IV. SUMMARY OF FINDINGS

After careful review, EPA has determined that 48 mineral commodity sectors generated a total of 553 waste streams that could be classified as either extraction/beneficiation or mineral processing wastes (Exhibit 4-1). Based on further analysis, the Agency identified 358 waste streams out of the total that could be designated as mineral processing wastes from 40 mineral commodity sectors.

Exhibit 4-2 presents the 358 mineral processing wastes by commodity sector. Of these 358 waste streams, EPA has sufficient information (based on either analytical test data or engineering judgment) to determine that 133 waste streams are potential RCRA hazardous wastes because they may exhibit one or more of the RCRA hazardous characteristics (toxicity, ignitability, corrosivity, or reactivity) and, thus, would be subject to the Land Disposal Restrictions. The hazardous waste streams and their characteristics are listed in Exhibit 4-3. The mineral processing commodity sectors that generate these wastes are shown in Exhibit 4-4. This exhibit also summarizes the total number of hazardous waste streams by sector and the estimated total volume of hazardous wastes generated annually.

At this time, EPA does not have sufficient information to determine if the following eight sectors also generate wastes that could be classified as mineral processing wastes: Bromine, Gemstones, Iodine, Lithium, Lithium Carbonate, Soda Ash, Sodium Sulfate, and Strontium.

EXHIBIT 4-1

SUMMARY OF EXTRACTION/BENEFICIATION AND MINERAL PROCESSING WASTE STREAMS BY COMMODITY

Commodity	Waste Stream	Nature of Operation
Alumina and Aluminum	Water softener sludge	Extraction/Beneficiation
	Anode prep waste	Mineral Processing
	APC dust/sludge	Mineral Processing
	Baghouse bags and spent plant filters	Mineral Processing
	Bauxite residue	Mineral Processing
	Cast house dust	Mineral Processing
	Cryolite recovery residue	Mineral Processing
	Wastewater	Mineral Processing
	Discarded Dross	Mineral Processing
	Flue Dust	Mineral Processing
	Electrolysis waste	Mineral Processing
	Evaporator salt wastes	Mineral Processing
	Miscellaneous wastewater	Mineral Processing
	Pisolites	Mineral Processing
	Scrap furnace brick	Mineral Processing
	Skims	Mineral Processing
	Sludge	Mineral Processing
	Spent cleaning residue	Mineral Processing
	Spent potliners	Mineral Processing
	Sweepings	Mineral Processing
	Treatment Plant Effluent	Mineral Processing
	Waste alumina	Mineral Processing
Antimony	Gangue	Mineral Processing
	Wastewater	Mineral Processing
	APC Dust/Sludge	Mineral Processing
	Autoclave Filtrate	Mineral Processing
	Spent Barren Solution	Mineral Processing
	Gangue (Filter Cake)	Mineral Processing
	Leach Residue	Mineral Processing
	Refining Dross	Mineral Processing
	Slag and Furnace Residue	Mineral Processing
	Sludge from Treating Process Waste Water	Mineral Processing
	Stripped Anolyte Solids	Mineral Processing
	Waste Solids	Mineral Processing
Beryllium	Gangue	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Beryllium (continued)	Acid Conversion Stream	Extraction/Beneficiation
	Bertrandite thickener slurry	Extraction/Beneficiation
	Beryl thickener slurry	Extraction/Beneficiation
	Spent Raffinate	Extraction/Beneficiation
	Sump Water	Extraction/Beneficiation
	Spent Barren filtrate streams	Mineral Processing
	Beryllium hydroxide supernatant	Mineral Processing
	Chip Treatment Wastewater	Mineral Processing
	Dross discard	Mineral Processing
	Filtration discard	Mineral Processing
	Leaching discard	Mineral Processing
	Neutralization discard	Mineral Processing
	Pebble Plant Area Vent Scrubber Water	Mineral Processing
	Precipitation discard	Mineral Processing
	Process wastewater	Mineral Processing
	Melting Emissions	Mineral Processing
	Scrubber Liquor	Mineral Processing
	Separation slurry	Mineral Processing
	Waste Solids	Mineral Processing
Bismuth	Alloy residues	Mineral Processing
	Spent Caustic Soda	Mineral Processing
	Electrolytic Slimes	Mineral Processing
	Excess chlorine	Mineral Processing
	Lead and Zinc chlorides	Mineral Processing
	Metal Chloride Residues	Mineral Processing
	Slag	Mineral Processing
	Spent Electrolyte	Mineral Processing
	Spent Material	Mineral Processing
	Spent soda solution	Mineral Processing
	Waste acid solutions	Mineral Processing
	Waste Acids	Mineral Processing
	Wastewater	Mineral Processing
Boron	Crud	Extraction/Beneficiation
	Gangue	Extraction/Beneficiation
	Spent Solvents	Extraction/Beneficiation
	Particulate Emissions	Extraction/Beneficiation
	Waste Brine	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation
	Spent Sodium Sulfate	Extraction/Beneficiation
	Waste liquor	Extraction/Beneficiation
	Underflow Mud	Extraction/Beneficiation

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Bromine	Slimes	Extraction/Beneficiation
	Waste Brine	Extraction/Beneficiation
	Water Vapor	Extraction/Beneficiation
Cadmium	Waste Tailings	Extraction/Beneficiation
	Caustic washwater	Mineral Processing
	Copper and Lead Sulfate Filter Cakes	Mineral Processing
	Copper Removal Filter Cake	Mineral Processing
	Iron containing impurities	Mineral Processing
	Spent Leach solution	Mineral Processing
	Lead Sulfate waste	Mineral Processing
	Post-leach Filter Cakes	Mineral Processing
	Spent Purification solution	Mineral Processing
	Scrubber wastewater	Mineral Processing
	Spent electrolyte	Mineral Processing
	Zinc Precipitates	Mineral Processing
Calcium Metal	Off-gases	Extraction/Beneficiation
	Overburden	Extraction/Beneficiation
	Calcium Aluminate wastes	Mineral Processing
	Dust with Quicklime	Mineral Processing
Cesium/Rubidium	Alkali Alums	Extraction/Beneficiation
	Calciner Residues	Extraction/Beneficiation
	Cesium Chlorosonnate	Extraction/Beneficiation
	Non-Pollucite Mineral Waste	Extraction/Beneficiation
	Precipitated Aluminum	Extraction/Beneficiation
	Precipitated Barium Sulfate	Extraction/Beneficiation
	Spent Chlorine solution	Extraction/Beneficiation
	Spent Ion-exchange solution	Extraction/Beneficiation
	Spent Metal	Extraction/Beneficiation
	Spent Ore	Extraction/Beneficiation
	Spent Solvent	Extraction/Beneficiation
	Waste Gangue	Extraction/Beneficiation
	Chemical Residues	Mineral Processing
	Digester waste	Mineral Processing
	Electrolytic Slimes	Mineral Processing
	Pyrolytic Residue	Mineral Processing
	Slag	Mineral Processing
Chromium, Ferrochrome, and Ferrochromium-Silicon	Gangue and tailings	Extraction/Beneficiation
	Dust or Sludge from ferrochromium production	Mineral Processing
	Dust or Sludge from ferrochromium-silicon production	Mineral Processing
	Treated Roast/Leach Residues	Mineral Processing
	Slag and Residues	Mineral Processing
Coal Gas	Baghouse Coal Dust	Extraction/Beneficiation

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
	Coal Pile Runoff	Extraction/Beneficiation
	Fines	Extraction/Beneficiation
	Gangue	Extraction/Beneficiation
	API Oil/Water Separator Sludge	Mineral Processing
	API Water	Mineral Processing
	Cooling Tower Blowdown	Mineral Processing
	Dissolved Air Flotation (DAF) Sludge	Mineral Processing
	Flue Dust Residues	Mineral Processing
	Liquid Waste Incinerator Blowdown	Mineral Processing
	Liquid Waste Incinerator Pond Sludge	Mineral Processing
	Multiple Effects Evaporator Concentrate	Mineral Processing
	Multiple Effects Evaporator Pond Sludge	Mineral Processing
	Sludge and Filter Cake	Mineral Processing
	Spent Methanol Catalyst	Mineral Processing
	Stretford Solution Purge Stream	Mineral Processing
	Surface Impoundment Solids	Mineral Processing
	Vacuum Filter Sludge	Mineral Processing
	Zeolite Softening PWW	Mineral Processing
Copper	Crud	Extraction/Beneficiation
	Spent Kerosene	Extraction/Beneficiation
	Raffinate	Extraction/Beneficiation
	Process Wastewaters from Cooling and Refining	Extraction/Beneficiation
	Slime	Extraction/Beneficiation
	Slimes or "Muds"	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Spent Ore	Extraction/Beneficiation
	Acid plant blowdown	Mineral Processing
	Acid plant thickener sludge	Mineral Processing
	APC dusts/sludges	Mineral Processing
	Spent bleed electrolyte	Mineral Processing
	Chamber solids/scrubber sludge	Mineral Processing
	Waste contact cooling water	Mineral Processing
	Discarded furnace brick	Mineral Processing
	Process wastewaters	Mineral Processing
	Scrubber blowdown	Mineral Processing
	Spent black sulfuric acid sludge	Mineral Processing
	Surface impoundment waste liquids	Mineral Processing
	Tankhouse slimes	Mineral Processing
	WWTP liquid effluent	Mineral Processing
	WWTP sludge	Mineral Processing
Elemental Phosphorous	Calcining offgas solids	Extraction/Beneficiation

