CMD 25-H9.11

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Written Submission from Stephen Lawrence

Mémoire de Stephen Lawrence

In the matter of

À l’égard de

Denison Mines Corporation

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Licence Application to Prepare Site and Construct for Denison Mines’ Wheeler River Mine and Mill Project

Demande de permis pour la préparation de l’emplacement et la construction du projet de mine et d’usine de concentration d’uranium Wheeler River de Denison Mines

Commission Public Hearing

Audience publique de la Commission

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The Phoenix project is a fairly complex one. The ore body is located in the Athabasca Sandstones just above the unconformity with the Basin's basement rock. The exact location is associated with a fault zone at the WS Shear that extends upwards into the Sandstones. The deposit is sedimentary in nature but the source of the uranium is the basement rocks themselves, as the sandstones are predominantly quartz with little mineralization. It is probable that groundwater moving through the sandstones through pores, but mostly along fractures at faults, found their way through the fault structures in the basement rock, where tectonic activity provided geothermal heat and the mineralization before the groundwater was vented back out into the sandstone formations, mixed with cooler groundwater from the Athabasca and its heat and dissolved minerals created the Phoenix ore body and altered the surrounding sandstones. It appears that, at the northeast end of the ore body, geothermal waters continued to move upwards towards Whitefish Lake, desilicifying the sandstone in that area, creating a more porous medium for groundwater and a more direct path to the surface for groundwater movement. Near the venting source source, graphitic material conducted heat upward. Deposition from saline mineralizing fluids took place at temperatures between 150 and 225°C, probably in a reducing environment. Feldspars in the sandstone were hydrothermally converted to clay. In the area delineated as ore zone 2b, uranium became highly concentrated, apparently up to 46%, and the medium was highly fractured, and contained less clay, making this a candidate for ISR mining and is the main focus for extraction. Several other ore bearing areas, with differing characteristics and proportions of clay, are nestled into 2b. Around the ore body is a silica halo of altered sandstone that has served to isolate the ore body for over a billion years. This halo also contains the upper portion of the basement rocks, that were also altered, which are also very friable and conducive to ISR, albeit with higher clay content. The temperature of the ISR solutions will be about 10°C - quite different from the temperature the mineralization was precipitated at.

The EA incorporates a great deal of science and modelling. The modelling is dependent on a lot of assumptions and data and interpretation. The ISR process is completely different from previous mines and needs to follow different rules. The nature of ore body itself is altered when the elements are freed from the stable bonds they were in and remobilized.

The ISR project proposes to further isolate the ore body by drilling holes around the ore body that extend 30m into the basement that will circulate a chloride solution to freeze a 10m thick vertical wall around the entire ore body. It is felt that the halo above and below the ore body will be sufficient to contain the ISR solutions vertically and the wall itself will prevent groundwater outside the orebody from coming in contact with the ISR solutions. The idea for extracting the ore, since it was formed in a reducing environment, is to inject it with oxygen, which will break up its bonds within the orebody and sulphuric acid will do the rest to allow the uranium to move towards extraction wells that will take it to the surface. The ISR solution is injected into the ore body through a ring of injection wells that surround the extraction wells. The rate of injection is slightly less than the extraction rate creating a negative pressure gradient towards the ejection wells. It is expected the makeup water will come from water stored below, in the basement rock and lower sandstone formation and from above in the Sandstone aquitard, through faults and fractures. If additional water is needed, it is expected that well water from outside the freeze wall could be pumped in from above the ore body. This is important because it confirms that groundwater can flow into the ore body from above. The negative pressure gradient is expected to prevent mining solution from moving upward into the sandstones, at least, no more than 50m, or moving to within 10m of the freeze wall.

The extracted solution is pumped to the surface where it is milled.

It is what is left down below that really concerns me over the very long term, beyond the timelines of decommissioning. About 30% of the ore body is dissolved and brought to the surface, leaving a honeycomb matrix filled with water. Together, with the containing freeze wall, this is expected to be sufficient to maintain the physical integrity of the ore zone during mine operation, so it will not collapse inward. I don't know what kind of calculation that has been done on the proposed sandstone matrix, as most of the tests done at the SRC lab were done with cores can results really be projected to the actual mine conditions. I suspect the real test will come at the time the freeze wall is removed. Is there enough sandstone structure left to support the 400m of sandstone above? Further, water is a fluid, if pressure is applied to it, it will displace itself through the easiest path available. would not this path be through the desilicified sandstone to the northeast, that connects upward with Whitefish Lake?? At first I was concerned that there would be remobilized uranium mineralization flowing through underground aquifers to who knows where, but perhaps Whitefish Lake is the main concern. From the plastic deformation during mining of potash deposits under pressure from above, I know the pressure is there. What kind of pressure are we talking about? I know that during the decommissioning the mine is rinsed out until the monitoring indicates contamination in the rinse water reaches respectable values, but, again, I also know water takes the path of least resistance so the rinse cycle will leave pockets of 'lint' behind. From the EA, I do not know what proportion of radioactive and other mineralization is left in the ore body or how tightly it remains bonded. I assume it still has some significance. I suspect that it is no longer in a stable bond, it is mobile. The pressures from above could force significant amounts of mineralized water outward, that the low pressures endured during ISR could not remove. With mineralized water flowing into the desalinized sandstone, for a period of time, until pressures stabilized, how would this reflect on the modeling already done?

