

Alberta's Water Research and Innovation Strategy



Annual Report 2017

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Acknowledgements

The Third Annual Report of Alberta's Water Research and Innovation Strategy 2014 (AWRIS): A Renewal is the result of collaborative efforts made by researchers, students, program delivery agents, service providers, industry partners, and funders. This is a summary of the progress and impacts resulting from Alberta's water-related research and innovation activities as reported in 2017.

We gratefully acknowledge our contributing partners (listed in Appendix 3) for their continued partnership and providing the information within this report on provincial water research and innovation activities.



Message from the Ministers

We are delighted to present the Third Annual Report of Alberta's Water Research and Innovation Strategy 2014 (AWRIS): A Renewal, which outlines the actions that Alberta's research and innovation community are taking to support the vital role water plays in a healthy environment and Albertans' quality of life.



*Honourable Deron Bilous
Minister of Economic
Development and Trade*

Our water related research and innovation activities are focused on ensuring safe and reliable water resources to sustain the environment, industries, municipalities, recreational activities, indigenous communities, and traditional practices. The Government of Alberta's previous and ongoing investments in water research and innovation have resulted in:

- development of world-class research and innovation capacity in water resources management;
- enhancement of knowledge and tools available for sustainable water resources management;
- best practices, technologies and processes developed for water conservation, efficiency, and productivity; and
- development of technology and management options for oil sands tailings management.



*Honourable
Shannon Phillips
Minister of Environment
and Parks*

Investments made in these activities reflect our commitment to a highly collaborative, transdisciplinary culture, which produces innovations that will benefit Albertans for years to come.

The Government of Alberta recognizes the important contribution that the water research and innovation system makes to a resilient and diversified economy. AWRIS aligns with Water for Life, the overarching government-wide strategy that has guided water management in the province since 2003. AWRIS plays a critical role in ensuring that stakeholders from the public, private, and non-governmental organizations have the information they need to make sound and effective decisions related to water. Continuing strategic investments in talent, infrastructure, and collaborative opportunities contribute directly to the success of our province.

Executive Summary

One of the key priorities for the Government of Alberta (GoA) is to make sure that Albertans have access to quality water to support healthy communities, a resilient economy and a cleaner environment. To achieve these outcomes, the GoA is strategically investing in a range of research and innovation activities to help grow Alberta's capacity to meet existing and emerging water needs. Alberta has made significant progress in water conservation, efficiency and productivity (CEP); however, the demand for high quality water continues to rise due to increasing population and expanded economic activities.

The Third Annual Report of AWRIS is a summary of actions resulting from water research and innovation investments (including GoA funding and leveraged by other partners) in Alberta in 2017. This report describes the knowledge and economic value delivered to Albertans through these investments. Water research related activities are creating value through new knowledge that addresses challenges related to water use, re-use and conservation. For example, a partnership between Alberta Innovates (AI) and Sustainable Development Technology Canada (SDTC) led to joint funding for technologies that address water challenges in hydraulic fracturing, enhanced oil recovery, oil sands, and municipal water management.

The provincial water research and innovation system is seeing effective outcomes of the Alberta's Water Research and Innovation Strategy. Government is working to improve data collection, enhance access to data, and raise awareness about the importance of reporting among partners and stakeholders.

Following are examples of some of the key achievements made through research and innovation activities that are aligned with Water for Life goals:

- **Safe secure drinking water** – University of Calgary water researchers from the Department of Geography and the Faculty of Veterinary Medicine, in collaboration with the Alberta Health Services Provincial Laboratory, conducted a study on the effects of the 2013 Calgary flood and assessed the risk of drinking water well contamination. The study recommended that homeowners who live in a high-risk area ensure their wells are properly maintained to reduce risk of water well contamination.
- **Healthy aquatic ecosystems** – University of Lethbridge-led project that enhanced understanding of ecological impacts of river flows and water diversions on aquatic ecosystems. This knowledge supports both environmental health and socio-economic uses. A novel environmental flow management strategy used for Alberta's rivers is now being applied to other western North America river systems.
- **Reliable, quality water supplies for a sustainable economy** – University of Alberta-led project developed a model to assess water supply, water demand, sector-based risks and opportunities. This model can be used in public policy and planning to predict future water availability.





More water research and innovation success stories are highlighted in the reporting and evaluation section of this report.

Figure 1 shows how strategic investments, ongoing/new partnerships and synergies are contributing to meet the goals of the provincial water agenda.

Figure 1: Overview of Alberta's Water Research and Innovation activities

Innovation Focus (IF)

Strategic investments supporting research and innovation activity to generate reliable knowledge

 <p>Water Innovation Program funded 49 research projects</p> <p>~ \$9.7 million invested in projects through WIP and Health Protection grants</p> <p>\$79 million of direct investments leveraged from partners for water and tailings projects active and completed in 2017.</p>	 <p>Around 94 project collaborators & 68 funding partners</p> <p>*Note: some overlap between project collaborators and funding partners</p>  <p>50% increase in visiting users to the Alberta WaterPortal over previous year</p>	 <p>Alberta researchers published >160 peer reviewed papers supporting Water for Life Strategy goals since 2013.</p>
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Innovation Platform (IP)

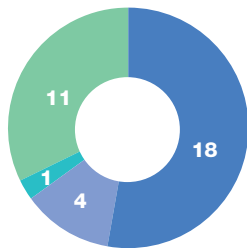
Technological and organizational environments are conducive to discovery and application

 <p>~\$3.64 million infrastructure/equipment funding</p>	 <p>27 Working Well workshops for the public were conducted that engaged 636 participants</p>	 <p>Improved data access through reporting websites, reports & data tools</p>
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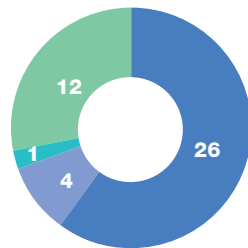
Innovation Capacity (IC)

Building water research and receptor capacity

 <p>> 250 High Quality Personnel supported through WIP</p>	 <p>Research and innovation influencing framework, policies, programs</p>	 <p>Recognized Water research community through awards and other incentives including travel grants</p>
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34 Programs



43 Specializations

- Non-credentialed
- Certificate
- Diploma
- Degree

- Partnering for knowledge transfer
- Attracting, developing & retaining HQPs
- Improving information access
- Research & innovation is informing policies & practices

Introduction

The Government of Alberta (GoA) has a long history of water research and innovation investments. The government formally recognized the importance of water by releasing Water for Life: Alberta's Strategy for Sustainability (WFL) in 2003, which guided management of water resources in the province. The government made an initial investment of \$30 million to support WFL followed by a further investment of \$15.3 million, specifically targeted for water and tailings projects. These investments in water research and innovation continue to advance knowledge and technologies for sustainable water management in the province. The GoA released AWRIS to support WFL's knowledge and research needs. This strategy provides direction for water research and innovation in Alberta for the coming decade and beyond.

The province is leveraging support and investment from the federal government along with other partners. Alberta Budget 2017 stated that the province would spend \$100 million over the next four years to integrate drinking water systems with federally supported water systems to bring safe, reliable drinking water to all First Nations across Alberta¹. Recently, Western Economic Diversification Canada (WD) and Canada's Oil Sands Innovation Alliance (COSIA) committed to invest \$800,000 in a new oil sands water testing facility, located at the Northern Alberta Institute of Technology (NAIT). This will enable participating Canadian oil companies to test new technologies and implement their innovations to enhance environmental and economic benefits².

In 2017, the GoA released the Alberta Research and Innovation Framework (ARIF), which establishes shared outcomes and innovation targets for Alberta's research and innovation organizations. The aim is to build a stronger research and innovation system that delivers measureable results. This framework identified Sustainable Water Management as a key innovation target with four focus areas and seven flagship initiatives³.

Goals (identified in WFL)

- Safe, secure drinking water
- Healthy aquatic ecosystems
- Reliable quality water supplies for a sustainable economy

¹ <https://globalnews.ca/news/3318328/alberta-budget-2017-100m-committed-for-clean-drinking-water-on-first-nations/>

² <http://www.jwnenergy.com/article/2018/1/nait-receives-800000-advance-oilsands-water-treatment-technologies/>

³ <https://www.alberta.ca/alberta-research-innovation-framework.aspx>

Reporting and Evaluation

Leadership and Accountability:

AWRIS is an initiative led by Economic Development and Trade (EDT) and Alberta Environment and Parks (AEP). The GoA receives data from water research community partners, and other stakeholders, including industry and environmental non-government organizations. This report describes the progress made towards achieving goals outlined in the AWRIS.

Report Highlights:

Enabling Outcomes:

Innovation Focus (IF)

Highlights strategic investments supporting collaborative, transdisciplinary research and innovation activity in focus areas of water, and which generates applicable and reliable knowledge for the water resource system.

Investments/Leverage

- Water Innovation Program (WIP) funded 49 projects in various water research themes, including climate change adaptation, with total funding of \$6.2 million in 2017.
- Alberta Health's (AH) Health Protection grants provided a total funding of \$3.5 million toward water research in 2017-2018.
- Seventy nine million in direct investments by industry and non-government partners has been leveraged for water and tailings management.
- In 2017, water technology projects funded with a total of \$3.1 million in AI and SDTC support, advanced to various stages of contracting and execution.
- Alberta Innovates funded projects leveraged \$9.25 million from federal partners such as Agriculture and Agri-Food Canada (AAFC), Natural Science and Engineering Research Council (NSERC), Social Science and Humanities Research Council, Global Water Futures, Canada Foundation of Innovation (CFI).
- Current provincial investments in water research managed through AI have an average leverage of 2.5:1 with the greatest leverage in tailings at 5:1 and conservation, efficiency and productivity projects at 3.5:1.

Key highlight:

University of Alberta led project "Predicting Alberta's Water Future" used hydrological and economic modelling to assess water supply, water demand, and risks to develop an integrated risk map for the province. Multiple data sources (climate data, hydrological data, groundwater, glacier, and economic data) were compiled to develop a model. This model allows for integration with situations of future demand to assess sector-based risks and opportunities, and for integration of future water availability (at both provincial scale and sub-watershed scale) into government policy and planning. Risks identified for Alberta are overall warming and changes in weather extremes; climate change results in decreased crop yields for barley, canola, and spring wheat; and different parts of Alberta will experience water scarcity differently.

University of Waterloo led project "Sustainable Wetland Habitat: Reclamation Targets, Design Criteria and Wetland Policy Implementation" delivered two multi-metric index tools for assessment of parkland and grassland semi-permanent wetlands and characterization of wetland configuration across landscapes in parkland, grassland and boreal natural regions. The first phase of this research project took place at University of Alberta whereas the second phase was conducted at University of Waterloo but focus remains consistent i.e. wetlands in Alberta.

- University of Calgary water researchers received \$4.26 million in funding from the Alberta government and \$11.65 million from other funding sources including federal, industry, and external organizations.
- Alberta researchers received Canadian Institutes of Health Research (CIHR), CFI, NSERC, and other international collaborative grants for water-related research projects.
- WaterSMART Solutions leveraged provincial investment at a rate of 7:1 in Athabasca River Basin Project Phase 3. The GoA, in collaboration with other industry partners, continued supporting the WaterSMART-led project on the Athabasca River Basin (\$1.5 million).

Collaborations/ Partnerships

- Alberta Innovates, COSIA, and Natural Resources Canada (NRCan) co-hosted the bi-annual “Oil Sands Innovation Summit” (March 21-23, 2017). The conference addressed water, tailings, land, and air issues related to in-situ and mineable oil sands development.
- Alberta Irrigation Projects Association (AIPA) is collaborating with Alberta Agriculture and Forestry (AAF) and AAFC to continue long-term water quality testing in the 13 Irrigation Districts of Alberta.
- The City of Calgary Water Resources and Water Services hosted a workshop in summer 2017 to highlight the research activities and ongoing work of the University of Calgary research chairs, involved in Advancing Canadian Wastewater Assets (ACWA) research. This workshop included discussions on new joint research and development projects with the City.
- University of Lethbridge researcher Dr. Stefan Kienzle and his team’s work on geographical information systems (GIS) explored using geo-spatial technologies for a company “FarmersEdge” (Precision Farming Information to over 1 million acres), which helps farmers increase production by providing tools to manage risks and maximize farm profitability.

Key highlight:

AIPA funded an invasive mussel veliger-sampling program within 11 irrigation reservoirs during summer 2017 to monitor for the presence of invasive mussels. Total cost of the contract was \$90,000. Four irrigation districts collaborated with AAF on a research project to determine treatment techniques for control of aggressive mussels in water transportation infrastructure. Potash is considered the best potential pest management option to treat aggressive mussels. Districts contributed access to varying pipeline segments.

Awareness/ Training

- Engagements at various levels were held ranging from presentations at conferences/workshops to conducting training sessions for stakeholders.
- AIPA held the 2017 Water Conference in Lethbridge in November to report on their research studies and water management options. This conference increased awareness of water issues and management options.

Key highlight:

WIP funded the Septic Sense workshop program, delivered by the Land Stewardship Centre of Canada, which informed rural residents on the operation and maintenance of septic systems. A total of 19 workshops were held between January 18, 2017 and March 30, 2017 with participation of 623 individuals. Survey respondents suggested that the Septic Sense workshop increased their understanding of proper sewage treatment and how a septic system works.

Published Research

- Alberta researchers have published more than 160 peer-reviewed papers supporting WFL goals since 2013.
- Some of the published papers with practical applications include:
 - “Performance management of small water treatment plant operations: a decision support system (DSS)” published in *Water and Environment Journal* 31(3) 2017.
 - “Lessons learned from the 2013 Calgary flood: Assessing risk of drinking water well contamination” published in *Applied Geography* 80 (1) 2017.
 - “River regulation and riparian woodlands: Cottonwood conservation with an environmental flow regime along the Waterton River, Alberta” published in *River Research and Applications* 33(7) 2017.
 - “Growth of riparian cottonwoods: heterosis in some intersectional *Populus* hybrids and clonal expansion of females” published in *Trees* 31(3) 2017.

Policies, Processes, Practices and Programs

- University of Calgary water researchers in collaboration with the Alberta Health Services (AHS) Provincial Laboratory conducted a study on the 2013 Calgary flood and assessed the risk of drinking water well contamination.
- University of Calgary water researchers, in collaboration with researchers from Brock University, Qassim University (Saudi Arabia), and University of British Columbia (Okanagon), have developed a decision support system to optimize the performance of small-scale water treatment systems to improve day-to-day decisions and assess system performance. The system includes a data management system, performance assessment, fault-tree analyses, preventative and corrective actions and event-tree analysis tools.

Key highlight:

Scott Jasechko (University of Calgary) published the paper “Global aquifers dominated by fossil groundwaters but wells vulnerable to modern contamination” in *Nature Geoscience* 10(6) 2017. The paper demonstrated the vulnerability of groundwater to modern-era pollutants and concluded that water quality risk should be considered along with sustainable use when managing fossil groundwater resources. The paper received extensive international news and social media attention.

Dr. Chris Le and his team published four papers in 2017 on the topics of water and/or arsenic in their paper “Keep swimming but stop peeing in the pools”, *Journal of Environmental Sciences* 53, 2017.

Key highlight:

In Winter 2017, ACWA Scientific Director Dr. Leland Jackson and the Alberta Pharmacists Association launched the ENVIRx program, which aims to stop expired prescription drugs from entering the water systems and landfills in the Calgary area and reduce the impact these “dead drugs” have on environment. The pilot program began with participation from six pharmacies and has since grown to over 500 pharmacies (<http://www.rxa.ca/for-the-public/medication-disposal.aspx>).