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
	Fugitive Dust	Extraction/Beneficiation
	Condenser phossy water discard	Mineral Processing
	Cooling water	Mineral Processing
	Furnace building washdown	Mineral Processing
	Dust	Mineral Processing
	Waste ferrophosphorus	Mineral Processing
	Furnace offgas solids	Mineral Processing
	Furnace scrubber blowdown	Mineral Processing
	Precipitator slurry scrubber water	Mineral Processing
	Precipitator slurry	Mineral Processing
	NOSAP slurry	Mineral Processing
	Sludge	Mineral Processing
	Spent furnace brick	Mineral Processing
	Surface impoundment waste liquids	Mineral Processing
	Surface impoundment waste solids	Mineral Processing
	Waste Andersen Filter Media	Mineral Processing
	WWTP liquid effluent	Mineral Processing
	WWTP Sludge/Solids	Mineral Processing
Fluorspar and Hydrofluoric Acid	Gangue	Extraction/Beneficiation
	Lead and Zinc sulfides	Extraction/Beneficiation
	Spent flotation reagents	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	APC Dusts	Mineral Processing
	Off-spec fluosilicic acid	Mineral Processing
	Sludges	Mineral Processing
Gem Stones	Overburden	Extraction/Beneficiation
	Spent chemical agents	Extraction/Beneficiation
	Spent polishing media	Extraction/Beneficiation
	Waste minerals	Extraction/Beneficiation
Germanium	Waste Acid Wash and Rinse Water	Mineral Processing
	Chlorinator Wet Air Pollution Control Sludge	Mineral Processing
	Germanium oxides fumes	Mineral Processing
	Hydrolysis Filtrate	Mineral Processing
	Leach Residues	Mineral Processing
	Roaster off-gases	Mineral Processing
	Spent Acid/Leachate	Mineral Processing
	Waste Still Liquor	Mineral Processing
	Wastewater	Mineral Processing

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Gold and Silver	Black sand	Extraction/Beneficiation
	Filter cake	Extraction/Beneficiation
	Mercury bearing solution	Extraction/Beneficiation
	Mine water	Extraction/Beneficiation
	Carbon, carbon fines, and acid wash solution	Extraction/Beneficiation
	Spent leaching solution	Extraction/Beneficiation
	Spent ore	Extraction/Beneficiation
	Spent stripping solution	Extraction/Beneficiation
	Sulfur dioxide	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Waste rock, clay and sand from amalgamation	Extraction/Beneficiation
	Waste rock	Extraction/Beneficiation
	Waste sulfuric acid	Extraction/Beneficiation
	Waste steel wool	Extraction/Beneficiation
	Zinc cyanide solution	Extraction/Beneficiation
	Spent Furnace Dust	Mineral Processing
	Refining wastes	Mineral Processing
	Retort cooling water	Mineral Processing
	Slag	Mineral Processing
	Wastewater treatment sludge	Mineral Processing
	Wastewater	Mineral Processing
Iodine	Filtrate waste	Extraction/Beneficiation
	Sludge	Extraction/Beneficiation
	Sulfur compounds	Extraction/Beneficiation
	Waste acid	Extraction/Beneficiation
	Waste bleed liquor	Extraction/Beneficiation
	Waste brine	Extraction/Beneficiation
Iron and Steel	Tailings	Extraction/Beneficiation
	Wastewater and Waste Solids	Extraction/Beneficiation
	Wastewater	Mineral Processing
Lead	Concentration Wastes	Extraction/Beneficiation
	Mine water	Extraction/Beneficiation
	Waste Rock	Extraction/Beneficiation
	Acid Plant Blowdown	Mineral Processing
	Acid Plant Sludge	Mineral Processing
	Baghouse Dust	Mineral Processing
	Baghouse Incinerator Ash	Mineral Processing
	Cooling Tower Blowdown	Mineral Processing
	Waste Nickel Matte	Mineral Processing
	Process Wastewater	Mineral Processing
	Slurried APC Dust	Mineral Processing

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Lead (continued)	Solid Residues	Mineral Processing
	Solids in Plant Washdown	Mineral Processing
	Spent Furnace Brick	Mineral Processing
	Stockpiled Miscellaneous Plant Waste	Mineral Processing
	Surface Impoundment Waste Liquids	Mineral Processing
	Surface Impoundment Waste Solids	Mineral Processing
	SVG Backwash	Mineral Processing
	WWTP Liquid Effluent	Mineral Processing
	WWTP Sludges/Solids	Mineral Processing
Lightweight Aggregate	Overburden	Extraction/Beneficiation
	Waste Rock	Extraction/Beneficiation
	Raw fines form primary crushing operations	Extraction/Beneficiation
	Sludge from rock washing	Extraction/Beneficiation
	APC control scrubber water and solids	Mineral Processing
	APC Dust/Sludge	Mineral Processing
	Surface impoundment waste liquids	Mineral Processing
	WWTP liquid effluent	Mineral Processing
Lithium and Lithium Carbonate	Acid roaster gases	Extraction/Beneficiation
	Flotation Tailings	Extraction/Beneficiation
	Gangue	Extraction/Beneficiation
	Magnesium/Calcium Sludge	Extraction/Beneficiation
	Roaster Off-gases	Extraction/Beneficiation
	Salt solutions	Extraction/Beneficiation
	Wastewater from Wet Scrubber	Extraction/Beneficiation
Magnesium and Magnesia from Brines	Calcium sludge	Extraction/Beneficiation
	Offgases	Extraction/Beneficiation
	Spent seawater	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	APC Dust/Sludge	Mineral Processing
	Calciner offgases	Mineral Processing
	Calcium sludge	Mineral Processing
	Casthouse Dust	Mineral Processing
	Casting plant slag	Mineral Processing
	Cathode Scrubber Liquor	Mineral Processing
	Slag	Mineral Processing
	Smut	Mineral Processing
	Spent Brines	Mineral Processing
Manganese, Manganese Dioxide, Ferromanganese and Silicomanganese	Flotation tailings	Extraction/Beneficiation
	Gangue	Extraction/Beneficiation
	Spent Flotation Reagents	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Manganese, Manganese Dioxide, Ferromanganese and Silicomanganese (continued)	APC Dust/Sludge	Mineral Processing
	APC Water	Mineral Processing
	Iron Sulfide Sludge	Mineral Processing
	Ore Residues	Mineral Processing
	Slag	Mineral Processing
	Spent Graphite Anode	Mineral Processing
	Spent Process Liquor	Mineral Processing
	Waste Electrolyte	Mineral Processing
	Wastewater (CMD)	Mineral Processing
	Wastewater (EMD)	Mineral Processing
	Wastewater Treatment Solids	Mineral Processing
Mercury	Gangue	Extraction/Beneficiation
	Flotation tailings	Extraction/Beneficiation
	Spent flotation reagents	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation
	Dust	Mineral Processing
	Mercury Quench Water	Mineral Processing
	Furnace Residues	Mineral Processing
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	Flotation tailings	Extraction/Beneficiation
	Gangue	Extraction/Beneficiation
	Spent Flotation Reagents	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation
	APC Dust/Sludge	Mineral Processing
	Flue Dust/Gases	Mineral Processing
	Liquid Residues	Mineral Processing
	H2 Reduction Furnace Scrubber Water	Mineral Processing
	Molybdic Oxide Refining Wastes	Mineral Processing
	Refining Wastes	Mineral Processing
	Roaster Gas Blowdown Solids	Mineral Processing
	Slag	Mineral Processing
	Solid Residues	Mineral Processing
	Treatment Solids	Mineral Processing
Phosphoric Acid	Waste Scale	Mineral Processing
Platinum Group Metals	Filtrate	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation
	Slag	Mineral Processing
	Scrubber offgases	Mineral Processing
	SO2 waste	Mineral Processing
	Spent Acids	Mineral Processing
	Spent Solvents	Mineral Processing

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Pyrobitumens, Mineral Waxes, and Natural Asphalts	Spent coal	Extraction/Beneficiation
	Spent solvents	Extraction/Beneficiation
	Still bottoms	Mineral Processing
	Waste catalysts	Mineral Processing
Rare Earths	Magnetic fractions	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Spent ammonium nitrate processing solution	Mineral Processing
	Electrolytic cell caustic wet APC waste	Mineral Processing
	Spent Electrolytic cell quench water and scrubber water	Mineral Processing
	Spent iron hydroxide cake	Mineral Processing
	Spent lead filter cake	Mineral Processing
	Lead backwash sludge	Mineral Processing
	Monazite solids	Mineral Processing
	Process wastewater	Mineral Processing
	Spent scrubber liquor	Mineral Processing
	Off-gases from dehydration	Mineral Processing
	Spent off-gases from electrolytic reduction	Mineral Processing
	Spent sodium hypochlorite filter backwash	Mineral Processing
	Solvent extraction crud	Mineral Processing
	Spent surface impoundment solids	Mineral Processing
	Spent surface impoundment liquids	Mineral Processing
	Waste filtrate	Mineral Processing
	Waste solvent	Mineral Processing
	Wastewater from caustic wet APC	Mineral Processing
	Waste zinc contaminated with mercury	Mineral Processing
Rhenium	APC Dust/Sludge	Mineral Processing
	Spent Barren Scrubber Liquor	Mineral Processing
	Spent Rhenium Raffinate	Mineral Processing
	Roaster Dust	Mineral Processing
	Spent Ion Exchange/SX Solutions	Mineral Processing
	Spent Salt Solutions	Mineral Processing
	Slag	Mineral Processing
Scandium	Crud from the bottom of the solvent extraction unit	Mineral Processing
	Dusts and spent filters from decomposition	Mineral Processing
	Spent acids	Mineral Processing
	Spent ion exchange resins and backwash	Mineral Processing
	Spent solvents from solvent extraction	Mineral Processing
	Spent wash water	Mineral Processing
	Waste chlorine solution	Mineral Processing
	Waste solutions/solids from leaching and precipitation	Mineral Processing

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Selenium	Spent filter cake	Mineral Processing
	Plant process wastewater	Mineral Processing
	Slag	Mineral Processing
	Tellurium slime wastes	Mineral Processing
	Waste Solids	Mineral Processing
Silicon and Ferrosilicon	Gangue	Extraction/Beneficiation
	Spent Wash Water	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	APC Dust Sludge	Mineral Processing
	Dross discard	Mineral Processing
	Slag	Mineral Processing
Soda Ash	Airborne emissions	Extraction/Beneficiation
	Calciner offgases	Extraction/Beneficiation
	Filter aid and carbon absorbent	Extraction/Beneficiation
	Mother liquor	Extraction/Beneficiation
	Ore insolubles	Extraction/Beneficiation
	Ore residues	Extraction/Beneficiation
	Overburden	Extraction/Beneficiation
	Particulate emissions from driers	Extraction/Beneficiation
	Particulates	Extraction/Beneficiation
	Purge liquor	Extraction/Beneficiation
	Scrubber water	Extraction/Beneficiation
	Spent brine	Extraction/Beneficiation
	Spent carbon and filter wastes	Extraction/Beneficiation
	Spent dissolution wastes	Extraction/Beneficiation
	Suspended particulate matter	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Trona ore particulates	Extraction/Beneficiation
	Trona ore processing waste	Extraction/Beneficiation
	Waste mother liquor	Extraction/Beneficiation
Sodium Sulfate	Waste Brine	Extraction/Beneficiation
	Clarifier overflow filtrate	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation
Strontium	Calciner offgas	Extraction/Beneficiation
	Dilute sodium sulfide solution	Extraction/Beneficiation
	Filter muds	Extraction/Beneficiation
	Spent Ore	Extraction/Beneficiation
	Vacuum drum filtrate	Extraction/Beneficiation
	Waste sodium sulfate solution	Extraction/Beneficiation
	Waste solution	Extraction/Beneficiation

