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Ore Mining and Dressing Preliminary Study Report

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Cover photos clockwise from top left: Bagdad pit; tailings embankment for the Mammoth Tailings Impoundment; pregnant leach solution pond at the toe of the Bagdad Mine's leach pad; saleable copper cathode produced from Morenci's SXEW plant. All photos were taken during EPA's site visits to Freeport McMoran copper mines in Arizona during August 2009 (see *Site Visit Report: Arizona Copper Mines* [DCN 07219]).

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1.0 INTRODUCTION

The purpose of this report is to summarize the analytical approach, research activities, and findings of the Ore Mining and Dressing Preliminary Study that EPA conducted to examine why discharge concentrations controlled under pollutant limitations in the Ore Mining and Dressing Effluent Limitations and Guidelines (ELG) (40 CFR Part 440) ranked relatively high compared to other industries in the 2002 through 2008 304(m) effluent guidelines program plans. The purpose of the study was to identify, collect, and review readily available information to determine whether additional analysis or revision of 40 CFR Part 440 might be warranted.

The main focus of the preliminary study was on active mines covered under 40 CFR Part 440 Subpart J: “Copper, Lead, Zinc, Gold, Silver, and Molybdenum Ores.” These types of mines comprise approximately 76 percent (263) of the approximately 345 ore mines in the United States. Approximately 294 mines currently have National Pollutant Discharge Elimination System (NPDES) water discharge permits. There is a discrepancy between the total number of mines and the number of mines with NPDES permits because not all mines have water discharges. The approximately 1,870 placer mines, covered under 40 CFR Part 440 Subpart M, were not examined by this study because they employ mining practices and produce wastewater streams that are fundamentally different from mines covered under the other subparts of 40 CFR Part 440.

The preliminary study examined information pertaining to the two types of wastewater discharged by ore mines: process wastewater (including mine drainage) and stormwater. Process wastewater is covered under 40 CFR Part 440. Stormwater is not covered under 40 CFR Part 440 unless it is commingled with process wastewater prior to discharge to a surface waterbody. The comprehensiveness of the preliminary study was limited by incomplete national-level process wastewater discharge data, and the lack of any nationally representative stormwater data.

To facilitate this study, EPA identified and collected existing discharge monitoring data, assessed mine-specific process wastewater discharge information, reviewed available Total Maximum Daily Load (TMDL) reports, reviewed mine site stormwater discharge information for 19 mines in Arizona and Montana, and reviewed an industrial wastewater treatment technology known as high density sludge recycling.

1.1 Key Definitions

This subsection clarifies key terms used in this report.

Mining, Dressing (Beneficiation), and Mineral Processing

Ore mining consists of three major types of operations: mining, dressing, and mineral processing. 40 CFR Part 440 pertains to wastewater from mining and dressing activities, but not from mineral processing, which is covered under 40 CFR Part 421.

The term “mining” is specific to the process of extracting ore from the earth, which mostly involves either open pit excavation or deep mining. The term “dressing,” no longer used by the ore mining industry, has been replaced by the term “beneficiation.” They mean the same thing, however, which is the initial attempt to liberate and concentrate the mineral from the mined rock. Beneficiation operations include crushing, grinding, washing, dissolution, crystallization, filtration, sorting, sizing, drying, pelletizing, briquetting, or roasting in preparation for leaching, gravity concentration, magnetic separation, electrostatic separation, flotation, amalgamation, and heap, dump, vat, tank, and *in-situ* leaching.

Mineral processing operations generally follow beneficiation and include techniques that change the chemical composition of the ore mineral, such as ion exchange, solvent extraction, smelting, electrolytic refining, and acid attack or digestion. The physical structure of the mineral is often destroyed, producing products and waste streams that are not earthen in character, bearing little or no resemblance to the materials that entered the operation.

Overburden, Waste Rock, and Tailings

The distinction between overburden and waste rock determines how these materials are managed. Overburden is any non-mineralized material that overlies an ore body. Waste rock is mineralized material that has been mined but lacks sufficient mineral content and value to warrant further processing.

Because overburden is non-mineralized, overburden management is generally less rigorous. Waste rock is generally placed in engineered structures with stormwater run-off controls in a part of the mine away from the ore body. Overburden piles may or may not need stormwater controls.

Wastes from beneficiation processes are known as tailings. If they contain sufficiently high concentration of minerals, tailings piles may be leached to recover additional dissolved minerals. Any potential discharges from tailings piles, or from leachate ponds at the base of tailings piles, are covered under 40 CFR Part 440.

Total waste (waste rock and tailings) produced during the extraction and beneficiation of minerals can range from 10 percent of the total material removed from the earth (potash) to more than 99.99 percent (gold).

Active and Inactive Mines

40 CFR Part 440 defines “active mining area” as the place where work or other activity related to the extraction, removal, or recovery of metal ore is being conducted, except, with respect to surface mines, any area of land on or in which grading has been completed to return the earth to desired contour and reclamation work has begun.

Active mines, moreover, produce a saleable product, whether or not extraction operations at the site are currently underway. For example, a mine where extraction has stopped, but heap leaching of ore is being performed is considered an active mine. In contrast, inactive mines are those that are not currently producing a saleable product. Inactive mines may be temporarily closed, undergoing reclamation and closure, permanently closed, or abandoned. Estimates of the number of abandoned mines vary. The United State Geological Survey's Abandoned Mine Lands Initiative uses the estimate of 557,650 abandoned mine sites in 32 states compiled by the Mineral Policy Center, an environmental research and advocacy group (Lyon and others, 1993.)

The Superfund Final National Priority List[1] of 1277 Superfund sites includes approximately 23 mines.

Process Wastewater, Mine Drainage, and Stormwater

There are three types of wastewater discharged by ore mines: process wastewater, mine drainage, and stormwater. Process wastewater and mine drainage are covered under 40 CFR Part 440. Stormwater is not covered under 40 CFR Part 440 unless it is commingled with process wastewater and mine drainage prior to discharge to a surface waterbody. Table 1-1 presents legal definitions of these terms.

Table 1-1. Categories of Discharges from Mining Operations

Waste Stream	Definition
Process wastewater	"...any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, byproduct, or waste product." (40 CFR 122.22)
Mine drainage	Mine drainage includes water drainage from refuse, storage piles, wastes, rock dumps, and mill tailings derived from the mining, cleaning, or concentration of metal ores. Mine drainage may include process water still contained in the mine. Stormwater runoff and infiltration can contribute to mine drainage. "...any water drained, pumped, or siphoned from a mine." (40 CFR 440.132)
Industrial stormwater	Stormwater means rain water runoff, snow melt runoff, surface runoff, and surface drainage. Industrial facilities are required to obtain permit coverage for stormwater if they have a point source stormwater discharge associated with an industrial or commercial activity from their property either directly to waters of the United States or to a municipal separate storm sewer system. "... the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. ... (40 CFR 122.26)

Source: Adapted from EPA and Hardrock Mining: A Sourcebook for Industry in the Northwest and Alaska (EPA, 2003).

Toxic Weighting Factors and Toxic Weighted Pound Equivalents

Chemical pollutants discharged to surface water have different toxicities. EPA normalizes the toxicities of the various pollutants in a waste stream by multiplying the amount of each chemical by a Toxic Weighting Factor (TWF). The TWF for a chemical is a normalizing weight based on its toxicity relative to copper, which is commonly found in industrial wastewater. For example, cadmium, which is more toxic than copper, has a TWF of 2.6, whereas nickel, which is less toxic than copper, has a TWF of 0.11. EPA's TWFs database currently contains toxic weighting factors for more than 1,900 chemicals.

Using TWFs, EPA estimates pollutant discharges on a constant toxicity basis expressed as Toxic Weighted Pound Equivalents (TWPE). TWPE values allow EPA to rank and compare facilities and industries that discharge waste streams with different toxicities. For example, a facility discharging 40 pounds of cadmium ($40 \times 2.6 = 104$) and 20 pounds of nickel (20×0.11

[1] Available online at http://www.epa.gov/superfund/sites/npl.

= 2.2), releases 106.2 toxic weighted pounds to surface water. Another facility, discharging 30 pounds of cadmium (30 × 2.6 = 78) and 100 pounds of nickel (150 × 0.11 = 16.) releases 94.5 toxic weighted pounds to surface water, and would thus rank lower than the previous facility (ERG, 2005).

1.2 Key Findings

This section presents key findings of the Ore Mining Preliminary Study.

1.2.1 Process Wastewater Discharges

EPA found that in 2007, the most recent year for which quality-checked data are available, approximately two percent of the estimated 294 ore mining facilities with NPDES permits were responsible for approximately 90 percent of toxic weighted discharges by the industry[2]. Given that a small percentage of active mines account for the majority of toxic weighted discharges, discharge issues are best addressed through permitting, compliance, and enforcement activities rather than revision of 40 CFR Part 440.

1.2.2 Stormwater Discharges

The only readily available data for stormwater discharges from active mines that EPA was able to identify were for 19 mines in Arizona and Montana. The data were too limited, however, to support regional or national conclusions about stormwater discharges at ore mining sites. Statistically representative sampling of stormwater discharges would be needed to better assess the effectiveness of stormwater controls.

EPA used available information from Total Maximum Daily Load (TMDL) reports as an indicator of the extent to which stormwater from active mines may be a cause of water quality impairment. TMDL information was used because of the lack of nationally available stormwater discharge data for mining sites. TMDL reports list the sources of impairment in watersheds, and set point source and nonpoint source load limitations for waterbodies that have been determined to be impaired by EPA or by authorized state permitting authorities. EPA conducted a keyword search of 7,760 TMDL reports and found only seven instances where active ore mines were named among the sources within impaired watersheds. None of the TMDL documents, however, definitively stated that impairments resulted from active mines.

Interviews with EPA regional staff did not identify sites where stormwater discharges from active mining sites are a concern, except for a couple of mines in EPA Region 8 where stormwater retention ponds are sometimes inadequate to contain runoff from spring snow melt.

1.3 Overview of Remainder of Report

The remainder of this report is organized into the following sections:

- Section 2.0 summarizes how EPA identified and collected data to evaluate the ore mining effluent guidelines.

[2] Of the 54 facilities with available discharge data, 7 (13 percent) were responsible for 90 percent of the toxic weighted discharges.

- Section 3.0 provides a summary of the Ore Mining Category including a description of industry sectors as well as a facility list.
- Section 4.0 summarizes the laws and regulations that control operations in the Ore Mining Category.
- Section 5.0 discusses EPA's review of Total Maximum Daily Load (TMDL) studies relevant to the Ore Mining Category Review.
- Section 6.0 discusses EPA's analysis of process wastewater discharges from the Ore Mining Category.
- Section 7.0 discusses EPA's analysis of monitoring data for stormwater discharges from ore mining operations.
- Section 8.0 discusses EPA's evaluation of the High Density Sludge (HDS) treatment technology.

1.4 Introduction References

1. Lyon, J.S., Hilliard, T.J., and Bethell, T.N. 1993. Burden of Gilt. Mineral Policy Center, Washington, D.C.

2. U.S. EPA. 2004. Technical Support Document for the 2004 Effluent Guidelines Program Plan. EPA-821-R-04-014. Washington, DC (December).

3. Western Mining Action Project. 1998. Memo Re: Petition and Comment on Notice of Proposed Effluent Guidelines Plan (63 Fed. Reg. 29203-29213, May 28, 1998). Boulder, CO.

4. NMA. 2010. Comments on Preliminary 2010 Effluent Guidelines Program Plan. EPA-HQ-OW-2008-0517-0550. Washington, DC (February).

5. U.S. EPA. 2003. EPA and Hardrock Mining: A Sourcebook for Industry in the Northwest and Alaska. Seattle, Washington (January).

6. ERG. 2005. Draft Toxic Weighting Factor Development in Support of CWA 304(m) Planning Process. Lexington, MA (July).

2.0 DATA SOURCES

This section summarizes the available information that EPA identified and reviewed to better understand process water and stormwater discharges by the ore mining industry. More specifically, EPA reviewed information to do the following:

- Identify and determine the number of ore mining facilities in the U.S.;
- Identify mining facilities with NPDES permits;
- Characterize discharge pollutant concentrations;
- Estimate discharge loads and Toxic Weighted Pound Equivalent Loads; and
- Assess potential impacts of discharges on surface water quality.

Table 2-1 summarizes the main data sources used for the Ore Mining Preliminary Study.

Table 2-1. Primary Data Sources for the Ore Mining Preliminary Study

EPA National Databases [a]

• Toxics Release Inventory
• Discharge Monitoring Report (DMR) Databases
  – Permit Compliance System (PCS)
  – Integrated Compliance Information System and National Pollutant Discharge Elimination System (ICIS-NPDES)
  – Envirofacts
  – DMR Pollutant Loading Tool
• Enforcement and Compliance History Online (ECHO)
• Total Maximum Daily Load (TMDL) Studies

Data from EPA Regional Offices and States

• Stormwater monitoring data
  – Arizona Department of Environmental Quality
  – Minnesota Pollution Control Agency
• Facility lists
  – EPA Region 8
  – EPA Region 9
  – Missouri Department of Natural Resources
  – Nevada Division of Environmental Protection
  – New Mexico Environment Department

Non-EPA Data
• U.S. Economic Census • USGS Minerals Yearbook and Mineral Commodity Summaries • Monitoring data and cost information for the Leadville Mine Drainage Tunnel Treatment Plant

a – For more information on how EPA uses and processes these data for the Annual Review, see EPA's Technical Support Document for the Annual Review of Existing Effluent Guidelines and Identification of Potential New Point Source Categories (EPA, 2010).

