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The discontinuity of environmental effects monitoring in the Lower Athabasca region of Alberta, Canada: institutional challenges to long-term monitoring and cumulative effects management

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Abstract

Long-term regional environmental monitoring, coupled with shorter-term and more localized monitoring carried out under regulatory permitting processes, is foundational to identifying, understanding, and effectively managing cumulative environmental effects. However, monitoring programs that emerge to support cumulative effects science are often short-lived initiatives or disconnected from land use planning and regulatory decision making. This paper examines the history and evolution of environmental monitoring in the Lower Athabasca region of Alberta, Canada, and the enabling and constraining influences of institutional arrangements. Methods involved a review of regional-scale monitoring programs based on an analysis of monitoring agency mandates, performance reports, and external program reviews, supplemented by discussions with monitoring program or agency key informants to triangulate results. Results show that monitoring to support cumulative effects understanding in the Lower Athabasca has advanced considerably, especially since the mid 1990s, but its relevance to, and impact on, cumulative effects management and decision making has been stifled by institutional arrangements. Monitoring has been episodic, reflecting shifting priorities and competing mandates; criticized by stakeholders based on concerns about transparency, credibility, influence over decision making; and characterized by short-lived commitments by the agencies involved. This has generated significant uncertainty about the stability of institutional arrangements to support long-term environmental monitoring, and tensions between the need for scientific autonomy for credible science whilst ensuring the pursuit of monitoring questions that are relevant to the day to day needs of regulatory decision makers. Regional monitoring programs require, at a minimum, clear vision and agreed-upon monitoring questions that are of scientific

and management value, meaningful and balanced stakeholder engagement, and a clear governance process to ensure credibility and influence of monitoring results on decision making.

Key words: cumulative effects, environmental monitoring, Lower Athabasca, land use planning, institutional arrangements

Draft

Introduction

Government agencies and scholars have invested significant resources in cumulative effects science (Noble 2015; Jones 2016). Efforts have focused on the development of new methods and tools for assessing cumulative change and determining causal relationships (Culp et al. 2001; Dubé and Munkittrick 2001; Dubé 2003; Gummer et al. 2006; Kilgour et al. 2007; Seitz et al. 2011; Squires et al. 2012), and, recently, on regional cumulative effects frameworks for land use and watershed management (CCME 2009; Gunn and Noble 2009; Dubé et al. 2013; Fraser Basin Council 2016). Large-scale and long-term environmental monitoring programs, complementing other finer-scale monitoring efforts carried out by project proponents, are foundational to understanding and appropriately managing cumulative effects and for supporting both shorter- and longer-term decisions about land and water resource use and allocation (Dubé 2003; Squires et al. 2012; Ball et al. 2013a; Dubé 2015). However, numerous studies and program evaluations have shown that long-term monitoring data is often absent or insufficient in many regions, or so fragmented that its effectiveness for cumulative effects decision support is compromised (Spence et al. 2007; Squires et al. 2009; Federal, Provincial, and Territorial Governments of Canada 2010; Vörösmarty et al. 2010; Schindler 2010; WWF Canada 2017).

The main constraints to cumulative effects assessment and management are institutional in nature, more so than scientific or technical (Sheelanere et al. 2013; Jones 2016). Many programs designed to support cumulative effects, including those designed to support long-term, integrative or joint monitoring and management, either fail at the point of implementation (Noble 2008) or lose the long-term support and uptake needed to influence decisions (Lawe et al. 2008; Noble 2015). Parkins (2011) describes such initiatives as “short-term bursts of activity” often

with “short-lived organizational commitments.” Although recent research has begun to explore the institutional capacity for cumulative effects assessment and management, particularly within the context of watersheds (e.g. Kristensen et al. 2013; Sheelanere et al. 2013; Noble et al. 2014; Chilima et al. 2017), much less attention has been given to the complex challenges associated with sustaining cumulative effects monitoring and management programs (Parkins 2011; Noble 2015). The need to improve institutional arrangements for long-term monitoring is critical – especially in Canada, given ongoing review of the federal environmental assessment process and a renewed federal government commitment to establish “...a deliberative approach to the assessment and management of cumulative effects, working collaboratively with provinces, territories and Indigenous peoples to develop and implement it” (Government of Canada 2017).

The focus of this paper is on the institutional and programmatic arrangements for long-term monitoring to support cumulative effects initiatives. This paper examines the evolution of environmental monitoring in the Lower Athabasca region of Alberta, Canada, and the lessons emerging for cumulative effects initiatives. The Lower Athabasca presents a valuable test-bed for learning and knowledge transfer to other regions embarking on environmental monitoring initiatives. The region is home to a variety of land use activities, including the third largest oil reserves in the world, which has been the focus of numerous monitoring programs. The Lower Athabasca is also the center of several programs and organizations established to monitor effects for regulatory or scientific purposes (Lott and Jones 2010; Miall 2013) – some of which have been in operation for decades, and others have been relatively short-lived.

Study area and approach

Lower Athabasca, Alberta

The Lower Athabasca covers approximately 93,260 km² of northeast Alberta, Canada (Figure 1).

The region is home to diverse land uses, which have developed rapidly over the past two decades, including natural gas extraction and associated infrastructure (e.g. well-sites, seismic lines, pipelines); forestry, including pulp and paper mills; agriculture; tourism, including parks and protected areas; thermal electric generating stations; and aggregate mining. Surface and in situ oil sands mining is a dominant land use in the region, representing the largest share of economic activity. Oil sands development began in the region in the 1960s; increases in oil prices in the early 2000s triggered large-scale industry expansion (CAPP 2016). Between 2000 and 2011, production doubled to 1.7 million barrels per day of crude bitumen (LARP 2012). Despite the recent decline of world oil prices, oil sands production injected an estimated \$23 billion into the Canadian economy in 2015 (CAPP 2016), and generated \$8.4 billion in royalties for the province (CAPP 2015).

