Alberta Water Technology Asset Catalogue Report

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1.0 Introduction

Water management challenges and opportunities are prevalent throughout Alberta, crossing many jurisdictions and impacting various stakeholders, industries and communities. Water plays a significant role in Alberta's energy, agricultural and environmental sectors, and is a strong driver for technology development and innovation.
In 2013, Alberta's GDP was $331.9 billion and much of the economic activity that generated this GDP required water as an input, either directly or indirectly. Sectors that rely on water include energy (24.6% of 2013 GDP), manufacturing and forestry (6.9% of 2013 GDP), agriculture (1.9% of 2013 GDP), business and commercial services (10.6% of 2013 GDP), tourism and consumer services (4.4% of 2013 GDP) and health (5.0% of 2013 GDP)[1]. These statistics show that over half (53.4%) of Alberta's GDP depends directly or indirectly on water.

Water challenges related to water quality and quantity highlight the need for Albertans to pursue and support innovative water technologies and enhanced environmental management. Some of these water challenges include:

- Rapid population growth across the province, resulting in significant changing demands for water;
- A moratorium on the application for new water licenses in the South Saskatchewan River Basin as of 2006, which has resulted in a constrained water supply in southern Alberta;
- Rising global demand for irrigated agriculture production; and,
- Increasing production of fossil fuels with more technically challenging water management issues.

> *"It is safe to say that while Alberta's economy is fuelled by energy, it runs on water."*
>
> *– Dr. Sascha Zehnder, AI-EES*

The complexity of protecting, allocating and managing Alberta's water resources and water systems cannot be addressed by individual companies or technology solutions. Working collaboratively to focus on the issues of water, energy, agriculture and the environment will encourage the development of integrated technologies and solutions that will meet these challenges. Significant opportunities exist to capitalize on Alberta's growing water technology sector. For the purposes of this work, the term "Alberta water technology sector" refers to all water-related technology and service companies, researchers and commercialization initiatives in Alberta.

To better understand the growing Alberta water technology sector, Alberta Innovation and Advanced Education (IAE) commissioned the Alberta WaterPortal Society (WaterPortal) to research and catalogue existing technologies, service companies, researchers and commercialization initiatives that exist in the province. The WaterPortal also identified water-related economic management challenges and opportunities. The identification of these challenges and opportunities will help inform the Government of Alberta (GoA) as it explores how to support the province's emerging water industry.

This report presents the research findings of the WaterPortal team. In addition to this report, a Water Technology Asset Catalogue (the Catalogue) was created as a compliment to this report and to act as a resource for the GoA and water technology innovators in the province. The Catalogue provides a comprehensive collection of information on water technology and consulting companies, researchers and initiatives focused on innovation and commercialization. The Catalogue is intended to act as a resource to ultimately help bolster the province's technology capabilities in the global water industry.

[1] Government of Alberta, 2014. "Economic Diversity." Retrieved from http://albertacanada.com/business/overview/economic-results.aspx

The WaterPortal provides Albertans with accurate, insightful and balanced information on Alberta's water challenges and opportunities. All of the contents of this report and Catalogue are being shared through the WaterPortal to more rapidly disseminate this information to entrepreneurs, financiers, decision-makers and potential customers to support growth in the province's water technology industry. The challenge will be to keep the Catalogue and contents of this report up to date and relevant; a static Catalogue will quickly become irrelevant.

2.0 Methodology

This study was conducted by the WaterPortal team, which is uniquely placed to identify individuals and groups with water expertise across the province. This distinctive positioning is based on years of experience partnering and collaborating with numerous organizations in water management and technology development as well as knowledge of and engagement in commercialization efforts throughout Alberta.

The WaterPortal team and IAE initially determined key water market segments (meaning segments that rely on the application of water technology) that were used as a starting point to identify all the water technology players within Alberta. The market segments are outlined in greater detail in *Section 4* of this report.

The research conducted for the report and Catalogue was focused on the collection of information on the current state of the water technology sector in Alberta, as outlined in *Section 5*. When desktop research was insufficient, brief and selective interviews were conducted. In addition, research focused on and informed the summary of best practices for water technology development and commercialization implemented across Canada and international jurisdictions, as outlined in *Sections 6 and 7*.

To further inform the development of the Catalogue, the WaterPortal team consulted with relevant government organizations and industry members to acquire additional information on water technology assets throughout Alberta, as outlined in *Section 5*. The consultation process involved phone interviews with representatives from outside the province and face-to-face interviews with those residing within Alberta. The consultations also guided the identification of additional research sources on water organizations that operate within Alberta.

The water technology sector in Alberta and elsewhere is constantly evolving and may require more in depth interviews conducted specifically with technology providers and entrepreneurs. These would provide a greater understanding of challenges and opportunities throughout the development and commercialization process. A process for continually updating this information should be considered as a next step in this work.

3.0 Alberta Water Technology Sector

Alberta's water technology sector has the potential to make Alberta a world leader in innovative technologies and solutions capable of addressing current and future water management challenges, in those segments where Alberta has a specific business, environmental or social need. This potential is driven by Alberta's strong support network for technology innovation, the vast number of consulting and engineering firms and increasing presence of multinational companies in the province. The province's energy and agricultural sectors are the primary drivers for water technology development and innovation in water use, partly due to increasing demands for improved social and environmental performance. Energy and agricultural sectors around the world face the challenges of limited water supply and deteriorating water quality. Therefore, technologies developed in Alberta to address challenges in the province can also apply globally, opening opportunities to export these solutions to the world.

Alberta has a strong support network of internationally recognized universities and government organizations such as Alberta Innovates that are well positioned to address the province's water challenges. For these reasons, Alberta is a favourable location for excellent scientists, engineers and companies to develop water technology

solutions. To capture this potential, Alberta must participate in the global dialogue to further develop our knowledge and promote our innovations.

The water technology sector in Alberta is complex and fragmented, with no single company having a commanding market share. The industry reflects an array of small, medium, and large companies focused on the collection, conveyance, treatment, monitoring and analysis of water and wastewater for multiple purposes and end users. The water technology sector in Alberta is also home to a number of successful consulting and engineering firms that are building on the growing need to address water and other environmental challenges.

The increased presence of multinational corporations in Alberta reflects a mature customer base that favours proven water technology. Large multinational corporations such as General Electric (USA), Siemens (now EVOQUA) (Germany), and Veolia (France) have increased their water technology sales and marketing operations in Alberta in an effort to secure new opportunities from energy companies and municipalities. These corporations offer full 'design-build-operate' water treatment services, often bundled with their other transportation and/or energy solutions and support services. Smaller Alberta based companies, such as Filterboxx, have also grown to fill this 'design-build-operate' water treatment services niche.

Relatively few local water technology companies have insight into industry best practices, or have success in scaling their operations outside of niche applications and markets. This challenge results from water technology companies having limited access to detailed data and information on the parameters of current water issues. A major challenge for local water technology developers is that large oil and gas companies operating within Alberta tend to buy technology that is commercially proven, often requiring a minimum number of operating hours in a similar facility. This is a significant barrier to local technology providers because entrepreneurs within the province historically have had limited opportunities to test and demonstrate the potential operational capability of their technology. An example of how this barrier is currently being addressed in the in situ oil sands segment is the creation of the Water Technology Development Centre at Suncor's Firebag facility, planned to be operational by 2017, where various technologies can be tested in a live environment that is not in critical service.

Conversely, Alberta has been successful in applying water technologies developed elsewhere in the world and in other industries to current regional water management challenges. This entrepreneurial expertise rests in the ability to adapt and apply existing water technologies to meet the province's unique demands, geographical variability and climate realities. The application of desalination technologies to in situ operations to address high volumes of saline groundwater is an example of this activity.

There are signs of increased levels of collaboration among many industry players to explore regional partnerships and opportunities to protect the environment and better manage their collective water resources (Alberta Energy Regulator, 2013), an excellent example of which is Canada's Oil Sands Innovation Alliance (COSIA).

Alberta's economic and population growth will continue to increase demands on industrial, agricultural and municipal water and wastewater treatment systems and infrastructure. These demand-driven opportunities should coincide with new government regulations to better protect the environment and achieve desired environmental outcomes.

The immediate water technology challenges and opportunities in Alberta are summarized in *Table 1*.

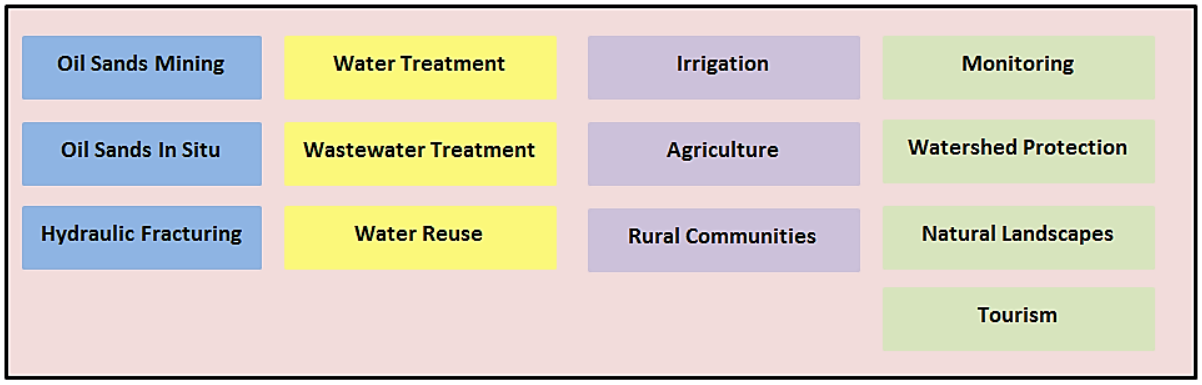
Table 1: Immediate Water Technology Challenges and Opportunities in Alberta

Challenge	Opportunity
• Industry's strict requirements for tested and proven technology, which is a limitation to local technology developers	• Encourage and showcase technology field testing collaborations, such as the Water Technology Development Centre and the Edmonton Waste Management Centre of Excellent
• Lack of access to accurate and relevant data, creating a gap in understanding of real water issues	• Provide greater support for monitoring (AEMERA) and collaboration among research organizations, technology developers and industry • Provide greater access to real-time data
• Alberta's limited active involvement in the global water technology dialogue	• Showcase Alberta's water technology companies at international water events such as World Water Week and World Water-Tech Summit
• Technology is advancing at a greater pace than government regulations, such that existing regulations block implementation (e.g. reuse)	• Encourage greater collaboration between government, industry and technology providers to help develop appropriate regulation and policy
• Water management and technologies are not well understood outside the water community, limiting the acceptance of new processes and technologies	• Continue encouraging and supporting public communication and educational platforms

4.0 Alberta's Water Technology Segments

Alberta's water technology entrepreneurs and businesses continue to develop new technologies to meet growing local industry needs and watershed management challenges. *Figure 1* presents the primary water technology segments currently active in Alberta. These segments are the basis for structuring the Catalogue. The Catalogue acts as a directory of the academic, technology, services, and other experts within the Alberta water community. The Catalogue also identifies resources that enable entrepreneurs and small businesses to research, develop and commercialize new water technologies and solutions that can be deployed in Alberta. This report complements the Catalogue by offering high level information on the different segments within the water community and their specific technology and service needs.

Figure 1: Major Water Technology Segments



The opportunities and challenges of each of these segments are discussed in further detail below. The opportunities and challenges for all segments are summarized in *Appendix H*.

4.1 Oil Sands

Production of bitumen from Alberta's oil sands has expanded in the past decade. However, the high costs associated with water treatment in bitumen recovery operations present economic challenges. In addition, uncertainties surrounding the future availability and quality of water resources have drawn national and international attention. These concerns have influenced operators in the oil sands industry to explore alternative water use and treatment solutions. Presently, large quantities of water are required for bitumen extraction in both the mining and upgrading processes. There is a need for innovative water technology to address challenges in areas such as water infrastructure, treatment and transportation.

4.1.1 Mining

The production of oil from bitumen mining operations in northern Alberta relies heavily on water management and treatment technologies. Water is used throughout the mining extraction process, which presents the need for solutions that limit the impact on fresh water sources through enhanced reuse and treatment technologies. The challenges associated with tailings water have received significant attention locally, nationally and internationally. There are opportunities for water technologies that improve the efficiency of water management within mining operation sites.

The primary water challenges in bitumen mining operations are:

- Reducing the amount of water used to extract each barrel of bitumen from the ore;
- Increasing the reuse of water in the extraction process;
- Reducing the cost of separating water from clay in tailings ponds;
- Treating the water separated from tailings to allow surface discharge; and,
- Determining the fate of contaminants in End Pit Lakes.

Additional opportunities for water treatment and management can be found in the development of new technologies that can help mine operators better manage and monitor their fresh water sources, which are the Athabasca River and its tributaries.

There are also challenges associated with dewatering the ore body prior to excavation of the pit, including managing pressurized saline aquifers. To address this issue, opportunities exist for efficient and cost-effective salt extraction technologies to aid in the management of increased brine flow on bitumen mining sites.

Summary of Oil Sands Mining Opportunities:

- Technologies that help producers better monitor surrounding freshwater quality, specifically the Athabasca River and tributaries
- Technologies that increase the reuse of water onsite
- Technologies that address challenges posed by the concentration of dissolved solids on their sites due to increased reuse of water
- Technologies that help manage highly saline groundwater that encroaches on the mine site

4.1.2 In situ Operations

With the risks associated with the uncertainty of future oil prices and access to alternative markets, oil sands producers are searching for technologies that improve the efficiency and automation of processes, steam

production, and environmental performance, as well as accessing smaller reservoirs, while reducing operating and capital costs. The in situ technologies that involve the greatest use of water are Steam Assisted Gravity Drainage (SAGD) and Cyclic Steam Stimulation (CSS).

The search for water replacement alternatives has produced a variety of different options available for extracting bitumen through in situ facilities. Such alternatives in development include: Thermal Assisted Gravity Drainage (TAGD); Vapor Extraction Process (VAPEX); Electro-Thermal Dynamic Stripping Process (ETDSP); and, Toe-to-Heel Air Injection (THAI), which was not successfully demonstrated through pilot testing.

In situ production facilities present great opportunities for new water technology because, although in situ facilities generally operate on a smaller scale than mining facilities, there could potentially be many more of them. Several of these opportunities include technologies that improve the automation of the SAGD water treatment process, improve the efficiency of steam production, aid in the management and disposal of water treatment wastes, improve the water treatment and reuse process and improve boiler design and steam generation.

