CANADA'S **ECOFISCAL** COMMISSION

Practical solutions for growing prosperity

RESPONSIBLE RISK

How putting a price on environmental risk makes disasters less likely

July 2018

CANADA'S ECOFISCAL COMMISSION

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A group of independent, policy-minded Canadian economists working together to align Canada's economic and environmental aspirations. We believe this is both possible and critical for our country's continuing prosperity. Our Advisory Board comprises prominent Canadian leaders from across the political spectrum.

We represent different regions, philosophies, and perspectives from across the country. But on this we agree: ecofiscal solutions are essential to Canada's future.

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A thriving economy underpinned by clean air, land, and water for the benefit of all Canadians, now and in the future.

OUR MISSION

To identify and promote practical fiscal solutions for Canada that spark the innovation required for increased economic and environmental prosperity.

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What is the value of the services that provide clean water? We examine new Canadian policy solutions for water pollution, over-consumption, and infrastructure.

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A REPORT AUTHORED BY CANADA'S ECOFISCAL COMMISSION

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SUMMARY FOR POLICY-MAKERS

Risks to the environment from economic activity often generate strong reactions. At one extreme, some see the risk of environmental damage as an unavoidable part of a modern economy that we must simply accept. At the other, some consider these risks unacceptable ones that must be avoided at all costs.

This report aims to take a more nuanced approach. While the costs of reducing environmental risks toward zero can exceed the benefits, the same can be true of leaving risks unmitigated. In most cases, neither eliminating nor disregarding environmental risk is a practical approach.

We explore how policy-makers can manage risks to the environment using economic instruments. In particular, we focus on circumstances where firms can generate private benefits from their activities while society bears the environmental risk. We show how policy-makers can use "financial assurance" policies to address this problem.

To explore both the problem and potential solutions in detail, we consider Canada's mining sector as a detailed case study. This executive summary provides a high-level review of our findings.

Economic activity comes with risks to the environment

A series of high-profile events have reminded Canadians that economic activity comes with risks to people and the environment:

- In July 2013, a train carrying crude oil derailed in the town of Lac-Mégantic, Quebec. The resulting explosion killed 47 people, and much of the oil spilled into local soil and waterways. Measured in terms of its human costs, it is one of the worst environmental disasters in Canadian history.
- In August 2014, a tailings-pond dam ruptured at the Mount Polley copper and gold mine in northern British Columbia, spilling tailings into Polley Lake, Hazeltine Creek, Quesnel Lake, and the Cariboo River. The tailings contained arsenic, selenium, and various heavy metals.
- In July 2016, a ruptured pipeline owned by Husky Energy spilled approximately 225,000 litres of oil into the North Saskatchewan River. The oil slick travelled downstream, covering 134 km of shoreline and forcing several communities to shut their water intake systems.

Dramatic events of this type are rare; the vast majority of rail transport, mining, and pipeline transport occurs without incident. But they can and do happen.

Resource extraction, transportation of goods, manufacturing processes — in short, many of the pillars of the economy that drive our well-being as Canadians — come with risks. When things go wrong, the environmental damage can be significant, even catastrophic. And the damage can lead to significant costs, whether in the form of health impacts or loss of life, taxpayer-funded cleanup costs, lost income, or reductions in the environmental benefits associated with clean water, air, and soil.

Society — rather than the firms who are responsible — sometimes bears the costs

When environmental damage occurs in Canada, the firm that caused that damage will not necessarily bear the cost. Gaps in existing policies — we call them "liability gaps" — can shift the costs of environmental damage away from firms and onto society.

Liability gaps arise when existing rules do not hold firms fully accountable for the environmental damages they cause. For example, liability rules might limit the circumstances under which firms can be held liable or exclude some types of environmental damage from their liability. Or, to enable risky projects that would not otherwise proceed, policy-makers may place a cap on the level of firms' liability.

Perhaps even more critically, a firm might avoid paying for environmental damage because it ceases to exist. If the costs of a tailings spill, for example, caused a firm's liabilities to exceed its assets, the firm can declare bankruptcy or enter insolvency under Canadian law, leaving society to bear its environmental costs.

The Redwater case — which is currently before Canada's Supreme Court — will have important implications for who bears the cost of bankrupt and insolvent firms' environmental liabilities in Canada. At issue in the case is who pays for the environmental cleanup of a bankrupt company's non-producing oil and gas wells. The Court of Appeal of Alberta upheld a lower court's decision that, in seeking funds to pay for the cleanup, the Alberta government should be treated as any other unsecured creditor and paid out after higher-ranking creditors. The case has far-reaching implications. If the Supreme Court upholds the decision, it will increase the probability that society will bear the cost of bankrupt firms' environmental liabilities in Canada.

When any type of liability gap exists — bankruptcy-related or not — firms are potentially able to generate private benefits from their activities while society bears the environmental costs. Whenever firms will not bear the cost of their actions, the risks they pose to the environment are *unpriced*.

Leaving risks unpriced can exacerbate them. When firms know they may bear less than the full cost of environmental damage arising from their actions, they have less incentive to take actions that reduce the risk of harm. As a result, overall risk to the environment can increase.

The goal is to manage risk, not eliminate it

When it comes to dealing with unpriced risks, policy-makers face a balancing act. On one hand, addressing unpriced risks with policy can reduce environmental risk and the likelihood that society will bear the cost of environmental damage. On the other hand, however, these policies are not costless: they can inhibit production and investment, thus reducing the economic and social benefits from economic activity.

Reducing risk toward zero is often not practical since the economic costs of doing so can exceed the environmental benefits. Indeed, to fully eliminate risk would require shutting down the activity that creates it. But similarly, unmitigated risk can have costs that exceed benefits. Leaving liability gaps unaddressed can exacerbate the risk of environmental damage and the possibility of social costs.

Instead, policy-makers can balance these trade-offs by implementing policies that manage environmental risk.

Pricing risk can help manage it

Policy-makers have a number of tools available to manage environmental risk. They can implement *regulations* that ensure certain minimum standards and practices are met and that rule out particularly high-risk activities. Or they can establish *liability rules* that clearly lay out firms' liability for environmental damage they cause. These are both legitimate ways of managing risk; however, in this report, we focus on a third type of tool — *financial assurance*.

Financial assurance offers a powerful tool for pricing environmental risk. Financial assurance policies require firms to promise or commit funds against potential environmental liabilities. The assurance they provide can come in different forms, for example, cash deposits, environmental bonds, insurance, or industry funds.

Financial-assurance policies can help policy-makers balance trade-offs. They can create economic incentives for firms to take more action to avoid possible environmental damage. They can, should environmental damage occur, provide compensation to those affected. And they can achieve these goals at low costs by harnessing market forces.

Of course, firms may already have *reputational* incentives to limit risk: causing environmental harm can badly damage a firm's public image, undermining profitability. But in the context of liability gaps, such as the ability to declare bankruptcy, these incentives may not be enough. Financial assurance can help fill these liability gaps.

Financial-assurance policies are not a panacea. For example, they should not replace environmental assessment, which considers much broader issues. But they can serve a valuable role by ensuring that project proponents bear the cost of the risks they pose and limiting the extent to which they can pass their environmental costs to society. This can help reduce the risk of proposed projects, as well as screen out particularly high-risk ones.

Financial assurance instruments price risk in different ways and offer different benefits

Table 1 summarizes the range of different instruments available to price environmental risks, across five main categories. It also illustrates trade-offs: some instruments provide stronger incentives to reduce risk (*deterrence*), others ensure firms will pay for environmental damage they cause (*compensation*), and others lower costs for firms (i.e., by allowing them to provide assurance more cost-effectively), supporting production and investment (*economic activity*).

Table 1: Summary of financial assurance instruments

Category	Description	Instruments	Effect on policy goals		
			Reducing risk (deterrence)	Paying for damages (compensation)	Minimizing costs (economic activity)
Hard financial assurance from firms	Firms provide liquid assurance that cannot fluctuate in value and is readily available. The assurance is held in trust until the risk subsides.	• Cash • Securities • Sinking funds • Trusts	Strong	Strong	Weak
Soft financial assurance from firms	Firms agree to cover the cost of a potential harm but retain possession of their assets.	• Self-assurance • Parent guarantees • Pledges of assets	Weak	Weak	Strong
Third-party assurance	In the event of a qualifying environmental harm, a third party like a bank or insurer covers the cost. In exchange for this coverage, the firm pays a regular premium.	• Bonds • Insurance • Letters of credit	Limited	Moderate	Moderate
Sector-level assurance	All firms in a sector collectively provide coverage. Individual firms pay a regular premium in exchange.	• Industry funds • Mutual insurance	Limited	Moderate	Moderate
Public assurance	A publicly-administered instrument provides firms with coverage in exchange for a regular premium.	• Public funds • Public insurance	Limited	Moderate	Moderate

Policy gaps in Canada's mining sector are exacerbating environmental risks

As a detailed case study, our report explores how provincial and territorial governments use financial assurance to address environmental risks in the mining sector. It compares mining sector financial assurance regimes in Yukon, British Columbia, Alberta, Ontario, and Quebec. It considers how financial assurance is applied to the risk of both mining disasters, such as tailings-pond spills, and mine sites not being cleaned up at the end of their life.

Financial assurance policies have become an essential policy tool in managing the risk of mines not being cleaned up at the end of their life. While there is room for improvement in some areas of policy design, all the jurisdictions we consider use financial assurance to help manage this risk. By putting a price on this

risk, Canadian governments help ensure that mining firms have incentives to limit the environmental damage done to mine sites and will bear the cost of their cleanup.

However, in all the jurisdictions we explore, the risk of mining *disasters* is left unpriced. None of the five jurisdictions applies financial assurance against the risk of disaster. If a tailings spill like Mount Polley were to occur in any of these jurisdictions and the responsible company was bankrupted, society would be left to bear the cost. The potential for mining firms to pass on their costs in this way reduces their incentive to reduce environmental risk, exacerbating the risk of a mining disaster.

Our case study underscores how the narrow or incomplete application of financial assurance can exacerbate environmental risk. The conclusions and recommendations we discuss below are drawn from both this case study and our broader analysis.

KEY RECOMMENDATIONS FOR POLICY-MAKERS

Canadian policy-makers should close gaps in existing policies by pricing risk

Policy-makers should make greater use of financial assurance. Increasing the extent to which firms are financially accountable for environmental damage they might cause gives them an incentive to avoid it. In particular, policy-makers should expand policy to price risks that are currently unpriced.

In the mining sector, the lack of financial assurance for disasters represents a missed opportunity to lower the risk and potential social costs of mining disasters.

But at the same time, strong safety regulations and clear, well-established liability rules provide an essential foundation for policies to address environmental risk and liability. Financial assurance should complement these other policies, not replace them.

Policy-makers should estimate risk comprehensively to inform their risk-pricing policies

Estimating risk is critical to determining *how much* financial assurance governments should require. Requiring too much can unnecessarily increase costs, but requiring too little can limit the extent to which financial assurance reduces risk and funds cleanup, should a disaster occur.

Estimating risks well requires considering all relevant sources of risk (i.e., financial, economic, legal, environmental, technological, etc.) and considering the full range of potential damage types (i.e., property, human health, livelihoods, ecosystems, etc.). It also requires taking care to account for low probability and catastrophic outcomes and to evaluate the potential for long-term or perpetual costs.

In the mining sector, for example, rather than using deterministic point estimates to set financial assurance requirements for the risk of non-remediation, policy-makers should use a risk-weighted estimation approach. This would help secure against a site's actual closure costs exceeding its estimated costs and help avoid these costs being borne by society.

Policy-makers should require firms to pay according to their riskiness

Customizing risk pricing to firms' specific context can make policy work better. Firms present different levels of risk based on (for example) their sector, where they operate, their financial context, or the kinds of technologies they use. Asking firms to pay according to their unique level of risk — or "risk differentiating" — can improve outcomes. Policy-makers can use risk differentiation in different ways — either to increase financial assurance requirements for risky firms or to decrease them for less risky ones.

In the mining sector, for example, a number of the provinces or territories we consider in the report already differentiate based on firms' financial risk. Ontario, for instance, requires different levels of financial assurance depending on firms' assessed financial risk. Firms that are more financially vulnerable — and thus more likely to declare bankruptcy — must provide stronger assurance.

Policy-makers should combine risk-pricing instruments when risks are severe

In some cases, individual firms may be unable to provide assurance that can cover the full range of potential costs, especially where high-cost, low-probability outcomes are possible (i.e., where risk has a "fat tail"). Similarly, third-party providers of financial assurance may be unable or unwilling to provide coverage high enough to guarantee full compensation in the event of severe costs.

To address this problem, policy-makers should use tiered financial assurance solutions. In a tiered scheme, firm-level and third-party assurance would provide coverage up to a point. Beyond this threshold, sector-level financial assurance or public instruments would kick in.

In the mining sector, for example, policy-makers should use a tiered financial-assurance scheme to protect against catastrophic mining disasters. Mining operations that pose a significant risk of disaster should provide a degree of assurance themselves, with third-party assurance (where it is available) providing a higher tier. But to cover non-insurable, "fat-tailed" risk, policy-makers should consider broader approaches that *pool* risk across firms or even across sectors (e.g., the United States' Superfund deals with contaminated industrial sites across a range of sectors).

Society should share environmental risks only when there is a clear case for doing so

In specific circumstances, risk sharing between private firms and society more broadly can be justified. For example, in many natural resource sectors, firms pay royalties to government. Because society shares in the benefits of the economic activity, there is a case for sharing in some of the risks as well.

But in other cases, the costs of risk sharing can outweigh the benefits. Risk sharing is an indirect subsidy, and it can create economic distortions that increase the likelihood or severity of costly environmental damage. And because any public costs for cleanup or compensation would be funded from tax revenue, risk sharing can also have a cost to the broader economy.

In the mining sector, there is a case for risk sharing. A number of jurisdictions in Canada already share the risk of non-remediation with mining firms. However, excessive risk sharing in the form of low financial-assurance stringency can tilt the policy environment toward economic activity at the expense of deterrence and compensation.

Jurisdictions in Canada that choose to share in the mining sector's risks should explore alternative ways of doing so, including by sharing in its financial risks rather than its environmental ones. For example, in place of relaxed financial-assurance requirements, jurisdictions could offer preferential loans. In doing so, they would share in mining's financial risk: Where ventures were successful, loans would be repaid. Where they were not, government would incur a loss. Such an approach could help Canada's mining sector remain globally competitive without compromising on environmental-risk reduction and compensation goals.

Policy-makers should articulate and justify their policy priorities — and then design and implement policies consistent with this vision

Policy-makers should justify their approaches to risk sharing (for example, having less stringent or more narrowly applied financial assurance), and make the case that they present a net benefit to society. Where policy design trades off risk reduction or full compensation from firms in favour of greater economic activity, policy-makers should demonstrate that the benefits of this approach (in the form of greater production and investment) outweigh the costs (in the form of greater environmental risk and potential social costs). Similarly, where policy design trades economic activity in favour of greater risk reduction or compensation, policy-makers should demonstrate how the benefits of avoided risk exceed the costs of reduced investment.

This report shows how financial-assurance policies can put a price on risk to the environment. Financial assurance can support safety regulations and existing laws in managing risk. But it can also do something these tools cannot by harnessing the power of market forces.

By creating incentives for firms to better manage their risk, by funding compensation or cleanup costs, and by minimizing the costs of doing so, financial assurance can ensure we take responsible risks.

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1 INTRODUCTION

A series of high-profile events have reminded Canadians that economic activity comes with risks to people and the environment:

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- In July 2016, a ruptured pipeline owned by Husky Energy spilled approximately 225,000 litres of oil into the North Saskatchewan River. The oil slick travelled downstream, covering 134 km of shoreline and forcing several communities to shut down their water intake systems (Government of Saskatchewan, 2016; Warick, 2017).

Dramatic events of this type are rare; the vast majority of rail transport, mining, and pipeline transport occurs without incident. But they can and do happen.

Resource extraction, transportation of goods, manufacturing processes — in short, many of the pillars of the economy that drive our well-being as Canadians — come with risks. When things go wrong, the environmental damage and human costs can be significant, sometimes even catastrophic. And the economic costs of these events can also be very high. Table 2 provides an overview of some notable events — in Canada and internationally — that underscore the risks posed by various kinds of economic activity.

What do all the events in Table 2 have in common? First, they all led to environmental damage that imposed *costs on society*, over and above whatever costs were borne by the businesses involved. The nature of the costs included health impacts or loss of life, taxpayer-funded cleanup costs, lost employment and income, and reductions in the environmental benefits associated with clean water, air, and soil.

The second common element in these events is that they all involved *risk*. In each case, either the event or the social costs that it led to were not certainties; rather, they were *possibilities*.

The existence of these kinds of risks does not imply that we should shut down all economic activity. But the potentially high costs for society does suggest it is worth taking a closer look at the policies we use to manage these risks.


Sydney Tar Ponds
Sydney, Nova Scotia

Table 2: Sample of incidents that underscore risks from economic activity

Event	Location	Description	Costs and Consequences
Mercury contamination in Grassy Narrows	Dryden, Ontario	Between 1962 and 1970, a pulp and paper mill released 10 tonnes of mercury into Wabigoon River, upstream of the Grassy Narrows and White Dog First Nations. The Wabigoon River and several locations near the site are still highly contaminated with mercury (Bruser & Poisson, 2017).	Members of Grassy Narrows and White Dog have been exhibiting symptoms of mercury poisoning for decades. The Ontario government is responsible for monitoring, cleanup, and compensation due to a deal it brokered to sell the mill in the 1970s. Total costs will likely exceed $100 million (Porter, 2016; Porter, 2017; Bruser & Poisson, 2017).
Cleanup of the Sydney Tar Ponds	Sydney, Nova Scotia	During its 100 years of operation, a now-decommissioned steel mill discharged over 500,000 tonnes of contaminants and sludge into a nearby pond. After Nova Scotia purchased the facility, past operators could not be held liable for contamination (Taylor & Kenyon, 2012).	In 2007, the federal and Nova Scotia governments committed over $400 million to remediate the site. Long-term environmental damage is unknown, but the contaminants in the ponds have been linked to ecological damage in the area (Taylor & Kenyon, 2012; Walker, 2014).
Remediation of Deloro Mine	Deloro, Ontario	The Deloro gold mine operated from the 1860s until 1961. After its abandonment, groundwater, surface waters, and soil onsite were heavily contaminated with low-level radioactive waste and arsenic, which was discharging into the Moira River. Ontario's Ministry of Environment assumed responsibility for the site in 1979 (CNSC, 2017a).	Ontario took the mine's owner to court in 1989 to help cover closure and monitoring costs. The courts awarded $3.5 million, but the order could not be enforced since the company no longer existed. Total remediation costs will likely exceed $45 million, plus the costs of long-term monitoring (Government of Ontario, 2004).
Union Carbide disaster	Bhopal, India	In December 1984, a Union Carbide pesticide plant leaked more than 40 tonnes of methyl isocyanate gas. At least 3,800 people were killed and thousands more were injured or died prematurely. It is regarded as the worst industrial disaster in history (Broughton, 2005).	Union Carbide admitted moral responsibility and paid out $470 million in compensation. The Indian government has estimated the disaster's economic damages at $3 billion. The soil and groundwater around the now-abandoned facility remain heavily contaminated (Broughton, 2005; Hanna, 2007; ICJB, 2013).

Deepwater Horizon explosion and oil spill
Mississippi Canyon, Gulf of Mexico

Table 2: Sample of incidents that underscore risks from economic activity *continued*

Event	Location	Description	Costs and Consequences
Chernobyl disaster	Pripyat, Ukraine	In April 1986, a steam explosion at the Chernobyl Power Plant resulted in the release of large amounts of radioactive material over Belarus, Ukraine, and Russia. It remains one of the worst nuclear disasters in history (Hasegawa et al., 2015).	Five million people were exposed to dangerous radiation and remain at a heightened risk for cancer. The town of Pripyat will remain uninhabitable indefinitely. The disaster caused an estimated $235 billion in damages (Cardis et al., 2006; UNDP, 2009).
Exxon Valdez spill	Prince William Sound, Alaska	In March 1989, the Exxon Valdez oil tanker struck a reef and ran aground off the coast of Prince William Sound. The tanker spilled 260,000 of its 1.3 million barrels of oil into the ocean, affecting over 1,700 km of Alaska's coastline (NOAA, 2014).	Cleanup costs were $2 billion, with an additional $300 million payout to affected industries. Additional out-of-court settlements totaled $3.2 billion. The wildlife death toll is still unknown (Paine et al., 1996; Picou, 2009; Elser et al., 2017; Ward et al., 2017).
Giant Mine cleanup liability	Yellowknife, Northwest Territories	The Giant Mine was a gold roasting operation from 1948 to 1999. A by-product of the operation was arsenic trioxide, and 237,000 tonnes of the highly toxic substance were blown into the mine's underground chambers. The mine's owner has since gone bankrupt (Taylor & Kenyon, 2012).	The site is a long-term liability that requires perpetual care. It is an estimated $600 million liability in the public accounts of the federal government (mining in NWT fell under federal jurisdiction at the time of the mine's abandonment) (OAGC, 2013).
Cheakamus River train derailment	Cheakamus River, British Columbia	In August 2005, a CN train derailed and spilled 41,000 litres of highly corrosive sodium hydroxide into the Cheakamus River (McCubbing et al., 2006).	As many as 500,000 fish were killed, with significant impacts on the river's biodiversity and ecology. The full extent of the damage was difficult to assess (McCubbing et al, 2006).
Deepwater Horizon explosion and oil spill	Mississippi Canyon, Gulf of Mexico	In April 2010, the Deepwater Horizon drilling rig exploded due to flawed well design and insufficient integrity testing, killing 11 people. Over the next several months, almost 5 million barrels of oil leaked into the Gulf of Mexico (Graham et al, 2011).	The spill had serious ecosystem impacts, and the oil's long-term fate is unknown. An area of 200,000 km^2 was closed off to fishing activity and 1,600 km of shoreline was contaminated, affecting local ecosystems and thousands of homes and businesses (Barron, 2012; Thibodeaux et al., 2011).

Lac-Mégantic train derailment
Lac-Mégantic, Quebec

Table 2: Sample of incidents that underscore risks from economic activity *continued*

Event	Location	Description	Costs and Consequences
Fukushima Daiichi nuclear disaster	Ōkuma, Fukushima, Japan	In March 2011, tsunamis disabled emergency generators at the Fukushima Daiichi nuclear plant, leading to three reactor meltdowns and hydrogen-air explosions and the release of radionuclide emissions into the air and ocean over three days (Morino et al., 2011; WNA, 2017).	Radionuclides contaminate soil, water, air, and food and have other adverse long-term health impacts. As of 2017, roughly 80,000 people remained displaced due to high radiation levels near their homes. The extent of the damage is still uncertain (Morino et al., 2011; Steinhauser et al., 2014; Hasegawa et al., 2015; Obayashi & Hamada, 2016; McCurry, 2017).
Rapid growth in number of orphaned wells	Alberta and Saskatchewan	Since 2012, the number of oil and gas wells in Alberta without a financially accountable owner has grown from 100 to 3,200. Recent analysis for Saskatchewan found that 24,000 of the province's 87,000 wells were not producing (PAS, 2012; Dachis et al., 2017).	Orphaned wells that fail can contaminate water supplies and emit greenhouse gases. The estimated public cost to clean up Alberta's orphaned wells ranges from $129 million to $257 million (Kang et al., 2014; King & Valencia, 2014; Dachis et al., 2017).
Lac-Mégantic train derailment	Lac-Mégantic, Quebec	In July 2013, a train carrying crude oil derailed near the town of Lac-Mégantic. The resulting explosion killed 47 people, and an estimated 6 million litres of oil spilled into the surrounding environment (de Santiago-Martín et al., 2015; Lacoursière et al., 2015).	Aside from the significant human costs, over 100,000 litres of oil spilled into the nearby Rivière Chaudière, harming aquatic ecosystems and downstream communities. The total cost of the disaster could exceed $1 billion (Lacoursière et al., 2015).
Mount Polley tailings dam rupture	Cariboo Region, British Columbia	In August 2014, a tailings-pond dam ruptured at the Mount Polley copper and gold mine, spilling 24 million cubic metres of tailings into Hazeltine Creek, Polley Lake, Quesnel Lake, and the Cariboo River (Byrne et al., 2015).	The spill released arsenic, selenium, and various heavy metals, damaging ecosystems and affecting water supplies in nearby communities. The company has still not been charged (Seucharan, 2017; Linnitt, 2018).

Fundão dam disaster
Bento Rodrigues, Brazil

Table 2: Sample of incidents that underscore risks from economic activity *continued*

Event	Location	Description	Costs and Consequences
Fundão dam disaster	Bento Rodrigues, Brazil	In November 2015, the Fundão mine's tailings dam collapsed, spilling an estimated 60 billion litres of iron ore tailings. The tailings flooded three rivers and several villages over an area of 15 km^2 (Segura et al., 2016; do Carmo et al, 2017; Lopes, 2017).	The spill killed 19 people and destroyed hundreds of homes. The total damage is estimated at $5.2 billion USD. The spill reached the Atlantic Ocean two weeks after the dam's collapse. The metals and minerals left along the riverbeds present health risks to humans and wildlife (BBC News, 2016; Lopes, 2017; Segura et al., 2016; Guerra et al., 2017).
Husky-Maidstone oil spill	Maidstone, Saskatchewan	In July 2016, a ruptured pipeline owned by Husky Energy spilled approximately 225,000 litres of oil into the North Saskatchewan River (Warick, 2017).	The oil slick travelled downstream, covering 134 km of shoreline and forcing several communities to shut down their water intake systems (Government of Saskatchewan, 2016; Warick, 2017).
Saanchi tanker collision	East China Sea	In January 2018, the Sanchi tanker, which was carrying 960,000 barrels of natural gas condensate, collided with a cargo ship. Sanchi caught fire and sank eight days later. It is the worst tanker spill at sea since 1991 and the largest condensate spill in history (Carswell, 2018; Madrigal, 2018).	All 32 crew members are presumed dead. As much as 110,000 tonnes of condensate spilled into the ocean, creating an invisible 140 km^2 slick. The spill had immediate toxic effects on fish and wildlife, and the long-term environmental impacts are largely unknown (Carswell, 2018; Madrigal, 2018; Myers & Hernández, 2018).

When it comes to using ecofiscal policies to reduce pollution, the case is clear-cut. Pollution damages the environment, imposing costs on society. When polluters do not have to bear these costs privately, they have little economic incentive to reduce them. Ecofiscal policies put a price on pollution and, by doing so, provide an economic incentive to cost-effectively limit environmental harm.

In all the examples above, the environmental damage and social costs were not certain to occur — but they were known to be *possible*. How can ecofiscal policy put a price on environmental harm that *might* occur? What should it do when the costs of damage *might* be large, and *might* be borne by society, rather than by the responsible firm? In other words: how can ecofiscal policy be used to manage environmental risk?

In many cases, firms already have an incentive to reduce environmental risk. Their legal liability for environmental damage provides an incentive to limit the risk their activities pose. And they also have reputational incentives: causing environmental harm can badly damage a firm's public image, undermining future profitability.

But these existing incentives may not be enough. In some cases, firms might not be fully liable for the environmental damage they cause or may only be liable for certain types of damages. Or they may be able to avoid their liability by declaring bankruptcy. When firms know they may bear less than the full cost of environmental damage arising from their actions, they have less incentive to reduce the risk of environmental harm.

In this report, we use the term *risk externalities* to describe situations where two factors coexist: the risk of economic activity causing significant environmental harm and the possibility that — should harm occur — the costs will be borne by society at large, rather than by the responsible firm. Like other externalities — for example, pollution and traffic congestion — these situations occur when firms' actions impose costs on others. But they are different from conventional externalities due to the presence of risk; damage *might* occur, but also might not.

When it comes to risk externalities, policy matters. Indeed, many of the events in Table 1 can be linked back to the presence or absence of specific policies. For example:

- In the case of the Sydney Tar Ponds, a lack of comprehensive environmental regulations at the time meant that the firm owning the steel mill was not responsible for cleaning up the site. This gave the firm little incentive to limit environmental impacts, and when the Nova Scotia government took control of the site in 1967, it assumed the site's environmental liability (Furimsky, 2002).
- In the case of the Lac-Mégantic train derailment, the operator was required to carry only $25 million of liability insurance, but the total costs of the disaster could exceed $1 billion (Lacoursière et al., 2015).[i]
- In the case of Giant Mine, Canadian bankruptcy law permitted the firm to terminate its operation without honouring its cleanup obligations. With no one left to hold liable for the costly remediation, the financial burden fell to the federal government (AANDC, 2013a).