In 2008, the Alberta government introduced a provincial Land Use Framework, under the authority of the *Alberta Land Stewardship Act*, establishing seven land use planning regions in the province based on watershed boundaries. Amongst the tasks set out under the Land Use Framework are to understand the current state of the environment through regional assessments, and to identify environmental targets and thresholds through the development of management frameworks. Management frameworks are intended to operate within regional plans, established for each planning region, and are described as a “key approach to manage the long term cumulative effects of development on the environment” (GOA 2016a). For each regional plan,

including the Lower Athabasca Regional Plan, management frameworks have been established for surface water quality (GOA 2012a), surface water quantity (GOA 2015a), air quality (GOA 2012b), groundwater (GOA 2012c), and tailings management (2015b). A biodiversity management framework is planned, but not yet established. In addition to the Land Use Framework, the governments of Alberta and Canada are also mandated with various responsibilities for implementing or overseeing environmental monitoring in the Lower Athabasca – such as water license allocation (i.e., *Alberta Water Act*), habitat protection (e.g., *Fisheries Act*), and project-specific environmental monitoring (e.g., *Alberta Environmental Protection and Enhancement Act, Canadian Environmental Assessment, 2012*).

Approach

The extent of environmental monitoring activity in the Lower Athabasca region is vast. For this study, the focus was on regional-scale environmental monitoring programs – those with the most potential to support cumulative effects management. The scope was also limited to monitoring programs that focus on the priority components identified in the Lower Athabasca Regional Plan – namely air, biodiversity, water quality, water quantity, and groundwater management – and the various organizations that either support monitoring, provide scientific oversight, or make use of these programs and their data. The review was based primarily on document analysis (Fink 2005), and focused on the sequencing of environmental monitoring initiatives over time. The documents reviewed included: monitoring programs and organizational mandates, policy documents, monitoring performance reports, white papers, government reports on program performance, peer reviewed scholarly critiques, and program-related provincial land use planning documents. All documents were either publicly accessible via the internet, often on the

websites of the monitoring agency or organization, or accessed through university library subscriptions in the case of journal articles. Where information contained in documentation could not be triangulated with other information sources, key informants from the various monitoring organizations or agencies were contacted to validate the information (see Cronmiller 2017).

Documentation was reviewed to determine the structure, function, intended influence, reported influence, and the factors or conditions that contributed to the persistence, transformation or demise of each monitoring program or organization. One of the most important, initial characteristics of an enduring and effective monitoring program is that it relies on carefully designed and implemented studies to answer scientific questions that are also relevant to policy options and management actions (Lindenmayer and Likens 2010). As such, attention was paid to the original motivation(s) for the monitoring program, including the types of monitoring questions and objectives, and critiques of how the monitoring program was implemented or evolved over time.

Results: Environmental monitoring in the Lower Athabasca

The review resulted in the identification of several programs and organizations contributing to environmental monitoring in the Lower Athabasca. The first commenced in the early 1900s, but most did not emerge until the late 1990s. The history and evolution of monitoring could be grouped into five *phases*, each reflecting specific monitoring mandates, types of activities, and institutional arrangements (Figure 2). Some of these programs and organizations have persisted for decades, whereas others have been short-lived. Each phase is presented below.

Phase 1 – long-term monitoring

The first phase of monitoring in the Lower Athabasca was marked by the establishment of two long-term water quantity and quality monitoring programs: the Water Survey of Canada (WSC), and the Long Term River Network (LRTN). Both programs are operated and jointly funded by the federal and provincial government. Established in 1919, the WSC is the primary agency for providing water *quantity* data on the Athabasca River. Eleven WSC hydrometric stations are operating in the Lower Athabasca that support the province’s water quantity management framework; however, only one station is used for setting thresholds for the Lower Athabasca region (GOA 2015a). All stations generate stream flow and water level data, with five stations including sediment transport data, but only two stations operate continuously year-round (Lindeman et al. 2011; EC 2013). WSC procedures are compliant with ISO 9001:2000 (Matrix Solutions Inc. 2012; Vaughan 2010), but there are limitations to WSC data for understanding baselines and cumulative change over time – including long intervals of missing data (Sauchyn et al. 2015), and uncertainty about data reliability due to program funding cuts starting in the mid-1990s (Spence et al. 2007). A 2010 report by the Auditor General of Canada concluded that monitoring stations were not located based on an assessment of risks and, as a result, WCS monitoring results may not capture the land and in-stream activities and substances that pose the greatest risks to water resources (Vaughan 2010).

The LTRN is a series of water *quality* monitoring stations, with the first on the Athabasca River implemented in the mid-1950s. A second station was added in 1978, approximately 200 km north of Fort McMurray (AEP 2016), and a third station added upstream of Fort McMurray in

2002 (WMDRC 2011). Monthly LTRN data are used for determining trends in provincial river systems (Hebben 2009), and provide input to the Alberta River Water Quality Index (ARWQI) – a water quality index calculated for each river basin and reported annually (AEP 2016). The LRTN and ARWQI report data for 62 variables, and are used to inform the identification of management triggers and limits under the province’s cumulative effects water quality framework.

Phase 2 – regional, science-based studies

The second phase encompasses three shorter-term, regional science-based studies: the Alberta Oil Sands Environmental Research Program (AOSERP), the Northern Rivers Basin Study (NRBS), and the Northern Rivers Ecosystem Initiative (NREI). All three programs were established to collect, analyze, and report data to better characterize baseline conditions and establish relationships between industrial development and environmental response. These were also amongst the first, formal efforts to investigate cumulative effects in the Lower Athabasca.

