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Report to Congress on Metal Recovery, Environmental Regulation & Hazardous Waste

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Abstract

This report has been completed in response to Congressional requests for EPA to conduct a study on the effects of existing regulations on metal recovery of the Nation's wastes, how metal recovery can be encouraged and how these materials should be regulated to protect human health and the environment and to implement the Resource Conservation and Recovery Act's (RCRA) goals of resource conservation and protection of human health and the environment. EPA has completed its analysis of the effect of RCRA Subtitle C regulation on metal recovery of hazardous waste in the United States. Information evaluated in completion of this report indicates that RCRA Subtitle C regulation has signficantly contributed to increases of metal recovery of hazardous waste over 1980 levels primarily due to increased treatment and disposal costs which creates markets for metal recovery services. At the same time, RCRA Subtitle C regulation may inhibit metal recovery of hazardous wastes from reaching its potential due to regulatory disincentives to recovery. The main RCRA Subtitle C provisions indicated by industry as being problematic in this regard include the derived-from rule, permit requirements and facility-wide corrective action. Other disincentives cited include hazardous waste transportation cost, perceived Superfund liability resulting from hazardous waste management, and financial assurance. One case study of a metal recovery firm indicates that RCRA may also impede innovative technologies. The case study indicates that provisions in RCRA to encourage innovation such as research, development and demonstration permits and treatability exemptions are not adequate to encourage innovation.

The issue is one of balancing the need to control the hazards by hazardous wastes being recycled against the additional recycling that might occur with less onerous regulations. This is a difficult issue, one of great interest to many parties. EPA established a Task Force to address this issue, and sponsored a series of public roundtable discussions in the summer and fall of 1993 to better understand these issues through public involvement. EPA expects to make decisions on what regulations, if any, should be changed as a result of the Task Force process and has also initiated other steps to encourage environmentally sound recycling such as the proposed Special Collection System regulations.

Executive Summary

In 1992, Congress directed the Environmental Protection Agency (EPA) to conduct a study of how current hazardous waste regulations affect metal recovery of the Nation's waste, how metal recovery can be encouraged, and how such metal-bearing hazardous wastes should be regulated to protect human health and the environment as well as effectuate the resource conservation and recovery goals of the Resource Conservation and Recovery Act (RCRA). To complete this report, EPA reviewed relevant literature and consulted with the Departments of Interior and Commerce as well as members of the metal recovery industries. EPA has conducted a series of case studies of metal recovery operations in order to obtain case-specific information about how RCRA Subtitle C regulation affects their operation.

Under current RCRA Subtitle C regulation, metal recovery is one type of recycling (the use or reuse of a waste directly is the other) and can be defined as the recovery of metal as separate end products from a metal-bearing secondary material. Metal-bearing hazardous wastes comprise a wide variety of secondary materials including sludges, by-products, and spent materials. These wastes are often defined as hazardous because they leach heavy metals in excess of regulatory levels. These metals can include lead, chromium, cadmium, mercury, and arsenic. Because metals are elements, they cannot be destroyed and exist in perpetuity. They can be stabilized to prevent their release to the environment or recovered and reused again. When mismanaged, metal-bearing hazardous wastes have contaminated the surrounding environment. Some metal recovery operations are listed on the National Priorities List (NPL) for Superfund cleanup.

EPA determined that the best means to assess the impacts of Subtitle C on metal recovery would be to focus on materials that are currently regulated as hazardous waste. Therefore, this study focusses on secondary materials such as emission control dust from electric arc furnaces, spent lead-acid batteries, spent pickle liquor from steel finishing operations and wastewater treatment sludge from electroplating operations. These are examples of metal-bearing hazardous wastes which are currently subject to most or all RCRA Subtitle C regulatory requirements. (Note: spent lead-acid batteries being reclaimed are subject to reduced regulatory requirements prior to be being reclaimed).

According to EPA data, there are at least 8 million tons of metal-bearing hazardous waste generated annually. Some of these wastes are managed for recovery. Many of these wastes are not amenable to recovery either because they are too low in content of recoverable metals or because they contain too many impurities that would interfere with the recovery process. Currently, EPA estimates that 1.9 million tons of hazardous waste are managed for metal recovery. These wastes include spent lead-acid batteries, emission control dust from electric arc furnaces, wastewater treatment sludge from electroplating operations, spent pickle liquor from steel finishing operations and other wastes.

A number of RCRA Subtitle C regulations may affect metal recovery operations. Under RCRA Subtitle C, a generator of a metal-bearing hazardous waste has 90 days after generation to store wastes on-site in tanks, containers, or containment buildings. After that time the generator must either dispose of the waste on-site (either as non-hazardous waste or in compliance with applicable hazardous waste standards) or ship the waste off-site for storage, treatment, recovery or disposal. If shipped off-site, the generator must ship the waste under manifest by a hazardous waste hauler. All metal-bearing hazardous waste is subject to the applicable land disposal restriction (LDR) treatment standard. These standards specify either a technology (such as thermal recovery) or more commonly a performance level (either a total or extract level concentration) that must be met prior to land disposal.

When hazardous waste is shipped off-site for metal recovery, the metal recovery operation is required to have a permit if the waste is stored prior to recovery. RCRA storage permit requirements trigger other regulatory requirements such as facility-wide corrective action (requiring remediation of affected solid waste management units on-site) and financial assurance (requiring a financial mechanism to assure proper closure of facility operations). If the metal recovery operation does not store the waste prior to reclamation, it generally does not require a permit since the recycling process is generally not regulated under RCRA. One exception to this general rule is if the operation meets the definition of an industrial furnace and is not burning solely for metal recovery (e.g., the process also destroys hazardous organic constituents or is recovering fuel value). In this case, the metal recovery operation is subject to Boiler and Industrial Furnace Permit requirements. Finally, any residuals from a metal recovery operations must be managed as a hazardous waste if either it exhibits a hazardous characteristic (i.e., corrosivity, reactivity, ignitability, or toxicity) or it was derived-from a listed hazardous waste.

Industry has complained that RCRA Subtitle C regulation is too stringent and has served as a disincentive to metal recovery in the United States. Major RCRA Subtitle C disincentive identified include the derived-from rule, storage permit requirements and facility-wide corrective action. Trade associations representing generators of steel or electroplating wastes and trade associations representing metal reclaimers of spent lead-acid batteries and industrial sludges and by-products have indicated to EPA their view that high compliance costs and increasing liability risk from RCRA Subtitle C regulation has decreased metal recovery capacity in the United States and decreased capital investment for new projects in their respective industries.

In general, these representatives favored some form of conditional exclusion from RCRA Subtitle C jurisdiction or conditional exemption from RCRA Subtitle C regulation. They favored conditions resulting in self-implementing management standards for the wastes such as a time limit on accumulating wastes prior to recovery or banning storage wastes on the ground prior to recovery. They also support regulatory modifications to the permitting process and expanded federal guidelines on recycling and storage although these are generally regarded as less satisfactory than conditional exclusions and exemptions.

EPA's review of economic analysis completed for the Agency in 1991 indicates that under current RCRA Subtitle C regulation metal recovery is a more cost-effective management alternative than traditional treatment and disposal. Additional data shows that RCRA Subtitle C regulation (particularly the Land Disposal Restrictions program) encourages metal recovery of hazardous waste by increasing treatment and disposal costs which are substitute forms of management to recovery. Increases in world metal demand have also been an important factor in encouraging metal recovery.

For spent lead-acid batteries, current data indicate that recovery rates have remained high in spite of a recent decrease in the world price of lead. It appears that RCRA is not a disincentive and may actually encourage recovery of spent lead-acid batteries. For industrial sludges, by-products and spent materials, metal recovery levels have increased substantially from 1980 levels. EPA currently estimates that over 1 million tons of these materials were recovered in 1992. In 1980, the GAO reported that fewer than 15,000 tons of metal (from an estimated 100,000 tons of waste) were being recovered from industrial sludges, by-products and spent materials.

While on balance RCRA Subtitle C regulation has contributed to increased metal recovery in the United States since 1980, some regulatory provisions may have constrained additional metal recovery capacity in the United States. It is possible that RCRA has made metal recovery in the United States less profitable than it would otherwise be. The derived-from rule that requires residuals from listed wastes to be managed as hazardous wastes, facility-wide corrective action and RCRA permit requirements are among the most expensive and time consuming provisions in RCRA to comply with. However, these are also among the most important provisions to prevent or remediate releases to the environment of metal-bearing hazardous wastes. Any proposals to modify these provisions must carefully evaluate the net benefits, if any, of the modification resulting from any additional metal recovery against any increased risk to public health and the environment due to any increase in the likelihood or severity of a release.

Conclusions from EPA's examination of case studies of metal recovery operations corroborate EPA's findings that RCRA has mixed effects in terms of providing incentives or disincentives to metal recovery. To assess the broadest possible impact of RCRA on different types of metal recovery operations, EPA completed case studies on a diverse selection of metal recovery operations with different processes and stages of commercial development. Each case study indicated a series of RCRA Subtitle C incentives and disincentives to metal recovery with varying impacts on the operation as a whole.

As other data have indicated, case study subjects benefited from markets created for their services largely due to RCRA treatment and disposal standards. However, case study subjects were also burdened with cost and liability concerns from the derived-from rule for process residuals. One case study subject, Molten Metal Technology, indicates that RCRA provisions to encourage innovative technologies may not be working adequately to meet that goal.

In addition to environmental benefits obtained from it, metal-recovery of hazardous waste may help to ameliorate the U.S. balance of trade deficit of mineral and metal commodities. Nickel, copper, zinc, lead and iron may be found in sufficient quantities in metal-bearing hazardous wastes to contribute to increased supplies of these materials for domestic consumption or export.

Metal recovery of hazardous wastes can also play an important role in conservation of strategic metals such as chromium, cobalt, manganese and platinum. Strategic metals are metal commodities that perform critical functions in the U.S. economy and which the U.S. is largely dependent on imports from vulnerable supplies from politically instable sources. More specifically, EPA data indicates that there are large quantities of chromium-bearing wastes generated in the United States. Chromium is an important strategic material used as an alloy for corrosion resistance in steel production.

Metal recovery from hazardous waste may be encouraged directly through changes to existing command and control regulation such as self-implementing standards or through non-regulatory and incentive-based approaches such as waste exchanges, pollution fees and transferable waste permits. EPA is currently conducting on-going activities to optimize environmental protection and safe recycling of hazardous wastes. These activities include the Definition of Solid Waste Task Force, the proposed Part 273 Special Collection System regulations, and the proposed universal treatment standards for metal hazardous constituents under the Land Disposal Restriction program. EPA has also provided financial support for non-regulatory approaches such as waste exchanges. The Agency has also examined a number of possible incentive-based approaches to encourage metal recovery in completion of this report. These incentives include pollution fees, tradeable permits, deposit-refund systems and removal of federal subsidies for production of virgin metals. Each approach has its own advantages and limitations depending upon the objectives sought and implementation required.

