

Contents

CHAPTER 1

Mining and the Environment	1
Introduction	1
Uniqueness of Mining	2
Environmental Effects of Surface Mining	4
Water Pollution	17
Land Use	18
Subsidence of Mined Land	26
Environmental Audits	29
Types of Environmental Audits	31
References	33

CHAPTER 2

Surface Coal Mining with Reclamation	35
Dragline Operation	35
Keycutting and Layered Cutting	37
Panel (Pit) Width	37
Extended Bench	39
Dragline Stripping Procedures	39
Single Seam Stripping with Nonselective Spoil Placement	40
Single Machine Subsystems	40
Shallow Overburden, One Lift, One Pass	40
Box Pits	45
End Cut	46

Side Cut	46	
Rehandle (End Cut)	46	
Rehandle (Borrow Pit)	49	
Moderate Overburden Depth, Single Lift, Single Pass	51	
Moderately Deep Overburden, Two Lifts, One Pass	53	
Deep Overburden, Split Bench Mining	54	
Deep Overburden, Multiple Lifts, One Pass	58	
Two-Pass Extended Bench Method	62	
Pullback Method	63	
Terrace Mining	67	
Tandem Machine Systems	67	
Tandem Dozer/Dragline Stripping	67	
Single-Seam Stripping with Selective Spoil Placement	70	
Moderate Overburden Depth, One Lift, Single Pass	70	
Moderate Overburden Depth, Two Lifts, One Pass	71	
Deep Overburden, Two Lifts, One Pass	71	
Multiple Seam Stripping with Draglines	72	
Single Dragline, Two Seams, Nonselective Spoil Placement	72	
Moderate Overburden and Interburden Depths	72	
The Extended Bench Method for Two Seams	73	
The One-Pass Extended Bench Method for Two-Seam Stripping	74	
The Two-Pass Spoil Side Method	77	
Elevated Bench Method	78	
Tandem Machine, Two-Seam Condition, Nonselective Spoil Placement	80	
The Tandem Shovel-Dragline System	80	
Dozer-Dragline System	81	
Tandem Machine-Multiple Dragline	81	
Selective Spoil Placement in Two-Seam Condition	81	
Stripping of Unstable Burden Material	83	
Multiple Seam Systems	85	
Horseshoe Mining Sequence	89	
Steep Slope Mining	91	
General Sequence of Mining and Reclamation Operations	91	
One-Cut, Single-Seam Conventional Contour Mining	92	
Other Conventional Contour Mining Situations	96	
Haulback Mining Methods	96	
Single-Cut Haulback Mining of Single Seams	96	
References	101	

CHAPTER 3

Reclamation and Revegetation of Mined Land	103
Introduction	103
Reclamation of Surface Mined Land in Australia	105
Material Characterization	106
Landform Design	107
Use of Topsoil	108
Reclamation Procedures	109
Revegetation Methods	110
Tree Planting	111
Pasture Management	111
Revegetation of a Surface Mined Land in Montana	112
Factors Affecting Natural Revegetation of Coal	
Mine Spoil Banks in Ohio	113
Vegetation Development on Old and Abandoned	
Lead and Zinc Mine	115
Revegetation at the Usibelli Coal Mine, Alaska	117
References	119

CHAPTER 4

The Acid Mine Drainage Problem from Coal Mines	121
Introduction	121
Chemistry of Formation	122
The Role of Bacteria	124
Conventional Neutralization Process Using Lime	126
High-Density Sludge Process	128
Other Treatment Processes	128
Chemical Treatment	129
Lime	129
Limestone	132
Caustic Soda	135
Iron Oxidation	135
Aeration Systems	137
Biological Oxidation	140
Oxidation Rate	142
Sludge Dewatering and Disposal	143
Reverse Osmosis	151
Ion Exchange	155
Sul-Bisul Process	156
Modified Desal Process	158
Two-Resin Process	158

