INTRODUCTION

The province of British Columbia is richly endowed with mineral wealth. Mining has been central to the provincial economy beginning some 150 years ago, with the coal mines of Vancouver Island and the placer gold camps of the Cariboo. The mining of minerals such as gold, silver, copper, lead, zinc, molybdenum and many others has been an important source of jobs and government revenues. The long history of mining in British Columbia is also part of the rich cultural heritage of the province, and is largely the basis for the infrastructure upon which the province was built.

Generally there is a low level of knowledge about the location and impacts of historic mines in the province. Notable exceptions are Mt. Washington, Britannia, and Anyox, where there are documented environmental impacts. It must be recognized however, that a historic mine is not synonymous with the terms pollution or contaminated site. Each site has unique geological and environmental conditions and one cannot extrapolate a mine such as Britannia to every other historic/abandoned site in the province.

The regulation of the mining industry has evolved and improved with the maturing of the sector. Historic mining in the province was undertaken using less sophisticated methods than those currently used today by the high-tech and efficient mining industry and before enactment of modern environmental regulations. Mining undertaken prior to reclamation legislation has resulted in a number of historic (abandoned or orphaned) mine sites that have been left unreclaimed. These sites are not documented in a comprehensive manner in British Columbia. Understanding the historical evolution of mining in the province is important, as it allows the current situation regarding historic mine sites to be viewed with an informed perspective.

PROJECT OVERVIEW

PHASE 1 - 2000/01

Phase 1 of the Historic Mine Sites Project was initiated by the Ministry of Energy and Mines in May 2000 by the Reclamation Section of the Mining Division. The purpose of the initial year of this project was to begin to inventory historic mine sites in an effort to understand the scope of the problem in British Columbia and to develop a Historic Mine Sites Database (HMSDB).

Sites were identified principally through review of existing ministry data and developing a working definition of a historic mine site. Initial classification of historic mine sites included 1,887 unpermitted, "past producing" mines in the province, based on information contained in MINFILE (database of all known mineral occurrences in British Columbia). Further prioritization of sites included mineral deposits known to have geoenvironmental characteristics, which present a potential for generating acid and/or leaching of metals into the environment. Of this type, there are 1,171 identifiable sites in the Province.

Further site prioritization for fieldwork was based on the size of the workings, degree of documentation on metal leaching/acid rock drainage (ML/ARD) issues, discussion with regional Ministry of Mines staff and accessibility. Access to many of these sites is costly due to remoteness and the fact that vehicle access is not possible.

Field based inspections were conducted primarily in July, August and September 2000, including sites from all regions of the province. This work was undertaken with mines inspectors from each regional office in order to provide logistical support, and to rely on their experience and knowledge of the historic sites in their region. To date, about 62 sites have been inspected, which included sampling of mine drainage for analysis of heavy metal content as well as other documentation of site specific information. This, however, represents only about 3.0% of the 1,887 identified historic sites in the province.

Many other provincial jurisdictions across Canada are undertaking similar studies that include locating, inventorying, characterizing and reclaiming historic/abandoned mine sites in Manitoba, Ontario, Quebec and Nova Scotia. Major mine rehabilitation programs are also being undertaken in the United States and Australia.

LONG-TERM OBJECTIVES

Long-term objectives of this project include identifying high priority sites where environmental or health and safety issues exist, and determining where reclamation is necessary. This however, will require more fieldwork to characterize sites in order to have a higher level of confidence that the sites requiring reclamation are identified.

The Ministry has initiated preliminary discussions with other resource agencies and the mining industry to develop a common strategy in order to facilitate addressing the issues of historic mine sites in British Columbia. This includes identifying persons having known responsibility to clean up sites and identifying those sites that are truly orphaned and may require government funding or partnership programs to facilitate cleanup.

The benefits gained from reclamation of historic mine sites include protection of life, health, and safety, improved environmental and social conditions, and better use of natural resources.

LEGACY OF MINING IN BRITISH COLUMBIA

The mineral resources in British Columbia are owned by the Crown provincial. This ownership stems from the terms of Confederation in which the Canadian provinces retained ownership over natural resources contained within their respective boundaries, and the right to exercise control over resource developments.

In most jurisdictions in North America where ownership of mineral resources have been retained by the public sector, governments do not explore for, develop and produce these resources. Such activities are carried out by the private sector-the mining industry-which raises cash required to search and develop sub-surface resources.

British Columbia has an impressive mineral endowment. Mining for metals and coal has been ongoing since the mid-1800s and has resulted in billions of dollars worth of production. The scale of this contribution is not always apparent; it lies buried in dry statistics on employment and international trade. In 1999 mineral production of solid minerals in British Columbia created $2.6 billion of new wealth (estimate 1999-MEM Mineral Statistics).

Mining has also had a major influence on the economic and social development of British Columbia. This influence commenced prior to the establishment of the province as a jurisdiction, and was instrumental in developing transportation and access routes from tidewater to the interior. As the mineral wealth of the province became recognized and the focus of mining shifted from placer gold to lode deposits of precious and base metals, mining activities, including processing of ores became a significant regional employer. This aspect of mining has continued to the present day.

A second noteworthy aspect of mineral development in British Columbia has been the historical importance of the southern third of the province. Ease of access using the north-south river systems, favourable geological environments and the presence of a trained cadre of prospectors and miners gave the south-east portion of the province an early start in successful mineral developments. This success was replicated in the south-central regions and along the coast, resulting in a multitude of mining operations of varying sizes.

