# Sediment Sampling in Portage Inlet and Gorge Waters for Metal Determination

# REPORT

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# Marine Sediment Chemistry Sampling for Portage Inlet and the Gorge Waterway.

## 1. INTRODUCTION

An extensive database of marine sediment sampling results exists for both Victoria and Esquimalt Harbours. However, little marine sediment sampling has been conducted in the Gorge Waterway and Portage Inlet, therefore, the status of the marine sediments in those areas is uncertain. To begin to fill in these data gaps, marine sediments in these areas were collected by Aquametrix Research Ltd. and analyzed for metals by the Pacific Environmental Science Centre.

This report provides a summary of the field sampling methods employed, the parameters analyzed and compares the collected data with established sediment quality criteria. No in-depth analysis was conducted due to budgetary considerations.

## 2. FIELD SAMPLING METHODS

Sampling was conducted on March 03 & 06, 2000 in the Gorge and Portage Inlet in a general grid across the area. Approximate station positions were pre-determined by plotting 40 locations on the CHS chart (No. 3415) with approximately equal spacing. All samples were taken from a boat and a DGPS location obtained for each sampling location. At each location, field measurements for the pH, temperature, dissolved oxygen and salinity of the water were also made and recorded using portable instruments supplied by the Capital Regional District Engineering Department. Field calibrations of each instrument were performed daily using supplied reagents and standards as per each instrument's operating manual.

Sediment samples were retrieved using a Ponar grab sampler constructed of stainless steel. One sample was collected at each station. At every 10 sampling stations, a duplicate field split was taken. Sampling generally followed the protocols for sediment sampling outlined in the Puget Sound Estuary Program (PSEP, 1997), which were as follows:

i. The inside of the grab sampler was thoroughly rinsed with seawater at the station being sampled.

ii. The grab sampler was lowered through the water column such that travel through the last 5 meters was no faster than 1 m/sec. This minimized the effects of bow wave disturbance to surficial sediments.

iii. The sampler was retrieved to the surface and then lowered onboard to determine if the sample is successful or not. A successful grab was one having relatively level, intact sediment over the entire area of the grab, and a sediment depth at the center of at least 7 cm. Grabs that did not contain sediments, or partially filled grabs, or grabs with shells or grossly slumped surfaces were deemed unacceptable. Grabs completely filled to the top,

where the sediment was in direct contact with the hinged top, were also unacceptable. If the grab was deemed unacceptable, the sediment was discarded and another grab conducted.

iv. The overlying water from the grab was carefully drained off using a siphon.

v. Sediment from the top 2 cm of each successful grab was transferred from the grab sampler into a polyethylene bowl using a disposable plastic spoon. Care was taken to ensure that the sediment was removed from the grab and did not come in direct contact with the sides of the grab sampler (i.e. the sediment was taken from the middle of the grab). The sediment were thoroughly homogenized using the spoon until a uniform colour and texture appeared.

vi. Subsamples were transferred from the bowl into appropriate pre-cleaned sampling containers and preserved as required (kept on freezer packs in a cooler).

vii. At each station, a new disposable plastic spoon was used, the bowl was washed and rinsed at least three times with seawater from the station being sampled.

viii. Steps i through vii were repeated until all samples were collected.

ix. Station, sample number, sample type, and required chemical analysis were labelled on each jar. In addition, the following information was recorded on field logs:

- collection date
- collection time
- DGPS location (real time)
- composite number (if required)
- other field measurements (DO, pH, temperature, salinity)
- field comments

x. The labelled jars were placed in a cooler containing ice to keep the samples cool. The samples were shipped to the lab for analysis.

## 3. QUALITY ASSURANCE AND QUALITY CONTROL

The following quality control (QC) procedures were employed:

i. The interior surfaces of the grab sampler was washed with seawater prior to use to assure that no sediment remained from the previous station.

ii. Prior to use, all supplies (e.g., bowl) were cleaned with nonmetal containing dish soap

and thoroughly rinsed with seawater. A new disposable plastic spoon was used at each sampling station.

iii. The grab was placed in a clean non-metal container all times to avoid contamination from boat fuel *et cetera*.

iv. Quality control samples: Duplicate field samples (field split) were taken at every 10th station. The field replicates were sampled, stored, prepared, and analyzed using the same methods. One per 10 samples are identified for the lab QC program.

## 4. RESULTS

The positions of each of the 40 stations sampled is presented in Table 1. This table also presents the field notes collected at each location including depth of sample, water temperature, salinity, dissolved oxygen (DO) and pH readings from the portable instruments as well as comments on the composition of each of the samples.

The location of each of the sample stations is presented in Figure 1. Differential GPS was used to determine position in the field with the NAD83 datum. Depths presented in Table 1 were estimated using a marked line and are not corrected for tide height. As such, the depths should be considered approximate and accurate to ±0.5 metre.

The analytical results are presented in Table 2. All units for metal ICP analysis are dry µg/g while moisture content was reported as percent. The third column of this table indicates the Method Detection Limit achieved by the laboratory for each parameter. The laboratory QA/QC procedures were not supplied in detail to Aquametrix Research, however, the results from PESC indicate that at least the following procedures were used to ensure quality and reliability of results:

- laboratory method blanks,
- reference materials (type not specified) and
- replicate samples.

Recoveries of reference material were generally within acceptable limits with most falling within ± 10%. Blanks were less than the method detection limit which is also acceptable. To further verify QA/QC more information on methods would be required from the laboratory (which was beyond the scope of this project).

A comparison was made between the reported results and the WDOE/CRD Standards for metals in sediments. The standards are presented in the second column of Table 2 with values exceeding the standard highlighted and printed in bold face in the results columns for each station. The locations and tpe of metals exceeding criteria are presented in Figure 2.

A total of 9 samples exceeded the criterion for cadmium while 6 samples exceeded the standard for mercury (Table 2). The majority of the stations exceeding criteria were located in the Gorge Waters, between the Trestle Bridge and the Gorge Bridge. The exceedances for cadmium ranged from 9.3 to 20.9 µg/g with a mean of 15.3 µg/g versus a standard of 5.1 µg/g. Exceedances of mercury were much closer in value to the standard of 0.41 µg/g with a range of 0.434 to 0.750 µg/g and a mean of 0.566 µg/g.