Knowledge Sharing

- Improved sharing and accessibility of data on water related issues through portal, websites, seminars and conferences.
- Knowledge-sharing events and presentation included:
 - Alberta Health staff and University of Alberta professors participated in the federal/provincial/territorialhealth working group for revising the “Guidelines for Canadian Recreational Water Quality.”
 - Alberta Innovates staff presented on WIP and water-related issues to industry, post-secondary students, teachers, government and other water stakeholder groups.
 - Multiple seminars were held with GoA staff and AHS to showcase the Alberta Environmental Public Health Information Network (AEPHIN) drinking water data visualization component.
 - The Technical Advisory Committee on Safe Drinking Water (TAC-DW) established collaborations across provincial and federal ministries and public health laboratories to respond to drinking water issues.
- WIP-funded project teams presented their work in ~46 national/international conferences/public events. Project teams supported by other funding sources presented in ~17 conferences/events.

Key highlight:

Viewership on the Working Well website increased significantly in 2017. Unique page views rose from 779 in 2015-16 to 2,606 in the 2016-17 with views peaking in January/February and again in October/November.

There was a 50 per cent increase in visitors to the Alberta WaterPortal (albertawater.com) in 2017 over 2016.

The Alberta Climate Records website <http://albertaclimaterecords.com/>, developed by the University of Lethbridge researchers had, according to Google Analytics, 1,793 new viewers in 2017.

Innovation Platforms (IP)

Technological and organizational environments encourage discovery and application, stimulating innovation in Alberta's water resource system.

Infrastructure

- GoA supports funding for equipment and research infrastructure to build capacity in Alberta's post-secondary institutions and support multidisciplinary research programs.
- AI supported 22 institutions, which received direct (10) and indirect (12) funding to support innovation infrastructure in Alberta, including the University of Alberta, University of Calgary, University of Lethbridge, Northern Alberta Institute of Technology, Southern Alberta Institute of Technology, NRCan's CanmetENERGY and AAFC through investing in projects such as establishing a world class metal-free ultra-clean laboratory (<https://swamp.ualberta.ca/>).
- AH supported infrastructure and equipment in 2017-18 by providing funding (\$1.58 million) to the Alberta Centre for Toxicology (ACFT) at the University of Calgary, Biogeochemical Analytical Service Laboratory (BASL), Environmental Microbiology Laboratory, and Freshwater Biodiversity Laboratory at the University of Alberta. These grants support infrastructure and laboratory equipment for the development of new analytical techniques in the areas of drinking and recreational water monitoring, water cytotoxicity testing, assessment of arsenic and other metals, and measuring polycyclic aromatic hydrocarbons in water and fish.
- AAF provided \$400,000 for water quality work.
- The University of Lethbridge initiated the planning phase of a new Headwaters Institute to partner with community, science and policy stakeholders in mountain environments. This effort will leverage their existing facilities in the Castle Headwater region and partnerships with provincial and federal parks.

Key highlight:

EDT's Research Capacity Program (RCP) invested \$2.06 million in water - related research projects (total project cost \$5.17 million) in 2017 and leveraged matching federal funding from the CFI. Example: A Canada Research Chair in Aquatic and Mechanistic Toxicology at the University of Lethbridge received this funding to buy equipment to culture fish in the Alberta Water and Science Building's Aquatic Research Facility.



Foster Pan-Alberta Knowledge

- The GoA's Working Well program held 27 public workshops supported by AAF, AEP, and AH.
- The annual AI Water Innovation Program Forum provides direct linkage between post-secondary institutions, provincial and municipal governments, corporate partners, non-government organizations and watershed monitoring groups. In 2017, more than 130 people registered and attended the event.

Data and Information Access (Wealth of Information)

- AI supported Alberta WaterPortal in the development of new content through a project titled "The Future of Water: Engaging Albertans in the Water-Energy-Food Nexus."
- AI online database was updated with the reports that are publicly available at <https://albertainnovates.ca/water-innovation-program-wip/>.
- Alberta Energy Regulator/Alberta Geological Survey (AER/AGS) websites provided improved access to water data and information. Approximately one and a half times as many AER/AGS reports were released in 2017 compared to 2016, and five times as many digital files were released in 2017 compared to 2016. AER updated its reporting on sector water use (<http://aer.ca/data-and-publications/water-use-performance>).
- WaterPortal launched their Watershed Reporting website in collaboration with the Bow River Basin Council and the Calgary Foundation (<http://watershedreporting.ca>). This website allows users to gain an understanding of natural features and processes influencing watershed conditions, links between watershed health and land and water uses, risks and actions.
- University of Lethbridge's West Castle field station, and associated weather station telemetry and web site meteorological data network, is regularly accessed and used by the Castle village community, recreation operators and AEP personnel. <http://artemis.uleth.ca:8080/CastleMet/index.html>

Key highlight:

In Fall 2017, University of Calgary Haskayne School of Business Centre for Corporate Sustainability hosted Alberta WaterSmart, to present on the topic of "Water for a Sustainable Economy in Alberta: Think Globally, Plan Regionally, Act Locally." This latest Enbridge Research in Action seminar provided perspective on the interconnectedness of our water, energy, and food resources, as well as the numerous risks, pressures, and trade-offs that result from this nexus, and how our ability to manage Alberta's water resources under a changing climate relies on finding collaborative solutions to these complex issues. This event was open to members of the public along with students, faculty, and other staff.

Key highlight:

The public launch of AEPHIN was delayed due to the Fort McMurray Wildfire Recovery effort. However, a key AEPHIN component, a mobile app named "Should I Eat this Fish?" launched in July 2017. The related mercury in fish from Alberta waterbodies dataset has also been updated on Open Government Portal.

*Note: The GoA's data visualization tool AEPHIN was publicly released in early 2018 (<http://aephein.alberta.ca/>). AEPHIN provides water chemistry data from samples from private water wells with the public. AEPHIN will also present data about cyanobacterial (blue-green algae) blooms in local recreational waters.

Innovation Capacity (IC)

This outcome relates to the effective mobilization of water research knowledge for the creation of innovative solutions to provincial water-related challenges.

Recruit and Retain Researchers

- Comprehensive Academic and Research Institutions (CARI) retained several distinguished Chairs:
 - University of Alberta: Tier 1 Canada Research Chair in Bioanalytical Technology and Environmental Health, AI Translational Health Chair, and two Chairs in Oil Sands Tailings (Water treatment and Geotechnique respectively); NSERC Senior Industrial Research Chair (IRC) in Oil Sands Water Treatment; NSERC Associate IRC in Sustainable Urban Water Development; Campus Alberta Innovation Program (CAIP) Chairs; NSERC IRC for Colleges for Optimization of Once Through Steam Generator (OTSG) Performance to Increase Water Recycling and Reduce Fouling and Green House Gas (GHG) Emissions.
 - University of Calgary: Canada Research Chair Tier I and II; CAIP Chair; AI/iCORE Strategic Chair; NSERC/City of Calgary Industrial Research Chair and NSERC Industrial Research Chair.
 - University of Lethbridge: CAIP Chairs, Canada Research Chairs, Board of Governors Research Chairs.
- In addition, retention of these key researchers led to the retention, recruitment and training of several graduate students, post-doctoral fellows, and technologists.
- AI continued supporting retention of existing scientific and research capacity. Some of the chairs supported by AI include: NSERC Associate IRC in Sustainable Urban Water Development; AI Translational Health Chair in Water Born Disease Prevention; and NSERC Senior IRC in Oil Sands Water Treatment; and NSERC IRC for Colleges for Optimization of OTSG Performance to Increase Water Recycling and Reduce Fouling and GHG Emissions.

Key highlight:

The GoA (EDT and Alberta Advanced Education-AAE) supports Mitacs', national, not-for-profit organization that delivers research and training programs with national and international collaborations, three internship programs: Accelerate, Elevate, and Globalink. The GoA invested approximately \$126,000 on water-related research projects in 2017 supporting 17 interns under Accelerate and Globalink programs. Total estimated federal funding for water-related research in these two programs were around \$149,000.

EDT through RCP also funds the CAIP Chairs. RCP funding is currently supporting CAIP chairs in water-related research including five at University of Alberta, two at University of Lethbridge, and two at Athabasca University.

Research to Practice – further translated into policy implementations and technology deployment

- University of Calgary led project (partnered with AER (AGS), AEP, AAF, and AI) on quantifying groundwater recharge for sustainable water resource management provided key information to the Groundwater Management Framework, particularly for the strategic focus area of the Edmonton-Calgary Corridor. Numerical tools for estimating groundwater recharge are expected to be used by AEP/AER to better understand groundwater availability and be used to guide the development of the water management framework and policy.
 - University of Calgary researchers provided water testing data to AH/AHS for risk analysis and policy development purposes as well as data for the development of advisories related to mercury and fish consumption.
- University of Alberta researchers at the School of Public Health continued to support development of policy on recreational water management programs through the introduction of Enterococcus quantitative Polymerase Chain Reaction (qPCR) as a water quality indicator.
 - University of Alberta post-doctoral fellow designed an algorithm to adjust a sprinkler flow for the watering of sport fields in real-time conditions. Early results show water savings of approximately 30 per cent as compared to conventional sprinklers covering the same area (<http://edmontonjournal.com/news/local-news/university-of-alberta-math-whiz-helps-develop-robotic-sprinkler-technology>).
- University of Lethbridge researchers developed:
 - a low cost, high accuracy LED-based snowpack and water surface monitoring system to compete with traditional low accuracy sonic based techniques. A number of commercialization avenues are being discussed.
- AAF project on developing nutrient objectives for small streams intended for use as a planning target and measure of success for agricultural watershed management programs in Alberta.

Key highlight:

The successful implementation of functional flows (research led by Dr. Stewart Rood and his team at University of Lethbridge) has led to healthier aquatic ecosystems, rivers, and riparian forests. This novel environmental flow management strategy is now being exported to other river systems in western North America.

Transdisciplinary Research

- WIP funded “Adapting to changing water in Alberta,” the research team included expertise in modelling, hydrology, glaciology, groundwater, biodiversity, agriculture, economics, climatology, and stakeholder engagement.
- Dr. Nicholas Ashbolt (University of Alberta) collaborated internationally on reclaimed and recreational water and recently assisted the U.S. Water Re-Use Foundation to develop a risk-based approach for standards for non-potable water systems.

Key highlight:

In 2017, University of Calgary water researchers published papers in collaboration with researchers from 112 organizations in 27 countries. Top collaborating institutions included the University of Alberta, China University of Petroleum, Aarhus University (Denmark), University of Victoria, University of Saskatchewan, Calvin College (U.S.), Princeton University (U.S.), University of Manitoba, University of British Columbia, University of Waterloo, Max Planck Institute (Germany).

- Dr. Dave Kinniburgh (ACFT, University of Calgary) has established provincial, national and international water research collaborations addressing various research interests.
- Dr. Chris Le collaborated internationally with the U.S. Environmental Protection Agency, the U.S. Water Research Foundation, Chinese Academy of Sciences, and 20 universities/institutes around the world.

Awards/Recognition

- The GoA supports “The Emerald Awards” that recognizes outstanding environmental achievements across all sectors including the “Emerald Challenge Award: Water.” In 2017, the Foothills Stream Crossing Partnership, a multi-industry and public sector partnership received the “Shared Footprints Award” for its program to improve the condition and performance of stream crossings by inventorying, prioritizing, repairing barriers to fish passage, and maintaining watershed health
- The AI supported Chair in Oil Sands Tailings, Mohamed Gamal el-Din, was a 2017 ASTech Award Winner for Innovation in Oil Sands Research.
- University of Calgary researchers were recognized for their work through the following awards: Innovation and Knowledge Engagement Award; Research Excellence Award from the Association of Professional Engineers and Geoscientists of Alberta (APEGA); Killam Annual Professor and Excellence in Science and Technology Public Awareness, ASTech.
- Dr. Chris Hopkinson, University of Lethbridge, received prestigious NSERC Accelerator funding of \$120,000 for ecosystem and wetland change research.

Key highlight:

Dr. Chris Le (Canada Research Chair - Tier 1 in Bioanalytical Technology and Environmental Health) was invited to join the editorial advisory board of “Metallomics”, an international journal of the Royal Society of Chemistry (U.K.). He was appointed to the scientific advisory board of the Overseas Chinese Office of the State Council (China).

Provincial Water-related Post-secondary Programs:

Figure 2: Number of water-related programs offered by various post-secondary institutions and per cent of enrolments (Data source: AAE)

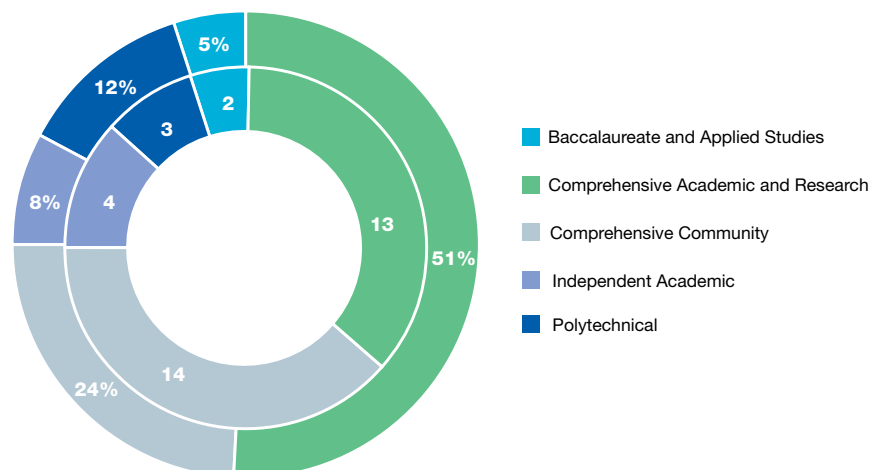


Figure 3: (a) Number of academic water-related **programs** in various post-secondary institutions based on credentials (Data source: AAE)

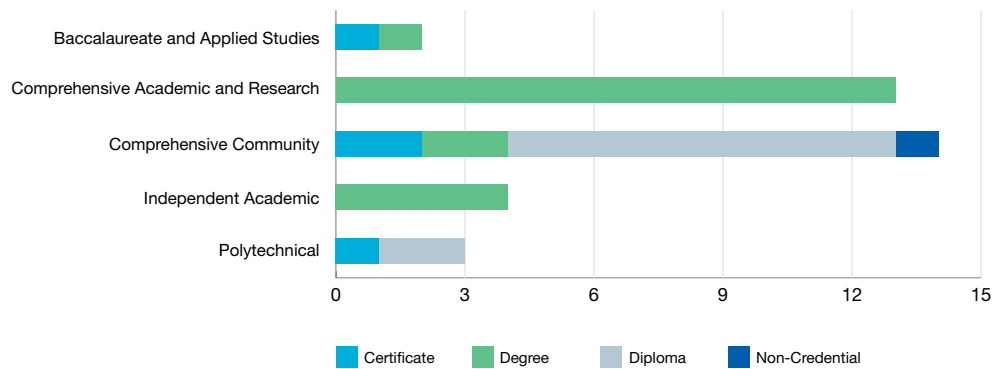


Figure 3: (b) Number of academic water-related **specializations** in various post-secondary institutions based on credentials (Data source: AAE)
*(multiple specializations can exist within a program)