Most of British Columbia's mines today are far from big cities and most city dwellers have never seen one. Even fewer have actually visited a mining operation. Many of us think of mines only as dark, damp and dangerous places, benefiting no one but the owners at the expense of irreversible damage to the environment. The industry, however, presently provides jobs for over 11,000 people, and thousands more work for employers who depend on it for a significant part of their business. In many cases the link is obvious, as with trucking, railways and port operations; in others less so, as in banking, financial services, and wholesale and retail trade.

The connection between mining and quality of life is rarely made. Mining provides the raw materials from which virtually all essential products are made. For example, iron ore and coal combine to provide steel, a basic component of modern living. Homes, buildings, electrical power, farm machinery, cars, computers, kitchen appliances and hundreds of thousands of other familiar products are processed from minerals.

Since the gold rush 150 years ago, thousands of mines have been developed. Many of these mines were immediately abandoned when insufficient minerals were found, others where abandoned later when poor economics of the commodity made mining unprofitable, while others where abandoned for reasons only known to the miners. The result is that British Columbia's landscape contains many historic mine sites that are not comprehensively documented or characterized.

Past mining practices paid little attention to the environment. We should realize that as our forefathers opened up vast areas of the province to settlement in the first half of the century, the natural resources, the forests, the minerals and the fishery, appeared limitless. Modern concepts of conservation would have been laughed at and it could not possibly have occurred to miners of the day that the results of their efforts to wrest a living from an unforgiving land might be looked at with disfavour by future generations.

Today, planning for environmental protection and ultimate reclamation of mining lands is a prerequisite for obtaining government approval to go ahead with a new mining project. Understanding the historical development of mining in British Columbia will however, help us place into perspective what has happened in the past, and better prepare us to make reasoned decisions in developing management practices for historic mine sites in British Columbia in the future.

OVERVIEW OF MINES ACT IN BRITISH COLUMBIA

British Columbia was one of the first jurisdictions in Canada to enact mine reclamation legislation and the first to extend this policy to exploration sites. Due to the leadership exercised by the government, the mining industry and, later, the exploration sector, British Columbia's mining industry has become widely recognized for its achievements in mine reclamation.

History of Legislation

Reclamation legislation was first enacted in 1969 when existing mining legislation was amended, requiring reclamation for major coal mines and hardrock mineral mines.

In 1973, legislation was amended to include coal exploration, mineral exploration, sand and gravel pits and quarries.

In 1984, the Minister of Energy, Mines and Petroleum Resources published reclamation guidelines.

The *Mines Act* remained relatively unchanged until it was amended in 1990. This amended Act and its accompanying Health, Safety and Reclamation Code for mines in British Columbia (Code) continues to provide the framework for reclamation policy.

Part 11 of the Code (the Mineral Exploration Code) was amended in 1997 and contains standards for mineral and coal exploration activities, and a streamlined process for permitting these activities.

Although the *Mines Act* has remained constant during the 1990's, there have been a number of significant guideline and policy initiatives, which have been developed and are complimentary to the legislation. Some of these include:

Mine Reclamation Security Policy in British Columbia. Ministry of Energy, Mines and Petroleum Resources, February 1995.

Policy for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia. Ministry of Energy and Mines and Ministry of Environment, Lands and Parks, July 1998.

Guidelines for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia. Ministry of Energy and Mines, August 1998.

Application Requirements for a Permit Approving the Mine Plan and Reclamation Program Pursuant to the Mines Act. Ministry of Energy and Mines, March 1998.

Current Policy Framework

Standards for mine reclamation are described in Part 10 of the Code and pertain largely to major coal and metal mines. These standards define mine reclamation, and include provisions for returning the land and watercourses to a productive end land use, ensuring that impoundment structures and waste rock dumps are stable over the long-term, and ensuring that water quality released from a mine site is of an acceptable standard.

Mining

Mining, especially open pit metal mining, has an intense impact in a relatively small area of the provincial land base. For example, for every kilogram of copper produced in British Columbia there may be 200 kilograms of waste rock excavated and stored in waste dumps and another 200 kilograms of tailings. The environmental acceptability of mining hinges on being able to confine these impacts to a limited area and, following closure, to achieve an acceptable reclamation standard.

For major mines, the Ministry's philosophy is to set broad reclamation standards which allow each company to develop their own program on a site-by-site basis. The standards set out in the *Mines Act* and accompanying Code maintain this philosophy. They were produced following considerable discussion with industry and other government agencies.

Since reclamation legislation was first introduced, companies have now largely integrated their reclamation planning into the overall mine planning process.

Environmental Assessment Process

The *Environmental Assessment Act* (EAA) was proclaimed on June 30, 1995. It replaced the Mine Development Review Process and applies to new mine developments (or modifications to existing mines) meeting threshold criteria established under the EAA. The EAA establishes a single, comprehensive provincial review and approval process. It is intended to provide a means of identifying potential effects of major projects and an evaluation of opportunities to prevent or mitigate impacts.

Mines Act Permitting Process

The permit system itself has remained relatively unchanged since 1969 and provides for:

A Reclamation report - to be submitted prior to commencement of operations outlining a program for the protection and reclamation of the land and watercourses affected by the mine.

Publication of a Notice of Filing in the B.C. Gazette and local newspapers - this is a requirement for major mines and, depending on the level of public concern, can be required for exploration activities or placer mines.

