Canada Foundation for Innovation

Description of Infrastructure Project and Assessment Against CFI Criteria

Date 19/05/2003 Project number 7588

Descriptive title of infrastructure project (no more than 200 characters):

Innovative Research for the Challenges of Mining in the 21st Century - the Canadian Environmental Mining Research Centre

Funding program applied to: Innovation Fund

Language of application: ☒ English ☐ French

Institution (See next page for multi-institution applications)

University of British Columbia

Total cost of infrastructure project and amount requested from the CFI

Note that for each year the CFI request should not exceed 40% of the cumulative cost to that year.

Costs	Year 1	Year 2	Year 3	Year 4	4-year TOTAL
Total project	2 693 183	6 767 573	1 163 240		$10,623,996
Partner contributions	1 615 910	4 060 544	697 944		$6,374,398
CFI request	$1,077,273	$2,707,029	$465,296		$4,249,598

Designated Project Leader

Name: Meech, John Title: Professor

Department: Mining Engineering Telephone: Ext.:

E-mail: Fax:

Key words: Provide a maximum of ten (10) words that describe the infrastructure project and the research to which it will contribute. Use commas to separate each key word.

CEMR, Mining, Environment, Sustainability, Acid Rock Drainage, Pollution Reduction, Energy Use Reduction, Raw Materials and Waste Reduction, Mining Communities and the Work Environment, System Integration, The 'Green' Mine

Research discipline/field code:

Primary: 10500

Secondary: 10600

Area of application code:

Primary: 3.0

Secondary: 1.7

Signature: It is agreed that the general conditions governing the matching provisions and the use of CFI funds as outlined in the Institutional Agreement and the CFI Policy and Program Guide apply to the infrastructure project outlined in this application and are hereby accepted by the institution.

Name _____ Signature _____ Date _____

CEO or President of the Institution (or authorized representative)

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Multi-institutional application. To be completed by **eligible** institutions (other than the institution identified on page 1) that **would share CFI funding** for this project, if approved by the CFI.

The following eligible institutions that will receive CFI funding for this project, agree that the general conditions governing the partner contributions and the use of CFI funds, as outlined in the Institutional Agreement and in the CFI Policy and Program Guide, apply to the project outlined in this application and are hereby accepted by each institution.

Institution:

Name (CEO or President of the institution or authorized representative):

Date:

Signature:

Institution:

Name (CEO or President of the institution or authorized representative):

Date:

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Name (CEO or President of the institution or authorized representative):

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Project overview

In language appropriate for a multidisciplinary committee, use this page and up to one additional page to describe the **infrastructure** that will be acquired or developed and indicate where the infrastructure will be located. Indicate briefly why the infrastructure is needed, what research it will enable to be performed and why that research is important.

The University of British Columbia intends to create a Research Centre at Britannia Beach in conjunction with the work we have been doing to assist in remediation of this derelict mine site. This facility will be called the Canadian Environmental Mining Research Centre (CEMR) and will become a world-class facility dedicated to solving environmental problems in the mining industry.

The proposed Centre consists of an 18,000 sq.ft. two story structure containing 21 individual, yet interconnected laboratories to conduct research in all aspects of the new field known as Sustainable Mining. This term was coined to describe a broad approach to mining that encompasses technical, economic, social-political, environmental, and health issues as set out by the recently-completed Global Mining Initiative in London, U.K. Despite the best intentions, we believe a gap exists in the dialog on Sustainable Mining with respect to defining sustainable technology targets. We intend to fill this gap with our new research centre and to conduct the innovative research necessary to develop sustainable mining technologies for the 21st Century.

The research is classified into 6 themes: People, Energy, Materials, Waste, Biota, and High-Technology. Fifteen collaborative research projects that fall under each theme are described in this proposal. This work will conducted at the new research labs at Britannia Beach by 35 UBC Faculty Members currently associated with CERM3 on the main campus. This group has collectively made significant breakthroughs with novel research concepts and approaches over the past two years. All of the infrastructure requested in the proposal will be located at Britannia Beach. A cellular constructed wetlands will be created to support innovative research into passive treatment processes for mine effluents.

The CEMR Centre will link with three other facilities at Britannia Beach: The BC Museum of Mining, The BC-Ministry of Water, Land, and Air Protection's Water Treatment Plant (WTP), and the proposed Natural Resources-Canada Centre for Mining Innovations. We will support the Museum with new exhibits on our research. We will provide the WTP with project support to reduce the operating costs of the plant. We will trade access to the research labs with the NRCan Centre in exchange for housing all adminstrative facilities. These groups form a tightly-knit, yet independent set of unique facilities that will transform Britannia Beach from the derelict eye-sore it is today into a vibrant, effective tourist destination with extremely positive messages on history, on current mining practices, and on environmental mining research to be transferred to the general public.

The research will encompass the following elements:

- Sustainable practices in mine closure, landscape architecture and community relations.
- Geothermal energy from high-temperature Canadian sites and from mine effluents.
- Energy reduction in milling using efficiency improvements and energy recycle.
- Metal recovery process enhancement - hydrometallurgy, flotation, physical separation.
- Acid-Rock-Drainage and metals emissions from existing and abandoned mine sites.
- Sub-aqueous waste disposal options.
- Relationship of geochemical and geotechnical aspects of waste rock piles.
- Rheological properties of waste dumps and related slurries.

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- Phyto-reclamation, remediation, and revegetation practices.
- Mine-Mill integration, telerobotics, and environmental remote sensing.

These projects are very important to maintaining the Canadian mining industry as a mainstay of our economy. The reputation of our industry is poor with the perception that significant damage to the environment results from a mine. In fact, Canadian mining practices are second to none in terms of the environment and our environmental technology is in high demand around the world. Yet there are still problems related to spills, dam failures, social upheaval, and other societal issues. The proposed facility at Britannia will project a balanced image about mining and miners. It will help industry by developing even better methods to protect the environment and serve to demonstrate the power of research as an economic driver that benefits all aspects of society.

This Centre is of critical importance to the mining industry for the following reasons:

FOCUS: It provides a focus on research in environmental protection that is not yet available anywhere else in the world with the collective respect of all stakeholders.

OUTPUT: The research output aims to provide innovative solutions to existing pollution problems and to developing ways to avoid future impact. In order to mine in the 21st Century, society will demand even higher standards than in the past. Our research will contribute to the ability of industry to meet this challenge.

SHOWCASE: It provides an opportunity to show how research can be a catalyst for good in creating an environment for collaborative approaches to solve complex problems and changing society's image of the industry.

LOCATION: The innovation includes the actual location itself, with the mine site providing resources that support our research in the form of ARD, subaqueous tailings, unremediated waste dumps, a water treatment plant, and a site contaminated with heavy-metals.

"GREEN" MINING: The over-riding proposal to create the "Green Mine" is a new idea about incorporating "green" technologies into the design of a mine and mill. By showing how such an approach can result in major cost savings, mines can become more efficient at the same time that enhancements in environmental protection are introduced.

The proposal fits in with virtually all elements of UBC's current research plans regarding sustainability, the environment, cross-disciplinarity and the desire of the university to engage the community in our research and educational values. This project presents the "chance of a lifetime" for a university to demonstrate how research can work directly to change a derelict site into something of great value. With the 2010 Winter Games coming to Vancouver, Britannia Beach will be an ideal location to showcase UBC and its research efforts.

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Self-assessment

A1 - The Research
Choose the statement that best represents the research

The proposed infrastructure will be used for research that is:

☐ (a) high quality and potentially useful;

☐ (b) competitive at the national level and may lead to innovation;

☐ (c) competitive at the international level and will lead to innovation;

☒ (d) at the leading edge internationally, transformative, and can be expected to have a major impact on innovation.

Using the space below and up to 5 additional pages, address all the following:

- outline the major research and how the infrastructure will be used to enable it;
- explain how the proposed research is innovative and how it is different from similar research being done by other groups regionally, nationally and internationally;
- describe the research opportunity and how the proposed research will capitalise on this opportunity.

As mining companies are learning to deal with environmental problems, the issues are becoming more and more complex. The context in which one examines a specific problem takes on greater importance and attempts to "optimize" fail since the objective function is so difficult to define. For example, local community issues now cross over such diverse aspects as aboriginal heritage and culture, health care and education, social values and services, among a myriad of other factors. Increasingly, companies are expected to provide services formerly considered the responsibility of a government and yet by implementing such systems they run the risk of alienation by appearing to be "Big Brother" taking away freedoms. As government, industry, and communities blur together, companies must assume a greater role in order to sustain lifestyles and other needs and at the same time avoid the appearance of "domination".

Increasingly, these different contexts to a decision or problem have the potential to come into conflict. The term 'triple-bottom-line" (shareholder, social, and environmental responsibilities) has been coined by industry to attempt to demonstrate that corporate decisions encompass more than simply shareholder value, but todate little has been done to attempt to merge these three components into a single entity for evaluation. Recently the term "sustainable mining" has arisen out of the debate with about 600 different definitions being bandied about in the literature.

Despite this confusion over definition, in fact, sustainable mining is central to the research to be conducted in the CEMR Centre. In general, this term describe a new approach to problem-solving that considers the conventional technical and economic issues but also includes on an "equal footing", the socio-political and environmental factors. At the risk of adding yet another novel definition to the term, we have set up the following definition:

"Sustainable Mining attempts to reduce uncertainty
associated with the business of mining."

These uncertainties encompass:

the orebody (its location, shape and grade),
the marketplace (competition, prices, substitution),
the environment (pollution today and in the future),
the landscape (open pits/caved areas and closure plans),
the impact on employment (local opportunities and links to other communities),

the impacts on native populations (cultural issues and social problems),
the technologies (process and orebody stability),
the sharing of wealth (benefits of new infrastructure vs. resource exploitation),
the political and social stability (government regulations and access to land),
etc.

Uncertainty leads to misunderstandings and sometimes "error". Reducing uncertainty through technology and dialog are two key ways that research can help provide solutions. By increasing our understanding and knowledge, all people can make the right decisions about themselves and their community or company.

