# Contents

NTRODUCTION ..... History, Current Status, Projected Problems, References.

EGAL CONSIDERATIONS ..... Legal Classification of Water. The Basic Water Doctrines. Diffused Surface Water. Groundwater. Comparison of Doctrines. The Federal Government. Interstate Problems. Acquiring Water Rights. Waste Treatment. References. Problems. 8

WATER REQUIREMENTS AND WASTE VOLUMES ..... 22 POPULATION ESTIMATES. Types of Population Estimates. Methods of Forecasting. Short-Term Estimating. Long-Term Population Predictions. Population Densities. WATER REQUIREMENTS. Factors Affecting the Use of Water. Residential Water Use. Fire Demands. Com-

mercial Water Use. Industrial Water Use. Agricultural Water Use. QUANTITIES OF WASTES. Residential Sewage Flows. Industrial-Waste Volumes. References. Problems.

## 4. DEVELOPMENT OF SURFACE AND GROUND WATER

THE DISTRIBUTION OF WATER IN THE UNITED STATES. Soil Moisture. Surface Waters and Groundwater. Runoff Distribution. Groundwater Distribution. WATER QUALITY. Groundwater. Surface Water. THE WATER BUDGET. Definition of Terms in the Water Budget. SURFACE-WATER SUPPLIES. Drainage Area Determination. The Equation of Continuity Applied to a Drainage Basin. Precipitation. Evaporation and Transpiration. Runoff. Recorded Stream Flows. Basin Characteristics Affecting Runoff. Natural and Regulated Runoff. Storage. RESERVOIRS. Locating the Reservoir. Site Preparation. Surface Area and Storage Volume Considerations. Determination of Required Reservoir Capacity. Methods of Computation. Losses from Storage. Flood Routing. GROUNDWATER. The Subsurface Distribution of Water. Aquifers. Fluctuations in Groundwater Level. Comprehensive Groundwater Basin Development. The Safe Yield of an Aquifer. Groundwater Flow. Collection of Groundwater. Boundary Effects. Salt-Water Intrusion. Groundwater Recharge. CONCURRENT DEVELOPMENT OF GROUNDWATER AND SURFACE-WATER SOURCES. References. Problems.

**v**i

#### Contents

5. TRANSPORTATION AND DISTRIBUTION OF WATER THE TRANSPORTATION PROBLEM. The Aqueducts of Ancient Rome. The Canadian River Project. The California State Water Project. Types of Aqueducts. Hydraulic Considerations. Design of Transpor- tation Systems. Types and Systems. Pressure and Capacity. Hydrau- lic Design of Distribution Systems. System Layout and Design. Evaluation of Existing Systems. System Analyzers. Distribution Reservoirs and Service Storage. PUMPING. References. Problems.	104
6. SEWERAGE AND DRAINAGE SYSTEMS	166
7. EXAMINATION OF WATER AND WASTE	219
8. PHYSICAL-TREATMENT PROCESSES	258
9. CHEMICAL-TREATMENT PROCESSES. WATER STABILIZATION. Chemical Equilibria. Carbonate Equilibria. Corrosion. COAGULATION, PRECIPITATION, AND ION EXCHANGE. Water Softening. Lime-Soda-Ash Process. Ion Exchange. Ion Ex- change in Waste Treatment. Iron and Manganese Removal. Coagu-	322

change in Waste Treatment. Iron and Manganese Removal. Coagulation. Zeta Potential. Coagulation of Colloids. Coagulation in Waste Treatment. SALINE-WATER CONVERSION. Introduction. Energy Requirements. Costs. Conversion Processes. Evaporation. Design Problems of a Vapor-Compression Plant. Freezing Process. Reverse Osmosis. The Osmionic Process. Electrodialysis., Mineral By-products from the Sea. VRADIOACTIVITY IN WATER AND WASTE TREATMENT. Radioactivity. Radioactive Pollutants. Removal of Radioactivity from Water. References. Problems.

## 10, BIOLOGICAL-TREATMENT PROCESSES

BIOLOGICAL CONSIDERATIONS. Cell Growth. Biological Oxidation. Nutrition. OXYGEN REQUIREMENTS. Theoretical Oxygen Demands. Biochemical Oxygen Demand (BOD). Formulation of the First-Stage BOD Curve. BOD's by Electrolysis. Organic Loads on Streams. SEWAGE-TREATMENT SYSTEMS. ACTIVATED SLUDGE. The Process. Modifications of the Activated-Sludge Process. Extended Aeration. Design Considerations. The Process. Trickling Filter Design. PHOTOSYNTHETIC PROCESSES. Introduction. Theory of Operation. Design. ANAEROBIC DIGESTION. Introduction. Theory. Digester Design. References. Problems.

438 . . . . . . . Sludge-Drying Beds. Vacuum Filtration. Centrifugation. Wet Oxidation. Incineration. Composting. Sanitary Landfill. Water Disposal Other Refuse Materials. References. Problems.

DISINFECTION. Theory. Chlorine. Chemistry of Chlorination. Disinfection with Chlorine. Chlorine in Waste Treatment. Chlorine Handling and Control. Other Disinfection Methods. Origin and Nature of Taste and Odor. Control of Taste and Odor. References. Problems.

#### 3. INDIVIDUAL WATER-SUPPLY AND WASTE-DISPOSAL 496 INDIVIDUAL WATER SUPPLY. Collection and Storage. Demand for Water. INDIVIDUAL WASTE DISPOSAL. Disposal of Excreta Without Water Carriage. Septic Tanks. Commercial Septic-Tank Systems. References. Problems.

THE NATURAL OF INDIRECT REUSE OF WATER. Indirect Municipal Reuse. Indirect Industrial and Agricultural Reuse. Pollution-Control Methods. Interstate Agencies for Pollution Control. Enforcement of Water-Pollution Abatement. DIRECT REUSE OF WASTE WATERS. Public Health Considerations. The Concept of Advanced Waste Treatment. Domestic Uses. Industrial Uses. Agricultural Uses. Recreational Uses. Legal Considerations. THE USE OF WASTE WATERS TO RECHARGE GROUNDWATER STORAGE. The Need for Recharge. Recharge with Sewage Effluent. Costs of Groundwater Recharge. References. Problems.

## 15. WATER-RESOURCES ENGINEERING

COMPREHENSIVE PLANNING FOR WATER-RESOURCES PROJECTS. Comprehensive Planning and Programming. Objectives of River-Basin Development Projects. Principal Steps in River-Basin Planning. Co-

510

#### Contents

ordination Between Economic and Technologic Concepts. Formulation of the Project. Analysis of the Project. Multipurpose Projects. ENGINEERING ASPECTS OF RIVER-BASIN DEVELOPMENT. Natural Control of Rivers. Engineering Control Methods. Municipal Water Supplies. Stream Pollution. Navigation. Flood Control. Power Development. Irrigation. Land Management. ECONOMIC ASPECTS OF WATER-RESOURCES PLANNING. Engineering Economy. Economic Decision-Making. An Economic Model for Water Use. Product Demand Functions. Production Function. Resource-Supply Functions. Benefit-Cost Analyses. References. Problems.

INDEX

571