Summary of Oil Sands In situ Opportunities:

- Technologies that improve steam production efficiency
- Technologies that improve the automation of the SAGD water treatment process
- Technologies that aid in the management and disposal of water treatment wastes
- Technologies that reduce fouling and plugging
- Technologies that aid in chemical mixing and management
- Technologies that help improve the water treatment and reuse process
- Technologies improving boiler design and steam generation

4.2 Hydraulic Fracturing

Hydraulic fracturing technologies currently used in Alberta require large volumes of water for the pressurized fracturing processes. As field development using hydraulic fracturing increases in more populated areas, stress on water resources will increase due to competing demands for water. Furthermore, water management costs have placed a burden on the economics of shale gas development. These stresses and challenges have increased the need for enhanced water management and improved technologies in the hydraulic fracturing process.

As water availability remains a challenge for operators, opportunities exist for operators to use new technologies that can subsequently improve water use and management in the hydraulic fracturing process. For example, on-site water reuse reduces the disposal of flowback and produced water, a practice that further enables improved water management.

Of additional concern is the impact of hydraulic fracturing on surface and groundwater resources. Both resources are integral to watershed health and ensuring sustainable hydraulic fracturing operations. Therefore, the development of technologies that can improve our ability to map and monitor surface and groundwater resources and account for the connectivity between surface water and groundwater aquifers is essential.

There are two primary types of fluids used for deep well injection in the hydraulic fracturing process: slickwater fracture fluids and cross linked gel-based fracture fluids. The industry has shown that slickwater fracturing fluid can be reused with little or no treatment. Opportunities exist in the development of technologies to effectively treat cross linked gel fracture fluids for reuse.

Water challenges in the hydraulic fracturing industry can be addressed through collaboration between operators and technology companies. For technology developers to be successful in this sector there must be access to accurate data and engineering resources, as well as access to hydraulic fracturing facilities to test and pilot new technologies.

Summary of Hydraulic Fracturing Opportunities:

- Technologies that help operators better understand and manage their source water
- Technologies that help operators monitor the surrounding natural environment for any potential changes in water quantity, quality and ecological health
- Technologies that support groundwater mapping, monitoring and data collection
- Technologies that increase the reuse of water within their sites
- Technologies that aid in the management and disposal of water treatment wastes

4.3 Water and Wastewater Treatment

With Alberta's rapidly growing population, pressures on existing water and wastewater treatment facilities are increasing. While water and wastewater technologies currently implemented in Alberta can treat many contaminants such as bacteria and nutrients, some substances can only be partially treated.

In Alberta, pharmaceuticals, pesticides and endocrine disrupting chemicals are seldom monitored or treated. With growing populations in Alberta's municipalities, leading to increased use of water and wastewater treatment facilities, there is an opportunity to develop and introduce technology advancements in wastewater treatment processes that address the increasing levels of pharmaceuticals and chemicals in waste streams.

With some exceptions, Alberta has predominately imported proven water and wastewater treatment technologies that have already been fully tested and are readily available. Sometimes these technologies have been adapted or modified for local environments, climates and applications, with local companies providing support services. Relatively few of Alberta's technology companies are finding success in scaling their operations outside of niche applications and markets. Despite this difficulty, there is an opportunity to develop technologies that can reduce the amount of environmentally harmful or synthetic chemicals used in treating municipal, industrial and agricultural wastewater, while reducing the environmental footprint and overall cost.

The main challenge facing water and wastewater treatment is the risk-averse nature of large scale industrial, municipal and agricultural operators. Incentives should focus on support for demonstration and pilot projects that are located in smaller communities, facilities and operations. These opportunities exist and can occur in collaboration with Alberta's advanced educational and training institutes, as well as with research and development programs such as the Edmonton Waste Management Centre of Excellence and the Advancing Canadian Wastewater Assets (ACWA) at the Pine Creek Wastewater treatment plant in Calgary.

As is the case in a number of municipal and industrial water applications, the most effective and sustainable approach to eliminating or managing wastewater substances is through the development of regulatory policies, incentives and educational programs that promote a reduction of these substances at the source.

Summary of Water and Wastewater Treatment Opportunities:

- Adaptable technologies that enhance the treatment of domestic wastewater and industrial/process wastewaters, specifically focusing on the treatment of pharmaceuticals, pesticides and other chemicals
- Technologies that help treat and manage agricultural, industrial and municipal runoff
- Wastewater treatment technologies and processes that result in a smaller environmental impact and/or reduce the use of harmful or synthetic chemicals
- Adapting all of these technologies to deal with operational challenges in cold and variable climates

4.4 Water Reuse and Stormwater Use

Southern Alberta has joined many global communities where the demand for water has reached or exceeded the natural capacity of river systems that provide traditional water supply. For example, due to the restriction on new applications for water licenses in the Oldman and Bow River Basins, additional demand must be met by new and innovative methods to reduce existing use. Such methods could include increasing water reuse and stormwater use. However, updates to policy and regulations are necessary to facilitate the efficient adoption of these opportunities. Work undertaken by Alberta WaterSMART through an AI-EES project titled "Water Reuse: Case Studies and Policy Development to Support Continued Economic Development", supports the further development of a policy framework in Alberta that will encourage the implementation of water reuse and stormwater use projects. Significant research has also been undertaken on ways to increase the efficiency of water reuse and stormwater use methods, as well as technologies to reduce the demand for water and expand alternative sources.

Technology used for non-potable water use projects relies on a number of factors. The protection of public health and the environment is of primary importance, while protection of equipment is another critical consideration. These factors apply to both municipal and other types of wastewater reuse as well as to stormwater use.

Although many existing technologies are capable of removing most pathogens of concern, technologies must be chosen to suit the specific reuse application. Different applications of technology will result in varying levels of health risk, depending on the likelihood of exposure to pathogens, cysts, viruses or different forms of algae. This provides an opportunity to introduce appropriate monitoring technology and application techniques that are critical to ensuring a safe system.

In other regions, the use of appropriate technologies and processes has effectively mitigated risks associated with water reuse. End users of water reuse applications must have confidence in the relevant risk management practices to ensure efficient adoption. Furthermore, implementing a transparent decision-making system that integrates risk management with technology selection and creativity with new reuse applications is critical.

There are many proven water recycling and reuse technologies commonly used throughout the world today. However, gaps exist in the implementation of technologies in the Alberta context. For example, traditional greywater reuse systems are typically designed to operate year-round and are not designed for cold climates. Further, as some systems require a relatively large amount of space, residential buildings and commercial structures may not be able to accommodate the size and space requirements of these systems. The high cost of water reuse systems, combined with the potential costs of retrofitting existing buildings and homes, provides little incentive to adopt reuse technologies. Due to low water costs in many communities throughout Alberta, there is currently little incentive to adopt water reuse or greywater systems. That said there is an opportunity to develop reuse technologies specific to Alberta that can accommodate space and cold temperatures and improve our ability to conserve our water resources.

Summary of Water Reuse and Stormwater Use Opportunities:

- Water reuse and stormwater use technologies that can operate safely and effectively in Alberta's cold climate
- Software and database tools that assess the potential for matching water quality to use, water quality and quantity risk management, and identify cost-benefits of different approaches
- Pilot projects to test monitoring, treatment and risk mitigation technologies that can aid in the development of safe and effective policies and guidelines for water reuse and stormwater use
- Access to test facilities to accommodate field trial testing of new technologies
- Technology platforms that support public awareness and education programs, such as online communication platforms on water efficiency and reuse

4.5 Irrigation and Agriculture

Alberta receives an abundant amount of sunlight, making it a great region for agriculture. Future projections indicate that Canada will be one of very few countries able to improve crop yield between today and 2050. Pressure will increase for Canada to produce more food for the global community. Alberta contains 66 percent of the irrigated land in Canada, and this pressure will have a significant impact on the province. The main challenge for irrigation and agriculture is the future impacts of climate change such that water will become a limiting factor for future crop production. This includes both water availability and water quality issues.

Enhancements in the productivity of agricultural activities rely heavily on irrigation, especially in the warmer, semi-arid regions of the province. The business of irrigation involves diverting water from the water source (generally a river) to the crop with minimal losses due to evaporation, seepage and canals being blocked by aquatic plant growth. There are additional challenges in returning the water to the natural system while maintaining water quality. As agricultural irrigation accounts for over 40 percent of the province's overall surface water allocation and two-thirds of total use, improvements in water efficiency in this sector through the development of advanced technologies and management practices will have a major impact on water utilization, especially in the south.

There are opportunities to develop technologies that improve water efficiency through effective monitoring technologies and data management systems, as well as introducing storage and treatment processes for runoff from developed areas entering the irrigation canals, and runoff from livestock operations entering water courses.

Summary of Irrigation and Agricultural Opportunities:

- Technologies that limit the amount of unwanted aquatic plants growing in irrigation canals
- Technologies and best practices that help mitigate, and potentially treat, municipal and industrial stormwater runoff into irrigation canals
- Technologies that improve the efficiency of irrigation systems, specifically on point specific irrigation
- Technologies that monitor and report soil moisture to increase the efficiency of irrigating crops
- Technologies that aid in the development of advance crop breeding, such as breeding crops that have a high tolerance to drought
- Technologies that store and treat livestock waste runoff which will reduce the leaching animal waste into the soils or streams
- Agricultural runoff filtration technologies that reduce the amount of pesticides returning to water courses

4.6 Rural and Remote Communities

Access to safe drinking water is one of the pillars of the *Water for Life* Strategy. Globally, many regions and communities are challenged with balancing population growth and economic development against sustainable land use practices. In Alberta, industry, agriculture and municipalities all compete for the same land and water resources. The closure of the Bow River and Oldman River basins to applications for new water licenses in 2006 further challenged the access to water for rural and remote communities.

Over the last decade, the province has moved toward centralized water treatment facilities to deal with the poor quality of the local systems (Deloittes, 2004). However, there is an opportunity to develop more reliable small scale water treatment systems to support the growing need for safe drinking water in rural and remote communities. These small scale systems also need to be operated remotely, reducing the need for full time trained operators at each facility.

In many remote communities, groundwater from wells is often the source of drinking water for property owners. Traditional well water testing and monitoring technologies are expensive, cumbersome and slow to provide

results. There is a need for new technology that is affordable and easy to operate, and that provides more accurate and timely results that can be transmitted to the appropriate health authorities for reporting purposes. The dependence on local aquifers also requires enhanced monitoring technology to assess water levels in the wells to ensure recharge is occurring to maintain a sustainable water supply.

Water supply can be supplemented by rainwater capture and use. There are opportunities to develop technologies that support more rainwater harvesting, including filtration and sediment removal. This can be especially helpful in watersheds where access to water is limited, but must be balanced against the need for aquifer recharge. Improving the design and implementation of robust septic units that do not leak and contaminate groundwater can also improve the efficiency of water use for rural and remote households.

Finally, there is a growing need to provide support and training to water and wastewater treatment operators who deal specifically with small scale water and wastewater treatment facilities in remote communities. There is an opportunity to develop easier to operate and more robust remote sensing and response technologies to support these operators to ensure that water and wastewater are treated to provincial standards.

Summary of Rural and Remote Communities Opportunities:

- Technologies that provide reliable 'right-sized' water and wastewater treatment systems for remote communities
- Technologies for advanced rainwater harvesting, including filtration and sediment removal
- Technologies that aid in the development and monitoring of robust septic units that do not leak and contaminate groundwater
- Groundwater well pump technologies that are efficient for household use, and can adapt to varying climatic conditions
- Technologies that aid in the mapping and monitoring of groundwater resources

4.7 Environmental Monitoring

In Alberta, challenges have arisen due to insufficient environmental monitoring data collection and reporting, which significantly impacts our understanding of how our local environment is affected by population growth and expanding agricultural and industrial use. Regulators and operators hope to address the inconsistent documentation and collection of scientifically verified environmental monitoring data through the implementation Regional Plans throughout the province. In addition to the lack of environmental monitoring data, there are challenges in ensuring that cumulative effects (air, water, land, biodiversity) are reflected in the management decisions of industry and government.

To address these specific challenges, the Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA) was launched by the GoA in April 2014 to provide credible scientific data and information on the state of Alberta's environment. Support for AEMERA is critical for ensuring a robust and successful provincial environmental monitoring program. In addition to developing new and innovative technologies that create scientifically verifiable monitoring data (i.e. remote sensor data), this combination of policy and technology creates a progressive approach to environmental monitoring that are necessary to address the challenges in Alberta's energy and agricultural sectors.

The importance of providing access to reliable and up-to-date data cannot be overstated. For this reason, AEMERA has been tasked with preparing an independent, annual report for the South Saskatchewan, North Saskatchewan and Lower Athabasca Regional Plans, and developing an on-line environmental reporting and information system. These actions are integral to the successful growth of technology companies in Alberta to further develop and commercialize technologies that require environmental monitoring data and information to address industry

needs. For example, technologies that can provide real-time data from robust environmental monitoring programs have the potential to address water use challenges, spill mitigation, and contamination issues.

As the collection of environmental monitoring information and data improves in Alberta, there are growing opportunities for information technology software businesses and support services to aid in the growth of monitoring technologies by working in collaboration with AEMERA, industry and the government. The collection of accurate real-time data is critical, but it is equally important to be able to store, use and manipulate the data in a user friendly way. These services can be provided by large international corporations, such as IBM, that can offer 'concept to completion' services. This would involve managing and monitoring remote sensors, as well as providing database server and interface management technology. There are also opportunities to work with local watershed groups to incorporate data that they collect into the system. 'Citizen Science' is practiced in other parts of North America where local people gather information which forms part of the reporting. An example of this is the CoCoRaHS program which operates throughout much of the United States.

Summary of Environmental Monitoring Opportunities:

- Remote sensing technologies that create verifiable monitoring data
- Information technology systems that improve the collection and organization of real-time monitoring data
- Technologies that support the gathering and vetting of 'citizen science' contributions to monitoring data
- Technologies that provide public access to real-time data in an easy to use way, through online information platforms or portals
- Technologies that support collaborative monitoring and reporting efforts between government and industry

4.8 Natural Landscapes, Watershed Protection and Tourism

Ecosystem goods and services provide all Albertans with the potential to develop our economy. Alberta's social, environmental and economic vitality depend, in large part, on how the province manages these natural resources, particularly water. With an expanding population, accelerating economic growth and the increasing impact of this growth on the environment, it is vital to understand the intricacies of our natural landscape to further adapt to and manage future change. To do so, we need technologies that enhance our ability to manage and model current and future water management scenarios.

Proactive and informed management decisions will require a clearer understanding of how future climatic and land use changes, coupled with increased demands and growth, could affect land and water resources, the users who depend on them and Alberta's ability to respond and adapt. Developing technologies that support watershed management plans through enhanced public engagement and communication platforms can help address this challenge. There is an opportunity to develop advanced database and modelling technologies will support and inform water management decisions.

