CHAPTER 10

The Giant Mine's Long Shadow

Arsenic Pollution and Native People in Yellowknife, Northwest Territories

JOHN SANDLOS AND ARN KEELING

In a report from 2002, Canadian government economists Warwick Bullen and Malcolm Robb reviewed the production history of three major gold mines near the small northern Canadian city of Yellowknife: Con (1938–2003), Discovery (1950–68), and Giant (1948–2004). These mines, the reader learns, contributed an estimated 13.5 million ounces of gold and employment for Yellowknife citizens over sixty-five years of operation. Of these, Giant mine was the largest producer in the Northwest Territories, generating just over 7 million ounces of gold and just over $3.3 billion (adjusted to 2013 values) over the mine's life. Despite the fact that all the mines have now closed, Bullen and Robb suggest that Yellowknife's gold mines represent an example of sustainable development, because private wages flowed through the economy and because the generation of public wealth with mining taxes and royalties built more enduring infrastructure such as roads, schools, and hospitals.[1]

What this accounting failed to acknowledge, however, was the massive environmental and economic legacy of arsenic contamination at Giant mine (and to a lesser extent Con), an omission that neglects the fact that these gold mines caused low-level and sometimes acute poisoning of Yellowknife and nearby Aboriginal communities for more than a half century. Beginning in the late 1940s, the highly toxic compound arsenic trioxide traced a pathway outward from the mines via the tailings ponds and roaster stacks at Con mine and Giant mine. Falling from the air as a light dust or leaking as slurry from tailings ponds, the arsenic

dispersed through the region's rivers, streams, lakes, air currents, and surface soils, eventually working its way into the bodies of fish, terrestrial wildlife, plants, and humans. Although the arsenic represented a danger to the entire Yellowknife population, the toxic fallout from the mine represented a particularly dire threat to the Yellowknives Dene First Nation, located adjacent to Yellowknife, because the poison was deposited on local berries and vegetables and also in snow used as a water supply in winter. By 1951, several cases of acute arsenic exposure prompted a public health campaign over the following twenty-five years to reduce arsenic levels in the local environment and within the bodies of individuals to so-called safe threshold level values (TLVs).

If these pollution control efforts reduced acute water and air pollution problems in the short term, the techno-fix approach that was adopted produced additional problems in the long term through the disposal of arsenic trioxide dust. In 1951, Giant mine began to pump arsenic dust collected in a Cottrell electrostatic precipitator (ESP) into mine chambers, placing 237,000 tons of the material underground by 2004. This created the potential for massive toxic seepage as water tables began to rise and permafrost failed to reestablish itself (as mine officials had originally hoped). Currently the federal government's Indigenous and Northern Affairs Canada (INAC) is undertaking a remediation program involving surface restoration and the freezing and stabilization of underground arsenic. For the Yellowknives Dene, the remediation program has raised profound issues not only about the perpetual care issues associated with the so-called frozen block method of stabilization, but also about the historical environmental injustices associated with gold mining in Yellowknife.[2] These legacies of arsenic pollution at Giant mine run counter to the triumphal tone of local Yellowknife histories and commemorative activities equating gold mining with the advance of modern civilization in northern Canada.[3]

In a broader context, the history of arsenic loading at Yellowknife resonates with environmental histories of industrial mining and pollution at other sites in North America. The long struggle for adequate pollution control at Giant mine reflects the weak regulatory regimes surrounding mining pollution generally in Canada, the United States, and Mexico before the 1970s. Fearful of jeopardizing jobs and investment, state, federal, and territorial governments tended to accommodate industrial interests and addressed pollution problems only when forced to do so by the courts, cross-border disputes, or catastrophic pollution episodes.[4] For its part, the industry responded to environmental

regulation with political and legal resistance and, when pressed to deal with pollution, turned to "technological fixes" that often deferred or displaced contamination rather than preventing it. Timothy LeCain's work on the limits of environmental technologies such as the Cottrell ESP (which may remove toxic particulate matter such as arsenic from the air, but then produces new problems associated with the disposal of the collected material) finds ample reinforcement in the chambers under Giant mine containing thousands of tons of arsenic dust.[5] The critique of the techno-fix approach highlights both the politics of regulation surrounding industrial pollution and the persistent materiality of contaminants generated by industrial mining and dispersed into local human and animal bodies and environments.[6]

Another key element in this story, common to North American mining controversies, was the contested knowledge surrounding environmental pollution and human exposures. The works of several historians, principally Linda Nash and Nancy Langston, but also many of the contributors to forums on the historical dimensions of industrial toxins in the journals *Environmental History* and *Osiris,* have pointed to the historically constructed nature of scientific knowledge within the fields of toxicology and public health.[7] In particular, they have argued that the public health responses to crises analogous to the arsenic problem in Yellowknife have been bound up with the idea that science can determine safe TLVs for toxic loading in individuals and safe levels of toxins that can be consumed in food and water. These determinations ignore the complex interactions of bodies with the full panoply of chemicals in ecosystems and fail to account for the effects of chronic low-dose exposure to toxins over long periods of time.[8] More recently, historians Brett Walker and Joy Parr have expanded this discussion of toxic histories beyond the application of science to the issue, instead emphasizing the importance of sensory experiences such as pain or, in Parr's case, shifting soundscapes and smells that accompany human encounters with industrial development.[9]

All of these themes are clearly echoed in local perceptions of disease and sickness within bodies and local landscapes in Yellowknife. Nonetheless, the issue of arsenic pollution in Yellowknife finds its most relevant frame outside the field of environmental history, within the political ecology and anthropology literature tracing the environmental injustices and colonial dimensions of mining on indigenous lands throughout the globe.[10] Although much of this literature focuses on the developing world, broadly similar processes of "industrial colonization" are evident

in the recent history of mining-induced landscape and economic change in the Canadian north.[11] Indeed, the story of gold mining at Yellowknife is important precisely because it illustrates how industrial polluters have served as agents of colonial dislocation and dispossession in hinterland environments, appropriating local land and water as an industrial pollution sink and transforming the material subsistence base of Native communities into a threatening and hazardous landscape.

MINING GOLD AND POISON

In the 1930s, the Yellowknife Bay area became the epicenter of the second gold rush to hit Canada's territorial North, after the Klondike rush of the 1890s. The conservative mindset of Depression-era capitalists had created a high demand for gold, one of the only secure investments—and stable mining sectors—during this period of global economic upheaval. The Yellowknife region in the Northwest Territories (see fig. 10.1) was even more remote and difficult to access than the Klondike, however, with the former's gold deposits inconveniently encased in hard rock rather than fluvial deposits. Thus, from the very beginning large companies dominated gold production rather than hordes of individual miners. The result was industrial-scale mines that, due to the expense and difficulty of transport, contained processing facilities on site that completely transformed solid rock into finished gold bricks.

In 1935, Canadian government geologists discovered gold on the east side of Yellowknife Bay, and the Canadian mining giant Consolidated Mining and Smelting (CM&S, later known as Cominco) staked a large series of claims in 1936 near the shores of Great Slave Lake and quickly opened the Con mine (with the adjacent Rycon property forming part of the same operation) in September 1938. A new company, Negus Mines Ltd., opened a mine of the same name one year later adjacent to Con. In 1935 two prospectors with Burwash Yellowknife Mines staked the first twenty-five Giant claims. After a lengthy period of exploration and development, the new company, Giant Yellowknife Gold Mines, Ltd. (GYGML), began full production of gold at the head of Yellowknife Bay in May 1948.[12]

Arsenic pollution did not present a problem during the earliest years of gold production at Yellowknife. At Con and Negus, the first exploited ore bodies contained no arsenic, and the companies used the common process of dissolving gold in cyanide and separating the solution from the surrounding waste rock. In 1940, however, miners at Con discovered

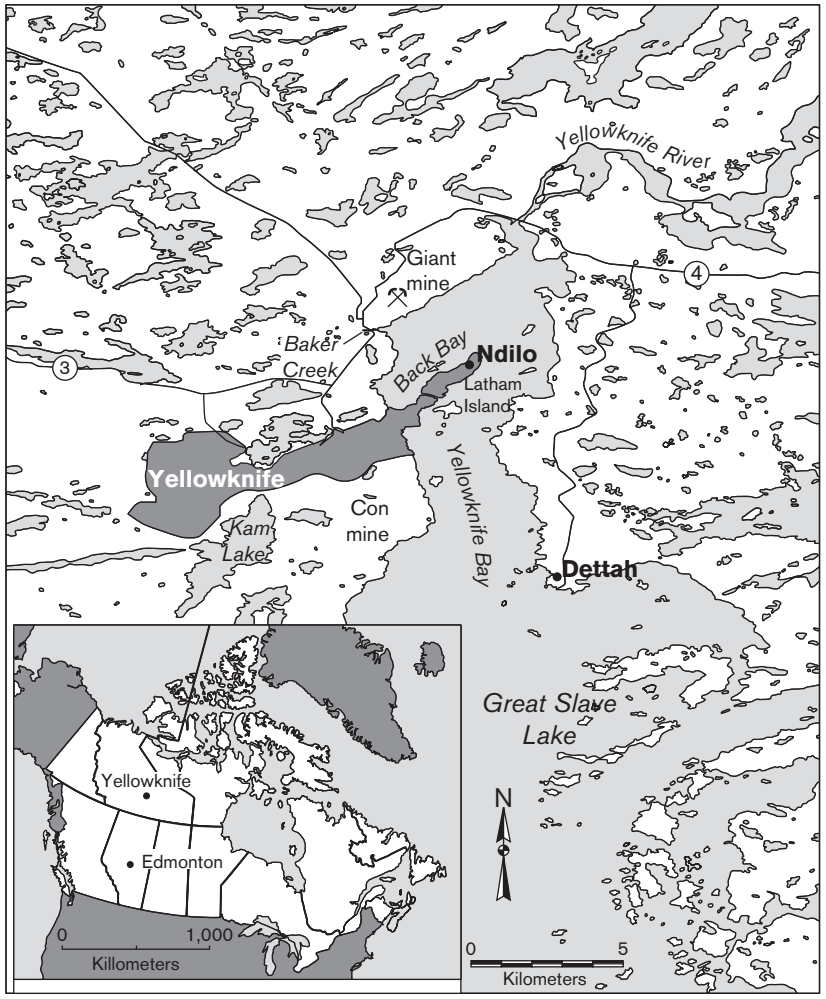

FIGURE 10.1. The mines, settlements, and water bodies around Yellowknife, Northwest Territories. Map by Charlie Conway.

gold within arsenopyrite formations, a type of ore in which sulfides prevent the cyanide from accessing the gold and leaching it from surrounding material. To burn off sulfur, such ores require roasting at extremely high temperatures (usually above 260 degrees Celsius) prior to cyanidation. The roasting process also produces the highly toxic compound arsenic trioxide in the form of a fine white dust that condenses as it cools.[13]

FIGURE 10.2. Aerial view of the Giant mine headframe and buildings in Yellowknife, Northwest Territories, 1955. Courtesy of Busse/NWT Archives/N-1979–052–1947.

