ABSTRACT

This paper presents the basics of EPA's Hazard Ranking System (HRS), which is used to evaluate sites for possible inclusion on the Superfund National Priorities List (NPL). The paper describes the surface water, ground water, air, and soil exposure pathways and how they are applied to mining sites. Key factors contributing to the site score include the likelihood of a release, waste characteristics, and the targets for each pathway. Waste volumes, definitions of landfills versus surface impoundments, and background concentrations are of particular importance to mining and smelting sites. Because of the presence of metals, large waste volumes, and observable releases, mining and smelting sites often receive high enough scores to be proposed for the NPL based on a single pathway. Neverthess, owners and operators can take steps to reduce the risk of being scored, and to reduce the potential for high scores.

INTRODUCTION

The Hazard Ranking System (HRS) is the numerical scoring mechanism that the Environmental Protection Agency uses under the Superfund program to assess the relative potential of sites to pose a threat to public health or the environment. Within the context of the HRS, a site is defined as any area where a hazardous substance has been deposited, stored, disposed of, or placed, or has otherwise come to be located through migration. Metals commonly found at many mining sites, such as arsenic, cadmium, and lead, are included in the list of hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). If a site scores over 28.5 on the Hazard Ranking System EPA can propose it for inclusion in the National Priorities List (NPL). The proposal of a site to the NPL is a formal rulemaking activity and is subject to public comment. EPA must respond to those comments when finalizing the listing of a site.

The Superfund National Priorities List includes, as of October 27, 2003, 1243 sites as final and 54 sites as proposed. Of these, 1133 are non Federal facilities and 66 of these have been identified as mining and smelting sites, representing 5.8 % of the total of non Federal facilities. Table 1 is a listing of the identified mining and smelting sites. The HRS scores for the mining and smelting sites range from 30 to 87, while twenty one of these sites have a score of 50. This is notable, because a site score of 50 can be achieved by achieving the maximum score (100) for only one pathway, as discussed herein. The following sections of this paper provide an overview of the HRS, with particular focus on conditions and issues commonly found at mining and smelting sites, and recommendations for minimizing HRS exposure at these sites.

OVERVIEW OF THE HARARD RANKING SYSTEM

October 29, 2003

The current Hazard Ranking System was issued by EPA on December 14, 1990 as Appendix A to the National Contingency Plan, 40 CFR 300. The system evaluates sites by means of four pathways: ground water migration, surface water migration, soil exposure, and air migration. A separate preliminary score is calculated for each pathway by multiplying the Likelihood of Release by the Waste Characteristics by the Target values. Each pathway score can range from 0 to 100. The overall site score is then calculated from the four migration pathway scores by the following equation:

$$S = \sqrt{\frac{S^2gw + S^2sw + S^2s + S^2a}{4}}$$

EPA is not required to evaluate all potential pathways at a site. A pathway is usually scored if there is an observed release, if targets are subject to actual contamination, or if there are major target areas for the pathway. The overall site score can range from 0 to 100 and sites scoring 28.5 and above, are eligible to be placed on the National Priorities List. The site score can be relatively high even if only one or two pathway scores are high. Because of the root mean square calculation higher scoring pathways exert a proportionately greater influence on the site score than lower scoring pathways. The mathematics of the above equation are such that one pathway with a score of 57.0 will result in a site score of 28.5. Two pathways of 40.3 and three pathways of 32.9 also result in overall site scores of 28.5. This reflects the reality that some high risk sites pose threats only through one pathway. Knowing the two highest pathway scores is usually sufficient to determine whether the site score is likely to be above 28.5.

Figures 1-4 provide an overview of the factors which are used in calculating each pathway score. The Ground Water and Air Migration Pathways evaluate single threats. The Surface Water Migration Pathway is more complex in that it evaluates three threats: drinking water, human food chain, and environmental. It also evaluates two separate migration mechanisms: overland/flood migration and ground water to surface water migration. The Soil Exposure Pathway evaluates two threats: resident population and nearby population.

