SNOW DISPOSAL IN WHITEHORSE:

CHEMICAL CHARACTERIZATION AND DISPOSAL ALTERNATIVES

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INTRODUCTION

Initially, this study was undertaken in an attempt to assess the impact of snow disposal on the Yukon River water quality; however, it has since evolved to include a brief review of the components considered as contaminants of waste snow in southern urban centres and, with this information, an assessment of the Whitehorse situation in respect of the limited data which was collected as part of the study. A recommendation of snow disposal practices based on the least environmentally damaging method on a long-term basis here in Whitehorse is presented.

The present practice by City Works for snow disposal is to remove the snow waste by truck to one of three identified dumping areas. These three areas include: an area on the south access road across from the Robert Service Park; another area, also along the south access road, identified as being near the skidoo racing track; and the third area being along the river edge in the White Pass train yard at the old riverboat site. This last area, however, has been discontinued as a dumping site for snow because concerns over the possible detrimental effects on the river water quality have been expressed by the Environmental Protection Service to the City Engineer as a result of information collected from this study.

In terms of ice control on city streets for the winter 1978-1979, the City has purchased the following de-icing and abrasive compounds:

(1) 500 tons 3/4 crushed gravel
(2) 100 bags (100 lbs/bag) NaCl
(3) 300 bags (100 lbs/bag) $CaCl_2$

Use of de-icing compounds are in combination with abrasives, with an approximate ratio of 400-500 lbs de-icer with 5 tons of 3/4 crushed gravel. The type of de-icer in use is temperature-dependant, with no de-icer being used at temperatures below $-15^{\circ}C$, generally speaking. Calcium chloride is used between -10° and $-15^{\circ}C$, and sodium chloride is used when temperatures are between freezing and about $-10^{\circ}C$.

(Source: Marshall Keleher - City of Whitehorse)

METHODS

Sample sites were selected with respect to possible impacts on receiving waters with control stations upstream and stations downstream from waste pile to determine influence of snow waste melt on river waters. Three stations are described in Table 1 and are shown in Figure 1.

During ice cover, stations 2, 4, 6 and 7 were sampled through an 8" bore hole made during sampling periods using an ice auger. Station 4a was located at the toe of the waste snow pile, about mid-point along the length of the pile. This location changed slightly according to run-off conditions.

Station 5 sampling was made initially by demarcating a one-foot square section at the toe of the waste pile and chipping ice and debris from this area into a two-gallon bucket; the ice was then melted and the melt water transferred to linear polyethylene sample bottles for shipment to Vancouver and analysis at the EPS Laboratory Services in West Vancouver. All analyses for metals plus chloride, turbidity, oils and grease, and hardness were carried out at the West Vancouver laboratory.

Conductivity and pH measurements were carried out within an hour of sampling at the EPS Yukon Branch laboratory in Whitehorse.

Samples shipped to Vancouver for analysis were preserved as per most recent instructions listed in the Pollution Sampling Handbook (EPS publication); they were:

Metals - nitric acid to pH less than 1.5
Chloride, turbidity - keep cool
Oils and grease - sulphuric acid to pH less than 2.0

The waste/snow disposal site and sampling stations along the river were sampled a total of six times, or once a week, from April 7 to May 10, 1978, during which time the waste snow pile melted approximately 90 to 95 percent.