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Sulfur	Air emissions	Extraction/Beneficiation
	Filter cake	Extraction/Beneficiation
	Frasch process residues	Extraction/Beneficiation
	Sludge	Extraction/Beneficiation
	Spilled sulfur	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation
	Airborne emissions from sulfuric acid production	Mineral Processing
	Spent catalysts (Claus process)	Mineral Processing
	Spent vanadium pentoxide catalysts from sulfuric acid production	Mineral Processing
	Tail gases	Mineral Processing
	Wastewater from wet-scrubbing, spilled product and condensates	Mineral Processing
Synthetic Rutile	APC Dust/Sludges	Mineral Processing
	Spent Iron Oxide Slurry	Mineral Processing
	Spent Acid Solution	Mineral Processing
Tantalum, Columbium and Ferrocolumbium	APC Dust Sludge	Mineral Processing
	Digester Sludge	Mineral Processing
	Spent Potassium Titanium Chloride	Mineral Processing
	Process Wastewater	Mineral Processing
	Spent Raffinate Solids	Mineral Processing
	Scrubber Overflow	Mineral Processing
	Slag	Mineral Processing
	WWTP Liquid Effluent	Mineral Processing
	WWTP Sludge	Mineral Processing
Tellurium	Slag	Mineral Processing
	Fumes of telluride dioxide	Mineral Processing
	Solid waste residues	Mineral Processing
	Waste Electrolyte	Mineral Processing
	Wastewater	Mineral Processing
Tin	Process Wastewater	Extraction/Beneficiation
	Tailings Slurry	Extraction/Beneficiation
	Brick Lining and Fabric Filters	Mineral Processing
	Dross	Mineral Processing
	Process Wastewater and Treatment Sludge	Mineral Processing
	Slag	Mineral Processing
	Slimes	Mineral Processing
	Waste Acid and Alkaline baths	Mineral Processing

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
Titanium and Titanium Dioxide	Flotation Cells	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Spent Brine Treatment Filter Cake	Mineral Processing
	FeCl Treatment Sludge	Mineral Processing
	Waste Ferric Chloride	Mineral Processing
	Finishing Scrap	Mineral Processing
	Leach Liquor and Sponge Wash Water	Mineral Processing
	Waste Non-Contact Cooling Water	Mineral Processing
	Pickling Liquor and Wash Water	Mineral Processing
	Scrap Detergent Wash Water	Mineral Processing
	Scrap Milling Scrubber Water	Mineral Processing
	Reduction Area Scrubber Water	Mineral Processing
	Chlorination Off gas Scrubber Water	Mineral Processing
	Chlorination Area - Vent Scrubber Water	Mineral Processing
	Melt Cell Scrubber Water	Mineral Processing
	Chlorine Liquefaction Scrubber Water	Mineral Processing
	Chip Crushing Scrubber Water	Mineral Processing
	Casting Crucible Contact Cooling Water	Mineral Processing
	Smut from Mg Recovery	Mineral Processing
	Spent Surface Impoundment Liquids	Mineral Processing
	Spent Surface Impoundment Solids	Mineral Processing
	TiCl4 Purification Effluent	Mineral Processing
	Spent Vanadium Oxychloride	Mineral Processing
	Sodium Reduction Container Reconditioning Wash Water	Mineral Processing
	Casting Crucible Wash Water	Mineral Processing
	Waste Acids (Chloride process)	Mineral Processing
	Waste Solids (Chloride process)	Mineral Processing
	Waste Acids (Sulfate process)	Mineral Processing
	Waste Solids (Sulfate process)	Mineral Processing
	WWTP Liquid Effluent	Mineral Processing
	WWTP Sludge/Solids	Mineral Processing
Tungsten	Alkali leach wash	Extraction/Beneficiation
	Calcium tungstate precipitate wash	Extraction/Beneficiation
	Ion exchange raffinate	Extraction/Beneficiation
	Ion exchange resins	Extraction/Beneficiation
	Leach filter cake residues and impurities	Extraction/Beneficiation
	Molybdenum sulfide precipitation wet air pollution control waste	Extraction/Beneficiation
	Scrubber wastewater	Extraction/Beneficiation
	Spent mother liquor	Extraction/Beneficiation
	Tungstic acid rinse water	Extraction/Beneficiation
	Waste fines	Extraction/Beneficiation
Tungsten (continued)	Waste rock and tailings	Extraction/Beneficiation

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
	Wastewater	Extraction/Beneficiation
	Wet scrubber wastewater	Extraction/Beneficiation
	Spent Acid and Rinse water	Mineral Processing
	Scrubber wastewater	Mineral Processing
	Process wastewater treatment plant effluent	Mineral Processing
	Water of formation	Mineral Processing
Uranium	Waste Rock	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Organic vapors	Extraction/Beneficiation
	Refuse	Extraction/Beneficiation
	Spent Extraction/Leaching Solutions	Extraction/Beneficiation
	Particulate Emissions	Extraction/Beneficiation
	Miscellaneous Sludges	Extraction/Beneficiation
	Spent Ion Exchange Resins	Extraction/Beneficiation
	Tailing Pond Seepage	Extraction/Beneficiation
	Waste Acids from Solvent Extraction	Extraction/Beneficiation
	Barren Lixiviant	Extraction/Beneficiation
	Slimes from Solvent Extraction	Extraction/Beneficiation
	Waste Solvents	Extraction/Beneficiation
	Waste Nitric Acid from Production of UO_2	Mineral Processing
	Vaporizer Condensate	Mineral Processing
	Superheater Condensate	Mineral Processing
	Slag	Mineral Processing
	Uranium Chips from Ingot Production	Mineral Processing
	Waste Calcium Fluoride	Mineral Processing
Vanadium	Roaster Off-gases	Extraction/Beneficiation
	Solid residues	Extraction/Beneficiation
	Spent Filtrate	Extraction/Beneficiation
	Spent Solvent	Extraction/Beneficiation
	Filtrate and Process Wastewaters	Mineral Processing
	Solid Waste	Mineral Processing
	Spent Precipitate	Mineral Processing
	Slag	Mineral Processing
	Wet scrubber wastewater	Mineral Processing
Zinc	Refuse	Extraction/Beneficiation
	Tailings	Extraction/Beneficiation
	Waste rock	Extraction/Beneficiation
	Acid Plant Blowdown	Mineral Processing
	Spent Cloths, Bags, and Filters	Mineral Processing
	Waste Ferrosilicon	Mineral Processing
Zinc (continued)	Spent Goethite and Leach Cake Residues	Mineral Processing

EXHIBIT 4-1 (Continued)

Commodity	Waste Stream	Nature of Operation
	Saleable residues	Mineral Processing
	Process Wastewater	Mineral Processing
	Discarded Refractory Brick	Mineral Processing
	Spent Surface Impoundment Liquid	Mineral Processing
	Spent Surface Impoundment Solids	Mineral Processing
	Spent Synthetic Gypsum	Mineral Processing
	TCA Tower Blowdown (ZCA Bartlesville, OK - Electrolytic Plant)	Mineral Processing
	Wastewater Treatment Plant Liquid Effluent	Mineral Processing
	Wastewater Treatment Plant Sludge	Mineral Processing
	Zinc-lean Slag	Mineral Processing
Zirconium and Hafnium	Monazite	Extraction/Beneficiation
	Wastewater	Extraction/Beneficiation
	Spent Acid leachate from zirconium alloy production	Mineral Processing
	Spent Acid leachate from zirconium metal production	Mineral Processing
	Ammonium Thiocyanate Bleed Stream	Mineral Processing
	Reduction area-vent wet APC wastewater	Mineral Processing
	Caustic wet APC wastewater	Mineral Processing
	Feed makeup wet APC wastewater	Mineral Processing
	Filter cake/sludge	Mineral Processing
	Furnace residue	Mineral Processing
	Hafnium filtrate wastewater	Mineral Processing
	Iron extraction stream stripper bottoms	Mineral Processing
	Leaching rinse water from zirconium alloy production	Mineral Processing
	Leaching rinse water from zirconium metal production	Mineral Processing
	Magnesium recovery area vent wet APC wastewater	Mineral Processing
	Magnesium recovery off-gas wet APC wastewater	Mineral Processing
	Sand Chlorination Off-Gas Wet APC wastewater	Mineral Processing
	Sand Chlorination Area Vent Wet APC wastewater	Mineral Processing
	Silicon Tetrachloride Purification Wet APC wastewater	Mineral Processing
	Wet APC wastewater	Mineral Processing
	Zirconium chip crushing wet APC wastewater	Mineral Processing
	Zirconium filtrate wastewater	Mineral Processing