Limitations in data quality and availability precluded EPA from determining the exact number of facilities in each subcategory, or completely characterizing discharges from some ore mining facilities. The data sources used for the Ore Mining Preliminary Study have the following general limitations:

- The data may not reflect current conditions because the most recent data are typically from 2006; and

- Discharge data are incomplete. Not all monitoring data from all states are reported to EPA national databases. Moreover, monitoring is not required for all pollutants that may be present in waste.

2.1 EPA's Databases

2.1.1 Toxics Release Inventory (TRI)

EPA reviewed ore mining water discharge information from the 2007 TRI database, which is the most recently available year. The TRI database was of limited usefulness for the Ore Mining Preliminary Study because it contains information for only a small subset of ore mining facilities, due to reporting requirement thresholds. The 2007 TRI database contains discharge information for only 28 of the 294 estimated ore mines with NPDES permits.

TRI contains facility data for industries in certain North American Industry Classification System (NAICS) categories. The following NAICS codes are available for the ore mining industry:

- 212210: Iron ore mining;
- 212234: Copper ore and nickel ore mining;
- 212231: Lead ore and zinc ore mining;
- 212221: Gold ore mining;
- 212222: Silver ore mining;
- 212291: Uranium-radium-vanadium ore mining;
- 212299: All other metal ore mining; and
- 213114: Support activities for metal mining.

The Technical Support Document for the Annual Review of Existing Effluent Guidelines and Identification of Potential New Point Source Categories contains a thorough discussion of how EPA uses TRI water discharge information in its annual effluent guidelines planning process (U.S. EPA, 2009).

2.1.2 Discharge Monitoring Report Data from the Permit Compliance System (PCS) and the Integrated Compliance Information System for the National Pollutant Discharge Elimination System (ICIS-NPDES)

DMRs, which facilities are required to submit to EPA or state permitting agencies as a condition of their NPDES permits, are stored in the PCS and ICIS-NPDES national databases. EPA began replacing PCS with ICIS-NPDES in 2006. Until the transition is complete, EPA retrieves certain data from both databases, as was necessary to prepare the Ore Mining Preliminary Study.

The DMR data used in the Preliminary Ore Mining Study included:

- Permit limitations;
- Pollutant concentrations and/or load by month, quarter, or other time period; and
- Flow by month, quarter, or other time period.

Similar to the TRI database, however, the PCS and ICIS-NPDES databases were of limited usefulness for the Ore Mining Preliminary Study because they contain information on only a subset of ore mines. DMR discharge data were available for only 54 of the 294 ore mines with NPDES permits.

As summarized in Table 2-2, most discharge data are only available for facilities classified as major dischargers. Very little data are available for facilities classified as minor dischargers because states are not required to upload data on minor facilities to the PCS and ICIS-NPDES databases. Moreover, most permitting authorities classify ore mine discharges as minor. Permitting authorities consider six factors when determining whether to classify facilities as major or minor (U.S. EPA, 2006):

- Toxic pollutant potential;
- Discharge flow to stream flow ratio;
- Conventional pollutant loading;
- Public health impact;
- Water quality factors; and
- Proximity to coastal waters.

Table 2-2. Summary of Ore Mining Facilities with Data in EPA's PCS and ICIS/NPDES Databases

Subpart	SIC and Description	Facilities by Type of NPDES Permit			# of Facilities with Discharge Data
		Major	Minor	Total	
A	1011: Iron Ores	5	23	28	4
J	1021: Copper Ores	11	15	26	5
J	1031: Lead/Zinc Ores	23	17	40	22
J,M	1041: Gold Ores [a]	13	118	131	10
J	1044: Silver Ores	1	24	25	1
J	1061: Ferroalloy Ores (Except Vanadium)	5	5	10	4
NA	1081: Metal Mining Services	0	3	3	0
C	1094: Uranium, Radium, Vanadium Ores	7	28	35	4
Others [b]	1099: Metal Ores, NEC	4	20	24	4
Total		**69**	**253**	**322** [c]	**54**

Source: EPA's *DMRLoads2007* Database.
a – Excludes Mechanical Placer Mining and Suction Dredge Mining; EPA identified 1,869 gold placer and suction dredge mining operations permitted under a general permit (all discharges classified as minor).
b – Subparts B, D, E, F, G, H, I, K
c – This number differs from the estimated 294 mines with NPDES permits because some mines may have multiple NPDES permits.
NEC – Not elsewhere classified.

2.1.3 Envirofacts

To augment DMR data available from EPA's annual review databases (PCS, ICIS-NPDES), EPA reviewed ore mining DMR data available through Envirofacts, an online database that stores data for various EPA programs (e.g., EPCRA, CWA, RCRA). Envirofacts is available online at http://www.epa.gov/enviro. It functions as a central repository of permitting information, including monitoring data for some facilities. Although these data are similar to the data maintained in EPA's annual review databases, they contain more information for facilities classified as minor dischargers under the NPDES program. EPA reviewed these data to better understand discharges from minor facilities permitted under general permits (e.g., general stormwater permits). Montana was the only state in Envirofacts with stormwater data; however, the data for Montana were incomplete. EPA also used Envirofacts to evaluate and augment the facility list developed during the Ore Mining Preliminary Study.

2.1.4 Enforcement and Compliance History Online (ECHO)

EPA used data from the ECHO database (available online at http://www.epa-echo.gov/echo) to help develop its ore mining facility list. Similar to the TRI and the PCS/ICIS-NPDES databases, the ECHO database was of limited usefulness for the Ore Mining Preliminary Study because it only contains discharge-related information for a subset of ore mines. Using information from ECHO, PCS, ICIS-NPDES, TRI, and Envirofacts, EPA estimates that there are 294 mines in the US with active NPDES discharge permits.

2.1.5 Total Maximum Daily Load (TMDL) Studies

EPA performed a keyword search of 7,670 TMDL studies to identify active mines that may be a source of water quality impairment. The TMDL studies are available online at EPA's *Waters* website (http://iaspub.epa.gov/waters10/text_search.tmdl_search), which contains a suite of water-related databases and analytical tools. The usefulness of the TMDL database was somewhat limited for Ore Mining Preliminary Study because information on TMDL studies is incomplete. There may be as many as 4,500 completed studies that have not yet been added to the TMDL database. Approximately 82 percent of the 42,000 TMDLs approved by EPA since 1995 have not yet been added to the online TMDL database. EPA's use of the TMDL database is discussed in Chapter 5.

2.1.6 Stormwater Data

The availability of stormwater data for ore mining operations is very limited due to minimal monitoring requirements and absence of requirements for states to report mining stormwater data to national databases such as the Permit Compliance System.

EPA regional offices and permitting authorities in western states with significant mining activities were contacted to determine whether they had recent mining stormwater data of sufficient quality and representativeness for use in the Ore Mining Preliminary Study. The only information identified were limited stormwater monitoring data for certain mines in Arizona (received from EPA Region 9) and Montana (available through Envirofacts). These data were not adequate to support any national or regional conclusions about stormwater discharges from ore mines (ERG, 2010).

2.2 Data from States and EPA Regional Offices

During the 2009 Annual Review, EPA's Office of Water requested discharge data and facility lists for ore mining facilities from states and EPA regional offices for areas with significant mining activities. Table 2-3 lists the responses that EPA received as a result of this request.

Table 2-3. Summary of Responses to EPA's Information Request

State/EPA Region	Agency	Information Provided	Date of Response
Minnesota	Minnesota Pollution Control Agency	Facility List & Discharge Data	7/22/2009
Missouri	Missouri Department of Natural Resources	Facility List	7/27/2009
New Mexico	New Mexico Environment Department	Facility List	7/7/2009
Arizona	Arizona Department of Environmental Quality	Facility List	8/4/2009
Region 8	EPA	Facility List	3/13/2009
Region 9	EPA	Facility List & Discharge Data	7/24/2009

2.3 Non-EPA Data Sources

2.3.1 U.S. Economic Census

The U.S. Economic Census, conducted by the U.S. Department of Commerce, is the systematic measurement of economic activity in the United States. The census collects information about the number of manufacturing establishments and the kind, quantity, and value of goods manufactured. Although the census provides data on the number of establishments by North American Industry Classification System (NAICS) and U.S. Standard Industrial Classification (SIC) codes, it does not publish a list of facilities. New facilities might have started operation since the census was taken (2000), and facilities that were counted in the census might have been shut down. The census also counts nonproduction facilities such as sales offices, distribution warehouses, etc., as establishments.

EPA used census data to evaluate and augment its ore mining facility list. EPA compares the number of mines identified in other data sources to the number summarized by the U.S. Economic Census in Table 3-2 (U.S. Census, 2005).

2.3.2 USGS Minerals Yearbook and Mineral Commodity Summaries

EPA used information from the 2005 to 2007 USGS Minerals Yearbook and Mineral Commodity Summaries, which assess the domestic and foreign production of all economic metal ores, to help develop a list of ore mining facilities.

EPA analyzed information for the following ores:

- Bauxite and Alumina;
- Copper;
- Ferroalloys;
- Gold;
- Iron;

- Lead;
- Molybdenum;
- Silver;
- Titanium; and
- Zinc.

2.3.3 Leadville Mine Drainage Tunnel (LMDT) Treatment Plant Information

EPA interviewed staff from the LMDT treatment plant and requested detailed information on the facility's operations, analytical data characterizing the site's HDS treatment system, and cost information. The Bureau of Reclamation provided this information to EPA, and the information was used for the case study discussed in Chapter 8.

EPA interviewed staff from LMDT treatment plant and requested detailed information on the facility's operations, analytical data characterizing the site's high density sludge treatment system, and cost information. Chapter 8 discusses information on the LMDT treatment plant, provided to EPA by the U.S. Bureau of Reclamation.

2.4 Data Sources References

1. U.S. EPA. 2009. Technical Support Document for the Annual Review of Existing Effluent Guidelines and Identification of Potential New Point Source Categories. EPA-821-R-09-007. Washington, DC. (October).

2. U.S. Census. U.S. Census Bureau. 2005. U.S. Economic Census. 2002 Economic Census. Subject Series. Mining. General Summary: 2002. EC02-21SG-1. (October). Available online at: http://www.census.gov/prod/ec02/ec0221sg1.pdf. EPA-HQ-OW-2006-0771 DCN 05982.

3. U.S. EPA. 2010, Enforcement and Compliance History Online (ECHO). Available online at: http://www.epa-echo.gov/echo. Date accessed: March 15, 2010.

4. U.S. EPA. 2010, Envirofacts. Available online at: http://www.epa.gov/enviro/ Date accessed: March 15, 2010.

5. NMED. New Mexico Environment Department. 2009. List of Ore Mining Facilities in New Mexico. (July 7). DCN 07220.

6. EPA Region 8. 2009. List of Ore Mining Facilities in EPA Region 8. (March 13). DCN 07221.

7. EPA Region 9. 2009. Discharge Data for Select Arizona Ore Mining Facilities. (July 24). DCN 07225.

8. MPCA. Minnesota Pollution Control Agency. 2009. List of Ore Mining Facilities in Minnesota. (July 22). DCN 07223.

9. MPCA. Minnesota Pollution Control Agency. 2009. Discharge Data for Select Ore Mining Facilities in Minnesota. (July 22). DCN 07223.

10. ADEQ. Arizona Department of Environmental Quality. 2009. List of Ore Mining Facilities in Arizona. (March 13). DCN 07226.

11. MDNR. Missouri Department of Natural Resources. List of Ore Mining Facilities in Missouri. (March 13). DCN 07222.

12. USGS. United States Geological Society. 2010. USGS Website. Available online at: www.usgs.gov. Date last accessed: April 23, 2010.

13. ERG. 2010. Memo Re: Range of Pollutant Concentrations in Arizona and Montana Ore Mining Stormwater Discharges. April 27, 2010.

3.0 PROFILE OF THE ORE MINING AND DRESSING POINT SOURCE CATEGORY

This chapter provides a brief overview of the subcategories of mines covered under 40 CFR Part 440, along with estimates of the number of active mines in each subcategory based on available data, and a brief summary of mining processes.

3.1 Ore Mining and Dressing Point Source Subcategories

The Ore Mining and Dressing Point Source Category, codified in 40 CFR Part 440, is divided into the subcategories shown in Table 3-1.

