Table of Contents

1.0 Introduction

1.1 General Considerations

This document was prepared by Earth Sciences Consultants, Inc. (Earth Sciences), and its technical subcontractor Sci-Tek Environmental Services Company (Sci-Tek), on behalf of the Pennsylvania Department of Environmental Protection, Bureau of Mining and Reclamation (BMR) and provides a detailed presentation of the field methods and results associated with the "Study of the Effects of Longwall Mining on Streams, Wetlands, and Riparian Areas". The study was implemented along segments of Robinson Fork that are located in West Finley Township, Washington County, Pennsylvania (Sheet 1). Study activities were conducted in accordance with Earth Sciences' October 13, 2000 Technical and Cost Proposals, the BMR's Contract No. BMR-00-01 dated March 14, 2001, Earth Sciences' April 3, 2001 Task Plan, and Earth Sciences' May 3, 2001 Site Selection Report.

In general, this report initially provides essential background information including a description of the study area, a discussion of land use and historical longwall mining operations within the Robinson Fork watershed, and an overview of regional and local geology, hydrogeology, and hydrology (Chapters 2.0, 3.0, and 4.0 respectively). Historical information associated with the evaluation of pre-mining geomorphologic and hydrologic stream conditions is then presented in Chapter 5.0. This discussion is followed by an assessment of post-mining, or current, geomorphologic and hydrologic stream characteristics (Chapters 6.0 and 7.0) for a mined and comparable unmined segment. Comprehensive biological evaluation data is contained in Chapter 8.0. The report closes with conclusions including comparisons with data provided from historic research as well as from the unmined segment, and recommendations for future mitigation and research (Chapters 9.0 and 10.0 respectively). A bibliography of sources referenced is provided following Chapter 10.0.

1.2 Purpose and Scope of the Study

The primary intent of this study was to determine the effects of longwall mining subsidence on streams, wetlands, and riparian areas within a selected valley floor setting. Secondly, the study findings were to provide a means, from a broader perspective, to determine whether the results could be applied as a predictive tool to forecast consequences within other watersheds designated for future undermining. In addition, the study was intended to provide data that would assist with developing approaches for monitoring and mitigating such effects.

The required work scope criteria and intent of this study, as specified in the project Contract, have been satisfied upon submission of this final report. Overall, this study has provided valuable and insightful

information regarding the application of current methods for conducting such studies and a substantial database that can be used as a comparative standard for streams with characteristics and deep mine conditions that are comparable to Robinson Fork.

1.3 Project Overview

1.3.1 Project History

Following the award of Contract No. BMR-00-01, BMR, Earth Sciences', and Sci-Tek's personnel attended a meeting at BMR's McMurray, Pennsylvania offices on March 23, 2001 to discuss the project work scope and schedule. Subsequently, a detailed Task Plan providing an estimated timeframe for the completion of each project task and subtask was submitted by Earth Sciences to the BMR on April 3, 2001. The Task Plan was approved by the BMR in a letter dated April 12, 2001. Activities related to the selection of the proposed study area were then initiated.

Selection of the study area was based on field reconnaissance, a review of mining and U.S. Geological Survey topographic maps, and other published literature. Specifically, preliminary field inspections for several candidate streams, including Robinson Fork, were conducted by Earth Sciences' and Sci-Tek's personnel on April 18, 2001. The streams were assessed per BMR basic project criteria for this study as well as additional qualifying attributes. Information regarding streams that were not selected, along with supporting justification, is provided in the following list:

- *Hoovers Run* – The primary excluding factor for this stream is the substantial amount of adjacent livestock and agricultural activity that has likely resulted in reduced riparian and in-stream species diversity as well as increased sediment load. The influence from these activities would be very difficult, if not impossible, to segregate from the potential effects of mine subsidence and, therefore, may have biased the study. Also, Hoovers Run is a very low gradient stream which may, in some instances, cause difficulty in discerning pooled areas associated with mine subsidence.

- *Enlow Fork* – This stream was excluded due to the abundance of upstream deep mining activity that prevented the selection of a local/comparable unmined study segment. Also, results from a study area other than Enlow Fork, for which an abundance of research data has already been generated, would be beneficial for broadening the existing database and for comparative purposes.

- *Templeton Fork* and main tributary *Rocky Run* – These streams were eliminated based on several factors including: 1) recent bulldozer restoration work along Templeton Fork; 2) lack of historical information; and 3) adjacent livestock and agricultural activity.

