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"Sustainability is finding the next mine": The complicated relationships among legacies, sustainability, and EA

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1. Introduction

Since the popularization of "sustainable development" in the late 1980's, the mining industry worldwide has initiated various efforts to integrate the concept into mining operations (Worrall et al., 2009). While mining can have positive sustainability effects (Hodge, 2004), the negative long-term effects can outweigh the positive short-term ones (Worrall et al., 2009; Roche et al., 2017; Li, 2015). Consequently, "mining" and "sustainability" still often seem to be contradictory (Gibson and Robinson, 2014). If mining is to be a sustainability-enhancing practice and lead toward greater and lasting regional well-being, then it seems sensible that the legacy effects of mining must be fully considered during environmental assessments (EA) and the inevitable tradeoffs weighed cautiously (Sandlos and Keeling, 2013). Instead, current EAs are often blind to tradeoffs and frequently do not ensure that mines are planned and operated to avoid negative mining legacy effects while also amplifying long term sustainability (Gibson, 2012; Johnston, 2014).

This paper identifies and confirms a set of legacy effects, introduced in an unpublished manuscript, which should be considered in EA. We start by establishing pertinent legacy effects and then introduce the methods and describe our case study for further testing these, Snow Lake, Manitoba. Next, we present findings related to the legacy effects and offer discussion on the use and suitability of EA in considering these effects. Finally, the concluding section summarizes ways forward through a legacy effects framework that applies next generation approaches to EA.

2. Context

2.1. Mining legacy effects

Mineral and metal resources are critical to modern-day living, but it is imperative that they be developed in a way that contributes positively to sustainability (Gibson and Robinson, 2014). Canada's history of nation building is closely linked to mining and other extractive industries, "so much so that resource development was once considered synonymous with public interest" (McAllister, 2004, 348). In many parts of Canada, mining and other geographically specific extractive industries attract the bulk of economic investment. Much the same is true of Australia, Brazil, and many other jurisdictions with colonial histories (Herbert et al., 2002; Furtado, 1963).

In an unpublished manuscript Gibson and Robinson (2014) outline a framework consisting of five key types of legacy effects (Fig. 1) associated with mining. While many of the legacy effects they describe have been documented in the literature, the focus here is on the suite of effects as captured in Fig. 1, rather than any one of the individual effects (e.g., new jobs or acid rock drainage) that often dominate any assessment of legacy. We adopt this framework to organize our discussion of mining legacy effects and to consider the importance of these effects to EA. Each of these five types of effects is discussed below.

2.1.1. Residual biophysical effects

Mining results in the movement of an incredible volume of material. Typically, only 2% of the desired ore mineral is found in the total rock excavated, leading to the adage that mining is primarily a waste management industry (Gibson and Klinck, 2005). The features associated with mining such as open pits, slag mounds, waste rock piles, and tailings ponds can cause biophysical issues (Sandlos and Keeling, 2013). Mining-related activities such as processing and smelting often generate toxic by-products from process chemicals such as cyanide, arsenic compounds and heavy metals (Bridge, 2004). Mine-generated tailings, plus spoil heaps and mineral stockpiles, require careful management lest they contaminate local water and soils through runoff of water with high concentrations of dissolved metals and other suspended solids. Recent tailings disasters (e.g., at Mount Polley in Canada and Fundão in Brazil) illustrate the threat of dam failure both during and after mine operations (Eisenhammer, 2015; Johnston, 2014).

Acid rock drainage (ARD also known as acid mine drainage) is a residual contamination problem that can also pose major biophysical risks (Bridge, 2004) and may be the biggest contamination issue facing the industry (MEND, 2014). Acids are created when sulfide minerals

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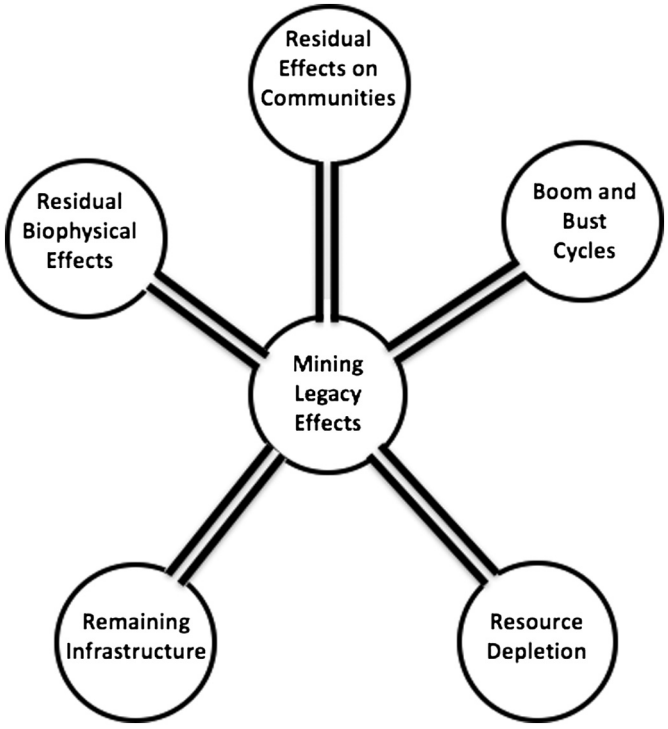

Fig. 1. Suite of legacy effects associated with mining.

(many metallic ores are found as sulfide minerals) oxidize to form sulfuric acid as they are exposed to oxygen and water (Bridge, 2004). Presently, there is no inexpensive technical fix or mitigation for ARD (Sandlos and Keeling, 2013). The effects of mining are also typically combined with the effects of ecosystem fragmentation due to mining projects plus their infrastructure, especially where that involves new roads and power transmission lines.

The legacy effects of one single mine also often contribute to the cumulative legacy effects of multiple mines, and/or other extractive industrial operations, power projects and infrastructure in the same region, watershed, or traditional territory of Indigenous people.