A source is any area where a hazardous substance has been deposited, stored, disposed of, or placed plus those soils that have been contaminated from migration of a

hazardous substance. Sources have specific definitions within the HRS and include tanks, drums, contaminated soil, landfills, piles and surface impoundments. A site can have more than one source and each source is evaluated separately in the scoring process.

The concept of an observed release is relevant to the ground water, surface water and air migration pathways. An observed release is very powerful in the score calculation resulting in the maximum score for release potential. It may be established either by chemical analysis or by direct observation. An observed release is established by chemical analysis if the concentration of a hazardous substance in a release is significantly increased above its background level and attributable to another source. If the background level is equal to or greater its detection limit the release sample must be at least three times greater than the background level. If the background level is below its detection limit the release sample must be greater than or equal to the background sample quantitation limit. Establishing an observed release by direct observation only requires information that a material containing a hazardous substance attributable to the site was placed into or has been seen entering the medium of concern. Examples of how this can occur include: particulates blowing off of a pile, direct deposition of wastes into surface water, flooding causing direct contact of the hazardous substance with surface water, and an elevated water table causing direct contact of the hazardous substance with ground water.

An observed release receives the maximum score for likelihood of release. The score of a potential release is dependent on a number of factors depending on the pathway including: degree of containment, net precipitation, depth to aquifer, distance to surface water, and flood frequency.

The waste characteristics score is a result of multiplication of the toxicity/mobility/persistence factors times the hazardous waste quantity. The hazardous substance, if there is more than one at a site, which poses the greatest hazard for that pathway is used in the scoring.

Different factors are used to determine the potentially most hazardous substance for a pathway:

Ground Water Pathway: toxicity and ground water mobility

Surface Water Pathway/Drinking Water Threat: toxicity and persistence

Surface Water Pathway/Human Food Chain Threat: toxicity, persistence, and bioaccumulation potential

Surface Water Pathway/Environmental Threat: ecosystem toxicity, persistence, and bioaccumulation potential

Soil Exposure Pathway: toxicity

Air Pathway: toxicity and air mobility

For the ground water pathway the targets are the number of residents, students, or workers served by drinking water wells within a four mile radius. Up gradient and down gradient targets are scored the same way. Site-related contamination found in drinking water wells significantly elevated above background levels is considered to be “actual contamination” for the purposes of scoring. Site related contamination found in monitoring wells and significantly elevated above background can be used to score “potential contamination”. If drinking water wells have been closed due to site related contamination they can still be used in scoring the site.

The surface water pathway is more complex in that it considers both the overland flow and flooding release mechanisms and three environmental threats: drinking water, human food chain, and the environment. The targets for the drinking water threat are the population served by drinking water intakes within 15 miles downstream of the site. The human food chain threat involves assessing fisheries used, or potentially used, for human consumption on a commercial, recreational, or subsistence basis. The environmental threat applies to specific listed sensitive environments including critical habitat for endangered or threatened species, wilderness areas, national parks, scenic and wild rovers, natural areas, wetlands, and areas important to the maintenance of unique biotic communities.

The soil exposure pathway applies to all surficial contamination and differs from the other pathways in that only observed contamination is scored. There is no score for “potential contamination” in this pathway. Areas of observed contamination only are calculated and used in the scoring process. Both resident and nearby population can be considered. A resident individual is a person who lives or attends school or day care within 200 feet of of an area of observed soil contamination. A resident worker is a person whose workplace area is within 200 feet of an area of observed soil contamination. A workplace area is any area where workers are regularly present and it can include lunch and parking areas. Terrestrial sensitive environments are also considered as targets in this pathway. The nearby population are those people living within one mile of an area of observed soil contamination.

The air pathway considers population within a four mile radius of the sources. Sensitive environments within the four mile radius are also considered.

