

ASSET MAP FOR BC'S MINING & ENERGY SECTOR



Genome
BritishColumbia
Leading > Investing > Connecting

GENOME BRITISH COLUMBIA

Vision

Genomics will revolutionize many aspects of our lives and provide solutions to humankind's challenges.

Mission

Genome British Columbia leads academia, government and industry in the growth of a world-class genomics R&D cluster to deliver sustainable social and economic benefits to British Columbia, Canada and beyond, through:

- Excellent projects and technology platforms,
- Innovative applications for the life sciences cluster,
- Strategic regional, national & international collaborations, and
- Proactive leadership in exploring societal impacts of genomics.

Genomics is the science that aims to decipher and understand the entire genetic information of an organism (i.e. microorganisms, plants, animals and humans) encoded in DNA and corresponding complements such as RNA, proteins and metabolites.

The knowledge and innovations emerging from this field are finding solutions to complex biological challenges, while at the same time raising questions of societal and economic importance.

Genomics has already brought huge economic and societal gains to Canadians through better healthcare, improving food quality, safety and production and protecting our environment and natural resources.

Looking ahead, genomics will be the foundation of Canada's growing bio-economy (all economic activity derived from life science-based research), which is estimated to be responsible for some 2.25 per cent of GDP, or about \$38 billion, by 2017.

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EXECUTIVE SUMMARY

BC's abundant energy and mineral resources have enabled development of an innovative, growing energy and mining sector. The percentage of total provincial GDP attributable to mining, quarrying, oil and gas extraction was 5% in 2012. Despite year-to-year fluctuations in mineral, metal, and energy prices, global demand for these commodities continues to grow. The recently signed free trade agreement with Korea is expected to further boost coal, metal and gas exports from BC. However, given the naturally limited supply of these resources, there is increasing pressure both to maximize the cost efficiency and to minimize the environmental impact of mining and energy operations which yields opportunities for applied research and innovation.

A competitive industry landscape, including companies, industry associations and service suppliers, an advantageous regulatory framework, and key enabling infrastructure for delivery of mining and energy products, provide incentives for investment in and development of this sector in BC. Nineteen mines are currently operating in BC (9 metal, 10 coal) and several are in late stages of permitting. The major commodities mined in BC are coal, copper, silver, and zinc. BC holds Canada's second largest unconventional gas reserves. Current estimates indicate that there is potentially 1,200 trillion cubic feet (Tcf) of shale gas in northeast BC which forms the basis of the Province's recent Liquefied Natural Gas (LNG) strategy. Most major oil and gas companies have operations in exploration, production and processing of natural gas in BC. With its proximity to Asia, BC is also an important enabler of getting extracted resources from the rest of Canada to new markets via rail, pipelines and ocean transport. The scale of activities in exploration, operations and transportation in the sector requires careful assessment of risk to environment and development of mitigation strategies.

In addition to industry assets, the mining and energy sector in BC is supported by significant innovation assets. These include strong mining and energy research capacity in research centres and institutes, education and training programs, and a robust investment environment and funding opportunities. BC is home to significant breadth and depth of mining, energy, and enabling technology researchers across its 25 publically funded higher education institutions in addition to the intensive research underway in many mining, oil and gas companies. Within the higher education sector, particular research strengths exist in geospatial, production, and remediation. The Province supports more than 40 Canada Research and other endowed Chairs with expertise relevant to the sector, hosted by 6 of the province's colleges and universities: University of Victoria, University of Northern BC, Simon Fraser University, Thompson Rivers University, UBC and UBC Okanagan. Many sector-relevant and government or regulatory agencies listed in such as Environment Canada and NRCan also engage in research programs.

BC has also built significant infrastructure and enabling capacity for genome sciences. Genome Canada and Genome BC in particular have enabled development of considerable genomic expertise and infrastructure in the province. This capacity is now deployed to address research questions across many different disciplines including the energy and mining sectors. In addition, all BC universities host laboratories and equipment capable of sequencing and interpreting genomic information. As the price of sequencing declines, genomics is becoming a standard tool for researchers to better understand biological processes.

Several longstanding and more recent funding programs offer support for research, development, and/or commercialization activities in mining and energy sector in BC. These programs present opportunities for growth, development, and sustainability for innovation using genomics in the mining and energy sector in BC.

INTRODUCTION

The mining and energy sector provides essential raw materials and fuel sources for industries and homes worldwide. In addition, mining and energy provide direct and indirect employment opportunities for a significant proportion of the population. Despite year-to-year fluctuations in mineral, metal, and energy prices, global demand for these commodities continues to grow. However, given the naturally limited supply of these resources, there is also increasing pressure both to maximize the cost efficiency and to minimize the environmental impact of mining and energy operations. Genomics-based innovations exploiting biological processes could play a significant role in meeting these challenges. While most exploration, production and remediation in the mining and energy sector is currently driven by chemistry-and engineering-based innovations, genomics could uncover causes and effects and enable development of more effective monitoring and troubleshooting tools. Thus, investing in genomics research could enable strong, competitive growth in BC's mining and energy sector by enhancing exploration and processing of raw resources, as well as increasing their economic viability and environmental sustainability.

BC's position on the Pacific Cordillera, a mountain belt rich in minerals and coal, means that mining and mineral exploration have been a significant part of BC's economy since the mid-1800s, when early explorers laid claim to initial discoveries of gold, copper, and coal. Hudson's Bay Company first started producing coal in BC the 1840s, and the discovery of gold along the Fraser River in the 1850s sparked a gold rush. Most mining historically took place underground; however, by the 1960s, open-pit mines became increasingly feasible and several large copper mines initiated production in BC.

Oil and gas exploration and development began in the twentieth century, based upon seeps suggesting that there might be underlying oil and gas reserves in BC. In the 1950s, the identification of the Western Canada Sedimentary Basin (WCSB) in northeastern BC led

to intense development and construction of pipelines to these resources. Today the oil and gas sector remains focused in the northeast, although nine other hydrocarbon basins and two geological troughs with development potential have been identified: the Bowser Basin (northern BC), the lower Fraser Valley, the Nechako Basin (central BC), the Queen Charlotte Basin and Vancouver Island (onshore and offshore), and the southern Kootenays.

This asset map focuses on extracted natural goods; it does not cover assets associated with hydroelectric, bioenergy (renewable energy produced from biological sources), or other alternative energy sources. In addition, it does not include assets associated with non-mineral mining (e.g. industrial minerals such as gypsum, magnesite, and limestone, or quarries producing sand, gravel or crushed aggregate).

An Overview of BC's Mining and Energy Sector¹

BC's abundant energy and mineral resources have enabled development of an innovative, growing energy and mining sector. Mining and energy are key economic drivers in BC; the sector contributed combined government revenues (including free miner certificates, mining receipts and taxes, royalties, and other fees and rentals) of \$1.35 billion in 2012. The percentage of total provincial GDP attributable to mining, quarrying, oil and gas extraction was 5% in 2012².

The Mining Subsector

BC is Canada's largest exporter of coal, and is particularly well known for high-quality metallurgical coal (i.e. for steelmaking). BC is the largest producer of copper in Canada, and the only province producing molybdenum.

Figure 1: Map of Key Mining Subsector Activities in British Columbia



Nineteen mines are currently operating in BC (9 metal, 10 coal; see **Figure 1 and Table 2**)⁴. The seven major commodities mined in BC are coal (52% of net provincial mining revenue in 2012, including metallurgical coal and thermal coal), copper (19%), silver (10%), zinc (9%), gold (4%), molybdenum (3%), and lead (2%)^{3,4}. Gross mining revenues in BC were \$9.2 billion in 2012, down from \$9.9 in 2011.

The mining sector is expanding in BC. Eight new mines are planned, and 9 others being expanded by 2015 under the BC Jobs plan, for a total of 15,000 projected new jobs⁵ (see **Appendix 1** for a full list of mines from late exploration to closure). More than 30,000 people were employed in the mineral exploration, mining, and related sectors in 2012 in BC⁶. Wages for these positions are well above BC's provincial average: BC miners earn an average annual salary of more than \$121,900 including benefits, and more than 15,000 job vacancies are projected in the industry over the next decade to accommodate growth and the retirement of more than 20% of workers⁷. In most cases, these job opportunities are localized to rural and/or First Nations communities (see **Figure 1**), where alternative development and employment opportunities may be limited.

The Energy Subsector

The energy (oil and gas) subsector in Canada has historically been concentrated in Alberta. Since the mid-1950s, some 17,000 oil and gas wells have been drilled in BC, though BC's industry remains closely tied to Alberta's.

BC is primarily a gas-producing jurisdiction and capacity is expanding rapidly, driven largely by unconventional gas developments (see **Figure 2**⁸). BC holds Canada's second largest reserves accounting for 41% of Canada's marketable natural gas reserves in 2012⁹. Canada's natural gas resources account for about 1% of world reserves and about 5% of world production¹⁰ making the BC gas industry an important contributor to Canada's economy. Industry investment in BC grew from \$1.8 billion in 2000 to \$7.1 billion in 2010¹¹.

In Natural gas production was roughly 38.2 billion cubic metres in 2011, a 9% increase over 2010 levels, while crude oil and condensate production was 1.2 million cubic metres in 2011 (some 20,000 barrels of crude oil per day), a 24.4% decrease over 2010 levels. The number of wells authorized and drilled has consistently decreased over the last decade as

³ BC's Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

⁴ The Mining Industry in BC 2012. PriceWaterhouseCoopers; 2013.

⁵ BC's Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

⁶ Annual Service Plan Report 2012/13. BC Ministry of Energy, Mines and Natural Gas; 2013.

⁷ The Mining Industry in BC 2012. PriceWaterhouseCoopers; 2013.

⁸ BC Energy Plan: A Vision for Clean Energy Leadership. BC Ministry of Energy, Mines and Petroleum Resources; 2009.

⁹ <http://statshb.capp.ca/SHB/Sheet.asp?SectionID=2&SheetID=150>

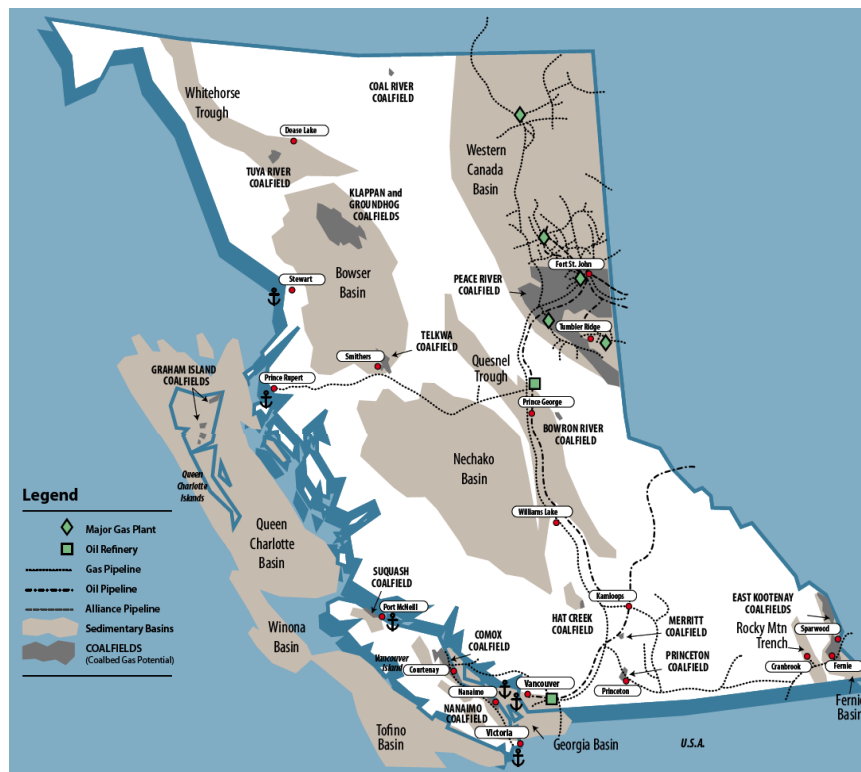
¹⁰ IEA Key World Energy Statistics 2013

¹¹ BC's Natural Gas Strategy. BC Ministry of Energy and Mines; 2012.

new horizontal drilling technology has been adopted which can extract resources in a more efficient manner¹².

Marketable reserves of gas were estimated at 782 billion cubic metres, while remaining oil reserves were estimated at 18.7 million cubic metres, in 2010¹³. The contribution that unconventional sources of gas (e.g. tight, coalbed, and/or shale gas) make to total gas resources is expected to increase significantly over the coming decade, as formerly inaccessible depots become extractable. Current estimates indicate that there is potentially 1,200 trillion cubic feet (Tcf) of shale gas in northeast BC¹⁴ which forms the basis of BC's recent Liquefied Natural Gas (LNG) strategy^{15,16}.

Figure 2: Map of Key Energy Subsector Activities in BC



¹² 2012 BC Financial and Economic Review. BC Ministry of Finance; 2012.

¹³ 2012 BC Financial and Economic Review. BC Ministry of Finance; 2012.

¹⁴ Adams C. Summary of shale gas activity in northeast British Columbia 2012; in Oil and Gas Reports 2013. BC Ministry of Natural Gas Development; 2013.

¹⁵ Liquefied Natural Gas: A Strategy for BC's Newest Industry. BC Ministry of Energy and Mines; 2012.

¹⁶ BC's Liquefied Natural Gas Strategy: one year update. BC Ministry of Energy and Mines; 2013.

Markets and Competitive Position of the Mining and Energy Sector in BC

The Mining Subsector

The mineral exploration and mining subsector faced significant economic uncertainty in 2013. The primary driver of the global mining industry's growth is commodity prices, which are set in response to global supply and demand. Global mineral supply is increasingly limited as the number of new operations decreases in response to lack of new discoveries, lack of sufficient capital for exploration and infrastructure costs, regulatory challenges, and environmental concerns¹⁷. On the demand side, rapid urbanization is driving increasing global demand for steel-making coal, metals and industrial minerals. To reduce the risk arising from fluctuations in commodity prices, most firms focus on minimizing capital and operating costs and maximizing extraction efficiencies. Only the most efficient mines can afford to continue operating when prices are low.

Metallurgical coal is BC's most valuable mineral commodity and is expected to remain in high demand. Most of BC's coal is exported to Japan and South Korea for steel production, and China is becoming a particularly strong investor in BC's coal mine developments. China is projected to become the biggest coal importer by the early 2020s. BC's mineral exports to Asia exceeded those to the US for the first time in 2011. Copper is expected to remain in strong demand for use in manufacturing of computer and cell phone technology, green technologies, and anti-microbial surfaces¹⁸. Molybdenum is used for making steel alloys (e.g. stainless steel), tools, and machine parts and is also expected to stay in high demand. Zinc, gold and silver exploration, especially in politically stable regions like BC, continues to receive attention from investors since supply of these commodities is limited. BC's rich mineral potential and stable policy environment is expected to encourage further investment into the province¹⁹.

¹⁷ McPhie, M. Prospects for Mining in British Columbia. A report for the BC Business Council in Support of the Opportunity 2020 Project. HB Global Advisors Corp; 2009.

¹⁸ BC's Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

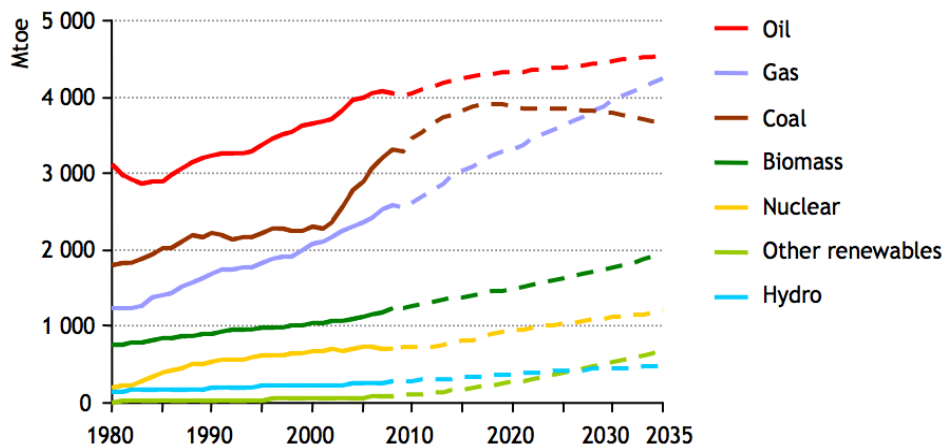
¹⁹ McPhie, M. Prospects for Mining in British Columbia. A report for the British Columbia Business Council in Support of the Opportunity 2020 Project. HB Global Advisors Corp; 2009.

The Energy Subsector

Oil

Historically, most energy needs were met by coal or oil, and oil remains in high demand (Figure 3²⁰).

Figure 3: Historical and Predicted World Energy Demand by Fuel Type.



The US is expected to overcome Russia and Saudi Arabia to become the world's biggest oil producer by 2020, as it applies horizontal drilling and hydraulic fracturing technologies to rock and shale layers in North Dakota and Texas²¹. Brazil is predicted to meet all domestic energy needs and to become a major oil exporter by 2030, based on recent offshore developments and significant investment in renewable energy developments²². As supply from Brazil and the US increases, the need for Middle East oil was predicted to decline up to 2020. However, beyond 2020 the Middle East is expected to again become a dominant supplier of oil, due to the limited resource base of the US tight oil²³.

The US, which has historically been a large energy importer, is on track to meet its own energy needs through domestic supply by 2035²⁴. China and India are becoming the biggest oil-importing countries. Because the supply of conventional crude oil is naturally limited, oil prices are predicted to continue rising, reaching \$128 per barrel (2012 dollars) by 2035²⁵. Given these increasing prices, growing demand for energy will be increasingly met by unconventional oil sources and natural gas reserves.

²⁰ From World Energy Report Special Report: Are We Entering a Golden Age of Gas? International Energy Agency. 2011.

²¹ U.S. to surpass Saudi as top oil producer by 2016 – IEA. Reuters; 2013.

²² BC's Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

²³ U.S. to surpass Saudi as top oil producer by 2016 – IEA. Reuters; 2013.

²⁴ World Energy Outlook 2013. International Energy Organization (IEA); 2013.

²⁵ BC's Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

BC's oil production is negligible compared to neighboring Alberta (20,000 versus 2 million crude oil barrels per day in 2011). Oil production in BC has been decreasing gradually since the early 2000's, and the Hay River Bluesky A oil pool is the major contributor to BC's remaining capacity for oil production²⁶. However, overall Canadian oil production, driven by Alberta's oil sands, is expected to grow steadily to 2030, which makes reaching new markets a top priority. Increasing demand in Asia is driving a growing number of transportation projects, some of which are proposed to cross BC (Enbridge Northern Gateway, Kinder Morgan Trans Mountain Expansion)²⁷ to expand transportation capacity. Increased offshore shipment by oil tankers from BC's shores and extra capacity by railway cars will also be required to connect energy supply from Western Canada to new markets. Thus, even if production volumes remain modest in BC compared to Alberta, increased volume of crude oil transported through BC will likely increase the risk of spills, leaks and failures on BC land and waters.

Gas

Global energy needs are increasingly expected to be met by natural gas (**Figure 3**), which is more versatile than oil or coal and is available in greater volumes, and can be economically used for heating, electricity generation and powering vehicles. The development of technologies to access unconventional gas reserves (e.g. shale gas, tight gas and methane hydrates) has inflated known global gas reserves such that gas production could continue to expand and meet demand for perhaps a century or more. Gas is expected to play an increasingly important role in Canada's economy, driven by exploitation of unconventional reserves (see **Table 1**)^{28,29}.

Table 1: Estimated Undiscovered Oil and Gas Resource Potential in BC³⁰

	Natural Gas (Tcf)*	Tight Gas (Tcf)	Shale Gas (Tcf)	Coalbed Gas (Tcf)	Oil (Bbl)**
Resource Potential					
Conventional	98				18
Unconventional		300	250	84	
Offshore	42				10

*Tcf: Trillion cubic feet **Bbl: Billion barrels

Other jurisdictions, including the US and Australia, are also expected to increase their natural gas export potential (**Figure 4**)³¹.

²⁶ Hydrocarbon and by-product reserves in British Columbia 2011, BC Oil and Gas Commission; 2011.

²⁷ 2013 Crude Oil Forecast, Markets & Transportation. Canadian Association of Petroleum Producers; 2013.

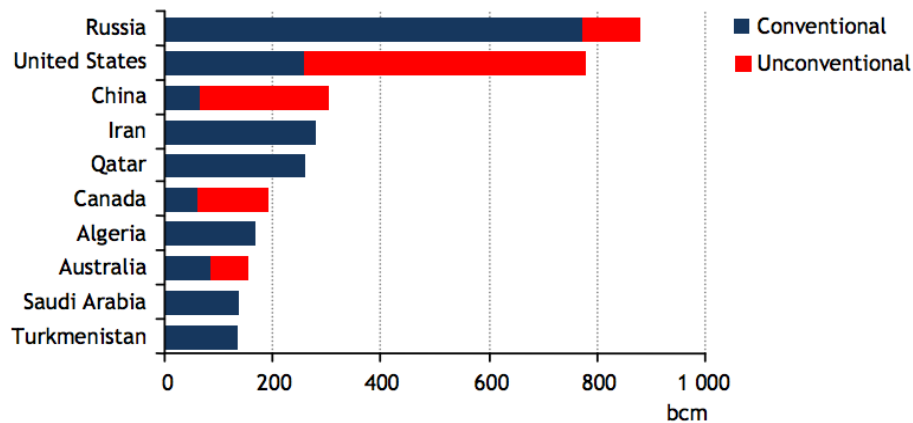
²⁸ <http://www.energybc.ca/profiles/naturalgas.html>

²⁹ The BC Energy Plan: A Vision for Clean Energy Leadership. BC Ministry of Energy, Mines and Petroleum Resources; 2009.

³⁰ The BC Energy Plan: A Vision for Clean Energy Leadership. BC Ministry of Energy, Mines and Petroleum Resources; 2009.

³¹ From World Energy Report Special Report: Are We Entering a Golden Age of Gas? International Energy Agency. 2011.

Figure 4: Predicted Largest Producers of Natural Gas in 2035.



BC is currently the second largest provincial producer of natural gas in Canada, producing 3.5 billion cubic feet per day compared to Alberta's 10 billion cubic feet per day in 2011. The contribution of unconventional gas to total BC gas production increased from 15% to 86% over three years and it is estimated to remain the main source for another 250 years³². Thus, the identification of large unconventional gas reserves in BC created a significant opportunity for BC to become a strong natural gas exporter.

Transporting natural gas to market remains a significant issue that has shaped development of natural gas markets. The pipelines that move gas from producing to consuming regions are huge political and economic investments. Natural gas can also be liquefied, by lowering its temperature to -162°C , to form LNG, which takes up roughly 1/600th of the volume of gaseous natural gas, making it far more economical for shipping. LNG technology is becoming an increasingly prevalent means of transporting natural gas across oceans, and is expected to break the regional pipeline networks that currently dominate the market, enabling producer access to more global markets³³.

While some of the LNG produced in BC will be used to meet regional energy needs (for example, as a replacement for diesel fuel), the majority of BC's growing LNG capacity is intended for export to China, which cannot meet national demand despite significant production and large gas reserves, and other Asian markets including Korea and Japan (**Figure 5**³⁴). The US is not expected to be a major market for BC LNG. BC's Ministry of Energy, Mines, and Natural Gas currently projects that LNG exports from BC could generate \$1 trillion in economic activity by the year 2046³⁵. However, as Chinese LNG supply increases over the coming decades, the window of economic opportunity for BC's LNG producers may narrow.

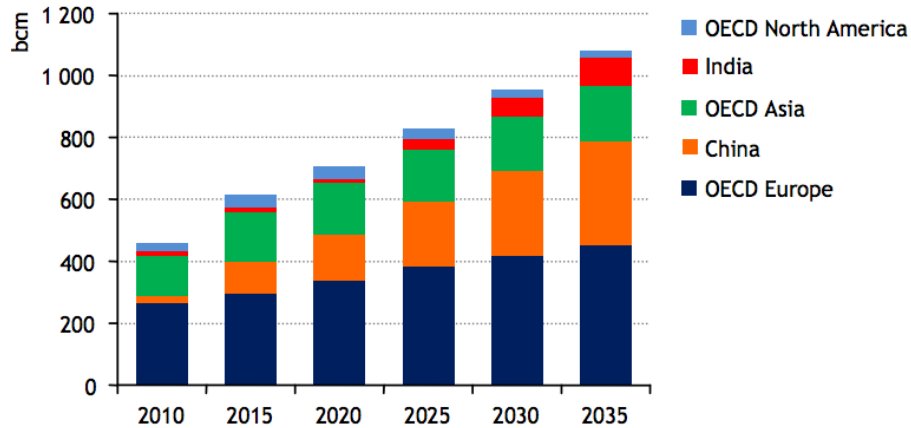
³² <http://www.energybc.ca/profiles/naturalgas.html>

³³ <http://www.energybc.ca/profiles/naturalgas.html>

³⁴ From World Energy Report Special Report: Are We Entering a Golden Age of Gas? International Energy Agency. 2011.

³⁵ BC's Liquefied Natural Gas Strategy: One Year Update. BC Ministry of Energy, Mines and Natural Gas; 2013.

Figure 5: Natural Gas Net Importers by Major Region, Projected to 2035.



BC'S MINING AND ENERGY SECTOR ASSETS

This section outlines assets associated with BC's natural energy and mineral resources. Recognising and understanding these assets is essential to developing genomics-driven strategies to improve the productivity and sustainability of the sector and to delivering mining- and energy-related economic and social benefits for BC. Natural resources form the foundation of the sector. A competitive industry landscape, including companies, industry associations and service suppliers, an advantageous regulatory framework, and key enabling infrastructure for delivery of mining and energy products, provides incentives for investment in and development of this sector in BC. A strong innovation ecosystem offers world-class research capabilities in geology, resource extraction, processing and remediation, and provides an enabling environment for application of genomics and related technologies.

Natural Resources

The heart of BC's competitive advantage in mining and energy lies in its vast reserves of minerals, metals, and oil and gas reserves.

The Mining Subsector

BC's underlying geology has given it rich mineral and coal resources. To date, mining activities have disturbed only 0.05% of BC's land base³⁶. Metallurgical and thermal coal is the major export, and holds potential for significant expansion. Copper and molybdenum are mined as primary commodities from a joint copper-molybdenum mine, and gold is

³⁶ Life Cycle of a Mine. Mining Association of BC; 2010.