Designing policy to address risk externalities is complicated by the fact that policy-makers face multiple, competing goals. First, good policy should create incentives for the businesses involved to reduce the risk of environmental harm. Second, it should reduce the extent to which society bears the costs of any environmental damage that does occur. Third, good policy should consider the economic costs of achieving the first two goals.

In some circumstances, *eliminating* a risk externality entirely might not be desirable because the costs of doing so may exceed the benefits. Some amount of public-private risk sharing might make sense — but how much, and in what circumstances? Trade-offs across the three goals makes managing environmental risk a difficult balancing act.

Ecofiscal instruments that use market-based mechanisms to provide financial assurance can help policy-makers balance these trade-offs. Financial-assurance policies require firms or an engaged third party (e.g., an insurer) to promise or commit funds against potential environmental liabilities. The assurance they provide can come in different forms, including cash deposits, environmental bonds, insurance, or industry funds.

Financial-assurance policies can play an important role in how we deal with risk externalities in Canada. They can create incentives for firms to reduce risk, fund cleanup activities, pay for damage, and harness market forces to reduce the costs of doing so. They can also act as an important complement to other policies such as safety regulations and liability rules. Overall, we find that financial-assurance policies should play a stronger role than they currently do.

The mining sector in Canada, which we examine in detail as a case study, provides a useful illustration, of both the challenges of dealing with risk externalities and the potential solutions offered by financial-assurance policies. The Mount Polley disaster of 2014 provides a graphic reminder of the environmental risks posed by mining operations. And the case of the Giant Mine illustrates the social costs that can result when mines are left abandoned and unremediated. Canadian governments are well aware of these challenges and have actively worked with the mining sector to develop solutions. Our case study examines different approaches across four provinces and one territory.

The remainder of this report is structured as follows. The policy problem of risk externalities is defined in Section 2. Section 3 explains how financial assurance can provide solutions to this problem, while Section 4 presents a detailed look at the various financial-assurance instruments. Section 5 explores Canada's mining sector as an in-depth case study, and Section 6 briefly discusses how financial assurance could be applied to many other sectors of the Canadian economy. Finally, Section 7 provides recommendations for policy-makers, both for managing risk externalities in general and in the mining sector in particular.

2 THE POLICY PROBLEM: MANAGING RISK EXTERNALITIES

In some cases, the risk of environmental damage might be borne by society, not just by private firms.[1] These *risk externalities* are the focus of this report.

Addressing risk externalities creates challenges. On one hand, when policy ensures that private firms will bear the cost of any environmental damage they cause, those firms have greater incentive to reduce environmental risk. But on the other, such policies are not costless: they can inhibit production and investment, thus reducing the economic and social benefits of economic activity.

This section defines a problem for policy-makers: how should governments manage risk externalities in a way that balances these trade-offs? And, in particular, how should they use financial assurance to do so?

2.1 DEFINING RISK EXTERNALITIES

In this report, risk externalities exist when both the following conditions are met:

1) There is a risk of environmental damage from an economic activity (in terms of whether harm will occur, how severe it might be, or both).
2) Gaps in the rules governing firms' liability mean that should environmental damage occur, society — not private firms — might bear some (or all) of the associated costs.

To unpack these conditions, we consider each in turn.

Condition #1: There is a risk of environmental damage

"Risk" refers to situations where environmental damage *might* occur or, when it does, where the harm done to the environment *might* be large.[2] For an overview of risk-related concepts, see Box 1.

[1] When we refer to "society" in this report, we refer to agents external to the firm that may unfairly bear the cost of environmental damage that it causes. These social costs can fall to taxpayers, citizens in general, or other firms, either directly (e.g., property damage, cleanup expenditure) or indirectly (e.g., environmental damage affecting recreational use of a waterway or the value Indigenous Canadians ascribe to their traditional lands). In contrast, "private firms" is used in this report to refer to the firm or firms that are responsible for an environmental harm, as well as any contracted third parties that would be liable in the event of it (e.g., insurers). The costs they bear are private costs.

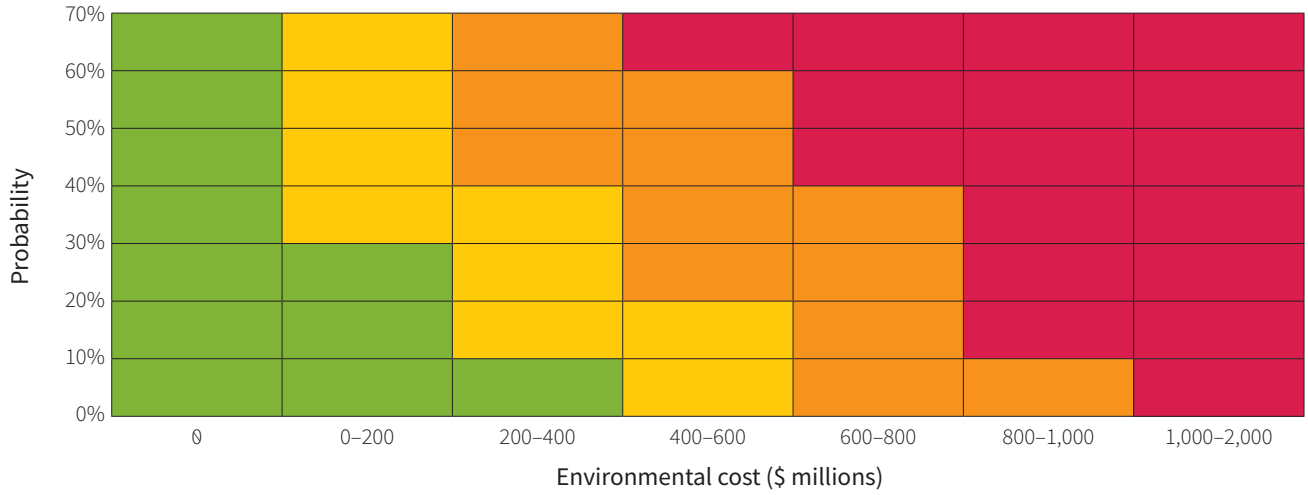
[2] In the context of environmental damage, risk refers to situations where we can estimate both the probability that an adverse event will occur and the magnitude of the environmental and societal damage that arises if it does. It is important to differentiate risk from uncertainty, which applies to situations in which we cannot reliably estimate potential levels of damage or their probabilities. The presence of uncertainty can significantly complicate the management of environmental risk. We return to the issue of uncertainty in Section 3.2. In practice, when we refer to "risk" in this report, we are referring to probabilistic outcomes that may — or may not — contain uncertainty.

Box 1: An overview of risk-related concepts

Risk is a function of both the probability of damage occurring and the magnitude of the resulting costs. In our context, risk describes the probability of different levels of environmental damage.

A **heatmap**, as illustrated in the figure below, is one way to conceptualize risk. It uses colour coding to signify the degree of risk (green being low risk, red being high risk). Risk increases as the harm to the environment becomes more probable or more severe. Figure 1 provides an example of a heatmap.

Figure 1: An example of a risk heatmap



Alternatively, we can conceptualize risk as a **probability distribution** for environmental costs, as seen in Figure 2. A probability distribution describes the range of environmental costs that are possible and their respective probabilities. The figure below shows a hypothetical probability distribution for the risk of environmental costs, using a probability mass function. As the figure illustrates, there is a 65% probability of environmental harm not occurring, and environmental costs therefore being nil. If the harm *does* occur, environmental costs are most likely to be in the $0–200 million range. However, they could also be higher than this. And there is a chance they could be *significantly* higher — exceeding $1 billion.

Box 1 continues on the next page

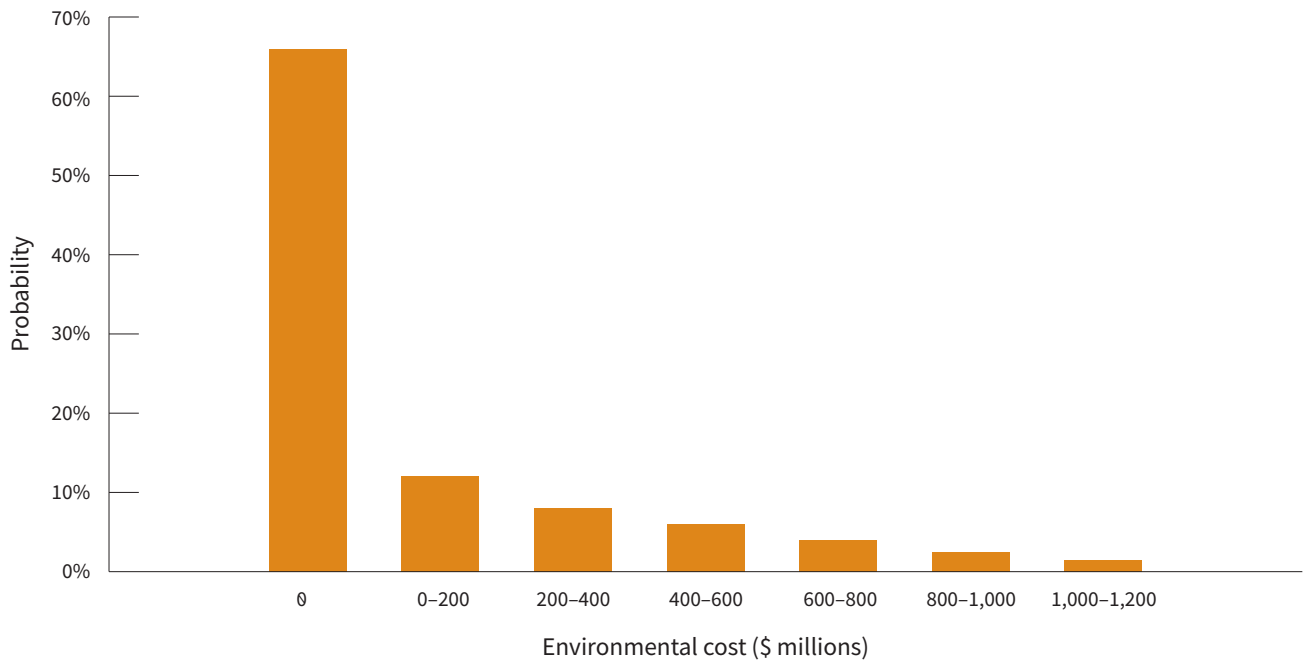
In this report, we focus on the risk of environmental damage that is — in most cases — unauthorized.[ii] This damage can stem from industrial disasters such as explosions, spills and leaks, but it might also come from the failure to clean an industrial site, from regulatory violations, or from more gradual impacts. For example, the pesticide DDT's bioaccumulation in humans and wildlife meant that the harm from exposure was marginal at first but worsened over time. This was part of the reason that its toxicity was underappreciated for so long (Sovacool, 2008; Eskenazi et al., 2009).[3]

Environmental risks can arise at any point in the industrial supply chain: *production* (e.g., the Deepwater Horizon oil spill, the Fukushima Daiichi nuclear disaster), *transportation* (e.g., the Cheakamus River train derailment, the Husky-Maidstone pipeline spill), or *storage and disposal* (e.g., Mount Polley, the Sydney Tar Ponds).

[3] We focus on the environmental risks from industrial processes. While some of the solutions we discuss in this paper can also be suited to the risks posed by natural environmental disasters (e.g., floods, earthquakes, and hurricanes), these risks are not the focus of this report. Similarly, we do not focus on the risks posed by climate change.

Box 1: An overview of risk-related concepts *continued*

Figure 2: An example of probability distribution



Based on such a probability distribution, we can calculate an **expected value** for environmental costs. The expected value is a weighted average of different environmental cost severities and their respective probabilities. Both a higher probability of an environmental harm occurring and a greater probability of large costs can drive an expected value higher. The expected value in the example above is $133 million. The expected value does not fall in the middle of the distribution because the high probability of *no* environmental harm occurring pulls the expected value's weighted average downward.

Condition #2: Liability gaps create the possibility that the costs of environmental damage will be borne by society

When environmental harms occur — especially large ones — private firms do not always bear the cost. Gaps in the rules governing a firm's liability can sometimes allow the benefits of economic activity to accrue to private firms but environmental costs to society at large. These costs can fall to taxpayers (e.g., when government pays for cleanup), citizens in general (e.g., effects on public health, damaged ecosystems), or other firms or individuals (e.g., personal injury, lost income, property damage).[4] We explore specific types of these *liability gaps* in Section 3.

Costs to society raise problems around fairness. Taxpayers, citizens, or firms can end up bearing the costs of environmental damage for which they are not responsible.

The potential for social costs also creates problems around incentives. If firms know they may only bear part of the cost of environmental damage arising from their actions (or none of it),

[4] Our focus is on the costs that these actors *ultimately* bear. Costs that they bear initially but later receive compensation for are, for the purposes of this report, not considered social costs. For example, the companies implicated in the Deepwater Horizon spill and Fukushima Daiichi nuclear disaster are expected to provide compensation of at least $62 billion and $188 billion, respectively (Amon & Panchal, 2016; Obayashi & Hamada, 2016). The social costs of these disasters would only be the portion of total costs that exceeds this compensation.

they have less incentive to reduce the likelihood of that damage occurring or its potential severity. This problem is what economists call *moral hazard* (Hölmstrom, 1979; Bennett, 1999; Mackie, 2014).[5]

In other words, the two things that together define risk externalities—the risk of environmental damage and the possibility of social costs — are mutually reinforcing. Environmental damage can lead to social costs. And that possibility can reduce incentives for firms to make choices that decrease environmental risk.

2.2 THREE DIFFERENT POLICY GOALS

When designing policy to address risk externalities, governments have three different — and at times competing — goals:

Deterrence: Reducing the probability of environmental harm occurring in the first place, as well as its potential severity (should it occur).

Compensation: Ensuring that, should environmental damage occur, private firms, not society, bear the cost.

Economic activity: Facilitating production and investment to benefit from the employment and income that it generates.

We discuss each goal separately below.

Deterrence creates incentives for firms to reduce environmental risk

A policy provides *deterrence* when it establishes incentives for firms to reduce the risk of their operations causing environmental damage. They might do so by taking action to reduce the probability of an event occurring (e.g., improving their safety measures and protocols). Or they might do so by acting to minimize environmental damage, should an event occur (e.g., choosing to locate their operation in a less environmentally sensitive area).

The *Bowtie Model* is a tool firms can use to manage risks. The model illustrates plausible causal pathways that could lead to environmental damage and the risk controls that can mitigate their likelihood or severity (or both), along these pathways (Ale et al., 2008; Ferdous et al., 2013). Figure 3 provides an illustration of the bowtie model using the risk of tailings dam failure at a mine site.

Deterrence is strong when it is in a firm's direct financial interest to prevent environmental harm (i.e., when polluters will pay for the damage they cause). Yet for reasons we will discuss in Section 3, in many cases firms do *not* bear the full costs of their environmental damage. To take one example, they may be liable for property damage and personal injury, but not liable for environmental impacts like biodiversity loss.

Moral hazard exists when a firm knows it will not have to absorb the full cost of a harm it causes. Its incomplete responsibility for environmental damage might lead it to behave in a way that increases the chance of an environmental harm occurring or makes it more severe than it would have been otherwise (or both). For example, a firm liable only for property damage and personal injury might not even consider its operation's potential impacts on local biodiversity or how they could be limited. This lack of incentive can increase the risk of biodiversity loss.

Policies that increase firms' liability for environmental damage improve deterrence. For example, policy-makers could institute a regulation requiring firms to carry out habitat restoration if their operations cause harm to local biodiversity. Firms' interest in avoiding this expense would create an incentive for them to limit the risk of this harm. In this way, the regulation would improve deterrence.

Compensation holds private firms accountable for the environmental damage they cause

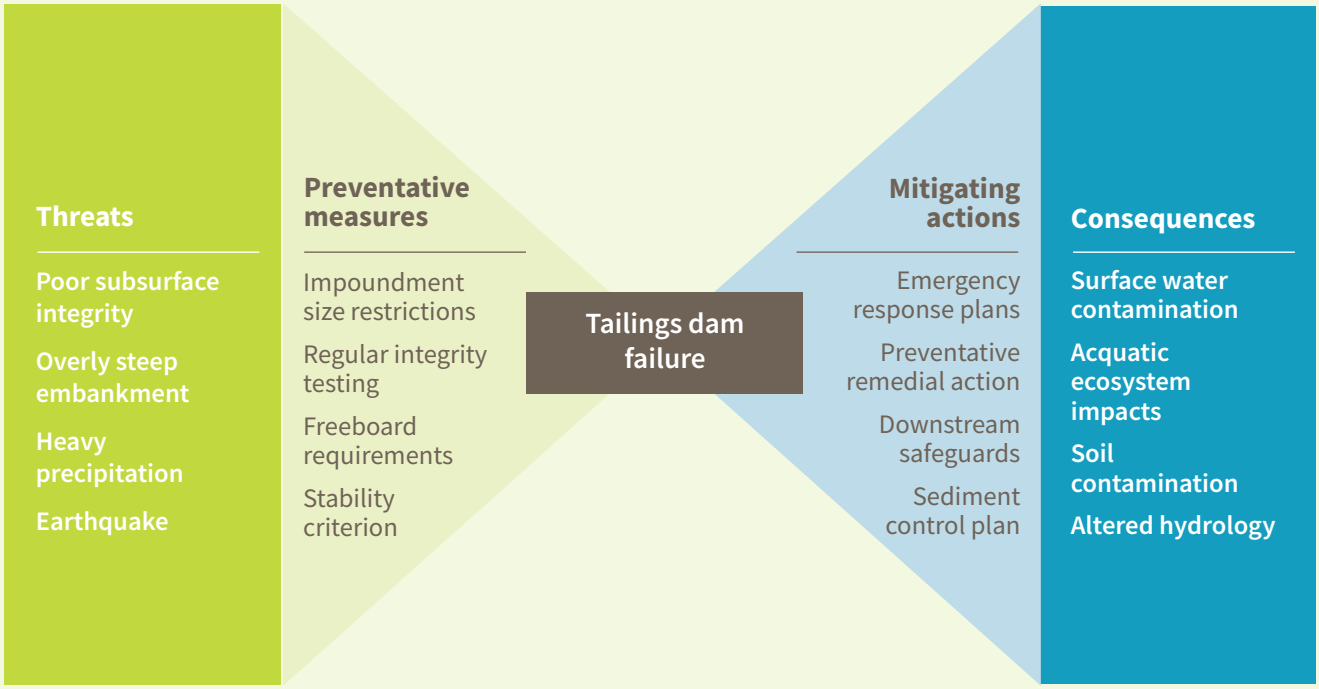
A policy provides greater *compensation* when it reduces the share of costs that society bears from a privately caused environmental harm. The compensation goal is motivated by concerns about fairness. Compensation requires that when environmental damage does occur, either the responsible firm or an engaged third party bears the cost.[iii]

Yet in practice, environmental damage resulting from private actions commonly leads to costs to society. As we will discuss in Section 3, firms' liability for environmental damage can be defined, capped, or scoped in a way that makes it difficult to hold them fully accountable (e.g., the Cheakamus River train derailment, Mount Polley). Or even where a firm is fully liable, it may become bankrupt or no longer be in business, and thus no longer accountable for environmental damage (e.g., cleanup of the Sydney Tar Ponds, Alberta and Saskatchewan's orphaned oil and gas wells).

Policies improve compensation if they reduce the risk that society will bear the cost of firms' environmental damage. For example, policy-makers might require that the assets of parent companies serve as collateral when their subordinates' activities pose risks to the environment. This approach would prevent firms from transferring their environmental liabilities to the public by

[5] Moral hazard is a technical term that describes a situation where incomplete exposure to costs reduces a firm or individual's incentive to reduce risk. It does not imply that the firm or individual is acting (or will act) in an immoral or illegal manner.

Figure 3: An illustration of the Bowtie Model using the risk of tailing dam failure at a mine site



having their subsidiaries declare bankruptcy when projects are no longer profitable.[iv]

As a general rule, improving compensation improves deterrence. But in some circumstances, there can be trade-offs between the two. In particular, instruments that pool risk can support compensation at the expense of deterrence. For example, the United States' nuclear industry as a whole is responsible for any damage from a nuclear accident that exceeds the responsible operator's liability insurance (Faure, 2016). This approach supports full compensation but provides less deterrence relative to a policy that would require individual operators to bear the full costs of their actions. On the other hand, policies that require operators to bear the full cost of their actions would undermine compensation, since the full costs of an accident might bankrupt an individual operator, leaving society to bear the cost.

Economic activity drives social and economic benefits

An environmental risk policy supports *economic activity* to the extent that it encourages production and investment and allows socially beneficial projects to take place. All else being equal, society benefits from the employment and income that economic activity generates (i.e., even when it poses environmental risks).

Policies aimed at the first two priorities — deterrence and compensation — carry real economic costs. They divert scarce resources that could otherwise be productively employed in the economy. For example, requiring firms to earmark funds to cover their liability for a potential disaster ties up a portion of their available capital. They are unable to invest these funds in improved production efficiency, greater capacity, or an altogether new project. (Mackie, 2014; Gerard, 2000).

To facilitate economic activity, policy-makers could, for example, place a cap on firms' liability for environmental damage. For instance, in 2013 the federal government set oil and gas companies' maximum liability for oil spills or blowouts off the East Coast at $1 billion (Government of Canada, 2016a).[v]

A cap on liability is a form of public-private risk sharing, since the government effectively agrees to absorb any costs that result from the firms' actions that exceed the cap. This type of policy reduces downside risk for firms, and thereby helps to encourage production and investment. However, it does so at the expense of greater deterrence and compensation (Faure, 2016).

2.3 MANAGING RISK EXTERNALITIES REQUIRES BALANCING TRADE-OFFS

Trade-offs across the three policy goals of deterrence, compensation and economic activity mean that managing risk externalities can be complex.

The overall goal is to manage risk, not eliminate it

Some stakeholders might like to see environmental risk dramatically reduced or even eliminated. But reducing environmental risk can have diminishing returns: at some point, the costs can exceed the benefits. Indeed, to fully eliminate risk would require shutting down the activity that creates it (Vanem et al., 2008; Psarros et al., 2011; Viscusi & Zeckhower, 2011).

In addition, most industrial sectors exist in global markets. Substantially reducing environmental risk might raise costs to the point that domestic production would no longer be viable. As a result, production and investment could shift to other countries with weaker environmental regulations and safeguards.

Policy-makers must weigh the benefits of reducing environmental risks against the costs of doing so. Managing the risk of environmental damage requires creating a balance across the three policy goals.[vi] Being transparent about how that balance is achieved can add to its public acceptance and sustainability.

Risk sharing can be justified in specific circumstances

Public-private risk sharing — where governments intentionally absorb part of a firm or sector's environmental risk — is often suggested as a way of facilitating economic activity. All else being equal, public–private risk sharing is not desirable. First, it is unfair since society may have to absorb the cost of environmental damage it did not cause. Second, it impairs economic efficiency. When firms do not have to bear the full cost of the risk they pose, it reduces their economic incentives for risk reduction. The result can be a level of risk taking for which costs exceed benefits (Radetzki & Radetzki, 2000; Viscusi & Zeckhower, 2011; Nguyen, 2013).[vii]

But under specific circumstances, sharing risk can be justified. When a firm develops publicly owned natural resources, it usually pays royalties to society. In order to share in the benefits of natural resource development with firms, governments may have to share in some of the risks as well.

Risk sharing may also be justified if market problems prevent the firm from being able to efficiently absorb the cost of its risks. In particular, uncertainty can inflate the cost of financial assurance provided by third parties (e.g., insurers), rendering some types of valuable economic activity unviable (Faure, 2007a; Kunreuther, 2015).

But even in cases where there is a clear rationale for risk sharing, policy-makers must be cautious. Not all risk-sharing arrangements balance the incentives to reduce the risk of environmental damage with the gains from the underlying economic activity. Some may transfer more risk than necessary to the public. Or they may transfer it inefficiently, unnecessarily compromising deterrence and compensation. For example, government may choose to act as a simple backstop for costs that fall beyond a given threshold. While this helps share risk, it provides limited risk-reduction incentives compared to a public-private *sharing* of any costs above the threshold.

We can improve how we manage risk externalities in Canada

Each jurisdiction can (and should) manage environmental risk externalities in line with its local context and priorities. Jurisdictions will differ in the balances they strike across the three policy goals. Yet in general, this report finds room for improvement in the balance that policies are striking in Canadian jurisdictions.

Current policy comes up short in a number of ways. Gaps in some of the rules that govern firms' liability for environmental damage create too large a burden on society. Excessive transfer of risk from private to public sectors exacerbates the risk of environmental damage occurring in the first place. And — as we will discuss below— the underuse of *financial assurance* increases the risk that society will bear the costs of privately caused environmental damage.

2.4 A FOCUS ON FINANCIAL ASSURANCE

Our focus in this report is financial-assurance instruments — mechanisms that put a price on environmental risk. But other policy instruments also have a role to play in how jurisdictions choose to manage risk externalities.

Three types of policy tools can help to manage risk externalities

When creating policy to deal with the risk of environmental harm and the possibility of social costs, governments have three main types of tools available:

1. **Command-and-control regulation:** Governments can regulate firms' safety practices, the technologies they use, and how they measure and report risk. For example, uranium mining operations in Saskatchewan are subject to strict standards and regular, detailed inspections and reporting requirements to ensure compliance (SMA, 2016).[viii]

2. **Liability rules:** Governments can write laws and regulations that define firms' liability for environmental damage. For example, the *Canadian Environmental Protection Act* (1999) makes the owners of particular toxic substances fully liable for environmental damage, as well as any expenses government incurs in responding to an environmental emergency (Government of Canada, 2004).[ix] Tort law, under which injured parties can sue for damages in civil court, is an important category of liability rules. Tort suits provide recourse for those who have suffered some kind of private harm (e.g., damage to property) that is outside the scope of the statutory compensation paid by a responsible party.[x]

3. **Financial assurance:** Governments can require firms to promise or commit funds against their future environmental liabilities. Financial assurance can take various forms (e.g., cash, environmental bonds, insurance, industry funds). For example, Canada's *Pipeline Safety Act* (2015) requires oil and gas pipeline operators to provide bonds, insurance, or guarantees against their liability for a potential oil spill (Government of Canada, 2015b). Unlike liability rules, which focus on assigning liability for a harm that *has happened*, financial assurance focuses on ensuring compensation for a *future* harm that may or may not occur.

All these instruments are legitimate ways of dealing with environmental risk and the possibility of social costs, and they represent important tools in the policy toolkit. Our focus here, however, is on financial assurance.

Greater use of financial assurance in Canada can improve outcomes

Financial assurance can help policy-makers pursue all three of their policy goals:

- It provides *deterrence*: By ensuring that the expected costs of environmental risks factor into firms' calculations, financial assurance limits moral hazard and thus reduces the risk of environmental damage.[xi]
- It helps ensure *compensation*: By securing funds to cover firms' expected or potential environmental liabilities, financial assurance decreases the possibility of public responsibility for dealing with the costs of environmental damage.
- It supports *economic activity:* By harnessing market forces, well-designed financial assurance can provide deterrence and compensation at a lower economic cost than its alternatives.[xii]

Financial assurance can also complement other policy tools. When policy-makers apply the three types of tools in a coordinated way, they can manage their risk externalities more effectively and at lower cost. Regulations ensure certain minimum standards and practices are met and rule out particularly high-risk activities. Liability rules clarify who will be liable for what in the event of environmental harm. And financial assurance ensures that firms have an incentive to limit risk and will bear the costs for which they are liable.

Finally, Canadian governments can make greater use of financial assurance. While most sectors exposed to risk externalities have safety regulations and liability rules, they are not necessarily asked to provide financial assurance against potential environmental liabilities. Especially in areas where it is under-applied, financial assurance can be a powerful new tool for managing risk externalities.

Box 2: A summary of Section 2

Key findings

- *Risk externalities* exist when there is a risk of environmental damage from firms' activities and some (or all) of its cost would be borne by society.
- The goal of policy is to manage risk externalities, not necessarily to eliminate them.
- Managing risk externalities requires considering trade-offs between:
  - *Deterrence* (creating incentives for firms to reduce environmental risk)
  - *Compensation* (holding firms accountable for the environmental damage they cause)
  - *Economic activity* (facilitating investment and production that drive economic and social benefits)
- *Financial assurance* policies can help manage risk externalities. They help policy-makers pursue their three goals. And they complement jurisdictions' safety regulations and liability rules.