Alberta Oil Sands Environmental Research Program, 1975 – 1985

AOSERP was formed by Alberta and the federal government with a mandate to address the potential impacts of expanding oil sands operations (Wallace 2013). The program focused on air, land, water, and human systems, with the intent that simulation modelling would facilitate integration across components to support planning and decision making (Smith 1981). However, AOSERP’s mandate was revised only two years after its establishment, and refocused on providing information about factors that will assist in establishing guidelines for socially acceptable limits of damage to biotic and abiotic resources (AOSERP 1978). Included amongst

the program's objectives were to establish monitoring networks for baseline data and to identify environmental and social problems that can be anticipated from oil sands development (Smith et al. 1979). AOSERP resulted in a substantial accumulation of baseline data, including 200 research reports, but the program did not meet its objective of data integration (Smith 1981). AOSERP concluded in 1985, based on an assumption that no further expansion of oil sands development was likely to occur, and thus no new baseline studies would be needed (Smith 1981; Lindeman et al. 2011). Wallace (2013) and Schindler (2013), however, suggest that the program's reorganization just two years after its inception, and withdrawal of the federal government, were likely the more significant factors that led to the program's termination.

Northern River Basins Study, 1991 – 1996

The NRBS was a five-year joint initiative of Alberta, Northwest Territories, and Canada to address the impacts of development in the Peace, Slave, and Athabasca River basins. At the time, an increase in forestry operations in the region, the rapid expansion of the pulp industry, and a proposal for the largest bleached kraft pulp mill in the world, the Alberta Pacific Pulp Mill (Schindler 2013), triggered the need to refocus environmental assessment evaluations to include a broader ecosystems perspective (NRBS 1996a). The NRBS was managed by a 25-member multi-stakeholder board. Its primary objectives were to: provide scientifically sound information for planning and management of the aquatic environment; collect and interpret data and develop models related to hydrology, water quality, fish and fish habitat; and ensure that technical studies in the basin are conducted in an open and cooperative manner and reported regularly to the public. The program concluded in 1996, with a final study report comprised of 161 research papers (NRBS 1996a). Wallace (2011) describes the NRBS as an impressive research endeavour

by way of science-investment and Aboriginal engagement. Several recommendations emerged from NRBS, mostly calling for further monitoring and research to understand the effects of climate, flow regulation and land-use on hydro-ecological changes (Prowse et al. 2006); but also that an integrated ecosystem monitoring program, coordinated by scientific expertise, be established (NRBS 1996b). NRBS also advocated for the Mackenzie River Transboundary Waters Master Agreement, which was subsequently established in 1997; however, Schindler (2013) argues that many of the study's recommendations for improved monitoring went unaddressed.

Northern Rivers Ecosystem Initiative, 1998-2003

The NREI was a second five-year joint program between Alberta, Northwest Territories, and Canada, and in part a response to NRBS recommendations. The program focused on identifying water management issues, with follow-up actions emerging that involved both policy initiatives and further scientific research (NREI 2004a). Included amongst the priorities of NREI were pollution prevention and risks to drinking water; understanding long range transport of air contaminants; integrated environmental monitoring; integrated planning of land and water; and communications and public outreach (NREI 2004b). Dubé et al. (2006) report that, combined, NRBS and NREI provided an important scientific foundation for future assessment and scientific work in the Lower Athabasca. NREI's completion, in some respects, concluded the previous work of NRBS and, with escalating oil sands development pressures, was viewed as providing "a comprehensive authoritative body of knowledge which will guide decision-making for decades to come" (Gummer et al. 2006).

267 **Phase 3 – multi-stakeholder and consensus-based programs**

268 The third phase of monitoring in the Lower Athabasca was characterized by the emergence of
269 multi-stakeholder and consensus-based monitoring programs and organizations. These include
270 the Regional Aquatics Monitoring Program (RAMP), the Cumulative Effects Management
271 Association (CEMA), and the Lakeland Industry and Community Association (LICA). These
272 programs and organizations were established to collect, or make use of existing, monitoring data;
273 facilitate stakeholder communication about development impacts and concerns; and make
274 recommendations for better monitoring and cumulative effects management.

275

276 ***Regional Aquatics Monitoring Program, 1997 - 2012***

277 RAMP was established with a mandate to determine, evaluate, and communicate the state of the
278 aquatic environment and changes that may result from development within the Regional
279 Municipality of Wood Buffalo (RAMP 2009). The multi-stakeholder program was funded by the
280 Oil Sands Development Group, driven largely by industry partners (Lott and Jones 2010).
281 Included amongst RAMP's objectives were to: monitor aquatic environments in the Athabasca
282 oil sands region to detect cumulative effects and regional trends; collect baseline data to
283 characterize natural variability in the aquatic environment; assess the accuracy of predictions
284 contained in regulatory environmental assessments; satisfy the monitoring required by regulatory
285 approvals and company-specific community agreements of oil sands operators and other
286 developers; incorporate traditional knowledge into monitoring; and communicate monitoring
287 results. RAMP grew out of the realization that duplication was occurring by early oil sands
288 operators in terms of their environmental effects monitoring programs (Lott and Jones 2010).

289

The program contributed to improved integration of aquatic monitoring efforts across the region; a better understanding of the aquatic environment; the identification of long-term trends; and improved knowledge about the effects of oil sands activity on the aquatic environment (Lott and Jones 2010). However, studies by Kelly et al. (2009; 2010), showed concentrations of heavy metals in the Athabasca River that were at levels up to 30-times higher than what was permitted by existing guidelines, triggering concerns about RAMP and whether there were impacts from oil sands activity that were not being detected. A 2010 joint letter to Prime Minister Harper from multiple First Nations community members, leadership, health professionals, and scientists identifying deformities and tumors in fish, coupled with other high profile events and critiques (Schindler 2010; Miall 2013), further raised national concerns about RAMP's credibility.

Reports from RAMP, in contrast, had largely concluded that the environmental impacts of oil sands development were negligible; and a report commissioned by the Alberta government concluded that baseline levels of contaminants are variable through space and time and thus comparisons before and after oil sands development were difficult to make (Conly et al. 2002; Headley et al. 2005; WMDRC 2011). A Royal Society Report (2010) concluded that claims of health effects in First Nations communities due to oil sands may be exaggerated, and that existing air and water-quality monitoring data could not explain increased incidences of cancer cases in the region. The conflicting evidence led to a series of government-led and independent reviews, and an inquiry by the Auditor General of Canada, consequently revealing shortcomings in RAMP's monitoring design and transparency. These shortcomings were highly publicized, leading RAMP to bear the brunt of national and international accusations of disregard for environmental protection due to expanding oil sands activity (Donahue 2011).