Of necessity then, our research must include social and political aspects if we hope to find workable solutions and understand societal interests and needs. At the CEMR Centre, three approaches will operate:

- dealing with abandoned legacy mine sites
- developing protective systems for operating mines
- developing innovative mining and processing methods

The first item relates directly to the siting of our facility at Britannia Beach. This derelict mine site located 45 km. north of Vancouver on the Sea-to-Sky Highway to Whistler is acknowledged by Environment-Canada to be North America's worst Acid Rock Drainage (ARD) problem in terms of total metals release. Since 1974, over 10,000 tonnes of copper, zinc, iron, aluminum, arsenic and cadmium combined have discharged into pristine Howe Sound. A major part of the mine site is judged to be contaminated under the BC Contaminated Sites legislation. The site contains a myriad of unremediated waste piles that are producing acid and leaching metals into the environment. Total effluent discharge averages 500 m3/hour (range = 200 to 1200 over the year with some spikes up to over 2000). The CEMR Centre will have direct access to this low pH effluent which contains high quantities of copper and zinc. The CEMR building and constructed wetlands will be situated on the fan area at the mouth of Britannia Creek beside the BC Museum of Mining and so, we will have to learn to deal with life on a contaminated site. The Ministry for Water, Land, and Air Protection (MWLAP) are completing a Water Treatment Plant in 2004 that will be available for our researchers to work on projects initially designed to reduce operating costs and the amount of lime sludge produced. The Canadian government's Department of Natural Resources Canada (NRCan) is planning to build the Britannia Centre for Mining Innovation that will become a major tourist destination in the Lower Mainland. All of these projects will work together to transform the Britannia site from an eyesore into a place of high value. UBC's presence at Britannia Beach since 2000 has acted as a catalyst to draw many of these new projects into the site.

In 2001, UBC established two facilities at Britannia Beach upon which our research activities will grow. One of these involves a full-scale plug to study the sealing of mine tunnels using bulk materials. The research has been dubbed "The Millennium Plug Project" as we intend to develop design guidelines for a bulkhead with a life of 1000 years. The second facility is a research lab to recover heat from the mine effluent. This work will pave the way to heat the CEMR Centre using the ARD as a "geothermal resource". The goal is to develop ways to reduce the payback period of this activity from 8-9 years down to 2-3 years.

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The Canadian Environmental Mining Research Centre is planned as 21 individual labs each dedicated to studying specific aspects of mining and the environment. A list of these labs is provided in the Financial Information section of this proposal. In this section we will now describe the research to be the initial focus of the centre. This facility will support true collaborative research involving experts with a broadly-based set of skills.

In managing the wide-ranging nature of our research projects, the central goal is to promote the concept of Sustainable Mining. To serve this aim, six research themes have been assigned to reflect the contexts that make-up sustainable mining. These themes are "People", "Energy", "Materials", "Waste", "Biota", and "High-Technology". At this stage, 15 separate projects have been selected for initial implementation of these themes. One project crosses over all six themes with the remaining 14 being allocated to one of each specific theme. This overriding project is termed "The Green Mine".

Project 1. Green Design in Mining
(Meech, Scoble, Condon, Lavkulich, Baldwin, Veiga, Klein, Cullen)

Little has been reported on the application of "green" design concepts to mine design. There are clearly some important attributes of "Green" Buildings on which the "Green Mine" can be based such as heating, lighting, ventilation, and health issues. Mine/mill design traditionally is directed at reducing costs and providing an environment to increase production without sacrificing quality. The critical question is

"Can Green Building Design be used to design the 'Green Mine'
without impacting negatively on production and product quality?"

Milling is particularly open to "green" design, i.e., in comminution, most energy (~98-99%) ends up as heat. Little attention has been paid to monitoring or recovering this heat. In cold climates, opportunities exist to recoup heat from process waters, and perhaps, elsewhere as well. A mill is rarely designed from an aesthetic or "comfort" viewpoint for the workers. Most mills are uninsulated, poorly-lit, noisy, and dirty. By designing for warmth, color, cleanliness and reduced noise, morale can be improved resulting in higher efficiency. Costs can be reduced through an integrated approach.

Other aspects include reducing the footprint of a mine and addressing the "look" of the property during the operating phase. A properly maintained facility can make for a cheaper closure plan. Surface waste should be minimized and a "tidy" site a major goal. CEMR intends to use its building and research to demonstrate these principles to the industry and to develop guidelines for applying "green" design in mining. We intend to research techniques to embody these design approaches into mining and milling that will not only improve the environment and working conditions but will also reduce costs and provide significant economic incentives.

MAJOR BREAKTHROUGH TARGET: Establishing design protocols for the "Green Mine and Mill".

The projects that make up each individual research theme will now be described.

THEME 1: PEOPLE

This theme will consider factors such as communities in which employees live or in which existing populations are directly impacted by a mining operation. Safety and occupational

health issues are involved in this theme together with the need for infrastructure to deal with cultural, health care, educational, and social-political issues. The desire to create "liveable communities" is a major component of this theme led by the Landscape Architecture department at UBC with particular reference to the post-mining stage following closure.

2. Sustainability of Mining Communities
(Scoble, Veiga, Meech, Dunbar, Klein, Lavkulich, Teschke)

The special research team has been put together by Malcolm Scoble and Marcello Veiga in the UBC Mining department. The vision is a unique, innovative and fresh approach to enhancing so many aspects of what a mining engineer must become today. The group is attempting to incorporate anthropological ideas into the technical issues of designing and operating a mine. Some of these topics include: interacting with First Nations; planning for closure; fly-in camps vs. new town development; creating alternative industrial activities; sustaining communities into the post-mining era; and addressing the health and education needs of societies in Third World Countries.

Sustainable Mining Communities

Scoble is the lead on this work with input from virtually all CERM3 researchers. Britannia represents a derelict site abandoned in the 1970s, yet a community of 250 people still reside amongst the pollution. Why? What are their ties to such a place? What improvements can be made with the advent of the new facilities at the site? Scoble's UBC group will find this site ideal to study community issues and apply the anthropological factors to other sites. Questions to address will include, "Can what we learn at Britannia Beach be transferred to other communities around the world; and, are there approaches being attempted at other communities around the world that can be applied in a North American context?"

Pandemics and Mining

Kay Teschke will lead this research through the UBC Bridge Program with strong interaction from Martin Schechter, Head of Epidemiology and a major HIV/AIDS researcher at UBC. The issue faced by mining relating to AIDS in Third World countries in Africa in particular, is simply mind-boggling. Many of the issues have direct impact on the company's bottom line in addition to the horrific social costs resulting. A stable workforce is a major benefit to a mining operation. It is estimated that over 50,000,000 Africans will die in the next decade from AIDS. Over 30 percent of the population in several countries in Southern Africa have HIV. Mining companies are just beginning to grapple with how to deal with the needs of their workers and the local communities - those who contract this deadly illness and their families. The number of orphans and destitute families resulting from this pandemic is daunting and the social problems enormous. Policies and protocols are desperately needed and the Bridge Program can provide unique support for industry by developing such options.

MAJOR BREAKTHROUGHS: 1. Integrating community planning into the mine life cycle.
2. Developing protocols to deal with pandemic disease (HIV/AIDS).

3. Landscape Architecture in Mine Closure Plans

(Condon, Lavkulich, Veiga, Meech, Scoble, Baldwin, Ghomshei, Teschke)

The exercise of developing this proposal brought us into close contact with Patrick Condon, Head of UBC-Landscape Architecture. His concepts of using the landscape to develop "Liveable, Sustainable Communities" fits in exactly with our plans to develop sustainable protocols for mine closure. Britannia Beach offers this research group some extremely interesting opportunities to develop approaches that integrate the science of Landscape Architecture into our research.

Condon is the lead in a research program aimed at creating liveable communities after a mine shuts down. Britannia Beach is a unique microcosm to study how to transform an ugly site into one that is enjoyable to live in. Veiga has an interest in using abandoned mines for aquaculture - either on-land or in abandoned pits. Britannia will support these efforts. Lavkulich is extremely knowledgeable about how proto-soils evolve into soil which will be important aspects of the transformation of this site through revegetation.

The work in this project will take a holistic approach to all aspects of landscape architecture and community needs. These include site-specific issues as well as generic approaches such as "the look" of buildings and open space, the need for infrastructural support – crime prevention, hospitals, schooling, alternative social and economic activities, protection of the environment, local environmental opportunities that present "green" approaches (geothermal heat, etc.) and local heritage and culture factors. We intend to marry the hard sciences (chemistry and physics) with soft science (social science, anthropology, arts and crafts) through the interaction of the experts in our centre in these various fields.

MAJOR BREAKTHROUGH TARGET: Development of protocols to applying the principles of Landscape Architecture and Sustainable Communities into Mine Closure plans.

THEME 2: ENERGY

Efficient use of energy and the need to reduce the use of carbon-based energy supply is the focus of this theme. Reducing energy consumption saves money for a mining operation and reduces the production of Green House Gases. Alternate sources of energy are important aspects of this research theme, particularly exploitation of low and high temperature geothermal resources. This includes developing techniques to recover and use heat from mine effluents.

4. Production of Geothermal Energy in Canada

(Ghomshei, Mortensen, Russell, Meech, R. Hall, Pakalnis, Lang)

Mory Ghomshei leads this work. He is likely Canada's leading expert of Geothermal Energy and has organized a Geothermal Group in BC to promote related geothermal projects.

Three scenarios are involved in this research:

- high-temperature geothermal electrical power production
- heat pumps for extracting ground heat using closed or open loop flows
- heat pumps for extracting heat from mine effluents and discharge waters

The first item is a "rarity" in Canada. We are the only country on the Pacific Rim to not be exploiting our geothermal resources. Two reasons for this are that we have few feasible sites, most being in remote parts of the BC coastal mountain range, and secondly,

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BC has such an abundance of hydroelectric power that high-temperature geothermal is not really taken seriously.

However, Meager Creek located not far from Britannia Beach shows signs of being a candidate for Canada's first geothermal project. Geothermal permit holders in the Meager Creek and Mt. Caley region have discovered high-temperature reservoirs close to surface. Research is needed to evaluate the extent of the aquifer, i.e., its reliability and stability, and the need to hydro-fracture the rock to increase permeability. CERM3 will collaborate with these entrepreneurs to help understand this potential resource.

The second project involves using the ground around a building to extract and store heat for use in space heating and air conditioning. The third project will be installed as a demonstration concept this summer to extract heat from Britannia ARD. Sponsored by NRCan, the project will establish proof-of-concept in a mining context and will attempt to find ways that reduce the payback period. The Geothermal lab will extract heat from the polluted mine waters for use as space-heating in the research centre and town.

MAJOR BREAKTHROUGH TARGET: Expansion of Canada's potential use of Geothermal Energy - high temperature, heat pump technologies, and heat recovery from mine effluent.

5. Reduction of Energy Use in Comminution Processes
(Tromans, Meech, Ghomshei, Klein, Veiga, Pawlik)

Comminution processes use only ~1% of the energy input to create new surfaces. Virtually all energy is converted to heat. Comminution represents between 65-80% of all energy used in mining. Even a slight increase in efficiency could have huge impact on power consumption with consequent cost savings and benefits regarding Green-House Gas emissions. Recently Tromans and Meech have determined a theoretical basis for this efficiency difficulty and can predict the fracture mechanics of virtually all minerals from a thermodynamic analysis for both cross-grain and intergranular breakage. We believe this work will lead us to develop new processes to break rock with higher efficiency, and to better understand the inefficiencies of current processes. The work is being expanded this year with a collaboration with the Computational Materials Science Group at Tohoku University using their supercomputer for First-Principles modeling. We are also mounting a project to survey energy distribution in grinding in collaboration with CSIRO in Australia funded through AMIRA, the Australia mining industry research agency.