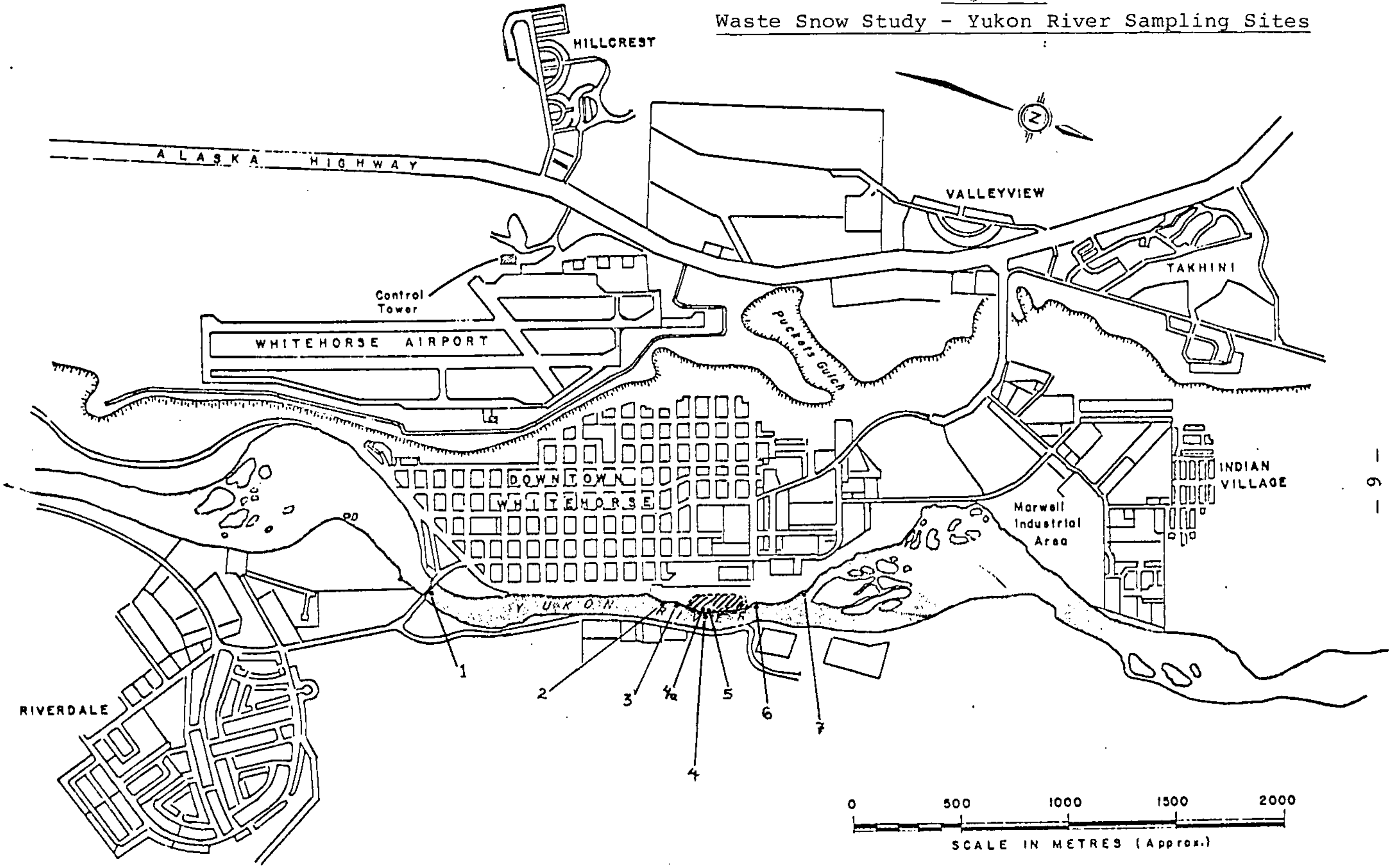
Table 1

Waste Snow Study Stations
April and May 1978

Station 1	-	Robert Campbell Bridge
Station 2	-	Yukon River at "New and Nearly New", about 60 metres upstream from the main snow waste pile
Station 3	-	Ditch between "New and Nearly New" and power transformer enclosure in White Pass & Yukon Route yard, about 30 metres upstream from the main snow waste pile
Station 4	-	Five metres out from toe of waste pile under surface of the ice (Yukon River)
Station 4a	-	Melt-water at toe of pile
Station 5	-	Waste pile ice and debris sample
Station 6	-	Twenty metres downstream of snow waste pile (Yukon River)
Station 7	-	Downstream of snow pile 350 meters, along east bank.

Figure 1

Waste Snow Study - Yukon River Sampling Sites



RESULTS

All data obtained through Environmental Protection Service sampling of the Yukon River and snow disposal area were included in the following pages. Parameters recorded in mg/ℓ unless otherwise indicated.

The continuity of sampling was interrupted for station 3 at the confluence of the Yukon River and the ditch draining the White Pass yard. This was a special station chosen only because of the observed run-off from the train yards which contained evidence of diesel fuel. The station was immediately upstream from the snow disposal site and was sampled only a few times when run-off was observed. Sampling this location was suspended when yard run-off was halted with small earth berms installed by White Pass.

Table 3 was extracted and condensed from Fisheries Pollution Sampling Handbook (3) to indicate relative levels of heavy metals which cause toxicity effects in various fish.

Tables 4 and 5 were taken from sample data as presented in Tables 6 to 11; they were included strictly for ease in comparison of the snow waste analysis and the run-off from the snow waste pile.

Table 2

Snow Waste Study - Averaged Values

	River Station 1	DISPOSAL SITE: Snow Pile Run-off Station 4a	DISPOSAL SITE: Snow Pile Station 5	River Station 6
Chloride	< 0.05	23.2	69.57	<0.55
Turbidity-FTU	1.75	175.7	>456	2.10
Oils & grease	< 7	22.67	23.80	< 7
Copper	<0.020	<0.020	<0.020	<0.020
Iron	<0.020	20.67	2600	0.04
Lead	<0.10	≈0.34	62.09	< 0.10
Zinc	<0.020	0.41	24.56	<0.020
Calcium	15.36	26.12	1059.5	15.62
Magnesium	2.41	92.61	924.0	2.42
Hardness as Mg/ℓ $CaCO_3$	48.33	110.8	6450	48.9
Sodium	1.32	19.44	76.35	1.31
Cadmium	<0.010	<0.010	<0.010	<0.010
Nickel	<0.020	<0.020	<0.20	<0.02
Manganese	0.01	0.52	45.83	0.01
Aluminium	< 0.30	20.41	1725.6	<0.30
Barium	0.03	0.31	25.2	0.03
Cobalt	<0.02	0.06	1.60	< 0.020
Chromium	<0.02	<0.020	1.92	< 0.020
Molybdenum	<0.02	<0.02	<0.02	<0.020
Antimony	<0.10	<0.10	<0.01	< 0.10
Tin	<0.10	<0.10	< 0.01	<0.10
Strontium	0.07	0.12	5.35	0.07
Titanium	<0.020	1.54	174	< 0.020
Vanadium	<0.030	<0.030	6.09	<0.030
Arsenic	<0.20	<0.020	<0.20	<0.020
Mercury	<0.10	< 0.10	<0.10	<0.10
Selenium	<0.10	< 0.10	<0.10	<0.10
Silicon	1.34	4.18	84.96	1.41
pH	7.56	7.99	8.71	7.77
Conductivity µmhos/cm^2	63.5	102.3	108.8	60

