.030	22083	10 76563	10441
Lead		Copper	Acid slant blowdown	Magma, San Manuel	AZ	02	22083	3 6125	10441
Lead		Copper	Acid clant blowdown	CBI	CBI	0.042	22083	80853	10441
Lead		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.42	17500	14.3325	3429
Lead		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0 42	17500	14.3325	3429
Lead		Elemental Phosphorus	Furnace scrubber browdown	Unknown	Unknown	0 357	17500	12 18263	3429
Lead		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.217	17500	7 40513	3429
Lead		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0 125	17500	4 26563	3429
Lead		Elemental Phosphorus	Furnace scrubber blowcown	Unknown	Unknown	0.11	17500	3 75 375	3429
Lead		Rare Earths	Process wastewater	Unknown	Unknown	2.5	117	0 56875	335
Lead		Rare Earths	Process wastewater	Unnamed Plant	Unknown	2.36	117	0.5369	385
Lead		Rare Earths	Process wastewater	Unknown	Unknown	1.99	117	0.45273	395
Lead		Rare Earths	Process wastewater	Unknown	Unknown	1	117	0.2275	385
Lead		Selenium	P ant process wastewaters	AMAX, East St Louis	IL .	1	550	1.0725	631
Lead		Selanium	Prant process wastewaters	Unknown	Unknown	0.629	550	0.67353	631
Lead		Tantaium, Columbium, and Ferrocolumbium		Linknown	Unknown	0 562	4375	4 79456	2517
Leac		Tantalum, Columbium, and Ferrocolumbium		Unknown	Urknown	0.25	4375	2.13281	2517
Leac		Tantaium, Columbium, and Ferrocolumbium		Unknawn Unknawn	Unknown	0 25	4375	2.13281	2517
Lead		Tantaium, Columbium, and Ferrocolumbium			Unknown	0 25	4375	2.13281	2517
Lead Lead		 Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium 		Unknown Unknown	Unknown Unknown	0.25 0.221	4375 4375	2 13281	2517 2517
Lead		Tantalum, Coumbium, and Ferrocolumpium		Unknown	Unknown	0.141	4375	1.20291	2517
Lead		Tantalum, Coumbium, and Ferrocolumbium		Unknown	Urknown	0,1	4375	0.353 3	2517
Lead		Tantalum, Co'umbium, and Ferrocolumbium		Unknown	Unknown	0.098	4375	0.93606	2517
Lead		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.025	4375	0.2 328	2517
Lead	,	Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.025	4375	0.21329	2517
Lead		Tarita:um, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.02	4375	0 17063	2517
Lead		Titanium and Titanium Diowde	Leach liquid & sponge wash water	Unknown	Unknown	0.01	4000	0.078	2341
Lead		Titanium and Titanium Dioxide	Leach liquid & sponge wash water	Unknown	Urknown	0.005	4000	0.039	2341
Lead		Titan um and Titanium Dioxide	Scrap milling scrubber water	Unknown	Unknown	0 016	42	0.0013	340
Lead		Titan um and Titan-um Dioxide	Scrap milling scrubber water	Unknown	Unknown	0.01	42	0 00081	340
Mercury	46	Copper	Acid plant blowdown	CBI	CBI	0.31	22083	3.34935	10441
Mercury		Copper	Acid plant blowdown	CBI	CBI	0.26	22033	1.19625	10441
Mercury		Copper	Acid plant blowcown	Magma, San Maruel	AZ	0.0223	22083	0 96029	10441
Mercury		Copper	Acid plant blowdown	Kennecott, Bingham Canyon	UT	0.0115	22083	0.49522	10441
Mercury		Copper	Acid plant blowdown	Magma, San Maruel	AZ	0.01	22083	0.43063	10441
Mercury		Copper	Acid plant blowdown	Kennecott, Bingham Canyon	UT AZ	0.007 0.005	22093 22083	0.30144 0.21531	10441
Mercury		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.005	22083	0 21531	10441 10441
Mercury Mercury		Copper Copper	Acid plant blowdown Acid plant blowdown	Magma, San Manuel Magma, San Manuel	AZ AZ	0.005	22083	0.21531	10441
Marcury		Copper	Acic plant blowdown	CBI	CBI	0.0013	22083	0.05598	10441
Marcury		Copper	Acic plant blowdown	CBI	CBI	0.0013	22083	0.05598	10441
Mercury			Acid plant blowcown	Magma, San Manuel	AZ	0.0004	22083	0 01723	10441
Mercury			Acid plant blowcown	CBI	CBI	0 0003	22083	0 01292	10441
Mercury		Copper	Acid plant blowdown	CBI	CBI	0.0003	22083	0 01292	10441
Mercury			Acid plant blowcown	Cyprus, Clay Pool	AZ	0.0001	22083	0.00431	10441
Mercury			Fumace scrubber blowdown	Unknown	Unknown	0 0005	17500	0.01706	8429
Mercury		Elemental Phosohorus	Fumace scrubber blowdown	Unknown	Unknown	0.00015	17500	0.00512	8429
Mercury			Fumace scrubber blowdown	Unknown	Unknown	0.00015	17500	0 00512	8429
Mercury		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.0001	17500	0.00341	8429
Mercury			Fumace scrubber blowdown	Unknown	Unknown	0.0001	17500	0 00341	8423
Mercury			Fumace scrubber blowdown	Unknown	Unknown	0.0001	17500	0.00341	8429
Mercury			Process wastewater	Unknown	Unknown	0.0065	117	0.00148	385
Mercury			Process wastewater	Unnamed Plant	Unknown	0.0029	117	0 00066	385
Mercury		Rare Earths	Process wastewater	Unknown	Unknown	0.0024	117	0.00055	385
Mercury			Process wastewater	Unknown Lleasenad Blant	Unknown	0.0024	117 117	0.00055	385
Mercury			Process wastewater	Unnamed Plant	Unknown	0.0023	117	0.00052	385 385
Mercury			Process wastewater Plant process wastewaters	Unknown Unknown	Unknown Unknown	0.0011	550	0.00025 0.00107	385 631
Mercury Marcupy			Plant process wastewaters Plant process wastewaters	Unknown	Unknown Unknown	0 001	550	0.03*37	631
Mercury Mercury			Plant process wastewaters Plant process wastewaters	Unknown	Unknown	0.00088	550	0.00094	631
Mercury Mercury		Selenium Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.00028	4375	0.00239	2517
manual y		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.00028	4375	0 00085	2517
Mercury		Tantalum, Columbium, and Ferrocolumbium		Urknown	Unknown	0.0001	4375	0 00055	2517
Mercury		Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.0001	4375	0 00085	2517
Mercury				Unknown	Linknown	0.0001	4375	0 00055	2517
Mercury Mercury		Tantalum, Columbium, and Ferrocolumbium				0.0001	4375	0 00085	
Mercury Mercury Mercury		 Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium 		Unknown	Unknown			0.00063	2517
Mercury Mercury		Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown Unknown	Unknown	0.0001	4375	0.00085	2517
Mercury Mercury Mercury Mercury		Tantalum, Columbium, and Ferrocolumbium	Process wastewater Process wastewater						
Mercury Mercury Mercury Mercury Mercury		Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium	Process wastewater Process wastewater Process wastewater	Unknown	Unknown	0.0001	4375	0.00085	2517
Mercury Mercury Mercury Mercury Mercury Mercury		Fantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium	Process wastewater Process wastewater Process wastewater Process wastewater	Unknown Unknown	Unknawn Unknawn	0.0001 0.0001 0.0001 0.0001	4375 4375 4375 4375	0.00085 0.00085 0.00085 0.00085	2517 2517 2517 2517
Mercury Mercury Mercury Mercury Mercury Mercury Mercury		Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium	Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater	Unknown Unknown Unknown	Unknawn Unknawn Unknawn Unknawn Unknawn	0.0001 0.0001 0.0001 0.0001 0.0001	4375 4375 4375 4375 4375	0.00085 0.00085 0.00085 0.00085 0.00085	2517 2517 2517 2517 2517 2517
Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury		Fantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium	Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater	Unknown Unknown Unknown Unknown Unknown Unknown	Unknawn Unknawn Unknawn Unknawn Unknawn Unknawn	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	4375 4375 4375 4375 4375 4375 4375	0.00085 0.00085 0.00085 0.00085 0.00085 0.00085	2517 2517 2517 2517 2517 2517
Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury		Fantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Tranium, Columbium, and Ferrocolumbium	Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater Loach kiquid & spcnge wash water	Unknown Unkcown Unkcown Unknown Unknown Zinc Corp of America, Monaca	Unknown Unknown Unknown Unknown Unknown PA	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	4375 4375 4375 4375 4375 4375 4375 4375	0.00085 0.00085 0.00085 0.00085 0.00085 0.00085 0.00085 0.00078	2517 2517 2517 2517 2517 2517 2517 2341
Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury Mercury		Fantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium Titanium, Columbium, and Ferrocolumbium Titanium and Titanium Dioxide Titanium and Titanium Dioxide	Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater	Unknown Unkcown Unkcown Unknown Unknown Zinc Corp of America, Monaca	Unknawn Unknawn Unknawn Unknawn Unknawn Unknawn	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	4375 4375 4375 4375 4375 4375 4375	0.00085 0.00085 0.00085 0.00085 0.00085 0.00085	2517 2517 2517 2517 2517 2517

