2016 NATIONAL WATER AND HYDRAULIC FRACTURING SURVEY: IDENTIFYING SHARED OPPORTUNITIES

Canadian Water Network

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HIGHLIGHTS

Canadian Water Network (CWN) conducted a national prioritization survey in 2015 to identify shared regional and national priorities for informing decision making related to water and hydraulic fracturing. Over 240 representatives were invited to complete the survey: federal, provincial and territorial government departments; local and Indigenous governments; industry and industry associations; non-governmental decision makers; and researchers in various sectors including government and academia.

Respondents were asked to self-identify as decision makers (those involved in making decisions related to hydraulic fracturing policy, regulations or investment), influencers (those who are influencing decisions by engaging with decision makers around hydraulic fracturing priorities and concerns) or informers (those informing decision making through research).

The survey asked respondents to identify priorities from lists of key knowledge needs, opportunities to advance knowledge through research and opportunities with the best potential to be addressed through a shared investor approach, all drawn from CWN's 2015 Water and Hydraulic Fracturing Report (overview report).

Results were analyzed by response perspective (decision makers, influencers, informers) as well as by region (Western, Northern, Central and Atlantic Canada, and National). Areas of agreement on priorities within sectors and regions, as well as alignment between sectors and regions, were also examined.

The following survey results will be used as the basis for further work to establish an understanding of shared regional and national priorities, and to identify opportunities to address knowledge needs through shared investment in research.

Key Priority Thread	• **Baseline, monitoring and cumulative effects.**
Shared Priorities	
Knowledge needs	• Establish **baseline data** to assess cumulative effects. • Understand **regional water balances** and water use forecasts.
Opportunities to advance knowledge through research	• Design cumulative effects monitoring frameworks. • Assess **risks** associated with contaminants of concern. • Develop regional cumulative effects-based water plans.
Best potential to be addressed through a shared investor approach	• Conduct **social and economic cost-benefit analyses**.

Multi-sectorial Priorities	• **Data disclosure**, **formats and standards**. • **Subsurface contaminant detection, toxicity assessment** and **impact monitoring**, including techniques and technologies. • **Indicators and thresholds** for managing cumulative effects.
Sectoral Priorities	
Government	• Shared priorities with influencers and informers: baseline data, cumulative effects monitoring and health risk assessment. • Strong agreement on **aquifer monitoring and toxicity concerns** regarding leakage of methane and other contaminants. • Moderate agreement on water balances, data disclosure and cost-benefit analyses.
Industry	• Shared priority with other sectors: strong agreement on regional water balances and forecasting, and cost-benefit analyses. • Moderate agreement on **indicators and thresholds** to manage cumulative effects, **public opinion** and how the public is informed.
Influencers (includes non-profit groups, Indigenous groups and industry associations)	• Agreed with all shared priority areas noted across sectors. • Additional agreement on **data/data disclosure**, long-term subsurface conditions, **indicators and thresholds** and assessing **public opinion**.
Informers (includes researchers, research managers and research funders)	• Shared priority with other sectors: cumulative effects and baseline data. • Additional agreement on **aquifer monitoring to detect impacts** of methane and other contaminants.

Indigenous perspectives (across sectors: influencers, informers and government)	• Agreed in particular on **vulnerable communities**, **Indigenous rights** and **comparison of experiences**, indicators and thresholds and **regulatory approaches** for integration.
Regional and National Government Priorities	
Western Canada	• Agreement on **risk assessment and toxicity** monitoring, regional water balances, data/data disclosure, **cumulative effects** monitoring/indicators and **regulatory approaches** for integration.
Northern Canada	• Beyond shared priorities, additional agreement on **data formats and standards**, baseline data to detect contamination, assessing **methane migration** and **wastewater** toxicity.
Central & Atlantic Canada	• Additional agreement on **toxicity concerns of methane leaks** and **wastewater**, and comparing **wastewater technologies**.
National	• In addition to shared priorities identified across sectors and region, focus on risk assessment and **data and disclosure**.

INTRODUCTION

The increase of hydraulic fracturing in recent years has led to discussion amongst a broad range of actors. Leading science must underpin decisions, but researchers informing this debate have found it challenging to keep up with the knowledge that is needed. Decision makers are similarly seeking effective ways to address needs and opportunities for diverse stakeholders, while balancing risks and concerns. The issues of water use, management and protection are central to many discussions about hydraulic fracturing. In response to these challenges, Canadian Water Network (CWN), an innovation hub for water policy and practice, and Canada's leading water research design and management organization, launched its water and hydraulic fracturing program, which is focused on identifying the priority knowledge needs of government and industry, and working to strategically address those needs by providing decision-ready knowledge.

In 2014, CWN funded five national multi-disciplinary research projects to identify the top priority knowledge needs and the best options to advance them to enable effective decisions related to management of risks and impacts of hydraulic fracturing on water. Based on the findings of these projects, CWN released its overview report in October 2015 identifying the most relevant knowledge needs impacting decision making, and the best opportunities to address these knowledge needs through research. Given the complex set of questions and knowledge needs around hydraulic fracturing, strategic prioritization of short- and long-term needs for decision making is required to ensure that relevant knowledge can effectively support decisions.

A survey was conducted between November and December of 2015 to identify national and region-specific priorities from the knowledge needs identified in the overview report. This current summary report summarizes the methods, results and observations of the survey. Survey results and observations were used as the basis for discussions during the Western Canadian Forum on Water and Hydraulic Fracturing in February 2016. The outcomes of the forum will be made available in subsequent reports.

Canadian Water Network would like to acknowledge Environment and Climate Change Canada for funding the survey, and thank all respondents who shared their perspectives.

METHODS

Survey development and distribution
CWN's 2015 Water and Hydraulic Fracturing overview report identified a number of areas where knowledge is needed to inform decisions around water and hydraulic fracturing in Canada. To gain a better understanding of the national and regional priorities and opportunities in these areas, CWN developed a survey to solicit input from key individuals who contribute to the discussion on hydraulic fracturing in Canada.

The survey was conducted from November 24 to December 18, 2015. Survey invitations were sent directly to approximately 240 potential participants from diverse sectors representing a variety of important perspectives involved in making, informing and influencing decisions around water and hydraulic fracturing in Canada. Invitees included: representatives from federal, provincial and territorial government departments; local and Indigenous governments; industry and industry associations; non-governmental decision-makers; and researchers in various sectors including government and academia. Industry associations were asked to complete the survey as well as distribute the survey to relevant members; university research offices were also asked to distribute the survey to relevant researchers; and government contacts were encouraged to ensure that other relevant departments were invited to submit a response. Where appropriate, groups were asked to coordinate a common response to avoid duplication. Thus, the total number of people who received the link to the survey is unknown but may be considerably higher than the initial 240.

Respondent groups
Respondents were asked to indicate which of the following perspectives best described their contribution to the discussion on hydraulic fracturing and water in Canada at the time of completing the survey:

- **Decision maker:** those involved in making decisions related to hydraulic fracturing policy, regulations or investment (includes but not limited to government regulators, policy analysts supporting decision making agencies, municipal governments, Indigenous governments, companies or investors involved in hydraulic fracturing operations or activities);
- **Influencer:** those influencing decisions by engaging with decision makers around hydraulic fracturing priorities and concerns (includes but not limited to watershed groups, Indigenous groups, community groups or members, industry associations); or
- **Informer:** those informing decision making through research (includes but not limited to university researchers, government researchers, research managers, research funders).

Survey questions
Based on their response perspective (decision maker, influencer or informer), respondents were guided through slightly different versions of the survey, which allowed for tailored demographic questions and provision of questions that were relevant to respondents' perspectives and experiences.

Following the demographic questions, the survey consisted of three main sections:

1. **Knowledge needs to inform decision making**

2. **Opportunities to advance knowledge through research**

3. **Opportunities with best potential to be addressed through a shared investor approach**

In section 1, respondents were presented with a list of 26 knowledge needs (drawn from the overview report) and were asked to select up to 10 priority knowledge needs that represent, from their perspective, what we most need to know to inform decisions related to hydraulic fracturing and water. Following this, respondents who had indicated they were decision makers were also asked to identify the decision timeline within which the knowledge is needed (less than 1 year, 1-2 years, 2-3 years, 3-5 years, 5-10 years, or 10 or more years).

In section 2, respondents were presented with a list of 24 opportunities to advance knowledge through research (also drawn from the CWN overview report) and were asked to select up to 10 opportunities that, from their perspective, have the most potential to inform decision making.

