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HIS MAJESTY'S GOVERNMENT OF NEPAL
MINISTRY OF WATER RESOURCES
DEPARTMENT OF HYDROLOGY AND METEOROLOGY

THE STUDY ON NATIONWIDE HYDRO-METEOROLOGICAL DATA MANAGEMENT PROJECT

FINAL REPORT

MANUALS

August 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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LIST OF REPORTS

SUMMARY

MAIN REPORT

ANNEXES

MANUALS

DATA BOOK

The cost estimate was based on February 1993 price level and expressed in NRs. according to the exchange rate of US$1.00 = Nepali Rupees 46.4315 = Japanese Yen 121.05 as of February 15, 1993.

NATIONWIDE HYDRO-METEOROLOGICAL DATA MANAGEMENT PROJECT

FINAL REPORT
MANUALS

CONTENTS

NATIONWIDE HYDRO-METEOROLOGICAL
DATA MANAGEMENT PROJECT

MANUAL OF ORDINARY RAINGAUGE FOR OBSERVERS

August, 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

1. Rainfall observation : वर्षाको पानी नाप्ने विधि :

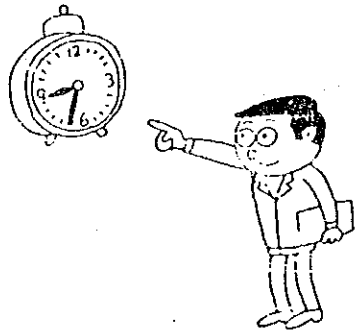
1.1 Ordinary rainfall gauge. साधारण रेनगेज।

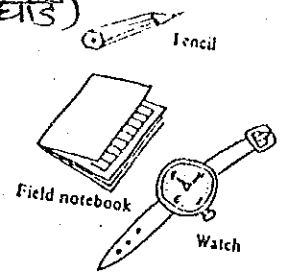
1) Go to the observation a little before observation time i.e. 8:45 every morning.

पूर्वनिर्धारित समय गन्तव्य केहि अघि (८:४५) निम्नलिखित सामानहरु सहित पुग्नु पर्छ।

Take these things.

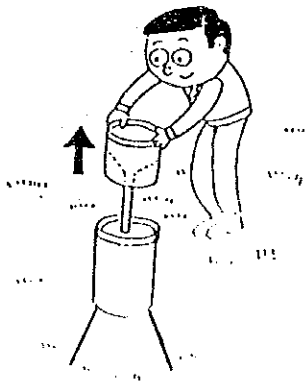
* Field notebook (फिल्ड बुक)
* Pencil (पेन्सिल)
* Watch (घडि)





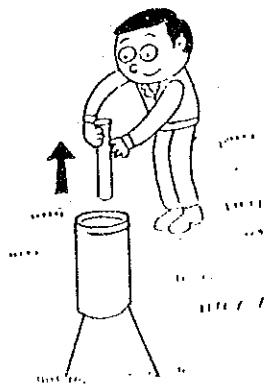
2) Remove the collector of the rain gauge

पहिले रेनगेजको कलेक्टरलाई हटाउने।



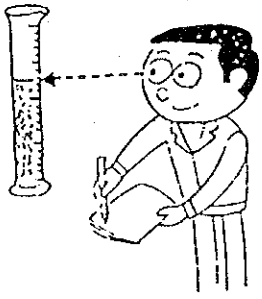
3) Take out the inner tube

भित्रको ट्युबलाई बाहिर झिक्ने।



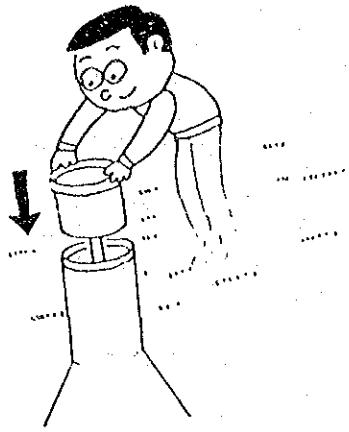
4) Record the observed reading in the field notebook.

त्यस ट्युबले देखाएको रिडिंग लाई फिल्ड बुकमा लेख्ने।



5) SPill water out of the inner tube and Replace it in the original place

रिडिङ लिँदा भित्रि युबमा भएको पानीलाई फ्यालेर युबलाई यथास्थानमा राख्ने।



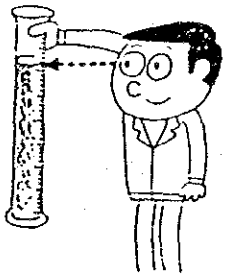
6) Replace the collector of the rain gauge

रेनगेज को कलेक्टर (पानी जम्मा गर्ने गोंडा) लाई यथास्थानमा राख्ने।

7) Check the rainfall amount (रिडिङ कसरी लिने)

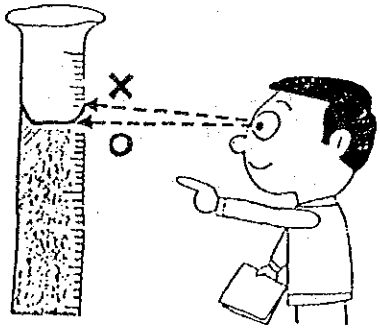
* while holding the measuring at the top so that your eyes are roughly parallel with the water level in the inner tube, read the level within 0.1 mm of its lowest position.

रिडिङ लिंदा युबको माथिल्लो आङलाई हातले समाते र आफ्नो आंखालाई पानीको लेभल (सतह) को समान्तर राखी पानीको तल्लो सतहबाट 0.1 मि.मी. सम्मको रिडिङ लिने।

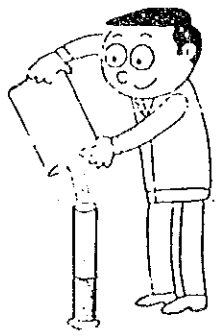


* Because the water level has tension on the edges of its surface which leads to swelling against the inner tube, reading at the upper position of the water level cause errors.

