D·I·A·N·D

Contaminants & Waste Management Program

ARCTIC GOLD AND SILVER MINE

ARSENIC CONTAMINATION

Date:

March 2000

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ABSTRACT

The Arctic Gold and Silver (AGS) Mine's abandoned mill and tailings site is located within the Carcross Tagish First Nations (CTFN) selected lands. In 1999, the DIAND Contaminants Program addressed a concern regarding arsenic levels in vegetation and sediment surrounding the site. An earlier study at the nearby Venus Mine site had found high levels of arsenic in raspberries, associated with dust from the tailings blowing around the site. An evaluation of vegetation and sediment at the Arctic Gold and Silver site was conducted to determine if a similar contamination of vegetation had occurred and if the sediment containing arsenic was reaching Bennett Lake. The study found that although there were elevated levels of arsenic near the tailings, they were not as high as those found at the Venus Mine site. The sources of vegetation contamination at AGS are probably a combination of airborne dust and acquired arsenic by the plants through their roots from tailings contaminated soils. Arsenic was also found in the background plant samples, due to the arsenic naturally occurring in the local rock. There was no evidence that tailings from the mine site are being transported to Bennett Lake in any significant concentration.

BACKGROUND

The ore deposit mined by Arctic Gold and Silver Mines Limited is located approximately 4 km south of Carcross, Yukon. It lies at an elevation approximately 1700m above sea level on Montana Mountain at the southwest side of Bennett Lake. (Map 1).
The deposit was discovered in 1905 and worked intermittently until the 1920's. In 1964, a mill was constructed and was in production until October 1969. Approximately 150 tons/day (136 metric tonnes) of ore was mined during the mine's operation with an estimated 20,000 tons (18,134 tonnes) deposited in the tailings pond. The sulfide ore was collected using a froth floatation process, and shipped to Sweden for roasting. (Environment Canada, 1976).

The tailings pond initially discharged into a marsh west of the mill site, where the headwaters of Tank Creek flowed. Today the marsh is a beaver pond, which incorporates the original headwater drainage. The water drains from the pond through a culvert under a road constructed across the Creek, and over a portion of the beaver dam along the road into Tank Creek. The Creek continues to drain directly into Bennett Lake (Map 2).

1975 Environment Canada Study

In 1975, Environment Canada investigated the CTFN concern that pollution seeping from the mine site into Bennett Lake would affect fish health. In the summer of 1976, the rate of discharge from the tailings pond was 2 to 5 litres per minute depending on the surface runoff. The study found that spring runoff had increased the extractable iron and arsenic levels through sediment transport. Dissolved sulfate levels in Tank Creek had also increased due to spring runoff. No adverse effect from the Arctic Gold and Silver Mine on the watershed of Tank Creek was concluded from the study. The absence of a resident fish population in the creek was more likely due to the location and nature of the creek (gradient and size) than to the presence of the mine.

1997 Water Resources Division Study – Northern Affairs Program

In 1997, a follow up study was performed by DIAND on the mill site. The original drainage route was found to currently be a beaver pond. The rate of discharge from the tailings impoundment into the beaver pond was measured at 6 to 10 litres per minute. Both sediment and water samples were taken from the mouth of Tank Creek, at Bennett Lake. This work confirmed the 1976 findings of Environment Canada; no measurable environmental effect from the tailings site was found on the water quality of the beaver pond and Tank Creek. Although the tailings on the site were found to contain metal concentrations, which could have been hazardous, the drainage was not large enough to produce a measurable affect on the water quality downstream.

