Sampling and Monitoring at Mining Sites

HARDROCK MINE GEOCHEMISTRY AND HYDROLOGY

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US EPA Region 8

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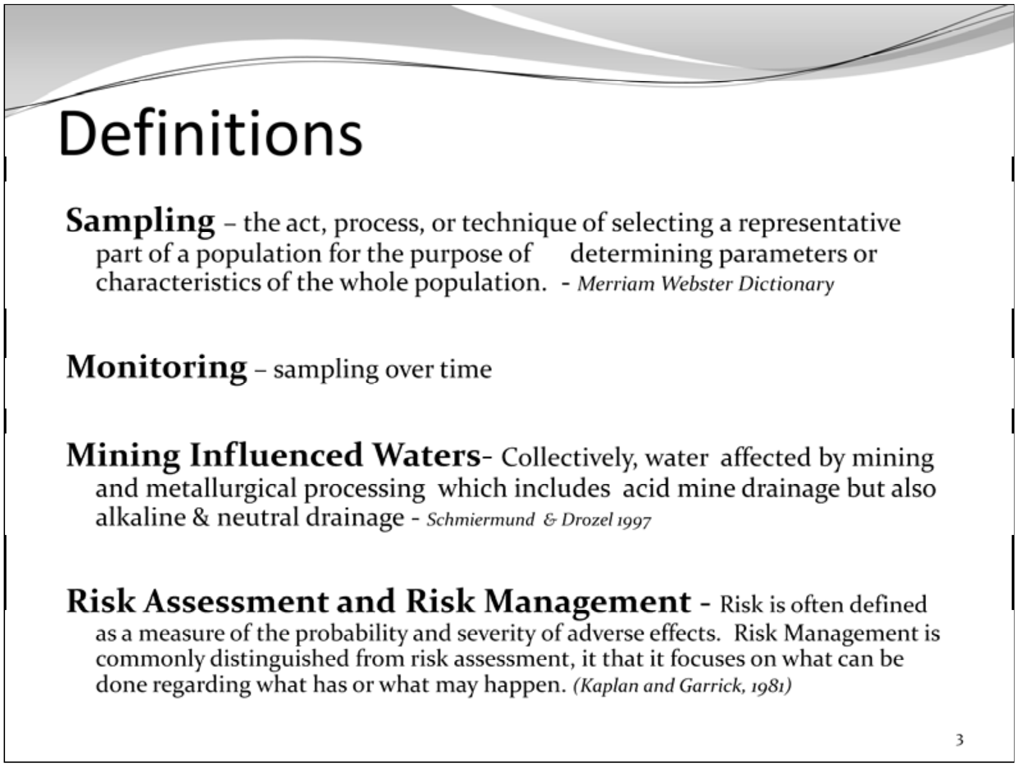
Outline

- Definitions
  - Mining Life Cycle
- Sampling and Monitoring Handbook for Mining Influenced Water
  - Planning Process
  - Questions (Data Quality Objectives – DQOs)
  - Conceptual Model
  - Water Balance
  - Risk Assessment
- More Information



Risk assessment answers the questions:

What can go wrong?

What is the likelihood that it would go wrong?

What are the consequences? (Kaplan and Garrick, 1981)