Section 3 was completed only by decision makers and influencers. These respondents were presented with the same list of 24 opportunities to advance knowledge through research that was presented in section 2. This time respondents were asked to select up to 10 opportunities that, from their perspective, had best potential to be addressed through a shared investor approach.

Each of the knowledge needs and opportunities to advance knowledge through research presented in sections 1, 2 and 3 were drawn directly from the overview report, and are based on the results of CWN's five national multi-disciplinary research projects. Each of the 26 knowledge needs and 24 opportunities to advance knowledge through research were identified by experts as key areas of interest for informing decision making. See Appendix A for the list of knowledge needs and opportunities, and corresponding instructions to survey respondents, presented in sections 1, 2 and 3 of the survey.

The goal of the survey was to determine where shared regional and national priorities exist, and to begin to identify the best opportunities to advance knowledge through a shared investor approach. The survey was not intended to eliminate interest areas from further consideration, or to generate a list of ranked priority areas.

RESULTS

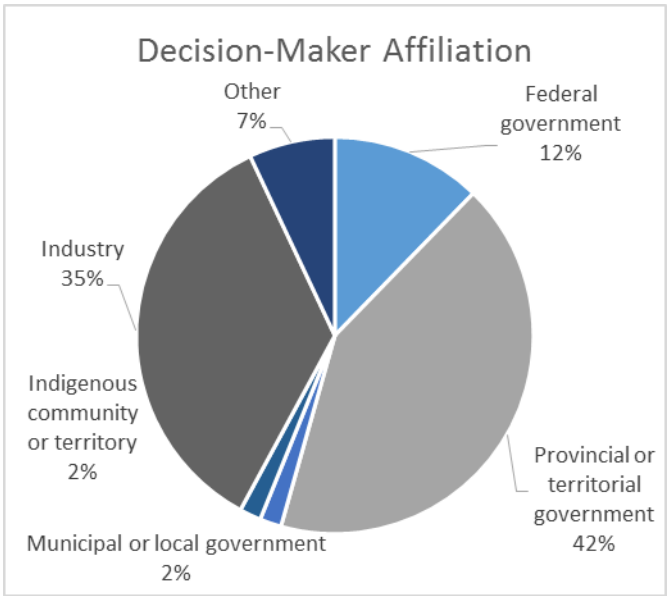
Demographics

Out of the 105 respondents that completed the survey, 57 identified as **decision makers**, 13 identified as **influencers** and 35 identified as **informers**. The geographic range of responses (see Table 1) was similar to the geographic range of potential participants based on the survey invite list, although representation from Western Canada was higher due to additional industry participation (presumably based on wider distribution of the survey from industry associations).

Table 1. Geographic coverage.

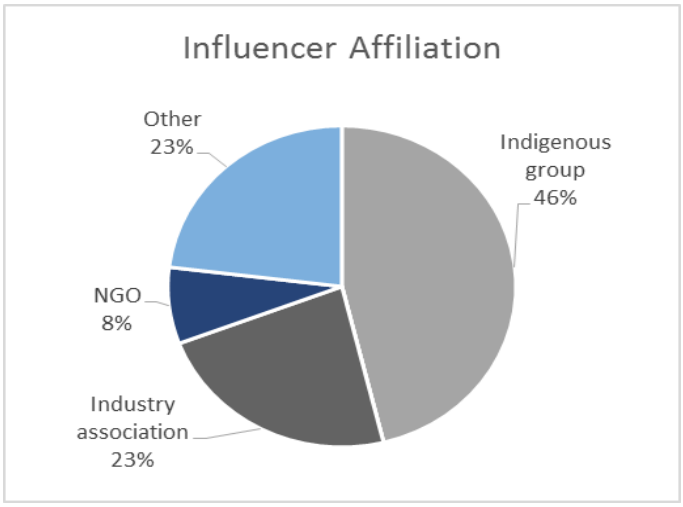
Region	Decision makers	Influencers	Informers	Total %
Canada-wide	6	3	9	17%
Western Canada (British Columbia, Alberta, Saskatchewan, Manitoba)	29	3	8	38%
Northern Canada (Yukon Territory, Northwest Territories, Nunavut)	12	1	7	19%
Central and Atlantic Canada (New Brunswick, Nova Scotia, Newfoundland, Prince Edward Island, Ontario, Québec)	8	3	8	18%
Indigenous community or territory	1	3	1	5%
Other	1	0	2	3%

Of the **decision makers**, most were provincial or territorial governments (42%) or industry (35%), with some federal government respondents (12%), and a few were municipal or local governments (2%) and Indigenous communities or territories (2%). 7% of respondents felt that they did not fall into those categories. Decision makers held roles that were non-management (41%), senior management (30%) or management (28%), with a focus on regulations (37%), policy (23%), operations (23%) or other roles (18%).



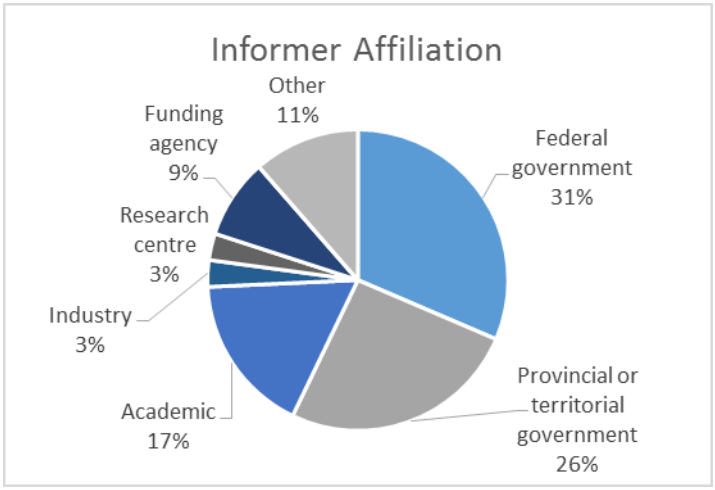
Based on observed response patterns reflecting regional and sectoral priorities, decision maker responses were further divided into five categories for the current analysis: governments in Northern Canada (12), governments in Western Canada (11), governments in Central and Atlantic Canada (8), national government (5) and industry (21). All industry decision makers were located in Western Canada, with the exception of one Canada-wide respondent.

Many **influencers** reported that they were affiliated with Indigenous governments or groups (46%), while others belonged to industry associations (23%), NGOs (8%) or other affiliations (23%). Influencers held either senior management (54%) or management (46%) roles.



Based on observed response patterns reflecting affiliation, influencer responses have been divided into two categories: Indigenous groups and NGOs (8), and industry associations and consultants (5).

Informers held roles in various organizations, including federal government (31%), provincial or territorial government (26%), academia (17%), and funding agencies (9%). A few informers held roles in industry (3%), research centres (3%) or other organizations that did not fall into these categories (11%). Informers held roles that were non-management (46%), senior management (31%) or management (23%).



Results were also analyzed by grouping together all respondents who identified that they held an **Indigenous perspective** in order to assess these responses across sectors, in addition to within the influencer sector. This grouping of Indigenous perspectives included mostly influencers (8), as well as one decision maker and one informer.

All responses to this survey have been kept confidential. Respondents are not identified in the survey summary, and the results have been aggregated.

Observations

Survey responses were analyzed to identify agreement on priorities within sectors as well as alignment on priorities across sectors.

Results are presented under the following subsections:

- **A.** **Shared priorities** (strong across sectors and regions)
- **B.** **Multi-sectoral priorities** (aligned across some sectors)
- **C.** **Sectoral priorities** (agreement observed within sectors)
- **D.** **Regional and national government priorities**
- **E.** **Other survey comments**

A colour-coding system was applied to facilitate the presentation of survey results. The colours represent the level of overall agreement among respondents in each group or subgroup (sector

or region represented as columns in the table) who selected the corresponding knowledge need, opportunity to advance knowledge through research or opportunity with best potential to be addressed through a shared investor approach, as one of their (up to) 10 priorities in sections 1, 2 and 3 of the survey. Agreement levels for each knowledge need and opportunity were coded (see Table 2).

Table 2. Agreement within survey respondent groups.

Level of agreement within respondent group	Colour	Criteria[1]
Strong agreement	Blue	Selected by 60% + of respondents in group
Moderate agreement	Green	Selected by 50-59% of respondents in group
Lesser agreement	Yellow	Selected by 40-49% of respondents in group
Little agreement	White	Selected by less than 39% of respondents in group

Due to the large number of knowledge needs and opportunities, and the overlapping content among them, some knowledge needs and opportunities have been combined in the presentation of the results.

For a full presentation of results for each knowledge need and opportunity, see Appendix B.