पानीको माथिल्लो (सतह) लेभल बाट लिएको रिडिङ गलत हुन जान्छ।

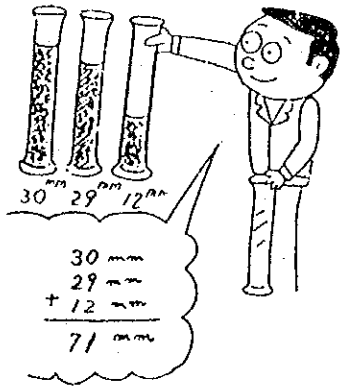


When the rainfall overflow the inner tube



* After gently lift the inner tube and measure, refill the inner tube by the water deposited in the overflow container and repeat measurement until it has emptied.

ओभरफ्लो भएँ गोंडेमा भएको पानीलाई फेरी त्यस प्यूबमा राखेर रिडिंग लिने। यसै तरिकाले त्यो भाँडा खाली नभएसम्म रिडिंग लिने।

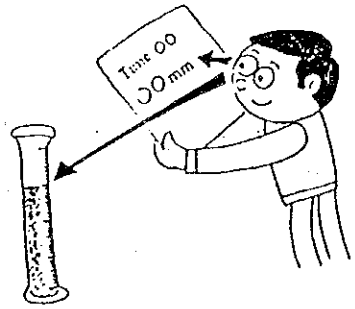


* It is better to distribute quickly approximately 30 mm of a inner tube, Record the figures accurately and then calculate them.

अन्दाजी ३० मि.मी. को मात्रै प्यूब वितरण गरे राम्रो हुन्छ र त्यसको हिसाब राख्नु जरुरी छ।

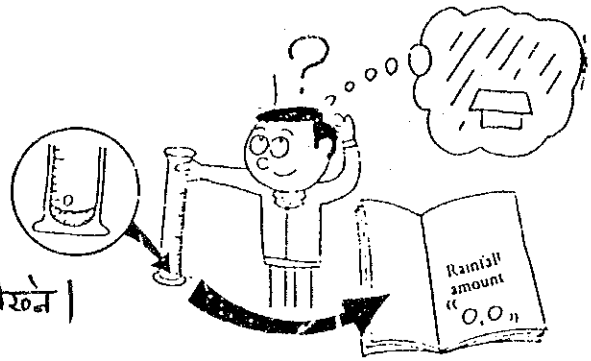
8) How to make field notebook entries

फिल्ड बुक लेख्ने तरिका:



a. Entries are made in the field notebook according to the actual time schedule for taking out the inner tube (for example, 9:00 A.M.)

साँझ र पूर्व निर्धारित समयमा रिडिंग लिने र फिल्डबुकमा लेख्ने।

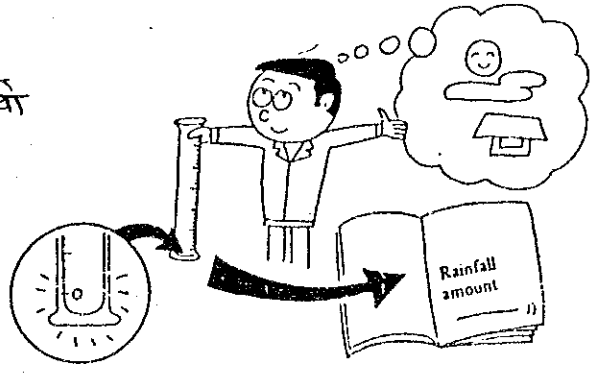


b. There seened to have been rain since the last measurement, but there is less than 0.1 mm in the inner tube, Rainfall amount is "0.0".

मात्रको प्यूबको रिडिंग यदि 0.9 मि.मी. भन्दा कम हुन्छ त्यो रिडिंगलाई 0.0 लेख्ने।

c. There was no water in the inner tube, Rainfall amount is "T"

यदि मात्रि प्यूबमा पानी छैन भने त्यो रिडिंगलाई "T" अक्षरले जनाउने।

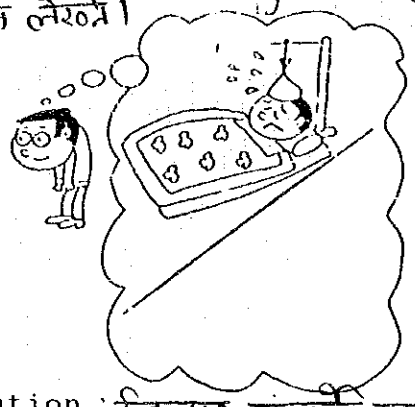


9) Missing Measurement रिडिंग छुटको रकम्मा :

Please ask an alternate observer to take measurement if you can not observe due to some reasons, otherwise follow as bellow : रिडिंग लिन आफू जानसकैको रकम्मा र अर्को मानिस पनि नभएको रकम्मा

Correct (ठिक)

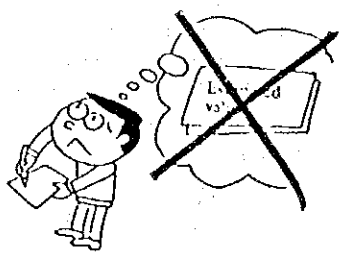
When measurements are not made, record this fact accordingly. (* रिडिंग नलिएको कुरालाई पनि लेख्ने।)



Wrong (बेठिक)

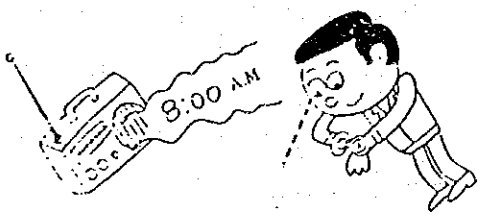
Do not use estimated value, your judgement could be mistaken! रिडिंग नलिएको रकम्मा आफ्नो अनुमानित रिडिंग नलिने गर्नु।