2.1.2. Residual effects on communities

The community benefits of mining are mostly economic through providing impetus and funds for improvements to community facilities, equipment, and services (Gibson and Robinson, 2014). New mining activities come with new opportunities for both direct employment and contract work. In Canada, the mining industry boasts the highest wages in the resource sector (HudBay Minerals Inc., 2015). Many mining companies provide local training and tout preferential local hiring and local purchasing practices to increase local community benefits and support (see for example Rio Tinto Alcan, 2015). Positive effects often diminish over time once the mine closes, investments are not being made in the community, and skilled individuals move to attain work elsewhere. Not all individuals however, are able to move to find work. This is especially true of some remote Indigenous populations.

In order to avoid the issues associated with mining dependent communities, many mining companies in Canada and around the world have employed a fly-in/fly-out (FIFO) model of operation for the last several decades (2001, 135; HudBay Minerals Inc., 2015). According to Storey (2001, 135), FIFO are mining operations where employees are flown in and provided lodging and food and "employees spend a fixed number of days working at the site, followed by a fixed number of days at home". From one perspective, the FIFO model can reduce or eliminate the need for new resource dependent communities (e.g., Snap Lake Diamond Mine, Mary River Iron Mine) (Storey, 2010, 1163). The FIFO model is more complicated when a community already exists. FIFO typically reduces direct employment and typically reduces direct and indirect opportunities for nearby existing communities. Consequently, it reduces not just related income benefits during mine life but also opportunities to develop capacities and non-mining livelihoods that may serve after the mines close.

2.1.3. Boom and bust cycles

Global demand for a natural resource drives up development and production of the resource, leading to economic growth (boom) through the growth in jobs, increase in taxes and royalties, additional construction, etc. (Freudenburg and Gramling, 1998; Gibson and Robinson, 2014). A drop in demand or a glut of these natural resources in the market leads to lower mineral prices and an economic decline (bust) in the region as mines cut back or suspend operations and jobs, revenues, population and taxes drop (Putz et al., 2011). The bust can have negative implications for individuals and local businesses. Rapid economic growth can also lead to local price inflation and harmful economic dependencies on a single resource sector (Gibson and Robinson, 2014; Michael, 1995). This problem is exacerbated by the fact that many mining communities are geographically remote and therefore removed from most other viable economic opportunities. All aspects of community existence can become enveloped in the dominant sector so, for example, house prices in the community rise and fall with mineral prices. Economic benefits diminish in the later stages of the mine life and all mines eventually close, most after less than 20 years. Nearby communities associated with FIFO operations, as noted above, are provided fewer economic opportunities but are therefore less dependent and less likely to have severe bust effects when operation ends.

2.1.4. Remaining infrastructure

Roads, energy corridors, and other related infrastructure necessary for mining activities may connect remote communities as a spinoff effect (Gibson and Robinson, 2014; Pegg, 2006). This infrastructure is built with extraction in mind rather than community use during mining or use after the mine closes (for example see Ring of Fire transportation corridor discussion in Porter, 2015). Some see increased connection between remote areas and major centres as a positive as it allows for more easier access to various goods and services. Others see the increased connection as negative since it opens these areas up to more influence and destruction both culturally and ecologically (Reed and Miranda, 2007). Remaining infrastructure is also costly to maintain which may pose a burden to communities.

2.1.5. Resource depletion

Since mineral ore bodies are finite, mineral reserves offer a one-time opportunity for both the mining company and the community (Gibson, 2014). This opportunity has potential for great conflict between parties as short-term gains may lead to long-term loss and preclude future use of the resource (Gibson and Robinson, 2014). This has resulted in the development of tools such as impact benefit agreements, income sharing, and heritage funds to increase long term benefits of mining and use "mines as bridges" to more sustainable futures (Gibson and Robinson, 2014; Gibson, 2014; Prior et al., 2012).

2.2. Environmental assessment

To address the above challenges, environmental assessment (EA) has been growing in use, scope and ambition since its inception in the US *National Environmental Policy Act* of 1969 (Gibson et al., 2005). EA has been applied to mining development in Canada and worldwide (e.g., Franks et al., 2010; Noble and Bronson, 2005), though many prospecting activities are exempt from EA. Despite the evident shortcomings of EA processes in properly predicting and effectively managing the impacts associated with mining, it is still the main vehicle for assessing and planning mining proposals. EA has benefits for assessing mining in that it is applied worldwide, has many best practices

associated with it (e.g., Principles of Environmental Impact Assessment Best Practice), and is often oriented toward sustainability (Gibson, 2006; Morrison-Saunders and Retief, 2012; Bond and Morrison-Saunders, 2009). There have also been innovations in EA practice associated with mining assessments, for example in the Canadian context the rise and use of independent monitoring agencies (e.g., Ekati and Diavik Diamond mines in Ross, 2004).

As well, current conceptions of next generation assessment (e.g., Johnston, 2016; Gibson et al., 2016) and of sustainability assessment (e.g., Pope et al., 2017) offer direction in terms of the ways conventional EA practice needs to evolve to incorporate the legacy effects of mining. For example, some suggest that EA needs to include a purpose to deliver positive contributions to sustainability, a broad scope covering relevant effects (socio-economic as well as biophysical, cumulative as well as individual, interactive as well as specific), meaningful public engagement, tiered strategic as well as project based application, and emphasis on monitoring and response, including post-closure (Morrison-Saunders and Arts, 2004).

3. Methods

Since Canada has many decades of experience with EA, as well as number of ongoing EA legislative reform processes (Canada, 2017; MLRC, 2015) and more than a century of active mining and associated legacy effects, a Canadian case was undertaken. We applied selection criteria that included considerations such as a recent mine EA (5–10 years), close community proximity, and historic mining in the region to several potential cases from across the country and the Snow Lake MB case best fit. We used purposive and snowball sampling to collect data from 15 participants, including residents, and representatives of environmental non-governmental organizations, civil society groups, mining corporations, and government agencies through a series of semi-structured interviews.

Additionally, we interviewed nine mining and assessment experts from across Canada to broaden our perspective.[1] Questions were designed with the aid of relevant literature and focused on impact assessment process, mine legacy, and sustainability issues. The empirical data collected was considered in light of the international literature on mine legacy effects and EA. Data were managed and analyzed using the QSR NVivo™ software that allowed data to be broken down into data segments, coded, and placed into meaningful categories to show themes and key ideas.