By the late 1940s the city of Yellowknife and its environs were sitting on a ticking arsenic pollution time bomb. The roasting facility at Con mine, shut down in 1942 due to wartime restrictions after only six months of operation, was reopened in 1948. One year later, GYGML opened a roasting facility at the new mine and began to send arsenic dust into the air around Yellowknife. Although the mining companies did not formally monitor emissions from the roaster stacks until 1954, a government report from the 1960s estimated total arsenic dust output at Con and Giant at 22,000 pounds per day between 1949 and 1953. While Con Mine had a higher mill capacity than Giant at this time, arsenic emissions at Giant accounted for the lion's share of this total (approximately 16,500 pounds per day) because 100 percent of its gold deposits were contained in arsenopyrite ore, while only 20 percent of the ores at Con required processing in the roaster. Regardless, in their rush to process gold as quickly as possible, both gold mines sent arsenic dust up their roasting stacks without any pollution control equipment, Con from 1948 to 1949 and Giant from 1949 to 1951.[14]

Arsenic was hardly a new poison in the late 1940s. Although much of its popular notoriety comes from its history as a murder weapon, it also caused sickness and death within many nineteenth-century homes

in Europe and North America due to its use in the pigmentation of wallpaper. By the early twentieth century, arsenic pollution was a focal point for disputes over the impact of smelter smoke from large-scale facilities such as the Washoe smelter in southwestern Montana. More recently, wells contaminated by arsenic from surrounding rock in South and Southeast Asia have provoked broad-scale public health crises and campaigns for safe drinking water.[15]

The health impacts of arsenic exposure depend in part on the dose ingested. We know that arsenic trioxide kills quickly with a single dose of 70–180 milligrams. Short-term exposure to levels just below the lethal threshold may cause abdominal pain, muscle pain, vomiting, diarrhea, skin rashes, burning or tingling feelings in the extremities (paresthesias), and thickening of the skin in hands and feet (keratosis). Lower-dose exposure over longer periods of time (over ten years) may also cause black spots to appear on the skin (hyperpigmentation). Long-term exposure to arsenic may also produce nausea and diarrhea and disrupt normal heart rhythm and blood vessel circulation, as well as brain and kidney function. It may also produce potentially fatal bladder, liver, skin, and lung cancers. The human body has some defenses against arsenic: it is absorbed only through ingestion of contaminated water, food, or dust and cannot be absorbed through the skin while swimming or being exposed to dust. Human bodies can also jettison the material over time through urine and sweat, and it does not readily bioaccumulate, limiting risks from eating fish and terrestrial mammals exposed to arsenic. Although the United States and Canada have designated a concentration of 0.01 parts per million (PPM) as a safe level of arsenic in drinking water, recent studies of the long-term exposure risks suggest that a value of zero is the only safe threshold level.[16]

In Yellowknife, the 11 tons of untreated arsenic dust emitted from the Giant and Con roasting stacks each day in 1949 spread widely with even the lightest breezes. When it settled in water, the arsenic was readily soluble in its compound form of arsenic trioxide, posing potential health risks to all organisms that lived in or drank from a contaminated water source. It also settled on soil and snow, concentrating particularly well on the latter during the long winter months because there was no rainfall to wash it away. In spring, meltwater suddenly mobilized months of accumulated arsenic, contaminating local waterways with dangerous levels of the toxin. Poor tailings management at Giant and Con compounded water pollution problems, as archival documents suggest several spills of arsenic-laden slurry and waste rock into Baker

Creek, Great Slave Lake, and other, smaller water bodies in the 1950s and 1960s. Arsenic trioxide dust also inevitably settled on local food sources, including berries, vegetables, and the leafy browse and grasses favored by wildlife.[17]

The impacts of such intensive arsenic loading in the Yellowknife area became apparent almost immediately in the late 1940s. In 1949 two workers at the Akaitcho mine exploration site just north of Giant mine received treatment in hospital after using melted snow as drinking water.[18] The most acute human health issues occurred at the Yellowknives Dene settlement on Latham Island (now called Ndilo). This community is located across a narrow channel to the northwest of Yellowknife's Old Town and, when winds blew out of the north, directly downwind from the Giant mine roaster stack. While not officially a Native reserve, the congregation of Dene on Latham Island reflected discrimination by local non-Native settlers who objected to Native people moving into town.[19] Another settlement, located on the east side of Yellowknife Bay at Dettah, predated the town of Yellowknife as a seasonal camping site, but became one of the two main Native settlements when the Yellowknives Dene were pressured to settle permanently after 1959.[20] These communities remained unserviced long after sewerage and water supplies were provided to Yellowknife proper in the 1940s (at a new town site, located farther from the mine), and residents relied on polluted snow and lake water rather than municipal supplies.

The location of these underserviced Dene communities proved dangerous, even deadly, in the face of widespread arsenic pollution. In April 1951, arsenic deposition from the gold mines killed a two-year-old Dene boy on Latham Island. A coroner's inquest ruled that the boy had died from "acute gastroenteritis caused by arsenical poisoning administered by unknown means."[21] Subsequent reports clarified the precise cause of death. Superintendent of Indian Affairs I.F. Kirkby reported that the boy had died from contaminated drinking water.[22] The minutes of a meeting of government officials held in June 1951 to assess the arsenic situation suggest that inspectors of the Department of Resources and Development had noticed large concentrations of arsenic in snow in the Yellownife area, "particularly at the northern end of Latham Island." The inspectors contacted Dr. O.L. Stanton, the Yellowknife medical health officer, who placed advertisements in the local paper (*News of the North*) and signs around the area warning people to be cautious with their use of water during spring runoff. The Yellowknife Indian agent had previously warned the local chief of the arsenic danger,

but government officials at the June 1951 meeting suggested that "in spite of these precautions certain Indians living on the north end of Latham Island used the water in the vicinity, with the result that a number of them had to be given hospital treatment and one died."[23]

This was a fairly transparent attempt on the part of government officials to deflect blame from the mining company and local health officials. It is not clear how the Yellowknives Dene were supposed to respond to the posted warnings and determine which sources of water were dangerous, especially since arsenic is tasteless and odorless. Barriers of literacy and language (at least some Yellowknives elders did not speak English fluently) also likely reduced the effectiveness of the local advertising campaign, as did its limited scope. Through all of 1951, for example, only five small advertisements appeared in the back pages of the *News of the North*. In addition, the release date of April 6 for the first advertisement likely came far too late for a community that had undoubtedly melted snow as a water source all through the long Yellowknife winter. Remarkably, the local press published no news stories on arsenic poisoning or the death of the young Dene boy in 1951, failing to inform the public of the severe health crisis in its community.[24] Giant Yellowknife Gold Mines, Ltd. did not completely absolve itself of responsibility for this crisis, however. In August, the mine compensated the family of the boy who had been poisoned with $750 for the loss of their son.[25]

Existing records do not make clear how many other Yellowknives Dene were sickened by arsenic after April 1951. Nonetheless, a November 1953 memo describes one additional possible case associated with an "indigent Indian" named Henry Lafferty. In 1977 a Yellowknife doctor, recalled treating a "middle aged Indian" in winter 1957–58 for several arsenic-related anemia and skin conditions.[26]

The severity of arsenic pollution around Yellowknife can also be traced through local ecological changes and impacts on domesticated animals. A Yellowknives Dene community history refers to elders' stories about sled dogs, cattle, and chickens dying in large numbers during Giant mine's early years. In retrospect the elders believe the animals died from drinking water contaminated with arsenic.[27] Oral histories that focus on Yellowknife's gold-mining glory days contain very little discussion of arsenic, but some testimony supports the Yellowknives' observations of animal mortality and suggests at least some formal medical study of the issue stemming from a legal dispute. Laurie Cinnamon recalled that her father's horse team died in spring 1950 because it "got arsenic poisoning from drinking the spring run-off water lying

about in puddles."[28] Similarly, Barbara Bromley remembers that fresh milk deliveries came to an end in 1951 because "they [the cows] died and I think he had an investigation and stated that they were poisoned by arsenic and that Cominco was to blame. I don't remember the outcome, although I believe there was a court case."[29] Helen Kilkenny, a farmhand at the Bevan family farm from 1947 to 1951, similarly describes the "hard luck" that plagued the farm a result of arsenic: "We watered the cows from Kam Lake about 500 yards from the barn. In winter we would cut a hole in the ice for the cows to drink. In the summer the cows would feed along the road and in the grassy places in the rocks. But after four years the cows got arsenic poisoning and they all died."[30] These incidents raise questions about the effectiveness of warning signs and advertisements. Government officials clearly identified Kam Lake as an arsenic hot spot at a June 1951 meeting, a situation that arose because CM&S officials had admitted to previously dumping arsenic-laden slurry from the company's stack scrubbers directly into Pud Lake, which drained directly into Kam. The fact that a local farmer deliberately cut holes in the ice to water his cattle in a water source that industry and government officials knew was contaminated further illustrates the lax pollution control and public information regime regarding the dangers of arsenic in 1950s Yellowknife.[31]

