TESTING AND ANALYSIS OF UBC WATER DISCHARGE SITES DURING NON-STORM EVENTS

UBC SEEDS PROJECT

CHBE 484

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SUMMARY

The objectives of this report are to sample five different stormwater discharge points around the University of British Columbia campus during non-storm events and analyze five parameters (pH, turbidity, temperature, specific conductivity and total metals). The five sites include Spiral Drain, Trail 7 outfall, west of 16th Avenue outfall, Booming Grounds Creek and undeveloped Cutthroat Creek. Sampling data was collected on February 22, 2005, March 03, 2005 and March 10, 2005.

The results outlined in this report contribute to the understanding of stormwater dynamics. This is the first study which looks at the testing and analysis of stormwater discharge points on the UBC campus during non-storm events.

All data collected is compared with the baseline site Cutthroat Creek, and the 'UBC Storm Water Quality Standards' which were adopted from *British Columbia Water Quality Guidelines (Criteria).*

Summary of Results

Temperatures are higher in samples taken from Spiral Drain indicating possible condensate leaks in the UBC steam heating system. Temperatures at Booming Grounds Creek and Trail 7 are also higher than Cutthroat Creek.

Turbidity values at the four discharge locations are all higher than the values at Cutthroat Creek. The values during storm events were quite a bit higher than that of the non-storm events.

pH levels at the four discharge points are more alkaline than Cutthroat Creek. The increase in pH may be a result of human activities in the area.

Specific conductivity levels at the four discharge sites are at least 4 times higher than Cutthroat Creek. Trail 7 and west of 16th Avenue levels may be due to hardness from groundwater seepage. Booming Grounds Creek and Spiral Drain levels are suspected to be a result of urban activities.

Metals analyses show that aluminum levels are consistently above water quality standards at all sites indicating high natural aluminum content in the soils. High levels of arsenic are recorded in two different samples at Trail 7. Cadmium levels exceed the

water quality standards in all sites indicating that cadmium could be naturally occurring in these soils. All samples taken from Trail 7, Spiral Drain, west of 16th Avenue and Booming Grounds Creek have high levels of copper. It may be beneficial to determine if copper is a result of point sources at construction sites. Lead levels do not exceed water quality standards. Mercury levels exceed water quality standards in specific samples taken from Cutthroat Creek and west of 16th Avenue. Zinc levels are high in samples taken from Booming Grounds Creek.

Summary of Recommendations

It is suggested that in order to reduce the temperature in Spiral Drain, the UBC steam heating system be renovated, thus reducing the condensate leaks. Since zinc and iron concentrations are elevated at Booming Grounds Creek, it is suspected that they are a result of contamination caused by the close proximity to vehicles. Other high metals concentrations should be examined in order to identify point sources upstream of contamination. In order to determine whether or not groundwater seepage is influencing the hardness and specific conductivity at Trail 7 and west of 16th Avenue, further testing of groundwater flow and characteristics is recommended. We also recommend that further sampling be completed to confirm or refute the presence of the harmful contaminants, mercury and arsenic in the sampled streams. It is recommended that future developments on the UBC campus utilize preventative measures and stormwater management practices in order to reduce the amount of stormwater caused by a high percentage of impervious areas. Methods are available and can also be used to treat stormwater prior to discharge, for example the use of compost material to remove metals from road surface runoff.

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Acknowledgments

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1.0 INTRODUCTION

1.1 Stormwater Description

Stormwater consists of the water runoff from roads, pathways, buildings and sometimes construction sites. Urban stormwater occurs during both storm and non-storm events. Possible sources of runoff during non-storm events include construction, equipment washing and watering of green areas. The runoff water usually contains debris, litter, dirt, oil and grease from various sources. It may also contain garden wastes, chemicals, excess nutrients, fertilizers and animal feces.

1.2 Site Description

Stormwater at the University of British Columbia campus originates in three different catchment areas. The North catchment drains into Spiral Drain, the South catchment drains into Booming Grounds Creek and the West catchment drains into Trail 7, as well as a culvert south of Trail 7 on Old Marine Drive (referred to as west of 16th Avenue).

Spiral Drain is located north of the Museum of Anthropology on Cecil Green Park Road. This site drains the north and central portions of campus, where there is currently construction. Before being discharged into the ocean, the stormwater spirals down a 60-m deep, 1.2-m diameter concrete drain. Figure 5a illustrates the manhole east of the Spiral Drain from which samples were taken.

Trail 7 and the west of 16th Avenue site are located along old Marine Drive, West of the UBC Botanical Gardens. This catchment area is the smallest of the three. Many parking lots (including Lot B) and sports fields drain into this catchment. The water travels through an eroded ravine into an estuarine habitat. Samples were taken at both Trail 7 (Figure 5c) and west of 16th Avenue (Figure 5d).

Booming Grounds Creek is found on the east side of Southwest Marine Drive (refer to Figure 4). The South Catchment discharges into this creek, where the runoff originates from housing, playing fields and the Triumf research area. A sample was taken in the center of the creek upstream of the green weir. Figure 6b illustrates the point from where samples were taken.

Cutthroat Creek (Figure 6c), located in Pacific Spirit Park southwest of UBC, was used as a control. This stream is considered to be free of human contamination. All data was compared to this baseline site.

1.3 History

Current and future development of the UBC campus has invoked concern over the possible threats which stormwater may pose on the waters surrounding the campus. In 2001, engineering consultants were contracted to analyze stormwater discharges and recommend future requirements of the UBC Stormwater Quality Program. A stormwater quality monitoring study was conducted for temperature, specific conductivity and turbidity measurements at Booming Grounds Creek, Spiral Drain, and Trail 7 outfalls. In addition, more intensive sampling of selected storm events was performed. Parameters analyzed during storm events included metals, hydrocarbons, fecal coliform bacteria, and suspended solids. Flow was also being continuously monitored at the Spiral Drain and Booming Grounds Creek. In May 2003, a Storm Water Subcommittee was formed to address stormwater quality practices as part of an integrated stormwater management plan.

1.4 Aquatic Life Definition

There are six major water uses outlined in the *Environmental Management Act*: aquatic life (marine and freshwater), drinking water, wildlife, recreation and aesthetics, agriculture and finally industrial. The surface waters at the sites tested in this report are identified as aquatic life water use and were not suspected to be used for the purpose of consumption by humans. “Aquatic life water use means the use of water as a habitat for any component of the freshwater or marine aquatic ecosystem, including phytoplankton, zooplankton, benthos, macrophytes and fish (Contaminated Sites Regulation, *Environmental Management Act*)."