A. SHARED PRIORITIES

This section compares shared priorities across the three main survey sections for respondents across all sectors. Overall, respondents across sectors strongly aligned with the following shared priority areas:

Knowledge needs

- Establish baseline data that allow for determining long-term trends and identifying system changes in response to new uses (i.e., supporting design of cumulative effects approach to watershed management).
- Understand water availability and use through regional water balances and future development forecasts within cumulative effects management frameworks.

Opportunities to advance knowledge through research

- Inform the design of monitoring frameworks that focus on key characteristics indicating system changes and support cumulative effects assessment, including baseline data on water quality and availability.
- Assess human and environmental health risks associated with contaminants of concern in injected fluids, flowback and produced water.

[1]In subgroups with a sample size of less than 10, the criteria for strong agreement was increased to 80% +, moderate agreement was increased to 60-69%, lesser agreement was increased to 50-59%, and little agreement was increased to less than 49%.

- Address knowledge needs in developing regional cumulative effects-based water plans.

Opportunities with best potential to be addressed through a shared investor approach

- Develop more credible, broad social and economic cost-benefit analyses.

Table 3. Summary of shared priorities across sectors.

KNOWLEDGE NEEDS		GOV'T	INDUSTRY	INFLUENCERS	INFORMERS
cumulative effects	**Baseline** data to determine long-term trends and design **cumulative effects** approach				
water use data	**Regional water balances** and **forecasts**				
OPPORTUNITIES TO ADVANCE KNOWLEDGE THROUGH RESEARCH		**GOV'T**	**INDUSTRY**	**INFLUENCERS**	**INFORMERS**
cumulative effects	Design **monitoring frameworks** that support **cumulative effects** assessment				
cumulative effects	Develop regional **cumulative effects-based water plans**				
risks & toxicity	Assess **human/environmental health risks associated with contaminants of concern**				
BEST POTENTIAL TO BE ADDRESSED THROUGH A SHARED INVESTOR APPROACH		**GOV'T**	**INDUSTRY**	**INFLUENCERS**	**INFORMERS**
cost- benefit	Develop **social and economic cost-benefit analyses**				

Blue strong agreement Green moderate agreement Yellow low agreement White little agreement

There was notable overlap in the degree to which cumulative effects monitoring, assessment, and planning were identified and aligned across all three sections of the survey. Priority knowledge needs focused on baseline data, water availability and water use forecasting, as compared to research opportunities aligning on monitoring frameworks and assessment of risks.

See Table 3 for a visual summary of shared priorities across sectors, and Appendix B for a complete summary of shared priorities across the three survey sections.

B. MULTI-SECTORAL PRIORITIES

In addition to the shared priorities noted above, other priorities were identified as being strong priorities for several sectors, with moderate or little agreement in other sectors.

Knowledge needs

- Understand how to monitor and detect impacts of methane leaks and other contaminants.
- Understand how lack of data and data disclosure inhibit decision making.
- Identify indicators and thresholds to assess and manage cumulative effects.
- Understand subsurface conditions to manage impacts over time.

Opportunities to advance knowledge through research

- Assess toxicity concerns of methane leaks or other contaminants.
- Develop approaches to assess baseline groundwater quality to enable detection of methane and other contaminant impacts.

Opportunities with best potential to be addressed through a shared investor approach

- Recommend data formats and standards for comparison.
- Develop techniques and technologies to detect methane leaks and other contaminants.
- Identify data disclosure required to advance understanding of toxicity and risks.

These multi-sectoral priorities were identified around three key threads: toxicity; data and disclosure; and indicators and thresholds.

Toxicity

Informers and government respondents aligned on understanding how best to detect impacts of fugitive methane or other contaminants, with little agreement from the other sectors. Influencers strongly agreed on understanding long-term behaviour of subsurface conditions and how impacts can be managed, with select governments in moderate agreement. It was the reverse for assessing toxicity concerns of leakage of methane and other contaminants, with government strongly agreeing, and influencers less so.

Data and disclosure

Influencers strongly agreed on understanding how lack of data or disclosure inhibits decision making, with moderate agreement from respondents from western and national governments, and less by others. There was moderate agreement by government respondents on research related to recommending data formats and standards for comparison, but less agreement for others.

Indicators and thresholds

Agreement on indicators and thresholds required to manage cumulative effective was moderate for influencers and industry respondents only.

See Table 4 for a visual summary of multi-sectoral priorities, and Appendix B for a complete summary of multi-sectoral priorities across the three survey sections.

Table 4. Summary of multi-sectoral priorities (does not include shared priorities).

KNOWLEDGE NEEDS		GOV'T	INDUSTRY	INFLUENCERS	INFORMERS
risks & toxicity	Monitor **aquifer conditions to detect impacts** of fugitive methane or contaminants				
data & disclosure	Understand how **lack of data** or **data disclosure** inhibit decisions				
cumulative effects	**Indicators and thresholds** required to manage **cumulative effects**				
risks & toxicity	Understand **subsurface conditions** to manage impacts over time.				
OPPORTUNITIES TO ADVANCE KNOWLEDGE THROUGH RESEARCH		**GOV'T**	**INDUSTRY**	**INFLUENCERS**	**INFORMERS**
risks & toxicity	Assess **toxicity concerns** of **leakage** of methane or other contaminants				
cumulative effects	Develop approaches to assess **baseline** groundwater quality to enable detection of methane and other **contaminant** impacts				
BEST POTENTIAL TO BE ADDRESSED THROUGH A SHARED INVESTOR APPROACH		**GOV'T**	**INDUSTRY**	**INFLUENCERS**	**INFORMERS**
data & disclosure	Recommend **data formats and standards** for comparison				
risks & toxicity	Develop **techniques and technologies to detect methane leaks** and other contaminants.				
data & disclosure	Identify **data disclosure** required to advance understanding of toxicity and risks				

Blue strong agreement Green moderate agreement Yellow low agreement White little agreement

C. SECTORAL PRIORITIES

The following section outlines areas of agreement within the sectors surveyed regarding what knowledge is most needed to inform decisions, which opportunities to advance knowledge through research have the most potential to inform decision making, and which research opportunities have the best potential to be addressed through a shared investor approach. The focus was on identifying knowledge needs that most need to be filled and/or the most practical research on which to move forward. See Tables 5 and 6 for a visual summary, and Appendix B for details.

Government

Government respondents strongly aligned with other sector respondents on baseline data and the design of monitoring frameworks that support cumulative effects assessments. On the whole, government respondents prioritized needing research related to assessing health risks and toxicity concerns of fugitive methane and other contaminants. Government respondents showed moderate agreement on social and economic costs-benefit analysis, data disclosure, formats and standards, as well as baseline data and monitoring of groundwater quality as priorities.

Industry

Industry respondents showed strong agreement on addressing the knowledge need associated with understanding regional water balances and water use forecasting, presumably given business risks associated with water availability, competing demands on water, and climate change. Translated as a research opportunity, industry respondents further agreed on projecting current and future water availability from all sources as a priority, including methods to estimate future water needs. They also prioritized shared investment in research involving social and economic cost-benefit analyses. Industry respondents moderately agreed on indicators and thresholds required to manage cumulative effects – notably public opinion and major concerns, including how the public is informed.

Decision timelines

Decision makers, consisting of government and industry respondents, were also asked to select approximate decision timelines for each knowledge need that they indicated as a priority. Two years was the average response for decision makers, with industry respondents' average slightly less at 1.8 years. Estimated timelines across knowledge needs were fairly consistent between government and industry respondents with a few exceptions; industry respondents proposed approximately three years for baseline data, long-term subsurface conditions and governance approaches to cumulative effects, and half a year to evaluate reference sites.

Influencers

In addition to aligning with the shared priorities identified across all sectors, influencers prioritized understanding where lack of data or data disclosure currently inhibits decision making, and how data disclosure could advance understanding of toxicity and risk. They also prioritized better understanding the long-term behaviour of subsurface conditions and expected impacts. Potential impacts felt by vulnerable or disproportionately impacted communities and collaborative governance in remote and rural regions were highlighted as priorities for research.

Influencers were further divided into two subgroups: (a) Indigenous groups and non-profit organizations, and (b) industry associations and consultants.

For those identifying as Indigenous groups and non-profit organizations, several areas of agreement were unique to this subgroup. Honouring the rights of Indigenous communities in governance practices was a key priority. Respondents agreed around the need to incorporate non-market externalities and uncertainties regarding long-term implications (e.g. safety and community impacts). They were also in strong agreement on understanding impacts to vulnerable and disproportionately-impacted populations, and ensuring these communities are adequately considered. For this subgroup, priority opportunities to advance knowledge through research included assessing toxicity concerns of leaked methane and identifying how improved data disclosure can advance understanding of toxicity and risk. This subgroup showed moderate agreement around evaluating collaborative governance opportunities in remote and rural regions. Indicators and thresholds required to manage cumulative effects, and regulatory approaches for improved integration of landscape and watershed impacts were also identified as priorities by this subgroup.