EXHIBIT 4-2

SUMMARY OF MINERAL PROCESSING WASTE STREAMS BY COMMODITY

Commodity	Waste Stream	Nature of Operation
Alumina and Aluminum	Anode prep waste	Mineral Processing
	APC dust/sludge	Mineral Processing
	Baghouse bags and spent plant filters	Mineral Processing
	Bauxite residue	Mineral Processing
	Cast house dust	Mineral Processing
	Cryolite recovery residue	Mineral Processing
	Wastewater	Mineral Processing
	Discarded Dross	Mineral Processing
	Flue Dust	Mineral Processing
	Electrolysis waste	Mineral Processing
	Evaporator salt wastes	Mineral Processing
	Miscellaneous wastewater	Mineral Processing
	Pisolites	Mineral Processing
	Scrap furnace brick	Mineral Processing
	Skims	Mineral Processing
	Sludge	Mineral Processing
	Spent cleaning residue	Mineral Processing
	Spent potliners	Mineral Processing
	Sweepings	Mineral Processing
	Treatment Plant Effluent	Mineral Processing
	Waste alumina	Mineral Processing
Antimony	Gangue	Mineral Processing
	Wastewater	Mineral Processing
	APC Dust/Sludge	Mineral Processing
	Autoclave Filtrate	Mineral Processing
	Spent Barren Solution	Mineral Processing
	Gangue (Filter Cake)	Mineral Processing
	Leach Residue	Mineral Processing
	Refining Dross	Mineral Processing
	Slag and Furnace Residue	Mineral Processing
	Sludge from Treating Process Waste Water	Mineral Processing
	Stripped Anolyte Solids	Mineral Processing
	Waste Solids	Mineral Processing
Beryllium	Spent Barren filtrate streams	Mineral Processing
	Beryllium hydroxide supernatant	Mineral Processing
	Chip Treatment Wastewater	Mineral Processing

EXHIBIT 4-2 (Continued)

Commodity	Waste Stream	Nature of Operation
Beryllium (continued)	Dross discard	Mineral Processing
	Filtration discard	Mineral Processing
	Leaching discard	Mineral Processing
	Neutralization discard	Mineral Processing
	Pebble Plant Area Vent Scrubber Water	Mineral Processing
	Precipitation discard	Mineral Processing
	Process wastewater	Mineral Processing
	Melting Emissions	Mineral Processing
	Scrubber Liquor	Mineral Processing
	Separation slurry	Mineral Processing
	Waste Solids	Mineral Processing
Bismuth	Alloy residues	Mineral Processing
	Spent Caustic Soda	Mineral Processing
	Electrolytic Slimes	Mineral Processing
	Excess chlorine	Mineral Processing
	Lead and Zinc chlorides	Mineral Processing
	Metal Chloride Residues	Mineral Processing
	Slag	Mineral Processing
	Spent Electrolyte	Mineral Processing
	Spent Material	Mineral Processing
	Spent soda solution	Mineral Processing
	Waste acid solutions	Mineral Processing
	Waste Acids	Mineral Processing
	Wastewater	Mineral Processing
Cadmium	Caustic washwater	Mineral Processing
	Copper and Lead Sulfate Filter Cakes	Mineral Processing
	Copper Removal Filter Cake	Mineral Processing
	Iron containing impurities	Mineral Processing
	Spent Leach solution	Mineral Processing
	Lead Sulfate waste	Mineral Processing
	Post-leach Filter Cakes	Mineral Processing
	Spent Purification solution	Mineral Processing
	Scrubber wastewater	Mineral Processing
	Spent electrolyte	Mineral Processing
	Zinc Precipitates	Mineral Processing
Calcium Metal	Calcium Aluminate wastes	Mineral Processing
	Dust with Quicklime	Mineral Processing
Cesium/Rubidium	Chemical Residues	Mineral Processing
	Digester waste	Mineral Processing
	Electrolytic Slimes	Mineral Processing
	Pyrolytic Residue	Mineral Processing

EXHIBIT 4-2 (Continued)

Commodity	Waste Stream	Nature of Operation
Cerium/Rubidium (continued)	Slag	Mineral Processing
Chromium, Ferrochrome, and Ferrochromium-Silicon	Gangue and tailings	Extraction/Beneficiation
	Dust or Sludge from ferrochromium production	Mineral Processing
	Dust or Sludge from ferrochromium-silicon production	Mineral Processing
	Treated Roast/Leach Residues	Mineral Processing
	Slag and Residues	Mineral Processing
Coal Gas	API Oil/Water Separator Sludge	Mineral Processing
	API Water	Mineral Processing
	Cooling Tower Blowdown	Mineral Processing
	Dissolved Air Flotation (DAF) Sludge	Mineral Processing
	Flue Dust Residues	Mineral Processing
	Liquid Waste Incinerator Blowdown	Mineral Processing
	Liquid Waste Incinerator Pond Sludge	Mineral Processing
	Multiple Effects Evaporator Concentrate	Mineral Processing
	Multiple Effects Evaporator Pond Sludge	Mineral Processing
	Sludge and Filter Cake	Mineral Processing
	Spent Methanol Catalyst	Mineral Processing
	Stretford Solution Purge Stream	Mineral Processing
	Surface Impoundment Solids	Mineral Processing
	Vacuum Filter Sludge	Mineral Processing
	Zeolite Softening PWW	Mineral Processing
Copper	Acid plant blowdown	Mineral Processing
	Acid plant thickener sludge	Mineral Processing
	APC dusts/sludges	Mineral Processing
	Spent bleed electrolyte	Mineral Processing
	Chamber solids/scrubber sludge	Mineral Processing
	Waste contact cooling water	Mineral Processing
	Discarded furnace brick	Mineral Processing
	Process wastewaters	Mineral Processing
	Scrubber blowdown	Mineral Processing
	Spent black sulfuric acid sludge	Mineral Processing
	Surface impoundment waste liquids	Mineral Processing
	Tankhouse slimes	Mineral Processing
	WWTP liquid effluent	Mineral Processing
	WWTP sludge	Mineral Processing
Elemental Phosphorous	Condenser phossy water discard	Mineral Processing
	Cooling water	Mineral Processing
	Furnace building washdown	Mineral Processing
	Dust	Mineral Processing
	Waste ferrophosphorus	Mineral Processing
	Furnace offgas solids	Mineral Processing

EXHIBIT 4-2 (Continued)

Commodity	Waste Stream	Nature of Operation
Elemental Phosphorous (continued)	Furnace scrubber blowdown	Mineral Processing
	Precipitator slurry scrubber water	Mineral Processing
	Precipitator slurry	Mineral Processing
	NOSAP slurry	Mineral Processing
	Sludge	Mineral Processing
	Spent furnace brick	Mineral Processing
	Surface impoundment waste liquids	Mineral Processing
	Surface impoundment waste solids	Mineral Processing
	Waste Andersen Filter Media	Mineral Processing
	WWTP liquid effluent	Mineral Processing
	WWTP Sludge/Solids	Mineral Processing
Fluorspar and Hydrofluoric Acid	APC Dusts	Mineral Processing
	Off-spec fluosilicic acid	Mineral Processing
	Sludges	Mineral Processing
Germanium	Waste Acid Wash and Rinse Water	Mineral Processing
	Chlorinator Wet Air Pollution Control Sludge	Mineral Processing
	Germanium oxides fumes	Mineral Processing
	Hydrolysis Filtrate	Mineral Processing
	Leach Residues	Mineral Processing
	Roaster off-gases	Mineral Processing
	Spent Acid/Leachate	Mineral Processing
	Waste Still Liquor	Mineral Processing
	Wastewater	Mineral Processing
Gold and Silver	Spent Furnace Dust	Mineral Processing
	Refining wastes	Mineral Processing
	Retort cooling water	Mineral Processing
	Slag	Mineral Processing
	Wastewater treatment sludge	Mineral Processing
	Wastewater	Mineral Processing
Iron and Steel	Wastewater	Mineral Processing
Lead	Acid Plant Blowdown	Mineral Processing
	Acid Plant Sludge	Mineral Processing
	Baghouse Dust	Mineral Processing
	Baghouse Incinerator Ash	Mineral Processing
	Cooling Tower Blowdown	Mineral Processing
	Waste Nickel Matte	Mineral Processing
	Process Wastewater	Mineral Processing
	Slurried APC Dust	Mineral Processing
	Solid Residues	Mineral Processing
	Solids in Plant Washdown	Mineral Processing
	Spent Furnace Brick	Mineral Processing

EXHIBIT 4-2 (Continued)

Commodity	Waste Stream	Nature of Operation
Lead (continued)	Stockpiled Miscellaneous Plant Waste	Mineral Processing
	Surface Impoundment Waste Liquids	Mineral Processing
	Surface Impoundment Waste Solids	Mineral Processing
	SVG Backwash	Mineral Processing
	WWTP Liquid Effluent	Mineral Processing
	WWTP Sludges/Solids	Mineral Processing
Lightweight Aggregate	APC control scrubber water and solids	Mineral Processing
	APC Dust/Sludge	Mineral Processing
	Surface impoundment waste liquids	Mineral Processing
	WWTP liquid effluent	Mineral Processing
Magnesium and Magnesia from Brines	APC Dust/Sludge	Mineral Processing
	Calciner offgases	Mineral Processing
	Calcium sludge	Mineral Processing
	Casthouse Dust	Mineral Processing
	Casting plant slag	Mineral Processing
	Cathode Scrubber Liquor	Mineral Processing
	Slag	Mineral Processing
	Smut	Mineral Processing
	Spent Brines	Mineral Processing
Manganese, Manganese Dioxide, Ferromanganese and Silicomanganese	APC Dust/Sludge	Mineral Processing
	APC Water	Mineral Processing
	Iron Sulfide Sludge	Mineral Processing
	Ore Residues	Mineral Processing
Manganese, Manganese Dioxide, Ferromanganese and Silicomanganese (continued)	Slag	Mineral Processing
	Spent Graphite Anode	Mineral Processing
	Spent Process Liquor	Mineral Processing
	Waste Electrolyte	Mineral Processing
	Wastewater (CMD)	Mineral Processing
	Wastewater (EMD)	Mineral Processing
	Wastewater Treatment Solids	Mineral Processing
Mercury	Dust	Mineral Processing
	Mercury Quench Water	Mineral Processing
	Furnace Residues	Mineral Processing
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	APC Dust/Sludge	Mineral Processing
	Flue Dust/Gases	Mineral Processing
	Liquid Residues	Mineral Processing
	H2 Reduction Furnace Scrubber Water	Mineral Processing
	Molybdic Oxide Refining Wastes	Mineral Processing
	Refining Wastes	Mineral Processing
	Roaster Gas Blowdown Solids	Mineral Processing

EXHIBIT 4-2 (Continued)