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Nickel Nickel Nickel Nickel Nickel Nicke Nicke Nicke Nicke Nicke Nickel Selenum Selenum Selenum Selenum Selenum Selenum Selenum Selenum	45	Copper Elemental Phosphorus Elemental Phosphorus Elemental Phosphorus Elemental Phosphorus Elementa: Phosphorus Elementa: Phosphorus Elementa: Phosphorus Rare Earths Rare Earths Rare Earths Rare Earths Serenum Selenum Selenum Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper	Furface scrubber blowdown Furface scrubber blowdown Furface scrubber blowdown Furface scrubber blowdown Furface scrubber blowdown Process wastewater Process wastewater Process wastewater Process wastewater Plant process wastewaters Plant process wastewater um Process wastewater um Process wastewater um Process wastewater aum Process wastewater Ac d plant blowdown Ac d plant blowdown	Urknown Cay Pool Magma. San Manual Konon Cay Cay Cay Cay Cay Cay Cay Cay Cay Cay	Unknown Unknown Unknown Unknown Unknown Unknown Unkrown Unkrown Unkrown Unkrown Unkrown Unknown Unknown Unknown Unknown Unknown Unknown Az Az J	2 25 0 155 0 35 0 05 0 05 0 5 0 17 0 17 0 35 0 35 0 35 0 35 0 35 0 35 0 35 0 35	17500 17500 17500 17500 17500 17500 17500 17500 117 117 117 117 117 117 550 550 4375 4375 4375 4375 4375 4375 22083 22083	8 53125 5 63063 1 7/2625 1 0/2375 0 51:38 0 11375 0 0/3868 0 0/3868 0 0/3863 0 0/3863 0 0/3863 0 0/3863 0 0/3863 0 0/2656 0 4/2656 0 4/2656 0 4/2656 0 4/2656 0 4/2656 0 4/2656 0 4/2656 1 2/2447 0 0/2413 3/28 55698 2/15 3/25 1/27 3/25
Nickel Nickel Nickel Nicke Nicke Nicke Nicke Nicke Nickel Selen um Selen um	46	Elemental Phosphorus Elementa: Phosphorus Elementa: Phosphorus Elementa: Phosphorus Elementa: Phosphorus Elementa: Phosphorus Rare Earths Rare Earths Rare Earths Rare Earths Serenuin Serenuin Serenuin Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper	Furnace scrubber blowdown Furnace scrubber blowdown Furnace scrubber blowdown Furnace scrubber blowdown Protess watewater Process watewater Process watewater Process watewater Process watewater Process watewater Plant process watewater um Process term Ac d plant blowdown Ac d plant blowdown Ac d plant blowdown Ac d plant blowdown Ac d plant blowdown	Urknown Orknown Urknown Orknown Urknown Cay Pool Magra San Manual Konecou Cay Dol Konecou Cay Dol Cay	Unknown Unknow	0 155 0.05 0.05 0.03 0 015 0 5 0.5 0.17 0.17 0.75 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.25 0.25 0.25 0.25 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.	17500 17500 17500 17500 17500 117 117 117 117 550 4375 4375 4375 4375 4375 4375 22083 22083	5 63063 1 7/625 1 7/625 1 0/2375 0 51:88 0 1/1375 0 1/3668 0 0/3868 0 0/3868 0 0/3868 0 0/3868 0 0/3868 0 0/3868 0 4/2656 0 4/2656 0 4/2656 0 4/2656 0 4/2656 0 4/2656 0 4/2656 0 4/2656 2 7/3413 3/28 55698 2/15 3/25 1/25 3/25
Nickel Nicke Nicke Nicke Nicke Nicke Nicke Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Selen um Selen um	46	Elementa: Prosphorus Siementa: Prosphorus Elementa: Prosphorus Elementa: Prosphorus Rare Earths Rare Earths Rare Earths Rare Earths Seienium Selenium Selenium Columoium, and Ferrocolumb Tantalum Columoium, and Ferrocolumb Tantalum Columoium, and Ferrocolumb Tantalum Columoium, and Ferrocolumb Tantalum Columoium, and Ferrocolumb Tantalum. Columoium, and Ferrocolumb Tantalum. Columoium, and Ferrocolumb Tantalum. Columoium, and Ferrocolumb Tantalum. Columoium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Furnace scrubber blowdown Furnace scrubber blowdown Furnace scrubber blowdown Furnace scrubber blowdown Process wastewater Process wastewater Process wastewater Plant process wastewater Plant process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater do plant blowdown Ac diplant blowdown	Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhowm Urkhowm Urkhowm Urkhowm Urkhowm Urkhowm Urkhowm Orbaown Urkhowm Cay Dis Cay Pool Magma, San Manuel Kennecott, Bingham Canyon CBI	Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Az AZ UT	0.05 0.25 0.23 0.015 0.5 0.5 0.5 0.25 0.25 0.25 0.25 0.25 0	17500 17500 17500 17500 17500 117 117 117 117 550 550 4375 4375 4375 4375 4375 4375 22083 22083	1 7.625 1 7.625 1 7.2375 0 51188 0 11375 0 03868 0 05383 0 05383 0 42656 0 42656 0 42656 0 42656 0 42656 0 42656 0 42656 0 42656 2 28447 0 03413 328 55698 215 3125 124 83 25
Nickel Nicke Nicke Nicke Nicke Nicke Nicke Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Selen um Selen um	45	Elementa: Prosphorus Elementa: Prosphorus Elementa: Prosphorus Rare Earths Rare Earths Rare Earths Rare Earths Selenium Fantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper	Furface scrubber blowdown Furface scrubber blowdown Furface's scrubber blowdown Process wastewater Process wastewater Process wastewater Pant process wastewaters Plant process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater a d plant blowdown A d plant blowdown	Urkhown Cay Pool Magra Kana Cay Dol Magra Cay Dol Cay Do	Unknown Unknown Unknown Unkrown Unkrown Unkrown Unkrown Unkrown Unkrown Unkrown Unkrown Unkrown Unkrown Az Az Az UT	0 25 0 33 0 015 0 5 0 5 0 17 0 17 0 35 0 35 0 35 0 35 0 35 0 35 0 35 0 35	17500 17500 17500 117 117 117 117 550 550 4375 4375 4375 4375 4375 4375 22083 22083	1 7:2625 1 0:2375 0 51:38 0 1:1375 0 :1375 0 :1375 0 :03868 0 0:3868 0 0:3863 0 4:2656 0 4:2656 0 4:2656 0 4:2656 0 4:2656 0 4:2656 0 4:2656 0 4:2656 0 4:2655 1 :2487 1 :25 1 :2887 1 :25 1 :2887 1 :25 1 :2887 1 :25 1 :2887 1 :25 1 :2887 1 :28877 1 :28877 1 :28877 1 :28877 1 :28877 1 :28877 1
Nické Nické Nické Nické Nické Nické Nické Nickél Nickél Nickél Nickél Nickél Nickél Nickél Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um	46	Elementa Phosphorus Elementa Phosphorus Rare Earths Rare Earths Rare Earths Rare Earths Selenium Selenium Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Furface scrubber blowdown Furface scrubber blowdown Process wastewater Process wastewater Process wastewater Process wastewater Pant process wastewaters Plant process wastewaters um Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater Ac d plant blowdown Ac d plant blowdown	Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Cagma, San Manual Kennecon, Bingham Canyon CBI	Linknown Linknown Linknown Linkrown Linkrown Linkrown Linkrown Linknown Linknown Linknown Unkinown Unkinown Unkinown Az Az Lit	0.03 0015 05 0.5 0.17 0.17 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.0	17500 17500 117 117 117 550 4375 4375 4375 4375 4375 4375 4375 22083 22083	1 02375 0 51 28 0 11375 0 03868 0 03868 0 03868 0 03868 0 05363 0 42656 0 42656 0 42656 0 42656 0 42656 0 42656 0 42656 2 21447 0 03413 328 55698 215 3125 124 83 25
Nicke Nicke Nicke Nicke Nicke Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um	46	Elementa Prosphorus Rare Earths Rare Earths Rare Earths Rare Earths Rare Earths Selenium Selenium Selenium Selenium Columoium, and Ferrocolumb Tantalum Columoium, and Ferrocolumb Tantalum Columoium, and Ferrocolumb Tantalum Columoium, and Ferrocolumb Tantalum. Columoium, and Ferrocolumb Coloper Copper	Furnacé scrubber blowdown Process wastewater Process wastewater Process wastewater Process wastewater Process wastewater Plant process wastewaters plant process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater de plant blowdown Ac diplant blowdown	Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhowm Urkhowm Urkhowm Urkhowm Urkhowm Urkhowm Urkhowm Caynos Cay Pool Magma, San Manuel Kennecott, Bingham Canyon CBI	Linknown Linknown Linknown Linknown Linknown Linknown Linknown Linknown Linknown Linknown Linknown Linknown Linknown Araown Az Az Lit	0 015 0 5 0.5 0.17 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.35 0.35 0.03 5 0.04 7.63 5 2 9 0.668	17500 117 117 117 550 550 4375 4375 4375 4375 4375 4375 22083 22083 22083	0 51 8 0 1375 0 1375 0 03868 0 03868 0 05363 0 42656 0 42656 0 42656 0 42656 0 42656 0 42656 0 42656 0 42656 1 42656 0 28447 0 03413 328 55698 215 3125 124 83 25
Nicke Nicke Nicke Nicke Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Selen um Selen um	45	Rare Earths Rare Earths Rare Earths Rare Earths Rare Earths Selenium Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Columbium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Process wastewater Process wastewater Process wastewater Plant process wastewaters Plant process wastewaters Plant process wastewaters um Process wastewater um Process wastewater um Process wastewater um Process wastewater ac of plant blowdown Ac of plant blowdown	Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Magma, San Manuel Kennecott, Bingham Canyon CBI	Linknown Linknown Linknown Linknown Linknown Linknown Linknown Linknown Uinknown Uinknown Az AZ AZ LIT	0 5 0.5 0.17 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.7	117 117 117 550 550 4375 4375 4375 4375 4375 4375 22083 22083	0 *1375 0 :1375 0 :03668 0 :03868 0 :05363 0 :05363 0 :42656 0 :42656 0 :42656 0 :42656 0 :42656 0 :42656 0 :25447 0 :02413 328:55698 215 :3125 122 :8125
Nicke Nicke Nicke Nickel Nickel Nickel Nickel Nickel Nickel Nickel Selen um Selen um	46	Pare Earths Pare Earths Pare Earths Selenium Selenium Salanium Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Process wastewater Process wastewater Process wastewater Plant process wastewaters Plant process wastewaters um Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater Act o plant blowdown Act o plant blowdown	Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Urkhown Magma, San Mant.et Cypus, Ciay Pool Magma, San Manuel Kennecott, Bingham Canyon CBI	Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Az AZ AZ UT	0.5 0.17 0.17 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.0	117 117 550 550 4375 4375 4375 4375 4375 4375 22083 22083 22083	0::1375 0:03668 0:03628 0:05363 0:42656 0:42656 0:42656 0:42656 0:26447 0:03413 328:55698 2/15:31:25
Nicke Nicke Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Selen um Selen um	46	Pare Earths Pare Earths Selenium Selenium Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Colopper Copper	Process wastewater Process wastewater Plant process wastewaters Plant process wastewaters um Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater Ac diplant blowdown Ac diplant blowdown	Urknown Urknown Urknown Urknown Urknown Urknown Urknown Urknown Urknowm Urknowm Urknowm Gyprus Cay Pool Magma, San Manuel Kennecott, Bingham Canyon CBI	Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown Az AZ AZ UT	0.17 0.17 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.0	117 117 550 550 4375 4375 4375 4375 4375 4375 22083 22083 22083	0 03868 0 03868 0 05363 0 05363 0 42656 0 42656 0 42656 0 2656 0 26447 0 03413 328 55698 215 7:25
Nicke Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Nickel Selen um Selen um	46	Rate Earths Seienum Salenum Tantalum Columpium, and Ferrscolumb Tantalum Columpium, and Ferrscolumb Tantalum Columpium, and Ferrscolumb Tantalum Columpium, and Ferrscolumb Tantalum, Columpium, and Ferrscolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Process wastewater Plant process wastewaters Plant process wastewaters rum Process wastewater ium Process wastewater ium Process wastewater ium Process wastewater ium Process wastewater ium Process wastewater Ac d plant blowdown Ac d plant blowdown	Urknown Urknown Urknown Urknown Urknown Urknown Urknown Urknown Magma, San Manei Cyprus, Cay Pool Magma, San Manuol Kennecon, Bingham Canyon CBI	Unknown Unknown Unknown Unknown Unknown Unknown Unknown Unknown AZ AZ AZ	0 17 0.25 0.05 0.25 0.25 0.25 0.35 0.35 0.05 0.03 0.004 7.53 5 2.9 0.658	117 550 550 4375 4375 4375 4375 4375 4375 22083 22083 22083	0.03868 0.05363 0.05363 0.42656 0.42656 0.42656 0.42656 0.25447 0.03413 328.55698 215.325
Nickei Nickei Nickei Nickei Nickei Nickei Nickei Nickei Selen um Selen um	46	Serenium Serenium Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Plant process wastewaters Plant process wastewaters um Process wastewater um Process wastewater um Process wastewater um Process wastewater and plant blowdown Ac d plant blowdown	Urknown Urknown Urknown Urknown Urknown Urknown Urknown Urknown Gryna, San Maner Cypus, Clay Pool Magma, San Manuel Kennecott, Bingham Canyon CBI	Unknown Unknown Unknown Unknown Unknown Unknown Unknown Az AZ AZ UT	0.05 0.05 0.05 0.05 0.05 0.05 0.03 0.004 7.63 5 2.9 0.668	550 550 4375 4375 4375 4375 4375 4375 22083 22083 22083	0 05363 0 05363 0 42656 0 42656 0 42656 0 42656 0 2:2447 0 03413 328.55698 215 3:25
Nickel Nickel Nickel Nickel Nickel Selen um Selen um	46	Selenum Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Copper	Plant pricess wastewaters rum Process wastewater um Process wastewater um Process wastewater um Process wastewater um Process wastewater ac diplant blowdown Ac diplant blowdown	Ur khown Ur khown Ur khown Ur khown Ur khown Ur khown Ur khown Wagma, San Manei Cyprus, Clay Pool Magma, San Manuei Kennecott, Bingham Canyon CBI	Unknown Unknown Unknown Unknown Unknown Unknown Az AZ AZ	0.05 0.05 0.05 0.05 0.05 0.03 0.03 0.03	550 4375 4375 4375 4375 4375 4375 22083 22083 22083	0 05363 0 42656 0 42656 0 42656 0 42656 0 20447 0 03413 328,55698 215 325 124 83 25
Nickel Nickel Nickel Nickel Nickel Selen um Selen um	46	Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	I'UT Process wastewater IUT Process wastewater IUT Process wastewater IUT Process wastewater IUT Process wastewater Act d plant blowdown Act d plant blowdown	Urkhown Urkhown Urkhown Urkhown Urkhown Magma, San Mant.ei Cyprus, Ciay Pool Magma, San Manual Kennecott, Bingham Canyon CBI	Unknown Unknown Unknown Unknown Unknown AZ AZ AZ	0.05 0.05 0.05 0.05 0.03 0.04 7.63 5 2.9 0.668	4375 4375 4375 4375 4375 4375 22083 22083 22083	0.42656 0.42656 0.42656 0.2646 0.26447 0.03413 328.55698 215.3125 124.83125
Nickel Nickel Nickel Nickel Selen um Selen um Selenium Selenium Selenium Selenium Selen um Selen um Selen um Selen um Selen um Selen um Selen um	46	Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Tantalum Columpium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	IIIT Process wastewater IIIT Process wastewater IIIT Process wastewater IIIT Process wastewater IIIT Process wastewater Ac d plant blowdown Ac d plant blowdown	Urknown Urknown Urknown Urknown Urknown Wagma, San Manei Cyprus, Clay Pool Magma, San Manuol Kenrecott, Bingham Canyon CBI	Unknown Unknown Unknown Unknown AZ AZ AZ	0.25 0.25 0.35 0.03 0.004 7.53 5 2.9 0.668	4375 4375 4375 4375 4375 22083 22083 22083	0 42656 0 42656 0 26447 0 03413 328,55698 215 3125 124 88125
Nickel Nickel Nickel Selen um Selen um	46	Tantalum, Columpium, and Ferrocolumb Tantalum, Columpium, and Ferrocolumb Tantalum, Columpium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	IUM Process wastewater IUM Process wastewater IUM Process wastewater IUM Process wastewater Ac di plant blowdown Ac di plant blowdown	Urkhown Urkhown Urkhown Wagma, San Manuei Cyprus, Clay Pool Magma, San Manuei Kenrecott, Bingham Canyon CBI	Unknown Unknown Unknown AZ AZ AZ UT	0.05 0.05 0.03' 0.004 7.53 5 2.9 0.668	4375 4375 4375 22083 22083 22083 22083	0 42656 0.42636 0 2::447 0 03413 328.52698 215 3:25 124 83:25
Nickel Nickel Selen um Selen um Selen um Selenium Selenium Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um	46	Tantalum Columbium, and Ferrocolumb Tantalum Columbium, and Ferrocolumb Tantalum. Columbium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Ium Process wastewater Ium Process wastewater Act d plant blowdown Act d plant blowdown	Urkhown Urkhown Urkhown Magma, San Manei Cyprus, Ciay Pool Magma, San Manuei Kennecott, Bingham Canyon CBI	Unknown Unknown Unknown AZ AZ AZ UT	0.05 0.03' 0.004 7.63 5 2.9 0.668	4375 4375 22083 22083 22083 22083	0.42656 0 2::447 0 03413 328.56698 215 3:25 124 83:25
Nickel Nickel Selen um Selen um Selenium Selenium Selenium Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um	46	Tantalum Columpium, and Ferrocolumb Tantalum. Columpium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Imp Process wastewater imp Process wastewater Ac d plant blowdown Ac d plant blowdown	Urkhown Urkhown Magma, San Maner Cyprus, Clay Pool Magma, San Manuel Kennecott, Bingham Canyon CBI	Unknown Unknown AZ AZ AZ UT	0 03' 0 004 7.53 5 2 9 0 668	4375 4375 22083 22083 22083	0 23447 0 03413 328.55698 215 3125 124 83125
Nickel Selen um Selen um Selen um Selenium Selenium Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um	46	Tantalum, Columbium, and Ferrocolumb Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Ium Process wastewater Ac d plant blowdown Ac d plant blowdown	Urknown Magma, San Manitei Cyprus, Ciay Pool Magma, San Manuei Kennecott, Bingham Canyon CBi	Unknown AZ AZ AZ UT	0 004 7.53 5 2 9 0 658	4375 22083 22083 22083	0 03413 328.55698 215 3125 124 83125
Selen um Selen um	46	Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper Copper	Ac d plant blowdown Ac d plant blowdown	Magma, San Manu si Cyprus, Ciay Pool Magma, San Manuel Kenrecott, Bingham Canyon CBI	AZ AZ AZ UT	7.53 5 2 9 0 668	22083 22083 22083	328.55698 215 3125 124 89125
Selen um Solen um Solen um Selenium Selenium Solen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um		Copper Copper Copper Copper Copper Copper Copper Copper Copper	Ac d plant blowdewn Ac d plant blowdewn	Cyprus, Clay Pool Magma, San Manuel Kennecott, Bingham Canyon CBI	AZ AZ UT	5 29 0668	22083 22083	215 3125 124 83125
Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium		Copper Copper Copper Copper Copper Copper Copper Copper	Ac d plant blowdown Ac d plant blowdown	Magma, San Manuel Kennecott, Bingham Canyon CBI	AZ UT	0 658	22083	124 88125
Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium		Copper Copper Copper Copper Copper Copper Copper	Ac d plant blowdcwn Ac d plant blowdcwn Ac d plant blowdcwn Ac d plant blowdcwn Ac d plant blowdcwn	Kennecott, Bingham Canyon CBI	υT	0 658		
Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium		Copper Copper Copper Copper Copper Copper	Ac d plant blowdown Ac d plant blowdown Ac d plant blowdown Ac d plant blowdown	CBI				
Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium		Copper Copper Copper Copper Copper	Ac d plant blowdown Ac d plant blowdown Ac d plant blowdown		00	0.51	22083	26 26813
Selenium Solenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium Selenium		Copper Copper Copper Copper	Ac d plant blowdown Ac d plant blowdown		υT	0 444	22083	19 1975
Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um		Copper Copper Copper	Ac d plant blowdown	CBI	CBI	0.28	22083	12.0575
Selen um Selen um Selen um Selen um Selen um Selen um Selen um Selen um		Copper Copper		CBI	CBI	0.16	22083	6.89
Selen um Selen um Selen um Selen um Selen um Selen um Selen um		Copper	Acid plant blowdown	CBI	CBI	0.16	22083	6.89
Selenium Selenium Selenium Selenium Selenium Selenium			Ac d plant blowdown	CBI	CBI	0.068	22083	2 92825
Selen um Selen um Selenium Selenium Selen um Selenium		~~ppu	Acid plant blowdown	Magma, San Manuel	AZ	0.05	22083	2.15313
Selen um Selenium Selen um Selen um Selenium		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.05	22083	2 15313
Selen um Selenium Selenium Selenium Selenium Selenium		Copper	Acid plant blowdown	Maçma, San Manuel	AZ	0.05	22083	2 15313
Selenium Selenium Selenium		Copper	Acid plant blowdown	CBI	CBI	0.028	22083	1 20575
Selen um Selen um		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0 005	22083	0 21531
Selenium		Elementa Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.44	17500	15 015
		Elementa Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.25	17500	8.53125
		Elemental Phosphorus Flemental Phosphorus	Furnace scrubber blowdown	Unknown Unknown	Unknown	0.05 0.05	17500 17500	1.70625
		Elementa Prosphorus	Furnace scrubber blowdown Furnace scrubber blowdown		Unknown			1 70625
Selenium Selenium		Elementa Prosphorus	Fumace scrubber blowdown	Unknown Unknown	Unknown Unknown	0.0025	17500 17500	0.08531 0.08531
Selenum		Rare Earths	Process wastewater	Unxnown	Unknown	0.5	117	0.11375
Selenum		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0 11 375
Selenum		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0.1:375
Selen um		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0.11375
Selenium		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0.11375
Selenium		Pare Earths	Process wastewater	Unknown	Unknown	0.5	117	011375
Selenium		Selenium	Plant process wastewaters	Unknown	Unknown	0.5	550	0 53625
Selenium		Selenium	P ant process wastewaters	Zinc Corp of America, Monaca	PA	0.5	550	0.53625
Selen um		Tantalum, Columbium, and Ferrocolumb	ium Process wastewater	AMAX, East St. Louis	IL I	0.2	4375	1 70625
Selenium		Tantalum, Columpium, and Ferrocolumb	ium Process wastewater	Unknown	Unknown	0.095	4375	0 8*047
Selenium		Tantalum, Columbium, and Ferrocolumb		Unknown	Unknown	0.05	4375	0.42655
Selenium		Tantakum, Columbium, and Ferrocolumbi		Unknown	Unknown	0.05	4375	0.42655
Selenium		Tantalum, Columbium, and Ferrocolumbi Tantalum, Columbium, and Ferrocolumbi		Unknown Unknown	Unknown	0.05 0.05	4375 4375	0 42556
Selenium		Tantatum, Columbium, and Ferrocolumbi		Unxnown	Unknown Unknown	0.05	4375	0.42656 0.42656
Selenium		Tantalum, Columbium, and Ferrocolumb		Unknown	Urknown	0 05	4375	0 42656
Selenium		Tantalum, Columbium and Ferrocolumbi		Unknown	Unknown	0.036	4375	0.307*3
Selenium		Tantalum, Columbium, and Ferrocolumbi		Unknown	Unknown	0.023	4375	0.19622
Selenium		Tantalum, Columbium, and Ferrocolumbi		Unknown	Unknown	0.01	4375	0.28531
Selenium		Tantalum, Columbium, and Ferrocolumpi		Unknown	Unknown	0 01	4375	0 28531
Selenium		Tantalum, Columbium and Ferrocolumpi		Unknown	Urknown	0.0065	4375	0 05545
Selenium		Tantalum, Columbium, and Ferrocolumbi		Unnamed Plant	Unknown	0.003	4375	0.02559
Selenium		Tantalum, Columbium, and Ferrocolumbi	um Process wastewater	Unknown	Unknown	0 0025	4375	0.02133
Selenium		Titanium and Titanium Dioxide	Scrap milling scrubber water	Unnamed Plant	Unknown	0.001	42	0 00008
Selenium		Titan um and Titanium Dioxide	Scrap milling scrubber water	Unnamed Plant	Unknown	0.001	42	0.00009
Silver	48	Copper	Acid plant blowdown	Cyprus. Clay Pool	AZ	5	22083	215 3125
Silver		Copper	Acid plant blowdown	Magma, San Maruel	AZ	0 25	22033	0.76563
Silver		Copper	Acid plant blowdown	CBI	CBI	0.2	22083	8 6125
Silver		Copper	Acid plant blowdown	CBI Kanangan Biagham Canyon	CBI	0 15	22083	6 45938
Silver		Copper	Acid plant blowdown	Kennecott, Bincham Canyon Macma, San Manuel		0.1 0.1	22083 22083	4.30625 4.30625
Silver Silver		Copper	Acid plant blowdown	Magma, San Manuel CBI	AZ CBI	0.1	22083	4.30625
Silver		Copper -	Acid plant blowdown Acid plant blowdown	CBI	CBI	0.07	22083	3.01438
Siver		Copper =	Acid plant blowdown	Kennecott, Bingham Canyon	UT	0.05	22083	2.15313
Siver		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.04	22083	1,7225
Siver		Copper	Acid plant blowdown	CBI	CBI	0.015	22083	0 64594
Silver		Copper	Acid plant blowdown	CBI	C8i	0.015	22083	C 64594
Silver		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.005	22083	0.21531
Silver		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.005	22083	0.21531
Siver		Copper	Acid plant blowdown	Magma, San Manuel	AZ	0.005	22083	0 21531
Si ver		Elemental Phosphorus	Furnace scrupber blowdown	Unknown	Unknown	0 25	17500	8.53125
Siver		Elemental Phosphonus	Fumace scrubber blowdown	Unknown	Unknown	0.05	17500	1.70625
Siver		Elemental Phosphorus	Fumace scrubber clowdown	Unknown	Unknown	0.05	17500	1.70625
Silver		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.02	17500	0.6825
Silver		Elemental Phosphonus	Furnace scrubber blowdown	Unknown	Unknown	0.01	17500	0 34125
Silver		Elemental Phosphorus	Fumace scrubber blowdown	Unknown	Unknown	0.01	17500	0.34 25
Silver		Bare Earths	Process wastewater	Urknown	Unknown	05	117	0 11375
Siver		Rare Earths	Process wastewater	Urknown	Unknown	0.5	117	0 11375
Siver		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0 11375
Si ver		Rare Earths	Process wastewater	Unknown	Unknown	05	117	0 11375
Siver		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0 11375