3.1. Case study

Snow Lake is in Northern Manitoba, approximately 700 km north of Winnipeg, the provincial capital. With a population of 900 (Statistics Canada, 2016), Snow Lake is a mining community situated on the eastern edge of “the Paleoproterozoic Flin Flon–Snow Lake greenstone belt [that hosts] more than 18 volcanogenic massive sulfide (VMS) deposits” (Gagné, 2010, 118). Mining is the largest employer and the community's population fluctuated greatly over time as old mines closed and new mines opened (C-6, C-7, C-8, C-10, C-11, C-12, C-14, and C-16) mirroring the history in other parts of Canada and internationally.

More than five gold mines operated in the area in the first half of the century. Howe Sound operated the Nor-Acme Gold Mine starting in 1947 and constructed a dormitory and dining hall, a staff house, 43 residences, a four-room school, an eight-bed hospital, the community hall, and a curling rink, in turn establishing the town (MMM Group Limited, 2009; Town of Snow Lake, 2011).

[1] Participants are indicated throughout the paper using an alphanumeric identifier. Community participants from northern Manitoba are identified with ‘C’ and mining and assessment experts from across Canada are identified with ‘E’.

Base metal mining began in the 1950s in the region (MMM Group Limited, 2009; Parres and Jackson, 2009). Hudson Bay Mining and Smelting Co. Ltd. (HBM&S), (referred to as HudBay throughout this paper), became the dominant employer in the late-1950s with the establishment of Chisel Lake Mine on the rich Chisel Lake basin (Parres and Jackson, 2009; MMM Group Limited, 2009). Currently one mine operates on the Chisel Lake basin. The Lalor mine, began limited production in 2012 and full production in 2014 (HudBay Minerals Inc., 2014). HudBay also operates Reed Lake Mine in a joint venture (VMS Ventures, 2015). Reed Lake Mine began production in 2013 (Parres and Jackson, 2009; VMS Ventures, 2015). Six other base metal mines located on deposits in the Snow Lake area operated and closed since the 1950s (Parres and Jackson, 2009). In total, 19 mines have operated in the surrounding region.

Renewed exploration around the old Nor-Acme Gold Mine began in 1994 and by 1995 the old property began production again under the name New Britannia Mine (Parres and Jackson, 2009). New Britannia's rebirth helped turn the town's bust around as many HudBay employees working in Flin Flon could take jobs at the gold mine and move back to Snow Lake. After HudBay recommenced exploration activities in the mid-nineties, the Photo Lake deposit was quickly found and also entered production in 1995 (C-6, C-7, and C-11; Parres and Jackson, 2009).

The town again entered a low period in 2005 when New Britannia Mine ceased production and their entire workforce was laid off (Parres and Jackson, 2009; Town of Snow Lake, 2011). Exploration proved successful in 2007 when HudBay found the Lalor Lake deposit, which now supports possibly the company's biggest mine yet (Parres and Jackson, 2009). In the same year, a junior exploration company, VMS Ventures, found significant copper deposits on their Reed Lake property (HudBay Minerals Inc., 2014; VMS Ventures, 2015). Participants estimate that currently between 80% and 90% of the town population relies directly or indirectly on the mining industry (C-6, C-8, C-14, C-15 and C-17).

In 2010 HudBay obtained a permit to build and operate a 200-person camp in the town of Snow Lake to house workers during the construction and early production stages of the Lalor mine (Cash, 2013). The original camp permit lasted for four years and in 2014 the Snow Lake Town Council agreed, in a contentious meeting, to extend the camp's licence to operate for another two and a half years, half of the company's preferred five-year extension. As of the time of publishing, the camp is still in operation. A participant suggests that this status will likely continue indefinitely through the life of the mine.

4. Legacy effects and EA in Snow Lake

The following section presents the findings of the case study in relation to the mining legacy effects (Table 1) described by participants as outlined below. This section also explores the current role that EA plays in managing mining legacies.

4.1. Residual biophysical effects

When asked about mining legacy issues participants most commonly identified the long-term environmental ramifications of mining. Of the 24 participants interviewed, 21 spoke about environmental impacts. Instances and examples of residual environmental effects provided by participants were all negative. Two dominant sub-themes associated with residual environmental effects emerged in the data: water health and mine site footprint.

4.1.1. Water health

Both expert and community participants noted the importance of clean water and the dangers of water contamination, especially in relation to mine waste and tailings ponds (C-11, C-14, C-18, E-1, E-3, and E-22). There is a fear, common with many mining operations and

Table 1
Mine legacy effects categories in theory and grounded in Snow Lake data.

Legacy effects framework categories	Positive legacy effects (grounded)	Negative legacy effects (grounded)
Residual biophysical effects		• Water health • Mine site footprint
Residual effects on communities	• Job training and experience • Wealth generation	• Dependence on mining • Changes to town culture • Land rights and relationships
Boom and bust		• Dependence on the mine and mining company • Lack of diversification • Unstable population and housing market
Remaining town infrastructure	• Roads and connectivity	• Ageing town infrastructure
Resource depletion	• Heritage funds • Taxes and royalties	

echoed in the interviews, that improperly stored acid generating mine waste will oxidize and create ARD. Participant E-22 noted the dangers to water quality and the potential for long term negative legacy effects on mining areas,

> The environmental problems are mostly water related and deal with the physical disturbance and the waste materials. Approximately 90% of the material is moved but not removed as part of the mining process and now there are mobilized potentially acid generating sulfides, heavy metals, arsenic – all kinds of nasty things.

C-8 comments on how the mining community of Snow Lake deals with ARD because of historic improper storage of acid generating mine waste.

> This community is built upon waste. A lot of the piping around town is backfilled with acid generating mine waste and it just eats the pipes away […].

Some participants also identified and criticized the need for perpetual water treatment in Snow Lake and in other mining areas, "what about water treatment in perpetuity? How is that okay and yet it is something that we accept as a society" (E-2).