Report review - by an inter-agency committee of government. The Regional Mine Development Review

Committees provide the detailed technical review, and the Victoria-based Reclamation Advisory Committee is the coordinating body.

Reclamation security - originally, bonds to secure mine reclamation obligations where limited to $1,000.00, and then $2,500.00, per hectare. This cap was not eliminated until 1990, when the *Mines Act* was amended and the Code came into effect. Reclamation security is now a condition of a *Mines Act* Permit and is in an amount, form, and subject to conditions specified by the Chief Inspector. Over the last several years, reclamation security bonds have been increased on many properties, as permits have been issued or amended. This policy reflects government's desire to reduce the possibility that public funds may be required to reclaim a mine in the case of company default, by more accurately reflecting outstanding reclamation obligations of each mine property. Additionally, recognition of ML/ARD as a significant environmental issue has occurred within the past decade.

The *Mines Act* also makes provision for a mine-specific reclamation fund which enables companies to set aside money today for obligations which are being incurred (such as acid mine drainage) that will require funds to be expended at some future date.

More information about the *Mines Act*, **the Code, the Environmental Assessment Process and the permitting process can be found on the Ministry's web site, at http://www.gov.bc.ca/em.**

HISTORIC MINE SITES

Mining has taken place in British Columbia since the mid-1800s, however, reclamation requirements were not legislated until 1969. This has resulted in a number of old mining sites, which were not reclaimed when operations ceased. In many cases, nature has successfully undertaken this function and the surface disturbance at many sites is no longer visible. In other cases, the mines are of historic significance and the remnants of mining are protected and preserved.

Although the Ministry has extensive records on exploration and mining activity dating back to the previous century, much of this information is not consolidated in a readily accessible database. At present there are only a few known historic sites considered likely to require significant remedial action to mitigate environmental damage; however, one of the principle objectives of the Historic Mine Sites project is to determine if other sites in the province warrant attention.

Historic Mine Sites Database

The HMSDB (Figure 1) was built using Microsoft Access as the platform and was designed to incorporate geological, geochemical, geotechnical and administrative information for each site. The strength of the database is the ability of the user to input a wide range of data sources and the ease at which detailed queries can be performed.

The primary purpose of the database is to house an inventory of historic mine sites containing technical information, which characterizes sites. A secondary purpose of the database is to collect technical data on operating mines, which have been permitted by the Ministry to assist in regulatory functions. The database is currently a 'work in progress' as it is still being tested, amended and updated.

Constructing the Historic Mine Sites Database

Construction of the HMSDB was performed in three steps:

- extracting records from MINFILE.
- matching *Mines Act* permits to the extracted MINFILE records;
- data entry of technical information for each site (ongoing).

Extracting Records from MINFILE

The records in the HMSDB are an extract of the MINFILE database maintained by the B.C. Geological Survey Branch. MINFILE contains geological, location and economic information on over 12,000 metallic, industrial mineral and coal mines, deposits and occurrences in British Columbia. Not all 12,000+ MINFILE records were incorporated into the HMSDB. Records in MINFILE having one or more of the following three criteria qualified to be included:

- status of "past producer";
- contained any documented value for ore mined;
- method of mining is described as either open pit or underground.

Mines that have valid *Mines Act* permits were also included in the database to facilitate compiling technical information for regulatory purposes. These mines, however, are not considered historic sites.

A total of 2,949 MINFILE records were extracted from MINFILE using the above criteria. Specific fields contained in MINFILE were incorporated into the HMSDB that were determined to provide important information for documenting and classifying sites. The fields included were (Figure 1):

- site name and aliases, including mine name if different.
- spatial position (georeferenced latitude/longitude, NTS map sheet, elevation).
- deposit-type information.
- economic information (commodities, years mined, tonnages mined and milled).