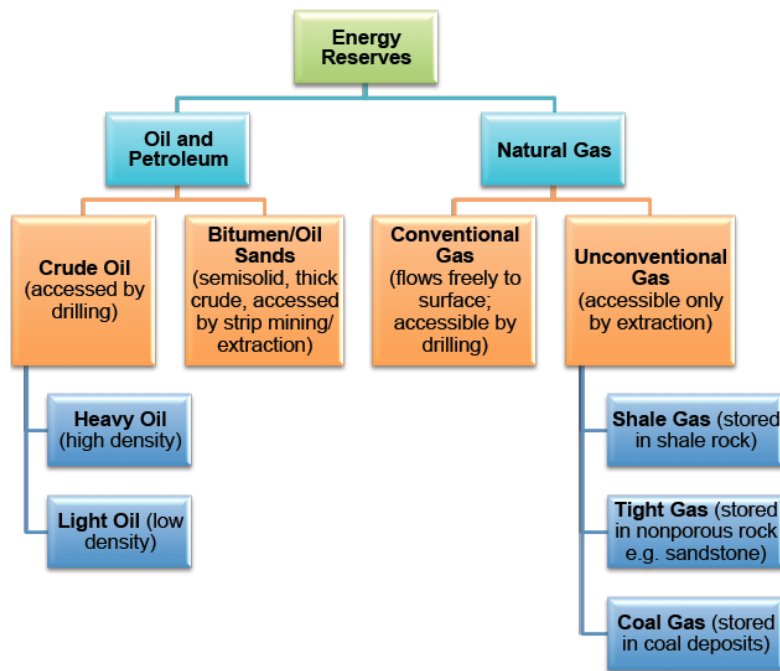
produced primarily as a coproduct at copper mines. BC's large volcanogenic and sedex sulphide deposits yield zinc, lead, silver and other precious metals. Several new zinc, lead, and silver developments are in the advanced stages of exploration (**Appendix 1**)³⁷.

An important resource asset arises from BC's geographical position. Much of the growth in demand for minerals and metals is projected to arise from rapid population expansion and urbanization in Asia. BC's position in the Pacific Northwest allows not only easy access to traditional North American markets via rail, road, and pipeline, but also via shipping to Asia (BC is home to the two North American ports that are closest Asia). This is expected to become an even more prominent feature of BC's mining and energy sector in coming years as shipping capacity to Asia expands to meet growing demand.

The Energy Subsector

Oil and gas are fossil fuels, formed when decaying organic material is buried and subjected to intense heat and pressure beneath sedimentary rock. There are multiple types of energy reserves (see **Figure 6**). Conventional crude oil, primarily accessed by drilling, may

Figure 6: Types of Energy Reserves. BC's energy subsector is primarily focused on natural gas production, with an increasing emphasis on unconventional sources.



be considered heavy (high density) or light (low density), and may be sweet (containing little sulphur) or sour (containing substantial sulphur). Since the 1950's in BC, conventional technologies have provided access to discrete pools of gas that flow readily to the earth's

³⁷ Opportunities to Explore: BC Minerals and Coal Industry. BC Ministry of Energy and Mines; 2012.

surface, but new technologies now facilitate access to unconventional gas resources that cover immense subsurface areas, often referred to as basins. Though production of both conventional and unconventional gas requires drilling and processing, the relatively new techniques of horizontal drilling and hydraulic fracturing are added to the production process for unconventional gas. Production growth in BC over the past ten years has derived primarily from the development of unconventional shale reservoirs (shale gas) or other tight sandstone, siltstone or carbonate rock formations (tight gas), though the other main types of unconventional gas resources, coalbed methane³⁸ and marine gas hydrates³⁹, are also abundant in BC. BC's primary energy resource is in gas fields, and the provincial government is making a major effort to make BC an international leader in LNG development and export⁴⁰. Current estimates indicate that there is potentially 1,200 trillion cubic feet (Tcf) of shale gas in northeast BC⁴¹. In the context of BC's current production levels, there thus remains room for significant growth.

Industry Assets

The landscape surrounding BC's mining and energy subsectors includes industry assets, a strong network of industry associations and support organizations, critical enabling infrastructure, and a competitive and sustainability-focused regulatory environment. These assets are reviewed in the following sections.

The mining and energy sector is very cyclical in nature. During times of economic expansion and attractive commodity prices, companies maximize operations and expand, while during downturns they may close down mines and oil and gas field operations, leaving them dormant until economic conditions improve. This creates an opportunity for mergers and acquisitions, making the industry landscape quite dynamic. The sector is also unique in the interplay between small, high-risk exploration firms and larger production companies. The main industry focus is on finding new deposits and increasing reserves. However, few exploration projects yield new production sites, and the time and cost of getting to operations is extremely high, making financing, merging and acquisition activities all dominant features of the sector.

Companies

BC Mines and Mining Companies

The mining value chain is comprised of three major processes before closure and remediation: exploration and identification of resource depots, resource extraction, and resource processing. The mining subsector in BC is characterized by dynamic interaction

³⁸ Owsjacki G, Payle G. Coalbed Methane Potential in British Columbia. BC Ministry of Energy and Mines; 2000.

³⁹ Strong D et al. BC Offshore Hydrocarbon Development: Report of the Scientific Review Panel. BC Ministry of Energy and Mines; 2002.

⁴⁰ BC's Natural Gas Strategy. Ministry of Energy and Mines; 2012.

⁴¹ Adams C. Summary of shale gas activity in northeast British Columbia 2012; in Oil and Gas Reports 2013. BC Ministry of Natural Gas Development; 2013.

between small exploration companies (termed juniors) and large established players (termed majors) carrying out extraction and processing. The high capital investment requirements and economies of scale and earning associated with mining mean that only majors have the capital and scale to open and operate mines. In BC this group includes Teck Coal, Teck Resources, Barrick Gold (2 closed mines in BC), Goldcorp (1 closed mine in BC), Imperial Metals, Anglo, and Thompson Creek Metals. These companies have the means to invest in R&D activities and drive innovations, including genomics technologies that could aid productivity and reduces costs.

BC also has the largest concentration of mining exploration companies in the world (>850 companies, representing an astonishing 18% of global mining investment in 2011)⁴². These firms are typically smaller and specifically focused on the exploration part of the value chain. More the \$700M was invested in mineral exploration in BC in 2012⁴³. However, most exploration companies based in BC undertake exploration primarily in territories outside of Canada. Canadian mining companies, led by BC, were one of the most active national sectors on the global merger and acquisition stage in 2012. Vancouver-based First Quantum Minerals Ltd (copper and others), Pan American Silver Corp. (silver), and B2Gold Corp (gold) were the buyers in 10 of 2012's largest global mining deals⁴⁴.

BC's mining landscape includes currently producing mines, historical mines no longer operating, and proposed new mines. Operating and proposed new properties are at various stages of exploration or development, or are undergoing permitting and environmental assessment (see **Table 2** for BC's producing mines and **Appendix 1** for a full listing including late stage exploration companies).

Table 2: Mines Currently Producing Metals and/or Coal in BC

Name	Current owner	Location	Closest town	Type of mine
Bralorne Pioneer Mine	Bralorne Gold Mines Ltd, Vancouver BC	South Central BC	Lillooet BC	gold
Brule Operations	Walter Energy Inc, Birmingham, AL	North East BC	Prince George BC	coal
Coal Mountain Operations	Teck Coal Ltd, Calgary AB	South East BC	Sparwood BC	coal
Copper Mountain Mine	Copper Mountain Mining Corporation, Vancouver BC	South Central BC	Princeton BC	copper/gold
Elkview Operations	Teck Coal Ltd, Calgary AB	South East BC	Sparwood BC	coal
Endako Mine	Thompson Creek Metals Co, Denver CO	North West BC	Prince George BC	molybdenum
Fording River Operations	Teck Coal Ltd, Calgary AB	South East BC	Elkford BC	coal

⁴² BC's Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

⁴³ Annual Service Plan Report 2012/13. BC Ministry of Energy, Mines and Natural Gas; 2013.

⁴⁴ Down, but not out: Global Mining Deals 2012 Review 2013 Outlook. PriceWaterhouseCoopers; 2012.

Name	Current owner	Location	Closest town	Type of mine
Gibraltar Mines	Taseko Mines Ltd, Vancouver BC	North Central BC	Williams Lake BC	Copper/ molybdenum
Greenhills Operations	Teck Coal Ltd, Calgary AB	South East BC	Elkford BC	coal
Highland Valley Copper	Teck Resources Ltd, Vancouver BC	South Central BC	Kamloops BC	Copper/ molybdenum
Huckleberry Mine	Imperial Metals Corp, Vancouver BC	North West BC	Huston BC	Copper/ molybdenum
Line Creek Operations	Teck Coal Ltd, Calgary AB	South East BC	Sparwood BC	Coal
Mount Polley Mines	Imperial Metals Corp, Vancouver BC	North Central BC	Likely BC	Copper/gold
Nyrstar Myra Falls	Nyrstar NV, Balen Belgium	South West BC	Campbell River BC	Copper/gold
Quesnel River (QR) Barkerville Gold Mine	Barkerville Gold Mines Ltd, Vancouver BC	North Central BC	Wells BC	gold
Quinsam Mine	Hillsborough Resources Ltd, Vancouver BC	South West BC	Campbell River BC	coal
Shasta	Sable Resources Ltd, Vancouver BC	North Central BC	Smithers BC	gold
Trend Mine	Anglo American PLC, London UK	North East BC	Tumbler Ridge BC	coal
Wolverine (Perry Creek) Operations	Walter Energy Inc, Birmingham, AL	North East BC	Tumbler Ridge BC	coal

During preliminary exploration, areas holding potential deposits are evaluated by mapping and geological sampling surveys⁴⁵. Exploration companies are looking for better methods for detecting underground deposits, and would benefit from cheaper and faster analysis of core samples. A claim is staked (in BC, via Mineral Titles Online for minerals or via an application for coal) if a potentially valuable deposit is identified, providing sufficient rights to more carefully characterize the deposit. The *Mines Act* requires a Notice of Work submission for the exploration phase. Permitting and environmental assessments are the second phase, and time to obtain permit and receive environmental and social license to operate becomes priority. Current methods for environmental baseline studies and assessment of potential harm to environment are fragmented, expensive and time consuming. During this phase the potential value and economics of the site are assessed and government and community consultations are pursued to evaluate social and economic impacts of the proposed project. Proposals below production and environmental

⁴⁵ Opportunities to Explore: BC Minerals and Coal Industry. BC Ministry of Energy and Mines; 2012.

risk thresholds are reviewed according to the *British Columbia Environmental Assessment Act* (BCEAA). An Environmental Assessment (EA) certificate and a permit are issued if the project meets requirements⁴⁶. The next phase involves mine and infrastructure construction, followed by mine operation (extraction, separation, disposal of wastes, shipment, and ongoing inspections). Expansions, with associated permitting and environmental assessment, may occur if additional deposits are identified. At the end of the mine's life, it must be decommissioned, and the site must be restored, with ongoing environmental and structural monitoring. Companies with late exploration projects in BC are Pretivm, Cardero, Xtrata, Avanti, and Capstone (full list in **Appendix 1**).

Currently operating mineral mines are located at various sites across BC, while coal mines are centred in the East Kootenay and Peace River Coalfields, and on Vancouver Island (see **Table 2 and Figure 1**). In addition to currently producing mines, BC is home to multiple historical mine sites. About 20 historical mines in BC are estimated to have significant environmental problems⁴⁷. Nevertheless, BC's closed historical mine sites (see **Table 3 and Appendix 1**) provide significant opportunities for developing improved methods for site management and remediation. BC's Crown Land Restoration Branch has identified many of the sites in **Table 3** to be priority restoration sites because they pose high risk to human health and the environment.

Britannia Mine, a historical copper mine between Vancouver and Squamish, provides a good example of historical site management. When the mine was closed in 1974, mine outflows were diverted from Britannia Creek to Howe Sound via a dam. The dam failed in the 1980s or 1990s, causing significant pollution of Britannia Creek and triggering a remediation effort led by UBC's Centre for Environmental Research in Minerals, Metals and Materials. The "Millenium Plug Project" involved installation of an earth plug in the old mine, diverting mine water from Britannia Creek to a water treatment plant where metals are removed and the water pH is raised before discharge. There is a perpetual treatment plan that will remain in operation indefinitely, at significant cost to the Province.

The primary environmental issues facing the mining subsector are related to managing acid rock drainage (ARD) and tailings. ARD remains a significant issue for BC's mining subsector and must be managed on an ongoing basis even at closed mining sites. ARD occurs naturally when sulphides in earth are exposed to air and water and produce sulphuric acid; it occurs at a higher rate near mines because their larger surface area increases the exposure to air and water. Since ARD can introduce high acidity and dissolved heavy metals to nearby water sources and aquatic ecosystems, mine effluents must be treated, at significant cost, before discharge. ARD can be managed by sealing closed underground mines, minimizing air oxidization by flooding waste rock, and buffering outflows with basic compounds. Iron and sulphur-oxidizing bacteria play an important role

⁴⁶ Opportunities to Explore: BC Minerals and Coal Industry. BC Ministry of Energy and Mines; 2012.

⁴⁷ http://www.miningwatch.ca/files/Mackasey_abandoned_mines_0.pdf

in ARD as they use sulphur as an energy source; thus remediation of ARD via manipulation of microbial populations is possible. New mines plan to avoid ARD by careful selection and placement of waste rock and layering with lime to neutralize the acid. However, even with the best planning ARD often remains a challenge, and it is almost impossible to stop once it develops. Prevention of ARD would offer significant cost benefits to the mining subsector.

Tailings are the materials left over after separating the valuable fraction of an ore from the remainder. Metal extraction is typically accomplished by placer mining, which uses water and gravity, or hard rock mining, in which rock is pulverized and treated with chemicals, to extract the metals of interest. Tailings typically consist of crushed bare rock or a slurry of rock particles and the chemical solutions used to extract ores. Ideal tailing treatment would make tailings inert, but in many cases this is not possible, so tailings are stored in ponds. Tailings are a significant cost and a major environmental concern for most mining projects. Improperly stored tailings may leach heavy metals and chemicals into local ecosystems and water sources, posing danger to humans and wildlife. Extraction of residuals from tailing in an economical manner would benefit the industry and the environment simultaneously.

Table 3: Selected Closed Coal and Metal Mines in BC

Name	Current owner	BC Location	Closest Town	Type of Mine	Opportunities for Research
Atlin Ruffner	BC Crown	North West	Atlin BC	metal	Tanks of diesel in mine shaft and tailings pond require remediation
Bralorne-Takla	BC Crown	North Central	Lillooet BC	metal	Remediation of Sb, As, Cd, Cr, Hg in soil
Britannia Mine	Britannia Bay Properties Ltd	South Central	Squamish BC	Cu	Ongoing ARD* treatment
Cork Province	BC Crown	South East	Nelson BC	Au, Ag, Zn	Tailings with Pb, Zn, As threaten creek
Cronin	BC Crown	North Central	Smithers BC	metal	Remediation of Pb, Zn, Cu, Cd contamination
Emerald Glacier	BC Crown	Central West	Huston BC	Cu, Au, Ag, Zn	Remediation of Ag, Au, Pb, Zn, Cu, Cd in land and water
Howard	BC Crown	South East	Nelson BC	Ag	Remediation of silver and lead eroding into salmon-bearing river
Iron Crown	BC Crown	South West	Campbell River BC	metal	Remediation of tailings contaminating a local lake
Island Copper Mine	BHP Billiton Base Metals, UK	South West	Port Hardy BC	Cu, Au, Mo, Ag	Biogeochemistry of layers in pit lake, tailings on seabed
Island Mountain	BC Crown	Central	Wells BC	Au	Tailings, soil, and well contamination with As
Midway	BC Crown	South East	Cranbrook BC	Zn	Zn contamination
Mowson Pond	BC Crown	South West	Lillooet BC	metal	Hg contamination from Hg processing
Mt	Better	South	Courtenay	Cu	ARD remediation and

Name	Current owner	BC Location	Closest Town	Type of Mine	Opportunities for Research
Washington Copper Mine	Resources Ltd, Nanaimo BC	West	BC		restoration of fish ecosystems
Pacific Place	BC Crown	South West	Vancouver BC	metal	Soil and groundwater contaminated with metal/organics
Quinette Babcock	Teck Resources Ltd, Vancouver BC	North East	Tumbler Ridge BC	coal	Determining biological drivers of calcite precipitation
Two Mile Creek	BC Crown	North Central	Smithers BC	metal	Tailings contamination of drinking water with Pb, As, Cu, Sn
Union Bay Coal Hills	BC Crown	South West	Courtenay BC	coal	ARD remediation
Yankee Girl Mine	BC Crown	South West	Nelson BC	metal	Removal of heavy metals from tailings
Ymir and Protection	BC Crown	South East	Nelson BC	Au, Ag, Zn	Management of dangerous As contamination

*ARD: Acid Rock Drainage

BC Oil and Gas Companies

The BC energy subsector includes oil and gas exploration and development companies and energy infrastructure companies.

Oil Exploration and Production Companies in BC

Oil and gas activities in BC are concentrated in the northeast, bordering Alberta (see **Figures 2 and 7**). BC's remaining oil reserves are concentrated in the Boundary Lake area (Boundary Lake "A" pool, east of Fort St. John), the Hay River area (Bluesky "A" pool in segment 094I on **Figure 7**), and in the newly discovered Heritage field (Montney "A" pool) between Fort St John and Dawson Creek⁴⁸. Oil drilling in BC is concentrated around Fort Nelson (Greater Sierra field) and Fort St. John. Companies with a strong presence in the Fort Nelson area in 2008 included: Devon Energy, Encana Corporation, Canadian Natural Resources, Petro Canada (Suncor Energy) and Husky. The busiest operators in the Fort St. John area were Canadian Natural Resources, ConocoPhillips Canada, ProEx (Progress) Energy and Advantage Energy Income Fund⁴⁹.

⁴⁸ Hydrocarbon and By-Product Reserves in British Columbia. BC Oil and Gas Commission; 2012.

⁴⁹ BC Oil and Gas Exploration Activity Report 2007-2008, BC Ministry of Energy, Mines and Petroleum Resources, Oil and Gas Division, Resource Development Geoscience Branch; 2008.

Gas Exploration and Production Companies in BC

To meet LNG development goals, the Province is aiming for continual growth in production, approaching 3.0 Tcf per year by 2020⁵⁰. Approximately half of the 1.5 Tcf total natural gas produced in BC in 2012/13 was produced in the two most active shale basins, the Montney (40%) near Dawson Creek and Fort St John and the Horn River Basin (10%) near Fort Nelson. Over 85% of the 444 new wells drilled in 2013/2013 targeted unconventional sources; 339 were drilled in the Montney, 39 in the Horn River Basin, two in the Liard Basin northwest of Fort Nelson and one in the Cordova Embayment northeast of Fort Nelson⁵¹.

Between 2003 and 2013, 379 well drillings targeted shale gas zones in Horn River. Major industry players were Encana (82 wells), Apache (72 wells), Nexen (66 wells), EOG Resources (40 wells), Devon Canada (33 wells), Imperial Oil (29 wells), and Quicksilver (16 wells). Between 2003 and 2013 producing well count in the Montney area grew to 1,251. In 2012 alone, 366 wells were drilled in Montney region, led by Shell (80 wells) and followed by Encana (71 wells), Progress Energy (46 wells), Talisman Energy (33 wells), Tourmaline Oil Corp (21 wells), Murphy Oil Corp (20 wells), Canadian Natural Resources (19 wells), and ARC Resources (15 wells).

The largest industry players in BC's oil and gas subsector include BG Group, Shell and Chevron (see **Table 4** for a selected list and **Appendix 2** for a full list of companies with BC interests). Several large multinationals have recently established offices in Vancouver (BG Group, Shell, and Progress Energy Canada)⁵², largely based on the promise of LNG (see details on LNG under **1. Infrastructure b) The Energy Subsector** below).

⁵⁰ British Columbia's Natural Gas Strategy: Fuelling B.C.'s Economy for the Next Decade and Beyond. BC Ministry of Energy and Mines; 2012.

⁵¹ Oil and Gas Land Use in Northeast British Columbia. BC Oil and Gas Commission; 2013.

⁵² McBride, B. Is Vancouver the new Calgary? Canadian Business; Feb 19, 2013.

Figure 7: BC Oil and Gas Areas by Geographic Region.

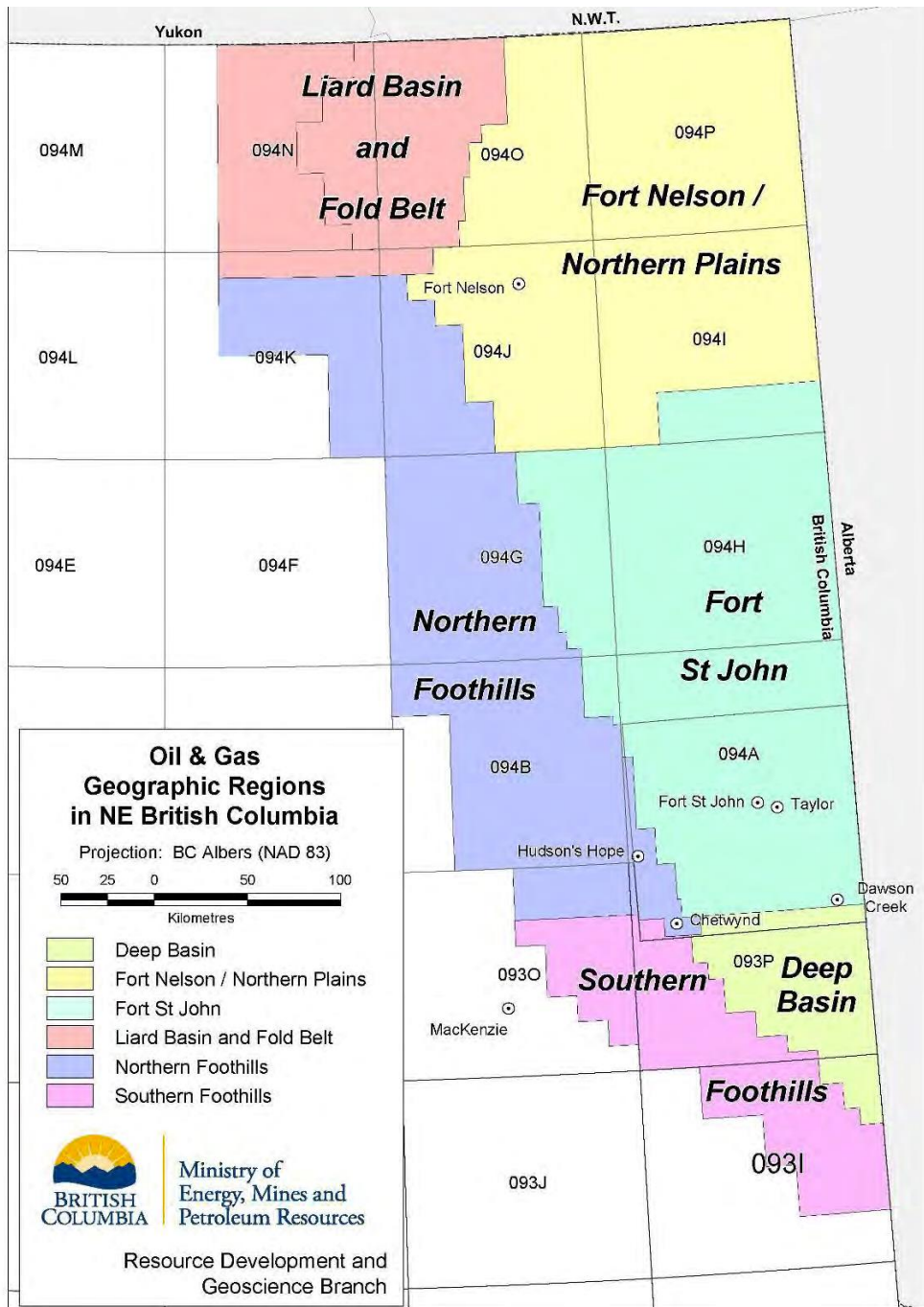


Table 4: Selected Oil and Gas Exploration, Development, Production, and Infrastructure Companies in BC

Institution	BC Operations	HQ	Main BC interest
Advantage Energy Income Fund (Advantage Oil and Gas)	Fort St John, Montney Play	Alberta	oil
AltaGas	Vancouver	Alberta	infrastructure
Apache Canada (Chevron)	Fort Nelson, Dawson Creek	Texas	gas, LNG, refinery
ARC Resources	Fort Nelson, Dawson Creek	Alberta	gas
BG Gas Group	Northern Foothills, Southern Foothills, Prince Rupert	United Kingdom	LNG
Calfrac Well Services		Alberta	fracking
Canadian Natural Resources	Fort Nelson, Fort St John, Northern Foothills, Southern Foothills, Dawson Creek	Alberta	oil, gas
China Petroleum (Sinopek)	Northern Foothills	China	gas
CNPC		China	gas
ConocoPhillips Canada Resources	Fort St John, Deep Basin, Southern Foothills	Alberta	oil
Devon Energy	Fort St John, Fort Nelson, Deep Basin, Southern Foothills	Oklahoma	oil, gas
Enbridge		Alberta	pipeline
Encana	Fort Nelson, Dawson Creek, Deep Basin	Alberta	oil, gas
EOG, Canada	Fort Nelson, Horn River, Liard Basin, Ford Belt	Texas	gas
Husky Energy	Fort Nelson	Alberta	oil, refinery
Imperial Oil (Esso)		Alberta	Gas, terminal
JGC	Prince Rupert	Japan	infrastructure
Kinder Morgan		Texas	pipeline
Kogas	Kitimat	Korea	LNG
Methanex Corporation		British Columbia	downstream
Mitsubishi	Kitimat	Japan	terminal
Murphy Oil Corp	Montney Play, Deep Basin, Dawson Creek	Arkansas	gas
Nabors Energy		Bermuda	drilling
Nexen	Fort Nelson	Alberta	gas
PCL	Kitimat	Alberta	terminal
Petronas	Prince Rupert	Malaysia	gas, LNG
Polarstar Oil and Gas (Tusk Energy)		Alberta	oil, gas, LNG
Progress Energy (ProEx Energy)	Fort St John, Northern Foothills, Prince Rupert, Dawson Creek	British Columbia	gas
Quicksilver	Horn River, Fort Nelson	Alberta	gas
Spectra Energy	Prince Rupert	Texas	LNG
Shell Canada Energy	Fort St John, Deep Basin, Northern Foothills, Southern Foothills, Dawson Creek	Alberta	gas, terminal

Suncor (Petro Canada)	Deep Basin, Southern Foothills	Alberta	terminal
Syncrude		Alberta	oil
Talisman Energy	Montney Play, Northern Foothills, Southern Foothills	Alberta	gas
Total E&P (TEPCA)		Alberta	oil
Tourmaline Oil Corp (Huron Energy)	Montney Play	Alberta	gas

Infrastructure

The mining and energy sector depends heavily on enabling infrastructure. This includes not only mines and oil/gas fields and associated processing plants, smelters and refineries, but also pipelines, ports, road, rail lines, and airports linking the sector to global markets. Electricity and natural gas are key inputs, given the energy-intensive nature of mining and oil and gas extraction. The Northwest Transmission Line is a 322 km, 287 kilovolt power line to be constructed in northwest BC⁵³. The project will extend the current grid and enable further mining and energy developments in this area.