4.1.2. Mine site footprint

Mine site footprint, the total area affected by mining activities, can be problematic for both open-pit and underground mines as well as exploration. Typically, a mines footprint includes waste and tailings impoundments, the areas covered by buildings, transportation, and power infrastructure.

Participants noted that mine site footprints and lasting effects vary greatly throughout history. They suggest that historic mines, before modern environmental regulations, exhibit larger and longer lasting footprints.

> Certainly, there are long-term effects in the area. Most of them appear to be from historical and not current mining […]. Since the mine was established in the 1920s and environmental regulations came into place in the late 60s or early 70s – so for 50 or so years – there was essentially no environmental regulation (C-16).

Many community participants believe that the citizenry is aware of the environmental effects of mining and, while today they would not accept historic mine footprints as they feel they are larger than necessary, they seem comfortable with current impacts.

4.2. Residual effects on communities

In the case of Snow Lake, and many other single industry towns in Canada, the community was created to support mining in the area. Key themes in the data that are associated with residual community effects included job training and experience; wealth generation; economic dependencies; changes to town culture, land rights and community relationships.

4.2.1. Job training and experience

As the literature establishes, community members can experience positive effects of mining through employment. C-13 explains the sorts of community benefits of mining in Snow Lake:

> But what the industry has done is with corporate social responsibility, we're trying to be a good corporate citizen and provide local folks with training opportunities and start-up assistance so that when the mine disappears the community has some sort of ability to carry on and make money – a skill that they are able to then use for future potential opportunities […]. Communities and businesses and individuals should have gained skill levels while the mine was operating.

Some participants stated that this opportunity for job training and experience is especially valuable in northern remote areas since there are limited employment opportunities. This idea corroborates other literature on the topic (e.g., Gibson and Klinck, 2005; Gibson, 2014).

> In the far north, very often you have communities with no experiences of wage employment and relatively low skill level. So, building up, even in the EA, building up that skill base is very important. Helping the community develop the skills that they can translate into long-term employability (E-4).

Besides on the job training, mining companies may partner with other organizations to offer training and skill development in Snow Lake. The Northern Manitoba Mining Academy in Flin Flon, Manitoba is one example of this kind of educational partnership (HudBay Minerals Inc., 2015). The Mining Academy is a joint partnership between HudBay, the University College of the North, Northern Manitoba Sector Council, the Government of Manitoba, the Government of Canada, the City of Flin Flon, and the University of Manitoba (Jamasmie, 2010).

4.2.2. Wealth generation

Mining provides well-paying careers. As E-21 pointed out:

> The metrics are that the average mining job is about $100,000 a year - it's the highest in the industrial sector in the province. It comes down to can you maximize the local employment in the region?

Some participants stated that these high paying mining jobs allow community members to live in a community they love and give a better life to their children through higher education.

> The fact is that the community is only here because of mining. My dad worked underground for 35 years. There are four kids in our family and we all went to university and college and we grew up fine and the mine paid for that. When you look at the community, you have the highest per capita income in the province… (C-17).

Some noted that the province also benefits from the wealth that is created through mining activities. This wealth is then used to maintain services and infrastructure across the province.

4.2.3. Dependence on mining

Data supported many of the boom and bust issues noted above, for example in relation to dependency on mining. Participants noted that reliance on mining means they often have an uncertain future after mining activities ultimately end.

> When the mine leaves and the resource are depleted – now you have a town whose only method of funding is taxing its residents. It is very difficult to tax people when they have walked away from their

house, or there is no house, or they have moved […]. So, then the community is basically sitting there destitute (C-13).

4.2.4. Changes to town culture

In the interviews, many community participants reported changes in their community that they attributed to modifications in mining practices and policy. Chiefly, participants spoke of the introduction of more intense shift work and a camp in Snow Lake for employees to stay at for a minimal cost during their shifts. The combination left the employees more likely to stay in camps than settle in the area. C-19 explains her view of the camp:

> There are more people - well sort of. Through the camp, you notice some more bodies in town but there aren't necessarily more permanent residents […]. If there has been much of a rise [in population since Lalor's opening] it has been hard to notice.

Civil life and community activities are on the decline in many small towns and many participants attributed their demise, at least in part, to the advent of more intense shiftwork including 12-hour shifts with no uniform "weekend" (C-10).

4.2.5. Land rights and relationships

Some of the participants, especially the EA and mining experts, identified land rights and relationships as a major lasting effect on the community. Mining activities, because they are so high stakes and oftentimes have the ability to make or break a community, can lead to strained relationships and conflict between communities, First Nations, and mining companies (Gibson and Robinson, 2014). We chose not to delve into the local territorial and ownership issues without proper representation from local First Nations. E-3 offered the following general comment in this regard:

> The one big one […] in terms of legacy is community relationships. Because there is a somewhat gray area in terms of land rights and to what extent community should be involved I think that it is tricky (E-3).

These relationships can be further strained when local communities hold different development ideals. E-4 explains this situation:

> It is something that as a society we will always struggle with. Who makes the decisions? […] You might have an Aboriginal group that says, 'we have more than enough employment and we don't want the impact that this will bring to our traditional land-use.' Where a local non-Aboriginal community in the area might say, 'oh we want jobs and this will help our local retail and supply companies - so let's go!'

4.3. Boom and bust effects

Boom and bust themes identified in the research include dependence on the mine and mining company, mine life cycle, diversification, as well as population and the housing market issues. With Snow Lake's close economic ties to the mining industry, the town has experienced significant booms and busts (Parres and Jackson, 2009). One particular boom reached its apex by the late 1970's, plateaued for a period, and then steadily declined until the nineties when mineral prices bottomed out (Parres and Jackson, 2009). The failure in the mining industry led to drastic cuts in exploration and project development. Consequently, as mines closed in the area there was no new development to re-employ the laid off workforce (C-6 and C-11). Many of the HudBay employees viewed this bust as temporary, chose to stay on with the company and transferred to the Flin Flon mines (200 km west), causing many families to live apart and support two households (C-11).

4.3.1. Dependence on the mine and mining company

Simply put, most participants believe that small single industry communities like Snow Lake are too economically tied to mining activities to exist long after the mines close permanently and well-paying jobs leave.