Table 3-1. Ore Mining Category Subcategory Applicability

Sub-part	Subcategory Title	Related SIC Code(s)	Related NAICS Code(s)	Subcategory Applicability
A	Iron Ore	1011: Iron Ores	212210: Iron Ores	Iron Ore Mines and Mills using Physical or Chemical Separation or Magnetic & Physical Separation in the Mesabi Range
B	Aluminum Ore	1099: Miscellaneous Metal Ores, NEC	212299: All Other Metal Ores	Bauxite Mines Producing Aluminum Ore
C	Uranium, Radium, & Vanadium Ores	1094: Uranium-Radium-Vanadium Ores	212291: Uranium-Radium-Vanadium Ores	Open-Pit or Underground Mines and Mills using Acid Leach, Alkaline Leach, or Combined Acid & Alkaline Leach to Produce Uranium, Radium, & By-product Vanadium
D	Mercury Ore	1099: Miscellaneous Metal Ores, NEC	212299: All Other Metal Ores	Open-Pit or Underground Mercury Ore Mines and Mills using Gravity Separation or Froth-Flotation
E	Titanium Ores	1099: Miscellaneous Metal Ores, NEC	212299: All Other Metal Ores	Titanium Ore Mines from Lode Deposits and Mills using Electrostatic, Magnetic & Physical Separation, or Flotation; Dredge Mines and Mills for Placer Deposits of Rutile, Ilmenite, Leucoxene, Monazite, Zircon, and Other Heavy Metals
F	Tungsten Ore	1061: Ferroalloy Ores, Except Vanadium	212234: Copper and Nickel Ores	Tungsten Mines and Mills using Gravity Separation or Froth-Flotation
G	Nickel Ore	1061: Ferroalloy Ores, Except Vanadium	212234: Copper and Nickel Ores	Nickel Ore Mines and Mills
H	Vanadium Ore (Mined Alone, not as By-product)	1094: Uranium-Radium-Vanadium Ores	212291: Uranium-Radium-Vanadium Ores	Vanadium Ore Mines and Mills
I	Antimony Ore	1099: Miscellaneous Metal Ores, NEC	212299: All Other Metal Ore Mining	Antimony Ore Mines and Mills

Table 3-1. Ore Mining Category Subcategory Applicability

Sub-part	Subcategory Title	Related SIC Code(s)	Related NAICS Code(s)	Subcategory Applicability
J	Copper, Lead, Zinc, Gold, Silver, & Molybdenum Ores	1021: Copper Ores 1031: Lead and Zinc Ores 1041: Gold Ores 1044: Silver Ores 1061: Ferroalloy Ores, Except Vanadium	212234: Copper and Nickel Ores 212231: Lead and Zinc Ores 212221: Gold Ores 212222: Silver Ores 212299: All Other Metal Ores	Copper, Lead, Zinc, Gold, Silver, & Molybdenum Ore Open-Pit or Underground Mines, except for Placer Deposits, and Mills using Froth-Flotation and/or Other Separation Techniques; Mines and Mills using Dump, Heap, In-Situ Leach, or Vat-Leach to Extract Copper from Ores or Ore Waste Materials; Gold or Silver Mills using Cyanidation; Except for Mines and Mills from the Quartz Hill Molybdenum Project in the Tongass National Forest, Alaska
K	Platinum Ore	1099: Miscellaneous Metal Ores, NEC	212299: All Other Metal Ores	Platinum Ore Mines and Mills
M	Gold Placer Mine	1041: Gold Ores	212221: Gold Ores	Placer Deposit Gold Ore Mines, Dredges, & Mills using Gravity Separation

3.2 Estimates of the Number of Active Mines

As discussed in Section 2, the exact number of active mines, and the exact number of mines with NPDES permits, is unknown. During the Ore Mining Preliminary Study, EPA developed a facility list using the data sources discussed in Chapter 2. Table 3-2 lists the number of facilities in each subcategory, based on the sources discussed in Chapter 2. Figure 3-1 illustrates the distribution of different mine types across the U.S.

EPA developed the facility list starting with the TRI and PCS/ICIS-NPDES databases. EPA augmented these data with US Census information from the 2005 to 2007 USGS Minerals Yearbook and Mineral Commodity Summaries, along with facility lists provided by EPA regional offices and state agencies.

As discussed in Section 2, the exact number of active mines, and the exact number of mines with NPDES permits, is unknown. During the Ore Mining Preliminary Study, EPA developed a facility list using the data sources discussed in Chapter 2. Table 3-2 lists the number of facilities in each subcategory, based on the sources discussed in Chapter 2. Figure 3-1 illustrates the distribution of different mine types across the U.S.

A detailed facility list is contained in DCN 07228. However, EPA considers each of the data sources used to compile the list to be incomplete. EPA developed the facility list starting with the TRI and PCS/ICIS-NPDES databases. EPA attempted to correlate facilities between data sources using available information, but some facilities may be double-counted due to facility name differences between data sources. The "Estimated Total Number of Facilities" in Table 3-2 is different than the numbers from each data source for some subcategories because no single data source contained all of the known facilities. EPA augmented data from TRI and PCS/ICIS-NPDES with US Census information and from the 2005 to 2007 USGS Minerals

Yearbook and Mineral Commodity Summaries, along with facility lists provided by EPA regional offices and state agencies.

Table 3-2. Estimated Number of Facilities in the Ore Mining Category

Subpart (of 40 CFR 440)	2002 U.S. Economic Census	Number of Facilities Reporting to TRI [a]	Number of Facilities with Discharges in EPA's DMR Pollutant Loading Tool	Estimated Total Number of Facilities [b]
A: Iron Ore	24	0 [c]	27	32
C: Uranium, Radium, and Vanadium	17	0 [c]	24	24
J: Silver	11	3	23	25
J: Lead/Zinc	22	19	32	37
J: Gold	180	43	113	143
J: Copper and Nickel Ore [d]	33	25	54	59
J: Molybdenum	39	4	8	9 [e]
E: Titanium Ore		1	6	7
F: Tungsten Ore		0	0	1 [f]
I: Antimony Ore		0	0	1 [g]
K: Platinum Ore		1	1	1
D: Mercury Ore		0	0	0 [h]
B: Aluminum Ore		0	2	2
Total (Excluding Placer Mines)	**326**	**96**	**290**	**345** [i]
M: Gold Placer Mines	0 [j]	0	1679	1679

a – All facilities reporting to TRI (including facilities without discharges).
b – EPA estimated the total number of facilities in each database by compiling USGS , Census, Envirofacts, TRI, and DMR data into one list (see DCN 07228). EPA identified situations where a facility was in only one databases or in all databases.
c – Facilities mining iron, uranium, radium, or vanadium ores are not required to report to TRI.
d – Many U.S. mines co-produce nickel and copper. For all of the mines reporting the NAICS code for copper and nickel ores that EPA reviewed in detail, copper is the principal product. EPA has not identified any U.S. mines for which nickel is the principal product.
e – Assumes that all facilities reporting SIC 1061 (Ferroalloy except vanadium) are molybdenum mines.
f – Although one mine is listed in the USGS Minerals Yearbook (the Andrew Mine in California), EPA's databases have no information for this mine.
g – Although one mine is listed in the USGS Minerals Yearbook (the Fencemaker Mine in Nevada), EPA's databases have no information for this mine.
h – Based on the USGS Minerals Yearbook, there are no mines in the U.S. producing this metal as their principal product.
i – Total number of facilities includes some mines for which the applicable subpart is unknown.
j – The Economic Census does not distinguish between placer mines and other types of gold mines.
ND – No data.

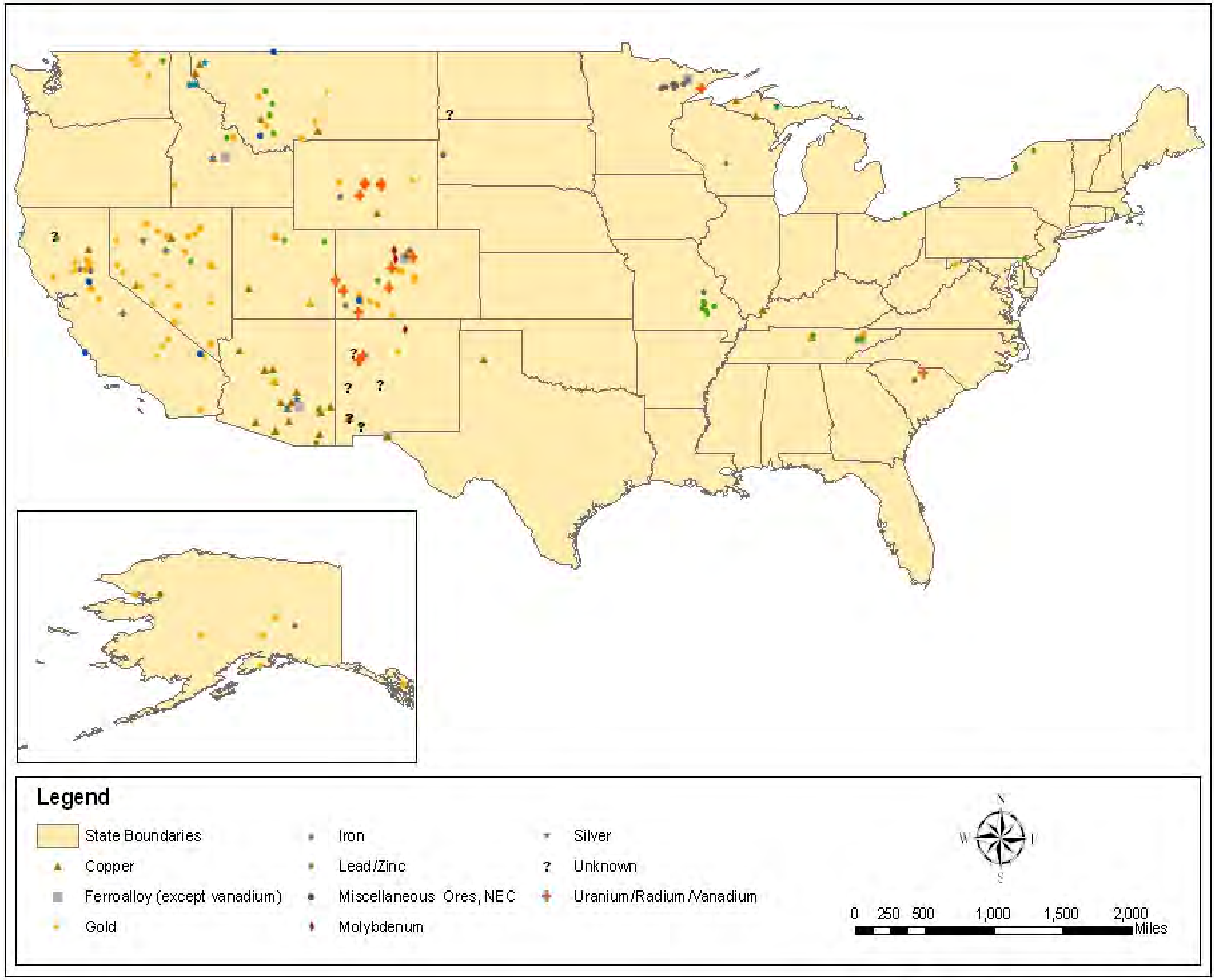

Figure 3-1. Ore Mines in the U.S. by Type (Based on Primary Commodity)

3.3 Ore Mining Processes

EPA's *Technical Resource Document: Extraction and Beneficiation of Ores and Minerals* presents a detailed discussion of the processes used in some of the major ore mining subcategories. This document consists of seven volumes, discussing the following types of ore extraction and processing (EPA Publication Number in parenthesis):

- Volume 1: Lead-Zinc (EPA 530-R-94-011);
- Volume 2: Gold (EPA 530-R-94-013);
- Volume 3: Iron (EPA 530-R-94-030);
- Volume 4: Copper (EPA 530-R-94-031);
- Volume 5: Uranium (EPA 530-R-94-032);
- Volume 6: Gold Placer (EPA 530-R-94-035); and
- Volume 7: Phosphate and Molybdenite (EPA 530-R-94-034).

Other useful descriptions of ore mining processes are contained in *Site Visit Report: Arizona Copper Mines*, prepared as part of the Ore Mining Preliminary Study.

3.4 Profile of the Ore Mining Category References

1. ERG. 2010. Site Visit Report: Arizona Copper Mines. (March). Chantilly, VA. DCN 07219.

4.0 REGULATORY FRAMEWORK FOR ORE MINING DISCHARGES

Under Section 304(b) of the Clean Water Act (CWA), EPA first promulgated Ore Mining and Dressing Point Source Category Effluent Limitation Guidelines (ELGs), (40 CFR Part 440) on December 3, 1982, (47 FR 54609) to set national technology-based pollutant limits for wastewater discharges from ore mining and dressing facilities. 40 CFR Part 440 consists of 12 subcategories, as outlined in Table 3-1 (U.S. EPA, 1982; U.S. EPA, 1988). Discharges from mining and dressing operations must meet best available technology/best practicable technology (BAT/BPT) limits for metals such as arsenic, cadmium, copper, lead, mercury, nickel, and zinc; as well as meeting BPT limits for total suspended solids and pH. Certain facilities in some subcategories must also meet the New Source Performance Standards (NSPS) of no discharge except in areas where net precipitation (precipitation minus evaporation and infiltration) is greater than zero. Storm exemptions are provided in some cases for all subcategories. Tables A-1 and A-2 in Appendix A summarize the numeric limits for each subpart.

4.1 Overview of NPDES Permitting

Under Section 402 of the Clean Water Act (CWA), EPA and authorized states regulate direct point source discharges to waters of the United States by issuing National Pollutant Discharge Elimination System (NPDES) (40 CFR 122.44) permits to facilities. A point source is defined in Section 502 of the CWA as a confined and discrete conveyance, natural or man-made, such as a pipe, ditch, or outfall from which a pollutant may be discharged. For mining facilities, point source discharge sources include mine drainage and process wastewater; and may or may not include stormwater runoff (U.S. EPA, 1996).

EPA has authorized state agencies to administer the NPDES program in all but New Mexico, Idaho, Massachusetts, New Hampshire, and Washington D.C. For these States, some Tribal Lands, some federal facilities, and U.S. Territories, EPA Regional offices retain NPDES permitting authority.