The Mining Subsector

BC already possesses strong transportation infrastructure for minerals and mine products. Road and rail links offer transcontinental delivery capabilities, with Canadian National (CN) and Canadian Pacific Railway (CPR) providing most rail transport for coal and other minerals to the coast. The ports at Metro Vancouver and Prince Rupert are the closest ports to Asia from North America and offer multiple mineral and coal export facilities (e.g. Westshore Terminal, on the Strait of Georgia near Tsawwassen; Port Riddell, in Prince Rupert; and Neptune Port, on Burrard Inlet in North Vancouver), all of which have capacity to expand. Significant expansions are also planned both at the Port of Prince Rupert, the deepest natural harbour in North America, and at the Stewart Bulk Terminals, a mineral concentrate facility serving Northern BC⁵⁴.

The Energy Subsector

BC has two major refineries, one in Prince George operated by Husky, producing 12 million barrels per day (mbpd), and another in Vancouver, operated by Chevron (55 mbpd). BC represents only a fraction of Canada's total refinery output (2,092 mbpd), with a small output compared to other regions (Prairies, 591 mbpd; Ontario, 474 mbpd; Quebec, 475 mbpd; Atlantic, 484 mbpd)⁵⁵. Burnaby Oil Refinery is connected to the WCSB by Kinder Morgan's TransMountain pipeline, which originates in Alberta. Kinder Morgan plans to double the capacity of this pipeline, though environmental opposition has been raised.

⁵³ Opportunities to Explore: BC Minerals and Coal Industry. BC Ministry of Energy and Mines; 2012.

⁵⁴ Opportunities to Explore: BC Minerals and Coal Industry. BC Ministry of Energy and Mines; 2012.

⁵⁵ <http://www.neb-one.gc.ca/clf-nsi/rnrgynfmrtn/prcng/crdlndptrlmprdcts/cndndstr-eng.html>

Port Metro Vancouver has a number of petroleum terminals, including Suncor's Burrard Products Terminal; Imperial Oil Limited's Ioco in Burrard Inlet East; Kinder Morgan Westridge in Burnaby; Shell Canada's Shellburn, and Chevron Canada Ltd.'s Stanovan in Burnaby⁵⁶. The existing natural gas pipelines (Figure 2) and processing plants around Fort Nelson and Fort St. John, developed for conventional gas, can also be used to transport unconventional gas, lowering the cost of developing unconventional reserves⁵⁷.

The development of an LNG industry in BC was announced as a significant priority of the current government in 2012⁵⁸. Under proposed plans, gas from BC and Alberta will be piped to the coast, cooled and condensed into LNG at plants in Kitimat and Prince Rupert, stored in insulated tanks, and transferred into double-hulled LNG ocean tankers for shipping to Asia Pacific markets for re-gasification. To achieve the \$1 trillion in annual economic activity that LNG exports could yield by 2046, the Province has proposed multiple developments, including⁵⁹:

- Douglas Channel: Tatham Family, Texas in Kitimat to ship LNG to Asia
- Kitimat LNG Plant: Chevron, Apache to complete LNG plant by 2015 in Kitimat
- LNG Canada: Shell, PCL, KOGAS, Mitsubishi, PetroChina to build export terminal in Kitimat
- BG Group: To develop LNG facility with Spectra Energy in Prince Rupert
- Pacific Northwest LNG: Petronas and Progress Energy to develop liquefaction and export facility in Prince Rupert

Kitimat LNG has already earned federal and provincial environmental assessment approvals and the first-ever federal export licence for LNG in Canada. It has strong support from the local Haisla Nation. The facility will draw LNG from BC's Horn River and Liard fields, and via a natural deepwater, ice-free harbour, enable tanker shipping of LNG to Asia Pacific markets. It would also serve as the port for Enbridge's proposed Northern Gateway pipeline, which will connect the Kitimat LNG to the Alberta oil sands. This infrastructure is critical for ensuring long-term production from the first phase of the proposed Kitimat LNG plant, and could result in \$90 million annually in revenue⁶⁰. Suppliers supporting the oil and gas industries are described in more detail under 5. *Suppliers, Service Providers and Consultants* below and are listed in **Appendix 5.**)

Regulatory Environment

The mining and energy sector in BC is regulated by a series of government agencies, and the regulatory regime has historically been regarded as very stable compared to other jurisdictions. The BC Environmental Assessment Office, under the *BC Environmental*

⁵⁶ <http://www.portmetrovancover.com/en/portusers/landoperations/terminalsandfacilities/bulk.aspx>

⁵⁷ <http://www.energybc.ca/profiles/naturalgas.html>

⁵⁸ Liquefied Natural Gas: A Strategy for BC's Newest Industry. BC Ministry of Energy and Mines; 2012.

⁵⁹ BC's Liquefied Natural Gas Strategy: One Year Update. BC Ministry of Energy, Mines and Natural Gas; 2013.

⁶⁰ BC's Natural Gas Strategy. BC Ministry of Energy and Mines; 2012.

Assessment Act, reviews proposed mining and energy projects in BC according to their potential environmental, social, economic, health, and heritage impacts⁶¹. A list of government and regulatory bodies serving the mining and energy sector in BC is in **Table 5**.

The Mining Subsector

In addition to provincial environmental assessments, many mining developments are also reviewed under the federal *Canadian Environmental Assessment Act*. BC is in the process of harmonizing these two review systems to minimize duplication of efforts while ensuring high review standards. Under the *Mines Act*, provincial staff issue mining exploration permits once proposals (deemed ‘Notices of Work’) have been submitted and reviewed in the context of health, safety, water, and environmental codes and reviewed in consultation with First Nations parties. In 2011, the *Mines Act* was amended to exempt some low-risk activities from having to undergo the full permitting process. In 2012, the BC government committed to clearing the backlog of exploration permits (including Notices of Work) and to achieving an average turnaround time of 60 days going forward⁶², which will help reduce uncertainty and support new investment in mineral exploration in BC.

The Province also bears responsibility for ensuring worker safety in the mining and energy sectors, including health and safety aspects of mining and exploration proposals, monitoring sites for compliance, conducting safety audits, maintaining records of accidents and health and safety data, and participating in research to improve the standards of practice. Companies are legally required to reclaim all lands that are disturbed by mining or energy activities or exploration. The BC Technical Research Committee on Reclamation (BC TRCR) for example is led by government and industry in collaboration in response to a demonstrated need in BC for greater government-industry communications in the area of environmental protection and reclamation associated with mining. More detail on associations and innovation assets are discussed in following sections (*4. Industry and Professional Associations* and **C. Innovation Assets**).

Waste discharge from resource extraction activities is regulated under the *Environmental Management Act*. A new *Water Sustainability Act*, which will replace BC’s current *Water Act*, will continue to guide mining activities with respect to ensuring stream and aquatic environment health.

Table 5: Government and Regulatory Agencies Serving the Mining and Energy Sector in BC

Institution	Main Area / Responsibility	Jurisdiction
Alberta Energy	energy	Alberta
BC Ministry of Natural Gas Development	energy	BC

⁶¹ Opportunities to Explore: BC Minerals and Coal Industry. BC Ministry of Energy and Mines; 2012.

⁶² BC’s Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

BC Oil and Gas Commission (BCOG)	energy	BC
National Energy Board	energy	Canada
Natural Resources Canada(NRCAN) ecoEnergy Innovation Initiative	energy	Canada
Natural Resources Canada (NRCAN) Office of Energy Efficiency	energy	Canada
BC Ministry of Environment (MOE)	environment	BC
BC Ministry of Forests, Lands and Natural Resources	environment	BC
BC Ministry of Forest, Lands and Natural Resources Crown Land Restoration Branch (CLRB)	environment	BC
Environment Canada	environment	Canada
Environmental Protection Agency (EPA)	environment	International
Fisheries and Oceans Canada (DFO)	environment	Canada
Fisheries and Oceans Canada (DFO) Metal Mining Effluent Regulations (MMER)	environment	Canada
Future Forest Ecosystems Scientific Council of BC (FFESC)	environment	BC
Natural Resources Canada (NRCAN)	environment	Canada
BC Ministry of Energy and Mines	mining	BC
BC Ministry of Energy and Mines BC Geological Survey (BCGS)	mining	BC
BC Ministry of Energy and Mines Mineral Development Office (MDO)	mining	BC
BC Ministry of Energy and Mines Permitting and Reclamation	mining	BC
BC Ministry of Technology Innovation and Citizen's Services	mining	BC
Mineral Statistics in BC	mining	web
Natural Resources Canada (NRCAN) Mining and Metal Sector	mining	Canada
Natural Resources Canada (NRCAN) CANMET Mining	mining	Canada
National Research Council Canada (NRC) Industrial Metals Institute	mining	Canada
Surface Rights Board of BC	mining & energy	BC
BC Ministry of Environment Watershed Science and Adaptation	regulation	BC
BC Ministry of Environment Environmental Assessment Office (EAO)	regulation	BC
Canadian Environmental Assessment Agency (CEAA)	regulation	Canada
Major Projects Management Office (MPMO)	regulation	Canada

In addition to government agencies directly regulating mining and energy projects in BC, several other government organizations and stakeholder groups play important roles. The British Columbia Geological Survey (BCGS; <http://www.empr.gov.bc.ca/Mining/Geoscience/Pages/default.aspx>) develops, disseminates and maintains geoscientific maps and knowledge, which are crucial for a successful, sustainable mining industry. Geological surveys are publically available via MapPlace (www.mapplace.ca), an interactive website providing customizable surveys, maps, and reports, and through various BCGS publications.

The Ministry of Energy and Mines also maintains an extensive mineral statistics website that features production, market, employment and mine development project data. BC was the first province in Canada to develop an online mineral tenure acquisition system, Mineral Titles Online (MTO). MTO offers continuously updated placer and mineral tenure information; robust search and mapping abilities; and integration with related data including mineral occurrences, land status and other information clients need to make informed decisions. Coal tenure acquisition and management information are being

integrated into the MTO system, extending its benefits to potential coal clients and investors.

The Energy Subsector

Oil and gas activities are regulated by the BC Oil and Gas Commission (BCOGC), which works with industry, First Nations and other groups, reviews oil and gas applications and, once approved, inspects and monitors construction, operation and reclamation. BCOGC is also responsible for reviewing and approving land tenure, water use, forest harvesting, waste disposal and potential heritage impacts. Tenures for oil and gas exploration and extraction are guided by the *The Oil and Gas Activities Act* and associated regulations introduced in 2010 to encompass unconventional gas extraction activities⁶³. Most petroleum and natural gas rights in British Columbia are owned by the province. The surface owner of property rarely owns underlying petroleum and natural gas rights, except in areas of early settlement such as Vancouver Island and the Fraser Valley. The Titles Division, Ministry of Energy and Mines, manages provincially-owned petroleum and natural gas rights⁶⁴.

To prepare a permit application, applicants must obtain tenure rights, plan well/equipment spacing and engineering specifications, prepare construction plans, ensure compliance with drilling, production, and environmental regulations, secure surface agreements with landowners, complete an archaeological assessment, estimate sour content of proposed wells and prepare an emergency planning zone, and comply with Land Act and Water Act requirements⁶⁵. LNG projects also require an export licence from the National Energy Board (NEB); licenses are granted for projects deemed to be in the public interest for commodities surplus to Canada's energy needs. The NEB does not review environmental impact.

Industry and Professional Associations

The interests of companies operating within the sector are supported by a number of industry associations, professional associations and other organizations. These organizations are a great source of information on industry assets, stakeholders, opportunities and challenges. Some may even lobby government or provide funding for research. They hold meetings, networking events, publish written communications, provide forums for discussion, and in general, link stakeholders with common interest for advancing the sector. Innovation Assets will be discussed in a later section but it is important to mention that associations have a great role in catalyzing innovation in the sector. While the focus of the asset map is on BC, Canadian, North American and International groups are involved in similar work and in some cases are very active and

⁶³ BC's Natural Gas Strategy. Ministry of Energy and Mines; 2012.

⁶⁴ <http://www.empr.gov.bc.ca/Titles/OGTitles/Pages/PNGRightsinBC.aspx>

⁶⁵ <http://www.bco.gc.ca>

collaborative within BC. Specific associations are discussed in the upcoming sections; see **Appendix 3** (mining subsector) and **Appendix 4** (energy subsector) for a more complete listing.

The Mining Subsector

Several types of associations and societies support BC's mining subsector through advocacy and support services, knowledge-sharing, training, education, and/or publications (see **Appendix 3** for complete listing and description of relevant organizations, and **Table 6** for selected associations). Industry associations such as the Mining Association of BC (MABC), the Coal association of Canada (CAC), and the Association of Mineral Exploration BC (AME-BC) work directly to support mining firms through events and publications.

Other associations and societies, such as Canada Mining Innovation Council (CMIC), Canadian Institute of Mining, Metallurgy and Petroleum (CIM), Center for Excellence in Mining Innovation (CEMI) and Geoscience BC (GBC), focus on innovation and advancement of technologies. CMIC works closely with NRCan and academics for innovation in strategic areas such as water, tailings and closure. CEMI identifies, assesses and manages industry-focused applied research & development projects that extend from geology and engineering to the natural sciences. It provides funding for strategic research areas such as the January 2014 announcement of \$15M for ultra-deep mining development. Geoscience BC is an industry-led organization that collects, interprets and delivers geoscience data and expertise to promote investment in mineral exploration and development. Geoscience BC focuses on short-term priority projects that require larger budgets than are typically provided to geological surveys.

Table 6: Selected Mining and Related Associations in BC and of Interest to BC

Organization	Abbr.	Focus	Publications	Jurisdiction
Aquatic Toxicology Workshop	ATW	Aquatic toxicology and water quality research and dialogue	Annual Proceedings	Canada
Association of Mineral Exploration BC	AME BC	Mining Exploration Focus	Mineral Exploration Magazine	BC
Association of Professional Biologists (College of Applied Biology)	APB	Professional development; application, practice and understanding of biological sciences	Annual Conference	BC
BC Aboriginal Mine Training Association	BC AMTA	Connecting youth to training and jobs in mineral exploration and mining	Presentations	BC
BC Technical and Research Committee on Reclamation	BC TRCR	Government & Industry Communication	Reports	BC
Canada Mining Innovation Council	CMIC	Research and Innovation in Mining	Reports, presentations	Canada
Canadian Institute of Mining, Metallurgy and Petroleum	CIM	Technical Society for Mining	CIM Magazine, CIM Journal, Technical Papers	Canada

Canadian Land Reclamation Association	CLRA	Reclamation Knowledge Exchange	Canadian Reclamation, Annual Proceedings	Canada
Center for Excellence in Mining Innovation	CEMI	Industry Driven Applied Res. (ON)	R&D Publications	Canada
Coal Association of Canada	CAC	Promoting Coal	no	Canada
Geoscience BC	GBC	Priority projects in mineral exploration and development	Explorer Magazine	BC
Mine Environment Neutral Drainage Program	MEND-NEDEM	Develop technologies to prevent and control acidic drainage	MEND Monitor	Canada
Mining Association of BC	MABC	BC Industry Association	Mining Facts	BC
Mining Association of Canada	MAC	National Industry Association	Quarterly e-Newsletter	Canada
Mining Suppliers Association of BC	MSABC	Mining Industry Suppliers in BC	no	BC
Mining Watch Canada		Changing public policy and mining practices	Newsletters	Canada
National Orphaned and Abandoned Mines Initiative	NOAMI	Assessment, characterization and remediation/reclamation of orphaned and abandoned mine sites	Newsletters	Canada
Prospectors and Developers Association of Canada	PDAC	Mining Exploration Focus	Core, eNews	Canada

Other organizations provide resources or forums for precompetitive problem solving for challenges facing the mining subsector. Many focus on a niche area such as ARD (Mine Environment Neutral Drainage Program), reclamation (BC Technical and Research Committee on Reclamation (BC TRCR), Canadian Land Reclamation Association (CLRA)), water quality (Aquatic Toxicology Workshop, (ATW)), selenium (Elk Valley Selenium Task Force), or sustainability (Alliance for Responsible Mining, Coalwatch Comox Valley Society, First Nations Energy and Mining Council, Mining Watch Canada).

Other associations and societies provide professional certifications and professional development for members, ensuring industry quality, integrity and professionalism. Active professional associations serving BC's mining industry include Association of Professional Biologists, Certified Environmental Professionals, Institute of Professional Environmental Practice, and Qualified Environmental Professionals. Associations of engineers and geoscientists support and engage with both the mining subsector and the energy subsector (Association for Professional Engineers and Geoscientists of BC, Canadian Society of Exploration Geophysicists, Canadian Geotechnical Society, Engineers Canada, and Geological Association of Canada).

First Nations are important stakeholders in mining development through land claims, heritage protection, and education and employment opportunities. The BC Aboriginal Mine

Training Association (BC AMTA) connects youth to training and jobs in mineral exploration and mining. BC is the first province in Canada to share mineral tax revenues from new or expanded mines with First Nations, emphasizing community development to achieve social and economic goals. Revenue sharing is negotiated on a project-by-project basis, generally through Economic and Community Development Agreements (ECDAs). BC signed its first two ECDAs with First Nations in August 2010 and is working to develop others (with a target of 10 new agreements by 2015)⁶⁶. Many companies also directly negotiate with First Nations to establish Impact Benefit Agreements (IBAs), which may define jobs, economic, training, environmental, and dispute-resolution provisions for projects in First Nations territories. For example, in 2010 an IBA signed by Copper Mountain Mining Corporation and the Upper Similkameen Band defined provisions for the Copper Mountain mine project, which began producing in June 2011.

The Energy Subsector

Similarly to the mining subsector, the energy subsector is supported by several types of societies and associations (see **Appendix 4** for complete listing and description of relevant organizations and **Table 7** for selected associations). Industry advocacy groups include BC Petroleum Contractors Association (BCPCA), the Canadian Association of Petroleum Producers (CAPP), the Energy Industry Services Association of British Columbia (ESBC), and the Explorers and Producers Association of Canada (EPAC).

Associations/societies focusing on innovation and advancement of technologies include the Canada’s Oil Sands Innovation Alliance (COSIA) in Alberta, the Canadian Energy Research Institute (CERI), the Petroleum Technology Association of Canada (PTAC), the Petroleum Technology Research Centre (PTRC), and the Petroleum Technology Transfer Council. However, there is no BC association with specific mandate on innovation and research for the oil and gas industry.

Organizations focusing on a specific niche area include Enform BC (safety performance), Canadian Energy Pipeline Association (CEPA, pipeline development), Western Canadian Spill Services (WVSS, spill management), Orphan Well Association (OWA, reclamation of abandoned wells), and the Pembina Institute (environmental sustainability).

Table 7: Selected Energy and Related Associations in BC and of Interest to BC

Organization	Abbr.	Focus	Publications	Jurisdiction
BC Petroleum Contractors Association	BCPCA	Petroleum handling equipment industry stakeholders		BC
Canada's Oil Sands Innovation Alliance	COSIA	Alliance of oil sands producers for improvement in environmental performance of oil sands		Canada

⁶⁶ BC’s Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

Organization	Abbr.	Focus	Publications	Jurisdiction
Canadian Association of Petroleum Producers	CAPP	Enhance the economic sustainability of the Canadian upstream petroleum industry	Newsletters, fact sheets	Canada
Canadian Gas Association	CGA	Voice of Canada's gas distribution industry	CNG Magazine, Energy	Canada
Canadian Energy Pipeline Association	CEPA	Represents Canada's transmission pipeline companies	Reports, reviews	Canada
Canadian Energy Research Institute	CERI	Objective, independent studies to assist in energy-related decisions and policy choices	Reports, reviews	Canada
Canadian Society for Unconventional Resources	CSUR	Encouraging development of unconventional hydrocarbon resources	Presentations, videos, reports	Canada
Centre for Energy		Canada's key resource for credible, up-to-date energy information	Maps, statistics, facts	Canada
Energy BC		Educational resource on energy sources, uses and issues in BC		BC
Energy Industry Services Association of BC (was Energy Services BC)	ESBC	Advocate for the oil and gas service sector, member of Northern Society of Oilfield Contractors & Service Firms		BC
Explorers and Producers Association of Canada (formerly SEPAC)	EPAC	Advocates on behalf of its members for sound government policy that promotes a thriving independent oil and gas sector	Explorer Magazine	Canada
Gas Processing Association of Canada	GPAC	Promote the interaction and exchange of ideas and technology in hydrocarbon processing	Newsletters	Canada
Orphan Well Association	OWA	Manage the abandonment and reclamation of oil and gas orphan wells, pipelines, facilities	Reports	Alberta
Pembina Institute		Combines research and technical capacity for environmental sustainability	Reports, reviews	BC, AB, ON, NWT
Petroleum Services Association of Canada	PSAC	National trade association representing the service, supply and manufacturing sectors within the upstream petroleum industry		Canada
Petroleum Technology Association of Canada	PTAC	Innovation, tech transfer, collaborative research and technology development to improve performance of the Canadian oil and gas industry.		Canada
Petroleum Technology Research Centre	PTRC	R&D into enhanced oil recovery and carbon storage, while reducing the environmental footprint of the oil and gas industry	Facts sheets, reports	Canada
Science and Community	SCEK	Industry-sponsored fund overseen by the BCOGC, CAPP and EPAC. Serves to enable		BC

Organization	Abbr.	Focus	Publications	Jurisdiction
Environmental Knowledge		relevant applied research related to oil and gas exploration and development in BC		
Western Canadian Spill Services	WCSS	Ensure that industry is capable of safe, effective oil spill response	Reports	Canada
World Energy Council	WEC	Impartial network of leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system	World Energy Insight, Surveys	International
World Petroleum Council	WPC	Promotion of sustainable supply and efficient use of oil, gas and other energy resources	Congresses, Yearbook	International

Associations and societies providing professional certifications and professional development for members include the Association for Professional Engineers and Geoscientists of BC, Canadian Society of Exploration Geophysicists, Canadian Geotechnical Society, Engineers Canada, and Geological Association of Canada.

Attending annual meetings or reviewing publications and journals by these organizations can provide invaluable opportunities to understand sector challenges, and identify subject matter experts, collaborations, and opportunities for genomics.

Suppliers, Service Providers and Consultants

The mining and energy sector in BC is heavily dependent on the work of engineering, environmental, and other suppliers, service providers and consultants. Mining and energy-focused consulting and services are plentiful in BC (see **Appendix 5** for a more complete listing). Services offered include but are not limited to: analytical testing laboratories; exploration and geophysical consulting; processing and plant optimization; environmental assessment, remediation, and monitoring; waste management and spill cleanup; corporate social responsibility and government relationship; drilling and pumping services; water treatment; and forestry management. A significant number of consultancies help mining and energy firms navigate the regulatory landscape and facilitate receipt of permits for mines or oil/gas fields. While some companies rely on consultants to perform activities not directly related to production and exploration, other firms are fully integrated and develop such expertise in-house. For example, Shell, Teck, Imperial Metal all have internal innovation and non-core business R&D capabilities. Due to the large number of service providers, companies involved in biological processes are specially marked in **Appendix 5** for better navigation.

The Mining Subsector

In the mining subsector environmental assessment, permitting, waste management and remediation are often contracted to consultancy firms. Major environmental consultancy firms serving the mining subsector in BC include Golder, Hemmera, SNC Lavalin, Lorax, AMEC, CH2M Hill and TetraTech. These firms have extensive experience with mining operations in BC. Smaller environmental consultancies (Nautilus, Keystone Environmental,

Palmer Environmental Group) collaborate with other engineering or geotechnical consultants, while larger firms (SNC Lavalin) integrate engineering, geotechnical and hydrology expertise into one company. Industry wide issues such as ARD or selenium removal from wastes are often tackled collaboratively amongst several firms, with findings presented at technical meetings or symposia and in peer-reviewed publications.

Environmental consultants form an important link between the industry and academia given that they typically collaborate with university researchers on projects they expect to return innovative tools or better data for decision-making. Other consultants also communicate with regulators and ensure clients maintain compliance with environmental regulations.

During exploration, core samples are analyzed for metal content, typically via shipping the core samples to a laboratory. Water quality and toxicity also needs to be monitored. Laboratory service providers offering such services to BC mining firms include ALS, Maxxam, Axyx, Kemetco, and Taratech. BC does not have a laboratory that monitors biological events for the mining industry. Biohidrica Biotecnologias in Chile offers bioassays to monitor bioleaching processes and toxicology tests for the mining industry.

Mining activities affect natural water bodies and require large volumes of water for processing, making water resource and waste management critical to the mining subsector. Canada is not heavily invested in bioreactors that use bioleaching, bioremediation and biohydrometallurgy for the removal of metal from ores, waste piles or water. Emerging companies such as Veolia, GE Power and Water, Inotec, and Envirogen offer various purification devices that use microbial processes. In places such as Chile these processes are used in full scale operations. Gold Fields in South Africa offers bio-oxidation solutions via their proprietary Biox process. Bactech is a Canadian company now applying biooxidation technology in Manitoba to remove residual metal from waste rock.

Other suppliers and service providers offer financial, health and safety, IT and HR services. **Appendix 5** lists most of the BC relevant firms serving the mining and energy industry.

The Energy Subsector

Most major consulting companies, including Golder, AMEC, Stantec, SLR and Hatfield, offer services to the energy subsector similar to those described above for the mining subsector. Easwara Origins specializes in wastewater remediation and reclamation services for the oil and gas industry. Unique to oil and gas are pipeline companies, refineries, and well equipment and technology suppliers; see in **Appendix 2 & 5** for greater detail.

The energy subsector is closely dependent on suppliers of services such as fracking, pipelines, processing, pumping, etc. Calfrac, a fracking company and Kinder Morgan, a pipeline company are actively engaged in research to promote their efforts in environmental stewardship. These companies are also listed in **Appendix 5**.

Innovation Assets

In addition to industry assets, the mining and energy sector in BC is supported by significant innovation assets. These include strong mining and energy research capacity in research centres and institutes, education and training programs, and a robust investment environment and funding opportunities. Some government institutions and associations discussed in previous sections such as CMIC, COSIA, Geoscience BC, NRCan, Environment Canada, etc should also be considered under Innovation Assets. This section lists research centres, institutions, universities, training programs, funding and investment opportunities.

Research Capacity

BC is home to significant breadth and depth of mining, energy, and enabling technology researchers across its 25 publically funded higher education institutions in addition to the intensive research underway in many mining, oil and gas companies. Within the higher education sector, particular research strengths exist in geoexploration, production, and remediation. Taken together these assets offer the BC mining and energy sector new research opportunities aimed at increasing productivity of mining and energy assets, decreasing the resource-intensiveness of extraction, accelerating and improving remediation, and improving tools for assessment, monitoring, and compliance.

Research Centres and Institutes

BC hosts more than 250 researchers (likely many more, including technicians and trainees; see **Appendix 6** for partial listing) at BC's multiple research centres focusing on mining and energy research challenges covering all stages of the industry lifecycle from exploration to closure (see **Table 8**).