313
314 Many studies have alluded to RAMP's origins and operations under the umbrella of industry as
315 the main reason for its challenges (Kelly et al. 2009; 2010; RAMP Review Panel 2011; Donahue
316 2011; Schindler 2013; Wallace 2013; Miall 2013; Hodson 2013; Kurek et al. 2013). As a multi-
317 stakeholder program, there was concern that RAMP was appropriated by industry, which was
318 disproportionately represented (Donahue 2011), thus leading some stakeholders to withdraw
319 from the program (Schindler 2013). Inconsistent administration as new stakeholders came on
320 board, inconsistent financing, the absence of a lead agency, and a lack of access to monitoring
321 data, resulted in fragmented studies of varying quality (OSAP 2010; Wallace 2013) and
322 suspicion by some members of the scientific community about the program's credibility
323 (Schindler 2013; Wallace 2013). RAMP was absorbed into the federal-provincial Joint Oil Sands
324 Monitoring Plan in 2012 (JOSMP 2012).

325

326 ***Cumulative Environmental Management Association, 2000 – 2016***

327 CEMA emerged to address recommendations made in a 1998 regional development strategy for
328 the oil sands, which forecasted an increase in oil sands activity. As a multi-stakeholder advisory
329 group, included amongst CEMA's goals were to: recommend management frameworks, best
330 practices and implementation strategies that address cumulative effects on air, land, water and
331 biodiversity; and actively promote inclusive dialogue and information exchange. CEMA did not
332 execute its own environmental monitoring, but it played an important role in the use and
333 development of other regional monitoring programs. Lott and Jones (2010), for example, report
334 that information products generated by CEMA have been adopted and implemented widely by

government and have helped drive meaningful change. Current water management frameworks under the Lower Athabasca Regional Plan, for example, are based largely on the work of CEMA. CEMA's representation included over 50 stakeholders, making it a hub for information exchange in the oil sands region. However, the number and diversity of stakeholders also impeded its ability to define clear goals and make swift decisions (Hegmann and Yarranton 2011; Noble et al. 2014). A report commissioned by Alberta concluded that CEMA's consensus-based approach "can result in decisions being watered down to the extent that they do not meet the best interests of any party or the environment [and] an incentive to delay the decision-making process as long as possible" (Radke 2007). CEMA was also plagued by inconsistent governance structures and concerns by many members that the province was not implementing CEMA's recommendations regarding environmental limits and thresholds for oil sands activities (Severson-Baker et al. 2008; Schindler 2013). Most First Nations withdrew from CEMA, citing little faith in the organization and in its ability to deliver results that are respectful of First Nations' interests, meaningful, balanced, and timely (PricewaterhouseCoopers LLP 2008). Statements made by the Canadian Association of Petroleum Producers also labelled CEMA's activities as redundant as new monitoring programs had begun to emerge (ESAA 2015). Funding for CEMA was suspended in 2016.

Lakeland Industry and Community Association, 2000 - present

LICA is a partnership between industry, government and the community of Bonnyville, Alberta, to implement monitoring related to the environmental health of the region – specifically water quality and airshed monitoring (LICA 2008; OSM 2017a). The first phase of LICA's airshed

monitoring program commenced in 2003 (LICA 2004); the monitoring network has since expanded to include both passive and continuous air quality data collection, including soil acidification sample plots. LICA data also support regional airshed monitoring, reporting on the provincial Air Quality Health Index, and oil sands monitoring to characterize patterns of airborne contaminants (OSM 2017b). A strength of LICA is its community focus and emphasis on disseminating monitoring data and providing information sessions to towns and municipalities throughout the Lakeland region (Urban System Ltd. 2011). However, notwithstanding its strengths in community outreach, an external review of LICA's monitoring network found discrepancies between continuous and passive monitoring data and concluded that the network suffered from large measurement uncertainties and insufficient spatial and temporal resolution (RWDI AIR Inc. 2008). The report made nine recommendations to improve LICA's monitoring system. The program continues to generate and disseminate near real-time airshed monitoring data, which is used to inform provincial state of the environment reporting and supports the Lower Athabasca air quality management framework.

Phase 4 – targeted, component-specific monitoring

The fourth phase of monitoring was characterized by programs implemented to monitor specific environmental components to support targeted science or decision-support needs. These programs include the Wood Buffalo Environmental Association (WBEA), Alberta Biodiversity Monitoring Institute (ABMI), and the Regional Groundwater Monitoring Network (RGMN).

379 ***Wood Buffalo Environmental Association, 1997 - present***

380 In the mid-1980s, in response to First Nations' concerns about air quality in the Wood Buffalo
381 region, the Alberta government and the oil sands industry formed a joint task force to explore air
382 quality issues and establish monitoring priorities. Included amongst the recommendations of the
383 task force was the need for a consensus-based approach to addressing air quality, leading to
384 WBEA's establishment (WBEA 2016). WBEA initially operated community air monitoring
385 stations for the province, but transitioned to a fully independent monitoring network in 1998.
386 Monitoring activities are focused on compliance monitoring, community health monitoring, air
387 quality baseline monitoring, and source attribution of compounds to determine if emissions from
388 oil sands operations are having long-term effects (Percy et al. 2012a, 2012b). WBEA also
389 informs hourly monitoring for reporting under Alberta's ambient air quality objectives and the
390 federal air quality health index, and provides direction on the assessment and improvement of air
391 quality in Alberta (CASA 2016). WBEA has been subject to several scientific reviews, and in
392 2008 it underwent a transition towards an "air pollutant pathway-driven, emission source to
393 ecosystem receptor sink program" (Percy 2013), thus expanding its mandate well-beyond
394 compliance-based monitoring. Federal and provincial reviews of WBEA have been largely
395 positive (OSAP 2010; RSC 2010); and Lott and Jones (2010) report that WBEA has maintained
396 an effective relationship with stakeholders and communities. Currently, WBEA monitoring
397 activities are part of the Joint Oil Sands Monitoring Plan, and inform the air quality management
398 framework under the Lower Athabasca Regional Plan.

