Eagle's Nest Project – Slurry Pipeline

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THE PEATLANDS OF CANADA'S FAR NORTH

"Seen from above, Canada's boreal forest shimmers on a bright summer day" (PEW Environment Group 2011). Countless lakes, rivers and wetlands make up much of the surface of Canada's boreal forest; "it is literally a forest of blue" (PEW Environment Group 2011). Imagine this, having "half the world's lakes larger than a square kilometer in size; 5 of the world's 50 largest rivers; almost 810 000 square kilometers (200 million acres) of surface water; and the world's single largest remaining unpolluted fresh water body, Great Bear Lake" all tied up in the far north of Canada (PEW Environment Group 2011). Approximately, 400 million ha (equivalent to 3% of the earth's land surface) of peatland cover the earth's surface. This peatland is primarily concentrated within the northern hemisphere (approximately 350 million ha) in North America, Russia and Europe with the remaining being tropical peatlands located in mainland East Asia, Southeast Asia, the Caribbean and Central America, South America and southern Africa (International Peat Society 2008).

In a relatively short period of time, since deglaciation (10 000yrs or so), peatlands have widely become established in the northern environments (Wieder and Vitt 2006). Essentially a peatland ecosystem is a terrestrial environment over the long term, on an areal basis, that has its net primary production exceeding the decomposition of organic matter. This process leads to a substantial accumulation of deposits rich in incompletely decomposed organic matter or peat (Wieder and Vitt 2006). Where a wetland accumulates more than 30 cm of highly organic peat (40cm in Canada) it is said to be peatland (Gorham 1991). Peatlands, sometime several meters in depth, are particularly common in the northern landscapes as mentioned earlier. Peat when saturated consists of approximately 90-95% water and only about 5-10% solid material (MacCulloch 2006). The process of peat formation and accumulation is a timely process with approximate timescales of 1metre build up in 1000 years. Although a peatland from above looks the same, on the ground it is very different. The properties of peat vary from peatland to peatland and even from point to point in the same deposit. The origins of the peat, the type of plant from which it was derived, the mineral content of the deposit, and the amount of decay or humification that has occurred are all associated with the variation in peat formation (MacCulloch 2006).

A peatland area is an interconnected wetland ecosystem, having the groundwater flowing across vast areas (Price *et al.* 2005). The array of different habitats encountered within this system can vary from flooded forests, shrublands, dunes and meadows to continually water-saturated peatlands, fens, forests, taiga, marshes and tundra. The interconnected wetland system plays an important function in recharging aquifers, absorbing and filtering contaminants, regulating river flow by absorbing and releasing excess water, providing habitat for waterfowl, fish and other wildlife (Natural Resources Canada 2009a), and storing and releasing greenhouse gases, making them key regulators of climate (MEA 2005).

Within this pristine landscape, virtually untouched by humans (for now), according to McInnis (2008), is “a land that houses one of the biggest ecosystems on the planet and a land that many regard as the last frontier”. This area is globally significant for its conservation values. Not only are the boreal’s aquatic resources home to abundant fish, mussels and other species, but the forests themselves provide critical habitat for wolves, lynx and moose, and endangered species such as woodland caribou (PEW Environment Group 2011). Billions of songbirds and millions of waterfowl inhabit the interconnected boreal forests and wetlands (PEW Environment Group 2011).

PEATLANDS AS A CARBON SINK

“Globally, the boreal forest biome is the world’s largest and most important forest carbon storehouse (Pimm *et al.* 2009, Tarnocai *et al.* 2009, Carlson *et al.* 2009, 2010), holding almost twice as much carbon per unit area as tropical forests” (IPCC 2000). Northern peatlands currently store large amounts of carbon, nitrogen and sulfur. The carbon stock is estimated (Gorham 1991a) at 455 pentagrams (Pg) = 10^{15} g) (133kg m^{-2}): about 30% of the world pool of soil carbon excluding peat, about 64% of the atmospheric pool, and about 55% of the total of the plant biomass (of which northern peatlands make up only a fraction of 1%) (Gorham 1991).