There are wrong!
* Estimated value नलेख्ने।
* Copy from raingauge recorder



10) Caution : विचार गर्नुपर्ने कुराहरु :

a. Even if you think no rain has fallen, check the inner tube every morning at established time (8:45 A.M.)
वर्षा नभएको भएपनि आफ्नो पूर्व निर्धारित समयमा भित्रको ट्युबलाई प्रत्येक दिन जाँच गर्ने।



b. Before taking the measurement, set your watch to the correct time
रिडिंग लिनुभन्दा अघि आफ्नो घडिलाई सहि समयमा मिलाउने।

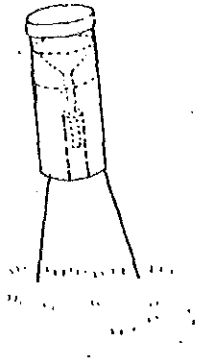
c. Be careful of water running off your umbrella when it is raining so that this does not fall into the receiver of the rain gauge.
पानी पर्दा छेलाम्मा आफ्नो छाताबाट झर्ने पानीलाई रेनगेजको कै गाँडोमा खस्न दिनुहुँदैन।

d. Do not spill a drop of the rainwater collected in the inner tube until it has been measured.
रेनगेज ट्युबमा भएको एक थोपा पानीलाई पनि रिडिंग लिइसक्नु मात्र मिल्काउनु पर्छ।

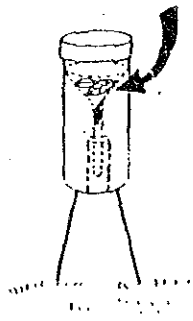
(* रिडिंग लिन नसकिने कारण)

11) Dairy Inspection (प्रत्येक दिन निरिक्षण गर्नुपर्ने कुराहरु)

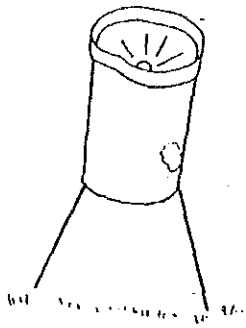
a. Is the raingauge installed level ?
के रेनगेज लेभलमा (सतहमा) राखिएको छ ?



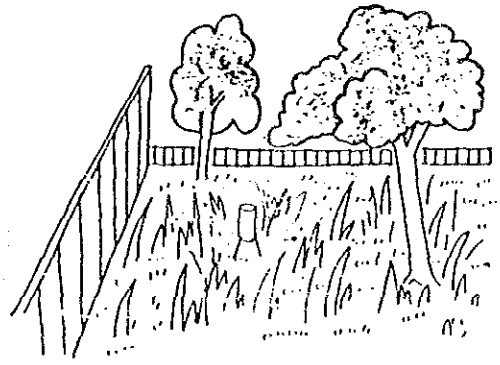
b. Have leaves or debris fall in the collector ?
के मारपातहरु, रेनगेजको कलेक्टरमा खसेको छ ?



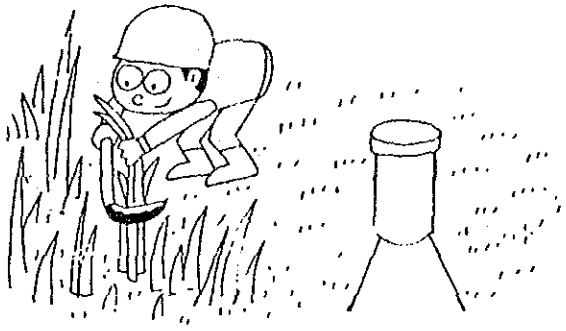
c. Has the collector damaged ?
के कलेक्टर बिग्रेको छ ?



d. Are there no obstacles such as fences, trees, houses etc ?
के त्यहां झाडि, रुख र घरजस्ता अवरोधहरु छन् ?



e. Is the surrounding grass cleared away ?
के रेनगेजको चारैतिर भएको घाँसहरु सफा गरिएको छ ?



12) When it snows (हिमपात गरेको बेलामा)

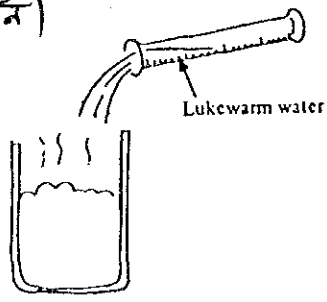
a) The water equivalent of snow is measured by removing the funnel the inner tube. पानी बराबरको हिउँलाई नाप्ने।

b) Whenever snow and hail clog the collector, take measurement soonly. यदि हिउ र हैल्लेकल्नेकरर अवरुद्ध गरेको भए तापु तुरुन्त लिनुपर्छ।

c) After melting the accumulated snow with a known amount of hot water and measuring the total, subtract the amount used for melting.

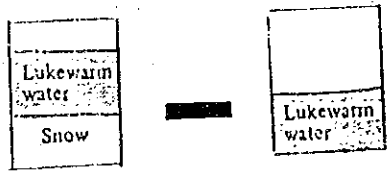
* Before snow is not overflow from the collector, take measurement additionaly.

तातो पानीको निश्चित मात्रालै हिउँलाई पगालेर पानीको सम्पूर्ण मात्रालाई नापे र पछि त्यसबाट तातो पानीको मात्रा घटाएर लेख्ने।



(Lukewarm water + Snow) − (Lukewarm water) = Amount of precipitation

(तातो पानी + हिउँ) − तातो पानी = वर्षाको मात्रा



DEPARTMENT OF HYDROLOGY AND METEOROLOGY
WESTERN REGIONAL OFFICE, POKHARA

TELPHONE : 20299 OR 20448

NATIONWIDE HYDRO-METEOROLOGICAL
DATA MANAGEMENT PROJECT

MANUAL OF RECORDING RAINGAUGE FOR OBSERVERS

August, 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

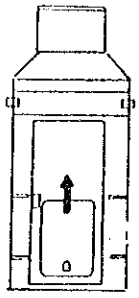
1.2 Obsevation of Recording Rainfall gauge | रेकर्डिङ जैन किसिमको रेनगेज बाट वर्षाको पानीमात्रा नाप्ने यन्त्रबाट तथ्य लिने विधि —

How to change Recording chart- ग्राफपत्रिने (ग्राफ कागज) रेकर्डिङ-चार्ट लाई कसरी बदल्ने

Recording chart is changed once a week, i.e. every Monday morning after manual observation, and simple checking of recording gauge should be conducted every day after manual observation. रेकर्डिङ चार्टलाई एक हप्ता को निश्चित वार एक हप्ता को साँझबाट विहान फेर्नु आवश्यक छ।

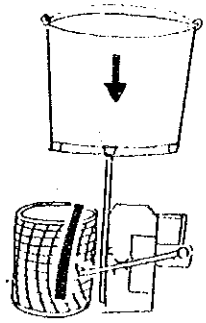
1) Open the sliding door.