A small number of industry associations and consultants responded to the survey. In addition to aligning with the shared priorities identified across all sectors, respondents from this subgroup of influencers prioritized addressing public concerns and lack of data and data disclosure, with moderate agreement on transparency through effective governance as an additional priority.

Informers

Informers included researchers from universities, governments and industry, as well as research managers and funders. Informers are shaped by the nature of their research teams and decisions related to what, where and how they conduct, manage or support research on hydraulic fracturing issues across the country. Although their backgrounds are divergent, their perspectives are important in proposing shared opportunities to advance knowledge through research and shared investment.

Informer respondents strongly prioritized cumulative effects issues such as establishing baseline data, designing monitoring frameworks and developing water plans. They agreed on the need for baseline data on groundwater quality as well as improved monitoring of aquifer conditions to detect impacts of fugitive methane and other contaminants. Moderate agreement was also noted around human health implications, and social and economic cost-benefit analysis as key opportunities to advance knowledge through research.

Indigenous perspectives across sectors

Some of the respondents sharing Indigenous perspectives identified not only as influencers but also as decision makers and informers. Results from this cross-cutting group were compiled and analyzed separately, showing slightly different results than the subset of Indigenous groups and non-profit organizations noted under influencers above. See Appendix B for detailed results for this subset of respondents.

Respondents representing Indigenous perspectives across sectors prioritized the importance of honouring the legal rights of Indigenous communities, understanding impacts to disproportionately-impacted populations, and ensuring they are considered. As a group, these

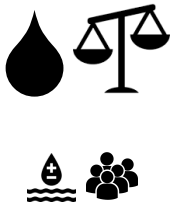
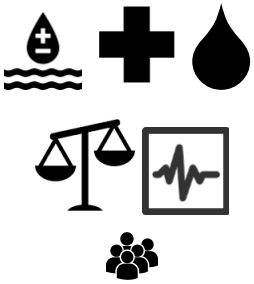
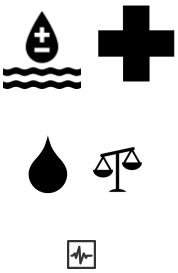
respondents also agreed on the need to advance knowledge through research involving comparison of Indigenous experiences to determine effective means of engagement. Indicators and thresholds, and regulatory approaches for improved integration were also identified as priorities.

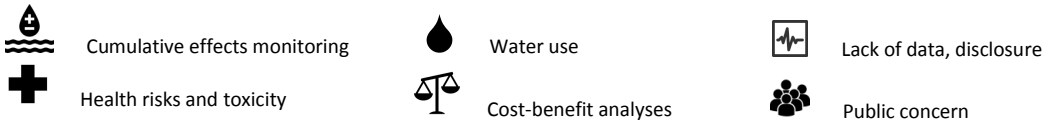
Table 5. Comparison of alignment across sectors (includes shared priorities).

		GOVERNMENT	INDUSTRY	INFLUENCERS	INFORMERS
cumulative effects	**Baseline** data to determine long-term trends and design **cumulative effects** approach				
cumulative effects	Design **monitoring frameworks** that support **cumulative effects** assessment				
risks & toxicity	Assess **human/environmental health risks associated with contaminants of concern**				
risks & toxicity	Monitor **aquifer conditions to detect impacts** of fugitive methane or contaminants				
risks & toxicity	Assess **toxicity concerns** of **leakage** of methane or other contaminants				
water use data	**Regional water balances** and **forecasts**				
cost- benefit	Develop **social and economic cost-benefit analyses**				
cumulative effects	Develop regional **cumulative effects-based water plans**				
data & disclosure	Understand how **lack of data** or **data disclosure** inhibit decisions				
cumulative effects	**Indicators and thresholds** required to manage **cumulative effects**				
public concern	**Public opinion**, major concerns, impacts on **vulnerable communities,** how informed.				

Blue strong agreement Green moderate agreement Yellow low agreement White little agreement

Table 6. Visual comparison across sectors.

GOVERNMENT	INDUSTRY	INFLUENCERS	INFORMERS
			



D. REGIONAL AND NATIONAL GOVERNMENT PRIORITIES

Each region of Canada has its own context defined by geological, social and economic factors influencing regional water use and hydraulic fracturing decisions. While these variations make it challenging to identify common ground, government respondents aligned across regions on several priorities related to cumulative effects monitoring, risk assessments, and toxicity. In addition to these shared priorities, there were also threads of priorities specific to certain regions. See Table 7 for a summary and Appendix B for details.

Western Canada
Government respondents in western Canada identified detecting fugitive methane, establishing indicators and thresholds, data disclosure, and developing regulatory approaches for integrated management as priorities for the region. There was notably more regulatory focus in the west compared to other regions, presumably due to longer history of hydraulic fracturing activity.

Northern Canada
Northern government respondents agreed with western governments on water balances and forecasting future use. Northern respondents noted toxicity concerns related to wastewater, as did Atlantic/Central Canada. Data formats and standards were also a priority in the north.

Atlantic/Central Canada
Outside the shared priorities held across sectors, respondents from Atlantic and Central Canada strongly prioritized the opportunity to advance knowledge through research comparing wastewater treatment technologies. Regulatory approaches for integration and public opinions were raised with moderate agreement.

National

Key priorities amongst national government respondents focused on cumulative effects, detection of contaminants, data disclosure as well as data formats and standards.

Table 7. Comparison of agreement across government respondents (includes shared priorities).

		OVERALL GOV'T (regional and national combined)	REGIONAL GOV'T			NATIONAL GOV'T
			Western	Northern	Central & Atlantic	
cumulative effects	**Baseline data** to determine long-term trends and design **cumulative effects** approach					
cumulative effects	Design **monitoring frameworks** that support **cumulative effects** assessment					
risks & toxicity	Assess **human/environmental health risks associated with contaminants of concern**					
risks & toxicity	Monitor **aquifer conditions to detect impacts** of fugitive methane or contaminants					
risks & toxicity	Assess **toxicity concerns** of **leakage** of methane or other contaminants					
water use	**Regional water balances** and **forecasts**					
data & disclosure	Understand how **lack of data** or **data disclosure** inhibit decisions					
cumulative effects, governance	Develop regional **cumulative effects-based water plans**					
baseline data, risk & toxicity	**Baseline** data to improve ability to **detect methane** contamination					
cost- benefit	Develop **social and economic cost-benefit analyses**					
data & disclosure	Recommend **data formats and standards** for comparison					
cumulative effects	**Indicators and thresholds** required to manage cumulative effects					
governance	Assess **regulatory approaches** in achieving **integration**					
risk & toxicity	Assess **toxicity concerns** related to **wastewater**					
risk & toxicity	**Compare wastewater treatment** technologies					
governance	Collaborative **governance** in **rural and remote regions**					
public concern	**Public opinion**, major concerns, how informed.					

Blue strong agreement Green moderate agreement Yellow low agreement White little agreement

E. OTHER SURVEY COMMENTS

The survey also provided an opportunity for respondents to suggest additional priority areas and offer general comments.

Various technical matters were raised in the survey comments that supported the need for greater understanding of baseline groundwater conditions as well as detecting and monitoring subsurface impacts. Industry association and/or consultant respondents prioritized confirming specific instances of groundwater contamination. While methane is important, one respondent from government noted it is one of many contaminants, and efforts ought to be directed toward the range of toxicity concerns.

While surface water quality monitoring was not included in the survey, it was noted as a priority area by more than one respondent. Indigenous and non-profit groups mentioned the need for testing alternative methods to hydraulic fracturing.

One industry respondent recommended further gap analysis between current regulations and issues of public concern. Industry respondents also suggested the need to strengthen public awareness and communications around hydraulic fracturing in general, including its benefits and risks.

A number of industry representatives recommended stronger engagement with industry experts during the research process to improve understanding of regional contexts. In turn, respondents from academia acknowledged the challenge of understanding regional contexts behind decision making. Representatives from government suggested linking future recommendations to responsible parties to ensure accountability during implementation.