Todate, no one has ever published a proper energy balance on a grinding circuit. Power consumption is monitored of course, but changes in the distribution of energy during grinding are not understood. By developing an on-line system to monitor energy distribution, we believe approaches to increase efficiency can be achieved.

Des Tromans is the driving force behind this work. Britannia presents a unique opportunity to study comminution practices and the recovery and recycling of heat extracted from mine-and-mill waters. Part of the heat recovered from the Britannia ARD will be applied to processes that break rock. We hope to find ways to decrease energy consumption by at least 10%.

MAJOR BREAKTHROUGH TARGET: A decrease in energy use in the mining industry of 10-20%.

(Continued on Page 4G in the Additional Pages Document)

Page 4G: A1 – The Research
(continued from Page 4F)

THEME 3: MATERIALS

Mining involves the extraction of mineral, energy or metal products and along the way it consumes raw materials such as steel, water, chemicals, etc. to achieve efficient and effective products for market. This theme will focus on enhancing the recovery of values from ores and on reducing the consumption of raw materials, especially toxic ones such as cyanide.

6. Processes to Recover Metals Economically from Mine Effluents
(Klein, Veiga, Meech, Pawlik, R. Lawrence, Baldwin, Dreisinger, Dixon)

Richard Lawrence is a Principal with BioTeQ Environmental Technologies Inc. and is an Adjunct Professor in the UBC-Mining department. BioTeq is a company that processes metals from mine effluent using sulfate-reducing bacteria (SRBs). The process is installed at the Caribou mine in New Brunswick and a second is being built at a Phelps-Dodge property in the US. The MWLAP design team are currently considering this option together with the High-Density Lime Sludge process that is currently considered state-of-the-art. Baldwin has extensive experience with SRB processes and she will examine ways to apply this process ahead of the HDS plant in collaboration with Lawrence. Possible options include producing a bulk Cu/Zn concentrate, producing separate products, or recovering metals by electrolysis or in other ways.

We will also study Selective Cementation. It is possible to design a relatively inexpensive process using scrap iron and other precipitating media or reagents to selectively pull copper and zinc from solution. One possibility is to use scrap aluminum. While Al oxidizes readily passivating its surface and stopping the reaction, high-speed attritors can possibly help to obtain active surfaces prior to entering the effluent. Direct electrolysis is also a possibility if a cheap source of electrical power is available.

Aqueous Processing of Ores
(Dreisinger, Dixon, Meech, Klein, Tromans, Baldwin, Veiga, R. Lawrence, Pawlik)

David Dreisinger leads this effort. The focus is to develop fundamental models of heap leaching and hydrometallurgical processing. These methods have revolutionized the industry over the past 25 years because of their reduced impact on the environment, their more efficient use of energy, and their applicability to low grade ores. The aqueous processing labs (flotation, surface chemistry, and hydrometallurgy) will provide significant support for this work. The research includes bioleaching, pressure oxidation, electrolysis, and cementation among other processes. The types of ores amenable to these techniques are copper, uranium, zinc, nickel, and gold or silver ores. One novel idea is to use hydrometallurgy to extract energy from coal. Most hydro-processes for coal have focused on pyrite reduction, but there is a real opportunity to use coal to produce steam within a high-pressure reactor for use in generating electricity by reacting with CaO. The solid product emitted from the reactor would retain all carbon in the form of carbonate that can be disposed of in a conventional waste pile or be used to neutralize acidic effluent from another process. By integrating a sulfide metal mine with a generating station, all of these processes can work together to produce the same amount of energy without producing GHGs and protecting the environment from ARD. The key to this concept is to marry the size of the generating station to the size of the metal-producing operation.

MAJOR BREAKTHROUGH TARGET 1: Development of practical processes to recover metals from mine effluents with low metal content.

MAJOR BREAKTHROUGH TARGET 2: Development of a new approach to coal utilization that completely eliminates GHG production and generates a neutralizing material to mitigate ARD from a sulfide metallic ore leaching process.

THEME 4: WASTE

All mines and mills produce solid and liquid (and sometimes gaseous) waste. Solid waste can vary from more than 99% of the run-of-mine ore to as low as 1% with some industrial

mineral processes. Safe, long-term storage of this solid waste is of central concern of all mining operations. The collapse of tailing dams during the past century around the world has been a major problem for the industry. It is estimated that over the past decade, the costs to recover from and mitigate the effects of such failures have been in excess of 1.5 billion US dollars. Prediction, treatment, and prevention of Acid-Rock-Drainage are ubiquitous concerns at most mines around the world and our research into this area will be a key component of this theme.

7. Arsenic and Old Mining
(Cullen, Meech, Dixon, Dreisinger, Baldwin, Lavkulich, K. Hall, Klein, Ghomshei)
William Cullen leads this research. Much of the efforts will be directed at the storage of As-bearing dusts in the underground workings in Yellowknife. Techniques to deal with this problem include: asphalting, sealing, freezing, autoclave-processing, etc. Although arsenic is not a significant issue at Britannia, CEMR will have all the tools necessary to support this work and there are potential arsenic-bearing "hot-spots" on the fan area of the site. Arsenic is increasingly being recognized as a major environmental hazard. The US-EPA recently lowered the acceptable discharge limit from 50 to 10 ppb – a controversial decision but one based on experiences in Bangladesh and N.E. India where arsenic contamination of artisanal wells has resulted in the poisoning of millions of people. Many mines around the world are concerned with the safe storage of arsenic-bearing materials on surface and underground. This project is considered to be crucial in developing advanced methods to deal with the problems.

MAJOR BREAKTHROUGH TARGET: Development of practical processes to deal with arsenic pollution from a mine site.

8. Innovative Approaches to Acid-Rock-Drainage (ARD) Mitigation
(Meech, Klein, Ghomshei, Mayer, Wilson, Smith, R. Lawrence, K. Hall, Lavkulich, Veiga, Baldwin, Suttle, Sobolewski)
ARD research can be broken down into three categories: prediction, containment, and prevention. ARD is the single most insidious and ubiquitous problem faced by virtually all mines around the world. Sulfide waste is abundant in most economic rock and upon exposure to water and oxygen these minerals react to form sulfuric acid that leaches heavy metals. Each site and material has unique characteristics that influence the problem such as sulfide level, climate, geography, presence of alkaline rock, particle size, etc. Prediction is fraught with difficulties that include parameter variation and sampling inaccuracies among many others. Predictive testwork can be done, but lab tests have significant scale-up issues requiring more research. Development of site-specific knowledge is key to finding reliable methods. The prediction work will be led by R. Lawrence, the containment work by Lavkulich, and the prevention work by Baldwin.

Methods to contain ARD are mandatory at all operating mines today as well as at those that have closed. These include dry and wet covers, sealing of waste piles, diversion of water, use of geomembranes and other barriers, wetlands to neutralize and remove heavy metals, and anoxic drains. Active methods control metal levels by adjusting pH with lime and then disposing of the sludge. Recovery methods show promise where metal levels are high. There are added benefits to using these processes with conventional containment approaches in that alkali consumption can be reduced which lowers operating and sludge disposal costs.

Prevention methods include ways to isolate deleterious materials to prevent water and/or oxygen coming into contact with sulfides. Passivation using dichromate and permanganate has been attempted, but these are expensive. Passive treatment is worthy of research since this represents a relatively inexpensive "natural" solution. Hybrid methods with both active and passive methods might apply wetlands and related processes to high metal and high flowrate situations. Britannia Mine is an ideal site to test out such approaches and our innovative constructed wetlands will support this research.

Microbiology, Reclamation, and Remediation
Dealing with bacteria that boosts the onset of ARD is also important. We are examining if a bacteriophage can suppress a bacterial population. Inoculating a waste dump is suggested, but the bacteria mutate and eventually become immune. Susan Baldwin is heading up this field

with strong support from Suttle and Sobolewski. The constructed wetlands will be a major asset for her group's research into passive ARD treatment. Sobolewski is a major player in the passive system approach through his company Microbial Inc. Suttle is pursuing a bacteriophage to deal with T. ferrooxidans. The ability to apply these processes and methods to Britannia ARD will help this work in many ways.

MAJOR BREAKTHROUGH TARGET: Development of protocols to use passive ARD treatment processes for high metal content and/or high flowrate effluents.

9. Sub-aqueous Waste Disposal
(Poling, Pederson – UVic, Meech, Lavkulich, Lang, Wilson, Veiga, G. Lawrence)

One of the most controversial waste management practices is deposition of solid waste into an aqueous environment. The term "out of sight - out of mind" springs to mind, but in fact, there are logical reasons to use this method in some cases. There are 3 basic alternatives: sub-marine, fresh-water lakes, and riverine disposal. This latter practice is particularly damaging and should be avoided at all costs although there is often no alternative but to leave the ore in the ground. We have a group at UBC and UVic with substantial experience in this subject as Poling and Pedersen were involved for many years in research at Island Copper that resulted in considerable science on tailings deposition in Rupert Inlet. At Britannia, there are close to 40 million tonnes of tailings in Howe Sound that cannot be studied properly while bioavailable metals are being discharged from the mine. Now that a water treatment plant will be installed, evaluation can be done on the true impact of these sediments on marine life. The group will study these sediments from the viewpoint of metal uptake, transient aspects of disturbing the ocean floor and slope stability of material on the bottom of the Sound. We will produce a Guidelines Document that details where such practices are acceptable, where they are not, and how they should be designed.

MAJOR BREAKTHROUGH TARGET: Establishing protocols for effective design of subaqueous waste disposal (WHEN-WHERE-HOW-and-NOT).

10. Influence of Geochemistry on Stability of Mine Waste Piles
(Mayer, Lang, Meech, Hungr, Ghomshei, Smith, Klein, Morin, Davies, Lavkulich, Baldwin)

UBC-CERM3 was recently selected by Molycorp Inc. in Questa, NM, as the top university candidate team in North America to perform research into how ARD may affect waste pile stability. As acid is created through weathering of sulfides, the acid can react with silicates to generate clay minerals. If the clay content increases or forms layers within the pile, slope failure may ensue, especially for high-angle waste piles. The problem is apparently ubiquitous at many mountainous mines, but has so far received little attention. Liability is considerable upon closure, especially if human activity is significant nearby - roads, walking trails, etc. We have a multi-disciplinary team with skills in the chemistry and physics of the problem. With diversity of waste materials at the site, Britannia Mine is an ideal location to support this work and extend the findings at Questa to other properties.

