STORMWATER MONITORING
SITE MANUAL

Edited by: L.G. Swain, P. Eng.

Water Management Branch
British Columbia Ministry of Environment

August 1985

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

ACKNOWLEDGEMENTS

This manual brings together written contributions made over a two year period by numerous individuals involved in the prototype stormwater monitoring program undertaken at Rupert and Rosemont in Vancouver. Other than the editor, these included Mr. G.B. Holms, Mr. D. Tutt, Mr. D.G. Newell, and Mr. P. Verdicchio. To these people and others involved in the preparation of this manual, we express our thanks.

1. INTRODUCTION

The procedures which follow in this manual were developed at the prototype stormwater monitoring site operated by the Aquatic Studies Branch (now Resource Quality Section, Water Management Branch) of the B.C. Ministry of Environment during 1981. This manual is intended for use by others within the Ministry who may undertake similar programs.

Many sections of the report are specifically oriented to the prototype site, which was located at Rupert and Rosemont in Vancouver from 1980-1981. However, the general information should be particularly relevant to anyone undertaking such a monitoring program in the future. A report interpreting the data obtained at Rupert and Rosemont is available on loan from the Resource Quality Section of the Water Management Branch.

2. EQUIPMENT REQUIRED

Equipment which is used at any particular stormwater site will depend upon several factors. However, generally there is some discretion as to the type of equipment for any particular use.

Accurate measurements of stormwater cannot be made without a primary measuring device, applicable to a particular situation. These include flumes or weirs which are pre-calibrated to relate certain flows to associated water levels in the measuring device. The type of primary measuring device chosen must be given careful site- specific consideration, in terms of size and suitability.

In addition, it is necessary to measure the flow of water through the primary measuring device on a continuous basis. It would be short-sighted to choose as a secondary measuring device the type which converts level readings directly to flows using a pre-programmed equation. The reason that level recorders are recommended versus flow recorders is that different sized flumes, for example, have different flow equations. Parshall flumes (Figure 1) were used both at Rupert and Rosemont and at a site established by Waste Management Branch (Surrey) in 1982. By replacing a probe at fairly minimal cost, the same level recorders could be used at both sites. A computer program has been developed for the Water Management Branch with the capability to transform level readings into flows, if the equation for the primary measuring device is known.

The most accurate level indicators are generally ultrasonic or capacitance probes (Figure 2), and are within 1% accuracy[2]. Capacitance probes were used at both sites with no maintenance problems directly related to the probes themselves. The probe was powered by an external 12-volt battery.

Output from the level indicators has to be recorded on charts, or onto a digitizer. Lack of funding has eliminated the latter option, thereby