399

400 ***Alberta Biodiversity Monitoring Institute, 1997 - present***

401 ABMI is an independent monitoring organization, jointly implemented by Alberta Innovates, the
402 Royal Alberta Museum, and the universities of Alberta and Calgary. It is responsible for
403 monitoring biodiversity by identifying species and measuring habitat characteristics at more than
404 1,600 sites across the province, with sites revisited every five years (ABMI 2016a). Initiated with
405 funding largely from the forestry sector, ABMI focussed initially on forest biodiversity but has
406 since expanded to include aquatic and wetland monitoring. ABMI data is available online, but
407 site locations are not public. Trend detection in biodiversity indicators established from site-
408 resampling is core to ABMI's mandate; but it wasn't until 2015, 18 years after ABMI's
409 establishment, that sites began being revisited (ABMI 2015). ABMI often operates in partnership
410 with academic researchers, governments, First Nations and industry to develop projects to
411 address ecological issues and help inform land use planning – such as its ecosystem services
412 assessment initiatives (ABMI 2016b). ABMI was instrumental in laying the groundwork for the
413 Ecological Monitoring Committee for the Lower Athabasca, which was established to oversee
414 terrestrial monitoring activities under the province's *Environmental Protection and Enhancement*
415 *Act*, and has been a key contributor to developing a biodiversity management framework under
416 the Lower Athabasca Regional Plan. Since its establishment, ABMI has maintained its
417 operations as an independent, arms-length organization. However, being the largest project of its
418 kind in Canada (AITF 2016), and requiring approximately \$10 million to deliver the program in
419 its entirety (ABMI 2008), ABMI has yet to be rolled out in full. Long-term, secured funding has
420 been a major challenge (ABMI 2015; Huot and Grant 2011).

421

Regional Groundwater Monitoring Network, 2012 – present

The RGMN was established to implement monitoring related to the province's groundwater management framework. Previous groundwater monitoring information was derived from various historic sources, including site-specific monitoring and the groundwater observation well network, which operated through the 1970s to 1990s (CAPP 2013). The province's groundwater management framework consists of three areas: north Athabasca oil sands, south Athabasca oil sands, and the Cold Lake–Beaver River area. The monitoring network for each area consists of a sub-set of industry and government monitoring sites for wells and aquifers. RGMN's objectives are to: understand the natural variability of groundwater conditions; provide baseline coverage in areas of no anthropogenic effects in each of the key regional aquifers; understand aquifer interactions, and how and where the groundwater system is connected to surface environments; and assess long-term water quality and water level trends, and the potential cumulative effects from current and future development activities (GOA 2012c). The RGMN currently informs regional decision-making under the Alberta Land Use Framework.

Phase 5 – search for coordination and integration

The final phase of monitoring depicts a recognized need for better oversight, coordination and integration of monitoring programs and organizations in the Lower Athabasca, but it also demonstrates the lack of clear consensus on how this is best achieved. Included in this most recent phase are the Joint Oil Sands Monitoring (JOSM), Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA), and the recently established Environmental Monitoring and Science Division (EMSD) of the provincial government.

444

445 ***Joint Oil Sands Monitoring, 2012 – present***

446 In 2011, an integrated oil sands environmental monitoring plan was introduced for the Lower
447 Athabasca, which provided technical details on what should be monitored as well as when,
448 where, and how monitoring should be executed. In early 2012, the Canada-Alberta JOSM
449 implementation plan was released to develop a process for administering monitoring activity.
450 JOSM describes how the governments of Alberta and Canada would “put in place a world class
451 monitoring program for the oil sands to provide assurance of environmentally responsible
452 development of the resource” (JOSMP 2012). It also set out funding arrangements, by way of an
453 amendment to the *Alberta Environmental Protection and Enhancement Act*, to allow the
454 collection of funds for monitoring from oil sands operators. The intent of JOSM was “to enhance
455 monitoring activities and work to integrate environmental monitoring across all environmental
456 components, which were historically monitored independently through separate organizations or
457 programs” (Hatfield Consultants 2015). Included amongst the program’s objectives are to
458 support sound decision-making by governments as well as stakeholders; ensure transparency
459 through accessible, comparable and quality-assured data; enhance science-based monitoring for
460 improved characterization of the state of the environment and collect the information necessary
461 to understand cumulative effects; and develop a better understanding of baselines and changes.

462

463 JOSM introduced a three year (2012-2015) “rationalization and integration of current monitoring
464 activities into a single, government-led program” (JOSMP 2012), co-led by the Assistant Deputy
465 Minister of Science and Technology, Environment Canada, and the Assistant Deputy Minister of
466 Science and Monitoring, Alberta Environment and Water, followed by a scheduled three-year

review. The review, by Stratos Inc. (2015), found that the program's scope was unclear in the context of ambient monitoring needs for Alberta's Lower Athabasca Regional Plan; lacked an overall strategic approach and key monitoring questions; lacked a meaningful and transparent approach for considering and addressing stakeholder interests; and that the program's financing lacked transparency. JOSM made some progress toward implementing scientifically defensible monitoring efforts, but was plagued by "limited evidence of efforts to evaluate and use the data collected" and "limited progress on harmonizing and rationalizing pre-existing disparate monitoring approaches and activities" in the oil sands region (Hopke et al. 2016). In December 2017, Canada and Alberta signed a memorandum of understanding formalizing their government's shared responsibility for long-term monitoring in the region, which also included a commitment to greater Indigenous involvement in monitoring priorities.