1.5 Parameter Descriptions

Turbidity

Turbidity, measured in nephelometric turbidity units (NTU), is a measure of the cloudiness of water and is used as an indicator of water quality. Cloudiness can be caused by suspended sediment or organic matter in solution which leads to a loss of clarity or transparency. Other causes of turbidity include construction, agricultural practices, wastewater discharges, and high volume water flow. Light is unable to penetrate the water column, increasing the temperature which leads to a decrease in dissolved oxygen levels. This is harmful to aquatic life, as it reduces growth rates, decreases resistance to disease, as well as provides other adverse affects.

Water Hardness

Water hardness is a water quality indicator of the concentration of dissolved salts of calcium, magnesium and iron, that can act as buffers to stabilize water when the hydrogen/hydroxyl ratio changes. Water that is poorly buffered (ie. soft water), is subject to higher pH fluctuations which can be harmful to aquatic life.

pH

pH is a measure of the acidity or alkalinity of water, or the ratio of the hydrogen ion (H^+) to the hydroxyl ion (OH^-). Changes in the pH of a system lead to an increase in the toxicity of dissolved compounds and can also affect how chemicals dissolve in water. There are many ways that a change in pH can affect fish health, including: physical damage to skin, gills and eyes, stress, increased mucus production, and fluctuations of blood pH. Most natural water systems have a pH in the range of 6.5-8.5. Acid rain is produced when atmospheric nitrogen oxides and sulfur dioxides are converted to nitric and sulfuric acid. Acid rain decreases the pH of water due to its acidic nature.

Temperature

Temperature can affect the chemistry of water. Cold water can hold more dissolved oxygen than warmer water, and if the temperature gets too hot some organisms may die. Increasing the temperature of a certain body of water allows for a reduction in quality which leads to what is referred to as thermal pollution. Thermal pollution can increase the rate of organic decomposition and photosynthesis; it can also increase the plant growth process and the biochemical oxygen demand (BOD).

Specific Conductivity

Specific conductivity is a measure of the ability of water to conduct an electrical current. It is used to estimate the total dissolved solids concentration in water (measured in micro-Siemens per centimeter at 25 degrees Celsius). Conductivity tends to increase with the presence of negatively charged ions such as chloride, nitrate, sulfate and phosphate, as well as positively charged ions such as sodium, magnesium, calcium, iron and aluminum. Conductivity appears to be found in low amounts in the presence of hydrocarbons, oils, phenols, alcohols and sugars.

1.6 Metals descriptions

Some metals are essential for plant and animal growth and metabolic activities, but can become potentially toxic in higher concentrations. Common metals found in stormwater include zinc from motor oil and grease, aluminum from engine wear and vehicular components, copper from brake linings, arsenic from herbicides and road salts, cadmium from phosphate fertilizers, mercury from mining, air pollution from power plants and incinerator emissions, lead from oil additives and brake wear and finally, and metals from natural sources.

Major sources of pollutants in water come from contaminated runoff draining into rivers, lakes and bays after storm events. Rain picks up dirt, oil, fertilizers, pesticides, animal waste and other substances as it drains over impervious surfaces (roads, parking lots, driveways). Of the total metals analysis, eight metals were observed including: aluminum, arsenic, cadmium, copper, iron, lead, mercury and zinc.

Aluminum

Aluminum is a metal with a silvery-white colour, it is easily malleable, and has no detectable odour. Usually aluminum occurs as a fine powdery dust in the natural environment; this dust is insoluble in water. Aluminum may become corrosive if it comes into contact with strong acids or other metals.

Aluminum is not considered to be a human carcinogen. The radioactive Aluminum–26 isotope is an extremely stable compound and has a half-life of 730,000 years. It becomes a risk due to bioaccumulation and it may cause brain damage and kidney damage in organisms if there is a large build up in tissues.

Aluminum occurs naturally in water, air and soil. Currently aluminum is being widely used in cars, therefore the runoff from the parking lots and bus loops may be sources of aluminum in stormwater. Many everyday household items like aluminum foil and cooking pans are made of aluminum. Aluminum found in garbage landfills may leach into ground water.

Arsenic

Inorganic arsenic is considered to be associated with copper acetoarsenite & all inorganic compounds containing arsenic except for arsine. The metal is silver, white or gray in colour, is very brittle, and has no detectable odour. Inorganic arsenic is considered to be insoluble in water.

The drinking water risk concentration for inorganic arsenic is 0.05 mg/L. Arsenic is a known carcinogen and usually comes into contact with human organs through the ingestion of drinking water. Arsenic is a major cause of skin disease and cancer. The half-life of radioactive arsenic isotope is approximately 18 days.

Organic arsenic exists as various organic compounds. Appearance and odour of the compound is dependant upon its constituents. The estimated lethal dose in humans is 120 mg.

In many areas arsenic occurs naturally, however levels are mainly a result of human activities. The main human sources include treated wood, fertilizers (arsenic is no longer used in fertilizers) and mining. Arsenic in UBC stormwater may be a result of past and current construction activity on campus.

Cadmium

Cadmium dust is silver, white or blue-tinged in colour and has no detectable odour. This metal is easily malleable. Cadmium is insoluble in water and can be burned in its powder form. It is present in most soils at a concentration of 0.15 mg/L.

Entry pathways for cadmium include inhalation and ingestion often through drinking water. Cadmium is considered to be a human carcinogen; it is known to cause both lung cancer and renal cancer. The radioactive cadmium isotopes found in water usually have a half-life of less than 45 days.

Cadmium can be found in common minerals such as sphalerite and greenockite, and is formed as a byproduct during production of zinc, copper, and lead. Most cadmium is used in cadmium-nickel batteries. It is often used as a coating for steel and iron to avoid corrosion due to weathering. Less common uses include semiconductors, plastics, dyes and neutron absorbers in various processes.

Copper

Copper is found in the Earth's crust and is an essential nutrient that is necessary for metabolism and the production of macromolecules. Copper is non-carcinogenic and is more likely to affect health when it is dissolved in water and not attached to other particles. Natural levels found in water are < 0.254 mg/L. If corrosive waters containing nitric, sulfuric and hydrochloric acids come in contact with copper piping, levels can exceed 63.54 mg/L.

The average atmospheric half-life and lifetime of radioactive copper isotope particles and particle associated chemicals are 3.5 to 10 days, and 5 to 15 days, respectively.

Sources of copper include: electrical wiring, switches, plumbing, heating, building material, chemical and pharmaceutical machinery, electroplating coating, piping, insecticides, pesticides, catalysts, anti-fouling paints, and it is also used in carbides and high speed steels. Copper has also been identified in motor vehicle exhaust.

Iron

Iron makes up at least 5% of the Earth's crust and is not considered a health hazard. It is essential for good health because it transports oxygen in the blood. Iron readily dissolves in water and is present in the natural water supply in concentrations no higher than 10 mg/L. At concentrations higher than 0.3 mg/L red, brown or yellow staining of laundry, glassware and dishes will occur, along with an offensive odour and metallic taste. Iron can become insoluble when it combines with different naturally occurring acids; organic iron is yellow or brown in colour. When iron exists with iron oxidizing bacteria, the bacteria can leave a reddish brown or yellow slime residue, and give off an offensive odour.