तिरने ढक्वाएको ढिगातिर धकेलेर ढोका खोल्ने।



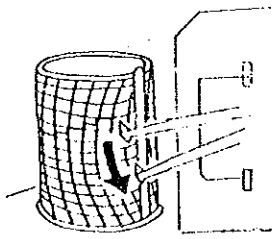
2) Make a short vertical mark at the pen's position by lightly touching the bucket platform.

बाल्टीन अड्याएको ढाँचालाई विस्तारै घोरेर कलम। पेन। रहेको ठाँउमा स्केटा ठाडो चिह्न (हार्सी) लगाउने।



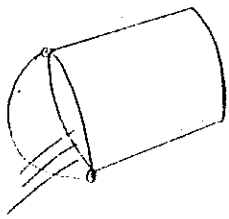
3) Lift the pen off of the chart by moving the pen shifter.

कलमलाई तलमाथी सर्न सकिने वस्तु (पेनशिफ्टर) को सहायतालै चक्रमाथी कलमलाई गाथी उठाउने।



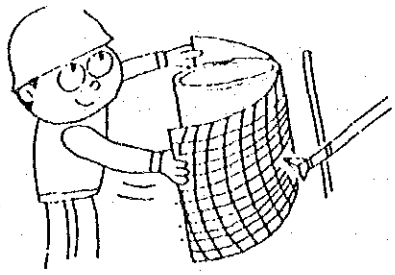
4) Remove the collector and empty the catch bucket.

जम्मा गरेको कलेक्टर लाई हटाउने र जम्मा भएको चिजलाई फालेर बाल्टीनलाई खाली गर्ने।



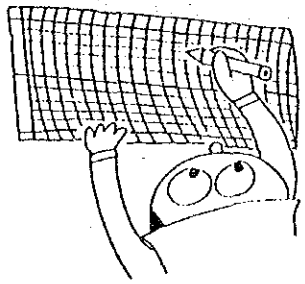
5) Release the chart drive and take off the recording chart.

चार्ट (नक्सा) ड्राइभ (नक्सा खिच्ने) वस्तुलाई निकालि दिनु र रेकर्डिङ चार्ट लाई झिक्नुहोस्।



6) Record the data, time, and your name at the point on the recording paper from which the pen was removed.

लिइएको तथ्याङ्क (समय र रिडिंगलिने व्यक्तिको नाम) रेकर्डिङ कागजको त्यो विन्दु मा लेख्नुहोस, जहाबाट पहिले कलम हटाइएको थियो।



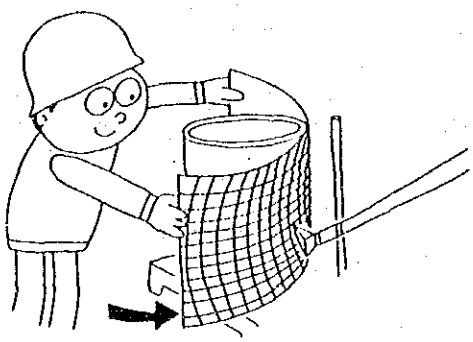
7) Wind the chart drive

चार्ट ड्राइभ लाई बेर्नुहोस्।

8) Mount the recording paper so that it is in the proper position as prescribed.

The recording paper should overlap properly

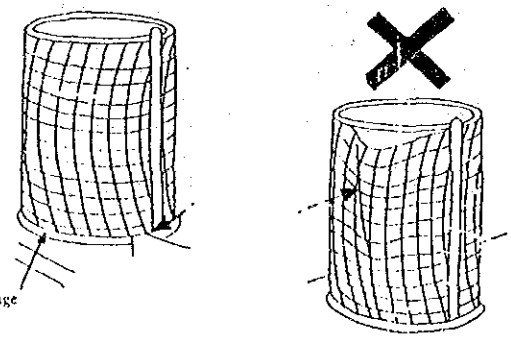
रकार्डिङ पेपरलाई यसरी घुमाउनु ता की यो चित्रमा देखाए अनुरूप होस। रेकर्डिङ पेपर राम्रो संग ग्लेटको छुनुपर्दछ।



9) Check to see that the bottom edge of the paper is stuck exactly to the flange at the bottom edge of the drum.

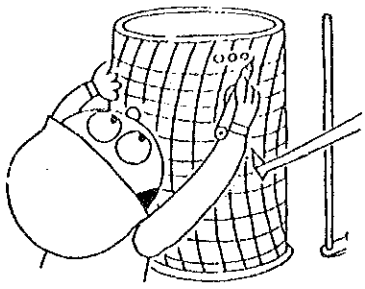
The recording paper should not sag.

रेकर्डिङ कागजको तल्लो किनारा ड्रमको तल्लो किनारको फ्लेज संग राम्रो गरि छुनुपर्दछ। रेकर्डिङ पेपर बाङ्गो वा खुम्चीएको हुनुहुदैन।



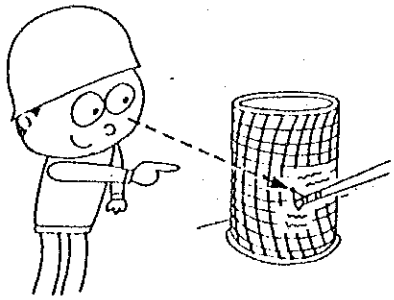
10) Record the data, time, and your name at installation.