Overall carbon accumulation is a result of the primary role that the decomposition of moss species in a peatland plays (Vitt 2000). Sphagnum species are the principal contributors to peat accumulation (Vitt 2000). The lower level of more decomposed peat otherwise known as the catotelm, is characterized by constant water content, very low hydraulic conductivity, and anaerobic conditions. As organic matter is accumulated at the base of the acrotelm (i.e., the thickening of the catotelm), carbon is sequestered (Clymo 1984). In wetlands where there is no peat formation, rapidly decomposing vascular plants dominate, thus preventing a significant overall accumulation of carbon (Vitt 2000).

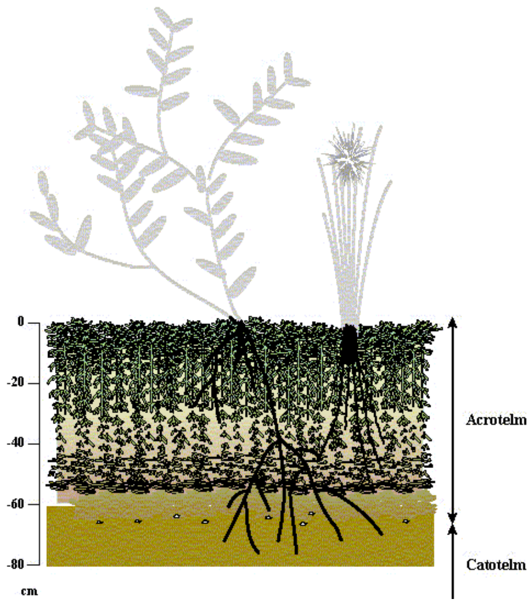

Figure 1: Diagram of the acrotelm and the catotelm (PERG, 2008).

Due to a lack of development in Canada`s boreal forest, in comparison to other countries, the peatlands remain largely intact and undrained (Gorham 1991). It is because of this that Canada`s boreal forest and peatland ecosystems are able to store an estimated 208.1 billion tonnes of carbon; which would be "equivalent to 26 years of global carbon emissions from fossils burning, as measured in 2006" (Carlson *et al.* 2009, 2010).

The amount of water present within peatlands is important. The loss of water from the upper peat through drainage, followed by oxidation, leads to compaction and settling at the surface. Removing the water from the peat results in increased levels of carbon dioxide (CO_2) and nitrous oxide (N_2O) being released into the atmosphere, however it decreases the emissions of methane (CH_4). The rate of release is all dependent upon the temperature of the peat, the ground water level and moisture content. It is important to manage water appropriately in order to minimize greenhouse gas emissions. In the process of peat extraction, the GHG sink function of the peatland is lost. Emissions also arise in the preparation of the surface for cutting (removing vegetation and ditching), extraction of peat and its storage and transportation, combustion and after-treatment of the cutaway area (IPS 2008).

An important component to the ability of peatlands to store and hold large amounts of carbon is the presence of permafrost. This continuously frozen ground is composed of dead plant and animal material that, because the ground is frozen, does not decompose releasing the carbon dioxide and methane that would otherwise occur. The thickness of permafrost in Canada varies from a few inches to 1 or 2 feet at the southern limit of the permafrost region to continuous reaching depths of 200 feet (at Churchill) (Brown 1974). According to Arctic scientist Kevin Schaefer (nd), "as Arctic temperatures rise, permafrost will thaw, releasing greenhouse gases that will accelerate the warming of the planet". As the northern environments warm up, the soil that is currently frozen (i.e., permafrost) will begin to melt and as it does so microbes will begin to break down the once frozen plant and animal matter, releasing carbon dioxide and methane into the atmosphere. An increase of these greenhouse gases released to the atmosphere could result in further warming of the climate (Schaefer n.d.). These northern environments, covered in peatlands, could soon become a carbon source rather than a carbon sink, what scientists refer to as a "tipping point". Tipping point essentially refers to something that was once relatively stable that switches to something that is an unstoppable cycle. If the permafrost releases more carbon than it absorbs, it would start a cycle where the extra carbon in the atmosphere leads to increased warming. The increased warming means more permafrost thawing and methane being released in a continuing cycle (Schaefer n.d.).