Table 3

Toxicity of Metals on Fish

COMPOUND	POSSIBLE SOURCE	TOXICITY CONC. (PPM)	ORGANISM	WATER	TIME	EFFECT
Hexavalent Chromium in the Form of -2 Chromate CrO_4	metal pickling, metal plating, anodizing aluminum, tanning agent paint manufacturing, dyes, explosives, ceramics, paper.	5.2 (as Cr)	brown trout	----	---	toxic ($K_2Cr_2O_7$)
		10 (as Cr)	silver salmon	fresh	---	toxic
		20 (as Cr)	rainbow trout	18 C	---	toxic ($K_2Cr_2O_7$ & K_2CrO_4)
		50 (as Cr)	trout	---	33 hours	killed ($K_2Cr_2O_7$)
		100 (as Cr)	trout	---	24 hours	TLm (K_2CrO_4)
		100 (as Cr)	trout	---	6 hours	fatal ($K_2Cr_2O_7$)
Maximum concentrations recommended -- fish: 1.0 ppm						
Cobalt -- General Co (stable) Co (strong oxidizer and unstable in natural waters)		10	Sticklebacks	---	---	lethal
Cobalt Chloride CoCl (soluble)	synthetic ink, barometers, hydrometers, galvanoplating, ceramics, feed supplement in salt licks	22	Sticklebacks	tap	---	lethal limit
		16	top minnow	---	5 days	lethal
		10	goldfish	soft	168 hours	fatal
Iron (general)	corrosion products, metal pickling operations, soil & rock	1-2	pike, tench, trout	pH 5.0-6.7	---	will die
		10	rainbow trout	---	5 min.	death and serious injury
Iron usually forms hydroxides in natural waters and precipitates out. It can deposit on the gills of fish, or, if heavy, may smother fish eggs.						
Lead (General)	natural waters (.9-.8) mining, lead pipe	.34	coho salmon	1-3000 NFR	48 hours	TLm
		.4	coho salmon	"	24 hours	TLm
		1.4	rainbow trout	soft	8.5 days	lethal
Sodium, (General) Na (sodium salts, extremely soluble)	leaching from soil or discharging into streams from industrial wastes	500	stickleback	---	---	lethal
Titanium (General) (Titanium Dioxide is insoluble) several of its salts, i.e. the ammonium oxalate, nitrate, sulphate, and tri-chloride are highly soluble.	earth's crust; present in plants, and in trace amounts in most animal tissues; alloys, Titanium salts used in paint industry, paper making, dyeing, and in the manufacture of glass ceramics	8.2 as Ti	fathead minnow	soft	96 hours	TLm - Titanium sulpha: $TiSO_4$
Vanadium (General) V	doesn't occur free in nature; used in metallurgy; its salts are used in the manufacture of glass, photography, and as a mordant in dyeing and printing fabrics.	4.8	fathead minnow	soft	96 hours	TLm - Vanadyl sulphate used TLm
		13	fathead minnow	soft	96 hours	TLm - Vanadium pentoxide used
Zinc (General) Zn ($ZnCl_2$ and $ZnSO_4$ are highly soluble) (Zinc Carbonate, Zinc Oxide and Zinc Sulphide are insoluble)	found abundantly in rocks and ores; used in galvanizing for alloys, for printing plates and for electrical purposes Zinc salts are used in paint pigments, cosmetics, pharmaceutics, dyes, insecticides, etc.	.01 - .4	young rainbow	---	---	lethal
		.13	rainbow fingerlg	---	12-24 hrs	lethal
		.15	salmon fry	---	---	lethal
		.15	trout	---	---	lethal
		.3	stickleback	---	---	lethal
		.5	fingerling rainbow	soft	3 days	lethal
		1.0	stickleback	soft	24 hours	lethal
		3.0	fingerling rainbow	soft	8 hours	lethal
		8-11	trout	---	---	lethal
		25-50	rainbow trout	tap	2 hours	lethal

(From Fisheries Pollution Sampling Handbook)