Sources of iron include: storage batteries, ammunition, fishing sinkers, coatings, fuel additives, piping, building materials, glass and ceramics, radiation shielding, cables, and electronics.

Lead

Lead occurs naturally in the Earth's crust and has a low solubility in water. It has been identified as a toxic air contaminant and is a probable human carcinogen.

The average atmospheric half-life and lifetime of radioactive lead isotope particles in air are 3.5 to 10 days and 5 to 15 days, respectively.

Natural emissions occur via windborne dusts created by the weathering of deposits, sea and salt lake emissions, aerosols, forest fires and volcanic eruptions. Since the phasing out of leaded gasoline in the mid-1970's inorganic lead emissions have decreased, but they are able to deposit and accumulate in soil for many years. Sources of lead include: aircraft fuel combustion, autobody refinishing, grid casting and lead oxide production at battery manufacturing facilities, cement manufacturing, cogeneration, sawmills, paperboard mills, foundries and steel mills, stationary source fuel combustion, incineration, painting and coatings manufacturers, sand and gravel facilities, and secondary lead recycling facilities.

Mercury

Mercury has been identified in meteorites and moon rocks. On Earth natural deposits are rare but it may be released in volcanic eruptions, forest fires and from other natural sources including water, soil, plants, oceans and rocks.

Mercury has been classified as a Canadian Environmental Protection Act (CEPA) toxic compound with the potential for long-range transport through the atmosphere. It is known to cause serious environmental and health impacts. Mercury is insoluble in water, alcohol and ether, but it is soluble in lipids.

The average atmospheric half-life and lifetime of radioactive mercury isotope particles and particle associated chemicals are 3.5 to 10 days, and 5 to 15 days, respectively.

Once mercury is released into the environment it cycles and converts to the toxic form, methylmercury. Methylmercury is very soluble, mobile and bioaccumulative. It accumulates in fish and shellfish tissue and keeps accumulating up the food chain to humans. The main effects of human exposure to mercury are understood to be neurological and renal (kidney) disturbances.

Sources of mercury include: emissions from metal mining and smelting, waste incineration, coal-fired power plants, chloroalkali plants, effluent from mineral ores processing, steel manufacturing, petroleum refining, and fossil fuel combustion. Mercury also enters the environment during the life cycle of the following products: fluorescent lamps, dental amalgams, fever thermometers, thermostats, electrical switches, pressure sensing devices, and blood pressure reading devices.

Zinc

Zinc is most commonly found as zinc peroxide in the environment. The metal is white in colour and has no detectable odour. Zinc peroxide is decomposed by water at a very slow rate.

Zinc is not considered to be a human carcinogen. The half-life of radioactive zinc isotopes are about 67 days.

In humans, zinc deficiencies are more common than zinc overdoses. If too much zinc is ingested it may interfere with other essential nutrients necessary for metabolism.

Zinc deposits are found naturally all over the world. Sources of zinc include steel coatings, construction materials and pharmaceuticals. At UBC, the parking lots and bus loops may have zinc in their stormwater runoff due to the use of coated steel in vehicles. Many coated steels are currently used in construction materials on the UBC campus.

2.0 METHODOLOGY

2.1 Field Sampling

Field sampling measurements were taken from five separate sites: Spiral Drain, Trail 7, west of 16th Avenue, Booming Grounds Creek and Cutthroat Creek. Sampling dates were February 22nd, March 3rd and March 10th 2005.

It was required that these samples were taken under non-storm events. Before samples were taken, observations were made regarding the immediate weather conditions.

For each site, 500 mL samples were prepared for analysis. A second 500 mL duplicate sample was prepared for accuracy purposes. Measurements were then recorded in-situ for temperature, conductivity and specific conductivity. Specific conductivity (measured in μS/cm) and temperature (measured in ˚C) were measured using a YSI Model 30M handheld conductivity, salinity and temperature system.

Samples were collected by hand in high density polyethylene (HDPE) bottles. Bottles were prepared in the laboratory by rinsing with 10% HCl solution, followed by a thorough rinsing with tap water and finally distilled water. The acid-washed bottles were dipped 2-4 times in the upper 5-10 centimeters of flow within the receiving waters. A 500 mL bottle was attached to a 4.6 m pole to obtain samples from the manhole at the Spiral Drain site. Samples were stored in a cooler with ice-packs during transport to the ALS laboratories for metals analysis.

2.2 Internal Laboratory Analysis

Turbidity (measured in NTU) was measured with a 2100P Hach Turbidimeter. Cuvettes rinsed and refilled with the stormwater samples were placed in the turbidity meter. It was ensured that there were no fingerprints on the cuvettes before taking readings.

pH was measured with a pH Testr3+ Double Junction meter. The pH probe from the meter was immersed in a 100 mL sample of the stormwater and was mixed with 1mL of a 72.5 g/L KCl solution.

2.3 External Laboratory Analysis

Samples for metals analysis were preserved with 1mL of HNO_3 in acid-washed 250 mL HDPE bottles.

ALS laboratories followed the procedures outlined in, "Standard Methods for the Examination of Water and Wastewater (APHA)" and "Test Methods for Evaluating Solid Wastes" published by the United States Environmental Protection Agency (EPA), to determine the levels of total metals and mercury contained in samples.

To determine metals in water, the pre-treated sample underwent instrumental analysis. This analysis included atomic emissions spectrometry (EPA Method 7000 series), inductively coupled plasma – optical emission spectrophotometry (EPA Methods 6010B) and inductively coupled plasma – mass spectrometry (EPA Method 6020).

Mercury levels were determined as follows. The acidified sample underwent cold oxidation using bromine monochloride. The sample then underwent reduction with stannous chloride. The instrumental analysis consisted of cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

3.0 DISCUSSION OF RESULTS

3.1 Weather

Precipitation data for the month of February and March was obtained from UBC Agricultural Sciences (Rick Ketler). The precipitation measurements were taken at the UBC meteorological station every 30 minutes. Atmospheric temperatures at specific times were obtained from the environment Canada weather website.

Samples were taken during non-storm events. Rainfall exceeding 2.54 mm in total did not occur within 24 hrs prior to sampling.

The first set of samples was taken on February 22nd, 2005 after a long dry period. The last major rainfall had occurred on February 12th, 2005. At the time of sampling cloud cover was 1/4 and the temperature was 5.1°C.

On March 3rd, 2005 the second set of samples was taken. The last major rainfall had occurred on March 1st, 2005. The cloud cover was 1/8 at the time of sampling and the atmospheric temperature was 10.1°C.