Based on information collected and analyzed in completion of this report, EPA finds the following with respect to metal recovery of hazardous waste and its relationship to RCRA Subtitle C regulation:

1. **RCRA Subtitle C regulation includes both incentives and disincentives to metal recovery of hazardous waste. Overall, RCRA Subtitle C regulation has been a substantial contributing factor to the increase in metal recovery of hazardous waste over 1980 levels.**

2. **RCRA Subtitle C regulation is also apparently constraining metal recovery from reaching its potential in the United States. Compliance costs and liability concerns with RCRA Subtitle C regulation may limit waste generators selection of metal recovery as an option. These costs and concerns also limit the ability of metal recovery operations to expand their capacity and invest in new projects.**

3. **RCRA Subtitle C regulation may inhibit innovative metal recovery technologies. RCRA regulatory provisions designed to encourage innovation such as the treatability exemption and the research, development and demonstration permits may not always be adequate to encourage innovation.**

4. **Notwithstanding the disincentives posed by RCRA Subtitle C regulation, damage incidents (including Superfund sites) involving metal recovery operations indicate that mismanagement of these materials can pose a significant risk to human health and the environment. For this reason, proposals to modify RCRA Subtitle C statutory or regulatory authority must assess the benefit of reduced compliance cost and liability from Subtitle C regulation against any incremental increase in risk due to reduced regulatory requirements. EPA has created the Definition of Solid Waste Task Force to assess these types of proposals.**

5. **Recovery of metals from metal-bearing hazardous waste has the potential to ameliorate the current U.S. balance of trade deficit. It may also become an important source of supply of strategic metals, particularly chromium.**

6. **Available data shows that metal recovery of hazardous waste should continue to increase in the 1990's as landfill capacity decreases and alternative forms of management are increasingly needed to support the U.S. hazardous waste management system.**

7. **EPA is currently in the process of conducting a series of activities which may encourage environmentally sound metal recovery of hazardous waste. These activities include the Definition of Solid Waste Task Force, proposed Special Collection System regulations, and proposed Universal Treatment Standards for hazardous wastes. EPA expects that each of these activities may encourage environmentally sound recycling.**

Chapter 1 Introduction and Overview to Metal Recovery of Hazardous Waste and Resource Conservation and Recovery Act Hazardous Waste Regulation

The United States Environmental Protection Agency (EPA) has developed this report pursuant to EPA's appropriation bill PL-102-389, signed by President Bush on October 9, 1992. This law requires EPA to conduct a report to: 1) assess the effect of existing regulations on efforts to recover metals from the Nation's wastes, 2) determine how such metal recovery can be encouraged, 3) determine how these materials should be regulated to protect human health and the environment and to effectuate the resource conservation and recovery goals of the Resource Conservation and Recovery Act (RCRA, 42 U.S.C. §§ 6901 to 6992k). PL-102-389 also directs EPA to consult with the Secretary of Commerce, the Secretary of Interior, the metals recovery industry and other interested parties. Upon completion of the report, EPA is required to submit its findings and recommendations to the Senate Committee on Environment and Public Works and the House Committee on Energy and Commerce.

Prior to passage of the appropriation bill in February 1992, EPA had committed to studying the relationship between metal recovery of hazardous waste and RCRA Subtitle C hazardous waste regulation. EPA initially committed to studying this issue as part of the RCRA Reform Initiative to evaluate RCRA Subtitle C regulatory impacts on the competitiveness of U.S. industries. The assumption underlying the study of this issue has been that RCRA Subtitle C regulation may be needlessly limiting metal recovery capacity in the United States from reaching its potential. Metal recovery as described in this report is believed to have important benefits for society including conserving hazardous waste landfill capacity, providing alternative sources of supply for strategic metals, mitigating our balance of trade deficit for metal commodities and creating new opportunities for investment for U.S. business. Metal recovery may also be more environmentally protective than traditional treatment and disposal although this depends on how metal-bearing hazardous wastes are managed.

The report is organized as follows. This chapter provides an introduction and overview of issues addressed in this report, including a definition of metal recovery, the relationship between metal recovery and pollution prevention, discussion of technologies for recovering metals from hazardous waste, an overview of metal-bearing hazardous wastes and an overview of RCRA Subtitle C regulatory requirements that impact metal recovery from hazardous waste. Chapter 2 discusses this report's methodology and limitations. Chapter 3 provides a characterization of metal-bearing hazardous waste including quantities generated and recovered, environmental risks posed by metal-hazardous waste and related issues. Chapter 4 provides a review of RCRA Subtitle C regulations affecting metal recovery of hazardous waste.

Chapter 5 provides an assessment of the effects of existing RCRA Subtitle C regulations on metal recovery of hazardous waste. Chapter 6 includes five case studies of metal recovery operations in the United States and how RCRA Subtitle C has affected their operations. Chapter 7 reviews the relationship between metal recovery of hazardous waste and balance of trade and strategic metals issues. Chapter 8 reviews ongoing EPA activities and other strategies to encourage environmentally sound metal recovery from hazardous waste including non-regulatory and incentive-based alternatives. Chapter 9 contains EPA's findings to Congress.

1.1 Description of Hazardous Waste/Terminology

Under RCRA, **hazardous waste** is defined as "a solid waste or combination of solid wastes which...may ... cause or significantly contribute to an increase in mortality or an increase in serious irreversible , or incapacitating reversible illness or... pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed" (42 U.S.C. §6903(5). As specified under RCRA Subtitle C, hazardous wastes are regulated by EPA (40 CFR Parts 260 to 272).

Under current EPA regulation, a solid waste may be hazardous in one of two ways. It may be **listed** by EPA through describing the materials from non-specific sources (F code wastes), specific sources (K code wastes) or commercial chemical products (P or U wastes). An example of a listed waste is K061, emission control dust from electric arc furnaces in steel production. A solid waste may also be a hazardous waste if it **exhibits a characteristic** for ignitability, corrosivity, reactivity or toxicity (D wastes). An example of a characteristic waste is D007, chromium-bearing wastes. Currently, there are eight metals that EPA has determined toxicity characteristic levels for: arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver (although a metal-bearing hazardous waste may exhibit a hazardous characteristic for reasons other than the metals contained). There are number of listed hazardous wastes that contain metal constituents. These are described in greater detail in Chapter 3.

Metal-bearing hazardous wastes refers to any RCRA Subtitle C hazardous waste that contains metal. It may or may not be amenable to recovery. Metal-bearing hazardous wastes are a subset of the larger group of **metal-bearing secondary materials** that also includes non-hazardous metal-bearing secondary materials. For purposes of this report, metal-bearing secondary materials refer to any material that contains metal and is not a raw material. Certain metal-bearing secondary materials are not considered to be hazardous wastes when managed for metal recovery such as characteristic sludges and by-products. Other materials such as scrap metal are exempt from Subtitle C hazardous waste regulation when reclaimed. These secondary materials are fully regulated as hazardous wastes when disposed of, used on or applied to the land, burned for energy recovery, used to produce a fuel or speculatively accumulated.

Because metal-bearing secondary materials such as characteristic sludges, characteristic by-products and scrap metal are closely related to metal recovery of hazardous wastes, these materials will be referred to in this report as **related secondary materials**.

1.2 Overview of Metal-Bearing Hazardous Wastes

This section provides background on metal-bearing hazardous wastes in the United States and aspects of their management for recovery or treatment and disposal. More detailed information on selected metal-bearing hazardous wastes is provided in Chapter 3. Metal-bearing hazardous wastes encompass a wide variety of materials. These can include process wastes like emission control dusts and wastewater treatment sludges or spent materials used in commerce such as solvents used for degreasing machinery or spent batteries. The hazardous metal constituents of these wastes include mercury, arsenic, chromium, cadmium, lead, nickel, barium, selenium, antimony, thallium, beryllium, and vanadium. These materials may or may not contain hazardous organic constituents. In contrast to hazardous organic constituents in hazardous wastes, hazardous metal constituents in metal-bearing hazardous wastes cannot be destroyed. They can only be reused or stabilized and disposed of to prevent exposure.

Not all metal-bearing hazardous wastes are amenable to recovery. Some metal-bearing hazardous wastes cannot be recovered or reused either because their metal content is too low or because of significant quantities of impurities or contaminants that cannot be removed due either to economic or technical limitations. Metal reclaimers usually set specifications for materials that they will process. Most often these specifications relate to levels of contaminants in feed material that can interfere with the process (e.g. limits on chlorides to prevent hydrochloric acid from forming in a furnace).

Often, the metal constituents being recovered from a metal-bearing hazardous waste is not the same metal constituents that make the waste hazardous. For example, for K061, emission control dust from electric arc furnaces, the primary metal constituents that are recovered are usually iron and nickel alloys or zinc. Two of the primary hazardous constituents of K061, lead and cadmium, are not the metal constituents initially recovered although the hazardous constituents may be shipped off site for further recovery. When the metal constituents that are recovered from a metal-bearing hazardous waste are primarily non-hazardous, the fate and transport of the **hazardous constituents** in the process becomes a concern. Rather than accompanying the recovered material, the hazardous constituents may partition to recycling process residuals such as slag or emission control sludge. If mismanaged, these constituents may pose a risk to human health or the environment through release to groundwater, surface water, crop uptake, air dispersion or direct human contact.

1.3 Definition of Metal Recovery

Under EPA regulations **recycling** is defined as either the **use, reuse or reclamation** of a material (40 CFR §261.1(c)(7)). Metal-bearing hazardous wastes can be recycled either through **reclamation** or through the **use or reuse of the material**. EPA defines reclamation as either **recovery** of useful product or **regeneration** of a product for its original use (40 CFR §261.1(c)(4)). Examples of recovery and regeneration are recovering zinc from emission control dust from a brass foundry (provided it is not land applied) or regenerating a spent solvent for its original use.

Under EPA's hazardous waste regulations, **metal recovery** is defined as the recovery of distinct components of a secondary material as separate end products (40 CFR § 261.1(c)(5)(i)). Metal recovery is a type of **reclamation** and is distinguished from **the use or reuse of the material**. An example of metal recovery of hazardous wastes is the smelting of lead plates from spent lead-acid batteries to recover lead values.

A secondary material may be used or reused either as **an ingredient in an industrial process to make a product** or as **an effective substitute for a commercial product**. An example of the use or reuse of metal-bearing hazardous waste as an ingredient in an industrial process is using electric arc furnace dust as an ingredient in the production of cement or fertilizer. An example of the use or reuse of a metal-bearing hazardous waste as a effective substitute for a commercial product is spent pickle liquor from steel finishing operations as a phosphorous precipitant and sludge conditioner in wastewater treatment.

Reclamation (including metal recovery) and the use or reuse of metal-bearing secondary materials to make a product are generally regulated differently by RCRA Subtitle C. Depending upon the type of material, materials being reclaimed can be solid wastes (that are also hazardous wastes) within RCRA Subtitle C jurisdiction. This is considered true for spent materials, listed sludges and by-products and scrap metal. Sludges and by-products that are characteristically hazardous (i.e., reactive, toxic, corrosive or ignitable) but not listed and commercial chemical products are not solid or hazardous wastes when reclaimed (40 CFR §261.2(c)(3)). (Please note that even though scrap metal being reclaimed is within RCRA Subtitle C jurisdiction, these materials are not currently subject to any Subtitle C regulatory requirements, 40 CFR §261.6(a)(3)(iv)). In contrast, when secondary materials that would otherwise be hazardous wastes are used to make new products without distinct components of the materials being recovered as end products, EPA generally considers this to be a type of direct use that is usually not considered to be a type of waste management (50 FR 633, January 4, 1985).

Accordingly, secondary materials are not considered to be solid waste when they are: 1) used as ingredients in an industrial process to make a product provided the materials are not being reclaimed, 2) used or reused as effective substitutes for commercial products or 3) returned to the original production process from which they were generated without first being reclaimed (40 CFR §261.2(e)). This does not apply to secondary materials that are either placed or applied on the land (although secondary materials applied in this manner are subject to reduced RCRA regulatory requirements), burned for energy recovery or used to produce a fuel.

This report concerns the metal recovery of hazardous waste and the effects RCRA Subtitle C regulation on such recovery. In Chapter 3, this report will discuss the use of metal-bearing hazardous waste as an ingredient to make a product as an alternative to metal recovery to assist understanding in possible policy outcomes that could result from Subtitle C regulatory modifications.

1.4 Relationship Between Metal Recovery and Pollution Prevention of Metal-Bearing Hazardous Wastes

This section outlines the relationship between pollution prevention and metal recovery of metal-bearing hazardous wastes. Traditionally, metal recovery of hazardous wastes has been viewed in contrast to other pollution management alternatives such as traditional treatment and disposal or other forms of recycling such as use as an ingredient. Because of limited capital for pollution prevention and management, proposals for regulatory or statutory modifications to encourage metal recovery that consider disposal as the only alternative to recovery may inadvertently undermine efforts to encourage pollution prevention. Because metal recovery is one form of recycling in a hierarchy between pollution prevention and traditional waste treatment and disposal, this section reviews the statutory basis for pollution prevention and reiterates the importance of viewing metal recovery broadly in order to consider its relationship to both pollution prevention and treatment/disposal.