Silver		Rare Earths	P:ocess wastewater	Unknown	Unknown	0.5	117	0.11375	385
Silver		Selen um	Plant process wastewaters	Unknown	Unknown	0.5	550	0 53625	631
Silver		Selen um	P ant process wastewaters	Zinc Corp of America, Monaca		05	550	0 53625	631
Silver Silver		Selectum Tantalum, Columbium, and Ferrocolumbium	Plant process wastewaters Process wastewater	AMAX East St. Leuis Unknown	iL Unknawn	0.07 0.05	550 4375	0 07508 0 42656	631 2517
Silver		Tantalum, Columbium, and Ferrocolumbiun	Process wastewater	Unknown	Unknown	0.05	4375	0 42656	2517
Silver		Tanta um, Columbium, and Ferrocolumbium		Unkrown	Unknown	0.05	4375	0 42656	2517
Silver		Tanta um, Columbium, and Ferrocolumbiun		Unknown	Jnknown	0.05	4375	0.42656	2517
Silver Silver		Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium		Unknown Unknown	Unknown Unknown	0.05 0.05	4375 4375	0.42656	2517 2517
Silver		Tanta um, Columbium and Ferrocolumbium		Ucknown	Unknown	0.05	4375	0 42656 0 42656	2517
Silver		Tania um, Columbium, and Ferrocolumbium	Process wastewater	Urkhown	Unknown	0 038	4375	0.32419	2517
Silver		Tantalum, Columbium, and Ferrocolumbium		Urknown	Unknown	0 025	4375	0.21328	2517
Silver Silver		 Tania um, Columbium, and Ferrocolumbiun Tania um, Columbium, and Ferrocolumbiun 		Urkaowa Urkaowa	Linknown Linknown	0 025	4375	0.21328	2517
Siver		Tanta um, Columbium, and Ferrocolumbium		Urnamed Plant	Linknown	0.02 0.02	4375 4375	0.17063	2517 2517
Siver		Tantalum, Columbium, and Ferrocollumbium		Urnamed Plant	Unknown	3.02	4375	0.*7063	2517
Siver		Tantaium, Columbium, and Ferrocolumbium		Urinamed Plant	Unknown	0 015	4375	0 2797	2517
Siver Siver		Tantaium, Columbium, and Ferrocolumbium Tantaium, Columbium, and Ferrocolumbium		Urknown Urknown	Unknown	0 009 0 005	4375	0.07678	2517
Siver		Tantalum, Columbium, and Ferrocolumbium		Urkhown	Unknown Unknown	0 005	4375 4375	0.04266 0.04266	2517 2517
Si ver		Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown	0.0015	4375	0.0128	2517
Thailium	22	Copper	Acid plant blowdown	Cyprus, Clay Pool	AZ	25	22083	076.5625	10441
Thalium		Copper	Acid plan: blowdown	Kennecott, Bingham Canyon	UT	0.25	22083	10 76563	10441
Tha lium Tha lium		Copper Elemental Phosphorus	Acid plant blowdown Fumace scrubber blowdown	Magma, San Manuel Unkhown	AZ Unknown	0.25 1.25	22083 17500	10.76563 42 65625	10441 8429
Trailium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.455	17500	42 00020	8429
Thalium		Elemental Phosphorus	Furnace scrubber blowdown	Unknown	Unknown	0.455	17500	15.52688	8429
Thalium		E emental Phosphorus	Furnace scrubber blowdown	Unkhown	Unknown	0.25	17500	8 53125	8429
Thalum		Elemental Phosphonus	Furnace scrubber blowdown	Unknown	Unknown	0.25	17500	8 53125	8429
Thalum Thalum		Elemental Phosphorus Rare Earths	Furnace scrubber blowdown Process wastewater	Unkhown Unkhown	Unknown Unknown	0.014	17500 117	0 47775	8429
Tratum		Rare Earths	Process wastewater	Unknown	Unknown	25 25	117	0 55875 0 56875	385 385
Thalum		Rare Earths	Process wastewater	Unknown	Unknown	25	117	0 56875	385
Thalum		Rare Earths	Process wastewater	Unknown	Unknown	2.5	117	0 56875	385
Thallium Thailium		Rare Earths	Process wastewater Process wastewater		PA	2.5	117	0 56875	385
Trailum		Rare Earths Selenium	Plant process wastewaters	Unknown Unknown	Unknown Unknown	0.55	117 550	0 12513 0 58968	385 631
ידי u Hum		Selanium	Plant process wastewaters	Unknown	Unknown	0.25	550	0 26813	631
Thail um		Selenium	Plant process wastewaters	Unknown	Unknown	0.25	550	0 26813	631
Tha∎um Tha∎um		Tantalum, Columbium, and Ferrocolumbium Tantalum, Columbium, and Ferrocolumbium		Unknown	Unknown Unknown	0.25	4375	2.13281	2517
nalium		Tantalum Columbium, and Ferrocolumbium		Unkrown Unkrown	Unknown	0 25 0.25	4375 4375	2 13281 2.13281	2517 2517
Trailum		Tantalum, Columpium, and Ferrocolumbium		Unkrown	Unknown	0.25	4375	2.13281	2517
Vanadrum	2.	Copper	Acid plant blowdown	Cyprus, Clay Pool	AZ	5	22083	215.3125	10441
Vanadum		Copper Elemental Phosphorus	Acid plant blowdown	Kennecott, Bingham Canyon	UT .	0.05	22083	2.15313	1044
Vanadium Vanadium		Elemental Phosphorus	Fumace scrubber blowdown Fumace scrubber blowdown	Unkrown Unkrown	Unknown Unknown	0.794	17500 17500	27.09525 20 475	8429 8429
Vanadium		Elemental Phosphorus	Furnace scrubber blowdown	Unkrown	Unknown	0.58	17500	19 7925	3429
Vanadium		Elemental Phosphorus	Furnace scrubber blowcown	Unkrown	Unknown	0.05	17500	1 70625	3429
Vanadium Vanadium		Elemental Phosphorus Elemental Phosphorus	Furnace scrubber blowdown Furnace scrubber blowdown		Unknown	0.05	17500 17500	1 70625	3429
Variadium		Elemental Phosphorus	Furnace scrubber blowdown		Unknown Unknown	0 0*5 0.0*5	17500	0.51188 0.51188	3429 9429
Vanadium		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0.11375	385
Vanadium		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0.11375	385
Vanad um		Rare Earths	Process wastewater	Unknown	Unknown	0.5	117	0 11375	395
Vanadium Vanadium		Rare Earths Rare Earths	Process wastewater Process wastewater		Unknown Unknown	0.5 0.5	117	0.11375 0.11375	395 385
Vanad um		Rare Earths	Process wastewater	Zinc Corp of Amenca, Monaca		0.5	117	0.11375	385
Vanadium		Selenium	Plant process wastewaters	Unknow	Unknown	0.05	550	0.05363	631
Vanadium		Selenium	Plant process wastewaters		Unknown	0.05	550	0.05363	631
Vanadium Vanadium		Selenium Tantalum, Columbium, and Ferrocolumbium	Plant process wastewaters Process wastewater		Urknown Urknown	0.05	550 4375	0.05363 0.42656	631 2517
Vanadium		Tantalum, Columbium, and Ferrocolumbium			Unknown	0.05	4375	0.42656	2517
Varadium		Tantalum, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.05	4375	0.42656	2517
Znc	33	Copper	Acid plant b-owdown		CBI	467	22083	20110.1975	10441
Z no Z no		Copper Copper	Acid plant b-owdown Acid plant b-owdown	CBI Cyprus, Clay Pool	CBI AZ	365 115	22083 22083	5717 8125 4952 875	10441 10441
Zinc			Add plant b owdown		AZ	22 25	22083	958.14063	10441
Zinc			Acid plant blowdown		CBI	7 47	22083	321.67688	10441
Znc			Acid plant blowdown		UT	7 14	22083	307 46525	10441
Zinc Zinc			Acid plant blowdown Acid plant blowdown		AZ CBI	7 08 6 63	22083 22083	304.8925 285.50438	10441 10441
Znc			Acid plant blowcown		CBI	6.23	22083	268.27938	10441
Zinc			Acid plant blowdown	CBI	CBI	3 16	22083	36 0775	10441
Zinc			Furnace scrubber blowdown		Unknown	130	17500	4436 25	8429
Zinc Zinc			Furnace scrubber blowdown		Unknown	130 70	17500 17500	4436 25 2388.75	8429 8429
Zinc			Fumace scrubber blowdown Fumace scrubber blowdown		Unknown Unknown	3.8	17500	129 675	8429
Zinc			Fumace scrubber blowdown		Unknown	1 36	:7500	46 41	8429
Zno			Furnace scrubber blowdown	Unknown	Unknown	0 58	17500	19 7925	8429
Zinc			Furnace scrucber blowdown		Unknown	0 55	17530	* 9.76875	8429
Zinc Zinc			Process wastewater Process wastewater		Unknown Unknown	24 19.4	•17 17	5 46 4,4135	385 385
Znc			Process wastewater		Unknown	12.5	117	2.84375	385
Zinc			Process wastewater	Unnamed Plant	Unknown	10.7	117	2.43425	385
Zinc	•		Process wastewater		Unknown	8.94	117	2.03385	385
Znc			Process wastewater		Unknown	6.17	117	1.40368	385
Zinc Zinc			Plant process wastewaters Plant process wastewaters		Unknown Unknown	5 1.98	550 550	5.3625 2.*2355	631 631
Zinc	•		Plant process wastewaters		Unknown	0 599	550	0.64243	531
Zinc		Tantaium, Columbium, and Ferrocolumbium	Process wastewater	Unknown	Unknown	0.54	4375	4.60638	2517
Zinc		Tanta um, Columbium, and Ferrocolumbium		Unknown	Unknown	0.54	4375	4.60688	2517
Zinc		Tantaium, Columbium, and Ferrocolumpium	Process wastewater	Unknown	Unknown	0.5	4375	4.26563	2517