Commodity	Waste Stream	Nature of Operation
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	Slag	Mineral Processing
	Solid Residues	Mineral Processing
	Treatment Solids	Mineral Processing
Phosphoric Acid	Waste Scale	Mineral Processing
Platinum Group Metals	Slag	Mineral Processing
	Scrubber offgases	Mineral Processing
	SO2 waste	Mineral Processing
	Spent Acids	Mineral Processing
	Spent Solvents	Mineral Processing
Pyrobitumens, Mineral Waxes, and Natural Asphalts	Still bottoms	Mineral Processing
	Waste catalysts	Mineral Processing
Rare Earths	Spent ammonium nitrate processing solution	Mineral Processing
	Electrolytic cell caustic wet APC waste	Mineral Processing
	Spent Electrolytic cell quench water and scrubber water	Mineral Processing
	Spent iron hydroxide cake	Mineral Processing
	Spent lead filter cake	Mineral Processing
	Lead backwash sludge	Mineral Processing
	Monazite solids	Mineral Processing
	Process wastewater	Mineral Processing
	Spent scrubber liquor	Mineral Processing
	Off-gases from dehydration	Mineral Processing
	Spent off-gases from electrolytic reduction	Mineral Processing
	Spent sodium hypochlorite filter backwash	Mineral Processing
	Solvent extraction crud	Mineral Processing
	Spent surface impoundment solids	Mineral Processing
	Spent surface impoundment liquids	Mineral Processing
	Waste filtrate	Mineral Processing
	Waste solvent	Mineral Processing
	Wastewater from caustic wet APC	Mineral Processing
	Waste zinc contaminated with mercury	Mineral Processing
Rhenium	APC Dust/Sludge	Mineral Processing
	Spent Barren Scrubber Liquor	Mineral Processing
	Spent Rhenium Raffinate	Mineral Processing
	Roaster Dust	Mineral Processing
	Spent Ion Exchange/SX Solutions	Mineral Processing
	Spent Salt Solutions	Mineral Processing
	Slag	Mineral Processing
Scandium	Crud from the bottom of the solvent extraction unit	Mineral Processing
	Dusts and spent filters from decomposition	Mineral Processing
	Spent acids	Mineral Processing

EXHIBIT 4-2 (Continued)

Commodity	Waste Stream	Nature of Operation
Scandium (continued)	Spent ion exchange resins and backwash	Mineral Processing
	Spent solvents from solvent extraction	Mineral Processing
	Spent wash water	Mineral Processing
	Waste chlorine solution	Mineral Processing
	Waste solutions/solids from leaching and precipitation	Mineral Processing
Selenium	Spent filter cake	Mineral Processing
	Plant process wastewater	Mineral Processing
	Slag	Mineral Processing
	Tellurium slime wastes	Mineral Processing
	Waste Solids	Mineral Processing
Silicon and Ferrosilicon	APC Dust Sludge	Mineral Processing
	Dross discard	Mineral Processing
	Slag	Mineral Processing
Sulfur	Airborne emissions from sulfuric acid production	Mineral Processing
	Spent catalysts (Claus process)	Mineral Processing
	Spent vanadium pentoxide catalysts from sulfuric acid production	Mineral Processing
	Tail gases	Mineral Processing
	Wastewater from wet-scrubbing, spilled product and condensates	Mineral Processing
Synthetic Rutile	APC Dust/Sludges	Mineral Processing
	Spent Iron Oxide Slurry	Mineral Processing
	Spent Acid Solution	Mineral Processing
Tantalum, Columbium and Ferrocolumbium	APC Dust Sludge	Mineral Processing
	Digester Sludge	Mineral Processing
	Spent Potassium Titanium Chloride	Mineral Processing
	Process Wastewater	Mineral Processing
	Spent Raffinate Solids	Mineral Processing
	Scrubber Overflow	Mineral Processing
	Slag	Mineral Processing
	WWTP Liquid Effluent	Mineral Processing
	WWTP Sludge	Mineral Processing
Tellurium	Slag	Mineral Processing
	Fumes of telluride dioxide	Mineral Processing
	Solid waste residues	Mineral Processing
	Waste Electrolyte	Mineral Processing
	Wastewater	Mineral Processing
Tin	Brick Lining and Fabric Filters	Mineral Processing
	Dross	Mineral Processing
	Process Wastewater and Treatment Sludge	Mineral Processing
	Slag	Mineral Processing
	Slimes	Mineral Processing

EXHIBIT 4-2 (Continued)

Commodity	Waste Stream	Nature of Operation
Tin (continued)	Waste Acid and Alkaline baths	Mineral Processing
Titanium and Titanium Dioxide	Spent Brine Treatment Filter Cake	Mineral Processing
	FeCl Treatment Sludge	Mineral Processing
	Waste Ferric Chloride	Mineral Processing
	Finishing Scrap	Mineral Processing
	Leach Liquor and Sponge Wash Water	Mineral Processing
	Waste Non-Contact Cooling Water	Mineral Processing
	Pickling Liquor and Wash Water	Mineral Processing
	Scrap Detergent Wash Water	Mineral Processing
	Scrap Milling Scrubber Water	Mineral Processing
	Reduction Area Scrubber Water	Mineral Processing
	Chlorination Off gas Scrubber Water	Mineral Processing
	Chlorination Area - Vent Scrubber Water	Mineral Processing
	Melt Cell Scrubber Water	Mineral Processing
	Chlorine Liquefaction Scrubber Water	Mineral Processing
	Chip Crushing Scrubber Water	Mineral Processing
	Casting Crucible Contact Cooling Water	Mineral Processing
	Smut from Mg Recovery	Mineral Processing
	Spent Surface Impoundment Liquids	Mineral Processing
	Spent Surface Impoundment Solids	Mineral Processing
	TiCl4 Purification Effluent	Mineral Processing
	Spent Vanadium Oxychloride	Mineral Processing
	Sodium Reduction Container Reconditioning Wash Water	Mineral Processing
	Casting Crucible Wash Water	Mineral Processing
	Waste Acids (Chloride process)	Mineral Processing
	Waste Solids (Chloride process)	Mineral Processing
	Waste Acids (Sulfate process)	Mineral Processing
	Waste Solids (Sulfate process)	Mineral Processing
	WWTP Liquid Effluent	Mineral Processing
	WWTP Sludge/Solids	Mineral Processing
Tungsten	Spent Acid and Rinse water	Mineral Processing
	Scrubber wastewater	Mineral Processing
	Process wastewater treatment plant effluent	Mineral Processing
	Water of formation	Mineral Processing
Uranium	Waste Nitric Acid from Production of UO_2	Mineral Processing
	Vaporizer Condensate	Mineral Processing
	Superheater Condensate	Mineral Processing
	Slag	Mineral Processing
	Uranium Chips from Ingot Production	Mineral Processing
	Waste Calcium Fluoride	Mineral Processing

EXHIBIT 4-2 (Continued)

Commodity	Waste Stream	Nature of Operation
Vanadium	Filtrate and Process Wastewaters	Mineral Processing
	Solid Waste	Mineral Processing
	Spent Precipitate	Mineral Processing
	Slag	Mineral Processing
	Wet scrubber wastewater	Mineral Processing
Zinc	Acid Plant Blowdown	Mineral Processing
	Spent Cloths, Bags, and Filters	Mineral Processing
	Waste Ferrosilicon	Mineral Processing
	Spent Goethite and Leach Cake Residues	Mineral Processing
	Saleable residues	Mineral Processing
	Process Wastewater	Mineral Processing
	Discarded Refractory Brick	Mineral Processing
	Spent Surface Impoundment Liquid	Mineral Processing
	Spent Surface Impoundment Solids	Mineral Processing
	Spent Synthetic Gypsum	Mineral Processing
	TCA Tower Blowdown (ZCA Bartlesville, OK - Electrolytic Plant)	Mineral Processing
	Wastewater Treatment Plant Liquid Effluent	Mineral Processing
	Wastewater Treatment Plant Sludge	Mineral Processing
	Zinc-lean Slag	Mineral Processing
Zirconium and Hafnium	Spent Acid leachate from zirconium alloy production	Mineral Processing
	Spent Acid leachate from zirconium metal production	Mineral Processing
	Ammonium Thiocyanate Bleed Stream	Mineral Processing
	Reduction area-vent wet APC wastewater	Mineral Processing
	Caustic wet APC wastewater	Mineral Processing
	Feed makeup wet APC wastewater	Mineral Processing
	Filter cake/sludge	Mineral Processing
	Furnace residue	Mineral Processing
	Hafnium filtrate wastewater	Mineral Processing
	Iron extraction stream stripper bottoms	Mineral Processing
	Leaching rinse water from zirconium alloy production	Mineral Processing
	Leaching rinse water from zirconium metal production	Mineral Processing
	Magnesium recovery area vent wet APC wastewater	Mineral Processing
	Magnesium recovery off-gas wet APC wastewater	Mineral Processing
	Sand Chlorination Off-Gas Wet APC wastewater	Mineral Processing
	Sand Chlorination Area Vent Wet APC wastewater	Mineral Processing
	Silicon Tetrachloride Purification Wet APC wastewater	Mineral Processing
	Wet APC wastewater	Mineral Processing
	Zirconium chip crushing wet APC wastewater	Mineral Processing
	Zirconium filtrate wastewater	Mineral Processing