NPDES permits are issued to control either industrial wastewater or stormwater. There are three types of NPDES permits (U.S. EPA, 1996):

- **Individual.** Individual NPDES permits set wastewater discharge limits and conditions for single facilities on a case-by-case basis. NPDES permit writers consider a facility's production processes, the characteristics of the discharge, and the quality of the receiving water quality in determining permit limits and conditions.

- **General.** A general permit covers multiple facilities with similar production processes and pollutant discharges within a specific geographical area. Some facilities with individual permits for process water discharges may also be covered under general stormwater permits.

- **Watershed.** Watershed permits are relatively new and are being implemented for certain industries by a subset of states. Similar to a general permit, watershed permits cover multiple facilities within a watershed and account for the effects of multiple pollutant discharges, habitat conditions, stream flow, ecology, and other factors such as any Total Maximum Daily Load (TMDL) developed for waterbodies in the watershed. No ore mines in 2010 are known to be covered under watershed permits.

4.2 NPDES Permitting of Process Water and Stormwater from Ore Mines

In the August 1998 Federal Register Notice (63 FR 42533-42548), EPA clarified the stormwater applicability of 40 CFR Part 440 in response to litigation with the National Mining Association: "runoff from waste rock and overburden piles is not subject to ELGs unless it naturally drains (or is intentionally diverted) to a point source and combines with 'mine drainage' that is otherwise subject to the ELGs."[3] Thus process water is covered under individual or general NPDES industrial wastewater permits based on 40 CFR Part 440. Some stormwater runoff at mines may be controlled under individual or general NPDES industrial wastewater permits based on 40 CFR Part 440, and other stormwater runoff at mines may be controlled under individual or general NPDES stormwater permits.

In jurisdictions that EPA has not authorized to implement the NPDES program, stormwater discharges are subject to Sector G of EPA's Multisector General Permit for Industrial Activities (MSGP) developed to implement Phase I Stormwater Regulations (40 CFR Part 122.26). Authorized states have developed their own general stormwater permits for mining discharges that conform to the MSGP.

Figure 4-1 illustrates the process used to determine the regulatory classification of discharges from ore mining operations, which depends on whether a discharge is process water or stormwater, and whether the water is managed by commingling with other wastewaters or individually conveyed to discharge point.

EPA's MSGP, and some state general stormwater permits, include requirements to conduct benchmark monitoring and develop Best Management Practices (BMPs). Stormwater pollution prevention plans are also required, but numeric discharge limits are not set, nor are stormwater containment and treatment requirements established. The MSGP benchmark monitoring concentrations are used as action levels to determine whether existing BMPs are sufficient. If benchmark concentrations are exceeded, the facility must augment existing BMPs and continue sampling stormwater. However, if pollutant concentrations are consistently below benchmark concentrations, the facility may cease stormwater sampling. The MSGP does require that storm water discharges comply with state water quality standards, but specific numeric limits are not included in the permit.

Most state stormwater general permits are less restrictive than the federal MSGP because they require less or no benchmark monitoring, which is used to assess the effectiveness of BMPs. Four states require no benchmark monitoring for metals concentrations, eight states require less frequent sampling than specified by the Federal MSGP; and two states require no routine sampling at all. Only one state, Washington, requires more stringent stormwater monitoring than the federal MSGP.

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[3] Table G-4 of the MSGP lists the wastewaters from mining activities covered by Part 440 versus the MSGP, as specified in an October 2000 Federal Register Notice: runoff from waste rock and overburden piles is not subject to effluent guidelines unless it naturally drains (or is intentionally diverted) to a point source and combines with "mine drainage" that is otherwise subject to the effluent limitation guidelines (65 FR 64774, October 30, 2000).

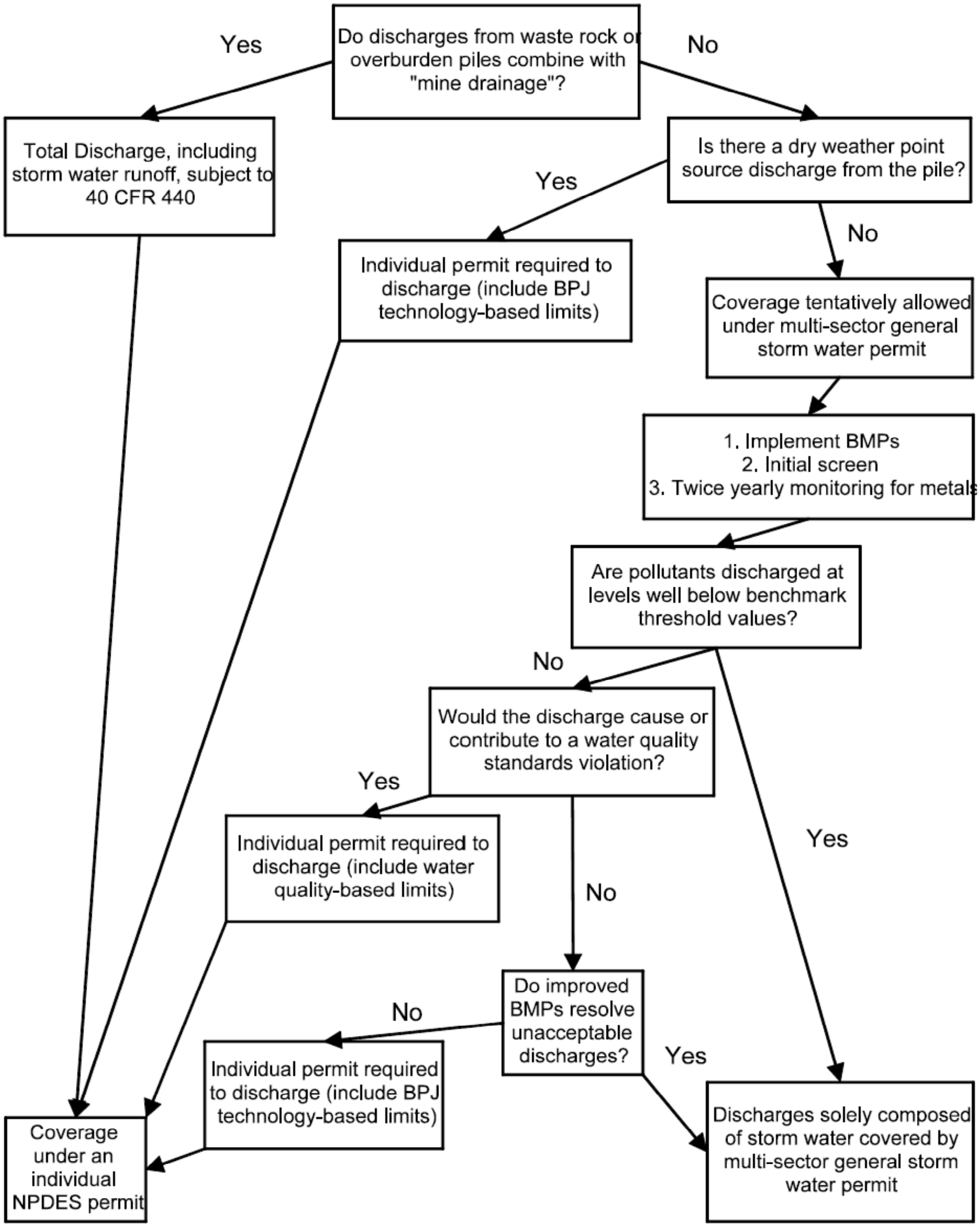

Figure 4-1. Example of Discharge Classification Depending on Wastewater Source and Management (U.S. EPA, 2003)

Table 4-1 compares MSGP benchmark monitoring requirements with those in stormwater general permits issued by authorized states with significant ore mining operations.

4.3 Distinction Between Technology-Based Permit Limits and Water Quality-Based Permit Limits

If a facility applies for an individual NPDES permit, the permit writer is required to first derive facility-specific Technology-Based Effluent Limits (TBELs) based on 40 CFR Part 440. The permit writer then derives discharge limits for the facility that are protective of state water quality standards, known as Water Quality-Based Effluent Limits (WQBELs). The permit writer is required to compare the TBELs with the WQBELS, and apply the more stringent of the two limits in the permit in order to ensure attainment of the state water quality standards in the receiving waterbody. If a state has adopted a Total Maximum Daily Load (TMDL) for the receiving waterbody, then the permit writer must also determine the water quality-based waste load allocation for the discharge.

4.4 Ore Mining Regulatory Framework References

1. U.S. EPA. 1982. Development Document for Effluent Guidelines and Standards for the Ore Mining and Dressing Point Source Category. EPA-440/1-82-061. Washington, DC.

2. U.S. EPA. 1988. Development Document for Effluent Limitations and Guidelines for New Source Performance Standards for the Ore Mining and Dressing Point Source Category Gold Placer Mine Subcategory. EPA-440/1-88-061. Washington, DC.

3. U.S. EPA. 1996. *NPDES Permit Writers' Manual*. Washington, D.C.

4. U.S. EPA. 2003. *EPA and Hardrock Mining: A Source Book for Industry in the Northwest and Alaska*. Seattle, WA.

5. U.S. EPA, 2006a. *Technical Support Document for the 2006 Effluent Guidelines Program Plan*. Washington, D.C.

6. U.S. EPA, 2006a. *Technical Support Document for the 2006 Effluent Guidelines Program Plan*. Washington, D.C.

Table 4-1. Comparison of Monitoring Requirements for Western States and Federal General Stormwater Permits

Permit [a]	Monitoring Requirements	Analytes to be Monitored								
		TSS	TDS	Turbidity	pH	Hardness	Metals [b]	Sulfates	COD	Nitrogen (NO_3+NO_2)
Washington	Permittee must monitor discharges four times per year until concentrations below benchmarks are measured for eight quarters.			✓	✓	✓	✓			
2008 Federal MSGP (covers Idaho and New Mexico [c])	Permittee must monitor discharges four times per year in the first year of permit coverage. If pollutant concentrations exceed benchmark values, then the permittee must implement additional BMPs to remedy the situation and continue to monitor four times per year until measured concentrations are below benchmark values.	✓		✓	✓	✓	✓			
California	Permittee must monitor discharges three times per year.	✓			✓					
Montana	Permittee must monitor discharges at least twice per year until all concentrations are below benchmarks for three consecutive sampling events.	✓			✓		✓		✓	✓
Arizona [d]	Permittee must monitor at least once during the first year of coverage. If pollutant concentrations exceed benchmark values, then permittee must implement additional BMPs to remedy the situation and must continue to monitor twice per year until measured concentrations are below benchmark values.	✓		✓	✓	✓	✓			
Utah	Copper mining and dressing facilities must monitor their discharges four times per year for COD, TSS, and nitrate plus nitrite nitrogen during years 2 and 4 of permit coverage. No requirements for other types of mines.	✓							✓	✓
Nevada	Permittee must monitor discharges once per year; alternatively, the permittee may submit a statement that these discharges will not cause exceedances of applicable WQS.	✓	✓		✓	✓	✓	✓		
Wyoming	Permittee must monitor discharges once per year.	✓							✓	✓
South Dakota	Except for coal pile runoff, monitoring is not required on a routine basis. [e]									
Colorado	Monitoring is not required on a routine basis. [e]									

Source: State general permits.
a – Ranked by amount of monitoring required.
b – Facilities are required to monitor for a variety of metals. Monitored metals vary by state and – in some states – mine type.
c – Facilities in Alaska are covered by the 2008 Federal MSGP until its state general permit is published.
d – Arizona continued the 2000 Federal MSGP until the state general permit is published.
e – State may require sampling if noncompliance with Stormwater Pollution Prevention Plan is suspected or to measure the effectiveness of BMPs.

5.0 REVIEW OF TMDL STUDIES TO DETERMINE THE EXTENT TO WHICH ORE MINES MAY BE A CAUSE OF WATER QUALITY IMPAIRMENTS

Under CWA Section 303(d) NPDES authorized states, territories, and tribes are required to develop lists of impaired waters that do not meet water quality standards. Permitting authorities are required to prioritize impaired waters and develop Total Maximum Daily Loads (TMDL) to restore their designated uses to support drinking water supply, aquatic life, or recreation. The TMDL study, which permitting authorities submit to EPA for approval, identifies sources of impairment and specifies the maximum amount of both point source and nonpoint source pollutants that can be discharged. Since 1995, EPA has approved approximately 42,000 TMDLs.

EPA reviewed the 7,760 TMDL studies that are stored electronically and available for keyword searching on EPA's *Waters*[4] website. The representativeness of these studies is somewhat limited, given that they comprise only 18 percent of the approved TMDLs. Nevertheless, in the absence of more complete information, they serve as an indicator of ore mines as potential process water and stormwater sources of water quality impairment.

EPA's review of TMDL studies identified many instances where past ore mining operations impaired surface water quality. However, EPA found no TMDL studies that identified active ore mines as sources of water quality impairments.

5.1 EPA's Approach to Screening TMDL Studies

EPA systematically searched all of the 7,670 electronically available TMDL studies for the terms "mine" or "mining." The search identified 1,668 TMDL studies that included references to ore mining, as well as to other types of mining such as coal mining and gravel mining. EPA then further screened the subset of TMDL studies with mining references to identify those that contained information relevant to ore mining facilities. This was done by limiting the search to TMDL studies in states with major ore mining activity (Alaska, Arizona, California, Colorado, Montana, New Mexico, Nevada, South Dakota, Utah, and Washington), which narrowed the number of TMDL studies to 158. EPA then performed the following steps:

1. EPA determined whether or not the mining operations discussed in the TMDL studies were ore mining operations. Studies that did not provide any detail on the type of mining present in the watershed were removed from further analysis, which reduced the number of studies for further review from 158 to 42.