No formal analysis of the water column data was performed and the following comments are provided as observations. Surface water temperature varied little with a range of 7.4 to 8.7 °C over all stations and both days of sampling. Salinity values ranged from 5.8 to 25.4 ppt with the lower values generally found in Portage Inlet and the highest values nearest the Selkirk Waters and the Trestle Bridge. The lowest salinity values were not found immediately adjacent to stream entry points and were likely due to storm drain inputs.

Dissolved oxygen concentrations varied little over the entire study area with a range of 9.7 to 10.5 mg/L. While not presented as data, the instrument indicated that the surface waters were always saturated with oxygen with values ranging from 90 to 110 % saturation.

The observed values for pH ranged from 7.37 to 8.38 with lower values found in Portage Inlet were salinity values were also lower.

## 5. CONCLUSIONS & RECOMMENDATIONS

The purpose of this preliminary sampling in Portage Inlet and the Gorge Waters was to gain some insight into the level of contamination throughout the system. The objective was met as the entire area was sampled, albeit without replication. Comparison of the results with the WDOE/CRD standard for metals indicated that few stations exceeded established values for the protection of aquatic life in sediment.

Future sediment sampling effort for metals should target the areas where exceedances were noted in this study. Triplicate grab samples should also be used at those locations to determine the ***in situ*** variability of the sediments.

Future effort should also include identification of possible sources of metal input into the Gorge Waters and Portage Inlet system and further testing for other parameters such as organics (PAH, organotins, chlorophenols and PCBs, ***et cetera***). The choice of which parameters to measure could be made using the CRD Storm Drain Program data as this should indicate contaminants which are being added to the system. There may be value in testing for all the organic compounds once to assess the present conditions that may be a result of past dumping practices and which would therefore be missed by the Storm Drain Program. Sediments are a useful indicator of historical input of contaminants.

A survey of biota in the Gorge Waters and Portage Inlet should also be conducted to indicate the

present health of the entire ecosystem. This could be conducted by sampling existing infaunal organisms in the same manner as is conducted off the Victoria Waterfront by the CRD to determine the area of impact in the vicinity of the sewage outfalls.

## 6. LITERATURE CITED

PSEP (Puget Sound Estuary Program). 1997. Puget Sound Estuary Program, Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Prepared for US Environmental Protection Agency, Region 10, Seattle, and Puget Sound Water Quality Action Team, Olympia, WA. 51 pp.

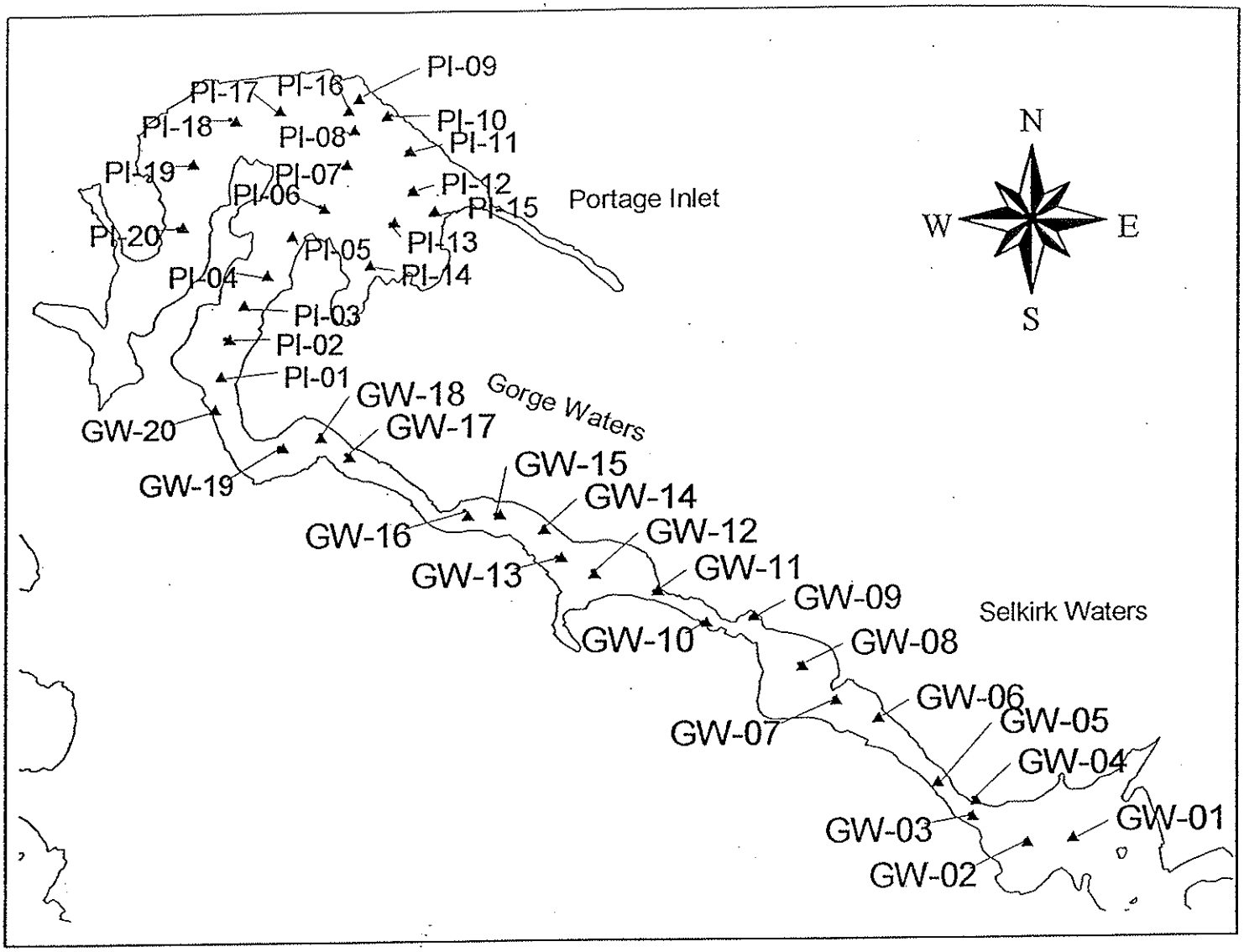


Figure 1. Locations of Sediment Sampling Stations For VEHEAP - March 2000. PI- designates stations in Portage Inlet and GW- designates Gorge Waters stations.