Solid Waste Management and Hydrology
(Wilson, Smith, Beckie, Mayer, Lang, Davies, Hungr, Pakalnis)

Ward Wilson is the lead researcher in this field. The main focus is on geotechnical stability of waste piles with a major interest in the hydrology of waste dumps and its impact on ARD generation. Britannia provides a unique opportunity to conduct long-term controlled trials on the numerous waste dumps located on steep slopes. The group will assess existing methods to monitor climate, gas fluxes, subsurface conditions, evaporation/transpiration, and net infiltration.

The work will integrate with the remote-sensing lab, the remediation/revegetation lab and the simulation facility by establishing an Eddy Covariance Monitoring station for real-time measurement of water evaporation and CO2 gas flux. Gas fluxes indicate acid neutralization by providing direct measurements of oxygen and carbon dioxide at the soil-air interface. The system is field-based, but can also be used for lab testwork on the kinetics of intrinsic oxidation rates. Fredlund Cells will be used to monitor unsaturated soils properties with the ability to test under compressive stress to understand the evolution of weathering waste.

MAJOR BREAKTHROUGH TARGET: Improved understanding of the linkage between Geochemistry and Geotechnology of waste piles and on the real-time monitoring of ARD generation.

11. Britannia – ARD and Soil Formation
(Lavkulich, Baldwin, Meech, Ghomshei)

The Britannia site is a unique place to study the evolution of proto-soil from mine waste. The contaminated fan consists of tailings and "hot-spots" of sphalerite and pyrite. Little revegetation has been done and where grasses and other plants have "volunteered", they are not thriving and appear unhealthy. The impact of ARD on soil is considerable with "relatively rapid" solubilization and decomposition of primary to secondary minerals and clay. Mine wastes will be assessed for their mineralogical stability and for release of minor and major elements. Soluble species will be measured to produce a dynamic and chronological model of acid production in the wetlands. X-ray diffraction (XRD), specific surface area, cation exchange capacity (CEC), and petrographic thin-section analyses will be used to study surface properties related to solution, sorption, and precipitation.

Fieldwork will allow depth profiles of O2 and CO2. Knowledge of these gases and their isotopic contents will be augmented with chemical analyses of solids. Pore-gas O2 profiles can quantify sulfide oxidation while CO2 species can quantify geochemical reactions. Understanding the dynamics of a new soil system has value for rehabilitation. The Britannia protocol will be generic allowing similar application at sites such as Mt. Washington. As soils are key ecosystem components, these data will support a process to establish successive plant communities. Lab simulations will help reveal conditions in which plants are in harmony with a new stage of succession. An innovative greenhouse nursery to propagate native species organically will be developed. This work is led by Lavkulich.

MAJOR BREAKTHROUGH TARGET: Better understanding of the impact of ARD on soil formation.

12. Rheology of Slurries and Debris Flows
(Klein, Hungr, Ghomshei, Meech, Dixon, Dreisinger, Pawlik, Veiga)

Bernhard Klein is the lead researcher in this area. Laterite slurries are one of the main focuses of this work with their unstable fluid flow properties that negatively affect leaching operations such as Pressure Oxidation. The unstable nature of the material leads to significant mixing and pumping problems.

The rheology of debris flows from waste dumps and natural scars is not well-understood and is fundamental to developing models that can predict flow. Mudflow studies will be extended to coarse rock debris with a view to characterizing conditions for the onset of flow. A large-scale rheometer will be built to support this work. The topology of the Britannia site will be important to this research.

MAJOR BREAKTHROUGH TARGET 1: Better understanding of the onset of unstable flow conditions in laterite slurries.

MAJOR BREAKTHROUGH TARGET 2: Better understanding of the rheological characteristics of debris flows.

Theme 5: Biota

Microorganisms and biota are extremely important considerations in research that addresses sustainable mining with respect to impact on ecosystems. Closure plans must consider biota when considering reclamation and revegetation. Recently, phyto-reclamation has received considerable interest from mining companies (Inco, Rustenberg Platinum, and Rio Tinto) to clean-up contaminated sites. Bacteria and other microorganisms also play major roles in the rate of ARD generation. Such types of research will be conducted under this theme.

13. Phyto-mining and Phyto-reclamation (Anderson - Massey University, Meech, Veiga, Klein, Ghomshei, Baldwin, Lavkulich)

Knowledge about the ability of certain plant to accumulate heavy metals from soils and other substrates is receiving considerable interest from industry. Rustenberg Mining and Inco are two companies using phyto-reclamation on Ni-contaminated sites. UBC-CERM3 has partnered

with Dr. Chris Anderson of Massey University in New Zealand, who leads a major research group studying phyto-mining and phyto-reclamation. His group have identified over 1000 plants that are able to concentrate specific metals, so native plants can likely be found to help mitigate serious contamination at many specific sites around the world. In collaboration with Massey, we have installed a field lab at two mine sites in Brazil seriously contaminated with mercury. Our goal is to develop a species that can retain mercury within its cells for recovery rather than increasing the transpiration rate to the atmosphere. The presence of gold in these substrates is also of interest. Canola plants (a Canadian development) have been selected as candidate species among others to recover Hg and Au from the mine waste.

Part of this research will focus on plants that accumulate copper, zinc and cadmium from contaminated soil at Britannia Beach. One additional metal to be investigated includes molybdenum of which no reports are available in the literature. Our wetland cells will examine the planting of different species to recover such metals. Use of a lixiviant to mobilize metals for uptake by the plants will be an important aspect of the work. Design of the wetlands to insure mobilization does not impact on the surrounding environment is an issue to be addressed.

MAJOR BREAKTHROUGH TARGET: Development of hyperaccumulating species of plants for copper, zinc, cadmium, mercury, molybdenum, and gold to assist in remediation of a contaminated site.

Theme 6: High-Technology

The development of innovative technologies to deal with pollution, health and safety issues, economic and technical modeling, etc. is a central part of a well-planned sustainable mining research program. This includes methods such as computer applications for simulation modeling, process control, remote monitoring, instrumentation, and robotics. These aspects will be the focus of this theme.

14. Integration of Mining and Processing Operations
(Meech, R. Hall, Scoble, Dunbar, Klein, P. Lawrence, Pawlik, Morin)

We plan to develop a software tool based on the latest Artificial Intelligence techniques to study scenarios to integrate the mine/mill operation. Some of the topics in this work will include: Treating the Mine-Mill Complex as a Factory; Industrial Automation and Telerobotics in Mining; and Simulation Modeling of the Mine and Mill. Robert Hall leads this group with significant support from P. Lawrence of Electrical Eng. Access to the underground workings also presents some unique opportunities to expand this innovative work.

MAJOR BREAKTHROUGH TARGET: Application of Agent-based Artificial Intelligence techniques in Mining/Milling to improve overall efficiency.

15. Remote Sensors to Monitor the Environment
(Meech, R. Hall, Pakalnis, Veiga, Klein, Ghomshei, Morin)

MacDonald-Dettwiler has expressed interest in establishing a program on satellite monitoring of the environment. Instrumentation to monitor aqueous environments for characteristics such as pH, conductivity, Eh, metal ion levels, solids content, etc. will be developed. Data can be continuously measured and passed up to a satellite using a number of state-of-the-art GPS systems. Robust, reliable instruments that survive in the "wild" are unavailable. Problems relate to materials selection (corrosion) and failure due to wear, and/or freezing. We will develop such instrumentation and test it in the field around the Britannia mine site. A common problem relates to equipment sabotage by curious folk with time on their hands. Part of the design criteria will consider how to camouflage such devices.

MAJOR BREAKTHROUGH TARGET: Development of monitoring systems to maintain efficient and effective process control of pollution in remote locations.

Table 1 on Page 4L in the Additional Pages document) provides a graphical image of the relative importance of each theme to each research project. This type of diagram is called a Kohonen Self-Organizing Map (SOM) - a visual technique developed in Finland that visually represents the input/output relationship in an artificial neural network. The diagram shows

the clusters of research activities and how the projects link to one another across each of the six themes. Each project has a primary focus with one or more secondary or tertiary impacts.

The projects involve a team of researchers who collaborate on elements of each research with interaction taking place across the themes depicted. A total of 40 researchers are involved in this plan. Each project or sub-project has a team leader with input of necessary skills drawn from one or more of the collaborators. Some projects will be led by major users of the facility while others will be under the leadership of more junior members with specific skills that have evolved in recent years. A technical support group consisting of senior full professors will provide overview input and advice (Lavkulich, Cullen, Tromans).

Table 1. Kohonen Self-Organizing Map of the Relative Importance of each Theme to each Research Project.

Research Projects	Research Themes in Sustainable Mining					
	People	Energy	Materials	Waste	Biota	High-Tech
Green Mine Design						
Sustainability of Mining Communities						
Landscape Architecture In Mine Closure						
Geothermal Energy						
Energy Reduction in Milling						
Metal Recovery from Mine Effluents						
Arsenic and Old Mining						
ARD Mitigation						
Sub-aqueous Waste Disposal						
Geochemistry and Geotechnology						
Rheology of Debris Flows						
Britannia – ARD, Soils and Clay						
Phyto-Reclamation and Revegetation						
Mine/Mill Integration						
Remote Sensing						

Small impact
Slight impact
High impact
Large impact

Note that all themes are of major importance to the Green Design Project as would be expected. Similarly, elements of Materials and High-Technology (computer hardware and software, instrumentation, robotics etc.) play roles in each of the 13 research projects.

Institution and Title of Infrastructure Project (from p. 1 of this module): Project number: 7588

University of British Columbia
Innovative Research for the Challenges of Mining in the 21st Century
- the Canadian Environmental Mining Research Centre

A2 - The Researchers

1) List the researchers who will **use** the infrastructure. Add one (1) additional page if required. This list may include researchers from non-eligible organizations.
2) Provide a CV module for the principal researchers, i.e. the main users essential to the justification of the project (the CFI will accept up to 10 CV modules).
3) For New Opportunities applications, include **only** the CVs of new researchers.