APPLYING THE HAZARD RANKING SYSTEM TO MINING SITES

Sources

Hazardous waste quantity is determined by one of four methods depending on the available data. If the quantity of specific hazardous substances in a source is known then that data is used. If information exists regarding the constituents of the hazardous waste stream that was deposited into the source is known then that information is used to determine waste quantity. For mining related sources, volume or area estimates are often the method used to determine the waste quantity. Because the waste quantity is multiplied times the toxicity/mobility/persistence factors to establish waste characteristics it can have a significant influence on the site score.

The identification of types of sources at a site is very important because of the significant difference in the way waste quantity factors are assigned. The waste quantity factor for a landfill, for example, is 1000 times lower than for a surface impoundment or pile of the same volume. When evaluated on the basis of area the landfill waste quantity is 261 times lower than either a surface impoundment or pile of the same area. The EPA guidance describes a landfill as "an engineered (by excavation or construction) or natural hole in the ground into which wastes have been disposed of by backfilling or by contemporaneous deposition of soil and wastes." "Landfills are generally characterized by the addition of fill (e.g., soil) during or after disposal, covering the wastes from view." Surface impoundments, such as tailings ponds, were intended to contain liquid wastes or wastes containing free liquids. Soil was not deposited with the wastes during disposal but a soil cover may have been placed after the final deposition of wastes. Even after the liquid has evaporated or leached the source is still considered to be a surface impoundment. Piles result from the periodic addition of wastes to stacks resulting in one large pile. The wastes are not mixed with fill during disposal. Piles can be used to dewater wastes containing liquids to accumulate a large pile of wastes in one area. "A tailings pile consists of any combination of overburden from a mining operation and tailings from a mineral mining, beneficiation, or processing operation."

Background Concentrations

Background concentrations of metals are very important in establishing an observed release at mining sites. The term is not specifically defined in the HRS and is open to interpretation. EPA may attempt to determine background by utilizing published metal concentration values or by taking only one background samples per pathway. One document that has been referred to in the past for background values is the U. S. Geological Survey Professional Paper 1270, "Normal Ranges of Element Concentrations in Soils and Other Surficial Materials of the Coterminous United States." However, surface metal concentrations may be naturally elevated in mining areas and not accurately reflected in published data or accurately portrayed by a limited sampling effort. A surface water may originate from a mine and thus have no upstream sampling location available. A background sample for the ground water pathway should be collected from nearby wells that are not expected to be impacted by the source of the contamination. Aquifers in mining areas may be influenced by mine drainage tunnels making it difficult to sample for a background ground water value. Background air samples should be taken in the predominant upwind direction from the site.

Metal Toxicity

The HRS utilizes the toxicity, mobility, persistence, volatility, solubility, bioaccumulation, and bench mark data for a list of over 300 hazardous substances stored in the Superfund Chemical Data Matrix, which was last updated in 1996. This Matrix establishes a toxicity factor for each hazardous substance utilizing chronic toxicity data, or acute toxicity data, if there is no chronic data. The maximum value which can be assigned is 10,000. Table 2 shows the toxicity factor for several of the common metals.

Table 2
Toxicity Factors of Common Metals

Metal	Toxicity Value
Arsenic	10,000
Cadmium	10,000
Chromium	10,000
Lead	10,000
Manganese	10,000
Nickel	10,000
Selenium	100
Zinc	10

As can be seen from the above table, many of the metals commonly encountered at metals mining sites have the maximum toxicity factor possible. This factor is multiplied by the hazardous waste quantity to obtain

the wastes characteristics value. Because mining sites typically have very large waste quantity values the waste characteristics factor is often maximized. EPA is in the process of updating the Superfund Chemical Data Matrix. When released it may contain revised toxicity values for these metals.

Targets

The targets often become a key factor in the scoring of mining sites. If an observed release is documented the likelihood of release factor is maximized. If there are large quantities of waste and the wastes are metals, then the waste characteristics factor may also be maximized. This leaves the targets factor as the last leg of the triangle to be determined. Even though the mining site may be in a relatively remote area it may still score over 28.5. The following table shows the small number of people which it would take to yield a single pathway score over 57 (and hence an overall site score over 28.5). This table assumes both the likelihood of release and waste characteristics factors have been maximized.