ARSENIC

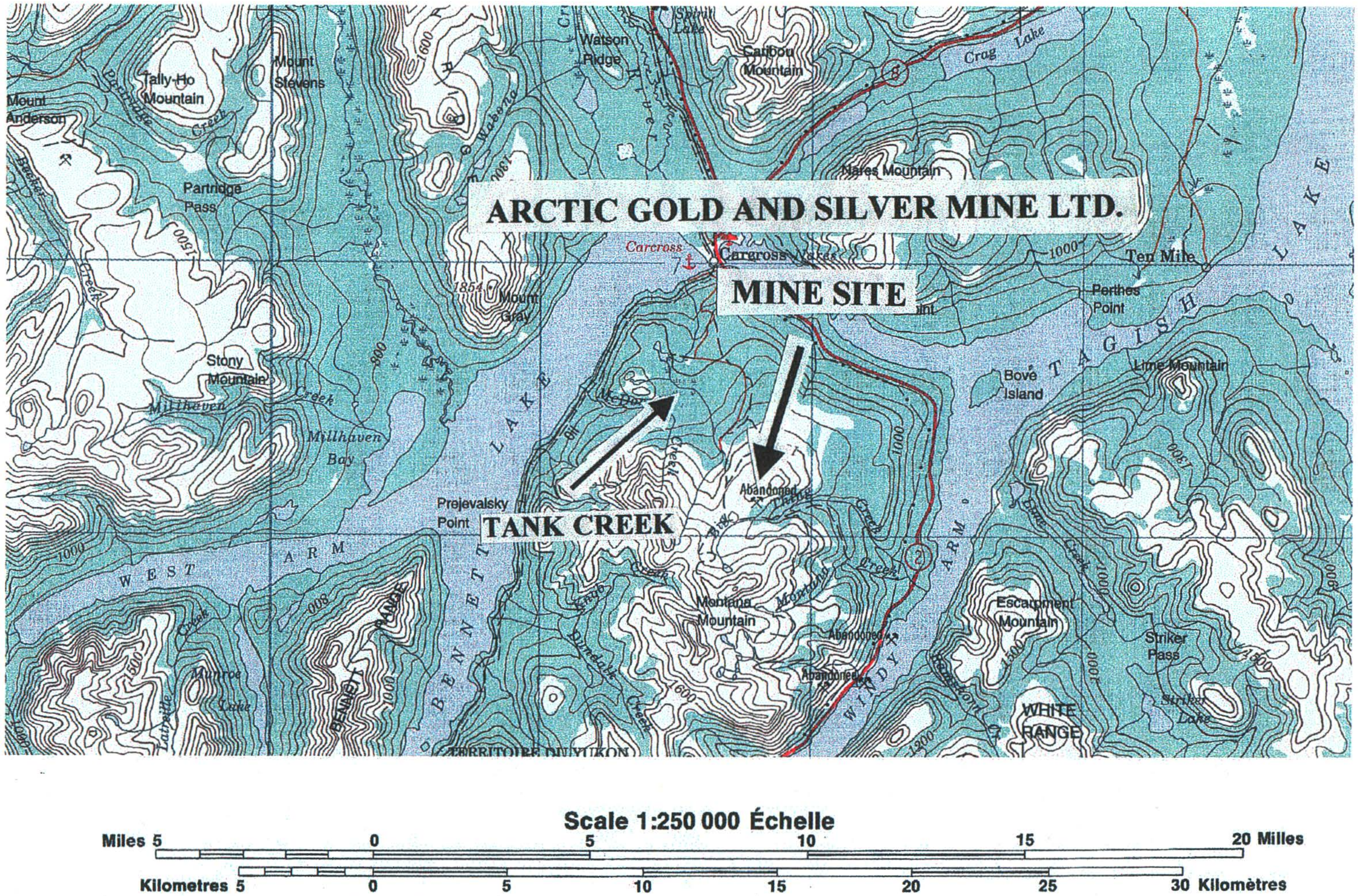
Arsenic (As) is widespread in nature. Bhumbla and Keefe (1994) estimated more than 99% of naturally occurring arsenic in the environment is present in rock. This element ranks twentieth in abundance in the earth's crust and is associated with many chemicals used in medicine, cosmetics and poison, the latter perhaps most well known. A dose of 200-300mg of arsenic is toxic to humans (Gorby, 1994 as sited from Law and Diamond, 1999). It is also a known carcinogen however no risk specific dose is known (Law & Diamond, 1999).

Montana Mountain's parent geologic material includes arsenopyrite (eg.Fe_3As_2) minerals. This form of arsenic is inorganic. The inorganic arsenic in the tailings can be converted to organic arsenic by chemical or microbial methylation, where bacteria modify inorganic arsenic so that they can excrete it from their systems. Organic arsenic is more readily taken up from soils by plants than inorganic arsenic.