2. EPA determined whether the studies identified abandoned or closed mines. EPA recorded this information, but did not use it to screen documents for further review.

3. EPA determined whether the document identified large-scale active mines, which excluded mining activities such as small-scale placer mining and recreational gold panning. Removing documents that did not specifically describe large-scale, active mines reduced the number of documents for further review from 42 to 9.

[4] Available online at http://iaspub.epa.gov/waters10/text_search.tmdl_search_form. Accessed on January 22nd, 2009.

4. EPA performed a text search using the terms "waste rock" and "tailing" to identify documents that discuss water quality impacts from waste rock and tailings piles, but did not use this step to screen documents for further review.

5. EPA verified that the remaining TMDLs studies listed ore mining as a source of impairment. In cases where it was not clear that mining was a source of impairment, EPA removed the study from further analysis, which reduced the number of documents for further review from 9 to 7.

5.2 Results of Screening the TMDL Studies

EPA identified seven TMDL studies that described impacts from mining operations that were active or recently active at the time the studies were written. Table 5-1 summarizes these studies. Ore mining operations will commonly close and re-open periodically according to the fluctuating prices of the metals they produce. Few mines are operated continuously over spans of time long enough to identify them as sources of impairment while they are still active. Consequently, EPA included TMDL studies that contained discussion of recently closed mines. EPA reviewed in detail the relevant information in these studies. Although mines were listed among the sources within impaired watersheds, none of the TMDL documents definitively stated that impairments resulted from any active mines.

For additional detail on the seven TMDL studies listed in Table 5-1, see DCN 06916.

5.3 Ore Mining Water Quality Impact References

1. EPA, 2001. *The National Costs of Implementing TMDLs*. Washington, D.C.

2. ADEQ, 1999. *Total Maximum Daily Load And Implementation Plan For Mercury Peña Blanca Lake, Arizona*.

3. NMED, 2006. *Total Maximum Daily Load for the Red River Watershed: Rio Grande River to Headwaters*.

4. ADEQ, 2005. *French Gulch TMDLs for Cadmium, Copper, and Zinc: Headwaters to Hassayampa River*.

5. EPA, 2001. *Trinity River Total Maximum Daily Load for Sediment*.

6. EPA, 2001. *Total Maximum Daily Load for Copper in Pinto Creek, Arizona*.

7. EPA, 2003. *Bryant Creek: Total Maximum Daily Loads – Arsenic, Iron, Nickel, Turbidity, and Total Suspended Solids.*

8. Washington State Department of Ecology, 2003. *Colville River Watershed Bacteria Total Maximum Daily Load.* Olympia, Washington.

Table 5-1. TMDL Studies with Information on Active and Recently Closed Ore Mines [a]

TMDL Study	Parameters Associated with Impairment	Active and Recently Closed Mines [b]	Summary of Data Available	Additional Comments
Pinto Creek, Pinto Creek, AZ	Cu	• Gibson Mine (closed) • BHP Pinto Creek Mine (active) • Carlota Copper Project (active)	Appendix A (data and figures) is not included in the available TMDL report; some data are provided in the text of the report.	The partial data that were available did not clearly identify documented surface water impacts from the active mines.
French Gulch, Hassayampa River, AZ	Cd, Cu, Zn	• Zonia Mine (closed)	Document includes extensive in-stream monitoring data for metals and load estimates for all stream segments.	No data documented that the Zonia Mine discharges led to stream impairment.
Pena Blanca, Pena Blanca Lake, AZ	Hg	• St. Patrick Mine (closed)	Study provides concentration data from sediment and fish tissue samples and some concentration data from water column samples	The TMDL study identified other past mining projects and current exploratory projects, but it does not provide information on their relative potential mercury loads.
Red River, Rio Grande to Headwaters. New Mexico	Al, turbidity, and sediment	• Molycorp Questa Mine (active)	Document includes in-stream monitoring data for aluminum, benthic macroinvertebrates, stream flow, turbidity, and TSS; it does not provide data for any mine sites.	None.
Bryant Creek, Doud Springs, NV	As, Cu, Fe, Ni, temperature, turbidity, TSS	• Leviathan Mine (closed)	Document includes statistical summary of stream flow, arsenic, iron, turbidity, and TSS measurements in creek. No data are provided for mine sites.	Although mining impacts are referenced throughout the TMDL document, the study describes only the Leviathan Mine.
Lower Similkameen River, Oroville, WA	As	• Similco Mine (active) • Dankoe Mine (active) • Corona Nickel Plate Mine (active) • Cadorado Mine (active) • (All in Canada)	Document includes in-stream monitoring data for arsenic. No data are provided for mine sites.	The TMDL study acknowledges that active mining occurs in the U.S. portion of the Similkameen watershed, but it does not specifically mention any mine sites in the U.S.
Trinity River, Trinity River Basin, CA	Sediment	• Deiner Mine (closed) • La Grange (closed)	Study estimates sediment loads from major sources.	None.

a – Listed in order of probable relevance to the Ore Mining Effluent Guidelines.
b – Mine status in parenthesis. “Closed” means both inactive and permanently closed.
TSS – Total Suspended Solids.

9. Washington State Department of Ecology, 2004. *Issaquah Creek Basin Water Cleanup Plan for Fecal Coliform Bacteria: Total Maximum Daily Load. 2003.* Bellevue, Washington.

10. Washington State Department of Ecology, 2004. *Lower Similkameen River Arsenic Total Maximum Daily Load.* Olympia, Washington.

6.0 PROCESS WATER DISCHARGES

Table 6-1 summarizes annual discharge estimates for ore mining facilities based on available 2007 data. Table 6-1 presents data just for 2007 because that was the most recent year with data available when EPA initiated the Ore Mining Preliminary Study. EPA checked the quality of the data by contacting facilities with high discharge concentration values that appeared to be outliers inconsistent with other data. EPA found that reporting errors had occurred in several cases and that actual discharge concentration values were significantly lower. EPA made adjustments to data based on information provided by facilities.

The data in Table 6-1 were taken from EPA's *DMRLoads2007* Database, which contains discharge data primarily for "major" facilities. Data for facilities classified as "minor" are not required to be reported at the national level, although some states report these data voluntarily. Permitting authorities classify facilities as either major or minor based on an assessment of six criteria (U.S. EPA, 2010):

- Toxic pollutant potential;
- Discharge flow to stream flow ratio;
- Conventional pollutant loading;
- Public health impact;
- Water quality factors; and
- Proximity to coastal waters.

Consequently, Table 6-1 only contains information for the 54 largest major ore mining facilities that reported discharge information for 2007. An estimated 240 minor facilities are not included in Table 6-1.

Table 6-1. 2007 Discharge Summary for the Ore Mining Category

Rank	NPID	Name	Location	Total Pounds Released [a]	TWPE
1	CO0000248	Climax Mine	Summit County, CO	225,030,925	50,502
2	MN0055301	Northshore Mining/Silver Bay	Silver Bay, MN	4,364,800	40,981
3	MO0100226	Doe Run Resources Co	Viburnum, MO	17,001,883	28,207
4	AK0053341	Teck-Pogo Inc	Delta Junction, AK	3,776,218	17,714
5	UT0000051	Kennecott Copper Co	Magna, UT	142,677,370	11,517
6	ID0000027	U.S. Silver Corporation	Wallace, ID	21,995	9,072
7	MO0000086	Doe Run Company	Viburnum, MO	133,893	6,920
8	MO0001856	Doe Run Resources Co	Viburnum, MO	1,821,703	5,022
9	MO0001848	Doe Run Resources Corp	Viburnum, MO	2,412,669	3,121
10	SD0026883	LAC Minerals	Central City, SD	4,972,369	2,004
11	CA0081876	Mammoth,Sutro,Keystone Et Al	Redding, CA	5,836	1,854
12	NY0001791	Balmat Mines & Mill	Balmat, NY	15,969,640	1,351
13	SD0025852	Wharf Resources (USA)	Lead, SD	3,071,229	1,227
14	AR0000582	Alcoa Arkansas Remediation	Bauxite, AR	132,152	924
15	MO0100218	Doe Run Company	Bunker, MO	48,310	916
16	AK0043206	Kennecott Greens Creek Mining	Juneau, AK	349,176	396

Table 6-1. 2007 Discharge Summary for the Ore Mining Category

Rank	NPID	Name	Location	Total Pounds Released [a]	TWPE
17	MI0000094	Empire Iron Mining Partnership	Palmer, MI	14,241,519	394
18	TN0001732	East Tennessee Zinc Co. LLC	Jefferson City, TN	77,583	373
19	MI0038369	Tilden Mining Company L.C.	Ishpeming, MI	13,320,379	315
20	CO0024562	Carlton Tunnel Portal Site	Teller County, CO	40,828	294
21	NM0022306	Chevron Mining Inc.	Questa, NM	5,670	252
22	UT0022403	Jordanelle Ssd	Park City, UT	11,017	186
23	CO0041467	Henderson Mine, Urad Minesite	Clear Creek, CO	93,143	142
24	SD0026905	Golden Reward Mining Co.	Lead, SD	4,339,129	131
25	CO0038334	London Water Tunnel	Park County, CO	1,309	95
26	TN0061468	East TN Zinc Co., Llc	Jefferson City, TN	9,530	86
27	MN0046981	Northshore Mining Co; Cliffs MN	Babbitt, MN	2,140,070	73
28	MO0001872	Cominco American Inc	Bixby, MO	5,676	71
29	AZ0020401	Bhp Pinto Valley Operations	Miami, AZ	7,079,818	51
30	TN0001759	East Tennessee Zinc Co., LLC	Mascot, TN	13,709	50
31	AK0050571	Coeur Alaska Inc	Juneau, AK	1,154,488	36
32	CO0035394	Mt. Emmons/Keystone Mine	Gunnison County, CO	1,864,673	29
33	AK0038652	Teck Cominco Alaska Inc	Kotzebue, AK	1,585,789	28
34	TN0001741	East Tennessee Zinc Co., LLC	New Market, TN	7,114	22
35	TN0027677	East Tennessee Zinc Co., LLC	Jefferson County, TN	4,487	17
36	ID0025402	Thompson Creek Mining	Challis, ID	1,064,984	16
37	ID0026468	Hecla Mining Company	Stanley, ID	653,375	16
38	CO0038954	Platoro Joint Venture	Conejos County, CO	196,805	14
39	WA0025721	Dawn Mining Company	Wellpinit, WA	1,035,549	13
40	FL0000051	Bradford County	Bradford County, FL	28,892	10
41	NM0020532	Rio Algom Mining, LLC	Mckinley County, NM	6,726	7
42	FL0040274	E.I. Dupont De Nemour-Maxville	Starke, FL	18,382	3
43	TN0060127	O-N Minerals(Luttrell) Co.	Thorn Hill, TN	5,058	2
44	FL0000035	State Route 125	Clay County, FL	2,659	1
45	TN0057029	Mossy Creek Mining, LLC	New Market, TN	179	0
46	NM0020435	Chino Mines Company	Hurley, NM	0	0
47	NM0028100	Rio Grande Resources Corp.	Cibola County, NM	0	0
48	NM0028169	Mineral Energy and Technology	Sarquez, NM	0	0
49	NV0023345	Esmeralda Project Gold Mine	Hawthorne, NV	0	0
50	SD0000043	Sd Science And Technology	Lead, SD	0	0
51	MT0000191	Montana Resources	Butte, MT	0	0
52	ID0000175	Hecla Mining Company	Mullan, ID	0	0
53	TN0004227	Mossy Creek Mining, LLC	Elmwood, TN	37,155	0
54	TN0029360	Mid-Tennessee Zinc Corporation	Gordonsville, TN	0	0

Source: EPA's *DMRLoads2007* Database.
a – Facilities with zero total pounds released had no discharges in 2007.

6.1 Process Water Discharges References

1. EPA, 2010. *NPDES Permit Writers' Manual*. Washington, D.C.

7.0 STORMWATER ANALYSIS

As noted in Section 2, EPA was only able to obtain stormwater discharge data for a subset of ore mines in Arizona and Montana, which EPA reviewed to assess the range of pollutant concentrations in stormwater from ore mining operations. The Arizona and Montana stormwater data, however, were not adequately representative to support any national or regional conclusions about stormwater discharges from ore mines (ERG, 2010a).

EPA Region 9 provided stormwater monitoring data for eight Arizona ore mines. EPA also identified a limited amount of stormwater monitoring data available through Envirofacts (see Section 4.1.2.2) for 11 ore mines in Montana. EPA also received discharge monitoring reports (DMR) for 17 Minnesota ore mines, along with monitoring data submitted with Form 2c of the NPDES Permit Application for 6 of these 17 facilities, from the Minnesota Pollution Control Agency. However, EPA determined that all but one of the Minnesota stormwater discharges covered by the Minnesota DMRs were commingled with process water discharges, so that no discharge data were available for segregated stormwater discharges. Consequently, EPA was not able to use the Minnesota data to characterize the range of pollutant concentrations in Minnesota ore mining stormwater discharges.