3 USING FINANCIAL ASSURANCE TO ADDRESS LIABILITY GAPS

Financial-assurance policies can help manage risk externalities in a very specific way. They do so by addressing *liability gaps*.

As we noted above, liability gaps transfer environmental risk from private firms to society more broadly. They are a function of a jurisdiction's liability rules — legislation, precedent-defining judicial decisions, and regulatory statutes (or the absence thereof) that define what a firm can be held liable for.

Policy-makers can address liability gaps in one of two ways. First, they can change their liability rules to close (or limit) liability gaps. However, in some cases, the costs of doing so might exceed the benefits. In others, it may not even be possible. Alternatively, policy-makers can address liability gaps using financial assurance.[6]

This section identifies five specific types of liability gaps that can create risk externalities. It explains the specific role that financial assurance can play in addressing liability gaps. And it describes how both risk-externality problems and financial-assurance solutions can be complicated by two additional issues: fat tail risk and uncertainty.

3.1 FIVE TYPES OF LIABILITY GAPS

Five specific types of liability gaps can create risk externalities. While the five types are distinct, multiple types of liability gaps can simultaneously exist in a sector or jurisdiction — and usually do.

Type #1: No one can be held responsible

If no one can be held responsible for environmental damage, society will bear the cost. This can occur for three main reasons.

First, it might be difficult to i*dentify* a responsible party. For example, in Northern Alberta, several pulp mills discharge effluents into the Athabasca River and cumulatively affect water quality and fish populations. However, the impacts of individual mills cannot be isolated from each other or from other sources of industrial discharge (Chambers et al, 2006; Environment Canada, 2014).

Second, *latency* can make it difficult to hold firms responsible. In some cases, it may take many years for a harm to become evident or for a responsible party to be identified. For example, proximity and long-term exposure to asbestos has been linked to elevated risk of respiratory illness and cancer. However, these health issues can take decades to arise (Selikoff et al., 1980). Latency can be especially significant where there is a statute of limitations on firms' liability (Faure, 2016).

Third, even in cases where it is possible to identify the entity likely responsible for environmental damage, it may be challenging, in legal terms, to *prove* they are responsible. For example, in some cases

[6] The third type of instrument available to policy-makers is regulations. Command-and-control regulations do not address liability gaps. Rather, they focus on limiting the first component of risk externalities: the risk of environmental damage (Faure, 2014).

hydraulic fracturing or "fracking" has been linked to contamination of groundwater sources. However, since aquifers can generate methane naturally and environmental baseline data is often limited, proving causation is often impossible (Tilley & Muehlenbachs, 2012; McIntosh et al., 2014; Vengosh et al., 2015).

Type #2: Liability rules release firms from liability in certain circumstances

Liability rules can define firms' liability for environmental damage in different ways.

Absolute liability is the most stringent. Under absolute liability, the mere occurrence of environmental harm is enough to make a firm liable. For example, a pipeline company operating under absolute liability would be responsible for any spill that originated from its pipeline. Even if the firm had taken all appropriate safety precautions and the rupture had been caused by an "act of God" (e.g., an earthquake), it would still be liable.

Strict liability is a less stringent standard.[xiii] Firms are liable for damage by default, but can escape liability if they can prove they took care to try to prevent it.[xiv] A company operating a steel mill under strict liability would not be liable for damage caused by air pollution where it could show it had exercised due diligence.[xv] Under strict liability, it is not always clear whether a firm will be liable for a particular harm (Katzman, 1988; Faure, 2016; Klar & Jefferies, 2017).

Defining firms' liability for environmental damage using anything short of absolute liability creates a liability gap: firms may not be liable for the damage they cause. The less stringent the definition used, the greater the liability gap.

Type #3: Liability rules cap firms' liability

Regardless of how firms' liability is defined in liability rules — that is, whether they are absolutely or strictly liable for environmental damage — costs can fall to society where their liability has been *capped* at a particular level.

When liability rules limit the level of firms' liability (i.e., define a maximum dollar value for it), a liability gap exists. For example, under *Canada's Nuclear Liability and Compensation Act* (2015), an operator's liability for a nuclear incident is capped at $1 billion (CNSC, 2017b).[xvi] Any costs exceeding this cap will be borne by society.

Type #4: Liability rules exclude some types of environmental damage

Where liability rules constrain the *types* of damage that firms are liable for — either explicitly or by omission — the costs of this damage will fall to society.

Non-market environmental costs are a common gap in firms' liability.[7] Liability for cleanup costs, personal injury and property damage is usually clearly established in liability rules. But because non-market environmental costs can be difficult to identify, measure, or value monetarily (and because the results of their valuation can be contentious), they are often excluded from firms' liability (Monti, 2002). These costs can be significant, especially given the potential for irreversible ecosystem damage (e.g., species extinction).

For example, in the case of *R v Zellstoff Celgar Limited Partnership*, the defendant released 500 million litres of effluent containing substances that violated permit requirements into the Columbia River. However, because the prosecution could not provide evidence of any direct and immediate adverse effect on the river, the court ruled that it could not hold the firm liable for environmental damage (R v Zellstoff Celgar Limited Partnership, 2012).

A legal precedent exists for governments in Canada to recover the costs of non-market environmental damage in civil court.[xvii] However, to date, it has not been exercised.

Type #5: The responsible firm can be "judgment proof"

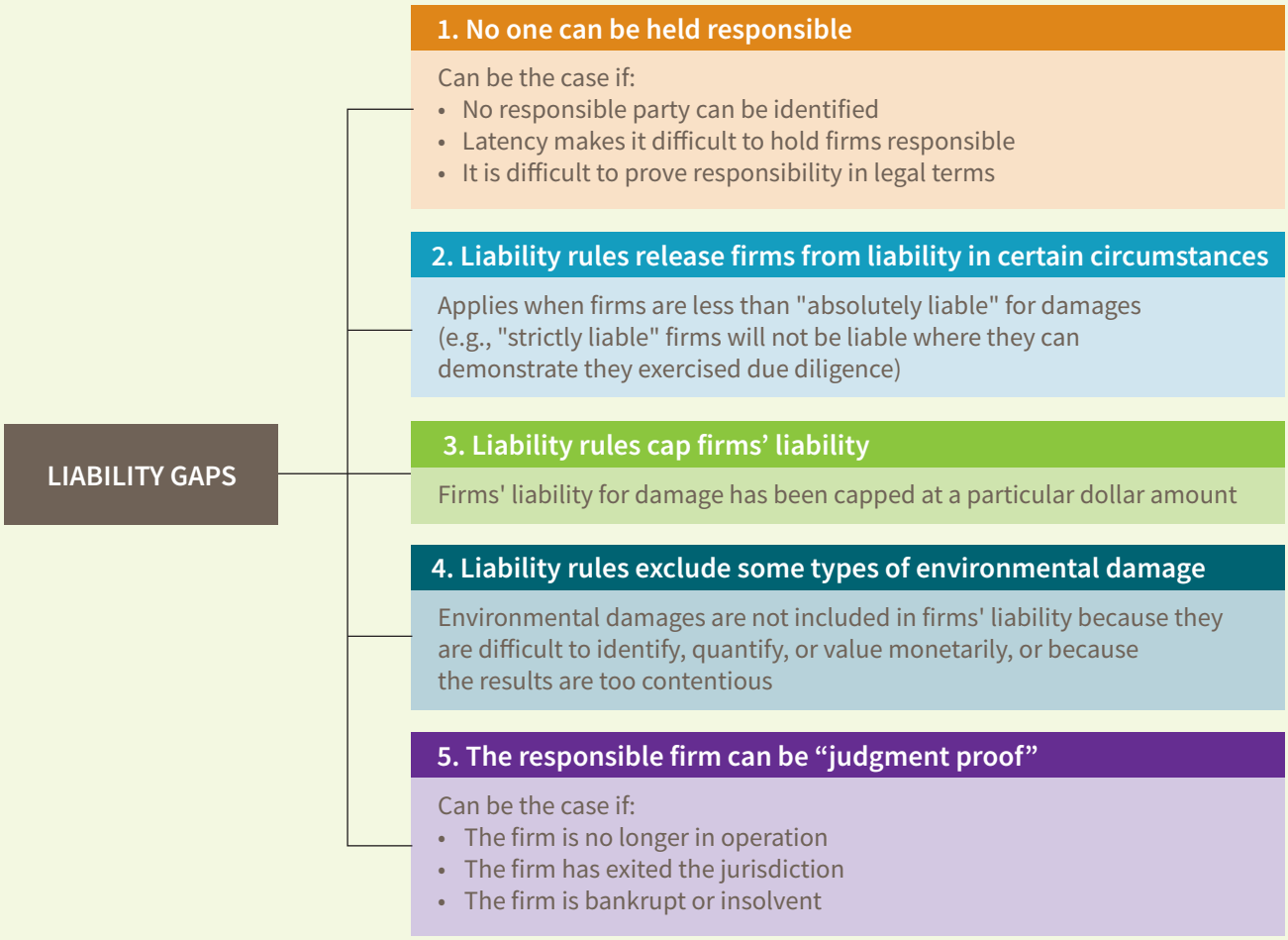
Even where a liability regime holds firms fully liable for the damage they cause, they may be able to avoid paying for them by declaring bankruptcy, by dissolving before they become liable, or by exiting the jurisdiction.[xviii] In legal language, this is referred to as being "judgment proof" (Shavell, 1986).

When firms are able to avoid responsibility in this way, significant costs can fall to society. For example, remediating Giant Mine in the Northwest Territories is expected to cost nearly $1 billion. The site is highly toxic and sits directly next to the city of Yellowknife. The mine closed in 2006, and its owners, Miramar Mining Corporation, are no longer in operation. Therefore, the public will bear the entire remediation cost, as well as the cost of any environmental damage that occurs (AANDC, 2012).

The business structure of the corporation creates an important type of liability gap. In a corporation, shareholders can generally only be held liable for damages up to the amount they have invested in the firm.[xix] If a corporation's debts exceed its assets

[7] *Market* environmental costs are measurable in dollar terms using observable data on market prices and quantities, while *non-market* ones are not. For example, agricultural fertilizer runoff into a water body can cause eutrophication. This can reduce tourism and affect commercial fishing incomes (market environmental costs). At the same time, it can also affect locals' recreational uses of the water body and harm local biodiversity (non-market costs). While non-market environmental costs are not visible in the same way that market costs are, they nevertheless represent a real — and important — dimension of a harm's total costs (Hallegatte & Pryzluski, 2010).

Figure 4: The five types of liability gaps



or if it is unable to pay its bills, it can declare bankruptcy. Where its remaining assets are insufficient to meet the cost of its environmental liabilities, society will bear the cost.

Under Canadian law, when a corporation declares bankruptcy or enters insolvency, secured creditors recover their claims ahead of unsecured creditors and shareholders. In the recent landmark Redwater case, the Alberta Court of Appeals found that liabilities to government for environmental cleanup represented an *unsecured* claim.[xx] The Court found that governments should receive compensation only after secured creditors had been paid out and receive a share of the firm's remaining assets that was in line with its share of total outstanding unsecured claims.

The Redwater decision decreases the probability that bankrupt or insolvent corporations will bear the cost of their environmental liabilities in Canada. The decision has been appealed to the Supreme Court of Canada, which heard oral arguments in this case on February 15, 2018. The Court's decision will set an important precedent for how environmental liabilities are handled in bankruptcy and insolvency proceedings in Canada (Dachis et al., 2017; Seskus, 2018).

Figure 4 provides an overview of the five types of liability gaps discussed in this section.

3.2 THE SPECIFIC ROLE OF FINANCIAL ASSURANCE

Financial assurance offers policy-makers a powerful way to address liability gaps. But it is better suited to some gaps than others.

Financial assurance can help address liability gaps by complementing liability rules

Financial assurance can address liability gaps in one of two ways.

First, financial assurance can *reinforce* a jurisdiction's liability rules. For example, policy-makers can use financial assurance

to ensure that funds are readily available in the event of an environmental harm for which a firm is liable. This can be especially important where timely intervention and cleanup might be required (e.g., an oil spill at sea). Using financial assurance in this way can ensure funds are available when needed and that government does not need to rely on firms liquidating their assets or raising funds in capital markets (Gerard, 2000; Boyd, 2001).

Second, financial assurance can *supersede* liability rules. For example, a firm that operates under strict liability will not be liable for environmental harm if it can demonstrate due diligence. Governments concerned about this liability gap could choose to require financial assurance from the firm that would be available in the event of *any* environmental harm resulting from its operations (i.e., due diligence or not). In this context, financial assurance would circumvent the liability rules of regulatory and tort law, closing the liability gap in a way that avoided both social costs and costly civil litigation (Shavell, 1986; Faure, 2014; Faure, 2016; Arnold, 2017).

However, for some liability gap problems, the best solution may be for policy-makers to revise their liability rules. For example, if policy-makers are concerned about the possibility of a cap on firms' liability leading to social costs, they might consider lifting or raising it (and *then* requiring greater financial assurance), rather than simply requiring financial assurance over and above firms' liability in law.

Financial assurance is particularly suited to the judgment-proof liability gap

Liability gaps 1 to 4 relate to how liability rules in a given jurisdiction define firms' liability. In general, governments seeking to close or manage these types of liability gaps can either use financial assurance, revise their liability rules, or both.

But liability gap 5 (the responsible firm can be judgment proof) is different. Firms and individuals' ability to declare bankruptcy in the event that their liabilities exceed their assets is a fundamental tenet of Canadian law and commerce. Changing liability rules to do away with the judgment-proof liability gap would require upending Canadian bankruptcy and insolvency law — a policy change that would have far-reaching implications. So long as governments wish to maintain the business structure of the corporation, the judgment-proof liability gap will remain.

Critically, while not all five types of liability gaps exist in a given sector, the judgment-proof liability gap always does. That means that social costs from environmental damage are a possibility in any sector—regardless of how a jurisdiction's liability rules define firms' liability for environmental damage.

The judgment-proof liability gap is the reason financial assurance is often needed as a complement to liability rules. By helping ensure that firms bear the cost of their liabilities, it provides an essential backstop to *all* a jurisdiction's liability rules (Boyd, 2001; Boomhower, 2014; Faure, 2014).

3.3 TWO EXACERBATING FACTORS

Two types of exacerbating factors — fat tails and uncertainty — can interact with liability gaps to make them more difficult to address or to increase the size of the risk externalities that might result. They also make designing suitable financial-assurance policies more complex.

Fat tails can interact with liability gaps, exacerbating risk externalities

When risk is "fat-tailed," events with *very* high environmental costs are possible (see Box 3 for a description of how fat tails affect risk). Fat-tail events are by definition unlikely, but when they occur, they can be catastrophic. For example, the Deepwater Horizon blowout's non-market environmental costs alone were estimated at US$17.2 billion. The firm's total liability for the disaster will exceed US$60 billion (Bishop et al., 2017).

Fat tails interact with two particular liability gaps in a way that can exacerbate risk externalities. In both cases, fat-tailed risks lead to a higher probability that society will bear environmental costs:

- Fat tails interact with liability gap 3 (liability rules cap firms' liability). When risk is fat-tailed, there is a higher probability that the costs of an environmental harm will exceed a firm's liability cap.
- Fat tails interact with liability gap 5 (the responsible firm can be judgment proof). In some cases, a firm's environmental liabilities might be large enough to bankrupt it only in cases where the costs of an event are extreme.

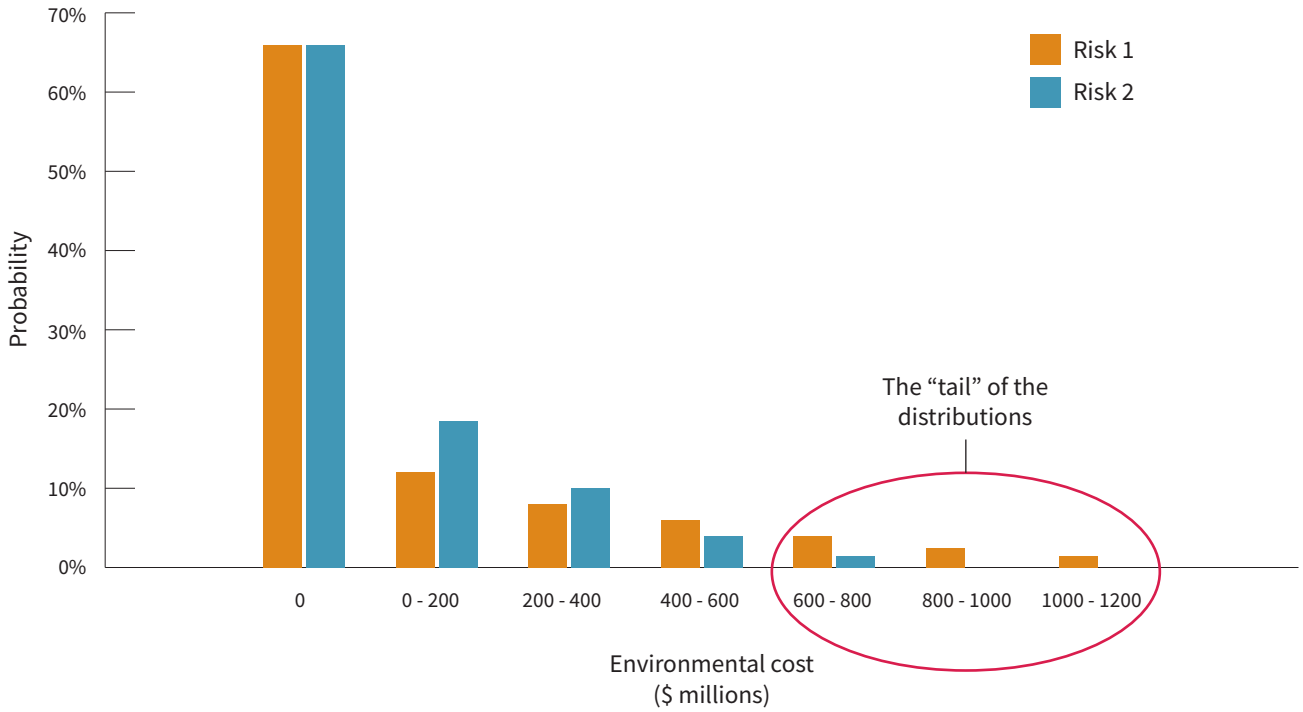
Fat tails are particularly important for environmental risks. Environmental damage tends to be non-linear and in some cases irreversible. For example, low-levels of pollution might lead to small damages, but past a given threshold, damages can become extreme. And if ecosystem damage cannot be remediated (e.g., the Chernobyl nuclear disaster), the damage can be particularly costly (Scheffer et al., 2001; Pindyck, 2007; Faure, 2007a).

Box 3: An overview of risk-related concepts *continued*

The "tail" that the term *fat tail* refers to is the far end of a risk's probability distribution. A probability distribution with a "fat" tail is one in which possible outcomes extend far along the x-axis, where environmental costs become massive in scale.

In the figure below, we show two risks with differing probability distributions, using a probability mass function. Risk 1 has a distribution with a fat tail. (The "tail" is the right-most part of the distribution, circled in red.) The tail is considered "fat" because possible environmental costs extend far along the x-axis, to over $1 billion. In contrast, Risk 2 has a comparatively "thin" tail.

Figure 5: Two risks with different tails



Uncertainty can make liability gaps larger or create new ones

Uncertainty can exacerbate risk-externality problems. Efforts to respond to uncertainty through policy choices can *create* liability gaps.

Uncertainty is a fundamentally different problem than risk: under uncertainty, the probability distribution around damage *cannot be reliably estimated* (see Box 4 for a discussion of risk versus uncertainty). Uncertainty can exist in various dimensions, such as environmental, financial, technological, or legal uncertainty (Monti, 2002; UNEP, 2003).

Box 4: Risk versus uncertainty

In *Risk, Uncertainty, and Profit*, Knight (1921) distinguishes risk from uncertainty:

> Uncertainty must be taken in a sense radically distinct from the familiar notion of Risk, from which it has never been properly separated.... The essential fact is that 'risk' means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomena depending on which of the two is really present and operating.... It will appear that a measurable uncertainty, or 'risk' proper, as we shall use the term, is so far different from an unmeasurable one that it is not in effect an uncertainty at all.

Knightian uncertainty is the type of uncertainty that we refer to in this report. It is distinguished from risk in that, under Knightian uncertainty, underlying probabilities or the range of possible costs cannot be estimated with confidence — they are fundamentally unknowable.

The distinction between risk and uncertainty is critical. The two concepts were famously illustrated by Donald Rumsfeld, former U.S. Secretary of Defense, in his discussion of the lack of evidence linking the government of Iraq with the supply of weapons of mass destruction:

> There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know (NATO, 2002).

In these terms, risks are *known unknowns* — they have an unknown outcome, but we know what the underlying outcome distribution looks like (that is, we do not know if it will occur or not, but we can define a probability for its occurrence). Uncertainty, on the other hand, is an *unknown unknown* — it also implies an unknown outcome, but we don't know what the underlying distribution looks like (that is, we do not know the probability of it occurring, how severe it might be if it did, or both).

When trying to manage uncertainty, policy-makers can use available policy tools to respond in one of two ways.

First, they can err on the side of caution. For example, policy-makers might closely monitor industrial facilities. In Newfoundland and Labrador — as well as other provinces — hydroelectric dams undergo regular reviews that evaluate the risk of loss of life, economic impact, and environmental damage should they fail (Government of Newfoundland and Labrador, 2017). Policy-makers could also require stringent financial assurance against reclamation or the costs of a potential accident. In Maine, mining firms are required to provide financial security in full and up front against an independently verified worst-case scenario (Bowker & Chambers, 2017). These types of measures decrease the risk of environmental damage. But they are also increase firms' compliance costs and may reduce economic activity.

Alternatively, policy-makers can err the other way, by accepting that environmental costs are uncertain and trying to manage or accommodate them. For example, policy-makers might use liability rules to institute a liability cap, recognizing that uncertainty around potential environmental liabilities might make private firms reluctant to undertake an activity (e.g., in Canada, pipeline companies' liability for a potential oil spill is capped at $1 billion (Government of Canada, 2015b)).[xxi] These types of responses to uncertainty can facilitate economic activity. But they can also create a new liability gap or grow an existing one.

The corporation (i.e., the business structure that can contribute to firms being judgment proof) is itself a response from policy-makers to uncertainty. It ensures that firms are not paralyzed by potential liabilities and unintended consequences (Innes, 1999). But in the context of environmental damage, it also creates a significant liability gap. For example, in the United States, six companies were able to pass $700 million USD in pollution cleanup costs onto the federal government by declaring bankruptcy (Bogardus, 2007).

Fat tails and uncertainty also make designing financial assurance more complicated

Fat-tailed risks can limit the number of financial-assurance instruments available as options for policy-makers. Firms may not have sufficient financial capacity to provide assurance against fat-tailed risks or they be may be unable to find third parties (e.g. insurers) willing to provide high enough coverage against them (Faure, 2014).

Uncertainty creates the scope for both policy failure and market failure in the application of financial assurance. In the presence of uncertainty, policy-makers may not know the appropriate amount of financial assurance to require from firms.[xxii] This can lead to a policy failure where policy-makers require too little assurance, increasing both environmental risk and the possibility of social costs.

Uncertainty can also lead to a market failure in the coverage that third-party intermediaries provide. In the presence of uncertainty, third parties may not know how to estimate and thereby *price* risk. As a result, the costs of coverage may rise significantly (i.e., as third parties raise premiums to protect themselves against uncertainty), or not be available at all (Monti, 2002; Faure, 2007b; Faure, 2014).

Because exacerbating factors can cause some types of financial assurance to work inefficiently (or to not work at all), public-private risk sharing might be appropriate when these factors are present.

Box 5: A summary of Section 3

Key findings:

- Five types of *liability gaps* can create risk externalities:
  1. It might be difficult to hold particular private firms responsible for a given environmental harm when their responsibility is not clear, where there is latency, or where responsibility is difficult to prove.
  2. The way firms' liability is defined might mean they are not liable in certain circumstances.
  3. Liability rules or regulations may cap firms' liability (i.e., define a maximum dollar value for it).
  4. Whether explicitly or by omission, liability rules might exclude some types of environmental damage from firms' liability (in particular, non-market environmental damage).
  5. Firms may be able to avoid paying for environmental damage by declaring bankruptcy, dissolving before they become liable, or by exiting the jurisdiction.
- *Financial assurance* offers a powerful way for policy-makers to address different types of liability gaps (and thereby manage their risk externalities). Financial assurance is particularly suited to addressing the judgment-proof liability gap.
- *"Fat-tailed" risk* (i.e., where extremely high costs have low, but non-zero likelihood of occurring) and *uncertainty* (i.e., where risk cannot be reliably estimated) can exacerbate risk externalities. And they can also make financial assurance solutions less effective or more difficult to design.

4 FINANCIAL ASSURANCE: INSTRUMENTS AND TRADE-OFFS

Financial-assurance instruments can be grouped into five categories. We discuss each in turn, outlining key features, the specific types of instruments included in each category, and trade-offs across the three policy goals of deterrence, compensation, and economic activity. Our analysis focuses on each instrument category's general implications for policy goals. However, at times we also comment on how impacts might differ across instruments available within a category. We focus on the most important distinctions.

Our analysis compares financial-assurance instruments *ceteris paribus* — all else being equal. We therefore assume they have similar underlying liability rules, stringency, enforcement, etc. In practice, the details of how a given financial-assurance instrument is applied can be as important as the inherent features that we discuss here. In Section 5, we compare mining sector financial-assurance policies across five Canadian jurisdictions, exploring how instruments' design and implementation affect their performance.

4.1 HARD FINANCIAL ASSURANCE FROM FIRMS

Financial assurance is "hard" when firms provide assets against their potential liabilities that are liquid, cannot fluctuate in value, and cannot suddenly become unavailable. Hard assurance is held either directly by government or in trust by a third party. When a qualifying environmental liability arises and the firm does not bear the cost, government (or other affected third parties) can receive compensation from the assurance held. Where no liability arises and there is deemed to be no further risk of one, government returns the assurance held to the firm (Gerard, 2000; Miller, 2005).

Hard assurance includes *cash, securities, sinking funds* and *trusts*

Cash is the most liquid type of financial assurance that governments can require. While it can depreciate in real value over time due to inflation, holding it in an interest-bearing account offsets this effect (Boyd, 2001; Sassoon, 2009).

Securities are tradable financial instruments such as bonds, stocks, or derivatives. Securities are liquid, but they may not hold their value in the same way as cash. For example, while bonds yield a fixed rate of return, their market value fluctuates with the current interest rate. Stocks can lose their value entirely. Governments seeking to call in security-based financial assurance may risk having to sell it at a discount when market conditions are not favourable. As such, there are often limits to the specific types of securities they will accept.

A *sinking fund* is cash assurance that a firm builds up over time, usually funded out of revenues. While the fact that it is cash ensures liquidity, the value of the fund will be limited during the early phases of operation. In particular, when funded out of resource royalties, the pace at which a sinking fund will build up can be uncertain: royalties that firms pay can fluctuate, depending on factors like commodity prices, firm profit levels, etc. (Boyd, 2001; Hawkins, 2008; Munchmeyer et al., 2009; Gorton et al., 2010).

A *Qualifying Environmental Trust* (QET) is a special financial-assurance vehicle that allows firms to provide cash financial assurance in a way that confers tax advantages.[xxiii]

Hard assurance provides strong *deterrence*

Hard assurance requires firms to provide credible, certain assets against their environmental risks. But if no environmental harm occurs, the assurance is returned. This creates a strong incentive to reduce environmental risk.

Deterrence will vary across specific instruments in this category. In particular, a sinking fund initially creates limited deterrence incentives that grow over time.

Hard assurance provides strong *compensation*

Hard assurance is held directly by governments (or in trust), ensuring compensation in the event of an environmental harm. However, compensation might be less than complete in cases where securities provided as financial assurance fluctuate in value. Further, compensation from a sinking fund might be insufficient if an environmental liability arises early in a project's life.

Hard assurance provides weak support for *economic activity*

Providing cash or securities ties up a firm's capital and can constrain its borrowing capacity. Requiring hard assurance in full and up front introduces costs early in a project's life, when capital costs are high and the project might not yet be generating revenue. (This is in contrast with a sinking fund, which does not carry the same up-front costs). These costs can make some projects uneconomical and constrain investment capacity in others. This effect may be particularly pronounced for new or small firms that face higher costs of capital than large, established firms.