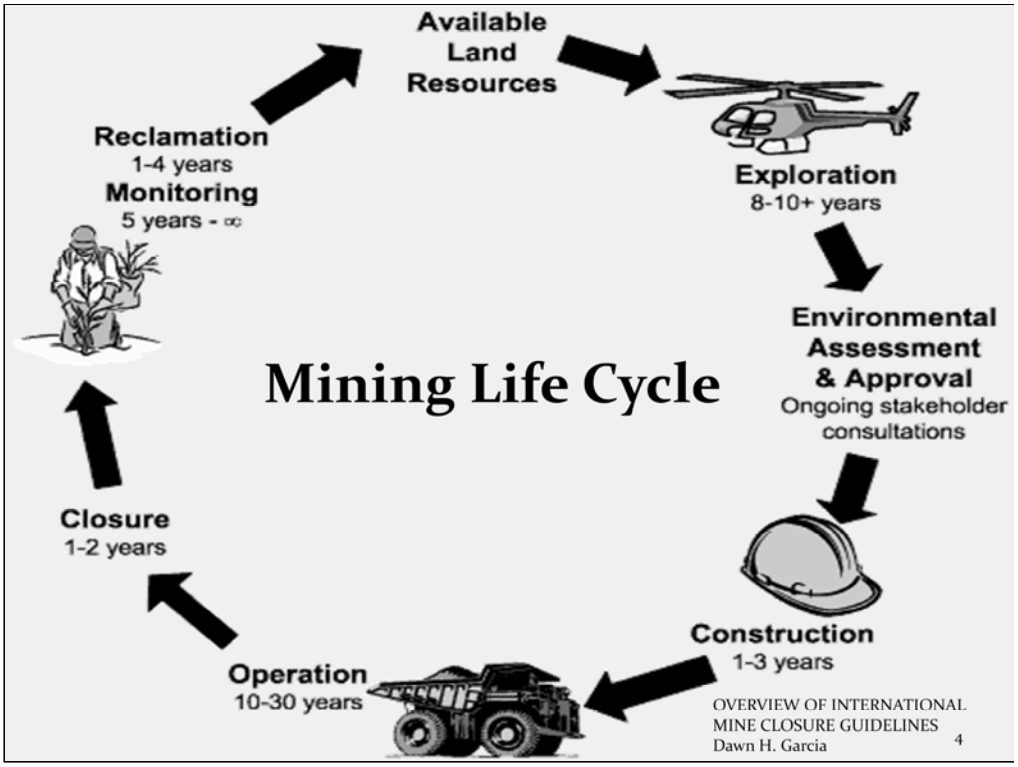
Answers to these questions help risk analysts identify, measure, quantify, and evaluate risks and their consequences and impacts.

Risk Management builds on the risk assessment evaluating:

What can be done and what options are available?

What are the associated tradeoffs in terms of all costs, benefits, and risks?

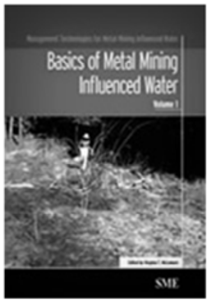
What are the impacts of current management decisions on future options?



Risks span the entire minerals production cycle.

OVERVIEW OF INTERNATIONAL MINE CLOSURE GUIDELINES1
Dawn H. Garcia, CPG-083132
The perception that a new modern mine will create the same impacts during operation and at closure as abandoned historic operations must be overcome during the initial steps of an exploration program. The closure planning begins during project conception. The mining industry has learned that plans for closure of mine and plant facilities, plus post-closure use of the land, must be presented to stakeholders as part of a successful planning process and to obtain the “social license to operate” from the community.

We are seeing greater environmental scrutiny of mining operations at all stages of development. These commonly adversarial situations are underlain by a general lack of an equal minimal understanding of the environmental issues surrounding mining by all parties involved.



Series of handbooks by the Acid Drainage Technology Initiative-Metal Mining Sector (ADTI-MMS):

1. Basics of Metal Mining Influenced Water
2. Mitigation of Metal Mining Influenced Water
3. Mine Pit Lakes
4. Geochemical Modeling for Mine Site Characterization and Remediation
5. Techniques for Predicting Metal Mining Influenced Waters
6. **Sampling and Monitoring for the Mine-Life Cycle**

Acid Drainage Technology Initiative

Metal Mining Sector

"Sampling and Monitoring for Mining Influenced Waters"

1 – Introduction

2 – Guidance Documents

3 – Overview of Sampling and Monitoring during the Phases of Mining

4 – The Planning Process

5 – Sampling Considerations in the Mining Environment

6 – Program Implementation

7 – Data Analysis and Management for Decision Making

8 – Key Issues and Research Needs/

McLemore, Smith and Russell eds (in preparation) 6

"Sampling and Monitoring for Mining Influenced Waters" Appendices

1- Online Resources

2 – Methods

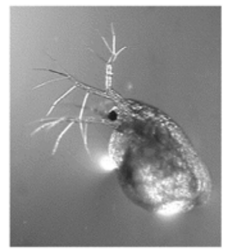
- Climatological information and air measurements
- Water – Collection, measurement & specialized methods
- Solids – Preparation, collection & measurement methods
- Biological Methods
- Analytical Methods

3 - ASTM Methods

4 - Sampling Plan Examples

5 - Case Studies

6 - GeoEnvironmental Models (GEM)