> One legacy effect that I'm aware of is the ghost town that is left after boom and bust cycles. When mines open, they generate jobs and infrastructure is created and the local economy thrives then the mine closes out and the whole economy dwindles (E-1.)

This means that, unless the situation drastically changes in Snow Lake, the community will not exist long after mining in the region ceases.

Snow Lake's heavy dependence on the mining industry is similar to that of many single resource communities (e.g., McAllister and Fitzpatrick, 2010; McAllister et al., 2014). While the ultimate bust has yet to happen, participants living in Snow Lake held no romantic idea that the community could exist in the long term without an active mine in the region. Paradoxically, for the community, some participants noted that sustainability means finding another mine to stave off the ultimate bust.

4.3.2. Lack of diversification

Participants noted that diversification, or the lack of it, is closely related to mining's boom and bust cycle. They indicated that the community has little interest and incentive to aggressively pursue diversification away from mining so long as the industry is booming.

> It can be very difficult to get people to understand the need for [a robust sustainability plan], especially with the announcement of a new mine it seems like any work is put off for another 20 years. Lalor has a very long life ahead of it so probably Snow Lake is content to rely on the mining industry for their revenue until the end of its life (C-16).

C-13 explains the difficulties associated with diversifying a single industry town, "Well, look at the downtown - it is so sad. It is hard to get companies to come in here. They drive around and say, 'once the population starts to increase then we will consider it.'" These actions bolster the already damaging boom and bust cycle. Some participants believe that there is a way out of the boom and bust cycle, but this escape requires careful planning and strategizing before the excitement of a boom period hits.

4.3.3. Unstable population and housing market

The population and housing market of a mining community are tightly connected to the economic boom and bust cycle. C-6 explains how the housing market is tied to the boom and bust cycle,

> We've had houses here that were $60,000 one year and $10,000 the next and some were just walked away from. Now with Lalor starting up again and new employees coming and employees coming back prices are jumping up again. Now everything is in the $200,000 range.

Some participants note that the new Lalor employee camp has greatly changed both the population and housing dynamics in the community.

> Yes, since they got the new mine the town was supposed to be booming but it is not booming because no one wants to come up to here for work and if they do then they stay at the camp for their shifts. And why wouldn't you stay there? It's free, you get all the food you want, you don't have to clean, so there isn't a lot of incentive to move (C-12).

Participant C-15 noted their displeasure with the camp, "the company is not doing the right thing and the camp prohibits houses from being bought, the school from being filled, infrastructure from being

repaired (C-15)."

4.4. Remaining town infrastructure

The research found that the legacies associated with remaining town infrastructure can be significant. The key factors include the challenges of dealing with ageing town infrastructure and the mixed effects of established roads and connectivity.

4.4.1. Ageing town infrastructure

The town of Snow Lake did not exist before mining. Mining companies plan and build town infrastructure with materials and designs that minimized costs and will wear out requiring replacement if the mine exists long enough. C-15 gives an example of the negative legacy of ageing infrastructure:

> A lot of the infrastructure in Snow Lake was substandard so instead of half-inch lead pipes or whatever they used in the day that they thought was best, in Snow Lake's case they used quarter inch culverts […]. In Snow Lake pipes in the ground have corroded. Basically, just water is being pushed through holes in the ground.

As C-17 explains, though the company built most of the town originally, they have no interest in updating or building new infrastructure in the town:

> When you look around Snow Lake basically the mining company built everything originally. I mean, most of the houses were built by the mining company, the arena, curling rink, community hall…

Now the town must deal with, repair, and rebuild the legacy effect of ageing infrastructure without the paternalistic help of the mining company.

4.4.2. Roads and connectivity

Participants did not agree whether roads and connectivity are a positive or a negative infrastructure legacy. Road and rail developments are often built to support mining operations, "[the government] generally [is not] going to do that sort of thing for the people but they will do that for the people as long as there is also an economic benefit for it as well" (C-23). All the community participants who mentioned the increased connectivity that new roads provide suggest that they are positive legacies that make it easier for them to travel and ultimately live in Northern Manitoba. C-7 simply states that, "Infrastructure is a benefit to the community. We get roads built that are usable."

The mining and assessment experts are more divided on the topic. E-4 explains her view of roads and the connectivity they provide:

> As a positive it might improve the quality of life, improve the provision of healthcare, provide a basis for additional economic development and independence for the community. You could also say that it gives more access to people will add stresses on the regional ecosystems and wildlife.

4.5. Resource depletion

Resource depletion is an obvious legacy effect of mining; however, participants spoke about this category less often. Responses that emerged in the interviews included heritage funds as well as taxes and royalties.

4.5.1. Heritage funds

Recognizing that mines, by nature, do not last forever, participants noted that the province or company should create some sort of heritage fund so that a certain percentage of the profits generated through the mine is reserved for community use after a mine closes (C-5 and C-13).

It was noted that the government of Manitoba currently has a type of heritage fund, the Manitoba Mining Community Reserve Fund, established in 1970 to help mining communities in economic distress (Government of Manitoba, 2010). Provincial mine tax revenues fund the reserve.

> It was set up to help mining communities that were in dire straits. There is a move afoot in Snow Lake to try to get some of that money for infrastructure. Rather than waiting for a mining town to be in the dumps and moving people out of the community – why don't you try to put a little money into helping build and improve the community (C-15).

Some participants note that, while better than nothing, this current heritage fund has some issues. It is a pool of funds held for all mining communities in the province and is not community or mine specific as established in the Mining Tax Act.

4.5.2. Taxes and royalties

Many mineral-rich countries employ a mandatory mining royalty system, including Canada (Otto, 2006). Mining companies pay mining royalties, meant to compensate for the use of a public resource, to the provincial, territorial, or federal governments depending on who has jurisdiction[2] (Hart et al., 2012).