A third and final sample set was taken March 10th, 2005. The last rainfall had occurred the morning of March 9th, 2005. The cloud cover was 1/8 and the atmospheric temperature at time of sampling was 12.0°C.

3.2 Temperature of Water

Temperature levels were noticeably higher at the Spiral Drain site. Temperatures ranged between 19.2˚C and 21.3˚C (Refer to Figure 1d). The BC water quality standard for temperature is 19°C, in which the Spiral Drain exceeded on all three sampling dates.

It is suspected that the high water temperatures are a result of steam condensate flowing from the UBC heating system into the north catchment.

Trail 7 and Booming Grounds Creek generally have temperatures higher than Cutthroat Creek. For example on February 22 the temperatures were 12.3°C at the Booming Grounds site, 11.3°C at the Trail 7 site, and 3.5°C at the Cutthroat Creek site.

It was suspected that removal or lack of forest cover and vegetation lead to an increase in water temperature. The west of 16th Avenue site had water temperatures averaging only a couple of degrees higher than that of Cutthroat Creek.

3.3 Turbidity

Turbidity levels (shown in Figure 1a) were found to be variable with Spiral Drain and Trail 7 showing the largest differences between sampling dates. The high variability is most likely due to rain occurrences prior to the sampling period. This would allow the soil to wash into the storm drains creating higher turbidities.

The average turbidity at Spiral Drain was calculated to be 3.02 NTU in comparison with the stormwater mean turbidity level 88.7 NTU. The average turbidity at Booming Grounds Creek was calculated to be 3.95 NTU in comparison to a mean level of 24.8 NTU for the rainfall event discharge study. These considerably lower levels suggest that turbidity is not an issue during non-storm events. On the other hand, this also suggests that the high differences between the two events create a question of where turbidity originates. Turbidity is most likely due to the erosion of soils from the roads and embankments surrounding the discharge zones. This is more likely to be the case rather than construction purposes due to the variably low differences between the two events.

Cutthroat Creek turbidity levels were found to range between 0.60 and 1.33 NTU. These levels are lower than all four of the other sampled sites, which suggest that there could be outside causes in the increase of turbidity for the other sites.

3.4 pH

pH levels in the UBC area should range between mid-6 to high-7. However, this is not the case for Spiral Drain, Trail 7 and west of 16th Avenue. Cutthroat Creek pH levels were found to range between 6.48 and 6.97. Natural unchanged ecosystems in this area exhibit a lower pH value due to the acidity of the soil surrounding the area.

The rest of the sampled sites showed rather high pH levels ranging from a low of 7.29, to a high of 8.64. These higher ranges suggest that there are outside sources leading to a pH increase. The increase of pH can be a result of increased human activity in the area. A comparison to the rainfall events could not be made as there was no pH levels measured during those events.

3.5 Specific Conductivity

The average specific conductivity measurements taken at the four sampling sites were generally more than four times higher than the specific conductivity measurements taken at Cutthroat Creek (Figure1b). There are no water quality guidelines for specific conductivity, but it is commonly found to be an indicator of water quality.

Cutthroat Creek specific conductivity measurements were consistent for the three sampling dates, ranging between values of 49.1 to 51.6 µS/cm.

Trail 7 and west of 16th Avenue specific conductivity measurements were high, with average measurements of 337 and 330 µS/cm, respectively. On the other hand, the Spiral Drain and Booming Grounds Creek measurements were lower, averaging 183 and 207 µS/cm, respectively. This observation is consistent with data collected during storm events and may be due to the effect of steam condensate lowering specific conductivity at the Spiral Drain site (Page, 2003).

The specific conductivity is higher at the four sites sampled, when compared with the undeveloped site, Cutthroat Creek, due to the presence of charged ions. It is suspected that the source of water hardness in Trail 7 and west of 16th Avenue is caused by the seepage of groundwater. Booming Grounds Creek and the Spiral Drain specific conductivity levels are higher than Cutthroat Creek possibly as a result of urban runoff.

Water hardness is a result of the presence of positively charged ions including calcium, magnesium and sodium. The hardness and concentrations of these ions are ten times higher in Trail 7 and west of 16th Avenue in comparison to Cutthroat Creek. Sodium and chloride concentrations may also be a result of the close proximity to the ocean. Charged ions may be caused by the use of fertilizers and construction or maintenance activities.

3.6 Metals

The concentration of aluminum at Cutthroat Creek exceeded the water quality standards for every sampling date (Figure 2a). These values may be due to natural soil conditions. Forest soils and soils in regions where the rainfall exceeds 63 cm/year are often found to be naturally acidic. Rainfall encourages the weathering and oxidation of minerals releasing aluminum which is very soluble under acidic conditions. Since the baseline site showed high levels of aluminum, it can be assumed that high aluminum levels occur naturally in the area. The local aquatic life is likely accustomed to the naturally occurring aluminum. Aluminum levels in stormwater are not a concern during non-storm events. The aluminum levels recorded during storm events at Booming Grounds Creek and Spiral Drain are roughly 0.2 mg/L higher. Therefore, aluminum is most likely being washed from roadways, parking lots and construction sites during rain events (Page, 2003).

The only times arsenic concentrations exceeded water quality standards were on March 3rd and March 10th at Trail 7 (Figure 2b). It is possible that residues from old fertilizers have leached from the Botanical Gardens, or these levels may be due to the weathering of natural rock in the area. The level of the arsenic found is well below the drinking water level standards of 0.05 mg/L. Future sampling and testing for arsenic at this site may be required. According to Nick Page, arsenic levels were not a concern during rainstorm events.

Cadmium standards exceeded the water quality standards at all sites (Figure 2c). The high levels of cadmium in Cutthroat Creek indicate that the local soils have a relatively high content of cadmium. Furthermore, some of the cadmium levels at other sites were slightly higher. Sources of cadmium on campus may include car batteries and coated steel or iron alloys. The results indicate that cadmium levels are not a concern during non-storm events. Cadmium levels were similar during storm and non-storm events. (Page, 2003).

Copper levels at Cutthroat Creek did not exceed the water quality standards (Figure 2d). On February 22nd, March 3rd and March 10th, Trail 7, Spiral Drain and Booming Grounds Creek all exceeded the baseline and water quality standards. Possible sources of copper on campus may include pesticides, vehicle exhaust, fuel additive leakage and construction. It may be beneficial to determine if copper originates from point sources at construction sites. The values for storm events and non-storm events do not vary greatly (Page, 2003).

Iron levels at Cutthroat Creek are below the water quality standards (Figure 3a). On March 3rd the iron levels at west of 16th Avenue exceeded the standards. All samples taken from Trail 7 and Booming Grounds Creek exceeded the standards. The iron at these sites may be a result of vehicles, parking lots and construction. Further testing should be done on point sources related to construction sites and parking lots during non-storm events.