There is also a growing opportunity to better communicate to Albertans, and our growing number of tourists, on their ability to access to vast amounts of information on our provincial parks and recreational activities. The use of enhanced technology platforms that improve the government's ability to communicate and engage with the public on access and availability could help grow the tourism sector across Alberta.

Summary of Watershed Protection, Recreation and Landscape Opportunities:

- Technologies that enhance watershed modelling capabilities, including advanced database and modelling information technology
- Technologies that improve the communication of watershed projects and research, providing easy to use platforms for the public, such as the Web-based State of the Watershed projects

- Technologies that enhance the ability of the government to engage and communicate with the public on recreational and park activities, including future development decisions
- Technologies that support the integration of Land-use Plans and Watershed Management Plans

In summary, each of the segments described above involve developing, adapting and implementing technologies that overcome existing problems with water use. The common theme across the segments is an ambition to improve efficiency of water use to further reduce quantities of source water required, amounts of water lost, and the amount of wastewater produced. There is also a growing need to introduce technologies that improve monitoring of the natural environment, while enhancing communication and engagement with the public.

While each segment requires a different lens for addressing water management decisions, there are common challenges that include water sourcing through use, reuse, water return and disposal. Water technology innovation to date has improved water use by Alberta's various industry and municipal water users, as evidenced by the Conservation, Efficiency and Productivity sector plans produced by the Alberta Water Council. Each segment has been successful in developing technologies that have been able to adapt to difficult conditions such as specific land-use demands or the cold climate. As innovation in each segment continues, Alberta has the opportunity to become a leader in innovative water technology in those segments where Alberta has a specific business, environmental or social need, which will enable our position as a global leader in water management. A summary table of Alberta's water technology challenges and opportunities is included in *Appendix H*.

5.0 Alberta's Water Expertise

Alberta's expertise lies in the ability to adapt, respond and apply tried and tested water technologies to meet our industry, geography and climatic realities. Specifically, Alberta's energy industry has a reputation for innovatively applying water technologies developed in other parts of the world for other applications. However, challenges exist to implementing this strategy because water expertise has been drawn out of consulting companies and into production companies, complicating the process of incorporating these new technologies into new facilities. Also, current water experts in all segments are expected to retire in the next few years, which will result in significant knowledge and experience gaps for the industry.

As noted earlier, Alberta's main challenge for local water technology development is that large producers and water management companies operating within Alberta are biased towards using technology that has a proven track record, often requiring a substantial number of successful operating hours in similar facilities. This is the single largest barrier to a made-in-Alberta technology solution, because Albertan entrepreneurs have not had the opportunity to test the potential operational capability of their technologies. This is a significant barrier to market entry for many local companies. To address this challenge, the Water Technology Development Centre at the Suncor Firebag facility is developing a platform in which water treatment technology companies can field test their technology using fluids with the same physical, chemical, temperature and pressure characteristics that occur at commercial in situ operations. This presents a great opportunity for technology providers to have direct contact with oil sands producers, speeding up the development and implementation of new water treatment technologies, while reducing development costs and risks to individual producers.

To assist in connecting the various participants in the water technology sector, Alberta's water expertise has been catalogued into different focus areas working within the sector. The Water Asset Catalogue focus areas are academic and research institutions, funding and commercialization support groups, service providers, technology providers, water experts and water services. The different sections of the Catalogue are detailed below.

5.1 Academic and Research Institutions

Alberta has a range of academic and research institutions to educate and train the next generation of water engineers, technologists and innovators. These institutions also provide the capacity for the basic research needed to develop the science behind water issues leading to new solutions. Supporting these academic and research institutions enables new technologies to be applied to Alberta's water management market, which enhances our ability to address water challenges throughout the province. Often these institutions have technology commercialization offices to help academic researchers commercialize their inventions.

There are opportunities to partner with these institutions to test and evaluate the effectiveness of Alberta-based water technologies. Also, support can be provided for entrepreneurial partnerships that can test made-in-Alberta technologies within these institutions. A list of institutions providing facilities and training programs for water entrepreneurs, as well as the research expertise and capacity in each institution, are documented in *Appendix A*. Contacts within each academic and research institution are listed in the Catalogue.

5.2 Government of Alberta

Most technology improvements are driven by changes in policy and regulations. Alberta Environment and Sustainable Resource Development (AESRD) is the ministry for the GoA that is responsible for the oversight of environmental outcomes and the sustainable development of Alberta's natural resources. AESRD has set provincial goals and has developed the guidelines to ensure a sustainable environmental future for all Albertans. These guidelines include the Water for Life strategy, Land Use Framework and Wetland Policy, and involve administering approvals under the *Water Act* and the *Alberta Environmental Protection Act (APEA)*. The policies and guidelines developed under AESRD inform all activities that have the potential of impacting the environment. The policies developed by AESRD dictate the standards for water quality and quantity, which in turn drive the changes and improvements in technology required to meet these standards.

The Alberta Energy Regulator (AER) is specifically responsible for regulating oil sands, natural gas and coal projects. AER achieves this mandate by making decisions on applications, and monitoring company compliance, site conditions and environmental impacts. For water management, AER administers the *Water Act* and *APEA* as they apply to water licenses and approvals for the oil, gas, oil sands and coal industries. As part of the AER, the Alberta Geological Survey (AGS) provides hydrogeological and geological data and support services, including mapping services and detailed mineral reports.

The Alberta Environmental Monitoring, Evaluating and Reporting Agency (AEMERA) is responsible for collecting scientific data about the state of Alberta's environment and then reporting this information to the public. AEMERA's mandate is to provide integrated and transparent information to Albertans. Measuring and reporting performance on water management supports the science behind new policy and regulations, which will drive innovation in the water sector.

Overall coordination of the innovation system in Alberta is provided by the Ministry of Innovation and Advanced Education (IAE). To ensure Alberta has the science and technology required to support our quality of life, the health of our communities, the economy and the environment, the GoA has formed the Alberta Innovates system, which includes Alberta Innovates Technology Futures (AITF), Energy and Environmental Solutions (AI-EES), Bio Solutions and Health Solutions. These research organizations provide insight and information on specific water issues, as well as funding to the academic institutions and other organizations focused on solving specific issues. AITF also has product testing and analysis facilities to assist in product development.

A detailed summary of GoA initiatives is included in *Appendix B.*

5.3 Service Providers

Alberta-based technology providers have access to a number of technology and business support services throughout the province. Organizations such as Innovate Calgary (partnering with the University of Calgary), TEC Edmonton (partnering with the University of Alberta), the Canadian Environmental Technology Advancement Corporation (CETAC-WEST), National Research Council Canada (NRC), Natural Sciences and Engineering Research Council (NSERC), Sustainable Development Technology Canada (SDTC) and many others offer important support services. These groups specialize in assisting with the research and development of specific technologies and the entrepreneurs responsible for developing these technologies, by providing advisory services from local expertise, knowledge on improved access to funding opportunities, research facilities and potential industry partners. There is also at least one private company start-up venture intended to support entrepreneurs through facilities and advice, which is MakerSpace Inc. located in Calgary.

5.3.1 Early Stage: Research

The early stage of technology development involves conducting fundamental research and the expansion of a bench scale or small scale version of a specific technology if required. This early stage research is one of Alberta's strongest areas of technology development. Most of the technology support service providers in Alberta provide access to research expertise and facilities, although these services come at a cost to the start-up company.

5.3.2 Middle Stage: Development and Testing

The middle stage of technology development involves growing the technology to a scale that is suitable for testing, followed by the demonstration or piloting of the technology. Although early stage research support is relatively effective at providing a high-level evaluation of a technology's potential, access to funding support for development, as well as access to facilities to pilot the technology, are often challenging for entrepreneurs. Increased collaboration among research institutions, government support services and industry would contribute to increased success in this area. For example, the SDTC is an organization working towards addressing these challenges by supporting and funding collaboration among industry and technology providers to further improve access to pilot testing facilities. Collaborations such as the Water Technology Development Centre are also working to help technology providers address these challenges.

5.3.3 Late Stage: Commercialization

Late stage water technology development often involves preparing the entrepreneur to market the technology and attract financing or investors. Institutions such as Innovate Calgary and TEC Edmonton provide business strategy, and development support and expertise. Technology providers in their late stage of development that have successfully field tested their technology will find many commercialization support services available to them.

5.3.4 Funding

Access to funding for technology providers is vital in supporting the water technology industry and future developments, and is almost always the biggest challenge for entrepreneurs. Financial support is needed in each stage of technology development and commercialization; however, funding support from the venture-capital sector is most often obtained after the technology has been proven successful through field trials or a track record of sales. Financial support for research and development can be found in research grants from institutions such as Alberta Innovates, NSERC and SDTC, as well as the federal Science, Research and Experiment Development tax credit program. Funding for prototyping and pilot testing is most challenging in the Middle Stage of commercialization. This is a gap in the innovation system particularly in Alberta.

5.4 Water Services

There are hundreds of companies providing services to the water sector. These include the largest engineering and consulting companies down to single person operators who use trucks to haul away waste from hydraulic fracturing sites to downhole disposal sites. The Catalogue includes as many of these companies as could be identified within the scope of this project. The most significant groups of service providers are outlined below.

5.4.1 Laboratories and Testing Facilities

A vast array of laboratories and testing facilities operate within Alberta. They are highly specialized and skilled in the fields of chemistry, biochemistry, microbiology, geology and engineering. These laboratories support different industries operating within Alberta specifically in the environment, energy, mining, manufacturing, transportation, agri-food and life sciences segments.

Each laboratory and testing facility provides a range of environmental analytical testing services, specializing in the analysis of soil, sediment, water (raw, waste, drinking, catchment, recycled, saline, product), leachates, dust, air (indoor, stack, ambient), gas, biota, industrial hygiene and radiochemistry. Analytical laboratory testing services for these materials includes routine, trace and ultra-trace level organics (volatile and semi volatile, herbicides, pesticides, PCBs and disinfection byproducts), metals and nutrients, inorganic non-metallics, microbiological, biological, toxicological parameters, particle sizing and radio nuclides. For a complete list of laboratories and testing facilities operating within Alberta, refer to the Catalogue.

5.4.2 Engineering Consulting Firms

In recent years, Alberta has seen an increase in the number of environmentally focused engineering and consulting companies formed to take advantage of this expanding sector. These consulting companies often include water experts from industry or academia that have identified the growing need for enhanced water management practices and guidance. These groups range from small organizations that specialize in strategy or specific expertise to larger organizations that provide engineering and hydrogeology services from project development and planning through to project management and completion. The smaller firms are generally employee-owned spinoffs from larger companies, while the large firms are generally internationally owned Engineering, Procurement and Construction (EPC) companies. Smaller firms inevitably merge or are acquired by the larger firms, making a listing of these smaller firms difficult to keep current. The Catalogue includes the most current listing.

5.5 Water Experts

5.5.1 Watershed Planning and Advisory Councils

Watershed Planning and Advisory Councils (WPACs) were developed under the *Water for Life* Strategy in 2003. Alberta's WPACs are non-profit organizations whose membership is made up of a number of stakeholders from within their watershed, including municipalities, irrigation districts, and environmental groups. WPACs are responsible for conducting assessments on the health and well-being of their watershed and using these assessments to develop plans and policy advice to help manage and mitigate watershed challenges. The WPACs and their smaller affiliates, the Watershed Stewardship Groups, provide an opportunity for engagement in educational campaigns to further inform the public about the importance of water conservation and technology innovation.

Alberta's WPACs are an excellent source of information for water sector companies and organizations to better understand water management challenges, the impact of economic development on the environment and future

changes to water related regulations within specific regions. For a full list of WPACs operating within Alberta please see *Appendix C.* The Catalogue includes the contact information for WPACs.

5.5.2 Irrigation Districts

The development of agriculture plays a major role in Alberta's current economy, and will have an even greater impact on the future of Alberta's economic impact and international status. Currently there are fourteen major irrigation districts within Alberta, located primarily in the southern half of the province. The irrigation districts effectively control over 40 percent of the water allocation within the province, and consume about two-thirds of the water, constituting a significant input to agricultural activities.

Irrigation districts rely on the health and well-being of our rivers and aquifers to continue providing farmers and ranchers with a clean reliable source of water. Therefore, their involvement and interest in water management activities within the province is very high. Irrigation districts provide an excellent source for information and data on water availability, flow rates, drought and flood mitigation, and invasive species as well as in-depth knowledge of water quality requirements and quantity demands for agriculture in Alberta.

5.5.3 Sole Practitioners

A great deal of Alberta's water expertise can be found within individuals that have served and worked in the water sector for their entire careers. These individuals, often near retirement, tend to stay connected and involved in the water sector on a part-time consulting basis. The impending departure of many of these individuals from the industry is a significant risk. Where known, these sole practitioners have been included in the Catalogue.

6.0 Best Practices for Water Technology Commercialization across Canada

Across Canada there is a growing water technology and commercialization market. For the purpose of this study three jurisdictions across Canada were examined. Ontario, Manitoba, and British Columbia (B.C.) were chosen due to the strength and number of programs in these jurisdictions which specifically support water technology promotion and commercialization.

Ontario was selected because it has a large innovation sector that is connected to Alberta's innovation sector through collaborative efforts and jointly funded projects between the Ontario Centre of Excellence (OCE) and AITF. Additionally, WaterTAP, a government-funded innovation organization and a leader in cataloguing the Ontario water technology sector, was a key resource for this study. A summary of Ontario's water technology and commercialization programs is included in *Appendix D.*

Manitoba was selected because of its focus on the water technology sector. For example, Innovation Alley in Winnipeg has been very active in creating new water technologies. Also as a prairie province, Manitoba faces similar water challenges that are present in the prairie regions of Alberta, specifically including deteriorating water quality in prairie lakes and flooding. A summary of Manitoba's water technology and commercialization programs is included in *Appendix E*. Many of Manitoba's programs could be implemented quite quickly in Alberta.

B.C. was selected due to its proximity to Alberta and common water challenges. From an industry perspective, B.C. has extensive hydraulic fracturing production, hydro power, and irrigated agriculture, thus creating water management issues similar to Alberta. A summary of B.C.'s water technology and commercialization programs is included in *Appendix F.*

The common theme between all jurisdictions is their commitment to supporting market entry of local technologies and commercialization projects. Technology commercialization is a high priority in these jurisdictions, and significant resources are committed to delivering support services. This is primarily delivered by mentoring and

facilitating linkages between local research institutions, levels of government, and experts in the field in order to ensure successful development and implementation of new entrepreneurial ideas and local start-ups. Other similarities across these jurisdictions include support for young entrepreneurs, researchers, and graduate students to apply their research, projects and ideas to market needs. There is a similar emphasis particularly in Manitoba on helping start-up commercialization and technological projects protect their intellectual property rights for market entry. Most programs support early stage commercialization start-ups targeting companies that are less than three years old.