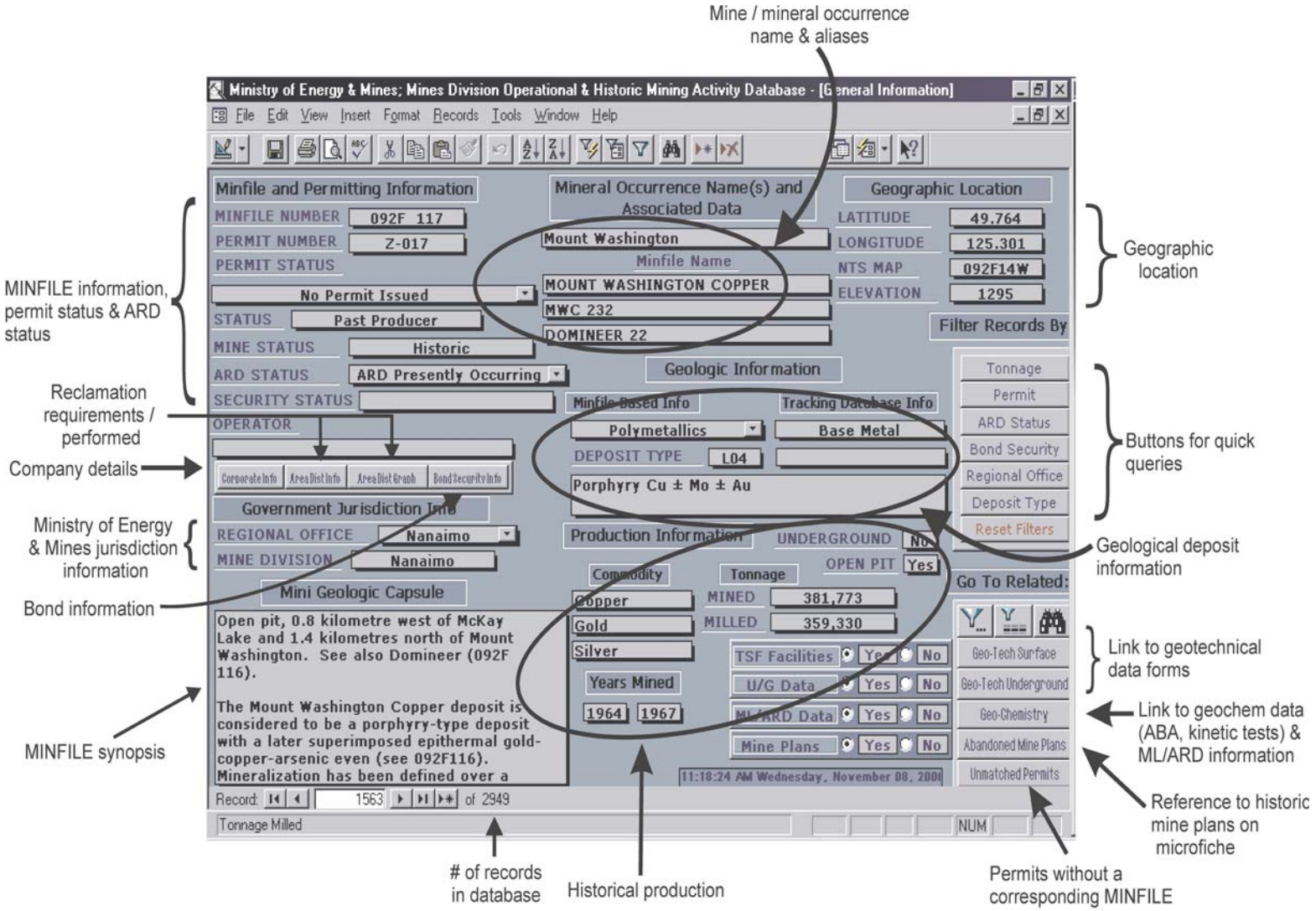

Figure 1. Main form of the Historic Mine Sites Database.

- status (past producer, producer, prospect, developed prospect).
- short geological description of the site, including access and some historical notes.

For more information on MINFILE, consult the MINFILE web page:

Http://www.em.gov.bc.ca/Mining/Geolsurv/MINFILE/.

Matching Mines Act permits to the extracted MINFILE records

All *Mines Act* permits excluding mineral (MX) and coal (CX) exploration permits were matched with the MINFILE records in the HMSDB. *Mines Act* permits and MINFILE records had never been cross-referenced before. This linkage provides an increased ability for database users to query sites and extract information on mines that are currently or formerly permitted. Only selected MX permits that were considered advanced exploration projects were included in the HMSDB.

DEFINITION OF A HISTORIC MINE SITE

Many terms have been used to refer to old mines including abandoned, derelict and orphaned. There is no standard definition for classifying old mines in British Columbia that are dormant, may or may not have an owner, and have not been reclaimed.

The Code defines an abandoned mine as: "a mine for which all permit obligations under this Act have been satisfied and in respect of which the mineral claims have reverted to the government."

This definition makes sense in the context of its application under the *Mines Act*, in that it applies to mines that have been permitted under this legislation. It is not, however, a definition that most people would use to characterize an "abandoned/orphaned" mine site.

Mine sites without a valid *Mines Act* permit are considered, for the purpose of addressing "abandoned/orphaned" sites in British Columbia, "historic" because they are not being regulated by a permit under current mining legislation. Based on this rational, the use of the term "abandoned" has been avoided and "historic" has been adopted to refer to these sites.

The term "mine site" is used as it encompasses all infrastructure related to a mine, including, but not limited to tailings facilities, waste rock dumps, buildings and mills.

A working definition of a historic mine site in British Columbia is:

"a place where mechanical disturbance of the ground or any excavation has been made to produce coal, mineral bearing substances, placer minerals, rock, sand or gravel, or other mined materials, including sites used for processing, concentrating, and waste disposal, and where a Mines Act permit does not exist for the mine site."

For the purpose of defining a historic mine site, there was no attempt to determine current or past ownership through review of subsurface tenure records. The status of MX permits was also not determined for identified sites.

Quantifying Historic Mines Sites in British Columbia

In British Columbia, there are an estimated 1,887 historic mine sites (Figure 2), which range in magnitude from full-scale past producing mines with documentation of hundred of thousands of tonnes of ore mined, to small mines where as little as 1 tonne of ore has been mined, to exploration sites. Table 1 gives the breakdown of historic mine sites according to their status type. Of these 1,887 sites, some may have contemporary *Mines Act* permits approving exploration programs and/or be covered by valid mineral tenures.