CONCLUDING OBSERVATIONS

CWN's overview report listed nine focus areas that the survey was based on:

- Opportunities to understand costs and benefits
    - Social and economic analyses (1)
    - Water use (2)
    - Health risks and contamination (3)
- Evaluate risks and impacts
    - Baseline data needs (4)
    - Cumulative effects (5)
    - Data and disclosure (6)
    - Groundwater risks (7)
    - Wastewater management (8)
- Public concern and engagement (9)

The survey results identified shared, sectoral and regional priorities that spanned each of the focus areas illustrating common thread connections to cumulative effects and toxicity concerns.

The knowledge needs identified as priorities relate to cumulative effects, water balances and use, and toxicity and risk management. Fugitive methane, data disclosure, thresholds and indicators, and subsurface impacts were also identified as priorities, although primarily for specific sectors.

Opportunities to advance knowledge through research as a priority included the design of monitoring frameworks to support cumulative effects, assessing human and environmental health risks, and developing regional cumulative effects-based water plans. Other key priorities focused on contaminant and wastewater toxicity, regulatory approaches, and baseline data specific to groundwater quality.

Opportunities with best potential to be addressed through a shared investor approach included social and economic cost-benefit analysis, with additional priorities across sectors and regions in data disclosure, standards and formats and toxicity particularly around wastewater.

While there are a variety of priority knowledge needs and opportunities to advance knowledge through research, Table 8 summarizes the common ground identified through the survey as key priorities for moving forward with a shared investor approach on water and hydraulic fracturing in Canada.

Table 8. Overall shared priorities.

KNOWLEDGE NEEDS	OPPORTUNITIES TO ADVANCE KNOWLEDGE THROUGH RESEARCH	OPPORTUNITIES FOR SHARED INVESTMENT IN RESEARCH
Establish **baseline data** to determine long-term trends and assess **cumulative effects**. Understand water availability and use through **regional water balances** and **forecasting** within cumulative effects management frameworks.	Design **monitoring frameworks** that support **cumulative effects** assessments, including baseline data. Develop regional, **cumulative effects-based water plans**. Assess **human/environmental health risks associated with contaminants of concern i**n injected fluids, flowback & produced water.	Develop **social and economic analyses** that reflect more complete and socially-relevant balancing of **costs and benefits**.

FOLLOW UP

The Western Canadian Forum on Water and Hydraulic Fracturing was held in Edmonton in February 2016. The objectives of this meeting were to confirm and further refine a common understanding of shared priorities and opportunities to advance knowledge through research, and identify ongoing work or existing commitments that can advance these priority areas. The ultimate goal was to identify additional near-term opportunities to address priority areas through shared investment in research. The outcomes of the forum discussions and proposed next steps will be made available in subsequent reports.

APPENDIX A: SURVEY QUESTIONS

To request a full list of survey questions (includes demographic questions and full instructions) for each group of respondents, please email Katrina Hitchman at khitchman@cwn-rce.ca.

Survey section 1: Knowledge to inform decision making

CWN's 2015 Water and Hydraulic Fracturing report presented a list of knowledge needs to inform decision making, grouped under nine different focus areas. From your point of view, what do we most need to know to inform decisions related to hydraulic fracturing and water? Please select up to 10 knowledge needs (regardless of focus area).

Understanding the Net Social and Economic Costs and Benefits of Hydraulic Fracturing

- A clearly articulated definition of what constitutes a sufficient benefit to the overall community to better inform when benefits outweigh implicit risks and costs.
- How to incorporate non-market externalities and uncertainties regarding long-term implications in calculations that address key concerns (e.g. safety, security of water supplies, community impacts) most effectively.
- How to ensure that portions of the population that are either vulnerable or disproportionally impacted by hydraulic fracturing are adequately considered (e.g., Indigenous communities).

Water Use Issues Associated with Hydraulic Fracturing

- Understanding of regional water balances and future development forecasts within cumulative effects management frameworks.
- The anticipated trade-offs associated with water conservation and reuse approaches and the use of alternative fluids/gases in hydraulic fracturing.

Understanding Human Health Risks and Contamination Concerns in Hydraulic Fracturing

- The immediate and long-term human health implications of hydraulic fracturing in Canada, based on the best available understanding of potential risks.
- The potential human health impacts to either vulnerable or disproportionately impacted communities (e.g., Indigenous communities).

Baseline Data Needs in Hydraulic Fracturing

- The baseline data that most effectively allow for determining long-term trends and identifying system changes in response to new uses— i.e., supporting the design of a cumulative effects approach to watershed management (e.g., key chemical, biological, flow system measurements).
- The baseline data to improve the ability to detect or understand methane contamination and transport in groundwater.

Cumulative Effects and Monitoring, Assessment and Management in Hydraulic Fracturing

- The specific knowledge elements, including the best indicators and appropriate thresholds, required to effectively manage the cumulative effects of resource development involving hydraulic fracturing.
- An evaluation of the adequacy of reference sites that will provide a baseline for comparisons.
- The efficacy of possible governance approaches/models for cumulative effects monitoring.

Information Availability and Disclosure Needs to Support Knowledge Generation, Best Practices and Regulations in Hydraulic Fracturing

- An understanding of where a lack of data or data disclosure is most inhibiting decision making regarding water use, wastewater disposal, and managing risks from toxicity of hydraulic fracturing fluids and flowback fluids.
- Opportunities for addressing proprietary concerns that could lead to better disclosure of data in Canada.
- Consistent data approaches for water use and the fate of wastewater that would support broader comparisons of water management across regions and jurisdictional boundaries.

Managing Risks to Groundwater and Subsurface Impacts in Hydraulic Fracturing

- The behaviour and main transport pathways of methane gas relative to aquifers and groundwater supplies associated with hydraulic fracturing.
- How to most effectively monitor aquifer conditions to detect the impacts of fugitive methane or other contaminants.
- Practical expectations and best practices for assessing well performance (such as detecting leakage from well casings).
- A better understanding of the potential for induced seismicity from hydraulic fracturing activities and wastewater injection.
- An understanding of long-term behaviour of wells and subsurface conditions and how expected impacts over time (such as geochemical aquifer changes or groundwater short-circuiting from deteriorating wells) can be effectively managed.

Managing Wastewater in Hydraulic Fracturing

- Improved characterization of the composition of hydraulic fracturing fluids.
- Improved knowledge of the greatest risks related to wastewater handling and disposal.
- The efficacy of various on-site treatment methods or existing wastewater treatment plants to ensure wastewaters are acceptable for release.

Achieving Constructive and Effective Engagement in Hydraulic Fracturing

- How to most effectively address key governance challenges, including transparency, trust, and capacity related to water use in hydraulic fracturing.
- The public's opinions and major concerns with respect to hydraulic fracturing and how they are informed.
- The most effective means of honouring the legal and constitutionally guaranteed rights of Indigenous communities across Canada in the governance practices for hydraulic fracturing and water.

Other (please specify)

Survey section 2: Opportunities to advance knowledge through research

CWN's 2015 Water and Hydraulic Fracturing report presented a list of opportunities to advance knowledge through research, grouped under nine different focus areas. From your point of view, which of the following opportunities to advance knowledge through research have the most potential to inform decision making? Please select up to 10 opportunities (regardless of focus area).

Understanding the Net Social and Economic Costs and Benefits of Hydraulic Fracturing

- Develop more credible, broad social and economic analyses that reflect a more complete and socially-relevant balancing of negative ("cost") and positive ("benefit") elements associated with shale gas development.

Water Use Issues Associated with Hydraulic Fracturing

- Address knowledge gaps in development of regional, cumulative effects-based water plans, including improved understanding of groundwater conditions and deep saline resources.
- Project current and future water availability from all sources, including methods to estimate future water needs of the industry.
- Assess the lifecycle and impact(s) of strategies for conservation, reuse or alternatives to freshwater.

Understanding Human Health Risks and Contamination Concerns in Hydraulic Fracturing

- Assess toxicity concerns of leakage of methane or other contaminants from wells to groundwater/drinking water.
- Assess toxicity concerns related to hydraulic fracturing wastewater.
- Advance the effectiveness of risk communications approaches.

Baseline Data Needs in Hydraulic Fracturing

- Inform the design of monitoring frameworks that focus on key characteristics that indicate system changes

and support cumulative effects assessment, including establishing baseline water quality and availability.
- Develop approaches that more effectively assess and establish baseline groundwater quality to enable the possible detection of methane gas or other contaminant impacts.

Cumulative Effects and Monitoring, Assessment and Management in Hydraulic Fracturing
- Assess evolving experience and advance approaches for implementing cumulative effects management that includes the impacts of hydraulic fracturing.
- Assess the effectiveness of evolving regulatory approaches in achieving improved integration of landscape and watershed-level considerations in assessing impacts of hydraulic fracturing.