4.2 SOFT ASSURANCE FROM FIRMS

Some firm-level financial-assurance instruments allow firms to remain in possession of their capital or assets. Under these instruments, nothing is transferred to government (though in some cases, firms' assets may be earmarked). As a result, they are "soft" in nature: they are less liquid than hard assurance, and their value is less certain (Boyd, 2001).

Under firm-level soft assurance, the particulars of the firm matter a great deal. Soft assurance provided by large and diversified firms will usually be more reliable than that from small, thinly capitalized ones. But because even a large company's situation can change, governments often must closely monitor the financial health of companies from which they accept soft assurance, or contract third parties to do so.

Soft assurance includes *self-assurance*, *guarantees*, or *pledges of assets*

Firms *"self-assure"* when governments accept their strong financial standing, favourable reputation, or general good faith in lieu of more concrete types of assurance. When firms self-assure, no assets are earmarked. If the firm goes bankrupt, government or other parties that suffered harm from the firm's environmental damage are considered creditors. The degree of compensation they receive will depend on the status they receive in insolvency proceedings and the size of the firm's liabilities relative to its remaining assets (Boyd, 2001; Munchmeyer et al., 2009; Sassoon, 2009; Gorton et al., 2010). The pending Supreme Court decision in the Redwater case will have important implications for whether Canadian governments attempting to recover environmental cleanup costs get a high-priority claim on firms' assets, or whether they are treated as an unsecured creditor.

In some cases—particularly for small or poorly capitalized firms—governments may accept a *parent company guarantee* in lieu of more concrete financial security. This approach is essentially self-assurance by a parent company instead of the firm itself.[xxiv] Where parent companies are large and diversified, this self-assurance is more dependable (for especially large firms, it may even be more secure than assurance provided by an insurance company). But because funds are not earmarked under this type of instrument, a risk remains that government will not receive compensation for the

subsidiary's environmental liabilities in the event both the parent and the subsidiary are bankrupt (Boyd, 2001; Munchmeyer et al., 2009; Sassoon, 2009; Gorton et al., 2010).

Finally, firms might also offer a *pledge of assets*, such as equipment, land, or natural resource reserves, as financial assurance. In this case, assets are earmarked for government, so it has a strong claim on them if the firm is bankrupted. However, because these assets can be illiquid and uncertain in value (their value might fluctuate depending on market conditions or depreciate over time), pledges of assets are still considered a soft type of assurance (Sassoon, 2009; Guzman, 2017).

Soft assurance provides weaker *deterrence* than hard assurance

Because firms do not actually have to put up funds, they have no additional incentive to limit environmental risk (i.e., their incentives are similar to firms that provide no financial assurance at all). However, deterrence can be stronger with parent company guarantees since the parent will have incentive to take interest in its subsidiary's risk. But problematically, in cases where a potential environmental harm would bankrupt the firm (or its parent), there is little economic incentive to limit the severity of the potential harm.

Soft assurance provides relatively weak *compensation*

When governments accept self-assurance and guarantees, they are betting that the firm will both exist and have the capacity to absorb an environmental liability should it arise. (In the event that the firm does not have this capacity, it will typically be too late to require harder types of financial assurance.) Similarly, a pledge of assets is a bet that the value of the assets will be enough to cover the costs of the liability. But the nature of bets is that they do not always pay off. As a result, compensation will not always be realized. And if the Supreme Court upholds the Alberta Court of Appeal's Redwater decision, compensation from this category of instruments will prove even more elusive.

Soft assurance provides strong support for *economic activity*

Critically, when firms provide soft assurance their capital is not tied up. This allows them to invest funds in their operations or in altogether new ventures. While guarantees and pledges of assets may in some cases affect firms' borrowing capacity or ability to raise equity, the effect is marginal compared to other available instruments.

4.3 THIRD-PARTY ASSURANCE

All the instruments that fall into this category involve the use of third-party intermediaries, whether banks, capital providers, insurers, or other institutions. In the event of a qualifying environmental liability, engaged third parties bear the costs, either directly or by reimbursing government or other affected parties. In exchange for this coverage, firms pay a regular premium. Ideally, these premiums would be "actuarially fair" — calibrated to equal the *expected value* of the provider's losses, plus a profit margin for the firm. The coverage that third parties provide is usually capped at a particular level (Boyd, 2001; Monti, 2002; Miller, 2005; Mackie, 2014).

An important strength of third-party assurance instruments relates to the market competition and innovation they can drive. In a well-functioning market, third parties will compete with each other on both the terms and the costs of the coverage they provide. This not only helps drive the cost of coverage toward an actuarially fair premium, it also encourages third parties to innovate by developing new products that pool and price risk in novel — and more cost-effective — ways (Arnold, 2017).

However, a competitive market requires a sufficient supply of willing third parties. Where third parties are unwilling to provide coverage (or only willing to provide it at a very high cost), the benefits of third-party assurance might not be available. Third parties' willingness to provide coverage can depend on the nature of the environmental risk, the specific circumstances of the firm, and market conditions. In particular, fat tails and uncertainty-driven market failures may affect the availability of coverage (Faure, 2007b; Mackie, 2014).[xxv]

Third-party assurance includes *bonds*, *insurance*, and *letters of credit*

In the case of *bonds*, capital providers are the typical third party.[8] In exchange for a regular premium, the providers pay out a sum (the bond's "principal") in the event of a qualifying environmental harm. Bonds can differ widely in their focus and scope (Boyd, 2001; Monti, 2002; Gorey et al., 2014):

- *Surety bonds* cover the risk of a firm being judgment proof and not being able to meet its obligations (e.g., reclamation of an industrial site). They can be general purpose or designed to specifically apply to a firm's potential environmental liabilities (Arnold, 2017; Gerard, 2000).
- *Environmental bonds* can apply to a wide range of potential environmental liabilities, but usually define specific events or harms that trigger payouts.

[8] Firms can also provide bonds themselves. For our purposes, this is a type of firm-level cash assurance.

- *Catastrophe bonds* are triggered when a given low-probability high-consequence event occurs (these are usually focused on extreme weather events).

Insurance similarly involves paying a regular premium in exchange for coverage — in this case, from an insurance company — in the event a qualifying environmental harm occurs. (For a discussion of what makes a risk "insurable," see Box 6). Most firms carry *liability insurance*, but such policies commonly exclude environmental liability. *Environmental insurance* policies provide coverage against a firm's potential environmental liabilities. They can vary widely in their scope (Boyd, 2001; Munchmeyer et al., 2009; Sassoon, 2009; Gorton et al., 2010):

Finally, *letters of credit* involve banks acting as the third-party intermediary. They function similarly to surety bonds but are provided by a bank instead of an insurer or capital provider (Boyd, 2001; Munchmeyer et al., 2009; Sassoon, 2009; Boomhower, 2014).

Third-party assurance offers limited *deterrence* incentives

Under third-party instruments, if an environmental harm occurs, firms do not bear the cost themselves. This inherently limits their economic incentive to reduce environmental risk.

But on the other hand, third parties' refusal to provide coverage for particularly high-risk operations can improve deterrence. In order

Box 6: Insurable versus non-insurable risk and the factors that can affect coverage

Insurance allows risk to be transferred from a private firm to a third party. For a risk to be insurable, it must meet two basic conditions:

- **The risk can be reliably estimated:** Insurers must be able to estimate the chance of an event occurring and the extent of the losses they are likely to incur under different levels of coverage.
- **Premiums can be set based on *specific* risk:** Insurers must be able to set premiums for each potential consumer or consumer class based on its risk relative to other policy holders (i.e., they must be able to "risk-differentiate" premiums).

A risk that does not meet either of these conditions is uninsurable (Freeman & Kunreuther, 1997).

For risks that meet the two conditions of insurability, insurance solutions offer benefits from *pooling* risk. For example, the cost of addressing contamination from a leaking underground fuel tank can be very high for an individual firm. Insurance can pool this risk across a number of firms, spreading the financial consequences of a leak across a broader group and lowering the costs of assuring against that risk.

Pooling works for insurers because of the *law of large numbers*. To return to our fuel tanks example, as the number of tanks covered by the insurer increases, its annual losses (in the form of paying out claims associated with leaking tanks) will tend toward the *expected value*. Therefore, as the number of policies grows, insurers can have more confidence in their assessment of risk across their portfolio, which can help drive down the costs of coverage.

But just because a risk is insurable does not mean coverage will be available in the market. Insurers must expect to be able to make a profit on the insurable risk — that is, revenues from premiums must cover the insurer's expected costs. Insurers' costs include not only the claims they expect to pay under the policy, but the cost of developing, marketing, and administering the insurance product, the cost of monitoring insured parties (where necessary), and general overhead costs. Where insurers do not expect to be able to charge premiums high enough to cover these costs, they will not provide coverage.

continued on following page

Box 6: Insurable versus non-insurable risk and the factors that can affect coverage *continued*

A number of factors can interfere with the two conditions for insurable risk and insurers' willingness to provide coverage:

- **Uncertainty** can interfere with insurers' ability to estimate risk or to risk-differentiate premiums. Where historical data on the risk is lacking, or where scientific information is not sufficient to inform a reliable estimate of it, insurers may be unwilling to provide coverage or only willing to provide it at a very high cost — an "incomplete information" market failure.
- **Adverse selection** refers to a situation where firms with the highest risks are the most likely to buy insurance, driving up premiums to the point where insurance coverage is not attractive for low-risk firms. As a result, insurance coverage might be provided only to a small subset of high-risk firms willing to pay high premiums or the market for insurance might entirely collapse. Adverse selection arises when firms have more information about their risks than insurers — an "information asymmetry" market failure.
- **Moral hazard** can also interfere with an insurer's willingness to provide coverage. Firms that possess insurance coverage might behave more carelessly than they would otherwise. If the insurer cannot induce the insured to undertake damage prevention activity (for example, through the use of deductibles or co-insurance), the costs of coverage may increase, or the availability of coverage may decrease (or both).
- **Correlated risk** is another area of concern for insurers. A falling oil price is an example of a correlated risk — if oil prices decline, the number of firms in the oil and gas sector that are declaring bankruptcy and abandoning wells might increase. The law of large numbers works when the events expected to lead to losses are independent of each other. Where environmental risks can be correlated across policies, insurers may be unwilling to provide coverage, or the cost of coverage may rise.
- **Market conditions** are an important additional factor. If the insurance market as a whole has recently experienced severe losses, it can affect the terms and availability of coverage. In addition, subjective drivers like the *perception* of risk can also affect market conditions, especially in areas where uncertainty is prevalent. Finally, the competitiveness of the market for a given type of insurance will also be a factor. Where the number of firms is limited, costs will tend to be higher (Faure, 2002; Faure, 2006; Kunreuther, 2015).

In some cases, insurers can overcome these barriers through specific design choices. For example, to mitigate moral hazard, they can improve monitoring and risk differentiation, introduce deductibles or co-payments (i.e., requiring the firm to cover a share of the losses) or cap available coverage. These types of design features may not fully resolve the issues above, but they can help to establish terms of coverage that work for both insurers and those they insure. Still, the presence of these factors will typically raise the cost of premiums.

Finally, the availability of *reinsurance* is an important factor affecting insurance coverage. Reinsurance is insurance for insurance companies. They use it to protect themselves against catastrophic losses. For example, insurers that provide home insurance will commonly reinsure against the risk of large losses due to a natural disaster that would trigger a large number of claims. Many of the same constraints and factors that affect insurance markets also affect reinsurance markets. Where reinsurance for a particular type of risk is not available or is excessively costly, front-line insurers may be unwilling to insure against it, or only willing to provide coverage at a high cost (Kunreuther, 2015).

to gain access to third-party coverage, firms will aim to reduce their projects' risk or put forward less risky projects. In some cases, third parties may even require risk-reduction measures as a condition of coverage. Box 7 discusses how this practice emerged in the context of fire insurance for New England factories in New England in the nineteenth century.

The design details of third-party approaches will affect deterrence incentives:

- Deterrence improves when the premiums that firms pay are *risk-differentiated*. This requires not only charging a higher premium for firms that present greater risk, but also rewarding firms with lower premiums when they introduce measures or protocols that demonstrably reduce risk, as well as raising them when risks rise (Freeman & Kunreuther, 1997; Faure, 2014; Dachis et al., 2017). The greater the risk differentiation, the greater the deterrence.
- Deterrence also improves when firms pay a *deductible* in the event of environmental harm — the larger the deductible, the larger the deterrence incentive it will provide. *Co-payment* (where firms pay a portion of the costs) has a similar effect (Freeman & Kunreuther, 1997).

Third-party assurance moderately supports *compensation*

Third-party instruments do not depend on the solvency of the firm. This supports compensation. However, the ultimate value of third-party coverage may be less than that stated in coverage policies for two reasons. For one, third parties may not be able to honour their obligation if they themselves are bankrupted.[xxvi] Second, and perhaps more significantly, agreements between firms and third parties might come with numerous exclusions, and provisions in the fine print might invalidate coverage in certain cases (Boyd, 2001; Faure, 2007b; Munchmeyer et al., 2009; Smith, 2012; Mackie, 2014; Kelly, 2016).[9]

Further, in cases where the cost of a potential harm could be catastrophic (i.e., where risk is fat-tailed), third parties may not be willing to provide coverage, or where they are, the premiums they charge may be excessively costly. As a result, the coverage they provide typically applies only up to a pre-defined maximum. If the costs of an environmental harm were to exceed this level, society will not receive full compensation.

Third-party assurance moderately supports *economic activity*

Under third-party assurance, firms need not bear large up-front costs. This frees up capital — an important benefit.

But third-party assurance does still have costs. Premium payments raise operating costs. And letters of credit in particular can constrain firms' borrowing capacity (since letters of credit are extended by banks).

Box 7: Attaching risk-reduction conditions to insurance

Insurance firms have a history of driving innovation and risk reduction across a number of sectors.

An early example dates back to 19th century New England. Insurance companies offered fire insurance to factories and took active steps to reduce risks at the factories they insured. They conducted factory inspections for both existing and prospective policy holders. Lower risks meant lower premiums, and customers whose risks were deemed excessive had their policies cancelled or were denied approval.

In addition, the insurance companies also established their own research departments to study fire risk and loss prevention. They disseminated their findings to industry associations and factory owners and pushed industry to adopt new practices. For example, to qualify for coverage, some policy holders were required to install sprinkler systems or purchase lanterns and fire hoses from manufacturers with pre-approved safety specifications. The adoption of these practices by industry reduced the overall risk of fire and created a market for coverage in risks that were previously uninsurable (Freeman & Kunreuther, 1997).

[9] For example, a firm may be required to adhere to specific safety practices. Where they can be shown to have not followed them in the lead-up to a qualifying environmental harm, the third party may not be liable. The firm itself would be liable; however, if it was judgment-proof, it may not be able to meet its obligations. As a result, regulators commonly review the terms of firms' third-party coverage.

Premiums can also fluctuate. Large environmental liabilities in the sector could affect the market for third-party coverage, and the cost of premiums could increase significantly.

Finally, involvement of a third party can increase costs in itself: premiums go not only toward providing coverage against a risk, but toward administrative costs and the profits of third parties. On the other hand, market competition among third parties can help drive down the cost of coverage.

4.4 SECTOR-LEVEL ASSURANCE

Sector-level financial-assurance instruments are similar to bonds, insurance, and letters of credit in that firms pay regular premiums in exchange for coverage. However, firms within the sector collectively provide the coverage rather than a third party such as a bank or an insurer.[10]

Sector-level instruments have an advantage in that they can leverage the sector's expertise in its own risks. Third parties may lack the technical knowledge to evaluate a firm or operation's risks, and as a result, be unable or unwilling to provide coverage against them (or unable to provide it cost-effectively). In contrast, the sector can tap its technical capacity and expertise to devise a financial-assurance instrument for its members that can cover fat-tailed risks that might be uninsurable in the private sector. On the other hand, the sector may lack expertise in how to pool risk and set premiums, though it can contract underwriters to provide support.

Sector-level assurance might also be able to better accommodate uncertainty. Third-party schemes commonly refuse coverage or significantly raise premiums in response to uncertainty. In contrast, sector-level schemes may be willing to provide coverage despite uncertain risks because the sector has a stake in ensuring available coverage. And where individual firms' *relative* risks are known, such schemes can still provide valuable risk differentiation (i.e., despite individual firms' *absolute* risks being uncertain) (Freeman & Kunreuther 1997; Faure, 2002; Smith, 2012; Dana & Wiseman, 2015).

However, sector-level schemes' willingness to accommodate uncertainty can also be double-edged. While it can increase the availability of coverage, it can also, in the event of a high-cost harm, undermine full compensation. For example, if firms across the sector became liable for a harm that had not been previously known or understood (as was the case, for example, with the health impacts of asbestos), a large number of firms could become bankrupt. This would undermine the certainty of payment for damages.

Sector-level assurance includes *industry funds* and *mutual insurance*

Industry funds involve building a dedicated fund that provides compensation to government or other affected parties (either directly or via the responsible firm) in the event of a qualifying environmental harm. Funds might be built up over time, funded with an initial endowment, or a combination.[11] Firms might pay into the fund on the basis of their production volume, revenues, or profits. Ideally, they would contribute based on their unique risk — paying an actuarially fair premium. The fund might hold cash or securities, but typically would not accept illiquid assets like equipment, land, or natural resource reserves (Sassoon, 2009; Gorey et al. 2014).

Alberta uses an industry fund to finance the cleanup of unremediated oil and gas wells in the province, in the event the owner goes bankrupt or cannot meet its obligation to remediate. It is funded by the province's Orphan Well Levy, which is imposed on oil and gas well license holders based on their share of total expected cleanup costs (Dachis et al., 2017). (The Orphan Well Fund's priority claim on insolvent firms' assets is what is at issue in the Redwater case).

Mutual insurance is similar to third-party insurance. The only distinction is that it is managed by the sector itself (or an underwriter that is contracted by the sector) and can be managed on a not-for-profit basis (Bennett, 1999; Kunreuther, 2015).

A special sub-type of mutual insurance is a *Protection and Indemnity (P&I) club*. P&I clubs are a type of sector-provided insurance scheme that covers members against risks that private insurers will not cover, or for which the costs of private insurance would be extremely high. P&I clubs act as a complement to third-party-provided insurance (Bennett, 1999; Mackie, 2014; Faure, 2016).

[10] For instruments in this category, we are assuming that participation in the sector would be universal (where universal *voluntary* participation was not possible, this would require government legislation or regulation). Where participation was only partial, risk could not be pooled as broadly, and adverse selection would be a concern. Both (or either) of these effects would undermine these instruments' cost-effectiveness.

[11] They can also be pay-as-you-go, with the sector contributing to a fund that covers the cost of harms that have *already happened*. However, because it provides compensation for harms ex-post, this would qualify as a liability rule, rather than a type of financial assurance (which covers *potential* harms).

Sector-level assurance provides limited *deterrence* incentives

Sector-level assurance has many of the same limitations as third-party assurance. Because firms will not bear the full cost of environmental harm that they cause, their economic incentive to limit environmental risk is limited. Again, risk-differentiated premiums and use of deductibles and co-payments can create stronger deterrence incentives (Bennett, 1999).

Deterrence incentives might also be strengthened under sector-level assurance by *mutual monitoring*. Since firms are indirectly liable for each other's environmental damage, they have a strong incentive to take an interest in one another's risk. Firms' technical knowledge around sector-specific risks and risk-mitigation options can make this monitoring more effective than that provided by a third-party intermediary (Bennett, 1999).

Sector-level assurance provides fairly strong *compensation*

Because sector-level assurance can potentially offer higher coverage caps than third-party assurance (i.e., by covering fat-tailed, non-insurable risks), it can offer stronger compensation. However, in the early stages of industry funds, collected funds may be insufficient to cover liabilities.

Correlated risk — i.e., the fact that risks from individual firms may not be independent of each other — may pose a challenge for compensation from sector-level assurance. For example, a commodity-price downturn is a risk faced by the sector as a whole. If a significant downturn occurs, the solvency of some or all of its members could be in jeopardy, and the financial assurance that they commonly provide will be less secure (i.e., the sector may no longer be able to pay premiums to the degree necessary to cover expected liabilities; indeed, as some firms go bankrupt, premiums for those that remain would rise, which could trigger further insolvency, undermining compensation even further). In contrast, banks' and insurance companies' risk will tend to be spread across a range of sectors, and therefore less correlated.

Sector-level assurance provides moderate support to *economic activity*

When firms contribute regular payments to an industry fund — or premiums to a mutual insurance scheme — they avoid large up-front capital outlays. Fewer capital constraints support economic activity. However, similar to third-party assurance, the regular payment of premiums raises operating costs.[xxvii]

4.5 PUBLIC ASSURANCE

Public assurance includes instruments that are administrated by government, or arms-length bodies appointed by government. It *excludes* government acting as a simple backstop (i.e., directly absorbing all or part of a firm's or a sector's environmental liability).

The instruments in this category are very similar to industry funds and mutual insurance. Firms pay regular premiums in exchange for coverage, and this coverage can potentially extend higher than that provided by third parties (i.e., to cover fat-tailed, non-insurable risk). And similar to sector-level schemes, public schemes may be more willing than third-party ones to provide coverage against uncertain risks.

However, the potential scope of public instruments is broader than sector-level instruments. If desired, public funds and public insurance can pool risk across sectors. That broader base for risk-pooling can lower costs even more than sector-level approaches.

Public schemes also have downsides. Politically driven decision-making can undermine performance (e.g., a government's desire to see a particular project go ahead could cause them to insist that the proponent's premiums be lowered). Operating public-assurance schemes at arms-length from government through separate, independent institutions can mitigate these concerns.

Public assurance includes *public funds* and *public insurance*

*Public fund*s are similar to industry funds. They are typically built up over time but might also receive an initial endowment. Firms might pay into the fund on the basis of production volume, revenues, or profits. As with industry funds, firms ideally contribute based on their risk's expected value (i.e., paying an actuarially fair premium). Alternatively, public funds might be funded out of royalties, or other taxes or fees paid by the sector.[xxviii]

The U.S. Environmental Protection Agency's Superfund is one well-known example of a public fund. Founded in 1980, Superfund pays for the remediation of contaminated industrial sites and, in some circumstances, emergency cleanup. Initially, 87 percent of Superfund's revenues came from new excise taxes on the petroleum and chemical industries, with smaller amounts from income taxes, interest payments, and cost recovery. The federal government initially conceived of Superfund as a self-sustaining model. However, remediation costs in Superfund's early years far exceeded its revenues, and the excise taxes that were intended to fund it in perpetuity expired in 1995. Superfund is now largely paid for with general revenues (i.e., it has since gone from being a public-assurance instrument to a simple backstop) (Hird, 1994; Anderson, 2017; USEPA, 2017).

Public insurance schemes mimic private insurance. They collect premiums from the firms to which they provide coverage. Ideally these premiums are risk-differentiated and actuarially fair. In some cases, public insurance schemes retain collected premiums in a dedicated fund, to cover expected future losses. In others, the premiums simply go into general revenue, with the government meeting any future losses as an expense at the time. Public insurance schemes are most common in areas where private insurers will not cover a given type of risk, offer coverage that is too expensive, or cap their coverage at too low of a ceiling (Freeman & Kunreuther, 1997).

Public assurance generally provides limited *deterrence*

Because firms will not bear the cost of environmental harm that they cause, they have limited economic incentives to limit environmental risk. However, risk-differentiated premiums or use of deductibles or co-payments can strengthen deterrence.

Public assurance provides fairly strong *compensation*

Public assurance is similar to third-party and sector-level assurance in terms of the strength of compensation it can provide.

Like industry funds, public funds might be unable to cover liabilities in full during their early stages, while they are still being built up. And like sector-level assurance, public assurance can be vulnerable to correlated risk in a sector threatening the sufficiency of collected premiums relative to expected liabilities (e.g., Alberta's Orphaned Well Association is essentially insolvent following a wave of bankruptcies in the sector, that increased the number of orphaned and abandoned wells it is responsible for — which the Redwater decision will exacerbate if it is not overturned by the Supreme Court). However, having public instruments pool risk *across* sectors may mitigate this effect.[12]

Critically, public-assurance instruments can provide compensation only to the degree they are funded by contributions from the private sector. Although public instruments are technically not limited in how much compensation they can provide (since they are backed by government), any compensation that originates with *government* contributions to the scheme (rather than contributions from the private sector) amounts to government paying itself. For our purposes, this does not count as compensation.

Public assurance provides moderate support for *economic activity*

Similar to industry funds and mutual insurance, public-assurance schemes allow firms to avoid large up-front capital outlays. They will, however, lead to larger operating costs, due to the payment of premiums. Premiums may be slightly lower as a result of the benefits of pooling risk across sectors.

4.6 A SUMMARY OF AVAILABLE FINANCIAL-ASSURANCE INSTRUMENTS

Table 3 provides an overview of available financial instruments, summarizing their implications for the three policy goals of deterrence, compensation and economic activity. As illustrated in the table, every instrument presents trade-offs. None is able to offer strong outcomes across all three policy goals.

[12] This type of risk pooling may not resolve all correlated risk, since some risks (e.g., disasters from impacts from climate change) might still be correlated *across* sectors.

Table 3: Summarizing financial assurance instruments and their implications for policy goals

		Effect on policy goals		
Category	**Instrument**	**Deterrence**	**Compensation**	**Economic activity**
Hard financial assurance from firms	Cash	Very strong. Firms have a powerful economic incentive to reduce their environmental risk	Very strong (however, it needs to be interest-bearing to offset inflation)	Very weak. Ties up available capital early in project life and can affect firms' borrowing capacity
	Securities		Strong. Value is fairly stable, although some types of security can fluctuate in value	
	Sinking funds	Moderate. Weak while the fund is being built up, but stronger later	Moderate. Funds may be insufficient while the fund is still being built up	Moderate. Less up-front costs than other types of firm-level hard assurance
	Trusts	Very strong (assuming that the trust's holdings are not built up over time)	Very strong. Assurance is certain in value and available in case of liability	Weak. Trusts' high costs for firms are partially offset by their tax benefits
Soft financial assurance from firms	Self-assurance	Very weak. Firms have no additional economic incentive to reduce risk	Very weak. Vulnerable to firms being judgment proof	Very strong. Does not tie up firms' available capital
	Parent company guarantees	Moderate. The parent company has an interest in limiting the subsidiary's risk	Weak. Parent companies are also vulnerable to being judgment proof	
	Pledges of assets	Very weak. Firms have no additional economic incentive to reduce risk	Moderate. Assets are earmarked for government, but value can fluctuate	Strong. Assets are earmarked, but any effects on borrowing capacity are small
Third-party assurance	Bonds	Limited. Firms do not directly bear the costs of their actions, which limits their incentive to reduce the probability or severity of a potential environmental harm. However, deterrence improves when firms pay risk-differentiated premiums, deductibles or co-payments	Moderate. Caps in the coverage provided can inhibit full compensation. And where the third-party can be judgment proof, compensation will not be certain	Moderate. No up-front costs for firms but raises operating costs. Costs can rise because premiums partly go toward third parties' profits, but market competition helps to offset this
	Insurance			
	Letters of credit			Moderate. No up-front costs, but raises operating costs and affects borrowing
Sector-level assurance	Industry funds	Limited for the same reasons as third-party assurance. However, firms' mutual monitoring incentives can strengthen deterrence	Moderate. Funds might be insufficient while a fund is still being built up	Moderate. No up-front costs for firms, but raises operating costs
	Mutual insurance		Strong. Coverage caps can be higher, but correlated risks are a concern	
Public assurance	Public funds	Limited for the same reasons as third-party assurance	Moderate. Funds might be insufficient while a fund is still being built up	Moderate for the same reasons as sector-level assurance. But pooling risk across sectors can potentially lower costs
	Public insurance		Very strong. Coverage caps can be higher; can pool risk across sectors	

5. FINANCIAL ASSURANCE IN PRACTICE: A CASE STUDY OF CANADA'S MINING SECTOR

Risk externalities play out differently across different sectors. This section explores risk externalities in the context of Canada's mining sector.

Mining is a major economic driver in Canada, contributing 3.2% of national GDP in 2015, worth $56 billion ($2007, chained) (Statistics Canada, 2017a). Mining provides essential inputs for other industries, including manufacturing, construction, energy production, and technology, many of which will play an important role in decarbonizing Canada's economy.