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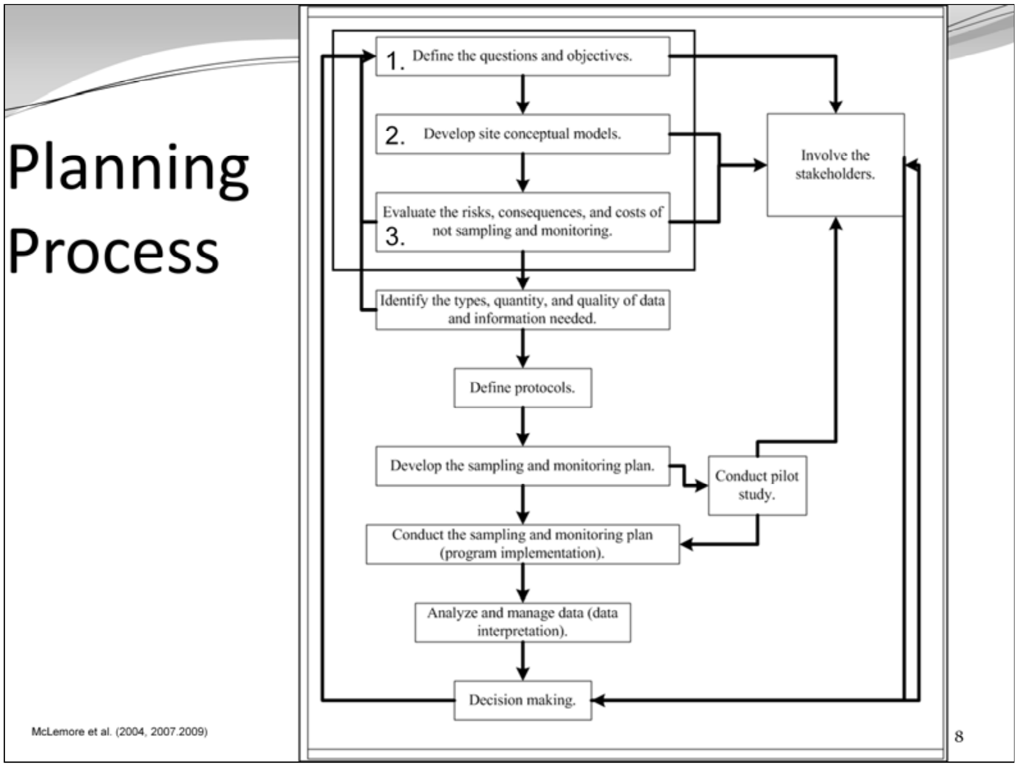

The primary purpose of the use of a quality system, using data quality objectives, is to ensure that you don't collect data that you:

Don't need,

Don't use, or

Can't use.

1. Answering Questions - DQOs

- Compliance monitoring
  - Compliance point at discharge –permit
  - Stream standards – acute vs chronic
    - Detection levels & all important parameters
- Adaptive management – trigger or action levels
  - To evaluate progress toward objectives
  - Early warning system for robust decisions
  - Verify predictions
  - Initiate mitigation
- Insurance policy