Considering the pressures brought to bear to the volume previously occupied by the mineralization, if this does cause a deformation and collapse, what will this do to the halo that has been protecting the ore body all this time. It must fracture, along with surrounding sandstone, allowing unfettered access to the ore zone for groundwater flow. We must also allow that the new physical state of the ore body may remain much more conductive to water flow than it was originally. The situation has become much more dynamic.

Perhaps we should be looking at total load to the Whitefish system, including the effluent from milling that was released into the lake. When I talk about climate change, I will bring relevance to this.

If fracturing and collapse of the entire ore body volume is likely, causing the expression of more contamination to the groundwater system, how will this impact the planned decommissioning process and responsibilities and oversight required? Perhaps the time frames we are considering for the EA decommissioning and post decommissioning are too short for monitoring to pick up these kind of changes.

I find it hard to believe that they can remediate the ore body, by rinsing, so that no contaminants appear to be available. At first, it seems like magic. It is not clear to me how much of the ore they are able to recover, but they couldn't possibly get it all because of the variable porosity of the ore body - some will be trapped still. Let's say 20% of the ore body is not recovered and remains in some state of solvency.

I also found it interesting, in the Phase 1 part of the hearings, that there was concern of the ISR solutions reaching or penetrating the freeze wall but no concerns after the freeze wall was removed. This also makes me wonder what would happen if the pump houses were somehow destroyed - perhaps by forest fire. - what mitigation would be available? Also, with the freeze wall, I assume removal of the calcium chloride solution from the freeze wells will not be an issue?

The fact that no radioactive material will be left on the surface at the mine sight is also troubling. It is my understanding that only about 15% of the mineralogy is useful to make up the yellowcake. The other 85% went out with the tailings waste. They can't put it back into the ore body because it obviously wouldn't be washed clean. They plan to put this waste in totes in one of the ponds, to be disposed of at the time of decommissioning. I don't even want to think of how these totes might be handled by mine employees. At first they had planned to put it back into the underground Gryphon mine, once it was mined out, but they have decided against that. This material still contains 2 to 3% usable uranium so it is still economical to process out, so they want to send it to another mine for processing and the tailings would become part of that mills problem. I don't think an MOU covers it. I think another mill would have to renegotiate its license to do this. Without rock flour, the nature of this waste would be quite different from the feed rock at the other mills. Another troubling thing that comes into this, is exposure to Beta and Gamma radiation is never discussed. These mill tailings do not contain the rock waste that other underground mines would have. The material in these totes would be quite radioactive and a special license would be needed to transport it and likely special vehicles that would shield the operators from Beta and Gamma emissions from this highly concentrated mill waste. It reminds me of the special concrete containers that were used for special waste at Cluff Lake - on the surface they were freezing and leaking so they were eventually enclosed but the building became too radioactively hot so it was pulled down and waste was processed for its gold and the remainder pushed into the rest of the tailings. Not Great! I think another problem with waste, if were left inside Gryphon or underground in Phoenix is that the contaminants are way more mobile than they were in the orebody. Exposure to oxygen has released them from the mineral bonds that held them for a billion years. They can never be left uncontrolled, to migrate where water takes them. The findings from the 1977 Report from the Joint federal Provincial Panel on mine development in northern Saskatchewan, concerning cumulative effects on operating mines as well as considerations for Midwest and Cigar Lake mines concluded "The tailings are going to have to be monitored into perpetuity". The conventional method of dealing with uranium tailings is to place them into a mined out pit and cover them with a membrane and about a metre of ground cover. I don't think this is appropriate either, as anything left on the surface, as these mine pits are, are going to be subject to erosion - providing cover that is going to last for a fraction of the time required does not cut it and this concept needs to be reconsidered before we add to this mistake any further. And yet we continue to add to the capacity of the JEB pit volume - 2017 & 2020.

As the ISR solution enters processing, the radon is vented off into stacks. I assume this is also common at other mills as it must not be breathed in or consumed. Venting this material to the atmosphere so it is taken beyond the parameters of the sight has always made me wonder how this alpha emitter, and its daughters, affects the environment beyond the mine. Monitoring stations beyond the mine seem to be in very short supply!