रेकर्डिङ कागज राख्नेको डाँडगा डाटा, समय र आफ्नो नाम रेकर्ड गर्ने।



11) Wait three to five minutes after the paper has been installed to reconfirm that movement is correct.

पेपर राखि सके पछि, राख्नेको ठिक छ कि छैन जान्नको लागी, ३देखि ५ मिनेट सम्म पर्खेर पेनको (कलम) गतिको दिशाको निश्चितता गर्ने।



12) Please contact the Regional office in these cases :

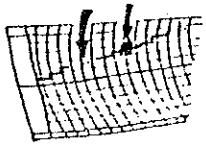
निम्न अवस्थामा कृपया क्षेत्रिय कार्यालयमा सम्पर्क गरेनु होला :-

a. When considerable rainfall is measured by ordinary rain gauge but not by the recording paper.

भारी वर्षा भएको बेलामा जब साधारण रेनगेजबाट वर्षा नापिन्छ तर रेकर्डिङ पेपरबाट होइन।

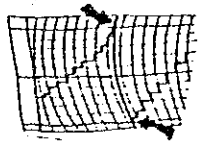
b. When the line is blurred, blotted or does not connect.

धर्साहरु (Line) नजोडिएका, तलमाथी परेका भए।



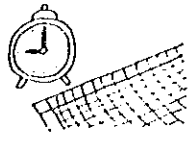
c. When the scale does not switch from top to bottom.

स्केल तल देखि सम्म घुम्न नसकेे।



d. When the time on the recording paper does not agree with standard time.

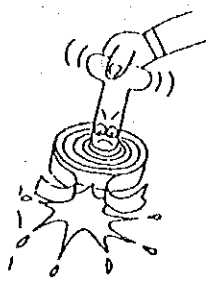
रेकर्डिङ पेपरमा देखाएको समय पूर्वनिर्धारित समय सँग मिलेको भए।



13) Caution [सावधानी दिनुपर्ने कुराहरू]

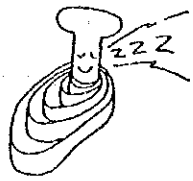
a. Don't just wind the spring one turn. Give it slightly less than a full wind. Slightly less than a full wind is the secret to long spring life.

स्प्रीङ्गलाई दिने एक फन्का मात्रै अल्पकति कम सम्म चाबी दिने। पुरै नदिनु हुदैन।



b. Don't forget to wind the spring.

स्प्रीङ्गलाई दिन नबिर्सनु होला।

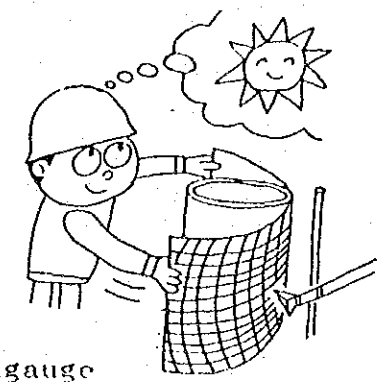


c. Don't touch the mecanical portion of the instrument.

सरसामानको यान्त्रिक भागहरुमा हुन नमाइ ह।

d. Change the recording chart every week even if it does not rain

पानी नपरेको अवस्मा पनि रेकर्डिंग चार्टलाई हरेक हप्ता फेर्नु आवश्यक छ।

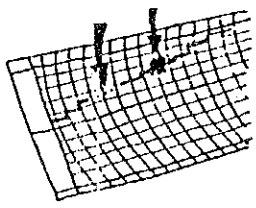


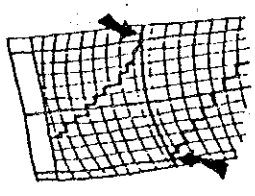
14) Daily Inspection of the recording raingauge
रेकर्डिंग रेनगेज को दैनिक निरिक्षण
After observation of Manual raingauge, simple checking of the raingauge is to be done every morning as follow :
रेनगेजको एकहप्ताको निरिक्षण पछि हरेक दिनमा रेनगेजको साधारण जाँच गर्नुपर्छ –

a. Inspection of the recording chart
रेकर्डिंग चार्ट को निरिक्षण।

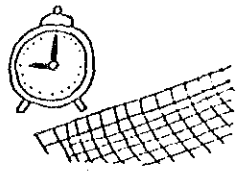
* No blur, blotch, fuzzy and interruption of the trace.

रेकर्डिंग चार्टमा नखुम्चोने, गज्याङ्ग, गजुरुङ्ग र लाइनहरु छुट्टिएका हुनु हुदैन।





* No big difference of time.
समयको फरक व्यक्ति धेरै नभए।

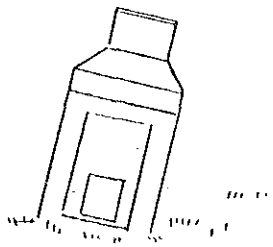


* No stop of clock.
घडी बन्द नभए।

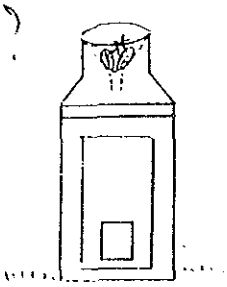
b. Inspection of the ordinaly/recording gauge
साधारण रेकर्डिङ जेजको निरिक्षण।

* Is there damage or deformation of the collector ?
के कलेक्टर कोहि कारणले विग्रिएको वा ठिक अवस्थामा नरहेको छ?