How did federal government and mining company officials respond to the arsenic crisis in Yellowknife? At the previously mentioned meeting in June 1951, A.K. Muir and A.C. Callow, the general manager and secretary treasurer, respectively, of Giant Yellowknife Mines, Ltd., met with a dozen government officials in Ottawa. The discussion focused on a three-pronged approach to mitigating arsenic impacts: continuation of the public information campaign warning about the dangers of consuming local water, fruit, and vegetables; a stepped-up program of testing and monitoring of public water and food sources as well as taking urine samples from humans; and most important, the installation of pollution control technology on the Con and Giant stacks. On the last-named issue, federal officials heavily criticized the impinger (or scrubber) method of pollution control CM&S had developed, noting that because the technology was based on cleaning the arsenic gas with water spray, the resulting contaminated slurry might leak from containment ponds and pollute local water sources, including Great Slave Lake. Government officials, along with Chief Medical Officer Stanton, were unanimous in preferring Giant's proposed approach—the installation of a Cottrell electrostatic precipitator with the storage of dry arsenic

underground—to Con's wet method.[32] Remarkably, however, Muir reported that, due to shipping delays, his company had not yet installed the precipitator at Giant mine. At the meeting and in subsequent correspondence, government officials expressed only mild concern, and the Cottrell ESP was not operational until October 29, 1951.[33] Giant mine was thus permitted to operate at full tilt for more than six months with no pollution control equipment on a roaster stack that had poisoned a small boy to death and sickened an unknown number of his fellow community members.

Over the next three decades, the efforts of the federal government and the company to contain arsenic pollution remained intermittent at best. Officials reacted erratically to the issue, acting only with the emergence of public controversy and internal scares about spikes in contamination levels, rather than consistently applying program principles. Perhaps the most damning evidence of a lax regulatory regime is the fact that Giant mine's Cottrell ESP was not a particularly effective form of pollution control on its own. Tests from 1954 to 1958 revealed a relatively large percentage reduction in total Yellowknife arsenic emissions from an estimated 22,000 to 7,250 pounds per day due to the installation of a second Cottrell ESP. In absolute terms, however, a large amount of toxic material was still being loaded into the local environment through much of the 1950s, the majority of which originated with Giant mine. The installation of a baghouse (a secondary treatment method that captured arsenic dust in a large filter) at Giant between 1957 and 1959 resulted in a much more dramatic absolute reduction in total arsenic emissions to 695 pounds per day.[34]

Through the 1950s and 1960s, the federal government continued to monitor the impact of arsenic on water and food supplies in the region. Dr. Kingsley Kay, chief of the federal government's Industrial Health Laboratory, led a survey team to Yellowknife to conduct water and vegetable testing in the fall of 1951, while archived results suggest ongoing monitoring to 1960.[35] At the initial June 1951 meeting called in response to the Yellowknife arsenic crisis, federal officials adopted the Canadian standard of 0.05 PPM as the concentration of arsenic considered a safe threshold level for drinking water (this is five times the current threshold level in Canada). If higher concentrations were detected, warning signs would be posted around the contaminated body of water.[36] On a broad scale, the adoption of the 0.05 PPM threshold clearly indicates that federal officials were steeped in the "dose makes the poison" thinking that prevailed at the time, failing to account for or

consider possible harms that might accrue from continued exposure to arsenic over long periods of time.[37]

In any case, the federal government failed to enforce even this standard. Data from the late 1950s reveal consistent spikes in arsenic above the 0.05 threshold for drinking water in Yellowknife and at the mines.[38] In other words, despite the strong rhetoric surrounding pollution control and public health after the crisis of 1951, roaster emissions and tailings spills from the mines into Back Bay resulted in the contamination of the Yellowknife tap water supply with arsenic concentrations above an already–dangerously high threshold level. One retrospective report suggested that the Yellowknife water supply contained arsenic levels above the acceptable limit of 0.05 PPM approximately 15 percent of the time between 1951 and 1960.[39] Similarly, reports from the 1950s and 1960s on arsenic contamination of vegetables and grass samples revealed staggeringly high levels of arsenic contamination, with mean values ranging from 18 PPM to 2,228 PPM over eight years. Federal officials acknowledged that such contamination levels were many orders of magnitude greater than the U.S. Public Health Service–recommended value of 1 PPM.[40] Clearly the installation of the Cottrell ESP at Giant mine failed to prevent the ongoing arsenic contamination of food and water in the Yellowknife area through the 1950s, with tests merely confirming that status quo mining operations continued to poison local residents.

If federal and Yellowknife public health authorities seem to have adopted a relatively passive approach to the arsenic issue through the late 1950s and early 1960s, public health officials nevertheless did begin to focus again on the issue in 1965. One official from the Indian and Northern Health Services Division declared on December 10: "I have recently discovered that the problem of arsenic pollution at Yellowknife is far from solved," based on tests showing 40–50 PPM of arsenic on lettuce and cabbage leaves in the area and on the fact that roaster stacks were still pumping out 300 to 400 pounds of the material every day.[41] Public health officials from across several divisions of the Department of National Health and Welfare called for a study of the issue.[42] Dr. G. C. Butler, the department's regional director, alerted Ottawa to the fact that local doctors were reporting high rates of anemia, an indicator for low-level arsenic poisoning, among female patients who had moved to Yellowknife more than four months previously.[43] Arsenic contamination of the local water supply in Back Bay continued to be a problem through the 1960s, one that public officials tried to solve in 1969 by moving the pipeline intake further upstream from pollution sources to

the mouth of the Yellowknife River.[44] This solution failed to help Native residents of Latham Island and Dettah, who were not connected to the new system. Many continued to collect ice and water from the bay because they could not afford the cost of water trucked to their community. In 1973 Latham Island resident Michel Sikyea wrote to Jean Chretien, minister of Indian affairs and northern development, to protest the fact that the city of Yellowknife had "been after us to pay" for the past few years and had threatened to cut deliveries of trucked water. Sikyea wrote,

> Why should we pay others who poisoned our water? Most of the people in the valley don't get enough welfare to have food; we can't pay $5.00 a month for water too. None of us have the money, and even if we did, we should not be forced to pay for all this trouble. Starting tomorrow people will begin having to drink the water from Yellowknife Bay and soon our people will be sick and maybe some will die again.[45]

The federal government's response to these ongoing concerns about the danger of arsenic was tentative at best, reflecting a tendency to control and limit the flow of public health information. Between 1966 and 1969, Dr. A. J. de Villiers from the Biomedical Unit of the Department of National Health and Welfare led a comprehensive study, but information on results was not forthcoming until 1971, even for other federal officials who made repeated requests for further information.[46] In 1967 a health engineer of the Northern Health Service raised the possibility that current arsenic levels in Yellowknife's water could be carcinogenic, but the director general of medical services suggested dismissively that the claim was based on a single article from the United States, and wrote that "we are unwilling to assume, without some further evidence, that 0.1 ppm of arsenic in the water would be as toxic in a cold climate as in a warm one since in the former the water consumption per capita would be far less."[47] Regional Director Butler replied derisively that there were extensive references pointing to the possible carcinogenic properties of arsenic and that northerners did tend to drink lots of water in the form of tea, coffee, and alcohol with a water mix.[48]

Three years later, Dr. Butler had managed to pry enough information from his department's arsenic survey to determine that rates of contamination on vegetables had declined, but were still in most cases 0.05 PPM to 3 PPM above the allowable limit. Butler threatened to commission an independent investigation of the arsenic situation from a university or a provincial government (one that might actually be completed),

and warned he would issue a public statement informing Yellowknife residents not to eat locally grown vegetables, a move "likely to make headlines."[49] The commissioner of the Northwest Territories requested that Dr. Butler contact the mines to see what preventative action could be taken before making a public statement and "allowing this problem to be blown out of proportion."[50] Two cabinet ministers—Jean Chrétien, minister of Indian affairs and northern development (and a future prime minister), and John Munro, minister of health and welfare—agreed to order Butler to remain silent on the issue. Munro suggested that the large reduction in arsenic levels on vegetables "indicate[s] that the problem is under reasonable and practical control," even if some samples showed contamination rates four times the federal government's own safety standards.[51]

Such attempts at secrecy came back to haunt the federal government in the 1970s, prompting the third wave of public concern about the arsenic issue. One measure of this concern is the large number of angry requests the federal government received for more information on the 1966 survey from the city of Yellowknife, the Indian Brotherhood of the Northwest Territories (a Native advocacy group), and the Canadian Broadcasting Corporation. In 1975 CBC radio's *As it Happens* brought the issue to national attention by suggesting that the results of the de Villiers report had been suppressed, particularly the sections pointing to high rates of lung cancer in Yellowknife due to long-term arsenic exposure and the fact that some Yellowknife residents still used the water from Back Bay.[52] In response to the CBC story, Health Minister Marc Lalonde issued a statement in 1975 claiming that the de Villiers report contained no data on links between arsenic and cancer rates in Yellowknife, but promising to conduct a study on arsenic rates in Yellowknife residents as a precaution.[53] The federal government proceeded with these public health studies in 1975, testing arsenic rates in human hair and urine samples and finding elevated levels only in mill workers at Giant mine, results that public health officials interpreted as a minor localized workplace matter rather than a widespread health issue.[54]