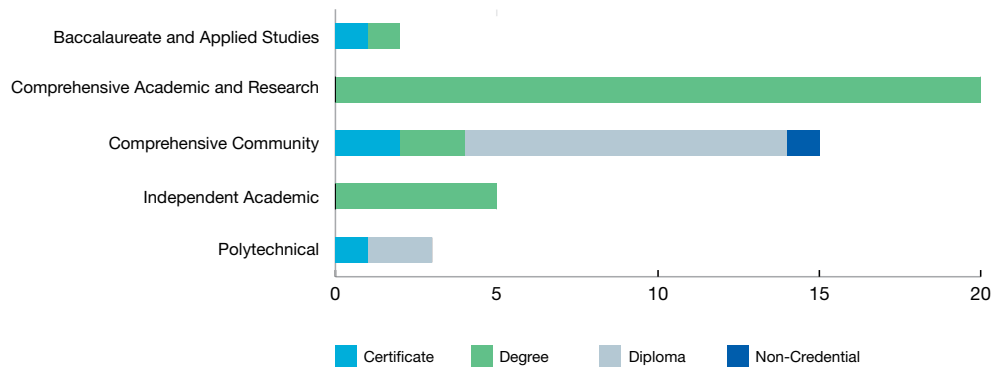
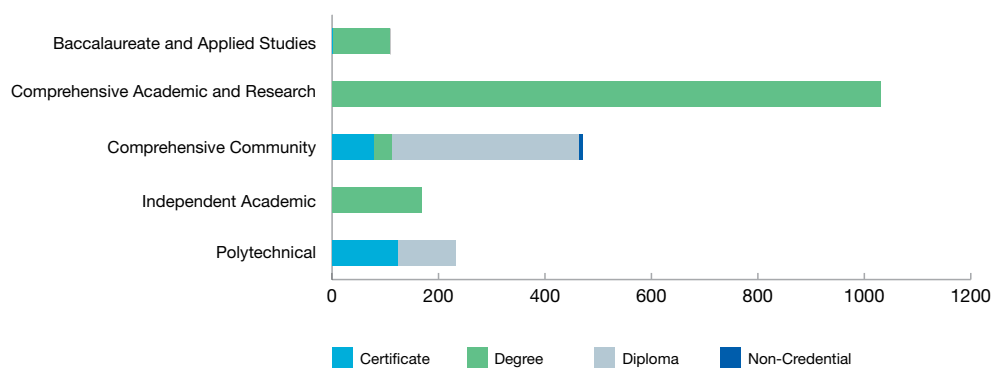


Figure 4: Number of enrolments in water-related programs offered by various post-secondary institutions based on credentials (Data source: AAE)

- A total number of enrolments ~ 1997



Appendix 1:

Table 1: Summary of the results achieved under outcome “Innovation Focus”

Action IF-1 Implement mechanisms that engage government, academia, and industry in the assessment of water research and innovation priorities, key opportunities and principle initiatives	
Indicator	Conferences and workshops are held to engage government, academia and industry that will inform priority decisions and identify opportunities and initiatives
Results	<ul style="list-style-type: none"> • AI hosted the annual “Water Innovation Program Forum” (WIP) in May 2017. The WIP Forum provided direct and key linkage between researchers, governments, corporate partners, non-government organizations, and watershed and local monitoring groups. New partnerships and opportunities were identified at the forum. • AI, COSIA, and NRCan co-hosted the bi-annual “Oil Sands Innovation Summit” in March 2017. The conference addressed water, tailings, land and air issues related to in-situ, and mineable oil sands development. The summit provided a forum for provincial, national, and international scientists, industry, government, and other stakeholders to get together and learn about knowledge and technology advancements addressing water management and other environmental challenges in Alberta’s oil sands. • AIPA held its 2017 Water Conference in Lethbridge in November 2017. Session themes included 1) Water Supply, 2) Water in Other Jurisdictions, 3) Collaboration, and 4) Water Quality. Results of four research studies were reported and numerous water management presentations were given. This conference increased awareness of irrigation and water management issues and management options and encouraged networking. • The City of Calgary Water Resources and Water Services hosted a workshop in summer 2017 to highlight the research accomplishments and ongoing work of the University of Calgary NSERC/ IRC research chairs they support, who are involved in ACWA research. The workshop included an interactive poster session to allow City personnel to engage actively with the students and postdocs carrying out the research. Highlights included progress in developing anaerobic granulation, advanced oxidation, and nutrient removal for improving the efficiency and effectiveness of municipal wastewater treatment, and in understanding the impact of untreated and treated wastewater effluent on native fish in the Bow River. • The WaterSMART-led Athabasca River Basin Project engaged stakeholders from across government, industry, academia and indigenous communities as part of a working group to discuss strategies for future water management in the basin. The initiative held four workshops in 2017, and used models to build a common understanding of issues and the potential effectiveness of management strategies that could be employed. • Drs. Ashbolt and Neumann (University of Alberta) attended the Drinking Water Quality in Buildings Workshop (sponsored by AEP, July 2017). • Dr. Neumann (University of Alberta) participated on the City of Edmonton technical team working on water quality issues related to the Edmonton International Triathlon. • Dr. Le and team (AETL) University of Alberta: <ul style="list-style-type: none"> · presented several lectures and posters at the 100th Canadian Society for Chemistry conference, held in Toronto in May 2017; · presented a lecture on “Arsenic Species and Chlorination Byproducts in Drinking Water” at the 2017 Pittsburgh Conference, held in Chicago in March 2017; and · co-chaired the Xiangshan Science Conference on water contaminants and health, held in Beijing in May 2017. • Dr. Xing-Fang Li (AETL), University of Alberta co-chaired the Gordon Research Conference on Drinking Water Disinfection Byproducts, held in Massachusetts in July 2017.

- Dr. Hopkinson (University of Lethbridge):
 - co-chaired the session on Synthetic Aperture Radar (SAR) in floodplain monitoring and wetland classification in the Canadian Remoting Sensing Symposium, Montreal, June 2017; and
 - presented Alberta LiDAR/SAR water monitoring portal framework in WEB ICT special session in an International Association of Hydrological Scientists (IAHS) conference held in Port Elizabeth, South Africa, July 2017.
- GoA staff attended:
 - the Canadian Water Network (CWN) workshop on urban impacts of storm water and waste-water to assist in identifying policy needs and research priorities; and
 - the COSIA Oil Sands Process Water Science Workshop.
- AER:
 - participated as the scientific organizing committee for the International Association of Hydrogeologists (IAH) Regional Flow Symposium held in June, 2017;
 - coordinated two AER-Deltares workshops on regional groundwater flow and gas migration (Calgary, Alberta, August, 2017 and Delft, Netherlands, October-November, 2017); and
 - participated in approximately fourteen other events to discuss water issues.

Indicator

Research investments are addressing priorities identified by government in water research

Results

- WIP funded 49 projects in various research themes with a total funding of \$6.2 million. Examples from each water research theme are provided below:
 - Water supply and watershed management - 13 projects (three completed). Completed Project – University of Alberta research project on “Predicting Alberta’s Water Future.” The project used hydrological and economic modelling to assess water supply, water demand and risks to develop an integrated risk map for the province. Multiple data sources (climate data, hydrological data, groundwater, glacier, and economic data) were compiled to develop a functioning model and to calibrate the model.
 - Healthy aquatic ecosystems – eight projects (two completed). Completed project –University of Waterloo led project on “Sustainable Wetland Habitat: Reclamation Targets, Design Criteria and Wetland Policy Implementation.” The project delivered two multi-metric index tools for assessment of parkland and grassland semi-permanent wetlands and characterization of wetland configuration across landscapes in parkland, grassland and boreal natural regions. Results are being communicated through peer-reviewed journal articles, presentations and theses; they have also been shared directly with AEP and consultants to encourage rapid uptake and use.
 - Water use CEP – 15 projects (two completed). Completed project – Statoil (now Athabasca Oil) completed pilot testing of a ceramic membrane in-situ oil sands water treatment technology (Veolia ROSSTM). The industry partners concluded that based on the pilot operational experience the ROSSTM system showed that it was capable of treating water to meet or exceed the water quality produced by the existing WLS/after filter system. The testing completed did not provide sufficient support to qualify the system for commercial use. Modifications to the equipment and operation would be required for the system to achieve the original design capacity.
 - Water quality protection – 12 projects (two completed). Completed project – Land Stewardship Centre of Canada delivered the Septic Sense workshop program to inform rural residents on the operation and maintenance of septic systems.
 - Tailings Management – four projects (one completed). University of Alberta researcher completed his project on “Mammalian and Zebrafish Toxicity of Raw and Physico-Chemically-Treated Oil Sands Process-Affected Waters” and results suggested that crude oil sands process-affected water (OSPW) is acutely toxic in a dose-dependent manner whereas whole OSPW (organic fraction only) is not toxic at all doses tested.

** Past and present project collaborators are listed in Appendix 2a and b.*
- GoA water grant-funded projects (past and present) involved more than 250 highly qualified personnel (HQP), more than 80 collaborators and more than 20 institutions while producing more than 160 peer reviewed publications since 2013. This work supported improvements in water management policy, planning, regulations, and operational practices.

- AH contributed a total funding of \$3.46 million toward the following grants (value in brackets is the total value of grant funding allocated toward water research in 2017-18 - includes all expense categories):
 - ACFT Operating Grant (University of Calgary) - domestic well water and recreational water testing, mercury in fish testing and water cytotoxicity testing;
 - ACFT (University of Calgary) - Environmental monitoring post-Horse River wildfire surface water quality monitoring using the water cytotox test;
 - AETL (University of Calgary) - metals and arsenic speciation in water and fish;
 - Biogeochemical Analytical Service Laboratory (BASL), University of Alberta - polycyclic aromatic hydrocarbons (PAHs) in water and fish;
 - Environmental Microbiology Laboratory, University of Alberta - Waterborne pathogen monitoring;
 - Freshwater Biodiversity Laboratory, University of Alberta - Monitoring harmful cyanobacterial blooms; and
 - University of Alberta – Investigating spatial patterns in heavy metal concentration in the tissue of major fish species within the Red Deer River Watershed.
- Alberta WaterSMART Solutions/WaterPortal Society:
 - continued working on the Athabasca River Basin project Phase 3 (\$1.5 million) funded by AI, GoA, and industry partners;
 - completed the Bow River Working Group project on flood and drought mitigation options for the Bow River (\$300,000);
 - launched Water-Energy-Food Nexus project (\$85,000) Phase two funding by anonymous contributor, Alberta Real Estate Board, AI; and
 - launched Water Quality project (\$90,000) funded by Calgary Foundation, Bow River Basin Council (BRBC), Royal Bank.
- AAF is leading a project, in collaboration of the University of Alberta that evaluates aquatic ecosystem health in relation to nutrient concentrations in small streams in order to identify nutrient endpoints for agricultural watershed management programs. Total project budget is over \$1.2 million with AI support of \$400,000.
- The AIPA:
 - is partnering with AAF and Agriculture and Agri-food Canada to continue long-term water quality testing (~160 parameters) in the 13 Irrigation Districts of Alberta for the period 2016 to 2019. AIPA has committed up to a maximum of \$450,000 over the term of the project.
 - funded an invasive mussel veliger sampling program within 11 irrigation reservoirs during summer 2017 to monitor for the presence of invasive mussels. Total cost of the contract was \$90,000. Four irrigation districts collaborated with AAF on a research project to determine treatment techniques for control of invasive mussels in water conveyance infrastructure. Potash is considered the best pest management potential to treat invasive mussels in water conveyance infrastructure. Districts contributed access to varying pipeline segments.
- University of Calgary water researchers received more than \$15.91 million in research funding. Their industry collaborators include Lundin Norway AS, Total E and P Canada, Husky Energy, Petroleum Technology Alliance Canada, Cenovus, Chevron, Aramco Services Canada, and ConocoPhillips and external collaborators including, the Saskatchewan Pulse Crop Development Board, the Edmonton Community Foundation, Genome Alberta, Mitacs Inc., Petroleum Technology Alliance Canada, and the Freshwater Fisheries Society of BC. University of Calgary water researchers collaborated on research projects with various national and international universities, including St. Francis Xavier University, University of Alberta, University of South Florida, University of Quebec, and Korea University.
- University of Alberta collaborated nationally with the universities of Waterloo, British Columbia, Dalhousie, Calgary, Toronto, Lethbridge, Regina, AAFC, Environment and Climate Change Canada, NRCan, City of Edmonton, GoA ministries; internationally with Texas A and M University, University of Oregon (U.S.), Rothamsted Res (U.K.), University of Southampton (U.K.), Shiv Nadar University, Indian Institute of Technology (India), Nankai University (China), KWR Water Recycle Institute, RIVM, Delft University of Technology (Netherlands), University of Gothenburg (Sweden); with industry such as EPCOR, Sciex, Trojan Technology, WaterWerx, Armorix Inc., InteliTain Inc., Vive Crop Protection, Syncrude, Ducks Unlimited.

- University of Lethbridge CAIP Chair in Terrestrial Ecosystems Remote Sensing received \$620,000 in 2017 fiscal year for seven distinct projects. Their collaborators and funders include AI, Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring (JOSM), NSERC, City of Calgary, Mitacs, Ducks Unlimited, NRCan Canada Centre for Remote Sensing.

Indicator

Mechanism is in place where GoA/ AI or any contributing organization can interact with provincial and international organizations to identify opportunities to influence the water research agenda

Results

- AI worked with GoA staff in the Environment Collaboratory led by EDT to develop targets, focus areas and initiatives for water and environment sectors. Specific to water, the focus areas and initiatives are linked at a high level to government business plans and the needs of water users and stakeholders in the province in support of key knowledge and technology gaps identified associated with the WFL Strategy.
- AI continued participation on the Alberta Water Council (AWC) board, GoA cross-ministry WFL steering committee, shared opportunities with the CWN by supporting technical evaluation processes and co-sponsoring work where Alberta's priorities align, an associate member of COSIA and has a formal agreement for collaboration.
- Presentations by various Alberta researchers to the AHS's Natural Recreational Water Committee assisted in evaluating and responding to local recreational water issues.
 - Dr. Neumann (University of Alberta) provided analysis and expertise when reviewing water quality information and data from Hawrelak Park in Edmonton in regards to the Edmonton International Triathlon event.
 - Dr. Ashbolt (University of Alberta) provided technical expertise to the City of Calgary and AHS regarding risks associated with a natural recreational pool.
- Collaboration across provincial and federal ministries, and public health laboratories through the TAC-DW to respond to drinking water issues (e.g., lead in drinking water).
- Dr. Ashbolt participated and provided information and advice on risks associated with reclaimed water at the Public Health Working Group on Reclaimed Water (provincial).
- Drs. Ashbolt and Neumann received a CIHR grant to develop a Framework for Wastewater Re-Use in Canada.
- Joan Yee (AHS) participated in a workshop in New Brunswick, Canada with the non-governmental organization Swim, Drink, Fish Canada and recreational water quality experts from other governments (U. S. Environmental Protection Agency) to develop a recreational water open data standard (October 2017).
- Jennifer Graydon (AH) and Dr. Ashbolt participated on the federal (Health Canada) provincial territorial working group tasked with revising the "Guidelines for Canadian Recreational Water Quality."
- Dr. Neumann (as a representative from ProvLab), participated on the Alberta Drinking Water Laboratory Technical Advisory Committee. He also provided several presentations to the AHS Provincial Committee for Drinking Water.
- Drs. Neumann and Ashbolt provided updates at quarterly recreational water meetings with the Office of the Chief Medical Officer of Health and AHS.
- Drs. Rolf Vinebrooke and Mark Graham (Freshwater Biodiversity Laboratory, University of Alberta) presented and helped facilitate the Algal Taxonomy Workshop at the North American Lakes Management Society. They also worked with the Alberta Lake Management Society to taxonomically analyze phytoplankton samples collected through the provincial program LakeWatch. They also serve as scientific advisors to the Alliance of Pigeon Lake Municipalities regarding concerns with cyanobacterial blooms and their management.
- Dr. Le (AETL, University of Alberta) serves as a member of the External Advisory Committee for the National Institute of Environmental Sciences' Superfund Project "Arsenic and Manganese in Water," operated at Columbia University (New York).
- WaterSMART Solutions participated at International Desalination Association AGM in Brazil.
- The GoA participated in national committees such as Canadian Council of Ministers of the Environment (CCME).