The Province also supports more than 40 Canada Research and other endowed Chairs with expertise relevant to the sector, hosted by 6 of the province's colleges and universities: University of Victoria, University of Northern BC, Simon Fraser University, Thompson Rivers University, UBC and UBC Okanagan (chairs are marked next to the researchers name in **Appendix 6**). Many sector-relevant associations (**Appendix 3 & 4**) and government or regulatory agencies listed in **Table 5** such as Environment Canada and NRCan also engage in research programs.

Table 8: Major Mining and Energy Research Centres and Institutes in BC

Research Centre/ Institution	Description
Canadian International Institute for Extractive Industries and Development (CIIEID)	SFU and UBC, in association with AME BC, were selected to lead a \$25 million grant from Foreign Affairs, Trade and Development Canada, focusing on improving the capacity of developing country governments to optimize the contribution of mining, oil, and gas production to sustainable economic growth and poverty reduction
Greentech Exchange	Delivers industry relevant forums, networking events, trade missions and market oriented programs to help advance innovation and expertise in the

Research Centre/ Institution	Description
	green economy
Environment Canada; Pacific Environmental Science Centre-North Vancouver	Marine water quality monitoring surveys and microbiological analyses. Ecotoxicology, toxicogenomic analysis, sulfur in fuels analysis, aquatic biomonitoring, fixed and mobile labs for shellfish water quality work, fresh water quality monitoring and surveillance
Responsible Minerals Sector Initiative (RMSI)	Simon Fraser University's Beedie School of Business is hosting series of invitational dialogues and a growing portfolio of projects designed to advance responsibility and sustainability in the mineral sector
Simon Fraser University Biological Sciences	Aquatic ecotoxicology, ecology and conservation. Collaborations with environmental consultancy firms and mining companies
Thompson River University Biological Sciences	Biodegradation of oil and petroleum, biofermentation, water management, remediation. Collaborations with several oil gas and mining companies
UBC Centre for Environmental Research in Minerals, Metals and Materials (CERM3)	The centre consists of 25 faculty and researchers who seek to mitigate the environmental impact of mining through research in conjunction with mining companies and government agencies. Facilities include environmental quality lab, bioremediation and reclamation lab, environmental technology lab, mine health and safety lab and mine automation and environmental simulation lab
UBC Chemical and Biological Engineering	Remediation, bioreactors, passive treatment systems, waste recycling, collaborations with BC mining companies
UBC Earth And Ocean Sciences	Extensive collaborative research in all aspects of conventional as well as unconventional oil and gas resources and remediation. Partnerships with energy and mining companies.
UBC Mineral Deposit Research Unit	Collaborative venture between the mining industry and UBC. Internationally recognized research group devoted to solving mineral exploration-related problems
UBC Norman B. Keevil Institute of Mining Engineering at UBC	The Institute conducts mining research and works with the mining industry to develop innovative technologies and practices to reduce environmental harm.
University of Northern BC Natural Resources and Environmental Studies Institute (NRESI)	Studies of ecological patterns/processes; societal structures and values; and earth systems and dynamics. Studies around pipelines, monitoring habitats
UBC Okanagan School of Engineering	Environmental studies, engineering combined with microbiology, applied to water, soil, sediment research, geotechnical research
University of Victoria Biochemistry and Microbiology	Cutting edge proteomics research, environmental microbiology, genomics, applied to environmental toxicology

Genome Sciences Centres and Institutes

BC has also built significant infrastructure and enabling capacity for genome sciences. Genome Canada and Genome BC in particular have enabled development of considerable genomic expertise and infrastructure in the province (see **Table 9**).

Table 9: Genome Sciences Infrastructure in BC

Facility	Services Offered
Genome BC Microarray Platform and Gene Array Facility	Microarrays

(Prostate Centre, Vancouver General Hospital)	
Michael Smith Genome Sciences Centre, BC Cancer Agency (BCGSC)	Sequencing, mapping, gene expression and bioinformatics facilities
UBC Bioinformatics Centre (UbiC)	Bioinformatics
UVic- Genome BC Proteomics Centre	Proteomics
The Metabolomics Innovation Centre (TMIC) U. Alberta and UVic	Metabolomics

These groups can be deployed to address research questions across many different disciplines, and have a history of collaborating with industrial clients including the energy and mining sectors. In addition, all BC universities host laboratories and equipment capable of sequencing and interpreting genomic information. As the price of sequencing declines, genomics is becoming a standard tool for researchers to better understand biological processes.

A partial list of BC academic researchers who collaborate with the energy, mining and environment sector using genomics, proteomics or metabolomics as a tool can be found in **Table 10**. Most of these individuals have been or are part of Genome BC funded projects and many have well established ongoing research partnerships with industry (see **Appendix 6** for a more complete listing of sector-relevant academic researchers in BC).

Table 10: Selected Academic Researches in BC Using Genomics in Mining, Energy or Environment Research

Name	Inst.	Department	Research Area
Agnes, George	SFU	Chemistry	Analytical chemistry in environmental applications; biological applications of mass spectrometry; proteomics
Anholt, Bradley	UVic	Natural Sci. and Eng.	Biodiversity, models, invasions, evolutionary genetics
Baillie, David	SFU	Mol Biology & Biochem	Stress response pathways, genetics, genomics, epigenomics
Baldwin, Sue	UBC	Chem. and Bio. Eng.	Bacterially mediated precipitation of metals from water
Beavis, Ronald	UBC	Biomed Rsch Centre	Experimental bioinformatics in proteomics
Beckenbach, Andrew T	SFU	Biological Sciences	Population genetics; molecular evolution; complete genomes for insects; mitochondrial genomics of insects
Borchers, Christoph	UVic	Science	Applications of mass spectrometry, proteomics, photo affinity labeling, and molecular modeling
Brandhorst, Bruce	SFU	Mol Biology & Biochem	Embryonic and larval development, genomics
Brinkman, Fiona	SFU	Mol Biology & Biochem	Computational and laboratory characterization of bacterial genomes, sub-cellular localization, microbial virulence
Brock, Hugh	UBC	Zoology	Gene regulation; role of non coding RNA
Bryan, Jennifer	UBC	Statistics; Michael Smith Labs	Integrated analysis/hypothesis generation by statistical inference/ bioinformatics, genome wide assays
Chauve, Cedric	SFU	Mathematics	Computational methods for metagenomics, combinatorial models and algorithms for comparative genomics

Name	Inst.	Department	Research Area
Chen, Jiahua	UBC	Natural Sci. and Eng.	Statistical genetics, subgroups, bioinformatics
Chen, Nansheng	SFU	Mol Biology & Biochem	Identification and analysis of gene batteries in <i>C. Elegans</i>
Christians, Julian	SFU	Biological Sci., CFRI	Physiological and genetic mechanisms underlying variation in growth within species; evolution; health; ecology
Condon, Anne	UBC	Computer Science, PIMS	Improving genome annotation, molecular structure and interaction prediction
Crowe, Sean	UBC	Microbiol & Immunol;	Role of microorganisms in geochemical processes, methane cycling, oil sands, process rate determination
Davies, Julian	UBC	Microbiology & Immunology	Microbial Envirogenomics, source tracking, biofilms, antibiotics and resistance, genomics
El-Kassaby, Yousry	UBC	Forest Resource Mgmt	Applied forest genetics and biotechnology; biofuels
Ellis, Brian E.	UBC	Michael Smith Laboratories, Botany	Plant biology, hybridization station, signaling pathways, genomics
Eltis, Lindsay D.	UBC	Microbiology & Immunology	Genomic, proteomics studies, environmental enzymes, bioremediation, health
Emberly, Eldon	SFU	Physics	Computational design of molecular electronic systems, gene regulation, biochemical networks, bioinformatics
Foster, Leonard J	UBC	Mol Biology & Biochem, ChiBi	Organelle proteomics: cell biological, biochemical and bioinformatical infrastructure, bioengineering
Fraser, Lauchlan	TRU	Natural Sciences and Engineering	Community and ecosystem ecology, grassland, wetland, wastewater treatment, restoration
Gillingham, Michael	UNBC	Ecosystem Science and Management	Application of quantitative analyses and modeling to aspects of behavioural ecology, and wildlife ecology and management
Grayston, Susan	UBC	Forest Sciences Centre	Identification of microbial indicators to enhance carbon sequestration and reduce GHG emissions, metagenomics
Gupta, Arvind	SFU	Computing Science	Bioinformatics and combinatorial algorithms
Hallam, Steven	UBC	Microbiol & Immunol	Hydrocarbon degradation, pathways, biodiversity, environmental genomics
Harden, Nicholas	SFU	Mol Biology & Biochem	Signaling pathways, embryonic development
Haynes, Charles	UBC	Chem. & Bio. Eng, Michael Smith Labs	Integrated technologies and platforms for separation and characterization of biological analytes, biomaterials, genomics
Helbing, Caren	UVic	Biochemistry and Microbiology	Development of methods for diagnosing and differentiating toxicological modes of action, genomics, proteomics
Hoos, Holger	UBC	Computer Science	Improving genome annotation, molecular structure and interaction prediction
Huber, Dezene	UNBC	Ecosystem Sci/Mgmt	Insect physiology, evolution, ecology, pest mgmt, genomics
Isaac-Renton, Judy	BCCDC		Watershed health, public health
Keeling, Patrick	UBC	Botany	High-throughput genomic analysis

Name	Inst.	Department	Research Area
Kennedy, Chris	SFU	Biological Sciences	Biological fate and adverse effects of environmental contaminants in aquatic environments
Maddison, Wayne	UBC	Botany & Zoology	Computational phylogenetics, evolution, bioinformatics
Marziali, Andre	UBC	Physics and Astronomy	Technologies for genomics , microarrays, nanosensors
Moerman, Donald	UBC	Zoology	Formation and function of muscle in c. elegans, genomics
Mohn, William	UBC	Microbiol & Immunol	PCB bioremediation, environmental biotechnology, genomics
Ng, Raymond	UBC	Computer Science	Intelligent computational methods for analysis of gene expression profiles, database mining, bioinformatics
Otto, Sally	UBC	Zoology	Population genetics and evolutionary biology, modeling
Roberts, Deborah	UBCO	School of Engineering	Application of microbial processes to treat contaminated water, soil and sediments
Russello, Michael	UBCO	Biology	Genetic basis of adaptation within a conservation context
Sahinalp, Cenk	SFU	Computing Science	Laboratory for computational genomics and bioinformatics
Suttle, Curtis	UBC	Earth and Ocean Sci.	Viruses and their role in the environment
Tang, Patrick	BCCDC		Watershed health, public health
Verheyen, Esther	SFU	Mol Biol & Biochem	Growth and development in Drosophila, proteomics
Wong, Judy	UBC	Pharm'l Sciences	Mechanisms of genome maintenance, cellular pathways

Education and Training Programs

Mining, energy, and related sectors provide long-term, high-quality career opportunities for many British Columbians, yet recruitment and retention of skilled workers remains a significant issue for the sector. Many of the projected labour shortages in the sector will require trades certification and apprenticeships and/or post-secondary degrees. Several institutions have developed programs to meet projected employment needs in mining and energy. As one example, Northwest Community College offers unique, hands-on education through its School of Exploration and Mining (SEM), founded in 2004. In partnership with Smithers Exploration Group and the Province, SEM develops and delivers courses and programs that equip students with the practical skills and knowledge needed for employment in the mineral exploration and mining industry. The Norman B. Keevil Institute of Mining Engineering at UBC (mining.ubc.ca) offers undergraduate and graduate programs in mining engineering, and professional development for mining engineers. BC Institute of Technology (www.bcit.ca) offers a two-year diploma in mining and creates customized courses to meet industry training needs.

WorkBC's Employment Skills Access (ESA) program provides additional training opportunities via tuition-free, group-based training at local post-secondary institutions. This includes:

- Underground Mining (North Island College), a four-month program for participants to address labour shortages and skills gaps in underground mining;
- Mining Fundamentals (Northern Lights College), a 12-week program to prepare people from Chetwynd for entry-level positions at a surface mine operation;
- Mothers to Miners (Northern Lights College), a 12-week program to prepare women from Tumbler Ridge for entry-level positions at a surface mine operation;
- Introduction to Geographical Information Systems (University of Northern BC), a three-month certificate program for 14 participants. Designed for workers with little or no experience, this program will provide a broad skill set for employment in the oil and gas and mining sectors; and
- Northern Skills Training Pilot, an 18-month essential skills training initiative to upgrade the skills of 840 forestry and mining workers in northern B.C.

Education of the mining and energy sector about opportunities in genomics is undertaken by Genome BC's Communication Department and Energy & Mining Sector Strategy. Geneskool, a hands-on in-person workshop for high school students have inspired over 25,000 students in BC, from Dawson Creek to Prince George to Vancouver⁶⁷. Through classroom visits, workshops and summer camps students are provided with unique opportunities to investigate the world of genomics and life sciences. Under Genome BC's Energy and Mining Strategy opportunities for genomics applications in the sector are communicated through wide-ranging outreach activities.

In February 2011, Genome Canada initiated a program called Entrepreneurship Education in Genomics (EEG). This program aims to support initiatives to educate the Canadian genomics research community about creating and capturing value from research and translating discoveries into marketable applications and processes⁶⁸. Under this program, UBC received funding for its Genomics Research Entrepreneurship to Accelerate Translation (GREAT) program. The GREAT program leverages the strengths of UBC's University-Industry Liaison Office and Sauder School of Business to assemble a network of entrepreneurial expertise for knowledge sharing between commercialization experts, students, researchers, end-users and stakeholders in the natural resource sector. Students and researchers in natural resources sector take advantage of educational modules in basic genomics, communication, and access internship opportunities and entrepreneurial training. While the project was funded for a limited time period, it is expected to leave a legacy of training modules such as Genomics 101 in collaboration with the Michael Smith Laboratories, Genomics as a Tool, and Lean Launch Pad for Genomics⁶⁹.

⁶⁷ <http://www.genomebc.ca/education/outreach-programs/>

⁶⁸ <http://www.genomecanada.ca/en/portfolio/research/eeg-program.aspx>.

⁶⁹ <http://genomics.entrepreneurship.ubc.ca/training/entrepreneurial-education/lean-launch-pad/>.

Investment Landscape

BC's mining and energy sector has already attracted significant investment. The mining industry had an estimated \$680 million invested in exploration in 2012, a 47% increase over 2011 levels⁷⁰. BC's stake in the natural gas industry is growing substantially, with investment increasing from \$1.8 billion in 2000 to \$7.1 billion in 2010⁷¹.

BC offers low combined federal/provincial corporate tax rates for mining and energy operators in BC, as well as tax incentives to encourage new exploration. The Mineral Exploration Tax Credit provides a 20% refundable tax credit for eligible mineral exploration in BC, (30% for exploration in areas affected by the Mountain Pine Beetle). An additional Mining Flow-Through Share Tax Credit provides a non-refundable 20% tax credit, while the New Mine Allowance and other provisions enable new mines and major mine expansions to deduct 133% of capital costs through to 2016⁷². BC is also regarded as having a rigorous but fair and straightforward review process for new mining and energy projects. The recent implementation of a "one project, one review" environmental review process is will encourage further mining investment in BC by harmonizing federal and provincial reviews for projects in BC.

Historically, the majority of investments in mining and energy in BC have been directed towards identifying, qualifying, developing, and managing new mines and oil and gas fields. However, investments are increasingly focused on improving recovery rates from aging mining and energy assets, enhancing or hastening remediation processes, and developing better monitoring and assessment tools. There is significant potential for such issues to be addressed with genomics-based solutions. Several longstanding and more recent funding programs offer support for research, development, and/or commercialization activities in mining and energy sector in BC (see **Table 11** and **Appendix 7**). These programs present targeted opportunities for sector growth, development, and sustainability.

The federal government provides funding for basic research and for some market and commercialization activities through a number of agencies and programs. Canada's tri-council agencies, in particular the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and Humanities Research Council (SSHRC), are a major source of research funding for post-secondary institutions in Canada, including those focused on mining and energy research. The federal government is also supporting more than 30 Canada Research Chairs in the sector.

Table 11: Funding Programs Supporting Applied Research in BC's Mining and Energy Sector

Program Name	Program Focus	Funding Source
Canada Research Chairs	Academic research	Federal

⁷⁰ Clark. B.C. mining investment surged in 2012. Business in Vancouver; Tue Jan 29, 2013.

⁷¹ ref. <http://britishcolumbia.ca/Invest/Industry-Sectors/Natural-Gas.aspx>

⁷² BC's Mineral Exploration and Mining Strategy. BC Ministry of Energy and Mines; 2012.

Program Name	Program Focus	Funding Source
Environment Canada Science and Technology Applications of Genomics in the Environment (STAGE) program; part of Genomics Research and Development Initiative (GRDI)	Application of genomics	Federal
Genome BC	Genome based R&D	Non-profit
Genome Canada	Genome based R&D	Non-profit
Mitacs	Students and fellows	Federal
National Research Council (NRC)- Industrial Research Assistance Program (IRAP)	Firm-based applied R&D	Federal
National Science and Engineering Research Council (NSERC)	Basic and applied research	Federal
Sustainable Development Technology Canada (SDTC)	Development and pre-commercial funds for clean tech	Non-profit
Science and Community Environmental Knowledge (SCEK)	Industry-sponsored fund for energy overseen by the BCOGC, CAPP and EPAC.	Industry
Western Economic Diversification Canada (WD)	Community economic development; trade/investment; innovation; business development in Western Canada	Federal

In addition, the National Research Council's Industrial Research Assistance Program (IRAP) provides funds to small- and medium-sized Canadian enterprises, including those engaged in mining and energy, to enable technological, firm-driven innovation. The Science and Community Environmental Knowledge (SCEK) Fund is an industry-sponsored fund overseen by the BCOG, CAPP, and the Explorers and Producers Association of Canada. The fund supports applied research to inform environmental and social matters related to oil and gas exploration and development in BC. The goal is to improve the efficiency, effectiveness and transparency of regulation of oil and gas activities in BC⁷³.

Since 2000, Genome British Columbia and Genome Canada have made significant investments in genomics research in BC and across Canada. Projects with a Genome BC contribution are shown in **Table 12**; see **Appendix 7** for a more complete list of genomics-based projects.

Table 12: Genome BC Funded Projects in Mining, Energy and Environment

Project	Institution	Budget	Partners
Passive Mitigation of Mine Drainage	UBC	\$1.55M	Teck and Imperial Metals
Mount Polley Heap Leach Metagenomics Project		\$28K	Imperial Metals
Explosives Biodegradation	UBC	\$3.45M	US Department of

⁷³ <http://scek.ca>

			Defence – SERDP, Canadian Dept. of National Defence
Greener Hydrocarbon	U.Calgary, UBC	\$1.93M (in BC)	Conoco, Encana, Shell, Suncor, Syncrude
Frog Sentinel species: FrogScope	UVic	\$402K	Environment Canada, UBC
Health Assessment Tool for Marine Mussels: Myt-OME	VIU	\$407K	
Microbial Envirogenomics	UBC	\$4.6M	
Microbial Community Monitoring as a Forest Management Tool	UBC	\$1.3M	
Applied Metagenomics of the Watershed Microbiome	UBC	\$3.2M	BCCDC
Environmental Genomics of RNA Viruses	UBC	\$104K	
Community Genomics of Subarctic Oxygen Minimum Zones	UBC	\$432K	

In the last decade, approximately \$8 million has been invested in mining and energy-targeted genomic research by Genome BC. The “Development of Genomic Tools for Monitoring and Improving Passive Mitigation of Mine Drainage” project, funded by Genome BC (AGIP program) and partners provides a useful example. The project, led by Dr. Susan Baldwin at UBC, seeks to better understand the dynamics of sulfate-reducing bacteria at bioremediation sites for mine drainage. Understanding microbial communities at these sites could enable passive water bioremediation and replace chemically-based ARD and metal leaching mine drainage treatment.

The “Metagenomics for greener production and extraction of hydrocarbon energy” project, funded through the Applied Genomics in Bioproducts or Crops (ABC) competition received \$11.6M to build a metagenomics database for the hydrocarbon energy sector, determining “who is there, what are they doing, and how can we steer their actions to our advantage”⁷⁴. The database of microorganisms, genes and biological processes was a necessary first step for future development of biotechnology applications, which may include reducing bio-corrosion, controlling oil field souring, safe tailings pond closure, and waste remediation. UBC professor Steve Hallam is the leader of the BC part of this research program.

As another example, under Genome Canada’s Large Scale Applied Project (LSARP) competition a BC research team including the BC Centre of Disease Control was awarded \$3.2 million to develop tools that detect changes in watershed health much sooner than current culture based method. Scientists led by Drs. Patrick Tang and Judy Isaac-Renton are using metagenomics to compare healthy watersheds with those that have been affected by industry, population, environmental degradation or changing land use pressures, and will develop tools to match the microbial fingerprint of contaminated watersheds to the

⁷⁴ <http://www.hydrocarbonmetagenomics.com>

specific source of pollution. These tools could save millions of dollars in water treatment and monitoring.

As a final example, as a result of applying genomic research to environmental challenges, a commercialized microbial consortia (KB-1®) is already being used for global groundwater clean-up. KB-1® cultures introduce chlorine-removing microbes to sites, leading to faster bioremediation and lower overall project costs⁷⁵. KB-1® was developed by Elizabeth Edwards at the University of Toronto and is being further investigated under a Genome Canada and Ontario Genomics Institute funded project called Bioproducts + Enzymes from Environmental Metagenomes (BEEM). A new application arising from BEEM is being tested at pulp and paper mills to reduce harmful by-products and generate energy from anaerobic digestion of waste streams. These examples provide clear precedent for the value that applied research can bring to BC's mining and energy sector. See **Appendix 7** for a more complete listing of sector relevant genomic research programs in Canada.

In 2013, Genome Canada and its regional centres embarked on a new sector specific initiative. Part of this initiative is "Advancing Operations in the Canadian Energy and Mining Sector through State-of-the-Art Genomics Applications"⁷⁶. Through extensive consultation culminating in a March 2013 workshop and follow-up survey, the Genome Canada energy and mining sector strategy process provided stakeholders with a greater appreciation of commercial and environmental needs for applied genome sciences.

In January 2014, Genome BC with the aid of industry leaders and AME-BC hosted a roundtable event for a group of representatives from the mining industry, academia and government. The group was brought together to determine the level of interest in applying biological methods, specifically genomics, to improving operational and cost performance in the mining industry. Scientists gave concrete examples about discoveries that may lead to improved processes for treating wastes, recovering metals and maximizing mineral yield. Some of the examples include gold and copper extraction, bioremediation of wastewater using specific microbial communities and the application of organisms that bind to minerals to better separate them. Future opportunities include extraction of rare earth metals, exploration for new deposits and applications of bioreactors in Northern Canada. Attendees of the roundtable all agreed that there is the will and technological expertise to move forward making it an attractive investment opportunity.

Additionally, Genome Canada has announced a new partnership program called Genomic Applications Partnership Program (GAPP), which aims to: promote the application of genomics to sector challenges; promote commercialization of genomics technologies by enabling the transfer of genomics-derived solutions from academia to users; increase the socio-economic impact of genomics research by accelerating its translation to application

⁷⁵ <http://www.siremlab.com/products/kb-1>

⁷⁶ www.genomecanada.ca

or market; and create and foster a more productive interface between academia and users⁷⁷.

Genome BC also launched a new User Partnership Program (UPP) in 2013. UPP is designed to directly address the challenges defined by users in BC's key sectors including, including mining and energy. By engaging industry, government regulators, health authorities, not-for-profit organizations and other sector users early in the implementation process, Genome BC aims to improve the translation of research innovations to products, services, policy, and practices. The favorable investment landscape described above and the genomics research assets developed to date provides a good foundation for developing a genomics sector strategy for energy and mining in BC that is the subject of a follow-on document.

⁷⁷ Genomic Applications Partnership Program (GAPP) Investment Strategy & Guidelines. Genome Canada; 2013.