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Zinc	Tantaium, Columbium, and Forrocolumbium Process wastowalter	Unknown	Unknown	0.5	4375	4.26563	2517
Zinc	Tantaium, Columbium, and Ferrocolumbium Process wastowater	Unknown	Unknown	0.5	4375	4.26563	2517
Zinc	Tantaium, Columbium, and Ferrocolumbium Process wastowater	Unknown	Unknown	0 371	4375	3.16509	2517
Zinc	Tantaium, Columbium, and Ferrocolumbium Process wastowater	Unknown	Unknown	0.207	4375	1.76597	2517
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(20 l/kg = ratio of leachate mass to solid sample mass)

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NOTES:

1. V_{wp} (m³) = 1/4 Annual Average Recycled Volume (MT) * 0.7346 m³/t (Waste density = 85lb/(l³ = 1361 kg/m³)

2. M_{ep} (kg) = $C_{b,ec}$ (mg/kg) * V_{ep} (m³) * 1.361X10⁻⁹

(1.36X10-3 = 1.361 MT/m³ * 1000 kg/MT * 1X10⁻⁶ kg/mg) (Waste Density = 62.4 lb/(1³ = 1000 kg/m³) 3. V_a (m³) = 1/12 Average Annual Recycled Volume (MT) * 1.0 MT/m² 4. $M_{s_{c}}(kg) = C_{hell}(mgA = mgAg) + V_{s_{c}}(m^{3}) + 1X10^{3}$ (1X10⁻³ = 1.0 MT/m³ * 1000 kg/MT * 1X10⁻⁶ kg/mg)

5. $M_{machanistic}$ (kg) = $C_{loadhaic}$ (mg/l) * 20 l/kg * V (m³) * 1.363X10⁻³

Μ_{ματο} (kg) = C_{ματο} (rug/l = rug/kg)* 1.95 l/kg* Vsi (m³)* 1.0X1(11.95 l/kg = ratio of extraction solvent plus 'icuid fraction to original sample mass)

DATA SUMMARIES FOR HIGH-RISK MINERAL PROCESSING FACILITIES

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APPENDIX L

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The following appendix summarizes EPA's efforts to gather data to support site-specific (or facility-specific) assessment of health and environmental risks associated with the management of high-risk recycled waste streams. These waste streams were identified in Section 4.2.

L.1 Facility 1 (Beryllium Production)

L.1.1 Facility Background

Facility 1 is located in Millard County, 1 mile west of Highway 6, and 10 miles northeast of Delta, Utah.ⁱ The site's location is 39.417219 degrees latitude and -112.472777 degrees longitude.ⁱⁱ The mill extracts beryllium from low-grade bertrandite ore (mined about 55 miles to the west) and from high-grade beryl ore imported from foreign sources.ⁱ Bertrandite is a hydrous beryllium silicate, $Be_4Si_2O_7(OH)_2$. The extraction processes for each ore are slightly different.ⁱⁱⁱ The concentrate from the mill is packed in drums and shipped to the company's facility in Ohio.ⁱ

The open-pit commenced in 1968 and the milling facility began operating in September, 1969. Between the years of 1978 and 1981, additional facilities were constructed on the site. This was done to accommodate the extraction and recovery of beryllium values from imported beryl ore, increase capacity of the bertrandite plant by 25 percent, and recover the uranium values associated with the bertrandite ore as a salable uranium by-product. The life of the ore reserve, as of 1990, was said to be 50 years (at the existing ore production rate); consequently, this was estimated to be the life span as the tailings pond used to manage wastes for the facility used to manage wastes from the facility (discussed below).ⁱⁱⁱ

L.1.2 Wastes

The mill processes result in the following waste streams for which we currently have data^{tiv}

- Tailings;
- Treated sanitary wastewater;
- Solid wastes; and
- Treated water from the oil water-separator of an underground storage tank remediation system.

Both beryllium extraction processes produce leached or spent solids, which are separated from the beryllium sulfate leach liquor using thickeners and washing by countercurrent decantation (CCD) before discarding the solids to the tailings pond.ⁱⁱⁱ Solid waste includes inert materials such as packaging, pallets, process sludges, ore samples, and other beryllium-contaminated items.^{iiv} The average tailings slurry discharge rate ranges from 800 to 920 gallons per minute. In 1989, the total annual discharge of tailings slurry was 258.6 million gallons.ⁱⁱⁱ

The tailings slurry contain about 9 to 10 percent solids by weight and consists mainly of fine sand, silt, and clay. Tailings deposition is controlled mainly by the grain size and distance from the discharge point. The waste solutions are generally acidic with a pH between 1.5 and 2. Filtered analyses of the tailings solutions show high concentrations of ammonia, fluorine, sulfate, dissolved solids (TDS), and various metals (constituent/concentration data available). Typical samples of tailings pond water contain more than 40,000 mg/l dissolved solids and 29,000 mg/l sulfate. Water forming the seepage mound beneath the pond has a neutral pH and generally lower concentrations of dissolved constituents.'

The barren filtrate from a filtration process contains uranium values. This waste stream was identified as the high-risk waste stream in the RIA. No composition data is available for this stream other than the five samples used in the RIA. This waste was transferred to solar ponds for storage and subsequent processing for uranium recovery.ⁱⁱⁱ The State of Utah was contacted (November 1997) and indicated there were 3 ponds from 1979 to 1985. The solar ponds were officially closed in 1994. At the time, they were synthetically lined and one pond was 2 acres, while the other two ponds were 1 acre. This

L.1.3 Solid Waste Management Units (SWMUs)

As a result of the Ground Water Discharge Permit, the documents currently focus on the tailings pond. The 220-acre tailings pond is just north of the plant and holds solid wastes and all liquid wastes (including the treated sanitary wastewater) from the facility.¹ The treated sanitary wastewater has been historically mixed with the tailings slurry before being discharged to the tailings pond. Solid waste has also been disposed of by being buried in the tailings, under the 1987 permit and the renewed permit in 1994 (running to March 1999).¹⁴⁷ The treated water from the oil water-separator was planned to be test mixed with the tailings slurry before being discharged under the renewed permit for a 15-day period.⁴

As of 1990, the waste slurry is transported to the tailings pond through a pipe and dumped in one location for a period of time. The sand portion of the tailings slurry settles out in a mound directly under the discharge point; the finer grained material flows with the water along the gradual south to north slope of the settled tailings in the pond. The fine sand and silt portion of the tailings settles out on the broad slope between the discharge points and the northern end of the tailings pond. The clay fraction is deposited in the northern portion of the pond area. The location of the discharge point is moved around the pond area as needed to uniformly deposit the tailings solids.ⁱⁱⁱ

The construction permit for the pond was issued in 1969. In 1986, the facility determined that additional tailings pond storage was needed and applied for a permit to raise the dike levees. As part of the permit, the facility made a groundwater study to better determine the subsurface hydrology, water quality, and to monitor the rate of growth of a perched seepage mound beneath the tailings pond. Efforts since 1986 to seal the pond have only been partially successful. This resulted in the need for a groundwater discharge permit, which was issued in 1992.

As a result of the permit requirements, the capacity of the tailings pond was to be increased by adding a lift which was to provide 15 additional years of life (starting 1993). This was to be constructed out of earth borrow obtained on site and was to be built in a downstream manner. The discharge rate was to be 872 acre-feet per year. The evaporation rate from the tailings pond was to be increased by pumping collected tailings water from the submerged low end of the tailings basin through pipes to the upper, dry end where it was planned to be spread out on the tailings surface. This was to increase the evaporation rate of the tailings facility to about 472 acre feet per year. The scepage rate from the tailings pond was to be reduced by scaling the surface of the tailings solids with a 24-inch thick layer of low-permeability tailings slimes (fine silt and elay); this was to be done by processing the tailings with cyclones to remove the sand and then evenly discharging the slime slurry through pipes. All told, it was expected to take 5 to 6 years to complete and reduce the seepage rate down to 250 acre-feet per year. Recovery wells were also planned to be installed over the seepage mound. The wells were to extract approximately 250 acre-feet per year from the seepage mound and this water was to be disposed of in the tailings pond by evaporation. The well field was to be designed to remove up to 541 acre-feet per year, the additional water would be disposed of by evaporation in the tailings ponds and/or recycling it to the mill where it would replace fresh water currently being used in the process.ⁱ

L.1.4 Facility Setting

Little information is currently available on the facility setting. The population in the area is, however, known in detail. About 987 people live within a half mile of the facility. The population within one mile of the site is estimated to be 2,991, and 5,689 people live within three miles of the facility, based on 1990 US Census data. Most of the population lives east of the facility and only about 20 percent of the people live west of the facility.

The ground water geology and the hydrology at the facility is also fairly well understood. The USGS has made a digital model and water level maps of the Sevier Desert, which includes the facility site. . . In addition, more than 100 boreholes have been drilled in the area.