As discussed in Section 4, and reflected in Table 4-2, the availability of stormwater data for ore mining operations is very limited due to minimal benchmark monitoring requirements. Moreover, many states do not maintain electronic copies of stormwater data, and there are no requirements for states to report mining stormwater data to national databases such as the Permit Compliance System.

Based on the information presented in Appendix B, the following states have at least ten permitted discharges regulated by general stormwater permits (number of permitted discharges in parentheses):

- Arizona (31);
- Alaska (25);
- Montana (15);
- Wyoming (12);
- Idaho (13);
- California (11);
- Colorado (10); and
- Nevada (10).

In addition to searching for available stormwater data, EPA also observed stormwater controls at three Arizona copper mines during site visits in September 2009, to better understand stormwater management at ore mines. Detailed information on the facilities that EPA visited is included in the site visit report (ERG, 2010b).

7.1 Quality Procedures Used to Create Analysis Spreadsheets

EPA entered stormwater monitoring data into a spreadsheet database and calculated statistical parameters (e.g., median, maximum) for parameters regulated by the Ore Mining Effluent Guidelines. Data were excluded from analysis in the following cases:

- Where more than one measurement was made for a parameter at one outfall during a reporting period, EPA used the maximum value only (the reported quantity is a daily maximum) and excluded all other values.
- EPA excluded data points where the DMR indicated no discharge.
- EPA excluded measured pollutant concentrations where QA issues (e.g., holding time exceedances, insufficient sample volume) were indicated in the DMR.

For metals, EPA considered “total” and “total recoverable” measurements to be equivalent (EPA, 1998).

For the purposes of the statistical analyses, EPA assumed that a pollutant’s concentration was zero when it was reported “not detected” or less than the detection limit. This approach likely underestimates average pollutant concentrations, but it does not affect any other elements of the statistical analysis.

EPA verified that all data to be used were for stormwater discharges only using the following procedures:

- For the Arizona data, EPA verified that each of the permit IDs under which the monitoring data were collected and reported were general stormwater permit IDs.
- For the Minnesota data, EPA reviewed the outfall descriptions provided in the NPDES permit applications. EPA did not analyze these data because none of the outfalls with monitoring data were purely stormwater (based on outfall descriptions).
- For the Montana data, EPA verified that each of the outfalls was classified with an “R” code in Envirofacts, indicating that it was a stormwater outfall.

EPA also compared stormwater pollutant concentrations to daily maximum limits specified in Subpart J of the Ore Mining Effluent Guidelines (Copper, Lead, Zinc, Gold, Silver, and Molybdenum Ores Subcategory) [5] and benchmark concentrations specified in the 2008 Multi-Sector General Permit (MSGP) for industrial stormwater discharges (EPA, 2008)[6].

7.2 Stormwater Monitoring Data for Arizona

EPA received hardcopies of DMRs from the Region 9 Office for eight copper mines. These DMRs include daily maximum values for each parameter measured, but do not include monthly average values. In addition to pollutant concentrations, the DMRs include estimated cumulative flow, data qualifiers for quality control issues (e.g., holding time exceedances, insufficient sample volume), and a check box to indicate periods when no discharge occurred. Table 7-1 summarizes the facilities and time periods covered by these data, as well as the parameters monitored at each facility.

[5] The Ore Mining Effluent Guidelines do not apply to the discharges discussed in this chapter. They are used here for comparison.

[6] EPA did not compare metals concentrations to MSGP benchmark concentrations (which are dependent on the hardness of the receiving water), because hardness measurements for the receiving waters were unavailable.

Table 7-1. Stormwater Monitoring Data Available for Arizona Ore Mines

Facility Name	Permit ID	Mine Type	Monitoring Period [a]	Monitored Parameters							
				Flow	Metals	pH	TSS	COD	Hardness	Turbidity	N (NO_3 + NO_2)
Copper Cities	AZR05A798	Copper	January 1999 – August 1999	✓			✓	✓			✓
Florence	AZR05A795	Copper	April 1999 – September 1999	✓	✓		✓	✓		✓	✓
Pinto Valley	AZR05A796	Copper	January 1999 – September 1999	✓			✓	✓			✓
Morenci	AZR05A711	Copper	January 1999 – September 1999	✓	✓	✓	✓	✓	✓		✓
Sierrita	AZR05A550	Copper	January 2000 – December 2000	✓	✓	✓	✓		✓	✓	
San Manuel Mine	AZR05B412	Copper	July 2001 – September 2001	✓	✓	✓	✓	✓	✓	✓	✓
Silver Bell	AZR05A789	Copper	January 1999 – March 2002	✓	✓	✓	✓	✓	✓	✓	✓
Superior	AZR05A800	Copper	January 1999 – December 2000	✓	✓	✓	✓	✓	✓	✓	✓

a – In some cases, monitoring data are not continuous for the period specified (some periods without data).

EPA entered the DMR data into a spreadsheet database, and used the methods to process and analyze the data described in Section 7.1. Table 7-2 summarizes the Arizona stormwater data and compares them to the limits and benchmarks.

Copper, zinc, and TSS all exceed the numerical limits from the Ore Mining Effluent Guidelines in the majority of the stormwater data for Arizona.

All 35 TSS samples exceed the daily maximum limit set by the Ore Mining Effluent Guidelines (30 mg/L)[7], and 32 of the 35 samples exceed the MSGP benchmark value (100 mg/L). The average and median TSS concentrations in the Arizona stormwater data are 3,200 and 2,000 mg/L, respectively.

The average and median concentrations for copper and zinc exceed the daily maximum limits set by the Ore Mining Effluent Guidelines. Of the 16 copper samples taken, 14 exceed the daily maximum limit set by the Ore Mining Effluent Guidelines. Of the 14 zinc samples taken, 9 exceed the daily maximum limit set by the Ore Mining Effluent Guidelines.

[7] The Ore Mining Effluent Guidelines do not apply to these discharges; they are used here only as screening levels.

Table 7-2. Summary of Arizona Stormwater Monitoring Data, in mg/L

			Comparison to Regulatory Levels			Statistical Summary			
Pollutant [a]	# of Samples	# of Detections	MSGP Benchmark	ELGs Limit [b]	% of Samples Exceeding ELGs Limit	Min.	Avg.	Median	Max.
Cadmium	15	5	*	0.1	0	ND	0.0063	ND	0.034
Copper	16	16	*	0.3	91	0.015	5.3	4.4	26
Lead	15	11	*	0.6	17	ND	0.26	0.24	0.74
Mercury	13	4	0.0014	0.002	0	ND	0.00013	0	0.00052
pH (S.U.)	14	NA	6 - 9	6 - 9	7.1	5.8	7.3	7.7	8.6
TSS	35	35	100	30	100	31	3,200	2,000	30,000
Zinc	14	11	*	1	68	ND	2.2	2.2	6.8

a – All metals are total recoverable.
b – Daily Maximum from Subpart J.
* – The benchmark values of some metals are dependent on water hardness.
ELGs – Ore Mining Effluent Guidelines (40 CFR Part 440).
S.U. – Standard Units.

7.3 Stormwater Monitoring Data for Montana

The stormwater monitoring data that EPA downloaded from Envirofacts cover 11 ore mines in Montana. Similar to the Arizona data, these data include daily maximum values for each parameter measured but do not include monthly average values. Table 7-3 summarizes the facilities and time periods covered by these data, as well as the parameters monitored at each facility.

EPA copied the Envirofacts data into a spreadsheet database, and used the same methods to process and analyze the data that were used for the Arizona DMR data (see Section 7.1).

Table 7-3. Summary of Stormwater Monitoring Data Available for Montana Ore Mines

Facility Name	Permit ID	Mine Type [a]	Monitoring Period [b]	Monitored Parameters							
				Flow	Metals	pH	TSS	COD	Hardness	Turbidity	N ($N0_3$ + $N0_2$)
Golden Sunlight Mines, Inc	MTR300012	Gold	July 1998 – June 2006	✓	✓	✓	✓	✓			✓
Stillwater Mining Company	MTR300017	Unknown	July 2003 – December 2003	✓	✓	✓	✓	✓			✓
CR Kendall Corporation	MTR300026	Gold	July 1999 – June 2006	✓	✓	✓	✓	✓			✓
Asarco Black Pine Mine	MTR300080	Silver	January 2006 – June 2006	✓	✓	✓	✓				
Seven Up Pete Joint Venture	MTR300085	Gold	January 2003 – December 2005	✓	✓	✓	✓	✓			✓
Seven Up Pete Joint Venture	MTR300086	Gold	July 1998 – June 2005	✓	✓	✓	✓				✓
M & W Milling & Refining	MTR300139	Gold	January 1998 – June 2006		✓	✓	✓				✓
Asarco Upper Blackfoot Mining Complex	MTR300157	Lead and Zinc	January 2005 – June 2006	✓	✓	✓	✓	✓			
Golden Sunlight Mines, Inc.	MTR300199	Gold	July 1999 – June 2006	✓	✓	✓	✓	✓			✓
Stillwater Mining Company	MTR300226	Copper	January 2003 – June 2006	No Discharges Reported							
Independent Milling, LLC	MTR300260	Gold	January 2004 – June 2004	No Discharges Reported							

a – Determined by SIC code.
b – In some cases, monitoring data are not continuous for the period specified (some periods without data).

Table 7-4 summarizes the Montana stormwater data and compares them to the numerical limits from the Ore Mining Effluent Guidelines and the benchmark concentrations from the Federal MSGP.

Table 7-4. Summary of Montana Stormwater Monitoring Data, in mg/L

Pollutant [a]	# of Samples	# of Detections	Comparison to Regulatory Levels			Statistical Summary			
			MSGP Benchmark	ELGs Limit [b]	% of Samples Exceeding ELGs Limit	Min.	Avg.	Median	Max.
Cadmium	66	43	*	0.1	18	ND	0.015	0.00035	0.16
Copper	82	79	*	0.3	26	ND	2.1	0.019	89
Lead	80	57	*	0.6	17	ND	0.85	0.025	32
pH (S.U.)	86	N/A	6 - 9	6 - 9	16	2.2	6.9	7.7	9
TSS	85	72	100	30	72	ND	2,200	200	46,000
Zinc	74	73	*	1	20	ND	2.1	0.1	31

a – All metals are total recoverable. Monitoring data did not include mercury measurements.
b – Daily Maximum from Subpart J.
* – The benchmark values of some metals are dependent on the hardness of the receiving water.
ELGs – Ore Mining effluent guidelines (40 CFR Part 440).
S.U. – Standard Units.

While cadmium concentrations are higher in Montana stormwater; copper, zinc, and TSS concentrations are consistently higher in Arizona stormwater.

Of the 85 TSS samples taken, 60 exceeded the daily maximum limit set by the Ore Mining Effluent Guidelines (30 mg/L), and 49 of 85 samples exceeded the MSGP benchmark value (100 mg/L). The average and median TSS concentrations in the Montana stormwater data are 2,200 and 200 mg/L, respectively.

Although the average concentrations of copper, lead, and zinc all exceed the daily maximum limit set by the Ore Mining Effluent Guidelines, the majority of stormwater samples are below these limits for each of these pollutants. Average values for copper, lead, and zinc are skewed by a few high measurements.

7.4 Conclusions

Due to the limited scope of the data that EPA was able to obtain, it is not possible to make national conclusions about the constituents in stormwater from mining operations, nor about the adequacy of stormwater controls at ore mines. The stormwater data that EPA was able to identify and review pertain to a small subset of mines. Moreover, the data may not represent current conditions because they were not recently collected, and were collected during relatively short time periods.

Based on the analysis of the stormwater monitoring data summarized in this chapter, EPA concludes:

- Stormwater discharges from ore mines in Montana and Arizona differ. While cadmium concentrations were higher in the stormwater monitoring data for Montana; copper, zinc, and TSS concentrations were consistently higher in the monitoring data from Arizona.

- TSS is the only pollutant that consistently exceeds ELGs and MSGP benchmarks in both the Arizona and Montana stormwater monitoring data.

  — In the Arizona data, all 35 TSS measurements exceeded the daily maximum limit set by the Ore Mining ELGs (30 mg/L), and 32 of the 35 measurements exceeded the MSGP benchmark value (100 mg/L). The average and median TSS concentrations observed in the Arizona data were 3,200 and 2,000 mg/L, respectively.

  — In Montana, 60 of 85 TSS measurements exceeded the daily maximum limit set by the Ore Mining ELGs (30 mg/L), and 49 of 85 measurements exceeded the MSGP benchmark value (100 mg/L). The average and median TSS concentrations observed in the Montana data were 2,200 and 200 mg/L, respectively.

- Two other pollutants in the Arizona monitoring data consistently exceed ELGs: copper and zinc. Both average and median concentrations for each of these pollutants exceeded the daily maximum limits set by the Ore Mining ELGs.

  — Of the 16 copper measurements in the data set, 14 exceeded the daily maximum limit set by the Ore Mining ELGs.

  — Of the 14 zinc measurements in the data set, 9 exceeded the daily maximum limit set by the Ore Mining ELGs.

7.5 <u>Stormwater Analysis References</u>

1. ERG. 2010a. Memo Re: Range of Pollutant Concentrations in Arizona and Montana Ore Mining Stormwater Discharges. April 27, 2010.

2. ERG. 2010b. Site Visit Report: Arizona Copper Mines. (March). Chantilly, VA. DCN 07219.

3. U.S. EPA. 1998. Memorandum from William Telliard to Pat Sosinski (Region 3) Re: Total vs. Total Recoverable Metals. Engineering and Analysis Division. Washington, DC.