In Canada, mineral resources are in most cases owned by the Crown. Firms that wish to develop mineral resources require licences and permits and must pay royalties on the resources they extract (natural resources are provincial jurisdiction, so royalty regimes differ across the country).

In a sense, governments and mining firms are partners: Without government consent, firms would have no access to mineral resources to mine. Without mining firms, this mineral wealth would remain locked in the ground. Each benefits from the arrangement. This partnership commonly extends to Indigenous communities, who benefit in different ways from mining operations in Canada.

Because mining firms and governments share in the benefits of mining, there is a rationale for sharing in the risks as well.

This section discusses environmental risks and the possibility of social costs in Canada's mining sector. It explores key design features in mining-sector financial assurance and compares financial-assurance regimes in four provinces and one territory. Finally, it discusses best practices and key challenges in mining-sector financial assurance that emerge from this evaluation.

5.1 RISK EXTERNALITIES IN CANADA'S MINING SECTOR

Like many types of economic activity, mining carries environmental risks. And when environmental damage does occur, liability gaps mean society can bear the cost.

The mining sector presents environmental risks

In this report, we focus on two particular types of environmental risk in the mining sector: the risk associated with non-remediation of mines and the risk of mining disasters.[13] We discuss each in turn, below.

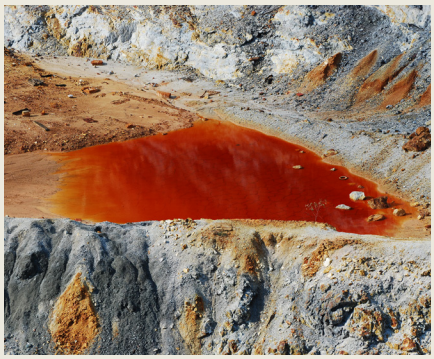
1. The **non-remediation of mines** poses significant risk to the environment. Mining activities and infrastructure create environmental disturbance both onsite and offsite. Impacts can include local contamination, altered hydrology, habitat loss and fragmentation, reduced biodiversity, and the loss of ecosystem services. When mines are not remediated at the end of their life, these impacts are more likely to become permanent (Lima et al., 2016).[14]

[13] *Remediation* is the act of removing contamination at a mine site. It is sometimes distinguished from *reclamation*, which involves returning land to its original (or an equivalent) use. Mine operators develop *closure plans* that outline how the site will be remediated and reclaimed at the end of the mine's life. The requirements around closure plans and standards and definitions for remediation and reclamation vary across jurisdictions. At times we use the term "reclamation" to include both remediation and reclamation.

[14] In this case study, we focus on existing and future mines. Mines that are already orphaned or abandoned by their operators (and that still require remediation) are outside this case study's scope. The environmental impacts of prospecting and mineral exploration are also out of scope.

Box 8: The environmental consequences of acid mine drainage (AMD)

When mining wastes with sulfur content come into contact with both water and air, they can oxidize and turn highly acidic, creating a substance called acid mine drainage (AMD). When AMD-contaminated water flows offsite, it can devastate surrounding land and water bodies (Hoffert, 1947; Akcil & Koldas, 2006).



AMD can be created both during and after a mine's operating life, but inactive and non-remediated mines pose the greatest risk. Once AMD forms, it becomes a perpetual risk to the surrounding environment, so avoiding it through proper site management and remediation is essential.

A well-known case of AMD in Canada is Britannia Beach in British Columbia. The Britannia Mine discharged billions of litres of AMD and several tonnes of metals into Howe Sound after its closure in 1974, with significant impacts on fish mortality and soil and water quality. The site remains a priority of the province's Crown contaminated sites program, which is now successfully treating AMD onsite (Barry et al., 2000; Wilson et al., 2005; Solomon, 2009; CNSC, 2015; Government of British Columbia, 2017b).

Other significant environmental risks from non-remediated mines include the leaching of heavy metals or other waste by-products into surrounding land and waterways. In particular, the risk of contamination from a substance called *acid mine drainage* (AMD) is a concern (See Box 8 for more detail) (Gorton et al. 2010).

The main driver of non-remediation is operators walking away from their obligations. Historically, this has been a significant problem in Canada: as many as 10,000 orphaned and abandoned mine sites exist across the country, with varying degrees of environmental risk (Cowan & MacKasey, 2006). Canada has seen significant progress in decreasing the number of new orphaned and abandoned sites and in ensuring that the majority of operators fulfil their closure obligations, but non-remediation still occurs.[xxix]

2. **Mining disasters** occur when the by-products from mining and mineral processing migrate offsite. These disasters can be gradual, with significant environmental damage accumulating over long periods of time (e.g., leaching, groundwater contamination, AMD). Or they can be one-time catastrophic events (e.g., tailings dam breaches).

   Some of the costliest mining disasters involve tailings — a specific mining waste stream and a major by-product of mineral processing. They are usually a "slurry" mix of rock, soil, water, processing reagents, and sometimes other materials such as heavy metals. The composition and toxicity of tailings varies widely from mine to mine (Fourie, 2009).

   Mines can generate millions of tonnes of tailings over their lifetimes. Tailings are often stored onsite indefinitely because treating or transporting them tends to be difficult or costly. While it is possible to "dry" tailings and store them in heaps or piles, this can be costly and can increase the risk of AMD. As a result, wet tailings stored in engineered ponds or dams are much more common (Environment Canada, 2012).

   The accidental or unauthorized release of tailings into the surrounding environment can have severe environmental consequences (Kossoff et al, 2014; UNEP, 2017).

   Box 9 discusses the consequences of a catastrophic tailings-dam breach in Canada: 2014's Mount Polley tailings spill.

A mine's environmental risk on these two fronts will always be case-specific. Risk depends on the composition of ore and tailings at the mine, the production and waste management processes used, and the sensitivity of the surrounding environment. The nature and severity of these risks can also change across a mine's lifecycle. And they can be affected by external factors such as climate change

Box 9: The environmental consequences of the Mount Polley tailings dam failure

In August 2014, a tailings dam ruptured at Imperial Metals' Mount Polley copper and gold mine in British Columbia, spilling 24 million cubic metres of tailings across the landscape and into nearby creeks and rivers. It is the largest tailings dam failure in Canadian history.

The spill had a significant impact on the region's physical landscape, depositing sediment layers as thick as 10 metres in Quesnel Lake, altering river flows, destroying habitat, and reducing water quality (Byrne et al., 2015; Schoenberger, 2016; Nikl et al., 2016).

While the tailings have exhibited low toxicity so far, the potential long-term effects on regional biodiversity and water quality are uncertain. Mount Polley's solid tailings were a mixture of metal contaminants, including arsenic, and selenium. Any soil contamination may persist for thousands of years, and large spring snow melts have the potential to remobilize the tailings. The company undertook significant remediation work following the spill to address this risk and restore habitat. BC's Ministry of Environment is overseeing impact assessment and remediation, and has a long-term monitoring plan in place (Byrne et al., 2015; Nikl et al., 2016; Kennedy et al., 2016; Government of British Columbia, 2018b).

(Ford et al., 2010; Conesa et al., 2006; Macklin et al., 2003; Miranda et al., 2003).

Liability gaps in the mining sector create the possibility of social costs

For several reasons, environmental risks from tailings spills or non-remediated mines might not be borne by mining firms. In particular, four of the five liability gaps discussed in Section 3 exist in Canada's mining sector.

Liability gap #1: No one can be held responsible

Society may bear the cost of environmental damage from mining if it is difficult to conclusively link contamination to a particular operation. For example, multiple studies have attributed contamination in the Athabasca River and nearby groundwater to oil-sands operations. Natural contamination is distinguishable from contamination attributable to oil-sands operations, but attributing contamination to specific operations remains a work in progress (Kelly et al., 2009; Frank et al., 2014).

Liability gap #2: Liability rules release firms from liability in certain circumstances

In Canada, mining firms are usually "absolutely liable" for environmental damage on their mine sites.[xxx] Therefore, this liability gap typically does not apply to environmental risks associated with the non-remediation of mine sites.

However, mining operations in Canada usually operate under strict liability for environmental damage that occurs offsite — they will not be liable where they can show they exercised due diligence.

Liability gap #3: Liability rules cap firms' liability

This liability gap does not apply to Canada's mining sector. Existing policies do not cap mining firms' liability for environmental damages.[xxxi]

Liability gap #4: Liability rules exclude some types of environmental damage

Whether environmental damage stems from non-remediation or from a mining disaster, some of the environmental damage might not register on a financial balance sheet. Such non-market costs might include water or soil contamination, biodiversity loss, or reduced ecosystem services. Where these costs are excluded from firms' liability, society will bear the cost.

The judgment in the landmark case of *R. v. United Keno Hill Mines (1980)* established that while damage and potential damage to the environment must be considered, the "difficulty of proving an ascertainable and quantifiable harm is present in most environmental cases." Further, the judge established that the size, wealth, and power of the offender should be taken into consideration, meaning certain types of damage might be excluded during sentencing for larger incidents (Olszynski & Boxall, 2014; Ingelson, 2014).

Liability gap #5: The responsible firm can be judgment proof

Mining firms' ability to be judgment proof is the most significant liability gap in the mining sector. It can arise at any point in a mine's lifecycle but is particularly significant for mines at or near the end of their operating life.

If the costs of a tailings spill cause a firm's liabilities to exceed its assets, it can declare bankruptcy or enter insolvency, leaving society to bear its environmental costs. Whether or not a spill will make a firm insolvent will depend not only on the severity of the spill and the extent of the firm's liability for it, but also on the mine's unique financial situation. This itself will be affected by factors such as commodity prices, interest rates, the size and quality of mine reserves, and the level of the firm's debt.[15]

Judgment-proof mining firms also create social costs when they leave behind non-remediated mines. Because the site presents a risk to the surrounding environment, governments are forced to undertake the remediation work themselves (or pay contractors to do so) to avoid environmental harms such as AMD. Further, if any environmental harm occurs before this remediation, society bears the full cost.

Importantly, firms might have an incentive to declare bankruptcy in advance of remediation. Most remediation occurs at the end of a mine's lifecycle when no further revenues will be generated. This can create perverse incentives for small firms to walk away from their sites before costly remediation and reclamation work begins, and for large firms to do the same by structuring their mining projects as independent subsidiaries.

To address this liability gap, governments in Canada commonly require financial assurance against the risk of non-remediation. Questions remain, however, as to the sufficiency of what they require. We explore specific jurisdictions' financial-assurance regimes in detail below.

The presence of liability gaps in the mining sector increases environmental risk

When mining firms know they will bear only a portion of the costs of a tailings spill or mine remediation (or none of them), they have less incentive to take steps that reduce the risk of environmental damage. For example, a firm might not pursue socially beneficial measures to reduce the risk of a tailings spill, perceiving them as uneconomic. Or it may manage its mine site in a way that does not strongly factor eventual remediation costs or the risk (and cost) of creating AMD. These choices increase the risk of environmental damage. And while mining firms' reputational risk does provide an incentive for them to manage these types of environmental risk, in the context of the judgment-proof liability gap, it may not be enough, especially for small firms with a single operation.

5.2 A SURVEY OF KEY DESIGN FEATURES IN MINING-SECTOR FINANCIAL ASSURANCE

In this section we explore mining-sector financial-assurance regimes in Yukon, British Columbia, Alberta, Ontario, and Quebec. We provide an overview of each jurisdiction's financial-assurance regime for the mining sector. And we assess key design features of the regimes in terms of how they affect the three policy goals of deterrence, compensation, and economic activity.

The design features we discuss for each jurisdiction are not exhaustive (for greater detail on the design of individual regimes, see the Annex). Rather, they provide a survey of available design choices and how they affect policy goals. We compare and evaluate the five jurisdictions' financial-assurance regimes overall in Section 5.3

[15] Larger firms with multiple operations are more likely to be able to weather a large spill-related liability than smaller firms. However, if a spill was costly enough, it could bankrupt even a larger, well-capitalized firm.

YK MINING SECTOR FINANCIAL ASSURANCE IN YUKON

Mining plays a large role in Yukon's economy relative to other Canadian jurisdictions. Commodity-price slumps illustrate the importance of the sector to the territory's economy. In 2013, the mining sector and ancillary services accounted for 23% of territorial GDP ($529 million $2007, chained), while in 2015 it accounted for 13% ($277 million, $2007, chained). Products of note in Yukon include gold, silver, and copper (YBS, 2016; NRCan, 2017a).

In 2003, as part of its devolution agreement with the federal government, Yukon assumed responsibility for managing its natural resources, including regulation of the mining sector (AANDC, 2013b).[xxxii] Its post-devolution financial-assurance regime has, to date, not been significantly applied. However, a mining boom is anticipated in the territory, so its regime will be increasingly tested.

Table 4 highlights key features of the financial-assurance regime in Yukon (for more details, see Annex 1). Mines must provide financial assurance against the full estimated cost of reclamation up front (i.e., before operations commence). For firms with a low perceived financial risk, the government may accept soft types of assurance, at its discretion. The territory does not require financial assurance for tailings spills or other potential environmental disasters in the sector.

Table 4: Design features of Yukon's financial-assurance regime for mining and their implications for policy goals

Financial-assurance regime feature	Deterrence	Compensation	Economic activity
Firms must provide financial assurance against the risk of non-remediation both in full and up front, in line with existing site disturbance.	Positive*	Positive	Negative
When the Department of Energy, Mines and Resources (EMR) determines that a firm presents a low financial risk, it will at times accept soft financial assurance (usually a pledge of assets) from the firm in place of hard assurance.	Negative	Negative	Positive
The regime requires assurance levels based on *existing* (rather than eventual) land disturbance, and progressively returns financial assurance to firms as they reclaim. This helps differentiate operations based on actual environmental risk and avoids needlessly tying up firm capital. Monitoring must demonstrate that reclamation activities were successful before financial assurance is returned.	Positive	Little to no direct impact	Positive
Based on a mine's current state and its closure plan, the regime estimates a mine's expected reclamation cost at present, two years into the future, and at the end of its life. EMR must reapprove reclamation plans every two years to ensure they are holding an appropriate amount of financial assurance.	Little to no direct impact	Positive	Little to no direct impact
Financial-assurance requirements assume that all remediation and reclamation will be undertaken by a third party, including mobilization of equipment. This helps to ensure that government has sufficient financial assurance to cover the expense of hiring a contractor to reclaim the site in the event the firm goes bankrupt.	Positive	Positive	Negative
The regime includes the estimated cost of long-term monitoring and perpetual care in required financial assurance (these costs are incorporated based on their Net Present Value, using a 3% social discount rate). This helps ensure sufficient funds are available for expected *post-reclamation* costs.	Positive	Positive	Negative

Table 4: Design features of Yukon's financial-assurance regime for mining and their implications for policy goals *continued*

Financial-assurance regime feature	Deterrence	Compensation	Economic activity
The territory's *Quartz Act* requires government to avoid situations of over-bonding (i.e., asking for financial assurance against the same environmental risks more than once), which would needlessly add costs for firms.	Little to no direct impact	Little to no direct impact	Positive
Financial assurance does not cover potential disasters (e.g., a tailings spill).	Negative	Negative	Positive

Note: This analysis shows the trade-offs across goals for key individual design features in the regime. It does not attempt to weigh the three policy goals against each other in any way. Nor does it assess the overall performance of the regime.

* The deterrent effect will vary depending on the type of financial assurance provided. The territory accepts cash, letters of credit, bank letters of guarantee, surety bonds, insurance, and security held in trust. Third-party assurance such as surety bonds, letters of credit, and insurance will have less of a deterrent effect than cash or security provided by firms themselves.

BC MINING-SECTOR FINANCIAL ASSURANCE IN BRITISH COLUMBIA

In absolute terms, the mining sector in BC is one of the country's largest. In 2016, mining and quarrying contributed $4.1 billion to BC's economy, or 1.9% of GDP ($2007, chained). Coal and copper are the largest sub-sectors: they accounted for 44% and 35% of all mineral production by value in 2015, respectively. Other minerals of note include gold, silver, and industrial metals (Clarke, 2016; Government of British Columbia, 2017a; NRCan, 2017a).

Table 5 highlights key features in BC's financial-assurance regime (for more details, see Annex 1). The province's Chief Inspector of Mines has broad authority and discretion when it comes to financial assurance. But in practice, the government has not required stringent assurance. As a result, the province does not hold sufficient financial assurance to cover its potential reclamation liabilities. The government is currently evaluating aspects of its mining regulatory regime, including the use of financial assurance (AGBC, 2016; EY, 2017).

Table 5: Design features of British Columbia's financial-assurance regime for mining and their implications for policy goals

Financial-assurance regime feature	Deterrence	Compensation	Economic activity
The Chief Inspector has the authority — should they choose to exercise it — to make financial assurance stringent and broadly scoped (e.g., it can include costs related to long-term monitoring, perpetual care, or even the protection of watercourses or cultural heritage resources). In addition, the Ministry of Environment can request additional assurance if there is a high risk of offsite contamination.	Positive	Positive	Negative
In practice, the stringency of financial assurance in the regime can be limited (it is commonly phased in over time).	Negative	Negative	Positive
The province has been working to increase the assurance it holds from mining firms. It currently holds $1 billion in financial assurance, a fivefold increase over the last ten years. And it is scheduled to collect an additional $846 million in financial assurance over the next eight years.	Positive	Positive	Negative
Firms submit annual reclamation reports, as well as a schedule of anticipated changes to their long-term reclamation liabilities. This helps government remain up-to-date on the amount of reclamation work that remains, and thereby, to ensure that required financial assurance is adequate and reflects conditions on the ground.	Little to no direct impact	Positive	Negative
Cost estimates provided by firms in their closure plans (which inform how much financial assurance the province requires) are not standardized and, according to BC's Auditor General, the Ministry lacks the expertise to verify their estimates (AGBC, 2016).	Little to no direct impact	Negative	Little to no direct impact
BC's Auditor General has found that monitoring and enforcement in the sector can be lacking (AGBC, 2016).	Negative	Negative	Positive
Financial assurance does not cover potential disasters (e.g., a tailings spill).	Negative	Negative	Positive

Note: This analysis shows the trade-offs across goals for key individual design features in the regime. It does not attempt to weigh the three policy goals against each other in any way. Nor does it assess the overall performance of the regime.

AB MINING SECTOR FINANCIAL ASSURANCE IN ALBERTA

Mining in Alberta includes oil, coal, sand, and gravel, and a small volume of metals. Hydrocarbons in particular are vital to Alberta's economy. Hydrocarbon industries accounted for $56 billion in revenues in 2016 — 17% of provincial GDP (2016 dollars) (NRCan, 2017a; Government of Alberta, 2018).

We focus here on Alberta's Mine Financial Security Program (MFSP), which governs financial-assurance requirements for the reclamation of oil-sands and coal-mining sites in Alberta and is administered by the Alberta Energy Regulator (AER). From a reclamation perspective, oil sands and coal are distinct from conventional oil and gas because they produce tailings. With an estimated reclamation cost of $27 billion, tailings from oil sands represent the province's largest environmental liability — up from $21 billion in 2015 (AGA, 2015; Orland, 2018).

Table 6 highlights key features of the MFSP, which requires an initial base amount of financial assurance from firms. Firms that do not have a certain ratio of assets and liabilities are asked to provide additional funds. The AER has structured the MFSP such that it will hold full financial assurance against a mine's estimated reclamation cost five years before the end of the mine's life. It also requires additional assurance when companies defer on their reclamation obligations. The AER does not require assurance against potential disasters.

An important complicating factor for oil-sands mines is that reclamation technologies to deal with their tailings are still unproven (AER, 2017d). Much of the sector's reclamation work is in its early stages, and only two firms — Suncor and Canadian Natural Resources Limited — have submitted tailings management plans to the AER.

Table 6: Design features of Alberta's financial-assurance regime for mining and their implications for policy goals

Financial-assurance regime feature	Deterrence	Compensation	Economic activity
The MFSP (under the Operating Life Deposit program) asks for full financial assurance against reclamation costs only as a mine nears the end of its life. Compared to up-front assurance requirements, this creates a lighter financial burden on firms during mines' early and mid-life. However, it also increases the public's exposure to potential social costs in the interim.	Negative	Negative	Positive
The MFSP (under the Base Security Deposit program) requires a set amount of financial assurance based on project type. Projects that present greater environmental risks are not required to submit additional assurance.	Negative	Negative	Positive
The MFSP (under the Asset Factor Safety Deposit program) aims to differentiate firms' financial-assurance requirements based on their estimated financial risk — more financially risky firms face more stringent financial-assurance requirements.	Positive	Positive	Negative
Annual reports that firms submit under the Asset Factor Safety Deposit program detailing their asset and liability estimates do not require supporting documentation. In addition, the methodologies that the program uses allow firms to include both proven *and* probable reserves in their assets, which may overstate their financial health.	Negative	Negative	Positive

Table 6: Design features of Alberta's financial-assurance regime for mining and their implications for policy goals *continued*

Financial-assurance regime feature	Deterrence	Compensation	Economic activity
Technological uncertainty in oil-sands remediation is not reflected in the MFSP's financial-assurance requirements. The remediation technique of "water capping" is still unproven at scale.[16] If water capping is not effective, then other, more costly approaches may be required. However, financial assurance is calculated based on the assumption that water capping will prove a successful reclamation method at scale.	Negative	Negative	Positive
The regime faces challenges around the sufficiency of monitoring, closure plan updating, enforcement, and overall transparency (AGA, 2015).	Negative	Negative	Positive
Financial assurance does not cover potential disasters (e.g., a tailings spill).	Negative	Negative	Positive

Note: This analysis shows the trade-offs across goals for key individual design features in the regime. It does not attempt to weigh the three policy goals against each other in any way. Nor does it assess the overall performance of the regime.

[16] Water capping is a process where tailings are treated and then "capped" with a layer of water, creating an artificial water body such as a wetland or a lake. It has been shown to be effective in a laboratory setting but is yet to be proven at scale.

ON MINING SECTOR FINANCIAL ASSURANCE IN ONTARIO

Mining plays a smaller role in Ontario's economy today than it did historically. The sector was responsible for 1.2% of provincial GDP in 2016 — $7.6 billion ($2007, chained). While the province is working to expand the role of mining in its economy, the sector has not grown in absolute terms over the last 10 years. Products of note in the province include gold, silver, nickel, copper, zinc, and platinum group metals (OMA, 2012; Government of Ontario, 2016; Government of Ontario, 2017a; NRCan, 2017a).

Table 7 highlights key features of the financial-assurance regime for mining in Ontario. The province takes a two-track approach to financial assurance. Firms that can pass a corporate financial test (based on the assessments of ratings agencies) are permitted to self-assure against the costs of reclamation. Firms that cannot face more stringent requirements: they are asked to provide full, hard, and timely financial assurance. The province does not require financial assurance against potential disasters like tailings spills.

Table 7: Design features of Ontario's financial-assurance regime for mining and their implications for policy goals

Financial-assurance regime feature	Deterrence	Compensation	Economic activity
Ontario's two-track financial-assurance treatment for mining firms permits those with lower financial risk to face less stringent financial-assurance requirements.	Negative	Negative	Positive
Firms that do not pass the financial test receive stringent treatment: they must provide up-front, hard assurance, in line with existing site disturbance.	Positive*	Positive	Negative
However, at the government's discretion, softer types of assurance can also be accepted. These can include a pledge of assets, a sinking fund, or per-tonne royalties.	Negative	Negative	Positive
Reclamation liability estimates are based on the cost of a third party completing the firm's approved closure plan (rather than the firm itself). This helps to ensure that government has sufficient financial assurance to cover the expense of hiring a contractor to reclaim the site in the event the firm goes bankrupt.	Positive	Positive	Negative
The regime includes the estimated cost of long-term monitoring and perpetual care in financial assurance (these costs are incorporated into financial assurance based on their Net Present Value, using a 3% social discount rate). This helps ensure sufficient funds are available for expected *post-reclamation* costs.	Positive	Positive	Negative
Ontario's Auditor General flagged the timely review and updating of closure plans and financial assurance as an issue. The department has dedicated resources to addressing the issue, including the development of benchmarking guidelines for closure plans (OAGO, 2015).	Positive	Positive	Negative
Financial assurance does not cover potential disasters (e.g., a tailings spill).	Negative	Negative	Positive

Note: This analysis shows the trade-offs across goals for key individual design features in the regime. It does not attempt to weigh the three policy goals against each other in any way. Nor does it assess the overall performance of the regime.

* The deterrent effect will vary depending on the type of financial assurance provided. The province accepts cash, letters of credit, reclamation trusts, and insurance bonds. Third-party assurance such as letters of credit and insurance will have less of a deterrent effect than cash or trusts provided by firms themselves.

QC MINING SECTOR FINANCIAL ASSURANCE IN QUEBEC

Quebec is undertaking significant efforts to expand the size of its mining sector. The sector contributed $4.6 billion to the economy in 2016 — 1.3% of provincial GDP ($2007, chained). Minerals of note include gold, silver, nickel, zinc, and copper (Gouvernement du Québec, 2016; NRCan, 2017a; Statistics Canada, 2017b).

Table 8 highlights key features of Quebec's financial-assurance regime for mining. In 2013, Quebec overhauled its *Mining Act* in response to recommendations from the province's Auditor General. Part of this reform included substantial changes to how government approaches mining-sector financial assurance. Quebec now strictly requires hard assurance. Assurance is required in full (i.e., covering the entire estimated cost of reclamation) within two years of a mine commencing operations. The province does not require financial assurance against the risk of tailings spills. It does, however, collect additional charges based on the volume of waste that a mine generates.[17]

Table 8: Design features of Quebec's financial-assurance regime for mining and their implications for policy goals

Financial-assurance regime feature	Deterrence	Compensation	Economic activity
Quebec's regime is stringent, requiring hard, full and timely financial assurance from all firms.	Positive*	Positive	Negative
Quebec's 2013 overhaul of its *Mining Act* (which was much broader in scope than the changes to the financial assurance regime we are examining) has helped to update and improve the coherence of the regulatory environment.	Little to no direct impact	Little to no direct impact	Positive
Collaboration between the province's mining and environmental ministries (MERN [Ministère de l'Énergie et des Ressources naturelles] and MDDELCC [Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques]) to review and approve the mines' closure plans helps government ensure that those plans (and thereby, the financial assurance that government requires against reclamation costs) more accurately reflect mines' unique environmental risks.	Positive	Positive	Negative
The province makes mines' closure plans public at the assessment and permitting stage. This provides external stakeholders the opportunity to vet firms' plans and cost estimates, helping create more robust cost estimates and better-informed financial assurance requirements.	Little to no direct impact	Positive	Little to no direct impact
Mines must update closure plans every five years. This frequent updating raises compliance costs for firms, but it also decreases the likelihood of MERN holding insufficient financial assurance to address expected reclamation costs (i.e., since a site's closure needs may have changed).	Little to no direct impact	Positive	Negative
MERN has discretion to require more frequent updating of closure plans from specific mining projects. When there are significant changes to mining activities, companies *must* resubmit their closure plans.	Little to no direct impact	Positive	Negative
Financial assurance does not cover potential disasters (e.g., a tailings spill).	Negative	Negative	Positive

Note: This analysis shows the trade-offs across goals for key individual design features in the regime. It does not attempt to weigh the three policy goals against each other in any way. Nor does it assess the overall performance of the regime.

* The deterrent effect will vary depending on the type of financial assurance provided. The province accepts cheques, government guaranteed securities, investment certificates, surety bonds, letters of credit, immovable hypothecs, environmental trusts, and insurance. Third-party assurance such as surety bonds, letters of credit, and insurance will have less of a deterrent effect than cash or security provided by firms themselves.

[17] As of January 2017, Québec charges a $0.21 per-tonne royalty for inert mine tailings from ore treatment, pyrometallurgy operations and surface mineral substances. In addition, Québec also charges for any tailings storage facilities on Crown land — an annual fee of $99/hectare (Gouvernement du Québec, 2017a).

5.3 COMPARING MINING-SECTOR FINANCIAL-ASSURANCE REGIMES IN CANADA

In this section, we compare the five jurisdictions' overall approach to mining-sector financial assurance. The assessments we present here are based on the analysis presented in Section 5.2 as well as the inventory of regime design features provided in Annex A.

Overall, Canadian jurisdictions' financial-assurance regimes for mining are more similar than different. But they also diverge in key ways. These similarities and differences highlight important lessons for well-designed financial-assurance policies.[18]

Each regime offers its own balance across the three goals. Some regimes' trade-offs across the three goals are intentional — the result of deliberate policy decisions. Others are unintentional — the result of a policy's legacy or particular policy-design features. And still others, particularly as they relate to offsite environmental damage or disasters, stem from a narrow use of financial assurance in the sector.