None of the samples taken at the five sites exceed the water quality standards for lead. From these samples we can conclude that lead is not a concern during non-storm events.

Mercury levels exceeded the water quality standards in three separate samples: Cutthroat Creek on February 22nd, and west of 16th Avenue on February 22nd and March 3rd (Figure 3c). The cause of the high mercury levels at Cutthroat Creek is unknown and may be the result of activities upstream. The high mercury levels at the west of 16th Avenue site may be a result of fossil fuel combustion. More sampling at these locations is required to ensure that the high levels were not one-time events or erroneous data.

The zinc levels exceeded the water quality standards at Booming Grounds Creek twice; all other samples had relatively low levels of zinc (Figure 3d). The zinc in Booming Grounds Creek may be a result of vehicle runoff and construction. An analysis should be done on potential point sources from construction sites in the catchment area.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Overall the monitoring showed contaminant levels lower than those of rainstorm events, with the exception of high concentration levels both in arsenic and mercury. During non-storm events, levels of copper, iron and zinc were generally found to exceed the BCWQ standards at the sites sampled. It was also noted that aluminum and cadmium exceeded the water quality standards for each sampled site including Cutthroat Creek.

Levels of turbidity, pH, temperature and specific conductivity were also measured. It was found that the temperature had exceeded the BCWQ standards in Spiral Drain, while the other sites showed variable levels of temperature ranging between 5 and 12˚C. Specific conductivity levels were rather high in comparison to Cutthroat Creek, suggesting that most of these levels were due to groundwater seepage or human activities (eg. construction and maintenance). Turbidity and pH levels were analyzed, but comparisons to rainstorm events as well as Cutthroat Creek suggest that there are no unnatural sources of these parameters.

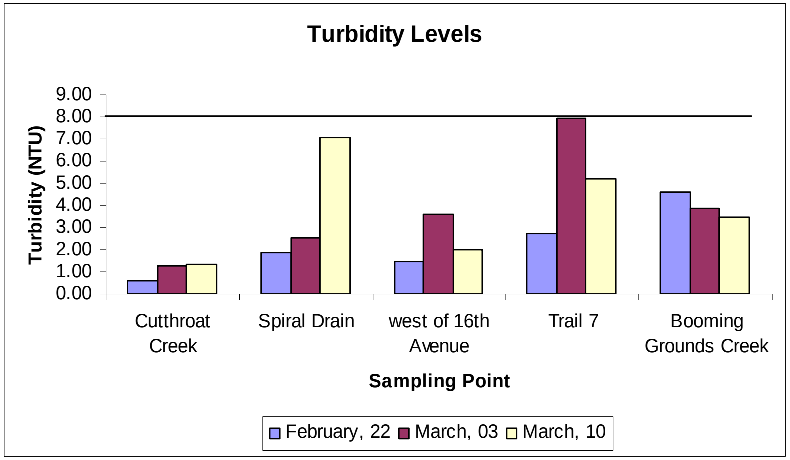
The following recommendations have been proposed in order to decrease the levels of contamination and improve other water quality parameters in the water discharged through the outfalls on the UBC campus:

1. To decrease temperature levels it was proposed that the steam heating system be repaired to prevent condensate from exiting the grid.
2. To reduce metals contamination, it was determined that the capacity of construction and other vehicles moving around campus be further limited creating a pedestrian oriented campus.
3. Turbidity levels from construction sites on campus could also be decreased through the use of best management practices (BMP's); for example silt fences which limit the amount of sediment entering the storm drains.
4. To further enhance the clarity and cleanliness of the stormwater, a reduction in impermeable surfaces (such as roadways) is proposed. This would limit the amount of runoff which enters the storm drains.
5. If not possible to reduce immediate runoff, measures should be created to treat the downstream runoff before it leaves the campus grid and is discharged into

receiving waters; for example the use of compost material to remove metals from road-surface runoff.

6. To determine the reason for high metals concentrations it is suggested that the point sources and origins of the metals upstream be investigated.
7. To understand why the two outfalls (Trail 7 and west of 16th Avenue) in the central catchment area near Wreck Beach have high levels of charged ions it is suggested that further analysis be made on the groundwater flow and content.
8. It is suggested that future sampling for arsenic be done at Trail 7, due to the high levels found.
9. It is suggested that future sampling for mercury be done at Cutthroat Creek, Spiral Drain and west of 16th Avenue due to the unnatural levels reached at these sites.

FIGURES

(a)


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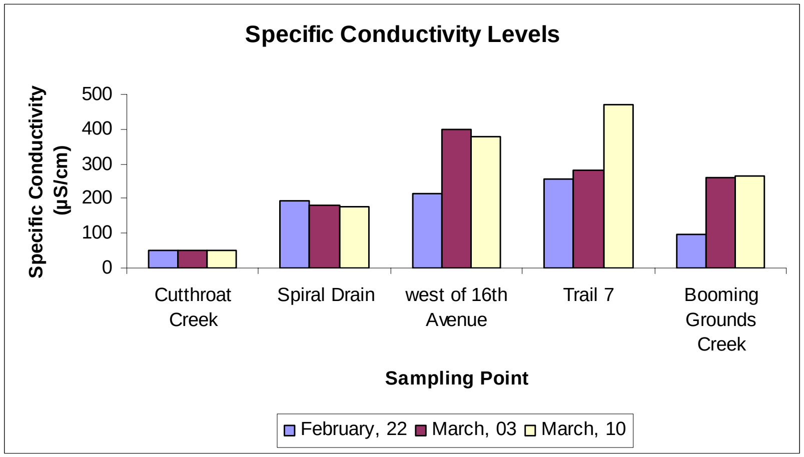

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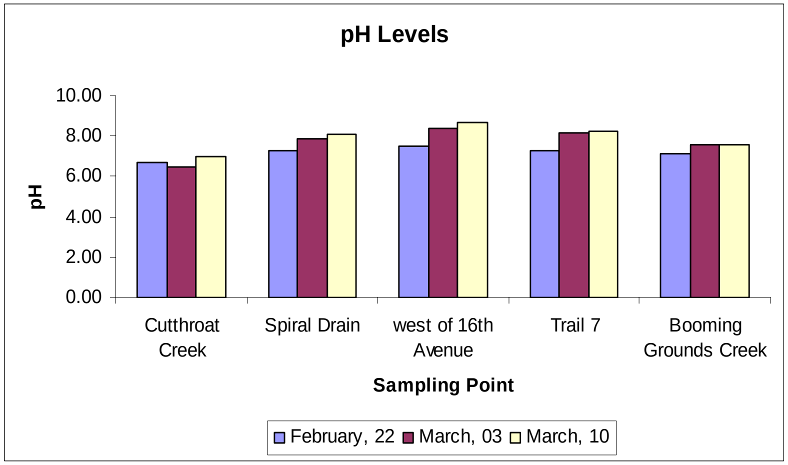