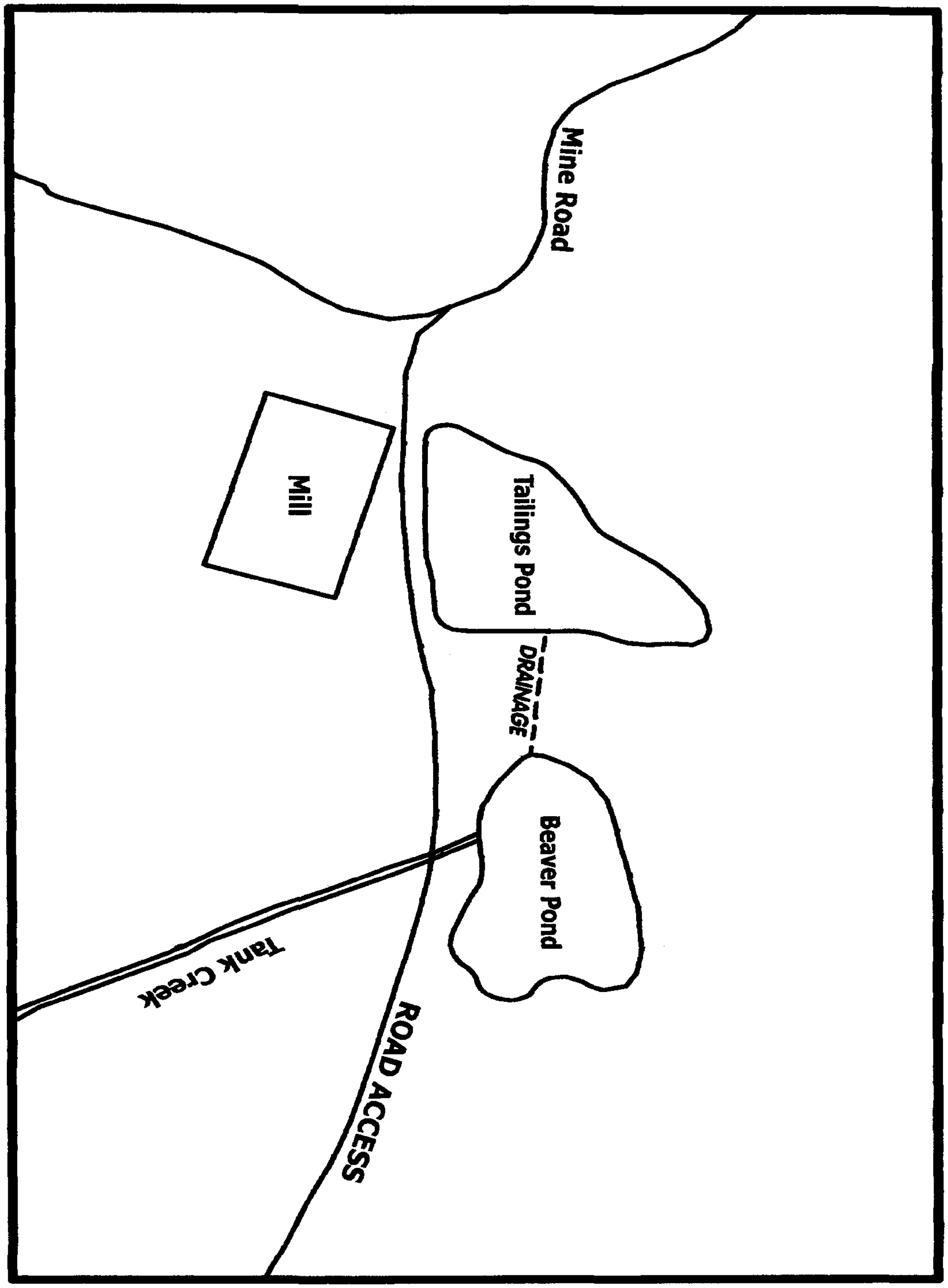
There are two possible pathways of arsenic, both organic and inorganic, to vegetation. One involves transport on wind where fine particles from the tailings can be blown into the porous structure of the berries. These particles may not be removed by rain. The second pathway is via the biological uptake of arsenic by plants.