Table 3
Targets Resulting in a Site Score Greater than 28.5

Number of individuals subject to actual contamination above a health based benchmark	Number of individuals subject to actual contamination below a health based benchmark	Total number of individuals
4	0	4
3	6	9
2	16	18
1	26	27
0	41	41

This table only considers human targets. An environmental target may also exist at a site and add to the target factor. Endangered species are examples of significant environmental targets. Examples of actual contamination include an observed release in a drinking water well and a drinking water intake on a river that meets the definition of an observed release.

HRS TOOLS

Calculating a site score utilizing the HRS can involve up to 600 calculations. Because of this complexity, EPA has developed automated tools to calculate site scores. The initial electronic scoring tool was PREscore, which was DOS based and difficult to use. EPA has recently completed the development (Version 1.2) of two new electronic scoring tools, HRS QuickScore and HRS SUPERScreen. They can be downloaded from the web site:

http://www.epa.gov/superfund/programs/siteasmt/index.htm#announce

These Windows-based, user friendly tools still utilize the 1996 Superfund Chemical Data Matrix. Version 2.0 of these tools are expected soon. QuickScore is intended for quick calculations and identification of data gaps for planning site inspections. SUPERScreen is more sophisticated and can be used to develop the score sheets for the HRS documentation record.

Site owners and operators may use these tools to predict the range of HRS scores that might result from an EPA listing investigation; however, users should be familiar with EPA guidance, policies, and practices to improve the predictive power of the exercise.

LISTING OUTLOOK

Although reduced focus and resources have been placed on Superfund in recent years (compared to the RCRA program) EPA is still actively proposing and finalizing sites to the NPL. Therefore, mining and smelting site owners and operators should still be aware of the potential liabilities posed by HRS ranking and NPL listing. Tables 4 and 5 show the number of sites listed in recent years.

Table 4
Recent Final Listing Rules

Date	Total Number of Sites	Number of Mining/Smelting Sites
9-29-03	12	4
4-30-03	7	2
10-24-02	1	1
9-05-02	19	2
9-13-01	11	3

Table 5
Recent Proposed Listing Rules

Date	Total Number of Sites	Number of Mining/Smelting Sites
4-30-03	14	3
9-5-02	7	0
2-26-02	2	2
9-13-01	17	3

STRATEGIES FOR REDUCING RISKS OF BEING PLACED ON THE NPL

Experience has shown that HRS scores can be very dependent on individual interpretations and the focus of listing site investigations. Further, mining and smelting sites are at significant risk of receiving high scores by only one pathways, due to the presences of metals, large volumes of waste, and observable releases. Nevertheless, owners and operators can still take steps to reduce potential scores, and even the risk of being scored in the first place. At a minimum, the following actions are recommended:

1. Keep a low profile

Address aesthetics, show some cleanup progress, maintain good community relations. Unhappy local citizens can pressure EPA to list a site.

2. Eliminate real health hazards where they exist

Reduce or eliminate exposures to humans or the environment where feasible. This responsible land management may reduce the HRS score of the site if performed strategically.

3. Divert surface runoff around the site if possible

This would reduce the drainage area and thus reduce the potential to have an observable release score in the surface water pathway.

4. Find an alternative clean up program

Research state voluntary cleanup programs, other state programs (mine reclamation), and facility lead arrangements. Cleanup can be performed in these programs with limited regulatory oversight and may result in an assurance of No Further Action when completed.

5. Avoid conditions where a regulatory agency can establish an observed release by direct observation

Observable releases makes it very easy for the regulatory agency to list a site. Avoid blowing tailings. Do not allow tailings seepage or contaminated stormwater to flow directly into a surface water body.