The available information indicates the deposits beneath the tailings pond consist of alluvial and lacustrine material composed of interbedded sand, silt, gravel and clay, to a depth of 40 to 70 feet.ⁱ More specifically, the soil type for the area of the tailings pond is the Yenrab-Uvada association (Soil Conservation Service as cited in 4). These are well drained, strongly to very strongly saline, moderately to strongly alkali sands and silt loams.ⁱⁱⁱ

L.1.5 Environmental Contamination

The tailings pond or seepage mound could potentially penetrate the upper artisian aquifer in the area. According to calculations using site-specific geohydrological data, this will not occur for at least 1,000 years. In 1992 and 1993, the facility owner sampled and analyzed wells tapping the upper artesian aquifer near the plant to determine if contaminants from the seepage mound had entered the aquifer. The evidence suggested the aquifer had not been contaminated. However, the water quality of the aquifer is not consistent across the property and appears to locally contain dissolved arsenic in clevated concentrations not unlike the condition described by the USGS for other areas of the Sevier Basin (sample data available).⁴

In 1987, the northwest portion of the tailings pond had very little of the (low-permeability) tailings solids in it and the tailings water was able to readily seep into the foundation soils. This was proposed to be mitigated so that the seepage rate would be decreased; the State of Utah agreed that no additional mitigative action was necessary but inposed an expanded monitoring requirement.ⁱⁿ

L.1.6 References

EPA Region 8 referred us to the Utah Department of Environmental Quality (UDEQ). The following officials from the UDEQ assisted our efforts in gathering data for this site:

- Blake Robertson;
- Shelly Milligan, State RCRA Program; and
- Larry Mize, Ground Water Division.

ENDNOTES

- i. Statement of Basis. Beryllium Mill. Author and date not given. 1993-7?.
- ii. ENVIROFACTS (EPA database).

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- iii. Ground Water Discharge Permit Application for the (Company Name) Tailings Pond. Delta, Utah. November 15, 1990. Prepared by JBR Consultants Group for the facility owner.
- iv. Groundwater Discharge Permit. Permit No. UGW270001. State of Utah. Division of Water Quality. Department of Environmental Quality. Date not given, but, it is 1993 or 1994.

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L.2 Facility 2 (Copper Processor)

L.2.1 Facility Background

Facility 2 is located in Gila County, on Highway 60 near Claypool, Arizona. The site's exact location is 33.43981 degrees latitude and 110.87455 degrees longitude.¹ The facility began operations around 1906, and currently uses a smelter and converter system, an anode furnace, and an electrolytic refinery system in mining and processing copper ore.^{10,10} Because the facility is not a large quantity generator and does not generate any wastes (since all potential waste streams are supposed to be recycled) it is not regulated under RCRA. A Preliminary Assessment was performed at the site in 1983, and it was believed that hazardous waste may have been disposed of on site. Inclusion in the Superfund program, however, was delayed pending further investigation. To this date, the facility is not regulated under CERCLA, but it is currently monitored by the Arizona State Superfund program as part of Arizona's groundwater protection strategy.

L.2.2 Wastes

The waste streams that we have data for from this facility are:

- Smelter slag;
- Converter and anode furnace slag;
- Flu dust;
- Acid plant blowdown; and
- Tankhouse slimes (from the electrolytic refinery and the copper leaching circuit).

Smelter slag is generated in the greatest quantity of all the waste streams at facility 2. This waste is a typically gravel or cobble sized solid material, composed primarily of iron silicates, calcium oxide, and alumina. The material also contains trace amounts of copper, lead, zinc, and other metals. The amount of smelter slag generated is in the range of 165,000 to nearly 500,000 metric tons per year. The facility also generates between 30,000 and 250,000 metric tons of converter and anode furnace slag. The flu dust, recovered from converter electrostatic precipitators may contain up to 25 percent copper concentration. Because of its value, this material is reprocessed in the flash furnace.¹⁹

Acid plant blowdown and tankhouse slimes are perhaps most significant because of their potential threat to human health and the environment. Acid plant blowdown, which also contains APC dust sludge and scrubber blowdown, is a liquid waste with a pH of approximately 2. Tankhouse slimes produced in the electrolytic refinery are stored in 55 gallon drums before being shipped to gold and silver refineries, and tankhouse slimes from the copper leaching circuit are stored in boxes and eventually sold as scrap metal.^{iv}

L.2.3 Solid Waste Management Units (SWMUs)

While information regarding the exact number and locations of SWMUs are not yet available (we may obtain these data from the Arizona Department of Environmental Quality), it is known that the site uses both waste piles and tanks to treat and store generated waste streams. Slag is deposited on waste piles at the edge of a tailings pond. The basal area of the piles may range from 7 to 26 hectares, and the height from 6 to 45 meters. Acid plant blowdown was treated in unlined surface impoundments until at least the mid 1980's, but is now managed using heap leaching piles and a solar evaporation containment pad.^v The solid portion of the blowdown is filtered out and sent to the lined evaporation pad, and the liquid material is piped to heap leaching piles. Tankhouse slimes, as mentioned above, are stored in 55 gallon drums and roll-off boxes before being shipped to gold and silver refineries. Thus, it appears that recycled materials are not currently managed in land units.

L.2.4 Facility Setting

Gila County is a mountainous region with rugged peaks separated by narrow, deep canyons. Much of the area surrounding the facility is characterized by foothill terrain, with colorful rock out cropping and desert flora. The climate tends to be cool and sub-humid at higher elevations, and warm and semi-arid in lower areas. The two seasons in which precipitation is the most frequent are summer and winter, with average monthly precipitation of 3.33 inches in August and 2.40 inches in December. The average annual rainfall is about 18 inches.⁵¹

Currently, we do not have much detailed information regarding land use in the area, but we will probably receive better data from AZDEQ. We do know, however, that much of the land in the area is administered by the U.S. Forest Service. In the Globe/Miami area, which includes Claypool, it is estimated that there are over 100 active and inactive mines. The population of the area is known in greater detail. The closest residence is located 60 meters from the site, and about 150 people live within a half mile of the facility.ⁱⁱⁱ The population within one mile of the site is estimated to be 3,728, and 9,541 people live within three miles of the facility, based on 1990 US Census data. Most of the population in the surrounding area lives south and west of the facility, and only about 10 per cent of the people live east of the site. Furthermore, there are three nearby sensitive ecological receptors; (1) Salt River, the nearest surface water body, located about 24 km from the mine; (2) Roosevelt Lake, a resort area in the vicinity; and (3) a National Forest (the name of which is not indicated in any documentation we gathered).ⁱⁱⁱ

L.2.5 Environmental Contamination

Information on the type and extent of environmental contamination is limited, but there has never been any observed human death or ecological damage attributed to a mineral processing waste.ⁱⁱⁱ Additionally, as of 1988, there had been no observed releases of hazardous materials to surface water, ground water, or air.^{vii} Although the Emergency Response Notification System (ERNS) does not track chronic releases (e.g., leaching to groundwater), the database does track isolated releases from the facility. The database indicated that in 1997, there were four incidents of releases at the site: (1) air release of 800 pounds of ammonia; (2) release into the soil of 10 gallons of liquid material spilled from a box containing F006 material; (3) release into soil of 10,000 gallons of copper sulfate; and (4) a soil release of an unknown quantity of mercury.^{viii} The sources of these releases, as well as the responses to the spills are unknown.

On a more regional scale, there is evidence of regional groundwater pollution. A large proportion of the area in Gila County has been disturbed by open-pit mining, tailings piles, and surface impoundments. Thus, there certainly has been significant environmental degradation, but the extent to which facility 2 is responsible is unclear.

L.2.6 References

The following officials from the Arizona Department of Environmental Quality assisted our efforts in gathering data for this site:

- Jack Kemper, Aquifer Protection Program;
- Lowell Carty, State Superfund Program; and
- Ed Pond, State Superfund Program.

ENDNOTES

- i. ENVIROFACTS (EPA database).
- ii. "Currently" means as of October, 1997.
- iii. Report to Congress on Special Wastes from Mineral Processing, Volume II: Methods and Analyses. United States Environmental Protection Agency, Office of Solid Waste. July 1990.
- iv. Memorandum from Jim O'Leary, Definition of Solid Waste Task Force, summarizing the results of a site visit to facilities 2 and 6.
- v. *Preliminary Assessment*. U.S. EPA Region 9. February 1983; and the Memorandum from ICF reporting waste management information gathered during an interview with Mr. Larry LeCompte of Facility 2.
- vi. *National Prototype Copper Mining Management Plan.* Central Arizona Association of Governments. September 1983.
- vii. Reassessment of (Company Name). ICF Technology Incorporated. September, 1988.
- viii. Emergency Response Notification System (EPA database).

L.3 Facility 3 (Elemental Phosphorus)

L.3.1 Facility Background

Facility 3 is located in Bannock County, on Highway 30, near Pocatello, Idaho. The site's exact location is 42.938 degrees latitude and -112.488 degrees longitude.ⁱ Since 1949, the facility has continuously been producing elemental phosphorus from shale, silica, and coke by using the electric arc furnace method. Operations at the facility include ore handling and preparation, furnace feed preparation, furnace operation, and by-product handling. Originally, mineral processing wastes generated at the plant were excluded from RCRA regulation by the Bevill exemption. In 1989, however, the exemption was removed for almost all production processes. In the early 1990s, the facility submitted both Part A and B RCRA applications. In 1987, a site investigation conducted under CERCLA indicated that groundwater contamination existed in the northeast part of the site. As a result of this and other findings, the site was placed on the National Priorities List in August, 1991. The CERCLA work plan called for a remedial investigation and feasibility study, and this was conducted at the site in 1992.ⁱⁱ

L.3.2 Wastes

The waste streams that we have data for from this facility are:

- Precipitator dust slurry;
- Blowdown wastewater from the Anderson and Medusa scrubbers;
- Phosphorus-laden wastewater from furnace washdown (identified as a high-risk waste); and
- Phosphorus-containing wastewater from surface impoundments.

These waste streams are regulated as hazardous waste, and are recycled after being processed in treatment units. The precipitator dust slurry, generated during the process that removes particulates from furnace off-gasses, exceeds the toxicity characteristic leaching procedure (TCLP) standard for cadmium. The blowdown wastewater from the Medusa scrubber, which also exceeds the TCLP criterion for cadmium, is combined with the Anderson scrubber wastewater before being diverted to the scrubber blowdown wastewater treatment unit. The furnace washdown phosphorus-containing wastewater used to exceed the TCLP criterion for cadmium when it was routed through the slag pit before being collected in a sump. The facility changed its management practice by collecting the waste in a tank, and the waste no longer contains excess cadmium. The wastewater from surface impoundments does exceed the cadmium standard (cadmium concentration is 2.0 mg/L), and also exhibited the hazardous waste characteristic of ignitability.ⁱⁱ

Other wastes produced on-site include waste slag and ferrophos, both of which are not recycled. Waste slag contains various metals including arsenic, barium, cadmium, lead, and zinc. It is not regulated as a hazardous waste, as it is exempt from RCRA due to the Bevill exclusion. The facility stores furnace slag in stockpiles that contain between 1.5 to 21 million tons of slag. Ferrophos waste is a mixture of iron-phosphorus compounds that contains chromium and vanadium. The material is stored on waste piles on site.

L.3.3 Solid Waste Management Units (SWMUs)

Maps indicating the exact location of the SWMUs are available. There are a total of 84 SWMUs on site including storage piles, treatment units (tanks), and surface impoundments. Of these 84 units, the CERCLA remediation investigation feasibility study identified nine units for further investigation; there are 16 such RCRA-identified units.

The precipitator dust slurry is pumped to a 2.8 acre surface impoundment that is double lined with polyvinyl chloride material. The pond, constructed in 1984, holds approximately 27 acre-feet of slurry with suspended solids that are stirred in the pond and occasionally dredged to another surface impoundment. The unit is equipped with a leachate detection and collection system to prevent environmental contamination.ⁱⁱ

Phosphorus-laden wastewater and, until 1981, some precipitator dust slurry used to be discharged into an unlined surface impoundment. In 1981, a Phosphorus Recovery Process was installed near the impoundment to recover elemental phosphorus from the pond solids. From 1981 through 1991, the facility dredged solids from the pond and diverted them to the recovery process. During this period, wastewater containing phosphorus continued to be discharged into the impoundment. The pond, which was constructed in 1970 with a capacity of 70 acre-feet, was determined in 1993 to be causing groundwater contamination. The unlined impoundment ceased operation in August, 1993 and the facility initiated a "time-critical removal" of the unit in October of that year. The facility removed waste water from the pond, installed a temporary cap, and submitted monitoring progress reports to EPA on a quarterly basis. Final closure activities identified in 1997 include placing a low permeability flexible membrane liner on the impoundment."

The wastewater from furnace blowdown is combined with the Medusa scrubber and Anderson filter media wash water. The combined waste stream is sent to a scrubber blowdown wastewater treatment tank. The treated effluent is then sent to settling ponds, and the clarified water is recycled back to the scrubbers. The waste slag and ferrophos are extracted from process furnaces several times a day and transported to a storage pile or crushing plant."