Reseacher (name and title)	Affiliation (department or faculty & organization)
Principal users:	
Condon, Patrick Professor	Architecture University of British Columbia
Dixon, David Associate Professor	Metals and Materials Engineeri University of British Columbia
Dreisinger, David Professor	Metals and Materials Engineeri University of British Columbia
Klein, Bernhard Assistant Professor	Mining Engineering University of British Columbia
Lavkulich, Les Professor	Agricultural Sciences University of British Columbia
Mayer, Ulrich Assistant Professor	Earth and Ocean Sciences University of British Columbia
Meech, John Professor	Mining Engineering University of British Columbia
Scoble, Malcolm Head of Department	Mining Engineering University of British Columbia
Teschke, Kay Professor	School of Occ and Env Hygiene University of British Columbia
Wilson, Gordon Professor	Mining & Mineral Processing University of British Columbia
Other Users:	
Anderson, Chris Assistant Professor	Soil Sciences Massey University, New Zealand
Baiden, Greg Professor and Director	Engineering Program Laurentian University
Ghomshei, Morteza Adjunct Professor	Mining Engineering University of British Columbia
Hall, Kenneth Professor	Civil Engineering & Westwater Research University of British Columbia
Lawrence, Greg Professor	Civil Engineering University of British Columbia

Institution and Title of Infrastructure Project (from p. 1 of this module): Project number: 7588

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Reseacher (name and title)	Affiliation (department or faculty & organization)
Lawrence, Peter Professor	Electrical Engineering University of British Columbia
Lawrence, Richard AdjunctProfessor	Mining Engineering University of British Columbia
Mortensen, James Associate Professor	Earth and Ocean Sciences University of British Columbia
Pakalnis, Rimas Associate Professor	Mining Engineering University of British Columbia
Pawlik, Marek Assistant Professor	Mining Engineering University of British Columbia
Pederson, Tom Professor and Head	Earth & Ocean Sciences Unviersity of Victoria
Poling, George Emeritus Professor & Vice President	Mining Engineering/Rescan Environmental University of British Columbia/Rescan
Robert Hall Assistant Professor	Mining Engineering University of British Columbia
Susan Baldwin Associate Professor	Chemical & Biological Eng. University of British Columbia
Suttle, Curtis Professor	Earth & Ocean Sciences / Microbiology University of British Columbia
Tromans, Desmond Professor	Metals and Materials Engineering University of British Columbia
Veiga, Marcello Associate Professor	Mining Engineering University of British Columbia
William Cullen Emeritus Professor	Chemistry University of British Columbia

Institution and Title of Infrastructure Project (from p. 1 of this module): Project number: 7588
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- the Canadian Environmental Mining Research Centre

Self-assessment

A2 - The Researchers

Choose the statement that best describes the principal research users.

The researchers who will be the **main users** of the infrastructure:

☐ (a) have the skills and expertise to accomplish the proposed research;

☐ (b) are recognized for their accomplishments, or are new researchers who are promising in the proposed research field(s);

☐ (c) are acknowledged leaders, or have demonstrated potential for leadership in the proposed field(s);

☒ (d) are international pioneers in the proposed research field(s), or have the potential for major breakthrough(s) in the proposed field(s).

Using the space below and up to 1 additional page, describe how each researcher will use the infrastructure to contribute to the proposed research. If major new users are to be recruited, describe the recruitment plan.

1. JOHN MEECH has been conducting research in Mining and Processing for the past 30 years. He has published over 120 papers on process design and control, artificial intelligence and environmental control. His research has evolved from simulation modeling and process control into the application of AI methods in industry. He is recognized as the person who introduced these techniques into mining. In 1986 he published the seminal paper on fuzzy logic in mineral processing and in 1994, his paper in Nature on Mercury Pollution from Deforestation was the first to identify this pollution distribution vector. He has worked on many environmental problems such as cyanide destruction, fine-particle recovery, Hg pollution in gold mining, ARD sampling and remediation, tailing backfill systems and biological solutions to pollution. In 1993, the Canadian Institute of Mining and Metallurgy awarded him a CIM Fellowship to recognize his contributions and services to mining and processing. In the year 2000, he was named CIM Distinguished Lecturer.

2. MALCOLM SCOBLE became Head of MMPE at UBC in 1997 following a distinguished 15-year career with the McGill Mining program where he founded CCARM -- a research centre dedicated to automation in mining. He is an expert on surface and underground mine equipment and design and has been involved with the development of mining automation systems through his collaboration with companies such as Inco and Syncrude. In addition to mine automation, his focus at UBC has been to develop a coordinated approach in the MMPE department to introduce sustainable practices into the mining industry in particular as they deal with community issues.

3. KAY TESCHKE is Professor and Director of The Industrial Hygiene Unit in the Department of Health Care and Epidemiology. Dr. Teschke is an expert in respiratory diseases caused by particulate matter - specifically, wood dusts, moulds, flour, and various organic aerosols. She is also conducting several epidemiological studies into occupational risk factors of Parkinson's disease. Her expertise will be essential in developing protocols and measurement methods for ultra-fine dust and underground gas emission risks in the MSHL facility. She heads up the UBC Bridge Program created in 2001 to bring together three groups - Engineering, Health Care and Health Policy. This program was an outgrowth of the CERM3 initiative.

4. DAVID DREISINGER is a Professor of Metals and Materials Engineering and holds the Industrial Chair in Hydrometallurgy funded by 19 organizations from around the world. Dr. Dreisinger is a world-renowned expert in the field of hydrometallurgy and is in demand as a consultant and lecturer at many mine sites around the world. He has given over 100 short

courses outside UBC since 1988. His research is industrially-oriented yet his group strives to understand the basics of complex processes. He has developed numerous process improvements and holds several patents that are licensed by UBC to the sponsors of the Chair. In 1994, he received the CIM Sherritt Hydrometallurgy Award.

5. G. Ward Wilson is Professor of Mining Eng. and holds the Chiar in Mining and the Environment. He came to UBC in 1999 from Civil Engineering at the University of Saskatchewan. He conducts research into all aspects of mine waste and hydrology of waste piles with a focus on evaluating infiltration and evapo-transpiration at the ground surface with application to the design of soil covers for waste rock and tailings. Dr. Wilson is a collaborator. He is highly respected by industry around the world and consults on numerous waste rock problems. Several spin-off companies in Saskatchewan have emerged from his research group. Dr. Wilson will lead as research group working on co-deposition of tailings and waste rock as well as research into impact of hydrology on ARD generation.

6. PATRICK CONDON holds the James Taylor Chair in Landscape and Livable Environments. He has organized a series of round table multi-party planning and design processes throughout North America with a shared goal of creating more sustainable communities. The work has produced approved and workable plans providing thousands of new housing units and job sites in a sustainable community context. He has become well-known for producing alternate models for walkable and complete communities - ones that work with, not against, the natural capacities of a site, and doing this planning with the people involved - citizens and stakeholders of the area. The community design strategies from this work have received widespread attention provoking a fundamental re-examination of how we plan our neighborhoods and how we provide the urban infrastructure needed to serve them.

7. LES LAVKULICH is Director of the UBC Institute for Resources and Environment where he conducts research into soil science and resources, environmental chemistry, maintenance of environmental services, sustainable agricultural systems, land use hydrology, mining and the environment, and environmental risk assessment and policy development in the natural sciences. His knowledge and experience with environmental analytical equipment and laboratory practice will be invaluable to the operation of the CEMR Centre's microbiology lab, reclamation lab, and the constructed wetlands.

8. DAVID DIXON is Associate Professor of Metals and Materials Engineering. He is an expert on the mathematical modeling of heap-leach operations and consults widely on the subject. He recently completed a sabbatical leave with the CSIRO hydrometallurgy research group in Perth Australia where he developed an industrially-funded project to model metallurgical processes. His approach is from a fundamental viewpoint rather than being empirical. His expertise will be invaluable in the hydrometallurgy and hydrological modeling facilities at the CEMR Centre.

9. BERN KLEIN is Associate Professor of Mining Engineering and Director of the Centre for Industrial Mineral Innovations which he founded. His research attempts to find new uses for industrial minerals particularly for environmental control through their high adsorption capacity. He is also an expert in rheology and will head up a program aimed at characterizing the instability of laterite slurries during processing and to apply mud-flow modeling to debris flows from waste dumps and natural scars. Dr. Klein's approach to research is extremely practical due to the 10 years of industrial experience he gained running commercial pilot plant testwork.

(continued on Page 6C of the Additional Pages Document)

Page 6C: A2 – The Researchers
(continued from Page 6B)

10. Ulrich Mayer is an Assistant Professor in Earth and Ocean Sciences. His research group have developed a versatile, multi-component, reactive transport model (MIN3P)that can be used at to study long-term effects of sulfide mineral oxidation and feldspar weathering in variably-saturated mine waste. The model includes ingress of atmospheric oxygen, oxidation of multiple sulfides, and interaction of the resulting acidic pore water with the waste. The work includes kinetically-controlled dissolution and precipitation reactions suitable to model aluminosilicate weathering. The model has been successful at assessing acid mine drainage release and attenuation at a number of mine sites.

Other Research Leaders

11. Chris Anderson is with the department of Soil and Earth Sciences of the Institute of Natural Resources, Massey University, New Zealand. He is also a Principal with Phytomine Environmental Ltd in New Zealand. Dr. Anderson heads up a group of researchers involved with the identification of plants that hyper-accumulate or can be forces to hyper-accumulate metals. His group has identified over 100 species that are specific accumulators of different metals that include but are not limited to copper, zinc, nickel, gold, silver, mercury, arsenic, antimony among many others. His research focuses on developing approaches to waste dump rehabilitation that employ phyto-reclamation to accumulate metals into the cells of a plant for harvest and eventual recovery.

12. Susan Baldwin is an Associate Professor in the department of Chemical and Biological Engineering where she conducts research into a various aspects of biological and microbiological processes for waste-water treatment. Among these, she is particularly skilled at applying Sulfate Reducing Bacteria and in ARD Passive Treatment methods. She is Head of CERM3's Bioremediation and Reclamation Laboratory.

13. William Cullen is Emeritus Professor of Chemistry with a distinguished career in the chemistry of arsenic compounds. He has published over 350 papers and has received many awards: UBC President's Service Award for Excellence - 1998, UBC Killam Research Prize - 1994; Fellow of the Royal Society of Canada - 1993; UBC Killam Senior Fellowship - 1989. His current research focuses on the biogeochemistry of arsenic and antimony. He has been a Visiting Professor at the University of Graz; de Montfort University; and the University of Adelaide. His work includes: As-microorganism interactions in sediments and tailings and As-compounds in biota near Yellowknife; stabilization of As-dust stored at the Giant Mine; and environmental assessment of Miramar's Con Mine. He is a member of the US National Research Committee on As in drinking water and he consults for US-EPA, NATO, Environment-Canada, US Institute of Enviro-Health, DIAND, and the Ontario Ministry of the Environment.

14. Mory Ghomshei is an Adjunct Professor in Mining Engineering where he teaches and conducts research in Geothermal Energy. He has been Research Manager of CERM3 and has overseen the installation of all infrastructure in the CERM3 laboratories. His expertise is broadly based and he can contribute to research in all aspects of Acid Rock Drainage – testwork, interpretation, and modeling, in particular the application of stable isotope analysis in tracing environmental pollutants back to their source.