- *Whitely Creek* – Similar to Hoovers Run, the primary excluding factor for Whitely Creek is the substantial amount of adjacent livestock and agricultural activity that has likely resulted

in reduced riparian and in-stream species diversity as well as increased sediment load. The influence from these activities would be very difficult, if not impossible, to segregate from the potential effects of mine subsidence and, therefore, may have biased the study. Also, Whitely Creek is a very low gradient stream which may, in some instances, make pooled areas associated with mine subsidence difficult to definitively identify.

- *Laurel Run* – Laurel Run was not selected due to excavation work and related activities around a major pooled area southeast of Waynesburg, Pennsylvania and downstream excavation work for a natural gas pipeline. These activities would have likely interfered with the study and have provided biased results.

- *Pursley Run* – Reasons for not selecting this stream are similar to those previously indicated for Hoovers Run and Whitely Creek.

Following the field inspections and map/document review, Robinson Fork was preliminarily identified as the watershed in which the study was to be conducted. On April 25, 2001, Earth Sciences' and Sci-Tek's personnel performed a focused field evaluation within the Robinson Fork watershed for confirmation purposes and for selecting specific study segments.

Results from the field evaluation indicated that the excluding factors identified above for the other candidate streams were either not applicable to, or were of a lesser magnitude, in the Robinson Fork watershed. Specifically, although some agricultural and grazing lands exist upstream of the selected study segments, only minor land use of this type was present along the selected segments. Robinson Fork also appeared to have a slightly higher gradient than some of the other candidate streams, was not associated with stream restoration work, and afforded a local and comparable unmined reference segment. Although historical data for Robinson Fork was limited, this situation existed for most of the other candidate streams. The limited availability of premining information, however, provided an opportunity for expanding the current stream database. Also, as indicated in Section 1.3.2, Robinson Fork satisfied the BMR's site selection criteria.

Based on favorable results that indicated segments of Robinson Fork were sufficient for satisfying project criteria, a Site Selection Report was prepared by Earth Sciences and submitted to the BMR on May 3, 2001. The Site Selection Report was approved by the BMR in a letter dated June 20, 2001. Per the BMR's request, the Site Selection Report also provided a work plan describing the approach for evaluating pre-mining and post-mining geomorphologic/hydrologic variation.

As previously indicated, the area selected for this study consists of segments of Robinson Fork that are located in West Finley Township, Washington County, Pennsylvania. These segments include a mined

study area and an upstream study area that has not been mined and that is substantially beyond the expected angle of draw from deep mining. In coal mine subsidence, the "angle of Draw" is the angle assumed to bisect the angle between the vertical and the angle of repose. The angle of draw for flat (or nearly flat) seam is approximately 20 degrees. Although the focus of the study was concentrated within these areas, supplemental evaluations (especially biologic work) were conducted within other portions of the Robinson Fork watershed for purposes of data correlation and consistency. The locations of the mined and unmined study segments are depicted in the Site Location Map (Sheet 1).

The primary stream segments surveyed within the mined and unmined study areas generally coincided for the geomorphologic/hydrologic evaluation and the biologic assessment. The lengths of channel surveyed for these two investigative phases, however, were slightly different due to the methods used (geomorphologic assessment according to Rosgen [1996] versus the biological channel unit assessment [Peterson and Rabeni, 2001]). Specifically, the geomorphologic/hydrologic work was conducted along 2,068 feet of channel in the mined study area and along 3,011 feet in the unmined area. Wetlands, riparian vegetation, and in-stream macroinvertebrate studies were conducted for channel lengths of approximately 2,641 feet (805 meters) and 2,756 feet (840 meters) within the mined and unmined study segments, respectively. Not all channel units were sampled in each reach for fish for the following reasons: 1) sampling bias introduced by certain channels units (i.e., too short to effectively sample or due to the presence of ducks), 2) time factor involved in weighing fish, and 3) use of block nets. Therefore, the channel lengths for fish sampling were slightly less; 2,254 feet (687 m) (mined segment) and 2,379 feet (725 m) (unmined segment). The longitudinal extent of stream channel surveyed for the geomorphologic/hydrologic and biologic investigations is depicted in Sheets 10 (mined study area) and 11 (unmined study area).

1.3.2 Study Area Selection Criteria

The following list presents the selection criteria that were to be satisfied according to the BMR's August 21, 2000 RFP along with supporting information regarding how the segments selected along Robinson Fork fulfilled those criteria:

1) *The study area must be underlain by longwall mining panels* – The mined study segment is underlain by longwall mining panels associated with Consol Pennsylvania Coal Company's (Consol) Enlow Fork Mine. Chapter 3.0 provides details regarding the historical deep mining operations beneath this segment.

2) *The study area must contain at least 1,000 feet of subsided channel and 1,000 feet of unsubsided channel* – The mined study segment contained over 2,000 feet of subsided channel and the unmined segment was over 3,000 feet in length.