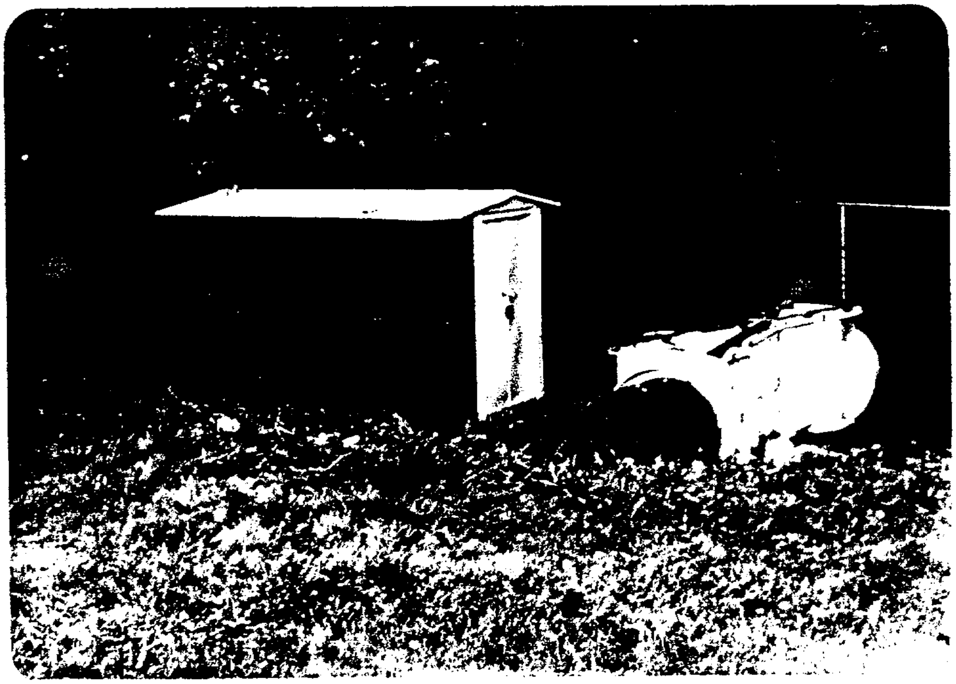


FIGURE 1 Flume on End of Pipe

FIGURE 2 Capacitance Probe

FIGURE 3 Strip Chart Recorders on Top of Bench

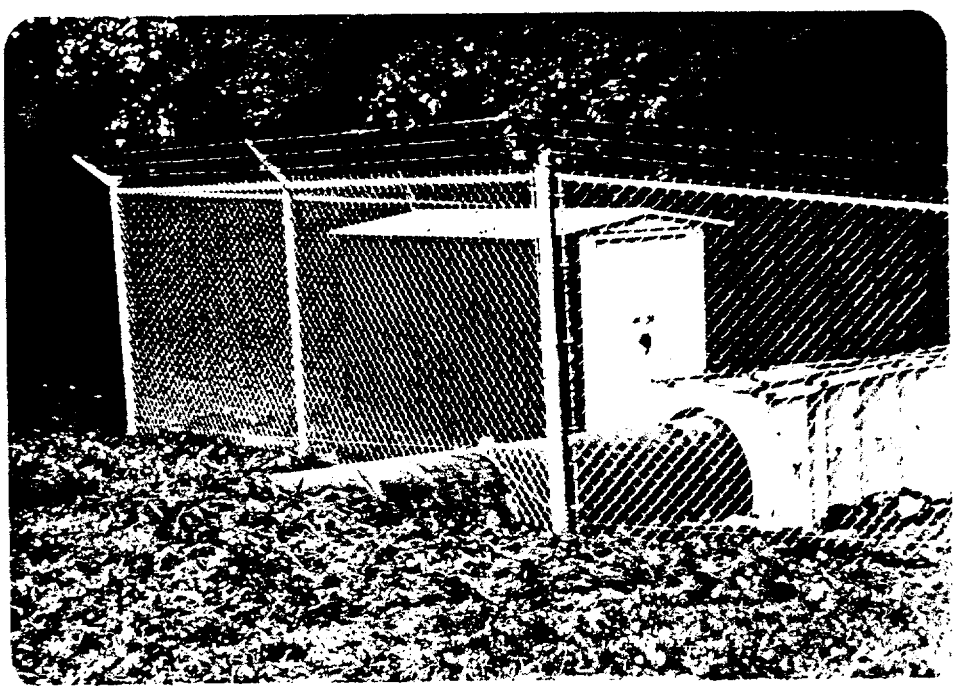


FIGURE 4 Site Enclosed by "Security-Type" Fencing - Shed in Background

necessitating the use of strip chart recorders (Figure 3). The strip chart recorders, although equipped with internal batteries, were powered by external 12-volt batteries. It was found that these recorders performed best when the internal power supply was eliminated. Two recorders were always obtaining and recording signals in series, one being calibrated to record levels to a maximum of one-half the height of the flume. The second recorder was calibrated to record water levels to the maximum flume capacity. The operation of these recorders in series therefore permitted better resolution at low flows as well as back-up capabilities.

It is highly recommended that any site be fenced with 6 foot high security type chain link fencing (Figure 4). Vandalism has proved to be a problem, even with fencing. As well, a building (or garden shed) to house equipment such as strip chart recorders, sampling supplies, etc. is required since it is difficult to operate without some form of shelter. If a garden shed is chosen, some means of increasing the headroom is suggested. It is recommended that the shed be placed on 2" x 10" lumber on edge, so that a 6 foot tall individual can stand comfortably.

Automatic water quality samplers (such as SIRCO or Manning) (Figure 5) which can be pre-set with optional sampling intervals, are necessary, since it is unlikely that a technician can always be at the site when a storm begins. Integral with the use of these samplers would be a moisture sensitive switch which would automatically initiate sampling with the samplers when a pre-determined water level was reached in the primary measuring device. Such devices can be produced by the Instrumentation Section of the Environmental Laboratory.

A raingauge (Figure 6), although not mandatory in areas where other precipitation records are kept, is recommended in areas where no records are kept, in order that runoff coefficients can later be determined. The raingauge will permit accurate rainfall measurements to be obtained on an hourly basis. If a suitable site is not available at which to place a raingauge,

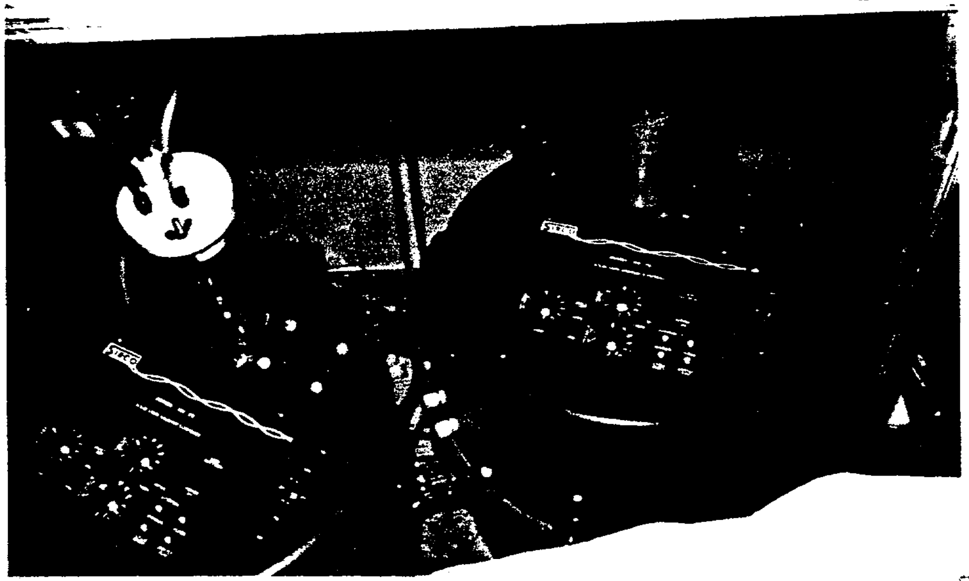


FIGURE 5 Automatic Water Quality Samplers

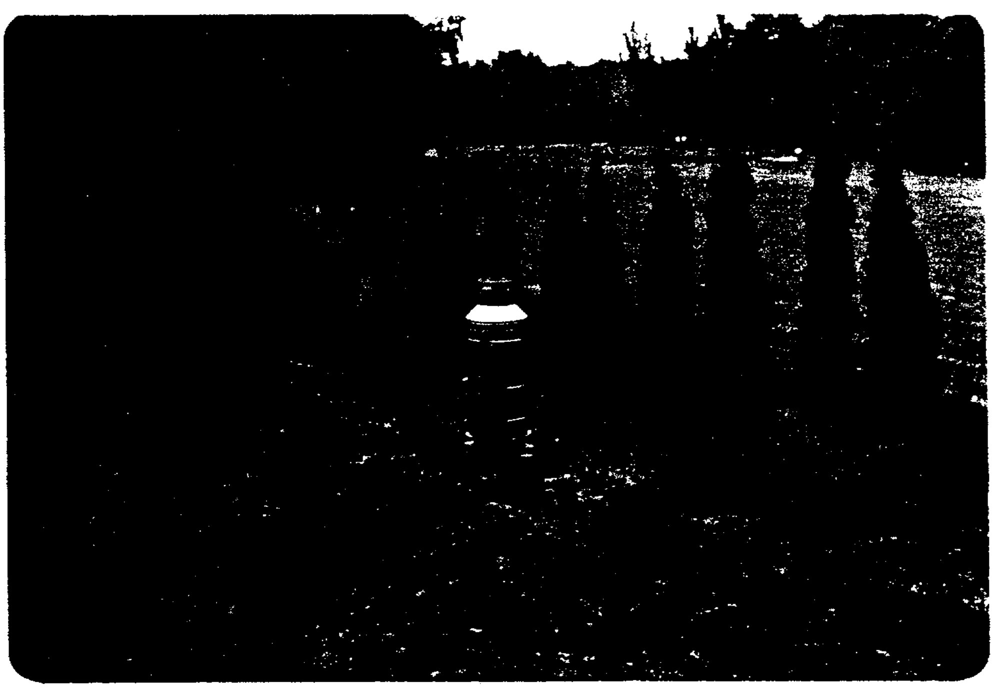


FIGURE 6 Raingauge (Supplied by Air Studies Section of the Waste Management Branch)

the availability of existing recording sites should be investigated. The Air Studies Section of the Waste Management Branch should be consulted about installing a raingauge.