1.4.1 RCRA Philosophy on Resource Conservation

The Congress stated its national goals for the RCRA statute in § 1003(a) (42 U.S.C. 6902(a)) as promotion of health and environmental protection, and conservation of "valuable material and energy resources." With respect to metal recovery of hazardous wastes, these goals support a general presumption toward keeping metals in the stream of commerce through minimizing their land disposal or other release to the environment.

Relative to hazardous wastes, the 1984 amendments to RCRA explicitly stated the concept of eliminating or reducing wastes in the first place. In the 1984 amendments, the Congress declared that the reduction or elimination of hazardous waste generation at the source should take priority over the management of hazardous wastes after they are generated. In particular, Section 1003(b), 42 U.S.C. 6902(b), of RCRA provides:

> The Congress hereby declares it to be the national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment.

In this declaration, the Congress established a clear national priority for eliminating or reducing the generation of hazardous wastes. At the same time, however, the national policy recognized that some wastes will "nevertheless" be generated, and such wastes should be managed in a way that "minimizes" present and future threat to human health and the environment.

To the extent that metal-bearing hazardous wastes can be reduced or eliminated from generation in the first place, the policy confirms the Act's objective of conserving resources, including metals, that would otherwise enter the nation's waste streams. Those metal-bearing hazardous wastes that cannot be prevented from being generated should be managed so that health and the environment are protected.

Examples of organizations which generate metal-bearing hazardous wastes, and which have taken specific measures to reduce or eliminate those wastes, are listed in Appendix A to this report. The examples listed in Appendix A show situations in which natural resource use decisions resulted in cost savings.

1.4.2 Pollution Prevention Act Policy, Source Reduction And Its Relationship To Metal Recovery of Hazardous Waste

In 1990, the Congress further clarified the role of pollution prevention in the nation's environmental protection scheme, by passing the Pollution Prevention Act (PPA) (Public Law 101-508, 42 U.S.C. 13101, et seq.). In Section 6602(b) of this law, 42 U.S.C. §13101(b), the Congress stated that:

> [T]he national policy of the United States [is] that pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.

Thus, the Congress set up a hierarchy of management options for pollutants in descending order of preference: prevention or source reduction, environmentally safe recycling, environmentally safe treatment, and environmentally safe disposal. This hierarchy is consistent with the national policy stated in RCRA; it essentially expresses a preference for reducing generation of wastes and related secondary materials, and then for recycling them in a manner that will be protective of human health and the environment, over using them and then treating them and discarding them.

The PPA[1] defines the term "source reduction" as:

"any practice which (i) reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment or disposal; and (ii) reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants. The term includes equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvement in housekeeping, maintenance, training or inventory control. ...The term "source reduction" does not include any practice which alters the physical, chemical or biological characteristics or the volume of a hazardous substance, pollutant or contaminant through a process or activity which itself is not integral to and necessary for the production of a product or providing of a service."

There is still considerable discussion about whether and what type of on-site recycling activities may qualify as either "pollution prevention" or "source reduction". However, there is general agreement that source reduction includes material substitution, process modification, modified operating practices.

Material substitution involves replacing high toxicity feedstocks with those that are less toxic or non-toxic (or those that generate less waste). Process modifications involve changes to the equipment that lead to the reduced generation of wastes. Modified operating practices are changes that are dependent upon human participation to effect a reduction in waste generation.[2] The metal finishing/electroplating industry has several examples of each type of source reduction. Materials substitution alternatives do exist for metal production operations, although these alternatives primarily focus on reducing non-metal-bearing wastes such as wastewater or eliminating the use of toxics. Examples in the plating industry include the use of deionized water to reduce the generation of waste solutions, and the use of non-cyanide plating solutions and trivalent chromium plating and chromating solutions to reduce the generation of cyanide and hexavalent chromium.

Process modifications in the plating industry include the use of drain boards to catch drips and re-direct them back to the correct process bath, modified rinse techniques (agitation, flow restrictors, conductivity cells, spray and air rinses, and multiple rinse-tanks) and dragout recovery tanks to recapture process solution. These techniques tend to focus on forms of recovery that reduce the generation of wastewater and loss of process solution. Such modifications reduce the generation of metal-bearing waste by reducing the volume of the metal-bearing wastestream that is disposed and recovering the metals within those streams.

The third method for reducing metal-bearing waste generation is altering operating practices. For the plating industry alternatives include improving controls on process solutions, prolonging withdrawal and drain times, reducing rinse (i.e., contact) time, orienting the process to retain process solution, and improved housekeeping and employee training and education.

Since this report focuses on encouraging metal recovery (a type of recycling) relative to treatment and disposal, it is important to recognize the potential disincentive to source reduction through encouraging metal recovery of hazardous waste. In evaluating the cost-effectiveness of source reduction options, businesses generating hazardous waste may compare the cost of alternatives to source reduction; recycling, treatment and disposal. If the cost of either recycling or treatment/disposal is significantly less than source reduction, this may serve as a disincentive to source reduction. So, while encouraging environmentally sound metal recovery may be generally preferable to treatment and disposal of metal-bearing hazardous waste, it may also be a potential disincentive to source reduction.

Given the national policies on pollution prevention that have been stated in environmental legislation, the question that arises is how to alter the structure of U.S. laws and regulations in a manner that provides incentives for reducing metal-bearing hazardous wastes at the source, and also provides incentives for recovering metal-bearing hazardous wastes. The difficult policy issue involved in addressing the issue is how to modify RCRA statutory authority or Subtitle C regulation in a manner that protects human health and the environment through taking advantage of both source reduction and metal recovery opportunities. It is an issue that although EPA has identified, the Agency has not yet finalized an approach to assure that incentives for source reduction are maintained if compliance costs for metal recovery are substantially reduced. EPA will continue to study this issue in order to develop approaches to implement the hierarchy established by Congress in the PPA.

1.5 Overview of Metal Recovery Technologies

While a thorough discussion of metal recovery technologies for hazardous wastes is beyond the scope of this report, this section provides a brief description of various metal recovery technologies that are available for hazardous waste.[3] To simplify this discussion, most metal recovery technologies for hazardous wastes can be classified into one of two general types of extractive metallurgy: 1) pyrometallurgy or 2) hydrometallurgy. Please note as mentioned above in Section 1.2 that applying these technologies to any metal-bearing secondary material may be limited by technical and/or economic factors such as the level of recoverable metals in the material or the amount of contaminants that may preclude recovery.

1.5.1 Pyrometallurgy

Pyrometallurgy is defined by the American Society of Metals (ASM) as the "high temperature winning or refining of metals".[4] Pyrometallurgical technologies "uses heat to separate desired metals from undesired constituents based on differences between constituent oxidation potential, melting point, vapor pressure, density, and/or miscibility when melted".[5] Examples of pyrometallurgical processes include drying, calcining, roasting, sintering, retorting, smelting.

Drying is used to remove bulk water from wet concentrates, ores and fluxes. These processes usually operate near the boiling point of water. **Calcination** involves heating a metal-bearing material around 1000°C to 1500°C to cause metal carbonates to form metal oxides.

Roasting is a process where a metal-bearing material is heated to just below the melting point in the presence of a gas to cause a chemical change to remove impurities such as sulfur from the material. Roasting differs from calcination in that the latter heats material without adding air or oxygen to the charge.

Sintering is one form of roasting where temperatures are raised high enough to cause a partial fusion of the feed materials to form a "sinter" or "sintercake".[6] Sintering is used to process feed materials for further pyrometallurgical recovery to eliminate particulates that might partition to the off gases of the process.

Retorting refers to the distillation of metals in a vessel to reduce them above their boiling point from a metal oxide or other compound to a base metal form (e.g., elemental mercury). Previously common for zinc refining, retorting is now used commonly for mercury.

Smelting is a generic term for applying heat and a reductant to a metal to reduce it to elemental form. For example, adding coke (carbon formed without oxygen) and iron ore (in the form of an iron oxide) to form elemental iron.

1.5.2 Hydrometallurgy

Hydrometallurgy is defined by ASM as the "industrial winning or refining of metals using water or an aqueous solution".[7] Hydrometallurgical technologies "separate desired metals from undesired constituents based on differences between constituent solubilities and/or electrochemical properties in aqueous solutions (or organic solutions in the case of solvent extraction)".[8] Examples of hyrdometallurgical processes include leaching, chemical precipitation, electrolytic recovery, membrane separation, ion exchange, and solvent extraction.

Leaching refers to dissolving a solid material into solution using a solvent, usually a strong acid or base material such as sulfuric acid or ammonia.

Chemical precipitation involves the addition of substances to metals suspended in solution to cause the metals to separate from solution through sedimentation. Substances used to precipitate metals out of solution include caustic soda, lime, ferrous and sodium sulfide, soda ash, sodium borohydride, and sodium phosphate. One common application is for chemical precipitation is removing metals from electroplating wastewaters.

Electrolytic recovery or **electrowinning/electrodialysis** involves running an electric current through an aqueous solution to charge suspended metals which then deposit onto a plate immersed in the solution with an opposite charge.

Membrane separation technologies such as microfiltration, ultrafiltration and reverse osmosis are means of physically separating metals from solution through various types of filters. This form of technology is commonly used with chemical treatment for rinse waters.

Ion exchange involves suspending a medium, either a synthetic resin or mineral, into solution where suspended metal ions in solution are exchanged onto the medium with hydrogen or hydroxyl ions which transfer into the solution. Metal ions that are exchanged onto the exchange medium can be regenerated through leaching or other processes.

Solvent extraction uses either an organic or aqueous solvent to selectively extract metals from solid, liquid or sludge material.

Both pyrometallurgical and hydrometallurgical process have been used for years to extract, beneficiate and process primary metals from raw ores. More recently, these technologies have been applied with varying degrees of success to metal-bearing hazardous wastes. Rather than being used separately, these processes are used in combination with one another to produce finished metals available for commerce.

1.6 Overview of RCRA Subtitle C Provisions Affecting Metal Recovery From Hazardous Waste

This section provides an overview of RCRA Subtitle C regulations that currently affect metal recovery. Chapter 4 will discuss the most significant RCRA regulatory provisions such as, land disposal restrictions (related to residual management costs at metal recovery operations), the derived-from rule, permitting, and corrective action in more detail.

A number of regulatory incentives currently exist in Subtitle C to encourage environmentally sound metal recovery of hazardous waste. As discussed in Chapter 5, the greatest regulatory incentive in RCRA Subtitle C are the combination of increasing hazardous waste disposal costs and rising treatment costs. The latter are largely attributable to the **Land Disposal Restriction (LDR) treatment standards**. These standards specify either performance or technology standards that must be met for restricted wastes prior to land disposal.

An example of a performance standard is requiring that a lead-bearing hazardous waste cannot leach more than 5 parts per million prior to land disposal. Often, to meet a performance standard, some form of treatment such as stabilization is required. A technology standard requires that a particular form of technology such as incineration or high temperature metal recovery be used prior to any land disposal.

LDR treatment standards encourage metal recovery of hazardous waste in two ways. These treatment standards have added significantly to treatment and disposal costs of metal-bearing hazardous wastes which has forced generators of these materials to consider metal recovery as a cost-effective management alternative. Also, a limited number of treatment standards under the Land Disposal Restrictions specify recovery for metal-bearing wastes including lead-bearing and cadmium-bearing batteries, high mercury-bearing wastes and emission control dust from secondary lead smelting. Thus, in both ways, LDR treatment standards have contributed to the creation of markets for metal recovery services.

A second regulatory incentive is the **exemption for scrap metal that is reclaimed** from Subtitle C regulation. This exemption was promulgated with the amended definition of solid waste in 1985 to ensure that scrap metal being reclaimed was not inhibited by RCRA regulation.