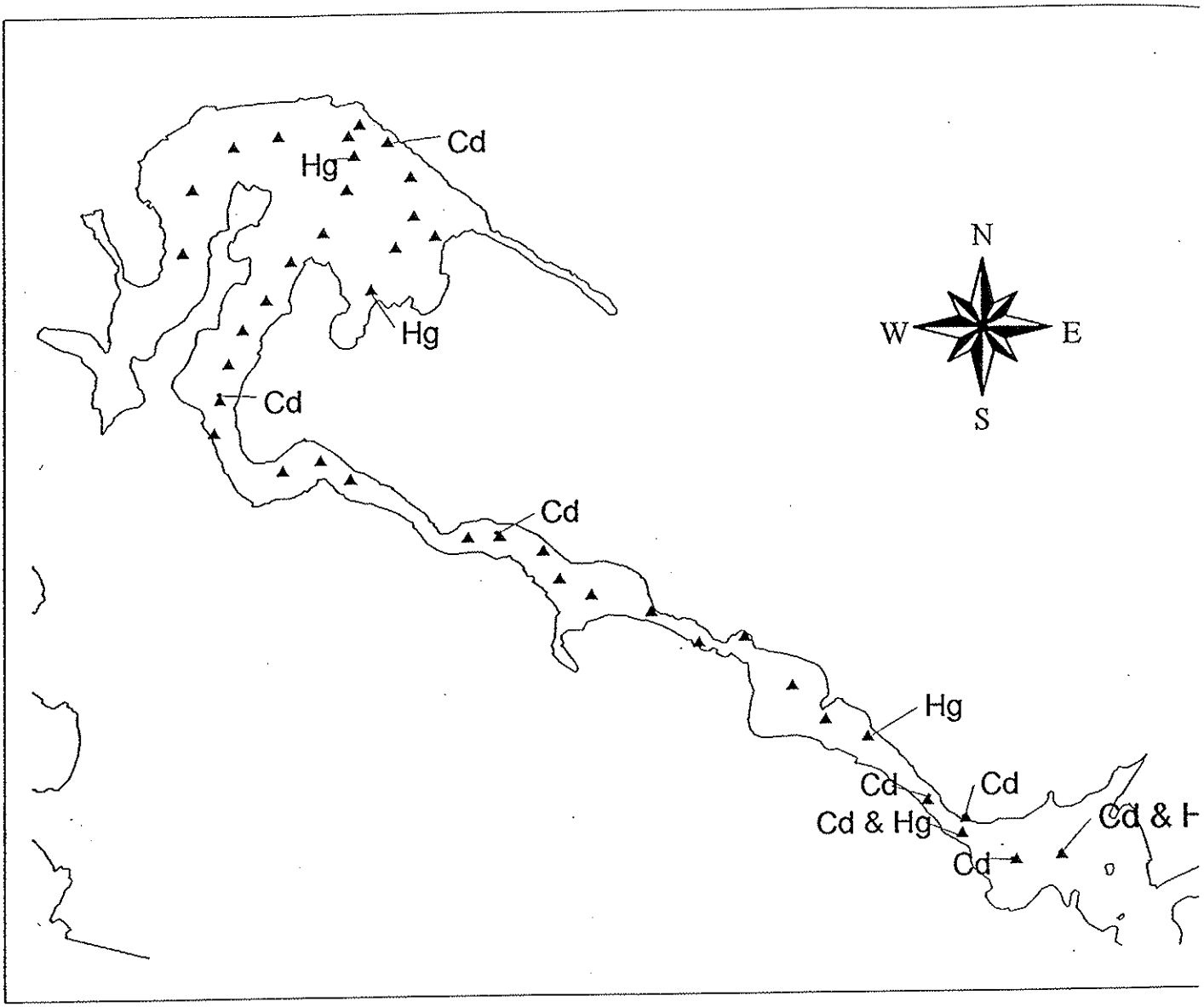


Figure 2. Locations of stations sampled for metals indicating those that exceeded WDOE/CRD standards for the indicated metals (Cd = cadmium, Hg = mercury). Sampling conducted in March 2000.

Table 1. Sampling Locations and Field Log Data for Sediment Sampling in Portage Inlet and Gorge Waters for VEHEAP in March 2000.