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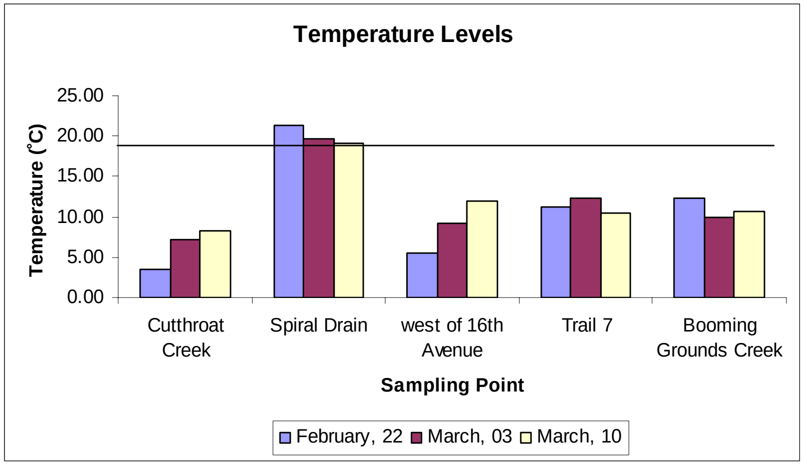

FIGURE1: COLLECTED MEASUREMENTS OF TURBIDITY, PH, SPECIFIC CONDUCTIVITY, AND TEMPERATURE.

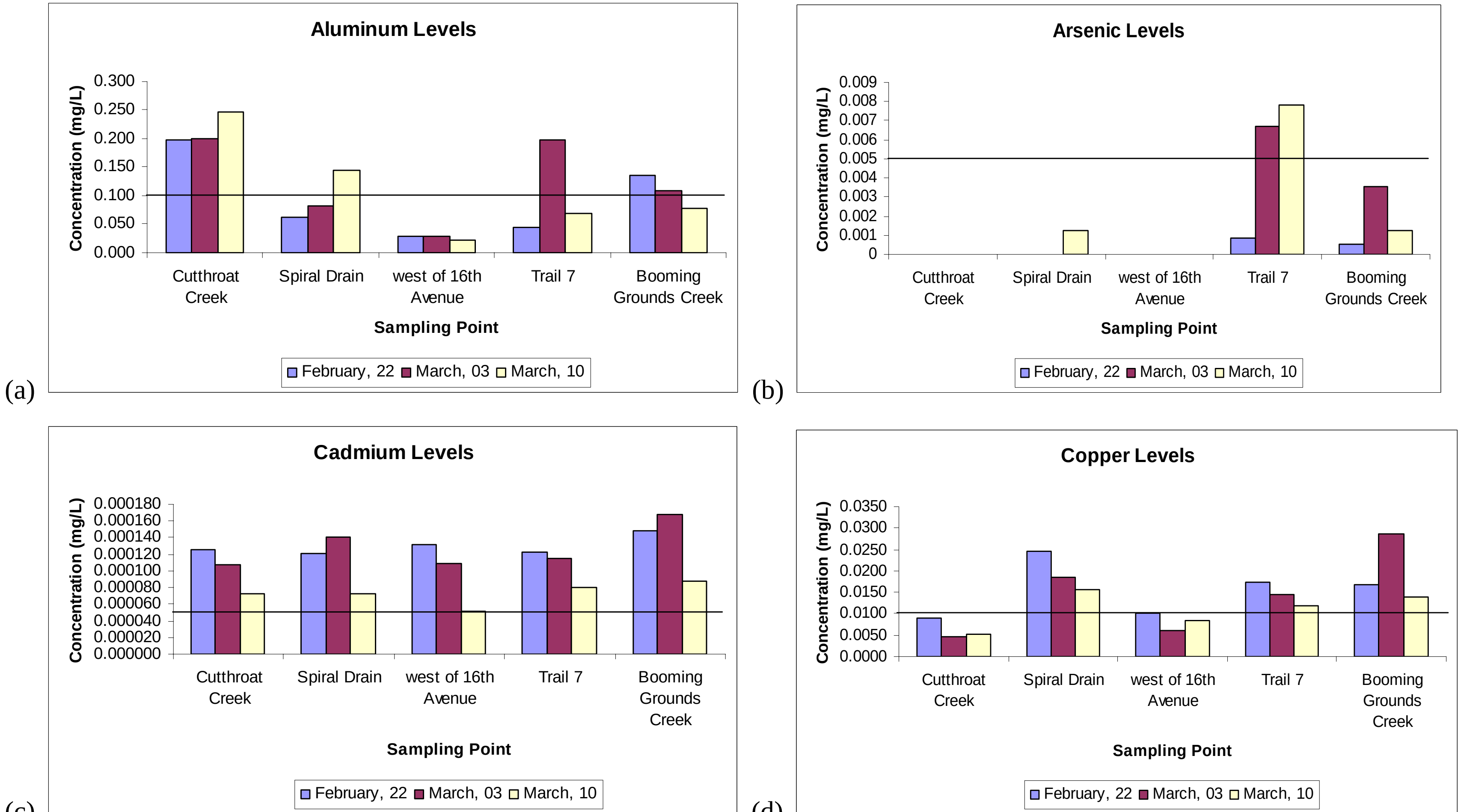

FIGURE2: COMPARISON OF METALS LEVELS AT SELECTED DISCHARGE SITES FOR FEBRUARY 22ND, MARCH 03RD AND 10TH TO GOVERNMENT REGULATIONS.

* THE LINE ON THE GRAPH REPRESENTS AQUATIC LIFE GOVERNMENT STANDARDS.