According to the CCME guidelines for Soil Quality for Protection of Environmental and Human Health, only soluble inorganic arsenic is available for plant uptake. The solubility of arsenic is primarily determined by pH and redox potential and mobility on the arsenic speciation and flow rates. The actual uptake of arsenic is influenced by several factors. These include but are not limited to; plant species, soil properties and the concentration of arsenic in the soil, and the type of arsenic involved, as plants may reject certain species or arsenic preferentially. Arsenic availability to plants tends to be highest in coarse-textured, less developed soils. Other factors affecting the availability of arsenic to plants include the clay, aluminum, organic, iron, calcium and phosphorus content.

Arsenic is accumulated by plants growing in soils that contain inorganic arsenic and where their roots are exposed to bacteria producing the organic form of arsenic. For arsenic to reach a concentration of 1 mg/kg or 1ppm in a plant, on a fresh weight basis, the concentration of arsenic in the soil must exceed 200-300 ppm. Accumulation concentrates in different components of plants. The highest concentrations tend to be found in the roots. Decreasingly smaller concentrations are usually found as follows; leaves, stem with the lowest concentrations occurring in the fruit and seeds (Law and Diamond, 1999).



MAP 1: CARCROSS, YUKON TERRITORY



MAP 2: LAYOUT OF ARCTIC GOLD AND SILVER MILL SITE

METHOD AND MATERIALS

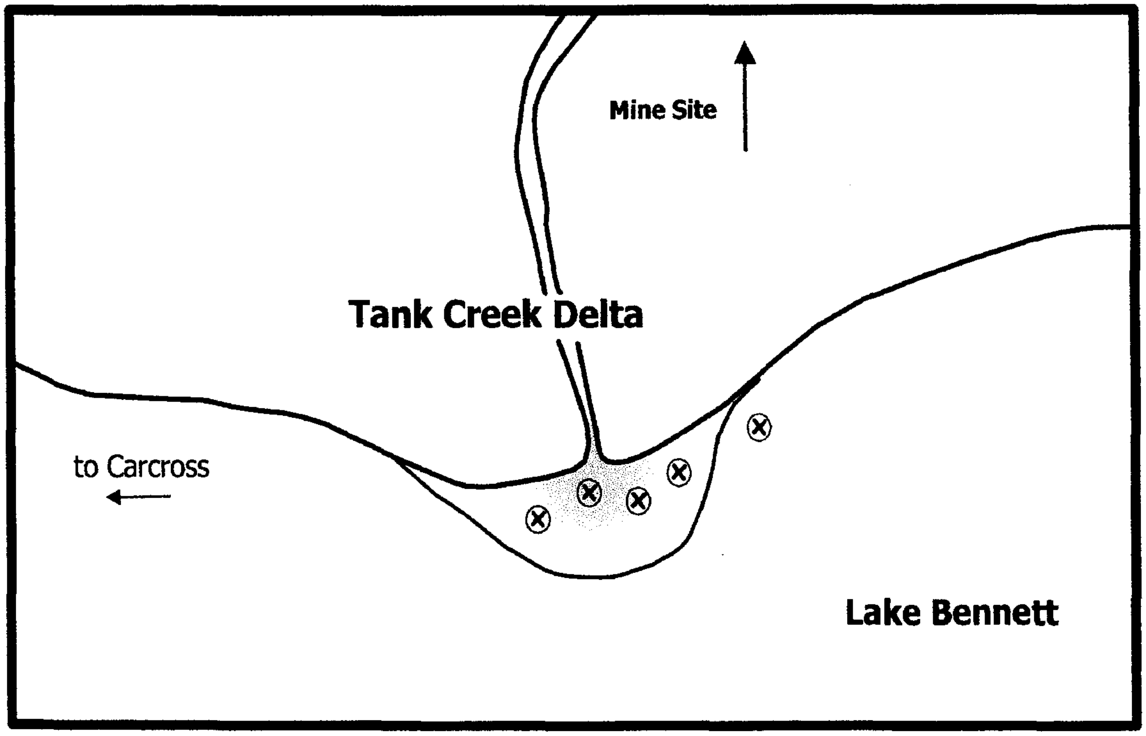
Five samples of sediment were collected in the delta area at the mouth of Tank Creek in Lake Bennett (Map 3). The samples were collected in the same direction as the lake flows, which is toward Carcross. Tank Creek #1 is closest to the mouth of the creek and Tank Creek #5 is farthest from the mouth. This was to aid in capturing any light tailing fractions that had escaped from the mouth and into Lake Bennett. A background sample was collected west of Tank Creek in Lake Bennett.