Another regulatory incentive is the **conditional exclusion from the definition of solid waste for sludges and by-products that are characteristically hazardous (e.g., leaching hazardous metal constituents above regulated levels) that are reclaimed**. This exclusion provides that characteristic sludges and by-products that would be hazardous wastes if disposed of, burned for fuel or placed on the land are excluded from RCRA Subtitle C jurisdiction when reclaimed. Although this exclusion was developed for jurisdictional purposes, it appears to have had a substantial impact on metal recovery of these materials.

A fourth regulatory incentive is that persons who generate, transport or store but do not reclaim **spent lead-acid batteries that will be reclaimed** are exempt from certain Subtitle C regulations including manifesting and storage permit requirements (40 CFR §266.80). This provision has been promulgated to encourage efficient collection of these batteries prior to reclamation. EPA has also recently proposed a rule that accomplish the same result for cadmium-bearing batteries.

A fifth regulatory incentive to encourage metal recovery in RCRA Subtitle C is the precious metal exemption. Under Subtitle C, persons who generate, transport or store precious metal-bearing wastes for **precious metal recovery** are subject only to notification and limited reporting requirements (40 CFR §266.70). This exemption has been promulgated because EPA recognizes that these materials are valuable and are likely to be managed in a manner that minimizes their potential for loss.

A related regulatory variance exists for **partially-reclaimed secondary materials**, which is available for metal-bearing as well as other secondary materials. Materials that have been reclaimed but must be reclaimed further, including secondary metal concentrates, that would otherwise be solid and hazardous wastes, may be excluded from the definition of solid waste through a variance procedure at the discretion of the Regional Administrator (40 CFR § 260.30).

While normally a hazardous waste being reclaimed remains a hazardous waste until the reclamation process is complete, some partially-reclaimed materials may be more commodity-like (e.g., managed in a manner to minimize loss) than waste-like and qualify for the variance.

A seventh regulatory incentive under RCRA Subtitle C is that **the recycling process itself** is generally not subject to regulation although, as mentioned below, storage prior to metal recovery is a regulated and permitted activity (40 CFR §261.6(c)(1)). One exception to this general rule is that pyrometallurgical metal recovery operations may be subject to **Boiler and Industrial Furnace (BIF) requirements**. However, metal recovery operations are conditionally exempt from recently promulgated BIF requirements when burning solely for metal recovery (e.g., not energy recovery or destruction).

Slag generated from **high temperature metal recovery of electric arc furnace dust (K061), wastewater treatment sludge from electroplating operations (F006) and spent pickle liquor from steel finishing operations (K062)** that is disposed of in RCRA Subtitle D (i.e., non-hazardous) landfill may be generically excluded provided it meets specified health-based levels.

The regulated community has also identified a number of RCRA Subtitle C requirements that are **impediments** to metal recovery. These provisions are described in greater detail in Chapter 4. Briefly, the most important of these regulatory impediments includes the derived-from rule which affects the status of process residuals, storage permit requirements, facility-wide corrective action and financial assurance.

The **derived-from rule** states that residuals from processing listed metal-bearing hazardous waste, such as slag from metal recovery operations, remain hazardous waste and must be managed in compliance with Subtitle C regulations (40 CFR Part 261.3(c).

A second regulatory disincentive may be **storage permit requirements** for metal-recovery operations that store metal-bearing hazardous wastes prior to reclamation (40 CFR Part 261.6(c)(1). Industry has commented that the permitting process is expensive and time-consuming.

Additional impending Subtitle C regulatory requirements that metal recovery operations that are regulated as TSDFs have identified include **facility-wide corrective action and financial assurance** requirements. Facility-wide corrective action would require a metal recovery operation that stores prior to reclamation, in a manner for which it would require a RCRA permit, to address **all** solid waste management units within facility boundaries such as waste piles or surface impoundments without regard to the current owner/operator's responsibility for creating these units.

These units would be subject to corrective action if hazardous waste or constituents of hazardous waste are released to the environment. Such facilities are also subject to financial assurance requirements to ensure environmentally sound closure and post-closure care along with financial assurance for any corrective action obligations.

Both facility-wide corrective action and financial assurance requirements are statutorily mandated for owner/operators of permitted facilities (RCRA §§ 3004(a),(t),(u),(v), 3005(a);42 U.S.C. §§ 6924(a),(t),(u),(v) 6925(a)). For metal recovery of hazardous wastes, facilities usually become subject to facility-wide corrective action and financial assurance requirements when the facility is required to obtain either a storage permit or a Boiler and Industrial Furnace permit when the facility is not burning solely for metal recovery.

Chapter 2 Report Methodology And Limitations

The purpose of Chapter 2 is to lay out the scope and approach of this report and explain how EPA plans to respond to the issues Congress directed the Agency to study in PL-102-389. Chapter 2 will also discuss some of the limitations of this report as well as major sources of uncertainty surrounding the analysis.

Congress directed EPA to study three issues in PL-102-389 in October 1992: 1) the effect of existing regulations on efforts to recover metals from the Nation's wastes, 2) how such metal recovery can best be encouraged, and 3) how the materials should be regulated in order to protect human health and the environment and effectuate the resource conservation and recovery goals of the Resource Conservation and Recovery Act. The main question Congress seemed to be asking was whether changes in Subtitle C regulation could be expected to increase metal recovery. As discussed below, the Agency has attempted to answer this question, but due to many data limitations, the Agency can only answer in a general sense.

The scope of wastes that EPA has chosen to study are metal-bearing hazardous wastes that are subject to most or all Subtitle C regulatory requirements. These include listed metal-bearing hazardous wastes and spent materials that are hazardous wastes when reclaimed, such as spent-lead acid batteries. Due to time and resource constraints, EPA believes that Subtitle C wastes that are subject to most or all Subtitle C regulation would emphasize regulatory effects more clearly than other metal-bearing secondary materials that are subject to comparatively fewer regulations because managing these wastes entails greater regulatory compliance cost.

2.1 Data Sources and Limitations

EPA has tried to use a diversity of approaches to address the questions raised by Congress. To study these questions, EPA has conducted data collection and research through literature search, consultation with experts both within EPA and other Federal agencies, and outreach with representatives of the metal recovery industry, generators of metal-bearing hazardous wastes and state regulatory agencies.

EPA has used in-house resources to complete on-line data base searches and literature searches from its library system to retrieve relevant studies, articles and reports on the metal recovery of hazardous waste. EPA has consulted with the Department of Interior and the Department of Commerce. EPA has conducted informal briefings for both Departments and has consulted with them through peer review of portions of this report.

EPA has also consulted the regulated community and selected state governments in completion of this report. EPA has reviewed information submitted by trade associations representing generators and reclaimers of metal-bearing hazardous waste and information provided by case-study respondents. Time limitations and limited data availability affected the quality of some of the submissions. In addition, EPA has completed five case studies of metal recovery operations to provide case specific information on the effect of RCRA Subtitle C regulation on metal recovery of hazardous waste. Drafts of case studies in Chapter 6 were peer reviewed by both the respondent as well as the state regulatory agency responsible for oversight of the facility. EPA has not conducted audits or other verification of claims made by case study respondents and trade association respondents. Trade association responses are discussed generally throughout the report and specifically in Chapter 5. Case studies are presented in Chapter 6.

These approaches have enabled EPA to analyze the issue of how RCRA Subtitle C regulations affect metal recovery of hazardous waste. The Agency has tried to look not only at regulatory impacts on metal recovery of hazardous waste, but also, where possible, market factors related to metal demand that may affect the end uses and demand for recovered metals. As mentioned below, both economic and technical feasibility are important independent factors affecting metal recovery of hazardous waste.

The Agency has looked at data on the generation and management of metal-bearing hazardous wastes between 1980 and 1989. One limitation of analysis is that the most current data are over three years old, preceding the March 1990 Toxicity Characteristic (TC) rule. This rule revised the testing procedure for determining whether or not a waste exhibits a toxic characteristic (i.e., leach amounts of toxic constituents above regulated levels in simulated landfill conditions; the new procedure is called the Toxicity Characteristic Leaching Procedure or TCLP). The data examined under this report were subject to the old extraction procedure (EP) toxicity test. Because materials that would be non-hazardous under the EP test may be hazardous under the TCLP (the TCLP is generally regarded as the more conservative test of the two), the current universe of metal-bearing hazardous waste subject to Subtitle C regulation may be much larger than the data analyzed in this report.

Data limitations have affected the level of analysis throughout this report. Determining how RCRA Subtitle C regulation affects metal recovery of hazardous wastes is difficult due to data limitations and uncertainty resulting from independent factors influencing metal recovery such as world metal demand. In the process of completing this report, EPA has identified several data limitations to a more accurate evaluation of metal recovery of hazardous waste and related secondary materials.[9] These limitations include:

- limits on data to determine what proportion of particular hazardous waste stream is technically amenable to recovery,

- limits on data to evaluate and quantify the metal recovery of related secondary materials such as scrap metal and characteristic sludges and by-products that would be regulated as hazardous wastes if discarded in a manner other than reclamation,

- limits on data to accurately determine recovery rates for all metal-bearing hazardous wastes and related secondary materials including materials recovered and reinserted into the original production process.

EPA has used, where feasible, other data bases such as the Toxics Release Inventory to draw inferences where more direct data is not available.

2.2 Other Factors Affecting Metal Recovery

In the course of doing this report, EPA learned that identifying the impacts of Subtitle C regulations on metal recovery is quite a complex task. One should note that a major limitation in answering the question of how RCRA Subtitle C regulation affects metal recovery from hazardous waste is the uncertainty in distinguishing between RCRA Subtitle C regulation and other statutory/regulatory requirements and non-regulatory factors (non-RCRA factors) affecting metal recovery from hazardous wastes. Other statutes and regulations affecting metal recovery frequently mentioned during EPA's report include Superfund (the Comprehensive Environmental Response, Compensation and Liability Act or CERCLA), Clean Water Act, and the Clean Air Act. State and local government regulation may also affect metal recovery operations.

The main non-regulatory factors affecting the metal recovery of hazardous waste are the technical and economic feasibility of applying metal recovery technologies to hazardous wastes. The technical feasibility of recovering metals addresses the question of whether or not a given hazardous waste is amenable for recovery. Some metal-bearing hazardous wastes may not be recovered either because they do not contain recoverable levels of metals or because they are so contaminated with undesirable constituents that they cannot be processed sufficiently to make them saleable in the market.

In traditional microeconomic analysis, one would expect that the economic feasibility of a metal recovery operation will depend upon the owner/operator making sufficient revenue to cover the total cost of operation plus a fair return on the investment. Metal recovery operations processing hazardous wastes can derive revenue in one of two ways: 1) user fees, and 2) sale of recovered metals. The operation can charge a user fee to generators of hazardous waste to process it and/or it can gain revenue through the sales of its recovered product. In most cases, sufficient revenues must be obtained from this fee to make the operation profitable. Few metal recovery operations processing hazardous waste are profitable solely on the sale of recovered metals. (Precious metal reclaimers may be the exception to this case). The user fee that a metal recovery operation can charge a generator of hazardous waste depends largely on the fees charged for alternative management methods of the waste: traditional treatment and disposal, or use as an ingredient.

To minimize costs, a generator of hazardous waste will generally evaluate the alternatives available and select the most cost-effect alternative. Of course, there are factors other than cost which may influence this decision such as perceived long term liability of disposal, and land disposal restrictions requirements specifying recovery of hazardous waste as the treatment standard prior to land disposal. One point worth noting is that one of the main ways in which RCRA Subtitle C has encouraged metal recovery of hazardous waste is by raising treatment and disposal costs increasing the viability of metal recovery as an alternative. This is elaborated on in Chapter 5.