Best Practices for Technology Commercialization Programs in Canada:

- Encourage strong collaboration among local research institutions, levels of government and experts operating in the water space
- Support innovation and company creation and development as a pillar of economic diversification
- Provide tax credits for research and development for start-up enterprises
- Provide 'one-stop shops' to support entrepreneurs from idea generation through to sales, including funding
- Provide support for young entrepreneurs, researchers, graduate students in applying their research and projects to current market challenges
- Provide educational and support services for inventors to assure protection of intellectual property
- Provide educational business support for technical/first time entrepreneurs
- Deliver government funded research and technology development programs, through for example Centres of Excellence programs

7.0 International Linkages

Six different international jurisdictions were reviewed linked to technology companies operating within Alberta: Denmark, Netherlands, Finland, the United Kingdom, Germany and Milwaukee, USA. Israel and Singapore were considered but not detailed in this review, since these two jurisdictions have extreme water shortage challenges that have driven them to make focussed and significant investments in technologies that will generate clean water for drinking and food production. Specific linkages are discussed in greater detail in *Appendix G*.

A common theme emerging from all of the jurisdictions was that each one seeks to encourage their country's commercial development in our industry sectors. Some are driving research toward a greater understanding of climate change affects, while others seek research collaborations with Canadian and international groups to increase market access. Some programs focus on the development of carbon neutral, sustainable, closed loop technology products for Canadian "green" markets.

These technologies are generally developed regionally, focussing on addressing a specific issue. In Denmark, efforts are committed towards the reduction of CO_2 emissions; while efforts in the Netherlands are dedicated to addressing flooding and water mapping. Milwaukee focusses on water treatment technologies due to challenges with their water treatment and stormwater management systems. The key challenges of each region become the drivers for innovation that meets the specific needs of that environment. Once the technologies are developed, they can be piloted in other jurisdictions with similar environments, or adapted to regions that are somewhat different. The Dutch have developed a multitude of flood related technologies and innovations that work very well in the Netherlands. They promote these technologies all over the globe where countries experience flooding.

In the case of Alberta, the same line of thinking could be used to introduce our technologies into other markets with similar climatic demands and water management needs. For instance the Netherlands has recently expressed interest in how Alberta manages the water demands of the hydraulic fracturing sector. Hydraulic fracturing is a growing global industry and Alberta has significant potential to play a role in the application of water technologies

specially designed to meet the needs of this sector. Determining Alberta's unique water expertise is crucial in deciding how to position Alberta in the global water market stage.

When it comes to building stronger relationships with Alberta's current international connections, as well as introducing Alberta to new international connections, there is an opportunity to partner with Canadian professional associations such as Engineers Canada and provincial water and wastewater associations. The Canadian Information Centre for International Credentials (CICIC) is a great source for connecting Alberta based institutions and technology providers with Canadian professional associations that are linked internationally.

Best Practices for Water Technology Commercialization from International Jurisdictions:

- Build on country-specific challenges to develop world-class technologies
- Support local companies by providing a strong home market to build operating experience and business skills
- Identify other jurisdictions that have similar challenges and form partnerships with those jurisdictions to promote our local companies
- Build mutually beneficial trading relationships with countries that need our technologies and that have products that we also need
- Develop a clear GoA strategy for managing multinational and state-supported international technology companies that supports the growth of the water technology sector in Alberta
- Make the technology sharing relationship a political priority

8.0 Findings from the Water Asset Catalogue

As noted earlier, the Catalogue acts as a directory of the academic, technology, services, and other experts within the Alberta water community. The Catalogue also identifies resources that support entrepreneurs and small businesses to research, develop and commercialize new water technologies and solutions. The Catalogue is organized into the water technology segments, as outlined in Section 4 of this report. The purpose of this section is to summarize the key findings from the Catalogue, and identify potential strategies for further supporting the development of water technology sector in Alberta.

The Catalogue has about 900 entries, which shows the breadth and diversity of the water sector in Alberta. However, about 90% of the entries are for small, local companies that provide specific services to the water technology industry. Figures 2and 3 break down the industry groups we have identified within the Catalogue.

Figure 2: Summary of Water Technology Sector Industry Companies

Multinational Corporations ~ 15

International Technology Companies ~ 12

Canadian Technology Companies~ 24

Local Service Providers ~712

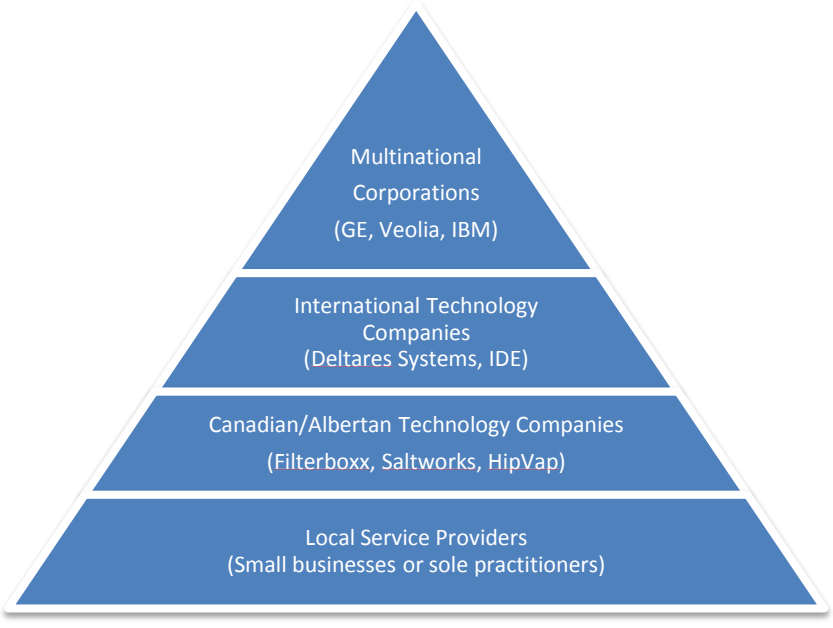
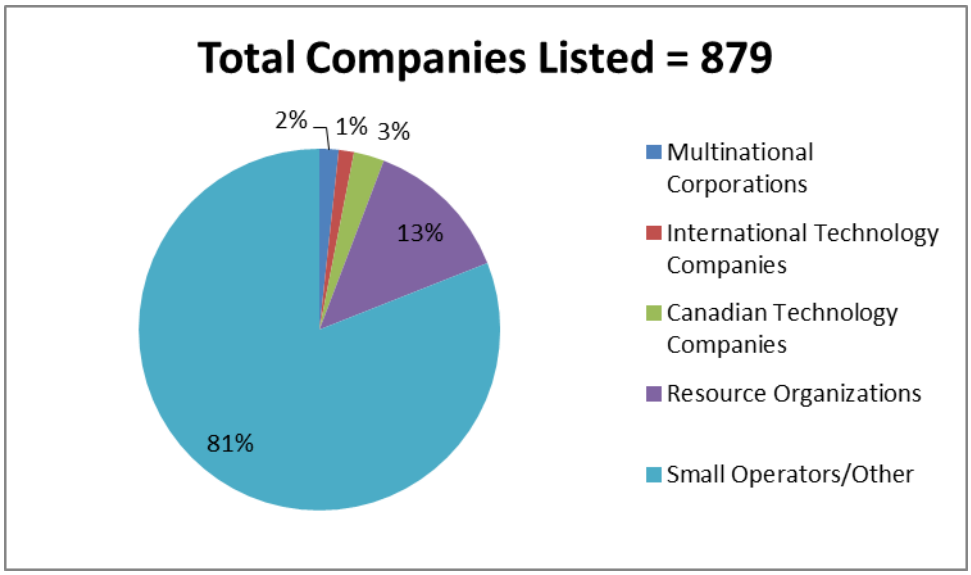


Figure 3: Breakdown of Companies in the Water Asset Catalogue



Multinational Corporations: This group is comprised of a small number of very large international companies that supply equipment and services in Alberta. These corporations generally offer integrated solutions to water-related problems. Examples include GE, Veolia, IBM, Lockheed Martin, EVOQUA (formerly Seimens Water), and Xylem. Since these corporations are international, they enter the market through direct relationships with the customers, which most often are the large energy companies or occasionally the large municipal water and wastewater treatment facilities. These companies have technologies developed elsewhere in the world and are often looking for new markets for these existing technologies. They may be looking for opportunities to lever provincial funding programs and partnerships to support the customization of these technologies to the Alberta application or situation. GE has been particularly successful in establishing strong relationships within the Alberta innovation system and with COSIA.

International Technology Companies: As noted in Section 7, certain countries around the world have focussed their resources on developing technologies to address their specific water issues. Companies inside these countries build on these technologies and skill sets, and then offer these to other jurisdictions with similar issues. Examples include IDE Technologies (Israel), and Deltares Systems (Netherlands). Because these companies often were heavily supported by their governments through the start-up phase, the governments will actively engage in the market entry of these companies into other jurisdictions, leveraging their local trade offices. This strategy can be very effective for the international companies since their market entry costs are often shared by their national government. The recent success of both IDE and Deltares in securing contracts in Alberta, supported in part by the Alberta Innovates system, shows how effective this strategy can be.

Canadian and Alberta-based Technology Companies: Alberta-based technology companies generally start from either an idea developed in academic institution or a solution identified by someone working in the field, either as an equipment supplier or a consultant. These start-ups go through the technology development and commercialization systems as outlined elsewhere in this report. The biggest challenges facing these technology start-ups are lack of financing, limited access to production sites to pilot test their products and services, and difficulty in securing contracts with Alberta companies due to their lack of demonstrated operating experience. Currently in Alberta most of these start-up companies are focussed on the energy industry and irrigation. If successful, these companies have the potential to expand outside of Alberta and Canada by reapplying their work

to new markets. Examples of these companies in the industrial sector are Filterboxx, Saltworks, and HipVap. An example of a company in the municipal sector is New Energy Corporation.

Local Water Service Providers: These are small businesses and sole practitioners, which make up the majority of businesses in the Alberta water community and the Catalogue. They provide a wide range of services including instrumentation, monitoring, well drilling, trucking, disposal, and a variety of other services. They are not generally market specific and are able to move into new industries and markets if the market shifts. As an example, Hydraulic fracturing operations require short-term, intensive support for water movement and disposal, which can be supplied by small, nimble operators with trucks and specialized equipment, such as Flo-Dynamics.

Resource Organizations: This includes the academic institutions, GoA departments, the Alberta Innovates companies, the AER, AMERA, the technology accelerators, and other organizations that exist to provide research and technology commercialization support to the water technology sector in Alberta. These are the organizations that would often be listed under the Network of Partners.

Each of these types of companies has a different set of needs for developing their businesses, which are summarized in Table 2. Government programs should be tailored to support these different needs.

Table 2: Summary of Needs for Water Industry Groups

Groups	Funding for Development	Business Advice	Pilot Testing Opportunity	First Contracts	Network of Partners
Multinational Corporations			✓		✓
International Technology Companies			✓		✓
Canadian/ Albertan Technology Companies	✓	✓	✓	✓	✓
Local Service Providers				✓	

Given the conservative nature of the user organizations in Alberta, the most important need for technology companies of any size or origin is access to pilot test sites to generate the operating hours and experience to convince the users that the technology is sound. Programs are needed that support pilot testing, including funding and possibly risk sharing. Alberta Innovates provides some programs of this kind, such as the Edmonton Waste Management Centre of Excellence for municipal applications. Industry-led efforts such as the Water Technology Development Centre should be actively encouraged.

Multinational and international companies need partnerships to access the markets in Alberta. They value programs that provide information and understanding of Alberta-specific industries and challenges so they can tailor their technologies and services to address these challenges. Since they initially do not have staff on the ground in advance of a first contract, these partnerships allow them to identify opportunities and build awareness. One example is Veolia utilizing Tundra Solutions as their agent as they built up their business in oil sands. Another example is Deltares, who effectively utilized the Dutch Trade Office to build relationships with the GoA after the 2013 flood to supply their services in support of flood mitigation.

The Alberta based start-ups need business advice and financial support that is common to all start-up companies; this support is generally supplied by the accelerator organizations such as Innovates Calgary and TEC Edmonton. The challenge with these organizations is that they do not have water-specific or application-specific expertise that would help move these companies forward. This makes it more difficult to secure the pilot test sites and the first orders, which are critical to the survival of these smaller companies. Programs to generate a critical mass of water expertise to support these start-ups would be helpful.

The Alberta based start-ups also suffer from difficulty in attracting the attention of potential customers for testing or orders. There appear to be programs in place that effectively increase the profile of multinational and international companies and their technologies and services. Alberta companies find themselves competing against well-funded and well-promoted multinational and international firms. This is a difficult challenge to overcome. Many approaches have been tried over the years with limited success. This is an area for further consideration for support programs.

Through the development of the Catalogue, it became clear that the water technology market in Alberta is growing and evolving at a rapid pace. As such, for the sustained understanding, relevance and effectiveness of the Catalogue it is important to continue directing efforts towards its ongoing development and maintenance.

Opportunities for Continued Growth of the Water Technology Segment:

- Explore the development of a Water Innovation Centre to incubate and support new water technologies, potentially leveraging best practices currently engaged at Innovate Calgary and other development and commercialization institutions
- Publicize successes through awards, media, etc.
- Showcase Alberta's water technology companies and research and development facilities at international water conferences and industry events
- Encourage and showcase collaborative technology field testing capabilities, such as the Water Treatment Development Centre
- Showcase and continue to support the water technology projects developed and supported by Alberta Innovates organizations
- Continually maintain and update the Water Technology Asset Catalogue to ensure accuracy and continued effectiveness so that the Catalogue is positioned to allow companies to connect to each other

9.0 Conclusions

The advancement and acceleration of the water technology market in Alberta, and elsewhere, requires a collaborative approach in developing a clear understanding of customer and industry needs, confirming relative regulatory guidelines and promoting end user innovation and technology adoption. Perhaps most importantly, it requires a clear commitment at the highest political level. This was shown in all the jurisdictions reviewed over the course of this project.

Water is a highly regulated resource that requires government involvement in almost all aspects of its management. Therefore, innovative water technology adoption is heavily reliant on the government's ability to adapt regulatory guidelines to match the growth and advancements in technology.