Table 4

Snow Waste Pile - Station 5

	April 7	April 13	April 19	April 26	May 3	May 10	$\overline{X}$
Chloride	87.5	22.1	147	80.8	53	27	69.57
Turbidity-FTU	>500	240	>500	>500	>500	>500	456
Oils & grease	--	30	20	29	<10	30	23.8
Cu	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.20
Fe	19.4	33.7	1,100	735	13,000	712	2600
Pb	<0.10	2.11	23.6	<0.10	323	23.8	62.09
Zn	2.14	0.516	11.1	<0.020	126	7.60	24.56
Ca	109	30.8	445	276	5,230	266	1059
Mg	71.6	14.8	349	272	4,580	261	924
Hardness as Mg/ℓ $CaCO_3$	567	138	2,550	1810	31,900	1,740	6450
Na	47.9	19.8	25.5	18.1	297	49.8	76.4
Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ni	<0.020	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Mn	4.06	1.20	21.1	13.2	221	14.4	45.83
Al	139	28.6	798	454	8,370	564	1725
Ba	2.83	0.678	10.7	8.40	119	9.42	25.2
Co	<0.020	<0.020	<0.020	<0.020	9.48	<0.020	1.60
Cr	<0.020	<0.020	<0.020	<0.020	11.4	<0.020	1.92
Mo	<0.020	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sb	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sn	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sr	0.650	0.151	1.79	1.81	26.0	1.71	5.35
Ti	12.8	1.49	72.7	49.0	848	60.8	174
V	<0.030	<0.030	<0.030	<0.030	36.4	<0.030	6.09
As	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Hg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Se	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Si	<0.10	1.45	<0.10	<0.10	67.0	441	84.96
pH	8.50	8.80	8.85	8.70	--	8.68	8.71
Conductivity μmhos/cm²	271	92	--	32	--	40	108

Table 5

Snow Waste Run-Off - Station 4a

	April 7	April 13	April 19	April 26	May 3	May 10	$\overline{X}$
Chloride	84.3	7.14	7.50	37.9	0.80	2.0	23.27
Turbidity-FTU	390	240	17	360	14	33	175.7
Oils & grease	35	8	<5	6	72	<10	22.67
Cu	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	--
Fe	4.47	25.1	2.59	83.3	6.43	2.14	20.67
Pb	1.50	<0.10	0.12	<0.10	<0.10	<0.10	≈0.34
Zn	0.356	0.259	0.032	1.43	<0.020	<0.020	0.41
Ca	35.7	13.3	17.1	55.4	18.5	16.7	26.12
Mg	16.8	8.84	3.30	29.4	494	3.32	92.61
Hardness as Mg/ℓ $CaCO_3$	158	69.6	56.3	259	66.5	55.4	110.8
Na	62.3	16.9	6.13	28.1	1.32	1.91	19.44
Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ni	<0.020	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Mn	0.841	0.450	0.0601	1.58	0.128	0.0482	0.52
Al	35.3	20.8	2.12	57.8	4.70	1.72	20.41
Ba	0.515	0.308	0.0658	0.832	0.104	0.0494	0.31
Co	0.281	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cr	<0.020	<0.020	<0.020	<0.020	<0.020	<0.023	<0.023
Mo	<0.020	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sb	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sn	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sr	0.135	0.0800	0.0836	0.275	0.0805	0.0815	0.12
Ti	2.47	1.47	0.189	4.49	0.483	0.158	1.54
V	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
As	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Hg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Se	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Si	<0.10	7.03	4.32	<0.10	8.29	5.33	4.18
pH	8.40	8.70	7.65	7.70	7.85	7.62	7.99
Conductivity µmhos/cm^2	230	60	60	135	61	68	102.3

Table 6: Chemical Parameters of River Water and Snow Waste April 7, 1978

Station	1	2	3	4	4a	5	6	7
Chloride	<0.05	4.15	146	0.53	84.3	87.5	0.82	-
Turbidity-FTU	<0.95	0.82	150	1.5	390	>500	1.8	-
Oils & Grease	-	<5	-	-	35	-	<5	<7
Cu	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Fe	<0.020	<0.020	0.693	<0.020	4.47	19.4	<0.020	<0.020
Pb	<0.10	<0.10	<0.10	<0.10	1.50	<0.10	<0.10	<0.10
Zn	<0.020	<0.020	0.345	0.022	0.356	2.14	<0.020	<0.020
Ca	15.1	15.2	58.3	15.2	35.7	109	15.3	15.2
Mg	2.37	2.40	7.13	2.41	16.8	71.6	2.40	2.35
Hard. as Mg/ ℓ $CaCO_3$	47.5	47.8	175	47.9	158	567	48.1	47.6
Na	1.22	1.27	116	1.56	62.3	47.9	1.78	1.81
Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ni	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Mn	<0.0040	0.0089	0.418	<0.0040	0.841	4.06	0.0090	0.0056
Al	<0.30	<0.30	4.57	<0.30	35.3	139	<0.30	<0.30
Ba	0.0268	0.0305	0.291	0.0281	0.515	2.83	0.0308	0.0291
Co	<0.020	<0.020	<0.020	<0.020	0.281	<0.020	<0.020	<0.020
Cr	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Mo	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Sb	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sn	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sr	0.0680	0.0724	0.293	0.0704	0.135	0.650	0.0708	0.0683
Ti	<0.020	<0.020	<0.020	<0.020	2.47	12.8	<0.020	<0.020
V	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
As	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Hg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Se	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Si	1.23	1.21	1.03	1.28	<0.10	<0.10	1.46	1.14