The media sensation associated with charges of a cover-up reflected, in part, the massive shift in Canadian attitudes toward pollution, northern development, and Native rights in the 1970s. As in the United States, the 1970s ushered in an era of environmentalism in Canada, with pioneering groups like the University of Toronto's Pollution Probe bringing issues, such as phosphate loading in the Great Lakes and urban air pollution, to public prominence. Federal and provincial governments

created new environment departments and issued regulations aimed at curbing pollution, including the federal Arctic Waters Pollution Prevention Act (1970).[55] Between 1974 and 1977, Justice Thomas Berger's high-profile inquiry into the proposed Mackenzie Valley Pipeline frequently brought northern Native criticisms of development and environmental destruction to the front pages of Canadian newspapers. During this period, the arsenic issue became another important focus for heightened Aboriginal activism and the increasing concerns of southern Canadians over the environmental impacts of northern development. Almost unique to the case of arsenic at Yellowknife is the fact that environmentalism and Native activism briefly coalesced with the labor and occupational health movements to challenge the federal government's declarations that pollution levels remained safe in the local area.[56]

Indeed, Native and labor groups remained so concerned about the safety of arsenic emissions that they joined forces to produce their own health and environmental research on the issue. In 1975 the National Indian Brotherhood (NIB) conducted a small hair-sampling study of eighteen Native people in the Yellowknife area and arranged for the samples to be analyzed in a laboratory at the University of Toronto's Institute for Environmental Studies. Although high arsenic levels were found in samples from children, the government refused direct requests from the NIB to conduct testing on this seemingly at-risk group. In response, the NIB joined forces in 1977 with the United Steelworkers union and researchers at the University of Toronto to release a comprehensive hair study of local Native children and Giant mill workers. The results showed arsenic rates greater than 10 PPM in 30 percent of the study group and greater than 5 PPM in 50 percent of the samples tested. Robert Jervis, a professor at the Institute for Environmental Studies, suggested that results above 5 PPM were extremely rare in Canada and that none of the samples collected from a control group study in Whitehorse showed arsenic levels above this level. In Jervis's analysis, the NIB and United Steelworkers hair samples "clearly demonstrate a very high degree of exposure to arsenic for Indian children living at Yellowknife."[57]

Health Minister Marc Lalonde faced intense media scrutiny almost immediately after the NIB and United Steelworkers went public with their findings. Not only did his department's previous research efforts come under fire, but accusations of a cover-up persisted because the department failed to release a major environmental study of arsenic in

the Yellowknife area completed in 1975, and because a confidential memo was leaked suggesting that an impending recommendation for dramatic reductions in arsenic levels in air should be kept from the public "as it may cause undue concern."[58] In response to the mounting criticism, Lalonde ordered a new independent study be conducted by the nonprofit Canadian Public Health Association (CPHA).[59] Much of the CPHA's work focused on urine samples from workers and local Native people. After extensive testing, the CPHA concluded that the impacts were largely confined to the workplace; arsenic levels in the general population remained below threshold safety levels. The CPHA's final report recommended ongoing monitoring of arsenic levels, careful washing of vegetables and berries, and the trucking of water to Ndilo and Dettah in winter, with warnings to locals not to use snow as a source of drinking water as studies still indicated high levels of concentration in this source.[60]

If the CPHA's report repeated the federal government's earlier claims that arsenic did not constitute a public health crisis, its release did not blunt criticism and concern. Dr. Hector Blejer, an occupational health expert from the United States who had been appointed as advisor to the task force at the request of the United Steelworkers and the NIB, suggested that the task force focused too narrowly on the threat from short-term arsenic poisoning while ignoring the increasingly well-established lung and skin cancer threat from long-term chronic exposure.[61] The final task force report ignored these criticisms, but the NIB and steelworkers union mentioned them liberally in public comments. The two groups questioned the idea that arsenic levels in Yellowknife were safe, because, as Dr. Blejer had suggested, safe levels simply do not exist for substances that cause cancer.[62]

The arsenic issue at Yellowknife did ultimately fade from public prominence in the 1980s. Official voices had declared that arsenic levels at Yellowknife were safe, while improvements to the arsenic collection technology for water and air emissions produced further dramatic reductions in pollution. At Giant mine, stack emissions fell from 850 pounds per day in 1973 to 29 pounds per day by 1979.[63] Although the substance may be retained in soils for long periods of time, there was a marked decline in arsenic on surface environments. One study indicated an 80 percent drop in arsenic trioxide in snow core samples from 1976 to 1986.[64] Combined with improvements to tailings storage and treatment (including the construction of an effluent treatment plant at Giant in 1981),[65] these results suggest that after nearly three decades, the

federal government finally managed to mitigate the problem of acute arsenic pollution problems in Yellowknife.

Concerns about arsenic resurfaced in the 1990s, however, when Yellowknife environmental activists Chris O'Brien and Kevin O'Reilly requested an investigation of the environmental and health impacts of arsenic and sulfur dioxide from Giant mine under the NWT Environmental Bill of Rights, focusing in particular on the fact that regulators were permitting a known carcinogen to be emitted in close proximity to an urban area. Subsequent investigation concluded that emissions were within safe limits, but the two activists continued to raise concerns about the issue in local media. In the end, the question of arsenic releases into the Yellowknife environment was not solved for good until the Giant mine closed in 2004.[66]

THE AFTERLIFE OF ARSENIC

The controversy over arsenic disposal at Giant mine continues unabated, as the abandoned mine presents a massive contemporary environmental liability. In the early 1950s, Giant general manager A.K. Muir and several government officials were confident that arsenic trioxide dust deposited underground would be contained as permafrost became reestablished in the mine, though Muir suggested that cold air might have to be pumped in to counteract the heat rising from deeper tunnels.[67] Even as mine operations were winding down in the 1990s, it became apparent that permafrost had not reestablished itself and the water table was rising dangerously toward the chambers storing the arsenic dust. Government memoranda obtained by the National Indian Brotherhood in the 1970s revealed mounting concern about the potential mobilization of this highly toxic stored arsenic in groundwater.[68] In 2002 the federal government's commissioner of the environment and sustainable development highlighted Giant mine as one of four abandoned mines in northern Canada where massive public investment was required to clean up severe toxic legacies.[69] Three years later the federal and territorial governments signed an agreement to develop a remediation plan for the site.[70] By 2006 the Department of Indian and Northern Affairs Canada developed a plan involving the use of thermosyphon technology (passive heat exchange using natural convection) to freeze the arsenic underground permanently. After freezing, the site will require ongoing monitoring and maintenance, with water pumped from the mine indefinitely. Such a perpetual-care scenario prompted the city of Yellowknife to request an

FIGURE 10.3. Thermosyphons at Giant mine remediation test plot, Yellowknife, Northwest Territories, May 2011. Photograph by John Sandlos.

environmental assessment (EA) through the Mackenzie Valley Environmental Impact Review Board.[71] Although the EA resulted in new commitments from the federal government to fund research toward a permanent solution to the underground arsenic problem within a century, local concerns remain over the long-term risk of maintaining 237,000 tons of toxic material should there be no lasting resolution of the issue.[72]

The environmental assessment has also provided a forum for the Yellowknives Dene to highlight their historical memory of cultural and environmental loss associated with gold mining in the area. Primary sources tracking Native reactions to the introduction of mining at Yellowknife in the 1930s and subsequent issues with arsenic are difficult to find as the archival record belongs exclusively to the voices of government and mine company officials. Nonetheless, recent forums such as the environmental assessment and a public workshop on perpetual care, and older sources such as a Yellowknives Dene Community History and a set of hearing transcripts from 1995 on revisions to the Canadian Environmental Protection Act (CEPA), offer a clearer window into the historical impacts of Giant mine on the Yellowknives Dene.

Many elders clearly see the mines as the central agent of colonialism in the Yellowknife region, a progenitor of social, economic, and ecological changes that dramatically altered the Yellowknives' way of life based on hunting and trapping. At the 1995 CEPA hearings, elder Michel Paper described that way of life as it was before the mine and suggested how little contact the Yellowknives had with non-Native southerners:

> At that time, trapping was the way the people survived. Caribou was another source [. . .] by which the people survived. All the fish that were available were known by the people. The people lived a very healthy life by hunting for wildlife. All year long we would follow the caribou, and at that time we did not have to pay for wood. We did not pay for the food we gathered. We travelled by dog team only. When the firewood ran low in the camping area, we would move on to another place where there was plenty of wood. We did not pay for the firewood. That was the way our people lived in the past.
>
> In 1934–35 we heard news that the white people had arrived in the Yellowknife area. It was at Burwash Point. We travelled at night by dog team back to Yellowknife and we could see Burwash Point lit up from a distance. We heard that the white people had arrived, and we were afraid of them so we travelled back around the way of Dettah. At that time, the white people were also afraid of us.[73]

A community history prepared by the Yellowknives Elders Advisory Council in 1997 describes the impact of these new arrivals on patterns of subsistence in the local area:

> Explosions of dynamite by prospectors, air traffic, the development of a town and mines, the building of commercial fish plants, a prison, and roads, and the use of the land and waters for recreation. These developments contributed to the gradual withdrawal of moose and other animals, and to caribou changing their migration route through the area. In spring, Weledeh Yellowknives Dene used to wait for caribou returning north where the Prince of Wales Northern Heritage Centre now sits on Frame Lake. Although now it is rare to see moose near the Weledeh, these animals used to be common and could be relied on by Weledeh Yellowknives for food and clothing.[74]

The Yellowknives were not passive in the face of such dramatic changes. Paper and elder Isadore Tsetta suggested that they and twelve to fifteen other Yellowknives Dene found work at the mines (often hauling lumber), but such adaptations to the new mining economy did not erase from the elders' memories the mines' deleterious impacts.