- The AWC's multi-stakeholder membership provides a forum for the discussion and resolution of provincial water management challenges. The GoA and AI contributed to these discussions through their participation on various AWC initiatives. In 2017, the GoA and AI provided input towards the following work:
 - Recommendations to Improve Lake Watershed Management in Alberta;
 - Review of Water for Life Implementation Progress Review 2012 – 2015;
 - Looking Back: Evaluating Sector Improvements in Water Conservation, Efficiency and Productivity
<https://awchome.ca/LinkClick.aspx?fileticket=TduvZKyw-d4%3dandtabid=59>.
- The annual AIPA water conference allows GoA, AI and other organizations involved in water management to interact within and outside of the Alberta water management industry. Some of the external organizations that participated included: the University of Saskatchewan, Saskatchewan Water Security Agency, South Saskatchewan Irrigation District, Roza Irrigation District (Yakima, Washington), Washington State Department of Ecology, the University of Nebraska, and Montana Bureau of Reclamation. Fifteen presentations were delivered in the conference.
- AER/AGS shares formal partnerships with Deltares (Netherlands) and the British Geological Survey (U.K.); participated in the Groundwater Protection Council Annual Forum; has a membership in the Western Regulators' Forum; is Co-chair of the International Association of Hydrogeologists (IAH) Commission on Regional Groundwater Flow; and participated in the Interstate Oil and Gas Compact Commission.
- AEP renewed AER/AGS Memorandum of Understanding for the Provincial Groundwater Inventory Program.
- The first meeting of the ACWA International Advisory Council of high-level international experts in wastewater technology and research was held in fall 2017 in Calgary. The Council gained in-depth knowledge about the ACWA research facilities and met with the ACWA Board, researchers, and City of Calgary leaders. They will provide an assessment of the strengths, weaknesses, and opportunities that will be key in helping ACWA achieve its full potential as a world-class research facility delivering solutions for local, national, and global needs in wastewater treatment and public and environmental health.
- Dr. Maribeth Murray (University of Calgary) was appointed to the Board of Directors of Polar Knowledge Canada (POLAR). The mission of POLAR is to conduct world-class cutting edge Arctic research. POLAR is responsible for advancing Canada's knowledge of the Arctic and strengthening Canadian leadership in polar science and technology. A key component of this is to increase the understanding of marine aquatic ecosystems, their crucial importance to Arctic and global communities, and the impacts of climate change and environmental degradation. This work considers aquatic systems as part of an integrated systems approach, with an important emphasis on human impacts, and therefore aligns very much with the goals of WFL. Much of the learning can be useful to understand aquatic ecosystems in other area outside the Arctic.
- Dr. Casey Hubert (University of Calgary) served on the Technical Scientific Committee for the International Symposium on Applied Microbiology and Molecular Biology in Oil Systems, June 2017. The Symposium included research presentations on the roles of bacteria in the oil and gas industry's impact on terrestrial and marine aquatic systems – biodegradation of oil spills, changes to microbial populations, and the use of microbial and molecular biology tools for environmental surveillance. Such research contributes to the understanding of the impact that oil and gas operations have on water quality.
- Dr. Hopkinson (University of Lethbridge) worked with and presented to the AEP and AI personnel on WIP funded Water Portal project and Wetland Monitoring and classification work. In addition, he presented at AI's WIP Forum on Castle Sentinel Project, Edmonton, May 2017 and was invited to present on Alberta Water Portal project to the Environment and Climate Change Canada's Downsview Wetland Working Group.

ACTION:**IF-2 Enable the appropriate business environment and partnership opportunities to increase investment from private enterprise in innovative products, processes and services that improve water-related environmental outcomes****Indicator****Provincial investment in water research projects is leveraged greater than 1:1****Results**

Outstanding outcomes have been achieved in enabling major business and partnership opportunities

- Water and tailings projects active in 2017 attracted \$79 million in direct investments by partners including:
 - \$10 million to Water Supply and Watershed Management;
 - \$2.9 million to Healthy Aquatic Ecosystems;
 - \$47.7 million to Conservation, Efficiency and Productivity;
 - \$6.0 million to Water Quality Protection; and
 - \$12.2 million in Tailings
- Current provincial investments in water research managed through AI have an average leverage of 2.5:1 with the greatest leverage in Tailings (5:1) and Conservation, Efficiency, and Productivity (3.5:1) projects.
- In 2016, AI completed a water technology funding opportunity with SDTC. Seven joint-funded projects have been approved to advance technologies in support of water use and recycling for in situ oil sands, enhanced oil recovery, hydraulic fracturing, municipal water treatment, and infrastructure rehabilitation and repair. AI investments in the projects will be \$3.1 million with the total value of the projects \$10.8 million.

Past and present funding partners are listed in the Appendices 2a and b.

- Drs. Ashbolt and Neumann received a CIHR grant to develop a Framework for Wastewater Re-Use in Canada (\$1.9 million).
- Drs. Neumann and Nicholas Ashbolt received AI Grant: “Evaluating Microbial Risks Associated with Stormwater Management and Reuse in Alberta,” Principal Investigators (\$1.3 million; 2016-2019).
- Dr. Le received a CIHR grant (Chemical Contaminants in Traditional Food Before and After the Alberta Wildfires) to study water and food safety: Co-Principal Investigators: Chris Le, Dr. Laurie Chan and 10 collaborators (\$250,000 per year; 2016-2018).
- AI co-funded grant to Dr. Pang “Monitoring and Risk Assessment of Human Enteric Viruses in Groundwater in Rural Alberta” under a co-funded grant – “Assessing Water Quality, Microbial Risks and Waterborne Pathogens in Rural Alberta” using a One Health Framework (\$441,430; 2015-2018).
- Dr. Pang received NSERC award for “Urban Storm Water and Municipal Effluents: Innovative Solutions for Source Water Protection.” PI-Dorner S, École Polytechnique de Montréal (\$536,844; 2016-2019).
- Dr. Kinniburgh (ACFT) is a co-applicant on a five-year NSERC grant to Monica Emelko (University of Waterloo). The NSERC Network for Forested Drinking Water Source Protection Technologies (for Water Network) will investigate the impacts of forest management strategies on drinking water source quality and treatability to assess their suitability as source water protection technologies across the major ecological/forest regions of Canada. The role of the ACFT is the measurement of disinfection by-products both regulated and emerging analytes (\$525,000; 2017-2021).
- Dr. Vinebrooke (Freshwater Biodiversity Laboratory, University of Alberta) received a \$15,000 grant from the Alliance of Pigeon Lake Municipalities to develop a predictive forecasting model of cyanobacterial blooms.
- AIPA funded an invasive mussel veliger sampling program within 11 irrigation reservoirs during summer 2017 to monitor for the presence of invasive mussels. Total cost of the contract was \$90,000.
- In the 2017 fiscal year, University of Calgary water researchers received \$4.26 million in funding from the provincial government and \$11.65 million from all other funding sources. Major leveraged funding came from NSERC, Canada Research Chair programs, CIHR and CFI.

- University of Alberta water researchers received provincial funding for water-related research. Other funding sources that were leveraged by these researchers include: SDTC, NRCan, NSERC, CFI, CIHR, COSIA, EPCOR, Alberta Biodiversity Monitoring Institute, National Research Council – Industrial Research Assistance Program, Social Sciences and Humanities Research Council, Emissions Reduction Alberta, Cities of Edmonton and Calgary, Suncor Energy, FoodNet, Cenovus Energy, AI, Alberta ARTS Foundation.
- University of Lethbridge water researcher leveraged funds from Mitacs, Ducks Unlimited, NRCan and NSERC. More importantly, these projects have enabled industry and community in-kind support (Teledyne Optech, Castle Mountain Resort) of approximately \$500,000.
- University of Lethbridge water researcher leveraged access to the multi-million cutting-edge laser mapping technology and to the 100 acres of mountain side land, infrastructure and network telemetry.

ACTION:

IF-3 Engage in public discussions on water research and technology advances and challenges, using researchers, sector leaders and thought leaders to increase public awareness, engagement and debate on water resources issues

Indicator Knowledge developed in WIP is used in AEP Water Literacy Program

Results

- AEP works with the public and stakeholders on topics including wetland policy implementation, watershed planning, lakes management, water management, water reuse, water conservation, water quality, groundwater and tailings management on a regular basis.

Indicator Traffic to OSIP and other water-related websites increased

Results

- Traffic on the Working Well website increased significantly in 2017. Unique page views rose from 779 in 2015 -2016 to 2,606 in the 2016-2017 with use peaking in January - February and again in October - November.
- There was a 50 per cent increase in visiting users to the Alberta WaterPortal (albertawater.com) over the previous year.
- AAF-led projects are presented in water quality, irrigation and water supply sections of AAF's Ropin' the Web information portal.
- The Alberta Climate Records website <http://albertaclimaterecords.com/>, developed by University of Lethbridge researchers had, according to Google Analytics, 1,793 new viewers in 2017. These viewers were mainly from Alberta, but also from British Columbia and United States, Russia, United Kingdom, Brazil, China, Japan, Italy, and other countries. At least six high schools in Alberta are using the site in their classes.

Indicator GOA/ AI/ and Post-secondary Institutions (PSI) staff spoke at events on water issues

Results

- AI staff gave collectively more than 12 presentations on WIP and water-related issues in 2017. Audiences included industry, post-secondary students, teachers, government and other water stakeholder groups. Topics included:
 - Overview of the WIP;
 - Water innovation in the oil sands;
 - Water and climate innovations in Alberta;
 - Forests and water;
 - Water innovation infrastructure (AI and Innotech) supporting oil sands research and development;
 - Advancing knowledge and technology to support clean energy, environment, and water; and
 - Advancing knowledge and technology in support of water use, watershed management, and climate adaptation in Alberta.

- GoA staff presented at various conferences, forums and events regarding a variety of water-related issues and topics that included:
 - AAF's project on the derivation of nutrient endpoints for agricultural watershed management has been presented at various public forums and technical conferences;
 - the Working Well program (AAF, AEP, and AH) delivered three additional workshops in partnership with Health Canada, First Nations and Inuit Health Branch (FNIHB) to First Nations community maintenance staff;
 - Working Well program staff presented at a training session hosted by FNIHB for their community water monitoring staff and participated in local municipal events on request;
 - COSIA Oil Sands Process Water Science Workshop on Integrated Water Management;
 - Canadian Ecotoxicity Workshop; and
 - presented updates at AWC board meetings with AI on the following topics: the Environmental Monitoring and Science Division, the Water Innovation Program, and the Whirling Disease outbreak.
- University of Alberta presented and participated in over 65 conferences/workshops. Some of the keynote and invited lectures given by University of Alberta water researchers include:
 - Solid phase extraction and HPLC separation with tandem mass spectrometry for identification of N-chloro-peptides in water. The ninth National Conference on Environmental Chemistry, Zhejiang University, Hangzhou, China. October 2017 (Keynote Lecture);
 - HPLC-MS/MS identification of new halogenated nitrogenous disinfection byproducts – halogenated peptides in drinking water. The 17th Beijing Conference and Exhibition on Instrumental Analysis (BCEIA), Beijing, China. October 2017 (Keynote Lecture);
 - Analytical development for discovery of disinfection byproducts in water. Institute of Environment and Health, Jiangnan University, Wuhan, China. September 2017 (Invited Lecture);
 - Identification of water disinfection byproducts of toxicological relevance. College of Chemistry, China University of Geosciences, Wuhan, China. September 2017 (Invited Lecture);
 - Real-time cell electronic sensing of cytotoxicity of nanoparticles and air particulates. The Sixth International Colloquium on Microfluidics/The Eleventh National Conference on Micro Total Analysis System/ The Sixth National Symposium on Micro/NanoScale Bioseparations and Bioanalysis. Northeast University, Shenyang, China. September 2017 (Keynote Lecture);
 - Identification of new disinfection byproducts of health relevance: analytical and toxicological studies. 2017 Gordon Research Conference on Drinking Water Disinfection Byproducts, South Hadley, MA, USA. July 2017 (Keynote Lecture);
 - Drinking water safety: pathogens and disinfection byproducts of health relevance. The 100th Canadian Society for Chemistry Conference and Exhibition, Toronto, Ontario. May 2017. (Keynote Lecture – CIC Environment Research and Development Award Lecture);
 - Advances in water disinfection byproducts. Xiangshan Research Conference (similar to Gordon Research Conference), Beijing, China. May 2017 (Keynote Lecture);
 - Sweetened swimming pools. International Conference of Analytical Sciences, Haikou, Hainan, China. May 2017 (Keynote Lecture); and
 - Analytical and toxicological studies of disinfection byproducts: halobenzoquinones. Special Symposium Tribute to Jerold Schnoor, the former Editor-in-Chief of Environmental Science and Technology. ACS 253rd National Meeting and Exposition, San Francisco, CA, USA. April 2017 (Invited Lecture).
- University of Lethbridge
 - Using Alberta's climate records to evaluate impacts of climate change on biodiversity, Ecosystem Services and Biodiversity Science Symposium, Lethbridge, Alberta, November 2017 (Invited);
 - Mapping trends of 43 climate indices at high spatial resolution for Alberta, Canada, for the period 1950 – 2010, Canadian Association of Geographers, York University, Toronto. May 2017;
 - Dr. Hopkinson was invited to present on Alberta Water Portal project to the Environment and Climate Change Canada's Downview Wetland Working Group; and
 - Dr. Hopkinson, Vice President, IAHS International Commission on Remote Sensing participated in the discussion on future conferences and hydrological research partnerships within IAHS.

Results

- WIP funded project teams are encouraged to present their work at various conferences, forums and public events. Each project team has presented their work at one or more event. Some examples are provided below:
 - The project team for “Assessing Water Quality, Microbial Risks and Waterborne Pathogens in Rural Alberta Using a One Health Framework” gave three presentations in 2017, including a refereed presentation at the Canadian Association of Veterinary Epidemiology and Preventative Medicine 2017 conference titled “Antimicrobial resistant Escherichia coli and extended-spectrum beta-lactamase producing E. coli in Alberta’s rural well water.”
 - The project team for “Evaluating Microbial Risks and Performance Criteria for Safe Management of Stormwater and Rainwater use in Alberta” presented at the 2017 at the Conference for the Canadian Institute for Public Health Inspectors on “Case studies: risks and opportunities for reuse.”
 - The project team for “Geochemical Resource Characterization of Alberta Groundwater” gave two presentations in 2017 including a presentation on “Assessing the environmental impacts on groundwater quality in areas of unconventional energy resource development” at a workshop in Ohio convened by the National Ground Water Association.
 - The project team for “Quantifying Groundwater Recharge for Sustainable Water Resource Management” gave seven presentations in 2017 including a presentation on “The role of soil freezing and thawing in hydrological processes: Canadian case studies” at the 2nd Asian Conference of Permafrost in Japan.
 - The project leads for “Predicting Alberta’s Water Future” and “Adapting to Changing Water in Alberta”, Drs. Monireh Faramarzi and Greg Goss, gave > 30 presentations at conferences / symposia including (i) a presentation on project results and implications to the November 2017 meeting of the Alberta Water Council; and (ii) the American Geophysical Union Fall Meeting (San Francisco).
 - The project team for “The Castle Watershed; a new water resource assessment framework for a sentinel system at the crown of the continent” gave five presentations at conferences in the last year including climate change impacts on tree line changes presented at the American Geophysical Union conference (San Francisco) and Canadian Symposium of Remote Sensing (Montreal).
 - The project team for “Expanding Functional Flows” gave five presentations at conferences in the last year including project updates on the importance of riparian forests and functional flows at the American Geophysical Union conference (San Francisco).
 - The project team for “The future of water supply and watershed management in Alberta: Best source to tap practices for source water protection in the eastern slopes” gave 18 presentations in the past year at science conferences and workshops including (i) American Geophysical Union Fall Meeting (San Francisco); (ii) Canadian Water Network, Blue Cities (Toronto); (iii) Canadian National Conference on Drinking Water (Ottawa). In addition, the team reached out to broader public audiences on 9 occasions to speak on the science of source water protection and were interviewed by the media including television, radio and print on at least 13 occasions.
 - The project team for “Rocky Mountain Water Supply Resilience and Vulnerability Evaluation” gave a number of presentations, including (i) “A hydrogeophysical survey of groundwater flow pathways in an alpine headwater basin” given at the 22nd European Meeting of Environmental and Engineering Geophysics (Barcelona, Spain) and (ii) “Evaluating the impact of blowing snow and avalanche redistribution on modelling alpine snowpack and snow covered area over the Canadian Rockies” given at the Western Snow Conference (Boise, Idaho).
 - The project team for “Sustainable Wetland Habitat: Reclamation targets, design criteria and wetland policy implementation” presented results at the annual meeting of the Canadian Geophysical Union (May 2017, Vancouver, B.C) and at the annual meeting of the Ecological Society of American (August 2017, Portland, Oregon).
- The team led by AAF provided updates on the project “Nutrient objectives for small streams in agricultural watersheds of Alberta” at the Canadian Aquatic Biomonitoring Network Science Forum (March 2017, Edmonton, Alberta) and at the North Saskatchewan River Watershed Alliance water quality forum (April 2017, Edmonton, Alberta).