EXHIBIT 4-3

Listing of Hazardous Mineral Processing Wastes by Commodity Sector

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Alumina and Aluminum Metallurgical grade alumina is extracted from bauxite by the Bayer process and aluminum is obtained from this purified ore by electrolysis via the Hall-Heroult process. The Bayer process consists of the following five steps: (1) ore preparation, (2) bauxite digestion, (3) clarification, (4) aluminum hydroxide precipitation, and (5) calcination to anhydrous alumina. In the Hall-Heroult process, aluminum is produced through the electrolysis of alumina dissolved in a molten cryolite-based bath, with molten aluminum being deposited on a carbon cathode.	Cast house dust	19	19	19	19	23			Y			Y			N?	N?	N?
	Electrolysis waste	58	58	58	58	23					Y?				N?	N?	N?
Antimony Primary antimony is usually produced as a by-product or co-product of mining, smelting, and refining of other antimony-containing ores such as tetrahedrite or lead ore. Antimony can be produced using either pyrometallurgical processes or a hydrometallurgical process. For the pyrometallurgical processes, the method of recovery depends on the antimony content of the sulfide ore, and will consist of either volatilization, smelting in a blast furnace, liquation, or iron precipitation. Antimony also can be recovered hydrometallurgically by leaching and electrowinning.	Autoclave filtrate	NA	0.32	27	54	6	Y?		Y?		Y?	Y?			Y?	N?	N?
	Stripped anolyte solids	0.19	0.19	0.19	0.19	2	Y?								N?	N?	N?
	Slag and furnace residue	21	21	21	21	6					Y?				N?	N?	N?
Beryllium Bertrandite and beryl ores are treated using two separate processes to produce beryllium sulfate, $BeSO_4$: a counter-current extraction process and the Kjellgren-Sawyer process. The intermediates from the two ore extraction processes are combined and fed to another extraction process. This extraction process removes impurities solubilized during the processing of the bertrandite and beryl ores and converts the beryllium sulphate to beryllium hydroxide, $Be(OH)_2$. The beryllium hydroxide is further converted to beryllium fluoride, BeF_2, which is then catalytically reduced to form metallic beryllium.	Chip treatment wastewater	NA	0.2	100	2000	2				Y?					N?	N?	N?
	Spent barren filtrate	55	55	55	55	1							Y		N?	N?	N?
	Filtration discard	NA	0.2	45	90	2					Y?				N?	N?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Bismuth Bismuth is recovered mainly during the smelting of copper and lead ores. Bismuth-containing dust from copper smelting operations is transferred to lead smelting operations for recovery. At lead smelting operations bismuth is recovered either by the Betterton-Kroll process or the Betts Electrolytic process. In the Betterton-Kroll process, magnesium and calcium are mixed with molten lead to form a dross that contains bismuth. The dross is treated with chlorine or lead chloride and oxidized by using air or caustic soda to remove impurities. In the Betts Electrolytic process, lead bullion is electrolyzed. The resulting impurities, including bismuth, are smelted, reduced and refined.	Alloy residues	NA	0.1	3	6	1					Y?				N?	N?	N?
	Spent caustic soda	NA	0.1	6.1	12	1					Y?				N?	N?	N?
	Electrolytic slimes	NA	0	0.02	0.2	1					Y?				N?	N?	N?
	Lead and zinc chlorides	NA	0.1	3	6	1					Y?				N?	N?	N?
	Metal chloride residues	3	3	3	3	1					Y?				N?	N?	N?
	Slag	NA	0.1	1	10	1					Y?				N?	N?	N?
	Spent electrolyte	NA	0.1	6.1	12	1					Y?				N?	N?	N?
	Spent soda solution	NA	0.1	6.1	12	1					Y?				Y?	N?	N?
	Waste acid solutions	NA	0.1	6.1	12	1									Y?	N?	N?
	Waste acids	NA	0	0.1	0.2	1									Y?	N?	N?
Cadmium Cadmium is obtained as a byproduct of zinc metal production. Cadmium metal is obtained from zinc fumes or precipitates via a hydrometallurgical or a pyrometallurgical process. The hydrometallurgical process consists of the following steps: (1) precipitates leached with sulfuric acid, (2) cadmium precipitated with a zinc dust addition, (3) precipitate filtered and pressed into filter cake, (4) impurities removed from filter cake to produce sponge, (5) sponge dissolved with sulfuric acid, (6) electrolysis of solution, and (7) cadmium metal melted and cast. The pyrometallurgical process consists of the following steps: (1) cadmium fumes converted to water- or acid-soluble form, (2) leached solution purified, (3) galvanic precipitation or electrolysis, and (4) metal briquetted or cast.	Caustic washwater	NA	0.19	1.9	19	2			Y?						Y?	N?	N?
	Copper and lead sulfate filter cakes	NA	0.19	1.9	19	2			Y?		Y?				N?	N?	N?
	Copper removal filter cake	NA	0.19	1.9	19	2			Y?						N?	N?	N?
	Iron containing impurities	NA	0.19	1.9	19	2			Y?						N?	N?	N?
	Spent leach solution	NA	0.19	1.9	19	2	Y?		Y?		Y?				Y?	N?	N?
	Lead sulfate waste	NA	0.19	1.9	19	2			Y?		Y?				N?	N?	N?
	Post-leach filter cake	NA	0.19	1.9	19	2			Y?						N?	N?	N?
	Spent purification solution	NA	0.19	1.9	19	2			Y?						Y?	N?	N?
	Scrubber wastewater	NA	0.19	1.9	19	2			Y?						Y?	N?	N?
	Spent electrolyte	NA	0.19	1.9	19	2			Y?						Y?	N?	N?
	Zinc precipitates	NA	0.19	1.9	19	2			Y?						N?	N?	N?
Calcium Calcium metal is produced by the Aluminothermic method. In the Aluminothermic method, calcium oxide, obtained by quarrying and calcining calcium limestone, is blended with finely divided aluminum and reduced under a high temperature vacuum. The process produces 99% pure calcium metal which can be further purified through distillation.	Dust with quicklime	0.04	0.04	0.04	0.04	1									Y?	N?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Chromium and Ferrochromium Chromite ore is prepared for processing using several methods, depending on the ore source and the end use requirements, although many of these beneficiation operations may not be conducted in the United States. Either ferrochromium or sodium chromate is initially produced, and may be sold or further processed to manufacture other chromium compounds, as well as chromium metal. Ferrochromium is made by smelting chromite ore in an electric arc furnace with flux materials and carbonaceous redcutant.	ESP dust	3	3	3	3	1				Y			Y		N?	N?	N?
	GCT sludge	NA	0.03	0.3	3	1				Y?					N?	N?	N?
Coal Gas Coal is crushed and gasified in the presence of steam and oxygen, producing carbon dioxide and carbon monoxide, which further react to produce carbon oxides, methane and hydrogen. The product gas is separated from the flue gas, and is processed and purified to saleable methane.	Multiple effects evaporator concentrate	NA	0	0	65	1	Y						Y		N?	N?	N?
Copper Copper is recovered from ores using either pyrometallurgical or hydrometallurgical processes. In both cases, the copper-bearing ore is crushed, ground, and concentrated (except in dump leaching). Pyrometallurgical processing can take as many as five steps: roasting, smelting, converting, fire refining, and electrorefining. Hydrometallurgical processing involves leaching, followed by either precipitation or solvent extraction and electrowinning.	Acid plant blowdown	5300	5300	5300	5300	10	Y		Y	Y	Y	Y	Y	Y	Y	N?	N?
	APC dusts/sludges	NA	1	220	450	10	Y?								N?	N?	N?
	Waste contact cooling water	13	13	13	13	10	Y?								N?	N?	N?
	Tankhouse slimes	4	4	4	4	10	Y?				Y?		Y?	Y?	N?	N?	N?
	Spent bleed electrolyte	310	310	310	310	10	Y		Y	Y	Y		Y	Y	Y	N?	N?
	Spent furnace brick	3	3	3	3	10				Y?					N?	N?	N?
	Process wastewaters	4900	4900	4900	4900	10	Y		Y		Y	Y	Y?		Y	N?	N?
	WWTP sludge	6	6	6	6	10			Y?		Y?				N?	N?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Elemental Phosphorus Phosphate rock or sintered/agglomerated fines are charged into an electric arc furnace with coke and silica. This yields calcium silicate slag and ferrophosphorus, which are tapped. Dusts are removed from the furnace offgases and phosphorus is removed from the dusts by condensation.	Andersen Filter Media	0.46	0.46	0.46	0.46	2			Y						N?	N?	N?
	Precipitator slurry	160	160	160	160	2			Y?						N?	Y	Y
	NOSAP slurry	160	160	160	160	2									N?	N?	Y
	Phossy Water	670	670	670	670	2			Y?						N?	Y	Y
	Furnace scrubber blowdown	410	410	410	410	2			Y						Y	N?	N?
	Furnace Building Washdown	700	700	700	700	2			Y						N?	N?	N?
Fluorspar and Hydrofluoric Acid Raw fluorspar ore is crushed, ground, and concentrated. Acid grade fluorspar (a pure form of concentrate) is mixed with sulfuric acid in a heated retort kiln, reacting to produce hydrogen fluoride gas and fluorogypsum. The gas is cooled, scrubbed, and condensed, and sold as either hydrofluoric acid solution or anhydrous hydrogen fluoride.	Off-spec fluosilicic acid	NA	0	15	44	3									Y?	N?	N?
Germanium Germanium is recovered as a by-product of other metals, mostly copper, zinc, and lead. Germanium-bearing residues from zinc-ore processing facilities, a main source of germanium metal, are roasted and sintered. The sintering fumes, containing oxidized germanium, are leached with sulfuric acid to form a solution. Germanium is precipitated from the solution by adding zinc dust. Following precipitation, the germanium concentrates are refined by adding hydrochloric acid or chlorine gas to produce germanium tetrachloride, which is hydrolyzed to produce solid germanium dioxide. The final step involves reducing germanium dioxide with hydrogen to produce germanium metal.	Waste acid wash and rinse water	NA	0.4	2.2	4	4	Y?		Y?	Y?	Y?		Y?	Y?	Y?	N?	N?
	Chlorinator wet air pollution control sludge	NA	0.01	0.21	0.4	4	Y?		Y?	Y?	Y?		Y?	Y?	N?	N?	N?
	Hydrolysis filtrate	NA	0.01	0.21	0.4	4	Y?		Y?	Y?	Y?		Y?	Y?	N?	N?	N?
	Leach residues	0.01	0.01	0.01	0.01	3			Y?		Y?				N?	N?	N?
	Spent acid/leachate	NA	0.4	2.2	4	4	Y?				Y?				Y?	N?	N?
	Waste still liquor	NA	0.01	0.21	0.4	4	Y?		Y?	Y?	Y?		Y?	Y?	N?	Y?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Gold and Silver Gold and Silver may be recovered from either ore or the refining of base metals. Extracted ore is crushed or ground and then subjected to oxidation by roasting, autoclaving, bio-oxidation, or chlorination, and then cyanide leaching (heap, vat, or agitation). The metals are recovered by activated carbon loading or the Merrill Crowe process. Activated carbon loading involves bringing precious metal leach solutions into contact with activated carbon by the carbon-in-column, carbon-in-pulp, or carbon-in-leach process. Gold and silver are then separated by acid leaching or electrolysis. The Merrill Crowe process consistes of filtering and deaerating the leach solution and then precipitating the precious metals with zinc powder. The solids are filtered out, melted and cast into bars. The recovery of precious metals from lead refinery slimes is a normal part of the operation called "desilverizing." Lead from previous stages of refining is brought into contact with a zinc bath which absorbs the precious metals. Base metals are removed and the dore is sent to refining.	Slag	NA	0.1	360	720	16								Y?	N?	N?	N?
	Spent furnace dust	NA	0.1	360	720	16								Y?	Y?	N?	N?
Lead Lead ores are crushed, ground, and concentrated. Pelletized concentrates are then fed to a sinter unit with other materials (e.g., smelter byproducts, coke). The sintered material is then introduced into a blast furnace along with coke and fluxes. The resulting bullion is drossed to remove lead and other metal oxides. The lead bullion may also be decopperized before being sent to the refining stages. Refining operations generally consist of several steps, including (in sequence) softening, desilverizing, dezincing, bismuth removal and final refining. During final refining, lead bullion is mixed with various fluxes and reagents to remove remaining impurities.	Acid plant sludge	14	14	14	14	3									Y?	N?	N?
	Baghouse incinerator ash	NA	0.3	3	30	3			Y		Y				N?	N?	N?