Table 7: Chemical Parameters of River Water and Snow Waste — April 13, 1978

Station	1	2	3	4	4a	5	6	7
Chloride	<0.50	<0.50	119	<0.50	7.14	22.1	<0.50	0.50
Turbidity-FTU	0.63	0.59	2.20	0.75	240	240	0.80	0.72
Oils & Grease	<5	<5	3400	<5	8	30	<5	<5
Cu	<0.020	<0.020	0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Fe	0.071	0.036	28.3	0.064	25.1	33.7	0.119	0.045
Pb	<0.10	<0.10	<0.10	<0.10	<0.10	2.11	<0.10	<0.10
Zn	<0.020	<0.020	0.503	<0.020	0.259	0.516	<0.020	<0.020
Ca	14.9	14.6	63.9	14.9	13.3	30.8	14.6	14.8
Mg	2.33	2.19	14.0	2.30	8.84	14.8	2.31	2.29
Hard. as Mg/ℓ $CaCO_3$	46.8	45.5	217	46.7	69.6	138	46.0	46.4
Na	1.43	1.43	113	1.23	16.9	19.8	1.27	1.35
Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ni	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Mn	0.0081	0.0112	0.709	0.0040	0.450	1.20	0.0418	0.0040
Al	<0.30	<0.30	19.0	<0.30	20.8	28.6	0.30	<0.30
Ba	0.0282	0.0342	0.700	0.0259	0.308	0.678	0.0271	0.0261
Co	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cr	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Mo	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sb	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sn	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sr	0.0696	0.0690	0.327	0.0709	0.0800	0.151	0.0697	0.0705
Ti	<0.020	<0.020	1.53	<0.020	1.47	1.49	<0.020	<0.020
V	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
As	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Hg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Se	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Si	1.04	1.04	1.54	1.09	7.03	1.45	1.14	0.85

Table 8: Chemical Parameters of River Water and Snow Waste

April 19, 1978

Station	1	2	3	4	4a	5	6	7
Cnloride	<0.50	<0.50	-	<0.50	7.50	147	<0.50	<0.50
Turbidity-FTU	1.6	1.8	-	2.0	17	>500	1.9	1.4
Oils & Grease	<5	<5	-	<5	<5	20	<5	<5
Cu	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	<0.020
Fe	0.090	0.066	-	0.169	2.59	1,100	0.148	0.087
Pb	<0.10	<0.10	-	<0.10	0.12	23.6	<0.10	<0.10
Zn	<0.020	<0.020	-	<0.020	0.032	11.1	<0.020	<0.020
Ca	14.8	14.9	-	15.0	17.1	445	14.7	14.5
Mg	2.30	2.24	-	2.34	3.30	349	2.09	2.05
Hard. as Mg/ℓ $CaCO_3$	46.4	46.4	-	47.1	56.3	2,550	45.3	44.6
Na	1.63	1.22	-	1.21	6.13	25.5	1.23	1.15
Cd	<0.010	<0.010	-	<0.010	<0.010	<0.010	<0.010	<0.010
Ni	<0.20	<0.20	-	<0.20	<0.20	<0.20	<0.20	<0.20
Mn	<0.0040	<0.0040	-	0.0058	0.0601	21.1	0.0056	<0.0040
Al	<0.30	<0.30	-	<0.30	2.12	798	<0.30	<0.30
Ba	0.0266	0.0260	-	0.0271	0.0658	10.7	0.0251	0.0255
Co	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	<0.020
Cr	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	<0.020
Mo	<0.20	<0.20	-	<0.20	<0.20	<0.20	<0.20	<0.20
Sb	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Sn	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Sr	0.0700	0.0700	-	0.0708	0.0836	1.79	0.0698	0.0687
Ti	<0.020	<0.020	-	<0.020	0.189	72.7	<0.020	<0.020
V	<0.030	<0.030	-	<0.030	<0.030	<0.030	<0.030	<0.030
As	<0.20	<0.20	-	<0.20	<0.20	<0.20	<0.20	<0.20
Hg	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Se	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Si	1.22	1.30	-	1.26	4.32	<0.10	1.33	1.18