The following criteria were selected to best reflect the definition of a historic mine site and, therefore, determine the number of historic mine sites in the province:

TABLE 1
BREAKDOWN OF HISTORIC MINE SITES IN BRITISH COLUMBIA ACCORDING TO THEIR STATUS TYPES

STATUS TYPE	DESCRIPTION	NUMBER
Past Producer	occurrences that are not currently being mined and have recorded production in the past. This does not include bulk samples for testing purposes.	1,761
Developed Prospect	occurrences on which exploration and development have progressed to a stage that allows a reasonable estimate of the amount(s) of one or more of the potentially mineable commodities.	40
Prospect	occurrences documented as containing mineralization which warrants further exploration.	68
Showing	occurrences hosting minor in-situ mineralization.	18
	Total Number of Historic Mine Sites	**1,887**

Each mine sites has a documented value for the amount of ore mined, this amount can be as little as 1 tonne.

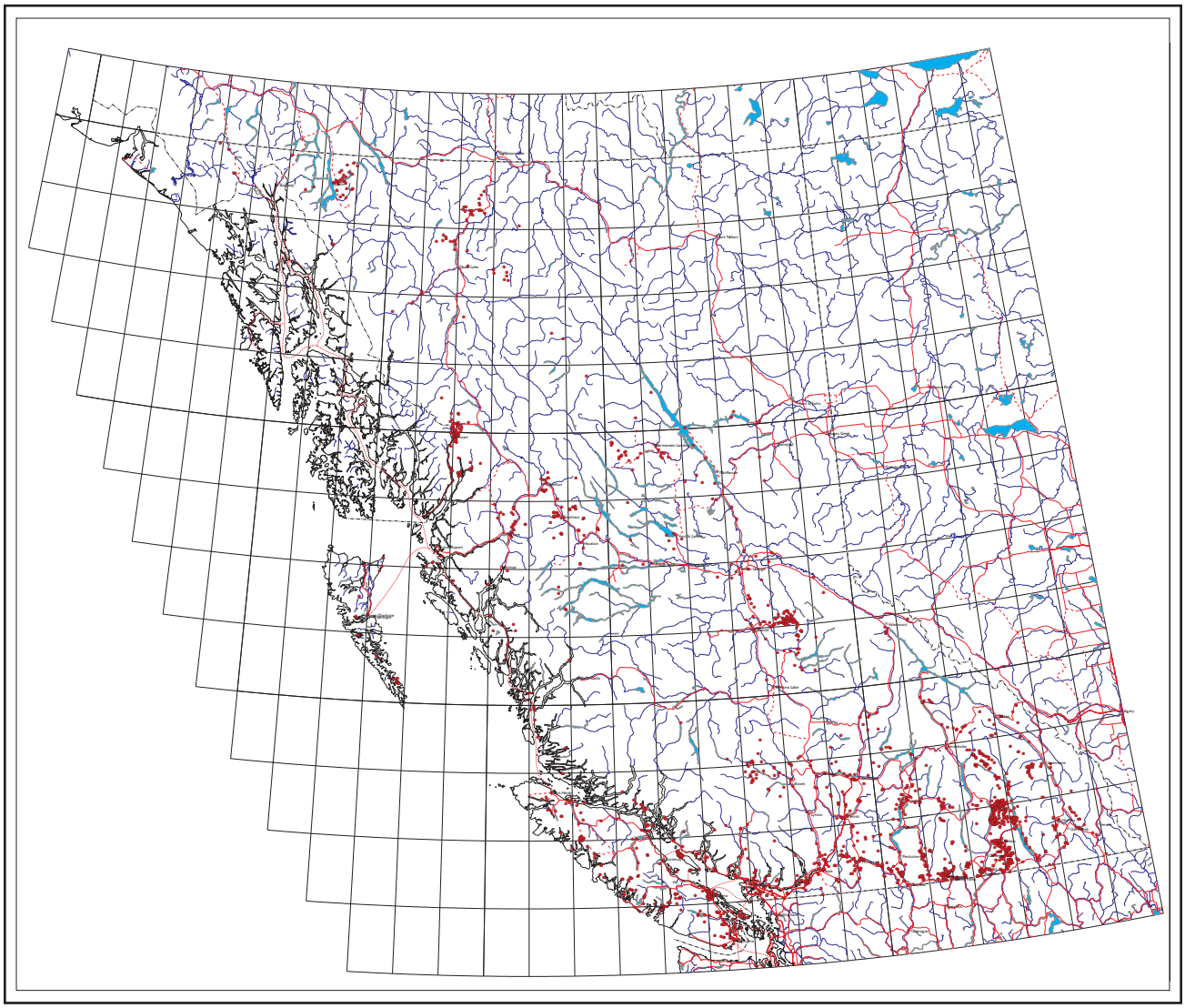

Figure 2. Map of the 1,887 historic mine sites in British Columbia.

a) a status of "past producer"; and

b) without a *Mines Act* permit

OR

a) not a status of past producer (e.g. developed prospect, prospect, showing) but with a documented value of ore mined; and

b) without a *Mines Act* permit.

This total is considered preliminary at this time because the HMSDB does not contain records of some of the exploration sites (showings, prospects and developed prospects) contained in MINFILE. These excluded sites were not incorporated, as they did not meet the criteria selected for constructing the database. It is expected that once a more comprehensive screening of the MINFILE database is performed, a relatively small number of additional sites will be incorporated into the HMDB.

METHODS: HISTORIC MINE SITES PROJECT - 2000/01

SITE SELECTION OF 1,887 HISTORIC MINE SITES

Prioritization of the 1,887 historic sites for site inspections was based on following:

1. Mineral Deposit Type

For the purpose of this study, polymetallic mineral deposits known to have geoenvironmental characteristics, which present a potential for generating acid and/or leaching of metals into the environment, were selected (Table 2). A total of 1,171 sites were determined to have ML/ARD potential. This value excludes coal, placer, industrial mineral and certain metallic deposit types.