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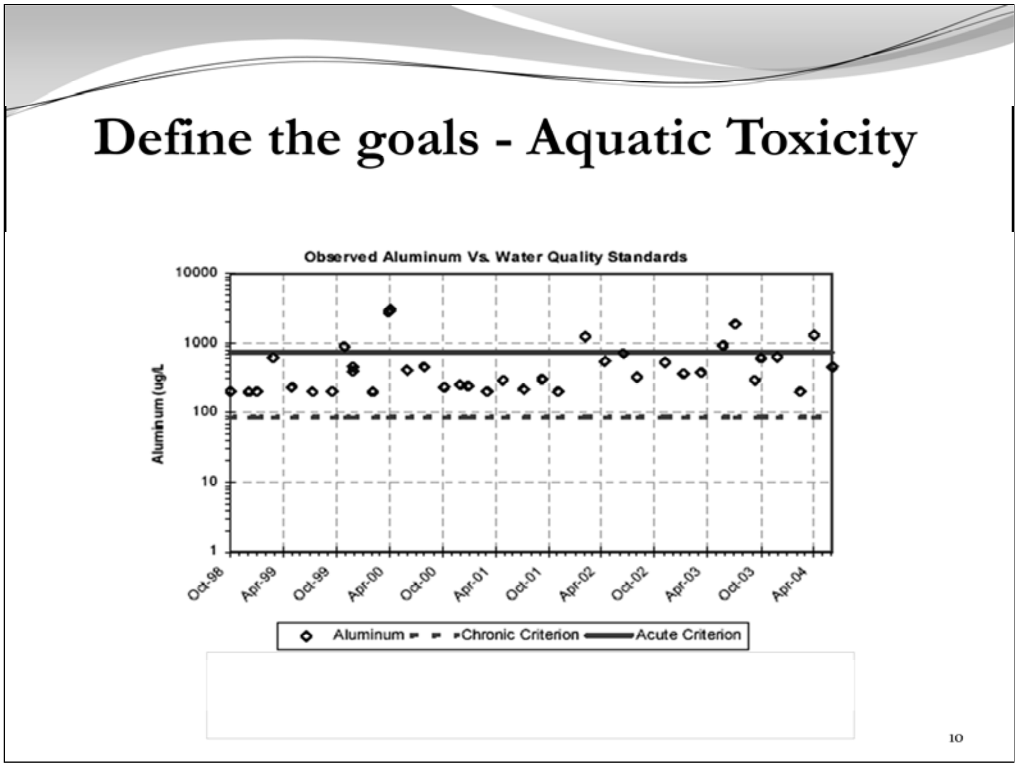
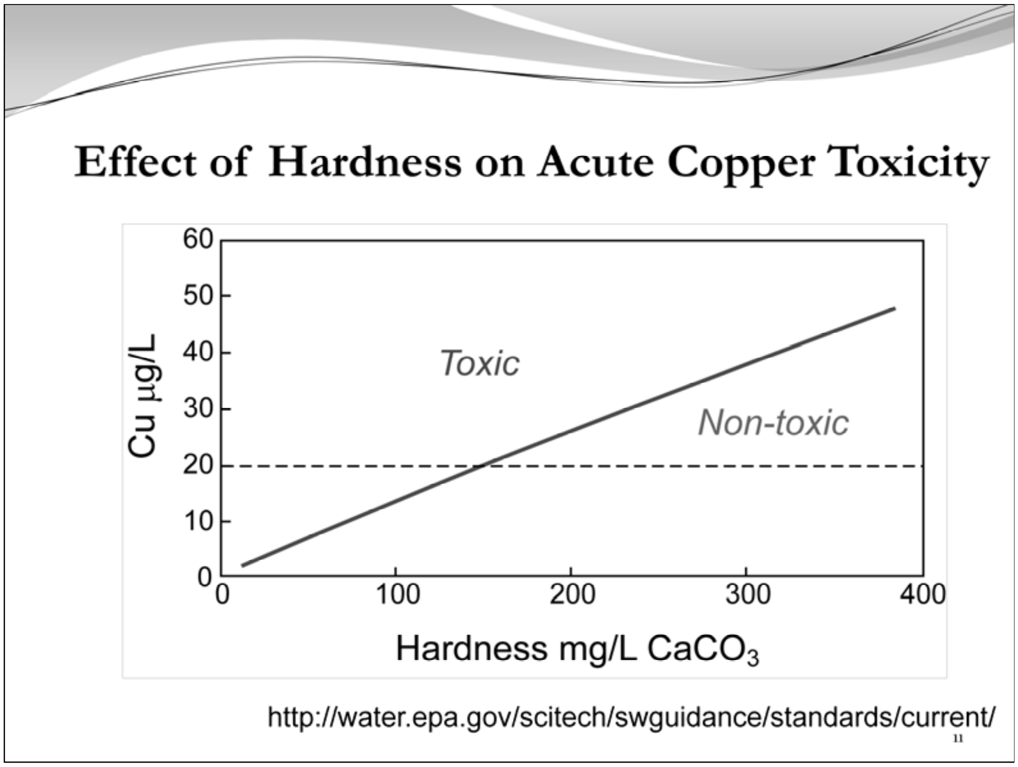
Focus on answering questions by gathering sound scientific data and analyzing the data to provide information upon which to base decisions



Observed and modeled seasonal trends in dissolved and particulate Cu, Fe, Mn, and Zn in a mining-impacted stream as compared to chronic or acute toxicity for a specific stream segment.