Table 9: Chemical Parameters of River Water and Snow Waste

April 26, 1978

Station	1	2	3	4	4a	5	6	7
Chloride	<0.50	<0.50	-	<0.50	37.9	80.8	<0.50	<0.50
Turbidity-FTU	1.4	2.3	-	3.4	360	>500	3.4	2.6
Oils & Grease	<5	<5	-	<5	6	29	<5	<5
Cu	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	<0.020
Fe	0.156	0.190	-	0.260	83.3	735	0.302	0.263
Pb	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Zn	<0.020	<0.020	-	<0.020	1.43	<0.020	<0.020	<0.020
Ca	15.8	15.8	-	16.0	55.4	276	15.8	15.9
Mg	2.35	2.43	-	2.45	29.4	272	2.39	2.43
Hard.as Mg/ℓ aC0_3	49.1	49.5	-	50.0	259	1810	49.3	49.7
Na	1.25	1.22	-	1.33	28.1	18.1	1.27	1.19
Cd	<0.010	<0.010	-	<0.010	<0.010	<0.010	<0.010	<0.010
Ni	<0.20	<0.20	-	<0.20	<0.20	<0.20	<0.20	<0.20
Mn	0.0088	0.0093	-	0.011	1.58	13.2	0.0112	0.0099
Al	<0.30	<0.30	-	<0.30	57.8	454	<0.30	<0.30
Ba	0.029	0.028	-	0.030	0.832	8.40	0.029	0.028
Co	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	<0.020
Cr	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	<0.020
Mo	<0.20	<0.20	-	<0.20	<0.20	<0.20	<0.20	<0.20
Sb	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Sn	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Sr	0.0700	0.0686	-	0.0698	0.275	1.81	0.0682	0.0700
Ti	<0.020	<0.020	-	<0.020	4.49	49.0	<0.020	<0.020
V	<0.030	<0.030	-	<0.030	<0.030	<0.030	<0.030	<0.030
As	<0.20	<0.20	-	<0.20	<0.20	<0.20	<0.20	<0.20
Hg	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Se	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10
Si	1.32	1.31	-	0.47	<0.10	<0.10	1.08	1.33

Table 10: Chemical Parameters of River Water and Snow Waste — May 3, 1978

Station	1	2	3	4	4a	5	6	7
Chloride	<0.50	<0.50	-	-	0.80	53	<0.50	<0.50
Turbidity-FTU	2.5	2.0	-	-	14	>500	1.7	1.7
Oils & Grease	<10	<10	-	-	72	<10	<10	<10
Cu	<0.020	<0.020	-	-	<0.020	<0.020	<0.020	<0.020
Fe	0.081	0.129	-	-	6.43	13,000	0.121	0.122
Pb	<0.10	<0.10	-	-	<0.10	323	<0.10	<0.10
Zn	<0.020	<0.020	-	-	<0.020	126	<0.020	<0.020
Ca	16.0	16.3	-	-	18.5	5,230	16.7	16.9
Mg	2.54	2.56	-	-	494	4,580	2.65	2.76
Hard. as Mg/ℓ $CaCO_3$	50.4	51.2	-	-	66.5	31,900	52.6	53.6
Na	1.20	1.25	-	-	1.32	297	1.05	1.11
Cd	<0.010	<0.010	-	-	<0.010	<0.010	<0.010	<0.010
Ni	<0.20	<0.20	-	-	<0.20	<0.20	<0.20	<0.20
Mn	0.0062	0.0070	-	-	0.128	221	0.0071	0.0065
Al	<0.30	<0.30	-	-	4.70	8,370	<0.30	<0.30
Ba	0.0278	0.0300	-	-	0.104	119	0.0272	0.0280
Co	<0.020	<0.020	-	-	<0.020	9.48	<0.020	<0.020
Cr	<0.020	<0.020	-	-	<0.020	11.4	<0.020	<0.020
Mo	<0.20	<0.20	-	-	<0.20	<0.20	<0.20	<0.20
Sb	<0.10	<0.10	-	-	<0.10	<0.10	<0.10	<0.10
Sn	<0.10	<0.10	-	-	<0.10	<0.10	<0.10	<0.10
Sr	0.0760	0.0787	-	-	0.0805	26.0	0.0793	0.0807
Ti	<0.020	<0.020	-	-	0.483	848	<0.020	<0.020
V	<0.030	<0.030	-	-	<0.030	36.4	<0.030	<0.030
As	<0.20	<0.20	-	-	<0.20	<0.20	<0.20	<0.20
Hg	<0.10	<0.10	-	-	<0.10	<0.10	<0.10	<0.10
Se	<0.10	<0.10	-	-	<0.10	<0.10	<0.10	<0.10
Si	1.44	1.50	-	-	8.29	67.0	1.42	1.42

Table 11: Chemical Parameters of River Water and Snow Waste

May 10, 1978

Station	1	2	3	4	4a	5	6	7
Chloride	<0.50	<0.50	-	-	2.0	27	<0.50	<0.50
Turbidity-FTU	3.4	2.9	-	-	33	>500	3.0	2.8
Oils & Grease	<10	<10	-	-	<10	30	<10	<10
Cu	<0.020	<0.020	-	-	<0.020	<0.020	<0.020	<0.020
Fe	0.156	0.155	-	-	2.14	712	0.157	0.116
Pb	<0.10	<0.10	-	-	<0.10	23.8	<0.10	<0.10
Zn	<0.020	<0.020	-	-	<0.020	7.60	<0.020	<0.020
Ca	15.7	15.7	-	-	16.7	266	16.6	16.2
Mg	2.57	2.64	-	-	3.32	261	2.69	2.67
Hard. as Mg/ℓ $CaCO_3$	49.8	50.1	-	-	55.4	1,740	52.5	57.4
Na	1.17	1.15	-	-	1.91	49.8	1.24	1.31
Cd	<0.010	<0.010	-	-	<0.010	<0.010	<0.010	<0.010
Ni	<0.20	<0.20	-	-	<0.20	<0.20	<0.20	<0.20
Mn	0.0085	0.0075	-	-	0.0482	14.4	0.0084	0.0073
Al	<0.20	<0.20	-	-	1.72	564	<0.20	<0.20
Ba	0.0251	0.0251	-	-	0.0494	9.42	0.0268	0.0253
Co	<0.020	<0.020	-	-	<0.020	<0.020	<0.020	<0.020
Cr	0.024	<0.020	-	-	<0.023	<0.020	0.021	<0.020
Mo	<0.20	<0.20	-	-	<0.20	<0.20	<0.20	<0.20
Sb	<0.10	<0.10	-	-	<0.10	<0.10	<0.10	<0.10
Sn	<0.10	<0.10	-	-	<0.10	<0.10	<0.10	<0.10
Sr	0.0747	0.0741	-	-	0.0815	1.71	0.0766	0.0757
Ti	<0.010	<0.010	-	-	0.158	60.8	<0.010	<0.010
V	<0.030	<0.030	-	-	0.030	<0.030	<0.030	<0.030
As	<0.20	<0.20	-	-	<0.20	<0.20	<0.20	<0.20
Hg	<0.10	<0.10	-	-	<0.10	<0.10	<0.10	<0.10
Se	<0.10	<0.10	-	-	<0.10	<0.10	<0.10	<0.10
Si	1.76	1.89	-	-	5.33	441	2.04	1.86