The revenue that a metal recovery operation can obtain through the sale of its recovered products depends upon world market conditions for metal commodities. Other things being equal, a higher price for metals will encourage metal recovery; a lower price will discourage it. Market price for metal is a function of both supply and demand for metals. Market demand for metal commodities is a function of global economic activity and the availability of non-metal substitutes for metal end uses (e.g., substituting plastic for metal in automobiles). Market supply of primary metals is a function of short term and long term factors. Short term factors include labor disputes, political conflicts, liquidation of commodity stockpiles and natural disasters. Long term factors may include proven commodity reserves and development of new technologies for extracting metal from ores.

Both regulatory and non-regulatory factors limit EPA's ability to accurately answer the questions of how RCRA Subtitle C affects metal recovery and how metal recovery can be encouraged. These non-RCRA factors will independently encourage or discourage metal recovery irrespective of whatever regulatory modifications for RCRA Subtitle C the Agency may propose.

2.3 Summary of Impact of Data Limitations

For all of these reasons, EPA cannot accurately predict that a certain amount of additional metal recovery will result from a specific change in RCRA Subtitle C regulations. Where possible, EPA will identify in this report how non-RCRA factors have or may affect metal recovery. Therefore, regulatory modifications to RCRA Subtitle C may be necessary, but not sufficient, conditions to encourage increased environmentally sound metal recovery. Where possible, however, EPA has identified areas where metal recovery may be increased, at least in a qualitative sense.

Chapter 3 Characterization of RCRA Subtitle C Metal-Bearing Hazardous Waste

Chapter 3 describes the characteristics and provides background information of metal-bearing hazardous wastes evaluated in this report. This description includes information about the types and quantities of the wastes generated, recovery rates of these materials where this information is available, damage incidents at hazardous waste sites from metal recovery operations, metal hazard descriptions, releases to the land of metals, elaboration on the use of metal-bearing hazardous waste as an ingredient in a production process as an alternative to metal recovery (e.g., metal-bearing hazardous waste used to produce cement vs. recovery to produce metal).

3.1 Metal-Bearing Hazardous Wastes: Generation and Recovery

This section summarizes available data on metal-bearing hazardous wastes and related secondary materials, including the quantity generated as well as the type and quantity of these materials managed for recovery, and metals recovered. To obtain the information available on metal-bearing hazardous waste, EPA has consulted three sources: 1) 1989 Biennial Reporting Systems (BRS) data on metal recovery[10], 2) industry/trade association estimates submitted in completion of this report [11], and 3) engineering firms and consulting firms knowledgeable regarding metal recovery of hazardous waste.[12]

3.1.1 Quantities of Metal-Bearing Hazardous Wastes Generated

This subsection provides estimates of metal-bearing hazardous wastes generated in the United States. The scope of wastes described in this subsection is limited to the types of metal-bearing hazardous wastes that may be amenable to metal recovery. For example, K048-K052 are metal-bearing petroleum wastes that are generally not considered amenable to metal recovery. They are not included in this subsection. Also, certain hazardous wastes and related metal-bearing secondary materials are not included in this data because they are exempt from the reporting requirements, e.g., such as scrap metal (exempt from BRS reporting and exempt from RCRA regulation when destined for reclamation), characteristic sludges and by-products destined for reclamation (not a solid waste, exempt from BRS reporting).

Table 3-1 summarizes 1989 Biennial Reporting Systems data analyzed in completion of this report on quantities of metal-bearing hazardous waste generated in the United States. These wastes were selected as metal-bearing hazardous waste streams that may have portions that are amenable to recovery. As is true with any estimate, the quantities listed in Table 3.1 are approximations of the actual quantity of waste generated, but it gives the reader general information on quantities generated. The estimated 8.224 million tons of these metal-bearing hazardous waste represent 4.2 percent of the total 197.5 million tons of hazardous waste generated.

Table 3.1 Estimated Quantities of Selected Metal-Bearing Hazardous Waste In The U.S.

Waste Code/Description	Quantity In Short Tons
1. D004/Characteristic Arsenic Waste	482,737
2. D005/Characteristic Barium Waste	16,184
3. D006/Characteristic Cadmium Waste	274,252
4. D007/Characteristic Chromium Waste	3,016,404
5. D008/Characteristic Lead Waste	1,121,555
6. D009/Characteristic Mercury Waste	17,895
7. D010/Characteristic Selenium Waste	392,255
8. F006/Wastewater Treatment Sludge From Electroplating Operations	1,252,072
9. F007/Spent Cyanide Plating Bath Solutions From Electroplating Operations	92,757
10. F008/Bottom Plating Bath Residues From Electroplating Operations	11,895
11. F019/Wastewater Treatment Sludge From Conversion Coating of Aluminum	51,879
12. K061/Emission Control Dust From Electric Arc Furnaces In Steel Production	550,000
13. K062/Spent Pickle Liquor Generated From Steel Finishing Operations	904,945
14. K069/Emission Control Dust From Secondary Lead Production	3126
15. K071/Brine Purification Muds From Chlorine Production	23,881
16. K088/Spent Potliners From Primary Aluminum Production	11422
17. K106/Wastewater Treatment Sludge From Chlorine Production	826
Total	8,224,085

3.1.2 Metal-Bearing Hazardous Wastes Managed For Metal Recovery

Based on literature reviewed, 1989 BRS data and information provided by trade association, EPA estimates that approximately 1.9 million tons of metal-bearing hazardous waste are annually managed for metal recovery. This estimate represents a partial estimate for six metal-bearing hazardous waste categories of the total amount of hazardous waste being managed for metal recovery. This is true because of the BRS limitations identified above and because the trade association information was submitted within a relatively short time frame with available data. It is likely that this estimate underestimates the true quantity of these wastes being managed for metal recovery.

This estimate also excludes metal-bearing hazardous wastes that are: 1) exempt from regulation (including BRS reporting) such as scrap metals or 2) related secondary materials such as characteristic sludges and by-products that would be hazardous wastes if disposed of but are excluded from the definition of solid waste because they are reclaimed and are therefore not reported. Also, some metal recovery operations will not comply with BRS reporting requirements, thus excluding their metal recovery from EPA data. Table 3.2 summarizes the amount and type hazardous wastes and related secondary materials being reclaimed as well as the recovery rate (where available) and metals recovered.

Table 3.2 Estimated Quantities of Hazardous Wastes And Related Secondary Materials Managed For Metal Recovery

Type of Waste	Quantity Managed For Metal Recovery (000 Tons)	Recovery Rate (Percent of Total Managed For Metal Recovery)	Metals Recovered
K061/Electric Arc Furnace Dust	500	90	Zn, Pb, Cr, Cd, Ni, Fe
F006/Wastewater Treatment Sludge From Electroplating Operations	163 (EPA estimate)	15 to 20 percent (NAMF estimate)	Zn, Cd, Fe, Cr, Ni, Cu, Ag, Au
K062, Spent Pickle Liquor From Steel Finishing Operations	193 (AISI, SMA estimate)	52 of reported subtotal of K062; total recovery rate probably lower	Fe, Cr, Ni
Miscellaneous Characteristic Metal-Bearing Hazardous Wastes	164.6 (BRS estimate of mixed D wastes)	unknown	Cr, Pb, other
Nickel-cadmium batteries	1.686	23.5,[13] (EPA 1993)	Ni, Cd
Spent-lead acid batteries	873 (BCI estimates)	96.5 percent (1991 National Recycling Rate Study, BCI 1993)	Pb
Total	1895.28	23 percent	

3.1.3 Summary of Metal-Bearing Hazardous Waste Generation and Recovery

Based on data reviewed in completion of this report, large quantities of metal-bearing hazardous wastes are not being managed for metal recovery, but rather for treatment and disposal. While the exact proportion is not known, many of these wastes are not technically amenable for recovery either because they are too contaminated with impurities or because they are too low in metal content.

These wastes will continue to be treated and disposed of irrespective of what regulatory modifications are made to RCRA Subtitle C until new technologies are developed to make these wastes amenable to recovery. Other metal-bearing hazardous wastes that are amenable to recovery are being treated and disposed of currently and may be a potential source for increased recovery in the future resulting from regulatory modifications to RCRA Subtitle C.

While data limitations preclude estimating quantities of metal-bearing hazardous wastes that are amenable to recovery but managed for disposal, information submitted by trade associations to EPA (and discussed in more detail in Chapter 5) indicates that lead based paint remediation waste, K062 spent pickle liquor from steel finishing wastes, F006 wastewater treatment sludge, brass foundry waste, ferrous foundry waste, surface finishing waste, galvanizing waste and others may be in plentiful supply (i.e., well over 1 million tons total generated annually). As mentioned later in this report, opportunities to facilitate this recovery may depend as much on markets for recovered metals as it does on regulatory modifications to RCRA Subtitle C. Of the waste streams EPA identified in Table 3.2, F006, wastewater treatment sludge from electroplating operations, may have the greatest potential for additional recovery. With an estimated recovery rate of only 15 to 20 percent, the 1.2 million tons F006 generated annually represents the second largest metal-bearing hazardous waste stream identified in this report (behind characteristic chromium wastes).

3.2 Metal Recovery Use or Recycling Alternatives: Use/Reuse of Metal-Bearing Hazardous Waste

As mentioned in Chapter 1, EPA considers recycling under Subtitle C to include the use, reuse, or reclamation of secondary materials which may or may not be considered hazardous wastes under RCRA depending on how the materials are managed. The importance of understanding the distinction between the use or reuse of a secondary material and the reclamation of secondary materials is that any changes to RCRA Subtitle C regulation that affect metal recovery (a type of reclamation) may influence quantities of secondary materials managed for use or reuse as well.

The use or reuse of metal-bearing secondary materials as ingredients in an industrial process or a substitute for a commercial product (hereafter referred to as use/reuse) represents an alternative form of management to either metal recovery or traditional hazardous waste treatment and disposal. As mentioned in Chapter 1, EPA traditionally views use/reuse as being more similar to a normal production process in contrast to reclamation which is considered to be more similar to waste management activities. EPA made this distinction in the 1985 modifications to the definition of solid waste largely on a jurisdictional basis rather than a risk basis. This difference has lead to different status under RCRA Subtitle C regulation.

Metal recovery is a type of reclamation and is subject to some RCRA Subtitle C regulation (e.g., storage prior to reclamation) for many types of secondary materials. Notable exceptions include characteristic sludges and by-products being reclaimed (which are not solid wastes and therefore not hazardous wastes) and scrap metal being reclaimed (which are solid and hazardous wastes but are currently exempt from Subtitle C regulation).

In contrast to metal recovery, the use or reuse of a secondary material as either an ingredient in an industrial process or as an effective substitute for a commercial product are generally not within the definition of solid waste (40 CFR §261.2(e)(1)). As mentioned in Chapter 1, this general rule does not apply to the use or reuse of secondary materials used directly in a manner constituting disposal or used to produce products that are applied to the land, burned directly for energy recovery or used to produce a fuel, that are speculatively accumulated or are inherently waste-like (40 CFR §261.2(e)(2)).

Products derived from hazardous wastes that are recycled by being used on the land are conditionally exempt from full RCRA Subtitle C regulation. These waste-derived products must be available for the general public's use, have undergone a chemical reaction to become inseparable by physical means, and (with the exception of K061 derived fertilizer) must meet treatment standards specified in Part 268 of the Code of Federal Regulations (or RCRA Section 3004(d) where no treatment standard is specified).

The result of the difference in regulatory status between use/reuse and reclamation is that the current RCRA Subtitle C regulatory structure may do more to encourage use/reuse than reclamation. Since the use/reuse of metal-bearing hazardous wastes are generally excluded from the definition of solid wastes, this form of management is not subject to any RCRA Subtitle C regulatory requirements.

By contrast, the process of reclaiming metal-bearing hazardous waste is generally exempt from regulation (BIF permit requirements are one exception). However, residues from the reclamation process are still subject to the derived-from rule and storage prior to reclamation is subject to Subtitle C regulation including permit requirements. Due to time and data limitations, EPA has not reached a conclusion as to whether this difference under the current Subtitle C regulatory structure is warranted.