The economic impacts of water use in energy, agriculture and the environment have been addressed by a number of water technology segments. Across the board, there is a need for more efficient water use. Companies in each of these segments strive to design innovative technology focused on addressing current and future challenges. Many of the technologies are designed to reduce water demand, reduce the amount of water lost through processing, reduce the amount of wastewater produced and improve water quality.

For Alberta based water technology companies to be successful within the province, technology development must be based on relevant and accurate data. Developing and maintaining partnerships and relationships with industry is important to gaining a better understanding of the issues, as well as access to site specific data and information. Because it is rare for technology adoption to occur without proven success in implementation, access to industry resources is paramount for technology developers to be successful.

Alberta has the opportunity to learn from the experience of other jurisdictions and markets to develop local best-in-class technologies and management practices to grow and create innovations to address the challenges facing our province. The water technology and commercialization market is growing across Canada. Canadian provinces share similar governance structures and are connected geographically. The excellent work done separately in each province is being shared between researchers, government groups and industry. There is a major focus on promoting the technologies of small to medium enterprises (SMEs) and endorsing their growth. Some collaborative programs are already in place to connect technology and commercialization programs from province to province. However, there are opportunities to further break down provincial silos and work towards greater collaboration. Some of the commercialization programs from particularly Manitoba could be quickly adapted for Alberta.

Alberta's changing climate and geological history, combined with a strong network of universities and research and development centres, provides an excellent platform for Alberta to become a world-wide leader in innovative technology solutions to water challenges experienced in Alberta. To achieve this status, Alberta must demonstrate its ability in the global market place, aggressively promoting its know-how, technological and societal solutions. Currently, there are a number of international jurisdictions that are collaborating with Alberta-based research groups. The driver for international collaboration is found in commonalities between jurisdictions. Often this is based on similar geography, topographies and climates; in other cases it is based on a shared commitment to improving sustainable development. Jurisdictions with common goals are motivated to work together to achieve the best solutions.

In a province blessed with an abundance of natural resources, it can be difficult to communicate the need for conservation and enhanced resource management initiatives. Nonetheless, public outreach initiatives such as the Alberta WaterPortal and the GoA's Water Conversation have facilitated advancements in public engagement and education. The water technology market in Alberta relies on the consumer's acceptance of advanced technologies that will improve efficiency of water use, even if it leads to an increased financial cost to the consumer. In order for Alberta to become a global innovator in water technology, it will be important to build on the success of these and similar initiatives focused on the public's understanding of the need to adopt new approach to how we think about water in the province.

Appendices

Appendix A: Research Institutions

The following institutions provide facilities and training programs for water entrepreneurs.

Centre for Research and Innovation (CRI) is based out of Grand Prairie and is focused on assisting in the evaluation of technology, intellectual property development and market assessment, primarily for ideas arising from Grand Prairie Regional College.

Red Deer College (RDC) has developed the $80 million Centre for Innovation and Advanced Manufacturing (CIAM), which houses facilities to support mechanical design, prototyping, testing and manufacturing of new and innovative technology. RDC also provides a number of training programs for operating water technologies.

Southern Alberta Institute of Technology (SAIT) has the mandate, facilities and expertise to educate and train students on opportunities to develop new technologies associated with produced water and oil field wastewater treatment. SAIT provides a number of programs and course focused on training the operators of water technologies. SAIT also has product development and testing facilities that are available to entrepreneurs for a reasonable fee through their Applied Research and Innovation Services.

Olds College School of Innovation is in the process of constructing a twelve acre wetland and water treatment facility designed as a research tool to educate students on the opportunities to naturally treat storm water, municipal wastewater, produced water from oil and gas facilities, and run-off from intensive livestock operations. The facility will be able to showcase how managed wetlands can naturally treat wastewater for reuse and other purposes.

Northern Alberta Institute of Technology (NAIT) is constructing the new Centre for Applied Technologies (CAT). The CAT will house the new water and wastewater treatment program, which will provide high-level research and training for those looking for employment in water distribution, water treatment, wastewater collection, and wastewater treatment. This facility will also provide several opportunities for applied research in the field of water and wastewater treatment technology.

University of Alberta is home to the Alberta Water Initiative, a research collaborative that brings together the interdisciplinary capacity of over 100 researchers whose work spans resource economics, water treatment, toxicology and microbiology, northern and cold weather research, ecosystem biology, energy and the environment, water policy, nanotechnology and sensors. The Alberta Water Initiative's goal is to equip the next generation of thinkers, policy makers and scientists to develop a holistic and integrated understanding of the challenges we all face in water use and supply, for municipal, industrial and environmental interests. The University of Alberta has strong research programs in oil sands technology and impacts, as well as in municipal water and wastewater treatment through the Edmonton Waste Management Centre of Excellence. The technology commercialization arm of the University of Alberta is TEC Edmonton, which is a not-for-profit joint venture of the University of Alberta and the City of Edmonton, through the Edmonton Economic Development Corporation. TEC Edmonton was named the 10th best university business incubator in the world by the Sweden-based University Business Incubator index, and ranked third in North America and second in Canada for 2014.

University of Calgary is home to the Advancing Canadian Wastewater Assets (ACWA) a program specializing in the development of innovation in wastewater research. Currently partnering with the City of Calgary through its Pine Creek Wastewater Treatment plant, the main goal of the ACWA is to develop wastewater treatment technologies that will remove existing and emerging contaminants to improve ecosystem and human health. It is intended to provide researchers, practitioners and industry with a facility to work together solving the important water problems facing human populations everywhere. The University of Calgary is also home to the Hydrogeology Working Group, which in partnership with Alberta Innovates Technology Solutions undertakes focused research on hydrogeology issues throughout Alberta. The technology commercialization arm of the University of Calgary is

Innovate Calgary. Innovate Calgary is a full-service organization offering technology transfer and business incubator services to researchers, entrepreneurs and businesses within the advanced technology sector. It was formed in 2010 as a partnership between University Technologies International (UTI) and Calgary Technologies Inc. (CTI). These two organizations have more than 50 years combined experience supporting the technology community, and are physically located in the Alastair Ross Technology Centre in the Research Park adjacent to the main campus of the University of Calgary.

University of Lethbridge is home to the Water Institute for Sustainable Environments (WISE). WISE researchers are examining water resources to include natural science analyses of watersheds specifically water quantity and quality. The goal of WISE is to overlap social science investigations related to aspects such as water policy and economics into the ecosystem health dynamic. WISE looks at technological solutions throughout North America that can be applied to local watersheds. WISE specializes in applying global solutions to watershed management challenges primarily in the South Saskatchewan River Basin, but also in all of the river basins in Alberta. Their investigations consider fundamental aspects of water science, as well as applied science and management directed towards the simultaneous goals of environmental health and socioeconomic prosperity.

Appendix B: Government of Alberta

Alberta Innovation and Advanced Education (IAE) is the ministry responsible for supporting economic development throughout Alberta to promote the success of small businesses, industry, and communities. To grow Alberta's economy, IAE aids in promoting economic diversification by inviting new technologies and businesses into the province. Funding and leadership is also provided for research and innovation initiatives such as new technology or collaborative enterprises. IAE's support for Alberta Innovates enables teams of water experts to provide technical expertise and third party advice to new innovation and research. IAE's mandate is to deliver new opportunities for Alberta's key focus areas, which are energy, environment, food, fibre, and health, through innovation and research. The Alberta Innovates system is funded and managed through this ministry.

Alberta Innovates and Energy and Environmental Solutions (AI-EES) is a GoA agency responsible for investing in environmental research initiatives throughout Alberta. Specifically, starting in 2013 AI-EES provided $10 million in funding for 18 water-based research projects. Implementation of this agency has helped to support and achieve goals established in the Water for Life strategy originally released in 2003. The goals outlined in the strategy include supporting safe and secure drinking water, healthy aquatic ecosystems, and reliable, quality water supplies for a sustainable economy. The projects funded to date encompass these goals and intend to find solutions to Alberta's most challenging water issues. Conducting this research are leading researchers from academic institutions, government research centers, not-for-profit agencies and private industry specialists. AI-EES also funds several institutes related to water, including the In Situ Energy Centre at the University of Calgary.

Climate Change Emissions Management Corporation (CCEMC) is a corporation that provides funding for projects that focus on reducing greenhouse gas emissions and provide technological solutions for the adaption of climate change. CCEMC has funded one climate adaptation project on watershed management. The project management and technical support for CCEMC is provided through AI-EES. Funding for CCEMC comes from the provincial levy on producers of carbon emissions.

Alberta Innovates Technology Futures (AITF) is a GoA agency responsible for developing scientific and technological solutions to emerging issues in Alberta, which include environmental issues such as water quality, quantity and management. To achieve this mandate, AITF uses a range of scientific and technology development programs to address water issues. For example, programs that integrate supply and demand, address overall watershed management and monitor water quality have proven successful. AITF also provides solutions to Alberta's most pressing environmental issues by developing technology capable of addressing water quality issues in the oil sands region, studying watersheds to determine water quality and quantity issues and potential solutions, as well as providing expert advice to operators that require specific water knowledge. AITF has a number of facilities that can be used by companies to test and evaluate their technologies, including facilities in Edmonton, Calgary and Vegreville.

Alberta Environment and Sustainable Resource Development (AESRD) is the ministry that is responsible for the oversight of environmental outcomes and the sustainable development of Alberta's natural resources. ESRD has set provincial goals and developed the guidelines to ensure a sustainable environmental future for all Albertans. These guidelines include the Water for Life strategy, Land Use Framework and Wetland Policy, and involve administering approvals under the Water Act and the Alberta Environmental Protection Act (APEA*)*. The policies and guidelines developed under AESRD inform all activities that have the potential of impacting the environment. The policies developed by AESRD dictate the standards for water quality and quantity, which in turn drive the changes and improvements in technology required to meet these standards.

The **Alberta Energy Regulator (AER)** is responsible for regulating the life cycle of Alberta's upstream oil, oil sands, natural gas and coal projects. To achieve this mandate, AER reviews and approves applications, monitors compliance, site conditions and environmental impacts, as well as oversees site reclamation efforts. AER combines the regulatory responsibilities of AESRD and the previous Energy Resources Conservation Board (ERCB) into a single regulator to specifically address the management of public lands, protection of the environment, as well as the conservation and management of water. For water management, AER is responsible for administering the Water Act and AEPA as they apply to water licenses and approvals for the oil, natural gas, oil sands and coal industries.

The **Alberta Geological Survey (AGS)** is a part of the AER and provides the government, industry and public with geological information and expertise to help in the exploration, development and conservation of Alberta's natural resources. The AGS provides data, maps and reports on energy sources, environmental conditions, groundwater, and the discovery of minerals.

The **Alberta Environmental Monitoring, Evaluating and Reporting Agency (AEMERA)** is responsible for obtaining scientific data about that state of Alberta's environment as well as ensuring this information is available and reported to the public in an open and transparent manner. This includes reporting on water, air, land and biodiversity across the entire province. AEMERA is specifically responsible for the Joint Canada-Alberta Implementation Plan for Oil Sands (JOSM), a federal and provincial government initiative that monitors air, water, wildlife and forests in Northeastern Alberta. Environmental monitoring in the oil sands region includes data collection, storage, and management to further analyze and evaluate trends in Alberta's environment. AEMERA's goal is to become a world-leader in environmental monitoring.

Appendix C: WATERSHED PLANNING AND ADVISORY COUNCILS

Under Alberta's Water for Life strategy, Watershed Planning and Advisory Councils (WPACs) are multi-stakeholder, non-profit organizations that assess the conditions of their watershed and develop plans and activities to address watershed issues. Alberta's WPAC community is a network of skilled, educated, responsible and dedicated organizations committed to the future of Alberta water. The community is made up organizations that are run by volunteers and paid positions, varying in size from five to 300 members. Currently, eleven watersheds have organizations formally recognized as WPACs. The executive directors and contact information for these WPACs are included in the Catalogue.

Athabasca Watershed Council (AWC): The AWC-WPAC is a registered not-for-profit organization formed in August 2009. The AWC-WPAC is a neutral Council working with academia, industry, environmental groups, various levels of government, communities, and citizens to provide timely, credible information about the Athabasca Watershed. The AWC-WPAC actively promotes, fosters respect, and plans for an ecologically healthy watershed by demonstrating leadership and facilitating informed decision-making to ensure environmental, economic and social sustainability. This diverse stakeholder organization champions scientific reports on the State of the Watershed and outreach initiatives aimed at educating the communities and citizens from Jasper to Fort Chipewyan about the watershed.

Battle River Watershed Alliance (BRWA): The BWRA is an inclusive, collaborative and consensus-based community partnership that is working to guide, support and deliver actions to sustain or improve the health of the Battle River watershed. They seek to achieve this through knowledgeable community participation and an adaptive approach. The BRWA is a group representing four orders of government (First Nations, municipal, provincial and federal), watershed groups, environmental organizations, industry, academia and private citizens in a collaborative initiative to plan for the sustainable management of land and water resources in the Battle River Watershed.

Beaver River Watershed Alliance (BRWA): The Beaver River watershed is ecologically healthy and environmentally sustainable. The BRWA will maintain or improve the ecology of the Beaver River watershed while respecting the diverse values of the watershed community. The goal is to achieve this through broad community engagement, partnerships, sound scientific study, education, and the support and encouragement of implementing sustainable water management and land use practices.

Bow River Basin Council (BRBC): The BRBC is a multi-stakeholder, registered non-profit charitable society that has a broad mandate of encouraging cooperative and effective strategies for water use management and environmental stewardship. Representatives of the BRBC include urban and rural municipalities, irrigation agriculture, commercial and industrial companies, educational, recreational and ecological interests, First Nation peoples, the provincial and federal governments, along with the general public.

Lesser Slave Watershed Council (LSWC): The LSWC is a non-profit group of volunteers who work with the provincial government to maintain the health of the Lesser Slave Watershed. Members of the LSWC are representatives from towns, municipalities, First Nations communities, industries, cottage owners, non-profit organizations as well as recreation and tourism groups who have an interest in how the waters of Lesser Slave Lake and its tributaries are managed.

Mighty Peace Watershed Alliance (MPWA): The MPWA is a multi-sector, not-for-profit society committed to planning for an ecologically healthy watershed while ensuring environmental, economic and social sustainability.

The Might Peace Watershed Alliance is a group of active stakeholders and communities that use consensus, adaptive management, and innovation to understand and promote sustainable living within the watershed. The MPWA reports on the state of the watershed, leads watershed planning activities, promotes best management practices, and develops educational programs.