Dustfall and precipitation monitoring is also desirable so that loadings in the stormwater from these sources can be calculated. Cannisters for these measurements (Figure 7) can be obtained through the Environmental Laboratory. The dustfall cannisters are simply open-mouthed plastic containers held in a raised position about 2 metres above the ground. The precipitation monitoring cannisters utilize a wide mouth funnel, about twice the diameter of the dustfall containers, which are equipped with a snap-on lid to prevent contamination from dustfall. The lids are removed manually when a rain event commences. The inside of the funnel is lined with a plastic bag, placed there at the onset of the rain event and held in place with clothes pegs.

Rain collectors can be used to check whether rainfall has occurred uniformly over the catchment area. The collectors are PVC tubes which also contain a metal insert to prevent the entry of debris. Oil is added in the summer to prevent evaporation and anti-freeze in the winter to prevent freezing. However, the collectors are not a substitute for a proper raingauge.

Infiltration rates may be desirable if a water balance for the system is to be obtained. Infiltration/runoff columns (Figures 8 and 9) have been designed by Dr. N. Nagpal of the Resource Quality Section of the Water Management Branch. These columns were used at Rupert and Rosemont, and were constructed from 20 cm diameter PVC pipe. The columns are made up of "undisturbed" soil samples obtained by sliding the PVC column itself around the soil. This procedure requires great care and patience. Runoff is collected from the top of the column through the runoff drainage pipe into the collection bottle. Infiltration accumulates in the bottom chamber of the column, and is subsequently collected using a hand-vacuum pump for measurement in a graduated cylinder.

FIGURE 7 Dustfall and Precipitation Cannisters (Supplied by Environmental Laboratory)

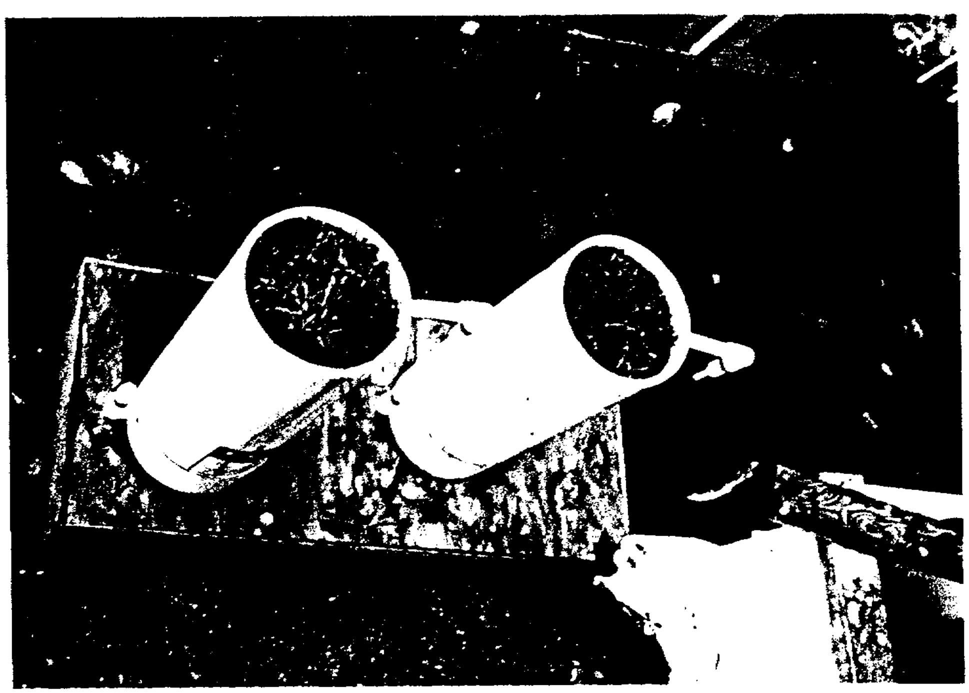
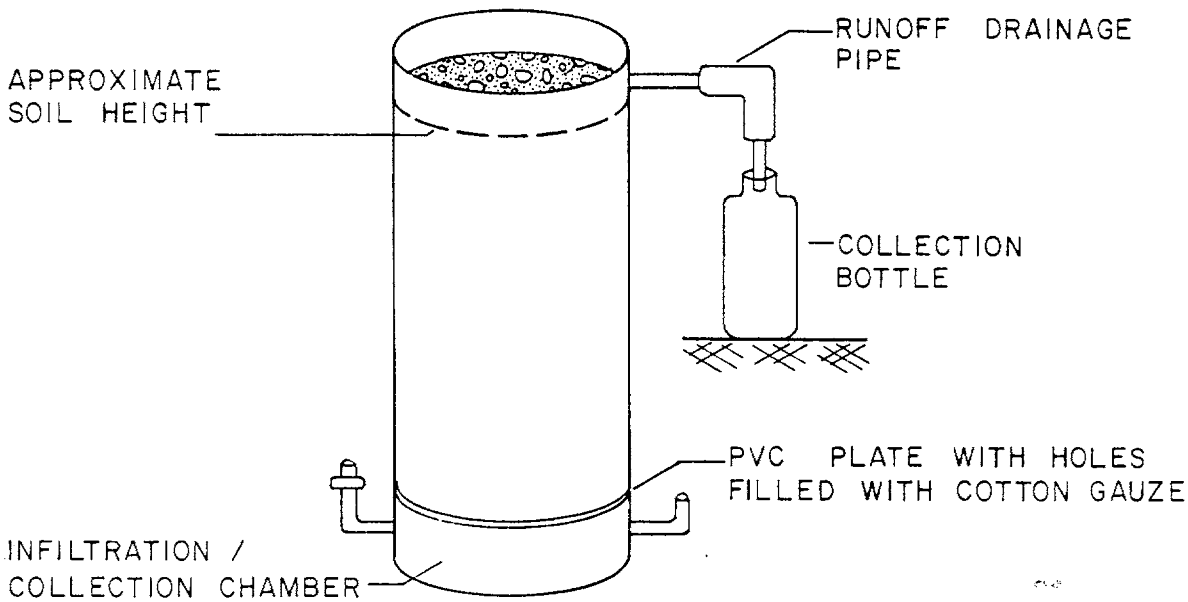