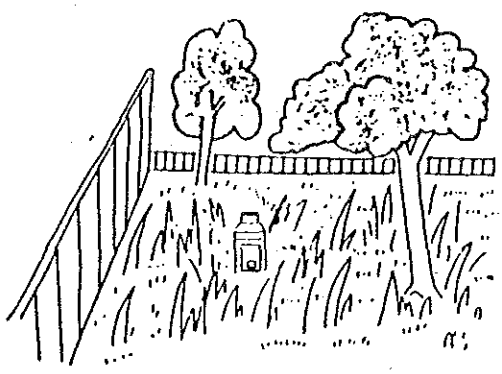
* Does the collector set horizontally ?
के कलेक्टर सिधा राखिएको छ?



* Are leaves or debris fallen in the collector ?
के कलेक्टरमा कुनै झारपातहरु पर्नेगरी छन्।



* Are there no obstacles such as trees, fences, house etc?
के त्यहाँ कोहि अवरोधहरु जस्तै:- रुखहरु, बारहरु र घरहरु छन् ?



* Is the surrounding glass cleared away ?
के छेउको सिसालाई सफा गरिएको छ।

c. Others (अरु)

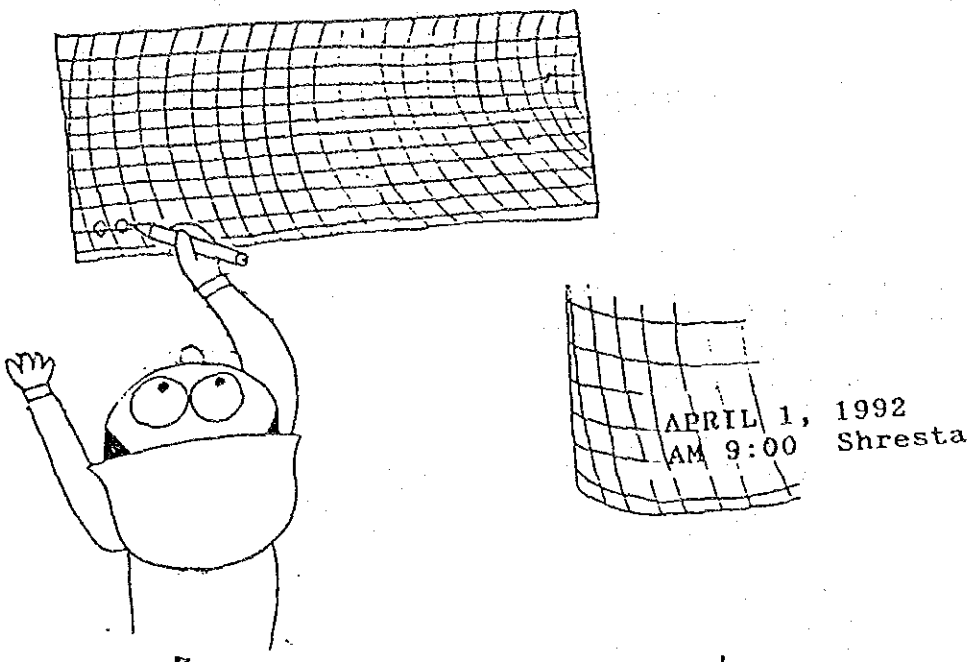
* No shortage of recording charts, pens, field book etc.
रेकर्डिङ चार्टहरु, कलमहरु र फिल्डबुक हरु को कमी छैन।

DEPARTMENT OF HYDROLOGY AND METEOROLOGY
WESTERN REGIONAL OFFICE, POKHARA

TELEPHOE : 20299 OR 20448

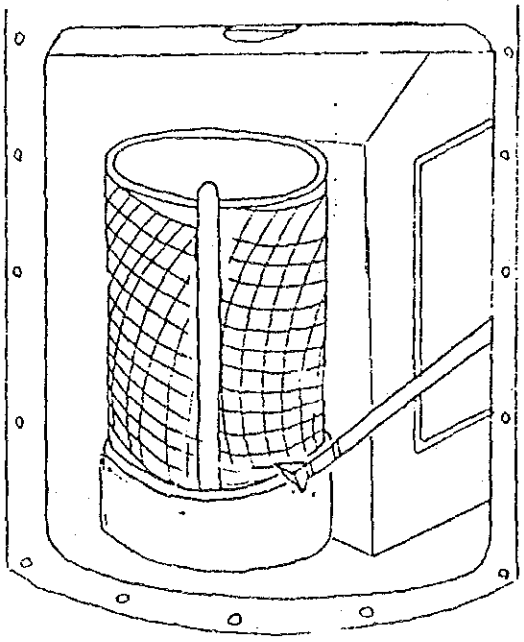
HOW TO SET THE RECORDING CHART
(Weighing-type Recording Raingauge)