Milk River Watershed Council (MRWC): The MRWC is a broad partnership of interested and informed people living and working in the Milk River Watershed that provides leadership in watershed management and planning. As a transboundary watershed, they foster good relationships with their Montana neighbours for the continued co-management of the Milk River waters. The MRWC is an independent organization that supports the goals of Alberta's Water for Life strategy in the Milk River Watershed, which includes safe, secure drinking water; healthy aquatic ecosystems; and reliable, quality water supplies for a sustainable economy.

North Saskatchewan Watershed Alliance (NSWA): The NSWA supports stakeholder and public discussion concerning all aspects of integrated watershed management for the North Saskatchewan River watershed. NSWA's vision is people working together for a healthy and functioning North Saskatchewan River watershed – today and tomorrow. Their mission is to protect and improve water quality, water quantity (instream flow) and the health of the watershed by seeking, developing and sharing knowledge; facilitating partnerships and collaborative planning; and working in an adaptive management process.

Oldman Watershed Council (OWC): The OWC is a not-for-profit organization of southern Albertans that maintains and improves the Oldman watershed by improving and sharing knowledge, building and strengthening stakeholder partnerships, promoting community action and stewardship and developing and implementing integrated land and water plans. The vision of the OWC is to have a healthy, resilient watershed where people, wildlife and habitat thrive.

Red Deer River Watershed Alliance (RDRWA): The RDRWA is a multi-sector, non-profit organization that promotes the good use and proper management of water within the Red Deer River watershed. Their vision is that the Red Deer River watershed will be healthy, dynamic and sustainable through the efforts of the entire community. The mission of the RDRWA is to create an inclusive, collaborative partnership that promotes a healthy watershed to ensure a legacy of ecological integrity and economic sustainability.

South East Alberta Watershed Alliance (SEAWA): SEAWA is a conduit between all stakeholders that are engaged in the development and management of a sustainable watershed. SEAWA's vision is to obtain a healthy watershed that provides balance between social, environmental and economic benefits. SEAWA's mission brings together diverse partners to plan and facilitate the sustainable use of the South Saskatchewan River watershed for present and future needs.

Appendix D: Ontario's Water Technology and Commercialization Programs

Ontario Centres of Excellence (OCE) is an independent not-for-profit organization that is incorporated under Ontario law, and receives funding from the Ontario Government. Their commercialization programs target technology coming from publicly funded academic and research institutions. OCE runs the Market Readiness Program, which is an initiative that works to support early stage commercialization for start-up companies. The goal is to shape the start-up company to be attractive to investors and funders. The program is limited to companies that are less than three years old, in the pre-investment stage, and advancing technology linked to an academic institution.

The Market Readiness Program (MRP) is divided into two stages:

- *Customer Creation Stage:* The goal of this stage is to create demand and grow the customer base. The MRP assists in this by developing a plan, testing the product with alpha customers, designing marketing and production plans, production/manufacturing process development, alpha customer satisfaction surveys, financial feasibility assessments, team development, developing a repeatable scalable sales process, and engaging potential follow-on investors.
- *Company Building Stage:* Once the company has found a scalable, repeatable business model, the MRP helps them develop into a sustainable company. They assist in executing a marketing strategy, scaling the product and production/manufacturing process, personnel training, engagement of first customers, engagement of potential follow-on investors, key team development, and finding investors.

This program is a framework for transitioning technologies in research centers into industry, specifically focussing on getting technologies out of the universities and into the market.

A model similar to this would be of value to incubators operating within Alberta.

The **Ontario Research Commercialization Program** (ORCP) is operated under the Ministry of Research and Innovation. The program was developed to help business innovators take their products to market. The program is composed of three strategies: linking research institutions to companies, linking companies to researchers, and connecting small and medium enterprises (SMEs) with the top researchers. Numerous projects have been funded by this program. Many of them are led by universities, or technology innovation groups.

Another program is the **Ontario Centre for Environmental Technology Advancement** (OCETA) which organizes workshops to connect industry, academia and government researchers. This is a program focused on building regional and province-wide networks in order to give the next generation of thinkers a head start.

Both of the above mentioned programs are organized directly by the provincial government, creating a top down approach to increasing innovation in Ontario. This is a model that could be implemented here in Alberta to increase water technology innovation.

There are networks currently in place that support cross provincial collaboration between Alberta and Ontario. One example is **Alberta-Ontario Innovation Program** (AOP) a partnership fostered by AITF and OCE designed to support trans-province collaboration between innovators in industry and academia. The goal is to combine research efforts that can benefit industry needs for both provinces.

Appendix E: Manitoba's Water Technology and Commercialization Programs

In 2014 the Government of Manitoba launched a new initiative, called the Manitoba Innovation Strategy. This program is designed to support innovators, entrepreneurs and skilled workers to pursue their dreams, creating the jobs of tomorrow in Manitoba. The program has six priority areas:

1. **Build on Manitoba's research excellence**. The Manitoba government has created a central advisory body for research and innovation, Research Manitoba. It acts as a research-funding, advisory and administrative body.
2. **Support collaborative models for the commercialization of research.** Manitoba's commercialization cycle will be strengthened so that research can become commercially viable products that can be adapted to markets around the globe. A focus of this step is collaborating on intellectual property. The end result is a one-stop shop for research groups to access technical and commercialization expertise, allow shared costs and resources, and access IP and technologies generated by leading researchers.
3. **Create a clear path for innovators and entrepreneurs in Manitoba.** The strategy will create a co-ordinated network of programs, services and partners in order to streamline the commercialization activities so that entrepreneurs can bring their products to market effectively.
4. **Help Manitoba graduates and young entrepreneurs find the 'jobs of tomorrow' in Manitoba.** The Manitoba Innovation Strategy will continue to invest in quality education, encourage high school students to pursue a career in innovative high-tech industries, work with post-secondary institutions and local industry to ensure the curriculum is relevant to the job market, and encourage local industry to hire new local graduates.
5. **Enable existing businesses to grow and prosper through innovation**. Manitoba is putting a focus on maintaining its competitive advantage in the market, creating more jobs by developing and using advanced technologies. The research and development tax credits are currently some of the best in the country, an incentive the province will continue to invest in.
6. **Create an environment that fosters private sector investment for entrepreneurs and innovators in Manitoba.** Access to capital investment is a major challenge in Manitoba. The Manitoba Innovation Strategy will increase investor confidence by streamlining the Commercialization Support for Business program, improving the Small Business Venture Capital Tax Credit, and promote crowdfunding and the use of social media for investment. It will also work to develop programs that connect investors with investment-ready firms.

The strategy is designed to bring the whole innovation community closer, and foster collaboration and co-operation. A new office called Research Manitoba has been created which will support innovation in this framework. As one part of the strategy, all provincial research money will be pooled into one pot under Research Manitoba which will bring major provincial research funding programs together. Given that this program is new, it is too early to gauge the success; there is not much detail on new programs or funding opportunities to date. However, the province has said that the Commercialization Support of Business program will be streamlined, and the small business venture capital tax credit program will undergo some changes.

Commercialization Support for Business Program is run by the government of Manitoba through the Jobs and the Economy Branch. The program supports commercialization in all sectors and all regions of Manitoba. It includes three phases:

> *Product Development:* This funds market validation studies, registration of intellectual property, and construction of a prototype.
>
> *Commercialization:* This funds the process of moving a prototype to a market ready product.

Market Development: This funds the process of entering new markets outside of Manitoba.

This program is run out of the provincial government and focuses on small to medium sized businesses.

University of Manitoba's **Technology Transfer Office** (TTO) have launched around 40 start-up ventures, and managed over 100 tech-based alliances internationally. The program provides technology managers the opportunity to meet the researchers and determine if there is commercialization potential. If there is commercialization potential then a market strategy is developed. There are four steps to determine if the technology is viable for market entry:

Disclosure: The TTO determines if the technology has market potential, and a patentability assessment is completed.

Evaluation: An intellectual property assessment helps determine the patentability, and a market assessment helps to evaluate the commercial potential, and identify licensees.

IP Protection: This step helps with all of the processing and filing required in completing a patent application. The TTO identifies the countries in which the greatest commercial opportunity lies, and ensures that the invention is protected in those jurisdictions.

Marketing: This is the biggest step in the process. The TTO identifies companies, which the technology can be marketed to, and finds business networks in order to bring the technology to market.

The TTO is set apart from other incubator programs in Manitoba because it is housed in a University rather than in the private sector, or government.

The **Manitoba Technology Accelerator** is a not-for-profit business accelerator and incubation program located in Winnipeg's Innovation Alley district, a two-block strip which includes Red Deer River College and other innovation groups working with young entrepreneurs. The program is designed to help companies enter the market, secure investment or get acquired by providing them with business mentoring, coaching, active participation, networking infrastructure, financing and investment services. One of the unique elements of the program is that is provides the incubator with infrastructure necessary to be in business and also offer them the option of relocation to a professional lab or office.

Appendix F: British Columbia's Water Technology and Commercialization Programs

The **BCIC-Mitacs Commercialization Voucher Program** is run jointly by BC Innovation Council, a Crown Agency of the Province of BC and Mitacs, not-for-profit research organization. This program is designed to accelerate the commercialization of BC technologies by supporting job creation and development of highly skilled talent for start-up companies and entrepreneurs. This program partners with companies, government and academia to develop scientific and business skills for developing innovators.

The BCIC-Mitacs Commercialization Voucher Program places grad students with established companies, so that people who are highly skilled in science and business can help developing entrepreneurs and start-up companies commercialize technologies. Graduate students can apply for a $15,000 voucher for opportunity assessments of new products or services, or new market opportunities for existing products at established BC companies.

The focus of this program is getting people who possess the know-how of commercialization of technology into the industry. The program helps businesses take their technology to market faster. The program places importance on people by creating jobs, and developing collaboration between industry and post-secondary institutions. In addition to helping businesses take their product to market faster, the program develops a critical mass of graduate students with important knowledge translation skills. The collaboration of industry, government and academia is something that has been identified as an area that needs improvement in Alberta, and this is an interesting way to accomplish this goal.

Commercialization BC is a government initiative to make BC the centre for technological advancements and commercialization, in environmental management, flaring, carbon sequestration and hydrogeology. Commercialization BC connects companies to service providers that supply research and development, new product design, prototype development, funding, investment, business consulting, and advisory services. They focus on connecting start-ups, SMEs and corporations to the commercialization services and resources that will get their product to market faster and with a higher chance of success. This hub is more efficient and straightforward than if a company were to try to find one of these programs on their own.

This initiative helps product commercialization by supporting the entire market entry process from the initial idea to generating sales. It provides a hub with extensive networks and associations that share a common goal of accelerating the technology and innovation sector within BC. Any company looking for commercialization support would look here to find the program that is best suited to their needs.

Appendix G: International Linkages

Denmark

Denmark is a progressive country committed to "going green" with a goal to be resource efficient and entirely independent of fossil fuels by the year 2050. Since 1980, the Danish economy has grown by almost 80% without increasing gross energy consumption.[2] Denmark is a world leader in the green economy. In 2012, Copenhagen became the world's leading green city. Their programs in general focus on researching green technology by creating partnerships between research groups, industry and international groups. Denmark's niche is sustainable green technology that reduces CO2 emissions. Danish investment in research on climate change in the Arctic is strongly related to their commitment to reducing CO2 emissions. Denmark has had great success exporting these green technologies to foreign markets. Collaboration with the Danes has been established through this program, and Alberta can leverage this partnership to create further linkages.

The **Ministry of Foreign Affairs of Denmark** has said that Canada is the most attractive construction industry in the developed world and has the most attractive business environment. The growth rates of the Canadian market are higher than those of many emerging markets. In addition to its robust and growing economy, Canada is known for its international engagement. There are strong existing relationships between Denmark and Canada with Arctic issues, and international security. There are existing exports/imports between Canada and Denmark. Canada is exporting aircraft, fish, machines and plant and fruit oils to Denmark. Denmark is exporting machines, windmills, medical products and agricultural products to Canada.

State of Green is a Danish collaborative group which brings companies and organizations together to find technology solutions which lead to a green future. State of Green is a private-public partnership, founded by the Danish Government, the Confederation of Danish Industry, the Danish Energy Association, the Danish Agriculture & Food Council and the Danish Wind Industry Association. Since then they have partnered with Copenhagen Cleantech Cluster, Ministry of Foreign Affairs of Denmark, Ministry of Business and Growth Denmark, Danish Ministry of the Environment, Danish Ministry of Climate, Energy and Building, Danfoos, Haldor Topsoe, SE, DONG Energy, European Union European Regional Development Fund, Green Tech Center, Growth Forum, Region Zealand. H.R.H. Crown Prince Frederik of Demark is a patron of State of Green.

Since 2011, they have helped Denmark keep its pledge to lead the transition into a green growth economy which will be independent of fossil fuels by the year 2050. Water is one of the 10 sectors they have identified. The others are energy efficiency, heating and cooling, intelligent energy, wind power, solar and other renewables, bioenergy, water, climate adaptation, environment and resources, and sustainable transportation. They specialize in bringing various people together, and offer tours in each sector to businesses, politicians, civil servants, and media correspondents.

State of Green promotes innovative green solutions that are developed in Denmark, or can be used in Denmark. They act as a hub for green water innovation in the country. Technologies developed in Denmark are heavily supported. By promoting Danish technology, other countries have begun looking to Denmark for green technologies. This increases Denmark's green perception in the world, and generates revenue within the country.

The **Arctic Science Partnership** (ASP) is collaborative research group consisting of The Centre for Earth Observation Science (CEOS) at the University of Manitoba, the Greenland Climate Research Centre (GCRC) in Nuuk, and the Arctic Research Centre (ARC) at Aarhus University in Denmark. This partnership aligns with the Kingdom of

[2] State of Green. 2014. *Demark – Becoming the State of Green*. Accessed from the web from: https://stateofgreen.com/en/pages/denmark-becoming-the-state-of-green

Denmark's Strategy for the Arctic 2011-2020, an agreement between Denmark, Greenland and the Faroe Islands. The goal of the project is to bring leading climatologists from around the world together in a collaborative research group to study the effects of climate change effects on the Arctic. The research explores the impact of climate change on the Arctic population's lifestyle, ecosystems, ocean currents and disease patterns. Canada has supported this partnership from its launch in 2012. Currently the University of Manitoba's Sea-ice Environmental Research Facility (SERF) is conducting research on Arctic sea ice. The research is tasked with watching ice crystals grow and taking daily measurements in order to study the geophysical and biogeochemical processes and properties of sea ice.

AKVA group Denmark is a Danish company with an office in British Columbia. Their main product is Aquaculture recirculation systems which have been sold across the globe. They also have developed a water based system in Victoria. This land Based Aquaculture system could be used in Alberta for fisheries or other freshwater aquaculture needs. Presently AKVA's partnership with Canada has been limited to seawater systems and ocean technologies.