- Dr. Le (AETL, University of Alberta) delivered 6 presentations at national and international conferences. For example, Dr. Le presented an invited lecture on “Arsenic Species and Chlorination Byproducts in Drinking Water” at the 2017 Pittsburg Conference, held in Chicago in March, 2017.
- Dr. Le (AETL) and his team published four papers in 2017 on the topics of water and/or arsenic. Their paper “Keep swimming but stop peeing in the pools” (Zheng, Q.; Blackstock, L.K.J.; Deng, W.; Wang, H.; Le, X.C.; Li, X.-F. *Journal of Environmental Sciences*, 2017, volume 53, pages 322-325. DOI: 10.1016/j.jes.2017.03.006) has both scientific and public educational value.
- Dr. Kinniburgh (ACFT) gave an oral presentation, “Alberta Cyanobacteria Beach Monitoring Program - Microcystins”, at the Canadian Trace Organic Workshop, April, 2017.
- Dr. Huang (ACFT) gave an oral presentation, “Methodologies for the Alberta Cyanotoxin Monitoring”, at the Canadian Trace Organic Workshop, April 2017.
- Xu Zhang (ACFT) participated at the International Symposium on Halogenated Persistent Organic Pollutants (POPs) - DIOXIN 2017, Aug 2017. The purpose of the conference is to promote scientific education and research on POPs in the environment.
- Dr. Elham Zeinjahromi (ACFT) participated at the Agilent ICP-QQQ symposium, Gatineau, QC, April, 2017. Technical experiences related to the application of IC/MS/MS in analyzing environmental contaminants in water were shared with peers.
- Birget Moe (ACFT) shared research findings on the Effects of Halobenzoquinone and Haloacetic Acid Water Disinfection Byproducts on Human Neural Stem Cells at the Gordon Research Seminars and Conference on Drinking-Water Disinfection By-Products, South Hadley, MA, USA, July, 2017.
- Amy MacDonald (ACFT) participated in the 11th international Symposium on Recent Advances in POPs and Emerging Contaminant Analysis, Boston, MA, May 18-19, 2017. The symposium was to share research findings and discuss analytical challenges in POPs and emerging contaminants in the environment.
- Dr. Pang (University of Alberta) presented “Norovirus outbreaks in Alberta” in the Canadian Clinical Microbiology conference, Toronto, May 2017.
- CEO of WaterSMART Solutions and Executive Director a frequent speaker on water issues.
- Mike Nemeth, Alberta WaterSMART - Water supply challenges and opportunities: locally and globally.
- Brent Paterson: Proposed Strategic Management Plan to prevent, manage, and control Invasive Dreissenid Mussels in Alberta’s Irrigation District.
- AER/AGS staff involved in more than 20 events related to non-saline groundwater resources, saline aquifer mapping, groundwater use, regional groundwater mapping, and water-related regulatory issues.
- Dr. Sean Rogers (University of Calgary) presented at the Eawag Aquatic Research, Switzerland, Distinguished Lecture Series on the topic of “Genes Propose and Environments Dispose: Ecological Genomics and the Genetics of Adaptation in Fishes.”
- Dr. Rogers (University of Calgary) presented at the Canadian Society for Ecology and Evolution 2017 meeting on “Speciation seen through the lens of biomechanics: A multidisciplinary approach using fish locomotion and feeding in marine and freshwater three spine stickleback.” Dr. Cathy Ryan (University of Calgary) presented at the Farvolden Lecture Series at the University of Waterloo on the topic of “Groundwater, Bubbles, and Energy.” The presentation covered the basics of free-phase gas occurrence and transport in groundwater, and the implications for transport pathways and rates, sampling and analyses from wells.
- Dr. Jackson (University of Calgary and Scientific Director, ACWA) presented “ACWA Infrastructure: Next-generation wastewater treatment processes with applications to global water issues” at the York Region, Strategy and Innovation in Newmarket, Ontario.
- Dr. Scott Jasechko (University of Calgary) presented a Canadian Water Network webinar, entitled “Raindrops to Rivers,” on how naturally-occurring heavy and light types of water (isotopes) help water scientists track water as it flushes through shallow soils, streams and deeper groundwater aquifers.

- Dr. Jasechko (University of Calgary) published the paper “Global aquifers dominated by fossil groundwaters but wells vulnerable to modern contamination” in Nature Geoscience 10(6) 2017. The paper demonstrated the vulnerability of groundwater to modern-era pollutants and concluded that water quality risk should be considered along with sustainable use when managing fossil groundwater resources the paper received extensive international news and social media attention.
- Drs. Stephen G. Foster and Stewart B. Rood (University of Lethbridge) published “River regulation and riparian woodlands: Cottonwood conservation with an environmental flow regime along the Waterton River, Alberta. River Research and Applications. Released on line DOI: 10.1002/rra.3156 <http://onlinelibrary.wiley.com/doi/10.1002/rra.3156/full>
- Dr. Rood et al. “Growth of riparian cottonwoods: heterosis in some intersectoral Populus hybrids and clonal expansion of females. Trees” 31:1069-1081. doi:10.1007/s00468-017-1531-9. <https://link.springer.com/article/10.1007/s00468-017-1531-9>
- Dr. Rood et al. “Increasing discharge from the Mackenzie River system to the Arctic Ocean. Hydrological Processes” 31: 150-160. <http://onlinelibrary.wiley.com/doi/10.1002/hyp.10986/full>

ACTION:

IF-4 Invest in trans-disciplinary team-based research and innovation in areas of strategic priority to facilitate the emergence of innovative water policy and practice

Indicator

Trans-disciplinary teams are formed to address complex nature of water research

Results

- Efforts were made to encourage trans-disciplinary team-based approach in the WIP Grant (2016-2022). Most new projects are employing a trans-disciplinary team-based approach. For example, project “Adapting to changing water in Alberta”, the research team includes expertise in modelling, hydrology, glaciology, groundwater, biodiversity, agriculture, economics, climatology and stakeholder engagement.
Post-secondary institutions are leveraging on projects from municipal, provincial, national, and international expertise.
 - Alberta Cyanobacteria Monitoring Program for Public Health (ACMPPH; provincial).
 - Dr. Ashbolt (University of Alberta) ISO 305 technical advisor for sustainable sanitation systems; ISO 282 Technical Committee for Water Reuse standard; CSA/ICC voting member for rainwater and stormwater harvesting.
 - CIHR Team Grant: Environments and Health: Programmatic Grants in Intersectoral Prevention Research “Developing a Framework for Wastewater Reuse in Canada: Using Quantitative Microbial Risk Assessment, Risk Communication, and Community Engagement for Evaluating Water-Fit-For-Purpose Reuse,” PI Dr. Ashbolt with Dr. Neumann (University of Alberta), \$2,100,199 for 2017-2022.
 - As a PI, Dr. Le (AETL) participates in an NSERC CREATE program with a trans-disciplinary team of researchers from Universities of Alberta, Ottawa, Carleton, and Laval. This Collaborative Research and Training Experience (CREATE) national program includes expertise of chemistry, environment, toxicology, and public health.
 - As a team leader, Dr. Le organized a multi-disciplinary team of researchers and knowledge users to address environmental health questions relevant to the Alberta Aboriginal communities.
 - Dr. Kinniburgh and Lorinda Butlin (ACFT) are members of Alberta Drinking-water Laboratory Technical Advisory Committee (ADLTAC, Provincial).
 - University of Alberta researchers participated in several provincial, national, and international trans-disciplinary teams working on water issues.

- Dave Kinniburgh and Dorothy Huang are working with Dr. Jackson and Advancing Canadian Wastewater Assets (ACWA). This is a University of Calgary and City of Calgary partnership researching waste water treatment.
- Dave Kinniburgh is a co-applicant in NSERC grant: ForWater Network. The ACFT is measuring DBPs, regulated and emerging analytes.
- Cross-ministry (Health and AEP) and academic (University of Alberta, Mark Poesch) working group to study metals in the Red Deer River System.
- AAF regularly forms trans-disciplinary project teams with a variety of provincial and federal government researchers, agricultural commodity groups, and academic institutions to study agricultural water quality and water use efficiency as it relates to the provision of clean water for food and livestock production and the development of strategies to enhance environmental sustainability of the agriculture industry in Alberta.
- A multidisciplinary team from University of Calgary's Department of Geoscience joined up with researchers from the University of Guelph and the University of British Columbia for an unprecedented look into how leaking methane acts in shallow groundwater. Methane gas, which can be released both naturally and from man-made sources — is a primary component of the natural gas that fuels our kitchen stoves, heats our hot water, and powers the furnace that keeps our homes warm in the wintertime. However, when methane gas leaks into groundwater systems and into the atmosphere, it sparks environmental and climate change concerns. Underground methane can have negative impacts on drinking water quality, and contributes to greenhouse gas emissions if it escapes into the atmosphere. The team's findings provide important insight that will help other researchers and government bodies understand methane gas contamination of shallow groundwater. The study was funded by an NSERC Strategic Project Grant and the results were published in the paper "Mobility and persistence of methane in groundwater in a controlled-release field experiment" in Nature Geoscience 10(4) 2017.
- Drs. Sylvia Checkley and David Hall in the University of Calgary Faculty of Veterinary Medicine are conducting a study on microbial risks and waterborne pathogens in rural drinking water. A three-year study from 2014 to 2017, in collaboration with the Alberta Provincial Laboratory for Public Health (ProvLab) and the federal government's FoodNet sentinel site in Alberta, will assess water quality, microbial risks and waterborne pathogens in rural Alberta using a One Health Framework. The project is funded by the Alberta Livestock and Meat Agency and AI.
- University of Lethbridge researcher Dr. Kienzle and his team's work on geographical information systems (GIS) generated an idea of using geo-spatial technologies for a company "Farmers Edge" (Precision Farming Information to over 1 million acres). This company is still growing and hiring local Geographers and Computer Scientists.
- University of Lethbridge researcher Dr. Hopkinson is collaborating on water projects nationally with University of Waterloo and internationally with researchers in Germany and U.S.

Indicator

Innovative water policies, programs and practices, that are resulting from transdisciplinary teams addressing complex water problems

Results

- Teams investigating the opportunities and risk associated with municipal water re-use led by Drs. Neumann and Ashbolt (University of Alberta) are built with interdisciplinary science, policy, regulatory and stakeholder advisory committees to ensure the research addresses risks identified by multiple stakeholders and to provide results meaningful to policy, regulation and operations.
- The AHS cyanobacterial bloom public health advisory process is the process by which AHS monitors high-use recreational beaches for cyanobacterial blooms, conducts human health risk assessments and issues public health advisories related to presence of cyanobacterial blooms. This process has been in place (and managed at a provincial level) since 2010 and is refined annually based on research and assessment conducted using AH funding.
- A pilot project was undertaken with 10 partner sites to evaluate a new risk assessment tool for beaches. This pilot required collaboration between AHS, beach operators (including several operated through AEP) and the University of Alberta Environmental Microbiology Laboratory to analyze samples for a new indicator of fecal contamination (Enterococcus).

- Fish consumption advisories for the Red Deer River were revised based on the work of the cross-ministry (Health and AEP) and academic (University of Alberta, Mark Poesch) working group studying metals in the Red Deer River System.
- Bow River Working Group continues to address complex water problems.
- Cooperative Stormwater Management Initiative Master Agreement signed and Cooperative formed to manage stormwater east of Calgary.
- Alberta's Irrigation: A Strategy for the Future Strategy Measures 2016-17: An annual measurement of results identified in the strategy targets are reported. Research addresses Irrigation productivity, irrigation application efficiency, water conservation, water supply, and environmental stewardship. ([http://www1.agric.gov.ab.ca/\\$Department/deptdocs.nsf/all/irr14885/\\$FILE/2017_alta_irrigation_strategy_measures.pdf](http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/irr14885/$FILE/2017_alta_irrigation_strategy_measures.pdf)).
- Water reuse pilots are underway.
- Tailings Management Framework is being implemented.
- AWC brought together representatives from industry, municipalities, non-government organizations, the GoA and AI to work in three areas: lake watershed management, water CEP, and the implementation review of the Water for Life strategy. In particular, the AWC has supported Alberta's seven major-water using sectors in reporting and evaluating their results in relation to water CEP over the last ten years.
- AIPA members are collaborating with AAF in developing treatment techniques for control of invasive mussels in irrigation systems, and AEP and AAF are collaborating in registering a control product.
- AIPA participates in multidisciplinary teams including three WPACs –BRBC, Oldman Watershed Council (OWC) and South East Alberta Watershed Alliance (SEAWA); the Bow River Management Water Management Project; the WaterSMART-led “Watershed Resilience and Restoration Project”; the Wetland Stewardship Working Group (NAWMP); the Water Reuse Technical Advisory Committee; and the Alberta Water Council.
- AER and AEP received recommendations for the Area-Based Regulation from the multi-stakeholder panel on enabling the use of alternatives to high-quality non-saline water by the oil and gas sector in the Municipal District of Greenview and this report was released in June 2017. (https://aer.ca/documents/reports/AreaBasedRegulation_RecommendationReport.pdf)
- AER updated directive 085: Fluid Tailings Management for Oil Sands Mining Projects.
- University of Calgary water researchers, in collaboration with researchers from Brock University, Qassim University (Saudi Arabia), and UBC Okanagan, have developed a decision support system (DSS) to optimize the performance of different operations of small water treatment systems to improve day-to-day decisions. The support system includes a data management system, knowledge-based system, performance assessment of different unit processes, fault tree analyses, preventive and corrective actions and event tree analysis. The developed DSS is advanced to an automated user-friendly program that can be used by treatment plant operators to assess system performance. This system was outlined in the paper “Performance management of small water treatment plant operations: a decision support system,” published in Water and Environment Journal 31(3) 2017.
- University of Calgary water researchers from the Department of Geography and the Faculty of Veterinary Medicine, in collaboration with the Alberta Health Services Provincial Laboratory, conducted a study on the effects of the 2013 Calgary flood and assessed the risk of drinking water well contamination. The first objective of this study was to determine if the flood caused an increase in private drinking water well contamination in the Calgary Health Zone by comparing contamination rates to previous years. The second objective was to determine which environmental factors were associated with contamination during this flood event. The study recommended that homeowners who live in a high-risk area ensure their wells are properly maintained to reduce risk of water well contamination. This was published in the paper “Lessons learned from the 2013 Calgary flood: Assessing risk of drinking water well contamination” in Applied Geography 80(1) 2017.
- Activities conducted by University of Alberta research teams led to innovative water policies or practices.

