More than removing valuable rock

Mining supplies metals, minerals and fuels such as coal. Ore is material from which a valuable substance can be economically extracted. Its grade measures the concentration of the desired substance.

1. ACCESS DETERMINES THE EXTRACTION METHOD

SURFACE MINING

Remove vegetation and overlying soil and rock (overburden) to expose a shallow deposit. Strip mining removes material in strips; open-pit mining excavates a large pit.

Broad land disturbance removes habitat and exposes soil to erosion. Surface coal mining is generally cheaper than underground extraction.

SUBSURFACE MINING

Use shafts or tunnels to reach deeper deposits. As accessible coal is depleted, deeper extraction can become necessary and more expensive.

Ventilation, pumping and structural support add costs. The surface footprint may be smaller, but groundwater pollution, waste disposal and ground subsidence remain possible.

2. LOWER GRADE MEANS MORE ORE PER UNIT OF METAL

When richer, accessible deposits are depleted, mining may shift to lower-grade ores. More material must be extracted and processed to obtain the same quantity of metal, increasing potential energy use, water demand, waste and pollution.

2% METAL	1% METAL
1 / 0.02 = 50 tonnes of ore	**1 / 0.01 = 100 tonnes of ore**

Illustrative calculation for 1 tonne of metal, assuming 100% recovery. Halving the grade doubles the ore requirement. Real recovery losses increase it further. Overburden is additional material, not included here; impacts also depend on mineral chemistry, depth and processing technology.

Surface and underground extraction: EIA, Mining and Transportation of Coal.
Land disturbance and subsidence: EIA, Coal and the Environment.

Scope: College Board AP Environmental Science CED, Topic 5.9, p. 105.

Follow the waste and the water

Mining moves large quantities of material. Environmental effects depend on the waste composition, its storage, and whether wind or water carries contaminants beyond the site.

1. THREE WASTE TERMS TO DISTINGUISH

Overburden / waste rock	Material removed to reach the deposit, or rock with too little value to process. It is not the same as processed tailings.
Tailings	Material left after ore is crushed, ground and valuable minerals are separated or concentrated; often fine particles or slurry.
Slag	Residue from high-temperature metal processing, such as smelting. Tailings and slag originate at different processing stages.

2. EXTENSION: ACID MINE DRAINAGE

Exposed sulfides — React with air + water → **Acid forms** — Water pH falls → **Metals dissolve** — Contaminated drainage

Sulfur-bearing minerals exposed by mining can generate acidic drainage that mobilizes metals. Low pH and dissolved metals can harm aquatic organisms and contaminate surface water or groundwater. This can persist after closure; not every mine produces acidic drainage.

3. AIR, LAND AND WATER IMPACTS

Blasting, crushing and transport generate dust. Vegetation removal increases erosion and sediment runoff; drainage or leaking waste stores can pollute water. Coal seams can release methane, a greenhouse gas, during mining. Underground excavation may cause subsidence: sinking or collapse of the land above. These are extraction impacts, distinct from pollution when coal is burned.

Waste streams and processing: EPA, Explore a Metal Mine.
Acidity and metal pollution: EPA, Abandoned Mine Drainage.
Coal-mine methane and subsidence: EIA, Coal and the Environment.

Scope: College Board AP Environmental Science CED, Topic 5.9, p. 105.

Resources have benefits and costs

Mining supports energy supplies, construction and manufacturing. Evaluating it means considering both useful products and environmental costs that may continue long after extraction ends.

1. ECONOMIC VALUE IS NOT THE WHOLE COST

Mining provides raw materials, employment and income, and accessible deposits can supply relatively low-cost resources. Deeper or lower-grade deposits often cost more to exploit. Prices may not fully reflect habitat loss, polluted water, damaged land or long-term cleanup. A mine can be profitable while some costs fall on nearby communities or future generations.

2. EXTENSION: MATCH THE RESPONSE TO THE IMPACT

Erosion and unstable land	Regrade and stabilize slopes; replace suitable soil and establish vegetation to protect the surface.
Contaminated drainage	Limit water contact with reactive waste; collect and treat polluted drainage, then monitor water quality.
Tailings and waste rock	Use engineered storage and drainage controls, with inspections and maintenance to reduce leakage or failure.
Demand for new extraction	Reuse products and recycle metals; assess recovery of useful minerals from existing mine wastes.

3. RECLAMATION REDUCES HARM, NOT EVERY LOSS

Reclamation aims to leave mined land stable and suitable for a beneficial use, with controlled pollution and recovering vegetation. It does not recreate the removed mineral deposit, and planting grass alone does not restore an original forest or eliminate contaminated drainage. Water treatment and monitoring may be needed for years. Recycling and mine-waste recovery also require energy and controls; they reduce some demand for new mining rather than making all mining unnecessary.

Land and water restoration: OSMRE, Innovation in Action - Mine Reclamation.
Potential recovery of useful minerals: USGS, Mine Waste as a Resource.

Scope: College Board AP Environmental Science CED, Topic 5.9, p. 105.