Reliable estimates of the types or quantities of metal-bearing hazardous wastes that are recycled through use or reuse and related secondary materials recycled through use or reuse that would be hazardous wastes if otherwise managed are not available. Most of both types of materials are not subject to Agency reporting requirements such as the Biennial Reporting System. Through experience, the Agency has learned that much of the use/reuse of metal-bearing hazardous wastes has involved using these materials as ingredients in fertilizer, construction materials such as cement or aggregate.

The following example illustrates how a generator of a listed metal-bearing hazardous waste may choose to recycle the waste. K061 is an emission control dust from electric arc furnaces and the particulate matter is captured in an air pollution control device called a "baghouse". This pollution control dust is composed of various metals: zinc, lead, cadmium, iron and sometimes nickel and chromium. EPA has listed the waste as hazardous and set a treatment level for K061 extracts (i.e., leachate) based upon high temperature metal recovery (40 CFR §268.41). The generator (the operator of the steel mill) can select any management method for K061 so long as it meets this treatment standard for leachate prior to land disposal. As an alternative to stabilization and land disposal, a generator might select one of a variety of recycling alternatives (assuming it is legitimate) for the K061. Recycling alternatives for K061 could include:

- use as fertilizer
- use as an ingredient in glass frit for abrasive blast, roofing shingles, glass ceramic or ceramic glaze
- use as an ingredient in the production of cement
- use an ingredient in the production of aggregate
- management for zinc recovery, lead recovery, cadmium recovery, or ferronickel or ferrochromium recovery.

Although EPA has a general preference for environmentally sound recycling over treatment and disposal, the Agency has not studied the issue to determine whether reclamation of metal value is preferable to use or reuse of a material in its entirety as a substitute for a nonwaste material from a policy standpoint. Much depends upon the specific waste and recycling alternative and attendant risks and benefits. The K061 generator will select his management alternative for disposal or recycling in part on prospective liability and compliance costs (as a function of total cost). If the generator selects recycling as its choice, each recycling alternative would have a distinct impact on society in terms of the risk to human health and the environment as well as the value of the material recovered or used. These impacts may present tradeoffs that need to be considered to determine how these materials should be regulated to optimize RCRA's dual goals of environmental protection and resource conservation.

These tradeoffs may involve amenability of the material to future recovery (i.e., keeping the metal in commerce perpetually), the quality of material recovery (i.e., recycling a material for its highest use as opposed to downgrading a material to a lower value use), risk to human health and the environment (note: it is possible that some forms of treatment and disposal may be more protective than some forms of recovery).

In the example of K061 mentioned above, the zinc constituents of the waste may serve adequately, if recovered, as a zinc oxide or zinc metal for medicinal or manufacturing uses. The end use of the zinc may leave it in a form where it is amenable for further recovery such as galvanizing (i.e., the zinc in the scrap metal may be recovered) or put to an end use such as fertilizer where the zinc values are ultimately lost to the environment. Alternatively, if the K061 is used directly to make cement, the iron constituents of the waste may contribute to the production of the cement, while the zinc constituents may be downgraded to a lower value use relative to recovered zinc metals or compounds.

The risks to human health and the environment from the zinc recovery operation and the cement kiln may vary as well as the value of material recovery for the zinc constituents. In this example, the mobility of hazardous metal constituents in the waste-derived cement product would be compared with exposure from both slag from the zinc recovery operation as well as the end use of the recovered zinc itself.

In sum, one management option may offer superior material recovery but may or may not necessarily be more environmentally protective. Due to data limitations, an evaluation of these tradeoffs for metal-bearing hazardous waste streams is beyond the scope of this report.

3.3 An Overview of Damage Incidents, Hazard Descriptions, Management Methods and Releases to the Environment By Metal-Bearing Hazardous Waste

In order to understand how RCRA Subtitle C regulation of metal-bearing hazardous wastes may protect human health and the environment, it is necessary to understand how these materials may become a problem if mismanaged. Evaluating damage incidents at hazardous waste sites involving metal recovery, descriptions of the intrinsic hazards of metal constituents of hazardous waste, and estimates of releases to the environment of metals from hazardous waste support concerns about the mismanagement of metal-bearing hazardous waste. This section provides a perspective of how metal-bearing hazardous wastes have affected human health and the environment when mismanaged, what hazards are intrinsic in the metals themselves, how these materials are supposed to be managed currently, and what releases to the environment are currently on-going.

EPA has analyzed three sources of damage incidents involving metal-bearing hazardous waste: the Records of Decision (RODS) Data Base, involving NPL sites; the Damage Incident Data Base (DIDB), and the RCRA Implementation Study Update: The Definition of Solid Waste (Environmental Damages Caused by Hazardous Waste Recycling Practices). EPA also reviewed epidemiological literature regarding public health and hazardous waste to evaluate the relative impact of metals from hazardous waste on public health.[14]

To assess the intrinsic hazard of various metals, EPA reviewed relevant literature. Finally, EPA examined 1991 Toxic Release Inventory (TRI) data of releases to land and off-site transfers to estimate total loadings of hazardous metals constituents from hazardous wastes. It is possible that a portion of these loadings are not attributable to hazardous waste, so this indicator can only serve as an estimate or proxy of releases to the environment from metal-bearing hazardous wastes.

3.3.1 Damage Incidents At Hazardous Wastes Sites Involving Metal-Bearing Hazardous Waste

In 1991, the National Research Council of the National Academy of Sciences reported that heavy metals that were relatively prevalent at Superfund sites and which are toxic included lead, chromium, arsenic, cadmium, and nickel.[15] The report did not contain further information on the risks posed by these metals. The National Research Council also indicated that a significant number of activities at Superfund sites involved recycling operations (for metal and non-metal materials) and activities related to the generation of metal-bearing hazardous waste.

1991 EPA data reported in the National Research Council study indicated that over 9 percent of 1189 final Superfund sites involved recycling operations (including recycling of non-metals).[16] 1988 EPA data indicated that activities at 1177 proposed and final Superfund sites related to the generation of metal-bearing hazardous waste included 63 electroplating activities, 36 ore processing/refining smelting activities, and 23 battery recyclers .[17] Finally, the National Research Council report adapted 1989 ASTDR data involving documented migration of hazardous substances into specific media from 951 selected Superfund sites. The data involving metal migration is summarized below in Table 3.3.

EPA has recently compiled a list of damage incidents resulting from recycling operations.[18] A subset of these damage incidents have resulted from or are associated with metal recovery operations. To update this effort, EPA examined the RODS and DIDB data bases to retrieve more specific information about damage incidents associated with Superfund sites and other hazardous waste sites. These analyses revealed 38 sites including 21 Superfund sites where contamination of heavy metals was associated with metal recovery operations.

In some of the cases, activities other than metal reclamation occurring on site may have contributed to or been the cause of the metal contamination. Also, other releases from metal recovery activities such as fugitive air emissions may be responsible for contamination.

Table 3.3 Migration of Hazardous Metals Into Media At Superfund sites[1]

Metal	# of Sites with migration	Ground water	Surface water	Soil	Air	Food	Sediment
Lead	327	234	138	122	37	50	114
Chromium	224	159	84	88	28	39	84
Arsenic	(1)36*	92	46	54	16	19	50
Cadmium	112	72	49	45	18	21	44
Mercury	58.	29	24	20	6	10	19
Nickel	55	30	24	15	3	8	21
Beryllium	9	2	3	1	0	0	3

* Although the text indicates **36** sites rather than **136**, this appears to be a typographical error since the number of migration sites for each media exceed the number of total sites with migration. Since arsenic is located between chromium with 224 total sites and cadmium with 112, the correct number of total arsenic sites appears to be 136.

The database searches were not exhaustive and only a limited keyword search was used. These results may underestimate the total number of hazardous waste sites associated with metal recovery operations. The searches revealed limited information about the type of metal recovery operations involved at the site and the environmental risks or level of contamination at the site, or the type of activity at the site (e.g., processing, storage, spills, etc.).

Approximately 19 of the 38 sites involved lead recovery from spent lead-acid batteries. Generally, the site contamination resulted from improper disposal of battery casings (the outer shell of the battery after the lead plates have been removed) and battery acid. The abstracts of the site incidents indicated that soil and groundwater contamination resulted from the mismanagement. Other anecdotal information indicated air quality problems, increased facility employee blood lead levels and harming vegetation (e.g., killing cyprus trees) next to the facility.

Of the remaining 19 non-battery hazardous waste sites involving metal recovery, the activities there are as follows:

1 copper smelting facility
2 secondary copper recovery facilities
1 stainless steel slag recovery operation
2 precious metal recovery operations

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[1] Please note that the total number is less than the sum of all media because each site may include more than one type of medium of migration.

1 brass reprocessing operation
1 aluminum processing facility
1 drum recycling facility
1 metal and plastic parts manufacturing facility
1 titanium dioxide manufacturing plant
3 scrap metal operations including an auto salvage yard
1 steel emission control dust recovery operation
2 miscellaneous metal recovery operations
2 hazardous waste treatment facilities (the nature of metal recovery occurring at these sites, if any, is not clear from the abstract)

Based on the data, the environmental contamination and risks associated with these hazardous wastes appear to be comparable to the battery hazardous waste sites. Soil and groundwater contamination are the most prevalent types of contamination. In selected cases, public health may be threatened by site proximity to public drinking water wells.

This review of hazardous waste sites involving metal recovery indicates that when metal-bearing hazardous wastes being recovered are mismanaged that the resulting releases to the environment may threaten public health. It is also evident that the risk of mismanagement occurs across a variety of different types of metal recovery operations. However, it is not possible from this data to estimate the current population at risk from metals at hazardous wastes sites.

3.3.2 Descriptions of Metal Constituents of Hazardous Waste

Risk of metal-bearing hazardous waste is a function of the intrinsic hazard of the metal constituents of the waste and the **potential for exposure** of the material. This section summarizes relevant hazard information on selected metals.[19] Section 3.3.3 will describe current management methods and summarize the most current release information for these metals. Table 3.4 summarizes basic information regarding the uses and hazards associated with metal constituents found in hazardous waste. More detailed information on these metals is provided in Appendix B.

Table 3.4 Common Uses and Hazard Description of Metal Constituents Found In Hazardous Wastes

Metal	Common Uses	Hazard Description
Lead	batteries, solder, ammunition	acute and chronic toxin, symptoms: nerve & kidney dysfunction; brain damage
Cadmium	batteries, pigments, plastics	acute & chronic toxin, symptoms: nausea & abdominal pain; linked to kidney disease, heart disease, emphysema; possible carcinogen
Arsenic	wood preservatives, pesticides, electronics	acute & chronic toxic, symptoms: shock, coma, death; Class A carcinogen
Chromium	steel alloy, metal plating	hexavalent form is toxic; Class A carcinogen; ecotoxin
Mercury	batteries, electrical uses, chlorine manuf., light bulbs	neurotoxin, symptoms: memory loss, motor disturbances, kidney damage, death; ecotoxin
Nickel	steel alloy, batteries, electroplating	toxicity in nickel carbonyl or high doses; possible carcinogen
Selenium	colored glass, photocells, semi-conductors,	acute & chronic toxin, recorded cases are rare; ecotoxin
Zinc	metal alloy	low risk of toxicity in humans; ecotoxin
Barium	electric tubs, radium carrier	acute toxin
Beryllium	copper alloy, ceramics	acute & chronic toxin, probable human carcinogen

3.3.3 Management Methods and Estimates of Releases Resulting From Metal-Bearing Hazardous Wastes

EPA has reviewed literature to attempt to estimate potential releases of metal constituents from hazardous wastes. Data has been limited in this regard. The Agency has used 1991 Toxic Release Inventory (TRI) data listed in Table 3.5 below for this purpose.