ABORIGINAL PEOPLES AND THE FAR NORTH

For millennia, hundreds of Aboriginal communities have made Canada's boreal forest their home, due to the vast networks of rivers, lakes and wetlands. Aboriginal peoples for thousands of years have been stewards of water and know very well the importance of respecting and maintaining healthy ecosystems. They are a people that live off the land using the irreplaceable values of water, for drinking, food and transportation (PEW Environment Group 2011). For them, the values their ancestors held in the past are still as important today as they have ever been (Notzke 1994). Similar to the past, Aboriginal peoples of the boreal forest continue to fish, trap, collect and hunt freshwater dependent species of plants and animals for sustenance, a much cheaper, healthier and more abundant means to survival than prepackaged shipped food. Furthermore, water to the Aboriginal people is not just a means of survival, but a source of deep spiritual connection. This connection means that contamination and degradation of the water threatens not only communities' health and sustenance, but will also significantly impact their well-being. Finally, although there are very few economic opportunities in these far north communities, many of them rely on income from commercial and recreational fishing and hunting (PEW Environment Group 2011).

NORONT EAGLE’S NEST PROJECT PROPOSAL

Approximately 500 kilometers northeast of Thunder Bay, in the “Ring of Fire” within the James Bay Lowlands of Northern Ontario, Noront Resources Ltd.’s Eagle’s Nest Project is situated. After a discovery of a high grade deposit of nickel, copper and platinum group element (PGE) by Noront, the Eagle’s Nest Project was developed. Following this discovery, other deposits including the Blackbird chromite deposits (staked in 2008), as well as Eagle Two and AT-12 nickel, copper and PGE mineral occurrences were identified (Noront 2011). Noront holds the largest total area of exploration claims in the “Ring of Fire” covering an area that is over 110,000 hectares (Noront 2011).

Noront (2011) describes the Eagle’s Nest development as an underground mine, having essentially all facilities, including workshops, storage areas, and infrastructure constructed as standard underground development, where typical bulk mining methods will be applied. Due to the wetland terrain where the mine is located and the very competent rock around the deposit, the Eagle’s Nest mine will be place underground. A standard mill process is planned and will be used to upgrade the mined ore containing copper, nickel, platinum, palladium, gold, and silver into a “concentrate” for sale as a final product. From the underground mill, the concentrate will be pumped to the surface, and then will be pumped to a facility just south of Webequie, via a 90-kilometer buried slurry pipeline. From this facility, the concentrate will be dewatered to then be transported by road and then rail. The mineral concentrate will be transported by truck from Webequie Junction to Savant Lake and then placed on rail car to reach its final destination (still to be determined). Furthermore, the load-out facility is proposed to dewater the mineral slurry to prepare it for shipment by road and then by rail. The water that is removed from the slurry will be collected and returned to the mine for reuse, via the same 90-kilometer slurry pipeline. As for the rest of the mined rock (also known as waste rock to do its lack of value because it cannot be sold), it will be returned to the mined out openings or to the caverns created through the extraction of the aggregate rock. Alternatively, to aid in the mining operations, some of the waste rock will be mixed with cement and water and used as structural fill or for road development. Runoff water will be collected and treated to be used in the mill processes (Noront 2011).

SLURRY PIPELINE

Noront (2011), in its project description, outlines how the concentrate will be pumped to surface, and then pumped from the site via a buried slurry pipeline to Webequie Junction. The pipeline itself will be constructed from very thick steel with exterior protection and an interior liner. To provide early leak detection, the entire length of the pipe is to be monitored and containment systems in place to address concerns regarding spills. To minimize truck traffic across the winter road, the pipeline will be used to transport the concentrate.