| Station | Date | Time | Latitude | Longitude | Depth (m) | T (°C) | S (ppt) | DO (mg/L) | pH | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| PI-01 | 03-Mar-00 | 12:45 | 48° 27.251 N | 123° 25.440 W | 1.5 | 8.6 | 15.2 | 9.9 | 7.82 | Rep-02/<0.5cm green over black $H_2S$ smell |
| PI-02 | 03-Mar-00 | 12:40 | 48° 27.320 N | 123° 25.417 W | 1.5 | 8.6 | 12.6 | 9.9 | 7.81 | <0.5 cm green over black $H_2S$/smell |
| PI-03 | 03-Mar-00 | 12:35 | 48° 27.384 N | 123° 25.375 W | 1.5 | 8.6 | 13.5 | 9.9 | 7.77 | <0.5 cm green over black $H_2S$/smell |
| PI-04 | 03-Mar-00 | 12:30 | 48° 27.441 N | 123° 25.308 W | 2.0 | 8.6 | 18.0 | 10.0 | 7.95 | <0.5 cm green over black $H_2S$/smell |
| PI-05 | 03-Mar-00 | 12:25 | 48° 27.514 N | 123° 25.238 W | 3.0 | 8.7 | 15.0 | 10.0 | 7.69 | <0.5 cm green over black $H_2S$/smell |
| PI-06 | 03-Mar-00 | 12:20 | 48° 27.567 N | 123° 25.145 W | 2.5 | 8.1 | 7.1 | 10.2 | 7.65 | <0.1 cm green over black / smell |
| PI-07 | 03-Mar-00 | 12:10 | 48° 27.648 N | 123° 25.077 W | 2.5 | 8.6 | 17.2 | 9.9 | 7.54 | <0.5 cm green over black $H_2S$/smell |
| PI-08 | 03-Mar-00 | 12:05 | 48° 27.713 N | 123° 25.057 W | 2.0 | 8.5 | 17.0 | 10.0 | 7.45 | <0.5 cm green over black $H_2S$/smell |
| PI-09 | 03-Mar-00 | 12:00 | 48° 27.772 N | 123° 24.043 W | 2.0 | 8.4 | 16.0 | 10.0 | 7.61 | <0.5 cm green over black $H_2S$/smell |
| PI-10 | 03-Mar-00 | 11:55 | 48° 27.739 N | 123° 24.960 W | 2.0 | 8.6 | 17.5 | 9.8 | 7.61 | Rep1, field split, same as PI-11 |
| PI-11 | 03-Mar-00 | 11:45 | 48° 27.672 N | 123° 24.895 W | 2.5 | 8.5 | 18.1 | 9.8 | 7.54 | <0.5 cm green over black $H_2S$/smell |
| PI-12 | 03-Mar-00 | 11:30 | 48° 27.598 N | 123° 24.885 W | 2.5 | 8.5 | 17.0 | 9.8 | 7.48 | <0.5 cm green over black $H_2S$/smell |
| PI-13 | 03-Mar-00 | 11:25 | 48° 27.539 N | 123° 24.937 W | 2.5 | 8.4 | 16.0 | 9.9 | 7.50 | mainly black and smelly |
| PI-14 | 03-Mar-00 | 11:10 | 48° 27.459 N | 123° 25.007 W | 2.8 | 8.4 | 16.0 | 10.1 | 7.50 | mainly black and smelly |
| PI-15 | 03-Mar-00 | 11:05 | 48° 27.560 N | 123° 24.824 W | 1.5 | 8.6 | 17.9 | 9.9 | 7.60 | mainly black and smelly |
| PI-16 | 03-Mar-00 | 11:00 | 48° 27.750 N | 123° 25.074 W | 2.5 | 8.1 | 5.8 | 9.9 | 7.41 | black, strong smell |
| PI-17 | 03-Mar-00 | 10:50 | 48° 27.750 N | 123° 25.276 W | 1.5 | 8.6 | 19.1 | 10.1 | 7.76 | clam shells, dark green colour |
| PI-18 | 03-Mar-00 | 10:45 | 48° 27.731 N | 123° 25.404 W | 1.5 | 8.4 | 19.3 | 10.5 | 7.54 | olive green/black occasionally/some $H_2S$ smell |
| PI-19 | 03-Mar-00 | 10:40 | 48° 27.651 N | 123° 25.523 W | 1.5 | 8.4 | 18.0 | 10.4 | 7.37 | olive green/black occasionally/some $H_2S$ smell |
| PI-20 | 03-Mar-00 | 10:30 | 48° 27.531 N | 123° 25.551 W | 1.5 | 8.4 | 17.0 | 10.5 | 7.58 | olive green/black occasionally/some $H_2S$ smell |

Table 1. Sampling Locations and Field Log Data for Sediment Sampling in Portage Inlet and Gorge Waters for VEHEAP in March 2000.

| Station | | | Latitude | Longitude | Depth (m) | T (°C) | S (ppt) | DO (mg/L) | pH | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| GW-01 | 06-Mar-00 | 11:10 | 48° 26.378 N | 123° 23.019 W | 3.0 | 8.5 | 25.4 | 9.9 | 8.03 | Rep-04, <0.5cm green over black, some smell |
| GW-02 | 06-Mar-00 | 11:00 | 48° 26.369 N | 123° 23.148 W | 2.5 | 8.3 | 24.5 | 9.8 | 7.91 | <0.5cm green over black but little odour |
| GW-03 | 06-Mar-00 | 10:50 | 48° 26.450 N | 123° 23.305 W | 5.0 | 8.3 | 24.5 | 9.8 | 7.91 | <0.5cm green over black but little odour |
| GW-04 | 06-Mar-00 | 10:45 | 48° 26.449 N | 123° 23.294 W | 1.5 | 8.3 | 23.8 | 9.7 | 8.08 | green, no smell, no black |
| GW-05 | 06-Mar-00 | 10:40 | 48° 26.483 N | 123° 23.405 W | 1.5 | 8.2 | 23.3 | 9.8 | 8.02 | thin green layer over black, no smell |
| GW-06 | 06-Mar-00 | 10:30 | 48° 26.605 N | 123° 23.578 W | 2.0 | 8.2 | 24.0 | 9.8 | 7.94 | green <0.5cm black, smell |
| GW-07 | 06-Mar-00 | 10:20 | 48° 26.638 N | 123° 23.700 W | 3.0 | 8.1 | 23.7 | 9.8 | 8.06 | green, no smell, shell fragments |
| GW-08 | 06-Mar-00 | 10:15 | 48° 26.703 N | 123° 23.796 W | 2.0 | 8.1 | 23.7 | 9.8 | 8.05 | slight smell, green 1.5 cm over black |
| GW-09 | 06-Mar-00 | 10:05 | 48° 26.797 N | 123° 23.935 W | 1.5 | 8.0 | 22.7 | 9.7 | 8.04 | eelgrass, shell debris, no smell |
| GW-10 | 06-Mar-00 | 10:00 | 48° 26.786 N | 123° 24.067 W | 1.5 | 7.6 | 21.8 | 9.7 | 8.02 | eelgrass, shell debris, no smell |
| GW-11 | 06-Mar-00 | 9:50 | 48° 26.845 N | 123° 24.202 W | 1.5 | 7.6 | 20.4 | 9.8 | 7.95 | eelgrass, mud, sand, small sample |
| GW-12 | 06-Mar-00 | 9:45 | 48° 26.877 N | 123° 24.375 W | 1.0 | 7.6 | 21.5 | 9.8 | 7.88 | green over black, smell |
| GW-13 | 06-Mar-00 | 9:35 | 48° 26.908 N | 123° 24.467 W | 1.5 | 7.6 | 20.9 | 10.0 | 7.73 | greenish, no black, no smell |
| GW-14 | 06-Mar-00 | 9:30 | 48° 26.961 N | 123° 24.513 W | 2.0 | 7.4 | 19.3 | 10.0 | 7.61 | greenish, no black, no smell |
| GW-15 | 03-Mar-00 | 14:00 | 48° 26.989 N | 123° 24.635 W | 2.5 | 8.5 | 18.7 | 9.9 | 7.87 | Rep-03 |
| GW-16 | 03-Mar-00 | 13:50 | 48° 26.987 N | 123° 24.725 W | 2.0 | 8.5 | 16.4 | 10.2 | 7.77 | shells, green throughout, no black or smell |
| GW-17 | 03-Mar-00 | 13:40 | 48° 27.099 N | 123° 25.063 W | 2.5 | 8.5 | 19.6 | 10.0 | 7.83 | |
| GW-18 | 03-Mar-00 | 13:30 | 48° 27.135 N | 123° 25.149 W | 3.0 | 8.6 | 16.4 | 10.1 | 7.83 | |
| GW-19 | 03-Mar-00 | 13:15 | 48° 27.116 N | 123° 25.258 W | 2.0 | 8.5 | 15.2 | 10.3 | 7.85 | <0.5cm green over black but little odour |
| GW-20 | 03-Mar-00 | 13:00 | 48° 27.189 N | 123° 25.457 W | 1.5 | 8.6 | 6.0 | 10.2 | 8.38 | shells, black not too smelly |