Grants in lieu of taxes can be locally important. In the Snow Lake case, HudBay pays one million dollars as a grant in lieu of taxes each year to the town of Snow Lake and many participants believe that this is low. C-15 passionately explains this view:

> The thing about grant in lieu is that it is around $1 million and you share it with the school division and there has been an agreement in Snow Lake – just like there is an agreement in Flin Flon and Thompson and Lynn Lake for years – for 50 years […]. Thompson gets over $10 million a year and Flin Flon gets $7 million a year and Snow Lake gets $1 million. Clearly the bar needs to be moved up.

4.6. Environmental assessment

EA should be an important planning tool for considering the five categories of legacy effects during initial mine planning and approval to enhance prospects for mine contributions to sustainability. The host of negative legacy effects plaguing mining projects worldwide does not suggest that negative legacies are mysterious and unknown, but rather that they are overlooked and not fully considered in EA (Roche et al., 2017).

Many participants explained that they were unhappy with current EA practice and identified the need for effective EA that considers all aspects of mine legacies.

> The government never did ask the right questions when they came in and the process is strongly weighted in favor of the company applying. The number of jobs and economic benefits far outweigh the science. If they can produce something that will pacify the science people then it is doable. It is very odd this was my first experience of reading [an EA] in depth into an issue and I was a little dismayed (C-11).

[2] Resource royalties are determined by mine profit and not by the gross value of production (Hart, R., MiningWatch Canada, and Hoogeveen, D. 2012. *Introduction to the Legal Framework for Mining in Canada. http://www.miningwatch.ca/publications/introduction-legal-framework-mining-canada#_ftn45*, Natural Resources Canada. 2014. *Tables on the Structure and Rates of Main Taxes. http://www.nrcan.gc.ca/mining-materials/taxation/mining-taxation-regime/8886*). Mine royalties vary greatly from one province or territory to another – from 5% (Ontario remote mine) to 17% (Manitoba if profit > $105 million) (Government of Manitoba 2010. 'The Mining Tax Act.' in *The Mining Tax Act*, Hart, R., MiningWatch Canada, and Hoogeveen, D. 2012. *Introduction to the Legal Framework for Mining in Canada. http://www.miningwatch.ca/publications/introduction-legal-framework-mining-canada#_ftn45*, Natural Resources Canada. 2014. *Tables on the Structure and Rates of Main Taxes. http://www.nrcan.gc.ca/mining-materials/taxation/mining-taxation-regime/8886*).

> I think that [trade-offs] are one of the major downfalls and shortcomings of EA. That projects can be understood to have fairly significant legacy effects and they are still being approved because they provide certain other benefits (E-1).

Our results also show that many of the community participants initially stated that they were impressed with latest provincial EA done for the Lalor Mine and felt it thorough and effective at least when considering biophysical legacy effects. As noted by C-15,

> … EA is doing excellent job. I think they are comprehensive – in terms of the physical environment and habitat and water I think that they are rigorous and comprehensive so I think that they are good.

However, these same community participants, when asked further questions, spoke at length about social, environmental, and economic issues in the community related to mining activities, and to the new mine, especially regarding the FIFO camp, and money to support community infrastructure. These comments, and similar ones from others, underscore that the provincial EA did not adequately consider all mining legacy issues.

The Expert participants were more critical of current EA practice in Manitoba and more generally in terms of its ability to properly consider all legacy effects. Experts noted that current EA does not trigger enough project studies, does not consider cumulative effects well – or at all (E-1 and E-3), does not allow for meaningful public participation (E1, E-2, E-3, E-5, and E-22), operates with too tight timelines (E-1 and E-21), allows for too many unsustainable tradeoffs (E-1, E-2, E-4, and E-22) and generally does not focus on long term effects (E-1, E-2, and E-22). For participants, these shortcomings in EA process mean that it often does a poor job of considering mining legacy effects by not mitigating or avoiding negative legacies and amplifying positive legacies.

> It is tricky because the Environment Act in Manitoba does not require consideration of cumulative effects. It really is up to practitioners to think about those things […]. You would look at all these things and you would just include cumulative effects assessment. It was just something that you did […] I have always been a big advocate for cumulative effects assessment. I bring it up in every forum (E-3).

> The timeline for public participation is often too short. The notice period for groups and participants to become familiar with the material and retain experts and their responses and actual public comments periods themselves are often too short for participants to really meaningfully provide their input (E-1).

All the participants felt, however, that completing EA, even in a less than perfect way, was better than no EA at all. Most even suggested that EA have been steadily improving over time and in some places are much better than they were historically. However, as E-20 explains, “we are better than we used to be at considering legacy effects, especially social effects, but we could still improve a lot”. Current EA does not ensure adequate attention to legacy effects.

5. Discussion and conclusions

The community of Snow Lake, Manitoba provided a good case for studying legacy effects and further confirmed the effects identified by Gibson and Robinson (2014). We feel that the legacy effects established in our case are ones that should be well known in the mining sector yet decision processes like EA and regulatory approvals still appear largely ineffective in both identifying and addressing them. This claim is based not only on our case study and the concerns people raised about the lack of consideration of existing legacies, but also on the many reports of the negative effects of mining that continue to emerge (e.g., Bosso and Enzweiler, 2008; Sandlos and Keeling, 2013; Johnston, 2014).

While community and expert participants in the study agreed and diverged concerning specific legacy effects, both sets of participants were united in their concern about the environment, especially related to water and health. They were concerned that the tailing impoundment areas may fail and contaminated tailings water may enter the natural waterway and affect lake and fish health. Studies such as Johnson and Hallberg (2005) support these concerns in their examination of the potential environmental damages and legacies of AMD. Experts and participants also voiced concerns about needs for perpetual water monitoring, care and treatment (Gibson and Robinson, 2014). Many tailing impoundment areas are required in perpetuity, such as in Snow Lake and therefore the threat of environmental contamination persists long after the mine is shut down. There is a danger as well in the intergenerational injustice that comes with the need for such perpetual care (Gibson and Robinson, 2014; Johnson and Hallberg, 2005).