APPENDICES

Appendix 1: Mines in BC

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Ajax	KGHM International Ltd, Vancouver BC	Permitting and EA	South Central BC	Kamloops BC	metal	copper gold	
Atlin Ruffner	BC Crown	closed	North West BC	Atlin BC	Metal		Priority, tanks of diesel in mine shaft and tailings pond
Basin	Compliance Energy Corp, Vancouver BC	care and maintenance	South Central BC	Princeton BC	coal		
Berg	Thompson Creek Metals Co, Denver CO	Advanced Exploration	North West BC	Huston BC	metal	copper molybdenum silver	
Big Bull	Chieftain Metals Corp, Toronto ON	Advanced Exploration	North West BC	Atlin BC	metal	copper	
Blackdome	Sona Resources Corp, Vancouver BC	Proposed	South West BC	Clinton BC	metal	Gold	
Blackwater	New Gold Inc, Toronto ON	Proposed	Central BC	Vanderhoof BC	metal	gold	
Bluebell Mine	Teck Resources Ltd, Vancouver BC	closed	South East BC	Phoenix BC	metal	silver zinc	Surface and groundwater issues, ARD
Bonanza Ledge/ Cariboo Gold	Barkerville Gold Mines Ltd, Vancouver BC	Development	North Central BC	Barkerville BC	metal	gold	On Liberal platform
Bralorne Pioneer Mine	Bralorne Gold Mines Ltd, Vancouver BC	producing	South Central BC	Lillooet BC	metal	gold	

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Bralorne-Takla	BC Crown	closed	North Central BC	Lillooet BC	metal		priority, Sb, As, Cd, Cr, Hg in soil
Brenda Mine	Xstrata Copper Canada, Toronto	closed	South Central BC	Peachland	metal	molybdenum	water treatment, active treatment, closed 45 treatment, molybdenum different from other metals in terms of interaction with bacteria
Britannia Mine	Britannia Bay Properties Ltd	closed	South Central BC	Squamish BC	metal	copper	ARD perpetual treatment
Brucejack	Pretium Resources Inc, Vancouver BC	Proposed	North West BC	Bowser Lake BC	metal	gold silver	
Brule Operations	Walter Energy Inc, Birmingham, AL	producing	North East BC	Prince George BC	coal		Se
Carbon Creek	Cardero Resource Corp, Vancouver	advanced exploration	North East BC	Hudson's Hope BC	coal		
Central South	Xstrata Coal, Sydney Australia	advanced exploration	North East BC	Chetwynd BC	coal		Se, federal review status: terminated
Chu Molybdenum	TTM Resources, Vancouver BC	Permitting and EA	North Central BC	Vanderhoof BC	metal	molybdenum	
Coal Mountain Operations	Teck Coal Ltd, Calgary AB	producing	South East BC	Sparwood BC	coal		Se
Copper Mountain Mine	Copper Mountain Mining Corporation, Vancouver BC	producing	South Central BC	Princeton BC	metal	copper gold	On Liberal platform
Cork Province	BC Crown	closed	South East BC	Nelson BC	metal	Gold silver zinc	priority, Tailings with Pb, Zn, As threaten creek
Cronin	BC Crown	closed	North Central BC	Smithers BC	metal		priority, Pb, Zn, Cu, Cd contamination

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Davidson Property	Thompson Creek Metals Co, Denver CO	Permitting and EA	North West BC	Smithers BC	metal	molybdenum	
Dome Mountain	Metal Mountain Resources Inc, Vancouver BC	Permitting and EA	North West BC	Smithers BC	metal	gold	
Elizabeth	Sona Resources Corp, Vancouver BC	Proposed	South West BC	Bralorne BC	metal	gold	
Elkview Operations	Teck Coal Ltd, Calgary AB	producing	South East BC	Sparwood BC	coal		Se, Teck/Golder bioreactor (BioteQ!) not permitted (yes in cardinal River AB). Elk Valley Selenium Task Force! \$600M investment into watershed management over 6 sites, active and legacy. Teck hired molecular biologist
Emerald Glacier	BC Crown	closed	Central West BC	Huston BC	metal	copper gold silver zinc	priority, Ag, Au, Pb, Zn, Cu, Cd in land and water
Endako Mine	Thompson Creek Metals Co, Denver CO	producing	North West BC	Prince George BC	metal	molybdenum	On liberal platform
Equity Silver	Goldcorp Inc, Vancouver BC	closed	North Central BC	Huston BC	metal	silver	
Eskay Creek	Barrick Gold Corp, Toronto ON	closed	North West BC	Stewart BC	metal	gold silver	
Fording River Operations	Teck Coal Ltd, Calgary AB	producing	South East BC	Elkford BC	coal		Se
Foremore	Roca Mines Inc, Vancouver BC	Advanced Exploration	North West BC	Wrangell BC	metal	copper gold zinc	

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Frasergold	China Minerals Mining Corp, Beijing China	Advanced Exploration	North Central BC	Williams Lake BC	metal		
Galore Creek	Novagold Resources Inc, Vancouver BC	Permitting and EA	North West BC	Stewart BC	metal	copper gold silver	
Gething	Canadian Dehua International Mines Group Inc, Vancouver BC	Permitting and EA	North East BC	Hudson's Hope BC	coal		
Gibraltar Mines	Taseko Mines Ltd, Vancouver BC	producing	North Central BC	Williams Lake BC	metal	copper molybdenum	
Greenhills Operations	Teck Coal Ltd, Calgary AB	producing	South East BC	Elkford BC	coal		Se
Harper Creek	Yellowhead Mining Inc, Vancouver BC	Permitting and EA	South Central BC	Kamloops BC	metal	copper gold	
Hermann	Walter Energy Inc, Birmingham, AL	Permitting and EA	North East BC	Tumbler Ridge BC	coal		Se
Highland Valley Copper	Teck Resources Ltd, Vancouver BC	producing	South Central BC	Kamloops BC	metal	copper molybdenum	Trail Wetland, Biological drivers of calcite precipitation, Heather Lorette demo experiments (Glenda Fratton (Cardinal River AB) Robin Johnstone, Calgary)
Horizon	Anglo American PLC, London UK	Permitting and EA	North East BC	Tumbler Ridge BC	coal		Se
Howard	BC Crown	closed	South East BC	Nelson BC	metal	silver	priority, silver and lead eroding into salmon river
Huckleberry Mine	Imperial Metals Corp, Vancouver BC	producing	North West BC	Huston BC	metal	copper molybdenum	On liberal platform
Iron Crown	BC Crown	closed	South West BC	Campbell River BC	metal		priority, tailings contaminated a lake

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Island Copper Mine	BHP Billiton Base Metals, London UK	closed	South West BC	Port Hardy BC	metal	copper gold molybdenum silver	biogeochemistry of layers in pit lake, tailings on seabed, Clem Pelletier Rescan
Island Mountain	BC Crown	closed	Central BC	Wells BC	metal	gold	priority, tailings and soil with As including town wells
Kemess South	AuRico Gold Inc, Toronto ON	closed	North Central BC	Smithers BC	metal	copper gold	
Kitsault	Avanti Mining Inc, Denver CO	Permitting and EA	North West BC	Prince Rupert BC	metal	molybdenum	Role of microbes in preventing ARD, Moly research, water treatment
KSM Kerr-Sulphrets-Mitchell	Seabridge Gold Inc, Toronto ON	Permitting and EA	North West BC	Stewart BC	metal	copper gold silver	
Kutcho Creek	Capstone Mining Corp, Vancouver BC	Permitting and EA	North West BC	Dease Lake BC	metal	copper gold silver	
Line Creek Operations	Teck Coal Ltd, Calgary AB	producing	South East BC	Sparwood BC	coal		Se, Treating creeks, fixed capacity, Envirogen bioreactors
Max Molybdenum Mine	Roca Mines Inc, Vancouver BC	Care and maintenance	South East BC	Revelstoke BC	metal	molybdenum	
Midway	BC Crown	closed	South East BC	Cranbrook BC	metal	zinc	priority, Zn contamination
Millie Mack	BC Crown	closed	South East BC	Slocan BC	metal	gold silver	priority
Morrison	Pacific Brooker Minerals Inc, Vancouver BC	Permitting and EA	North West BC	Smithers BC	metal	copper gold	

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Mount Klappan (Arctos)	Fortune Minerals Ltd, London ON	Permitting and EA	North West BC	Stewart BC	coal		
Mount Polley Mines	Imperial Metals Corp, Vancouver BC	producing	North Central BC	Likely BC	metal	copper gold silver	Passive treatment, specific local problem
Mowson Pond	BC Crown	closed	South West BC	Lillooet BC	metal		priority, Hg contamination from Hg processing
Mt Milligan	Thompson Creek Metals Co, Denver CO	Permitting and EA	North Central BC	Prince George BC	metal	copper gold	McLeod Lake FN Economic and Community Development Agreement (ECDA) on liberal platform
Mt Washington Copper Mine	Better Resources Ltd, Nanaimo BC	closed	South West BC	Courtenay BC	metal	copper	impacted watershed, fish remediation, ARD, Peter Healy SRK Consulting, Tsolum River Restoration Society
Murray River Project	HD Mining International Ltd, China	Permitting and EA	North East BC	Tumbler Ridge BC	coal		
New Afton Mine	New Gold Inc, Toronto ON	permitting and EA	South Central BC	Kamloops BC	metal	copper gold silver	Tk'emlumps and Skeetchestn FN Economic and Community Development Agreement (ECDA) on liberal platform
New Prosperity	Taseko Mines Ltd, Vancouver BC	Permitting and EA	South Central BC	Williams Lake BC	metal	copper gold	
Nickel Plate Mine	Barrick Gold Corp, Toronto ON	closed	South Central BC	Hedley BC	metal	gold silver	Passive Treatment , CN degradation process using bacteria, As, Envirogen fluidized bed , has open as well as closed treatment systems, explosives, nitrates, Vanessa Bell Sr Env Specialist at Barrick

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Nyrstar Myra Falls	Nyrstar NV, Balen Belgium	producing	South West BC	Campbell River BC	metal	copper gold silver zinc	
Pacific Place	BC Crown	closed	South West BC	Vancouver BC	metal		priority, soil and groundwater contaminated with metal and organics from industrial activities
Quesnel River (QR) Barkerville Gold Mine	Barkerville Gold Mines Ltd, Vancouver BC	producing	North Central BC	Wells BC	metal	gold	On Liberal platform
Quinette Babcock	Teck Resources Ltd, Vancouver BC	closed	North East BC	Tumbler Ridge BC	coal		Biological drivers of calcite precipitation
Quinsam Mine	Hillsborough Resources Ltd, Vancouver BC	producing	South West BC	Campbell River BC	coal		demo scale sulphate removal
Raven	Compliance Energy Corp, Vancouver BC	Permitting and EA	South West BC	Courtenay BC	coal		
Red Chris	Imperial Metals Corp, Vancouver BC	Permitting and EA	North West BC	Dease Lake BC	metal	copper gold	On Liberal platform
Roman Mountain	Anglo American PLC, London UK	advanced exploration	North East BC	Tumbler Ridge BC	coal		Se, expansion of Trend
Ruby Creek Moly	Adanac Molybdenum Corp, Surrey BC	care and maintenance	North West BC	Atlin BC	metal	molybdenum	
Ruddock Creek	Imperial Metals Corp, Vancouver BC	Permitting and EA	South Central BC	Kamloops BC	metal	zinc	

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Schaft Creek	Copper Fox Metals Inc, Calgary AB	Permitting and EA	North West BC	Telegraph Creek BC	metal	copper gold molybdenum silver	
Shasta	Sable Resources Ltd, Vancouver BC	producing	North Central BC	Smithers BC	metal	gold silver	
Spanish Mountain	Spanish Mountain Gold Ltd, Vancouver BC	Proposed	Central BC	Likely BC	metal	gold	
Table Mountain (Cassiar Gold)	China Minerals Mining Corp, Beijing China	care and maintenance	North West BC	Dease Lake BC	metal	gold	
Treasure Mountain	Huldra Silver Inc, Vancouver BC	Advanced Exploration	South Central BC	Hope BC	metal	silver zinc	On Liberal platform
Trend Mine	Anglo American PLC, London UK	producing	North East BC	Tumbler Ridge BC	coal		Se
Tulsequah Chief	Chieftain Metals Corp, Toronto ON	Permitting and EA	North West BC	Atlin BC	metal	copper zinc	
Turnagain	Hard Creek Nickel Corp, Vancouver BC	Permitting and EA	North West BC	Dease Lake BC	metal	nickel silver	
Two Mile Creek	BC Crown	closed	North Central BC	Smithers BC	metal		priority, Pb, As, Cu, Sn in drinking water from tailings
Union Bay Coal Hills	BC Crown	closed	South West BC	Courtenay BC	coal		priority, high sulphur content, ARD
Willow Creek Operations	Walter Energy Inc, Birmingham, AL	advanced exploration	North East BC	Chetwynd BC	coal		Se, closed
Wolverine (Perry Creek) Operations	Walter Energy Inc, Birmingham, AL	producing	North East BC	Tumbler Ridge BC	coal		Se

Mine Name	Current owner	Status	Location	Closest town	Type of mine	Ores Produced	Opportunity for Genomics-Based Research
Yankee Girl Mine	BC Crown	closed	South West BC	Nelson BC	metal		priority, heavy metal from tailings
Yellowjacket	Athabasca Nuclear Corp, Cranbrook BC	Proposed	North West BC	Atlin BC	metal	gold	
Ymir and Protection Mines	BC Crown	closed	South East BC	Nelson BC	metal	gold silver zinc	priority, dangerous As contamination

Appendix 2: Energy and Energy Supporting Companies in BC and of Interest to BC

Institution	BC Operations	HQ	Main BC interest	Business Focus
Advantage Energy Income Fund (Advantage Oil and Gas)	Fort St John, Montney Play	Alberta	oil	Natural gas resource development and production
AltaGas	Vancouver	Alberta	infrastructure	Energy Infrastructure assets in natural gas and power
Apache Canada (Chevron)	Fort Nelson, Dawson Creek	Texas	gas, LNG, refinery	Oil & gas exploration/production
ARC Resources	Fort Nelson, Dawson Creek	Alberta	gas	Conventional oil and gas
Artek Exploration	Deep Basin	Alberta		Junior oil and gas exploration
BG Gas Group	Northern Foothills, Southern Foothills, Prince Rupert	United Kingdom	LNG	LNG exploration and production
Bonavista Energy Trust	Fort St John	Alberta		Oil and gas production
BP Canada Energy Group	Deep Basin	United Kingdom		Oil & gas exploration and production
Calfrac Well Services		Alberta	fracking	Pressure pumping
Canada Energy Partners	Northern Foothills	British Columbia		Natural gas development and production
Canadian Natural Resources	Fort Nelson, Fort St John, Northern Foothills, Southern Foothills, Dawson Creek	Alberta	oil, gas	Crude oil and natural gas producer
Canadian Spirit Resource	Northern Foothills	Alberta		Unconventional gas and energy
Cenovus Energy		Alberta		Oil company
Cequence Energy (Sabretooth Energy)	Fort Nelson	Alberta		Natural gas and oil resource play
Ch'nook	Fort St John, Fort Nelson	Alberta		Oil & gas exploration/production
China Petroleum (Sinopek)	Northern Foothills	China		Shale gas development, divesting
CNPC		China		Oil & gas exploration and production
ConocoPhillips Canada	Fort St John, Deep Basin,	Alberta	oil	Oil & gas exploration/production

Resources	Southern Foothills			
Crew Energy	Fort Nelson	Alberta		Natural gas producer
Crocotta Energy	Deep Basin	Alberta		Junior oil and gas exploration and development
Delphi Energy	Deep Basin	Alberta		Oil and natural gas producer
Devon Energy	Fort St John, Fort Nelson, Deep Basin, Southern Foothills	Oklahoma	oil, gas	Oil & gas exploration/production
Dolomite Energy	Fort Nelson	Alberta		Junior oil and gas producer
E4 Energy		Alberta		Junior oil and gas exploration and development
Enbridge		Alberta	pipeline	Energy transport
Encana	Fort Nelson, Dawson Creek, Deep Basin	Alberta	oil, gas	Oil and gas energy producer
Enerplus Resources	Fort St John	Alberta		North American energy
Enterra Energy (Equal Energy)	Fort Nelson	Alberta		Oil & gas exploration/production
EOG, Canada	Fort Nelson, Horn River, Liard Basin, Ford Belt	Texas	gas	Crude oil and natural gas producer
Exxon Mobil Canada		Texas (NS)		Oil & gas exploration/production
Forest Oil		Colorado		Oil and gas exploration
Guardian Exploration	Fort Nelson	Alberta		Oil and gas exploration
Harvest Operations (Korea National Oil)	Fort Nelson	Korea		Oil & gas exploration/production
Hemisphere Energy Corporation		BC		Oil & gas exploration/production
Hunt Oil	Northern Foothills	Alberta		Petroleum exploration and production
Husky Energy	Fort Nelson	Alberta	oil, refinery	Integrated energy company
Imperial Oil (Esso)		Alberta	Gas, terminal	Integrated energy company
Inpex	Horn River	Japan		Oil & gas and mineral exploration and production
Ironhorse Oil and Gas	Fort Nelson	Alberta		Junior oil and gas exploration and production
Ivanhoe Energy		Alberta		Heavy oil development/ and production
JGC	Prince Rupert	Japan	infrastructure	Oil and gas engineering and

				consulting
Kinder Morgan		Texas	pipeline	Energy and pipeline company
Kogas	Kitimat	Korea		LNG importer
Methanex Corporation		British Columbia	downstream	Methanol manufactures and sales
Mitsubishi	Kitimat	Japan	terminal	Gas, chemicals and advanced materials
Monterey Exploration (Pengrowth)	Deep Basin	Alberta		Oil and gas producer
Murphy Oil Corp	Montney Play, Deep Basin, Dawson Creek	Arkansas	gas	Oil & gas exploration/production
Nabors Energy		Bermuda	drilling	Drilling
Nexen	Fort Nelson	Alberta	gas	Oil & gas exploration/production
Northpoint Energy	Northern Foothills	Alberta		Oil & gas exploration/production
Nytis Exploration (Cadent Energy)	Fort Nelson	Colorado		Gas exploration and production
Painted Pony Petroleum	Montney Play	Alberta		Acquisition, exploration and development of petroleum and natural gas resources
PCL	Kitimat	Alberta	terminal	construction
Penn West Petroleum	Fort Nelson	Alberta		Conventional natural oil and gas producer
Petronas	Prince Rupert	Malaysia	gas, LNG	Integrated oil and gas company
Polarstar Oil and Gas (Tusk Energy)		Alberta	oil, gas, LNG	Oil and gas assets and production
Progress Energy (ProEx Energy)	Fort St John, Northern Foothills, Prince Rupert, Dawson Creek	British Columbia		Natural gas producer
Questerre Energy Corporation	Liard Basin, Ford Belt	Alberta		Shale and nonconventional energy
Quicksilver	Horn River, Fort Nelson	Alberta	gas	Oil & gas exploration and production
Spectra Energy	Prince Rupert	Texas	LNG	Pipeline, midstream
Shell Canada Energy	Fort St John, Deep Basin, Northern Foothills, Southern Foothills, Dawson Creek	Alberta	gas, terminal	Group of energy and petrochemical companies
SMR (Stone Mountain)	Fort Nelson, Northern	Alberta		Gas exploration and production

Resources) Oil and Gas	Foothills			
Suncor (Petro Canada)	Deep Basin, Southern Foothills	Alberta	terminal	Natural resources and renewable energy resources
Syncrude		Alberta		Crude oil from oil sands
Talisman Energy	Montney Play, Northern Foothills, Southern Foothills	Alberta	gas	Oil and gas producer
Terra Energy	South Peace	Alberta		Junior oil and gas exploration and production
Total E&P (TEPCA)		Alberta	oil	Oil & gas exploration/production
Tourmaline Oil Corp (Huron Energy)	Montney Play	Alberta	gas	Oil & gas exploration/production
Transeuro Energy Canada	Liard Basin, Ford Belt	Alberta		Junior oil and gas exploration and development

Appendix 3: Mining and Related Associations in BC and of Interest to BC

Organization	Abbr.	Focus	Publications	Jurisdiction
Acid Drainage Technology Initiative	ADTI	Advances in acid drainage prediction, prevention, control, sampling, monitoring, and treatment	Guides, research summaries, handbooks, methods	US
Alliance for Responsible Mining (Formerly Western Coal Council)	ARM	Sustainable development of small-scale mining worldwide, training, consultancy		International
American Coal Council	ACC	Resource for industry, policy makers and public interest groups. Supports activities that advance coal supply, consumption, transportation and trading.	American Coal Magazine, American Coal Online	US
American Exploration and Mining Association (formerly Northwest Mining Association)	AEMA	Prospecting, exploring, mining, and reclamation closure activities on USFS (US Forest Service) administered lands, especially in the West.	The Bulletin	US
American Institute of Mining, Metallurgical and Petroleum Engineers	AIME	US professional engineering society for mining engineers	no	US
American Society for Mining and Reclamation	ASMR	Promotes advancement of basic and applied reclamation science through research and technology transfer worldwide	J. of the Am. Society of Mining and Reclamation	US
Aquatic Toxicology Workshop	ATW	Aquatic toxicology and water quality research and dialogue	Annual Proceedings	Canada
Association of Mineral Exploration BC	AME BC	Mining Exploration Focus	Mineral Exploration Magazine	BC
Association of Professional Biologists (College of Applied Biology)	APB	Professional development opportunities and guidance; advocating for advancements in the application, practice and understanding of biological sciences	Annual Conference	BC
BC Aboriginal Mine Training Association	BC AMTA	Connecting youth to training and jobs in mineral exploration and mining	Present.	BC
BC Technical and Research Committee on Reclamation	BC TRCR	Government & Industry Communication	Reports	BC
Canada Mining Innovation Council	CMIC	Research and Innovation in Mining	Reports, present.	Canada

Organization	Abbr.	Focus	Publications	Jurisdiction
Canada Mining Innovation Council Western District	CIMIC	Technical Society for Mining	no	BC, AB, SK, YT
Canadian Institute of Mining, Metallurgy and Petroleum	CIM	Technical Society for Mining	CIM Magazine, CIM Journal, Technical Papers	Canada
Canadian Land Reclamation Association	CLRA	Reclamation Knowledge Exchange	Canadian Reclamation, Annual Meeting Proceedings	Canada
Canadian Land Reclamation Association BC Chapter	BC CLRA	Reclamation Knowledge Exchange	no	BC
Center for Excellence in Mining Innovation	CEMI	Industry Driven Applied Res. (ON)	R&D Publications	Canada
Certified Environmental Professionals (Environmental Careers Organization)	EP	Training and certification in: Environmental Protection, Conservation and Preservation of Natural Resources, and Environmental Sustainability.	no	Canada
Coal Association of Canada	CAC	Promoting Coal	no	Canada
Coalwatch Comox Valley Society		Identify and research issues regarding the proposed Raven Project near Fanny Bay.	no	BC
Elk Valley Selenium Task Force	EVST	Representing 5 coal mining operations that provide input into guidelines for Se; and, promoting development of site-specific environmental objectives	Reports	BC
Environmental Excellence in Exploration	e3 Plus	Framework for responsible explorations, principles, guidelines for environmental, social, health and safety	Guidelines, toolkits	Canada
First Nations Energy and Mining Council	FNEMC	Participants in the decision making, management processes, and economic benefits associated with the sustainable development of energy and mineral resources in BC	Reports	BC
Institute of Professional Environmental Practice	IPEP	Certifying organization for the Qualified Environmental Professional (QEP) and the Environmental Professional Intern (EPI) to improve practice and educational standards of environmental professionals around the globe.		International
International Affiliation of Land Reclamationists	IALR	Encouraging international collaboration. Provides medium for enhanced technical awareness of current technology and research programs.		International

Organization	Abbr.	Focus	Publications	Jurisdiction
International Council on Metals and the Environment	ICME	Promotes sustainable development policies and practices related to mining and metals, which will ensure the safe production, use, recycling and disposal		International
International Cyanide Management Code	ICMI	Responsible cyanide management practices in the gold mining industry.	International Cyanide Mgmt Code, Annual Reports	International
International Mine Water Association	IMWA	Mine water and mine drainage issues	Journal of Int. Mine Water Association	International
International Post Mining Alliance		Regeneration of old mine sites for the sustainable benefit of community and environment.	Documents	International
Mine Environment Neutral Drainage Program	MEND-NEDEM	Develop technologies to prevent and control acidic drainage	MEND Monitor	Canada
Mineral Education Coalition	MEC	Understanding mining and minerals through education K-12		International
Mining Association of BC	MABC	BC Industry Association	Mining Facts	BC
Mining Association of Canada	MAC	National Industry Association	Quarterly e-Newsletter	Canada
Mining Suppliers Association of BC	MSABC	Mining Industry Suppliers in BC	no	BC
Mining Watch Canada		Changing public policy and mining practices to ensure the health of individuals, communities and ecosystems	Newsletters	Canada
National Centre for Groundwater Research and Training	NCGRT	Australian and international researchers and industry partners for world class groundwater research	Brochures, Annual reports	Australia
National Mining Association USA	NMA	US national trade organization that represents the interests of mining before Congress	Membership and committee meetings	US
National Orphaned and Abandoned Mines Initiative	NOAMI	Assessment, characterization and remediation/reclamation of orphaned and abandoned mine sites	Newsletters	Canada
North American Metals Council (Selenium Workgroup)	NAMC	Risk assessment issues presented by metals (incl. Se) and regulatory implications	Reviews	International
Partnership for Acid Drainage Remediation in Europe	PADRE	Acid mine drainage remediation or research		International
Prospectors and Developers Association of Canada	PDAC	Mining Exploration Focus	Core, eNews	Canada
Qualified Environmental Professionals	QEP	Applied scientist or technologist within their area of expertise		BC

Organization	Abbr.	Focus	Publications	Jurisdiction
Registered Professional Biologists (through College of Applied Biology BC)	RPBio	Preserving and protecting scientific methods and principles, ensuring members objectivity, principles		BC
Society for Ecological Restoration	SER	Repair and recovery of degraded ecosystems utilizing a broad array of experiences, knowledge sets, and cultural perspectives	Restoration Ecology Journal	International
Society for Ecological Restoration BC Chapter	SER BC	Direct involvement in projects to restore BC ecosystems.	Newsletters	BC
Society for Mining Metallurgy and Exploration	SME	SME advances the worldwide minerals community through information exchange and professional development.	Mining Engineering Magazine	International
United Nations Environmental Programme	UNEP	Acts as a catalyst, advocate, educator and facilitator to promote the wise use and sustainable development of the global environment.	Reviews	International

Appendix 4: Energy and Related Associations in BC and of Interest to BC

Organization	Abbr.	Focus	Publications	Jurisdiction
American Petroleum Institute	API	US trade association that represents all aspects of oil and natural gas industry.	Statistics, reports	US
Association for Professional Engineers and Geoscientists of BC	APEGBC	Licensing and regulatory body responsible for BC's professional engineers and geoscientists		BC
BC Bioenergy Network	BCBN	Industry-led initiative supports research towards building a world-class bio-energy capability in BC.	Reports, fact sheets	BC
BC Petroleum Contractors Association	BCPCA	Petroleum handling equipment industry stakeholders.		BC
Canada's Oil Sands Innovation Alliance	COSIA	Alliance of oil sands producers accelerating the pace of improvement in environmental performance in Canada's oil sands		Canada
Canadian Society of Exploration Geophysicists	CSEG	Promote the profession of Geophysics, encourage education and facilitate social opportunities	CSEG Journal	Canada
Canadian Association of Petroleum Producers	CAPP	Enhance the economic sustainability of the Canadian upstream petroleum industry in a safe and responsible manner	Newsletters, fact sheets	Canada
Canadian Energy Pipeline Association	CEPA	Represents Canada's transmission pipeline companies	Reports, reviews	Canada
Canadian Energy Research Institute	CERI	Objective, independent studies to assist corporations and governments in energy-related decisions and policy choices	Reports, reviews	Canada
Canadian Gas Association	CGA	Voice of natural gas distributors in Canada	Canadian Natural Gas Magazine	Canada
Canadian Geotechnical Society	CGS	Premier organization for geotechnical engineers/geoscientists in Canada	Canadian Geotechnical Journal	Canada
Canadian Heavy Oil Association	CHOA	Forum for the exchange of technical and business information on all aspects of heavy oil development	CHOA Journal	Canada
Canadian Petroleum Products Institute (Centre for Energy)	CPPI	Association of Canadian companies involved in refining, distribution, and/or marketing of petroleum products for fuel	Factsheets	Canada
Canadian Society for Unconventional Resources	CSUR	Encouraging development of unconventional hydrocarbon resources	Presentations, videos, reports	Canada

Organization	Abbr.	Focus	Publications	Jurisdiction
Centre for Energy		Canada's key resource for credible, up-to-date energy information	Maps, statistics, facts	Canada
Energy BC		Educational resource on energy sources, uses and issues in BC		BC
Energy Council of Canada (part of World Energy Council)		Sustainable use and production of energy, strategic initiatives	Reports	Canada
Energy Industry Services Association of BC (formerly Energy Services BC)	ESBC	Advocate for the oil and gas service sector, member of Northern Society of Oilfield Contractors & Service Firms		BC
Energy Resource Conservation Board	ERCB	Regulates the development of Alberta's energy resources, including oil, natural gas, oil sands, coal and pipelines		Alberta
Enform BC (Chapter of Enform)		Advocate and leading resource for the continuous improvement of oil and gas industry's safety performance	Seminars	BC
Engineers Canada (formerly Canadian Council of Professional Engineers)	CCPE	National organization of the 12 provincial and territorial associations that regulate the practice of engineering in Canada and license the country's professional engineers.	Reports	Canada
Explorers and Producers Association of Canada (formerly SEPAC)	EPAC	Advocates on behalf of its members for sound government policy that promotes a thriving independent oil and gas sector	Explorer Magazine	Canada
Gas Processing Association of Canada	GPAC	Promote the interaction and exchange of ideas and technology to those involved in hydrocarbon processing	Newsletters	Canada
Geological Association of Canada	GAC	Multidisciplinary scientific society that leads the entire scope of the geosciences in Canada	Geolog, Geoscience Canada	Canada
Geoscientists Canada (formerly Canadian Council of Professional Geoscientists)	CCPG	National consortia whose members are the self-governing professional associations or constituent associations that regulate the profession of geoscience in each of the jurisdictions		Canada
Independent Petroleum Association of America	IPAA	US trade association represents independent oil and natural gas producers and service companies	Presentations	US
Orphan Well Association	OWA	Manage the abandonment and reclamation of upstream oil and gas orphan wells, pipelines, facilities and their associated sites	Reports	Alberta