L.3.4 Facility Setting

The facility is located at the northern end of the Bannock Mountains at an elevation of approximately 4,400 feet above sea level. The Portneuf River is the only perennial stream in the vicinity of the site. Adjacent to facility 3 is another facility that has produced concentrated phosphoric acid, ammonium phosphate, and other products from phosphate-containing ore since 1944.¹⁹ The climate of Pocatello varies depending on the season. The mean daily maximum temperature during the summer months is 51 degrees Fahrenheit, and the mean precipitation is 2.13 inches per month. During winter months, the mean daily maximum temperature is 35.4 degrees Fahrenheit, and the mean precipitation is 2.95 inches per month.¹¹

The land in Pocatello is zoned primarily for residential use. The current land use is 60 percent residential, 15 percent industrial, and 10 percent commercial. The nearest residences to the site are located 300 meters downgradient of the facility, and another residential area is located about 2.5 miles from the facility. Three schools and one nursing home are located in these two residential areas, and the entire Pocatello region has 28 schools and 5 nursing homes.ⁱⁱ

There are several sensitive ecological receptors located near the facility. The Portneuf River, a major tributary of the Snake River, is approximately half a mile northeast of the facility. The river is used

for fishing, recreation, and irrigation downstream from the site.^{iv} Additionally, there are numerous springs adjacent to the Portneuf River channel, including Batiste Springs and a fish hatchery located 2.4 km downstream from the facility. Batiste Spings has historically been used for drinking water by more than 1,000 employees of a nearby railroad and 30 residences in Pocatello.ⁱⁱ

L.3.5 Environmental Contamination

The greatest extent of contamination is due to leaching from the unlined surface impoundment used for precipitator dust slurry and phosphorus-containing wastewater. The contamination, which includes arsenic, chloride, fluoride, and sulfate, has affected on-site shallow groundwater and off-site springs to the degree that ingesting or coming into direct contact with the groundwater may pose a health threat.^{iv} On-site soils also contain high levels of toxic constituents such as cadmium, chromium, copper, and zinc. Finally, off-site soils located northwest of the facility contain elevated levels of fluoride, zinc and cadmium as a result of airborne releases from plant processes, roads, storage areas, and wastewater ponds. Direct contact with these soils may also pose a health threat.

There are also several toxic plumes that have been identified in the vicinity of the site. Three arsenic plumes and a major nitrate plume exist in the shallow interval of the uppermost aquifer at the site. These plumes are migrating in a northeasterly direction, which is consistent with the direction of groundwater flow. The highest detected arsenic concentration is 0.56 mg/L, and the highest concentration of nitrate was determined to be 23 mg/L. The source areas for this contamination is not fully determined, but the contamination is probably related to the numerous waste ponds, the slag pit, and/or the phosphorus recovery unit. Although there is a high degree of groundwater contamination from waste management activities at the facility, no damages have been attributed with confidence to a mineral processing special waste.^{iv} This may be because the residents of Pocatello rely on drinking water from a "deep aquifer" system comprised of the Tertiary Starlight Formation, Big Hole Basalt, and Sunbeam Formation. Additionally, gradients in the area are very flat, ranging from one to five feet per mile.

L.3.6 References

The following officials from EPA Region 10 assisted our efforts in gathering information on facility 3:

• Bill Adams and Tracy Chellis, Region 10 Superfund Program.

ENDNOTES

- i. ENVIROFACTS (EPA database).
- ii. Facility Assessment, (Company Name), Phosphorus Chemicals Division. June 1991.
- iii. Public Notice regarding Facility 3 published on the World Wide Web; US EPA Region 10; September, 1997.

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L.4 Facility 4 (Zinc Manufacturer)

L.4.1 Facility Background

Facility 4 is located in Montgomery County, on Zinc Plant Road, outside of Clarksville, Tennessee. The site's exact location is 36.208333 latitude and -86.766667 longitude.ⁱ The facility began operations in 1978, and as of 1995 operations consisted of producing zinc metal from concentrated ore using an electrolytic process. Facility 4 is listed as a RCRA Small Quantity Generator, and although it is not a Superfund site, several CERCLA studies have been conducted. A Preliminary Assessment was conducted in November, 1983, and a subsequent inspection was performed in March, 1984. A Site Inspection Prioritization Report, conducted in May 1995, called for further action to be taken at the site. Additionally, the facility is subject to NPDES permits issued by the State of Tennessee and EPA.

L.4.2 Wastes

The facility generates the following five waste streams that are regulated under the NPDES Permit issued by EPA in 1994: (1) Electrolyte Bleed; (2) Cathode/Anode Wash; (3) Casting Contact Cooling waste; (4) Cadmium Plant residue; and (5) Metallurgical Acid. The facility generates more than 300 tons per day of Electrolyte Bleed, Cathode/Anode Wash, and Casting Contact Cooling waste, and more than 500 tons per day of Metallurgical Acid. 1.71 tons per day of Cadmium Plant residue is produced at the facility.ⁱⁱ These wastes consist of metals such as cadmium, copper, lead, zinc, and arsenic.

Additional wastes include sulfuric acid generated during processing activities. The acid is returned by pipeline to barges on a nearby river, and is eventually sold to fertilizer companies. The facility also generates metal by-products, referred to as leachate residue. These wastes, which are generated during the ore purification process, contain zinc, cadmium, copper, cobalt, lead, and germanium.ⁱⁱⁱ Finally, the facility generates recycle slurry. None of the above wastes are identified with high-risk waste streams for zinc manufacturing.

L.4.3 Solid Waste Management Units (SWMUs)

The SWMUs consist of six outfalls, four surface impoundments, three waste piles, and numerous treatment and storage tanks. A map detailing information on the exact locations of the SWMUs is available.¹⁰ The Outfalls are used in the metals recovery and wastewater treatment process in the following manner:

- Outfall No. 1 discharges processed water beneath the surface of the Cumberland River. All of the five regulated waste streams are treated in a metals recovery facility prior to discharge in Outfall No.1. Additionally, the treated recycled slurry is discharged via Outfall No. 1. This occurs after heavy metals have been precipitated out of the waste, and the slurry has been neutralized;
- Oufall No. 2 is used to discharge wastewaster consisting of filter backwash water and demineralizer regeneration water into the Cumberland River;
- Oufall No. 3 discharges stormwater, exposed to the manufacturing portion of the plant, into a tributary of the Cumberland River;
- Oufalls No. 4 and 6 discharge stormwater onto near-by pasture land; and

 Oufall No. 5 drains pasture land and product storage facilities by discharging wastewater into an unnamed tributary of the Cumberland River.ⁱⁱ

The metal by-products are stored in four large, unfenced impoundments that are lined with clay and synthetic material. There is no evidence, however, that high-risk wastes are stored in the impoundments. The total surface area of the impoundments is 756,875 square feet, and the total volume is 339,740 cubic meters.^v The three separate waste piles, each approximately 150 cubic feet in volume, contain cobalt, copper, and zinc and are located near Impoundment No. 1.ⁱⁱⁱ

L.4.4 Facility Setting

The climate of Montgomery County is characterized by relatively mild winters and warm summers, with the average annual temperature at Clarksville around 60 degrees Fahrenheit. The average annual precipitation in the area is 48 inches, but due to a high mean lake pan evaporation rate of 37 inches per year, the net annual rainfall is only 11 inches.

A map of Clarksville indicates that the site is surrounded by wetlands, Lake Barkley, and the Cumberland River.^{vi} There are also several smaller bodies of water in the area where recreational and commercial fishing occur. There are many residential areas and schools in the vicinity of the site, with the nearest residence being approximately 500 feet south of the plant.ⁱⁱⁱ Based on 1990 US Census data, approximately 33,000 people live within 4 miles of the facility, with over half living between three and four miles away.

In addition to the substantial human population around the site, there are also several sensitive ecological receptors. Approximately 229 acres of wetlands, which provide habitat to state threatened and endangered species, are located within a four-mile radius of the site. The threatened plant species include sweet coneflower, muskingum sedge, and the Canada lily; endangered birds in the area include the osprey, bewick's wren, and the bachman's sparrow.ⁱⁱⁱ Finally, pasture land used for corn and soybean cultivation is located northwest of the site, between wetlands.

L.4.5 Environmental Contamination

Elevated concentrations of toxic metals such as copper, lead, mercury, and zinc represent the greatest soil contamination at the site. Sediment samples taken in 1995 from impoundment numbers 1, 2, and 3 showed high concentrations of these metals, as did soil samples collected downgradient from the impoundments. Sediment from impoundment number 1 contained a high concentration of arsenic, and sediment from the nearby wetlands area contained cadmium, manganese, and mercury.ⁱⁱⁱ In 1981, a sulfur dioxide release to air was detected at a nearby school, which is now equipped with a sulfur dioxide monitor. The 1995 Site Inspection Prioritization Report, finding that exposure to contaminated soil and potential air contamination poses a threat to human health and the environment, recommended that further action (under the Superfund program) be taken at the facility.

L.4.6 References

The following EPA Region 4 officials assisted our efforts in gathering data for this site:

- Mike Creeson, Region 4 NPDES Program;
- Loften Carr, Region 4 Superfund Program; and
- Kris Lipper, Region 4 RCRA Program.

ENDNOTES

- i. ENVIROFACTS (EPA database).
- ii. NPDES permit issued by U.S. Environmental Protection Agency; June, 1994.

iii. Site Inspection Prioritization Report. U.S. EPA, Waste Management Division. May 1995.

- iv. JMZ Electrolytic Zinc Plant, Facility Layout; EMPE, Inc; 1993.
- v. Site Inspection Prioritization Report. U.S. EPA, Waste Management Division. May 1995.
- vi. JMZ Electrolytic Zinc Plant, Location Map; EMPE, Inc; 1993.

L.5 Facility 5 (Titanium Dioxide Manufacturer)

L.5.1 Facility Background

Facility 5 is located in Chatham County, approximately 1.5 miles outside of Savannah, Georgia. The site's exact location is 32.081 degrees latitude and -81.029 degrees longitude.¹ The facility purchased the site in 1985 from a chemical manufacturing company that had operated on-site since around 1955. As of 1993, the facility manufactured titanium dioxide pigment by the chloride and sulfate processes. The process used was dependent on the quality of titanium ore feedstock, with the chloride process used for high quality ore and the sulfate process applied to lower quality ore. The former owner of the site operated a RCRA permitted facility, and the permit was transferred to the current owner in 1985. In 1991, the current owner requested and received revocation of their hazardous waste facility permit because the only hazardous waste management activity conducted at the site is operation of an elementary neutralization unit. A Site Inspection under the authority of CERCLA was conducted in 1993 to determine the need for additional investigation under the Superfund program. The facility received a NPDES permit in 1976 specifying the amounts and constituents of processed waste streams discharged into the Savannah River.

L.5.2 Wastes

The waste streams that we have data for from this facility are (1) weak and strong acid streams generated from the sulfate process; (2) Chloride process wastes; and (3) Contact cooling water, but we do not know the extent to which these wastes are recycled.

The chloride process, because it is used on high quality titanium ore, generates a small volume of waste which consists primarily of iron and titanium chlorides. The sulfate process, however, generates both weak and strong acid solutions from a process that filters precipitated titanium. Both of these acid solutions are identified as high-risk wastes. Approximately 15 percent of the filtrate can be reprocessed, and the remainder constitutes a strong acid waste stream containing 20 percent free sulfuric acid, 5 to 10 percent ferrous sulfate, and trace amounts of dissolved heavy metals." The weak acid, generated during the sulfate process, contains about three percent free sulfuric acid, approximately 0.5 percent ferrous sulfate, and smaller amounts of dissolved heavy metals. The waste stream generated from the chloride process and the strong acid stream are diverted to the weak acid stream.

The contact cooling water contains (1) process waste water; (2) storm water; (3) sanitary waste; and (4) leachate. The process waste water, wash water from scrubbers and filters, is neutral but contains suspended solids such as titanium oxide. The storm water is from the manufacturing areas of the plant, and the sanitary waste is collected from various points at the site and pumped into the contact cooling water stream. The leachate, which flows into the waste stream, is from an area that formerly stored copperas (an iron sulfate compound).ⁱⁱ

L.5.3 Solid Waste Management Units

The historical waste management area at the facility covers 64 acres and consists of five unlined surface impoundments, a settling pond, and two dredge spoils. A map of the management area indicates that the SWMUs are bounded on the north by the Savannah River, on the west by the manufacturing plant, and on the south and cast by marsh land.ⁱⁱⁱ The weak acid waste stream used to be pumped to the settling pond before being diverted to a neutralization plant. Similarly, the contact cooling water stream used to flow to a plant which neutralized the material with slaked lime $(Ca(OH)_2)$ before settling in an effluent pond. In 1988, however, the facility changed its management practices and stopped using surface impoundments to treat and store these waste streams. Instead, the facility started using elementary

neutralization systems (comprised of tanks) to treat all chloride and sulfate wastes.^{iv} The ponds were closed, and in 1991, the facility had its Hazardous Waste Management Permit revoked upon request. The revocation of the permit was granted because (1) the facility discontinued the practice of storing hazardous waste in surface impoundments; (2) the facility was not handling any waste previously excluded from RCRA by the Bevill Amendment; and (3) the facility was not managing any historical accumulations of wastes previously excluded by the Bevill Amendment.^{iv}

L.5.4 Facility Setting

The Savannah area is located within the Atlantic Coast Physiographic Province where the climate is characterized by a warm, moist climate. Temperatures range from an average of 51 degrees Fahrenheit in January to 81 degrees Fahrenheit in July, and the area's net annual precipitation is 4 inches.^{*}

While the Savannah watershed is mostly forested, the area around the facility is primarily industrial. Based on 1990 census data, there are no residential dwellings within a mile of the facility. The nearest residential development and school is located two miles from the plant, and it is estimated that more than 25,000 people live between two and three miles away. Over 90 percent of this population live southwest of the plant.⁴¹ Although the facility is located in an area of low elevation adjacent to the Savannah River, the nearby population is not a groundwater target because the river is not used for drinking water. Instead, residents in the Savannah area use municipal or subdivision water systems drawing from the principal artesian aquifer. The city of Savannah operates 21 wells, three of which are within 4 miles of the historical waste management area.