WHITEHORSE SNOW DISPOSAL ON THE YUKON RIVER

Surface water samples collected downstream of the snow disposal site in the White Pass rail yard indicate that the snow waste did not at this point in time produce a measurable impact. Levels of all parameters downstream were not significantly different from those of the upstream control stations (Table 2). This can be attributed to instrument limitations in analysis and an estimated dilution factor of 14000-times.

However, the snow waste itself was a source of contaminants which, when considered in isolation and undiluted, possess characteristics which may be harmful to the aquatic system in which the snow was dumped. Heavy metals in the waste snow have been associated with specific toxicity effects, well-documented in the literature. Table 3 indicates various metals and levels at which adverse effects on fish have been noted. In combination with high turbidity and oils and grease, the toxicity of the snow waste could be very significant. The release of this substance into waters frequented by fish is, in fact, in contravention of Section 33 of the Fisheries Act, should the material be proven toxic.

The visual pollutants included in the snow disposal piles, such as oil, trash, soil and soot, also provide an aesthetically unpleasing sight along the river course.

SOUTHERN URBAN SNOW DISPOSAL - POLLUTION ASPECTS

Significant quantities of pollutants in snow scraped from roads have been observed in southern urban areas. Some of the observed pollutants were: a high concentration of chlorides, suspended solids, organic material, lead, and other heavy metals (2).

These were not characteristics of fresh snow but were the result of the phenomena of urbanization and the resulting increase in population densities (4).

Three of these components were considered major contributors to the pollution load at the disposal sites in southern Canada. Road de-icing compounds such as sodium chloride, lead (for which both chronic and acute health effects have been documented) and suspended solids which arose from abrasives used in ice control have been identified as the major constituents (4). However, in view of the intimacy with which lead and other heavy metals are associated with the solids fraction, they will be reviewed together here.

DE-ICING COMPOUNDS - SODIUM CHLORIDE, CALCIUM CHLORIDE

In an aquatic system, salts which are added dissolve readily and dissipate rapidly if the water flow is sufficient. Salt loading to the river is now intermittent with a small shock type discharge occurring during the freshette period. Since the dilution factors were great, the salt deposits into the river were not significant at this time. However, fresh water organisms are adapted to live in waters of low salinity and, should disposal of very large amounts of salt on a continuous basis occur, then it is possible to upset the salt balance in the water which could affect the natural life cycle of different species.

The effects of salt on land are significantly different. The deposit of salt compounds results in producing a more alkaline soil, leading to a saline-alkali soil. The sodium and possibly calcium ions present will tend to bind the mineral colloids and form a tight, impervious soil cover. These soils will then exert a detrimental effect on plants (4).

Salt damage occurs by way of the soil solution and must penetrate or infiltrate the soil before damage is apparent. Sufficiently high salt concentrations will kill plants, due to changes in osmotic pressure while sub-lethal effects result in diminished growth rates, chlorosis and abscission (loss of leaves).

Infiltration to the groundwater can markedly affect the quality of this water. This is especially true for the chloride ion. Groundwater contamination, where drinking water supplies such as community wells are involved, is extremely difficult to eliminate. Care should be taken in disposing of salt-laden snow onto land to prevent the salt from reaching the groundwater.

The concentration of chloride in the Whitehorse snow waste was quite low, averaging 69.57 mg/ℓ, reflecting the fact that very little of the salting compounds reach the snow disposal site.

These levels are below the recommended limits in drinking water supplies (7). Little de-icer is used on Whitehorse streets over the course of a winter compared to amounts used in southern cities such as Ottawa, Montreal and Toronto where the tendency formerly was to use salt to eliminate snow and ice. Studies have indicated that perhaps ten percent of the salt compounds applied to streets end up in disposal sites.