Indeed, memories of the arsenic crisis of the early 1950s are widely recalled in the communities of Dettah and Ndilo and form the core narrative of the Yellowknives' encounter with the gold mines. The number

of the dead and dates often vary according to the speaker (and may indicate that more fatalities occurred beyond that of the young boy described in the archival record). Regardless, Yellowknives elders and community leaders continually point to the tragic death and sickness of the 1950s as the most profound injustice associated with the gold mines. At the 1995 hearings, then-chief Fred Sangris told the legislators:

> The first case of death within our community came in 1959, when three children in the same family died in the Yellowknife Bay area. At that time, there was no adequate water delivery from either the government or DIAND [Department of Indian Affairs and Northern Development]. You had the responsibility to look after first nations, because there was that fiduciary obligation to do so. The family that lost the three children were compensated $1,000. That's all they were given. They were told, "Here, take the money, and forget about everything." Eventually, this person and his wife got into drinking because they couldn't deal with that. A lot of the first nations in this area did the same thing. One person mentioned here that they were powerless; yes, it's true.[75]

The community history produced by the Yellowknives Elders Advisory Council tells the poisoning story in this way:

> The people were never warned about the impacts and risks of living near mines. In late December of 1949, a massive emission from the Giant mine dispersed huge amounts of arsenic into the air, settling into the ice and snow. Melting snow in the spring of the following two years was so toxic that notices were printed in Yellowknife newspapers warning people not to drink or use the meltwater. Few Weledeh Yellowknives Dene could read the notices. Anyone who washed their hair with arsenic-laden meltwater in the next two springs went bald. [. . .] But the greatest tragedy occurred in spring 1951: four children in family camps in Ndilo died. The mine owners gave their parents some money, as if it could compensate for the loss. Women stopped picking medicine plants and berries, which used to grow thickly in the area of Giant mine. The people moved away, avoiding the mine area for some years, although it had once been so important to them.[76]

Statements such as these suggest that the Yellowknives Dene experienced a toxicity-induced alienation from the land that had once sustained them. Anthropologist Stuart Kirsch has described this process as the cultural loss associated with the weakening of ties to local landscapes and ecologies that have been made dangerous through industrial development or military activity.[77] The memories of many Yellowknives elders focused on the broad-scale impacts of toxic loading on humans, animals, water, and local food sources and the broken relationships among these overlapping ecologies. In an interview transcribed as part

of a submission to the Giant Mine Remediation EA, elder Joseph Charlo described the impact of arsenic pollution:

> Ever since it started, I have never heard one good thing about mining: it destroys the land. We survive by the animals: all our ancestors lived by the animals on the land, and the animals were healthy. If we don't take care of the animals, if the mining starts up and the animals get contaminated, the people will also. They [i.e., the mining companies] should be careful as to how they work with the Dene and how they should work to protect the environment. And my wife, she remembers when she used to go berry picking in the Giant Mine area; she used to go there with her grandmother. Right now, you can't put anything in your mouth from that area: everything is contaminated. It's as if they've killed everything around here. We need to make a statement that we don't want to destroy anything on this land.[78]

Rachel Ann Crapeau further explained the sickness that spread from the land and water into the bodies of her people:

> Before the Yellowknives Dene understood what arsenic was, they were aware of changes that made them wary of the water, fish, berries and plants near the mine sites. When land users took their sled dogs through the tailings ponds that crossed their traditional trails, the dogs would lose the fur on their paws within a day or two. The Elders can recall people falling off their sled into the tailings ponds, which stayed open year-round, and becoming ill, losing their hair soon after. After many of their sled dogs died without obvious cause, dog owners stopped feeding them fish from Weledeh. People, too, started dying from cancer at a rate previously unknown to Yellowknives Dene.[79]

Isadore Tsetta suggested that that even in 1995 his community remained wary of the dangers associated with subsistence activity on the land, a loss of an economic base for which, he argued, the Yellowknives should be compensated:

> We do not know what to do with the contaminated water now. We cannot use the water now. After the land is spoiled, plants cannot grow in the contaminated soils. That is the situation with us now. If justice was done [. . .] we should be compensated somehow for the contaminated water. Giant Mines and Con Mines have ruined the water and we cannot use it any more. We were here first, before the white people arrived and the mining started. We all know how the land was.[80]

At a public workshop on perpetual care held in 2011, Michel Paper suggested much the same idea when he said very simply, "People love the land but mining has changed the land and made it dangerous."[81] Through sixty years of gold mining in Yellowknife, the area's Native

inhabitants have experienced not only pain associated with sickness and death but also fear associated with the hazardous nature of the land.

CONCLUSION: THE SHADOW OF THE GOLD MINES

Standing on the eastern shore of Yellowknife Bay in the community of Dettah, the huge Robertson shaft headframe at the Con mine once towered above all other city buildings located almost directly across the bay. When people from Dettah traveled around Back Bay to Yellowknife, the Giant mine's old roaster stack and headframes loomed over the narrow highway. Although these landmarks have recently been demolished as part of site reclamation plans, for decades the residents of what became Dettah and Ndilo (across the bay) lived almost literally within the shadows of Yellowknife's gold mines. These shadows had a long reach, causing one of the worst cases of industrial poisoning in the history of northern Canada. Although the Canadian government did mobilize public expertise and action in the face of the crisis, the campaign's narrow focus on data-driven threshold values for drinking water and air quality failed to account for the full range of ecological impacts that the production of a toxic landscape had on the Yellowknives Dene. The public health campaign was also limited by the fact that, for company and public officials, continued operation of the mines always remained sacrosanct regardless of the potentially dangerous material being loaded into the air and water bodies of the Yellowknife region. Never once did the federal government attempt to establish strict regulations for the amount of arsenic coming out of the gold mines' smelter stacks or contained in tailings effluent, so long as the local environment was able to assimilate and dilute the pollution to levels reasonably close to prevailing safe standards. Technological fixes such as the Cottrell ESP, the baghouse, and the Con impinger likely prevented further deaths in the short term, but government and company officials failed to consider mounting evidence suggesting the medical risks of low-dose arsenic exposure over long periods for mine workers and Yellowknife residents. Although no historical epidemiological study has traced these impacts in Yellowknife, certainly archival and oral records describing high rates of exposure among mill workers and First Nations people, and evidence of low dose impacts from other jurisdictions, all suggest that arsenic levels were not as safe as government officials claimed.[82]

The actual spread of arsenic also furthered the colonial advance of an industrial economy in the Yellowknife region. As a by-product of gold mining, arsenic emissions instigated material environmental changes and toxic exposures that reinforced the inequities associated with colonial resettlement of Dene territory.[83] The suddenness and severity of these ecological changes suggest that one need not rely on naïve notions of pristine nature or a static view of culture to acknowledge that arsenic poisoning precipitated a major disruption in the ties that bound the Yellowknives to their land. If the land and water became less toxic as public health initiatives reduced the amounts of arsenic in the local environment, it was as difficult for the Yellowknives to regain trust in a poisoned landscape as it was to reestablish fully the subsistence land base that had been invariably changed through related developments such as urban growth in Yellowknife and the expansion of surface impacts (including tailings ponds, infrastructure, and four open pits at Giant) associated with the mines.[84] The public health campaign also failed to find a long-term solution to the problem of arsenic disposal at Giant mine; the prospect of another mass poisoning from the many tons of arsenic trioxide stored in the mine continues to propagate the idea among the Yellowknives that the land is both sick and dangerous. For the Yellowknives, gold mining, environmental disaster, and cultural loss are all synonymous with one another, and are part of a history of environmental injustice and dispossession that continues to shape contemporary responses to mining in the Northwest Territories.

NOTES

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1. Warwick Bullen and Malcolm Robb, "Social-economic Impacts of Gold Mining in the Yellowknife Mining District," http://www.miningnorth.com/_rsc/site-content/library/Socio-Economic%20Impacts%20of%20Gold%20Mining%20in%20Yellowknife%202002.pdf (accessed January 10, 2017). By comparison, Bullen and Robb suggest that Con Mine produced 5.5 million ounces of gold, or just over $2.5 billion in revenue. Though smaller than the Timmins, Ontario, gold-mining complex, where Canada's biggest producer, the Hollinger mine, yielded close to 20 million ounces of gold, the Yellowknife gold-mining complex remains historically significant because it provided the economic basis for the development of Yellowknife, the major modern settlement in the Northwest Territories.

2. For an overview of the remediation project, including links to a historical overview of the arsenic issue, see "Giant Mine Remediation Project," Aborigi-

nal Affairs and Northern Development Canada (AANDC), http://www.aadnc-aandc.gc.ca/eng/1100100027364 (accessed March 12, 2012).

3. See Susan Jackson, ed., *Yellowknife, NWT: An Illustrated History* (Yellowknife: Nor'West, 1990); *Yellowknife Tales: Sixty Years of Stories from Yellowknife* (Yellowknife: Outcrop, 2003).

4. In the United States and Mexico, mine smelter emissions largely remained unregulated until the U.S. Clean Air Act of 1967 (and amendments to the act in 1970 and 1977), the creation of the U.S. Environmental Protection Agency in 1970, and the U.S.-Mexico La Paz agreement of 1983. For an overview, see John D. Wirth, *Smelter Smoke in North America: The Politics of Transborder Pollution* (Lawrence: University Press of Kansas, 2000). For further examples illustrating the unregulated nature of air and water pollution caused by mining in North America, see Robert V. Bartlett, *The Reserve Mining Controversy: Science, Technology, and Environmental Quality* (Bloomington: Indiana University Press, 1980); Gray Brechin, *Imperial San Francisco: Urban Power, Earthly Ruin* (Berkeley: University of California Press, 1999); Kathleen A. Brosnan, *Uniting Mountain and Plain: Cities, Law, and Environment along the Front Range* (Albuquerque: University of New Mexico Press, 2002); Nicholas A. Casner, "Toxic River: Politics and Coeur D'Alene Mining Pollution in the 1930's," *Idaho Yesterdays* (Fall 1991): 2–19; Christopher J. Juggard, "Mining and the Environment: The Clean Air Issue in New Mexico," *New Mexico Historical Review* 69:44 (Fall 1994): 369–88; Andrew Isenberg, *Mining California: An Ecological History* (New York: Hill and Wang, 2005); Keith R. Long, "Tailings under the Bridge: Causes and Consequences of River Disposal of Tailings, Coeur D'Alene Mining Region, 1886 to 1968," *Mining History Journal* 8 (2001): 83–101; David Stiller, *Wounding the West: Montana, Mining, and the Environment* (Lincoln: University of Nebraska Press, 2000).