Though both groups are concerned about legacy environmental effects, there was division on whether environmental legacies are only associated with historic mining activities. Many of the community participants felt that current mining assessment, regulation and technology are effective at encouraging mining companies to avoid major negative environmental legacies. They see major negative environmental legacies as a thing of the past and no longer a concern. It is not necessarily that they are unaware of possible issues but rather, as some participants pointed out above, they consider the positive legacies of mining as greater than the negative legacies. At the same time, many community participants identified serious concerns about environmental issues such as water quality. Unlike the community participants, expert participants held that current mining activities still hold enormous potential to create long lasting environmental damage and therefore, EA and approvals are not performing their intended duty.

Participants noted that they and their community benefit from the training, skills, education, and high wages that accompany employment in the mining sector; factors also captured in the literature (e.g., Gibson and Klinck, 2005; Gibson et al., 2005). Also, the data show that community participants were more likely to view the long-term effects on their communities in a more positive light than the expert participants (Adkin et al., 2017). This is most likely because Snow Lake residents are aware that their community would not exist without mining activities – nor would their high-paying jobs, plus they are accustomed to living with the legacies. They are proud of their mining history and are thankful for the opportunities that the mining industry affords them. Some participants also noted that they are resentful when groups or people “not directly affected” by a mine step in to block or slow development. Some see this as the “South” telling them how they should live. It is the opinion of many community participants that they weighed all their options and have considered all the legacy effects and still choose to pursue mining. Some experts, on the other hand, believe that the larger Manitoban and Canadian population should have some say in approvals because, untimely, their taxes will be spent on environmental remediation.

Participants in Snow Lake also saw improved roads in a positive light explaining that they made living and travelling in the North easier. Expert participants had differing views. One key issue is that it is unknown whether the valued infrastructure will be maintained adequately when the mines close in the area and there is little money or incentive for road repair. This currently positive legacy for locals may become burdensome negative legacy as some community participants recognized.

Some expert and community participants agreed that the boom and bust cycle associated with resource towns effect the community's dependence on mining. Both groups agree that diversification away from mining, or at least diversification away from one company, would benefit the town and create more stability for residents. The groups also agree that it is difficult for a northern remote community to diversify. Some participants from each group mentioned the need to invest in economic plans in the boom periods, not waiting for the bust periods, though this idea seemed to not be intuitive and not included in EA,

further entrenching the community's economic dependence on mining activities.

Only one participant, E-5, identified the final legacy effect, resource depletion, outright. Other participants, especially community participants only noted the same theme indirectly. Many community participants explained that they did not believe that the community benefitted enough from the mineral resources in the area. They expressed a desire to retain more benefits locally. Some favor mechanisms such as heritage funds that would use some tax and royalty revenues to a community fund for the future transitioning away from mining. This idea is present in recent literature on the subject as well, but is absent in current EA (e.g., Gibson and Robinson, 2014; Storey, 2001, 2010).

One challenge associated with considering these five types of effects that the data clearly reveals is that are not static, there are sometimes complex relationships between and among elements. For example, the costs of operating and maintaining community infrastructure constructed during "good" times and supported by grants in lieu of taxes or other company payments, might become negative residual community legacy effects in times of downturn when those costs become the responsibility of the community which no longer has company financial support. On the other hand, housing and other service infrastructure, built during the good times that might not otherwise have been there, might represent an ongoing positive legacy effect when a company leaves. Another challenge is that the distinction between legacy outcomes and processes that cause them is often not clear. For example, the residual effects on communities are outcomes, boom and bust cycles are part of the process which result in those outcomes, but boom and bust cycles are often identified as a legacy outcome (e.g., Gibson and Robinson, 2014).

5.1. Conclusion

Our work lends further strength to the validity of the types of mine legacy effects noted by Gibson and Robinson (2014). Each effect was highlighted in interviews as being critical to any consideration of mine development legacy effects. Further, the interaction of these effects was highlighted, as discussed above, underscoring that assessment of such effects are not meaningful if they focus on one category of legacy effect. The suite of mining legacies must be addressed more seriously in pre-approval EAs as well as throughout mine life if we are to move toward sustainability, or the sustainable development of mining. Legacy effects are real and not mysterious to anyone who works in the mining industry, regulates mines, or lives in mining communities. Years of experience and study suggest that the real issue is not that we are unaware of potential legacies, rather the issue is that we are not assessing these effects properly in pre-approval EA. Practically speaking, our data suggest that EA can be improved in several ways so that legacy effects are assessed properly.

First, if sustainability were a goal of mining EA, in addition to the sustainability goals set by the mining industry, it would help to ensure that the five key legacy effects confirmed in this research are considered and that the interactions among them also become a focus (Gibson, 2014, 2017). This would include considering the net contribution to sustainability of proposed mines to ensure that the lure of temporary positive economic gains does not lead to neglect of the long term negative socioeconomic and biophysical effects. As Gibson et al. (2005, 2016) and others (e.g., Morrison-Saunders and Pope, 2013) note, the establishment of explicit rules for evaluating trade-offs, and providing for case and context-specific elaboration of them would provide guidance on expectations for net sustainability gains and avoidance of significant adverse effects. Second, regional considerations need to be part of mining EA. Adopting a regional lens would ensure or at least enable more effective attention to cumulative effects, assessment of regional scenarios and planning options and consideration of more diverse perspectives and opportunities. This is especially important when many of the economic benefits of a project (or series of projects and associated infrastructure) are intense and localized geographically and temporally (as in the Snow Lake case) and the negative impacts are more diffuse, cumulative and persistent over time. A regional perspective would also allow for the determination of the full range of where, when and what costs and benefits are likely to occur. Third, public participation is important and should be utilized and required and go beyond the current "directly affected" limitation. As noted above, the communities closest to a project may have the most incentive for that project to continue or be built while those further from the project may benefit less and share in the negative effects. Broader participation may amplify some of the key legacy concerns and provide needed encouragement for decision makers to consider them (e.g., Sinclair and Diduck, 2016). Last, EA should require development and implementation of extensive effects management and monitoring plans. Minimizing negative legacies and ensuring that the project and its legacies are monitored into the future is essential if negative legacies are to be limited. Effects management is also needed to ensure positive effects are amplified. In this way, the adage "it is best to nip it in the bud" rings true. The best way to amplify positive effects and limit negative legacies is through a robust, sustainability-based assessment process and post-approval monitoring and effects management program. Such an approach can involve benefit agreements with communities but it is also dependent of government actions to establish suitable legacy funds and other fiscal arrangement, etc. as suggested in the results. These considerations are all foundational to next generation assessment (Gibson et al., 2016; Johnston, 2016) and in the Manitoba context would require further re-visioning of the existing EA process governed by the Manitoba Environment Act (Sinclair et al., forthcoming).