YK Financial assurance in Yukon appears stringent, but is untested

Yukon's financial-assurance policy for the mining sector appears to be stringent — firms must provide financial assurance against the risk of non-remediation both in full and up front. In addition, the regime's robust provisions around site monitoring, closure, and post-closure cost estimation help to ensure that the government is requiring sufficient financial assurance from mining firms. These features help to ensure strong deterrence and compensation.

However, the limited application of the territory's financial-assurance regime to date means there are open questions about how it will work in practice. In particular, it is not clear how the Department of Energy, Mines and Resources will use its authority to accept soft assurance for mines it deems to present a low financial risk.

BC Financial assurance in British Columbia is stronger in theory than in practice

In practice, the British Columbia Chief Inspector of Mines' broad authorities for financial assurance are used to support economic activity more than compensation and deterrence. The government's recent efforts to increase the amount of financial assurance it holds have helped to mitigate this. However, the province still holds only $1 billion in financial assurance against a $2.1 billion cleanup liability.

The low stringency of British Columbia's regime is largely due to the phase-in of financial-assurance requirements. Phasing financial assurance in helps keep projects' costs low during early, capital-intensive phases, which supports economic activity. By phasing in assurance, the province effectively accepts a mine's still-substantial reserves as a form of *soft* assurance. However, doing so provides weak deterrence incentives for firms during the early phases of an operation. Because the value of reserves can fluctuate, it also undermines compensation.

AB Financial assurance in Alberta facilitates economic activity but risks creating social costs

Many of the design features of Alberta's MFSP support economic activity at the expense of deterrence and compensation. Financial-assurance requirements become significant only late is a project's operating life. Further, the financial assurance required from firms assumes the efficacy of a still-unproven remediation technology.

These choices limit the financial-assurance burden on individual firms, supporting economic activity in the sector. But they also lead to weaker deterrence and compensation.

The MFSP attempts to partially mitigate this by increasing requirements for financially risky firms. However, the details of this program and its requirements provide a high bar for defining significant financial risk, and no firm has yet had to provide financial assurance under it.

ON Financial assurance in Ontario differentiates firms based on financial risk

Ontario's two-track financial-assurance system attempts to balance policy goals by treating mining firms differently based on their financial risk. Firms that the government deems financially healthy (and to therefore present a lesser risk of defaulting on their remediation obligations) are able to provide soft assurance, while those that are not must provide up-front and hard assurance.[19]

This differentiation helps support deterrence and compensation where it is most needed, but at the same time facilitates economic activity on the part of well-capitalized firms.[xxxiii] The regime's provisions around third-party costing and requiring financial

[18] We do not assess the overall approach of all jurisdictions to managing *risk externalities*. Financial assurance is one component of a larger policy package dealing with risk externalities. Assessing this larger package would require an integrated review of *financial assurance*, the *regulations* jurisdictions use to manage environmental risk in the mining sector (including technical specifications, health and safety standards), and their *liability rules* (both general and mining-specific). Our assessment here focuses strictly on the five jurisdictions' financial-assurance policies.

[19] At the government's discretion, softer types of assurance — a pledge of assets, a sinking fund, or per-tonne royalties — can also be accepted from firms that do not pass the financial test. Currently, only one firm receives this treatment.

assurance for long-term and perpetual costs also help support deterrence and compensation — albeit at the expense of greater economic activity.

QC Financial assurance in Quebec is the most stringent of the five jurisdictions considered

Mining firms in Quebec must provide hard, full, and timely financial assurance against the risk of non-remediation. The system makes no distinction between firms with low and high financial risk.

This stringent policy approach provides strong deterrence and compensation but also weakens economic activity. However, this effect has been partially offset by the improved coherence of the province's regulatory regime for mining, following its 2013 *Mining Act* overhaul.

Like all the other jurisdictions assessed, Quebec does not require financial assurance against the risk of mining disasters. While this choice supports economic activity, it leaves a large and important gap in the financial-assurance regime's support for deterrence and compensation policy goals.

5.4 BEST PRACTICES IN FINANCIAL-ASSURANCE REGIMES FOR MINING

What should we take away from this review of provincial and territorial approaches to financial assurance for the mining sector? Different approaches have different trade-offs. Yet clear examples of successes also emerge. We highlight three.

Using financial assurance to manage risks from abandoned mines can reduce environmental risk and limit social costs

A common thread runs across all five of the jurisdictions that we explore: Financial-assurance policies have become an essential policy tool in managing the risk of non-remediation. Governments have moved toward requiring financial assurance to avoid creating costly environmental liabilities such as Giant Mine in the Northwest Territories. This helps ensure that mining firms bear the cost of remediation and gives them incentive to limit the environmental damage done to mine sites. In short, provinces and territories are already making progress.

Risk differentiation can lower the costs of financial-assurance policies while supporting deterrence

In applying financial assurance, many of the jurisdictions we examine differentiate operations according to risk.

Ontario, for example, requires different levels of financial assurance depending on firms' *financial* risk. Firms that are more financially vulnerable — and thus more likely to declare bankruptcy — must provide stronger assurance.

Yukon differentiates financial assurance based on *environmental* risk. It requires assurance based on existing (rather than eventual) land disturbance at a mine and returns it as land is progressively reclaimed. This keeps financial assurance in line with the environmental risk presented by specific mine sites and operations.

Risk differentiation can help jurisdictions realize their policy goals. It provides *deterrence*: Firms that can reduce risk will face less stringent financial-assurance requirements, creating a powerful incentive. And risk differentiation can support *economic activity*: firms with low or manageable risks will face a lower financial-assurance burden, freeing up capital that they can invest in their operations.

Policy-makers can use risk differentiation in ways that either strengthen or weaken *compensation*. Depending on their policy goals, jurisdictions can use risk differentiation to decrease requirements for less risky firms, or to increase them for risky ones.

Financial assurance works best when it is part of a coherent policy package

In all jurisdictions, financial assurance is only one part of the mining-policy landscape. Laws, regulations, and the conditions of mine licenses provide liability rules for the sector. Mines follow local safety and environmental regulations. And they pay taxes, royalties, and fees.

When the larger policy package (including financial assurance) operates cohesively and efficiently and offers regulatory certainty, it supports economic activity. While we do not assess jurisdictions' overall mining-policy packages, Quebec stands out as a jurisdiction that has designed financial assurance with the bigger picture in mind. Its recent reforms addressed the larger regulatory environment for mining. It clarified environmental assessment and consultation requirements, modified the tax and royalty regime, and instituted new charges on mining waste (Amyot et al., 2013).

Of course, greater regulatory clarity is not the only reason Quebec remains an attractive province for mining investment; its royalty regime is less stringent than that of other jurisdictions. The latest regulatory reforms increased royalty rates, but not to the extent the government proposed initially (Paradis & Gagnon, 2013). Still, by coordinating increases to financial-assurance stringency with broader mining-policy reform, Quebec was able to reduce the overall impact of its financial-assurance reforms on economic activity.[xxxiv]

5.5 KEY CHALLENGES FOR FINANCIAL ASSURANCE IN THE MINING SECTOR

Despite some successes, provinces and territories' approaches to financial assurance in the mining sector also have limitations. Addressing these challenges through policy changes may present opportunities to better manage trade-offs between deterrence, compensation, and economic activity.

Financial-assurance policy is not always in line with stated goals

Policy-makers can and should arrive at a balance among deterrence, compensation, and economic activity goals according to their own priorities and the context of their jurisdiction. In some cases, however, jurisdictions have not explicitly and transparently defined their policy goals. And in others, their financial-assurance regimes are at odds with their stated goals.

For example, British Columbia has explicitly articulated an intent to make polluters pay. According to the province, British Columbia's *Environmental Management Act* (EMA) ensures that "those that pollute are held responsible under a polluter pay principle, so the taxpayer does not have to assume these cleanup costs" (Government of British Columbia, 2017d). Courts in the province consider polluter-pay to be a "foundational principle" of the EMA. And the Environmental Emergency Program establishes polluter-pay as one of its guiding principles (Government of British Columbia, 2010; Bennett Jones, 2016; Government of British Columbia, 2018a).

But the low stringency of British Columbia's financial-assurance regime for mining is to some extent at odds with the polluter-pay principle. Due to the regime's low stringency, mining firms in the province will not necessarily bear the cost of contamination they cause. For example, the province commonly phases assurance in over the life of a mine. This phase-in increases the risk of large social costs — if a firm becomes insolvent early in a mine's operating life, financial assurance will not cover the cost of the site's cleanup, leaving taxpayers to bear the cost.[xxxv] Weak monitoring and enforcement also act to limit the stringency of financial assurance in the province. When a site's estimated remediation costs grow, the financial assurance required by government does not necessarily grow along with it, or may only grow belatedly (AGBC, 2016).

The relatively low stringency in BC's system is a form of public-private risk sharing. The mining sector involves extracting publicly owned resources, so some sharing of risk between public and private interests may be justifiable. However, it also is inconsistent with the province's stated policy goals.

Policy-makers can use financial assurance to align their risk-externality policies with their stated goals. For example, British Columbia could opt to simply make existing firm-level financial assurance more stringent to ensure that the polluter will pay. Doing so would strengthen the deterrence and compensation its regime provides.

Some estimates of reclamation costs fail to comprehensively weigh risk, making social costs more likely

All jurisdictions we explore require financial assurance from firms on the basis of mines' estimated reclamation cost. In most cases, those costs are estimated based on a mine's approved closure plan.

But mine remediation and reclamation does not always go according to closure plans. For example, the federal government assumed responsibility for the Colomac mine in the Northwest Territories after its owner went bankrupt in 1999. As a result of non-compliance by the operator (including hydrocarbon spills, tailings spills, and inadequately designed tailings retention), cleanup costs massively exceeded those estimated in the closure plan (OAGC, 2002; AANDC, 2012).[20]

In other words, estimating costs based on closure plans does not necessarily account for the full range of risk factors — for example, flaws in design and engineering, unforeseen environmental impacts, or non-compliance. These factors, while low-probability, can nonetheless lead to very large reclamation costs. When policy-makers fail to fully consider the risk from these factors, they significantly underestimate the *expected value* of mines' reclamation costs. As a result, society bears more risk.

Basing financial assurance on estimates of expected value that consider risk, especially "fat-tailed" risk, improves the extent to which the financial assurance that governments require can — on average — cover the costs of mines' closure. Doing so would help to improve both deterrence and compensation outcomes in the mining sector.

Existing systems mostly do not address uncertainty (i.e., risk that they cannot reliably estimate)

A number of important uncertainties affect the mining sector. Potential environmental damage is hard to estimate given the complexity of ecosystems that might be affected. Climate change's effect on the risk of tailings dam failures and AMD is difficult to accurately predict. The long-term financial viability of a given firm

[20] Costs were approximately $70 million. Only $1.5 million in financial assurance was provided by the operator. Mine closure and financial assurance policies for the Northwest Territories and Nunavut were not yet fully developed when the operator walked away in the 1990s (OAGC, 2002).

or mining sub-sector is often unclear. And the ultimate efficacy and costs of remediation technologies can be uncertain.

These uncertainties make it difficult for policy-makers to know how much financial assurance they should require. How can they risk-weight financial assurance when they cannot estimate risk?

Uncertainty may be particularly challenging in the Alberta oil sands, for example. Large-scale remediation is still in its infancy, and the efficacy of the proposed technology — water capping — is still uncertain (AER, 2017d). If an oil-sands mine was judgment proof and water capping proved ineffective, required financial assurance might prove insufficient for covering remediation costs, leading to large social costs.[21] In addition, the long timeframe involved with water capping means that the adequacy of required financial assurance might not be known for decades. By the time that the uncertainty lifts, it may be too late to require greater financial assurance from firms whose operations are no longer active.[xxxvi]

Uncertainty premiums or contingencies may be one approach to manage uncertainty and protect the public against social costs. For example, Saskatchewan addresses the risk of unforeseen events by applying a contingency of 10 to 20% to estimates of a site's future monitoring and maintenance costs (NOAMI, 2010). Uncertainty premiums can be especially valuable in cases where costs could potentially be severe — that is, where there is reason to believe that the underlying, difficult-to-estimate risk has a fat tail.

The absence of financial-assurance policy for disasters exacerbates risks and potential social costs

None of the jurisdictions we considered apply financial assurance to the risk of tailing spills or other disasters. Rather, financial assurance is focused exclusively on environmental risks relating to remediation — an *expected* event. By not applying financial assurance to the environmental risk from *probabilistic* events like tailings spills, provinces may worsen the risk of a disaster occurring and expose themselves to possible large-scale social costs.

If a Mount Polley–scale tailings spill were to occur in any Canadian province or territory, massive social costs could result if the mining firm was financially marginal and became judgment proof as a result of the spill.[22]

The total absence of financial assurance for mining disasters means provinces are relying only on their regulations and liability rules to help them avoid social costs. This leaves them highly vulnerable to the judgment proof liability gap.

Governments could apply various financial-assurance instruments against the risk of a mining disaster, each with different trade-offs:

- Firm-level financial assurance would provide strong deterrence incentives. But it would come at a high cost to individual firms and could significantly dampen economic activity.
- Third-party, sector-level, or public-assurance instruments offer an alternative way to protect the public from disaster-related social costs. Such instruments have a smaller deterrence effect than hard financial assurance from firms. But, by *pooling* risk, they can support compensation while keeping firms' costs low — limiting impacts on economic activity.

To leverage the different strengths of firm-level and risk-pooling instruments, policy-makers can potentially combine them using a "tiered" approach. We return to this issue in Section 7.

[21] This risk is especially significant if a sector-level downturn leads to a wave of abandonment, similar to what has occurred with orphaned oil and gas wells in Alberta and Saskatchewan following the low oil prices of 2014–2016.

[22] As Bowker and Chambers (2015) point out, tailings spills are *more* likely to occur at financially marginal mines, since they often do not have the means to invest in the same degree of safety measures as financially healthier firms. Notably, the Mount Polley mining corporation was not bankrupted by its tailings spill: The firm bore a significant amount of costs responding to the spill. Had it been judgment proof, a large portion of these costs could have fallen to the public (Allan, 2016).

6 OTHER OPPORTUNITIES FOR FINANCIAL ASSURANCE IN CANADA

Risk externalities exist in sectors beyond mining. This section considers environmental risks, liability gaps, and financial-assurance policies in eight other sectors in Canada.

This assessment remains at a high level only. In some cases, we highlight key questions, rather than provide definitive answers. Deeper, more comprehensive analysis — similar to our case study on mining in the preceding section — could provide useful insights as to additional specific opportunities for financial-assurance policy to manage risk externalities in Canada.

CHEMICAL MANUFACTURING

Chemical manufacturing in Canada is a diverse set of sectors that generate about $16 billion in annual income, or 0.8% of GDP ($2007, chained). The environmental risks are similarly diverse and include explosions, accidental releases, and unremediated contamination near the production site following closure (National Post, 2012; Statistics Canada, 2017a).

Provinces' use of financial assurance for chemical manufacturing varies. To ensure that operators reclaim manufacturing sites, provincial governments generally require assurance for projects where environmental contamination is a risk (Government of Saskatchewan, 2010; Government of Ontario, 2017b; Gouvernement du Québec, 2017b).

Similar to the mining sector, governments do not require financial assurance against potential disasters from chemical manufacturing, such as explosions or the cumulative impacts of offsite pollution. In addition, financial assurance for offsite impacts is not well defined. The risk of offsite impacts is more likely covered by regulations and liability rules alone.

TANKER TRAFFIC

Tanker traffic accounts for a significant portion of port activity in Canada. There are approximately 20,000 oil tanker movements in Canada every year, and they account for about 20% of all marine transport by tonnage. Oil spills are the largest environmental risk from tanker traffic. They can result in large-scale ecosystem damages and chronic toxicity from both hydrocarbons and the dispersants used to clean them up. Since 2003, Canada has averaged one spill larger than 10,000 litres every four months (Kingston, 2002; Peterson et al., 2003; Almeda et al., 2014; CCA, 2016).

Canada is a signatory to international conventions that require tanker operators to carry liability insurance and pay into industry funds. The funds cover cleanup along coastlines of signatory nations when operators cannot absorb the costs. These conventions also assign strict liability to tanker owners for certain types of marine spills (Anderson & Spears, 2012; WSP, 2014; Government of Canada, 2017; SOPF, 2018; IOPC, 2018).

The scope of the international liability and financial-assurance regime for tanker traffic is somewhat limited. It excludes long-term damages and applies only to "persistent" hydrocarbons that do not dissipate rapidly through evaporation. "Non-persistent" substances such as gasoline and light diesel are excluded from the conventions (IMO, 2017; SOPF, 2018; IOPC, 2018).

NUCLEAR ENERGY

Nuclear power supplies 15% of Canada's electricity. The total number of plants is limited: Ontario has three plants and New Brunswick one. Catastrophic nuclear disasters such as Chernobyl and Fukushima are the most obvious environmental risk in the sector. However, most incidents involve releases of coolants or smaller amounts of radioactive material. The unique design of Canada's nuclear reactors makes them less prone to catastrophic meltdown than other reactor types, such as the one found in Fukushima. However, they still experience accidental releases (Hamilton & McLean, 2009; CBC News, 2011; NRCan, 2018).

Financial-assurance requirements apply throughout Canada's nuclear supply chain, including mining, power generation, decommissioning, and long-term waste management. While Canada does not collect financial assurance for nuclear disasters, operators are liable for up to $1 billion in damages in the event of an incident (Cowan, 1990; CNSC, 2017b; CNSC, 2018).

Financial-assurance and liability rules in Canada's nuclear sector have undergone significant changes in recent years, including increases in liability caps. However, several key questions remain, including the extent to which these changes have adequately addressed the full range of risk externalities along the nuclear supply chain, as well as their potential impacts on economic activity.

OIL PIPELINES

There are over 840,000 km of transmission, gathering, and distribution pipelines in Canada, including 117,000 km of large-diameter transmission pipelines. About 73,000 km of these pipelines are federally regulated (NRCan, 2016b). Spills are the main environmental risk. Pipeline ruptures can lead to soil, surface, and groundwater contamination, as well as habitat and biodiversity loss. Between 2010 and 2016, there were 47 incidents involving liquid releases from pipelines. The most significant of these was in 2011, when a pipeline owned by Plains Midstream leaked 4.5 million litres of oil near Little Buffalo in Northern Alberta (Dziubiński et al., 2006; Vanderklippe, 2011; Middlebrook et al., 2012; CEPA, 2016; CEPA, 2018; TSBC, 2018).

As of 2016, operators of federally regulated pipelines in Canada are absolutely liable for leaks up to $1 billion (this cap is lifted in cases of negligence). Operators must provide financial assurance against the risk of an oil spill and the costs of potential remediation. The amount of financial assurance is determined by a pipeline's "risk value," which is based on its diameter, operating pressure, and daily transport capacity. Operations with a capacity exceeding 250,000 barrels per day are required to provide $1 billion in financial assurance against the risk of a spill. Governments accept various types of financial assurance, including parent company guarantees — a soft type of assurance. Federal regulations give pipeline companies the option to meet part of their financial-assurance requirements using a pooled fund, provided it maintains a minimum value of $250 million (Government of Canada, 2015b; NEB, 2016; NRCan, 2017e).

The performance of these new policies and trade-offs across compensation, deterrence, and economic activity in the sector remains an open question.

TRANSPORT OF DANGEROUS GOODS BY RAIL

Rail transportation in Canada generates approximately $8 billion in annual income, or 0.4% of GDP ($2007, chained) (Statistics Canada, 2017a). Some cargo poses serious risks to the environment, including oil, toxic chemicals, and industrial wastes. Goods transported across provincial borders are subject to various federal regulations, depending on the risks they pose. In 2017, there were 115 accidents and five leaks involving hazardous substances on Canada's rails (Garber, 2018).

As of 2016, the Canadian Transport Agency requires operators and owners to carry a minimum of $25 million in liability insurance. Railways that carry "toxic inhalation substances" or oil may be required to carry up to $1 billion in liability insurance, depending on the amount of cargo they are carrying. Railway companies must also provide the financial rating of their insurers to establish that they are capable of providing the prescribed level of coverage (CTA, 2017). In the wake of the Lac-Mégantic tragedy, the *Safe and Accountable Rail Act* (2015) created an industry fund intended to cover the cost of future rail disasters. The fund is financed by per-tonne levies on crude oil shipping (Government of Canada, 2015a).

The extent to which these new policies adequately address the risk of rail disasters in Canada is an open question. In particular, the focus on general liability insurance may leave significant liability gaps open in the sector, since this type of insurance commonly excludes environmental liabilities such as cleanup orders or non-market environmental costs.

OFFSHORE DRILLING AND EXTRACTION

Offshore oil extraction in Canada accounts for about 5% of Canada's total oil production, and primarily takes place off the coasts of Newfoundland and Labrador, with some smaller operations in Nova Scotia. The environmental risks of offshore oil production are similar to those of tanker traffic, including damage to marine ecosystems. If an oil leak or blowout occurs below the ocean's surface, some of the oil may remain underwater. These oil plumes are difficult to locate, can persist for years following a spill, and in some cases are impossible to clean up (Kingston, 2002; Peterson et al., 2003; Spier et al., 2013; NRCan, 2017d).

Following policy changes in 2016, the liability and financial-assurance regime for offshore drilling and extraction is similar to that for pipelines. Firms undertaking drilling or development are absolutely liable for damages up to $1 billion, with the cap lifted in cases of negligence. They must prove they have financial resources to cover up to $100 million in damages. And they have the option to participate in a $250 million pooled fund instead of maintaining assurance on their own (Baines & Syer, 2016; Government of Canada, 2018a).

The economic and environmental implications of the 2016 changes to financial-assurance and liability rules in the sector are unclear. Notably, however, the approximately $60 billion cost of BP's Deepwater Horizon spill massively exceeds Canada's liability cap and financial-assurance requirements for the sector.

LANDFILLS

Canada's nearly 2,000 landfills receive over 25 million tonnes of industrial and household waste per year, some of which is toxic or environmentally persistent. Landfills and, in particular, leachates (the liquid that drains or leaches from a landfill) pose a broad range of environmental risks to drinking water, food resources, and ecosystems (Weber et al., 2011; CCME, 2014; Statistics Canada, 2018).

Provincial governments' use of financial assurance for landfills is not uniform across Canada. For example, financial assurance in BC must be hard and cover operating costs, closure plans, and long-term monitoring, plus a 20% contingency. In Quebec, owners must pay a fixed fee depending on landfill size. In Manitoba, owners are simply required to carry insurance (Government of British Columbia, 2016; Gouvernement du Québec, 2017b; Government of Manitoba, 2016).

The economic and environmental implications of these provincial regulatory regimes are unclear. However, the inconsistent application of financial assurance across provinces has important implications for landfill management practices, interprovincial transfers of waste, and post-closure environmental outcomes.

HYDRAULIC FRACTURING

Hydraulic fracturing (or "fracking") is an increasingly widespread form of fossil fuel extraction where a mix of water, sand, and chemicals are injected underground and used to extract oil or gas from rock formations. Environmental issues that arise from hydraulic fracturing remain controversial and heavily studied, but there is often insufficient information to accurately characterize local impacts. (Given these challenges, *uncertainty* is likely an issue for hydraulic fracturing.) Commonly-cited environmental risks include regional impacts to water and air quality, habitat fragmentation, earthquakes, fugitive greenhouse gas emissions, and potential long-term impacts from the chemicals used during injection (Adgate et al., 2014; Birdsell et al., 2015; Gagnon et al., 2015; King & Valencia, 2014; Rogers et al., 2015; Schultz et al., 2015; Atkinson et al., 2016; Boothroyd et al., 2016; Klaiber et al., 2017; Holding et al., 2017).

Regulatory approaches to hydraulic fracturing differ across Canada. Some provinces have integrated the industry into their existing regulatory frameworks. Others have treated it differently, even imposing full-on moratoriums against the practice. In provinces where hydraulic fracturing is permitted, the application of financial assurance is limited — it rarely extends beyond standard requirements to prevent the orphaning of oil and gas wells (AER, 2013; BCOGC, 2015; Carter & Eaton, 2016; McCarthy, 2016; Government of Alberta, 2017; Withers, 2018).[xxxvii]

There may be an opportunity for greater (or smarter) use of financial assurance in these sectors

All of the sectors here present risk externalities. In some, financial assurance is already applied. In others, it is either not applied or applied only in a limited way.

Where it is not used or is underused, financial assurance could be a valuable complement to these sectors' safety regulations and liability rules, helping provide cost-effective deterrence and compensation. And where it is already in use, there may be a case to apply it more stringently, to apply it against other types of risk, or to use different instruments altogether.

The sectors presented here suggest a research agenda for others focused on environmental risk and liability gaps in Canada. The Ecofiscal Commission may explore some of these topics in future work.

7 RECOMMENDATIONS

Based on the analysis in this report, we provide ten recommendations for how policy-makers should manage risk externalities using financial assurance. The recommendations are general and apply to various risks across different sectors. For each recommendation, however, we also comment specifically on implications for Canada's mining sector.

RECOMMENDATION #1:
Policy-makers should increase their use of *financial assurance* to help manage risk externalities, especially in sectors where it is underused

Policy-makers should make greater use of financial assurance. It offers a powerful tool to price environmental risk. It can create incentives for firms to take more action to avoid possible environmental damage. It can provide compensation to those affected should environmental damage occur. And it can achieve these goals at low costs by harnessing market forces.

At the same time, financial assurance should complement other policies, not replace them. Strong safety regulations and clear, well-established liability rules provide an essential foundation for policies to address environmental risk and possible social costs.

Implications for Canada's mining sector

Financial assurance in the mining sector does not currently apply to mining disasters in any of the jurisdictions we explore. This represents a missed opportunity to lower the risk and potential social costs of mining disasters.

For the risk of non-remediation, policy-makers may have scope to increase the stringency of financial-assurance instruments already in use (e.g., requiring harder and more timely financial security from firms) or to bring new instruments to bear (e.g., by permitting surety bonds, which not all jurisdictions do; or by developing an industry fund, as Western Australia has done with its *Mining Rehabilitation Fund*).[xxxviii]

Notably, there may be an opportunity for Canada's Indigenous communities to lead the way in developing new approaches to mining sector–financial assurance. Many mining projects occur on Indigenous lands. By seeking greater financial assurance against environmental risks — coordinated with other governments — Indigenous communities can help better protect these lands from the environmental risks that can come with mining. They could also receive compensation when harm does occur, while still enjoying the economic benefits of mining activity. Further, Indigenous communities' experimentation with new approaches can help to drive innovation in how financial assurance is applied in the mining sector.

RECOMMENDATION #2:
Policy-makers should estimate risk comprehensively to inform their financial-assurance policies

Credible estimates of risk underpin good financial-assurance policy. These estimates define how much financial assurance policy-makers require. Requiring too much can unnecessarily increase costs, undermining economic activity. Requiring too little can reduce deterrence incentives and the value of potential compensation.

When determining financial-assurance requirements, policy-makers should carefully and comprehensively estimate risk. This requires

considering all relevant sources of risk (i.e., financial, economic, legal, environmental, technological, etc.) and considering the full range of potential damage types (i.e., property, human health, livelihoods, ecosystems, etc.). It also requires taking care to account for possible fat tails and to evaluate the potential for long-term or perpetual costs.

Because external vetting can help improve the quality of expected value estimates, policy-makers' risk assessments, monetization methodologies, and corresponding financial-assurance requirements should be made public as much as possible. Requiring external expert reviews could also improve estimates.

Implications for Canada's mining sector

In the mining sector, provincial and territorial governments should define financial-assurance requirements for non-remediation of mines based on risk-weighted estimates of potential damages. Currently, many governments tend to rely on deterministic point estimates for the costs of completing closure plans. This approach can underestimate reclamation costs' true expected value. These estimates tend to be less than the risk-weighted expected costs, especially in the presence of fat-tailed risks.

In short, policy-makers should use financial assurance to protect against the risk of a site's actual closure needs deviating from its closure plan. Where they are reluctant to place this cost on individual firms, they can use tiered solutions (see recommendation #5).

RECOMMENDATION #3:
Policy-makers should use risk differentiation in defining required levels of financial assurance

Policy-makers risk-differentiate when they require different levels of financial assurance from firms depending on their unique risks (environmental, financial, technological, and other). Risk differentiation can support different policy priorities. Policy-makers can use it to increase financial-assurance requirements for risky firms or to decrease them for less risky ones.