Vegetation was sampled in around the tailings and Tank Creek area. Willow, alder, sedge grass, bearberries and raspberries were sampled. Three samples were collected by the tailings and four samples were collected in and around Tank Creek below the mine site (Map 4). A background sample was obtained on Montana Mountain by the road. The vegetation sampled was based on the wildlife's dietary preferences.

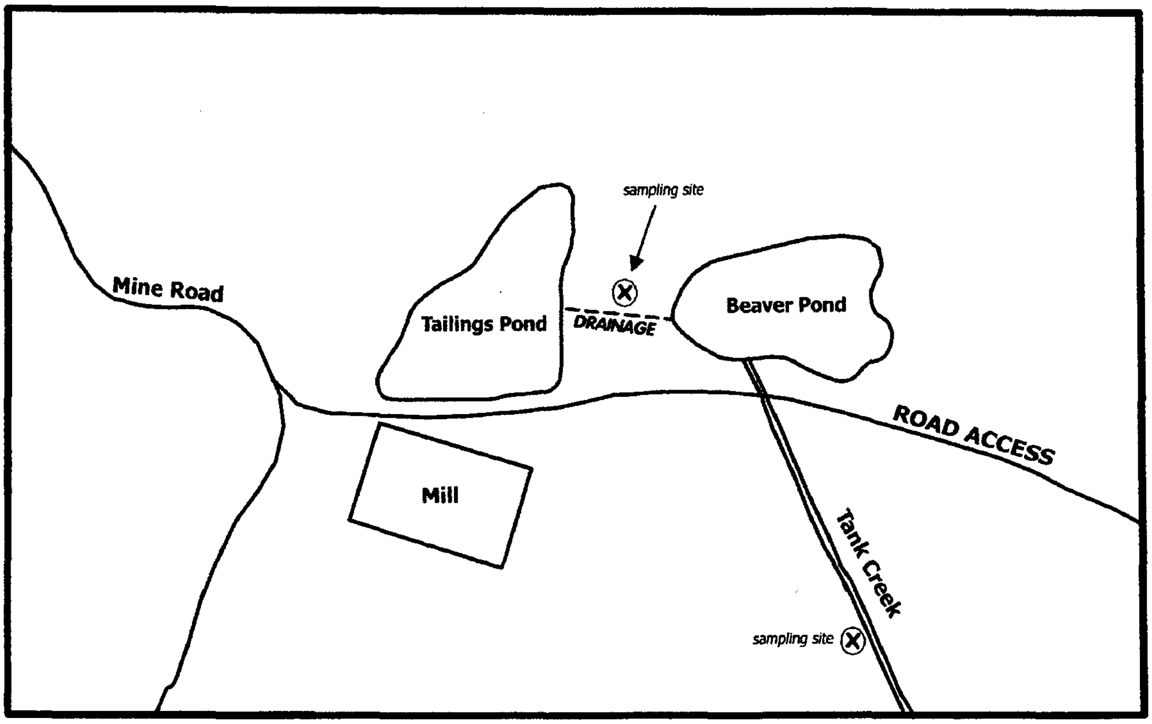
RESULTS

Table 1 compares the five sediment samples, from the mouth of Tank Creek, with a sample of tailings washed from tailings impoundment, into the beaver pond. Metal concentrations drop significantly with the exception of aluminum, iron and zinc, which have increased, presumably due to the rock over which the Creek flows. Tank Creek #3 and Tank Creek #4 have the highest concentrations, as compared to the other three samples.

The vegetation samples analyses are presented in Table 2. Minimal organic arsenic was found in all of these samples. Inorganic arsenic was highest in the willow samples, near the tailings. The raspberry fruit sampled had a concentration of 2.4 mg/kg, while the raspberry vegetation contained a concentration of 4.6 mg/kg. The arsenic concentrations were found to be consistently higher in the vegetation from the tailings area, than the vegetation sampled in and around Tank Creek, or in the background samples.