5. Timothy LeCain, "The Limits of 'Eco-Efficiency': Arsenic Pollution and the Cottrell Electrical Precipitator in the U.S. Copper Smelting Industry," *Environmental History* 5:3 (July 2000): 336–51; Timothy LeCain, *Mass Destruction: The Men and Giant Mines That Wired America and Scarred the Planet* (New Brunswick, NJ: Rutgers University Press, 2009). On attitudes toward the environment in the mining industry generally, see Duane A. Smith, *Mining America: The Industry and the Environment, 1800–1980* (Lawrence: University Press of Kansas, 1987).

6. Timothy J. LeCain, "When Everybody Wins Does the Environment Lose? The Environmental Techno-fix in Twentieth-Century American Mining," in *The Technological Fix: How People Use Technology to Create and Solve Problems,* ed. Lisa Rosner (New York: Routledge, 2004), 117–32. On questions of materiality and pollutants, see Gavin Bridge, "The Social Regulation of Resource Access and Environmental Impact: Production, Nature, and Contradiction in the US Copper Industry," *Geoforum* 31 (2000): 237–56; Gavin Bridge, "Material Worlds: Natural Resources, Resource Geography, and the Material Economy," *Geography Compass* 3 (2009): 1217–44; Jennifer Gabrys, "Sink: The Dirt of Systems," *Environment and Planning D: Society and Space* 27 (2009): 666–81.

7. Jody A. Roberts and Nancy Langston, "Toxic Bodies/Toxic Environments: An Interdisciplinary Forum," *Environmental History* 13 (2008): 629–35; Gregg Mitman, Michelle Murphy, and Christopher Sellers, eds., "Landscapes

of Exposure: Knowledge and Illness in Modern Environments," *Osiris* 19 (2004); Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: University of California Press, 2006); J. Samuel Walker, *Permissible Dose: A History of Radiation Protection in the Twentieth Century* (Berkeley: University of California Press, 2000).

8. Nancy Langston, *Toxic Bodies: Hormone Disruptors and the Legacy of DES* (New Haven: Yale University Press, 2010); Nash, *Inescapable Ecologies*; Linda Nash, "Purity and Danger: Historical Reflections on the Regulation of Environmental Pollutants," *Environmental History* 13 (October 2008): 651–58; Sarah A. Vogel, "From 'the Dose Makes the Poison' to 'the Timing Makes the Poison': Conceptualizing Risk in the Synthetic Age," *Environmental History* 13 (October 2008): 667–73.

9. Brett L. Walker, *Toxic Archipelago: A History of Industrial Disease in Japan* (Seattle: University of Washington Press, 2010); Joy Parr, *Sensing Changes: Technologies, Environments, and the Everyday, 1953–2003* (Vancouver: University of British Columbia Press, 2010).

10. Saleem H. Ali. *Mining, the Environment, and Indigenous Development Conflicts* (Tucson: University of Arizona Press, 2003); Subhabrata Bobby Banerjee, "Whose Land Is It Anyway? National Interest, Indigenous Stakeholders, and Colonial Discourses," *Organization and Environment* 13 (March 2000): 3–38; Al Gedicks, *Resource Rebels: Native Challenges to Mining and Oil Companies*. (Cambridge, MA: South End Press, 2001); Robert Wesley Heber, "Indigenous Knowledge, Resources Use, and the Dene of Northern Saskatchewan," *Canadian Journal of Development Studies* 26 (2005): 247–56; Richard Howitt, *Rethinking Resource Management: Justice, Sustainability, and Indigenous Peoples* (London: Routledge, 2001); Stuart Kirsch, *Reverse Anthropology: Indigenous Analysis of Social and Environmental Relations in New Guinea* (Stanford, CA: Stanford University Press, 2006); Marcus B. Lane and E. Rickson Roy, "Resource Development and Resource Dependency of Indigenous Communities: Australia's Jawoyn Aborigines and Mining at Coronation Hill," *Society and Natural Resources* 10 (1997): 121–42; Lianne Leddy, "Cold War Colonialism: The Serpent River First Nation and Uranium Mining, 1953–1988" (PhD dissertation, Wilfrid Laurier University, 2011); Nicholas Low and Brendan Gleeson, "Situating Justice in the Environment: The Case of BHP at the Ok Tedi Copper Mine," *Antipode* 30 (1998): 201–26; Joan Martinez-Alier, "Mining Conflicts, Environmental Justice, and Valuation," *Journal of Hazardous Materials* 86 (2001): 153–70.

11. John Sandlos and Arn Keeling, "Claiming the New North: Development and Colonialism at the Pine Point Mine, Northwest Territories, Canada," *Environment and History* 18 (2012), 5–34; Arn Keeling and John Sandlos, "Environmental Justice Goes Underground? Historical Notes from Canada's Northern Mining Frontier," *Environmental Justice* 2:3 (2009): 117–25.

12. For general overviews of mining development in northern Canada in the early to mid-twentieth century, see K. J. Rea, *The Political Economy of the Canadian North* (Toronto: University of Toronto Press: 1968); Morris Zaslow, *The Northward Expansion of Canada, 1914–1967* (Toronto: McClelland and Stewart, 1988); and Liza Piper, *The Industrial Transformation of Sub-Arctic Canada* (Vancouver: University of British Columbia Press, 2009). For details on

early staking in the Yellowknife Bay area, see Ryan Silke, *The Operational History of Mines in the Northwest Territories, Canada* (Yellowknife, Northwest Territories: privately printed, 2009).

13. For information on arsenic trioxide production in the roasting process, see Markus Stoeppler, *Hazardous Metals in the Environment* (Amsterdam: Elsevier, 1992), 289.

14. For early emissions data and a discussion of the unregulated nature of emissions from 1949 to 1951, see A. J. de Villiers and P. M. Baker, *An Investigation of the Health Status of Inhabitants of Yellowknife, Northwest Territories* (Ottawa, Ontario: Occupational Health Division, Environmental Health Directorate, Department of Health and Welfare, 1970), 3–5. Detailed emissions data were also contained in correspondence from Dr. O. Schaefer, Northern Medical Research Unit to the A/Regional Director, Northern Region, National Health and Welfare, 4 November 1971, Record Group (RG) 29, vol. 2977, file 851–5–2, pt. 1, Library and Archives Canada, Ottawa, Ontario (hereafter LAC). Details on the pollution control equipment at Con and Giant may be found in W. H. Frost, Senior Medical Advisor, Medical Services Branch, National Health and Welfare, "Arsenic—Yellowknife," 28 October 1970, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC. The roasting process also produced emissions of sulfur dioxide, the impact of which is not well documented save for references to local respiratory problems among asthmatics in testimony from Yellowknives chief Fred Sangris and Deh Cho grand chief Jim Antoine at hearings on the Canadian Environmental Protection Act in 1995. Fred Sangris and Gerry Antoine, Evidence, Parliamentary Hearings on Canadian Environmental Protection Act, 11 May 1995, Parliament of Canada, http://www.parl.gc.ca/content/hoc/archives/committee/351/sust/evidence/122_95–05–11/sust122_blk-e.html#0.1.SUST122.000001.AA1040.A (accessed March 13, 2012).

15. For discussion of wallpaper as a source of contamination, and also of the well-water contamination issue, see Andrew Meharg, *Venomous Earth: How Arsenic Caused the World's Worst Mass Poisoning* (New York: MacMillan, 2005). For the Washoe dispute, see LeCain, "The Limits of 'Eco-Efficiency.'"

16. Meharg, *Venomous Earth,* 7–12.

17. A comprehensive overview of all these issues, including the prevalence of tailings spills, is contained in de Villiers and Baker, *An Investigation of the Health Status of Inhabitants of Yellowknife,* and a report authored by the Canadian Public Health Association, *Task Force on Arsenic—Final Report, Yellowknife, Northwest Territories* (Ottawa: CPHA, 1977). The toxicity of these tailings overflows was documented in a federal Environmental Protection Service report, R. R. Wallace, M. J. Hardin, and R. H. Weir, "Toxic Properties and Chemical Characteristics of Mining Effluents in the Northwest Territories," EPS Report no. EPS-5-NW-75–4 (Ottawa, Ontario: Department of the Environment, February 1975).

18. De Villiers and Baker, *An Investigation of the Health Status of Inhabitants of Yellowknife,* 11.

19. These tensions are explored in Sheilagh Grant, *Sovereignty or Security? Government Policy in the Canadian North, 1936–1950* (Vancouver: University of British Columbia Press, 1988), 195–99.

20. Yellowknives Dene First Nation, *Weledeh Yellowknives Dene: A History* (Dettah, Northwest Territories: Yellowknives Dene First Nation Council, 1997), 53–54.

21. We have not used the boy's name in response to a request from a family member who participated in our research on this issue. The information on the fatality comes from a discussion of the coroner's report at a heavily minuted meeting among government officials and two Giant mine managers held in Ottawa on 1 June 1951 to discuss the fatality. The minutes are contained in the RG 29, vol. 2977, file 851–5–2, pt. 1, LAC. All information related to the fatality can be verified in this file and the documents cited below pertaining to follow-up measures.