4. U.S. EPA. 2010. Envirofacts Database. Available online at www.epa.gov/enviro. Date accessed: 27 January, 2010.

5. U.S. EPA, 2008. *Multi-Sector General Permit For Stormwater Discharges Associated With Industrial Activity (MSGP).* Washington, DC (September). Available online at: http://cfpub.epa.gov/npdes/stormwater/msgp.cfm. Date accessed: 27 January, 2010.

8.0 HIGH DENSITY SLUDGE TREATMENT TECHNOLOGY REVIEW

During the course of the Ore Mining Preliminary Study, EPA identified a highly efficient treatment technology for certain types of waste streams known as high density sludge (HDS) recycling. This technology may not be appropriate for all types of mining waste streams, but it could be beneficial to certain mine sites depending on the volume of their waste stream and its constituents. This section, which summarizes the HDS process, provides examples of HDS treatment systems, and discusses permit requirements at sites using HDS. It may serve as a resource for ore mine operators and NPDES permit writers when considering mine wastewater treatment systems.

8.1 Background of High Density Sludge Recycling

The HDS process was developed in the early 1970's by Bethlehem Steel Corporation. It was originally used to treat acid mine drainage and diluted waste pickle liquor discharges. The HDS process is most practical for acidic wastewaters containing high concentrations of dissolved metals. EPA identified one facility, the Leadville Mine District Tunnel, which uses the HDS process to treat alkaline wastewater with high concentrations of dissolved metals.

The mining industry has used the HDS process for the past 25 years. In addition, the following non-mining industries currently use this technology to remove heavy metals from wastewater streams (SGS, 2009):

- Metal finishing (electro-plating and galvanizing);
- Chemical manufacturing (i.e. pigment plants);
- Smelting/refining;
- Coal preparation;
- Metal molding and casting; and
- Site remediation of heavy metals.

One benefit of the HDS process is that sludge storage and disposal costs can be much lower than traditional sludge-generating treatment because the process generates a denser sludge. Sludge storage and disposal costs can often exceed the initial capital costs of conventional treatment plants over the life of their operation. Rather than disposing of the sludge after one pass through the treatment system like traditional sludge-generating treatment systems, the HDS process recycles the sludge back into the settling units to create a denser, more compact sludge, lowering the total sludge volume (Leon and Zick, 1997).

Part of the reason that the HDS process produces a denser sludge is that the recycling process creates metal compounds with a lower affinity for water. Traditional sludge-generating treatment systems treating metal-bearing wastewaters remove metals by forming metal hydroxides that bond with water molecules, producing wetter, less concentrated sludge. The HDS process, however, converts metal hydroxides into metal oxide particles which have a low affinity for water, thereby reducing the amount of interstitial water bound to the sludge and thus reducing its volume. The HDS process, in some instances, may concentrate the sludge enough to justify economical recovery of certain metals.

Because of the similarities between conventional lime-based treatment systems and the HDS process, conventional systems can generally be converted via small equipment additions (e.g., small tanks, mixers, pumps, meters). However, the HDS process requires precise control, and therefore requires experienced and knowledgeable operators for the system to function properly (Leon and Zick, 1997).

8.2 Overview of the HDS Process

While conventional lime treatment systems add the alkali (e.g., lime, sodium hydroxide) directly to the influent wastewater, most HDS systems mix the alkali with recycled sludge prior to combining it into the influent wastewater. Figure 8-1 illustrates an HDS process with this type of configuration. In contrast to this configuration, some HDS systems mix the recycled sludge with the influent wastewater and then add the alkali.

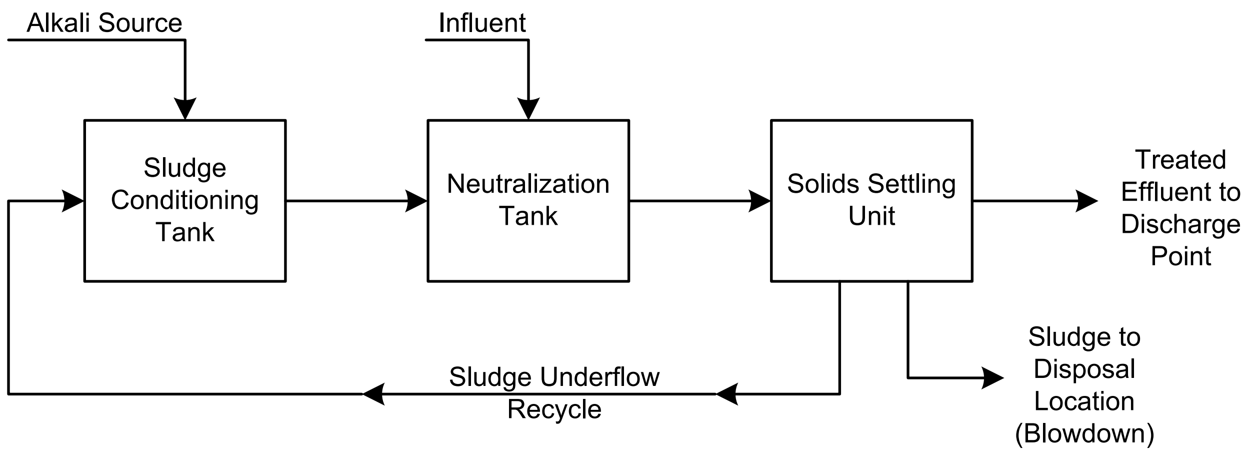

Figure 8-1. Simplified Schematic of the HDS Process (Leon and Zick, 1997)

The re-circulated sludge flows from the bottom of the solids settling unit back to the beginning of the treatment system. Operators decide how much alkali to add to the system based on differences between a pre-determined pH set point and the constant pH measurements taken in the neutralization tank. Because of each metal's optimum solubility for precipitation and treatment system efficiency, the pH set point is specific to the wastewater being treated. The specific pH is determined to optimize metals removal and alkali addition rates. In some cases, HDS systems also have the advantage of using less alkali to remove the same amount of metals compared to conventional treatment systems, because the recycled sludge creates additional sites for metal ions to form complexes (thereby increasing the system's treatment efficiency).

As with conventional systems, sludge must be periodically removed from the solids settling unit to keep too much sludge from building up in the system. While conventional lime treatment systems produce sludge containing 1 to 3 percent solids, HDS systems produce sludge with between 25 and 35 percent solids (Leon and Zick, 1997).

8.3 Prevalence of the HDS Process

Through internet searches and interviews with HDS treatment system experts, EPA was able to identify eight sites in the U.S. that use the HDS process to treat wastewater from mining sites (facility location in parentheses). Most of the sites identified below are not active mine sites and many are undergoing remediation.

- **Asarco Primary Lead Smelter (East Helena, MT) –** According to the Superfund Five-Year Review for this site, an HDS system treats previously generated process wastewater and stormwater associated with the site's smelter. The smelter is no longer active, but the two surface impoundments contributing influent to the HDS system continue to accumulate stormwater from the site (U.S. EPA, 1999).

- **Horseshoe Bend Water Treatment Plant at the Berkley Pit (Butte, MT) –** According to a site summary by the Montana Department of Environmental Quality, the facility treats mine water using the HDS process. The Berkley Pit is a superfund site that was formerly an open-pit copper mine; the pit also collects seepage from mines in the surrounding area. The site summary includes permit requirements and summary performance data for the HDS system (MDEQ, 2005).

- **Iron Mountain Mine Superfund Site (Redding, CA) –** According to a U.S. EPA case study, the mine drainage from the Iron Mountain Mine superfund site is treated using an HDS system. The case study says that the system removes over 99 percent of the copper, zinc, and cadmium in the mine drainage (U.S. EPA, 2006).

- **Leadville Superfund Site (Leadville, CO) –** The Leadville Superfund site includes the Leadville Mine Drainage Tunnel (LMDT) and Yak Tunnel. According to LMDT personnel, both tunnels operate HDS systems to treat mine water. The LMDT uses sodium hydroxide to add alkalinity to the system while the Yak Tunnel uses bulk lime (Krejci, 2009).

- **Mettiki Coal Mine (Oakland, MD) –** An article prepared by Mettiki Coal Company mentions that the Mettiki Coal Mine uses an HDS system to treat mine water. In addition to treating mine water, this system treats flue gas desulfurization wastes from wet limestone scrubbers at a local coal-fired power plant that were previously injected into abandoned portions of the Mettiki Mine (Ashby and Ziemkiewicz, 2007).

- **Red Dog Lead and Zinc Mine (Kotzebue, AK) –** According to the scoping document for the Supplemental Environmental Impact Statement for the Red Dog Mine, the facility has two independent HDS systems that treat runoff and seepage from ore stockpiles and tailings impoundments (U.S. EPA, 2007).

- **Summitville Superfund Site (Del Norte, CO) –** According to a U.S. EPA Technical Session Summary, the Summitville mine site has operated since the 1870s and became an NPL site in 1994. EPA operates an HDS system that uses bulk lime to treat surface water run-off and groundwater seeps (U.S. EPA, 2002).

- **Teck-Pogo Gold Mine (Delta Junction, AK) –** According to the Final Environmental Impact Statement (FEIS) for the Pogo Mine Project, Teck-Pogo uses an HDS system to treat mine seepage. The FEIS includes estimates of effluent water quality based on similar treatment systems (U.S. EPA, 2003a).

8.4 Permit Requirements and Level of Treatment Required for the HDS System

EPA obtained permits for four of the eight facilities listed in Section 8.3. Table 8-1 compares effluent limits for these systems to the most stringent concentrations specified in any of the subparts of 40 CFR Part 440. Information that that EPA reviewed shows that these HDS systems are able to achieve pollutant removals orders of magnitude lower than limits set in 40 CFR Part 440. However, further analysis of HDS treatment costs would be needed to support any conclusions about HDS cost effectiveness compared to other technologies currently used to treat ore mining wastewater. A case study of HDS treatment costs and pollutant removal efficiencies is discussed in a memo written by ERG and titled "High Density Sludge Recycling Technology" (ERG, 2009).

Table 8-1. Permit Limits for HDS Systems Treating Discharges Associated with Ore Mining (Units are in mg/L)

	Lowest Concentration Set by ELGs [b]			Butte Resources (ID: MT0000191)		Teck-Pogo (ID: AK0053341)		Red Dog Mine (ID: AK0038652)		Leadville Tunnel (ID: CO0021717)	
Pollutant [a]	Applicable Subparts [c]	Monthly Avg.	Daily Max.	Monthly Avg.	Daily Max.	Monthly Avg.	Daily Max.	Monthly Avg.	Daily Max.	Monthly Avg. [d,e]	Daily Max. [d,e]
Cadmium	**F,G,H,J,K**	**0.05**	**0.1**	0.0035	0.0052	0.00011	0.00022	0.002	0.0034	0.0009	0.0012
Copper	**F,G,H,J,K**	**0.15**	**0.3**	0.01	0.015	0.0022	0.0045	0.0151	0.0437	0.023	0.023
Lead	**F,G,H,J,K**	**0.3**	**0.6**	0.011	0.017	0.0006	0.0011	0.0081	0.0196	0.0015	0.032
Mercury	**D,J,K**	**0.001**	**0.002**	0.00005	0.000075	0.00001	0.00002	0.00001	0.00002	0.00013	NL
Zinc	**C,E,F,G,H,J,K**	**0.5**	**1**	0.158	0.238	0.0214	0.0429	0.1196	0.2573	0.084	0.329

Source: NPDES Permits AK0038652, AK0053341, CO0021717, and MT0000191.
a – Pollutant concentrations are measured as total recoverable except where otherwise noted.
b – ELGs are presented for comparison purposes only.
c – Subparts codes:

- C: Uranium, Radium, and Vanadium.
- D: Mercury
- E: Titanium
- F: Tungsten
- G: Nickel
- H: Vanadium (mined alone - not as a byproduct)
- J: Copper, Lead, Zinc, Gold, Silver, and Molybdenum
- K: Platinum

c – Limits are for potentially dissolved concentrations.
d – Although the permit sets limits for both the high-flow and low-flow seasons, limits are shown for the high-flow season only.
NL – No limit.

8.5 Observations about HDS

Based on information cited in this section, EPA made the following general observations about HDS.

- Conventional lime-softening systems can be converted to HDS systems via small equipment additions (e.g., tanks, pumps, meters);
- While conventional lime treatment systems produce sludge containing between 1 to 3 percent solids, HDS systems generally produce sludge between 25 and 35 percent solids;
- Use of the HDS system results in lower sludge storage and disposal costs;
- The HDS system provides for better removal of certain metals (e.g., cadmium, zinc) in some cases than a conventional lime precipitation system;
- In some cases, it may be possible to economically recover metals from the dense sludge produced by the HDS process; and
- The four HDS systems for which EPA obtained a permit were discharging treated effluent with cadmium, copper, lead, and mercury concentrations at least an order of magnitude lower than 40 CFR Part 440 limits.