Commercial Biofuel Plant. Aalborg University partnered with Steeper Energy, an Alberta-based Canadian company, to develop a pilot scale plant in Alberta for biofuel. They have created the world's first biomass-based plant to produce a sustainable marine fuel. The Port of Frederikshavn sees more than 1,000 ships pass through every year. By providing them with a sulphur-free renewable fuel, the port will decrease the overall amount of unsustainable marine fuel needed. The plant is based in Alberta, through Steeper Energy, so the technology is housed here in our province, creating a new sustainable energy solution. There is potential to use this fuel in other ports in the future.

Canada's Hydrogenics has supplied the plant for a large scale hydrogen and fuel cell project that was started in Lolland in 2006. The project was financed by Energinet.dk, Storstrom County Council, Nakskov Municipality, Loke and IRD A/S. The project was created to generate exposure for hydrogen technology, and show that Denmark is leading the way in this field.

The United Kingdom

The **Sustainable Economic Development Zones** (SEDZ) is a collaborative effort between NISP, a UK group, and Eco-Industrial Solutions Ltd., a Canadian group. This collaboration began in 2001. The goal of the project is to develop eco-industrial parks and eco-business regions. One such park has been constructed in Fort McMurray, Alberta. TaigaNova Eco-Industrial Park completed construction in 2009, and currently houses over 30 companies. It uses highly efficient green infrastructure and innovative sustainable designs. In some cases the parks are designed with alternative stormwater systems that support greywater cascading or materials transfer between businesses. By working on projects in Canada, NISP gains experience that it can bring back to the UK. The groups work with municipal governments to revise zoning bylaws in order to develop the land with green water, sewer, stormwater, energy, and road infrastructure and attract the ideal symbiotic businesses to build their own green buildings in this sustainable network.

Finland

The **Alberta Finland Innovation and Commercialization Program** is a collaboration between AITF and Tekes, a Finnish agency. The goal of this project is to support collaborative technology development between Albertan and Finnish SMEs. The program funds projects that promote innovation and collaboration in fields such as advanced materials, instrumentation and sensors, health, ICT and clean technologies. The collaboration has resulted in a partnership between the Albertan Company, Fluid Clarification and the Finnish company Sofi Filtration. They are working on a project that aims to improve water cleaning in the petroleum sector's industrial processes. Another collaborative project supported by this program is a partnership between the Albertan company Expert Decisions

Inc. and three Finnish companies: F-Secure, Avaus, and Invenco. This project is working to reduce the product development life cycle by creating efficient uses of digital resources/social media and integrating these into the product planning process.

Canada and Finland have a standing trade relationship that was worth $2.5 billion in 2011. This program enhances commercialization between the two countries and improves global competitiveness. In particular, this program is beneficial to SMEs in that it enables them to access international markets.

Finland is an innovation and clean technology leader with international recognition. They are consistently top in the field for innovation investment and performance. In both 2012 and 2013, Finland ranked 3rd in the World Economic Forum's "Global Competitiveness Index". The index had the following statistics on Finland:

- Best availability of scientists and engineers in the world
- 3rd highest number of patents filed per capita in the world
- 3rd highest company spending on R&D globally

Finland has an excellent trading relationship with Russia and other EU member states. By engaging with Finland, Alberta could gain access to these markets in the future. In the long term, due to Finland's existing partnerships, by establishing a partnership with Finland, Alberta could potentially gain access to all of Europe, and another entry point into Asian markets.

The Netherlands

The Netherlands embassy in Canada is very active, and is particularly strong in the water sector. The Dutch are known around the world for their innovative technologies regarding flooding. After the events of the Alberta Flood of 2013, the Netherlands played an active role in the development of the province's plan for recovery and mitigation. The Netherlands worked with AI-EES, the Government of Alberta, and Alberta WaterSMART's Flood Forecasting workshop, and presented on the technologies for flooding that the Dutch have developed. The Dutch company Deltares is also collaborating in the Room for the River program currently underway in southern Alberta.

The Dutch Trade Office has developed a program designed to inform the water industry in the Netherlands about the water market in Alberta. They are working with the AI-EES to establish a centre of excellence on water involving industry from both Alberta and the Netherlands. In December, 2014, a collaboration agreement was signed between the Alberta Energy Regulator and Deltares to support water management in Alberta.

Within their own country they have developed best practices and innovation for water technology, and have actively employed many of them throughout the rest of the world. There are around 2,000 companies in the water technology sector in the Netherlands. At a residential level, 99.9% of households have access to clean, chlorine-free drinking water and 99% are connected to the sewage system. The Netherlands is 6.76 metres below sea-level, so much of the country is prone to flooding. As a result, their technologies related to floods are well developed.

Flooding

Following the Alberta flood of 2013, Deltares and the Dutch government worked closely with the province to help provide insight on flood technologies used in the Netherlands. Since this connection, there has been sharing of water technologies between the two jurisdictions. The Netherlands have learned from Alberta's hydraulic fracturing methods, and Alberta has learned from the Netherlands' adaptive flood management approach of Room for the River.

Dredging is a dominant technique that Dutch companies practice around the world. Baskalis and Van Oord are two of the major companies that specialize in dredging. The method of dredging is environmentally friendly because it leaves the riverbed in an ecologically sound state, and is more sensitive to fish habitat.

A number of Innovative temporary water barriers which replace sandbags are being developed in the Netherlands. The Box Barrier is a set of interlocking stackable plastic trays, which when filled with water create a barrier. The Green Soil Bag is a type of sandbag which is permanent and has a mix of soil and seeds that help it establish in the riparian zone. Another innovation is the Water-Gate which is laid out over a stretch of water and self inflates to create a dam. These devises are more efficient than sandbags and are also relatively inexpensive.

For imaging and mapping of floods there is a Dutch company, SarVision, which collects and interprets geomatic information using satellites and radar planes. This mapping can be used to understand, identify and mitigate risk of flooding.

Some urban areas have been turned into multipurpose spaces. In Rotterdam there are water plazas for recreation during normal conditions, but have the capacity to retain excess rainwater during floods. The largest has a storage capacity of 10,000 m^3.

Agriculture

There are innovations in several sectors in the Netherlands. Salt-water horticulture is in the trial and experimentation phase. In some cases saltwater is more accessible than freshwater, so the need for saltwater irrigation systems could become more frequent. Plants which already have tolerance to salt are being bred to have a higher saline water tolerance.

In the agriculture and forestry sector, a Dutch innovator created the Waterboxx. This tool is a plastic circle which sits on top of a tree or plant that is growing. The devise captures water and releases it deeper into the soil, encouraging the plant to take root on its own. It also keeps the soil around the plant moist. It has been used in reforestation projects in Dubai, and in vineyards in California.

Water Quality and Treatment

Water Insight's BlueLeg Monitor is a handheld device which tests lake water quality by taking a picture of the surface of the water and uses spectroscopy to identify the concentrations of chlorophyll and other substances in the water. This device was demonstrated for AESRD officials last year.

A new sewage treatment technology, Nereda, uses aerobic silt granules with bacteria, rather than the normal silt flakes. This technology makes the treatment process more efficient and sustainable. In normal sewage treatment silt flakes are dispersed into the liquid sewage, and the flakes drop to the bottom of the tank at a very slow rate, clinging onto particles on the way down and bringing the waste with them. Nereda's aerobic silt granules with bacteria are used the same way, but the bacteria seek out and cling onto the waste so the granules sink to the bottom faster, which is faster and more efficient than traditional methods.

Water Technologies for the Ocean and Coastal Regions

Another Dutch company, O-foil, created a propulsion system for boats that cuts fuel consumption in half. Rather than a traditional propeller design, O-foil developed a vertically oscillating wing, which mimics the motion of a dolphin's tailfin.

On the coast, the Dutch use oysters to prevent erosion. The oysters are placed at the mouth of drainpipes where erosion is heavy, but also provides a suitable habitat for the oysters. The oysters are concentrated in a

large cage in which they produce cement to hold themselves to the sand. This holds the sand in place and reduces the amount of erosion.

Another innovation used in the Netherlands is Reverse Electro Dialysis. In this case, RED is used at the boundary of fresh and saline water. Negatively charged chlorine ions and positively charged sodium ions create a current which can be converted into electricity. (Note the similarity to the Canadian technology developed by Saltworks.)

Germany

Germany is well regarded around the world for its water technology research and promotion. According to the German Engineering Federation, Germany is the largest exporter of water and wastewater technology in the world[3], and is particularly well known for its closed loop recycling and sustainable water technologies[4]. The federal government is very involved in funding and promoting water technology development. In addition, the European Union (EU) provides funding to Germany to pursue water technology innovation work.

There are several notable organizations and government departments that promote research and development, and water technology, including:

- The European Innovation Partnership on Water (EIP)
- The Helmholtz Association of German Research Centres
- The German Water Partnership (GWP)
- The German Center for Research and Innovation
- The German Federal Ministry of Education and Research (BMBF)
- Germany Trade and Invest Agency (Federal Ministry of Economics and Technology)
- Alberta-Germany Collaboration Fund for Product Development and Commercialization

The European Innovation Partnership on Water (EIP)

The European Union promotes collaboration and innovation through its EIP program. EIP program brings together expertise and resources from EU member states. The EIP on Water is a Europe-wide program that focuses on: speeding up the development of water innovation; contributing to sustainable growth and employment; and stimulating the uptake of water innovations by the market and society[5].

The Helmholtz Association of German Research Centres

The Helmholtz Association of German Research Centres is the largest scientific organization in Germany and brings together 18 scientific, technical and biomedical research centres. The Association focuses on a variety of issues, including energy; earth and environment; and key technologies. Some of the research centres in the Association include:

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[3] German Water Partnership, "Networking is our Business", Retrieved from http://www.germanwaterpartnership.de/fileadmin/pdfs/gwp_materialien/networking_is_our_business.pdf

[4] Oweiss, Omar. 2012, September 27. "Germany Trade and Invest – Investment Promotion Agency." Retrieved from http://www.gtai.de/GTAI/Content/EN/Meta/Events/Invest/2012/Reviews/Chemical-healthcare/Downloads/Breakfast-seminar-presentation-omar-oweiss.pdf

[5] European Commission. "EIP Water." Retrieved from http://ec.europa.eu/environment/water/innovationpartnership/

- Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research
- Helmholtz Centre for Environmental Research
- Karlsruhe Institute of Technology (KIT): The KIT was founded in 2009 and works closely with German federal ministries. One of its focuses is on water technology development

In addition to the research conducted by the Association's 18 research centres, the Association also has created several funding programs that support knowledge and technology transfer in its centres, commercializes research findings and supports spin-offs.

The German Water Partnership

The German Water Partnership (GWP) is a joint initiative of the German private and public sectors, combining commercial enterprises, government and non-government organizations, scientific institutions and water-related associations". In total, over 300 members comprise the GWP. The German federal government supports the GWP.

The strategy of the GWP is four-fold[6]:

- Strategic positioning as the central contact for inquiries from abroad
- Raising the profile of the German water industry and research abroad
- Expanding internal communication (through committees, annual conferences)
- Networking and cooperation with professional associations, organizations and ministries

The German Federal Ministry of Education and Research (BMBF)

The BMBF funds work that focuses on the adaptation of water technologies to different climatic, ecological, economic and social conditions[7].

The Germany Trade and Invest Agency

The Germany Trade and Invest Agency is a promotion agency that is funded by the Federal Ministry of Economics and Technology and the Federal Commissioner for the New Federal States. The purpose of the agency is to "support German export-oriented companies with comprehensive foreign market information" and "promote Germany as a high-performance economic and technology location to attract investors."[8]

The Alberta-Germany Collaboration Fund for Product Development and Commercialization

Germany and Alberta have a strategic partnership to work together on technology projects. To date, none of the projects have had a water-technology focus but this could change in the future.

Milwaukee, Wisconsin, USA

Milwaukee, Wisconsin, is organizing itself as a hub for water technology research. In late 2014, Milwaukee was federally designated as one of four newly named regional innovation centres in America, and the United States Small Business Administration (SBA) gave the city over half a million dollars to put toward its water technology

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[6] German Water Partnership, "Networking is our Business", Retrieved from http://www.germanwaterpartnership.de/fileadmin/pdfs/gwp_materialien/networking_is_our_business.pdf

[7] "Federal Ministry of Education and Research, "Main Topic," Retrieved from http://www.bmbf.wasserressourcen-management.de/en/

[8] Oweiss, Omar. 2012, September 27. "Germany Trade and Invest – Investment Promotion Agency." Retrieved from http://www.gtai.de/GTAI/Content/EN/Meta/Events/Invest/2012/Reviews/Chemical-healthcare/Downloads/Breakfast-seminar-presentation-omar-oweiss.pdf

programs[9]. Milwaukee's work is considered to be a model for other jurisdictions; for example, the SBA has been promoting Milwaukee's collaborative water technology approach as a national model.

Milwaukee is focussed on water technology development for several reasons. First, many companies that historically have been involved in the manufacturing of water treatment equipment are located there. Second, Milwaukee was sued by the State of Illinois for polluting Lake Michigan from combined sewer overflows during storm events, causing the City to invest significantly in alternative storm management systems. Third, Milwaukee experienced an event where cryptosporidium passed through one of its water treatment plants, sickening thousands and causing several deaths. The City was highly motivated to research new water technologies to deal with these challenges.

Water technology development and commercialization is driven through public-private partnerships in Wisconsin. The best known public-private partnership is that of the Milwaukee Water Council.

The Milwaukee Water Council

Established in 2009, the Water Council is based on a collaborative approach that connects water technology researchers and companies. The mission of the Council is "to align the regional fresh water research community and water-related industries to establish the Milwaukee region as the World Water Hub for water research, economic development and education"[10].

The Water Council receives funding from the private sector (e.g. KPMG, US Bank, donated time and resources from private sector stakeholders) and the public sector (e.g. charitable foundations, State of Wisconsin, Wisconsin Economic Development Corporation [WEDC], City of Milwaukee, universities).

The Council is engaged in local, national and global initiatives that are focused on technology, as well as water stewardship (e.g. Alliance for Water Stewardship). Three key local initiatives are:

- Business Research Entrepreneurship in Wisconsin (BREW)
- Industry/University Collaborative Research Center
- Global Water Center

BREW

BREW is an accelerator program that helps businesses find out about new markets, both in the U.S. and globally. The goal of BREW is to "unleash unique water technology start-ups, expand Milwaukee's global water hub and create opportunities in the water industries"[11]. BREW is one of the first "mentor-driven accelerators in the world that serves as an incubator for start-ups", and was founded by the Water Council and WEDC. BREW is relatively new; it began in 2013, and has since gone through two rounds of funding applications.