Within the documents provided by Noront, there is no indication of how the slurry pipeline will be buried within the peatland, and it certainly does not make mention of the disturbance that installing such a pipeline will have to the environment. In conducting some research, installing a pipeline within a peatland does have some serious and legitimate concerns. According to Findlay and Bourdages (2000), linear constructions, such as seismic lines, pipelines and roads may result in "a significant loss of biodiversity at local and regional levels because of restricted movement between populations, habitat fragmentation and increased human and predator access." In fact, fragmentation is considered to be one of the principal causes of extinction in forested ecosystems (Wilcox and Murphy 1985). Along areas of linear development, boreal wildlife has been shown to stay clear. A study done by Dyer et al. (2001) showed that caribou avoid habitat within 250 meters of roads. Similarly, boreal birds avoid suitable habitat up to 100 m from roads, pipelines and seismic lines (Schneider and Dyer 2006). Moreover, it is extremely difficult to measure the effects that these developments that are actually having on the biodiversity of plants and reptiles due to the fact that the effects may be undetectable for decades (Findlay & Bourdages 2000).

In comparison to other disturbance geometries, linear constructions have a proportionally large edge effect (Collinge 1996; Tromboulak and Frissell 2000), meaning the area around a disturbance and how it has been affected by changes in physical or chemical conditions, predation patterns, and animal behavior (Sakhalin Energy 2005). In addition to these and more specifically related to pipelines, linear constructions alters the hydrology, thermal regime, soil structure and vegetation of the ecosystem (Ryder et al. 2004, Sakhalin Energy 2005).

The construction of a pipeline begins with stripping the topsoil and then digging a trench. Following the development of the trench, the pipelines are stringed, welded, coated, and laid in place. Finally, the trench is backfilled using the soil that was initially removed, and then the area is reseeded with appropriate vegetation (Ryder et al. 2004); however, it is not this simple. Due to changes in localized interception and/or disruption of flow with peat, the hydrology of the ecosystem is altered (Sakhalin Energy 2005). Also, when excavating to dig the trench, the peat layers are mixed, which ultimately affects the flow of water through the peat. When the peat is exposed to the elements and is not in its natural habitat, it quickly dries out making it more vulnerable to erosion. As a result of erosion and compaction, there is likely to be less peat used for backfilling as there was removed. Finally, after the ecosystem is left to its own devices, and with further settling of the pipe, a linear depression will often form, acting as a passage for water flow, resulting in further erosion (Ryder et al. 2004).

Modification to soil structure, removal of surface vegetation, and the pipelines themselves which act as a heat source, all contribute to the change in the thermal regime (Sakhalin Energy 2005, Naeth et al. 1993). Degradation of the permafrost zone in peatlands can result in changes in temperature (Turcheneck 1990). Furthermore, the escalation of frost penetration during winter months and the resulting erosion during summer months could be consequences of the removal of the vegetation layer (acrotelm) (Dykes and Gunn 2004, Sakhalin Energy 2005).

When constructing a pipeline through a peatland, there is also the potential for spills. An increased amount of stress is placed on the pipeline, resulting of a lack in structural support, which is different when constructing a pipeline within mineral soil. “Many types of peat exhibit negative buoyancy, which means the pipelines will float upwards causing stress on the pipe” (Ryder et al., 2004). Finally, peat is highly acidic (having a pH range from a very acidic 3.6 to slightly alkaline 7.5), depending on the type of peat (CSPMA 2012), and can quickly corrode the pipes (Ryder et al. 2004).