15. Kenneth Hall conducts research in the UBC Institute for Resources and Environment (Westwater Research Centre) in aquatic toxicity, cumulative effects, land/water interactions, watershed modeling and all aspects of water pollution. He is a founding member of Westwater and is widely recognized for his knowledge and research work in the field of water pollution. He is invited to many international conferences as a Keynote Speaker - most recently he addressed the Conference on Mercury Bioaccumulation held last December in Belem, Brazil.

16. Robert Hall is an Assistant Professor in Mining Engineering with a joint appointment in the Integrated Engineering Program at UBC. With a background in mechanical engineering, his research focuses on simulation modeling of mechanical processes and tele-robotic applications. He is Head of the CERM3 Mining Automation and Environmental Simulation Lab.

17. Richard Lawrence is Adjunct Professor of Mining Engineering and a Principal in BioTeQ Environmental Services Inc. Dr. Lawrence held the Chair in Mining and the Environment from 1992 to 1997 and was Head of Mining from 1995 to 1997. His main area of expertise is Acid Rock Drainage: chemistry, prediction, mitigation, prevention, and monitoring, and processes

for ARD treatment. BioTeQ markets an innovative metals-recovery process being used at mines around the world to replace High-Density-Lime-Sludge as state-of-the-art in many cases.

18. George Poling is Emeritus Professor of Mining Engineering and Vice-President of Environment for Rescan Environmental Services. Dr. Poling retired in 1996 from UBC after a long and distinguished career performing research into all aspects of mineral processing and environmental monitoring and control. Since the early 1970s, he was actively involved with the outstanding research program conducted by BHP on the monitoring of their Island Copper sub-marine tailings disposal system. Dr. Poling is widely respected across the industry and his wise counsel is sought by many in all aspects of environmental monitoring and control.

19. Tom Pederson is Head of Earth and Ocean Sciences at the University of Victoria and an Adjunct Professor in EOS at UBC. He is also an expert on sub-marine disposal methods with extensive work done on the tailings deposition in Rupert Inlet.

20. Curtis Suttle is an Associate Professor in the Department of Microbiology with a joint appointment in Earth and Ocean Sciences. His research is aimed at understanding the role of microorganisms in nutrient and energy cycling in the world's oceans. He is one of the world's leading experts on bacteriophage (natural viruses) that play key roles in the dynamics of organisms and nutrients in marine ecosystems. His work attempts to isolate and characterize novel viral pathogens; to apply molecular approaches to enumerate and identify such viruses; to study the effect of viruses on primary productivity and phytoplankton population dynamics; to determine the temporal and spatial distribution of specific viruses; and to identify the rates and the mechanisms of viral production and removal in marine environments. His knowledge is invaluable in our attempts to find a virus for acid-generating bacteria.

21. Des Tromans is Professor of Materials and Metals Engineering. Dr. Tromans has developed a reputation for applying thermodynamics to real-world problems in corrosion, electro-chemistry and fracture mechanics. This latter area conducted in collaboration with Meech, has resulted in models that accurately predict the strength characteristics of minerals and other brittle materials from First-Principles (both ionic and covalent bonding and both trans- and inter-granular cracking). We believe this work will evolve into a new approach to comminution that can lead to significant efficiency improvements in current processes.

22. Marcello Veiga is an expert on Mining and the Environment and Process Mineralogy. One of the world's leading experts on all aspects of mercury use in gold mining and on global mercury pollution, he recently was one of 20 scientists invited to Minimata, Japan, to attend a Delphi-Conference on Global Mercury Pollution. He has spent over 10 years working in the Amazon with "garimperos" (informal gold miners) and understands the chemistry, technology, social and political issues of this complex subject. He has published widely and has several seminal papers describing sources and mitigation methods for this insidious problem. He is currently on a leave-of-absence with UNIDO in Austria helping develop a UN-sponsored consistent approach to informal mining operations around the world.

Other Users

23. Diana Allen is an Associate Professor in the Earth Science department at Simon Fraser University. She works closely with Dr. Ghomshei on many aspects of environmental and geothermal systems and has considerable expertise in stable-isotope analysis.

24. Greg Baiden is an Adjunct Professor at UBC-Mining and Director of the Engineering program at Laurentian University. He assumed this latter posting in 2002 following a distinguished 17-year career with Inco Mines Research in Sudbury where he pioneered many applications in mine automation and tele-robotics for production, drilling and blasting and surveying. Dr Baiden is known in the Mining industry for being a leader in mine automation in which he almost single-handedly has led the industry into some extremely novel approaches to mine design and mine method adaptation. He has had a long collaborative association with Scoble and Meech and works closely supervising graduate students on field-based research.

25. Roger Beckie is Professor of Earth and Ocean Sciences with specific expertise in ground water hydrology. He is widely-recognized for his ability to provide practical solutions to ground water problems particularly with respect to waste piles.

26. Mike Davies is an Adjunct Professor of Mining Engineering and a Senior Geotechnical Consultant and Member of the AMEC Earth & Environmental Technical Council. His area of expertise includes the stability of waste dumps, tailings dam design, innovative technologies for mine waste storage (codisposal), engineering geology of natural and fill slopes,

liquefaction and deformation assessment, risk assessment, earth structures analysis and the physical modeling of lateritic/saprolitic soil and rock profiles.

27. Scott Dunbar is Professor of Mining Engineering and Head of the Integrated Engineering program at UBC. His area of expertise includes mine-mill integration and the use of tele-robotics and mini-machines in mining. He has recently completed a project with Syncrude on the application of Ant-Colony modeling to shovel-truck scheduling.

28. Oldrich Hungr is a Professor in the Department of Earth and Ocean Sciences. He leads an active group of UBC researchers whose main interest is rapid failure of slopes, avalanches and debris flows. During the early 90s, he was involved in a BC-funded research project on flow-sliding in coal waste piles in SW BC. His expertise is well-recognized by industry and he consults widely on several waste dump assignments in Canada and around the world.

29. Brennan Lang Brennan Lang is President of TSS Tunnel and Shaft Sealing, a company widely recognized for developing solutions to sealing mine openings. He has been Mine manager at Britannia Mine from Oct 2001 until February 2003 and has extensive knowledge of all aspects of the mine site. His area of expertise relates to mine closure – geomechanics, earth and concrete plugs, and diversion and sealing of openings and surface slopes.

30. Peter Lawrence is Professor of Electrical Engineering where has conducts research into the application of remote control of automated large equipment of wide use in the logging and mining industries. He is working closely with Dr. Robert Hall on all aspects of our tele-robotics application with digging and mine transportation equipment.

31. Greg Lawrence is a Professor of Civil Engineering with specific expertise in fluid dynamic modeling. His group have developed an innovative predictive model of the meromictic pit lake at Island Copper mine on the northern tip of Vancouver Island. His expertise will be invaluable in the studies on the tailings sediment deposits at the bottom of Howe Sound.

32. Mike Lipsett is An Adjunct Professor in Mining Engineering and Head of Automation at Syncrude-Canada. His expertise includes automation of all forms of surface equipment in open-pit and strip-mining operations including digging, loading and haulage vehicles. He collaborates with Scoble and Dunbar and supervises several graduate field-research programs.

33. Mario Morin is Assistant Professor of Mining Engineering. His areas of expertise include slope stability and waste dump management and application of information technology in mining. As a new member of the Mining department, Dr. Morin brings a fresh approach to all aspects of mine design as they relate to the environmental perspective.

34. James Mortensen is Professor of Earth and Ocean Sciences and Director of the Pacific Centre for Isotopic and Geochemical Research. This centre is one of the finest environmental analytical facilities in western Canada and CERM3 has entered into an agreement with PCIGR providing us with access to 7 different types of MS-ICP units for specific types of analyses.

35. Rimas Pakalnis is Associate Professor of Mining Engineering with expertise in all aspects of geomechanics and slope stability: – modeling, prediction, design, and mine safety issues in hard rock openings. Widely sought after by industry, Dr. Pakalnis is often called as an expert witness to testify on specific rock-fall problems in the industry.

36. Marek Pawlik is Assistant Professor in Mining Engineering with specific expertise in all aspects of surface chemistry and flotation.

37. Kelly Russell is Professor of Earth and Ocean Sciences. An expert on vulcanology, Dr. Russell has considerable knowledge on Canadian geothermal resources and interacts with Dr. Ghomshei on this subject.

38. Leslie Smith is Cominco Professor of Minerals and the Environment in the Earth and Ocean Science department at UBC. He is an internationally-renowned expert on ground-water hydrology and has received many awards for his work including the E.W.R. Steacie NSERC Fellowship in 1991 and the UBC Killam Research Prize in 1990. He consults widely for industry and government on hazardous waste management facilities. He has extensive knowledge of groundwater modeling which will be invaluable in our Hydrology and Hydrogeology work. He has extensive experience with groundwater hydrology, mathematical modeling, hydrogeology of waste rock piles, and the design of ground water monitoring networks at hazardous mine waste sites.

39. Researchers from NR-CAN CANMET Environmental Laboratories.

40. Researchers seconded from industrial and governmental affiliates.

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University of British Columbia

Innovative Research for the Challenges of Mining in the 21st Century - the Canadian Environmental Mining Research Centre

Self-assessment

B1 - Need for the infrastructure

Choose the statement that best represents the proposed infrastructure

The proposed infrastructure is essential for the proposed research and:

☐ (a) enhances institutional research capacity;

☐ (b) establishes a unique institutional research capability;

☐ (c) establishes a unique regional or national research capability;

☒ (d) establishes an internationally competitive research capability which would not exist otherwise.

Using the space below and up to 2 additional pages, address all of the following:

- the appropriateness of the infrastructure project for the proposed research;
- the project's potential impact on building institutional, regional or national capacity for innovation;
- the availability and accessibility of similar infrastructure within the institution, the region, the country or internationally, as well as issues of complementarity, duplication and sharing;
- how the infrastructure project helps build capacity in the institution's strategic research priority areas, including efforts to attract and retain highly qualified researchers in these areas. Describe the means the institution proposes to take to support these priority areas (e.g. institutional resources to capitalize on the infrastructure, creation of new academic staff positions, research chairs, etc.).

Establishing the Canadian Environmental Mining Research Centre at Britannia Beach will provide Canada and the global mining industry with a world-class facility to conduct innovative research to meet the needs of society in the 21st Century. It is still not widely recognized that Mining has transformed itself towards a focus on sustainable development and respect for and protection of the environment. In fact the term Sustainable Mining sounds like a contradiction in terms - doesn't it? UBC-Mining has been a leader in providing a vision of Mining in the 21st Century that considers the environment to be just as important, if not more so, in decision-making as economics and technology.

Many in our society today view mining as a backward industry that pollutes and destroys and exploits. Greed, stock-scams, strikes, and disasters are the order of the day in the minds of many people. It is time to wake up our population to understand that this view is dated and inaccurate. It is time to demonstrate that the industry is as modern and forward-thinking as any. It is time to show that research is the driver behind the changes that are taking place as the industry develops a "gentler" approach to its business.