To make risk differentiation practical for governments, the onus should be on individual firms to make the case that their operations present below-average risk. Third-party assurance has an advantage here in that policy-makers need not undertake risk differentiation themselves — it occurs as a result of market competition between different insurers or other third-party providers. Similarly, under sector-level assurance, the sector performs risk differentiation, using its expertise in its own risks.

Monitoring is a key aspect of effective risk differentiation because firms' risk profiles can change over time. Firms' risks should be periodically re-evaluated to ensure required financial assurance is sufficient and to provide incentives for ongoing risk mitigation. Where the cost of collecting firm-level risk data would exceed the benefits, policy-makers can use proxies for risk (e.g., adherence to voluntary industry safety standards). Alternatively, they can devote more resources to monitoring high-risk operations.

Implications for Canada's mining sector

In the mining sector, provincial and territorial governments should use risk differentiation in financial assurance for both the risk of non-remediation and the risk of mining disasters. For the risk of non-remediation, a number of the jurisdictions we explore already differentiate firms in some ways, in particular financial risk (although in some cases, there is room for improvement).

For mining disasters, where collecting risk data for individual mines was prohibitively expensive, adherence with the Mining Association of Canada's Tailings Management Protocol could be used as a proxy for prudent tailings dam management, helping risk-differentiate individual operations.[xxxix]

RECOMMENDATION #4:
Policy-makers should create a policy environment that facilitates private sector financial-assurance solutions

When considering financial-assurance instruments that pool risk, policy-makers should create a policy environment that facilitates third-party involvement. Despite their strengths, public-assurance solutions alone can crowd out third-party ones. As a result, they can limit the potential for market competition to drive down the cost of premiums. Moreover, limited competition can also inhibit the development of new and innovative approaches to financial assurance.

Policy-makers can facilitate third-party participation by — where feasible — being flexible across the types of financial-assurance instruments they will accept. Doing so can both increase firms' compliance options and help create new (or expanded) markets for third-party coverage.

Policy-makers can also facilitate third-party involvement by encouraging third-party assurance for insurable risks, reserving sector-level and public assurance for non-insurable ones.

Implications for Canada's mining sector

Due to tail risks and uncertainty, the risk of mining disasters may be uninsurable in the Canadian marketplace. Policy-makers should work with mining firms and the insurance industry to explore ways of making the risk of mining disasters commercially insurable. For example, risk monitoring and reporting could be standardized in a way that made it easier for insurers to assess mines' unique risks. Where there is a ceiling on

the coverage that third parties are willing to provide, policy-makers should consider tiered solutions (recommendation #5).

RECOMMENDATION #5:
Policy-makers should use tiered solutions when environmental risks are fat-tailed

In the presence of fat-tailed risks, firm-level financial assurance may be unable to provide sufficient coverage against potential social costs. And third parties may be unable or unwilling to provide coverage that is high enough to guarantee full compensation.

To address this problem, policy-makers should use "tiered" financial-assurance solutions. In a tiered scheme, firm-level and third-party assurance would provide coverage up to a point. Beyond this threshold, sector-level financial assurance or public instruments would kick in.

Any number of tiers is possible in such a scheme, but the relative order would typically be firm-level assurance, followed by third-party, then sector-level, then public. Requiring hard assurance from firms in the first tier supports deterrence, while higher tiers would pool risk, helping to ensure compensation at lower costs. However, to support economic activity, policy-makers need to be careful that the administrative and compliance cost of tiered schemes do not exceed the benefits.

For extreme tail risks (e.g., a catastrophic nuclear disaster), full compensation from a tiered scheme may not be possible. Even public assurance that pools risk across sectors will eventually reach a limit in how much coverage it can provide. In such cases, government may still need to provide a simple backstop for costs beyond the reach of a tiered scheme. However, governments can extend the reach of the highest tiers by securitizing risk in capital markets or acting as a "reinsurer of last resort."[xl]

Implications for Canada's mining sector

In the mining sector, policy-makers should use a tiered financial-assurance scheme to protect against catastrophic mining disasters — an important gap in mining-sector financial-assurance policy in Canada. Mining operations that pose a significant risk of disaster should provide a degree of hard firm-level assurance, with third-party assurance (where available) providing a higher tier. To cover non-insurable, fat-tailed risk, policy-makers should consider a sector-level approach that pools mining firms' risks or a Superfund-style public scheme that pools risk across economic sectors.[xli] To support deterrence, higher tiers should risk-differentiate individual firms' contributions as much as possible (recommendation #3).

RECOMMENDATION #6:
Policy-makers should adopt a portfolio approach to public assurance

Public-assurance instruments have a key advantage over other instruments in their ability to pool risk across sectors. Narrower assurance schemes (e.g., mutual assurance) may be more vulnerable to correlated risk. For example, a sector-level downturn or discovery of a previously unknown environmental harm could threaten the solvency of a sector-level scheme. In contrast, broader approaches that pool risk across sectors and risk types will be less vulnerable to these types of shocks, and a result, support the policy goal of compensation more strongly.

To diversify risk, policy-makers should integrate public assurance under a broad, overarching instrument. Using this type of portfolio approach — whether provincially or across the country — would allow a number of different risk types to be gathered in one place or institution. It would help reduce overall administrative costs and allow a centre of expertise in risk and financial management to develop.

Implications for Canada's mining sector

Where there is a case for using public-assurance instruments in the mining sector (for example, as part of a tiered solution dealing with fat-tailed mining disaster risk), policy-makers should explore ways to diversify risk. Options could include multi-sector approaches as discussed above, but also diversifying risks *within* the sector. For example, policy-makers could use the same scheme to assure against the risk of both mining disasters and remediation costs significantly exceeding their estimated costs.

RECOMMENDATION #7:
Policy-makers should apply contingencies or premiums when risks are uncertain

Uncertainty can complicate policy-makers' efforts to manage risk. It can be especially relevant at the environmental assessment stage of a project, where governments decide whether or not a project should proceed.[xlii]

For projects with uncertain risks that do go ahead, determining required financial assurance becomes subjective. In the face of uncertainty, calibrating financial-assurance requirements is difficult. As a result, policy-makers can end up requiring either too much assurance or too little. This problem can be especially significant when there is reason to believe the underlying risk distribution is fat-tailed — in such cases, requiring insufficient financial assurance could lead to very high social costs.

In the face of uncertainty, policy-makers should apply uncertainty premiums or contingencies. This is the approach that commercial insurers take: in response to uncertainty, they will commonly raise the cost of premiums to protect themselves against the possibility of poorly understood risks leading to significant losses. The Canadian Nuclear Safety Commission (CNSC) also uses this approach. It applies contingencies of 10 to 30% when estimating the costs of decommissioning a facility. The CNSC also suggests that where estimating the cost of decommissioning is complex or where the results may be deficient, it may be appropriate to set financial-assurance requirements based on credible worst-case scenarios defined under a multi-stakeholder collaborative process (CNSC, 2000).

Calibrating the size of an uncertainty premium or contingency is challenging. Policy-makers must make the best determination they can in choosing contingency levels to balance across deterrence, compensation, and economic activity.

Implications for Canada's mining sector

There is a strong case for requiring an uncertainty premium in the financial assurance that oil-sands mines provide for tailings-pond remediation. Unlike technologies for other types of mining, water capping (the remediation technology being proposed for oil-sands mines) is unproven, and its efficacy may not be known for decades. If water capping proved ineffective and the firm that operated the mine was no longer in operation, any costs of remediation over and above the financial assurance held by government would fall to Alberta taxpayers. Given the physical scale of oil-sands tailings in Alberta, these costs could be significant. Requiring an uncertainty premium or contingency would reduce the public's exposure to this risk.

RECOMMENDATION #8: Policy-makers should assess impacts on existing operations and, where necessary, phase in new requirements

Applying financial assurance to new projects and risks is — compared to applying it to existing ones — relatively straightforward. Projects that can bear the cost of the risk will either absorb those costs, pass the cost on to consumers, or some combination. Projects that cannot bear the cost of the risk will not proceed, preventing excessively risky projects from going ahead. And pricing risks explicitly in this way helps investors make decisions that better reflect environmental risk.

On the other hand, applying financial assurance to *existing* projects is more complex. Requiring greater financial-assurance requirements from existing projects might push some into insolvency. Where these projects have existing environmental liabilities, this can increase the likelihood of society bearing the costs of them.

In transitioning to a new financial-assurance regime, policy-makers should assess expected impacts on existing projects. In some cases, they may need to treat existing projects differently than new ones. But existing projects should not simply be exempted from the new requirements. Instead, more stringent financial-assurance requirements for existing projects should be phased in. This can give firms time to adjust and help avoid bankruptcies.

Implications for Canada's mining sector

In the mining sector, policy-makers should be cautious when changing existing operations' financial-assurance requirements. Mining firms are price-takers: the metals and minerals they sell are traded in competitive global markets. Existing projects could be pushed into insolvency if they could not absorb the cost of greater financial-assurance requirements.

At the same time, this vulnerability cannot be an excuse for inaction. Some mining projects may be marginal under a new financial-assurance regime because they pose excessive environmental risk. Propping these projects up with lax financial-assurance requirements can come at costs to society (in the form the risk it must bear) that exceed the benefits.

RECOMMENDATION #9: Society should only risk-share when there is a clear case for doing so

In specific circumstances, risk sharing between private firms and society more broadly can be justified. In many natural resource sectors, firms pay royalties to government over and above various taxes. Because society shares in the benefits of the economic activity, a case can be made for sharing in some of the risks as well. And when risks are uncertain, available financial-assurance instruments might be so limited or costly that firms are unable to both provide assurance against environmental risks and remain economically viable. This market failure can sometimes justify risk sharing.

But in other cases, the costs of risk sharing can outweigh the benefits. Risk sharing is an indirect subsidy, and it can create economic distortions that increase the likelihood or severity of costly environmental damage. And because any public costs for

cleanup or compensation would be funded from tax revenue, it can also have a cost to the broader economy.

Risk sharing does not necessarily require sharing *environmental* risk. Rather, governments could share financial or other types of risk (e.g., by providing discounted loans, offering subsidized electricity tariffs, or funding needed infrastructure). Sharing risk in these ways can help make an economic activity viable while preserving the valuable deterrence and compensation that financial assurance provides.

Where policy-makers choose to share environmental risk, they should do so intentionally, efficiently, and transparently. A range of options are available, from accepting soft assurance from firms, to phasing in financial-assurance requirements, to only requiring assurance against part of a firm's potential liability. Each will have different (and important) implications for deterrence, compensation, and economic activity, and the specifics of their design will matter a great deal.

Implications for Canada's mining sector

In the mining sector, there is a case for risk sharing. A number of jurisdictions in Canada already share the risk of non-remediation with mining firms. However, excessive risk sharing in the form of low financial-assurance stringency can tilt the policy environment toward economic activity at the expense of deterrence and compensation.

Similarly, the total lack of financial assurance for mining disasters in Canada prioritizes economic activity to the considerable potential expense of society and the environment. Jurisdictions in Canada should find ways to share in the mining sector's risks more fairly, including by sharing in its financial risks rather than its environmental ones. For example, in place of relaxed financial-assurance requirements, jurisdictions could offer preferential loans. In doing so, they would share in mining's financial risk: Where ventures were successful, loans would be repaid. Where they were not, government would incur a loss. This can help Canada's mining sector remain globally competitive but without compromising policy-makers' deterrence and compensation goals.

RECOMMENDATION #10:
Policy-makers should articulate and justify their policy priorities — and then design and implement policies consistent with this vision

Policy-makers should be transparent about the relative importance they place on the three policy goals of deterrence, compensation, and economic activity — and the resulting trade-offs. Doing so provides a benchmark that they can use to can guide their risk-externality policies. In addition, clearly articulating policy goals in this way gives stakeholders an opportunity to voice potential concerns or disagreements. And it provides them with a standard against which to evaluate outcomes.

But clearly articulating policy goals is not enough — policy-makers must also justify them. Where policy goals are tilted toward one particular goal — whether deterrence, compensation, or economic activity — policy-makers should make a case to demonstrate why such a balance creates benefits that will exceed the costs.

Finally, policy-makers should ensure that their policies are in line with stated goals. Where deterrence is a high priority, policy-makers should assess whether their policies encourage excessive risk taking. Where compensation is important, they should review the reliability of the financial-assurance instruments that they accept. And where economic activity is a high priority, they should determine to what extent their policies deter production and investment. Where policies are out of line with stated goals, they should be changed.

Policy-makers should be transparent about the choice they are making, the rationale for that choice, and the evidence base for that decision.

Implications for Canada's mining sector

Provincial and territorial governments in Canada should articulate a vision for how they wish to balance economic activity in the mining sector against deterrence and compensation goals. Since there is a case for risk sharing in the mining sector (given public ownership of mineral resources), governments should articulate how much risk they wish to share with the sector — if any — and how.

Policy-makers should justify their approaches to risk sharing in the mining sector (e.g., less stringent or more narrowly applied financial assurance) and make the case that they present a net benefit to society. Where deterrence or compensation is traded off in favour of greater economic activity, policy-makers should demonstrate that the benefits of this approach (in the form of greater production and investment) outweigh the costs (in the form of greater environmental risk and potential social costs). Similarly, where economic activity is traded off in favour of greater deterrence or compensation, policy-makers should demonstrate how the benefits of avoided risk exceed the costs of reduced investment.

8 CONCLUSION

This report has made the case that financial-assurance policies can put a price on environmental risk. They can create incentives for firms to better manage their risk, fund compensation or cleanup costs, and support economic activity by keeping the costs of doing so low.

Yet assessing the need for changes to financial-assurance policy can be complex. They interact with existing liability rules and safety regulations in different ways. They also depend on policy-makers' priorities.

This report has considered risks to the environment from mining, the role of financial assurance in the sector, and potential policy changes in some detail. It also considered risks and existing policy regimes in other sectors in a general way. There are likely to be opportunities to rely more on financial assurance to close or limit liability gaps in these other sectors. However, more detailed, sector-specific analysis is required to explore these opportunities.

We hope that the framework we have developed will provide a solid foundation for analysts exploring some of these issues in the future. Policies to manage potential environmental damage and potential costs to society can be challenging to conceptualize and design. Yet these risks are real and have significant implications for both our environment and our economy. Smart policy can ensure we take responsible risks.

9 Annex: Describing provincial and territorial financial-assurance regimes for the mining sector

9.1 Yukon

Legislative authority for demanding financial assurance	• Yukon's authority to require financial assurance for mining operations rests with both the Department of Energy, Mines and Resources (EMR) and the Yukon Water Board (Government of Yukon, 2013). • Five territorial acts contain provisions for financial assurance in the mining sector: *Placer Mining Act, Quartz Mining Act, Waters Act, Environment Act,* and *Territorial Land Act*. • The *Quartz Act* grants authority to demand financial assurance for hard-rock mining. Financial assurance for gold mining is covered by the *Placer Mining Act*. Financial assurance under the *Water Act* can apply to any type of mine, provided there is risk to a water body. • No other levels of government can demand financial assurance against mining's environmental risk in Yukon. • As in other jurisdictions, the federal government plays a role in the management of Yukon mines' offsite environmental damage (for example, the federal *Fisheries Act* covers releases into fish-bearing waters across Canada). However, it cannot demand financial assurance against potential damage. Rather, it issues fines in the event that federal environmental acts are violated and may require funds to offset mines' impacts on fish habitats (Government of Canada, 2018b; McNaughton & Unger, 2015). • Yukon's authorities over the mining sector and mining-sector financial assurance differentiates it from the Northwest Territories and Nunavut, both of which are still in the process of devolution.
Scope of financial assurance	• Yukon uses financial assurance to cover the potential costs of site remediation, as well as perpetual care and site monitoring, when necessary. • Financial assurance does not cover potential disasters or other offsite damage.
Stringency of financial assurance	• Hard assurance is usually necessary; acceptable types include cash, letters of credit, bank letters of guarantee, surety bonds, insurance, and security held in trust (Government of Yukon, 2014). • No credit is given for onsite salvage during closure.
Risk differentiation	**Financial risk:** • When demanding financial assurance, EMR and the Water Board may consider the specific degree of financial risk that a given mining project presents (Government of Yukon, 2007). • In such cases, at the discretion of EMR, soft forms of assurance may be considered for lower-risk project components (usually a pledge of assets) (Government of Yukon, 2014). • The Quartz Mining Act's Security Regulation outlines specific risks EMR should consider, including security furnished with other authorities, costs to the government should the operator be unable to reclaim, the nature and location of the project, and the cost of implementing the reclamation plan. **Environmental risk:** • EMR or the Water Board demand financial assurance based on actual land disturbance, rather than eventual planned disturbance. This ensures that firms do not have to provide assurance against risks that are not yet present. This policy choice necessitates the timely review of closure plans to ensure assurance held reflects the full cost of reclamation at any point in time. • EMR or the Water Board demand additional assurance as the site disturbance increases. • If the size of a firm's reclamation liability decreases demonstrably during its operational life, EMR or the Water Board can return a portion of its financial assurance (Government of Yukon, 2006). • Reclamation does not mean elimination of liability; monitoring must demonstrate that reclamation activities have been effective before security can be returned.

9.1 Yukon *continued*	
Estimation of liability and magnitude of financial assurance required	• Yukon has well-defined standards for reclamation that proponents must include in reclamation plans, including physical and chemical stability, health and public safety, ecological conditions, land use, aesthetics, socio-economic expectations, long-term certainty, and minimization of outstanding liability. • To ensure firms are posting the appropriate amount of security, proponents must break out their estimated remediation liability across three categories: the size of the currently liability, the estimate of the liability in 2 years, and liability at end of life. • Liability estimates must include all costs and must assume that a third party and not the proponent will reclaim the land. • Yukon provides guidance for reclamation, project planning, and closure costing to help ensure standardization (Government of Yukon, 2013). • EMR must reapprove reclamation plans every 2 years. • To avoid duplicative bonding requirements that needlessly raise firm costs, the *Quartz Act* requires authorities to consider security already required under other acts and authorities.
Enforcement, monitoring and transparency	• Because of higher operating costs in the territory (and associated economies of scale), Yukon deals with fewer, larger mines rather than a greater number of smaller operations. As a result, government capacity to monitor mines and enforce policy can be lacking. • Yukon makes closure plans public at the assessment and licencing stages of operation. • Yukon enforcement of the requirement to provide closure plans may be lacking. For example, the licence holder of Yukon's Keno Mine was originally supposed to submit a decommissioning and reclamation plan in 2008. The Yukon Water Board has granted multiple deadline extensions and has still not received a decommissioning and reclamation plan. • Yukon's financial assurance regime is relatively untested. The vast majority of unreclaimed mines are from prior to devolution.

9.2 British Columbia	
Legislative authority for demanding financial assurance	• The Ministry of Energy, Mines and Petroleum Resources (MEMPR) regulates BC's mining sector under the authority of the *Mines Act.* • MEMPR's mandate covers both the promotion and expansion of BC's mining sector as well as compliance and enforcement. The province's Auditor General has flagged this as a potential conflict-of-interest (AGBC, 2016). • The province's Chief Inspector of Mines oversees enforcement and collection of financial assurance within MEMPR (Government of British Columbia, 2017e). • If MEMPR considers it necessary and in the public interest, it may exercise all the powers that the Chief Inspector may exercise. • In addition, British Columbia has a codified cost recovery regulation (i.e., liability rule), known as "polluter-pay," under its *Environmental Management Act* (EMA) (Government of British Columbia, 2017d). This allows the Minister of Environment to levy charges in the event of a tailings release or other environmental harm, and to recover any related costs the government may incur, including resource diversion and remediation. In practice, this regulation is used when the government incurs extraordinary costs relating to a spill. • This polluter-pay policy allows for full-cost recovery after an environmental disaster (but not after non-remediation). This policy is the only one of its kind in Canada but is not always enforced.
Scope of financial assurance	• The Chief Inspector may request financial assurance to ensure reclamation of any mine site. This can include both direct remediation costs and also costs related to long-term monitoring, perpetual care, or the protection of watercourses or cultural heritage resources that may be affected by mining operations (AGBC, 2016). • Financial assurance does not cover environmental disasters in the sector, but the Ministry of Environment can request additional assurance if there is a high risk of offsite contamination.

9.2 British Columbia *continued*	
Stringency of financial assurance	• The stringency of financial assurance (in terms of both its form and amount) is at the discretion of the Chief Inspector of Mines. The Chief Inspector evaluates requirements on a case-by-case basis (AGBC, 2016). • Both hard and soft forms of financial assurance are permitted. Soft assurance can include mining equipment and performance-related standards (Allan, 2016; Government of British Columbia, 2018c). • The *Mines Act* calls for the submission of financial assurance over the entire life of the mine (i.e., the phasing in of financial assurance) (Government of British Columbia, 2017e). • Firms must submit annual reclamation reports, and the Chief Inspector may adjust assurance requirements accordingly, usually every five years (Stantec, 2016), meaning a firm should have the full amount of assurance in place as the mine is closing. • In practice, the stringency of financial assurance in BC tends to be limited, and remediation liabilities commonly exceed firms' posted financial security (AGBC, 2016). • MEMPR has quintupled the amount of financial assurance it is holding over the last decade (now approximately $1 billion) and is scheduled to collect an additional $846 million in financial assurance over the next eight years (EY, 2017). • As of 2017, the Chief Inspector of Mines held $1 billion in financial assurance against a $2.1 billion potential cleanup liability (AGBC, 2016; EY, 2017). • MEMPR is currently reviewing its financial assurance regime following a 2016 report by British Columbia's Auditor General (Government of British Columbia, 2018c).
Risk differentiation	• British Columbia's financial assurance regime allows for financial-risk differentiation at the discretion of the Chief Inspector. There is no formalized process for assessing financial risk (EY, 2017). • Where the Chief Inspector deems a firm to be of low risk, the Inspector may require the firm to provide only partial financial assurance against future remediation liabilities, or soft assurance (Government of British Columbia, 2017e). • Requiring partial financial assurance is usually reserved for larger firms, such as Teck Resources (Hoekstra, 2016). • Financial assurance relief is sometimes also extended to smaller firms. However, it is often unclear whether this is because the firm has a low perceived financial risk.
Estimation of liability and magnitude of financial assurance required	• British Columbia's Health, Safety and Reclamation Code for Mines has a robust set of rules governing mines' reclamation plans. • Firms are required to submit schedules of anticipated changes to their long-term environmental liabilities; the Chief Inspector can adjust the financial assurance requirements to reflect these anticipated changes. • Firms must also submit annual reclamation reports detailing activities, including a detailed estimate of remediation expenses over the next five years (Government of British Columbia, 2017f). Technical officers in MEMPR validate reclamation plans. • MEMPR provides a standardized template for liability estimation, but its use is voluntary (Government of British Columbia, 2017f). • Because British Columbia firms self-estimate their liabilities and estimation methods are not standardized, estimates of their remediation liabilities can vary. MEMPR is taking steps to improve standardization in response to the Auditor General's 2016 report.
Enforcement, monitoring and transparency	• According to British Columbia's Auditor General, MEMPR and the Ministry of Environment's enforcement activity in the mining sector are "inadequate to protect the province from significant environmental risks" due to a lack of resources, infrequent inspections and irregular permit review (AGBC, 2016). • In response to the Mount Polley disaster, BC amended the *Mines Act* to include administrative penalties — which do not require court proceedings — and increased punitive damage maximums (Government of British Columbia, 2017c). • MEMPR, the Ministry of Environment and the Environmental Assessment Office maintain a website that discloses authorizations, inspection records, and permits, but does not expose reclamation plans or financial assurance documents. • Liability estimates, annual reclamation reports and financial-assurance amounts are publicly available, but closure plans are generally not (Hoekstra, 2016; EY, 2017). • According to British Columbia's Auditor General, there is no clear guidance for the Chief Inspector's decision making, and their decisions are not well documented (AGBC, 2016).

9.3 Alberta	
Legislative authority for demanding financial assurance	• The Alberta Energy Regulator (AER) is a quasi-judicial body tasked with promoting energy development and environmental stewardship in Alberta. • The AER has the authority to require financial assurance through the Mine Financial Security Program (MFSP) under the province's *Environmental Protection and Enhancement Act*. • The MFSP governs financial-assurance requirements for the reclamation of oil-sands and coal-mining sites in Alberta. • In addition, the AER has the authority to investigate and issue charges for damage that occurs as a result of a disaster (a liability rule).
Scope of financial assurance	• The MFSP applies exclusively to onsite remediation, which includes operations, suspension, abandonment, remediation, and surface reclamation. • There are four different financial assurance programs under the MFSP: 1. The *Base Security Deposit* (BSD) is the most prevalent type of financial security required under the MFSP and is mandatory for all new projects. The amount of assurance required is fixed based on the project type and ranges from $2 million to $60 million for more complex oil-sands projects. The BSD allows the AER to maintain the site should the proponent go bankrupt and reclaim the site if no other firm acquires it (AER, 2017c). As of 2017, the AER is holding $1.4 billion in BSDs for the oil sands relative to an estimated liability of $27 billion (AER, 2017a). 2. If a project's asset-to-liability ratio falls below 3-to-1, the firm must submit an *Asset Factor Safety Deposit* to bring the ratio back up to 3-to-1. What constitutes an asset under the MFSP is discussed below, in the section dealing with risk differentiation. No funds have been collected under this program to date. 3. If a company defers on its reclamation obligations in a given year, the AER can demand an *Outstanding Reclamation Deposit*, a flat fee of $75,000 per hectare of land that the company planned to reclaim but did not (AER, 2017c). This figure represents the upper-end of per-hectare reclamation costs, as defined by the AER. No funds have been collected under this program to date. 4. The *Operating Life Deposit* takes effect when a site has 15 years of reserves remaining. The firm must begin to submit financial assurance to cover all future remediation liabilities, at a rate of 10% per year. The firm's environmental liabilities must be covered in full five years before a mine's end of life (AER, 2017c). Funds will be collected under this program starting in 2018. • The MFSP does not cover disasters, and there is no provision for financial assurance for probabilistic events in any other legislation.
Stringency of financial assurance	• The MFSP is stringent in that the *Operating Life Deposit* eventually requires full financial assurance for remediation. • However, it is not stringent with respect to the timing of this assurance since companies are not required to post assurance beyond the *Base Security Deposit* until later in a mine's life. • A firm that does not meet the required 3-to-1 asset-to-liability ratio would be required to post an *Asset Factor Safety Deposit*, and firms that do not meet their reclamation obligations would be required to post an *Outstanding Reclamation Deposit*. However, as of 2015, no security had been collected under these two programs to date (AGA, 2015).

Risk differentiation	**Financial risk:**
	• The MFSP's *Asset Factor Safety Deposit* is intended to differentiate firms' financial risk, relying on asset-to-liability ratios as an indicator of overall financial health, and demanding additional security where needed.
	• However, the methods the AER uses to calculate assets under the *Asset Factor Safety Deposit* may inflate valuations (AGA, 2015):
	  • Assets include proven reserves *and* probable reserves; that is, reserves to which the company does not currently have access but could in the future. No risk-based adjustment is performed for these probable reserves (AGA, 2015).
	  • The AER's calculation of resource-asset valuation may understate the effects of a decline in commodity prices and does not include discounting (AGA, 2015).
	  • The MFSP requires annual reporting, but there is no mechanism that would require a firm to post security in the event its financial health declines between reporting periods (AGA, 2015).
	
	Technological risk:
	• A key type of risk that the MFSP does not differentiate is technological risk. Recent reclamation plans approved by the AER, including Suncor's Millennium Mine and CNRL's Horizon Mine, intend to rely on a process called "water capping" to reclaim their tailings (AER, 2017b; AER, 2017d). Water capping involves treating tailings and then "capping" them with a layer of water, creating an artificial water body such as a wetland or a lake. Water capping has been proven only at lab scale (AER, 2017d).
	• Firms such as Suncor and CNRL are required to develop alternative technologies in case water capping does not work, but this risk (and the cost of these alternatives) is not reflected in their financial assurance requirements (AER, 2017b; AER, 2017d).