FIGURE 8 Infiltration/Runoff Columns (Designed by staff, Resource Quality Section of the Water Management Branch)



INFILTRATION / RUNOFF COLUMN

FIGURE 9

3. SAMPLING

3.1 PROCEDURES

3.1.1 WATER QUALITY

3.1.1.1 Hand-Sampling

The hand-sampling procedure should be conducted in conjunction with the automatic samplers. An intensive one and a half hour series of composite samples (or in some cases a series of composite samples collected over three hours) should be collected by hand. Automatic samplers can be used for longer durations (e.g. one hour sampling intervals) or when technicians can't or won't be at the site (e.g. after hours). It may be desirable to overlap hand sampling and automatic sampling procedures.

Hand-collected samples are placed in an acid washed plastic bucket. Each composite sample should be taken over a 15-minute period. The composite is made up from four discrete samples taken every 3.75 minutes. Six composite samples will represent one group taken over a period of 1.5 hours. The water quality bottles should be designated by Group Number and Sample Number.

The time and date should be written on each bottle before the label gets wet, following the standard bottling instructions issued by the Environmental Laboratory. Each group of samples should be preserved as needed immediately if time permits. Improperly bottled or preserved samples will not be accepted at the Environmental Laboratory so that the standard bottling instructions should be carried out carefully. The samples are to be sent to:

The Environmental Laboratory
3650 Wesbrook Crescent (UBC)
Vancouver, B.C.

Samples should be submitted to the laboratory before 2 P.M., Monday through Thursday to ensure same day analysis. On Fridays, samples must be submitted before 12 noon and the laboratory should be forewarned of their arrival.

3.1.1.2 Automatic Sampling

If there has been sufficient rain to activate the automatic samplers prior to a technician arriving, 24 samples will be taken by each automatic sampler at a predetermined interval. This interval can vary but would likely be 30 minutes if the next planned arrival at the site was to be between 8 and 10 hours. When only two samplers are used, the first eight samples from both samplers are made into one composite, as are the second set of eight and the third set of eight. This procedure should result in three composite samples of eight litres each. Each composite sample is taken over a period of time equal to eight times the sampling interval (i.e. 4 hours). Each of the three composite samples can be used to fill the required sample bottles.

(When three samplers are operational, composite the first set of six samples, the second set of six, third set of six and the fourth set of six from each sampler. This will result in 4 composite samples instead of 3).

It should be noted that if the chosen sampling interval for the automatic samplers is not long enough, the samplers could commence and finish sampling without anyone being onsite to record when the sampling began or finished. This is not totally unacceptable since sampling is triggered at a certain water level, and exact sampling times could be calculated later from the strip chart showing water levels.

It is suggested that nine to twelve samples for coliform analyses also be taken in the same time interval as water chemistry samples are composited (i.e. normally every 15 minutes). These are discrete samples and are taken in sterile bottles. The coliform samples are to be sent or taken to:

The Environmental Laboratory
3650 Wesbrook Crescent (UBC)
Vancouver, B.C.

3.2 ANALYSES

Test	Frequency
Total and fecal coliform	Each storm
Static bioassay	Composite taken quarterly during both wet and dry weather
Water chemistry	Each storm

Water chemistry analyses, in an initial scan, should include total alkalinity, total aluminum, total cadmium, calcium, magnesium, total organic and inorganic carbon, chloride, total chromium, colour, total copper, total iron, total lead, total manganese, total mercury, total nickel, ammonia, nitrate, nitrite, organic nitrogen, oil and grease, COD, pH, phenol, total and total dissolved phosphorus, suspended solids, fixed suspended solids, total solids, specific conductance, sulphate, and total zinc. After about 8 storm events, the results should indicate whether:

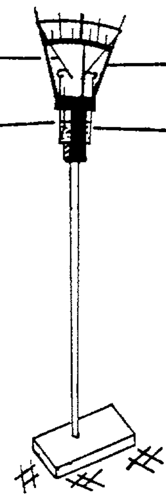
a. the data are below detection limits

b. cheaper metal analyses can be undertaken (it is recommended that analyses using AA should initially be carried out)

The list of characteristics should be modified to take these factors into account.

3.3 RAIN ANALYSES

When a rain event is about to begin, the lids from the rain collectors should be removed and the plastic bags placed inside. The bag should be sealed with the clothes pegs. The funnel and tube should be checked for blockage. The filling tube into the bottle should be attached and at the bottom of the bottle.



3.4 RAIN COLLECTORS

Rain collectors should be emptied frequently. The volume of rain in each collector should be recorded in the field book for each date by:

a. Substracting the amount of oil or anti-freeze that was added from the volume measured.

b. Calculating the rainfall in the collector from the following equation.

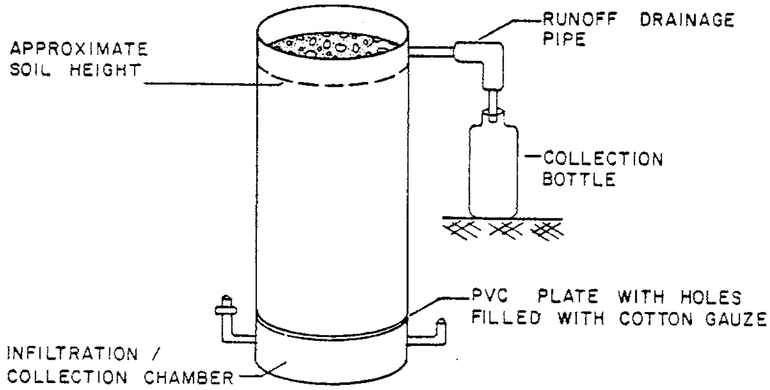
Equation I: $$\frac{\text{Volume collected (mL)}}{\text{Area of PVC tube (cm}^2\text{)}} = \text{Rainfall (cm)}$$

3.5 DUSTFALL CANNISTERS

The dustfall cannisters should be changed at least monthly or before rain will cause them to overflow or excess evaporation causes them to dry out in summer.