## Table 2. Analytical Results of Sediment Sampling in Portage Inlet and Gorge Waters for VEHEAP in March 2000.

| Parameter | WDOE /CRD Standard | MDL | GW-01 | GW-01 Dup | GW-02 | GW-03 | GW-04 | GW-05 | GW-06 | GW-07 | GW-08 | GW-09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moisture Content % | | 0.1 | 69.3 | 68.6 | 70.2 | 60.9 | 50.7 | 55.5 | 72.7 | 37.9 | 76.4 | 47.2 |
| Aluminum µg/g | | 8 | 21200 | 22900 | 29800 | 22600 | 23900 | 13400 | 27900 | 17800 | 26200 | 20400 |
| Antimony µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Arsenic µg/g | 57 | 8 | <8 | <8 | 12 | 12 | 9 | <8 | 13 | <8 | 11 | <8 |
| Barium µg/g | | 0.2 | 162 | 86 | 91.7 | 91.3 | 128 | 49.5 | 107 | 60.8 | 92.9 | 90.4 |
| Berylium µg/g | | 0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | 1.9 |
| Boron µg/g | | 2 | 56 | 91 | 160 | 134 | 142 | 61 | 148 | 72 | 173 | 101 |
| Cadmium µg/g | 5.1 | 0.8 | ***14.9*** | ***11.6*** | ***17.4*** | ***14.1*** | ***16*** | ***9.3*** | <0.8 | <0.8 | <0.8 | <0.8 |
| Calcium µg/g | | 20 | 5110 | 7140 | 7770 | 8800 | 24400 | 7310 | 8480 | 11300 | 9360 | 16400 |
| Chromium µg/g | 260 | 0.8 | 47 | 53.7 | 64.5 | 51.2 | 54.4 | 28.5 | 61.9 | 43.2 | 61.9 | 39.4 |
| Cobalt µg/g | | 0.8 | 10 | 5 | 6.8 | 4.2 | 6.4 | 3.5 | 6.8 | 4.4 | 6.5 | 5.9 |
| Copper µg/g | 390 | 0.8 | 29.1 | 52.4 | 78.7 | 115 | 146 | 39.3 | 100 | 44.8 | 94 | 49.2 |
| Iron µg/g | | 0.8 | 30000 | 22600 | 33600 | 27600 | 29700 | 17100 | 32200 | 20600 | 30300 | 21900 |
| Lead µg/g | 450 | 8 | 13 | 117 | 140 | 111 | 149 | 75 | 147 | 86 | 141 | 86 |
| Mangesium µg/g | | 20 | 8790 | 7370 | 11400 | 9300 | 9430 | 5020 | 11100 | 6290 | 11600 | 8500 |
| Manganese µg/g | | 0.2 | 331 | 287 | 352 | 294 | 259 | 283 | 326 | 257 | 299 | 247 |
| Mercury µg/g | 0.41 | 0.008 | ***0.546*** | ***0.526*** | 0.381 | ***0.601*** | 0.233 | 0.253 | ***0.434*** | 0.293 | 0.372 | 0.257 |
| Molybdenum µg/g | | 2 | <2 | 2 | 4 | <2 | <2 | <2 | <2 | <2 | 4 | <2 |
| Nickel µg/g | | 3 | 41 | 27 | 37 | 28 | 30 | 19 | 33 | 22 | 33 | 22 |
| Phosphorus µg/g | | 20 | 1050 | 830 | 1110 | 1440 | 1010 | 899 | 1310 | 867 | 1380 | 1220 |
| Potassium µg/g | | 20 | 4840 | 4130 | 5650 | 4510 | 4700 | 2280 | 5410 | 2810 | 5190 | 3980 |
| Selenium µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | 10 | 12 | 13 |
| Silicon µg/g | | 8 | 663 | 858 | 859 | 782 | 1280 | 776 | 1360 | 1030 | 1130 | 1730 |
| Silver µg/g | 6.1 | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Sodium µg/g | | 20 | 444 | 12200 | 25700 | 17800 | 15200 | 6880 | 19400 | 8030 | 27000 | 17400 |
| Strontium µg/g | | 0.2 | 37.5 | 64.9 | 81.7 | 80.6 | 133 | 57.9 | 85.4 | 73.5 | 92 | 394 |
| Sulfur µg/g | | 8 | 637 | 5740 | 13400 | 6430 | 10300 | 3510 | 10300 | 6050 | 9770 | 7070 |
| Tin µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Titanium µg/g | | 0.3 | 1870 | 1600 | 1740 | 1720 | 1800 | 1310 | 1910 | 1820 | 1710 | 1360 |
| Vanadium µg/g | | 2 | 67 | 80 | 99 | 80 | 88 | 53 | 95 | 68 | 92 | 70 |
| Zinc µg/g | 410 | 71.2 | 71.2 | 156 | 242 | 140 | 211 | 80.2 | 188 | 105 | 199 | 139 |