After viewing how releases to the environment of metal-bearing hazardous waste have affected the environment when mismanaged, it is important to note how metal-bearing hazardous wastes are supposed to be handled in light of current RCRA Subtitle C management standards as well as potential routes of exposure that may potentially pose a risk to human health or the environment.

Frequently, metal-bearing hazardous wastes that are solid (i.e., not wastewaters) are in the form of sludges from pollution control devices or by-products from production processes. These materials may be stored by the generator for up to 90 days in a tank, container or containment building provided they comply with management standards for these units.

Generators will frequently treat characteristic wastes on-site in tanks and then dispose of the residuals in Subtitle D facilities (e.g., landfills) either on-site or off-site. Alternatively, generators may elect to ship hazardous waste off-site in containers for treatment/disposal or recovery/reuse. Containers used to ship metal-bearing hazardous wastes off-site often include 55 gallon drums.

At off-site treatment, storage, or disposal facilities (TSDFs), metal-bearing hazardous wastes are off-loaded from hazardous waste transporters into storage areas where the materials are either stored until a sufficient quantity of the material is accumulated for processing or the materials are pre-processed for insertion into the treatment or reclamation process. Storage at these facilities in units other than tanks or containers is generally prohibited (40 CFR §268.50). This means that managing these wastes in outdoor waste piles would not permissible under current Subtitle C regulation.

The problem that RCRA Subtitle C regulation has tried to address in the handling of metal-bearing hazardous wastes is the release of metal constituents of the waste to the environment. There are several **routes of exposure** that are of potential concern including air releases from metal dusts, migration into groundwater, and surface water runoff. Other routes of exposure include crop uptake and soil ingestion (children). Humans are exposed to metal constituents from these routes through ingestion, inhalation or dermal contact.

In trying to evaluate the potential environmental impact of metal-bearing hazardous wastes, EPA looked at recent data from the Toxics Release Inventory (TRI)[20] to analyze estimates of total releases of metals and their compounds to land and off-site transfers. Releases to land and off-site transfers represent a surrogate for loadings to the environment from metal-bearing hazardous waste. However, TRI releases are <u>not</u> equivalent to exposure of hazardous wastes and so this data cannot be equated with risks to human health and the environment associated with these metals. As stated in the 1991 TRI Release Inventory, risk is a function of many factors including the toxicity of the chemical, persistence of the chemical in the environment, bioconcentration in the food chain and the environmental medium to which the chemical has been released.[21] Releases in TRI may include disposal of metal-bearing hazardous wastes in landfills or treatment in surface impoundments. Because design standards of these units and prior treatment of the wastes, the metal constituents themselves may be immobilized thus minimizing their risk to the environment.

TRI data is limited to manufacturing firms and so releases of metals from the service sector may not be included in TRI. Notwithstanding this limitation, the 1991 TRI data summarized in Table 3.5 show that the following metals and metal compounds released to land or transferred off-site for treatment or disposal (in thousands of pounds).

Table 3.5 Releases To Land and Off-site Treatment and Disposal of Selected Metals

Metal & Compounds	Release To Land/Offsite Transfers For Treatment and Disposal/**Total** (in thousands of pounds)
Zinc and zinc compounds	123,279/55,294/**178,573**
Chromium and chromium compounds	25,916/19,942/**45,858**
Lead and lead compounds	17,022/20,053/**37,075**
Barium & barium compounds	4,266/19,716/**23,982**
Nickel and nickel compounds	1,672/8,966/**10,638**
Arsenic and arsenic compounds	4,473/2,189/**6,662**
Cadmium and cadmium compounds	251/1407/**1,658**
Mercury and mercury compounds	5/193/**198**
Beryllium and beryllium compounds	59/120/**179**
Selenium and selenium compounds	80/59/**139**

3.3.4 Conclusions Regarding Damage Incidents, Hazard Descriptions, Management Methods and Releases to the Environment of Metal-Bearing Hazardous Wastes

Notwithstanding the prevalence of damage incidents associated with spent lead-acid battery recovery, it appears that the potential for mismanagement of hazardous wastes handled for metal recovery extends across a variety of many different metal recovery operations. From the damage incident abstracts, it appeared that most of the mismanagement occurred from abandoning wastes on site in piles or in surface waters where the material dispersed quickly. The most prevalent form of contamination mentioned was groundwater contamination.

The hazards posed to human health or the environment by different metal constituents of hazardous waste are also varied including acute and chronic toxicity, neurotoxicity, carcinogenicity, and ecotoxicity. Under RCRA Subtitle C management, metal-bearing hazardous wastes are supposed to be managed properly from generation until discard or recovery to prevent the release of these constituents.

In terms of estimated releases to the environment, one observation that becomes apparent when viewing the Tables in Chapter 3 is that from a quantitative standpoint, **chromium** and **lead** are the two most prevalent toxicity characteristic metals in terms of generation of characteristic metal wastes, prevalence in Superfund sites, or TRI release estimates. The other observation that follows is that lead appears to be recovered at greater rates than chromium due to the high recovery rates of K061 and spent-lead acid batteries. Chromium recovery is comparatively low owing in part to low F006 and D007 recovery. The importance of chromium as a strategic metal and opportunities for its recovery are mentioned in Chapter 7 of this report.

Chapter 4. RCRA Regulations Affecting Metal Recovery Operations

This chapter summarizes how several key RCRA regulatory provisions apply to metal reclamation. In general Subtitle C regulations were developed to protect human health and the environment, with some consideration given to the regulatory impact on recycling. The regulations discussed here are the ones thought to have the greatest impact on metal recovery of hazardous wastes. EPA determined this from information submitted by trade associations, economic data and related sources. Chapter 5 will assess the impact of these provisions on metal reclamation of hazardous waste.

At the outset it is important to note that, as discussed above, EPA chose to focus on hazardous wastes that are fully regulated under Subtitle C for this report. Therefore, the regulations governing metals reclamation discussed below do not apply to the reclamation of precious metals or scrap metal. Precious metals reclamation is subject to a reduced set of requirements under 40 CFR Part 266, Subpart F.[22] Scrap metal destined for recycling is exempt from Subtitle C regulation under 40 CFR §261.6(a)(3)(iv). Both of these industries have voiced concerns with the impacts of RCRA and CERCLA on their operations, but given limited time, EPA decided to focus on industries more fully regulated under RCRA. Also, it is important to recognize that metals reclamation is conducted in both on-site (i.e., at the same facility that generates the metal-bearing waste) and off-site processes. In general, on-site recycling is regulated somewhat less stringently than is described below. Also, metal recovery may be conducted in many steps which may all be on the same site but also may entail shipment of some sidestreams to off-site reclaimers. This affects storage permit requirements and the need for transportation.

4.1 Land Disposal Restrictions

The Land Disposal Restrictions (LDR) program, added to RCRA by the Hazardous and Solid Waste Amendments (HSWA) of 1984, requires that hazardous wastes that are to be land disposed[23] must meet treatment standards prior to disposal. The LDR program mandates that prior to land disposing of a hazardous waste the waste must either: contain concentrations of specified hazardous constituents in either the waste extract (i.e., leachate) or the wastes (i.e., total constituent concentration) that are below specific levels established by EPA; or, have been treated using a specific treatment technology designated by the Agency.[24]

Both the concentration-based standards and the treatment technologies designated under the LDR program are those determined by EPA to constitute levels or methods of treatment that substantially reduce the toxicity of the waste and reduce the likelihood of migration of hazardous constituents from the waste, thereby minimizing any threat posed by such waste to human health and the environment. These standards are considered to represent performance achieved using the best demonstrated available technology (BDAT).

The LDR standards have been implemented under a phased schedule. Most, but not all, of the standards are presently in place. Table 4-1 lists several of these metal-bearing wastes and the Federal Register notice containing the corresponding LDR treatment standards.

Table 4.1 Examples of Metal-bearing Wastes and Corresponding BDAT Publication Dates

Metal-Bearing Wastes	Federal Register Publication
F006, K004, K008, K061, K062, K069, K100, K048, K049, K050, K051, K052	53 FR 31137; 8/17/88
F006, F007, F008, F009, F010, F011, F012, F019, K005, K007	54 FR 26593; 6/23/89
F006, K060, K002, K003, K004, K005, K006, K007, K008, Characteristic Wastes	55 FR 22519; 6/1/90

Since many metal-bearing wastes are RCRA hazardous wastes[25], the LDR regulations apply to certain aspects of the generation, transport, and reclamation of these wastes. For example, generators of hazardous metal-bearing waste must determine if their waste is subject to the LDR and whether the waste meets LDR treatment standards. If the waste is restricted and does not meet LDR standards, the generator must provide a notice to the treatment or storage facility (i.e., reclamation facility) indicating the applicable treatment standards and applicable waste prohibition levels. Restricted wastes that meet LDR standards must be accompanied by a notice and certification of compliance with applicable standards. Generators must also maintain all data pertaining to the regulatory status of the waste as well as all notices, certifications, and other required documentation.

LDR requirements applicable to recycling (i.e., reclamation) facilities prohibit the storage of hazardous wastes restricted from land disposal unless the wastes are stored in tanks, containers, containment buildings or drip pads and such storage is solely for the purpose of accumulating sufficient quantities of hazardous wastes as are necessary to facilitate recovery, treatment, or disposal. If such storage is for purposes of legitimate accumulation, storage may occur for up to a year unless the Agency can demonstrate that storage for extended periods of time is not necessary. Where the owner/operator can prove that such extended storage is necessary to facilitate the recovery, treatment, or disposal of these wastes, storage may be conducted for longer than one year. As applied to reclamation, this restriction prohibits the storage of metal-bearing waste directly on the land in waste piles and/or surface impoundments and limits the flexibility of facilities storing metal-bearing wastes.

The LDR also prohibit the dilution of restricted hazardous wastes and residuals where dilution facilitates compliance with or avoidance of LDR treatment standards. Several forms of metals reclamation involve the addition of materials (i.e., reagents) to the metal-bearing waste as part of the recovery process. This could be construed as impermissible dilution if the practice serves only as a substitute for adequate treatment or allows the waste to avoid the applicable treatment standard. Where this is the case, the reclamation process would either have to be altered or abandoned.

4.2 Derived-From Rule

The derived-from rule[26] provides that a solid waste (e.g., sludge, spill residue, ash, emission control dust, or leachate) generated from the treatment, storage, or disposal of a hazardous waste remains a hazardous waste unless it is delisted, or, where the waste is hazardous solely because it exhibits a hazardous characteristic, the residual waste no longer exhibits a hazardous characteristic. The rule also provides that materials that are reclaimed from solid waste and then used beneficially are not solid or hazardous wastes unless burned for energy or used in manner constituting disposal, i.e., products of reclamation are not regulated unless the product is burned or placed on the land.

In addition, an amendment to the derived-from rule[27] conditionally exempts non-wastewater residues, such as slag, resulting from high temperature metals recovery (HTMR) processing of the listed hazardous wastes K061, K062 and F006 conducted in specified reclamation units,[28] provided the residue meets specified exclusion levels, does not exhibit any hazardous characteristics, and is disposed in Subtitle D units (e.g., non-hazardous landfill).

The effect of the derived-from rule is that where metals are being reclaimed from listed metal-bearing hazardous wastes, the recovered metals are not hazardous wastes when used beneficially (and not burned or applied to the ground). In addition, slag generated from high temperature metals recovery (HTMR) processing of K061, K062 or F006 is also not regulated as a hazardous waste provided it meets the conditions noted above. However, slag that does not meet the generic delisting HTMR exemption retains its identity as a listed hazardous waste subject to full RCRA regulation (including LDR requirements). Where metals are recovered from characteristic hazardous wastes, the slag is **fully** regulated under Subtitle C if it exhibits a hazardous characteristic (otherwise it is not regulated). Additionally, slag resulting from reclamation of a metal-bearing hazardous waste remains subject to LDR requirements even if the slag does not exhibit a hazardous characteristic at the point of disposal.[29] Thus, the products derived from metals reclamation are not generally regulated whereas the residuals, with specified exceptions, often are.