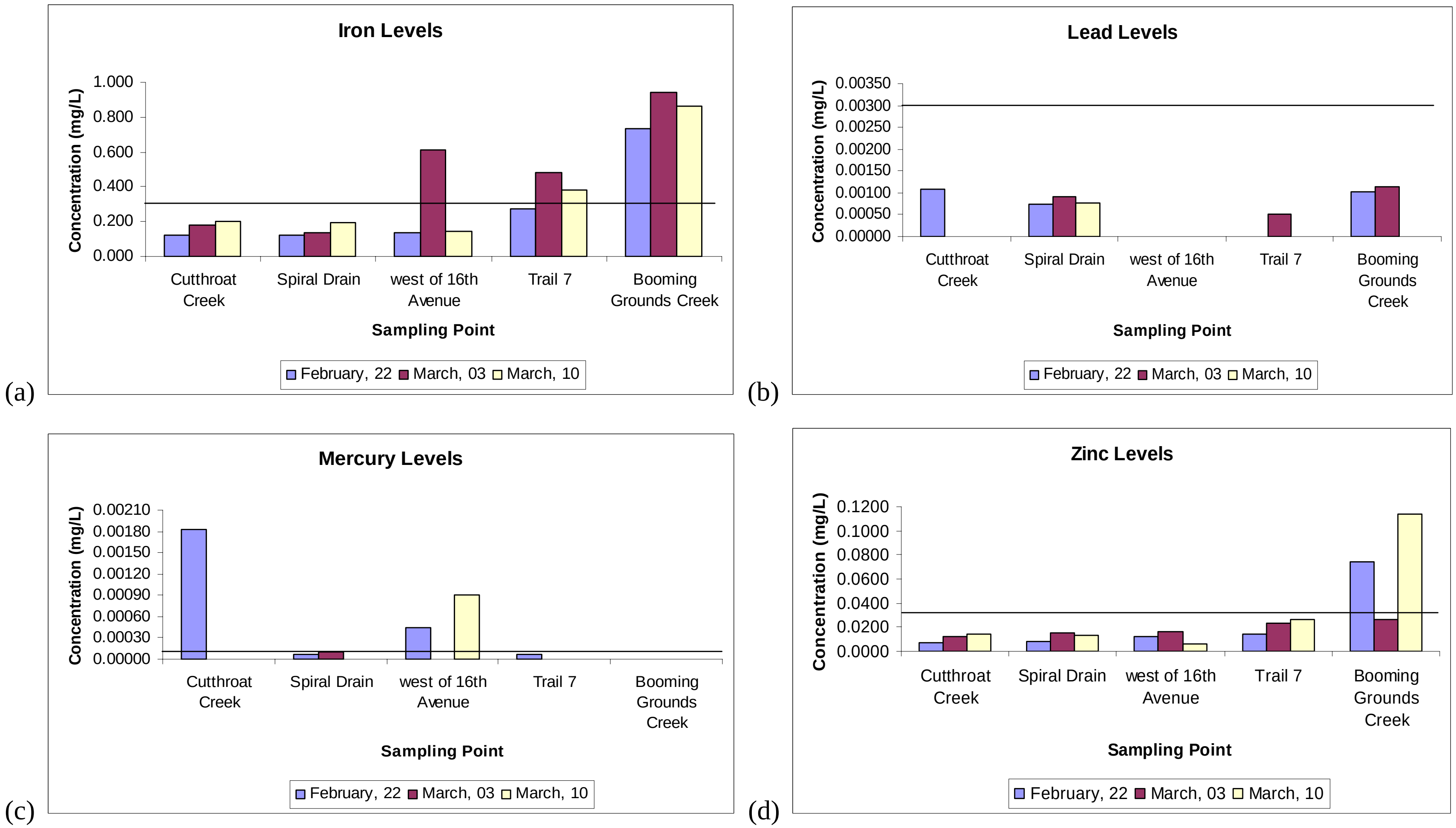

FIGURE3: COMPARISON OF METALS LEVELS AT SELECTED DISCHARGE SITES FOR FEBRUARY 22ND, MARCH 03RD AND 10TH TO GOVERNMENT REGULATIONS.

* THE LINE ON THE GRAPH REPRESENTS AQUATIC LIFE GOVERNMENT STANDARDS.

FIGURE4: A MAP OF THE FIVE SAMPLED CATCHMENT DISCHARGE POINTS.

FIGURE5: a) A PICTURE OF THE SPIRAL DRAIN SAMPLING MANHOLE; b) WEST OF THE SAMPLING MANHOLE IS THE ACTUAL SPIRAL DRAIN; c) THE TRAIL 7 SITE WHERE SAMPLES WERE TAKEN FROM; d) A CULVERT ENTERING 'WEST OF 16^{TH} AVENUE' SAMPLING SITE; e) A PICTURE OF THE THREE STUDENTS SAMPLING FOR CONDUCTIVITY AND TEMPERATURE ON SITE AT 'WEST OF 16^{TH} AVENUE'.