22. Kirkby's assessment of the situation is summarized in a memo from Dr. M. Matas to Dr. H. Falconer, 16 May 1951, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

23. See Minutes of Meeting held to Discuss the Death of Indian Boy, Latham Island, 1 June 1951, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

24. Advertisements appeared in the following editions of the *News of the North* in 1951: 6 April, p. 6; 13 April, p. 5; 20 April, p. 5; 6 July, p. 6; 13 July, p. 6. One article, titled "Cottrell Plant Now Operates at Giant Mine," appeared in the 9 November 1951 issue, but even here no mention is made of the public health issues that had emerged by 1951. A study produced in the 1970s by the National Indian Brotherhood (a Native advocacy group) claimed that warning signs about drinking water from Back Bay were not posted in local Native languages until fall 1974. See Lloyd Tataryn, "Arsenic and Red Tape," National Indian Brotherhood, unpublished manuscript, n.d., University of Alberta Library.

25. A.K. Muir, General Manager, Giant Yellowknife Gold Mines, Ltd., to G.E.B. Sinclair, Director, Northern Administration and Lands Branch, Department of Resources and Development, n.d., RG 85, vol. 40, file 139–7, pt. 1, LAC.

26. The reference to Henry Lafferty is contained in a memo from P.E. Moore, Director of Indian Health Services, to L.I. Pugsley, Laboratory Services, 16 November 1953, RG 85, vol. 40, file 139–7, pt. 1, LAC. The specific references to skin conditions such as keratosis, hyperpigmentation, and paresthesia are found in a memo from Dr. O. Schaeffer to Dr. B. Wheatley, Environmental Contaminant Program, Medical Services Branch, Health and Welfare Canada, 1 May 1978, Prince of Wales Northern Heritage Centre, Yellowknife, Northwest Territories (hereafter cited as PWNHC), G-2008–028, box 9, file 16.

27. Yellowknives Dene First Nation, *Weledeh Yellowknives Dene: A History,* 52–53.

28. Laurie Cinnamon, Oral Interview, in Jackson, *Yellowknife, NWT,* 85.

29. Barbary Bromley, Oral Interview, in *Yellowknife Tales,* 97–98.

30. Helen Kilkenny, Oral Interview, in Jackson, *Yellowknife, NWT,* 114–15.

31. Minutes of Meeting held to Discuss the Death of Indian Boy, Latham Island. See also K. Raht to W.G. Jewitt, Manager of Mines, CM&S, 28 June 1951, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

32. Minutes of Meeting held to Discuss the Death of Indian Boy, Latham Island. For Dr. Stanton's approval of the underground storage method, see his

letter to G. E. B. Sinclair, Director, Northern Administration and Lands Branch, Department of Resources and Development, 27 February 1951, in Giant Mine Environmental Assessment: IR Response, Round 1: Information Request, Alternatives North no. 01, 17 June 2011, p. 67, http://www.reviewboard.ca/upload/project_document/EA0809-001_IR_round_1_responses_to_Alternatives_North_1328902602.PDF (accessed October 29, 2013).

33. Muir's report of the shipping delays is contained in Minutes of Meeting held to Discuss the Death of Indian Boy, Latham Island. A reference to the request that Giant expedite installation of the Cottrell ESP is contained in a letter from Sinclair to S. Homulos, Mining Inspector, Yellowknife, 19 June 1951, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC. See also C. K. LeCapelain, Acting Director, Northern Administration and Lands Branch, to Muir, 14 August 1951, RG 29, vol. 40, file 139–7, pt. 1, LAC.

34. The Con impinger removed 85 percent of arsenic from roaster smoke, and in any case Con processed lower amounts of arsenopyrite ore (as noted above). For emissions data, see de Villiers and Baker, *An Investigation of the Health Status of Inhabitants of Yellowknife*. Reference to the second ESP and its impact on emissions is found in D. A. Gemmill, Yellowknife Environmental Survey, Summary Report (Ottawa: Environmental Protection Service, Department of the Environment 1975), RG 29, vol. 2977, file 851–5–2, pt. 4, LAC. Negus Mines was permitted to construct an impinger using Con's wet scrubber technology, though the government preferred Giant's dry storage method. See Minutes, Meeting held in Room 101 of the Norlite Building to discuss the Arsenic Problem at Yellowknife as the Result of the Proposal of Negus Mines Limited to Commence Roasting Operations, 30 July 1951, RG 85, vol. 40, file 139–7, pt. 1, LAC. Negus Mines constructed a roaster in November 1951, and the plant went into full operation in November 1952. Problems with the plant and the recovery of lower-than-expected ore grades resulted in the closure of the mine and the sale of all claims to Cominco in March 1953. See Silke, *The Operational History of Mines in the Northwest Territories, Canada*, 316.

35. Plans for the survey are laid out in a memo from Dr. Kingsley Kay, Chief, Industrial Health Laboratory, to G. E. B. Sinclair, Director, Northern Administration and Lands Branch, 25 October 1951, RG 85, vol. 40, file 139–7, pt. 1, LAC.

36. See Minutes of Meeting Held to Discuss the Death of Indian Boy, Latham Island.

37. On the toxicological approach to health and contaminants, see Nash, "Purity and Danger," 651–58.

38. The archival files contain two graphs displaying arsenic measurements from 1953 to 1960, titled, "Arsenic in Townsite Tap Water, Yellowknife, N.W.T." A third is titled "Arsenic in Giant Tap Water, Yellowknife, N.W.T.," and a fourth, "Arsenic in Con Tap Water, Yellowknife, N.W.T.," 1953–60. All in RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

39. Dr. O. Schaefer, Northern Medical Research Unity to the A/Regional Director, Northern Region, National Health and Welfare, 4 November 1971, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC. For background on liquid effluent

in Back Bay, see Canadian Public Health Association, *Task Force on Arsenic—Final Report, Yellowknife Northwest Territories,* 59–62.

40. Data on contamination of vegetation are contained in "Arsenic on Grasses in Yellowknife, 1954–61," and "Mean Values of Arsenic Yellowknife Vegetation, PPM," RG 29, vol. 2977, file 851–5–2, pt. 1, LAC. Mention of the US standard of 1 PPM is made in a memo from a person or persons coded "M17" to Dr. Procter, 10 December 1965, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

41. M17 to Dr. Procter, 10 December 1965.

42. The results of the meeting are reported in M17 to Dr. Procter, memorandum, 20 December 1965, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

43. Mention of the anemia is made in memos from Dr. Butler, Regional Director, National Health and Welfare, to Dr. Frost, Director General, Medical Services, Ottawa, 24 August and 17 August 1967, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

44. Canadian Public Health Association, *Task Force on Arsenic—Final Report, Yellowknife, Northwest Territories,* 49–51.

45. See the discussion of this issue in Tataryn, "Arsenic and Red Tape," 10–14. See also Michel Sikyea to Jean Chretien, 25 September 1973, Giant Mine Remediation Public Registry http://reviewboard.ca/upload/project_document/EA0809–001_Letter_-_YKDFN_to_DIAND_Minister_J__Chretien_-_Sept_1973.pdf (accessed November 28, 2012). Sikyea was a highly regarded elder in Ndilo.

46. Dr. G. C. Butler, Regional Director, Northern Region, to Director General, Medical Services, 9 June 1970, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

47. Dr. H. A. Procter, Director, Medical Services to Dr. E. A. Watkinson, Director, Health Services, 29 September 1967, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

48. Butler to Procter, 30 October 1967, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

49. Butler to Director General, Medical Services, 23 September 1970, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

50. S. M. Hodgson, Commissioner, NWT, to Jean Chrétien, Minister of Indian Affairs and Northern Development, 25 September 1970, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

51. Chrétien to John Munro, Minister of Health and Welfare, 2 October 1970, RG 29, vol. 2977, file 851–5–2, pt. 1, LAC. Reference to the order to Butler and the reasoning behind it are contained in a memo from Munro to Chrétien, n.d., RG 29, vol. 2977, file 851–5–2, pt. 1, LAC.

52. For an overview of this third period of heightened public concern over arsenic, see F. J. Colville, Senior Advisor, NWT Region, Arsenic in Yellowknife—A Perspective, 25 September 1979, G-2008–028, Box 9, File 17, PWNHC.

53. Statement by the Honourable Marc Lalonde on Arsenic Pollution in Yellowknife, NWT, 9 January 1975, RG 29, vol. 2977, file 851–5–2, pt. 2, LAC. The de Villiers study concluded that there was evidence of skin rashes among those occupationally exposed to arsenic in Yellowknife, and also high rates of respiratory disease that could be linked to arsenic. But the report concluded that

the links between arsenic and lung cancer were "uncertain." De Villiers and Baker, *An Investigation of the Health Status of Inhabitants of Yellowknife,* 10.

54. R.D.P. Eaton, Analysis of Hair Arsenic Results, Yellowknife, 1975, G-2008–028, Box 9, file 17, PWNHC.

55. Even when the Canadian public was concerned about air and water pollution, federal regulation tended to lag behind that of the United States. See Dimitry Anatsakis, "'A War on Pollution'? Canadian Responses to the Automobile Emissions Problem, 1970–1980," *Canadian Historical Review* 90:1 (March 2009): 99–136; Doug Macdonald, *The Politics of Pollution: Why Canadians Are Failing Their Environment* (Toronto: McClelland and Stewart, 1991); and Jennifer Read, "'Let Us Heed the Voice of Youth': Laundry Detergents, Phosphates, and the Emergence of the Environmental Movement in Ontario," *Journal of the Canadian Historical Association,* New Series 7:1 (1996): 227–50. For urban pollution, see Arn Keeling, "Sink or Swim: Water Pollution and Environmental Politics in Vancouver, 1889–1975," *BC Studies* 142–143 (Summer 2004): 69–101.