Sodium levels averaging 76.4 mg/ℓ were found to be generally within maximum limits for a public drinking water supply. Calcium was found in high concentrations, with an average of 1059 mg/ℓ. Calcium can cause adverse physiological effects in high concentrations but whether these effects are significant in the inorganic form in which calcium occurs in drinking water has not been determined (7).

LEAD - SOURCE: AUTOMOTIVE EMISSIONS

Lead is considered a cumulative body poison with both toxic and sub-lethal effects. Included in the sub-lethal effects are:

(1) Damage to human fertility;
(2) Disturbance of kidney function in young children;
(3) Evidence of mental retardation in children with above normal lead body burdens (4).

It is more toxic to the young and pre-adolescent than to the adult (4). When present in elevated levels in drinking water supplies, it is a hazard to public health. The recommended maximum limit in drinking water is 0.05 ppm.

Lead is toxic to fish (Table 3) and extremely toxic to the primary consumers in a food chain, the bacteria. Depending on its specific chemical form, it can bio-accumulate through the food chain. This has significant public health consequences in areas which act as a sink for lead and other heavy metals and which also support commercial or sport fisheries. Generally, heavy metal pollution tends to decrease the aquatic communities' diversity and thus de-stabilize existing community structures (4).

Lead as found in snow waste is usually associated with the solids fraction of abrasives used to reduce hazardous driving conditions. However, lead and other heavy metals (zinc, copper, nickel, mercury and chromium) are mainly associated with the finer particulates of street run-off and snow disposal sites. In one study, it was discovered that particles less than 43 μ accounted for 5.9% of solids and was responsible for more than half the heavy metal pollution (6).

With respect to our local situation, it is possible for the heavy metal fraction from the snow dump on the river to be carried long distances in rapidly-moving water and deposited in more sluggish waters. In effect, Lake Lebarge may become a sink for this source of heavy metals.

The lead levels encountered in the snow disposal site along the river varied with the sampling date. Table 4 shows the results of analysis for the snow pile on the various dates the pile was sampled. Lead values varied from non-detectable to a high of 323 mg/ℓ, with an average value of 62.1 mg/ℓ. This is well above the drinking water maximum limits and far exceeds mine effluent regulations for lead and zinc mining and milling operations.

Zinc, iron, chromium, manganese, aluminium, barium, cobalt, strontium, titanium and vanadium show incidents of elevated levels. Some of these elements have their effects on aquatic organisms documented (Table 3); however, other "exotic" metallic elements included above are not as well studied, with less information on their effects available. There is very little information available on the antagonistic and synergistic effects of these materials in combination with each other. We should, therefore, be prudent in assessing their safety when we do not have the information resources to assess it properly.

Lead as found in snow is in the positively charged ionic form and is easily adsorbed or bound by soil particles such as clay and/or humic material (4). When disposed of on land, this lead tends to displace calcium and sodium, making them available for leaching, while the lead can then be taken up by plants. Although it appears that very small amounts are absorbed by plants, where lead is present in high quantities, plants can acquire up to ten times the normal level of lead. This may not cause a direct toxic effect, but plants with high lead levels when introduced into the food chain may have an adverse effect on other organisms (4).

DISPOSAL STRATEGY

The choice of a disposal site should minimize the impact of the major pollutants of snow. All the components are potentially hazardous to either soil or water ecosystems.

Sodium chloride and calcium chloride are more hazardous when disposed onto land. Salts adversely affect plants and the drainage capabilities of the land, and may eventually affect groundwater.

In the Yukon River, salt is quickly diluted to extremely low concentrations. For the salt compounds, river disposal is a better alternative (4).

Lead and other heavy metals are intimately associated with the solids fraction and suspended solids of snow waste. This type of pollution is deleterious to both land and river ecosystems. Deposited lead could enter the aquatic food chain with adverse effects on community composition and toxicity effects directly through bio-accumulation.

In land disposal, lead and other heavy metals with the suspended solids tend to concentrate their effects in a confined area. Lead accumulation through the years of depositing snow waste would result in layers of lead-rich sediment (4). The alkaline soil though, partially contributed by the action of salts, restricts lead solubility, preventing surface and groundwater contamination (4).

The salt disposal problem in Whitehorse is really a minor consideration, as levels have indicated. Heavy metal contamination of aquatic systems can have ramifications not visible for many years due to the speed with which deposition and bio-accumulation proceed. The river may continue to be used as a disposal site for many years and no ill effects should be observed; but when the effects are manifested, then it is generally too late to do anything (e.g. mercury contamination in Ontario sport fishing areas).

Snow disposal sites tend to encourage and attract the disposal of materials other than street snow. Trash and litter accumulate through the winter season, with the make-up and quantity of such trash not being apparent until the snow has melted. If trash is deposited onto the river ice, little can be done to prevent it from entering the river systems, with unknown consequences. Land disposal, however, concentrates this litter, and it can be removed to local designated landfill sites if necessary. Land disposal would, then, be preferable for the solid trash fraction of snow waste.

All factors considered, a land disposal area for snow waste from Whitehorse would be the least damaging on a long-term basis. It is easier to monitor impacts on a confined area and, should reclamation be necessary, the pollutants should be confined to designated sites and clean-up is then a possibility.

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