There are several sensitive ecological receptors in the area. There are several surrounding water bodies, such as the Savannah, Wilmington, and Bull Rivers, that support recreational and commercial fisheries. Additionally, several endangered and threatened species may be found in the Savannah area, including the short-nosed sturgeon, the Atlantic green sea turtle, the brown pelican, manatee and bald eagle. Finally, the area has been proposed as a National Estuary Program/Near Coastal Water Program sensitive area due to its brackish water chemistry.^{*}

L.5.5 Environmental Contamination

In 1993, samples were taken from the waste management area that was closed five years earlier. The soil and groundwater samples indicated that there is no ongoing release of hazardous materials from the former hazardous waste management area.¹⁰ Analysis of surface water revealed that although samples of runoff and sediment indicate the presence of hazardous materials from the acid streams, the concentrations of hazardous constituents are low. Thus, it appears that there is little threat to human health and the environment from chronic releases of hazardous materials into soil, groundwater, or surface water.

Although there does not appear to be any ongoing releases, the facility has had several isolated hazardous waste releases in the past. In June, 1968, waste acid flowed through a break in the dike surrounding waste acid ponds. Approximately 30,000,000 gallons of waste flowed into the Savannah River through a drainage ditch. Additionally, during the period from 1982 to September 1984, seepage escaped through the dikes of the weak acid pond. The seepage, which had been treated in the cooling water treatment system, amounted to about 2 gallons per hour. This release was corrected in late 1984 by constructing a slurry wall in the dike.ⁱⁱⁱ

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L.5.6 References

The following officials from EPA Region 4 and the State of Georgia assisted our efforts in gathering data for this site:

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- Mike Creeson, NPDES Program;
- Alan Yarborough, Superfund Program; and
- Xiabing Chen, State RCRA Program.

ENDNOTES

- i. ENVIROFACTS (EPA database).
- ii. RCRA Part B Application, Revisions and Additions; November 4, 1985.
- iii. Pond Survey, Exhibit G; 1988.
- iv. Facility's letter to Georgia's Environmental Protection Division requesting that its Hazardous Waste Facility Permit be revoked.
- v. Site Inspection Narrative Report; Georgia Department of Natural Resources, Environmental Protection Division, Hazardous Waste Management Branch; April 23, 1993.

vi. Based on 1990 Census Data.

L.6 Facility 6

L.6.1 Facility Background

Facility 6 is located in Pinal County, on Highway 76, near San Manuel, Arizona. The site's exact location is 32.811059 degrees latitude and -110.75291 degrees longitude.¹ The facility began operations in 1956, and currently uses a smelter and converter system, an anode furnace, and an electrolytic refinery system in its mineral processing activities. The facility's processes include mining, milling and processing copper ore, and the mine has been a RCRA permitted facility since November, 1980. As of 1989, the facility was listed in the RCRA database as a Generator and as a Treatment, Storage, and Disposal Facility (TSDF) operating under interim status.¹¹ A Preliminary Assessment, conducted in the early 1980's, indicated that there was no evidence of waste disposal problems at the site and recommended no further action.¹¹¹ To this date, facility 6 is not regulated under CERCLA.

L.6.2 Wastes

The waste streams that we have data for from this facility are:

- Smelter slag;
- Slag tailings;
- Flue dust; and
- Acid plant blowdown slurry.

Smelter slag is a gravel or cobble sized solid material, composed primarily of iron silicates, calcium oxide, and alumina. The material also contains trace amounts of copper, lead, zinc, and other metals. The 2,000 tons of slag produced per day is comprised of 1.8 per cent copper, which is sufficient to recycle economically.^{iv} Slag tailings, settled from a slurry, are composed of particles smaller than sand. The tailings, generated from smelter slags sent to a concentrator, principally contain silicon, iron, magnesium, and sodium. The tailings also contain smaller amounts of copper, lead, and zinc. The flu dust, recovered from converter electrostatic precipitators, may contain up to 25 per cent copper concentration. This valuable material is reprocessed in the flash furnace.^v Acid plant blowdown, generated during a process in which off-gas from the flash furnace is cleaned, is a liquid recycled waste with a pH of approximately 2.

In addition to these waste streams, there are a total of 33 hazardous wastes generated on site. These substances include sodium cyanide, vanadium pentoxide, arsenic trioxide, acetone, chloroform, cyclohexane, ethyl acetate, isobutyl alcohol, molybedenum disulfide, and sulfuric acid.

L.6.3 Solid Waste Management Units (SWMUs)

A map which provides detailed information on the exact number and locations of SWMUs is available.^{vi} The site uses both waste piles and tanks to treat and store generated waste streams. While it is clear that the facility used surface impoundments in the 1980s, the map (produced in 1997) does not indicate such units. It is therefore apparent that the facility no longer uses surface impoundments to treat and store solid waste.

Smelter slag is deposited on waste piles, and slag tailings were deposited in six tailings ponds located on-site. The basal area of the slag piles may range from 7 to 26 hectares, and the height from 6 to 45 meters. The amount of slag in a particular pile ranges from 2.7 to 20.9 million metric tons. The total surface area of the six tailings ponds is 1,042 acres.^{iv} As of 1988, there were six settling ponds, three weak acid ponds, two oxidation and oil disposal ponds, and one spill pond.ⁱⁱ The map does not indicate these SWMUs, and they therefore may no longer be in use at the facility.

L.6.4 Facility Setting

We do not have detailed information regarding the climatology of the area, but we may receive more data from the Arizona Department of Environmental Quality. Facility 6 is located in a similar setting as facility 2, and therefore probably experiences the same degree of precipitation. A map of the area surrounding the facility indicates that much of the surrounding land belongs to the State of Arizona, and the Bureau of Land Management.

The immediate vicinity of the mine is sparsely populated. It is estimated that only 10 pcople live within one mile of the site, and the nearest town is San Manuel which is located approximately 1.5 miles from the tailings ponds.ⁱⁱ It is estimated from 1990 census data that 8,810 people live within three miles of the facility, most of whom live east of the site. Although the distance from the nearest tailings pond to surface water (the San Pedro River) is 1,000 feet, the river is a dry wash and there is no population served by surface water within three miles downstream of the facility. Furthermore, there is no ecologically sensitive environment within one mile of the site.ⁱⁱ

L.6.5 Environmental Contamination

Information on the type and extent of environmental contamination is limited, but there has never been any observed human death or ecological damage attributed to a mineral processing waste generated at this facility.^{iv} The Emergency Response Notification System (ERNS) does not track chronic releases, but the database does indicate isolated incidents. In 1997 there were three such releases at the site: (1) release to the soil of 2,861 pounds of sulfuric acid; (2) release to the soil of 186 gallons of sulfuric acid; and (3) release to the soil of 370 gallons of sulfuric acid. The sources of these releases, as well as the responses to the spills are unknown.

L.6.6 References

The following officials from the Arizona Department of Environmental Quality assisted our efforts in gathering data for this site:

- Mike Savka, Aquifer Protection Program;
- Lowell Carty, State Superfund Program; and
- Joe Giudici, State Department of Solid Waste.

ENDNOTES

- i. ENVIROFACTS (EPA database).
- ii. Reassessment of Magma Copper Company San Manuel Mine and Smelter. Ecology and Environment, Inc. October 1988.
- iii. Preliminary Assessment. U.S. Environmental Protection Agency, Region 9. Date unknown.
- iv. Report to Congress on Special Wastes from Mineral Processing, Volume II: Methods and Analyses. United States Environmental Protection Agency, Office of Solid Waste. July 1990.
- v. Memorandum from Jim O'Leary, Definition of Solid Waste Task Force, summarizing the results of a site visit to facilities 2 and 6.
- vi. Facility 6 map, "Mine Site Area Wide Aquifer Protection Permit Facilities"; Hargis & Associates, Inc; June, 1997.

L.7 Facility 7 (Titanium-Titanium/Dioxide)

L.7.1 Facility Background

Facility 7 consists of six plants at various locations in Baltimore, Maryland, according to EPA's FINDS database. The facility produces titanium and titanium dioxide. At this time, due to the lack of documents and references, we cannot determine the exact relationship and function of each of the plants. Documents that exist, but, have not been obtained include: a preliminary assessment conducted in 1980, two screening assessments done in 1980 and 1985, an RFA, and state site investigations.

For now, we will concentrate our efforts on the plant that matches the location of the facility in the January 1997 Population Studies report. Our only current reference is EPA's Envirofacts database. This database provides some information on location, environmental releases, and waste management units. Envirofacts indicates the selected plant's exact location is 39.205833 degrees latitude and -76.543333 degrees longitude. The facility is regulated under RCRA and CWA.

L.7.2 Wastes

Scrap milling scrubber water and waste acids (sulfate process) are the waste streams identified as high risk in the RIA. The scrubber water was also identified as being recycled. No other was composition data is available other than the one sample for each waste stream used in the RIA.

The facility had an NPDES permit (that expired in 1990) to discharge the following chemicals/substances through points (pipes): pH, total suspended solids, arsenic, cadmium, chromium, copper, total iron, dissolved iron, lead, nickel, zinc, antimony, and flow (in conduit or thru treatment plant). Information on what waste streams were allowed (to be discharged under this permit) is not available.

According to RCRIS, the facility has a RCRA Part A permit and is subject to comprehensive evaluation inspections. According to 1995 TRI data, the facility releases chemicals/substances to air, underground injection, land, and surface water (constituent and amount data available).

L.7.3 Solid Waste Management Units (SWMUs)

Relatively little data are available about SWMUs beyond the fact that the facility has a landfill with a design capacity of 1860 acre-feet. It is not known what wastes are disposed here or where the recycled waste stream is stored.

L.7.4 Facility Setting

According to a USGS quad map, the facility is in a fairly remote location, near the Patapsco River. Other facilities in the area are unidentified, except for the Coast Guard. The 1990 Census data confirms this. No people live within a half mile of the facility. The population within one mile of the site is estimated to be only 8, while 9,841 people live within three miles of the facility. Most of the population lives south of the facility and about 36 percent of the people live north of the facility. No hydrogeologic data have been attained, but it appears as if the groundwater at the site discharges to the Patapsco River. This appears to rule out groundwater consumption as an exposure pathway.

L.7.5 Environmental Contamination

No information is currently available on environmental contamination.

L.7.6 References

Only one document, or in this case a database, was available to analyze facility 7:

ENVIROFACTS (EPA database)

The following officials from EPA Region 3 and the Maryland Department of the Environment assisted our efforts in gathering data for this site:

- Mildred Orusko at Region 3 (RCRA);
- Jim Webb at Region 3 (Superfund);
- Jim Leizeare, State of Maryland, RCRA-Hazardous Waste; and
- Don Mouldin, State of Maryland, Public Information.

As mentioned, there are other documents available, but they generally require a FOIA Request:

- RFA is at Region 3 Document Center (FOIA needed);
- A Preliminary Assessment conducted in 1980 and two Screening Assessments done in 1980 and 1985 are available (may need a FOIA); and
- Site investigations on file.

L.8 Facility 8 (Zinc Production)

L.8.1 Facility Background

Facility 8 is located in Beaver County, on Frankfort Road in Potter Township, which is near Monaca, Pennslyvania.ⁱ The site's exact location is 40.671389 degrees latitude and -80.337778 degrees longitude.^a The facility is 29 miles downstream from Pittsburgh on the Ohio River.ⁱⁱⁱ The facility began operations in 1936 and was modernized in 1980, at which time four electrothermic furnaces began operation.^{iv}

The facility manufactures zinc products from zinc concentrates and purchased zinc bearing secondaries (recycled zinc scrap).^{1,iii} A electrothermic zinc smelter - using a pyrometallurgical process - produces zinc metal slabs and ingots, zinc oxide, zinc dust, and sulfuric acid.^{10,v} The annual production rate of zinc is approximately 156,000 tons per year, as of 1995.^v The facility is located on approximately 450 acres of land and the company owns more than 1,000 acres surrounding the smelter. A 120-Megawatt, coal burning power plant is also operated on site to provide energy for the smelter.¹¹¹

L.8.2 Wastes

We currently have data for the following waste streams:

- Zinc slag;
- Spent surface impoundment liquids;
- Process wastewater;
- Wastewater treatment plant (WWTP) solids; and
- Waste oils.

The waste streams identified as high risk in the RIA are spent surface impoundment liquids and process wastewater; both streams are currently recycled. From the RIA, composition data is available from four and eight samples of the waste streams, respectively.

Zinc slag is the major waste stream (by volume) generated at the site. The zinc slag is a rock-like solid material, with pieces ranging in size from 3 inches to a foot in diameter; it is composed primarily of iron, silicon, and unreacted coke. EPA evaluated the composition of zinc slag, processed slag, and ferrosilicon and found lead frequently exhibiting extraction procedure (EP) toxicity. The generation of furnace slag was approximately 157,000 metric tons in 1988, with the waste-to-product ratio of 1.6 metric tons of slag to each metric ton of zinc product.^{iv}

The facility has a NPDES permit that expires in 2000. A wide variety of discharge sources are allowed under this permit: outfall, sewage treatment plant, power plant cooling condenser, flyash settling ponds, flyash landfill, flue gas residual from landfill, stormwater runoff, process and storm water, and non-contact cooling water. The constituents/parameters allowed to be discharged under this permit are: thermal, dissolved oxygen, pH, total suspended solids, oil and grease, arsenic, cadmium, hexavalent chromium, copper, iron, lead, manganese, zinc, aluminum, selenium, flow (in conduit or thru treatment plant), total residual and free available chlorine, fecal coliform, and biological oxygen demand (most limits are available; in addition, samples were taken at various outfalls).ⁱⁱ The wastewater treatment plant effluent is from cooling tower blowdown, scrubber wastewater, roaster plant boiler blowdown, zinc oxide recovery wastewater, zinc sulfate production wastewater, chem lab wastes, zinc dust area floor drains, and stormwater runoff from production areas. The receiving waters are the Ohio River, Poorhouse Run, and Raccoon Creek.¹

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According to 1995 TRI data, the facility releases chemicals/substances to air, underground injection, land, and surface water (constituent and amount data available).ⁱⁱ

L.8.3 Solid Waste Management Units (SWMUs)

Most of the available data on SWMUs are from the 1980s. The following data is from a 1990 report. A series of crushing/separation operations are employed to separate the slag into four material streams: processed slag, ferrosilicon, zinc fines, and reclaimed coke. The fines and coke are recycled to beneficiation and processing operations at the facility. The processed slag is stored in slag waste piles, disposed in a flyash landfill (see below), or sold for such uses as road gravel or construction aggregate. The ferrosilicon is accumulated in a stockpile until it can be sold.