This research centre will capitalize on several major opportunities:

1. Britannia Beach will be transformed from an eyesore into something of value and environmental research will be the catalyst for this to happen.
2. The location between Vancouver and Whistler on the Sea-to-Sky highway is ideal to showcase Mining and its environmental technology to Canada and the World. Britannia Beach will be a gateway to the 2010 Winter Olympics.
3. Creating this research centre will encourage mining companies to expand their research and collaborate with one another, with universities, and with government.
4. Locating the research centre at Britannia is innovative in its own right - being at Britannia provides direct access to Acid-Rock-Drainage, a site with

contaminated sediments, sub-aqueous tailings, numerous waste dumps, mine tunnels, a community struggling to sustain itself, and a site with incredible heritage and historical values that will feed directly into the research directions.

5. Research will be identified as a significant contributor to the changes taking place in mining. It is a wonderful opportunity to showcase the power and benefits of intelligent research directly applied to solving significant problems.

The mining industry has mounted a number of sustainable initiatives around the world and they have been focused on the social, political, economic, and environmental factors associated with the field of sustainability and quite rightly so, as we attempt to engage our opponents in understanding the complexities of applying sustainable development concepts in mining. Unfortunately, concern for and integration of Technology into the dialog appears to be lacking. CERM3 and the Canadian Environmental Mining Research Centre intend to fill this gap and provide the innovations and new technologies necessary to support the introduction of sustainable mining technologies at the local, provincial, national, and global levels. We need technological goals that provide sustainable solutions such as: targets to decrease energy use; establishment of common guidelines for ARD treatment and sub-aqueous waste disposal; reclamation practices; safety and health issues; among numerous others.

Canada and other parts of the world have many legacy mine sites that have not been properly closed in accord with today's reclamation practices. A number of these sites are creating serious problems regarding effluent discharge of contaminants (acids and metals) and subsidence where communities have been build on top of old mine stopes that are now breaking through to surface causing significant caving and danger. The CEMR Centre intends to continue its research on legacy sites to attempt to implement solutions similar to that provided by the Millennium Plug installation at Britannia Beach in 2001.

The Mining Industry suffers from a poor image among the citizens that it serves. The average lay person does not have a good understanding of the role of mining in supplying the material needs of our modern society, but is certainly aware of the pollution and social problems created by some mining operations. The Press is quick to report on mine disasters and labour disputes but rarely tells us about the technological innovations and the industry's new approach to protect the environment. The establishment of a Research Centre at Britannia Beach provides an outstanding opportunity to "showcase" Canadian Sustainable Mining practices and the new way to mine in the 21st Century.

Other innovative developments are occurring at Britannia Beach. NRCan, who intend to sponsor our centre and collaborate with us on the research, are planning to build a major Interpretive Centre on Mining. The BC Museum of Mining is planning for the site to become a major tourist destination with hundreds of thousands of visitors each year. Installation of the UBC-CEMR Centre together with these other activities provides a way to demonstrate the Past, the Present, and the Future of Mining in one place. Our efforts at the site have contributed to drawing these different projects together to turn something that is currently an embarrassment into something of beauty that all British Columbians and Canadians can be proud of.

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Innovative Research for the Challenges of Mining in the 21st Century
- the Canadian Environmental Mining Research Centre

No other facility of its kind exists anywhere in the world to our knowledge and no other opportunity such as this exists to link research directly to a "real problem" and solve it immediately. If the research of UBC-CERM3 is to move into industry and be accepted, conducting these studies at a "real", albeit, closed mine is one way to demonstrate that some academics who inhabit the "ivory towers" are prepared to get dirty once in awhile and provide innovative, sustainable and economic solutions for industry.

With the Water Treatment Plant opening in 2004, the initial research efforts of the centre can focus on helping to reduce the costs of operating this plant "in-perpetuity".

Graduate students and researchers from industry and government can mingle and work together in an environment that is clean, attractive, and perform essential service to an industry in need of innovation and a new image.

The researchers who will use the CEMR Centre have substantial international collaboration with many outstanding international research groups. Among these are CSIRO in Australia, Tohoku University in Japan, Massey University in New Zealand, the University of Chile in Santiago, CETEM (Mineral Technology Centre of Brazil), Capetown University in South Africa, and numerous European schools of mining in Germany, France, Holland, England, and Italy. The presence of this centre will impact on our ability to attract the world's best researchers to BC and Canada. Mining companies from around the globe will want to participate in our centre because of its ability to conduct meaningful research and provide a positive image to the outside world.

We have taken great care to integrate this facility into the plans of existing facilities on the Point Grey campus. A plan is in place to ensure close contact is maintained with the main campus through secondments and sabbatical leaves. The CEMR Centre fits in to UBC's strategic research plan almost perfectly. A major plank of this plan is the promotion of sustainability with a focus on collaborative environmental research.

Collaborative approaches to research are now the norm at UBC rather than a unique experience. CEMR certainly will continue to stimulate this activity and will also contribute to the university's goal to reach out to the surrounding community and engage its members in its activities to help them understand the importance of research in a vibrant, sustainable country that contributes to its neighbours and partners around the world.

The senior administration at UBC is extremely supportive of this initiative and will provide in-kind contributions to the construction of the facility. As the work of the centre develops, it is likely that two new Faculty Chairs will be created - one in Waste Rock Management and a second in Mining and Communities. Discussions have already begun with industry to gauge support for these ideas.

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- the Canadian Environmental Mining Research Centre

Self-assessment

B2 - Training, through research, of Highly Qualified Personnel (HQP)

Choose the statement that best represents the infrastructure project.

The infrastructure project will support the training of HQP, through research, by imparting:

☐ (a) the basic skills and expertise required to undertake research activities or other endeavours;

☐ (b) an appropriate set of skills and expertise needed in areas of importance to Canada;

☐ (c) a broad range of high-level skills and expertise in areas of critical importance to Canada;

☒ (d) an exceptional set of high-level skills and expertise that are considered as "world class" in areas of critical importance to Canada.

Using the space below and up to 1 additional page, address all of the following

- how the proposed infrastructure will create a stimulating and enriched training environment for HQP;
- current HQP training at the institution(s) and future plans for HQP training to be carried out with the proposed infrastructure. Include the current number and level (undergraduate and graduate students, postdoctoral fellows, technicians, technologists other trainees/students) of HQP trained as well as the number and level of HQP to be trained as a result of the proposed infrastructure.

The presence of this innovative research centre will allow us to attract outstanding people to our graduate school programs from a variety of backgrounds. Not only will these students be working in Mining Engineering, but the centre will also support students from each of the departments involved in the proposal - Mining Eng., Earth and Ocean Sciences, Civil Eng., Electrical Eng., Metals and Materials Eng., Chemical and Biological Eng., Microbiology, Chemistry, Soil Science, and Landscape Architecture.

Evidence exists to support this statement. Before CERM3 commenced operation in 2000, enrolement in our Mining department graduate programs stood at about 25 students. After the creation of CERM3 in 2000 following the awarding of the CFI Innovation Grant, our enrolement rose dramatically to 50 students in 2002. This is a phenomenal growth rate and placed considerable strain on our facilities. However through careful planning and judicious reassignment of our space, we managed to make everyone feel at home. It is likely that this growth will continue as the CEMR Centre comes into operation in June 2006. UBC will become the research capital for mining and the environment in Canada and around the world.

A total of 30 graduate students are expected to be studying in our Centre at any one point in time by 2008. About 5 post-doctoral positions will also be created. At this level of activity, an additional output of 12-14 postgraduates would be expected (9-10 Masters and 3-4 Doctorates).

Exposing young graduates to Britannia Beach - the Museum, the Mine, the Treatment Plant, the Interpretive Centre, the old mill facilities, and the local community - will have a major impact on their education and knowledge. The researchers will consist of UBC faculty on sabbatical as well as seconded researchers and personnel from industry and government agencies. Interactions with these industrial researchers from other countries will compliment our graduates' educational needs. Working at a real contaminated site with real-world problems presents some opportunities to conduct extremely innovative research. Field testwork will be at "one's doorstep" so to speak ensuring the need for practical considerations of climate and other characteristics of the natural environment.

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Sustainability is a complex subject with multiple contexts and multiple disciplines involved in the work. For mining, processing, geological and metallurgical engineers who receive training in sustainability, a major improvement in the quality of their education will occur - a truly "World Class" experience at what will be a "World Class" site.

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Self-assessment

B3 - Research Collaborations and Partnerships

Choose the statement that best represents the infrastructure project.

The proposed research infrastructure will create or strengthen:

☐ (a) collaborations among researchers (e.g. collaboration on funded projects, co-authorship);
☐ (b) collaborations among researchers from different disciplines, institutions, sectors or countries;
☐ (c) partnerships (e.g. formal signed agreements) among research institutions in the same sector or from different sectors;
☒ (d) international partnerships among research institutions or among sectors.

Using the space below and up to 1 additional page, address all of the following aspects:

- what collaborations or partnerships already exist;
- what collaborations or partnerships are planned;
- what steps have been taken or will be taken to create or strengthen collaborations or partnerships;
- how the infrastructure is essential to the collaborations or partnerships.

The CEMR Centre intends to be a catalyst for provincial, national and international collaboration. We cannot expect to accomplish our broad-based program without attracting the best researchers in the world to our new research centre. Our collaborations are based on establishing a reputation for conducting practical, targeted research for industry. The presence of the CEMR Centre at Britannia Beach will enhance this atmosphere by providing a mechanism for outstanding researchers from other institutions and companies to come to Canada. Part of the annual budget of the Centre is designed to provide funding to bring these people to British Columbia to work.

The synergies we have developed with NRCan will lead to optimal and complementary work being conducted by various federal agencies studying mining and the environment through access to our facilities.

We plan to grow on our current collaboration in specific research projects with several national and international institutes. These include specific researchers from a number of BC, Canadian and international universities and organizations:

- NRCan - CANMET (Roy Sage - revegetation and geothermal energy);
- University of Victoria (Tom Pederson - sub-aqueous waste disposal);
- Simon Fraser University (Diana Allen - stable isotopes in environmental sourcing);
- Laurentian University (Greg Baiden - telerobotics and advanced control in U/G mines);
- University of Chile (Enrique Rubio - block caving methods);
- University of Arizona (Sean Desserault - automated mine design);
- University of Queensland (Don McKee - sustainable mining);
- Massey University (Chris Anderson - phyto-mining and phyto-reclamation);
- Tohoku University (Yoshiyuki Kawazoe - supercomputer support for First-Principles modeling);
- CSIRO, New South Wales, Australia, (Steve Spencer - energy use in comminution),
- other interested universities and organizations with relevant innovative expertise.