Organization	Abbr.	Focus	Publications	Jurisdiction
Pembina Institute		Combines research and technical capacity of a think tank with the values and advocacy of an environmental NGO and the business sense of a for-profit consulting firm.	Reports, reviews	BC, AB, ON, NWT
Petroleum Services Association of Canada	PSAC	National trade association representing the service, supply and manufacturing sectors within the upstream petroleum industry		Canada
Petroleum Technology Association of Canada	PTAC	Innovation, tech transfer, collaborative research and technology development to improve the financial, environmental and safety performance of the Canadian upstream oil and gas industry.		Canada
Petroleum Technology Research Centre	PTRC	R&D into enhanced oil recovery and carbon storage, while reducing the environmental footprint of the oil and gas industry	Facts sheets, reports	Canada
Petroleum Technology Transfer Council	PTTC	Forum for Transfer of Technology and Best-practices within the O&G Community	White papers	US
Science and Community Environmental Knowledge	SCEK	Industry-sponsored fund overseen by the BCOGC, CAPP and EPAC. Serves to enable relevant applied research related to oil and gas exploration and development in BC.		BC
Western Canadian Spill Services	WCSS	Ensure that industry is capable of safe, effective oil spill response	Reports	Canada
World Energy Council	WEC	Impartial network of leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system	World Energy Insight, Surveys	International
World Petroleum Council	WPC	Promotion of sustainable supply and efficient use of oil, gas and other energy resources	Congresses, Yearbook	International

Appendix 5: Major Suppliers and Consultants Serving BC's Mining and Energy Sector

Consultants, Suppliers, Experts	Biolog y	Specialties
ACME Analytical Laboratories	n	Lab testing for mining, soil, water, mineral, and plant
AGAT Laboratories	y	Lab testing for Environmental, Energy, Mining, Industrial, Transportation, Agri-Food and Life Sciences
Aeroquest International Limited	n	Geophysics surveys
Ainsworth-Jenkins Holdings Inc.	n	Minerals and mineral exploration consultants
Alex G. Doll Consulting Ltd.	n	Metallurgical engineering, computing
ALS Laboratory Group	y	Minerals, life sciences, environmental, energy and industrial testing service provider
AMC Consultants (Associated Mining Consultants)	n	Full service mining consultancy
AMEC	y	Full service mining consultancy
Amelunxen Mineral Processing	y	Mineral Processing, plant optimization, feasibility
Analytical Innovations (Analytical Consulting Group)	n	Operational efficiency, productivity
Analytical Laboratory Consultants	n	Setting up analytical laboratories for mining companies
Aqua - Calidad Del Agua Ltda. Or Aqua Laboratorio, Chile	y	Water softeners, bacterial laboratory, water quality testing
Arcadis (Senes Consultants Ltd)	n	International company providing consultancy, design, engineering and management services in the fields of infrastructure, water, environment and buildings
Arrowstone, Archaeological Research and Consulting Ltd.	n	Archaeological impact assessment, studies, mitigations
Arthur H. Winckers & Associates	n	Mineral processing consulting
ASL Environmental Sciences	n	Terminal, ports, offshore oil and gas, renewable energy, pipelines, modeling, environmental impact
Auracle Geospatial Science Inc. (AGS)	n	Remote sensing, spatial modeling
Axys Analytical Services	y	Analytical services for emerging and legacy contaminants, water, tissue, soil, bio-solids, air, bio-monitoring
BacTech Environmental Corporation	y	Bioleaching
Balanced Environmental Services Inc.	n	Marine engineering, marine biology, environmental consulting, approvals, assessments marine and riparian
Beacon Hill Consultants	n	Mining consultants

Consultants, Suppliers, Experts	Biolog y	Specialties
Beattie Consulting	n	Metallurgical and mining engineering, investment management
Behre Dolbear Group Inc.: Western States Mining Consultants	n	Construction, project evaluation, mine planning and design, permitting, geotechnical engineering, environmental engineering
BGC Engineering	n	Mining, construction, pipelines, hydroelectric, environmental, water
Binpal Engineering Ltd.	n	Engineering, biology, environment, water
Biohidrica Biotecnologias del Aqua, Chile	y	Microbial contamination, bio-mining, water treatment
Bioscan SA, Chile	y	Bacteriological laboratory, bio-chemicals, microbiology
BioSigma, Chile	y	Biotechnological solutions for mining
BioteQ Environmental Technologies Inc.	y	Water treatment, renewables, environment, bioleaching
Black & Veatch	n	Engineering and construction company for energy, oil gas, water, environment
Blue Coast Metallurgy Ltd.	n	Metallurgical and analytical tests
BMT WBM Pty Ltd.	n	Machinery, water and environment
Boojum Technology	y	Microbial processes for remediation
Breton, Banville & Associates	y	Engineering consulting for mining, energy, environment
Brinkman & Associates Reforestation Ltd.	n	Forest management, forest restoration, forestry services
Brody Consulting Ltd	maybe	Reclamation
BZ Environmental Consulting	y	Comprehensive environmental services
C. E. Jones & Associates Ltd.	n	Reclamation research, re-vegetation, tailings, dams
C3 Alliance Corp.	n	Community, commitment, cooperation, first nations relations, policies
Caelles Geological Consultants	n	Geoscience
Calfrac Well Services	n	Pressure pumping services provider focused on unconventional natural gas and light oil
Canadian Corps of Commissionaires	n	Security company, guarding
Canadian Dewatering LP	n	Fluid management, pumps, barges, diving services, dredges
Canam Laboratories	maybe	Remediation, waste management
Caracle Creek International Consulting Inc. CCIC BC office	no	Global mineral resource exploration and mining consulting including environmental and ARD
Cardno Entrix Inc.	y	Water resource management, natural resource management, permitting
Caslys Consulting Ltd.	maybe	Mining, oil and gas, forest land management, biodiversity modeling, water quality, monitoring, spill cleanup
Caspeo, France	y	Process analysis, material balance, software

Consultants, Suppliers, Experts	Biolog y	Specialties
Centro De Tecnologia Mineral (CETEM), Brazil	y	Mining sustainable development, remediation, contamination
CF Mineral Research Ltd.	n	Heavy metal mineral geochemistry
CH2M HILL Inc.	y	Full service consulting, design, operations and program management. Applied sciences laboratory, decontamination, environmental management, ecosystem management, wetlands, GHG, waste
Changefabric Consulting	n	CSR consultant for SME and large companies, impact measurements, environmental issues, stakeholder management
Cica, Ingenieros Consultores S.A., Chile & Peru	y	Consulting Engineers
CME Consultants (Canadian Mineral Exploration)	n	Mineral exploration
Coal Sense	n	Mine engineering for coal mines
Coal-ex Consulting	n	Coal exploration
Canada Research & Development Corporation	n	Industrial fluid dynamics, forensic analysis, process optimization, software, research equipment, testing facilities
Coast Mountain Geological Ltd.	n	Full service exploration, geological service
ConeTec Inc. Vancouver office	n	International in situ soil testing equipment, geophysical tools
Consult 5 Environmental Development Consultants	n	Environmental and social impact assessment, permitting, regulations, CSR in mining, oil gas, energy
Cook Pickering & Doyle Ltd.	n	Geotechnical engineers
Coopers Consulting Ltd.	n	Mine planning, mechanical engineering
CSA Global Vancouver Office	n	Resource industry consultants, exploration, evaluation, mine geology, sustainability
CSM Consulting	n	Information technology consulting
CWA Engineers Inc.	n	Multi-disciplinary engineering and project management company in the mining and minerals, ports and marine terminals, infrastructure, and wood products sectors
David Bustard & Associates	y	Fisheries consultant
Dejic Ltd. Consulting	n	Geoscientific and IT consulting
Deswik Mining Consultants (Pty) Ltd	n	Mining software and consultancy
Dillon Consulting	n	Environmental services, manufacturing and processing, regulatory strategy, stakeholder consultations
Discover Geological Consultants Inc.	n	Geological services for the mining industry worldwide
Discovery Consultants		Full service mineral exploration consulting

Consultants, Suppliers, Experts	Biolog y	Specialties
DKT Geosolutions Inc.	n	Geological models and mineral resource estimation
Doc's Consulting Ltd.	n	Communication, marketing, financing strategies for the energy industry
Dorsey & Whitney LLP	n	Attorneys
Dundee Wealth	n	Investments
E & E Consulting, Inc.	y	Ecology and environment, water, sustainability
Easwara Origins Corp.	y	Oil and gas wastewater remediation and reclamation
ECUTECH Barcelona S.L., Spain	y	Process equipment for specialty minerals, classification, grinding, coating
EDI Environmental Dynamics Inc.	y	Full scale environmental and natural resource consulting
ElectricPR Media Inc.	n	Social media presence
Ellen Frisch & Associates	n	Management consulting, stakeholder engagement, strategy
Empresa Nacional de Minería (ENAMI), Chile	y	Government initiative for Mining S&ME competitiveness. (common smelter, processing plants, tech support, tech transfer, financial aid for 2000 small private producers)
Enbridge	n	Energy delivery company focused on transporting and distributing crude oil, natural gas, and other liquids
Endeavour Financial Corporation	n	Fundraising, financing for junior mining companies
Envriogen	y	Environmental technology and process solutions provider, membrane bioreactors
Equity Exploration Consultants Ltd.	n	Geological and logistical services for effectively managing mineral exploration projects
ESRI, Inc.	n	Geographic information systems
Exp	y	Environmental services, project management worldwide
Fabcor pipelines	n	Focused in the oil and gas industry as a facility construction company
FGM International Consultants	y	Environmental waste management, recycling, hazardous waste
Flo Dynamics Systems	n	Water management solution, engineered frac water management
Fluor Corporation	n	Engineering, procurement, construction, maintenance and project management
Fourquest Energy	n	Steam blowing, air blowing, oil flushing, chemical cleaning, fluid pumping, nitrogen services, pipeline pigging and testing, chemical degassing and decontamination, hydro-milling, static load tank testing, hydro-testing
Fusion Oilfield Services	n	Water fracking, screw piping
G. N. Lustig Consulting Ltd	n	Geoscience consulting for mineral exploration
Gailforce Resources	n	HR solution
GE Power and Water, Water and Process Technologies	y	Comprehensive water resource services, ABMet biological selenium removing reactor
Geneq Inc	y	Scientific instruments, biotech, environment, geomatics, land surveying, materials testing
GENIVAR (WSP)	n	International engineering, environmental and construction consulting

Consultants, Suppliers, Experts	Biolog y	Specialties
Geocon Intl. Inc.	n	General engineering and construction
GeoFokus Consulting Ltd	n	Economic and financial analyses to meet the needs of the natural resource industries
GeoMinEx Consultants Inc.		Junior mineral exploration and development, geological services, project management
Geonor	y	Geotechnical, structural and environmental tests and equipment
GeoTDR Inc.	y	Geotechnical engineering, environmental consulting
Geotek	n	High-resolution, non-destructive analysis of geological cores
Global Inspections-NDT, Inc.	n	Advanced non-destructive testing in the mining and plant processing sectors
Gold Fields Limited, South Africa	y	Biox Process
Golder Associates	y	Environmental consulting, natural resource management, decontamination, engineering, planning, design
Greenspirit Strategies Ltd.	n	CSR development and sustainability communication
Groundradar Consulting Inc.	n	Ground penetrating radar (GPR) technology to mineral exploration and resource evolution applications
Gsi Ingenieros Consultores Ltda. Chile	y	Engineering, project management from mining, environment, hydraulics, sanitation
Hatfield Consultants Partnership	y	Environmental consultants
Heberlein Geoconsulting		Exploration geochemistry, geochemical surveys
Hemmera	y	Reactive permeable barriers for remediation including biodegradation
IMC Group Consulting Limited, UK	y	Broad spectrum services to the mining, environmental, minerals, engineering and energy industries world wide
Indigenuity Consulting Group Inc.	n	First Nations consulting firm for strategic planning, consultation
Inotec (USA)	y	Environmental biotechnology company providing solutions to remove metals and inorganics from water
Inspectorate	n	Full service metallurgical testing and certified assaying to the mining industry
Jacobs Engineering Inc.	n	Professional technical services, all aspects of engineering and construction, and operations and maintenance.
Jayrod Consulting & Sales Ltd.	n	Industrial equipment sales
JDS Energy & Mining Inc.	n	Full service project management
Jej Administracion De Proyectos Ltda., Chile	y	Project management and administration, engineering, construction
Jo Harris & Associates	n	Approvals, permitting, planning for mining and natural gas
Keefer Ecological Services Ltd.	y	Ecological restoration, plant ecology and research
Kemetco Research Inc.	y	Contract research and testing lab, extractive metallurgy
Kerr Wood Leidal Associates Ltd.	n	Water engineering services to the municipal infrastructure and resource development fields

Consultants, Suppliers, Experts	Biolog y	Specialties
Keypro Engineering, Chile	y	Fluid transport, tailings management, concentrating plants
Keystone Environmental Ltd.	y	Environmental consulting, natural resource management, due diligence
Keystone Wildlife Research	y	Full-service environmental consulting firm, providing biological and resource management consulting services
Kinane Engineering, LLC, US	y	Engineering, construction, metallurgy
KinderMorgan	n	Natural gas pipeline and storage operator, transporter of refined petroleum products terminal operator, transporter and marketer of CO2, oilsands pipeline
Kirkham Geosystems (Romios Gold, Mintec)	maybe	Professional geologist, extensive BC connections, leadership
Klohn Crippen Berger Ltd.	y	Full range of services in oil and gas, mining, environmental, water, power and transportation
Knight Piesold Consulting	maybe	Mine waste, environmental science, waste water
La Forêt de demain	y	Reforestation
Laberge Environmental Services	maybe	Mine soil reclamation, biochar
Latitude Geographics Group Ltd.	n	Web based mapping software
Lawrence Consulting Ltd.	y	ARD, water quality, metal precipitation, hydrometallurgy
Leading Edge Projects Inc.	y	Renewable energy, cold weather applications, water licensing, mineral processing
LETS Inc.	n	Multidisciplinary design engineering and Geomatics services
Levelton Consultants Ltd.	n	Multi-disciplinary consulting engineers, scientists and technologists. Comprehensive laboratory facilities provide field and laboratory testing services
Lorax Environmental Services Ltd.	y	Environmental consulting company, environmental, geochemical and project management services to the mining industry, selenium remediation
MarLim Ecological Consulting Ltd.	y	Fisheries, Forestry/Industry Services, contaminated sites, aquatic research, wildlife, raptor and amphibian studies, environmental permitting and RAR assessments, watercourse mapping
Marshland Environmental Associates MEABC	maybe	Environmental consulting for the mining industry
Maxwell GeoServices Inc.	n	Resource database management and consulting services, as well as software to the exploration and mining industry
Maxxam	y	Product testing, analytical testing, toxicology testing
McCue Environmental Contracting Inc.	maybe	Installation of soil and groundwater remediation technologies (remediation systems), including pilot test design and execution, system design consultation and installation, and system operation and maintenance.

Consultants, Suppliers, Experts	Biolog y	Specialties
Merit Consultants International Inc.	n	Project and construction management
Micon International Limited	n	Pre-feasibility and feasibility, metallurgical services, review of mining and mineral properties, engineering services, economic analysis, litigation support
Micromine	n	Mining and geological software
Microscopia De Minerales, Chile	y	Mineral analysis
Minconsult Exploration Services Ltd.	n	Geological, geophysical and logistical support services to mining companies throughout Canada and Mexico
Minnow Environmental Inc.	y	Aquatic science services
Mintek, South Africa	y	Mineral processing, metallurgical engineering, R&D
Morneau Shepell	n	HR consulting
Mountain Valley Geophysics Corp MVG	y	Environmental consulting, field surveys, water, leachate
Mqes Mine and Quarry Engineering Services, USA	y	Geology, geostatistics, mining, metallurgy, process engineering
MrC Global	n	Oilfield supplies, pipe, valve fittings
MWH	maybe	Water, wastewater, energy, power, mining, oil and gas engineering and water resource management
NAC Constructors Ltd.	n	Master Builder services to the civil, municipal, bio-fuels, energy, mining and industrial marketplace
Nampcy Solutions Ltd.	n	Survey support
NanoChem Solutions Inc	maybe	Unique protein-based polymers for various products and processes of environmental concerns, non-toxic products for a wide range of industrial, agricultural and consumer markets. – Product WaterSavr
Nature Works Remediation Corporation	y	Using natural processes to remediate contaminated sites. Combining skills in biology, botany, microbiology and engineering and metallurgical chemistry
Nautilus Environmental	y	Environmental toxicology services
Newterra (Ontario)	y	Biological filtration, metal removal
Nomadic Mobile Sewage Treatment Systems	y	Mobile sewage treatment
North Face Software Ltd.	n	Geological database management and plotting software for Mineral Exploration Geologists
North/South Consultants Inc.	maybe	Aquatic environment specialists
Northwest Hydraulic Consultants Ltd.	n	Engineering solutions to a variety of water resource challenges
Norwest Corporation	n	Consulting and engineering services

Consultants, Suppliers, Experts	Biolog y	Specialties
Oboni Riskope Associates Inc.	n	Identifies, quantifies, and prioritizes enterprise risks related to life, property, income, or reputation
Oceanetic Measurement	n	Custom precision oceanographic instrumentation design and manufacture
Odlum Brown Ltd.	n	Investment management
Omni Engineering Inc.	n	Sanitary water pipelines, drainage pump stations, booster reservoirs, pressure reducing control systems instrumentation, transient analysis of hydraulic networks, other wide range hydrologic solutions.
On Common Ground Consultants Inc.	n	International consulting company specializing in enhancing social performance and socially sustainable outcomes for the global resource sector
Ooleepeeka Consulting Ltd	n	Database management, GIS, community engagement and education
Opus DaytonKnight Consultants Ltd.	n	Asset management, wastewater, project management consulting
OreQuest Consultants Ltd.	n	Implementation and management of all aspects of exploration programs including research, property acquisition, geological mapping, geochemical sampling, trenching, surveying, geophysical surveys, diamond drilling reserve definition and underground development
Pacific Alliance Technologies	n	Provider of GIS, web-based mapping, and architectural and building design software and services
Palmer Environmental Group PEGG	maybe	Environmental assessment, water risk mitigation
Permasteel Corporation	n	Pre-engineered and general contracting
Piteau Associates Engineering Ltd.	n	Geotechnical, hydrogeological, and environmental consulting services to the mining, construction, municipal, first nations, and industrial sectors
Positive Attitude Safety System Inc.	n	PASS: dynamic safety process that assists line management to encourage and reinforce safe attitudes, decisions and behaviors
Pottinger Gaherty Environmental Consultants Ltd. (PGL)	maybe	Comprehensive, integrated environmental consulting services
Powertech Labs Inc.	n	BC Hydro subsidiary, specializes in clean energy consulting, independent testing and power system solutions
Process Mineralogical Consulting Ltd.	n	Comprehensive mineralogical and support services
Proxim Software Inc.	n	Full service IT solutions
PwC (PricewaterhouseCoopers LLP)	n	Industry-focused assurance, advisory and tax services to public, private and government clients in all markets
QEP Environmental	y	Wildlife, aquatic and fisheries biology, species at risk biology and local experience with various ecosystems

Consultants, Suppliers, Experts	Biolog y	Specialties
Quantum Environmental	maybe	Integrated environmental management, site assessment, hydrogeology, feasibility, in house laboratory testing
RayMac Environmental Services Inc.	maybe	Expertise in pipeline fuel storage, wastewater storage and treatment systems, potable water systems, hazardous materials management, spill supplies or spill containment solutions, and wind turbine equipment for remote applications
RCS Market Services Inc.	n	Investor relations and SEC regulatory compliance
Rescan Environmental Services Ltd. An ERM company	maybe	Wide range of science, engineering, and socioeconomic services to the resource development industry
Ridgeline Diamond Drilling Ltd.	n	Diamond drilling
RJR Mineral Services	n	Consulting services for mineral exploration
Robertson Geoconsultants Inc.	maybe	Geotechnical and environmental engineering for the mining industry
Rocky Mountain Soil Sampling Inc.	n	Difficult access drilling solutions for environmental, geological and geo-technical applications.
RTG Management Inc.	n	Marketing consultants
S2 Innovative LED Products Group Ltd.	n	Professional engineering group for design, development, and distribution of building automation solutions for industrial, commercial, and institutional facilities
Sacre-Davey Engineering	n	Oil, gas, mining, clean tech engineering and project management
SAFEmap	n	Safety consultancy
Salman Partners Inc.	n	Independent, research-driven investment dealer
Scaf Ingenieria Y Servicios S.A. Chile	y	Engineering services for mining
Schlumberger Water Services	maybe	Innovative groundwater monitoring and sampling instruments and software for environmental data
Scott Geophysics Ltd.	n	Geophysical contracting and consulting, induced polarization/resistivity surveys
Scott-Smith Petrology Inc.	n	Specialist in kimberlite geology and related consulting services to the diamond exploration and mining industry
Sea Science Inc.	n	Field-useable instrumentation for coastal and freshwater research
SEACOR Environmental Inc	maybe	Full range of environmental and engineering consulting services to the commercial, industrial, private and public market sectors
Seaport Group	n	Leader in global credit markets with one of the largest sales and trading platforms of any boutique investment bank
Seaward Engineering and Research Ltd.	maybe	Project management and consulting engineering services in the marine, industrial and environmental markets
SecuResources	n	IT security products

Consultants, Suppliers, Experts	Biolog y	Specialties
SGS Minerals Services	maybe	Very broad range of metallurgical process design
Sierra Systems Group Inc.	n	Management consulting, systems integration and application support, IT
Silvatech Consulting Ltd.	maybe	Forest resource management, environmental sciences & aboriginal consultations, land use planning & analysis, resource inventories & mapping
SJ Geophysics Ltd.	n	Geophysical instrumentation, electromagnetic (TDEM and HLEM) and magnetic surveys throughout Canada.
SLR Consulting Ltd.	maybe	Environmental consultancy that specializes in the energy, mining & minerals, waste management, planning & development, infrastructure and industrial sectors
Smee & Associates Consulting Ltd.	n	International geochemical consulting
SNC Lavalin	n	Engineering and construction group
Snowden Group	n	Independent, expert technical advice that spans the mine life cycle
Solidus Geological Services Ltd.		Generation, compilation, organization and interpretation of geological data. Also offers project management in the mineral exploration industry
South American Management S.A. Chile	y	Mining exploration and assessment
SPI Health and Safety	maybe	Preventive, protective safety products, spill kits including oil
SRK Consultants	n	Independent, international consulting practice providing consultancy services to the earth and water resource industries
Stantec	maybe	Provides engineering, consulting, and design services to both public and private clients in the areas of land development, building, water resources, oil and gas
Statistical Research Inc. (SRI)	n	Focus on practical solutions to cultural resource management issues, balancing economic development
Steeplejack Industrial Group Inc.	n	Workforce access solutions to industrial and commercial customers
Strandberg Consulting	n	Improving environmental and social performance, CSR
STT Stanco	n	Expertise in design, assembly and support of handling systems for reagents (such as lime, soda ash and magnesium oxide) required for environmental cleanups in mining, oil and gas and other industrial applications. Also specialize in tanks and silos for storage
Sullivan & Associates Ltd.	n	Nondestructive testing and evaluation (radiography, ultrasonics, magnetic particles), liquid penetrants, tank, piping, pressure vessel inspections, mechanical testing
SYLVIS Environmental	maybe	Environmental consulting firm providing a range of services including applied research, environmental monitoring and assessment, land reclamation and restoration, environmental policy and planning, and residuals recycling
Symmetry Project Solutions	n	Construction management company established to develop projects focused on junior mining companies building or expanding projects in Latin America

Consultants, Suppliers, Experts	Biolog y	Specialties
Synergy Engineering Ltd.	n	Large-scope solution provider, engaged in engineering, designing, supplying, commissioning, and training as well as after-sales support of electrical engineering packages including Power Distribution, Motors and Drives, and Instrumentation & Control
Tahltan Nation Development Corporation	n	Support service for the mining industry
Taratech Inspection Services Inc.	y	Non Destructive testing, magnetic, sonic, fluorescent, dye penetrant
Teknika HBA	y	Full service engineering, environmental, project management, sustainability consulting
Tenova Delkor	n	Industry specialist in solid / liquid separation and mineral processing applications for the minerals, chemical and industrial markets
Terrace Economic Development Authority	n	TEDA provides numerous services to encourage investment and development in Terrace. From relocation and expansion services, to information on existing and upcoming major development projects
TetraTech (EBA Engineering Consultants Ltd.)	y	Consultants in Mining, Energy, Transportation, Development
TEVO Consulting Inc.		Support companies in reaching their strategic goals by developing leadership and people management systems that allow employees to be at their best
The Ian Martin Group	n	HR consulting
Thurber Engineering Ltd.	n	Geotechnical, environmental and materials engineering and testing services for a variety of industries across Canada
Toyo Pumps North America	n	Slurry pumping
TraumaTech	n	First aid training
Trican Well Services	n	International pressure pumping company
Triton Environmental Consultants Ltd.	maybe	Environmental impact assessments, environmental planning, management and monitoring, biological and ecological inventories, risk assessments, water resources engineering, GIS services
UnixWorX System Design Data Engineering	n	IT systems
URS Corporation	n	Provider of engineering, construction and technical services for public agencies and private sector companies
UTM Exploration Service Ltd.	n	Complete (grassroots to brown fields) exploration services, camp development
Vdm Ingenieria Y Construccion Ltda. Chile	y	Mining equipment and construction
Veolia	y	Management of water and wastewater services for municipal and industrial clients. Also designs technological solutions and builds facilities

Consultants, Suppliers, Experts	Biolog y	Specialties
Vibe Strategies, Inc.	n	HR consulting
Vigaflow S.A.	y	Water purification
Waterloo Biofilter Systems (Ontario)	y	On-site wastewater treatment
Watterson Geoscience Inc.	maybe	Treatment and disposal specialists, hydrogeological consulting, contaminated sites
Weir Oil and Gas	n	Designs and manufactures pumps and ancillary equipment for the global upstream and downstream oil and gas markets
Weir-Jones Group	n	Automatic non-invasive draught indicator system, passive microseismic monitoring system, earthquake early warning, rockfall detection, structural integrity monitoring
Wellington Plastics Inc.	n	Plastic fabricating, welding and machining, as well as industrial grade sheet materials & products
Westcor Services Limited	n	Insulation, fireproofing, coatings, environmental services, scaffolding
Western Protection Alliance Inc.	n	On-site or remote location safety & security consulting, risk management & strike planning services
Whillans Mine Studies Ltd.	n	Management & supervision, analysis of mining methods, ore body studies, mining software training, underground designs
Williams Engineering Canada	n	Consulting engineering in civil, structural, mechanical, electrical, building science, and environmental
Wolverton Securities Ltd.	n	Investment firm
WOODPRO Engineering Ltd.	n	Professional engineering, drafting and project management services to the wood products and manufacturing industries
Xstrata Technology	n	Develops, markets and supports technologies for the global mineral processing and metals smelting and refining industries
Zostrich Geotechnical USA	y	Rock mechanics and characterization