3.6 INFILTRATION/RUNOFF COLUMN

Using the hand vacuum pump the water should be extracted from columns and placed in a measuring cylinder. The date, time, and amount should be recorded. This should be done before each storm.



The equivalent rainfall for the infiltrated water should be calculated from the following equation:

Equation II:

$$\frac{\text{Infiltration volume (mL)}}{\text{Surface Area of Column (cm}^2\text{)}} = \text{Infiltration rainfall equivalent (cm)}$$

4. INSTALLATION, MAINTENANCE AND OPERATION

4.1 DUSTFALL CANNISTERS

1. Maintenance: Check for any debris in the cannisters. If this debris cannot be removed without contaminating the sample, note the amount (e.g. one small leaf) and date. The laboratory will note the presence of the debris.

2. Operation: One of the most important factors in using dustfall cannisters is NOT TO LET THEM OVERFLOW, OR EVAPORATE, since the sample is invalid under these conditions.

4.2 RAIN COLLECTORS

1. Maintenance: Add oil to the collectors in summer to prevent evaporation, and antifreeze, in winter.

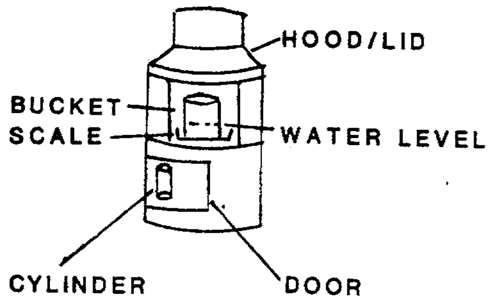
4.3 RAIN SAMPLERS

1. Operation: Check the lid to ensure that no precipitation has been collected. If the lid has leaked, replace the sample bottle and reseal the lid.

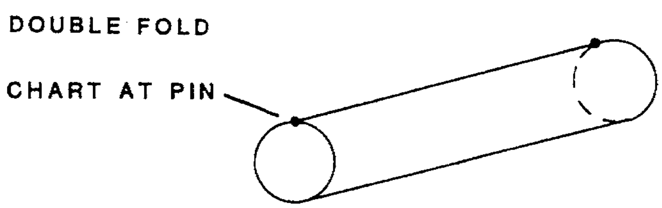
4.4 RAINGAUGE

Installation, Maintenance and Operation: On the first day of the work week the water level in the rain gauge bucket should be checked and the bucket emptied if necessary. Further detailed instructions for operation and maintenance follow.

1. Require: Kimwipes, antifreeze, oil, beaker, "A" bottle.
2. Unlock the gauge door and lid.



3. Remove lid and lift and lock door.
4. Pull bar to lift pen off roller. Moisten Kimwipe and remove ink from pen.
5. Empty bucket.
6. Place bucket into gauge, making sure it is level and the overflow is correctly fitted into the scale.
7. Remove roller and indicate on the chart when the pen was removed (i.e. time, date) and the total amount of precipitation collected.
8. Mark on the new chart the starting time and date. Place the chart on the roller as per the diagram. This allows for over run.



9. Use the beaker to measure 200 mL of antifreeze, 1150 mL of water, 3 drops of oil. Add this to the bucket (Summer time 1250 mL H_2O, 100 mL oil).
10. Place one drop of ink from the dropper, in the rainguage, making sure that the level of ink in the pen does not exceed the height of the pen wedge.

11. Place the roller back on the clock in the rain gauge. Move the bar and the pen so the pen makes contact with the chart.
12. Close the door and lock it. Make sure the lid is on and closed. Note start time in the field book. Do not slam the door.

4.5 AUTOMATIC SAMPLERS

4.5.1 SIRCO

Operation: Push the AC-DC toggle to the "DC" position. Push the power toggle to the "ON" setting. When the light at this toggle stops flashing press down on the "RESET" button. A pumping series will start and the "START" light will come on. Check all the hoses and connections in the sampler (especially the probes in collection chamber).

Detailed manuals on these samplers are available from the Instrumentation Section of the Environmental Laboratory.

4.5.2 MANNING

Operation and Maintenance: Connect the sampler to the 12-volt car battery and the Tutt trigger. Turn the knob on the left hand side of the control panel to "BOTTLE ADVANCE". The process should be conducted until the number 1 appears indicating the spigot is over the first bottle in the series. The knob should then be turned to the "FLOW" position allowing the Tutt trigger to initiate a sample sequence. At the end of a series the samplers should be flushed with distilled water to minimize external contamination from the sampler apparatus.

It should be noted that the system purges itself. Any problems which may arise from algae etc. forming in the tubes can be rectified by using a weak nitric acid solution to clean the system.

A detailed manual on operation and service of the Model S-4040 Manning sampler is available from the Resource Quality Section of the Water Management Branch.

4.6 THE FLUME

Maintenance

1. Make sure the capacitance probe is level in the stilling well.
2. Clean out the stilling well making sure the probe is free from debris. Indicate when this cleaning procedure was carried out on the charts (data and time).
3. Ensure water is flowing freely in the flume.
4. Check the flume to:
   a. prevent deposition build-up: this deposition should be cleaned out at regular intervals.
   b. make sure the tubes leading to the automatic samplers are secure and free from debris.
5. Check the Tutt trigger making sure it is free of debris and at the "appropriate" position in the flume.
6. Ensure the flume is level, approximately weekly.

4.7 BATTERY CHECKS

Battery Maintenance with Multi-meter

Batteries should be checked daily with the voltmeter.

1. Plug in the probes to the multimeter.
2. Turn the dial selector to "D.C.V".
3. Turn the multimeter "ON".
4. The Red probe goes to the positive terminal and the Black to the negative terminal.
5. Check and note the voltage readout for all the batteries in the shed.

6. Any 12-volt battery below or equal to 12-volts MUST be recharged. If a battery gives a readout of 12.2, it should be recharged.
7. Place the positive probe on the positive terminal and the negative probe on the negative terminal at the back panel of the 1/2 scale flow chart and measure the voltage. If this is 13 volts or less then a battery in its sytem MUST be recharged. Follow the same procedure for the full scale flow chart (reading should be 13·5).

Multimeter Maintenance:

8. To check the fuses (in cases of emergency) turn the dial selecter to "ohms" on the multimeter. Connect each probe to a different end of the fuse. If the resistance is 0.00 then the fuse is operative, otherwise replace with a new fuse.