## Table 2. Analytical Results of Sediment Sampling in Portage Inlet and Gorge Waters for VEHEAP in March 2000.

| Parameter | WDOE /CRD Standard | MDL | GW-10 | GW-11 | GW-12 | GW-13 | GW-14 | GW-15 | GW-15 Dup | GW-16 | GW-17 | GW-18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moisture Content % | | 0.1 | 55.5 | 43.2 | 77.6 | 69.6 | 67 | 60.1 | 59.6 | 67.6 | 49 | 47 |
| Aluminum µg/g | | 8 | 27400 | 19800 | 30000 | 26500 | 24500 | 20700 | 29200 | 25800 | 16100 | 19500 |
| Antimony µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Arsenic µg/g | 57 | 8 | 16 | 10 | 11 | 12 | 15 | <8 | 16 | 10 | <8 | 9 |
| Barium µg/g | | 0.2 | 108 | 71.1 | 104 | 88.1 | 79.2 | 67.2 | 131 | 87.8 | 47.7 | 60.7 |
| Berylium µg/g | | 0.2 | 1.2 | 1.4 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Boron µg/g | | 2 | 123 | 107 | 185 | 139 | 126 | 90 | 140 | 120 | 78 | 85 |
| Cadmium µg/g | 5.1 | 0.8 | <0.8 | <0.8 | <0.8 | <0.8 | <0.8 | <0.8 | ***17.2*** | <0.8 | <0.8 | <0.8 |
| Calcium µg/g | | 20 | 95600 | 110000 | 9460 | 7140 | 10200 | 6280 | 9460 | 7910 | 9260 | 9410 |
| Chromium µg/g | 260 | 0.8 | 61.4 | 47.8 | 81.7 | 94.1 | 51.2 | 54.1 | 64.8 | 59.3 | 34.9 | 43.5 |
| Cobalt µg/g | | 0.8 | 6.5 | 5.7 | 8.7 | 6.8 | 8.4 | 5.9 | 5.8 | 8.1 | 4.6 | 7.8 |
| Copper µg/g | 390 | 0.8 | 90.7 | 65 | 98.2 | 77.7 | 69.9 | 54 | 109 | 66.8 | 38.7 | 45 |
| Iron µg/g | | 0.8 | 32100 | 24600 | 35000 | 29200 | 30200 | 22300 | 32900 | 27200 | 18300 | 23500 |
| Lead µg/g | 450 | 8 | 155 | 118 | 168 | 156 | 109 | 129 | 143 | 142 | 72 | 83 |
| Mangesium µg/g | | 20 | 10500 | 8750 | 12300 | 9760 | 9500 | 7430 | 10900 | 9340 | 6020 | 7280 |
| Manganese µg/g | | 0.2 | 384 | 434 | 291 | 288 | 579 | 271 | 293 | 334 | 242 | 342 |
| Mercury µg/g | 0.41 | 0.008 | 0.359 | 0.247 | 0.386 | 0.388 | 0.28 | 0.286 | 0.285 | 0.312 | 0.184 | 0.214 |
| Molybdenum µg/g | | 2 | <2 | <2 | 7 | 6 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel µg/g | | 3 | 32 | 28 | 37 | 32 | 34 | 26 | 33 | 31 | 19 | 25 |
| Phosphorus µg/g | | 20 | 1720 | 1780 | 1060 | 1050 | 1810 | 899 | 1050 | 1170 | 1110 | 1300 |
| Potassium µg/g | | 20 | 5060 | 3850 | 5780 | 4710 | 4500 | 3420 | 6030 | 4640 | 2610 | 3170 |
| Selenium µg/g | | 8 | <8 | <8 | 10 | 13 | 8 | 10 | <8 | 15 | 9 | 9 |
| Silicon µg/g | | 8 | 1040 | 1100 | 956 | 1050 | 918 | 868 | 1130 | 869 | 952 | 914 |
| Silver µg/g | 6.1 | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Sodium µg/g | | 20 | 16600 | 17800 | 27400 | 16600 | 16900 | 11600 | 17500 | 17400 | 12500 | 12500 |
| Strontium µg/g | | 0.2 | 272 | 302 | 96.1 | 73.4 | 90.5 | 58.1 | 86.6 | 76.2 | 66.7 | 74 |
| Sulfur µg/g | | 8 | 6480 | 3480 | 15300 | 10600 | 5140 | 5760 | 11600 | 7350 | 2930 | 3030 |
| Tin µg/g | | 8 | <8 | 15 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Titanium µg/g | | 0.3 | 1610 | 1410 | 1830 | 1710 | 1520 | 1480 | 1920 | 1700 | 1340 | 1480 |
| Vanadium µg/g | | 2 | 93 | 77 | 103 | 92 | 81 | 75 | 97 | 87 | 59 | 71 |
| Zinc µg/g | 410 | 71.2 | 223 | 183 | 240 | 226 | 173 | 159 | 185 | 190 | 115 | 130 |

Table 2. Analytical Results of Sediment Sampling in Portage Inlet and Gorge Waters for VENLEAP in March 2000.

