
Protocols for the Remediation of Lands Impacted by Former Coal Mining Operations, Sydney Coalfield, Nova Scotia, Canada

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Abstract Abandoned underground coal mines may leave environmental footprints that remain long after the mines have closed. Both flooded and unflooded subterranean workings pose potential health and safety risks to persons working in close proximity to the former mining operations. Discharges of acid mine water may also impact the quality and ecology of receptor environments. This paper describes a number of protocols that address potential coal mining hazards in the Sydney Coalfield, Nova Scotia, Canada on lands owned by the Cape Breton Development Corporation (CBDC). The goal of this endeavor is to promote awareness of potential mining-related hazards on CBDC sites.

Key Words protocols, coal mine workings, mine hazards, database, PWGSC web site

Introduction

In May, 2001, Cape Breton Development Corporation (CBDC, which was recently integrated with the crown corporation Enterprise Cape Breton Corporation: ECBC) announced the termination of coal mining operations at its Prince Mine. This event marked the end of almost 300 years of continuous underground coal mining in the Sydney Coalfield. As owner of more than 700 properties in the Sydney Coalfield, CBDC inherited responsibility for the orderly closure of its mines and the reclamation of lands associated with these operations. It also retained responsibility for abandoned mine sites operated by others but which now exist on its lands. To assist in this undertaking CBDC entered into a strategic relationship with Public Works and Government Services Canada (PWGSC).

It was recognized early that many CBDC properties were impacted by mines that had been closed for decades and for which little detailed information was available. Accordingly, PWGSC initiated a program in 2002 to qualitatively screen all CBDC properties and document the locations of potential liabilities. This program identified 1758 potential environmental and 885 potential health and safety liabilities (PWGSC 2004). To adequately address these liabilities extensive intrusive mine site exploration and remediation construction activity would be required. These activities would, in many cases, bring personnel and equipment in direct contact with the potential hazards of abandoned underground coal mine workings. In appreciation of this fact PWGSC contracted Conestoga-Rovers & Associates (CRA) to develop a number of protocols to safely guide work activities on CBDC properties impacted by mining. The protocols document (PWGSC 2008) was developed under with guidance provided by a Mine Workings Group consisting of PWGSC, CBDC and Conestoga-Rovers & Associates (CRA).

Mining Hazards

Mining hazards associated with former underground coal mining operations include the following.

1. Currently existing unstable ground caused by the collapse of abandoned coal mine workings.
2. Unstable ground that could potentially develop during and after site remediation.
3. Unsecured abandoned mine openings.
4. Potential accidental discharges of untreated mine waters.
5. Potential existence and release of hazardous mine gases.

Reports describing such mining related hazardous events are known from all mining districts world wide. Locally, the media regularly report the development of sinkholes and ground subsidence features whereby buildings are damaged or destroyed and highways and roads are undermined. Less commonly, people and animals have been reported to have fallen into unsecured shafts and subsidence holes and on rare occasions persons have died when unknowingly exposed to mine gases in unsecured mine workings. The protocols were developed to offer an organized and systematic approach for identifying and assessing potential hazards on the CBDC lands.

Protocol Development

Protocol development followed a descriptive rather than a prescriptive approach. This methodology was adopted in recognition of the site-specific character of abandoned mine sites and the need for the flexibility to evaluate each site on its own merits. Protocol development followed concepts gleaned from local experience and Internet sources from other mining districts including the United Kingdom (NCB 1982), United States (US DOT 1999 and Nova Scotia (NSDNR 1998). It incorporates the measures and actions previously developed by CBDC (CBDC 2004) for addressing liabilities on its properties. All sources have recognized the safety and environmental implications of abandoned underground mines and have developed ways and means of dealing with them. Although differing in detail the general approaches adopted share many common features. These include:

- Importance of acquiring and documenting background information on mine workings prior to conducting site work.
- Recognition that understanding site characteristics promotes better selection of remediation options and provides focus for the collection of remediation design data for final construction.
- More and more the background information is being compiled in electronic databases to promote better communication and allow for broader access to information.

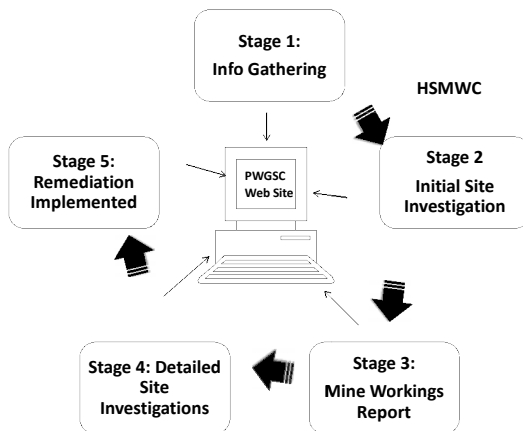
In recognition of these common features the five stage process shown in Figure 1 was proposed for CBDC properties in the Sydney Coalfield. A Health & Safety Mine Workings Committee (HSMWC) was set up to address exceptional hazards that may develop at any time during the remediation process. The protocols developed for each stage are described under the subsequent headings below.

PWGSC Web Site

Figure 1 illustrates the central position of the PWGSC Web Site as a repository for information collected during the remediation process. Its existence is crucial for the successful implementation of the protocols because it communicates data between the various consultants and investigators who work on the same CBDC properties. In this way it minimizes duplication of effort, promotes cost savings and supports the progressive accumulation of data.