- Assess water quality
- Provide data for contaminant loading calculations
- Identify contaminant source(s)
- Provide input for modeling
- Use in toxicological testing
- Establish baseline conditions
- Meet regulatory requirements



- ➢ Focusing sampling activities solely on regulated constituents often results in incomplete or incorrect characterization, which could lead to costly problems later
- ➢ Most modeling requires complete information

(e.g., Biotic Ligand Model, geochemical speciation models)

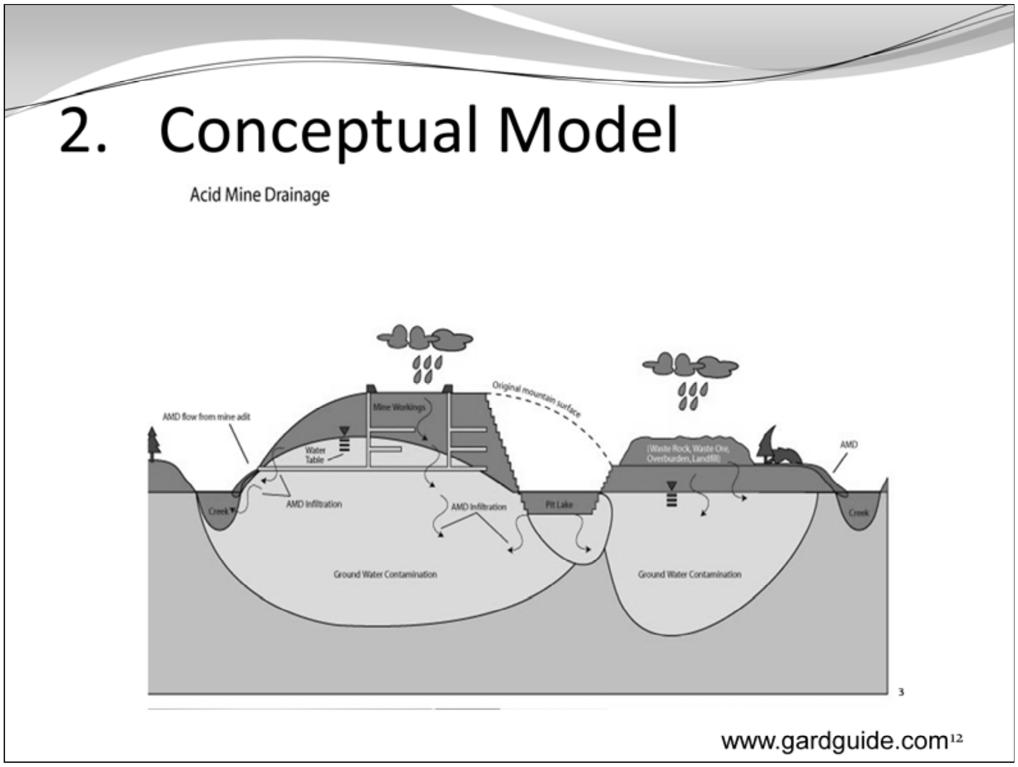
Hardness is concentration of divalent cations (e.g., Ca2+, Mg2+, etc.)

In mining impacted systems, Ca2+, Mg2+, etc. can originate from the weathering of a variety of minerals; not limited to carbonates

In mining impacted systems, other cations may contribute to hardness (e.g., Zn2+, Mn2+)