Alberta Environmental Monitoring, Evaluation and Reporting Agency, 2013 - 2016

AEMERA was formed in 2013, based on the findings of a provincial government review of environmental monitoring that determined "the amount and quality of environmental monitoring, evaluation and reporting in Alberta requires substantial improvement" (AEMP 2011), and that "only an independent, science-based monitoring authority, at arms-length from government and industry" could carry this out (Miall 2013). AEMERA was created under *Protecting Alberta's Environment Act* to obtain credible and scientific data regarding the condition of the environment in Alberta; and "to provide open and transparent access to scientific data and information on the condition of Alberta's environment, including specific indicators as well as cumulative effects, both provincially and in specific locations" (AEMERA 2015). One of its unique features was its

science advisory panel, which provided scientific oversight to the monitoring responsibilities of the organizations under its authority, as well as its traditional knowledge panel.

AEMERA became administratively independent, as a science-based monitoring authority, in 2015. That same year, however, a provincial election put a new government in power. A report was subsequently commissioned to review AEMERA's operations, which concluded that: an independent monitoring body was unnecessary; the implications of transferring science capacity from the province to AEMERA had not been fully considered; the program's governance costs are duplications of less expensive existing provincial monitoring arrangements; and that AEMERA was "a failed experiment in outsourcing core responsibility of government to an arms-length body" (Boothe 2015). In April 2016, the province announced that monitoring efforts under AEMERA would be folded back into the provincial government to strengthen scientific capacity and be more transparent and credible in reporting. The province reported that the "private model diverted overhead costs away from monitoring, led to confusion around roles and responsibilities, and limited resources" (GOA 2016b). This sparked criticism from some members of the scientific community, arguing that the Alberta government was "making a huge mistake by eliminating AEMERA just when it is beginning to show an accurate picture of the state of the Athabasca River and gain public support" (Schindler et al. 2016). Both the science advisory panel and the traditional knowledge panel survived AEMERA's dissolution into the provincial government.

Environmental Monitoring and Science Division (EMSD), 2016 - present

With the announcement that AEMERA would be folded back into the provincial government, a new division within the Alberta Ministry of Environment and Parks was formed to house it – the EMSD. Its mandate was to “provide open and transparent access to scientific data and information on the condition of Alberta’s environment, including specific indicators as well as cumulative effects” (EMSD 2016). EMSD was established to provide baseline environmental monitoring; cumulative effects monitoring; data evaluation and management; on-going condition of environment reporting; and data, evaluation, knowledge and reporting to inform policy and regulatory decision-making. Performance evaluations or reviews of EMSD have yet to be completed.

Discussion

The Lower Athabasca experience reflects a tension in the evolution of regional environmental monitoring. In many respects, the evolution of environmental monitoring in the region was a natural progression, commencing with the establishment of long-term baseline monitoring, followed by more focused baseline studies to improve regional science, the emergence of stakeholder-defined programs, implementation of targeted monitoring initiatives responsive to specific needs, and institutional reorganization to establish a longer-term governance structure. At the same time, the evolution of environmental monitoring in the Lower Athabasca reflects considerable discontinuity – a series of unnatural breaks. Monitoring program reviews and external critiques and conflicts, even if at times disruptive, played an important role in affirming the credibility and influence of some monitoring programs and the discontinuation of others. But the result was an episodic history of monitoring – reflecting shifting priorities, concerns about

credibility, and short-lived commitments by the agencies, industries and governments involved. This discontinuity has, by many accounts, eroded public trust in commitments to long-term monitoring (Wallace 2013) and in the ability to detect and appropriately manage the impacts of development. More ominously, it has contributed to a culture of uncertainty surrounding the stability of institutional arrangements and support for long-term environmental monitoring to address cumulative effects (Smith 1981; NRBS 1996b; Ayles et al. 2004; Gummer et al. 2006; Schindler 2010; Wallace 2013; Noble et al. 2014).

There are long-term monitoring programs in the region, such as the federal and provincially owned WSC and LTRN, which have been in operation since 1919 and 1968, respectively. Much of the region's monitoring activity, however, did not commence until the late 1990s as a response to rapid oil sands development. The programs that emerged at that time were shorter-term, science-based studies, with strong emphasis on characterizing baselines and establishing cause-effect relationships. These shorter-term programs were followed by the emergence of several multi-stakeholder monitoring initiatives, in recognition that stakeholder engagement, in addition to basic science, was essential to managing land use and environmental change. Like their predecessors, these programs were made possible through substantial financial injections from industry.

The next phase of monitoring was characterized by more targeted, component-specific monitoring, focused on air quality, biodiversity, and groundwater – emerging largely in response to specific industry or government regulatory needs. Most recently, several new organizations, such as JOSM, AEMERA and EMSD, have become the hub for monitoring activity, established

in response to criticisms about the state of the Lower Athabasca and challenges to the disjointed nature of previous monitoring initiatives. This shift to greater government oversight and centralization of monitoring may reflect expectations that the state should be responsible for monitoring ambient environmental conditions, engaging stakeholders, and providing data for regulatory decision support (Biber 2011; Olszynski 2014). However, given the history of concerns in the Lower Athabasca over government and industry control over monitoring programs and the reliability of monitoring data, there are differing philosophies as to whether monitoring is most effective and credible when managed in-house by government agencies or when under the control of external, arms-length science-based organizations.