| Parameter | WDOE /CRD Standard | MDL | GW-19 | GW-20 | PI-01 | PI-01 Dup | PI-02 | PI-03 | PI-04 | PI-05 | PI-06 | PI-07 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moisture Content % | | 0.1 | 70.5 | 74.5 | 76.9 | 76.8 | 73.1 | 81.1 | 83.5 | 81.2 | 79.1 | 81.1 |
| Aluminum µg/g | | 8 | 24600 | 31300 | 31500 | 36300 | 26400 | 33500 | 35900 | 36100 | 37800 | 40500 |
| Antimony µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Arsenic µg/g | 57 | 8 | 11 | 15 | 12 | 12 | 13 | 16 | 18 | 15 | 16 | 13 |
| Barium µg/g | | 0.2 | 92.1 | 103 | 107 | 105 | 88 | 117 | 128 | 118 | 127 | 137 |
| Berylium µg/g | | 0.2 | <0.2 | 0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Boron µg/g | | 2 | 108 | 129 | 169 | 162 | 124 | 198 | 261 | 209 | 193 | 196 |
| Cadmium µg/g | 5.1 | 0.8 | <0.8 | <0.8 | <0.8 | ***20.9*** | <0.8 | <0.8 | <0.8 | <0.8 | <0.8 | <0.8 |
| Calcium µg/g | | 20 | 8460 | 21100 | 8300 | 8160 | 7140 | 8000 | 8840 | 7830 | 8140 | 9000 |
| Chromium µg/g | 260 | 0.8 | 49 | 61.5 | 67.1 | 74.9 | 74.7 | 69 | 72.2 | 75.4 | 76.1 | 81.8 |
| Cobalt µg/g | | 0.8 | 7.5 | 9.9 | 9 | 6.6 | 8.1 | 10.9 | 9.7 | 11.7 | 11.2 | 10.3 |
| Copper µg/g | 390 | 0.8 | 53.2 | 71.3 | 80.6 | 98 | 62.1 | 80.7 | 91.5 | 98.1 | 96.8 | 101 |
| Iron µg/g | | 0.8 | 25200 | 35400 | 34100 | 39900 | 29600 | 35200 | 39800 | 41100 | 41500 | 42900 |
| Lead µg/g | 450 | 8 | 98 | 118 | 148 | 136 | 134 | 138 | 143 | 147 | 145 | 145 |
| Mangesium µg/g | | 20 | 8210 | 11800 | 11600 | 13900 | 9320 | 13100 | 15300 | 14500 | 14100 | 15400 |
| Manganese µg/g | | 0.2 | 337 | 625 | 381 | 333 | 378 | 332 | 405 | 329 | 336 | 352 |
| Mercury µg/g | 0.41 | 0.008 | 0.275 | 0.274 | 0.355 | 0.33 | 0.312 | 0.314 | 0.34 | 0.37 | 0.351 | 0.378 |
| Molybdenum µg/g | | 2 | 3 | <2 | 5 | <2 | 6 | 7 | 5 | 7 | 5 | 5 |
| Nickel µg/g | | 3 | 27 | 40 | 37 | 43 | 33 | 38 | 43 | 42 | 43 | 46 |
| Phosphorus µg/g | | 20 | 1100 | 2010 | 1150 | 1450 | 1090 | 1360 | 1690 | 1360 | 1310 | 1310 |
| Potassium µg/g | | 20 | 4520 | 5980 | 5900 | 6870 | 4700 | 6640 | 7440 | 7110 | 7310 | 7980 |
| Selenium µg/g | | 8 | 9 | <8 | 11 | <8 | <8 | 13 | <8 | 11 | <8 | 13 |
| Silicon µg/g | | 8 | 1230 | 1130 | 1040 | 948 | 1040 | 970 | 1090 | 1450 | 1230 | 910 |
| Silver µg/g | 6.1 | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Sodium µg/g | | 20 | 16800 | 25600 | 26100 | 31500 | 19100 | 31800 | 42000 | 35300 | 30200 | 37300 |
| Strontium µg/g | | 0.2 | 81.9 | 153 | 92.1 | 93.4 | 76.1 | 98 | 120 | 102 | 98.7 | 108 |
| Sulfur µg/g | | 8 | 8000 | 6670 | 13300 | 15200 | 11600 | 12300 | 14700 | 16400 | 15900 | 17600 |
| Tin µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Titanium µg/g | | 0.3 | 1610 | 1760 | 1840 | 2010 | 1680 | 1870 | 1860 | 1900 | 1990 | 2110 |
| Vanadium µg/g | | 2 | 80 | 98 | 102 | 110 | 87 | 105 | 112 | 113 | 117 | 120 |
| Zinc µg/g | 410 | 71.2 | 168 | 227 | 243 | 287 | 214 | 249 | 260 | 282 | 289 | 298 |

Table 2. Analytical Results of Sediment Sampling in Portage Inlet and Gorge Waters for VEHEAP in March 2000.