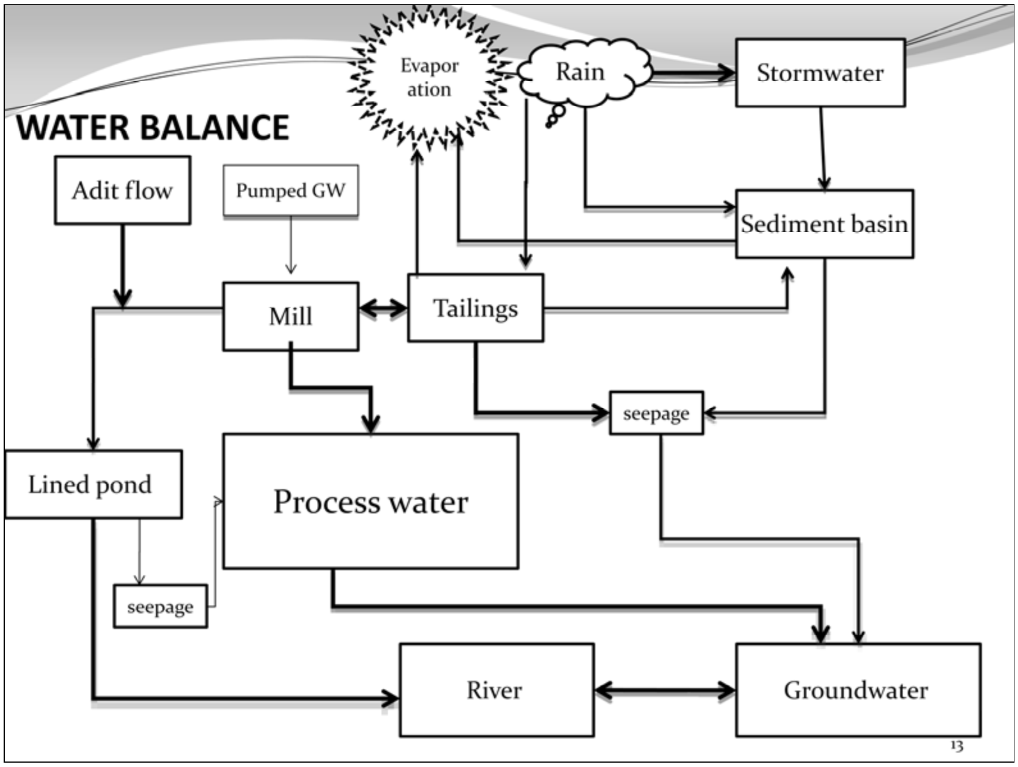
Water-quality criteria (aquatic life standards) for some metals are hardness-dependent

may need to reevaluate hardness-dependent water-quality criteria for mining impacted systems



The most important but probably the simplest tool for evaluating the environmental impacts of a project is the development of a conceptual model. The creation of a conceptual model for pre-mining (exploration), during the operation, closure and post-closure is an important first step in prediction of environmental impacts at mining projects. By definition, the conceptual model will always be a simplified abstraction of reality that aims to identify those key processes that may affect contaminant transport, behavior and risk. The purpose of the conceptual model is to illustrate and describe a basic understanding of potential sources and media pathways, and possible receptors, based upon available information. The ASTM standard for development of a conceptual model advises the development of a flow diagram that illustrates potential sources, transport mechanisms, exposure pathways and receptors; a schematic block diagram that depicts these site model components, and a map of surface units and other relevant features. ASTM (2008)

The conceptual model is used to integrate all site information and to determine whether information including data are missing (data gaps) and whether additional information needs to be collected at the site. A conceptual model is considered to be a dynamic tool that will allow for hypothesis testing of the concepts. The model is used furthermore to facilitate the selection of mitigation alternatives and to evaluate the effectiveness of remedial actions in reducing the exposure of environmental receptors to contaminants.



Water Balance is merely: ”inflow” equals “outflow”. However at a mine site this simple equation becomes more complex throughout the mine life where water demands, water discharges, drought and floods, stability concerns, operational specifications and water compliance issues all interact in direct and indirect ways.

Variation in flow rates for production operations such as milling, leaching or even road dust suppression must be balanced with treatment and disposal of stormwater , process water or discharge of water from an open pit. Most sophisticated mining operation use water balance models with mathematical computation procedures to continuously describe and quantify the spatial and temporal distribution of the water balance. The model would include essential components like precipitation, evapotranspiration, infiltration, water storage and runoff. Some models have visual interfaces similar to the conceptual model diagram to portray interdependencies and influences for decision-makers.

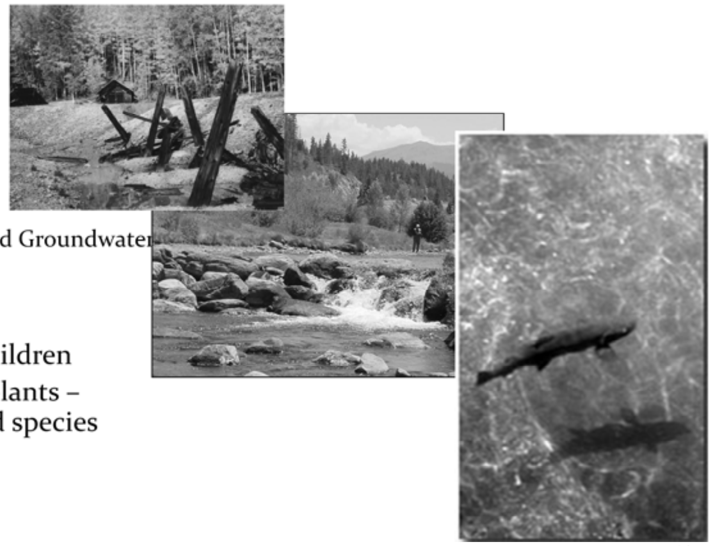
The importance of an accurate and dynamic water balance should not be underestimated. Review of all recent mining operations that subsequently became Superfund sites had inadequate water balance engineering and management.