Information Availability and Disclosure Needs to Support Knowledge Generation, Best Practices and Regulations
- Identify how improved data disclosure can advance understanding of human and environmental toxicity and risks.
- Provide recommended data formats and standards that would facilitate better industry-wide comparisons and analyses.

Managing Risks to Groundwater and Subsurface Impacts in Hydraulic Fracturing
- Assess pathways of methane or fluid leakage associated with active hydraulic fracturing activities.
- Assess expected groundwater quality issues related to methane migration over the short and long-term.
- Develop techniques and technologies to provide practical detections of methane leaks or other contaminants from wells.
- Improve knowledge surrounding induced seismicity due to hydraulic fracturing and wastewater injection.

Managing Wastewater in Hydraulic Fracturing
- Assess the human and environmental health risks associated with contaminants of concern in injected fluids, flowback and produced water to establish appropriate treatment targets and disposal mechanisms.
- Conduct a comparative assessment of the performance of industrial wastewater treatment technologies for hydraulic fracturing fluid.

Achieving Constructive and Effective Engagement in Hydraulic Fracturing
- Assess particular opportunities to advance transparency through effective water governance.
- Evaluate opportunities for collaborative or watershed-based governance in remote and rural regions with industry development potential.
- Establish effective governance approaches for collection and disclosure of baseline data.
- Assess public opinions of key concerns and most trusted knowledge sources for water and hydraulic fracturing across Canada to inform design of engagement strategies.
- Collect and compare experiences of Indigenous communities in North America to identify options that have more effectively involved them in water governance related to hydraulic fracturing.

Other (please specify)

Survey section 3: Advancing knowledge through a shared investor approach

In some cases, opportunities to advance knowledge through research can be adequately addressed through strategic investments by individual jurisdictions or organizations. In other cases, when issues are complex and affect multiple jurisdictions, and when significant costs and risks are involved, a collaborative, common investor approach may be preferable to share costs and risks, and to increase uptake of results within industry, governments, and communities.

From your point of view, which of the following opportunities to advance knowledge through research have the best potential to be addressed through a shared investor approach? Please select up to 10 opportunities (regardless of focus area).

Understanding the Net Social and Economic Costs and Benefits of Hydraulic Fracturing

- Develop more credible, broad social and economic analyses that reflect a more complete and socially-relevant balancing of negative ("cost") and positive ("benefit") elements associated with shale gas development.

Water Use Issues Associated with Hydraulic Fracturing

- Address knowledge gaps in development of regional, cumulative effects-based water plans, including improved understanding of groundwater conditions and deep saline resources.
- Project current and future water availability from all sources, including methods to estimate future water needs of the industry.
- Assess the lifecycle and impact(s) of strategies for conservation, reuse or alternatives to freshwater.

Understanding Human Health Risks and Contamination Concerns in Hydraulic Fracturing

- Assess toxicity concerns of leakage of methane or other contaminants from wells to groundwater/drinking water.
- Assess toxicity concerns related to hydraulic fracturing wastewater.
- Advance the effectiveness of risk communications approaches.

Baseline Data Needs in Hydraulic Fracturing

- Inform the design of monitoring frameworks that focus on key characteristics that indicate system changes and support cumulative effects assessment, including establishing baseline water quality and availability.
- Develop approaches that more effectively assess and establish baseline groundwater quality to enable the possible detection of methane gas or other contaminant impacts.

Cumulative Effects and Monitoring, Assessment and Management in Hydraulic Fracturing

- Assess evolving experience and advance approaches for implementing cumulative effects management that includes the impacts of hydraulic fracturing.
- Assess the effectiveness of evolving regulatory approaches in achieving improved integration of landscape and watershed-level considerations in assessing impacts of hydraulic fracturing.

Information Availability and Disclosure Needs to Support Knowledge Generation, Best Practices and Regulations

- Identify how improved data disclosure can advance understanding of human and environmental toxicity and risks.
- Provide recommended data formats and standards that would facilitate better industry-wide comparisons and analyses.

Managing Risks to Groundwater and Subsurface Impacts in Hydraulic Fracturing

- Assess pathways of methane or fluid leakage associated with active hydraulic fracturing activities.
- Assess expected groundwater quality issues related to methane migration over the short and long-term.
- Develop techniques and technologies to provide practical detections of methane leaks or other contaminants from wells.
- Improve knowledge surrounding induced seismicity due to hydraulic fracturing and wastewater injection.

Managing Wastewater in Hydraulic Fracturing

- Assess the human and environmental health risks associated with contaminants of concern in injected fluids, flowback and produced water to establish appropriate treatment targets and disposal mechanisms.
- Conduct a comparative assessment of the performance of industrial wastewater treatment technologies for hydraulic fracturing fluid.

Achieving Constructive and Effective Engagement in Hydraulic Fracturing

- Assess particular opportunities to advance transparency through effective water governance.
- Evaluate opportunities for collaborative or watershed-based governance in remote and rural regions with industry development potential.
- Establish effective governance approaches for collection and disclosure of baseline data.
- Assess public opinions of key concerns and most trusted knowledge sources for water and hydraulic fracturing across Canada to inform design of engagement strategies.
- Collect and compare experiences of Indigenous communities in North America to identify options that have

more effectively involved them in water governance related to hydraulic fracturing.

Other (please specify)

APPENDIX B: SURVEY RESULTS

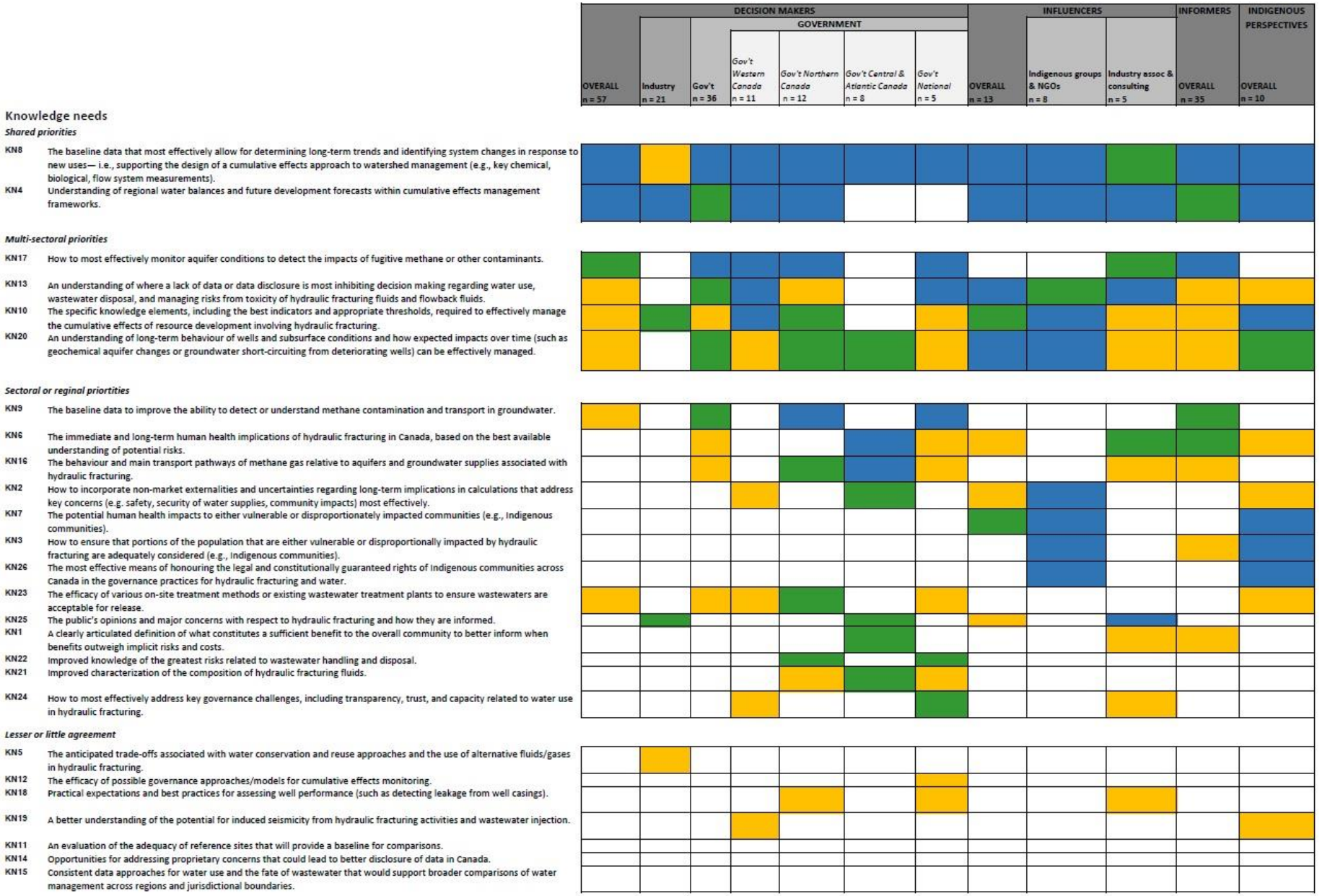
The following three pages contain the survey results for knowledge needs (survey section 1), opportunities to advance knowledge through research (survey section 2) and opportunities with the best potential to be advanced through a shared investor approach (survey section 3).