	Slurried APC Dust	7	7	7	7	3			Y		Y				N?	N?	N?
	Solid residues	0.4	0.4	0.4	0.4	3					Y?				N?	N?	N?
	Spent furnace brick	1	1	1	1	3					Y				N?	N?	N?
	Stockpiled miscellaneous plant waste	NA	0.3	67	130	3			Y		Y				N?	N?	N?
	WWTP solids/sludges	380	380	380	380	3			Y?		Y?				Y	N?	N?
	WWTP liquid effluent	2600	2600	2600	2600	3					Y?				Y?	N?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Magnesium and Magnesia from Brines Magnesium is recovered through two processes: (1) electrolytic and (2) thermal. In electrolytic production with hydrous feed, magnesium hydroxide is precipitated from seawater and settled out. The underflow is dewatered, washed, reslurried with wash water, and neutralized with HCL and H_2SO_4. The brine is filtered, purified, dried, and fed into the electrolytic cells. Alternatively, surface brine is pumped to solar evaporation ponds, where it is dried, concentrated, and purified. The resulting powder is melted, fed into the electrolytic cells, and then casted. The two thermal production processes for magnesium are the carbothermic process and the silicothermic process. In the carbothermic process, magnesium oxide is reduced with carbon to produce magnesium in the vapor phase, which is recovered by shock cooling. In the silicothermic process, silica is reacted with carbon to give silicon metal which is subsequently used to produce magnesium. Magnesia is produced by calcining magnesite or magnesium hydroxide or by the thermal decomposition of magnesium chloride, magnesium sulfate, magnesium sulfite, nesquehonite, or the basic carbonate.	Cast house dust	NA	0.076	0.76	7.6	1		Y?							N?	N?	N?
	Smut	26	26	26	26	2		Y							N?	N?	N?
Mercury Mercury currently is recovered only from gold ores. Sulfide-bearing gold ore is roasted, and the mercury is recovered from the exhaust gas. Oxide-based gold ore is crushed and mixed with water, and sent to a classifier, followed by a concentrator. The concentrate is sent to an agitator, where it is leached with cyanide. The slurry is filtered and the filtrate is sent to electrowinning, where the gold and mercury are deposited onto stainless steel wool cathodes. The cathodes are sent to a retort, where the mercury vaporizes with other impurities. The vapor is condensed to recover the mercury which is then purified.	Dust	0.007	0.007	0.007	0.007	7						Y?			N?	N?	N?
	Quench water	NA	63	77	420	7					Y?	Y?			N?	N?	N?
	Furnaceresidue	0.077	0.077	0.077	0.077	7						Y?			N?	N?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Molybdenum, Ferromolybdenum, and Ammonium Molybdate Production of molybdenum and molybdenum products, including ammonium molybdate, begins with roasting. Technical grade molybdic oxide is made by roasting concentrated ore. Pure molybdic oxide is produced from technical grade molybdic oxide either by sublimation and condensing, or by leaching. Ammonium molybdate is formed by reacting technical grade oxide with ammonium hydroxide and crystallizing out the pure molybdate. Molybdenum powder is formed using hydrogen to reduce ammonium molybdate or pure molybdic oxide. Ferromolybdenum is typically produced by reaction of technical grade molybdic oxide and iron oxide with a conventional metallothermic process using silicon and/or aluminum as the reductant.	Flue dust/gases	NA	1.1	250	500	11					Y?				N?	N?	N?
	Liquid residues	1	1	1	1	2	Y?		Y?		Y?		Y?		N?	N?	N?
Platinum Group Metals Platinum-group metals can be recovered from a variety of different sources, including electrolytic slimes from copper refineries and metal ores. The production of platinum-group metals from ore involves mining, concentrating, smelting, and refining. In the concentrating step, platinum ore is crushed and treated by froth flotation. The concentrates are dried, roasted, and fused in a smelter furnace, which results in the formation of platinum-containing sulfide matte. Solvent extraction is used to separate and purify the six platinum-group metals in the sulfide matte.	Slag	NA	0.0046	0.046	0.46	3					Y?		Y?		N?	N?	N?
	Spent acids	NA	0.3	1.7	3	3					Y?			Y?	Y?	N?	N?
	Spent solvents	NA	0.3	1.7	3	3					Y?			Y?	N?	Y?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Rare Earths Rare earth elements are produced from monazite and bastnasite ores by sulfuric and hydrochloric acid digestion. Processing of rare earths involves fractional crystallization and precipitation followed by solvent extraction to separate individual rare earth elements from one another. Ion exchange or calcium reduction produces highly pure rare earths in small quantities. Electrolytic reduction of rare earth chlorides followed by crushing produces a complex alloy of rare earth metals commonly known as mischmetal.	Spent ammonium nitrate processing solution	14	14	14	14	1									Y	N?	N?
	Electrolytic cell caustic wet APC sludge	NA	0.07	0.7	7	1									Y?	N?	N?
	Process wastewater	7	7	7	7	1					Y				Y?	N?	N?
	Spent scrubber liquor	NA	0.1	500	1000	1									Y?	N?	N?
	Solvent extraction crud	NA	0.1	2.3	4.5	1									N?	Y?	N?
	Spent lead filter cake	NA	0.17	0.21	0.25	1					Y?				N?	N?	N?
	Waste solvent	NA	0.1	50	100	1									N?	Y?	N?
	Wastewater from caustic wet APC	NA	0.1	500	1000	1				Y?	Y?				Y?	N?	N?
Rhenium In general, rhenium is recovered from the off-gases produced when molybdenite, a byproduct of the processing of porphyry copper ores for molybdenum, is roasted. During the roasting process, molybdenite concentrates are converted to molybdic oxide and rhenium is converted to rhenium heptoxide. The rhenium oxides are sublimed and carried off with the roaster flue gas. Rhenium is then recovered from the off-gases by the following five steps: (1) scrubbing; (2) solvent extraction or ion exchange; (3) precipitation (addition of H_2S and HCl) and filtration; (4) oxidation and evaporation; and (5) reduction.	Spent barren scrubber liquor	NA	0	0.1	0.2	2							Y?		N?	N	N
	Spent rhenium raffinate	88	88	88	88	2					Y?				N?	N?	N?
Scandium Scandium is generally produced by small bench-scale batch processes. The principal domestic scandium resource is fluorite tailings containing thortveitite and associated scandium-enriched minerals. Scandium can be recovered from thortveitite using several methods. Each method involves a distinct initial step (i.e., acid digestion, grinding, or chlorination) followed by a set of common recovery steps, including leaching, precipitation, filtration, washing, and ignition at 900°C to form scandium oxide.	Spent acids	NA	0.7	3.9	7	7									Y?	N?	N?
	Spent solvents from solvent extraction	NA	0.7	3.9	7	7									N?	Y?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Selenium The two principle processes for selenium recovery are smelting with soda ash and roasting with soda ash. Other methods include roasting with fluxes, during which the selenium is either volatilized as an oxide and recovered from the flue gas, or is incorporated in a soluble calcine that is subsequently leached for selenium. In some processes, the selenium is recovered both from the flue gas and from the calcine. To purify the crude selenium, it is dissolved in sodium sulfite and filtered to remove unwanted solids. The resulting filtrate is acidified with sulfuric acid to precipitate selenium. The selenium precipitate is distilled to drive off impurities.	Spent filter cake	NA	0.05	0.5	5	3							Y?		N?	N?	N?
	Plant process wastewater	66	66	66	66	2					Y				Y	N?	N?
	Slag	NA	0.05	0.5	5	3							Y?		N?	N?	N?
	Tellurium slime wastes	NA	0.05	0.5	5	3							Y?		N	N?	N?
	Waste solids	NA	0.05	0.5	5	3							Y?		N?	N?	N?
Synthetic Rutile Synthetic rutile is manufactured through the upgrading of ilmenite ore to remove impurities (mostly iron) and yield a feedstock for production of titanium tetrachloride through the chloride process. The various processes developed can be organized in three categories: (1) processes in which the iron in the ilmenite ore is completely reduced to metal and separated either chemically or physically; (2) processes in which iron is reduced to the ferrous state and chemically leached from the ore; and (3) processes in which selective chlorination is used to remove the iron. In addition, a process called the Benelite Cyclic process uses hydrochloric acid to leach iron from reduced ilmenite.	Spent iron oxide slurry	45	45	45	45	1			Y?	Y?					N?	N?	N?
	APC dust/sludges	30	30	30	30	1			Y?	Y?					N?	N?	N?
	Spent acid solution	30	30	30	30	1			Y?	Y?					Y?	N?	N?
Tantalum, Columbium, and Ferrocolumbium Tantalum and columbium ores are processed by physically and chemically breaking down the ore to form columbium and tantalum salts or oxides, and separating the columbium and tantalum salts or oxides from one another. These salts or oxides may be sold, or further processed to reduce the salts to the respective metals. Ferrocolumbium is made by smelting the ore with iron, and can be sold as a product or further processed to produce tantalum and columbium products.	Digester sludge	1	1	1	1	2									Y?	N?	N?
	Process wastewater	150	150	150	150	2	Y?		Y?	Y?	Y?		Y?		Y	N?	N?
	Spent raffinate solids	2	2	2	2	2									Y?	N?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Tellurium The process flow for the production of tellurium can be separated into two stages. The first stage involves the removal of copper from the copper slimes. The second stage involves the recovery of tellurium metal and purification of the recovered tellurium. Copper is generally removed from slimes by aeration in dilute sulfuric acid, oxidative pressure-leaching with sulfuric acid, or digestion with strong acid. Tellurous acid (in the form of precipitates) is then recovered by cementing, leaching the cement mud, and neutralizing with sulfuric acid. Tellurium is recovered from the precipitated tellurous acid by the following three methods: (1) direct reduction; (2) acid precipitation; and (3) electrolytic purification.	Slag	NA	0.2	2	9	2							Y?		N?	N?	N?
	Solid waste residues	NA	0.2	2	9	2							Y?		N?	N?	N?
	Waste electrolyte	NA	0.2	2	20	2					Y?		Y?		N?	N?	N?
	Wastewater	NA	0.2	20	40	2							Y?		Y?	N?	N?
Titanium and Titanium Dioxide Titanium ores are utilized in the production of four major titanium-based products: titanium dioxide (TiO_2) pigment, titanium tetrachloride ($TiCl_4$), titanium sponge, and titanium ingot/metal. The primary titanium ores for manufacture of these products are ilmenite and rutile. TiO_2 pigment is manufactured through either the sulfate, chloride, or chloride-ilmenite process. The sulfate process employs digestion of ilmenite ore or TiO_2-rich slag with sulfuric acid to produce a cake, which is purified and calcined to produce TiO_2 pigment. In the chloride process, rutile, synthetic rutile, or high-purity ilmenite is chlorinated to form $TiCl_4$, which is purified to form TiO_2 pigment. In the chloride-ilmenite process, a low-purity ilmenite is converted to $TiCl_4$ in a two-stage chlorination process. Titanium sponge is produced by purifying $TiCl_4$ generated by the chloride or chloride-ilmenite process. Titanium sponge is cast into ingots for further processing into titanium metal.	Pickle liquor and wash water	NA	2.2	2.7	3.2	3			Y?	Y?	Y?				Y?	N?	N?
	Scrap milling scrubber water	NA	4	5	6	1			Y?	Y?	Y?		Y?		N?	N?	N?
	Smut from Mg recovery	NA	0.1	22	45	2									N?	N?	Y
	Leach liquor and sponge wash water	NA	380	480	580	2				Y?	Y?				Y	N?	N?
	Spent surface impoundment liquids	NA	0.63	3.4	6.7	7				Y?	Y?				N?	N?	N?
	Spent surface impoundments solids	36	36	36	36	7				Y?	Y?				N?	N?	N?
	Waste acids (Sulfate process)	NA	0.2	39	77	2	Y			Y			Y	Y	Y	N	N
	Waste acids (Chloride process)	49	49	49	49	7				Y?	Y?		Y?		Y	N	N
	WWTP sludge/solids	420	420	420	420	7				Y?					N	N	N