Table 2: Summary of the results achieved under outcome “Innovation Platform”

Actions IP-1 Maintain and enhance critical provincial innovation infrastructure that supports leading-edge water research and innovation	
Indicator	AI role in maintaining and enhancing water innovation infrastructure in Alberta
Results	<ul style="list-style-type: none"> AI funded directly the following institutions: <ul style="list-style-type: none"> University of Alberta University of Calgary University of Lethbridge University of Regina University of New Brunswick University of British Columbia University of Saskatchewan University of Waterloo Southern Alberta Institute for Technology (SAIT) Northern Alberta Institute for Technology (NAIT) *AI invests in projects and not directly in infrastructure. Some projects may include purchasing of new equipment for labs that will remain the property of the project team/institution after the project is complete. AAF has used AI funding to procure equipment for studying aquatic ecosystem health in agricultural watersheds. These capital items will provide AAF with capacity to maintain long-term projects on agricultural water quality and outside of current funding cycle.
Indicator	All GoA investment in innovation infrastructure
Results	<ul style="list-style-type: none"> AH contributed funding toward the following grants (value in brackets is the total value of grant funding allocated toward water research infrastructure/ equipment in 2017/18): <ul style="list-style-type: none"> University of Calgary ACFT Operating Grant - ACFT is AH’s primary toxicology laboratory and is part of the public health laboratory network in Alberta. This lab is funded to conduct routine (drinking and recreational) water monitoring as well as cutting edge research (cytotoxicity program). AH funding in 2017/18 included infrastructure for laboratory equipment and space at the University of Calgary (\$1,419,433); University of Calgary ACFT – Environmental monitoring post-horse river wildfire surface water quality monitoring using the water cytotox test (\$45,000); University of Alberta (Dr. Le) – AH funding is provided annually to maintain expertise, laboratory methodology to assess arsenic and other metals in different media including water, soil, fish and other traditional foods (\$30,000); University of Alberta BASL– develops low level techniques for measurement of polycyclic aromatic hydrocarbons (PAHs) in water and fish (\$37,500); University of Alberta Environmental Microbiology Laboratory – Using previous AH funding, Dr. Pang developed comprehensive methods “detection of viruses in different water samples” which can only be performed in her research lab in Canada. Currently this technology is maintained by research funds such as NSERC and CIHR. In 2017/18, AH funding contributed to the development and implementation of new analytical techniques (e.g., quantitative polymerase chain reaction, qPCR) for characterization of pathogens in drinking and recreational water (\$35,000); University of Alberta Freshwater Biodiversity Laboratory - AH funding contributed to development and maintenance of new analytical techniques (e.g., flow cytometry) for rapid assessment of harmful algal (cyanobacterial) blooms (\$10,000); and AAF Water Quality Section - \$400,000.

Results

- ACWA - The University of Calgary's ACWA Research Facility, embedded within the City of Calgary's Pine Creek Wastewater Treatment Centre, bridges the research gap between bench/pilot-scale testing and applications used in full-scale municipal wastewater treatment plants. ACWA replicates real-world situations and enables research that cannot be performed elsewhere in the world.
- International Microbiome Centre – The University of Calgary's International Microbiome Centre (IMC) is a translational research centre designed to investigate the microbiome of plants, animals, and the physical environment, including lakes, rivers and other water sources. One of the applied research objectives is to look at the impact of microbes in food and water sources for the optimization of agriculture and livestock industries. Other research areas relate to the identification of human and animal pathogens in various water sources, and understanding the roles of waterborne microbial communities in environmental health and industrial applications. As such, the centre can contribute to research on water quality and water management. The IMC is funded through Western Economic Diversification Canada, the GoA, and the Cumming School of Medicine (CSM) in Calgary.
- Biogeoscience Institute – The University of Calgary's Biogeoscience Institute (BGI) is a leading field research station located in Kananaskis Country that provides support to researchers and research groups, university courses, education groups and community partners. The research is conducted at the institute by individual scientists, and groups of scientists within five research clusters, of which water is an important component:
 - Animal ecology and wildlife conservation biology;
 - Ecohydrology, meteorology, and watersheds;
 - Vegetation dynamics and forestry;
 - Ecosystem services and environmental economics; and
 - Human, domestic animal and wildlife disease interactions.

Examples of water-related research projects include (see more complete list at https://bgs.ucalgary.ca/research/science-research-projects#quickset-field_collection_quicktabs_6):

 - Groundwater processes of the Fortress Ski Area;
 - Flow monitoring and modelling at Sulphur Mountain Thermal Springs;
 - Subsurface hydrological processes in alpine and lowland permafrost environments; and
 - Sustainable exploitation of freshwater fisheries

The institute is funded by the University of Calgary and through user fees from universities, schools, community partners and international organizations. The research program supports more than 75 researchers representing more than eight countries and 20 national and international organizations.

- Bamfield Marine Sciences Centre (BMSC) (BC) – The BMSC supports diverse coastal and marine research of the highest calibre, and is recognized as among the very best research and training facilities in the world. Situated in the Town of Bamfield, within the traditional territory of the Huu-ay-aht First Nation in Barkley Sound, and adjacent the Pacific Rim National Park Reserve, BMSC offers unparalleled access to a wide array of environments – including unique coastal, marine and rainforest habitats and exceptional species diversity. The BMSC is a shared campus of the Universities of Victoria, British Columbia, Alberta, Calgary, and Simon Fraser.
- Arctic Institute of North America (AINA) and Kluane Research Station (Yukon) - The mandate of AINA is to advance the study of the North American and circumpolar Arctic through the natural and social sciences, the arts and humanities and to acquire, preserve and disseminate information on physical, environmental and social conditions in the North. The Kluane Research Station, located in the Yukon, has fostered research projects spanning the disciplines of glaciology, geomorphology, geology, biology, botany, zoology, hydrology, limnology, climatology, high-altitude physiology, anthropology and archaeology.

- Energy Bioengineering and Geomicrobiology Research Group (led by CAIP chairs Drs. Marc Strous and Hubert). The mission of the Energy Bioengineering and Geomicrobiology Group is to develop new solutions for a clean energy future and to apply subsurface and marine microbiology for energy sector innovation.
- University of Lethbridge initiated the planning phase of a new Headwaters Institute to partner with community, science and policy stakeholders in mountain environments. This effort will leverage their existing facilities in the Castle Headwater region and partnerships with provincial and federal parks.
- University of Lethbridge's West Castle field station and associated weather station telemetry and web site. Met (meteorological data) network is regularly accessed and used by the ski hill, the Castle village community, public recreationalists and AEP personnel. <http://artemis.uleth.ca:8080/CastleMet/index.html>

Actions

IP-2 Support timely, affordable access and use of existing research infrastructure and commercialization capacity in Alberta and other jurisdictions.

Indicator Investments in WIP projects leverage existing research infrastructure and capacity

Results

- Two projects supported by the WIP are leveraging program support and funding from Global Water Futures: Solutions to Water Threats in an Era of Global Change, a University of Saskatchewan-led research program that is funded in part by a \$77.8-million grant from the Canada First Research Excellence Fund. The projects are (i) Rocky Mountain Water Supply Resilience and Vulnerability led by Dr. John Pomeroy and (ii) Wetland Ecosystem Functions: Drivers, Evaluation, and Management Implications, led by Dr. Rebecca Rooney.

Indicator Access and use of post-secondary and AI research infrastructure

Results

- University of Alberta water research labs were used by internal and external partners/ organizations. Some of the external partners/organizations include: EPCOR, Scienx, Trojuan Technology, Firmenich, Merck, Worley Parsons, Kehewan first nations, provincial and federal governments, cities of Edmonton and Calgary, U.S. Environmental Protection Agency, U.S. National Cancer Institute, University of Michigan.

Actions

IP-3 Foster pan-Alberta knowledge and action networks and communities of practice to share evidence-based information, activities and best practices.

Indicator Annual forums/ conferences, workshops that bring the community together

Results

- AI supported Land Stewardship Centre of Canada to develop the Septic Sense program. The program raised awareness, shared knowledge and informed practice change regarding septic system operation and maintenance. A total of 19 workshops were held between January 18, 2017 and March 30, 2017. 623 individuals participated in these workshops.
- 27 Working Well Workshops (with 636 participants) focused on best practices for the public were conducted (AF, AEP, and AH supported). Workshop speakers include staff from AAF, AEP, AHS, and Alberta Water Well Drillers Association.
- AAF presented AI-funded water research to AEP Limnology Community of Practice and Alberta WPAC public forums.
- 2017 AIPA Water Conference: a number of GoA representatives attended the conference.
- In Fall 2016, The University of Calgary Sustainability Office held a panel discussion on "Water: Too Much or Too Little?" as part of its Sustainability Speaker Series. The event included a roundtable discussion exploring the future of water over the next 20 years in Calgary and beyond. Speakers discussed a variety of issues relating to water such as, scarcity, water rights, flood mitigation, water treatment and pollution of municipal water, and wetland conservation. Panelists included: Arlene Kwasniak, professor emerita, University of Calgary; Leland Jackson, Scientific Director, ACWA and professor, University of Calgary; Paulette Fox, President, Harmony Walkers; and David Laidlaw, Research Fellow, Canadian Institute of Resources Law.

- In Spring 2017, the Calgary Institute of Humanities hosted its 37th annual community forum, “Water in the West: Rights to Water/Rights of Water,” which explored environmental concerns about water and First Nations’ perspectives on the resource. Speakers included Michelle Daigle, postdoctoral researcher at UBC; David Laidlaw, Research Fellow at the Canadian Institute of Resources Law at University of Calgary; and Adrian Parr, UNESCO co-chair of Water Access and Sustainability and director of Taft Research Centre at the University of Cincinnati.
- In Fall 2017, University of Calgary Haskayne School of Business Centre for Corporate Sustainability hosted Dr. Kim Sturgess, CEO of Alberta WaterSmart, to present on the topic of “Water for a Sustainable Economy in Alberta: Think Globally, Plan Regionally, Act Locally.” This latest Enbridge Research in Action seminar provided perspective on the interconnectedness of our water, energy, and food resources, as well as the numerous risks, pressures and tradeoffs that result from this nexus, and how our ability to manage Alberta’s water resources under a changing climate relies on finding collaborative solutions to these complex issues. The event was open to members of the public as well as University of Calgary students, faculty and staff.
- In Fall 2017, the University of Calgary Haskayne School of Business Centre for Corporate Responsibility held its Conoco-Phillips IRIS seminar featuring a talk by Dr. Arlene Kwasniak, Faculty of Law, University of Calgary. The talk, “Climate Change Adaptation: The water/policy conundrum,” outlined the climate change/water/policy nexuses and how governments, citizens, industries, and groups can facilitate climate change adaptation.
- In Winter 2017, ACWA Scientific Director Dr. Jackson and the Alberta Pharmacists’ Association launched the ENVIRx program, which aims to divert expired prescription drugs from the water systems and landfills in the Calgary area and mitigate the impact these “dead drugs” have on our environment. The pilot program began with participation from six pharmacies and has since grown to over 500 participating pharmacies (<http://www.rxa.ca/for-the-public/medication-disposal.aspx>).
- University of Lethbridge water researcher initiated a meeting with the Minister, AEP to discuss hosting a Canadian Mountain Network Centre of Excellence in Alberta where University of Lethbridge would like to lead the technology cluster of the network.



Actions

IP-4 Improve access to water data and information to enable research in areas of strategic priority.

Indicator

AEP and AER coordinate data management so that public data is available through respective web portals (e.g., Oil Sands Information Portal (OSIP), WaterPortal, Water Use Reporting System (WURS)).

Results

- Reports and data releases are available on the AER and the AER/AGS websites to improve access to water data and information.
- AER updates reporting on sector water use (<http://aer.ca/data-and-publications/water-use-performance>).
- AH is working with AEP to assess data needs and share data, where possible;
 - acquired access to AEP's Fisheries and Wildlife Management Information System (FWMIS) to improve QA/QC of fish data used by both ministries.
 - creating a data visualization tool called the AEPHIN which will provide water chemistry data from private drinking water wells to the public. The underlying AEPHIN datasets are currently available through the Open Government Portal (OGP, January 2017). AEPHIN will also present data about cyanobacterial blooms in local recreational waters when completed (this dataset will also be released on OGP). The public launch of AEPHIN was delayed due to the Fort McMurray Wildfire Recovery effort. However, a key AEPHIN component, a mobile app named "Should I Eat this Fish?" was successfully launched in July 2017. The associated mercury in fish from Alberta waterbodies dataset has also been updated recently on OGP (March 2017).
 - in the process of standardizing and formalizing sample and data management processes.

Additional relevant information sources other than AEP and AER coordinated data are listed below:

- AI continued to support the Alberta WaterPortal. New content is being developed for the WaterPortal through a project titled "The Future of Water: Engaging Albertans in the Water-Energy-Food Nexus."
- Reports from completed projects are publicly released and available at AI online database (<http://eipa.alberta.ca/>).
- AI funded projects, Mountain hydromet: <http://artemis.uleth.ca:8080/CastleMet/index.html> and Water Portal project: <http://artemis.uleth.ca/>.
- The AWC website houses a wealth of reports on provincial solutions to water management challenges in Alberta. Partners and the public can access this information to make better water management decisions.



Table 3: Summary of the results achieved under outcome “Innovation Capacity”

Actions	
IC-1 Recruit and retain researchers and practitioners in water-related sciences and applications, with specific emphasis on advancing trans-disciplinary environmental sciences	
Indicator	Leading water related scientists are recruited and retained in Alberta. WIP provides investment resources to support the outcome

Results

- AI continues to support retention of existing scientific and research capacity.
- Some of the scientists retained/ recruited are listed below:
 - With a Distinguished University Professor award and a Tier 1 Canada Research Chair, Dr. Chris Le is retained at the University of Alberta. Dr. Le provides leading expertise in water arsenic and environmental health effects.
 - Dr. Ashbolt, international reclaimed water expert, was recruited to AIHS Translational Chair at the University of Alberta in 2014.
 - Dr. Tao Dong, Canada Research Chair Tier II in Molecular Ecology of Waterborne Microbes, University of Calgary. His research study centers to understand how the microbial community responds to wastewater treatment and whether the current strategy is effective in preventing the spread of waterborne pathogens and transfer of genetic materials including genes for virulence and antimicrobial resistance.
 - Dr. Jasechko, University of Calgary focuses his research on the impact of climate change on one of the most important resources on the planet — fresh water. He explores how changes to the global climate impact the ways that precipitation transforms into river water or groundwater and how those changes affect both humans and other terrestrial life forms.
 - Dr. Susana Kimura-Hara joined University of Calgary in summer 2017 to work closely with researchers at ACWA. Dr. Kimura’s research interests are in the areas of drinking water treatment, analytical chemistry and toxicology.
- Approximately 30 scientists were retained or recruited at University of Alberta.

Indicator	GoA and GoC invest in water related researchers (chairs)
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Results

- AI is currently supporting the following water-related chairs:
 - NSERC Associate IRC in Sustainable Urban Water Development, Dr. Yang Liu;
 - NSERC IRC for Colleges for Optimization of OTSG Performance to Increase Water Recycling and Reduce Fouling and GHG Emissions, Dr. Vita Martez;
 - AI Translational Health Chair in Water Born Disease Prevention, Dr. Ashbolt; and
 - NSERC Senior IRC in Oil Sands Water Treatment, Dr. Mohamed Gamal El Din.
- University of Calgary Chairs:**
 - Chair in Natural Resources Law, Canada Research Chair Tier II in Molecular Ecology of Waterborne Microbes, in Physical Hydrology, in Hydrogen and Catalysis, and in Climate Change;
 - Campus Alberta Innovation Program (CAIP) Chair in Geomicrobiology and in Reservoir Biogeoscience;
 - Canada Research Chair Tier I in Petroleum Geology, Wastewater Engineering and Environmental Physiology and Toxicology;
 - AITF/iCORE Strategic Chair in Sensing and Monitoring; NSERC/City of Calgary Industrial Research Chair in Advanced Technologies for Wastewater Treatment; and
 - NSERC Industrial Research Chair in Petroleum Microbiology.
- University of Lethbridge Chairs:**
 - CAIP Chairs in: Terrestrial Ecosystems Remote Sensing and Aquatic Health, Canada Research Chair in Aquatic and Mechanistic Toxicology, Board of Governors Research Chairs in Natural Sciences and Human Sciences.