2. Degree of Documentation on ML/ARD

Historic mine sites with documented occurrences of ML/ARD, such as Anyox and Mount Washington Copper, were excluded from the field site selection. The intent of this project was to inventory sites where the environmental and health and safety hazards were not documented.

3. Jurisdictional Area

The Mining Division has five Regional Offices, located in Kamloops, Nanaimo, Prince George, Cranbrook and Smithers. As the 2000 fieldwork program aimed to gain a provincial overview of historic mine sites, prioritization of mines sites was not on a provincial scale. Rather, mine sites were ranked and selected according to region.

4. Magnitude of Mining Operation

For each region, the properties were ranked according to the tonnage of ore mined. The rationale was the value of ore mined reflects the scale of the operation and therefore onsite disturbance. The tonnage of ore mined is documented in MINFILE.

The Ministry does not have records of the amount of waste rock generated for each property. Large volumes of waste rock and extensive underground workings may exist, but this can only be verified through site inspections and possibly research, if such documentation exists.

It was recognized while undertaking field inspections that the amount of ore mined and the status of the mine site (past producer, developed prospect, etc.) are not necessarily indicative of the extent of the disturbance on site. Sites such as Jim and Warspite are classified in MINFILE as a showing and prospect respectively. Both Warspite and Jim were inspected in the 2000 field season on the advice of the Regional Inspector. In both cases, the MINFILE status underes-

TABLE 2
DEPOSIT TYPES SELECTED FOR THE PRELIMINARY SCREEN OF ML/ARD BY HISTORIC MINES SITES IN BRITISH COLUMBIA

Massive Sulphides
Carbonate hosted Cu-Pb-Zn
Carbonate hosted Pb-Zn
Kootenay Arc Pb-An (sedex)
Sedex Zn-Pb
Massive sulphide Cu-Co
Besshi massive sulphide Zn-Cu-Pb
Cyprus massive sulphide Cu (Zn)
Noranda/Kuroko massive sulphide Cu-Pb-Zn
Skarns
Cu skarn
Zn-Pb skarn
Fe skarn
Au skarn
W skarn
Sn skarn
Lode Gold
Sulphide manto Au
Epithermal Au-Ag: high sulphidation
Epithermal Au-Ag: low sulphidation
Au-Ag-Te veins
Gold-quartz veins
Sub-volcanic shear-hosted gold
Polymetallic Veins & Stockwork
Polymetallic manto Ag-Pb-Zn
Polymetallic veins Ag-Pb-Zn
Cu-Ag quartz veins
Porphyry (alkalic & calc-alkalic)
Subvolcanic Cu-Ag-Au (As-Sb)
Porphyry-related Au
Alkalic porphyry Cu-Au
Porphyry Cu±Mo±
Porphyry Mo
Porphyry Sn
Porphyry W
Climax-type porphyry Mo
Other
Subaqueous hot spring Ag-Au
Hot spring Au-Ag
Tailings

timated the degree of surface and underground disturbance; the 'showing' Warspite contains hundreds of metres of underground workings that drain water. The activities undertaken at historic mine sites classified as prospect, developed prospect or showing may have enough surface disturbance to potentially be a concern either environmentally or from a health and safety perspective. Sites such as these will need to be identified through research and inspections as well as canvassing the general public, government field inspectors, and the mining industry, who may have knowledge of the location of sites.

5. Input from Ministry Staff

Ministry Inspectors and in some cases, Regional Geologists provided input into the site selection based on their personal knowledge, accessibility and regional concerns.

6. Time and Budget

Travel time to many of the historic mine sites was lengthy given their remote nature and poor road access. This was a major logistical constraint when selecting sites for inspection.

Properties north of 56 latitude were automatically excluded due to the expense and length of travel required. As seen in Figure 2, relatively few historic mine sites are situated in the northern one-third of British Columbia.

7. Accessibility

Of these factors, accessibility played the largest factor in selection. Access to many of these sites is costly due to their remoteness and the fact that vehicle access is not possible. Many sites require specialized modes of transport, such as helicopter or ATV bikes.

In total, 62 historic mine sites were inspected Figure 3.

FIELDWORK

The Ministry hired a geologist (recent graduate) to undertake field based site inspections in the company of one or more senior ministry staff. Fieldwork involved characterizing each site including the sam-