While the suggestions of participants do not capture the full suite of key elements associated with next generation EA as identified in the literature (e.g., Gibson et al., 2016; West Coast Environmental Law Centre, 2015) improvements regarding the elements identified and recognition of the suite of effects and their interactions will surely improve outcomes. The implications of this, and other issues raised in the discussion above, lead us to modify Fig. 1. We feel that the data do confirm the suite of five effects and also underscore the interactions and complexities of these effects that pre-approval EA must consider. Fig. 2 is therefore cast within the context of the elements essential to next generation EA, as established by participants, that is equipped to assess legacy effects and captures the potential interactions of those effects. Each type of effect can have both positive and negative legacies associated with it as the figure captures and each of these can interact with other of the key legacy effects as captured by the dotted line connecting them. Considering such interactions is central to sustainability and next generation assessment (Gibson et al., 2016).

The Snow Lake case presented several unique and important community legacy effects because of the presence of a local community associated with mining. Priority legacy issues include jobs, skill training, and wealth generation. These are important positive legacies to consider but meaningful EA must recognize that these cannot just be traded for negative environmental legacies like substandard tailings facility design and management. This research also underscores the fact that infrastructure planning should be a priority issue for provincial and local decision makers. Roads and related infrastructure built to support mining activities may benefit the community during the life of the mine but steps must be taken to ensure that infrastructure is cared for and does not deteriorate and become a burden after a mine closes. Achieving more sustainable mining development is not easy or straightforward, but rather fraught with complexity. One community participant underscored this by stating, "sustainability is finding the next mine" and as many good prospectors and developers know – the most desirable next mine is right beside the first mine and is one that leaves a positive legacy.

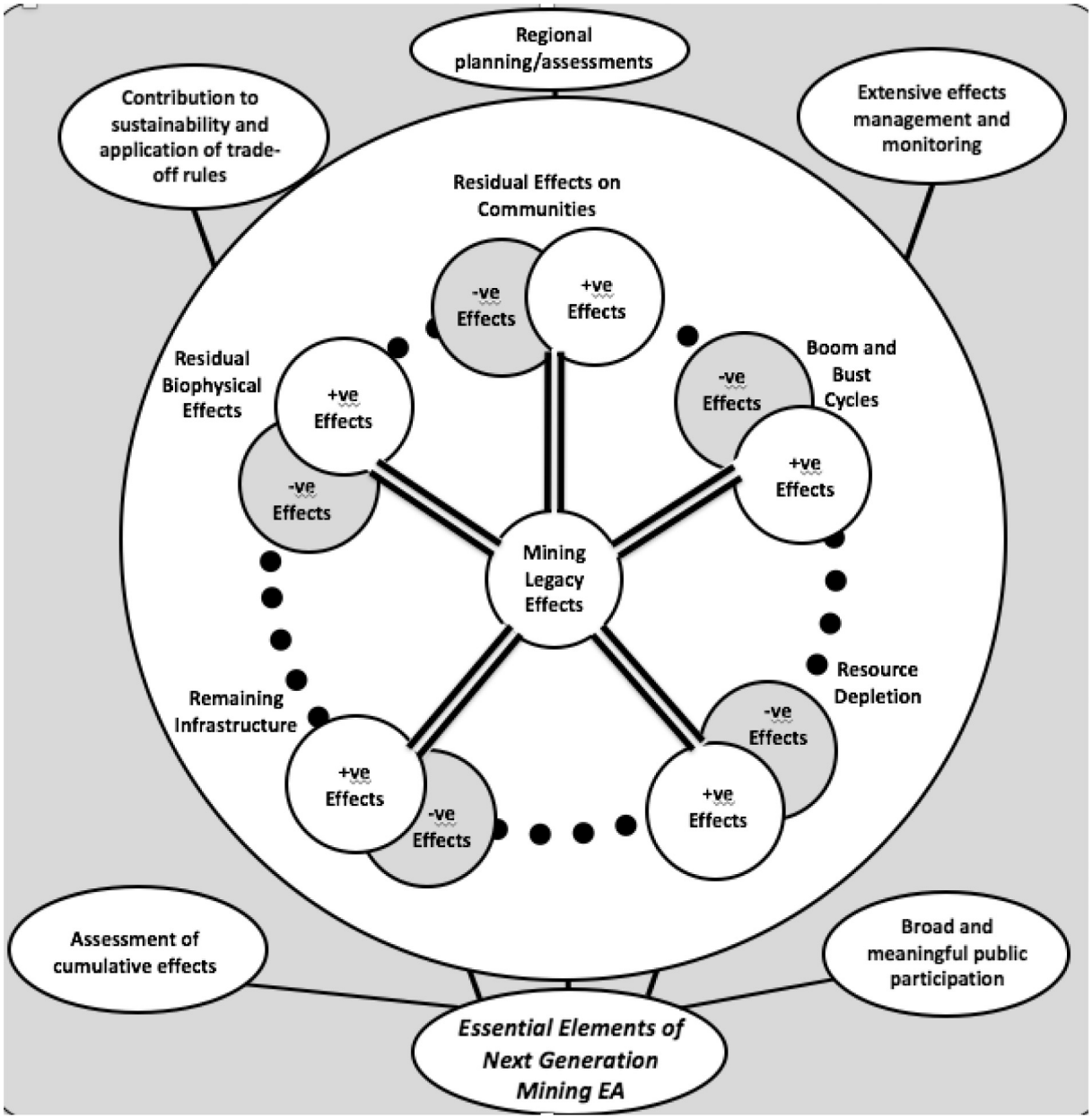

Fig. 2. Revised mining legacy effects framework.

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