Battery Maintenance with Hydrometer: Batteries should be checked weekly with the hydrometer when in operation as well as during recharging operations:

1. Place end in battery.
2. Suck enough liquid into meter to float the probe. The probe will indicate if the battery needs to be recharged. The hydrometer is drained, then rinsed. Care must be taken to avoid acid spills or drops of acid coming into contact with skin or clothes.

4.8 STRIP CHART RECORDERS

Operation:

1. Each day mark the time, date, and level of water in the flume, on the flow chart.
2. Check amount of chart remaining in the recorder, i.e. anticipate when to change a roll in a specific recorder. For ease in future data handling, change rolls for both recorders at the same time.

Maintenance:

3. Calibration should be done whenever a roll (which can last 3 weeks) or battery (which can last one week) is replaced. The capacitance probe may be removed from the stilling well and placed in a bucket, or a stopper can be placed in the stilling well to permit onsite calibration. The probe should be supported ensuring that it is level and not resting on the bottom of the bucket. Indicate on the chart (i.e. time, date) that calibration tests are being conducted. Lift the probe out of the water to the surface and, using the "Zeroing" knob, adjust the pen on both recorders 1/2 scale and full scale to the zero position on the left hand side of the chart. Lower the probe to the 1/2 maximum level mark (in the bucket). The "ATTEN" knob is then used to show full pen deflection on the 1/2 scale level chart and half deflection on the full scale level chart (i.e. the 1/2 scale level chart's pen will be on the extreme right of the chart while the full level chart's pen will be at the mid-point). Repetition of this process has shown that the original settings are not accurate enough therefore fine tuning is required. This is accomplished by repeating the process until adjustment is no longer required.

4.9 CAPACITANCE PROBE

Installation:

4.9.1 EQUIPMENT LIST

2 - strip chart recorders
1/2 scale (1/2 flume depth)
full scale (full flume depth)

1 - WIRE (A) with a RED banana jack on one end and BLACK banana jack on the other end.

1 - WIRE (B) with a red banana jack on one end and a Mueller #25 battery clip on the other.

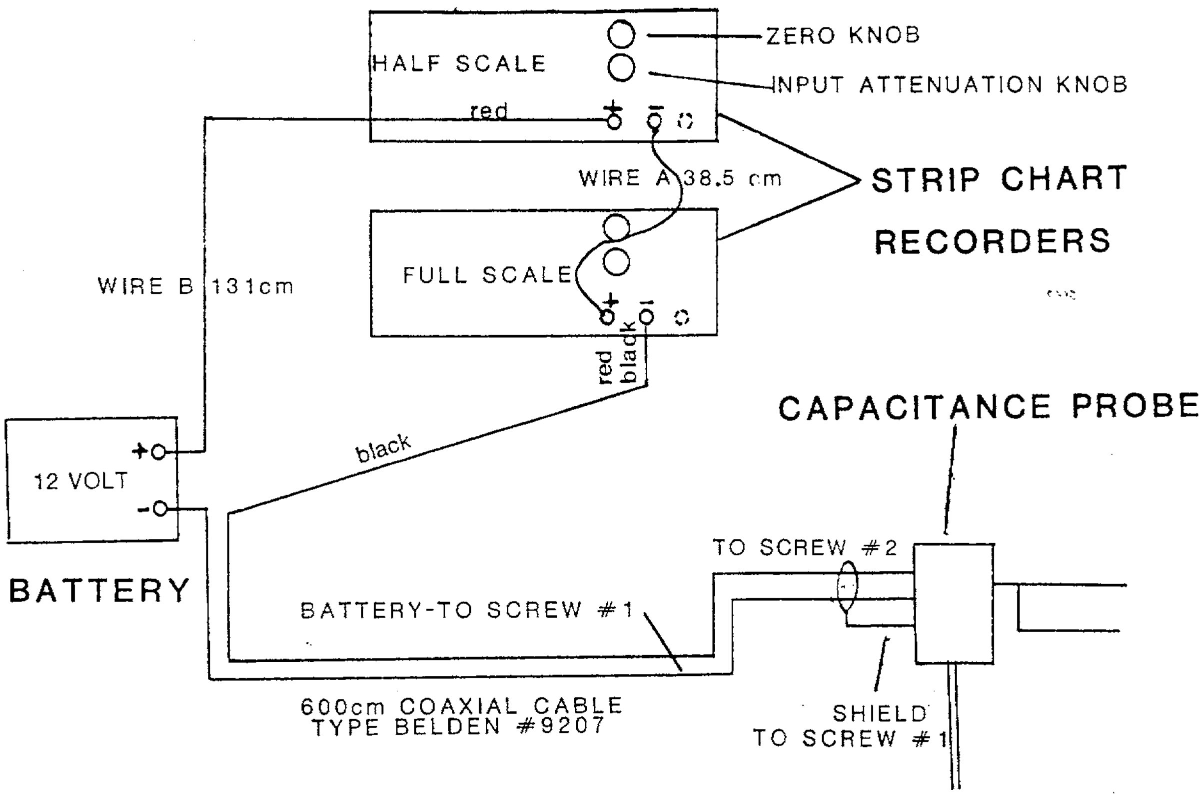
1 - capacitance probe (Robertshaw #160-B1)

1 - 12-volt battery.

1 - coaxial cuble

4.9.2 ELECTRICAL CONNECTIONS

The following is based upon the assumption that 2 strip chart recorders will receive a signal from a Robertshaw capacitance probe. The following set-up will send a signal to each strip chart recorder, in series. Stack the 1/2 scale stripchart recorder on top of the full scale stripchart recorder and wire up according to the following diagram:



4.9.3 SYSTEM ADJUSTMENTS

Check the paper rolls inside each recorder. They should be tightly wound or else they will bind up later. The batteries must be in good, well charged condition or else non-linear response occurs. Linear response on the strip chart recorders is verified as per maintenance instructions in Section 4.8.

<u>Maintenance</u>: Ensure on a weekly basis that the probe is clean and grease free.

4.10 FLOW CHECKS

Maintenance:

1. By timing the filling of a bucket of known volume at the end of the flume, flows can be calculated.
2. Repeat this process three times and record the readings.
3. Record temperature in the stilling well.

5. SUGGESTED ROUTINE WEEKLY EQUIPMENT PROCEDURES

Before touching any electronic equipment touch the negative terminal of the battery in order to eliminate any static charge.