Appendix 6: Key Mining, Energy, Environment, and Genomics Researchers in BC

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Abraham, Ninan	Microbiology & Immunology; Zoology	UBC	Functional genomic and proteomic approaches; inherited immunodeficiency; IL-7; lymphocyte development; Molecular and genetic bases of development of cellular function in mammals	www.zoology.ubc.ca/person/~ninan	
Adams, Keith	Botany	UBC	Plant Evolutionary Genomics and Gene Expression; environmental stress conditions; duplicate genes; polyploidy; canola; cottonwood; thistle	http://www.botany.ubc.ca/people/keith-adams	
Agnes, George	Chemistry	SFU	Single droplets and mass spectrometry; biological applications of mass spectrometry	www.sfu.ca/chemistry/faculty/Agnes/	N
Aitken, Sally	Forest Sciences	UBC	Forest biology; Conservation genetics; climate change; adaptation	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=78	Industrial Res. Chair in population genetics
Alfantazi, Akram	Material Engineering	UBC	Electrochemical processes, corrosion, coatings, hydrometallurgy	http://www.mtrl.ubc.ca/department/faculty-staff/alfantazi.php	
Alila, Younes	Forest Resources Management	UBC	Forest management effects on flooding in rain-on-snow coastal British Columbia: an innovative experimental - numerical modelling approach	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3031	
Allen, Diana	Earth Sciences	SFU	Groundwater resource evaluation, hydrogeology, environmental geoscience	http://www.sfu.ca/earth-sciences/people/faculty/allen.html	
Angelo, Mark	School of Construction and the Environment	BCIT	river restoration : river management : watershed planning : environmental monitoring	http://www.bcit.ca/construction/research/directory.shtml	

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Angert, Amy	Botany	UBC	Species adaptation, lab to field studies, ecology, biodiversity	http://www.botany.ubc.ca/people/amy-angert	
Anholt, Bradley	Natural Sciences and Engineering	UVic	Biodiversity, models, invasions	http://www.chairs-chaire.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=1043	Y Experimental and Applied Community Ecology
Arocena, Joselito	Environmental Science, Chemistry, Environmental Engineering, Natural Resources	UNBC	Canada Research Chairs Infrastructure Fund - Laboratory for IN SITU and Small Volume Environment Analysis	http://web.unbc.ca/~esmweb/faculty.html	Y soil and environmental sciences
Atwater, Jim	Civil engineering	UBC	Solid waste management, leachate generation, groundwater, toxic waste	http://www.civil.ubc.ca/people/faculty/faculty-atwater.php	
Auld, Vanessa	Zoology	UBC	Role of glia in the development of the nervous system, molecular interactions; tissue imaging; drosophila	http://www.zoology.ubc.ca/person/auld	N
Baillie, David	Molec Biology & Biochem	SFU	C. Elegans, genetics, genomics, epigenomics, stress response pathways	www.sfu.ca/mbb/mbb/faculty/baillie/baillie.html	Y Genomics / Bioinformatics
Baldwin, Sue	Chemical and Biological Engineering	UBC	Bioreactors, waste remediation, environmental monitoring	http://www.chbe.ubc.ca/faculty-staff/baldwin.php	
Beatty, Thomas	Microbiology and Immunology	UBC	Bacterial gene expression regulation	http://www.microbiology.ubc.ca/research/labs/beatty/research	
Beavis, Ronald	Biomedical Research Centre	UBC	Laboratory for experimental bioinformatics in proteomics	www.brc.ubc.ca/brc/Faculty/Beavis/beavis.html	Y Experimental Bioinformatics
Beckenbach, Andrew T	Biological Sciences	SFU	Assembling the dipteran tree of life, evolution, complete genomes for insects, mitochondrial genomics of insects	www.sfu.ca/biology/faculty/beckenbach/	N
Beckie, Roger	Earth, Ocean and Atmospheric Sciences	UBC	Groundwater hydrology, geochemistry, geotechnical engineering	http://www.eos.ubc.ca/about/faculty/R.Beckie.html	
Bendell, Leah	Biological Sciences	SFU	Ecotoxicology, invasive species, habitat, aquaculture, environmental contamination	http://www.biology.sfu.ca/people/profiles/bendell	

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Best, Mairi	Earth and Ocean Sciences	UVic	Carbon cycle, NEPTUNE, environmental sensors	http://communications.uvic.ca/research/details.php?go=1&id=1179	
Bevier, Mary Lou	Earth, Ocean and Atmospheric Sciences	UBC	Geology, mineralogy-petrology, geoscience	http://www.eos.ubc.ca/about/faculty/M.Bevier.html	
Black, Andrew	Applied Biology	UBC	Soil Science, biometeorology, GHG, carbon balance	http://www.landfood.ubc.ca/directory/faculty/professors-and-instructors/andrew-black	
Bohlman, Joerg	Forest Science and Botany; Michael Smith Labs.; Wine Research Centre	UBC	Forest health genomics; plant metabolism; grapevine genomics; cloning	http://www.msl.ubc.ca/faculty/bohlmann	
Booth, Annie	Environmental Studies	UNBC	First Nations and the Environment	http://unbc.ca/annie-booth	
Borchers, Christoph	Biochemistry and Microbiology	UVic	The BC Proteomics Network, Metabolomics Centre	www.proteincentre.com; www.genomebc.ca/research_tech/researcher_profiles/c_borchers.htm	
Bradfield, Gary	Botany	UBC	Plant community ecology, marshes and bogs, disturbances	http://www.botany.ubc.ca/people/gary-bradfield	
Brandhorst, Bruce	Molecular Biology & Biochem	SFU	Embryonic and larval development	www.sfu.ca/mbb/mbb/faculty/brandhorst/brandhor.htm	N
Branion, Richard	Chemical and Biological Engineering	UBC	Microbial leaching, wastewater treatment	http://engineering.ubc.ca/eng/research/faculty-experts	
Brauner, Colin	Zoology	UBC	Environmental adaptation, gas exchange, acid-base balance	http://www.zoology.ubc.ca/person/brauner	
Breden, Felix	Biological Sciences	SFU	Genetic and genomic approaches to sexual selection	www.sfu.ca/biology/faculty/breden/	N
Breuil, Colette	Wood Science	UBC	Tree diseases; genomic of fungi; molecular tools	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3078	

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Brinkman, Fiona	Molecular Biology & Biochem	SFU	Computational and laboratory characterization of genomic islands of potential relevance to bacterial pathogenicity, subcellular localization, microbial virulence	www.pathogenomics.sfu.ca/brinkman/fbrinkman.html	N
Brock, Hugh	Zoology	UBC	Characterization of an activating PRE from Drosophila and mice, gene regulation, role of non coding RNA	http://www.zoology.ubc.ca/person/brock	N
Brown, Sandra	Applied Biology	UBC	Soil and global environment, sustainable soil management, field and laboratory methods	http://www.landfood.ubc.ca/directory/faculty/professors-and-instructors/sandra-brown	
Bryan, Jennifer	Statistics; Michael Smith Labs	UBC	Regulatory analysis for biological systems in computational biology: Integrated analysis and hypothesis generation by statistical inference and bioinformatics, genome wide assays, statistical methods	http://www.stat.ubc.ca/~jenny/	N
Burgess, Michael	Applied Ethics	UBC	Democracy, Ethics and Genomics: Consultation, Deliberation and Modeling	http://www.ethics.ubc.ca/people/burgess/index.htm	N
Burton, Phil	Ecosystem Science and Management	UNBC	Ecosystem restoration	http://www.unbc.ca/ecosystem-science-management/burton-dr-phil	
Bustin, Marc	Earth, Ocean and Atmospheric Sciences	UBC	Unconventional petroleum resources, gas shales, oil shales, coalbed methane	http://www.eos.ubc.ca/about/faculty/M.Bustin.html	
Chan, Laurie	Community Health Sciences	UNBC	Environmental toxicology, mercury contamination, nutritional toxicology, organic pollutants	http://www.unbc.ca/chan/current-projects	
Chanway, Christopher	Forest Sciences	UBC	Nitrogen balance in pine forests	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3088	
Chauve, Cedric	Mathematics	SFU	Computational methods for metagenomics, Combinatorial models and algorithms for comparative genomics	www.math.sfu.ca/people/profile.php?ID=chauve_c	N

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Cheeptham, Naowarat (Ann)	Biological Sciences	TRU	Microbiology, diversity, metabolite production, bioactive products	http://faculty.tru.ca/ncheeptham/research.html	
Chen, Jiahua	Natural Sciences and Engineering	UBC	Statistical genetics, subgroups	http://www.chairs-chaires.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=2038	Y Statistical Genomics
Chen, Jin-Gui	Botany	UBC	High Throughput Platform for Plant Functional Genomics	http://www.cecm.sfu.ca/~cchauve/	
Chen, Nansheng (Jack)	Molecular Biology & Biochem	SFU	Identification and analysis of gene batteries in caenorhabditis Elegans	www.sfu.ca/mbb/mbb/faculty/chen/chen.html	N
Cheng, Kim	Animal Science	UBC	Conservation and management of genetic resources, avian mating	http://www.landfood.ubc.ca/about/faculty-history/faculty-staff/kim-cheng	
Christensen, Villy	Fisheries Centre	UBC	Ecosystem modeling	http://www.globaloceanmodeling.org/team/villy-christensen/	Nippon Foundation Professor of Ecosystem Modeling and Management
Christians, Julian	Biological Sciences, CFRI	SFU	Physiological and genetic mechanisms underlying variation in growth within species	www.sfu.ca/biology/faculty/christians/	N
Cohen Freue, Gabriela	Natural Sciences and Engineering	UBC	Biomarker identification, personalized medicine	http://www.chairs-chaires.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=3027	Y Statistical Genomics
Condon, Anne	Computer Science, PIMS	UBC	Improving genome annotation, molecular structure and interaction prediction: An algorithm study of biomolecular functions	http://www.cs.ubc.ca/people/profile.jsp?id=condon	NSERC/General Motors Canada Chair for Women in Science and Engineering

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Coops, Nicholas	Forest Resources Management	UBC	Multi-scale assessment of forest carbon dynamics using near-field, airborne and satellite remote sensing	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=22700	Y Remote Sensing
Costa, Maycira	Geography	UVic	Monitoring biophysical processes, wetlands, field work,	http://communications.uvic.ca/research/details.php?go=1&id=301	
Crespi, Bernie	Biological Sciences	SFU	Evolutionary and behavioral ecology, social behavior, role of genetics, taxonomy	http://www.biology.sfu.ca/people/profiles/crespi	
Cronk, Quentin	Biodiversity Research Centre	UBC	Ecogenomics of poplar and other model species	http://cronklab.wikidot.com/home	
Crowe, Sean	Microbiology & Immunology, Earth, Ocean and Atmospheric Sciences	UBC	Role of microorganisms in geochemical processes, methane cycling, oil sands, process rate determination for microbial activity	http://www.eos.ubc.ca/about/faculty/S.Crowe.html	Nominated for CRC Geomicrobiology
Crutsinger, Gregory	Zoology	UBC	Biodiversity from genes to ecosystem	http://www.zoology.ubc.ca/~crutsinger/Crutsinger_lab/home.html	
Cullen, Jay	Earth and Ocean Sciences	UVic	Biogeochemistry, marine science, trace elements, environmental perturbations, biogeochemical cycles, algal physiology	http://communications.uvic.ca/research/details.php?go=1&id=172	
Cullen, William	Chemistry	UBC	Biogeochemistry, metal biotransformation, bioremediation, oysters, cadmium	http://www.chem.ubc.ca/our-people/profiles/william-cullen	
Daniels, Lori	Forest Sciences	UBC	Canopy gaps and tree coexistence in coastal old-growth forests of British Columbia	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=22722	
Dashtgard, Shahin	Earth Sciences	SFU	Sedimentology, petroleum geology, clastic rocks, well reservoirs, rock record research	http://www.sfu.ca/earth-sciences/people/faculty/dashtgard.html	
Davidson, William	Molecular Biology & Biochemistry	SFU	salmon genomics, GRASP, cGRASP, ecology, conservation biology	http://www.sfu.ca/mbb/People/Davidson/	
Davies, Julian	Microbiology & Immunology	UBC	Microbial Envirogenomics, source tracking, biofilms, antibiotics and resistance	http://www.microbiology.ubc.ca/140.0.html	N

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Dawson, Russell	Natural Sciences and Engineering	UBC	Bird's response to change in environment, stress response, response to resource extraction, field work in Northern BC	http://www.chairs-chaire.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=1681	y Avian Ecology
Dery, Stephen	Environmental Science and Engineering	UNBC	River discharge, hydrometeorology	http://www.unbc.ca/research/dery-stephen	Y Northern Hydrometeorology
Dipple, Gregory	Earth, Ocean and Atmospheric Sciences	UBC	Fluid-rock interactions, GHG,	http://www.eos.ubc.ca/about/faculty/G.Dipple.html	
Dirk van Zyl	Norman Keevil Institute of Mining	UBC	Tailings, Sustainable development, heap leaching	http://mining.ubc.ca/about/people/dirk-van-zyl/	
Doebeli, Michael	Zoology	UBC	Evolution of diversity in bacterial microcosms; studying the genetic, physiological and ecological mechanisms of adaptive diversification	www.zoology.ubc.ca/person/doebeli	
Douglas, Carl	Botany	UBC	Plant gene expression, biofuels, poplar	http://www.botany.ubc.ca/people/carl-douglas	
Dreisinger, David	Material Engineering	UBC	Hydrometallurgy, ion exchange, refinery, leach chemistry, bioleaching	http://www.mtrl.ubc.ca/departments/faculty-staff/dreisinger.php	Chair in Hydrometallurgy
Duff, Sheldon	Chemical and Biological Engineering	UBC	Treatment and upgrading of industrial wastes	http://www.chml.ubc.ca/faculty-staff/duff.php	
Dunbar, Scott	Norman Keevil Institute of Mining	UBC	Geophysics, engineering, bacteria, bacteriophage	http://mining.ubc.ca/about/people/scott-dunbar/	
Eberhardt, Eric	Earth, Ocean and Atmospheric Sciences	UBC	Rock mechanics, rock engineering	http://www.eos.ubc.ca/about/faculty/E.Eberhardt.html	
Egger, Keith	Biology	UNBC	Genetic impacts on organisms	http://web.unbc.ca/~egger/	
Ehltting, Juergen	Centre for Forest Biology	UVic	Functional genomics of plants, wood formation, poplar	http://communications.uvic.ca/research/details.php?go=1&id=953	
El-Kassaby, Yousry	Forest Resource Management	UBC	Applied Forest Genetics and Biotechnology	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=22506	Grant-Industrial Res. Chairs

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Ellis, Brian E.	Michael Smith Laboratories, Botany	UBC	Hybridization station	http://www.michaelsmith.ubc.ca/faculty/ellis/	N
Ellis, Guy	School of Energy, Industrial Mechanical Trades	BCIT	Energy research, oil and gas processing, manufacturing methods	http://www.bcit.ca/energy/research/committee.shtml	
Eltis, Lindsay D.	Microbiology & Immunology	UBC	Fosmid Mapping of PNG-276 Genome, proteomics studies	www.microbiology.ubc.ca/318.0.html	N
Emberly, Eldon	Physics	SFU	Computational design of molecular electronic systems	www.sfu.ca/~eemberly/	Y Materials and Structural Biology
Eskicioglu, Cigdem	Civil Engineering	UBCO	Biosolids digestion, bioenergy, biological water treatment	http://www.ubc.ca/okanagan/engineering/faculty/cigdemeskicioglu.html	
Farrell, Anthony	Applied Biology	UBC	Aquatic toxicology, stress adaptation and recovery in fish	http://people.landfood.ubc.ca/anthony.farrell/	Chair in Sustainable Aquaculture
Fast, Naomi	Botany	UBC	Genome evolution in single cell eukaryotes	http://www.botany.ubc.ca/people/naomi-fast	
Finley, Brett	Michael Smith Laboratories	UBC	Molecular mechanisms of pathogenic bacteria	http://www.msl.ubc.ca/faculty/finley	
Foster, Leonard J	Biochemistry & Molecular Biology, CHiBi	UBC	Organelle proteomics: cell biological, biochemical and bioinformatical infrastructure	http://www.biochem.ubc.ca/fac_research/faculty/foster.html	Y Organellar Proteomics
Fraser, Lauchlan	Natural Sciences and Engineering	TRU	Community and ecosystem ecology, grassland, wetland, wastewater treatment, UPP? Kinder Morgan, mining collaborations	http://www.chairs-chaire.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=1229	Y Community and Ecosystem Ecology
Frigaard, Ian	Applied Mathematics and Mechanical Engineering	UBC	Fluids in the petroleum industry, modeling, restarting crude oil pipelines	http://www.sites.mech.ubc.ca/~frigaard//research/index.htm	
Gardy, Jennifer	Microbiology & Immunology	UBC	Genomic epidemiology	http://www.bccdc.ca/util/about/UBCCDC/People/Faculty/DrJenniferGardy.htm	

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Gates, Byron	Natural Sciences and Engineering	SFU	Rapid screening devices, biological analytes, imaging, nanotechnology, renewable energy	http://www.chairs-chaire.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=1697	Y Surface Chemistry
Gergel, Sarah	Forest Sciences, Centre for Applied Conservation Research	UBC	Ecosystem mapping, monitoring, baselines	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3227	
Gillingham, Michael	Biology	UNBC	population ecology	http://web.unbc.ca/~michael/research/research.htm	
Glass, Anthony	Botany	UBC	Nitrogen and potassium transport	http://www.botany.ubc.ca/people/anthony-dm-glass	
Gosselin, Louis	Biological Sciences	TRU	Ecology, population biology, marine ecology	http://faculty.tru.ca/lgosselin/gosselinpubl.html	
Grace, John	Natural Sciences and Engineering	UBC	GHG production, fluidized bed combustion, petroleum refining, hydrogen production from natural gas, clean energy	http://www.chairs-chaire.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=209	Y Clean Energy Processes
Graham, Sean	Botany	UBC	Plant evolution, biodiversity, phylogeny, plastid genomics	http://www.botany.ubc.ca/people/sean-graham	
Grayston, Susan	Forest Sciences Centre	UBC	Forest fertilization and identification of microbial indicators to enhance C sequestration and reduce GHG emissions	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3228	Y Soil Microbial Ecology
Green, Beverly	Botany	UBC	Chloroplasts, photosynthesis, genetic origins	http://www.botany.ubc.ca/people/beverley-r-green	
Green, Scott	Ecosystem Science and Management	UNBC	Adaptability of northern forests to future climate change	http://www.unbc.ca/ecosystem-science-management/green-dr-scott	
Grigliatti, Thomas	Zoology	UBC	Genetic and biological characterization of Su(var) genes and nuclear proteins	www.zoology.ubc.ca/person/grigliatti	N
Groat, Lee	Earth, Ocean and Atmospheric Sciences	UBC	Environmental mineralogy, mine wastes, bioleaching	http://www.eos.ubc.ca/about/faculty/L.Groat.html	

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Gunton, Thomas	REM	SFU			
Gupta, Arvind	Computing Science	SFU	Bioinformatics and combinatorial algorithms	www.cs.sfu.ca/people/Faculty/Profile/arvind.html	N
Guy, Robert	Forest Sciences Centre	UBC	Comparative physiology of plant adaptation: C and N isotope discrimination and trade-offs in traits related to resource acquisition in black cottonwood	http://farpoint.forestry.ubc.ca/Faculty/Search/Faculty_View.aspx?FAC_ID=3109	
Hall, Eric	Civil Engineering	UBC	Forest products waste management	http://www.civil.ubc.ca/people/faculty/faculty-hall.php	
Hallam, Steven	Microbiology & Immunology	UBC	Centre for Microbial Diversity and Evolution (CMDE), methane oxidation, biodiversity, environmental genomics	http://www.microbiology.ubc.ca/cmde/322.0.html	Y Environmental Genomics
Hansen, Carl	Physics and Astronomy, CHiBi	UBC	Single cells genetics and proteomics	www.physics.ubc.ca/~chansen/	
Harden, Nicholas	Molecular Biology & Biochem	SFU	Characterization of signaling pathways	www.sfu.ca/mbb/mbb/faculty/harden/harden.html	N
Harley, Christopher	Zoology	UBC	Ecological patterns, climate change, pH, Temperature	http://www.zoology.ubc.ca/person/harley	
Harshaw, Howie	Forestry	UBC	Oil and gas sustainability issues, public perception of shale gas, landscape impact	http://calp.forestry.ubc.ca/people/howie-harshaw/	
Hart, Michael	Biology	SFU	Population analysis, gene flow, population divergence, adaptive evolution, advisor to Karson Keever from Hemmera	http://www.biology.sfu.ca/people/profiles/mwhart	
Hart, Miranda	Biology	UBC	Soil microbes, agri, ecological restoration	http://soilmicrobialeecology.ok.ubc.ca/Group_Site/Home.html	
Haughn, George	Botany	UBC	Cell differentiation, morphogenesis, genomics	http://www.botany.ubc.ca/people/george-haughn	
Hawkins, Barbara	Centre for Forest Biology	UVic	Nutrient uptake dynamics in conifers - genetic and environmental variation	http://web.uvic.ca/forbiol/hawkins	

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Hawkins, Nancy	Molecular Biology & Biochem	SFU	Asymmetric cell division in c. Elegans	www.sfu.ca/mbb/mbb/faculty/hawkins/index.html	N
Haynes, Charles	Chemical & Biological Eng, Michael Smith Laboratories	UBC	Integrated technologies and platforms for separation and characterization of biological analytes	www.chml.ubc.ca/people/faculty/haynes.htm	Y Surface Biotechnology
Heise, Brian	Natural Resource Sciences	TRU	Freshwater ecosystems, recovery after disturbance, aquatic macroinvertebrate, wetland	http://kamino.tru.ca/experts/home/main/bio.html?id=bheise	
Helbing, Caren	Biochemistry and Microbiology	UVic	Development of methods for diagnosing and differentiating toxicological modes of action	http://web.uvic.ca/~chelbing/	Scholar
Helle, Steven	Environmental Engineering	UNBC	wastewater treatment	http://www.unbc.ca/experts/environmental-issues	
Herrmann, Felix	Earth and Ocean Sciences, Seismic laboratory for Imaging and Modeling (SLIM)	UBC	exploration seismology, modeling, 10 major oil and gas companies in research collaboration	http://www.eos.ubc.ca/about/faculty/F.Herrmann.html	
Hieter, Philip	Michael Smith Laboratories, Medical Genetics	UBC	Computational identification and quantitative modeling of dynamic cellular pathways, genome stability, cell cycle control, cancer	http://www.michaelsmith.ubc.ca/faculty/hieter/	N
Higgs, Eric	School of Environmental Studies	UVic	Ecosystem management, sustainability, restoration	http://communications.uvic.ca/research/details.php?go=1&id=282	
Hodges, Karen	Centre for Species at Risk and Habitat Studies (SARAHS)	UBCO	conservation of populations, critical habitat designation	http://biol.ok.ubc.ca/faculty/hodges.html	Y Conservation Biology
Holt, Robert	Michael Smith Genome Sciences Centre	BCCA	Steps towards assembly of a modular microbial genome, immunogenetics, metagenomics, cancer genomes, neurobiology, synthetic biology	www.bcgsc.ca/faculty/rholt	
Honda, Barry	Molecular Biology & Biochem	SFU	Chromatin structure and gene expression	www.sfu.ca/mbb/mbb/faculty/honda/honda.html	N
Hoodless, Pamela	Terry Fox Laboratory	BCCA	TGFβ signal transduction pathways in development	http://www.bccrc.ca/tfl/people_hoodless.html	

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Hooker, Laura	Biology	UBC	Aquatic ecology	http://biol.ok.ubc.ca/people/faculty.html	
Hoos, Holger	Computer Science	UBC	Improving Genome annotation, molecular structure and interaction prediction: An algorithmic study of biomolecular functions	http://www.cs.ubc.ca/~hoos/	N
Hsiao, William	Public Health Microbiology and Reference Laboratory	BCCDC	Whole genome analysis, comparative genomics	http://pathology.ubc.ca/faculty/william-hsiao/	
Huber, Dezene	Ecosystem Science and Management	UNBC	Insect physiology	http://www.unbc.ca/research/huber-dezene	Y Forest Entomology and Chemical Ecology
Hungr, Oldrich	Earth, Ocean and Atmospheric Sciences	UBC	New and improved techniques for landslide hazards assessment	http://www.eos.ubc.ca/about/faculty/O.Hungr.html	
Isaac-Renton, Judy	Public Health Laboratory Director	BCCDC	Medical microbiology, environmental microbiology, pathogens, metagenomics	http://www.bccdc.ca/util/about/UBCCDC/People/Faculty/DrJudithIsaacRenton.htm	
Jenne, Richard	School of Exploration and Mining	NWCC	Instructor, Smithers campus	http://www.nwcc.bc.ca/departments-contacts?title=&field_department_value=SchoolOfExplorationAndMining	
Johnson, Mark	Institute for Resources, Environment and Sustainability	UBC	Ecohydrology, watershed management	http://ires.ubc.ca/person/mark-johnson/	
Jones, Melanie	Biology & Physical Geography	UBCO	In situ ecophysiology of ectomycorrhizal associations, nutrient dynamics	http://biol.ok.ubc.ca/faculty/jones.html	
Jovel, Eduardo	Applied Biology	UBC	Mercury chelating in plants, environmental contamination, bioactive molecules	http://www.landfood.ubc.ca/directory/faculty/professors-and-instructors/eduardo-jovel	
Karsan, Aly	Clinical Diagnostic Genomics	BCCA	Dissecting Gene Expression Networks in Mammalian Organogenesis	www.bccrc.ca/mb/people_akarsan.html	