BREW enables companies to thrive in the current market through a three-pronged approach:

- Unleashing innovation by bolstering the start-up process
- Accelerating results by linking them with a strong and vibrant water network
- Inspiring action by providing an engaging and interactive workplace

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[9] Bauter, Alison. 2014, September 30. "Milwaukee designated as federal water technology cluster." *Milwaukee Business Journal.* Retrieved from http://www.bizjournals.com/milwaukee/news/2014/09/30/milwaukee-designated-as-federal-water-technology.html?page=all

[10] The Water Council, "Industry/University Collaborative Research Center", Retrieved from http://www.thewatercouncil.com/temp2/iu-crc/

[11] "The Brew", Retrieved from http://www.thebrew-mke.com/about-us.html

Companies must apply to the program, and selection is based on the following criteria:

- Unique product/service in the water industry
- Solving a long time problem in the industry
- Creating a new market and opportunity
- Commercialization potential
- Expertise of team

Successful groups are required to relocate to Wisconsin for a 6-12 month period, and are provided with low cost office space in the Global Water Center, low cost housing, access to labs, $50,000, access to mentors, global trade missions and more[12].

Industry/University Collaborative Research Center (Water Equipment and Policy Center)

The Water Equipment and Policy Center (WEP) "serves as a catalyst for synergizing the region's assets to create the next generation of products and processes and advance the water industry". The WEP is a collaborative of universities, corporations and government agencies. The annual membership fees that are collected are used to fund pre-competitive research in four areas related to the water industry: materials, sensors and devices, systems and policy[13].

Global Water Center

The Global Water Center opened in 2013 and hosts "31 different established and start-up organizations comprised of a number of industry, academia and government sources". The Center hosts everything from university programs (e.g., University of Wisconsin – Whitewater Institute for Water Business) to established companies, such as Veolia North America[14]. Veolia contributed access to the Veolia Innovation Accelerator, a technology initiative where start-up companies can get evaluated by Veolia domain experts and explore partnership opportunities to accelerate the deployment of these technologies. Partnership elements could include lab testing, pilot demonstrations, engineering and operational support and marketing support.

The main purpose of the Center is to provide accelerator space for new and emerging water technology companies (companies selected through the BREW program are hosted at the Center). The Center "merges collaboration with commercialization to better address water issues related to quality, technology and policy" and its main goal is to link large established international water businesses with university researchers/students and technology entrepreneurs[15]. To support the entrepreneurs in the Centre, the City of Milwaukee will leverage its water and wastewater facilities for testing and piloting.

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[12] Ibid.
[13] "Industry/University Collaborative Research Center," Retrieved from http://www.thewatercouncil.com/temp2/iu-crc/
[14] Haddaway, Art. "Inciting inspiration: Milwaukee Global Water Center provides research, accelerator platform for existing, emerging companies," *Water World*, Retrieved from http://www.waterworld.com/articles/print/volume-30/issue-5/editorial-features/inciting-inspiration-milwaukee-global-water-center-provides-research-accelerator-platform-for-existing-emerging-companies.html

[15] Ibid.

Appendix H: Summary of Water Technology Challenges and Opportunities

Oil Sands: Mining	
Challenges	**Opportunities**
Conflicting views around the interaction between oil sands development and the surrounding environment	Technologies that monitor surrounding freshwater quality
Reducing the amount of source water required	Technologies that increase water reuse onsite
Reducing the cost of separating water from clay in tailings ponds	Technologies that address increasing concentration of dissolved solids on site
Increasing volumes of saline groundwater seepage onsite	Technologies that help manage highly saline groundwater

Oil Sands: In Situ	
Challenges	**Opportunities**
High costs associated with steam production	Technologies that improve steam production efficiency Technologies that improve boiler design and steam generation
Highly complicated water treatment process with many changing variables	Technologies that improve the automation of the SAGD water treatment process
High water reuse volumes generates large amounts of waste from the treatment process	Technologies that aid in the management and disposal of water treatment wastes
Process additives react with water and hydrocarbons that plug systems, requiring clearing	Technologies that reduce fouling and plugging
Chemical mixing is highly complex and precise, requiring great accuracy	Technologies that aid in chemical mixing and management
Reducing the amount of source water required	Technologies that improve water treatment and reuse process

Hydraulic Fracturing	
Challenges	**Opportunities**
Increasing competing demands for water and high water management costs	Technologies that help operators better understand and manage their source water
Growing public concern over the impact of hydraulic fracturing development on the natural environment	Technologies that help monitor the surrounding environment for changes in water volume and ecological health
No real understanding of groundwater aquifers recharge rates and connectivity with surface sources	Technologies that support groundwater mapping, monitoring and data collection
Reducing the amount of source water required	Technologies that increase reuse of water onsite
Large amounts of waste are being generated from the water treatment and reuse process	Technologies that aid in the management and disposal of water treatment wastes

Water and Wastewater Treatment	
Challenges	**Opportunities**
New developments are limited in ability to connect to existing treatment infrastructure	Mobile technologies that aid in the treatment of domestic and industrial/process wastewaters
Need for more efficient updated wastewater treatment facilities and processes	Wastewater treatment technologies that result in smaller environmental impact and/or reduce the use of harmful or synthetic chemicals
Population and economic growth are creating greater volumes of untreated runoff	Technologies that help treat and manage industrial, agricultural and municipal runoff in cold climates

Water Reuse and Stormwater Use	
Challenges	**Opportunities**
Increased need for public awareness and education on water reuse and stormwater runoff	Technology platforms that support public awareness and educational programs
Limited availability of tested cold climate reuse systems	Water reuse technologies that can operate safely and effectively in cold climates
Limited testing of water quality from industrial, agricultural and municipal runoff	Technologies that assess the potential for matching water quality to use, risk management and identify cost-benefits

Irrigation and Agriculture	
Challenges	**Opportunities**
High levels of aquatic plant growth in canals that can block flow	Technologies that limit the growth of aquatic plants in irrigation canals
Increasing runoff from municipal and industrial sites negatively affect the quality and levels of nutrients in the canals	Technologies that help mitigate and treat municipal and industrial runoff into irrigation canals
Some canals still require manual monitoring and operation of gates	Technologies that improve the efficiency of irrigation systems
Dry aired parts of Alberta require greater volumes of water for irrigation and	Technologies that monitor and report soil moisture levels
Some types of crops require larger amounts of water for effective growth	Technologies that aid in the development of advanced crop breeding

Rural and Remote Communities	
Challenges	**Opportunities**
Rural treatment systems are often out of date or too small to handle current volumes	Technologies that provide reliable 'right-sized' water and wastewater treatment systems
Simple rainwater harvesting systems don't allow for additional uses beyond irrigation and often get blocked	Advanced rainwater harvesting technologies, including filtration and sediment removal
Growing number of outdated, difficult to monitor septic systems	Technologies that aid in the development and monitoring of robust septic units
Growing number of outdated well pumps	Groundwater well pump technologies suitable for household use and adaptive to cold climates
Limited knowledge and data on groundwater resources for domestic use	Technologies that aid in the mapping and monitoring of groundwater resources

Environmental Monitoring	
Challenges	**Opportunities**
Need for technologies that provide scientifically verifiable monitoring data	Remote sensing technologies that create verifiable monitoring data
Need for a single source for accessing monitoring data that is up to date and relevant	Information technology systems that improve the collection and organization of real-time monitoring data
Need for greater public access to relevant and easy to use data	Technologies platforms that provide public access to real-time data
Need for succinct and reliable monitoring data that can be verified and trusted by the public	Technologies that support collaborative monitoring and reporting efforts between government, industry and public

Natural Landscapes, Watershed Protection and Tourism	
Challenges	**Opportunities**
Need for enhanced planning tools to help mitigate flood and drought conditions	Technologies that enhance watershed modelling capabilities, including advanced database and modelling information systems
Need for greater public involvement and communication of water challenges that are greatest importance	Technology platforms that improve the communication of watershed projects and research
Lack of public awareness of the recreational activities available, as well as access to current development plans and potential decisions	Technologies that enhance the government's ability to communicate and engage with the public on recreational and park activities, and development and management decisions
Limited local knowledge of, and access to bio-engineering solutions	Technologies that enhance the development of bio-engineering solutions
Need for greater understanding of land use connectivity with surface and groundwater resources	Technologies that support the integration of Land Use Plans and Watershed Management Plans

Appendix I: Select List of Academic Programs in the Alberta Water Community

The following list summarizes a select number of academic leaders in the Alberta Water Community. This appendix is a requested complement to the Water Asset Catalogue Report. The appendix contains information on specific programs and individuals taken from the websites of each of these programs. Each paragraph identifies the areas of expertise, organizations and key contacts within each institution, based on research conducted in December, 2014, and therefore is subject to change. This is not an exhaustive list, but should provide some guidance on who is providing leadership in some of the key areas of academic and industry interest in the province.

University of Alberta

Water Quality Management for Oil Sands Extraction: The Water Quality Management for Oil Sands Extraction is a partnership between Alberta Innovates Energy and Environment Solutions (AI-EES), Kemira Oil & Gas/Kemira Water Solutions (Canada) Ltd., Suncor Energy Services Inc., Statoil Canada Ltd., ConocoPhillips Canada, and the University of Alberta. The research undertaken aims toward fundamental studies that can provide pathways for sustainable management of the freshwater resources during oil sands extraction. The immediate focus of the research program is management of produced water quality during *in situ* oil sands extraction, particularly employing the steam assisted gravity drainage (SAGD) process. The two current postdoctoral fellows are Mohtada Sadrzadeh and Rajesh Pillai. The primary contact is Mona Pattison (wqmgmt@ualberta.ca).

The University of Alberta Water Initiative: The University of Alberta Water Initiative brings together researchers from across campus to participate in multi-disciplinary water projects funded by grants, donations or sponsored contracts. The Water Initiative provides leadership, research and teaching expertise for industry, government and non-governmental organizations seeking innovative solutions for water quality, use and supply. The Managing Director is Jason Brisbois (jason.brisbois@ualberta.ca) and the Research Director is Greg Goss (water@ualberta.ca).

Engineering Processes in Oil Sands: The University of Alberta acts as a hub of researchers to collaborate on the responsible development of Alberta's Oil Sands. The two objectives are optimizing existing processes and creating new breakthrough solutions for technical problems. David Lynch (david.lynch@ualberta.ca) is the primary contact.

Edmonton Waste Management Centre of Excellence: This facility is located at the Gold Bar wastewater treatment plant, and leverages the active facility to support research in wastewater treatment. The partners in this facility are the University of Alberta, the City of Edmonton, EPCOR, NAIT, AITF and AMEC. Dr. Daryl McCartney is the Executive Director and Director of Research (daryl.mccartney@ualberta.ca).

University of Calgary

Hydrogeology Research Group: Consists of five faculty members working on topics including applied isotope geochemistry, hydrogeophysics, groundwater modeling, alpine hydrogeology, and agricultural impacts on water. They are considered the top groundwater academic institute in Alberta, and Lawrence Bentley (lbentley@ucalgary.ca) is the primary contact. They also have a noteworthy River Ecology group

that is led by Cathy Ryan (cryan@ucalgary.ca). In addition, there are two projects currently funded by AI-EES, including the Groundwater Recharge in the Prairies (GRIP) project lead by Dr. Masaki Hayashi, and the Baseline Isotope Geochemistry of Alberta Groundwater project lead by Dr. Bernhard Mayer.

Advancing Canadian Wastewater Assets: Advancing Canadian Wastewater Assets (ACWA) is a partnership between the University of Calgary and The City of Calgary. ACWA's main goal is to develop wastewater treatment technologies that will remove existing and emerging contaminants to improve ecosystem and human health. ACWA's infrastructure is imbedded within The City's Pine Creek Wastewater Treatment facility and includes advanced, large scale wastewater treatment processes and 12 replicate, experimental streams that can be dosed with various constituents of municipal effluents. Together these facilities will be used to demonstrate advanced treatment techniques and the impact of the resultant effluent on the environment. ACWA's onsite laboratory has state-of-the-art facilities to quantify contaminant residues, identify and culture cells, determine water-borne pathogens and examine gene expression in model organisms. Additional ACWA laboratories (Microbiology, Aquatic and Stable Isotope) on the University of Calgary campus complement and support ACWA's research program. Glen Armstrong (glen.armstrong@ucalgary.ca) is the Head and Primary Contact for ACWA.

Lethbridge College

Aquaculture Centre of Excellence: The Aquaculture Centre of Excellence (ACE) conducts research primarily dealing in the aquatic realm, particularly aquaculture, aquatic ecosystem health, water quality and fish disease. With biosecure isolation facilities, water recirculation technologies, green house operations, and water quality testing and molecular lab capabilities, ACE provides a solid base to conduct a wide variety of aquatic based research. The head of research is John Derksen (j.derksen@lethbridgecollege.ca).

University of Lethbridge

Alberta Terrestrial Imaging Centre: The Alberta Terrestrial Imaging Centre (ATIC) is advancing scientific knowledge in remote sensing, imaging spectroscopy, and LiDAR for natural resources and environmental monitoring for the goal of global sustainability. The Centre’s research and development is supporting innovation, leadership and new applications in these areas utilizing cutting-edge remote sensing technologies developed at the Centre in projects ranging from Alberta, to other parts of Canada and internationally. ATIC's expertise lies in the research and development of new tools for optical remote sensing including the design of sensor characteristics for space missions. R&D is focused on image calibration, processing, validation, and information extraction from hyperspectral, multispectral, and LiDAR data. Dr. Karl Staenz (karl.staenz@uleth.ca) is the director of ATIC and acts as the primary contact.

Canadian Centre for Research in Advanced Fluorine Technologies: The Canadian Centre of Research in Advanced Fluorine Technologies (C-CRAFT) is the first Canadian centre focusing on research and training around the element fluorine. C-CRAFT brings together a local, national and international team with wide ranges of expertise in fluorine chemistry. The director and primary contact for C-Craft is Dr. Michael Gerkin (michael.gerken@uleth.ca).

Water Institute for Sustainable Environments: WISE researchers are analyzing water resources, including natural science analyses of watersheds, and water quantity and quality; and overlapping social science investigations related to aspects such as water policy and economics. The studies often investigate water resources and river systems of western North America, including the Saskatchewan River Basin and adjacent watersheds. The investigations consider fundamental aspects of water science, as well as applied science and management directed towards the simultaneous goals of environmental health and socioeconomic prosperity. Dr. Joseph Rasmussen (joseph.rasmussen@uleth.ca) is the director and primary contact for WISE.