When connecting any equipment, make sure the polarity is correct. All positive leads are coded red (copper terminals) and all negative leads are coded black (zinc terminals).

MONDAY (or other alternative first day of week)

1. Switch on samplers as per instructions in Section 4.5.
2. Check that the moisture sensitive switch is clear of the water and then reconnect it to the battery; set the switch by pressing the reset button, when the green light is on the switch is set.
3. Perform maintenance checks outlined in Chapter 4.

TUESDAY - THURSDAY

1. Check all equipment for malfunctions.
2. Remove all debris from flume and stilling well and ensure water is flowing freely in flume.
3. Mark date and time on charts.
4. Check for vandalism.
5. If there has been much rain, check the water level in the rain gauge bucket and empty if necessary. Replace oil.

FRIDAY

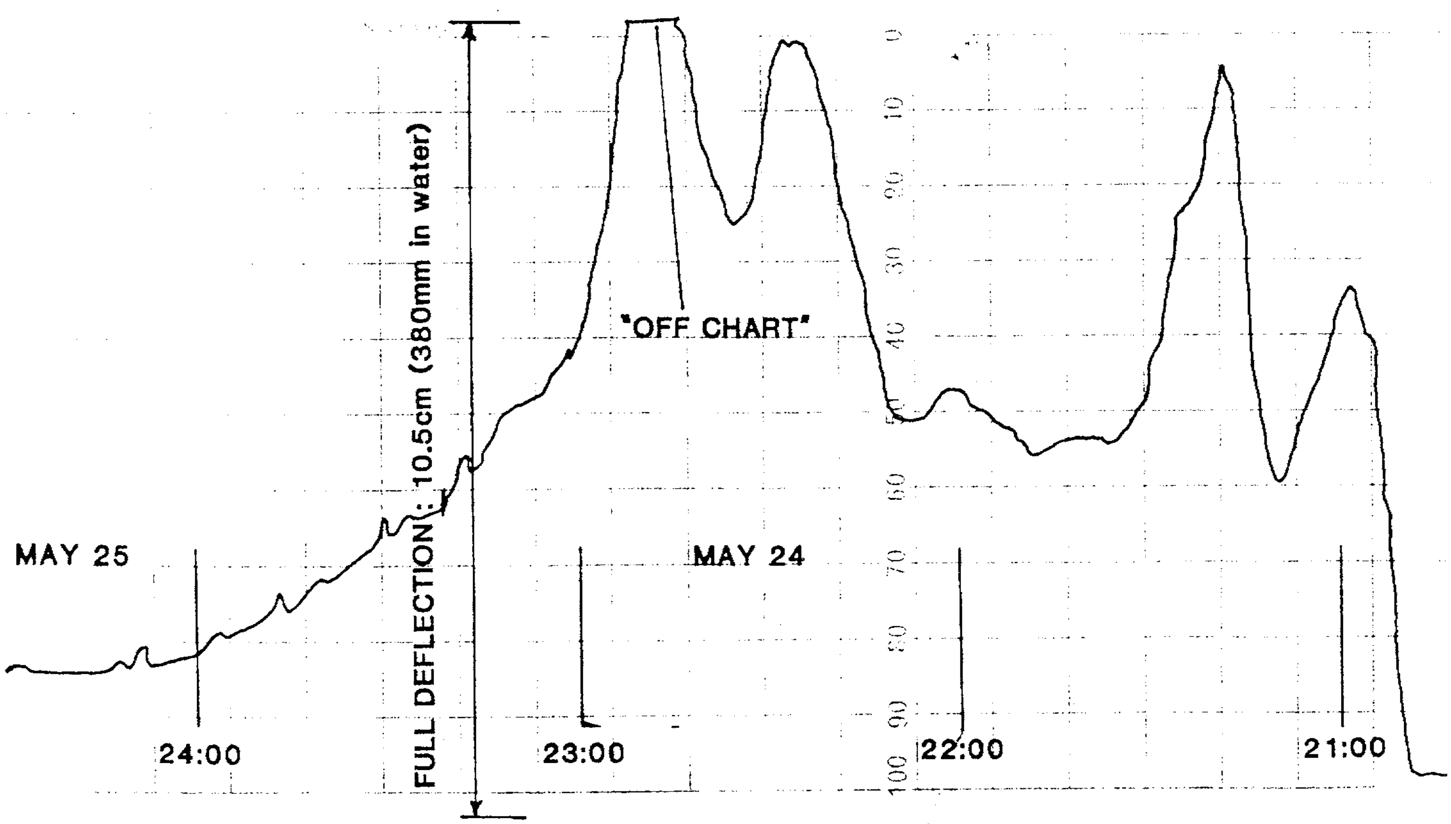
1. Switch off automatic samplers by turning both switches to the "off" position.
2. Disconnect moisture sensitive switch.
3. Check the rain gauge and strip chart recorders for malfunction. Mark date and time on charts.

6. DATA PROCESSING

6.1 FLOW CHARTS

The Resource Quality Section of the Water Management Branch hold a computer program to store flow data for flumes. Upon request this data can be retrieved in terms of total flow over any prescribed time period. The following outlines procedures for reading strip charts so that data can be entered into the computer.

1. Read through the 1/2 scale level chart initially by:
   a. preparing a plastic overlay with hours marked on it. The length of each hour will depend upon the chart speed (i.e. if speed is 5 cm/hr, each hour is 5 cm long).
   b. using the plastic overlay, mark hourly times on the chart using a 24-hour clock (i.e. 0.02 is about 1 minute after midnight, 23.99 is about 1 minute before midnight).



SAMPLE CHART (HALF SCALE)

c. adjusting times between actual field time checks. The charts do not run precisely, however, if frequent field checks (e.g. daily) are placed on the chart, adjustments to times can easily be made.

d. noting any times when the 1/2 scale level chart went off scale (see previous chart), and repeating a similar procedure to that cited in "a" to "c" above to interpret data on the full scale level chart for these points.