MAP 3: SEDIMENT SAMPLING SITES ON TANK CREEK DELTA



MAP 4: VEGETATION SAMPLING SITES

PHOTO A: TANK CREEK DELTA

PHOTO B: ARCTIC GOLD AND SILVER SITE

TABLE 1:

METAL PROPERTIES OF TANK CREEK MOUTH SEDIMENT SAMPLES COMPARED TO SEDIMENT FROM THE TAILINGS DRAINAGE

Total Metals (ug/dry g)	Tailings Drainage	Tank Creek #1	Tank Creek #2	Tank Creek #3	Tank Creek #4	Tank Creek #5
Aluminum	16300	18600	19000	22600	22300	19800
Arsenic	41800	79	67	252	245	36
Cadmium	3.2	1.5	1.2	1	2	1
Calcium		8790	9250	11300	12500	8630
Copper	51.4	25.4	23.6	29.8	38.3	26
Iron	97000	29000	27000	49000	45000	21000
Lead	2340	28	24	34	42	55
Nickel	0.6	19.3	18.7	23.9	24.5	18.3
Silver	116					
Zinc	66	128	113	119	166	98.9

TABLE 2:

ORGANIC ARSENIC AND ARSENIC LEVELS IN VEGETATION AND FRUIT SAMPLED AT THE ARCTIC GOLD AND SILVER MINE SITE

Origin of Sample	Organic Arsenic mg/kg (ppm)	Inorganic Arsenic mg/kg (ppm)
Fruit—Raspberry		
Venus	<0.01	2.4
Background	<0.01	0.2
Tailings—Vegetation		
Willow	0.1	43.8
Sedge Grass	0.03	4.3
Bearberry	<0.01	0.6
Tank Creek--Vegetation		
Sedge Grass	0.06	4.5
Willow	0.05	1.9
Alder	<0.01	2.5
Bearberry	<0.01	0.3
Raspberry	<0.01	4.6

CONCLUSION

The sediment samples in the delta of Tank Creek show a minimal transport of metals from the tailings at the Arctic Gold and Silver Mine mill and tailings site, to Bennett Lake. In comparison to the arsenic levels at the drainage, concentrations are significantly lower at the Creek mouth. The higher values obtained at the delta, at sites #3 and #4, may be related to the preferential deposit of sediment within the delta itself. This material may or may not be from the tailings site. With the rock of the mountain containing arsenic rich minerals, it may be a factor of material eroding in the steep Tank Creek channel, as it drops to the Creek mouth. The studies conducted since 1975, have shown that while sediment in the drainage from the tailings pond does contain tailings, there is no evidence that this material is being carried beyond the beaver pond.

The Tank Creek sediment samples all show high levels of iron, as does the parent rock on the mountain. This would produce high levels of iron in the soils in which the sampled vegetation is growing. From the literature, high levels of iron can reduce the ability of plants to take up arsenic (Law & Diamond, 1999), and may be acting to reduce the levels of arsenic present in the samples.

The TDI (tolerable daily intake) as given by the CCME guidelines is 0.18 to 0.73 ug/kg of body weight per day for adults. This means that a 71 kg person could eat 51.83 ug of inorganic arsenic in a day with no effect. That represents approximately 11 grams of raspberries at the Tank Creek sampling site, where the arsenic levels were highest, due to impact from the tailings. Concentrations in the background samples are low enough to allow consumption of 259 grams of raspberries. This suggests that raspberries around the Montana Mountain area are safe to consume in reasonable quantities, while those near the tailings area should be avoided. All consumption guidelines are intended to prevent negative effects caused by the continued eating of a certain food over a long period of time. A seasonal increase in consumption may be tolerated by individuals, but cannot be recommended.

Testing of raspberries at the nearby Venus mine site, before and after a capping operation, showed a significant drop in the arsenic concentrations present. This suggested that the arsenic concentrations in the plants had been largely due to windborne material. A similar assumption could be made for the vegetation in the area close to the Arctic Gold and Silver Mine Site. The vegetation beyond the direct effects of wind blown material or tailings washed directly onto it should be considered as natural background samples.

There is little indication in the vegetation samples of organic arsenic uptake. However, there is still potential for arsenic to enter into the food chain through windborne dispersal from the tailings. The reclamation of the Venus Mine tailings pond produced a dramatic drop in total arsenic concentrations. Similar results could be expected at the Arctic Gold and Silver site, but only follow-up sampling would confirm this theory.

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