Pipeline repair will be very difficult given the nature of the landscape; however, Noront (2011) claims they will do what they can to prevent ruptures, spill out and leaks. The pipeline will be fabricated with carbon steel piping with high-density polyethylene (HDPE) liner approximately .7–1 cm thick. There will be pressure and flow transducers spaced out along the pipeline in order to locate leaks or ruptures as soon as possible. When the pipeline is being assembled, X-rays will inspect welding spots to ensure that they are done properly. Pipe inspection will be done via a “pig” (pipeline inspection gauge) which uses magnetic flux leakage and ultrasound to inspect the condition of the pipeline assessing wear and tear from the slurry. The pig will store data such as location, dimensions, and corrosion, which can then be later retrieved and interpreted. Multiple gauges will be used to determine if there is a leak to avoid unnecessary stops in production. If a leak is detected alarms will sound and if the operator does not respond, the pump will automatically shut off after a given amount of time. Repairs are expected to be done using a helicopter; this includes excavation, repair of the damaged section, and removal of contaminated soil. Helicopter repairs will not be carried out during the winter months and Noront's description does not touch on how such repairs would be performed.

CONSEQUENCES OF A PIPE FAILURE

If a pipeline failure were to occur, it could have significant implications to the surrounding wetlands, as mentioned above. Pipeline failures are not very common; however, they do happen frequently enough to cause concern. Figure 2 illustrates the frequency of pipeline bursts in Canada from 1991 through to 2009. The graph illustrates that there was a significant time between 2003–2006 where there were no bursts. However, more recently, in 2009, even with advances in technology, notably there were a total of five ruptures. All five of the ruptures which occurred in 2009 were from natural gas pipelines according to the Canadian National Energy Board (CNEB 2011).

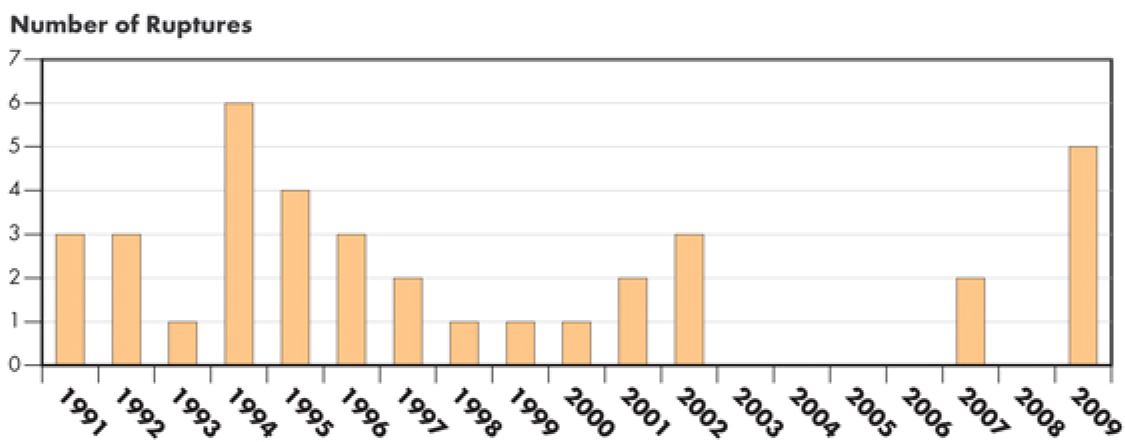

Figure 2: Frequency of pipeline bursts in Canada from 1991 through to 2009 (Canadian National Energy Board)

Figure 3 illustrates cracking and metal loss as the primary cause of pipeline ruptures. These two forms of failure would be common for a slurry pipeline due to the high corrosion rate. Something like this would require extremely high grade steel and possibly frequent maintenance to ensure the integrity of the pipeline coating. Pipeline integrity is considered to be affected by factors such as movement *of* vehicles or equipment over pipelines, construction activities with no soil disturbance, construction, landscaping, or grading that result in soil disturbance, and construction, landscaping or grading that result in pipeline contact (CNEB 2011).