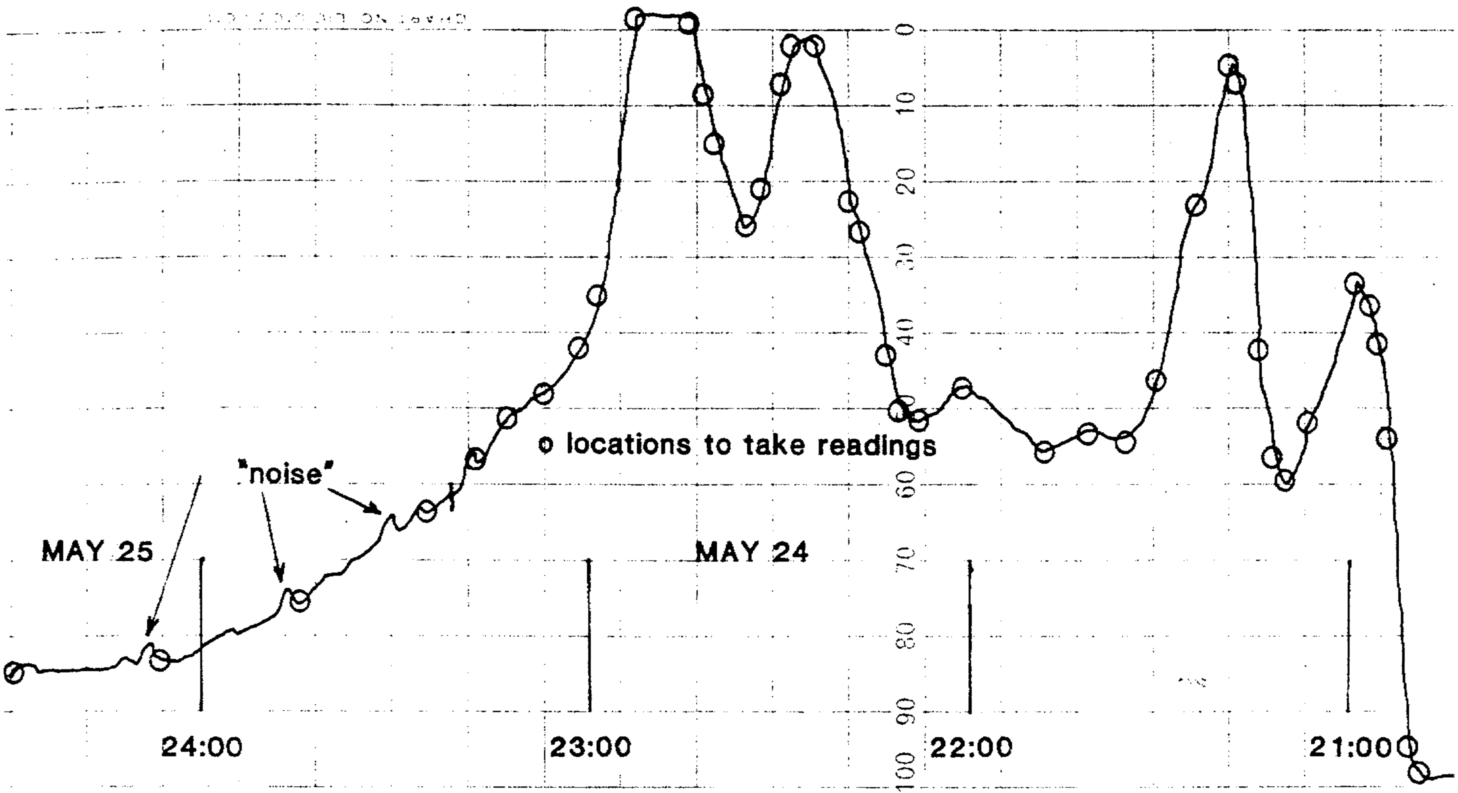
2. Prepare a second plastic overlay marking heights from 0 mm to 1/2 level for use with the 1/2 scale level chart. If readings are required from the full level chart, prepare a plastic overlay from 0 mm to full level.

   NOTE: When calibrating the chart, the zero and full scale will determine the length of line. This length must be used for preparing new plastic overlays.

3. Read heights from chart in equivalent height on flume (mm). If 760 mm is the chart equivalent to the total height of water that can pass through the flume, the maximum reading on the half scale is 380 mm. If the chart is 10.5 cm wide as above, each cm on the chart equals 36.2 mm in the flume.

As a minimum, two readings per day are required, one at 0.01 hours and one at 23.99 hours. However, a reading is required at every deflection (or inflection) point from a straight line (see chart which follows). The reason for this is that the computer program assumes a straight line between every point entered in the data set. This results in many points being recorded during a storm at very small time intervals, but a very limited number of points being recorded when there is no rain.

NOTE: If some failure does not permit data to be obtained, zeros should be entered.



SAMPLE CHART (HALF SCALE)

TYPICAL DATA ENTRY SHEET

Site Number	Date	Time	Height in Flume	Time	Height in Flume	Time	Height in Flume
XE0312701	81-02-03	0.01	0	23.99	0		
	81-02-04	0.01	0	4.62	0	4.63	13

NOTE: - times are recorded as decimals; 10:40 is recorded as 10.67.

- both spaces to the right of the decimal in the time must be filled in.

- only one space, as a minimum, has to be filled in to the left of the decimal.
- heights are recorded to the full number of mm of flow in the flume, i.e. 387 not, 387.0 or 386.8.
- heights are entered and are right-hand justified.
- only the actual number of the height has to be entered, i.e. 17 not 017.
- formula for flow through our 12" flume, based upon the height/flow calibration is:

$$\text{Flow} = 0.00112552\ h^{1.52209}\ \text{m}^3/\text{min.}$$

where h = height (mm)

A similar equation will yield the flow through other flumes of different throat widths. The computer program can be modified for these changes.

6.1.1 GENERAL RULES

- start each day on a new line on the computer coding sheet (portion illustrated in Section 6.1).
- numbers which are repeated from line to line can be indicated as such using arrows (see example in Section 6.1).

6.1.2 FINAL PROCESSING

When charts have been read:

- file the original charts chronologically for future reference.
- xerox a copy of data sheet for your office.
- send original to Resource Quality Section, Water Management Branch, 765 Broughton Street, Victoria, B.C. for further processing.

REFERENCES CITED

(1) L.G. Swain; Stormwater Monitoring of a Residential Catchment Area, Vancouver, B.C.; Internal Water Management Branch Report; June 1983.

(2) J. Marsalek; Instrumentation for Field Studies of Urban Runoff; Canada-Ontario Agreement on Great Lakes Water Quality, Research Report No. 42; Project 73-3-12.