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Keeling, Patrick	Botany	UBC	A High-Throughput Facility for Genomic Analysis, adaptation, infection, diversity, evolution	http://www.ciar.ca/web/home.nsf/pages/home.0536!opendocument	N
Kennedy, Chris	Biological Sciences	SFU	Environmental contaminants, cause and effect relationships, cellular defense	http://www.biology.sfu.ca/people/profiles/ckennedy	
Kennepohl, Pierre	Chemistry	UBC	Sulfur based redox processes, catalysis	http://www.chem.ubc.ca/our-people/profiles/pierre	
Kimmins, James(Hamish)	Forest Sciences	UBC	Complexity and scale in forest ecosystem management and agroforestry modeling	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3130	retired
Kingsley, Donkor	Chemistry	TRU	Analytical and environmental chemistry, metal antibiotic complexes, classification of origin of pollution	http://kamino.tru.ca/experts/home/main/bio.html?id=kdonkor	
Kirste, Dirk	Earth Sciences	SFU	Aqueous geochemistry, lab and field work, sampling, monitoring, acid sulfate systems, geosequestration of CO2, mineral exploration	http://www.sfu.ca/earth-sciences/people/faculty/kirste.html	
Klein, Bern	Norman Keevil Institute of Mining	UBC	Dept Head, geology, mineral processing, metal leaching from waste, Rick Lawrence invited to UBC	http://mining.ubc.ca/about/people/bern-klein/	
Klironomos, John	Biology	UBC O	Soil ecology, microbial ecology, biodiversity, restoration	http://johnklironomos.com/publications	
Koop, Ben	Biology	UVic	Molecular biology, genetics, evolution, salmon genome, biological informatics	http://communications.uvic.ca/research/details.php?go=1&id=42	
Kronstad, Jim	Michael Smith Laboratories, Microbiology and Immunology, Agricultural Sciences	UBC	Fungal biology, pathogenesis, morphogenesis,	http://www.michaelsmith.ubc.ca/faculty/kronstad/	N
Lank, David	Biological Sciences	SFU	Effects of terrestrial and marine habitat on nesting performance of marbled murrelets	http://www.sfu.ca/biology/wildberg/lank.html	

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Laskowski, Janusz	Norman Keevil Institute of Mining and Engineering	UBC			
Lau, Anthony	Chemical and Biological Engineering	UBC	Bioconservation, waste recycling, environmental engineering	http://www.chbe.ubc.ca/faculty-staff/lau.php	
Law, Francis	Biological Sciences	SFU	Environmental toxicology, exposure scenarios, ADME, metabolites, models, analytical techniques	http://www.biology.sfu.ca/people/profiles/flaw	
Lawrence, Gregory	Natural Sciences and Engineering	UBC	Environmental impact of waste water, conservation, sustainability, restoration	http://www.chairs-chaires.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=223	Y Environmental Fluid Mechanics in Aquatic Systems
Lefebvre, Louis	Medical Genetics	UBC	Genomic imprinting, medical genetics, epigenetics	http://biology.mcgill.ca/faculty/lefebvre/	Y Genomic Imprinting
Lemay, Valerie	Forest Resources Management	UBC	Structural diversity measures and relationships with remotely sensed data	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=2529	
Lertzman, Ken	Environment	SFU	Ecosystem dynamics, conservation, management, First Nations, adaptation, restoration	http://www.rem.sfu.ca/people/faculty/lertzman/	
Lesack, Lance	Biological Sciences	SFU	Limnology, biogeochemistry of inland waters, arctic, mountain, tropical regions, hydrology, food webs	http://www.biology.sfu.ca/people/profiles/llesack	
Lewis, Kathy	Ecosystem Science and Management	UNBC	Epidemiology of forest pathogens in sub-boreal forests ecological interactions	http://unbc.ca/lewis	
Li, Loretta	Civil Engineering	UBC	Environmental contaminants, VOC, remediation, mine tailings, waste	http://www.civil.ubc.ca/people/faculty/faculty-li.php	
Li, Paul	Chemistry	SFU	Microfluidic microarray, detection of protein biomarkers	http://www.chemistry.sfu.ca/people/profiles/paulli	
Li, Xin	Botany	UBC	Plant immunity	http://www.botany.ubc.ca/people/xin-li	

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Lindgren, B. Staffan	Forestry	UNBC	Invertebrate indicators for woody debris management	http://web.unbc.ca/~lindgren/	
Livingston, Nigel	Biology	UVic	The control of whole plant transpiration and photosynthesis in conifers	http://communications.uvic.ca/research/details.php?id=44	
Lo, Victor	Civil Engineering	UBC	Biological process application in waste, agri	http://www.civil.ubc.ca/people/faculty/faculty-lo.php	
Maddison, Wayne	Botany & Zoology	UBC	Computational phylogenetics	http://salticidae.org/wpm/home.html	Y Biodiversity and Systematics
Mandy, Margot	Chemistry	UNBC	Environmental chemistry	http://www.unbc.ca/experts/science-technology	
Mansfield, Shawn	Wood Science	UBC	Elucidating the variations in fiber chemistry and morphology of aspen clones to improve pulp processing and quality	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3146	Y Wood and Fiber Quality
Maria Maldonado	Earth, Ocean and Atmospheric Sciences	UBC	Trace metal acquisition by phytoplankton, N metabolism and Fe acquisition, algal blooms	http://www.eos.ubc.ca/about/faculty/M.Maldonado.html	Y Phytoplankton Trace Metal Physiology
Marra, Marco	Medical Genetics	BCCA	Centre for Integrated Genetics: Genome Sequence Centre	www.bcgsc.ca/faculty/mmarra	
Martin, Kathy	Forest Sciences Centre	UBC	Ecology of alpine and forest birds	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3155	
Marziali, Andre	Physics and Astronomy	UBC	New technologies for genomics and life sciences	http://www.physics.ubc.ca/~andre/	N
Massicotte, Hugues	Ecosystem Science and Management	UNBC	Biodiversity, forest mycology	http://www.unbc.ca/ecosystem-science-management/massicotte-dr-hugues	
Mattsson, Jim	Biology	SFU	On-going New Opportunities Fund -Plant Molecular Breeding Centre at SFU	http://www.biology.sfu.ca/people/profiles/jmattsso	
Mavinic, Donald	Civil Engineering	UBC	Environmental engineering, biological waste, pipe corrosion	http://www.civil.ubc.ca/people/faculty/faculty-mavinic.php	

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Mayer, Ulrich	Earth, Ocean and Atmospheric Sciences	UBC	Groundwater hydrology, contamination, remediation, model development	http://www.eos.ubc.ca/about/faculty/	
Mazumder, Asit	Biology	UVic	Ecology of freshwater and marine ecosystems, fisheries, water quality	http://communications.uvic.ca/research/details.php?go=1&id=45	NSERC Industry Research Chair
Meech, John	Norman Keevil Institute of Mining	UBC	Metallurgy, engineering, artificial intelligence, environmental protection	http://mining.ubc.ca/about/people/john-meech/	
Meitner, Michael	Forest Resources Management	UBC	Interactivity and usability of environmental visualization systems	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=6	
Meyer, Irmtraud	Computer Science	UBC	Improving genome annotation, molecular structure and interaction prediction: An algorithm study of molecular functions	http://bioinformatics.ubc.ca/meyer/	
Mills, Dawn	School of Mining, Faculty of Law	UBC	Oil and gas regulatory review, aboriginal rights, land tenure,	no website	
Misra, Santosh	Forest Biology	UVic	Regulation of gene expression during conifer embryogenesis	http://web.uvic.ca/forbiol/misra	
Moerman, Donald	Zoology	UBC	Formation and function of muscle in c. elegans	http://www.genomebc.ca/research_tech/researcher_profiles/moerman.htm	N
Mohn, William	Microbiology & Immunology	UBC	PCB bioremediation in an anaerobic-aerobic two-phase bioreactor system, arsenic, environmental biotechnology	www.microbiology.ubc.ca/?id=323	N
Mohseni, Madjid	Chemical and Biological Engineering	UBC	Bioprocess engineering, environment, fuel cell, air and water treatment	http://www.chbe.ubc.ca/faculty-staff/mohseni.php	
Moors, Arne	Biological Sciences	SFU	Patterns of biodiversity, phylogeny, traits, evolution	http://www.biology.sfu.ca/people/profiles/amoors	
Moore, Daniel	Geography	UBC	Catchment hydrology and the stream environment	http://www.geog.ubc.ca/~rdmoore/ResearchProjects.htm	
Moore, Jonathan	Biological Sciences	SFU	Conservation and ecology of aquatic systems, streams, lakes, food webs, population dynamics, disturbances	http://www.biology.sfu.ca/people/profiles/jwmoore	

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Morin, Gregg	Michael Smith Genome Science Centre	BCCA	British Columbia Proteomics Network	http://www.bcgsc.ca/faculty/gmorin/	
Murphy, Michael	Microbiology and Immunology	UBC	Iron uptake and storage in bacteria	http://www.microbiology.ubc.ca/research/labs/murphy	
Myers, Judith	Zoology	UBC	Forests insects in a changing environment	http://www.zoology.ubc.ca/person/myers	
Nano, Francis	Biochemistry and Microbiology	UVic	Biodiversity, biofuels, vaccines	http://communications.uvic.ca/research/details.php?go=1&id=23	
Nelson, John	Forest Resources Management	UBC	Decision support systems for forest land use planning	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3171	
Nelson, Louise	Biology	UBCO	Environmental microbiology, sustainability	http://soilmicrobialecolgy.ok.ubc.ca/Group_Site/Faculty/Entries/2010/6/26_Louise_Nelson,_Ph.D..html	
Ng, Raymond	Computer Science	UBC	Intelligent computational methods for analysis of gene expression profiles	http://www.cs.ubc.ca/people/profile.jsp?id=rng	N
Novak, M.D.	Applied Biology	UBC	Biometeorology, soil physics, soil and waste conservation	http://www.landfood.ubc.ca/directory/faculty/professors-and-instructors/mike-novak	
Orians, Kristin	Chemistry	UBC	Environmental analytical chemistry, biogeochemical controls, trace metal distribution	http://www.chem.ubc.ca/our-people/profiles/kristin-orians	
Otter, Kenneth	Biology	UNBC	Effects of habitat disturbance on behaviour and reproduction of forest generalist birds	http://web.unbc.ca/~otterk/	
Otto, Sally	Zoology	UBC	Controlling weeds with selfish genetic elements	http://www.zoology.ubc.ca/~otto/	Y Theoretical and Experimental Evolution
Owens, Phil	Environmental Science	UNBC	Effect of landscape disturbance on water, sedimentation, erosion, tracers, nutrients, contaminants	http://www.unbc.ca/owens/research	Research Chair in Landscape Ecology

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Palen, Wendy	Biological Sciences	SFU	Evolutionary and behavioral ecology, aquatic communities, alpine, river, lake, field experiments, food webs, conservation	http://www.biology.sfu.ca/people/profiles/wpalen	
Parker, Katherine	Wildlife Ecology and Nutrition	UNBC	Nutritional and physiological ecology, bioenergy strategies, survival	http://web.unbc.ca/~parker/	Ian McTaggart Cowan Muskwa-Kechika Research Professor
Petticrew, Ellen	Geography	UNBC	Effect of landscape disturbance on water, sedimentation, erosion, biogeomorphology, restoration	http://www.unbc.ca/ellen-petticrew/research	Research Chair in Landscape Ecology
Piret, James	Chemical and Biological Engineering	UBC	Engineering cells, bioreactor engineering, analytical technologies	http://www.chbe.ubc.ca/faculty-staff/piret.php	
Pitcher, Tony	Fisheries Centre	UBC	Ecosystem restoration	https://sites.google.com/site/tonypitcherwebsite/Home	
Pither, Jason	Biology & Physical Geography	UBC	Community ecology and biodiversity, data management	https://people.ok.ubc.ca/jpither/Biodiversity_and_Landscape_Ecology_Research_Facility/Home.html	
Plant, Aine	Plant Molecular Biology	SFU	Strategies to improve genetic resistance to white pine weevil attack in spruce	http://www.sfu.ca/biology/faculty/plant/	
Poole, Warren	Material Engineering	UBC	Material engineering, microstructure, mechanical behavior	http://www.mtrl.ubc.ca/department/faculty-staff/poole.php	Rio Tinto Alcan Chair in Materials Process Engineering
Price, Bill	School of Exploration and Mining	NWCC	Instructor, Smithers campus		
Redfield, Rosemary	Zoology	UBC	Ability of bacteria to take up DNA from surroundings, molecular biology, bioinformatics, evolution	http://www.zoology.ubc.ca/%7Er edfield/index.html	
Reid, Scott	Biology	UBCO	Metal metabolism in fish, environmental adaptability	https://people.ok.ubc.ca/reidsd/Site/My_Page.html	

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Reynolds, John	Biology	SFU	salmon ecosystems, aquatic biodiversity, marine, freshwater, terrestrial connections, human impact	http://www.biology.sfu.ca/people/profiles/reynolds	Tom Buell BC Leadership Chair in Aquatic Conservation
Rieseberg, Loren	Botany	UBC	Plant evolutionary genomics, evolution, domestication	http://botany.ubc.ca/people/loren-rieseberg	Y -Plant Evolutionary Genomics Infrastructure
Ritland, Kermit	Forest and Conservation Sciences	UBC	Evolutionary genetics, mating, statistical genetics, conservation genetics	http://genetics.forestry.ubc.ca/ritland/kermit.pubs.annotated.htm	Y Population Genetics
Roberts, Deborah	Engineering	UBC	Anaerobic biological treatment, applied microbiology, proposed watershed monitoring tool for crypto and ARD project kill bacteria with virus	http://www.ubc.ca/okanagan/engineering/faculty/deborahroberts.html	
Roy, Real	Biology	UVic	Microbial ecology, GHG, environment, bacteria on methane gas, nitrogen transforming bacteria	http://communications.uvic.ca/research/details.php?go=1&id=51	
Russello, Michael	Biology	UBC	Exploring the Genetic Basis of Adaptation within a Conservation Context	http://web.ubc.ca/okanagan/biophgeo/faculty/mrussello.html	N
Rutherford, Michael	Environmental Science and Engineering	UNBC	Contaminated soils, waste management	http://www.unbc.ca/rutherford	
Sahinalp, Cenk	Computing Science	SFU	Laboratory for computational genomics and bioinformatics	www.cs.sfu.ca/~cenk/	Y Computational Genomics
Schulte, Patricia	Zoology	UBC	Environmental adaptation, fish	http://www.zoology.ubc.ca/person/pschulte	
Scoble, Malcolm	Norman Keevil Institute of Mining	UBC	Mining engineering, mineral exploration, sustainability, industry collaborations	http://mining.ubc.ca/about/people/malcolm-scoble/	Robert Hallbauer Chair in Mining and Sustainability

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Sen, Dipankar	Chemistry	SFU	DNA nanotechnology, sensor development	http://www.chemistry.sfu.ca/people/profiles/sen	
Sheppard, Stephen	Forest Resources Management	UBC	The mycorrhizal ecology laboratory - linking belowground with aboveground indicators of forest sustainability, forest sustainability, soil diversity	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3197	
Shi, Yang	Mechanical Engineering	UVic	environmental monitoring systems	http://communications.uvic.ca/research/details.php?go=1&id=1062	
Shrimpton, Mark	Biology	UNBC	Aquatic ecosystems, fish genetics, habitat	http://web.unbc.ca/~shrimptm/research.htm	
Simard, Suzanne	Forest Sciences	UBC	The mycorrhizal ecology laboratory - linking belowground with aboveground indicators of forest sustainability	http://farpoint.forestry.ubc.ca/FP/search/Faculty_View.aspx?FAC_ID=3198	
Smith, Leslie	Earth, Ocean and Atmospheric Sciences	UBC	Groundwater hydrology, waste rock piles, hydrothermal systems	http://www.eos.ubc.ca/about/faculty/L.Smith.html	
Srivastava, Diane	Zoology	UBC	Biodiversity, ecosystem, community ecology	http://www.zoology.ubc.ca/person/srivast	
Standish, Jace	School of Construction and the Environment	BCIT	Soils, reclamation, renewable energy, forest ecology	http://www.bcit.ca/construction/research/directory.shtml	
Stanley, Juniper	Earth and Ocean Sciences	UVic	NEPTUNE, marine conservation, hydrothermal vents, biomineralization, microbial communities, nitrogen cycle	http://communications.uvic.ca/research/details.php?go=1&id=883	
Starzomski, Brian	School of Environmental Studies	UVic	Biodiversity, ecosystems, monitoring, climate change	http://communications.uvic.ca/research/details.php?go=1&id=1064	
Stevens, Robert	Mining and Mineral Exploration	BCIT	Mining and mineral exploration	http://www.amebc.ca/about-us/Board-of-directors-detailed/Robert-Stevens.aspx	
Steyn, Douw	Earth and Ocean Sciences	UBC	Meteorology, air pollution, near surface emissions, modeling, oil and gas emission and LNG operations	http://www.eos.ubc.ca/about/faculty/D.Steyn.html	

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Sui, Jueyi	Environmental Science and Engineering	UNBC	Water resource engineering	http://www.unbc.ca/experts/water-resources-fisheries	
Sun, Bingyun	Chemistry	SFU	Molecular Biology, BC Proteomics network, single cell analysis, Leroy Hood, cell surface monitoring	http://www.chemistry.sfu.ca/people/profiles/bingyuns	
Suttle, Curtis	Earth and Ocean Sciences	UBC	Marine and freshwater viruses	http://www.ocgy.ubc.ca/~suttle/	
Tang, Patrick	TB/Mycobacteriology and Molecular Microbiology	BCCDC	Medical microbiology, genomics, public health, metagenomics	http://www.bccdc.ca/util/about/UBCCDC/People/Faculty/DrPatrickTang.htm	
Taylor, Eric	Zoology	UBC	Genetic variations within populations, molecular ecology, population structure	http://www.zoology.ubc.ca/person/etaylor	
Taylor, John	Biology	UVic	Characterizing the evolutionary consequences of gene and genome duplication	http://web.uvic.ca/~taylorjs/index.html	
Taylor, Martin	Geography	UVic	Coasts under stress, coastal communities, population and community health	http://communications.uvic.ca/research/details.php?go=1&id=313	
Tortell, Philippe	Botany	UBC	Phytoplankton CO2 interactions, bacterial trace metal interactions	http://www.botany.ubc.ca/people/philippe-d-tortell	
Turkington, Roy	Botany	UBC	Experimental field ecology, boreal forest, garry oak, nutrient limitation, community functioning	http://www.botany.ubc.ca/people/roy-turkington	
Turner, Nancy	School of Environmental Studies	UVic	Ethnobotany, First Nations, biodiversity, environment	http://communications.uvic.ca/research/details.php?go=1&id=285	
Upton, Chris	Biochemistry and Microbiology	UVic	Viral Bioinformatics Resource Centre	www.virology.ca	
Van Hamme, Jonathan	Biological Sciences	TRU	Biocatalysts, degradation of environmental pollutants, remediation SOF?	http://faculty.tru.ca/jvanhamme/pages/research.html	

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
van Kooten, G. Cornelis	Social Sciences	UVic	The economics of terrestrial carbon sinks: land use, land-use change and forestry	http://web.uvic.ca/econ/people/faculty_directory/vankooten.php	Y Environmental Studies and Climate Change
Varela, Diana	Biology	UVic	Biogeochemistry, environment, oceanography, phytoplankton, nutrient cycling, nitrogen, carbon cycle	http://communications.uvic.ca/research/details.php?go=1&id=55	
Veiga, Marcello	Norman Keevil Institute of Mining	UBC	Metallurgy, bioaccumulation, ARD, selenium, environment	http://mining.ubc.ca/about/people/marcello-veiga/	
Verheyen, Esther	Molecular Biology & Biochem	SFU	Crosstalk between signal transduction pathways mediating wing patterning and development in Drosophila	www.sfu.ca/mbb/mbb/faculty/verheyen/verheyen.html	N
von Aderkas, Patrick	Biology	UVic	Experimental reproductive biology of conifers	http://web.uvic.ca/~forbiol/vonAderkas/vonaderk.htm	
Wei, Xiaohua (Adam)	Chemistry & Earth and Environmental Science	UBC O	The effects of harvesting and wildfire disturbance on large woody debris dynamics: implications for stream fish habitat	http://eesc.ok.ubc.ca/faculty/adamwei.html	Forest Renewable BC Chair of Watershed Research and Management
Whiticar, Michael	Earth and Ocean Sciences	UVic	Biogeochemistry, energy, natural resources, GHG, trace elements	http://communications.uvic.ca/research/details.php?go=1&id=184	
Winchester, Neville	Biology	UVic	Conservation of biodiversity: canopy arthropods in ancient temperate rainforests	http://web.uvic.ca/~canopy/winchest.html	
Wixted, Brian	Centre for Policy Research on Science and Technology	SFU	Policy research, natural resources, industry mapping, science policy, innovation technology, research networks	http://www.sfu.ca/~bwa11/bwa11.htm	

Name	Department	Institution	Area of Expertise	URL	Canada Research or other endowed Chair
Wong, Judy	Pharmaceutical Sciences	UBC	Mechanisms of genome maintenance	http://www.pharmacy.ubc.ca/faculty_staff/faculty/pharm_toxi/pharm_toxi_judy_wong.html	Y Mechanisms of Genome Maintenance
Zhang, Yuelin	Botany	UBC	Microbial infection, pathogen recognition, immune receptors, acquired resistance	http://www.botany.ubc.ca/people/yuelin-zhang	

Appendix 7: Significant Mining and Energy Research Projects Funded in Canada

Institution	Program	Principal Investigator	Project
Environment Canada & National Research Council & McMaster University	Science and Technology Applications of Genomics in the Environment (STAGE) part of Genomics Research & Development Initiative (GRDI)	Sean Kennedy	Eco-Toxicogenomics: A promising new environmental technology for assessing risk
Genome Alberta	ABC	Gerrit Voordouw	Metagenomics for Greener Production and Extraction of Hydrocarbon Energy
Genome Atlantic	ABC	Michael Gray	The protist EST (expressed sequence tag) project
Genome Atlantic	ABC	Ford Doolittle	Understanding Prokaryotic Genome Evolution and Diversity
Genome BC	ABC	Loren Rieseberg	Genomics of Sunflower
Genome BC	ABC	[Not in Database]	Synthetic Biosystems for the Production of High-Value Plant Metabolites
Genome BC	AGIP	Carl Douglas, Shawn Mansfield	Optimized Populus feedstocks and novel enzyme systems for a British Columbia bioenergy sector
Genome BC	AGIP	Jack Saddler	Optimizing Hydrolytic Enzymes and Lignocellulosic substrates toward maximizing the saccharification and fermentation of lignocellulosic biomass for bioethanol production

Institution	Program	Principal Investigator	Project
Genome BC	LSARP	Carl Douglas, Shawn Mansfield	POPCAN: Genetic improvement of poplar trees as a Canadian bioenergy feedstock
Genome BC	ABC	Gerrit Voordouw (Steve Hallam)	Metagenomics for Greener Production and Extraction of Hydrocarbon Energy
Genome BC	AGIP	Lindsay Eltis	Genomic studies of explosives biodegradation
Genome BC	AGIP	William Mohn	Genomic approaches to microbial community monitoring as a forest management tool
Genome BC	Comp I	Julian Davies, William Mohn, Lindsay Eltis	Microbial Envirogenomics
Genome BC	LSARP	Patrick Tang, Judith Issac-Renton	Applied Metagenomics of the Watershed Microbiome
Genome BC	SOF1	Caren Helbing	FrogSCOPE (frog Sentinel species Comparative "Omics" for the Environment)
Genome BC	SOF1	Helen Gurney-Smith, Stewart Johnson	Development of a Health Assessment Tool for Marine Mussels (Myt-OME)
Genome BC	SOF2	Steven Hallam	Time Resolved Community Genomics of Subarctic Pacific Oxygen Minimum Zones
Genome BC	SOF2	Curtis Suttle	Environmental Genomics of RNA Viruses
Genome BC	SOF3	Michael Hart	Adaptive molecular evolution in a unique British Columbia community: Population genomics of Haida Gwaii
Genome BC	SOF3	Michael Russello	Population transcriptomics: harnessing next-generation sequencing technologies for adaptive genetic marker discovery to inform studies in ecology, evolution and conservation
Genome BC	AGIP	Susan Baldwin	The Development of Genomic Tools for Monitoring and Improving Passive Mitigation of Mine Drainage
Genome Prairie	AGIP	David Levin	MGCB2, Microbial Genomics for Biofuels and Co-Products from Biorefining Processes
Genome Prairie	WD	Wilf Keller	MEOR: Using Microbes in Oil Recovery
Genome Prairie	WD	Reno Pontarollo	MAVEN, Microbial Assessment for Value-Added, Environmental, and Natural Resources
Genome Quebec	LSARP	Michel Labrecque	GenoRem: Environmental genomics of willows and microorganisms applied to the decontamination of abandoned industrial sites
Genome Quebec	Quebec Vert	Connie Lovejoy	Genomes and Transcriptomes of Arctic Chromists (GTAC)

Institution	Program	Principal Investigator	Project
Genome Quebec	Quebec Vert	Francois Belzile	GreenSNPs: an enabling technology for environmental genomics in aquatic or land animals and plants
Genome Quebec	LSARP	Franz Bernd Lang	Improving Bioremediation of Polluted Soils through Environmental Genomics
GRDI	Food and Water Safety	Sabah Bidawid	multi-department effort to strengthen food and water safety
NRC Biotechnology Research Institute	Petroleum Technology Alliance of Canada PTAC	Charles Greer	Developing alder-Frankia symbionts for improved revegetation and remediation of oil sands tailings
Ontario Genomics Institute (OGI)	ABC	Robert Beiko	BEEM -- Bioproducts + Enzymes from Environmental Metagenomes
OGI	LSARP	Mehrad Hajibabaei	Biomonitoring 2.0, High throughput genomics for comprehensive biological assessment
University of Toronto	INTEGRATE	Brent Sleep	Innovative Combined Treatment Technologies for Remediating Contaminated Groundwater
University of Toronto	Biodegraders	Elizabeth Edwards	fundamental understanding of environmentally relevant biological processes
University of Toronto	Bioprocess Engineering	Grant Allen	BIOPROCESS ENGINEERING WITH ENVIRONMENTAL APPLICATIONS
University of Toronto	BioRed	Frank Loffler	BioReD: Biomarkers and Tools for Reductive Dechlorination Site Assessment, Monitoring, and Management
University of Toronto	Laboratory for Metabolic Systems Engineering		Systems Biology, Synthetic Biology and Metabolic Engineering for Sustainability
Environment Canada	STAGE		Application of genomics to monitor the health and activities of microbial communities in contaminated soils and stressed riverine environments
Environment Canada	STAGE		Development and standardization of test methods using environmental genomics techniques
Environment Canada	STAGE		Application of genomics methods and end-point measurements for aquatic toxicological testing and environmental effects monitoring
Environment Canada	STAGE		Development and application of novel genomics-based techniques for the detection of environmental microorganisms and the assessment of chronic toxicity in wastewater
Environment Canada	STAGE		Gene expression technologies – application of genomics to wildlife toxicology

Institution	Program	Principal Investigator	Project
Environment Canada	STAGE		Development and validation of a lobster eco-toxicogenomic array
Environment Canada	STAGE		Environmental safety of biotechnology to aquatic ecosystems – impacts of transgenic crops and commercial bacterial consortia to aquatic invertebrates
Environment Canada	STAGE		Validation of genomics tools for the prediction of environmental effects: response of fish to contaminated sediments
Environment Canada	STAGE		Application of genomics to microbial source tracking: identification of genetic markers specific for animal fecal pollution in aquatic environments.

POWERING BC'S MINING & ENERGY SECTOR

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