GSFLOW—Flow Model Based on the Integration of the PRMS and the MODFLOW-2005

GOLDSIM

3. Risk Assessment

- Source
  - nature
  - extent
- Pathway
  - air
  - water
    - Surface and Groundwater
  - ingestion
- Receptor
  - people – children
  - animals – plants – endangered species



Sources

- **What is the site?**
  - number, name, location, owner, mine name, features
- **What was mined?**
  - ore, waste minerology
- **How was it processed?**
  - milling, amalgam, or CN
- **Where?**
  - what features can be seen/mapped?
- **How big or how much?**
  - volume of mine waste, processed waste, or waste water
- **When?**
  - when was it mined/processed and when did problems start?

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Pathways (water, air, or soil)

- Climate
  - Amount of rainfall, wind
  - Seasonal changes, temperature extremes
- Elevation
  - Rain or Snow, when does it occur?
- Topography
  - Relief
- Geology
  - Mineralogy
  - Faulting and fracturing
- Relationship of waste to water/hydrology

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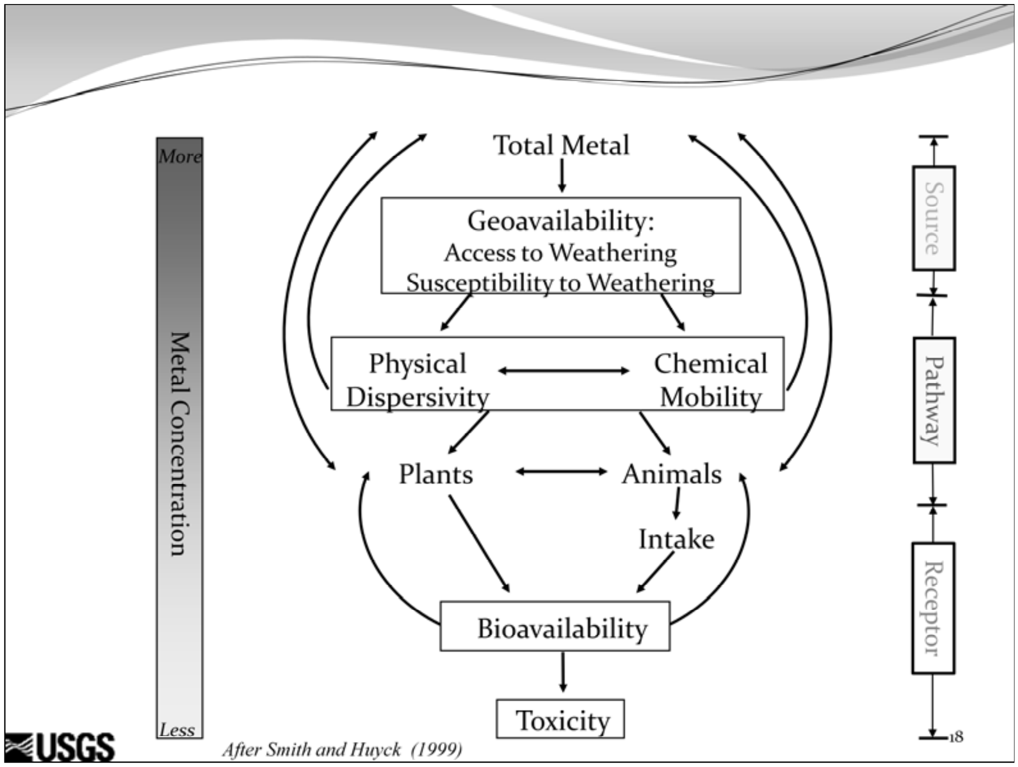
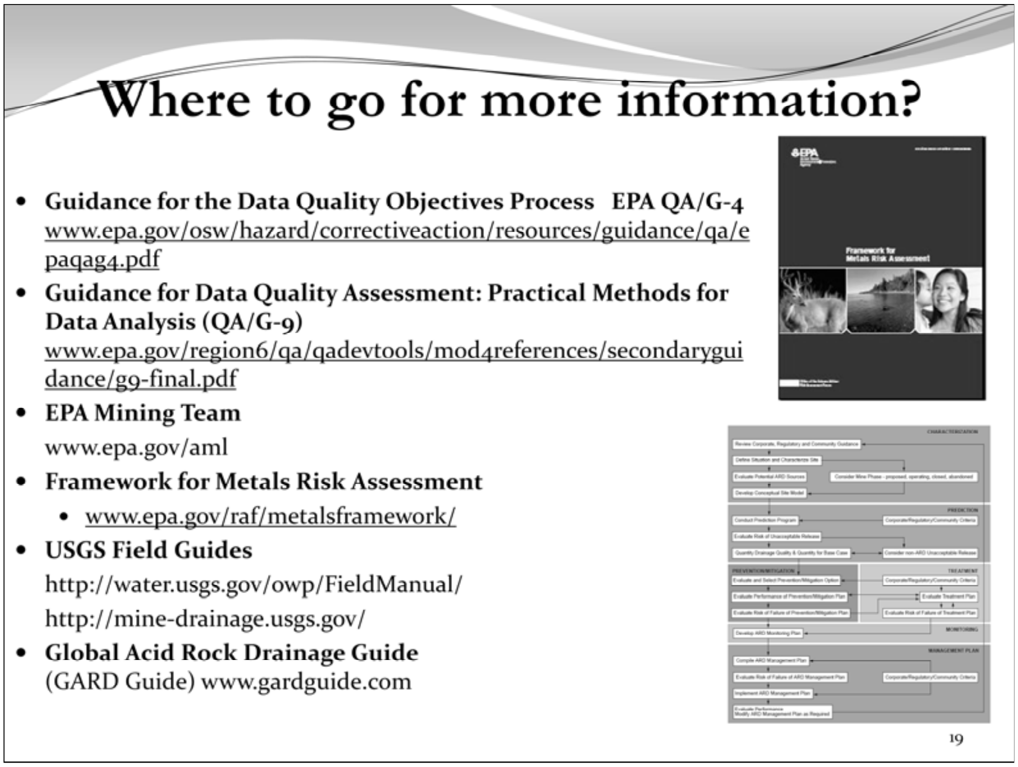
Receptors