3) *At a minimum, the selected stream must rank as third order* – Robinson Fork ranks as a third order stream.

4) *The study area must support adequate wetland area(s)* – Jurisdictional wetland areas were identified adjacent to the study segments of Robinson Fork.

5) *The study area must contain suitable areas of riparian vegetation* – The riparian habitat along Robinson Fork was highly suitable for the proposed study because several areas are forested with many rare plant species that were useful for evaluating response to earth disturbance. Many of the aggressive exotic and native plants known to invade floodplain areas in the region were also found in the watershed.

6) *Permission from adjacent property owners is such that at least 2,000 feet of the main stream channel (including the minimum 1,000 feet of subsided channel) and its associated wetland and riparian areas can be accessed* – Permission to access the identified study segments was secured from all property owners and, therefore, no data gaps exist as a result of access difficulties.

7) *Adequate historical information must be available so that premining conditions can be comprehensively evaluated* – Some historical information was obtained related to previous surface water quality, surface water discharge, land use, geology, macroinvertebrate studies, and aerial photographs used for wetland delineation. Sources for historic information are defined in the bibliography provided after Chapter 10.0. Historical data that is unavailable was augmented with data provided from the upstream unmined study segment.

8) *Longwall panels are perpendicular to the stream section to be studied* – As indicated in the Deep Mine Layout map for Consol's Enlow Fork Mine (Sheet 3), the longwall mining panels are oriented approximately perpendicular to Robinson Fork.

9) *Additional selection criteria* – 1) The mined and unmined study segments are not immediately adjacent to a major roadway which should greatly reduce effects from road salt or hydrocarbon compounds; 2) There were no observed construction activities near the study segments; 3) There is some agricultural and livestock grazing activity upstream of the study segments. A surface water sampling

program was designed, however, to assist with segregating impacts from these activities; and 4) The dates of mining beneath the primary study area are 1995 and 1996.

Based on the field inspections of several candidate streams and the list presented above, the study segments selected along Robinson Fork were the most suitable for fulfilling project criteria.

1.4 Public Notification

Prior to initiating fieldwork, property owners contiguous to the study segments were notified of the proposed activities by telephone. Also, property owners were visited in person and asked to sign an access agreement and complete a questionnaire regarding their historical knowledge of the conditions within and adjacent to Robinson Fork. As previously indicated, access to all designated stream locations was granted. Also before beginning the fieldwork, local watershed groups were contacted to apprise them of the study and to obtain historic information they may have regarding Robinson Fork. These groups included the following:

- The Greene County Watershed Alliance
- The Washington County Watershed Alliance
- The Wheeling Creek Watershed Conservancy
- The Tri-States Citizens Mining Network

Although some groups expressed their opinions on stream conditions and indicated possible sources for historical information, they had no data to offer. After securing property access and contacting the watershed groups, the field program was implemented. Fieldwork was conducted during July and August 2001.

1.5 General Description of Field Program Activities

The general field program included the following activities:

- Mapping of bedform features along the mined and unmined study segments
- Land use mapping within the Robinson Fork watershed
- Surveying of 13 channel transects (6 transects within the mined segment; 6 transects within the unmined segment; and 1 transect along a tributary to Robinson Fork within the unmined segment)
- Surveying of the water surface and channel bottom slopes within the mined and unmined study segments

- Water Depth measurements within the mined and unmined study segments
- Description of channel pavement material within the mined and unmined study segments
- Sediment thickness measurements within the mined and unmined study segments
- Bank height measurements within the mined and unmined study segments
- Measurement of bank slopes within the mined and unmined study segments
- Description of bank materials within the mined and unmined study segments
- Identifying and mapping areas of aggredation and degradation within the mined and unmined study segments
- Mapping bedrock exposures within the mined and unmined study segments
- Mapping of bedrock fractures within and adjacent to the mined and unmined channel using Very Low Frequency Geophysics Technology (VLF)
- Conducted a pebble count along 66 channel transects (20 transects within the mined study segment and 46 transects within the unmined study segment)
- Average surface water velocity measurements within the 13 channel transects for discharge calculations
- Surface water sampling at four locations
- Field inspection of the channel and surrounding areas near the mined/unmined boundary
- Riparian vegetation studies utilizing EMAP sample plots and general plant surveys analyzing the component of exotic or naturalized plant species in the riparian vegetation community.
- Wetland studies utilizing the three-parameter approach methodology and the hydrogeomorphic method.
- Fish and benthic macroinvertebrate analyses utilizing the channel unit and multihabitat approach

Geomorphological, hydrological, and surface water quality work was conducted by Earth Sciences' personnel and aquatic, wetlands, and riparian vegetation work was performed by Sci-Tek's personnel.