Record the date, time and your name
when the paper is set and removed



Put on the recording chart

Set the chart properly



Check date, time

and zero line

CHART No. 5-4046-MM
300 MILLIMETER DUAL TRAVERSE 192 HOURS
UNIVERSAL RAIN GAGE

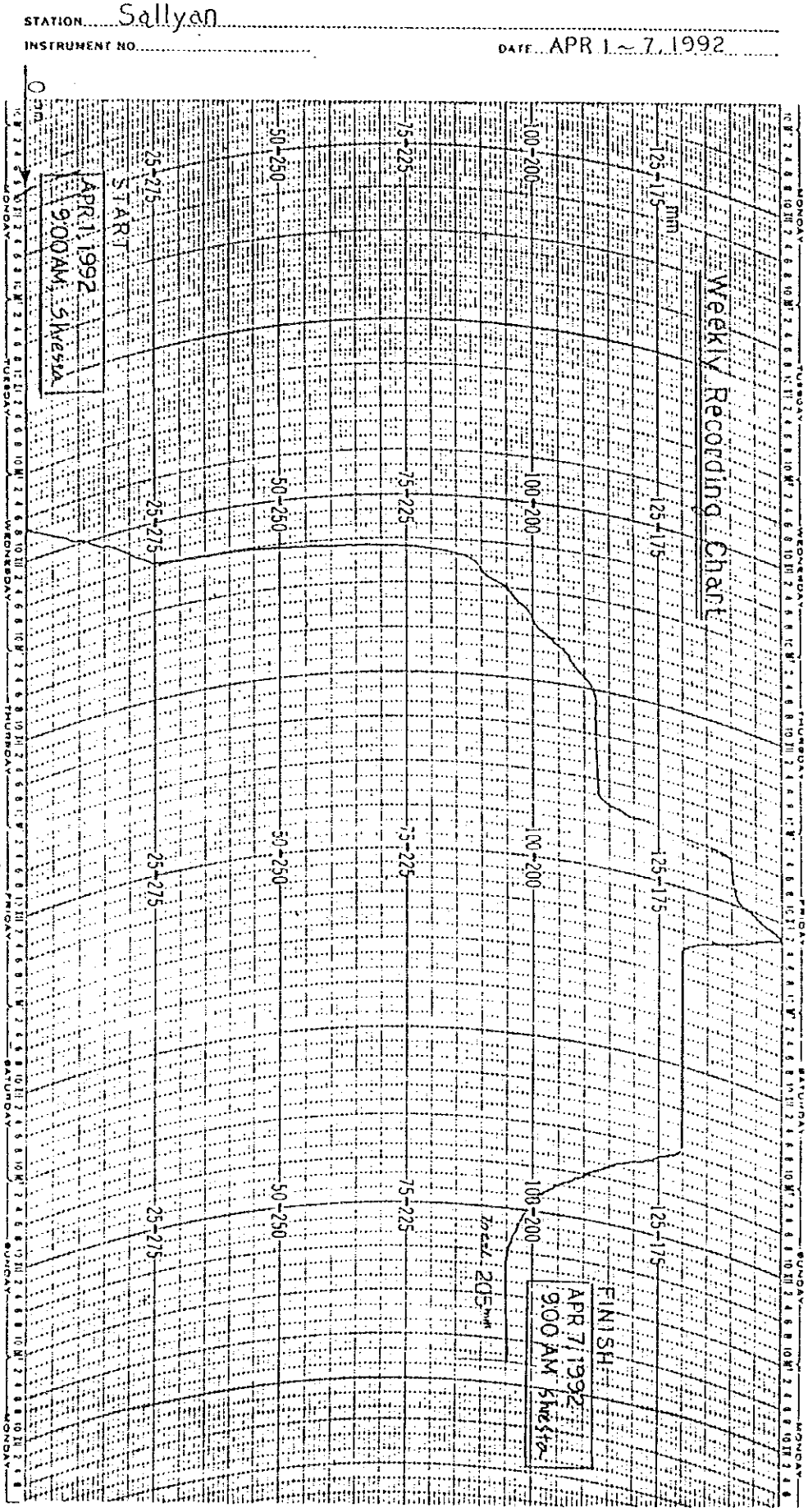


Chart of weighing-type recording raingauge
300 mm Dual traverse, 192 hrs.

NATIONWIDE HYDRO-METEOROLOGICAL
DATA MANAGEMENT PROJECT

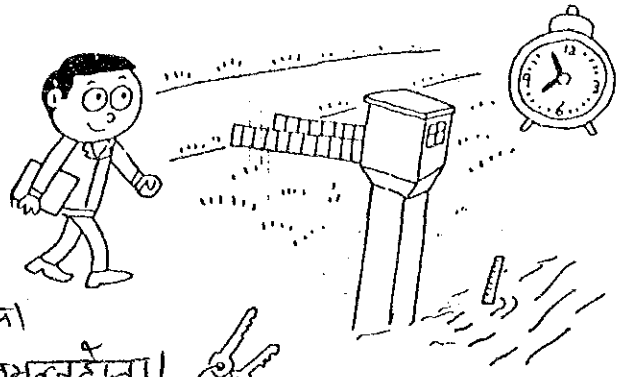
MANUAL OF STAFF GAUGE READING FOR OBSERVERS

August, 1993

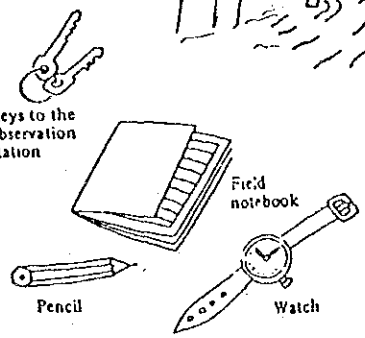
JAPAN INTERNATIONAL COOPERATION AGENCY

1. Water level Observation
स्टाफ गेजबाट पानीको सतह नाप्ने विधि:

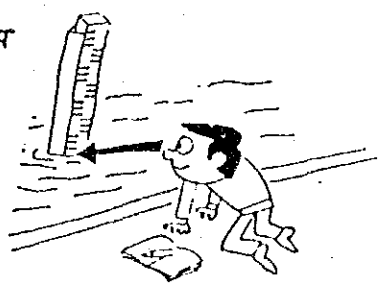
1.1 Ordinary Observation
साधारण निरिक्षण।



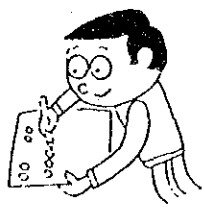
1) Go to the observation station a little befor measurement time, i.e. 8:00, 12:00 and 16:00. पानी को सतह लैजाने नाप्न जाँदा केहि आँच फिल्डमा जाने।
Go with these things.
सँगै स्थलमा जाँदा निम्न सामानहरु लान नभुल्नुहोला।
* Field note book (तथ्याङ्क कपि)
* Pencil (सिसाकलम)
* Watch (घडि)
* Keys to the observation station (निरिक्षण घर को साँचो)



2) Read the water level at the staff gauge.
स्टाफ गेजले देखाएको पानीको लेभल (सतह) पढ्ने।

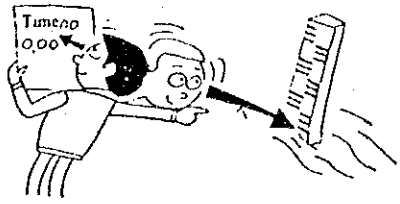


3) Enter the actual water level measured and the time in the field notebook.
लिएको सहि पानीको सतह र समय लाई फिल्डबुकमा लेख्ने।