| Parameter | WDOE /CRD Standard | MDL | PI-08 | PI-09 | PI-10 | PI-10 Dup | PI-11 | PI-12 | PI-13 | PI-14 | PI-15 | PI-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moisture Content % | | 0.1 | 81 | 82.2 | 79.3 | 79.1 | 79.3 | 78.6 | 80.8 | 81.7 | 66.2 | 82 |
| Aluminum µg/g | | 8 | 41900 | 41900 | 45700 | 25600 | 39500 | 40000 | 41700 | 41500 | 32500 | 42500 |
| Antimony µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Arsenic µg/g | 57 | 8 | 19 | 20 | 22 | 11 | 19 | 17 | 19 | 20 | 16 | 21 |
| Barium µg/g | | 0.2 | 112 | 112 | 138 | 102 | 110 | 113 | 115 | 110 | 95.8 | 118 |
| Berylium µg/g | | 0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Boron µg/g | | 2 | 166 | 181 | 172 | 135 | 166 | 155 | 158 | 168 | 123 | 175 |
| Cadmium µg/g | 5.1 | 0.8 | 1.9 | 1.1 | 2.1 | ***16.6*** | 1.9 | 2 | 2 | 1.9 | 1.7 | 1.9 |
| Calcium µg/g | | 20 | 7870 | 7470 | 8300 | 8820 | 8940 | 9010 | 8170 | 7300 | 9660 | 8310 |
| Chromium µg/g | 260 | 0.8 | 84.5 | 80.1 | 84.7 | 60.5 | 71.8 | 74.2 | 78.1 | 78.1 | 59.2 | 81.9 |
| Cobalt µg/g | | 0.8 | 21 | 20.5 | 20.2 | 6.1 | 20.2 | 20.9 | 21.3 | 18.8 | 20.2 | 21.3 |
| Copper µg/g | 390 | 0.8 | 82.4 | 80.8 | 85.3 | 107 | 72.2 | 73.4 | 77.2 | 80.1 | 51.5 | 76.8 |
| Iron µg/g | | 0.8 | 42000 | 41700 | 43300 | 31600 | 40800 | 42100 | 40900 | 40600 | 34700 | 41300 |
| Lead µg/g | 450 | 8 | 179 | 175 | 181 | 141 | 167 | 169 | 172 | 170 | 151 | 171 |
| Mangesium µg/g | | 20 | 13700 | 14000 | 13600 | 10600 | 12900 | 12800 | 13400 | 13600 | 8880 | 13900 |
| Manganese µg/g | | 0.2 | 338 | 339 | 341 | 265 | 384 | 420 | 329 | 321 | 405 | 332 |
| Mercury µg/g | 0.41 | 0.008 | ***0.537*** | 0.338 | 0.365 | 0.343 | 0.298 | 0.3 | 0.34 | ***0.75*** | 0.261 | 0.339 |
| Molybdenum µg/g | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel µg/g | | 3 | 42 | 44 | 42 | 32 | 43 | 42 | 41 | 41 | 34 | 43 |
| Phosphorus µg/g | | 20 | 1390 | 1470 | 1420 | 1100 | 1640 | 1830 | 1300 | 1220 | 810 | 1450 |
| Potassium µg/g | | 20 | 6730 | 6860 | 7380 | 5130 | 6190 | 6200 | 6690 | 6660 | 4600 | 6940 |
| Selenium µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Silicon µg/g | | 8 | 820 | 863 | 786 | 1050 | 928 | 908 | 870 | 700 | 781 | 735 |
| Silver µg/g | 6.1 | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Sodium µg/g | | 20 | 32800 | 35100 | 29200 | 17000 | 27700 | 26400 | 31600 | 33400 | 12800 | 36000 |
| Strontium µg/g | | 0.2 | 101 | 102 | 105 | 78.2 | 110 | 112 | 102 | 98.2 | 88.3 | 105 |
| Sulfur µg/g | | 8 | 14100 | 14200 | 14500 | 11300 | 10100 | 9980 | 13600 | 14400 | 12100 | 13800 |
| Tin µg/g | | 8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 | <8 |
| Titanium µg/g | | 0.3 | 1980 | 1950 | 1990 | 1750 | 1970 | 2100 | 2070 | 1960 | 2080 | 1950 |
| Vanadium µg/g | | 2 | 108 | 108 | 113 | 88 | 106 | 107 | 107 | 107 | 96 | 108 |
| Zinc µg/g | 410 | 71.2 | 262 | 266 | 270 | 183 | 252 | 253 | 260 | 261 | 222 | 258 |

## Table 2. Analytical Results of Sediment Sampling in Portage Inlet and Gorge Waters for VEHEAP in March 2000.

| Parameter | WDOE /CRD Standard | MDL | PI-17 | PI-18 | PI-19 | PI-20 |
|---|---|---|---|---|---|---|
| Moisture Content % | | 0.1 | 74.7 | 78.4 | 74 | 68.6 |
| Aluminum µg/g | | 8 | 38300 | 44300 | 41600 | 34900 |
| Antimony µg/g | | 8 | <8 | <8 | <8 | <8 |
| Arsenic µg/g | 57 | 8 | 19 | 18 | 17 | 16 |
| Barium µg/g | | 0.2 | 109 | 124 | 99.4 | 88.8 |
| Berylium µg/g | | 0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Boron µg/g | | 2 | 155 | 166 | 145 | 148 |
| Cadmium µg/g | 5.1 | 0.8 | 2.1 | 1 | 2 | 1.5 |
| Calcium µg/g | | 20 | 32200 | 8010 | 7650 | 7300 |
| Chromium µg/g | 260 | 0.8 | 74.6 | 80.5 | 76.8 | 57.5 |
| Cobalt µg/g | | 0.8 | 19.5 | 20.2 | 21.6 | 18.9 |
| Copper µg/g | 390 | 0.8 | 61 | 71 | 66.6 | 46.7 |
| Iron µg/g | | 0.8 | 38500 | 42700 | 43100 | 34300 |
| Lead µg/g | 450 | 8 | 157 | 162 | 148 | 108 |
| Mangesium µg/g | | 20 | 11300 | 12800 | 11700 | 8860 |
| Manganese µg/g | | 0.2 | 324 | 341 | 340 | 311 |
| Mercury µg/g | 0.41 | 0.008 | 0.373 | 0.371 | 0.313 | 0.308 |
| Molybdenum µg/g | | 2 | <2 | <2 | <2 | <2 |
| Nickel µg/g | | 3 | 38 | 42 | 42 | 35 |
| Phosphorus µg/g | | 20 | 884 | 1100 | 1230 | 609 |
| Potassium µg/g | | 20 | 6210 | 6850 | 5690 | 4780 |
| Selenium µg/g | | 8 | <8 | <8 | <8 | <8 |
| Silicon µg/g | | 8 | 945 | 848 | 866 | 724 |
| Silver µg/g | 6.1 | 2 | <2 | <2 | <2 | <2 |
| Sodium µg/g | | 20 | 25600 | 26600 | 21000 | 12700 |
| Strontium µg/g | | 0.2 | 185 | 94.6 | 87.3 | 76.1 |
| Sulfur µg/g | | 8 | 17100 | 14800 | 13600 | 14100 |
| Tin µg/g | | 8 | <8 | <8 | <8 | <8 |
| Titanium µg/g | | 0.3 | 1750 | 2030 | 2200 | 1890 |
| Vanadium µg/g | | 2 | 101 | 112 | 108 | 89 |
| Zinc µg/g | 410 | 71.2 | 246 | 269 | 258 | 189 |

Notes:
Units for metals are dry µg/g (ppm)
Values exceeding WDOE/CRD standards are highlighted