Underground Mines	199	
Open Pits	199	
Waste Rock Dumps and Spoil Piles	200	
Tailings Deposits	200	
Stockpiles and Spent Heap-Leach Piles	200	
Covers and Seals to Control Infiltration	200	
Soil Covers	200	
Synthetic Covers	209	
Placement of Covers	212	
Waste Rock and Tailings Placement Methods	214	
Monitoring	215	
Specific Monitoring Programs for		
Each Mine Component	217	
Environmental Monitoring of Open Pits	218	
Environmental Monitoring of Underground Workings	219	
Environmental Monitoring of Waste Rock Dumps, Ore		
Stockpiles, and Heap-Leach Sites	221	
Environmental Monitoring of Tailings Impoundments	222	
Environmental Monitoring of Quarries	223	
Environmental Monitoring of Haul Roads	224	
Impact of an Abandoned Mine on Water Quality	224	
Hydrologic Solution to Acid Mine Drainage	227	
Water Resource Problems in a Lead Belt	228	
Environmental Control Measures after the Closure of a Lead-Zinc		
Mine in Greenland	232	
Mine Environmental Rehabilitation	238	
Designing Closure of an Open Pit Mine in Canada	246	
Metal Contents and Treatment of Mine Water	249	
Water Types and Contents	250	
References	259	

CHAPTER 6

Hydrologic Impact	261
Introduction	261
Hydrologic Impact of Phosphate Mining	263
Hydrologic Impact of Phosphate Gypsum Disposal Areas in	
Central Florida	269
Hydrologic Effect of Subsurface Coal Mining in the	
Appalachian Region	274
Effects of Longwall Mining on Hydrology	276
References	281

CHAPTER 7

Erosion and Sediment Control 283

Preliminary Site Evaluation	284
Land Type	285
Soil and Rock	285
Streams	285
Floodplains	286
Impoundments	286
Groundwater Conditions	286
Vegetative Cover	287
Planning	287
Preliminary Site Investigation	287
Preliminary Design	287
Subsurface Investigations	288
Final Design	290
Formulation of an Erosion and Sediment Control Plan	296
Operation	297
Maintenance	298
Sedimentation Control in a Surface Coal Mine	300
Surface Mine Sedimentation Control	307
Surface Mine Drainage Control	317
References	323

CHAPTER 8

Wetlands 325

Introduction	325
Constructed Wetlands	328
Constructed Wetlands for Mine Drainage Treatment	335
Metal Removal in Constructed Wetlands	342
Site Selection	347
Performance Expectations	349
Hydraulic Design and Control Structures	351
Substrate	354
Substrate Evaluation for AMD Systems	354
Vegetation	361
Water and Soil Parameters Affecting Growth of Cattails	361
Where Cattails Grow	363
Effects of Cattails (<i>Typha</i>) on Metal Removal	368
Metal Retention Capacity of Wetlands for Treatment of	
Acid Mine Drainage	374
Role of <i>Sphagnum</i> Plants in Iron Uptake	376

Iron and Manganese Removal in a <i>Typha</i> -Dominated Wetland	381
The Role of Algae in the Treatment of Acid Mine Drainage	386
Constructed Wetlands for Acid Drainage Control in the Tennessee Valley	390
Windsor Coal Company Wetland	396
The Tracy Wetland	399
Wetland Treatment in Metal Mining	405
Big Five Tunnel Experimental Wetland, Colorado	407
Nickel and Copper Removal by a Natural Wetland	413
References	422

CHAPTER 9

Blasting 425

CHAPTER 10

Mining Subsidence 431

Introduction	431
Subsidence Investigations	434
Structural Damage	436
Damage Criteria	437
Remedial Measures	438
References	440

CHAPTER 11

Postmining Land Use 441

Introduction	441
Appalachian Region Case Study	445
Evaluation of Alternatives	446
Economic Evaluation	447
Environmental Evaluation	447
Social Impact Evaluation	447
Selected Alternatives	447
Midwest Case Study	448
Evaluation of Alternatives	449
Economic Evaluation	449
Environmental Evaluation	450
Social Impact Evaluation	450
Selected Alternative	450
References	451

CHAPTER 12

Environmental Effects of Gold Heap-Leaching Operations 453

Introduction	453
Hazard Identification	454
Exposure Assessment	454
Groundwater Pathway	459
Surface Water Pathway	462
Toxicity Assessment	466
Risk Characterization	467
Decommissioning of Heap-Leach Facilities —	
Industry Experience	468
Borealis Mine, Echo Bay Minerals Company, Hawthorne, NV	468
Barrick Goldstrike Mines, Inc., Carlin, NV	470
Fondaway Mine, Tenneco Minerals	471
Gilt Edge Mine, Deadwood, SD	472
Annie Creek Mine, Lead, SD	472
Golden Maple Gilt-Edge Mine	473
Previous Experience at ZMI	474
References	477

INDEX 479