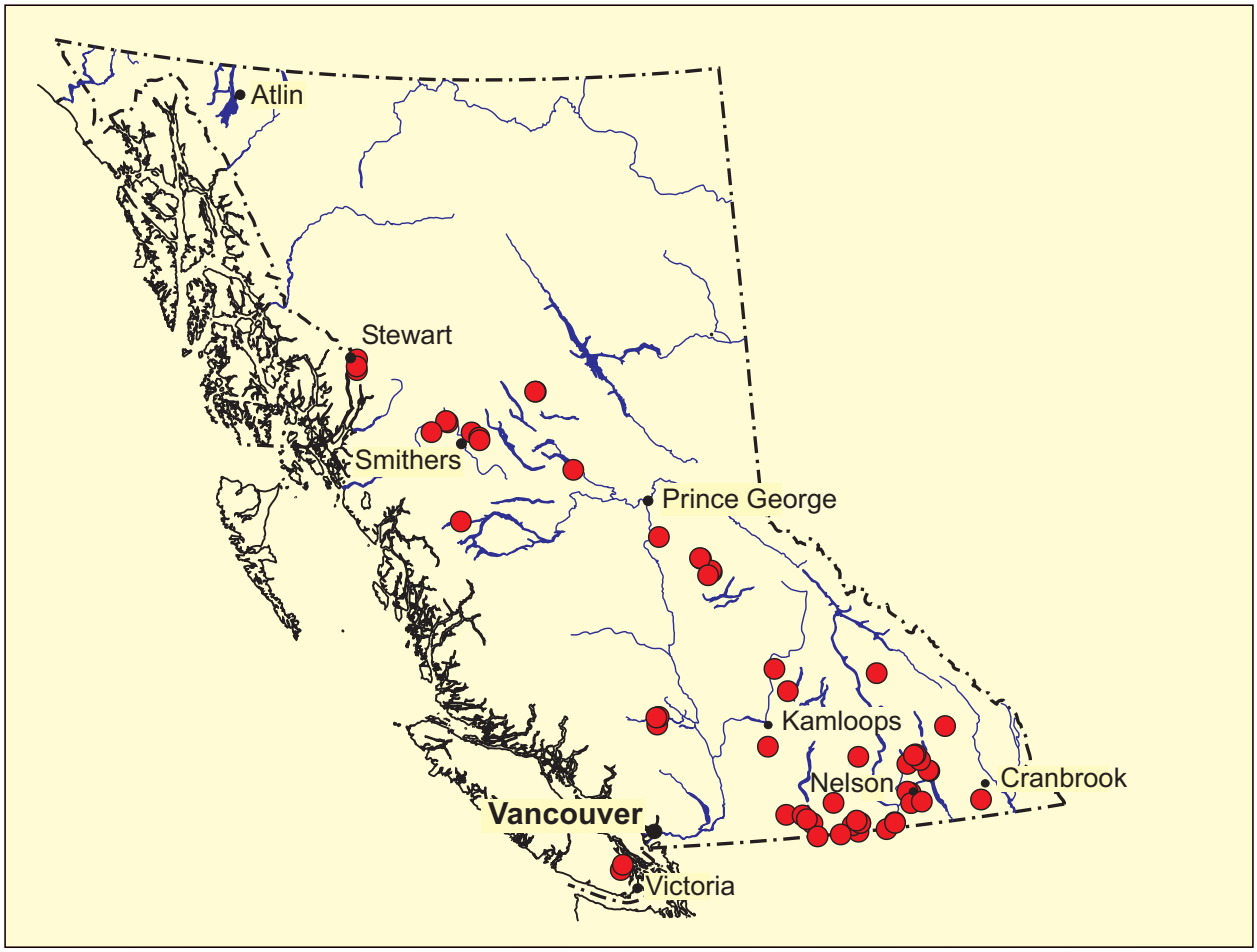

Figure 3. Map of historic mine sites inspected in the 2000 field season. For a more comprehensive map, *see* Appendix C.

pling of mine drainage where water was present. It should be noted that, given the limited budget and time frame of this project, the procedures described were intended to "screen" sites, and were not intended to provide a complete site characterization or constitute a detailed survey.

Onsite, the following information was recorded:

- the extent and distribution of mine workings and their physical stability (portals, waste rock dumps, tailings).
- buildings, mills and other structures.
- general site conditions (surface hydrology, state of vegetation, topography).
- sampled mine drainage.
- documentary photographs.
- field latitude and longitude, if the inspector had a GPS unit.

Locating historic mine sites can be difficult. The extent of mine workings may be unknown, as all of the mine components at a site may not be documented in reports or records or be inaccessible or overgrown with vegetation and not visible. Many sites are adjacent to each other, and may have been connected by roads, trams, rail and underground workings or had their ore processed at one common mill. These sites are difficult to characterize as a single discrete site.

Throughout the course of the fieldwork program, other historic mine workings were encountered. In such a case, the latitude and longitude coordinates of the workings were taken and later matched to a MINFILE property. In some instances, it was not possible to match the workings to MINFILE records and these sites are referred to in the text as 'Unknowns.'

WATER QUALITY PROGRAM

A water sampling program was included as an integral part of the fieldwork component of the project. The purpose of the program is to help prioritize sites where there is an indication of problems with water quality. The analytical results provide a quantitative measure of water quality, which is one piece of information in identifying high risk sites that may require remediation. With the large number of historic mine sites in the province, it is neither efficient nor cost effective to perform comprehensive studies on each individual site. Thus a preliminary survey of sites was initiated in the 2000 field season with the goal of 'flagging' sites, which may require more in-depth studies.

Although the water quality data is a quantitative indicator of ML/ARD, this data (Appendix B) must be interpreted with caution, as results may not be conclusive for the following reasons:

- samples were taken during low flow (not ideal).
- only one or two samples were taken for each site.

Photo 1. Water sampling.

- background or "natural" concentrations were not measured.
- only a simple understanding of the hydrogeology at the sites is known.
- downstream, receiving environment sampling was not undertaken (*i.e.* natural attenuation is unknown).

A potential problem with sampling at a specific time in one location is the possibility for sites with downstream impacts to be overlooked. Although one would expect the water quality to be at its worst during low flow, metal loading and acid can be generated and flushed out in one event such as freshet. However, given the number of historic mine sites in the province and their spatial distribution, a screening-style water sampling program was the most practical approach.