Indicator**University water-related researchers****Results**

- University of Alberta currently has approximately 47 water principle investigators in seven faculties including ALES, Arts, Education, Engineering, Medicine and Dentistry, School of Public Health and Science including:
 - Dr. Le (University of Alberta), a leading expert in arsenic and conducts research, teaches and collaborates with U.S. EPA on arsenic. He also serves as a panel member for the U.S. National Institute of Environmental Health Sciences (NIEHS) and for CIHR.
 - Dr. Kinniburgh, Clinical Professor University of Alberta and Adjunct Associate Professor (ACFT) University of Calgary, an expert in clinical chemistry and clinical and analytical toxicology. He leads research and service work in public health related topics including water chemistry, trace elements, volatile organic compounds, pesticides, arsenic, disinfection by products, phthalates, cyanotoxins and cytotoxicity in drinking water, recreational water and other environmental water, and mercury contamination in fish.
 - Dr. Pang, University of Alberta, is conducting research in viruses in water and qPCR detection of cyanobacterial genes coding for toxin procedures.
- University of Calgary has currently 75 water researchers in the Faculties of Science, Arts, Law, Environmental Design, Veterinary Medicine, Schulich School of Engineering, and Cumming School of Medicine.
 - Dorothy Yu Huang, (ACFT), University of Calgary leads research and service work in public health related topics including cytotoxicity profiling in surface water, cyanotoxins in recreational water, and mercury contamination in fish, as well as database management.
- University of Lethbridge currently has approximately 30 active water researchers from various faculties.

Indicator**Graduate students and postdocs employed in environmental science sector in Alberta and other provinces****Results**

- Two postdoctoral fellows were recruited to working on detection of cyanobacterial toxin genes and amoeba-related pathogens in Alberta Recreational waters with University of Alberta's Drs. Pang, Neumann and Ashbolt (Waterborne Pathogen monitoring). Total funding for water-related research in 2017-18 under this grant was \$50,000.
- Dr. Le (AETL) supervised (and employed) nine graduate students, four postdoctoral fellows, two research associates, and a summer research student for the project "Analysis of metals and arsenic species in Alberta food and water for human exposure assessment." Total amount of funding spent on salary for water-related research in 2017-18 under this grant was \$159,000.
- Two postdoctoral fellows were recruited for trace elements analysis and cytotoxicity profiling at the ACFT. A total of \$123,208 was received from the University of Calgary ACFT operating grant. Total amount of funding spent on salary for all water-related testing and research in 2017/18 under this grant was \$1,500,500.
- BASL (University of Alberta) hired and trained two laboratory technologists for analyzing PAH in water and fish. The grant also partially funded a senior technologist for monitoring quality control procedures. Total amount of funding spent on salary for water-related research in 2017-18 under this grant was \$110,000.
- AH funded project "Monitoring of harmful algal (cyanobacterial) blooms" supported a research associate and a technician to work on tracking harmful algal (cyanobacterial) blooms (HABs) using automated cell counting. Total amount of funding spent on salary for water-related research in 2017-18 under this grant was \$90,000.
- AAF is supporting two graduate students at University of Alberta under AI-funded water quality projects.
- GoA (EDT and AE) supports Mitacs' three internship programs. Following are the investments made on water-related research for the period of December 2015 – December 2016 (data provided by Mitacs):
 - Accelerate: \$76,000 supported 7 interns; and
 - Globalink: \$50,000 supported 10 interns

- University of Alberta currently has:
 - approximately 182 graduate students (PhD and Masters);
 - 41 postdoctoral scholars; and
 - 47 faculty members involved in water-related research as part of their research programs
- The University of Lethbridge maintains strong undergraduate programs enabling students to succeed in the environmental and water related industries. Students were recruited by consultants (e.g. Farmer's Edge, Water Smart, Golder Associates), industry (e.g. Cenovus), government institutes and offices. In the ARTEMIS laboratory, 20 trainees worked in water related themes in 2017.
- University of Lethbridge (ARTEMIS laboratory) recruited a post-doctoral fellow to work on machine learning algorithm implementation to aid with wetland classification and monitoring.

Actions

IC-2 Develop appropriate post-secondary trans-disciplinary programs to produce graduates that have the necessary skill sets to work in complex water resource environments

Indicator GOA post-secondary investment in water-related programming

Results

- Of the \$36.2 million AI has invested into water-related innovation projects ongoing or completed in 2017, \$21 million was directed to post-secondary institutions with \$18.7 million principally held by Alberta institutions.
- AER participated in two academic advisory committees.

Indicator Enrolled Students

Results

- The total number of enrolments were approximately 1,997 in various water-related programs offered by publicly funded institutions (Figure 4).

Indicator PSI programs

Results

- Publicly funded post-secondary institutions are currently offering approximately 34 water-related programs in the province (Figures 2 and 3a).
- University of Calgary water researchers Drs. Masaki Hayashi, Edwin Cey, and Edward Johnson are faculty investigators and collaborators with the University of Saskatchewan's NSERC CREATE for Water Security, along with researchers from the University of Manitoba, the University of Waterloo and McMaster University. The NSERC CREATE for Water Security is a comprehensive research and training program for graduate students and postdoctoral fellows.

Actions

IC-3 Encourage Alberta researchers and technology development organizations to be engaged in relevant national and global water-related networks

Indicator Alberta's research and innovation community communicate with and collaborate with national and international water-related innovation networks, water conferences

Results

Interdisciplinary teams built across institutions are common in Water Innovation Program research projects:

- The Southern Rockies Watershed Project led by Drs. Sillins (University of Alberta) and Emelko (University of Waterloo) includes researchers from University of Alberta, Oregon State University, University of Waterloo, Brock University, Rothamsted Research UK, Southampton University UK, and Environment and Climate Change Canada. The research and advisory team included membership from industry, municipalities, and government science staff.

- The Adapting to Changing Water in Alberta (ACWA) project led by Drs. Goss and Faramarzi (University of Alberta) includes researchers from University of Calgary, University of Regina, ABMI, Agriculture and Agri-food Canada, Alberta WaterSMART as well as EAWAG Switzerland.
- Dr. Ashbolt collaborated internationally on reclaimed and recreational water. Recently assisted the U.S. Water Re-Use Foundation to develop risk-based approach for standards for non-potable water systems.
- Dr. Le collaborated internationally with the U.S. EPA, the U.S. Water Research Foundation, Chinese Academy of Sciences, and 20 universities/institutes around the world.
- BASL (University of Alberta) provided analytical services to analyzing total mercury and methylmercury in water in the Red Deer River for Mark Poesch's research program.
- Dr. Pang has collaborated with the Institute of Microbiology in Academy of Sciences, Heilongjiang Province, P. R. of China on research and technical development of pathogens in water since 2012.
- Dr. Vinebrooke (Freshwater Biodiversity Laboratory, University of Alberta) is collaborating with Mark Lewis (Mathematics Department, University of Alberta) on modeling cyanobacterial dynamics in lakes.
- Dr. Kinniburgh (ACFT) has established provincial, national, and international collaborations based on various research interests:
 - microcystin analogue analysis with University of Montreal (Zofia Taranu);
 - water cytotoxicity with ACWA and City of Calgary (Leland Jackson and Norma Ruecker);
 - cytotoxicity profiling data mining with University of Alberta (Yau Shu Wong);
 - real-time cell analysis with ACEA Bioscience (Yama Abassi);
 - environmental contaminants cytotoxicity analysis with National Toxicology Program (U.S.);
 - arsenic in water with Veterinary Medicine, University of Calgary (Judit Smits);
 - disinfection by-product with University of Waterloo (Monica Emelko);
 - arsenic analysis with University of Alberta (Dr. Le);
 - freshwater oil spill remediation study with the International Institution for Sustainable Development-Experimental Lakes Area (IISD-ELA);
 - cyanotoxins in lake water with AEP (Ron Zurawell); and
 - post wildfire water quality monitoring using the water cytotox test with drinking and wastewater treatment facilities in Town of Athabasca and Regional Municipality of Wood Buffalo (Fort McMurray, Fort MacKay and Fort Chipewyan).
- AIPA is a member of the international Northwest Irrigation Operators group and regularly presents on Alberta Water Management topics.
- The AIPA agreed to act as an advisor on the Nebraska Water Centre research project "Revitalizing Food Production Systems in the Missouri River Basin: An Environmental, Social and Economic Approach to Water Management" if funding for the project allows it to proceed. The AIPA will provide input into the project regarding similarities and differences in the food production systems within the Missouri River Basin and in southern Alberta.
- AER-AGS staff participated in four international, two national and one provincial conferences where water issues were discussed. AGS/AER staff participate on one international commission (IAH).
- In 2017, University of Calgary water researchers published papers in collaboration with researchers from 112 organizations in 27 countries. Top collaborating institutions included University of Alberta, China University of Petroleum, Aarhus University (Denmark), University of Victoria, University of Saskatchewan, Calvin College (USA), Princeton University (USA), University of Manitoba, University of British Columbia, University of Waterloo, Max Planck Institute (Germany).
- International water research related networks University of Alberta researchers collaborated with:
 - American Water, Water Environment and Reuse Foundation, Water Research Foundation, KWR Water Recycle Institute, Wageningen University, Sydney Water Corp;
 - Canadian Institutes for Health Research (Healthy Signature Environments Initiative) - in collaboration with the Netherlands (Dr. Gertjan Medema), Mark LeChevalier (American Water), and Jay Garland (USEPA);

- community-based organization in New Zealand;
 - Water NSERC Strategic Partnerships for Networks;
 - University of Barcelona (Spain) on wastewater treatment research;
 - India-Canada Centre for Innovative Multidisciplinary Partnerships to Accelerate Community Transformation and Sustainability (IC-IMAPCTS);
 - International Desalination Association;
 - International Drought Experiment;
 - International Water Resource Economics Consortium;
 - Research group in Chile;
 - Trondek Hwechin First Nations; and
 - Water Research Foundation.
- Dr. Hopkinson (University of Lethbridge) participated as a Vice President in the IAHS International Commission on Remote Sensing Conference.

Indicator	Incentives are available to enable researchers and/ organizations to be engaged in networks, conferences, etc.
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Results

- AI supports its water researchers through attendance at conferences or workshops as allowable grant expenses.
- AI supported students with reduced-fee registrations who attended the COSIA-AI-NRCan Oil Sands Innovation Summit.
- Funds from the VPR conference/workshop grants are available to researchers in support of scholarly significant, national or international, conferences or workshops held in Calgary and area.
- Support from NSERC, CAIP, AI and University Professional Development fund.

Actions

IC-4 Accelerate the movement of discoveries and new applications into practice, commercial products and services by enhancing receptor capacity in industry and government

Indicator	Examples of technology deployment in industry
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Results

- AI and SDTC launched a joint call for Water Technology Projects in March 2016. Seven joint AI-SDTC projects and two AI only projects were selected for funding. The technologies address water challenges in hydraulic fracturing, enhanced oil recovery, oil sands and municipal water management. All nine projects include end-user partners that could be first adopters of the technology once commercialized.
- University of Alberta research led to deployment of methodologies on the following:
 - analytical methodologies for detecting contaminants in water;
 - Canadian Forest Products Ltd deployed best management practices for sediment control during forest harvesting operations;
 - Calgary Water Services, Regional Municipality of Wood Buffalo deployed “Technologies for rapid response to changing source water quality in drinking water utilities”;
 - health care protocols for evaluating water quality are being transferred into the health care sector (Provincial Laboratory for Public Health) as new tools for public health monitoring and surveillance for water quality;
 - life cycle water footprint models;
 - a decentralized wastewater treatment technology has received funding for a community scale demonstration - for source diverted blackwater treatment, which is under construction now;
 - peat application depths guided reclamation strategies in oil sands;

- rapid methods for *Cryptosporidium* viability testing, microbial source tracking qPCR to identify fecal sources in waters, setting local risk-based pathogen limits; and
- testing the modification in the sprinkler designs in the sports field (<http://edmontonjournal.com/news/local-news/university-of-alberta-math-whiz-helps-develop-robotic-sprinkler-technology>).
- University of Lethbridge researchers developed:
 - a low cost high accuracy LED-based snowpack and water surface monitoring systems to compete with traditional low accuracy sonic based tech. This work has been discussed with a Campbell Scientific for possible commercialization but researchers are more interested in supporting student entrepreneurship in University if suitable mechanisms are in place;
 - LiDAR snowpack sampling and scaling framework for headwater water resource modeling in collaboration with Airborne Imaging Inc., Calgary and AEP. Technology and application is proven and costs benefit could be demonstrated if desired but mechanism to move into monitoring policy / practice is not obvious at this point; and
 - tested a new LiDAR inland bathymetry technology through support from Optech Inc (Ontario) and project partnership with City of Calgary. Project did not work as hoped but researchers developed in house processing routines to enhance the commercial OTS processing routines and fed this information back to the manufacturer in Ontario.

Indicator **Research, technology, and applications have been translated into policy implementations in government**

Results

- Project outcomes are shared with policy makers where appropriate.
- WIP projects and outcomes are shared at monthly Technology Information Policy (TIP) meetings. TIP meetings include representatives from AEP, AAF, ADOE, EDT, and AER.
 - Quantifying Groundwater Recharge for Sustainable Water Resource Management: The spatial distribution of groundwater recharge resulting from the project provides key information to the Groundwater Management Framework led by the Water Policy Branch of AEP and the Provincial Groundwater Inventory Program of AEP and AER, particularly for the strategic focus area of the Edmonton-Calgary Corridor. Numerical tools for estimating groundwater recharge will be used by AEP/AER to better understand groundwater availability and be used to guide the development of the water management framework and policy.
 - Evaluating the Public Health Risks Associated with Wastewater Reuse in Alberta Through Quantitative Microbial Risk Assessment: The work carried out in this project has helped inform pathogen reduction targets in conjunction with water reuse guidance documents under development by AEP. Project team members participate in the GoA Water Reuse Committee and a parallel committee that is addressing health-related issues associated with water reuse.
 - Functional Flows – A Practical Strategy: Successful implementation of functional flows has led to healthier aquatic ecosystems, rivers and riparian forests. This novel environmental flow management strategy, developed by the University of Lethbridge team is now being exported to other river systems in western North America.
 - Towards Integrated Source Water Management: Research led by University of Alberta researchers (Southern Rockies Watershed Project) resulted in an enhanced understanding of the long-term effects of post-fire forests on water quality and quantity.
 - Drs. Ashbolt, Neumann and Pang (School of Public Health) continue to support development of policy on recreational water management program via introduction of *Enterococcus* qPCR as a superior water quality indicator.
 - Dr. Pang is developing qPCR techniques to detect cyanobacterial genes coding for toxin production in recreational water.
 - Dr. Vinebrooke (Freshwater Biodiversity Laboratory, University of Alberta) is developing rapid automated cyanobacterial cell count procedures used to assist AHS in assessing recreational water quality. This tool is being used by AHS when assessing risk at recreational sites.

- Dr. Kinniburgh (ACFT):
 - provided water testing data to AH and AHS for risk analysis and policy development purposes;
 - implemented routine use of an assay for the common cyanobacterial toxin microcystin in collaboration with Dorothy Huang (ACFT). This tool is being used by AHS when assessing risk at recreational sites;
 - provided fish mercury data to AH for the development of advisories related to fish consumption; and
 - provided technical advice and recommendations to government on policies and initiatives via ADLTAC and TAC-DW.
- Dr. Le (AETL) served on the U.S. National Institute of Environmental Health Sciences (NIEHS) panel on the U.S. Superfund program.
- AAF project on developing nutrient objectives for small streams is intended for use as a planning target and measure of success for agricultural watershed management programs in Alberta.