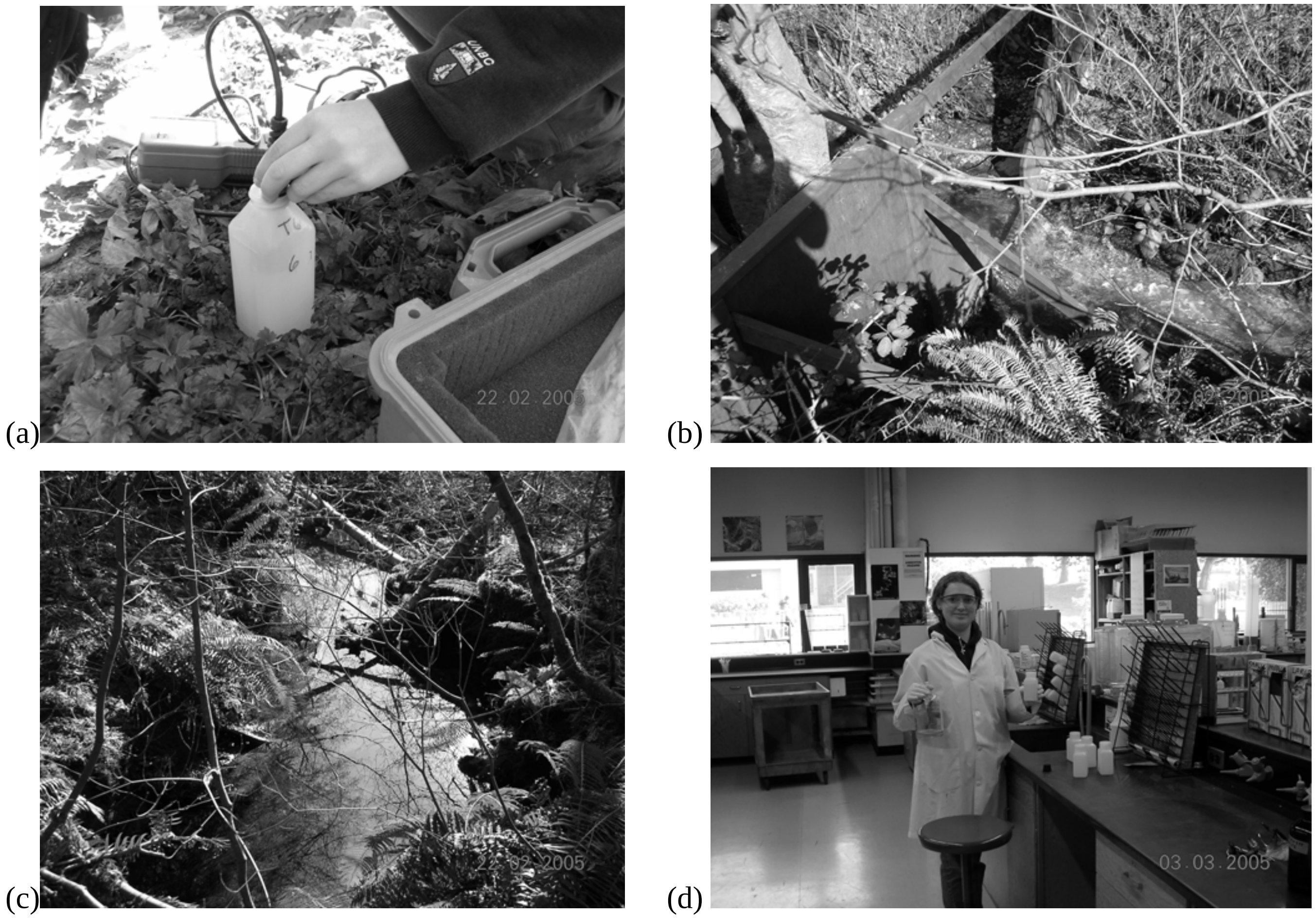

FIGURE6: a) A PHOTOGRAPH SHOWING HOW SPECIFIC CONDUCTIVITY AND TEMPERATURE WAS MEASURED; b) A WEIR AT BOOMING GROUNDS CREEK SAMPLING SITE; c) CUTTHROAT CREEK STREAM SAMPLING POINT, DOWNSTREAM OF THE RAINSTORM CUTTHROAT CREEK SAMPLING POINT; d) A PHOTOGRAPH OF A STUDENT ACID WASHING THE SAMPLING BOTTLES PRIOR TO SAMPLING.

(a) 

(b) 

(c) 

Figure7: a) a cooler with all of the metals sampling bottles inside to be taken to ALS Environmental; b) A photograph of the turbidity meter; c) a student preparing a solution for pH measurements.

Appendices

Appendix A: Sources of Error

Concentrations of constituents in stormwater vary greatly with time, though the samples were all taken in the morning, if the samples were taken at different times of the day the results may have changed.

Duplicate samples were taken for accuracy, however only one sample was sent for ALS testing. Many natural or human causes could have contaminated or changed the contents of the samples taken. There is no way of knowing of the conditions occurring upstream at the time of sampling.

Stream bed disturbances may have been caused by sampling activities. Another factor that may cause a variation in results is the weather. The first samples were taken after a long dry period, whereas the second and third samples were taken closer to storm events, leading to an increase in runoff.

Human error in taking samples and measurement may also contribute to error in for this stormwater analysis.

Appendix B: Chemical analysis report

Appendix C: Water quality standard guidelines

Appendix D: Sampling data

TABLE 1: TURBIDITY AND PH DATA DURING THE THREE SAMPLING DATES. THE SECOND SAMPLE INDICATES A

	February 22, 2005		March 3, 2005		March 10, 2005	
Sampling Site	Turbidity	pH	Turbidity	pH	Turbidity	pH
Spiral Drain - 1	1.86	7.29	2.54	7.83	6.41	8.10
Spiral Drain - 2	1.84		2.54	7.91	7.72	8.02
Trail 7 - 3	2.52	7.28	7.49	8.14	5.55	8.20
Trail 7 - 4	2.90		8.40	8.19	4.86	8.22
west of 16th Avenue - 5	1.56		3.77	8.33	2.18	8.64
west of 16th Avenue - 6	1.33	7.52	3.48	8.40	1.86	8.64
Cutthroat Creek - 7	0.66		1.24	6.55	1.45	7.07
Cutthroat Creek - 8	0.53	6.68	1.26	6.40	1.21	6.87
Booming Grounds Creek - 9	5.65		4.50	7.59	3.49	7.56
Booming Grounds Creek - 10	3.49	7.13	3.20	7.60	3.39	7.59

TABLE 2: TEMPERATURE AND SPECIFIC CONDUCTIVITY DATA DURING THE THREE SAMPLING DATES.

	February 22, 2005		March 3, 2005		March 10, 2005	
Sample	Temperature	Specific Conductivity	Temperature	Specific Conductivity	Temperature	Specific Conductivity
Spiral Drain	21.30	194.5	19.70	180.70	19.20	174.50
Trail 7	11.30	258.1	12.30	283.30	10.40	469.10
west of 16th avenue	5.50	215.5	9.20	398.60	11.90	377.20
Cutthroat Creek	3.50	49.1	7.10	50.00	8.30	51.60
Booming Grounds Creek	12.30	95.8	10.00	259.20	10.60	264.60

Appendix E: Proposal of report

<u>February 14, 2005</u>

Dr. Tony Bi
Department of Chemical & Biological Engineering
The University of British Columbia
Canada

Dear Dr. Bi:

This proposal describes a semester long strategy for performing an analysis of selected storm water outfalls located on the University of British Columbia campus. Included are these main sections:

1) Outline of the proposed project
2) Methods of testing and analysis
3) Student objectives and conclusion

OUTLINE OF THE PROPOSED PROJECT

Following our February 3rd meeting, the scope of our project has been defined by testing four discharge areas on campus and comparing our results to a discharge point off-campus during non-storm events. Students plan on completing this project by performing the following tasks:

- Lab orientation
- Field sampling
- Lab analysis

Our results and recommendations will be summarized both in a written report for CHBE 484 and an oral presentation for the Stormwater Subcommittee. The completion of this project will require assistance from Ray Hryciuk (Health, Safety & Environment), Ken Hall (Civil Engineering), Alek Paderewski (Utilities), Susan Harper (Civil Environmental Engineering Laboratory) and Nick Page (Raincoast Applied Ecology). A completed version of the written report will be made available at the UBC SEEDS Program website.

METHODS OF TESTING AND ANALYSIS

Field Testing

Starting the week of February 21st, grab samples, including one set of replicates, will be obtained from four different sites: Spiral Drain, Trail 7, Botanical Gardens, Booming Ground Creek and Cutthroat Creek (which will be used as a non-contaminated site comparison). These samples will be taken during non-storm events. Conductivity and temperature will be tested on-site. Grab samples for metals will be preserved for off-site testing.

Lab Analysis

Students will complete lab experiments to determine pH, turbidity, and total suspended solids (if turbidity >5 TUs). These tests will be done in the Civil Engineering Environmental Lab with guidance from Susan Harper. Preserved samples will be sent away for analysis.

STUDENT OBJECTIVES

We will analyze the data to compare the state of the selected discharge areas to a protected catchment stream located in the GVRD Spirit Park. Possible effects on the aquatic life will be discussed and recommendations based on our results will be made. Through this project we hope to provide relevant information to the Stormwater Subcommittee that can be used in future research and management of storm water on the UBC campus.

Dr. Bi please contact the team leader Karen Robinson if you have any questions, concerns or comments regarding the scope of this project as we plan to sample the week following reading week.

Sincerely,
Jennifer Fowler, Karen Robinson, and Ashley Phillips

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