Based on the Lower Athabasca experience, several observations emerge that are of value for future environmental monitoring initiatives in Alberta and in other jurisdictions. First, legacies of cross-agency and jurisdictional differences can substantially impede efforts to support integrative environmental monitoring (Dubé and Munkittrick 2001; Donahue 2011; Ball et al. 2013b; Schindler 2013; Wallace 2013). In 1996, the NRBS, for example, recommended that monitoring activities be integrated to identify priorities, avoid duplication, and redirect efforts and allow for monitoring at a basin scale (NRBS 1996b). The years following saw the contradictory inception of monitoring programs independent of one another, such as RAMP, WBEA and ABMI – each with their own mandate and monitoring protocols. The emergence of AEMERA and JOSM, as integrative institutional solutions, were unable to fully resolve this history of disparate monitoring programs and organizations (Lott and Jones 2010; Donahue 2011; Miall 2013). Funding for previously independent programs, such as WBEA and ABMI, was suddenly funnelled through the new monitoring organization, AEMERA, but other independent programs

579 remained, adding another layer of administrative complexity to existing monitoring
580 arrangements. For JOSM, jurisdictional differences between the federal and provincial
581 government over what the jointly-administered monitoring program should accomplish, namely
582 long-term ambient monitoring or shorter-term efforts to establish cause-effect, resulted in
583 strained governance relationships and the lack of an overall strategic approach to monitoring
584 (Donahue 2011; Miall 2013; Stratos Inc. 2015). The lack of transparency in longer-term vision
585 for the organization, lack of clarity about how federal authority would be exercised over
586 monitoring related to Aboriginal lands or national parks, the lack of full stakeholder engagement,
587 and the failure to establish clear leadership, were amongst the shortcomings that prevented
588 smooth transition toward a publicly accepted, joint government-led program.

589
590 Second, multi-stakeholder initiatives are often considered important to ensuring trust and validity
591 in environmental management at large (Fraser et al. 2006), but they are not a panacea for
592 effective environmental monitoring. Monitoring programs require clear goals and objectives,
593 such that data generated are meaningful to support specific questions of management or
594 scientific relevance – or both. RAMP started as an industry-only initiative and evolved over time
595 to include more stakeholders; however, it still suffered from transparency issues, industry
596 control, and the lack of a science focus. Multi-stakeholder initiatives can prove especially
597 challenging in regions subject to controversial land uses and resource development (Biber 2011;
598 Donahue 2011). The size and complexity of some multi-stakeholder initiatives in the Lower
599 Athabasca often impeded their ability to define clearly agreed-upon monitoring goals and to
600 make timely policy recommendations (Severson-Baker et al. 2008). Organizations like CEMA,
601 for example, experienced constant re-examination of mandate and governance, which can detract

from the ability of an organization to meaningfully establish clear management objectives (Truex and Soreide 2010). Part of the challenge to multi-stakeholder initiatives in the Lower Athabasca can be attributed to the competing values at the table, and the concerns of some stakeholders, namely First Nations and environmental organizations, that their values were not equally represented alongside industry's in setting monitoring goals and formulating management recommendations, and that recommendations were not being implemented by the province. Fraser et al. (2006) reports that multi-stakeholder processes must formally feed into decision making forums or they risk being viewed as irrelevant by stakeholders. Coupled with experiences reported from other watersheds across Canada (e.g. Kristensen et al. 2013; Chilima et al. 2017), lessons from the Lower Athabasca suggest that consistent administration under the direction of a lead agency is critical to coordinating interests, ensuring influence, and providing the stability needed to support long-term monitoring when multi-stakeholder organizations are involved. An ongoing challenge in the Lower Athabasca, however, is that not all monitoring programs have fully accepted a centralized planning process; governance structures are constantly being redesigned.

Third, scientific autonomy is essential to the credibility of regional monitoring programs – especially in regions characterized by multiple land uses, values, interests, and controversial resource development. Such autonomy requires monitoring design that is independent of political mandates, aligned instead with the science requirements for long-term understanding of cumulative change (Greig and Duinker 2011; Sheelanere et al. 2013; Westbrook and Noble 2013; Schindler et al. 2016). Criticisms about industry and government influence over environmental monitoring have emerged repeatedly in the Lower Athabasca, leading to questions

about the credibility of monitoring results and even to the disbandment of some monitoring programs (Kelly et al. 2009; 2010; OSAP 2010; RAMP Review Panel 2011; Donahue 2011; Schindler et al. 2016). Perceptions that RAMP was ‘industry controlled,’ for example, and CEMA’s power struggles between industry, First Nations, and environmental organizations, contributed to conflicts over what constituted credible monitoring results (Schindler 2010; Donahue 2011). There are independent monitoring programs in the Lower Athabasca that have emerged as reputable, science-based organizations functioning largely independent of industry and government. WBEA and ABMI, for example, both are recognized for the accessibility of their data and credibility as science-led programs (OSAP 2010; Lott and Jones 2010; RSC 2010). ABMI’s focus on answering a range of scientific questions (Nielsen et al. 2009; Cole Burton et al. 2009), and WBEA’s frequent reviews and science-based leadership (Percy 2013), have allowed these programs to grow and gain trust and credibility amongst data users – including industry, government and the public. The importance of scientific autonomy to monitoring credibility was also evident in the most recent shift in monitoring program administration in the Lower Athabasca. When the provincial government established EMSD to take over the monitoring responsibilities of the former independent AEMERA, AEMERA’s independent science advisory panel remained intact (GOA 2015c). Whether this independent panel will sufficiently substitute for a truly independent monitoring organization in the region, however, remains to be seen.

Finally, science-based monitoring programs must generate information that is responsive to regulatory decision-making needs (Hegmann and Yarranton 2011). Pursuing the ‘correct’ questions to support cumulative effects understanding and management decisions has been an

enduring criticism of monitoring programs in the Lower Athabasca (Stratos Inc. 2015; Hopke et al. 2016), and cumulative effects monitoring in general has been criticized for not reflecting regulatory decision support needs (Dubé et al. 2003; Noble 2015). In the Lower Athabasca, for example, despite its scientific credibility, ABMI has been criticized for being an “unfocused monitoring program...planned backwards on the collect [data] now, think-later principle” (Lindenmayer and Likens 2010). Accumulating monitoring data without clear relevance to regulatory decisions can add little value to cumulative effects management decision making (Lovett et al. 2007), resulting in long-term funding constraints and, in some cases, program failure (Reid 2001; Biber 2011). The problem, however, is that the ‘right’ monitoring questions for both cumulative effects science and management are far from resolved (Kilgour et al. 2007; Seitz et al. 2011; Dube et al. 2013). In 1996, for example, the NRBS (1996a) recommended that the first step in developing a monitoring framework must be deciding “what needs to be monitored and for what reason.” Subsequent reviews of monitoring programs across the Lower Athabasca region indicate that questions are still not being formulated or addressed to guide monitoring programs in a way that supports both cumulative effects science and decision needs (Ayles et al. 2004; OSAP 2011; Noble et al. 2014).

