

# Chapter 1

## INTRODUCTION

This Engineering and Design Manual for Coal Refuse Disposal Facilities (Manual), originally published by the Mining Enforcement and Safety Administration (MESA, 1975), has been updated for the Mine Safety and Health Administration (MSHA) of the United States Department of Labor to present current guidelines and procedures for design, construction and operation of coal refuse disposal facilities. Guidance related to dam safety issues for other impounding structures at coal mine sites, including fresh water impoundments and sedimentation and treatment ponds, is also provided in individual sections or through discussion of the associated design features. Emphasis has been placed on facility planning and materials handling and placement techniques. The input provided by MSHA, other regulatory agencies, the coal mining industry, consulting engineers and the general public has been beneficial to the preparation of this document. The guidance presented in this Manual is advisory and not intended to discourage new and innovative methods that may be applicable in specific situations.

The focus of this Manual is on design, construction and operational practices for achieving stable embankment and impoundment conditions based upon performance criteria, established regulations, and accepted engineering standards. Typical performance criteria are associated with long-term stability, flood and seismic conditions, and abandonment. Where the application to disposal practices requires interpretation that may not have been envisioned by the developers of design criteria, or where such criteria may not be available (as with some elements of seismic stability analyses), guidance is provided along with commentary describing the basis for development of the guidance. Criteria for environmental control of impacts from coal refuse disposal facilities vary from state to state. The Manual discusses features currently incorporated into disposal facilities for environmental control and provides guidance for their design and construction, as related to dam and embankment safety concerns of MSHA. Guidance for evaluating potential environmental impacts or for establishing environmental design criteria is left to other references and regulatory agencies. For example, the Manual provides information on the design and construction of liner systems for disposal facilities, but guidance relative to establishing the need for or the required hydraulic conductivity of a liner is available in other references.

Before the Buffalo Creek coal refuse facility failure in February 1972, coal refuse disposal was often subject to only cursory engineering, planning and design. Through the attention of the industry, ensuing regulatory programs, and guidance provided in the original 1975 Manual, improvements were made in the design and construction of disposal facilities. Since 1975, mining and coal processing

have undergone changes that affect the design of disposal facilities; advances in engineering practice have led to modification of design criteria; and other events such as the breakthrough of impoundment basins into abandoned underground mine workings have disclosed potential considerations that must be addressed. Thus, the original Manual has been updated to reflect these changes. While the structure and sequence of the previous Manual have been maintained, additional chapters have been added to address design components such as seismic stability, site mining and foundation issues, instrumentation, and emergency action planning.

This Manual is intended as a reference document for use by coal industry personnel and engineering staff, design consultants, and dam safety regulators involved with the planning, design, construction and regulation of refuse disposal facilities and other mine-related impoundments. It may be particularly valuable to industry personnel who perform design coordination, as a guidance document for exploration, testing, engineering analysis, design and construction document preparation, and construction monitoring and inspection. For design engineers, the Manual provides background information on coal refuse, along with methods and procedures for detailed design of coal refuse disposal facilities. Construction personnel will find descriptions of critical engineering issues that should be addressed during initial development and throughout the operational life of disposal facilities.

Chapter 2 presents an introduction to coal refuse including its origin, characteristics of the various materials making up coal refuse, and disposal practices. Current challenges in the disposal of coal refuse are also discussed.

Chapter 3 describes various types of coal refuse disposal facilities (both impounding and non-impounding) and other site impoundments and the operations and hazard potential associated with each. The classification and terminology used for embankments and impoundments are presented, consistent with conventions adopted in the 1975 Manual and MSHA publications. Additionally, underground injection of coal refuse and recovery (remining) of coal from refuse disposal facilities are also discussed.

Chapter 4 presents updated planning and technical considerations associated with disposal site selection and facility design and emphasizes the importance of close coordination between the designer and the coal operator's production staff. Past experiences with improving and expanding existing facilities and the planning of new facilities demonstrate the importance of integrating planning, design, construction and operations. The continually changing structure of refuse disposal facilities and the need to eventually reach an acceptable abandonment condition are important factors in the planning process.