9.3 Alberta *continued*	
Estimation of liability and magnitude of financial assurance required	• Firms must provide annual reports detailing asset and liability estimates and submit additional financial assurance where necessary. • Firms are not required to provide supporting documentation for their estimates (AGA, 2015). • A 2010 expert panel highlighted that inconsistent views between the sector and regulators on issues such as what constitutes reclamation and equivalent land use may be leading to discrepancies in estimated reclamation costs (Gosselin et al., 2010).
Enforcement, monitoring and transparency	• The AER did not have an enforceable directive around tailings management until 2016. • Alberta's Auditor General has highlighted enforcement issues related to the MFSP, including limited audit verification and the lack of risk-based planning to ensure the AER is requiring sufficient financial assurance (AGA, 2015). • Transparency is an issue as well: for example, some components of firms' liability estimates are not publicly disclosed, including how they are accounting for uncertainty in their operations (AGA, 2015).

9.4 Ontario	
Legislative authority for demanding financial assurance	• The Ministry of Northern Development and Mines (MNDM) regulates Ontario's mining sector under the authority of the *Mining Act*. • MNDM has a dual mandate: encouraging prospecting and development of mineral resources and minimizing the effects of these activities on public health, safety, and the environment. Ontario's Auditor General has recommended segregating the responsibility for the promotion of mineral exploration and development in Ontario from the oversight of mine-closure plans (OAGO, 2015; Government of Ontario, 2018a). • Financial assurance is covered in O. Reg 240/00: Mine Development and Closure. • In terms of broader mining sector policy, Ontario is in the process of overhauling its *Mining Act*, and has updated requirements for staking, early-stage exploration, and Indigenous consultation. It has added new enforcement measures and maximum fines for aggregate mining (Norton Rose Fulbright, 2017).
Scope of financial assurance	• MNDM requires financial assurance for onsite reclamation liabilities, including long-term monitoring and perpetual care (where necessary). • Offisite impacts fall under the *Environment Protection Act*, which permits the collection of financial assurance for measures to prevent adverse effects either during or following operations.
Stringency of financial assurance	• Mining firms face two possible treatments for financial assurance in Ontario. • Mining companies that can pass a corporate financial test may be waived of some or all of their reclamation security obligation, depending on their financial strength. This allows them to *self-assure* — a soft form of firm-level financial assurance — for the first half of the mine's life. • To receive this treatment, firms must obtain an appropriate credit rating from two of three selected ratings agencies (Moody's, Dominion, and Standard & Poor). Those that do can self-assure against their remediation liabilities. The only firm that currently receives this treatment in Ontario is Vale Canada (OAGO, 2015). • Firms that lose their credit rating are required to submit full, hard financial assurance within 30 days (Government of Ontario, 2018a). • Firms must specify in their initial closure plans the form and amount of financial assurance they will submit to MNDM if they close the mine early, lose their credit rating, or enter the second half of the mine's life (Government of Ontario, 2018a). • Firms that do not pass the financial test (or decline it) face the second, more stringent type of financial assurance treatment. These firms must provide full, hard financial assurance with the submission of a closure plan, prior to the start of work. • Acceptable forms of assurance include cash, letters of credit, reclamation trusts, and insurance bonds (Government of Ontario, 2018a). • At MNDM's discretion, softer types of assurance can also be accepted. These can include a pledge of assets, a sinking fund or per-tonne royalties (Government of Ontario, 2018a).
Risk differentiation	• By relying on external evaluation from credit ratings agencies and differentiating financial assurance requirements accordingly, Ontario's two-tiered system differentiates financial risk.

9.4 Ontario *continued*	
Estimation of liability and magnitude of financial assurance required	• Ontario's Mine Reclamation Code requires liability estimates in mines' closure plans to be based on third-party costing (Government of Ontario, 2018a), which assumes that contractors — rather than the firm — will carry out the reclamation work. Third-party costing raises the estimated cost of remediation but helps to ensure that the financial assurance required against remediation is sufficient to cover government's expected costs in the event the firm goes bankrupt. • Project proponents must certify that the cost estimates of the rehabilitation work described in the attached closure plan are based on the market-value cost, and the amount of financial assurance provided is adequate and sufficient to cover the cost of the rehabilitation work. Ontario allows for the "least-cost" method for calculating liabilities. • Long-term, post-remediation costs are converted into a Net Present Value using a 3% discount rate. • The government uses consultants to review closure plans. In a number of instances, the consultants accepted less stringent rehabilitation plans or recommended against requiring additional risk assessment of AMD or evaluating long-term structure stability. This was due to the potential cost burden on firms (OAGO, 2015).
Enforcement, monitoring and transparency	• As of 2015, one-third of closure plans had not been updated in over 10 years. Ontario had $63 million in reclamation costs uncovered by financial assurance due to failure to update closure plans since 2000 (OAGO, 2015). • Ontario's Auditor General has flagged the timely review and updating of closure plans and financial assurance as an issue, as well as MNDM's internal capacity for evaluation of closure plans. The department has dedicated resources to addressing the issue (OAGO, 2015). • With respect to onsite monitoring and enforcement, MNDM visited 62 sites between 2013 and 2014, finding that 45% of closure plans were non-compliant or required additional financial assurance. Inspectors recommended that these companies perform the necessary work to determine whether additional financial assurance was required. Just two firms responded; only one provided additional assurance (OAGO, 2015). • Penalties for non-compliance with closure plans are not more than $30,000 for each day on which the offence occurs or continues, or imprisonment for a term of not more than two years, or both. • Proponents must submit progressive rehabilitation reports during the life of the mines. MNDM is developing benchmarking and best-management practices guideline for closure plans and financial assurance. • A large number of mines in Ontario rely on letters of credit for financial assurance. The details of these private contracts may not always be available to the public. • In response to the Auditor General's report, MNDM has made the type and amount of financial assurance publicly available for every mine in the province (Government of Ontario, 2017c; Government of Ontario, 2018b).

9.5 Quebec	
Legislative authority for demanding financial assurance	• The *Mining Act* is the primary law governing resource extraction in Quebec, including mine closure, reclamation, and financial assurance. • The Ministère de l'Énergie et des Ressources naturelles (MERN) administers the *Mining Act.* • In 2013, MERN overhauled the *Mining Act* in response to recommendations from the province's Auditor General, including substantial changes to how it addresses financial assurance.
Scope of financial assurance	• Financial assurance covers all onsite environmental damage that is expected to take place during the life of a mine. • The aim of rehabilitation is to restore the site to a satisfactory condition by: 1) eliminating unacceptable health hazards and ensuring public safety; 2) limiting the production and circulation of substances that could damage the receiving environment and, in the long-term, trying to eliminate maintenance and monitoring; 3) restoring the site to a condition in which it is visually acceptable to the community; and 4) reclaiming the areas where infrastructures are located for future use. Liability estimates must address all four factors (Gouvernement du Québec, 2017b). • MERN does not require financial assurance against potential disasters.

9.5 Quebec *continued*	
Stringency of financial assurance	• As a result of the amendments to the *Mining Act*, Quebec's financial-assurance regime is very stringent. • Firms must cover 50% of their estimated reclamation costs within 90 days of MERN approving their closure plans. The remaining 50% is due in two installments over the following two years (Gouvernement du Québec, 2017b). Prior to these amendments, MERN required assurance of 70% of the estimated cost of rehabilitation and restoration, with more relaxed timelines (AGQ, 2009). • MERN will accept only hard assurance. Acceptable types of financial assurance include cheques, government-guaranteed securities, investment certificates, surety bonds, letters of credit, immovable hypothecs, environmental trusts, and insurance. Discretion is left to MERN as to which of these it accepts from any operation (Gouvernement du Québec, 2017b). • As of March 31, 2017, MERN has $1.2 billion in mining-related environmental liabilities, including $745 million for abandoned mine sites and $455 million for mine sites where the owners are at risk of bankruptcy (Gouvernement du Québec, 2018). • Quebec has pledged to reduce its mining-related environmental liabilities (a legacy of its old financial assurance system) by 80% by 2022 (Gouvernement du Québec, 2018).
Risk differentiation	**Financial risk:** • With respect to financial assurance, all firms receive the same stringent treatment in Quebec's regime, regardless of their unique financial risk. **Environmental risk:** • Environmental risk differentiation occurs through collaboration between MERN and the Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (MDDELCC). • MDDELCC provides input and corroboration for closure plans (Gouvernement du Québec, 2017a), ensuring closure plans (and thereby financial assurance demands) accurately capture the full scale and significance of an operation's expected environmental impacts. • Greater ministerial collaboration was a step recommended by the Auditor General and was part of the 2013 overhaul of the *Mining Act* (AGQ, 2009).

Estimation of liability and magnitude of financial assurance required	• Project proponents are responsible for providing and verifying liability estimations with submission of their closure plans, which they update at least every five years.
	• MERN is authorized to request additional details and supporting documentation related to cost estimates (Gouvernement du Québec, 2017b).
	• Closure plans have been available to the public since 2013.
	• While MERN is largely responsible for regulating the mining sector, it works closely with MDDELCC for permitting and reviewing and updating closure plans, including liability estimation (Gouvernement du Québec, 2017a).
	• Work to reclaim a mine site must begin no later than three years after operations cease. Following remediation, vegetation needs to take hold for 6 years without any maintenance.
	• The *Mining Act* allows MERN to issue a certificate releasing the company from its obligations and authorizing its financial assurance to be returned when MERN and MDDELCC are satisfied that the company has met three conditions:
	  • the rehabilitation work is completed in accordance with the approved plan
	  • the condition of the land no longer poses a risk to the environment or human health and safety
	  • there is no further risk of acid mine drainage from the site

Enforcement, monitoring and transparency	• Quebec's new mining strategy outlines a number of areas where it aims to improve enforcement outcomes, including making closure plans and financial assurance amounts public, creating new mechanisms to improve the sector's environmental and social performance, and implementing the Act Respecting Transparency Measures in the Mining, Oil and Gas Industries (Gouvernement du Québec, 2016). • If the proponent's rehabilitation measures fail to meet the general requirements outlined in the Reclamation Guidelines, they must demonstrate the validity of alternative approaches (Gouvernement du Québec, 2017b). • Failure to file and get the approval of a reclamation plan is subject to a fine up to $500,000 for an individual and $3 million for a corporation. The previous maximum fines were $3,500 in the case of an individual and $6,975 in the case of a corporation (Piette, 2014).

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Endnotes

[i] A settlement fund was also created by a number of companies implicated in the disaster, but it is focused on compensating for personal injury and property damage (Bernstein Shur, 2015). The majority of the derailment's environmental costs will be borne by society.

[ii] In contrast, some environmental harms are expected and authorized. For example, a manufacturing facility might emit particulates, sulphur dioxide, nitrous oxides, or volatile organic compounds. These pollutants can cause significant harm — including adverse impacts on human health — in sufficient concentrations. Yet policy-makers accept that some air pollution will occur and aim to limit and control the pollution (as opposed to eliminating it) so as to manage the environmental damage without stopping the related industrial activity (e.g., in Sarnia, home to Ontario's Chemical Valley, air pollution is subject to provincial emissions controls and federal ambient air quality standards (Government of Ontario, 2015; WHO, 2016)). Still though, concerns about air quality remain, and the provincial government has recently pledged to fund a study of the health impacts of local air pollution on Sarnia residents (Jarvis & Russell, 2017).

[iii] In this way, compensation is a distributional principle: It is about who pays the cost of a harm. In many cases, firms may object to having to having to bear the full costs of their environmental damage, arguing that these new costs represent too large a burden. However, it is important to remember that these costs are not new; rather, they are existing costs that are being shifted away from society (Boyd, 2001).

[iv] This type of strategic corporate structuring is a common driver of privately caused environmental harms leading to social costs (Mackie, 2014; Faure, 2014; Boomhower, 2014).

[v] The $1 billion liability also applied to offshore Arctic oil. However, in 2016, the Canadian government placed a moratorium on drilling in the Arctic (Government of Canada, 2016b).

[vi] In specific cases, policy-makers might choose to manage risk *by* eliminating it. Some types of risk (or levels of risk) might simply be unacceptable to policy-makers or the public. In particular, uncertainty or fat-tailed risk might cause a jurisdiction to block a potential project or to issue a moratorium against a certain activity. See Section 3.3 for a discussion of the significance of uncertainty and fat-tailed risk.

[vii] Governments sharing firms' environmental risk is an implicit subsidy (Strand, 1994). Subsidizing risk creates a situation of moral hazard that can increase the risk of environmental damage and associated economic costs. Further, when damage does occur, risk sharing means that a portion of cleanup costs and compensation toward affected parties must be paid out of government tax revenues — taxation that also carries an economic cost. As a result of these drivers, when governments subsidize firms' environmental risk in the absence of a sound rationale for doing so, the costs can exceed the benefits.

[viii] To help ensure compliance with regulations, legislation will often grant government the authority to issue regulatory fines. For example, in 2013, the federal government amended the Fisheries Act to increase maximum corporate fines for violations of the act to $6 million for first-time offenders and $12 million for second-time offenders (Brown, 2013).

[ix] In addition to assigning liability for environmental damage, liability rules can also channel it in different ways. For example, legislation could make a company's directors and officers personally liable for a particular type of environmental harm. Or it could hold firms "jointly and severally" liable for a given harm — either horizontally (to other firms in the sector) or vertically (to other parts of the industrial value chain) (Monti, 2002; Faure, 2016; Mutcheson, 2017).

[x] A tort, in common law jurisdictions, is a civil wrong in which an injurer (the "tortfeasor") is held to compensate an injured party for loss or harm that it has caused. Precedent and case law is used to establish the tortfeasor's liability toward the injured party and to award damages. In civil law jurisdictions, torts do not apply, and liability is instead based on a system of codified rules that define parties' legal obligations to each other. Quebec is the only province in Canada governed under civil law. One example of a tort being used to recover the cost of environmental damage is Midwest Properties Ltd. v. Thordarson, where the Court of Appeal for Ontario awarded damages to the plaintiff for contamination on its property caused by leaching waste that originated on the defendant's property (Midwest Properties Ltd. v. Thordarson, 2015).

[xi] Financial assurance reduces environmental risk not only by changing the incentives firms face in managing their operations, but also by providing a screening function. When financial assurance instruments efficiently price environmental risk, some particularly high-risk projects might no longer be economically viable. When these projects do not go ahead, the total risk of environmental damage falls. This might reduce economic activity, or it might not: Firms might respond by withdrawing projects altogether or by putting forward less environmentally risky ones.

[xii] Financial assurance can support economic activity by minimizing the cost of improving deterrence and compensation outcomes. It will usually not bolster economic activity since financial assurance typically adds costs. However, to the extent to which financial assurance can substitute for cost recovery via expensive civil litigation, it may lower costs overall, and thereby increase economic activity (Ben-Shahar & Logue, 2012; Mackie, 2014).

[xiii] *Criminal intent* is the least stringent standard in this context. A chemical company operating under a criminal intent liability standard would be liable for contamination only if government (or a private plaintiff) could prove that the company had caused the contamination intentionally and did so in knowing contravention of the law. Criminal intent is a relatively uncommon standard in liability rules dealing with environmental damage.

[xiv] However, even a negligent firm may not be fully liable for damage in situations of "contributory negligence" — when the negligence of an injured party (in this case, some member of society) contributes to a harm's occurrence or severity. In these cases, society may bear a portion of the costs of a harm. However, because it would be culpable in it, its costs would not count as "social costs" in the sense the term is used in this report. Situations of contributory negligence are therefore not considered liability gaps.

[xv] "Due diligence" is a legal obligation to adhere to a standard of care when performing an act that could harm others. For regulatory offences, the standard for due diligence is determined by a combination of factors, including applicable regulations and industry standards. This is more or less the same analysis as applied in tort suits, where the court must determine the applicable standard of care. In both contexts, courts can use standards provided by regulations or legislation to determine whether a firm took "reasonable care" (this term is used in both contexts) but are not limited to them. For example, they may consider whether air pollutants from a firm's steel mill exceeded concentrations laid out in regulatory statutes, or they might focus on whether the firm implemented available, reasonably-priced technologies to mitigate air pollution from the steel mill (i.e., regardless of what regulations might have called for). Once the standard of care is established, the court must determine whether it was breached. If a firm can be shown to have breached the standard, it will be liable; otherwise, it will not. For example, in the 2002 case of R. v. MacMillan Bloedel Ltd., a ruptured pipe released toxic substances into a creek in British Columbia, a violation of the Fisheries Act. But because the leak was caused by corrosion that was not foreseeable, the B.C. Court of Appeals ruled that the MacMillan Bloedel had exercised due diligence and was not liable (Her Majesty the Queen, 2002).

[xvi] This liability cap will be effective as of 2020. Canada's *Nuclear Liability and Compensation Act* has set liability at $650 million starting in 2017, increasing to $1 billion by 2020 (NRCan, 2017c).

[xvii] In *The Supreme Court's Canfor Decision: Losing the Battle but Winning the War for Environmental Damages*, Elgie and Lintner (2005) discuss the Canfor case, in which the Government of British Columbia sought damages from Canadian Forest Products Ltd. ("Canfor") for causing a fire that burned a large area of public forest, including environmentally sensitive areas. While damages were not awarded, the case set an important precedent for Canadian governments seeking damages for environmental harm (Denstedt & King, 2014). However, to date, no provincial government has attempted to use this precedent in a civil suit seeking damages for environmental harm.

[xviii] Canada is the relevant jurisdiction in this context, since liability would typically follow a firm that moved from one Canadian province or territory to another. Where international agreements permitted, Canadian governments may be able to hold a firm or its owners liable despite their having left the jurisdiction. Where this was not the case, the firm may be able to escape its liability.

[xix] There are some exceptions to this principle, including that a shareholder may lose limited liability if they have acted fraudulently.

[xx] In 2015, a small Alberta-based oil and gas company called Redwater Energy went bankrupt. A legal dispute soon followed between the government-run Alberta Energy Regulator (AER) and Orphan Well Association (OWA) and ATB Financial, a bank that was owed $5 million by Redwater. Grant Thornton, the trustee and receiver liquidating Redwater, wanted to sell Redwater's producing wells and renounce the non-operational ones, making them the responsibility of the OWA. The AER and OWA contended that buyers of the assets should also receive the liabilities and sued in 2016. The court sided with the receiver, but AER and OWA appealed to the Court of Appeal of Alberta, which upheld the decision.

[xxi] The cap is in nominal terms — it does not rise with inflation. Liability under the cap is absolute. In cases of negligence, the cap is lifted (Government of Canada, 2015b).

[xxii] Uncertainty can also cause policy-makers to *misjudge* how much financial assurance is needed to protect against social costs. For example, a regulator might believe that it has required enough financial assurance to appropriately limit the possibility of social costs associated with methane leaks in the oil and gas sector. But if, due to uncertainty, the regulator fails to appreciate key drivers of environmental costs, financial assurance may be insufficient. Researchers at the University of Guelph have recently shown methane to be more mobile in groundwater — and thereby, more environmentally consequential — than was previously understood (University of Guelph, 2017). As a result, the environmental cost of methane leaks from the oil and gas sector may be underestimated, and any financial assurance required from firms in the sector wrongly calibrated. In this way, the uncertainty surrounding methane's environmental impacts may have increased the probability that society will bear a portion of firms' environmental costs.

[xxiii] Firms are allowed to deduct QET contributions from their income, and earnings within the trust are taxed at corporate rates, not the higher trust rate. Firms are also able to deduct expenses related to reclamation, which can offset the costs of withdrawals made from the trust (Dixon et al., 2012).

[xxiv] As an alternative to a guarantee, a parent company might also form a *captive insurance* company to insure its subsidiaries' risks. This option is similar to a guarantee except that it involves the collection of premiums from the subsidiary. This can be an attractive option for large firms with a multitude of projects or numerous lines of business (Nevius, 2013). For a general discussion of insurance, see Section 4.3.

[xxv] In cases of fat-tailed or uncertain risks, insures will sometimes co-insure (i.e., provide coverage against a particular risk as a group). Co-insurance arrangements pool risk across insurance companies and can provide firms with coverage that might otherwise be unavailable in the market (Dana & Wiseman 2015; Faure, 2007b).

[xxvi] This risk differs across types of third party. Bankruptcy is highly improbable for Canadian banks, since the Bank of Canada acts as a lender of last resort. Insurers commonly *reinsure* themselves, providing a coverage backstop (reinsurance is insurance for insurance companies that protects them against the full financial cost of catastrophic events); therefore, their risk of default is also low (but not zero). The risk of capital providers defaulting is more significant (Bougen, 2003; Kelly, 2016).

[xxvii] It is not possible to generalize about how sector-level assurance's costs will compare to third-party assurance's. If third-party assurance was also able to pool risk across the entire sector, then the two instruments — assuming they provided equal coverage — would be comparable. However, firms might pay lower premiums under sector-level assurance, by virtue of the fact that sector-level schemes are commonly not-for-profit. Alternatively, they might pay lower premiums under third-party assurance, by virtue of the fact that these schemes can pool risk across sectors, and the fact that the costs of coverage might fall as third-party intermediaries compete to provide it.

[xxviii] A public fund that was funded out of government's general revenue would qualify as a simple backstop; for our purposes, this would not be a financial assurance instrument, since it would receive no direct funding from the sector. Because government would simply be earmarking funds against potential future social costs, the scheme would qualify as fiscal policy, rather than financial assurance.

[xxix] The National Orphaned and Abandoned Mines Initiative (NOAMI) — an interprovincial body formed by governments, non-government organizations, Canada's mining sector and First Nations — explores policies to limit the problem of companies walking away from their reclamation obligations. Some orphaned or abandoned sites are very old, predating legislation and regulations that would have required cleanup, but others are more recent. For example, due to financial trouble, Shear Diamonds vacated Nunavut's remote Jericho diamond mine over a single weekend in 2013. The company performed basic cleanup over a 48-hour period and then flew out its entire staff, disconnected its phones, and shut down its website. Nunavut's regulators learned of this only the following week. Jericho is now a federal contaminated site. The federal government will likely bear part of the costs of the mine's reclamation. Shear was required to post $3.4 million in financial assurance, but at least $1.4 million was outstanding at the time of abandonment (CBC News, 2013; Morgan et al., 2013).

[xxx] Mining licences typically require firms to remediate and reclaim a mine at the end of its life (i.e., they have a *legal obligation* to deal with onsite contamination). If a firm did not perform this remediation and reclamation and government was forced to, then the firm would become liable for the costs. However, even though firms would be fully liable at this time, they may not bear the cost of remediation and reclamation if they are judgment proof (liability gap 5).

[xxxi] Punitive fines issued under regulatory statutes will often be capped at a particular level. However, mining firms' liability for environmental damages is not capped in any of the five jurisdictions evaluated.

[xxxii] Yukon is home to Faro Mine, one of Canada's most expensive abandoned sites. Reclaiming it will cost an estimated $500 million. Faro was abandoned in 1998, prior to the implementation of Yukon's devolution agreement. Its abandonment has been influential in shaping its post-devolution financial assurance policy regime (Croft, 2017).

[xxxiii] In general, financial-assurance requirements will be more easily met by large and well-capitalized firms. As a result, increasing the stringency of financial-assurance requirements can tilt the playing field in favour of large firms or encourage consolidation. To the extent that policy-makers value the role that small firms play in a sector, this can be a weakness of more stringent financial-assurance policy (although there are ways to mitigate it). However, this change in industry structure can be economically efficient: only those firms that can afford the cost of the risks they impose will remain, and both deterrence and compensation will improve (Boyd, 2001; Viscusi & Zeckhower, 2011; Dana & Wiseman 2015; Boomhower, 2014; Dachis et al., 2017).

[xxxiv] Overall, Quebec's reforms do not appear to have significantly affected the competitiveness of its mining sector. In its most recent annual mining survey, the Fraser Institute ranked Quebec the sixth most attractive for investment out of 91 jurisdictions surveyed – the second highest in Canada. Quebec has ranked in the top 10 for eight of the last 10 years. Mining investment grew by 3% in 2016 and 18% in 2017. While overall investment is still down 41% from its peak in 2012, Canada-wide investment has fallen by 56% over the same time period (McMahon and Cervantes, 2011; McMahon and Cervantes, 2012; ISQ, 2017; Jackson and Green, 2017; NRCan, 2017a; NRCan, 2017b; Stedman & Green, 2018).

[xxxv] In such cases, governments would also have access to remaining onsite reserves. This is — arguably — an additional, soft type of assurance that in some cases might allow governments to avoid social costs stemming from the mine's non-remediation by its owner. Where a prospective new owner thought it could earn a sufficient return from remaining reserves, it might take over operation of the mine. In cases where this new owner performed eventual remediation at the site, society would not bear the cost. However, where this does not occur (or where the new owner also becomes judgment proof), society will bear the cost. For example, the owner of Saskatchewan's Gunnar Mine walked away in 1964 after operating for nine years. The open-pit uranium mine was flooded, leaving behind four million tonnes of tailings. In 1990, the site's mining and surface rights lapsed and the provincial government took control of the site. Reclamation will continue for several years, with a total estimated cost of $268 million (NRCan, 2016a; MacPherson, 2018).

[xxxvi] Another key uncertainty associated with long timeframes can be found in how financial assurance is collected against long-term or perpetual environmental costs (e.g., AMD). To determine the right amount of financial assurance to require against these costs, governments need to calculate a Net Present Value (NPV). For government to cover its costs, the funds collected from the firm in the amount of the NPV must earn a real rate of return that exceeds the discount rate used in the calculation. This means that if government does not realize a post-inflation rate of return on the invested funds that exceeds its selected discount rate forever it will bear significant costs. However, returns on investment decades into the future — let alone centuries — are highly uncertain.

[xxxvii] New Brunswick appears to be an exception. It requires oil and gas companies to post financial assurance to cover industrial accidents and contamination of drinking water. These regulations were in place prior to New Brunswick's moratorium on hydraulic fracturing in 2014 (Government of New Brunswick, 2012).

[xxxviii] Western Australia's *Mining Rehabilitation Fund* (MRF) is a pooled fund designed to cover the rehabilitation of abandoned mines where the licence holder or operator fails to meet their end-of-life obligations. Any firm with reclamation expenses exceeding $50,000 must contribute. The interest generated by the MRF covers its administration costs, with surplus directed toward the rehabilitation of legacy abandoned mine sites throughout the State. The target is to establish a fund of $500 million (Government of Western Australia, 2018).

[xxxix] The Mining Association of Canada's *Tailings Management Protocol* is a series of performance indicators, policies, and controls that mining companies can use to ensure that they are managing their tailings storage facilities in a safe and environmentally responsible manner. Use of the Protocol is mandatory for the Mining Association of Canada's members. The protocol is rated as one of the most comprehensive frameworks available internationally and is taken to be a useful proxy for compliance with good practice (Golder Associates, 2016; MAC, 2018).

[xl] "Securitizing" risk involves packaging a scheme's risks in a financial product and making them available for sale in financial markets. Environmental risk securities are not prone to the business cycles that many other types of securities are. As a result, they can be an attractive way for financial investors and institutions to diversity their portfolios. Risk securitization can be carried out by third parties, sectors, or governments. On the other hand, when government acts as a "reinsurer of last resort," it provides reinsurance to a third-party or sector-level scheme that the private sector will not. In exchange for a regular premium, the government reinsurer agrees to compensate these schemes in the event their costs exceed a given threshold. This helps facilitate higher degrees of coverage from third-party or sector-level solutions. By pricing premiums for this reinsurance above an actuarially fair level, the government can aim to eventually price itself out of the market: If a willing third-party reinsurer eventually comes along, it will be able to offer lower-cost premiums than the government scheme. This can help to facilitate a private-sector reinsurance solution (Pollner, 2001; Bougen, 2003; Kunreuther 2015; Faure, 2016).

[xli] This risk pooling will be most effective when it is cross-provincial. However, this is made complicated by the fact that mining is provincially regulated in Canada: mining firms or policy-makers may be reluctant to share risk with a jurisdiction they perceive to have a higher risk profile. Risk-differentiation of premiums can help with this, but only up to a point. To facilitate significant cross-provincial risk pooling, greater harmonization of regulations and safety standards may be needed. The potential benefits of risk sharing might help to incentivize provinces to undertake this harmonization. Not only would this facilitate more cost-effective risk pooling, it would also limit the scope for Canadian provinces to compete for investment with each other on the basis of their regulatory regimes. This would help avoid a "race to the bottom" in mining regulatory standards in Canada — an important additional benefit.

[xlii] While financial assurance can help inform environmental assessments, it cannot substitute for them, since environmental assessments consider much broader issues. However, financial assurance can help reduce the risk of proposed projects and screen out particularly high-risk ones by ensuring that project proponents bear the cost of the risks they pose and limiting the extent to which they can pass their environmental costs to society.

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