Indicator **Public engagements/ conferences have increased the movement of discovery to application**

Results

- In 2017, ACWA Scientific Director and University of Calgary professor Dr. Jackson and six Calgary Co-op Pharmacy stores launched the Medi-Bin pilot program to raise public awareness of the issue of “dead drugs” and promote diversion of expired prescription drugs from the water systems and landfills in the Calgary area in order to mitigate their impact on our environment. Dr. Jackson personally built self-funded dead drug drop-boxes that were installed in the co-op stores and provided educational inserts to be included when pharmaceuticals are sold to customers. The program was officially launched in June 2017 with significant media coverage. Statistics are being collected through ENVIRx, a drug disposal and collection program supported by the Alberta Pharmacists’ Association. Indications are that the six stores are experiencing a much higher rate of return of dead drugs and improved public understanding. <http://www.ucalgary.ca/utoday/issue/2017-06-15/university-calgary-and-calgary-co-op-launch-prescription-drug-dropoff-program>
- University of Lethbridge researchers presented snow sampling framework and technologies in various conferences.

Indicator **Alberta researchers are filing patents**

Results

- University of Alberta filed 18 patents with seven accepted.
 - Dr. Le filed two new U.S. patents in 2017. These new technologies will have potential applications for detecting environmental contaminants.

Indicator **Incentives (such as grants and grant renewals) are in place and facilitate the adoption of new technologies**

Results

- The WIP provides grants in support of technology development to address water challenges in Alberta. AI connects project teams with services such as AI Entrepreneurial Investments, Kinetica, Innovate Calgary, and TEC Edmonton to accelerate and strengthen the path to commercialization.
- Growing Forward 2 “Irrigation Efficiency program” helps producers to invest in new or upgraded Low Pressure Centre Pivot (LPCP) irrigation equipment for their operations, improving the efficiency of energy, and water use on Alberta farms.
- Growing Forward 2 “On Farm Water Management program” provides technical assistance to agricultural producers to complete a Long-term Water Management Plan (LTWMP) and shares the cost of related enhancements of their on-farm water supply management.
- Growing Forward 2 grants facilitate the adoption of the most efficient irrigation systems by farmers.

Indicator**Research and researchers are being recognized and/or receiving awards****Results**

- The AI supported Chair in Oil Sands Tailings, Mohamed Gamal el-Din, was a 2017 ASTech Award Winner for Innovation in Oil Sands Research.
- Natural Sciences and Engineering Research Council (NSERC) Canadian Graduate Scholarship (\$17,500 per year) and University of Alberta scholarship (\$6,500) to Caitlyn Donaldt.
- Dr. Le was invited to join the editorial advisory board of “Metallomics,” an international journal of the Royal Society of Chemistry (U.K.).
- Dr. Le was appointed to the scientific advisory board of the Overseas Chinese Office of the State Council (China).
- Lisa Gieg, Peak Scholars in Entrepreneurship, Innovation and Knowledge Engagement Award.
- Josephine Hill, Research Excellence Award, APEGA and Killam Annual Professor.
- Dr. Jasechko, Young Scientist Award, Canadian Geophysical Union.
- Bernhard Mayer, Killam Annual Professor.
- Marc Strous, Peak Scholars in Entrepreneurship, Innovation and Knowledge Engagement Award.
- Milana Trifkovic, Schulich Engineering Education Outreach team, Excellence in Science and Technology Public Awareness, ASTech.
- University of Alberta water researchers received Petro-Canada Young Innovator Award and CIC Environment Research and Development Award.
- Dr. Hopkinson, University of Lethbridge received prestigious NSERC Accelerator funding of \$120,000 for the ecosystem and wetland change research.

Indicator**Evidence based policy development with input from scientist****Results**

No update is reported on this indicator in 2017.



Appendix 2a

List of Project Collaborators

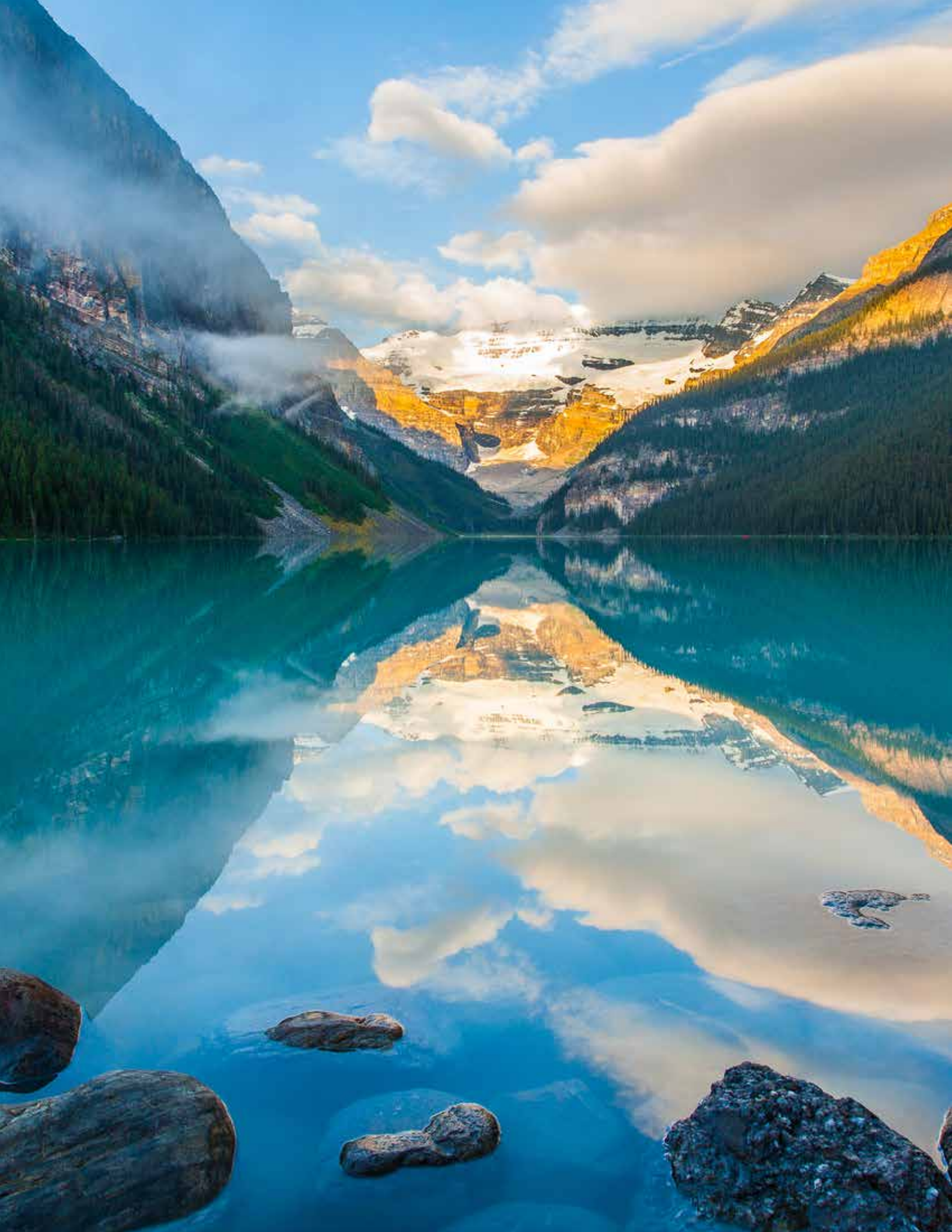
Alberta Agriculture and Forestry
Alberta Biodiversity Monitoring Institute
Alberta Energy Regulator
Alberta Environment and Parks
Alberta Health
Alberta Health Services
Alberta Irrigation Projects Association
Alberta Municipal Affairs
Alberta Real Estate Foundation
Alberta WaterPortal
Alberta Onsite Wastewater Management Association
Agar Canada Ltd.
Agriculture and Agri-food Canada
ATCO
Bow River Basin Council
Brewster Travel Canada
Brock University
Canadian Centre for Remote Sensing
Canadian Forest Products Ltd.
Canada's Oil Sands Innovation Alliance
Canadian Water Network
Castle Mountain Resort
City of Airdrie
City of Calgary
City of Edmonton
City of Red Deer
Conoco Phillips
County of Wetaskiwin
DeSaH
Devon Canada Corp.
Eastern Irrigation District
Eawag Switzerland
Enerplus
Environment and Climate Change Canada
EPCOR
Forward Water Technologies
Fortress Mountain Resort
Fossil Water Corporation
Ground Effects Energy Inc.
Imaginea Energy
Inside Education
Intensive Livestock Working Group
Irrigation Districts
Klohn Crippen Berger
Land Stewardship Centre
Luxmux Technology Corp.
Malvern Instruments
McMaster University
Mitacs
Nakiska Ski Resort
National Collaborating Centre for Environmental Health
Natural Resources Canada
NDT Ultrasonics
NSERC
Optimal Solutions Inc
Parks Canada
Public Health Agency of Canada
Regional Municipality of Wood Buffalo
Rothamsted Research
Saltworks
Shell Canada
SICON LLC
Spray Lakes Sawmills
SewerVue
Sustainable Development Technology Canada
Swirltex
Terrapure Environmental
Town of Drayton Valley
TransAlta
University of Alberta
University of British Columbia
University of Calgary
University of Lethbridge
University of New Brunswick
University of Regina
University of Saskatchewan
University of Southampton
University of Waterloo
Veolia Water Technologies Canada
Wageningen University
WaterSMART
waterStrider Treatment Inc.
WaterWerx Renewables Inc.

Appendix 2b

List of Funding Partners

**** Note there is some overlap with the project collaborators list.**

Agar Canada Corp	Luxmux Technology Corp
Agriculture and Agri-Food Canada	Mitacs
Alberta Agriculture and Forestry	Nexen
Alberta Biodiversity Monitoring Institute	NSERC
Alberta Economic Development Authority	Optimal Solutions Inc.
Alberta Energy Regulator	Pengrowth
Alberta Environment and Parks	Regional Municipality of Wood Buffalo
Alberta Irrigation Projects Association	Repsol Oil and Gas Canada
Alberta Real Estate Foundation	RJ Oil
Alberta WaterSMART	Saltworks Technologies
ATCO	SDTC
Canadian Forest Products Ltd.	SewerVue
Canadian Foundation for Innovation	Shell Canada Ltd.
City of Calgary	SICON LLC
City of Edmonton	Social Science and Humanities Research Council
Canadian Natural Resources Limited (CNRL)	Spray Lake Sawmills
ConocoPhillips	Statoil (Athabasca Oil)
COSIA	Suncor Energy Ltd.
Eastern Irrigation District	Swirtex
ecoEnergy Innovation Initiative	Syncrude Canada Ltd.
Economic Development and Trade	Teck Resources Ltd.
Electro-Kinetic Solutions Inc.	Total E&P Canada Ltd.
EPCOR	University of Alberta
fRI	University of Calgary
Global Water Futures (CFREF Program)	University of Lethbridge
IDE Technologies Ltd.	University of Saskatchewan
Imperial Oil Canada Ltd.	University of Waterloo
Irrigation Districts	WaterWerx
Israel Government (CIESTF)	Western Irrigation District
Land Stewardship Centre of Canada	Westmoreland Coal
Laricina	



Definitions of Acronyms

AAE – Alberta Advanced Education	DSS – Decision Support System
AAF – Alberta Agriculture and Forestry	EDT – Economic Development and Trade
AAFC – Agriculture and Agri-Food Canada	EKS – Electrokinetic Solutions
ACFT – Alberta Centre for Toxicology	FNIHB – First Nations and Inuit Health Branch
ACMPPH – Alberta Cyanobacteria Monitoring Program for Public Health	FWMIS – Fisheries and Wildlife Management Information System
ACWA – Advancing Canadian Wastewater Assets	GHG – Greenhouse Gases
ADLTAC – Alberta Drinking-water Laboratory Technical Advisory Committee	GIS – Geographical information Systems
AEP – Alberta Environment and Parks	GoA – Government of Alberta
AEPHIN – Alberta Environmental Public Health Information Network	HPLC – High-Performance Liquid Chromatography
AER – Alberta Energy Regulator	HQP – Highly Qualified Personnel
AETL – Analytical and Environmental Toxicology Laboratory	IAH – International Association of Hydrogeologists
AGS – Alberta Geological Survey	IAHS – International Association of Hydrological Scientists
AH – Alberta Health	IC – Innovation Capacity
AHS – Alberta Health Services	ICCVAM – Interagency Coordinating Committee on the Validation of Alternative Methods
AI – Alberta Innovates	IC-IMAPCTS – India-Canada Centre for Innovative Multidisciplinary Partnerships to Accelerate Community Transformation and Sustainability
AINA – Arctic Institute of North America	IDM – Irrigation Water Demand Model
AIPA – Alberta Irrigation Projects Association	IF – Innovation Focus
APEGA – Association of Professional Engineers and Geoscientists of Alberta	IMC – International Microbiome Centre
ARIF – Alberta Research and Innovation Framework	IP – Innovation Platform
AWC – Alberta Water Council	JOSM – Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring
AWRIS – Alberta’s Water Research and Innovation Strategy 2014: A Renewal	LiDAR – Light Detection and Ranging
BGI – Biogeoscience Institute	LPCP – Low-Pressure Centre Pivot
BRBC – Bow River Basin Council	LTWMP – Long-Term Water Management Plan
BASL – Biogeochemical Analytical Service Laboratory	MFT – Mature Fine Tailing
CAIP – Campus Alberta Innovation Program	NAIT – Northern Alberta Institute of Technology
CARI – Comprehensive Academic and Research Institute	NAWMP – North American Waterfowl Management Plan
CCME – Canadian Council of Ministers of the Environment	NIEHS – National Institute of Environmental Health Sciences
CEP – Conservation Efficiency and Productivity	NRCan – Natural Resources Canada
CFI – Canada Foundation of Innovation	NSERC – Natural Sciences and Engineering Research Council
CIHR – Canadian Institutes of Health Research	NSERC-IRC – Natural Sciences and Engineering Research Council- Industrial Research Chair
CIPHI – Canadian Institute of Public Health Inspectors	NWIO – Northwest Irrigation Operators
COSIA – Canada’s Oil Sands Innovation Alliance	OECD – Organization for Economic Cooperation and Development
CREATE – Collaborative Research and Training Experience	OSIP – Oil Sands Information Portal
CRI – Canadian Rivers Institute	
CSM – Cumming School of Medicine	
CWN – Canadian Water Network	



OSPW – Oil Sands Process-affected Water
OTSG – Once Through Heat Recovery Steam
Generators
OWC – Oldman Watershed Council
PAHs – Polycyclic Aromatic Hydrocarbons
POLAR—Polar Knowledge Canada
POPs—Halogenated Persistent Organic Pollutants
qPCR – quantitative Polymerase Chain Reaction
RCP – Research Capacity Program
SAGD – Steam-Assisted Gravity Drainage
SAR – Synthetic Aperture Radar
SDTC – Sustainable Development Technology Canada
SEAWA – South East Alberta Watershed Alliance
SSRB – South Saskatchewan River Basin
TAC-DW - Technical Advisory Committee on Safe
Drinking Water
U.K. – United Kingdom

U.S. – United States of America
U.S. EPA – United States Environmental Protection
Agency
TAC-DW— Technical Advisory Committee on Safe
Drinking Water
TDP – Technology Development Program
WFL – Water for Life: Alberta’s Strategy for Sustainability
WIP – Water Innovation Program
WISE – Water Institute for Sustainable Environments
WPAC – Watershed Planning and Advisory Council
WTDC - Water Technology Demonstration Centre

List of Contributing Organizations

Government of Alberta ministries and agencies:

Alberta Advanced Education
Alberta Agriculture and Forestry
Alberta Energy Regulator
Alberta Environment and Parks
Alberta Geological Survey
Alberta Health
Alberta Innovates
Alberta Water Council

Post-Secondary Institutions:

University of Alberta
University of Calgary
University of Lethbridge

Industry:

Alberta Irrigation Projects Association

Non-for-profit Organizations:

Mitacs
Alberta WaterSMART

Other organization:

Foothills Research Institute

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