My main concerns initially were the fact that the EA dealt only within the time frame involved in the life of the project and local area of the mine site. Those concerns still exist but I have wondered about the power usage at the mine and its impact on northern communities - will it be managed so they are subject to brownouts? At the time of the Millenium Mine hearings there was concern expressed that cancer rates in northern communities were far above average and that a thorough epidemiological study needs to be done to determine mine impacts on northern health - to my knowledge, this has never been done. Living in a relatively pristine environment, and consuming native foods should reflect a healthy population. Without some kind of baseline, how can you determine adverse impacts or benefits.

Something I brought forward at the Millenium Mine hearings in 2013 was the fact that at the Key Lake and Rabbit Lake Mill sites there are effluent pipes that go into the lake - just like is being proposed here and the mines in the Uranium City area. The difference being, the effluent from the mills around Uranium City was untreated - no rules existed - 5 million tons of tailings went into Fookes Lake alone. I had assumed that since Uranium was a heavy metal, it would settle out in the settling ponds before mill water was released to the environment. It is my understanding that once reintroduced into the environment, uranium will have potential impacts in its receiving environment for billions of years. In 2006 the CNSC found that uranium and uranium compounds were entering into the environment at uranium mine and milling operations in concentrations that may have immediate or long term effects on the environment and biodiversity. At that time the effluent being released into the environment (Horseshoe) at the Rabbit Lake operations had averaged out at 1.7 metric tonnes of uranium per year. Also molybdenum, selenium and likely many other elements. (they knew how much was being dumped or perhaps they were not paying attention to their monitoring results - the government asked them to monitor, so they did). They asked them to clean up their act and in 2007 CNSC Annual Report, the findings stated Cameco had managed to cut the uranium released back to 238 kg. – about an 80% reduction. Since 2006 the reduction in uranium has actually averaged out to about 61%, according to Cameco. At the time of the Millenium hearings, I calculated that over just a 16 years period, about 20 metric tonnes of uranium, as well as quantities of other elements, have passed into the environment at this one location. Key Lake was less successful in reducing releases.

Dennison claims that there will be no releases to the lake that do not meet predetermined water quality specifications. Key Lake and Rabbit Lake seemed to have trouble meeting objectives - what assurances do we have that Dennison will be able to meet them. The second issue with this issue is climate change. When water containing some level of mineralization is discharged and dispersed into the lake, it does bond with organic materials in the lake. I am pretty sure that as the climate heats up, it will be more and more difficult for the boreal forest to survive and forest fires will rage through the dead debris. It is likely the peat muskegs will also dry up in the heat. The net effect, as heat rises, is drought. What we learned at Beaverlodge is that as flow into lakes is reduced and lake levels fall, that sediments at the bottom of the lake will be exposed to wave action, particularly during severe storms. The tailings residue at the bottom of the lake will become oxygenated and released from its organic bonds. Add to this any contamination brought up through the desilicified sandstones under the lake. This is why I think we should be considering total loading into the environment of contaminants rather than just looking at concentrations in the effluent. Everything is now at the surface and interfacing and impacting with the environment. I do not wish on future generations the prospects that will likely unfold near Uranium City which we couldn't find a way to economically mitigate. With toxic chemicals, dilution can neutralize their impacts. Dilution of radioactive elements does not reduce their potential harm, it only disperses it over a wider area and population where it becomes a game of Russian Roulette as to what will be impacted.

Dennison is frank that spills and incidents will happen, although good management and thought out mitigation and training can eliminate most. To emphasize this, Cluff Lake had an incident where the tailings pond actually overflowed - how does that even happen? Rabbit Lake had a spill in 1989 of 2 million litres when a tailings pipe burst, on the way to the tailings pond, at a frozen valve contained in an area that had been left unheated - poor protocols. The effluent spilled into a drainage ditch whose culverts had been left open for spring runoff and the spill easily made its way to the nearby stream. Cameco, at first denied there was a problem but it had been spotted and reported by someone who was flying over. Media showed pictures of someone taking samples in a rushing stream and Cameco declaring no damage. They would have known exactly how much contamination entered the environment through their effluent. Cameco pleaded guilty in court. Poor corporate behaviour all around!!

Monitoring and collecting data has come a long way since the 70’s and 80’s when a clamshell bucket was used to grab samples off the bottom of a lake. When Beak consultants was commissioned to do a study of impacts of uranium mining in 1985. They found the sampling techniques and recording of data so poor and erratic that they could draw no conclusions from it. The government interpreted this as no problem and a new era of uranium mines went forward. In my mind poor data would be a red flag for revisiting sampling sites again, where possible, with proper core samplers that could delineated event horizons in soft sediments. Dennison seems to be taking a more scientific approach to sampling.