Based on the levels of agreement within and across survey respondent groups, results have been organized by: shared priorities, multi-sectoral priorities, sectoral or regional priorities, and areas of lesser or little agreement. Note that results are nested according to survey respondent category, with the most inclusive category on the left.

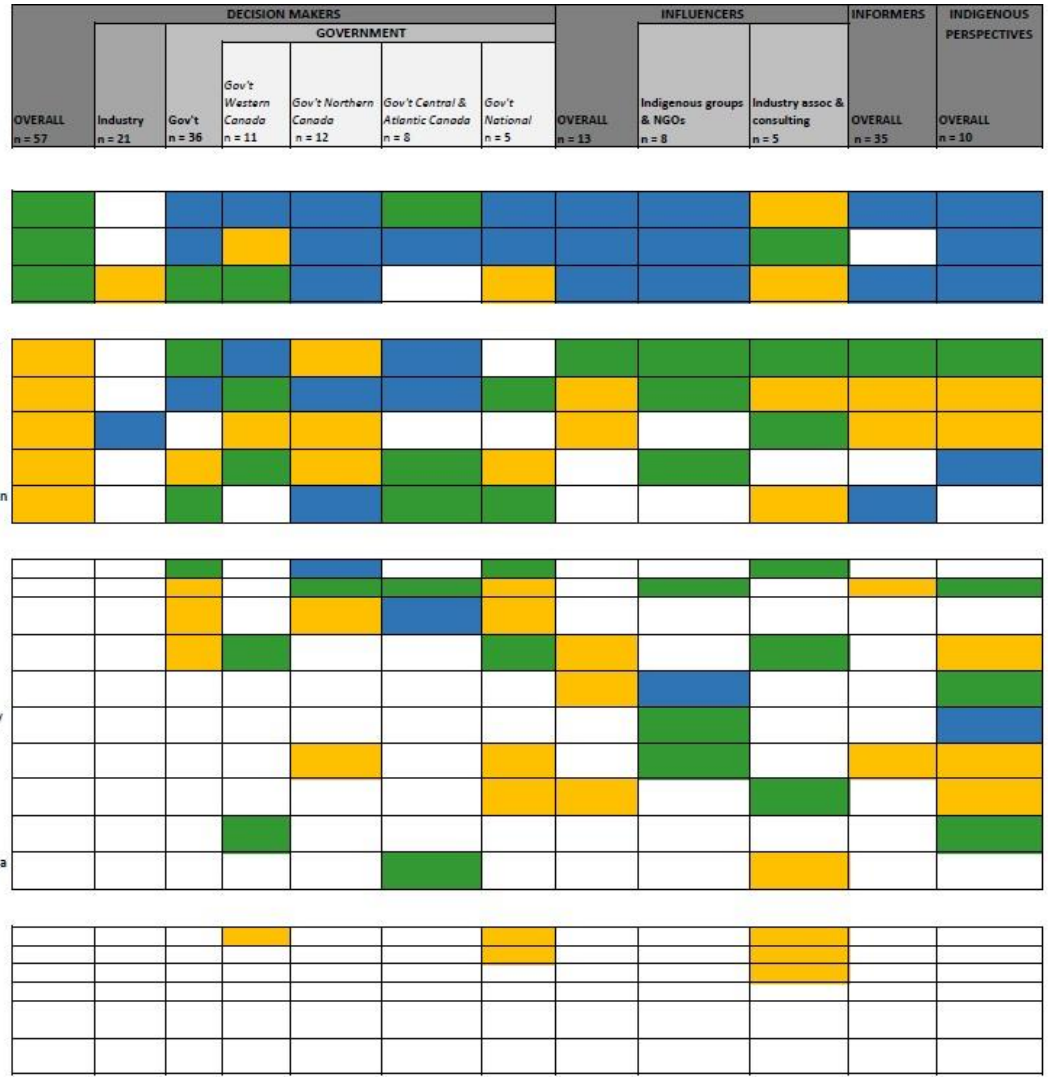
The same coding scheme used throughout the report (see below) has been applied here.

Level of agreement within respondent group	**Colour**	**Criteria[2]**
Strong agreement	Blue	Selected by 60% + of respondents in group
Moderate agreement	Green	Selected by 50-59% of respondents in group
Lesser agreement	Yellow	Selected by 40-49% of respondents in group
Little agreement	White	Selected by less than 39% of respondents in group

[2]In subgroups with a sample size of less than 10, the criteria for strong agreement was increased to 80% +, moderate agreement was increased to 60-69%, lesser agreement was increased to 50-59%, and little agreement was increased to less than 49%.


DECISION MAKERS
GOVERNMENT
INFLUENCERS
INFORMERS
INDIGENOUS PERSPECTIVES
OVERALL n = 57
Industry n = 21
Gov't n = 36
Gov't Western Canada n = 11
Gov't Northern Canada n = 12
Gov't Central & Atlantic Canada n = 8
Gov't National n = 5
OVERALL n = 13
Indigenous groups & NGOs n = 8
Industry assoc & consulting n = 5
OVERALL n = 35
OVERALL n = 10
Knowledge needs
Shared priorities
KN8 The baseline data that most effectively allow for determining long-term trends and identifying system changes in response to new uses— i.e., supporting the design of a cumulative effects approach to watershed management (e.g., key chemical, biological, flow system measurements).
KN4 Understanding of regional water balances and future development forecasts within cumulative effects management frameworks.
Multi-sectoral priorities
KN17 How to most effectively monitor aquifer conditions to detect the impacts of fugitive methane or other contaminants.
KN13 An understanding of where a lack of data or data disclosure is most inhibiting decision making regarding water use, wastewater disposal, and managing risks from toxicity of hydraulic fracturing fluids and flowback fluids.
KN10 The specific knowledge elements, including the best indicators and appropriate thresholds, required to effectively manage the cumulative effects of resource development involving hydraulic fracturing.
KN20 An understanding of long-term behaviour of wells and subsurface conditions and how expected impacts over time (such as geochemical aquifer changes or groundwater short-circuiting from deteriorating wells) can be effectively managed.
Sectoral or reginal priortities
KN9 The baseline data to improve the ability to detect or understand methane contamination and transport in groundwater.
KN6 The immediate and long-term human health implications of hydraulic fracturing in Canada, based on the best available understanding of potential risks.
KN16 The behaviour and main transport pathways of methane gas relative to aquifers and groundwater supplies associated with hydraulic fracturing.
KN2 How to incorporate non-market externalities and uncertainties regarding long-term implications in calculations that address key concerns (e.g. safety, security of water supplies, community impacts) most effectively.
KN7 The potential human health impacts to either vulnerable or disproportionately impacted communities (e.g., Indigenous communities).
KN3 How to ensure that portions of the population that are either vulnerable or disproportionally impacted by hydraulic fracturing are adequately considered (e.g., Indigenous communities).
KN26 The most effective means of honouring the legal and constitutionally guaranteed rights of Indigenous communities across Canada in the governance practices for hydraulic fracturing and water.
KN23 The efficacy of various on-site treatment methods or existing wastewater treatment plants to ensure wastewaters are acceptable for release.
KN25 The public's opinions and major concerns with respect to hydraulic fracturing and how they are informed.
KN1 A clearly articulated definition of what constitutes a sufficient benefit to the overall community to better inform when benefits outweigh implicit risks and costs.
KN22 Improved knowledge of the greatest risks related to wastewater handling and disposal.
KN21 Improved characterization of the composition of hydraulic fracturing fluids.
KN24 How to most effectively address key governance challenges, including transparency, trust, and capacity related to water use in hydraulic fracturing.
Lesser or little agreement
KN5 The anticipated trade-offs associated with water conservation and reuse approaches and the use of alternative fluids/gases in hydraulic fracturing.
KN12 The efficacy of possible governance approaches/models for cumulative effects monitoring.
KN18 Practical expectations and best practices for assessing well performance (such as detecting leakage from well casings).
KN19 A better understanding of the potential for induced seismicity from hydraulic fracturing activities and wastewater injection.
KN11 An evaluation of the adequacy of reference sites that will provide a baseline for comparisons.
KN14 Opportunities for addressing proprietary concerns that could lead to better disclosure of data in Canada.
KN15 Consistent data approaches for water use and the fate of wastewater that would support broader comparisons of water management across regions and jurisdictional boundaries.