4.3 Interim Status & Permitting

Under Subtitle C of RCRA, owners/operators of facilities that treat, store, or dispose of hazardous waste (TSDFs) are subject to standards and permitting requirements under Sections 3004 and 3005 of RCRA (promulgated as regulatory requirements under 40 CFR Parts 264 and 270). Qualified facilities may operate under interim status standards without a permit (40 CFR Part 265) pending an Agency decision on the permit application. All interim status facilities must submit a Part A application which includes general facility information such as name, address, types of hazardous wastes managed and processes conducted. A Part A application is required for TSDFs operating under interim status.

In addition to a Part A application, permit applicants are also required to submit a Part B permit application which contains more extensive information regarding the facility. Although there is no standard Part B application form, the application itself must address relevant TSDF standards including standards for the specific type of facility/unit such as a landfill or incinerator.

Part B applications usually address comprehensive information requirements such as waste analysis plans, closure and post-closure plans, financial assurances, contingency plans. Additional information provided in a Part B application includes groundwater monitoring data, specific information for the type of unit on-site (e.g., waste pile), and information on solid waste management units (SWMUs) on-site. The issuance of a RCRA Part B permit triggers facility-wide corrective action requirements, which are discussed in detail in section 4.5 below, and financial assurance standards.

Under RCRA Subtitle C recycling processes are generally not subject to permitting requirements (40 CFR §261.6(c)(1)). In contrast, storage of hazardous wastes prior to reclamation is subject to permit requirements (40 CFR §261.6(c)(1). Since metals reclamation is considered a form of recycling,[30] reclamation processes are among those that until recently have not had to obtain a RCRA permit.

The recently promulgated Burner and Industrial Furnace (BIF) rule, discussed in section 4.4 below, does generally require permits for smelting operations that are not burning solely for metal recovery (i.e. are burning for energy recovery or burning for destruction as well). However, the BIF rule provides a conditional exemption from this permitting requirement such that the reclamation process in a metals recovery operation may not have to operate subject to a RCRA permit (see discussion of BIF rule, below).

Generators storing hazardous metal-bearing waste on-site must have interim status or obtain a Subtitle C permit if they store the waste for longer than 90 days or if they store in a unit that is not a tank, container, or containment building, such as a surface impoundment or waste pile (40 CFR §262.34) (Please note that storage in waste piles or surface impoundments is prohibited unless the wastes meet LDR treatment standards). New off-site facilities must obtain their storage permit prior to commencing construction, and existing facilities must comply with interim status requirements prior to obtaining their final (i.e., Part B) permit.

4.4 Financial Assurance

Under the current RCRA Subtitle C regulations (40 CFR §264/265, Subparts F and H), hazardous waste treatment, storage, and disposal facilities (TSDFs) are subject to financial assurance requirements with respect to closure, post-closure, and corrective action activities. These requirements ensure that facilities have the ability to finance proper closure, post-closure care, and corrective action.

Both interim status and permitted storage facilities must meet financial assurance requirements for closure and post-closure care (note post-closure is required only if the facility has disposal units).[31] Essentially, facilities are required to develop and annually update detailed written cost estimates for closure and post-closure care and to establish financial assurance in the form of a trust fund, letter of credit, insurance, financial test and corporate guarantee, or surety bond guaranteeing performance or being paid into a trust fund. In addition, facilities must carry liability coverage, with coverage minimums of one million dollars per occurrence and two million dollars aggregate, annually, exclusive of legal defense costs.

The closure cost estimate must be based on third-party costs and must approximate final closure costs at the point during the facility's active life when closure would be most expensive. The post-closure cost estimate must be in current dollars and must be based on the current annual costs required for post-closure care maintenance, which are then multiplied by the post-closure care period. Both the closure and post-closure cost estimates must be revised annually to account for inflation.

Corrective action financial assurance is also required for any TSDF operating under interim status that contains a solid waste management unit and is applying for a RCRA hazardous waste permit. Where corrective action cannot be completed prior to applying for the permit, the permit must include assurances of financial responsibility for completing any corrective action needed due to prior or continuing releases. These assurances of financial responsibility must address on-site releases as well as releases that have migrated beyond the facility boundary.

4.5 Corrective Action

Any RCRA facility seeking an operating (e.g., storage) or post-closure permit must comply with corrective action requirements imposed under §3004(u) and (v) of RCRA. Under these requirements, facilities must address, on a facility-wide basis, all past releases of hazardous waste or hazardous constituents from solid waste management units (SWMUs). SWMUs are defined to include any discernable waste management unit at a RCRA facility from which hazardous waste or hazardous constituents might migrate, irrespective of whether the unit was intended for the management of solid or hazardous waste.

EPA retains authority under several other sections of RCRA to require either corrective action or remedies for hazardous waste releases. First, when there has been a release of hazardous waste into the environment from an interim status facility, EPA is authorized under §3008(h) of RCRA to issue an order requiring corrective action necessary to protect human health and the environment. Second, when there is evidence of imminent and substantial endangerment to health or the environment resulting from improper management of hazardous waste, the Agency is authorized under §7003 of RCRA to file suit in the appropriate U.S. district court to prevent or remedy the problem. Finally, under its omnibus authority, §3005(c)(3), EPA is authorized to include terms and conditions as necessary to protect human health and the environment.

Solid waste management units managing hazardous waste, as well as those managing non-hazardous waste, must be cleaned up as part of obtaining a RCRA permit. This means that a reclamation facility seeking a storage permit must conduct facility-wide corrective action for all solid waste management units before the permit may be issued or the permit must contain a schedule of compliance to conduct corrective action at the facility after permit issuance. Additionally, corrective action may encompass cleanup beyond the facility boundary in circumstances where the contamination has resulted from the migration of on-site releases beyond the facility boundary.

4.6 Boiler and Industrial Furnace Rule

Under EPA's Boiler and Industrial Furnace (BIF) rule,[32] smelting, melting and refining furnaces are regulated as industrial furnaces. However, these furnaces are conditionally exempt from regulation under the BIF rule provided that they process hazardous waste solely for metal recovery, and if the facilities meet the following requirements. First, to be exempt from requirements imposed under 40 CFR §266.102 (Permit Standards for Burners) and §266.111 (Standards for Direct Transfer), smelting furnaces must:

- provide a one-time notice to the Director indicating: the claim of exemption, that the waste is being burned for metals recovery and is not being burned for destruction or as a fuel (as defined in §266.100(c)(2)), that the waste contains recoverable levels of metals, and that the owner will comply with applicable sampling, analysis, and recordkeeping requirements;

- sample and analyze the waste and feedstocks as necessary to comply with 266.100(c) using accepted EPA analytical methods (SW-846); and

- maintain records documenting compliance for three years, including records of toxic organic constituents, Btu value, and levels of recoverable metals.

Second, hazardous waste meeting either of the following criteria are not considered to be burned solely for metals recovery and thus are fully regulated under the BIF rule:

- waste with a total concentration of Appendix VIII organic compounds exceeding 500 ppm by weight (as generated -- such wastes are considered to be burned for destruction);

- waste with a heating value of 5000 Btu/lbs. or more (as fired -- such wastes are considered to be burned as fuel).

In addition, despite the conditional exemption discussed above, smelting furnaces processing hazardous waste for metals recovery remain subject to the requirements established under 40 CFR §§266.101 (Management Prior to Burning), and 266.112 (Regulation of Residues). Under §266.101, generators and transporters are subject to 40 CFR §§262 and 263, respectively, and storage facilities are subject to the applicable provisions of Subparts A-L (General TSD standards and technical storage standards) of 40 CFR Parts 264, 265, and 270.[33] Section 266.112 provides that residues from furnaces processing hazardous waste are not exempt from the definition of a hazardous waste under §§261.4(b)(4), (7) and (8), (exemptions for special wastes) unless the device meets specific criteria[34] and the hazardous waste does not significantly affect the residue.

Thus, the BIF rule restricts the waste that can be reclaimed and imposes administrative provisions upon the reclamation process itself.

4.7 Hazardous Waste Manifesting And Transportation

Generators of metal-bearing hazardous wastes are generally subject to manifesting requirements (40 CFR Parts 262 Subpart B). Generators of spent lead-acid batteries destined for reclamation or scrap metal destined for recycling are not subject to these requirements. Generators who are subject to manifest requirements may not have their wastes shipped by transporters who have not received an EPA hazardous waste identification number (40 CFR §262.12).

Transporters of hazardous waste are subject to transportation standards in 40 CFR Part 263. These requirements include obtaining an EPA identification number (40 CFR 263.11), compliance with manifesting requirements (ensuring delivery to designated facility) (40 CFR §§263.20 and 21) and appropriate recordkeeping and reporting requirements.

Both the generator and the transporter are subject to Department of Transportation requirements promulgated under the authority of the Hazardous Materials Transportation Act (HTMA). For generators these requirements include identifying and classifying waste according to DOT's Hazardous Materials table (49 CFR §172.101), compliance with packaging, marking and labeling requirements (49 CFR Parts 172 and 173), determination if additional shipping requirements are appropriate (49 CFR 49 CFR Parts 174 to 177 and providing appropriate placards to the transporter (49 CFR §172.506). Transporters are required to follow applicable DOT regulations listed in 49 CFR Parts 171-179.

Finally, hazardous waste shipped under the manifest are subject to EPA's waste export regulations found at 40 CFR Part 262 Subpart E. The export regulations require that EPA and the State Department provide written notice to a country prior to the export of the waste. The export may proceed only after the receiving country consents to the shipment.

4.8 Summary

Table 4-2, below, summarizes the key regulatory requirements applicable to metals reclamation operations. As is apparent, metals reclamation is subject to a variety of requirements under RCRA. These requirements affect most aspects of the process. Key requirements include those addressing permits, the management of residual wastes such as slag, and the BIF rule. There is general agreement that the requirements discussed here are the ones with the greatest impacts on metal recovery.

As discussed above, Subtitle C permits may be required for storage of hazardous waste prior to reclamation or for the reclamation process itself under industrial furnace standards. These permit requirements are significant because facilities must expend significant time and resources to achieve compliance. In addition, permitted units become subject to corrective action and financial assurance requirements, each of which imposes additional significant costs upon the permitted operation. However, some smelters have configured their operations such that hazardous waste is fed directly into the process such that no storage permit is required.

Similarly, the management of residual slag is important largely because of the costs and potential liability associated with proper treatment and disposal. Such treatment and disposal includes compliance with applicable LDR requirements. However, some primary smelters that process hazardous waste generate slags are that are exempt from regulation as "Bevill Wastes"[35] so long as the character of the slag has not changed as a result of the hazardous waste used as a feedstock. Finally, the BIF provisions are key requirements because they may affect metal recovery operations that do not qualify for the exemption for burning solely for metal recovery.

Table 4-2. Key RCRA Provisions Applicable to Metals Reclamation

On-Site Metals Reclamation	
Metal-Bearing Hazardous Waste Generator	• LDR notice and certification
Storage	• 90-Day storage allowed without permit • Permit required after 90 days (corrective action/financial assurance) • LDR allows for legitimate accumulation and restricts storage to tanks, containers, drip pads, accumulation units. • Storage standards (40 CFR Parts 264, 265)
Reclamation	• BIF waste restrictions and notice, sampling, and recordkeeping requirements
Off-Site Metals Reclamation	
Transportation	• Manifest required • DOT HTMA requirements • Reporting and recordkeeping requirements • Export requirements
Storage	• Permit required • Corrective action/Financial assurance • LDR requires legitimate accumulation and restricts storage to tanks, containers, containment buildings and drip pads • Storage standards (40 CFR Parts 264, 265)
Reclamation	• BIF waste restrictions and notice, sampling, and recordkeeping requirements (BIF permit if not conditionally exempt)
Reclaimed Product	• Exempt from regulation where not burned or applied to ground
Reclamation Residual	• K061 Conditional exemption • Derived-from hazardous waste • LDR treatment standards & certification