Conclusions

Large-scale, long-term environmental monitoring programs, coupled with localized and shorter-term monitoring efforts of project proponents and development permitting processes, are foundational to understanding and effectively managing cumulative environmental effects. That said, numerous reviews have identified enduring challenges to monitoring programs and related cumulative effects assessment and management initiatives, and a disconnect between science and

671 decision making (Seitz et al. 2011; Noble 2015). The challenges are often attributed to the
672 difficulties associated with determining effect-cause relationships in regions characterized by
673 multiple stressors, the complexity of ecological systems and uncertainties in threshold
674 determination, limited long-term baseline data, and spatial and temporal inconsistencies in the
675 indicators used to monitor and evaluate cumulative change, among others (Reid 1998; Dube
676 2003; Squires et al. 2009; Seitz et al. 2011; Ball et al. 2013a; Schindler 2013).

677
678 The Lower Athabasca is probably one of the most monitored ecosystems in North America.
679 There is room for science-improvement, but institutional challenges tend to pose the most
680 enduring and significant constraints to long-term monitoring programs, often overshadowing
681 pursuit of the data needed to understand cumulative change and support land use and regulatory
682 decision making. Notwithstanding the persistence of some monitoring programs in the region,
683 the tendency has been to make shorter-term investments in monitoring organizations or science
684 initiatives that respond to immediate stakeholder needs, but often at the expense of longer-term
685 understanding of cumulative change (Biber 2011; Olszynski 2012). This, in addition to
686 difficulties associated with determining whether monitoring is effective (Irvine et al. 2015), and
687 to whose standards (Biber 2011; Schindler 2013), has contributed to significant disruptions in
688 monitoring programs in the Lower Athabasca and, notwithstanding decades of monitoring, only
689 a limited understanding of cumulative change.

690
691 The Lower Athabasca experience illustrates the tensions that exist in large-scale environmental
692 effects monitoring programs, tensions between: the competing mandates of agencies and
693 jurisdictions, that can substantially impede efforts to support integrative environmental

694 monitoring; the need for multi-stakeholder engagement to lend legitimacy to monitoring
695 initiatives, yet the importance of clear leadership and direction about monitoring priorities and
696 the types of questions pursued; and between the need for scientific autonomy to ensure
697 credibility of effects-based monitoring programs, whilst ensuring that autonomous, science-
698 based monitoring decisions are responsive to the day to day needs of regulatory decision makers.
699 The science of monitoring to support cumulative effects understanding is advancing (Duinker et
700 al. 2012; Dubé et al. 2013; Noble 2015), but its relevance to, and impact on, cumulative effects
701 management and decisions is often stifled by institutional arrangements. At a minimum, lessons
702 from the Lower Athabasca suggest that regional monitoring requires a clear vision, agreed-upon
703 monitoring questions, a coordinated multi-stakeholder approach to setting objectives, balancing
704 scientific autonomy and monitoring design with the needs of stakeholders and decision makers,
705 and a clear governance process. Further research and policy experimentation are still needed to
706 explore institutional and programmatic design for monitoring programs that support credible,
707 science-based monitoring for cumulative effects understanding, but that also ensure timely and
708 relevant results for land use planners and decision makers. Until the institutional challenges are
709 addressed by researchers and policy makers, and collaborative solutions identified, monitoring
710 programs will struggle to inform both science and decision making, and continue to emerge as
711 short-term bursts of activity.

712

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Draft

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1063 **Figure 1. Land-use in the Lower Athabasca planning region, Canada**

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1065 **Figure 2. Environmental monitoring timeline for the Lower Athabasca Alberta, Canada,**

1066 **showing phases of monitoring activity.** ABMI (Alberta Biodiversity Monitoring Institute); AEMP

1067 (Alberta Environmental Monitoring Panel); AEWG (Alberta Environmental Working Group);

1068 AMERA (Alberta Environmental Monitoring, Evaluation and Reporting Agency); AOSERP

1069 (Alberta Oil Sands Environmental Research Program); AWC (Athabasca Watershed Council);

1070 CEMA (Cumulative Environmental Management Association); EMSD (Environmental Monitoring

1071 and Science Division); JOSM (Joint Oil Sands Monitoring); LARP (Lower Athabasca Regional

1072 Plan); LTRN (Long Term River Network); LUF Land Use Framework); NRBS (Northern River Basins

1073 Study); NREI (Northern Rivers Ecosystem Initiative); OSAP (Oil Sands Advisory Panel); RAMP

1074 (Regional Aquatics Monitoring Program); RGMN (Regional Groundwater Monitoring Network);

1075 WBEA (Wood Buffalo Environmental Association); WSC (Water Survey of Canada)

Land Use in the Lower Athabasca Planning Region of Alberta, Canada

Legend

- Lower Athabasca Plan Boundaries
- Lower Athabasca River
- Towns and Cities
- Oil Sands Industrial Features (as of 2013)
- Agricultural Area
- Highways
- Lake Athabasca
- Protected Area
- Mixed Use Resource Area*
- Federal Lands**
- Recreation/Tourism Area

0 50 100 200 Kilometers

*Mixed-use resource areas are an area with significant and geographically shifting economic development activities of intensive energy and forestry. Forest cover is the largest surface feature (Regional Advisory Council, n.d.).
** Includes Cold Lake Air Weapons Range, Indian Reserve / Metis Settlement Area
Projection: NAD 1983 UTM Zone 12N
Map Data Source: Government of Canada, Government of Alberta

* Indicates program contributing to Lower Athabasca
Regional Plan Cumulative Effects Management Frameworks