8.6 High Density Sludge Treatment Technology References

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Appendix A

NUMERIC LIMITS SPECIFIED IN THE ORE MINING EFFLUENT GUIDELINES

Table A-1. Monthly Average Limits from Effluent Guidelines for Ore Mining Operations

Subpart	Ore Type	Discharge Sources	ELG Level	Required Parameters [a]																	
				Al	As	Cd	Cu	Fe	Fe (diss.)	Hg	Ni	Pb	Ra	Ra	U	Zn	COD	NH_3	pH (S.U.)	Settleable Solids (mL/L)	TSS
A	Iron Ore	Mine Drainage and Mills	BPT/BAT/NSPS	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	6 to 9	—	20
B	Aluminum Ore	Mine Drainage	BPT/BAT/NSPS [b]	1	—	—	—	0.5	—	—	—	—	—	—	—	—	—	—	6 to 9	—	20
C	Uranium, Radium, and Vanadium Ores	Mine Drainage	BPT/BAT/NSPS [c]	—	—	—	—	—	—	—	—	—	10	3	2	0.5	100	—	6 to 9	—	20
		Mills using acid or alkaline leach	BPT	—	0.5	—	—	—	—	—	—	—	10	3	—	0.5	500	100	6 to 9	—	20
D	Mercury Ore	Mine Drainage	BPT/BAT/NSPS [d]	—	—	—	—	—	—	0	0.1	—	—	—	—	—	—	—	6 to 9	—	20
		Mills	BPT/BAT/NSPS	No Discharge [e]																	
E	Titanium Ore	Mine Drainage (Lode Deposits)	BPT/BAT/NSPS [f]	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	6 to 9	—	20
		Mills	BPT/BAT/NSPS [g]	—	—	—	—	—	—	—	—	—	—	—	—	0.5	—	—	6 to 9	—	20
		Mine Drainage (Dredge Mines)	BPT/BAT/NSPS [h]	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	6 to 9	—	20
F	Tungsten Ore	Mine Drainage and Mills	BPT/BAT/NSPS [i]	—	0.5	0.05	0.15	—	—	—	—	0.3	—	—	—	0.5	—	—	6 to 9	—	20
G	Nickel Ore Subcategory	Mine Drainage and Mills	BPT [j]	—	0.5	0.05	0.15	—	—	—	—	0.3	—	—	—	0.5	—	—	6 to 9	—	20
H	Vanadium Ore	Mine Drainage and Mills	BPT [k]	—	0.5	0.05	0.15	—	—	—	—	0.3	—	—	—	0.5	—	—	6 to 9	—	20
I	Antimony Ore	Mine Drainage and Mills	N/A	No limits promulgated.																	
J	Copper, Lead, Zinc, Gold, and Silver Ores	Mine Drainage	BPT/BAT/NSPS [l]	—	—	0.05	0.15	—	—	0	—	0.3	—	—	—	0.75	—	—	6 to 9	—	20
		Froth Flotation Mills	BPT/BAT/NSPS [m]	—	—	0.05	0.15	—	—	0	—	0.3	—	—	—	0.5	—	—	6 to 9	—	20
	Copper Ores	Leach processes	BPT/BAT/NSPS	No Discharge [e]																	
	Gold and Silver Ores	Cyanide mills	BPT/BAT/NSPS	No Discharge [e]																	
	Molybdenum	Mine drainage	BPT/BAT/NSPS [n]	—	0.5	0.05	0.15	—	—	0	—	0.3	—	—	—	0.5	—	—	6 to 9	—	20
		Mill Discharges	BPT/BAT [o]	—	0.5	0.05	0.15	—	—	0	—	0.3	—	—	—	0.5	—	—	6 to 9	—	20
K	Platinum Ores	Mine Drainage	BAT	—	—	0.05	0.15	—	—	0	—	0.3	—	—	—	0.75	—	—	—	—	—
		Mill Discharges	BAT	—	—	0.05	0.15	—	—	0	—	0.3	—	—	—	0.5	—	—	—	—	—
M	Gold Ores (Placer Mining)	Process Water Discharges	BPT/BAT/NSPS	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

a – Units are mg/l unless otherwise stated. Metals are total unless otherwise stated.
b – BAT regulates only Fe and Al.
c – TSS and pH are not regulated by BAT.
d – BAT regulates only Hg; NSPS regulates only Hg, pH, and TSS.
e – Where annual precipitation exceeds evaporation, a volume of water equal to the difference between annual precipitation and evaporation for the drainage area may be discharged subject to the limitations for mine drainage.

f – BAT regulates Fe only.
g – BAT regulates Zn only.
h – For mines producing less than 10,000 tonnes per year, only TSS and pH are regulated. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). Lead is not regulated in mill discharges. BAT regulates Cd, Cu, and Zn only. NSPS regulates Cd, Cu, Zn, pH, and TSS only.
i – For mines producing less than 5,000 tonnes per year, only TSS and pH are regulated. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). Lead is not regulated in mill discharges.
j – For mines producing less than 5,000 tonnes per year, only TSS and pH are regulated in the mine drainage, and mill discharges are not regulated. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). Lead is not regulated in mill discharges.
k – Cadmium is not regulated by BPT. TSS and pH are not regulated by BAT.
l – TSS and pH are not regulated by BAT. Under NSPS limits, no discharge is allowed from froth flotation activities
m – For mines producing less than 5,000 tonnes per year, only TSS and pH are regulated under BPT. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). BPT does not regulate Hg. BAT does not regulate As, pH and TSS. NSPS does not regulate As.
n – For mills processing less than 5,000 tonnes per year, only TSS and pH are regulated under BPT. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). BPT does not regulate Hg. BAT does not regulate As, pH and TSS. NSPS does not regulate As. Under NSPS, no discharges are allowed from froth flotation mills.
o – Limit is for instantaneous max.

Table A-2. Daily Maximum Limits from Effluent Guidelines for Ore Mining Operations

Subpart	Ore Type	Discharge Sources	ELG Level	Required Parameters [a]																	
				Al	As	Cd	Cu	Fe	Fe (diss.)	Hg	Ni	Pb	Ra	Ra	U	Zn	COD	NH_3	pH (S.U.)	Settleable Solids (mL/L)	TSS
A	Iron Ore	Mine Drainage and Mills	BPT/BAT/NSPS	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	6 to 9	—	30
B	Aluminum Ore	Mine Drainage	BPT/BAT/NSPS [b]	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—	6 to 9	—	30
C	Uranium, Radium, and Vanadium Ores	Mine Drainage	BPT/BAT/NSPS [c]	—	—	—	—	—	—	—	—	—	30	10	4	1	200	—	6 to 9	—	30
		Mills using acid or alkaline leach	BPT	—	1	—	—	—	—	—	—	—	30	10	—	1	—	—	6 to 9	—	30
D	Mercury Ore	Mine Drainage	BPT/BAT/NSPS [d]	—	—	—	—	—	—	0	0.2	—	—	—	—	—	—	—	6 to 9	—	30
		Mills	BPT/BAT/NSPS	No Discharge [e]																	
E	Titanium Ore	Mine Drainage (Lode Deposits)	BPT/BAT/NSPS [f]	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	6 to 9	—	30
		Mills	BPT/BAT/NSPS [g]	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	6 to 9	—	30
		Mine Drainage (Dredge Mines)	BPT/BAT/NSPS [h]	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	6 to 9	—	30
F	Tungsten Ore	Mine Drainage and Mills	BPT/BAT/NSPS [i]	—	1	0.1	0.3	—	—	—	—	0.6	—	—	—	1	—	—	6 to 9	—	30
G	Nickel Ore Subcategory	Mine Drainage and Mills	BPT [j]	—	1	0.1	0.3	—	—	—	—	0.6	—	—	—	1	—	—	6 to 9	—	30
H	Vanadium Ore	Mine Drainage and Mills	BPT [k]	—	1	0.1	0.3	—	—	—	—	0.6	—	—	—	1	—	—	6 to 9	—	30
I	Antimony Ore	Mine Drainage and Mills	N/A	No limits promulgated.																	
J	Copper, Lead, Zinc, Gold, and Silver Ores	Mine Drainage	BPT/BAT/NSPS [l]	—	—	0.1	0.3	—	—	0	—	0.6	—	—	—	1.5	—	—	6 to 9	—	30
		Froth Flotation Mills	BPT/BAT/NSPS [m]	—	—	0.1	0.3	—	—	0	—	0.6	—	—	—	1	—	—	6 to 9	—	30
	Copper Ores	Leach processes	BPT/BAT/NSPS	No Discharge [e]																	
	Gold and Silver Ores	Cyanide mills	BPT/BAT/NSPS	No Discharge [e]																	
	Molybdenum	Mine drainage	BPT/BAT/NSPS [n]	—	1	0.1	0.3	—	—	0	—	0.6	—	—	—	1	—	—	6 to 9	—	30
		Mill Discharges	BPT/BAT [o]	—	1	0.1	0.3	—	—	0	—	0.6	—	—	—	1	—	—	6 to 9	—	30
K	Platinum Ores	Mine Drainage	BAT	—	—	0.1	0.3	—	—	0	—	0.6	—	—	—	1.5	—	—	—	—	—
		Mill Discharges	BAT	—	—	0.1	0.3	—	—	0	—	0.6	—	—	—	1	—	—	—	—	—
M	Gold Ores (Placer Mining)	Process Water Discharges	BPT/BAT/NSPS	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.215	—

a – Units are mg/l unless otherwise stated. Metals are total unless otherwise stated.
b – BAT regulates only Fe and Al.
c – TSS and pH are not regulated by BAT.
d – BAT regulates only Hg; NSPS regulates only Hg, pH, and TSS.
e – Where annual precipitation exceeds evaporation, a volume of water equal to the difference between annual precipitation and evaporation for the drainage area may be discharged subject to the limitations for mine drainage.
f – BAT regulates Fe only.

g – BAT regulates Zn only.
h – For mines producing less than 10,000 tonnes per year, only TSS and pH are regulated. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). Lead is not regulated in mill discharges. BAT regulates Cd, Cu, and Zn only. NSPS regulates Cd, Cu, Zn, pH, and TSS only.
i – For mines producing less than 5,000 tonnes per year, only TSS and pH are regulated. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). Lead is not regulated in mill discharges.
j – For mines producing less than 5,000 tonnes per year, only TSS and pH are regulated in the mine drainage, and mill discharges are not regulated. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). Lead is not regulated in mill discharges.
k – Cadmium is not regulated by BPT. TSS and pH are not regulated by BAT.
l – TSS and pH are not regulated by BAT. Under NSPS limits, no discharge is allowed from froth flotation activities
m – For mines producing less than 5,000 tonnes per year, only TSS and pH are regulated under BPT. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). BPT does not regulate Hg. BAT does not regulate As, pH and TSS. NSPS does not regulate As.
n – For mills processing less than 5,000 tonnes per year, only TSS and pH are regulated under BPT. TSS limits are less stringent (30 and 50 mg/L for monthly average and daily max., respectively). BPT does not regulate Hg. BAT does not regulate As, pH and TSS. NSPS does not regulate As. Under NSPS, no discharges are allowed from froth flotation mills.
o – Limit is for instantaneous max.

Appendix B

SUMMARY OF PERMITTED DISCHARGES COVERED BY THE ORE MINING POINT SOURCE CATEGORY

Table B-1. Summary of Permitted Discharges Covered by the Ore Mining Point Source Category [a]

State [b]	Facility Counts			Type of Permit		Available Discharge Data		
	# of Major NPDES IDs	# of Minor NPDES IDs	Total # of Facilities	# of Individual Permits	# of General Stormwater Permits [c]	# of Minor Permit IDs with Discharge Data	# of General Permit IDs with Discharge Data [d]	% of Minors with Discharge Data [e]
AK	5	35	40	15	25	1	0	3%
AZ	6	36	32	11	31	2	0	6%
CO	9	23	29	22	10	18	5	78%
MT	2	24	22	11	15	22	14	92%
ID	5	22	21	14	13	4	0	18%
CA	1	19	19	9	11	0	0	0%
MN	2	18	17	20	0	13	0	72%
WY	2	16	16	6	12	4	0	25%
NV	1	14	13	5	10	0	0	0%
TN	9	2	10	11	0	2	0	100%
UT	2	5	7	4	3	2	0	40%
MO	7	0	6	7	0	0	0	NA
NM	5	1	6	6	0	1	0	100%
SD	4	3	6	6	1	2	1	67%
FL	3	2	5	5	0	2	0	100%
SC	0	5	5	2	3	2	0	40%
WA	1	5	5	3	3	1	0	20%
MI	2	2	4	4	0	2	0	100%
AR	1	3	3	2	2	1	0	33%
PA	0	3	3	0	3	0	0	0%
VA	0	3	3	3	0	0	0	0%
AL	0	2	2	1	1	2	1	100%
NC	0	2	2	0	2	0	0	0%
NJ	0	2	2	2	0	1	0	50%
NY	2	0	2	2	0	0	0	NA
OR	0	2	2	2	0	1	0	50%
WV	0	2	2	0	2	0	0	0%
GA	0	1	1	1	0	1	0	100%
IL	0	1	1	1	0	1	0	100%
LA	0	1	1	1	0	0	0	0%
ND	0	1	1	1	0	0	0	0%
NE	0	1	1	1	0	1	0	100%
Total	**69**	**256**	**289**	**178**	**147**	**86**	**21**	**46%**

a – Excludes Mechanical Placer Mining and Suction Dredge Mining.
b – Listed in descending order of total number of facilities.
c – Includes multi-sector general stormwater permits, general stormwater permits for mining and oil and gas only, and general construction stormwater permits.
d – Included in the column titled “# of Minor Permit IDs with Discharge Data.”
e – Includes general stormwater permits and industrial permits.