Chapter 5 presents a new discussion of the design components of coal refuse disposal facilities, with emphasis on the objective of meeting the generation rates of coal preparation plants. The chapter provides the design coordinator and the engineer with an overview of the objectives of disposal facility design. The interrelationship between accommodating coal refuse generation rates, storm water and environmental control requirements, stable embankment development, and post-mining land use objectives are discussed.

Chapter 6 presents updated and new procedures for geotechnical exploration, engineering analysis, and design of coal refuse disposal facilities. Initially, the discussion addresses the unique characteristics of refuse disposal that affect facility design, as compared to the design of more commonly encountered geotechnical structures. Design concepts for embankment zoning, internal drainage control, and foundations are discussed with reference to related site exploration, testing, and geotechnical engineering analyses. The site exploration section provides new and updated guidance on cone penetration testing and geophysical methods applied to siting and design of impounding and non-impounding refuse embankments. The laboratory testing section presents descriptions and

references to standards for commonly used tests for refuse disposal facility design, along with summaries of coal refuse material properties. Geotechnical analysis topics discussed include seepage, settlement, stability, rock excavation, and conduit design. Chapter 6 is intended to provide an overview of geotechnical engineering requirements for disposal facilities for design coordinators who are familiar with coal mining operations, but may not routinely practice civil engineering as related to embankments and dams. It should also be a useful source to the practicing engineer for guidance on approaches, methods, and design elements of geotechnical engineering applied to coal refuse disposal facilities.

Chapter 7 presents new guidance for analysis of seismic stability and deformations applicable to dams and coal refuse embankments. Many slurry impoundments are constructed using the upstream construction method. Such sites are susceptible to instability during an earthquake because a portion of the dam is founded on relatively loose and saturated fine material. Major advances in the analysis of seismic stability of embankments and impoundments have occurred since the original 1975 Manual was published. Chapter 7 presents recommended design methods and flow charts to assist in seismic stability analyses. Also discussed is the importance of variation in material gradation (clay-like versus sand-like) that affects the selected approach and methods employed. Seismic hazard assessment is discussed, and guidance is provided for determining ground motion parameters considering the potential source zones and conditions found in coal regions. Deformational analysis is discussed along with criteria for tolerable deformations. Chapter 7 provides a condensed discussion of a complex subject that should allow design coordinators to gain an appreciation for the engineering required for addressing seismic stability. It will also help practicing engineers with this portion of the design by providing simplifying approaches in low-seismic-hazard regions. In regions of greater seismic hazard and for significant- and high-hazard-potential structures, more complex approaches for use by geotechnical engineers with experience in earthquake engineering are presented.

Chapter 8 has been added to the Manual to address site mining conditions, embankment foundation conditions, and impoundment stability at coal refuse facilities and the potential for subsidence and breakthrough into underground mine workings. Mitigation measures are also discussed. Additionally, unique foundation issues that may be encountered at mine sites are addressed, including evaluation of the effect of mine spoil materials and surface mine benches and highwalls on embankment and foundation design.

Chapter 9 summarizes hydrologic and hydraulic engineering methods applicable to the design of coal refuse disposal facilities. The Manual has been updated to reflect current design storm criteria. Examples of spillways, decants and channels with methods for performing design analyses and routing storms through disposal facilities are presented.

Chapter 10 addresses environmental considerations for coal refuse disposal facility design, including streams and wetlands, air quality, water quality, and reclamation. Updated guidance is provided as to methods for mitigating water quality concerns, including amendments and liner design. References are provided for evaluation of water quality impacts and treatment methods. Reclamation issues are also discussed. Design coordinators and engineers will find these sections useful when dealing with environmental issues and mitigation methods, but they will also need to be familiar with applicable state regulations and guidance.

Chapter 11 addresses disposal facility construction and operation, and Chapter 12 discusses construction monitoring, inspection and maintenance. These chapters reflect updates in construction and disposal practices since the 1975 Manual was prepared and discuss some of the issues associated with large production mines such as material handling, placement, and compaction requirements. Guidance has been added relative to the content of construction documents and quality control programs.

Chapter 13 provides a discussion of instrumentation for monitoring the performance of coal refuse disposal embankments and impoundments.

Chapter 14 provides a discussion of emergency action planning. It is recommended practice in dam safety that emergency action plans (EAPs) be developed and maintained for all dams that will have a significant downstream impact in the event of their failure.