Internal corrosion is also of serious concern and the impacts are often underestimated. Underground pipelines are susceptible to biocorrosion which results from microorganisms creating biofilms. These biofilms are cumulative and change the metal solution interface making it more susceptible to physical abrasion (Lutterbach et al. 2011). Physical erosion within the interior of the pipeline is affected by other factors including temperature, solids concentration, and impeller speed. The impacts of each seem to be greatest when combined with one another (Madsen 2003). There is a strong synergism between physical erosion and corrosion from microorganism as well as other acidic sources that may come from the source (Madsen 2003). Whether the pipeline is linear can greatly affect the rate of erosion, the more frequent “corners” there are, the more wear there will be in those sectors (Upadhayay 2010). Velocity as well as hardness can have a significant impact on erosion. Hardness generally affects the speed at which the slurry will travel; if the velocity is very high with a solid material, then erosion could be detrimental to the pipeline integrity. If the particles are being carried by the pipeline have sharp edges, it can result in significant “gashes” in its interior. Particle size can also greatly affect the amount of force which is being applied to the liner; this is especially important when the shapes of such particles are jagged. The concentration will also affect the erosion rate due to more frequent contacts with the liner. Very fine particles will generally not have sufficient force to remove anything substantial and the integrity of the pipeline could remain relatively intact (Upadhayay 2010).

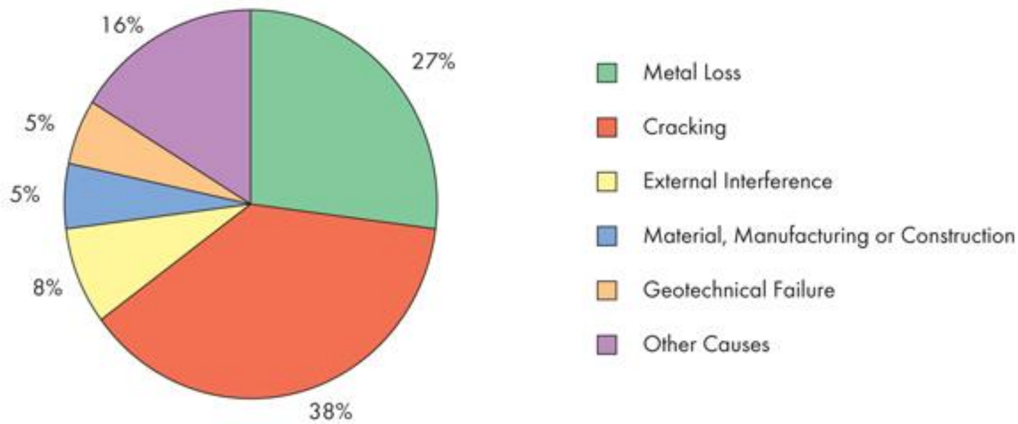

Figure 3: Primary causes of pipeline ruptures/bursts (CNEB 2011).

HUMAN HEALTH IMPACTS

The Eagle's Nest project is planning on mining a wide variety of metals, each having their own unique health effects if exposed to the environment. Platinum (Pt) and palladium (Pd) belong to the platinum group elements and therefore have similar characteristics. These are some of the most valuable elements in terms of cost and uses. Common uses of palladium are dental appliances, chemical catalysts, electrical appliances and jewellery. The most common use of the metal would be in automotive emissions control catalysts. Palladium is slightly less than half the price of gold, whereas platinum is often around the same value as gold.

Low concentration exposures of Pd are primarily airborne and can cause allergic reactions to susceptible individuals. People who are susceptible to nickel are also frequently susceptible to Pd. People who are occupationally exposed to Pd are dental technicians, miners, and chemical workers. They are primarily exposed to dust which can result in skin and eye irritation (Kielhorn et al. 2002). With increasing amounts of Pd, it has been found that it can cause acute toxicity or hypersensitivity with respiratory symptoms, urticaria, and dermatitis. Pd can also have significant effects on the immune system leading to the primary concern of exposure (Iavicolia 2011). Pt had similar health effects, and Pt has also resulted in a decrease in health, size, and protein levels within aquatic organisms (Haus 2010).