One must not presume that any single institute has the capability to support all

dimensions of the proposed research program. Accordingly, the CEMR Centre intends to be an international focal point for collaborative research with universities and government or industrial research institutes around the world that possess the specific skills needed to accomplish our goals.

For example, the possibility of this centre being created has already led to a collaborative research project in Bahia, Brazil to reclaim mercury and gold from a waste pile. These field experiments include input from UBC-CERM3, Massey University, and CVRD (the largest mining company in Brazil). This summer we will be harvesting the first crop of corn and beans growing on a coarse waste rock pile of an oxidized gold ore.

By attracting such researchers to our Centre, it will become a world-class facility for world-class researchers. Development of this research proposal has presented CERM3 with the opportunity to generate significant collaboration with many Britiannia-based stakeholders and interested parties. The two landowners at the site (BMARC and BHSS) have entered into agreements to provide us with land on which our building and constructed wetlands are to be located. The local Britannia Beach community was engaged through several workshops aimed at collectively develop our plans. Over 70 people from over a dozen organizations and community groups were involved in these discussions and site planning.

Prior to installing the Millennium Plug Research Station at the 2200 Level of the mine, we held information meetings with the local community to receive input and allay fears about the plug failing. This process has brought together certain groups that have not talked with one another for many years because of suspicions and other misunderstandings. The workshop process employed on this project has been a catalyst for change by bringing together groups of people for the first time in over a quarter of a century to develop a collective plan to restore the mine site to something of value for all Canadians. At this point in time, we cannot imagine how a better research plan could be drafted to serve Canada’s key industry and its communities.

The infrastructure (building, facilities, and equipment) is essential to help attract the best high-quality researchers to the Centre. Specific pieces of equipment and components such as the MagLev hoisting testbed, the remote-sensing facility and the microbiology and phytoreclamation labs will provide significant incentives to attract researchers not only from mining-related institutes, but also from other sectors such as manufacturing, high-technology, microbiology, etc.

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Self-assessment

C - Potential benefits of the research to Canada

Choose the statement that best represents the infrastructure project.

The proposed infrastructure will support research that has the potential to:

☐ (a) contribute indirectly to economic activities (e.g. economic growth, cost savings, job creation) **or** contribute indirectly to the improvement of society, quality of life, health, or the environment;

☐ (b) improve economic activities (e.g. economic growth, cost savings, job creation) **or** improve society, the quality of life, health, or the environment;

☐ (c) contribute to increased economic activity in strong or emerging areas of the Canadian economy **or** yield a major benefit in terms of society, quality of life, health, or the environment;

☒ (d) contribute significantly to increased economic activity; help Canadian industry increase its global competitiveness and create new economic ventures; **or** lead to dramatic sustained improvements to society, quality of life, health, or the environment.

Using the space below and up to 1 additional page

- identify potential users of the research results; including partnerships with industry, health providers, etc.
- describe expected benefits, how these will be realised and the timeframe over which they are expected;
- where appropriate, provide plans for the development of clusters and for technology transfer, other forms of commercialisation or transfer of know-how, as well as contributions to policies and practices.

The purpose of our research program is to develop innovative mining technologies that enhance sustainability of the industry and/or local impacted communities. Specifically, we see the research as support for mining companies to continue operating in a region of the world effectively and efficiently. The benefits to the company will ensue from cost savings from reductions in energy and raw material use, from less expensive environmental protection measures, from the goodwill gained by being know as an industry that protects the environment and cares for its people, and from developing an integrated design (the "Green" Mine) that produces synergies not yet fully appreciated. Local communities will benefit through lower pollution levels, a safer workplace, support infrastructure for local specific health and social problems, and creation of new employment opportunities.

Canada's mining industry represents about 4% of our GDP directly. With indirect contributions from the manufacturing sector and other service-related industries, this increases to 13%. The only other country in the First World with such a dependence on mining is Australia which relies on mining to the degree of about 30%. Obviously the economies of numerous Second and Third World nations - South Africa, Chile, Brazil, Mexico - have an even higher reliance. The world is still highly dependent upon on material wealth derived from the earth and, likely always will be. As the industry globalizes, interconnections between different countries and different sectors become increasingly important. The impact of a decision in a far part of the world can have significant ramifications on Canadian companies either through increased competition or directly on our economy through subsidiary partnerships that accompany such internationalization. Our research will provide knowledge on these complexities.

A major roadblock to continued operation of Canadian mining companies here in Canada and abroad is the increasing pressure from society for better environmental practices and improved social-political responses to the needs and desires of local populations, particularly indigenous people. Not only does impacts on the environment require

innovative approaches around the world but also a reaction to local pressures by communities that will experience change and upheaval through the intrusion of a new mine. Even the benefits of increased employment and better infrastructure support (roads, schools, hospitals) can lead to social unrest through attraction of undesirables to the area to exploit people. The best laid plans of a company to provide benefits can often "fly back in one's face" because of secondary negative effects such as increased crime and corruption. Health problems such as AIDS and SARS and other pandemics can also result. Just as the west coast First Nations in Canada were decimated by disease upon the arrival of the European explorers and settlers who inadvertently brought new viruses and other diseases, so too does the creation of a "better" life bring with it the need for vigilance in addressing community impacts.

The global mining industry is taking great care these days to introduce the concepts of sustainable development into their approach to new projects and existing ones. The Global Mining Initiative which began in 2000 is an example of how mining companies have come to understand that they must take on duties that previously were considered the role of local
government. In addition the planning of such actions must be done openly with collaboration of local communities or else suspicions arise about the company's true motives. While the Global Mining Initiative was successful in initiating change in industry with respect to social and environmental issues, there is a gap developing between the technologies of mining and the need for sustainable-technology targets. Engineers and scientists are not trained to deal with the breadth of issues that come with
sustainability. Often the "optimization" of a technical decision is not well-understood in terms of different contexts such as "sharing the wealth", "need for culture", "open dialog", etc.

What is missing in the discussions today is a focus on specific sustainability targets for mining technologies. For instance, the requirements of the Kyoto Protocol for Canada at this point simply stated are "to decrease energy consumption to 6% below the 1990 level by the year 2010". For our industry to meet such a target and the deeper cuts to come, it is necessary to develop new processes and nnovative solutions to energy consumption in crushing and grinding.

It is UBC's intention to see that the research conducted in the CEMR Centre fills this gap - that the research output will be adopted by industry to improve their processes, reduce their costs, eliminate pollution, create sustainable communities, and stabilize and optimize their mining operations by implementing sustainable technical and social practices.

If we are successful, especially in the area of energy reduction and development of new "clean" energy resources, the impact on Canada's contribution to the Kyoto Protocol can be substantial. While it takes time for an industry to implement new technologies, we intend to focus on two ways to encourage such technology transfer. In the short-term, we will
develop methods to be incrementally added to a process relatively cheaply and with relatively low impact on existing operations. In the longer term, we will examine revolutionary innovations that may demand complete replacement of a process or unit operation with one that improves the operation substantially in terms of efficiency, effectiveness, protection of the environment, or reduction in costs.

Page 10C - Potential Benefits to Canada
(continued from Page 10B)

The strategy of our research program will be aimed at quickly developing support for our research through direct feedback of the fruits of our work on individual projects of interest to a single operation. As our reputation builds, our efforts will expand to encompass broader projects to change the industry. In this way, acceptance of research as a catalyst for change for the good will be put into place and the Canadian mining industry can develop applications to maintain their competitiveness in the global marketplace and their attractiveness to other countries that currently welcome Canadian mining expertise.

The Canadian mining industry cannot compete effectively without developing and using innovative state-of-the-art technologies in order to maintain its position in the global marketplace. We also envisage a number of spin-off companies developing from our Centre to provide service to industry to supply new processes, new software, new tools to protect the environment, and new business opportunities from new markets and new products.

Several consulting service companies have expressed interest in being involved in the CEMR Centre. We are exploring financial models for our Centre to allow these smaller firms to access our equipment and research without having to outlay large amounts of money.

Technology Transfer has been a hallmark of UBC's approach to research and many of the methods (patents, trademarks, etc.) developed in other fields such as pharmacology, medicine, dentistry, forestry, pulp and paper, etc. will be studied for application in our centre.

The CEMR Centre will serve to enhance the understanding that research is an economic driver and must be used as the engine of new ideas, new products, new processes, and new companies. Furthermore, we firmly believe that by helping industry increase its use of sustainable practices on a global basis, the benefits to society in terms of employment, stable economies, reduced environmental impacts, healthier communities and workers, and a more-caring attitude towards the neighbourhood and the neighbours will continue to grow and receive wide recognition. Canadian practice in this regard is well-respected today, but there are problems, i.e., tailings dam failures, riverine disposal practices, etc. Our research can help evolve best-practice approaches to current and future mining development.

We believe the creation of the CEMR Centre will help increase economic activity in the mining industry by putting Canada in the forefront of innovation in Sustainable Mining. We wil help the Canadian mining industry increase its global competitiveness and create new economic ventures. This will lead to dramatic and sustainable improvements in society through continued wealth-generation and intelligent use of the earth's resources. Substantial improvements in the quality of life, health, and the environment for those dependent on mining for their livelihood and for those impacted by mining will result.

SUGGESTED REVIEWERS

Date: 19/05/2003 Project number: 7588

Title of project: Innovative Research for the Challenges of Mining in the 21st Century - the Canadian Environmental Mining Research Centre

Institution: University of British Columbia

Designated Project Leader Meech, John

Complete this module for all applications to the CFI. Identify six (6) reviewers appropriate for the application. **Reviewers must not** be current or recent (within the last 6 years) collaborators, departmental colleagues, students or supervisor(s).

Provide a complete mailing address, telephone number, fax number, **current e-mail address**, and the areas of expertise of potential reviewers. Suggested reviewers may be Canadian or international and should be able to evaluate the application in the language in which it is written.

The CFI reserves the right to make its own selection of reviewers.

Name: McKee, Dr. Don
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Area(s) of expertise (key words): all aspects of mineral processing, mineral policy, sustainability issues in mining

Canada Foundation for Innovation

SUGGESTED REVIEWERS

Date: 19/05/2003 Project number: 7588

Title of project: Innovative Research for the Challenges of Mining in the 21st Century - the Canadian Environmental Mining Research Centre

Institution: University of British Columbia

Designated Project Leader: Meech, John

Reviewers must not be curent or recent (within the last 6 years): collaborators or departmental colleagues, students or supervisors. Provide a complete mailing address, telephone number, fax number, **current e-mail address**, and the areas of expertise of potential reviewers. Suggested reviewers may be Canadian or international and should be able to evaluate the application in the language in which it is written.

The CFI reserves the right to make its own selection of reviewers.

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Area(s) of expertise key words): sustainability, life-cycle analysis, environmental studies, particulate processes, supply chains