Opportunities to advance knowledge through research



Shared priorities

OP8 Inform the design of monitoring frameworks that focus on key characteristics that indicate system changes and support cumulative effects assessment, including establishing baseline water quality and availability.

OP18 Assess the human and environmental health risks associated with contaminants of concern in injected fluids, flowback and produced water to establish appropriate treatment targets and disposal mechanisms.

OP2 Address knowledge gaps in development of regional, cumulative effects-based water plans, including improved understanding of groundwater conditions and deep saline resources.

Multi-sectoral priorities

OP1 Develop more credible, broad social and economic analyses that reflect a more complete and socially-relevant balancing of negative ("cost") and positive ("benefit") elements associated with shale gas development.

OP5 Assess toxicity concerns of leakage of methane or other contaminants from wells to groundwater/drinking water.

OP3 Project current and future water availability from all sources, including methods to estimate future water needs of the industry.

OP11 Assess the effectiveness of evolving regulatory approaches in achieving improved integration of landscape and watershed-level considerations in assessing impacts of hydraulic fracturing.

OP9 Develop approaches that more effectively assess and establish baseline groundwater quality to enable the possible detection of methane gas or other contaminant impacts.

Sectoral or regional priorities

OP15 Assess expected groundwater quality issues related to methane migration over the short and long-term.

OP6 Assess toxicity concerns related to hydraulic fracturing wastewater.

OP19 Conduct a comparative assessment of the performance of industrial wastewater treatment technologies for hydraulic fracturing fluid.

OP16 Develop techniques and technologies to provide practical detections of methane leaks or other contaminants from wells.

OP12 Identify how improved data disclosure can advance understanding of human and environmental toxicity and risks.

OP24 Collect and compare experiences of Indigenous communities in North America to identify options that have more effectively involved them in water governance related to hydraulic fracturing.

OP14 Assess pathways of methane or fluid leakage associated with active hydraulic fracturing activities.

OP10 Assess evolving experience and advance approaches for implementing cumulative effects management that includes the impacts of hydraulic fracturing.

OP21 Evaluate opportunities for collaborative or watershed-based governance in remote and rural regions with industry development potential.

OP23 Assess public opinions of key concerns and most trusted knowledge sources for water and hydraulic fracturing across Canada to inform design of engagement strategies.

Lesser or little agreement

OP17 Improve knowledge surrounding induced seismicity due to hydraulic fracturing and wastewater injection.

OP22 Establish effective governance approaches for collection and disclosure of baseline data.

OP4 Assess the lifecycle and impact(s) of strategies for conservation, reuse or alternatives to freshwater.

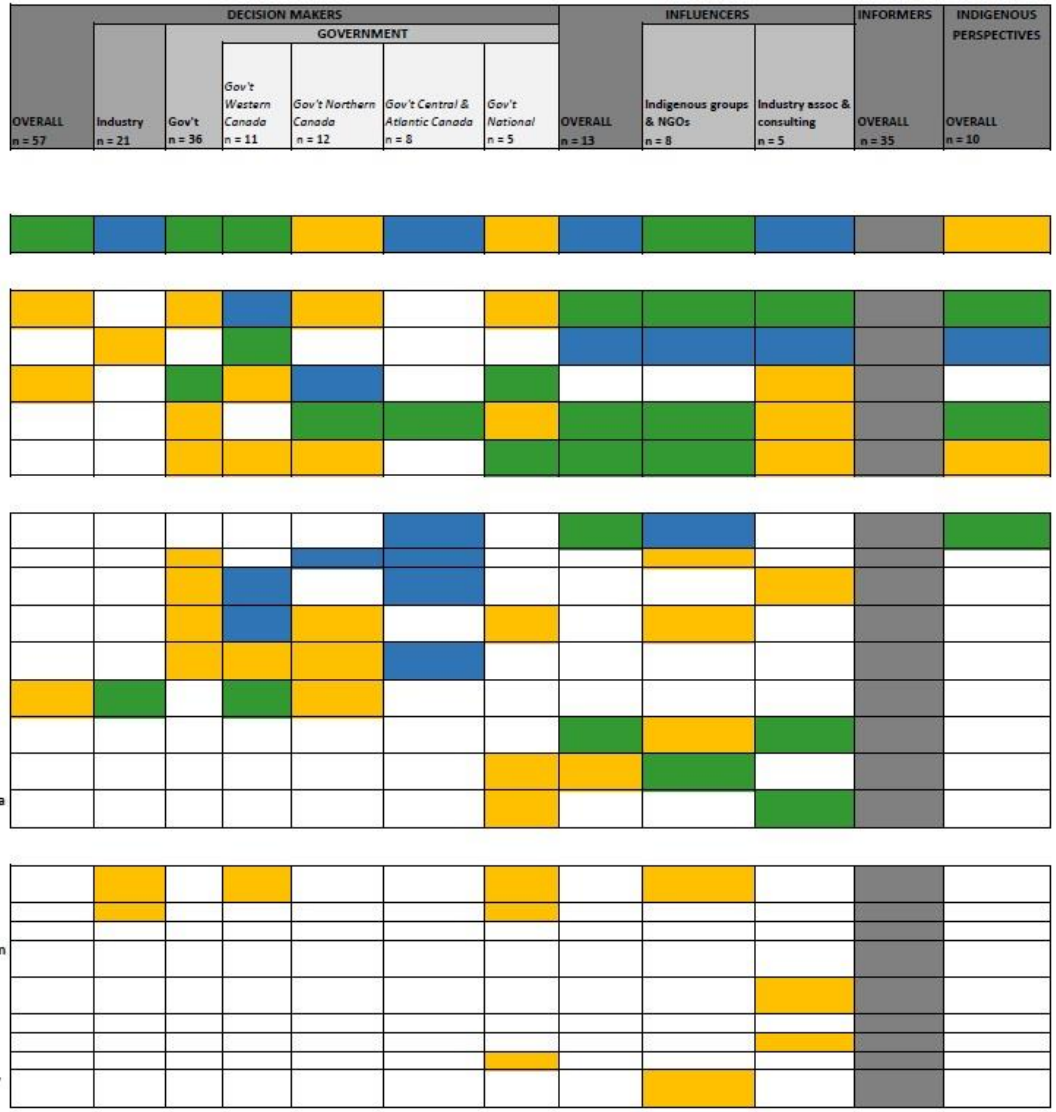
OP7 Advance the effectiveness of risk communications approaches.

OP13 Provide recommended data formats and standards that would facilitate better industry-wide comparisons and analyses.

OP20 Assess particular opportunities to advance transparency through effective water governance.

Opportunities with best potential to be addressed through shared investor approach

(answered by decision makers and influencers only)



Shared priorities

SI1 Develop more credible, broad social and economic analyses that reflect a more complete and socially-relevant balancing of negative ("cost") and positive ("benefit") elements associated with shale gas development.

Multi-sectoral priorities

SI8 Inform the design of monitoring frameworks that focus on key characteristics that indicate system changes and support cumulative effects assessment, including establishing baseline water quality and availability.

SI2 Address knowledge gaps in development of regional, cumulative effects-based water plans, including improved understanding of groundwater conditions and deep saline resources.

SI13 Provide recommended data formats and standards that would facilitate better industry-wide comparisons and analyses.

SI16 Develop techniques and technologies to provide practical detections of methane leaks or other contaminants from wells.

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SI21 Evaluate opportunities for collaborative or watershed-based governance in remote and rural regions with industry development potential.

SI23 Assess public opinions of key concerns and most trusted knowledge sources for water and hydraulic fracturing across Canada to inform design of engagement strategies.

Lessor or little agreement

SI10 Assess evolving experience and advance approaches for implementing cumulative effects management that includes the impacts of hydraulic fracturing.

SI4 Assess the lifecycle and impact(s) of strategies for conservation, reuse or alternatives to freshwater.

SI7 Advance the effectiveness of risk communications approaches.

SI9 Develop approaches that more effectively assess and establish baseline groundwater quality to enable the possible detection of methane gas or other contaminant impacts.

SI14 Assess pathways of methane or fluid leakage associated with active hydraulic fracturing activities.

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SI24 Collect and compare experiences of Indigenous communities in North America to identify options that have more effectively involved them in water governance related to hydraulic fracturing.