Stage 1 Remediation Protocol – Information Gathering

Stage 1 protocol describes the recommended process for gathering and compiling information on former coal mining operations and storing this information on the (PWGSC) web site. One of the most important contributions at this stage is the inclusion of geo-referenced digital copies of mine plans on the PWGSC web site. Here the workings can be viewed with a variety of overlays



*Figure 1 Stages of Mine Site Reclamation for which Protocols were developed.
HSMWC: Health & Safety Mine Workings Committee*

that include high resolution aerial photography, surface topographic contours, the locations of mine shafts, water level tunnels, boreholes, coal seam outcrops, coal seam depth contours, mine water outfalls, etc. Also included are locations of test pits, monitoring wells and soil and water samples collected during Environmental Site Assessment (ESA) investigations. This ability allows investigators to readily view collected data relative to the mine workings and establish potential cause and effect relationships.

Stage 2 Remediation Protocol – Initial Mine Site Investigation

In Stage 2, background information collected in Stage 1 is field verified by an initial reconnaissance survey of the mine site. This survey provides a hands-on introduction to the physical conditions and provides practical site accessibility data needed for planning follow-up field investigations. The protocol describes the organization and the actions taken to maximize the value and effectiveness of the initial visit to the site. In keeping with the potential existence of mine site hazards, it emphasizes the need for at least two person teams during site visits and to report any significant health and safety hazards immediately to PWGSC and CBDC.

Stage 3 Remediation Protocol – Mine Workings Report

The collection of information in Stages 1 and 2 culminates in the preparation of a Mine Workings Report. Here the mine workings that could potentially impact exploration and remediation activities on CBDC properties are identified. Mine operational history and the geological setting are described in detail. A general overview of the potential surface subsidence, mine water discharges and mine gas emissions is made, information gaps identified and recommendations for further work made. In many cases, this report could form the basis upon which remediation options are developed for the site. The report also clarifies whether project work (exploration and remediation construction) will be subject to the Canadian Environmental Assessment Act (CEAA).

Stage 4 Remediation Protocol – Detailed Mine Site Investigations

After identifying one or more conceptual remediation options field investigations may be implemented to provide the body of data needed to properly develop and design a favoured approach. Investigations may include the preparation of a detailed subsidence risk report, installation of monitoring wells to locate and monitor changes in the mine water level elevation; geophysical surveys, excavations and drilling to assess the extent, condition and stability of mine openings; water, rock and soil sampling for laboratory properties testing and an increased level of site monitoring. The stage 4 protocol presents guidelines to help insure investigations are carried out in a safe manner. To minimize the likelihood of accidents the protocol recommends the following preventative measures.

- Conduct a thorough review of mining-related data collected in Stages 1 to 3.
- Develop a comprehensive Health and Safety Plan (HASP) prior to conducting field work. It should contain, as a minimum,
 - Establishment of a danger zone around mine shafts outside of which personnel and equipment will operate; provide appropriate PPE, harnesses, ropes and anchoring stations to be available in the event of a mine shaft collapse.
 - Development of a process for informing equipment operators and personnel about potential dangers with actions to take in the event of an occurrence
 - Provide equipment and persons trained in the detection and handling of mine gases
 - Insure that drilling operations used to explore shafts and mine workings are conducted through casings cemented into bedrock and equipped with tees and valves at the collar to allow for sealing of the borehole if required.
- Submit site investigations plans to PWGSC and CBDC for approval prior to implementation.
- Immediately contact PWGSC and CBDC if open holes or other mining-related hazards develop or are discovered during on-site work activity.

Stage 5 Remediation Protocol – Mine Openings Remediation

During Stage 5 the information collected in Stages 1 to 4 is used to select, engineer and implement remediation of the site. Shafts have been highlighted in the current version of the protocols be-

cause they are potentially the most hazardous for remediation. With some modification it could also be used for other types of mine openings such as tunnels, slopes and sinkholes. The protocol contains a brief description of standard shaft remediation methods along with a list of reference literature describing sealing methods used traditionally in the Sydney Coalfield, Ontario and the United Kingdom. Because it is intrusive by nature shaft remediation is subject to the same potential hazards described for intrusive field work in Stage 4. It is also subject to the preventative measures identified for Stage 4 field work. This protocol stresses the need for maintaining detailed records of the reclamation process and preparation of as-built drawings. This information will be placed on the PWGSC web site where it will be available for post construction monitoring and to guide future mine opening remediation.

Mine Site Monitoring

Monitoring is an essential requirement at all stages of the site remediation process. It provides an awareness of site conditions where ground stability can rapidly change. Change may occur as a result of natural processes such as mine flooding or the collapse of mine roof strata or it may be a direct result of ground stresses induced by exploration and remediation activity. Should monitoring reveal a degradation in site conditions the risk level of the property may have to be raised and remediation may be carried out sooner than later. The monitoring protocol describes the manner and frequency of monitoring recommended for the various CBDC properties. Monitoring includes visual inspections, photography, measurements at installed instrumentation, follow-up sampling, etc. All findings are reported to an assigned Project Engineer and up-loaded to the PWGSC Web Site. Mining-related hazards discovered during monitoring activities must be immediately reported to PWGSC and CBDC, who will secure the site and address its permanent rectification by calling a meeting of the HSMWC.

Conclusions

Protocols have been developed for CBDC properties to help insure that site investigations and remediation construction activity is carried out in a safe manner. In their current form they are considered works in progress to be regularly reviewed and updated in response to lessons learned from experiences in the Sydney Coalfield. They present a general framework in which additional levels of increasing detail may be added if desired. It is hoped that in their current form they will reinforce the basic awareness that underground coal mines present significant potential hazards and may pose serious constraints on mine site investigations and remediation activities. If this fact alone is internalized by all investigators so that it becomes an integral part of all planned site activities then the preparation of these protocols will have attained its intended goal.

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