6. Avoid bringing targets onto a site or closer to a site

Keep workers and work areas (offices, locker rooms, cafeteria, parking lots, etc.) at least 200 feet from contaminated areas

- Allow no one to live on site
- Do not allow day care or schools on site
- Do not allow or encourage recreation on site
- Fence the site to prevent public access
- Buy up a buffer zone (the population within one mile is key under the HRS)

7. Avoid using on site wells for drinking water for employees

Having drinking water wells in close proximity to the source can dramatically increase the site score if there has been a release to ground water. Actual contamination of a drinking water well above a benchmark will score a site with very vew targets.

8. Document actual background concentrations of metals

Conduct a sampling effort to document background metals in nearby areas not affected by the mining operation. Document elevated background levels if they exist. If EPA proposes to perform a sampling site inspection provide these data to EPA. Pay close attention to the methods of analysis used and detection limits.

9. Install a cover over contaminated areas where reasonable

The HRS only evaluates the top 2 feet of soil for the soil exposure pathway. Two feet of clean soil or a layer of asphalt paving will eliminate the area covered from the calculated area of observed contamination in the soil exposure pathway.

10. Where possible, establish mine waste units as landfills

If they meet a definition of a landfill label them as landfills on reports and site maps. Refer to them as landfills in conversation. Waste quantity calculations result in much lower values for landfills than waste piles or surface impoundments.

11. Document any aquifer discontinuities which may exist

Provide a report to EPA documenting the discontinuities if EPA proposes to perform a sampling site inspection involving ground water samples. For HRS purposes a discontinuity must be a geologic or topographic feature which entirely transects an aquifer within the 4 mile target distance. Discontinuities can limit the number of targets scored.

12. Review EPA's sampling plan

When the granting of site access is requested by EPA for the purpose of conducting a sampling site inspection

it is appropriate to request a copy of the sampling plan which will be used. The sampling plan may provide valuable insight regarding which exposure pathways EPA is pursuing.

13. Take split samples

If EPA performs a sampling site inspection take split samples and perform appropriate analysis of the samples. EPA may attempt to use data which is qualified in some manner to list the site. The site owner may have higher quality data than EPA showing lower concentrations of contaminants.

14. Perform qualifying removal actions if the opportunity exists

To qualify for reducing a site score the removal must actually remove waste from the site and dispose of it at a facility permitted under RCRA, TSCA or the NRC. The removal must occur prior to EPA beginning work on a sampling plan to perform a sampling site inspection. This may work for relatively small quantities of high toxicity waste that may be on site. Removals should be completed as soon as possible after a preliminary assessment has been performed by EPA.

15. Organize your environmental data

If EPA attempts to list your site it will probably be using a very limited set of data from a sampling site inspection. This limited scope sampling event performed by a contractor or a state agency is designed to find the worst case contamination. It is not intended to be a detailed analysis of the nature and extent of site contamination. The owner may have voluminous ground water, surface water, air, or soil data which can be used to challenge the EPA data. The methods of analysis, detection limits, and data quality will, however, need to be closely reviewed to utilize this data in challenging a listing. Having environmental data organized in an Access database for easy retrieval and sorting, preferably with GIS capabilities for geographic display, is highly recommended.

16. Challenge the listing proposal

If a site is proposed for addition to the NPL a detailed review of the documentation record is recommended. Formal written comments should be provided to EPA during the public comment period. A legal challenge to the listing can be mounted after the final listing if the facts can support one. NPL listing is formal Federal rulemaking for EPA. Careful attention needs to be paid to the timelines for these challenges.

REFERENCES

Federal Register, December 14, 1990, 40 CFR Part 300, Appendix A.

Folkes, David J., 1991, "Technical Strategies For Limiting CERCLA Risks: Coping with the Hazard Ranking System"

U. S. Environmental Protection Agency, Hazardous Site Evaluation Division, November 1992, The Hazard Ranking System Guidance Manual, Interim Final, EPA 540-R–92-026

U. S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, September 1995, "Establishing Background Levels"

U. S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, September 1995, "Establishing an Observed Release"

U. S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, September 1995, "Establishing Areas of Observed Contamination"

U. S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, October 1991, "The Revised Hazard Ranking System: Evaluating Sites After Waste Removals"