56. On the linkage between southern environmentalism, northern development, and Native concerns in the 1970s, see Robert Page, *Northern Development: The Canadian Dilemma* (Toronto: McClelland and Steward, 1986). For a further analysis of complex and conflicting Dene attitudes to development and environmentalism, see Paul Sabin, "Voices from the Hydrocarbon Frontier: Canada's Mackenzie Valley Pipeline Inquiry, 1974–1977," *Environmental History Review* 18:1 (Spring 1995): 17–48. Evidence of southern environmentalist concern for northern pollution and development issues can be seen in the large number of protest letters directed at Minister Lalonde after the story broke on the CBC and in the newspapers. These letters are contained in RG 29, vol. 2978, file 851–5–1, pt. 5, LAC.

57. Statement by Prof. Robert E. Jervis, Department of Chemical Engineering and Applied Chemistry, and Institute for Environmental Studies, re: Yellowknife Arsenic Pollution Problem, 15 January 1977, University of Alberta Library. See also the report by Tataryn, "Arsenic and Red Tape," and "Document [*sic*] Released by the National Indian Brotherhood, the United Steelworkers of America, and the University of Toronto on January 15, 1977," unpublished manuscript, Canadian Circumpolar Institute Library. The federal government's acting director of the Environmental Contaminants program cited a consensus among some researchers that hair levels below 1 PPM indicated a person who was not exposed to arsenic, while others suggested anything below 5 PPM as a normal level for arsenic. See Brian Wheatley to L.M. Black, Director General, Program Management, 28 January 1977, RG 29, vol. 2977, file 851–5–2, pt. 4, LAC.

58. Editorial, "Ottawa Hides the Poison," *Toronto Globe and Mail,* 19 January 1977. See also Victor Malarek, "Yellowknife Arsenic Level 'Horrendously High,'" *Toronto Globe and Mail,* 17 January 1977; "Private Study Shows Yellowknife Arsenic Level Dangerously High," *Edmonton Journal,* 17 January 1977; all clippings found in RG 29, vol. 2977, file 851–5–2, pt. 4, LAC. The report in question is Gemmill, Yellowknife Environmental Survey, Summary Report.

59. News Release, "Task Force to Study Arsenic," 18 January 1977, G-2008–028, box 9, file 17, PWNHC.

60. Canadian Public Health Association, *Task Force on Arsenic—Final Report, Yellowknife, Northwest Territories*.

61. H.P. Blejer, Evaluation of Canadian Public Health Association Task Force on Arsenic Interim Report of May 1977, RG 29, vol. 2978, file 851–5–2, pt. B, LAC.

62. Tataryn, "Arsenic and Red Tape"; Paul Falkowski, Environmental and Occupational Health Representative, United Steelworkers of America, Presentation to the National Indian Brotherhood 8th Annual General Assembly, 14 September 1977, unpublished transcript, University of Alberta Library.

63. Associate General Director, Medical Services Branch, to A/Regional Director, NWT Region, 11 October 1984, G-2008–028, box 9, file 17, PWNHC.

64. Lorne C. James, Pollution Control Officer, Department of Renewable Resources, Government of the Northwest Territories, to Ranjit Soniassy, Northern Affairs Program, 23 June 1986, G-1993–006, box 19, file 13 408 024, PWNHC. For discussion of the complex issue of absorption and retention in soil, see S. Mahimairaja, N.S. Bolan, D.C. Adriano, and B. Robinson, "Arsenic Contamination and Its Risk Management in Complex Environmental Settings," *Advances in Agronomy* 86 (2005): 1–82.

65. Indian and Northern Affairs Canada, *Giant Mine Remediation Plan* (prepared by Giant Mine Remediation Team, SRK Consulting and SENES Consulting, July 2007), http://reviewboard.ca/upload/project_document/EA0809–001_Giant_Mine_Remediation_Plan_1328900464.pdf (accessed March 13, 2012), 14–15.

66. Chris O'Brien and Kevin O'Reilly to Titus Allooloo, Minister of Renewable Resources, Government of the Northwest Territories, 22 April 1991. The results of the study are summarized in Allooloo to O'Reilly, 5 July 1993. For media coverage, see Editorial, "Report Fails to Clear the Air," *Yellowknifer,* 9 July 1993, p. 7. All correspondence and clippings in the private papers of Kevin O'Reilly.

67. Muir to G.E. B Sinclair, Director, Northern Administration and Lands Branch, 24 February 1951, in Giant Mine Environmental Assessment: IR Response, Round 1: Information Request, Alternatives North no. 01, 17 June 2011, pp. 68–71, http://www.reviewboard.ca/upload/project_document/EA0809–001_IR_round_1_responses_to_Alternatives_North_1328902602.pdf (accessed October 29, 2013).

68. These memos from mining engineers and Environment Canada officials are reproduced in "Document Released by the National Indian Brotherhood, the United Steelworkers of America, and the University of Toronto on January 15, 1977."

69. Office of the Auditor General of Canada, *Report of the Commissioner of the Environment and Sustainable Development, 2002* (Ottawa: Minister of Public Works and Services, 2002), chapters 2 and 3. Giant featured again in the commissioner's most recent report on toxic sites in Canada; see Office of the Auditor General of Canada, Chapter 3, "Federal Contaminated Sites and Their Impacts," in *Spring Report of the Commissioner of the Environment and*

Sustainable Development (Ottawa: Office of the Auditor General of Canada, 2012).

70. Cooperation Agreement Respecting the Giant Mine Remediation Project between Canada and the Government of the NWT, 15 March 2005, Northwest Territories Municipal and Community Affairs, http://www.maca.gov.nt.ca/resources/Cooperation_Agreement_Giantmine_remediation.pdf (accessed March 13, 2012).

71. Indian and Northern Affairs Canada, *Giant Mine Remediation Plan*.

72. Alternatives North, *From Despair to Wisdom: Perpetual Care and the Future of Giant Mine,* A Report on a Community Workshop, September 26–27, 2011, https://anotheralt.files.wordpress.com/2016/02/2011–09–26-giant-perpetual-care-workshop-report.pdf (accessed 14 January 2017); Carol Raffensperger, "Principles of Perpetual Care: The Giant Mine, Yellowknife, Northwest Territories" (prepared for Alternatives North as a submission to the Mackenzie Valley Impact Review Board, December 2011), http://www.reviewboard.ca/upload/project_document/EA0809–001_Principles_of_Perpetual_Care-_Report_from_Alt_North_1329867038.pdf (accessed March 16, 2012). For more on the alternatives for remediating the Giant mine site, see SRK Consulting, *Study of Management Alternatives: Giant Mine Arsenic Trioxide Dust* (Yellowknife, May 2001).

73. Michel Paper, Evidence, Parliamentary Hearings on Canadian Environmental Protection Act, 11 May 1995, http://www.parl.gc.ca/content/hoc/archives/committee/351/sust/evidence/122_95–05–11/sust122_blk-e.html#0.1.SUST122.000001.AA1040.A (accessed March 13, 2012).

74. Yellowknives Dene First Nation, *Weledeh Yellowknives Dene: A History,* 50.

75. Fred Sangris, Evidence, Parliamentary Hearings on Canadian Environmental Protection Act, 11 May 1995, http://www.parl.gc.ca/content/hoc/archives/committee/351/sust/evidence/122_95–05–11/sust122_blk-e.html#0.1.SUST122.000001.AA1040.A (accessed March 13, 2012).

76. Yellowknives Dene First Nation, *Weledeh Yellowknives Dene: A History,* 52.

77. Stuart Kirsch, "Lost Worlds: Environmental Disaster, 'Culture Loss,' and the Law," *Current Anthropology* 42 (April 2001): 167–98.

78. Yellowknives Dene First Nation presentation to Mackenzie Valley Environmental Impact Review Board Scoping Session, 23 July 2008, http://www.reviewboard.ca/upload/project_document/12190991111_15606YKDFNUndertaking10.pdf (accessed May 20, 2011).

79. Ibid.

80. Isadore Tsetta, Evidence, Parliamentary Hearings on Canadian Environmental Protection Act, 11 May 1995, http://www.parl.gc.ca/content/hoc/archives/committee/351/sust/evidence/122_95–05–11/sust122_blk-e.html#0.1.SUST122.000001.AA1040.A (accessed March 13, 2012).

81. Alternatives North, *From Despair to Wisdom*.

82. For studies of long-term impacts of low-dose exposure to arsenic, see Chung-Min Liao, Huan-Hsiang, Chi-Leng, Ling-I Hsu, Tzu-Ling Lin, Szu-Chieh Cheh, and Chien-Jen Chen, "Risk Assessment of Arsenic-Induced Internal

Cancer at Long-Term Low Dose Exposure," *Journal of Hazardous Materials* 165 (2009): 652–63; Badal Kumar Mandal and Kazuo T. Suzuki, "Arsenic around the World: A Review," *Talanta* 58 (2002): 201–35; Jack C. Ng, Jianping Wang, and Amjad Shraim, "A Global Health Problem Caused by Arsenic from Natural Sources," *Chemosphere* 52 (2003): 1353–59; Lincoln Polissar, Kim Lowry-Coble, David A. Kalman, James P. Hughes, Gerald van Belle, David S. Covert, Thomas M. Burbacher, Douglas Bolgiano, and N. Karle Mottet, "Pathways of Human Exposure to Arsenic in a Community Surrounding a Copper Smelter," *Environmental Research* 53 (1990): 29–47.

83. For discussion of the links between landscapes of exposure and inequality, see Nash, *Inescapable Ecologies,* and Mitman, Murphy, and Sellers, "Landscapes of Exposure."

84. For the similar experience of the Yonggom people and the Ok Tedi mine, see Kirsch, *Reverse Anthropology,* chapter 7. Questions of indigenous trust in mining companies and scientific authorities are discussed in Leah S. Horowitz, "'Twenty Years Is Yesterday': Science, Multinational Mining, and the Political Ecology of Trust in New Caledonia," *Geoforum* 41 (2010): 617–26.