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Tungsten Tungsten production consists of four distinct stages: (1) ore preparation, (2) leaching, (3) purification to APT, and (4) reducing APT to metal. Ore preparation involves gravity and flotation methods. Concentration is usually accomplished by froth flotation, supplemented by leaching, roasting, or magnetic or high tension separation. The concentrate is then processed to APT via either sodium tungstate or tungstic acid (which was digested with aqueous ammonia) to solubilize the tungsten as ammonia tungstate. Further purification and processing yields APT. APT is converted to tungsten oxide by calcining in a rotary furnace. Tungsten oxides are reduced to metal powder in high temperature furnaces. Tungsten carbide is formed by reducing APT or tungsten oxides in the presence of carbon.	Spent acid and rinse water	NA	0	0	21	6									Y?	N?	N?
	Process wastewater	NA	2.2	4.4	9	6									Y?	N?	N?
Uranium Uranium ore is recovered using either conventional milling or solution mining (*in situ leaching*). Beneficiation of conventionally mined ores involves crushing and grinding the extracted ores followed by a leaching circuit. *In situ* operations use a leach solution to dissolve desirable uraniferous minerals from deposits in-place. Uranium in either case is removed from pregnant leach liquor and concentrated using solvent extraction or ion exchange and precipitated to form yellowcake. Yellowcake is then processed to produce uranium fluoride (UF_6), which is then enriched and further refined to produce the fuel rods used in nuclear reactors.	Waste nitric acid from UO2 production	NA	1.7	2.5	3.4	17									Y?	N?	N?
	Vaporizer condensate	NA	1.7	9.3	17	17									Y?	N?	N?
	Superheater condensate	NA	1.7	9.3	17	17									Y?	N?	N?
	Slag	NA	0	8.5	17	17									N?	Y?	N?
	Uranium chips from ingot production	NA	1.7	2.5	3.4	17									N?	Y?	N?

EXHIBIT 4-3 (Continued)

Commodity	Waste Stream	Reported Generation (1000mt/yr)	Est./Reported Generation (1000mt/yr)			Number of Facilities with Process	TC Metals								Other Hazardous Characteristics		
			Min	Avg.	Max		As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Corr	Ignit	Rctv
Zinc Zinc-bearing ores are crushed and undergo flotation to produce concentrates of 50 to 60% zinc. Zinc is then processed through either of two primary processing methods: electrolytic or pyrometallurgical. Electrolytic processing involves digestion with sulfuric acid and electrolytic refining. In pyrometallurgical processing, calcine is sintered and smelted in batch horizontal retorts, externally-heated continuous vertical retorts, or electrothermic furnaces. In addition, zinc is smelted in blast furnaces through the Imperial Smelting Furnace process, which is capable of recovering both zinc and lead from mixed zinc-lead concentrates.	Acid plant blowdown	130	130	130	130	1	Y		Y	Y	Y?	Y?	Y	Y	Y	N	N
	Waste ferrosilicon	17	17	17	17	1					Y?				N?	N?	N?
	Process wastewater	5000	5000	5000	5000	3	Y		Y	Y	Y		Y	Y	Y	N?	N?
	Discarded refractory brick	1	1	1	1	1	Y?		Y?	Y?	Y?				N?	N?	N?
	Spent cloths, bags, and filters	0.15	0.15	0.15	0.15	3			Y?		Y?	Y?	Y?	Y?	N?	N?	N?
	Spent goethite and leach cake residues	15	15	15	15	3	Y		Y	Y	Y?	Y?	Y	Y	N?	N?	N?
	Spent surface impoundment liquids	1900	1900	1900	1900	3			Y?						Y	N?	N?
	WWTP Solids	0.75	0.75	0.75	0.75	3	Y?		Y?		Y?	Y?	Y?	Y?	N?	N?	N?
	Spent synthetic gypsum	16	16	16	16	3	Y?		Y		Y?				N?	N?	N?
	TCA tower blowdown	0.25	0.25	0.25	0.25	1			Y?		Y?	Y?	Y?		Y?	N?	N?
	Wastewater treatment plant liquid effluent	2600	2600	2600	2600	3			Y?						N?	N?	N?
Zirconium and Hafnium The production processes used at primary zirconium and hafnium manufacturing plants depend largely on the raw material used. Six basic operations may be performed: (1) sand chlorination, (2) separation, (3) calcining, (4) pure chlorination, (5) reduction, and (6) purification. Plants that produce zirconium and hafnium from zircon sand use all six of these process steps. Plants which produce zirconium from zirconium dioxide employ reduction and purification steps only.	Spent acid leachate from Zr alloy prod.	NA	0	0	850	2									Y?	N?	N?
	Spent acid leachate from Zr metal prod.	NA	0	0	1600	2									Y?	N?	N?
	Leaching rinse water from Zr alloy prod.	NA	34	42	51	2									Y?	N?	N?
	Leaching rinse water from Zr metal prod.	NA	0.2	1000	2000	2									Y?	N?	N?

/ Corr., Ignit., and Rctv. refer to the RCRA hazardous characteristics of corrosivity, ignitability, and reactivity.

EXHIBIT 4-4

IDENTIFICATION OF HAZARDOUS MINERAL PROCESSING WASTE STREAMS LIKELY SUBJECT TO THE LDRS

Mineral Processing Commodity Sectors	Number of Waste Streams 1/	Estimated Annual Generation Rate (1,000 mt/yr) (Rounded to the Nearest 2 Significant Figures) Low Estimate	Medium Estimate	High Estimate
Alumina and Aluminum	2	77	77	77
Antimony	3	22	48	75
Beryllium	3	55	200	2,100
Bismuth	10	3.7	35	73
Cadmium	11	2.1	21	210
Calcium Metal	1	0.040	0.040	0.040
Chromium and Ferrochromium	2	3.0	3.3	6.0
Coal Gas	1	0	0	65
Copper	8	10,500	10,800	11,000
Elemental Phosphorus	6	2,100	2,100	2,100
Fluorspar and Hydrofluoric Acid	1	0	15	45
Germanium	6	0.84	5.0	9.2
Gold and Silver	2	0.2	720	1400
Lead	8	3,000	3,080	3,200
Magnesium and Magnesia from Brines	2	26	27	34
Mercury	3	63	77	420
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	2	2.1	250	500
Platinum Group Metals	3	0.45	3.5	6.5
Rare Earths	8	21	1,050	2,100
Rhenium	2	88	88	88
Scandium	2	1.4	7.8	14
Selenium	5	66	68	86
Synthetic Rutile	3	100	100	100
Tantalum, Columbium, and Ferrocolumbium	3	150	150	150
Tellurium	4	0.80	26	78
Titanium and Titanium Dioxide	9	890	1,050	1,250
Tungsten	2	2.2	4.4	30
Uranium	5	6.8	32	58

EXHIBIT 4-4 (Continued)

Mineral Processing Commodity Sectors	**Number of Waste Streams 1/**	**Estimated Annual Generation Rate (1,000 mt/yr) (Rounded to the Nearest 2 Significant Figures)**		
		Low Estimate	**Medium Estimate**	**High Estimate**
Zinc	11	9,800	9,800	9,800
Zirconium and Hafnium	4	34	1,000	4,500
TOTAL:	133	27,016	30,838	39,575

1/ In calculating the total number of waste streams per mineral sector, EPA included both non-wastewaters and wastewater mineral processing wastes and assumed that each of the hazardous mineral processing waste streams were generated in all three waste generation scenarios (low, medium, and high).