AQUATIC ECOSYSTEM IMPACT

Nickel can have significant impacts aquatic ecosystems. Bioaccumulation is present in many species and seems to be more prevalent and have more of an effect to those lower on the food chain. The fact that nickel is so persistent within an ecosystem is the cause of why it can be so harmful (Sreedevi et al. 1991). If exposed to extremely high levels of nickel not found in the natural world, then the dosage can be lethal. Even sub lethal concentrations can still have an impact. Copepods and mussels seem to accumulate nickel quite readily. The reproductive capacity of the copepods has been found to be reduced. Successful egg and offspring production were found to be greatly reduced and if concentrations were high enough proved to be detrimental (Mohammed et al. 2010). Nickel can also be genotoxic as well as carcinogenic for many mammalian creatures (Zelikoff 1993). In addition, it also greatly affects the immunological response within mammals as well as fish (Bowser et al. 1993). Copper, also being a heavy metal, has very similar health repercussions, primarily affecting immunological response times and functions. This results in more frequent cases of infections and malignant diseases. Tumors have also been found in terrestrial mammals which have been exposed to higher than normal concentrations of heavy metals (Zelikoff 1993).

Heavy metals can be soluble in water and it has been found that high organic content can increase their solubility even more. This solubility would increase the mobility through the environment as well as bioavailability (Ashworth and Alloway 2008). With the James Bay Lowlands having high organic matter and water content, this could cause heavy metals such as copper and nickel to spread readily and make them difficult to remove (Noront 2011). The increase use of Platinum Group Metals (PGE) has led to an increased interest in the effects on the natural world which were initially thought to be harmless (Haus 2010). The initial lack of concern was due to the fact that PGEs stay in their elemental form as they enter the water table and were thought to have no impact on wildlife. Further studies have revealed that aquatic animals and plants have been found to accumulate these elements and the effects have shown an increase in stress markers (Haus 2010).

CONCLUSION

Peatlands are a critical component of the biosphere and its functions. Peatlands interact with fundamental life-support processes, involving biogeochemical cycling, food-chain support, hydrological dynamics and water quality, and provide habitats for many characteristic, and some highly adapted, plant and animal species (IPS 2008).

The water cycle's ability, within the Canadian boreal forest, to maintain freshwater biodiversity is being threatened. An increase in freshwater withdrawal and disruption of freshwater flow, primarily for agricultural, oil and mineral extraction, and hydroelectricity production, may result in unpredictable effects on ecosystem functioning (PEW Environment Group 2011). According to the PEW Environment Group (2011), "continued overexploitation and degradation of freshwater resources and ecosystems, particularly peatlands, across the boreal forest has consequences for climate cycles, nutrient cycles and livelihoods of the people living there”.

If the development of the mine is not economically feasible, then Noront will obviously not be interested. The pipeline may seem well planned; however, there are lot of conditions which are not being considered and the physical geography poses many problems. This is very unstable land, especially in areas of semi annual frost causing the consistency to vary. This could cause weight to be distributed unevenly throughout the pipeline, which could possibly lead to cracks or increased abrasion resulting in even more wear and tear. This causes major problems because there is no access to the pipeline via road. In the event of a rupture during winter, it would take a lot of time and possibly additional habitat destruction to reach the area of failure. Having additional piping on location would also be required in order to complete the repair in a timely fashion. This would then require further X-rays to ensure the new welds have been done properly as well as inspection of the surrounding pipeline to see if it was disturbed. The nature of the material that is being harvested is of hard consistency, therefore interior erosion is of concern as well, especially when corrosion is also occurring (Upadhayay 2010). Given the significant implications of a leak and the unstable nature of the land that the pipeline is being built on, the potential for leakage in the pipeline seem probable. The lack of planning for a leak occurring during the winter is of great concern. There is no mention of how they would collect the contaminated soil if there was a leak or how they would excavate the soil via helicopter. The impacts of this project towards the environment will be great and could be detrimental if a failure were to occur.

Looking at the past two centuries of development in Canada, up to 68 percent of wetlands in southern Ontario and 70 percent of prairie wetlands have been lost. We continue to experience this loss today (Environment Canada 2009). Should we be taking the same approach in the north? Or should Canada take a proactive planning approach to protect this environment which is so critical to our future?

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