- Proximity of people (homes – recreation, drinking water)
- Number of receptors and susceptibility
- Protected areas or species
- Location of water bodies
- Ameliorating geochemistry



"…that portion of a chemical element's or a compound's total content in an earth material that can be liberated to the surficial or near-surface environment (or biosphere) through mechanical, chemical, or biological processes"



EPA recognized that metals present unique risk assessment issues, and saw the need to develop a framework document that puts forth key scientific principles for metals risk assessments to help ensure consistency in metals assessments across EPA programs and regional offices. This framework, called the "Framework for Metals Risk Assessment," is a science-based document that describes basic principles that address the special attributes and behaviors of metals and metal compounds to be considered when assessing their human health and ecological risks. The Risk Assessment Forum oversaw the development of this document, including input from stakeholders and experts throughout the Agency, and obtained through several expert workshops, followed by peer review by the EPA Science Advisory Board (SAB). The Framework for Metals Risk Assessment document is intended to serve as a guide for all EPA programs and regional offices to supplement or update the policies, practices and guidance they currently use in their respective metals assessments. This framework document is not a prescriptive guide on how any particular type of assessment should be conducted within an EPA program office. Rather, it outlines key metal principles and describes how they should be considered in conducting human health and ecological risk assessments to advance our understanding of metals impact and foster consistency across EPA programs and regions. Although the audience for the framework is primarily intended to be Agency risk assessors, it also will communicate principles and recommendations for metals risk assessment to stakeholders and the public. This framework will be used in conjunction with guidance developed by the programs and regions for site-specific risk assessment, criteria derivation, ranking or categorization and other similar Agency activities related to metals. The Framework for Metals Risk Assessment document is intended to serve as a guide for all EPA programs and regional offices to supplement or update the policies, practices and guidance they currently use in their respective metals assessments. EPA assessments can vary in level of detail from simple, screening analyses to complex, definitive assessments. More complex scientific tools and metal specific methods should be applied as the complexity of the hazard assessment or risk assessment increases.