Geochemical Mine Drainage Sampling

Mine drainage was sampled wherever observed and the source was determinable. In total, 45 mine sites were sampled. Sample types include:

- adit drainage.
- tailings ponds.
- waste rock dump seeps and drainage.
- flooded open pits, declines and shafts.

In the field, pH and conductivity were measured using colorpHast Indicator Strips (pH 2-9) and a Hanna DiST WP 3 meter respectively. Observations on the associated odour, precipitates, salts and the state of vegetation were noted.

A suite of samples were taken at each site and sent to a lab for total and dissolved metal concentrations (ICP-AES), SO_4 and pH analyses. For one mine, the Bralorne-Takla, the Hg concentration was also measured. Field duplicates were taken at random for each group of water samples sent to the lab.

TABLE 3
DETECTION LIMITS (DL) FOR METALS IN WATER ANALYZED BY ICP-OES

Element		Detection Limit (ppm)
Aluminum	Al	0.2*
Antimony	Sb	0.2*
Arsenic	As	0.2*
Barium	Ba	0.01
Beryllium	Be	0.005
Bismuth	Bi	0.1
Boron	B	0.1
Cadmium	Cd	0.01*
Calcium	Ca	0.05
Chromium	Cr	0.01*
Cobalt	Co	0.01*
Copper	Cu	0.01
Iron	Fe	0.03
Lead	Pb	0.05
Lithium	Li	0.01
Magnesium	Mg	0.1
Manganese	Mn	0.005
Mercury	Hg	0.00005
Molybdenum	Mo	0.03
Nickel	Ni	0.05
Phosphorus	P	0.3
Potassium	K	2
Selenium	Se	0.2*
Silicon	Si	0.05
Silver	Ag	0.01*
Sodium	Na	2
Strontium	Sr	0.005
Thallium	Tl	0.2
Tin	Sn	0.03
Titanium	Ti	0.01
Vanadium	V	0.03
Zinc	Zn	0.005

*Denotes DL below the BC Water Quality Guidelines for aquatic life (MELP, 1997).

As budget constraints only allowed for a standard water quality analyses, metal concentrations were measured in parts per million (ppm). This level was too high to capture the concentrations of select trace metals Table 3, but was selected in order to flag mine sites where metal concentrations exceeded B.C. aquatic life numeric standards.

The water sampling program results and the interpretation are included in the individual Inspection Reports for each mine. Water quality data for all of the mine sites sampled in the 2000 field program can be found in Appendix B.

Only historic mine sites with known MINFILE numbers are listed in this table. See inspection reports on unknown historic mine workings.

In total, 62 historic mine sites were inspected in the 2000 field season (Table 4). Figure 3 depicts the field locations throughout the Province, excluding those workings, which were encountered in the field and not linked to a MINFILE occurrence. For a more detailed map, *see* the map in Appendix C.

TABLE 4
NAMES AND RELATED MINFILE NUMBERS OF THE HISTORIC MINE SITES

MINE SITE NAME	MINFILE #	MINE SITE NAME	MINFILE #
Banbury	092HSE046	Lucky Jim	082KSW023
Big Onion	093L 124	Marmot (Montana)	103P 129
Blue Grouse	092C 017	Midas	093A 035
Bralorne Takla	093N 008	Midway	082GSW021
Camborne tailings	?082KNW076?*	Motherlode	082ESE034
	?082KNW064?*	Native (Lorraine)	093L 129
Canex tailings	082FSW010	Oro Denoro	082ESE063
	082FSW009	Phoenix	082ESE020
Canusa	093H058	Porter-Idaho	103P 089
Cariboo Gold Quartz	093H 019	Queen Victoria	082FSW082
Cariboo Hudson	093A 071	Quesnel Quartz	093G 015
Cariboo Thompson	093A 091	Red Rose	093M 067
Congress	092JNE029	Reno	082FSW036
Cork-Province	082FNW094	Richard III (Mt. Sicker)	092B 003
Cronin	093L 127	Rocher Deboule	093M 071
Dividend-Lakeview	082ESW001	Second Relief	082FSW187
Dunwell	103P 052	Slocan Sovereign	082FNW036
Emerald Glacier	093E 001	Snowbird	093K 036
Emma	082ESE062	Spitzee	082FSW121
Enterprise	092ISE028	Standard (Snowflake)	082ESW091
Gopher	082FSW125	Sultana	93M 061
Highland	082FNE015	Takla Silver (Lustdust)	093N 009
Homestake (Kamad Ag)	082M 025	Tremblay (Phoenix) tailings	082ESE262
Island Mountain	093H 006	Twin Lakes	082ESW011
Jackson	082KSW015	Tyee (Mt. Sicker)	092B 002
Jane (Snowshoe Gold)	093A027	Warspite	093H048
	093A030	Wayside	092JNE030
Jewel Lake tailings	?082ESE125?*	Windpass-Sweethome	092P 039
Jim	093A 037	Ymir tailings	082FSW067
Kenville	082FSW086		082FSW068
Kootenay Florence	082FNE016		
Lenora (Mt. Sicker)	092B 001		

Only historic mine sites with known MINFILE numbers are listed in this table. See inspection reports on unknown historic mine workings.

*?MINFILE # - indicates that the minesite location may not correspond with the MINFILE #.