The following information comes from 1995 reports. The solids generated at the industrial (smelter) wastewater treatment plant are recycled back into the manufacturing process. There is no information as to the type of units that are used to store and treat the WWTP solids. Other solids generated at this facility are landfilled.¹ Slag is disposed of in an off-site landfill.^v In addition, sewage sludge generated at the treatment plant is pumped and hauled to a municipal treatment plant for further processing. Stormwater from the 60-acre production area is collected, treated at the wastewater treatment plant and discharged in a permitted outfall.¹ This data does not indicate whether there are any waste piles. As for waste grease and oil, they are accumulated in several large waste oil tanks and in drums (located in the facility drum storage building) before being sent to disposal.ⁱⁱⁱ

L.8.4 Facility Setting

The facility is located in a 100-year floodplain near the Ohio River.^{iv} About 2,449 people live within a half mile of the facility. The population within one mile of the site is estimated to be 4,892, and 31,688 people live within three miles of the facility, based on 1990 US Census data. The majority of the population lives east of the facility and about 33 percent of the people live west of the facility.

L.8.5 Environmental Contamination

According to a 1990 report, of the four wastestreams arising from slag processing, zinc fines and reclaimed coke are recycled directly to the production process without any potential contact with the environment. The other two streams, ferrosilicon and processed slag, were evaluated and could (under very conservative assumptions) be a potential human health and environmental threat.¹⁴

In addition, there have been two reported release incidents. The first occurred in 1989, when approximately 350 pounds of chlorine gas was released. In 1990, approximately 1500 pounds of sulfur dioxide gas was released. No apparent damage was caused by either releases.¹¹

L.8.6 References

The following officials from the EPA Region 3 and Pennsylvania Department of Environmental Resources assisted our efforts in gathering data for this site:

- Edna Jones, Region 3 NPDES Branch;
- Gale Campbell, State of Pennsylvania;
- Ed Duval, State of Pennsylvania; and
- Shawn Stely, State of Pennsylvania.

ENDNOTES

- i. Authorization to Discharge under the National Pollutant Discharge Elimination System. Permit PA0002208. Commonwealth of Pennsylvania. Department of Environmental Resources. Bureau of Water Quality Management. August 29, 1995.
- ii. ENVIROFACTS (EPA database).
- iii. Preparedness, Prevention, and Contingency Plan for (Company Name). Monaca, Pennsylvania. February 1995.
- Report to Congress on Special Wastes from Mineral Processing, Volume II: Methods and Analyses.
 U.S. Environmental Protection Agency. Office of Solid Waste. July 1990. Chapter 14: Primary Zinc Processing.
- v. Application for NPDES Permit. New and Existing Industrial Dischargers. Pennsylvania Department of Environmental Resources. Water Management Program. March 30, 1995.

L.9 Facility 9

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L.9.1 Facility Background

Facility 9 is a located on a 150-acre property on the west side of Bartlesville, Oklahoma, near the Washington County line.¹ The site's exact location is 36.742429 degrees latitude and -95.989218 longitude.¹¹ Lead and zinc ores are present in the area, which led to the development of the facility. The facility began zinc smelting operations in 1907, and produces various metals, especially zinc, from refining zinc concentrates, secondary materials, and other materials that are rich in zinc. The facility began using three horizontal retort zinc smelters. Two of the smelters ceased operations in the 1920s. Numerous other industrial processes related to zinc refining were also conducted at the facility, but many of these processes have been altered significantly since the facility began producing zinc in 1907. As a result, there are remnants of outdated plants and industrial activities throughout the facility. Air emissions were uncontrolled until 1976 when the old gas-fired retort furnace was replaced with an electrolytic zinc refinery. As of 1996, the refinery was not operating and no longer engaged in zinc production. The State of Oklahoma reported that the new process reduced emissions of total suspended particulates (TSP) by 99.7 percent. The facility was previously regulated under the CWA and is currently regulated under RCRA. Under CERCLA, the surrounding area was proposed to the National Priorities List in 1993.^{1,11,10}

L.9.2 Wastes

The data we currently have are old, and probably outdated. This data provides little, if any, information on the quantity and constituent content of waste and recycled waste materials. Historical sources of metals at the site area included:

- Ore concentrates delivered to the facility by railcar;
- Dust from the transport and storage of ore concentrates and solid waste materials at the facility;
- Metals emissions from roasting and smelting processes; and
- Airborne particulates from smelting materials (e.g., retort and sinter residues, slag, crushed retorts, and condenser sands).

The waste streams cited in the RIA, and consequently we have sample data for, are:

- Process wastewater, the high-risk waste stream (also a recycled waste);
- Spent surface impoundment liquids; and
- Wastewater treatment plant liquid effluent.

During the time the horizontal retorts were in operation, metals contained in the airborne emissions from the smelter were deposited over much of the area of Bartlesville.

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In 1977, emissions of sulfur dioxide and sulfur trioxide (So_x) and/or acid mist, the result of an upset or malfunction at the sulfuric acid plant, affected properties next to the plant. Later in 1977, EPA surveyed SO₂, TSP, sulfate, and metal emissions from the facility and their effects on ambient air quality, soils, and vegetation in the area. EPA found high sulfate levels and high concentrations of metals - of particular concern were lead and cadmium - downwind of the plant.

L.9.3 Solid Waste Management Units (SWMUs)

Waste management procedures at the facility have changed over time in response to changing environmental regulations and manufacturing processes. In addition, two tracts on the site were originally (but not currently) operated as a solid waste landfill by the City of Bartlesville. Limited information was available on the type and capacity of waste management units. However, their locations and contents are for the most part not included in our current references.

In 1992, the facility submitted a RCRA Part A Permit application that identified 27 RCRAregulated units: 2 underground injection control (UIC) wells, 5 waste piles, 12 surface impoundments, and 8 tanks. There is a lead concentrate storage unit at the lead processing facility. The State of Oklahoma performed a compliance evaluation inspection and found, among other things, several incomplete manifest records, incomplete analysis of wastes at specific units, and inadequate management of waste piles. In addition there were the following failures: to provide run-on and runoff controls, listing waste piles on the Part A Permit application, and maintaining a 200-foot buffer zone for all surface impoundments. The facility failed to identify a goethite waste pile, two nickel and cobalt waste piles, and a north-central surface impoundment.

Later in 1992, a Part B Permit application was submitted. The new application included information on lead concentrate materials and units related to the processing of lead concentrate. Those units are: two Class I injection wells, two surface impoundments (the north and south UIC) basins, and units that manage wastes containing material derived from the processing of lead concentrate.

The regulated hazardous waste management units at the facility have been equipped with a groundwater monitoring system. A RCRA facility assessment (RFA) conducted in 1992 identified 41 SWMUs; each of these had at least a medium potential for release through one or more environmental pathways.¹

Under the RCRA Part A permit, the facility submitted information about the SWMUs. The facility utilizes underground injection well disposal (design capacity of 4,500,000,000 gallons), a waste pile (design capacity of 81,700 cubic yards), surface impoundment storage (design capacity of 53,027,313 gallons), and tank treatment (design capacity of 48,000 gallons/day). An EPA inspection verified the following: 2 landfills (0.001 and 125 acre feet capacities), a waste pile (610 cubic yard capacity), surface impoundment storage (113,000 gallon capacity), and surface impoundment treatment (likely the tank treatment cited above, 660,000 gallons/day capacity).ⁱⁱ Information on whether the surface impoundments were lined or stored and treated recycled waste streams is not available.

L.9.4 Facility Setting

Although a description of the county's landscape and climate is not in current references, information was provided on other aspects of the facility setting. The area surrounding the facility is a mixed residential, commercial, industrial, recreational, and agricultural area. There are also some undeveloped lands that serve as wildlife habitat.

The facility is bounded (as of 1996) to the west, northwest, and south by industrial and commercial properties. Further to the west and south land uses are primarily rural and agricultural. Residential properties border the facility to the north, northeast, east, and southeast. The central, eastern, and northern portions of the site are primarily urban. The main commercial district in the area is in the center of Bartlesville, approximately 1.5 miles to the east of the facility. The city is essentially bisected from north to south by the Caney River. Portions of the area lie within the flood plain of the Caney River.

The area includes schools, day care facilities, and playgrounds. Approximately 5,000 people live within 3 miles of the site. Houses occupied by members of the Cherokee Indian Nation are located adjacent to the east boundary of the facility. An estimated 1,700 students attend two schools and three day care centers located nearby that are known to have contaminated soils. Approximately 170 people work at these facilities. The population of Bartlesville is approximately 35,000.¹ The community has reported on numerous occasions to the State of Oklahoma that there have been difficulties in raising garden crops, ornamental plants, and grass in the area; it was not however determined that this was caused by environmental contamination.⁴

Since an extensive soil removal project was begun in 1992, contamination has been reduced in the surrounding area. In addition, in 1992 the facility owner met with EPA and indicated they eliminated all surface impoundments as a potential source of groundwater contamination at the facility by retrofitting them to meet minimum technology requirements under RCRA.ⁱ

In the lower reach of the North Tributary, which flows directly into Eliza Creek, there are mature trees along the riparian zone that provide an important bird habitat. Both the tributary and creek have established habitats that support a variety of aquatic and terrestrial organisms.^{vi} In 1989 the State of Oklahoma and U.S. Fish and Wildlife Service investigated the death of 19 migratory birds at the facility and identified one of the surface impoundments as causing the deaths.ⁱ

There are no groundwater contamination issues at the site as of June 1997. However, groundwater at the site is not used for drinking water because aquifers under the site yield only small amounts of poor quality water due to natural geologic conditions and historical oil production activities. Groundwater in the vicinity of the area is not used for public or private drinking water supply but does discharge into surface water in certain areas.^{vi}

L.9.5 Environmental Contamination

Widespread soil contamination in the area surrounding the facility, including a large portion of west Bartlesville and much of the downtown area, has been traced back to the uncontrolled air emissions of the smelting operations as well as the use of slag and other smelter waste for fill projects throughout the area. Approximately 8 square miles of surface soil surrounding the facility is contaminated. This contamination included air dispersion of heavy metals - lead, cadmium, arsenic, selenium, and zinc - and the community fill projects using smelter slag. Concentrations are highest at the smelter and decrease away from the smelter.

There is also sediment contamination by lead, cadmium, selenium, and zinc over a relatively widespread area. Sediments in two main areas of the North Tributary have metal concentrations that exceed preliminary remediation goals. Airborne emissions from historical smelting operations and associated activities appear to be a significant and likely the most important mechanism of dispersal of the contaminants across the site. In addition, spillage and wind transport of ore concentrates from rail cars may have also contributed to elevated metals at the site. It is also likely that solid waste materials from the smelters were physically moved to areas within the site boundaries for use as fill or for other purposes. The concentrations of metals are not uniform across the site and some areas within the site boundaries are not significantly affected. Studies of site-specific partitioning coefficient or Kds have indicated that site sediments have a high adsorption capacity.

Elevated metals concentrations in surface water have been observed coincident with elevated metals levels in sediment.⁴⁷ From 1975 to 1980, the facility's liquid effluent discharge to a tributary to Eliza Creek and a tributary to Sand Creek was allowed under its National Pollutant Discharge Elimination System (NPDES) permit. In 1976, EPA found violations pertaining to exceeding daily maximum levels of total suspended solids (TSS), cadmium, zinc, selenium, and mercury. Later in 1978, the facility responded to requirements including installing systems to halt discharge of effluent during power outages and to contain and treat contaminated storm water runoff from the ore waste storage areas. Since early 1981, the facility began injecting all storm water and wastewater from industrial operations into UIC wells. Treated wastewater is pumped to the north and south basins before being disposed of at UIC wells 1 and 2.⁴

Shallow groundwater is also a potential concern because metals may be transported from the facility to the surface water south of the facility.^{vi} A 1992 investigation collected soil, sediment, and groundwater samples at various SWMUs. High concentrations of arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, thallium, and zinc were detected in sediment samples collected from the north and south UIC basins. In addition, concentrations in groundwater samples from several monitoring wells exceeded the TCLP regulatory level for cadmium and lead.¹ The groundwater contamination does pose a potential ecological threat.^v Various other reports indicated that releases to air of particulates from waste piles, raw materials, and smelters constituted a potential hazard.¹

L.9.6 References

The following officials from the EPA Region 6 and Oklahoma Department of Environmental Quality assisted our efforts in gathering data for this site:

- Noel Bennett at Region 6 Superfund;
- Adolphis Talton and Mike Hebert at Region 6 RCRA;
- Scott Thompson at State Superfund;
- Don Barrett and Tammy Johnson at State RCRA.



ENDNOTES

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- i. Regulatory Compliance Review. U.S. EPA, Region 6. March 31, 1994. Prepared by PRC Environmental Management, Inc.
- ii. ENVIROFACTS (EPA database).
- iii. Site Summary. EPA Region 6. July 16, 1997.
- iv. EPA National Priorities List. Fact Sheet. Office of Emergency and Remedial Response. May 1996.
- v. Record of Decision for Operable Unit One. Oklahoma Department of Environmental Quality. Date not listed.
- vi. Record of Decision for Remedial Action at Operable Unit 2 (Ecological Unit). Oklahoma Department of Environmental Quality. September 27, 1996.