4) Write the time by hour and minutes and the water level by the nearest centimeter.
समय लाई घण्टा, मिनेटमा र पानीको सतहलाई (उचाई) नजिकको सेन्टी. माप पढने र त्यसपछि लेख्ने।

5) After recording the entry in the field notebook, confirm its accuracy again by reading the water level at the staff gauge.
Be sure the reading is corrent at the time! (Afterwards it cannot be comformed).
फिल्डबुकमा रिडिङ लेखिसकेपछि लिएको रिडिङलाई फेरि स्टाफ गेजमा पढेर जाँच गर्ने। किनभने पछि त्यो रिडिङलाई जाँच गर्न सकिदैन।



Always read the staff gauge clearly. After cleaning away debris, read the water level.
जहिले पनि स्टाफ गेजलाई स्पष्ट किसिमले पढने। स्टाफगेजको नजिकमा गएको झाँङ्गलाई सफा गरेपछि रिडिङ लिने।

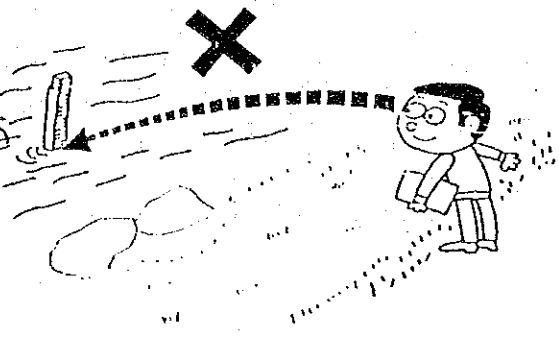
6) How to conduct correct recording (सही ताप कसरी लिने)

Correct (सही)

Be sure to read the water level a position near the mark where it can be easily seen and read from a horizontal position.

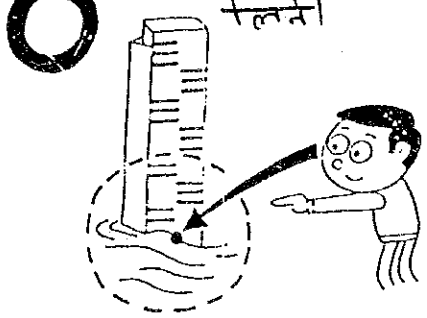
Wrong (गलत)

The water level cannot be correctly read from a distance.



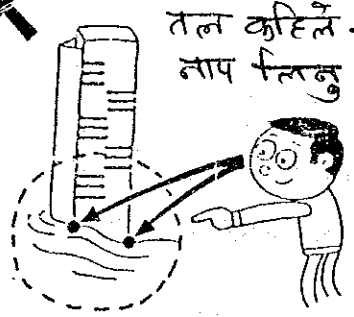
Read the water level from the exact middle of the water mark.

पानीको चिह्नको मध्यविन्दुबाट सिधा लिने।

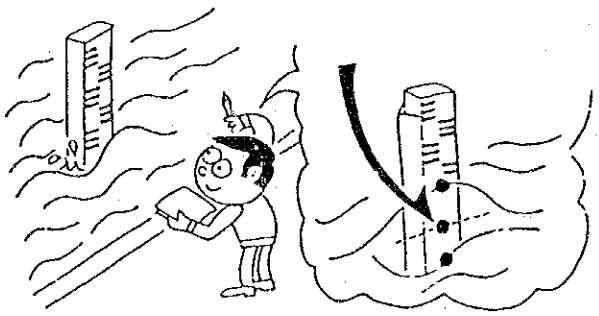


Reading the water level value at upstream/down-stream end is wrong!

पानीको (सतह) लेभल नाघ्दा कहिले तल कहिले माथी गरेर ताप लिनु हुँदैन।



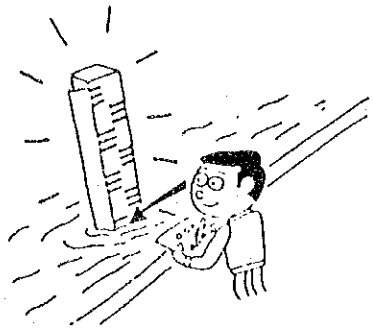
When there are waves, read the maximum and minimum values and compute their average.



पानी छाल भएको बेलामा अधिकतम र न्यूनतम सिधा लिएर त्यसको औसत निकाल्नु आवश्यक छ।

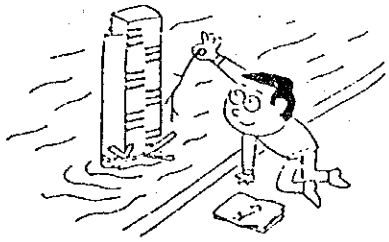
$$\left[\text{औसत} = \frac{\text{अधिकतम} + \text{न्यूनतम}}{2}\right]$$

7) Dairy Inspection [दैनिक निरिक्षण गर्नु पर्ने कुराहरु]



a. Is the installation of the staff gauge all right ? (leaning, fallen, washed away, or damaged)

स्टाफ गेज सहि स्थानमा छ कि छैन ?
(कतै ढलकीएको, विग्रिएको वा बगाएको त छैन)

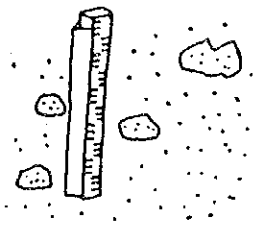


b. Is the staff gauge difficult to read due to surrounding debris

के स्टाफ गेजको वारीपरि भएको फोहर ले गर्दा रिडिंग लिन अप्ठ्यारो छ ?

c. Is the staff gauge above the water level due to falling river bed or change in the flow course ?

नदीको किनार तल धसिकोले वा नदिले आफ्नो बाटो बदलेको कारणले के स्टाफ गेज पानी को सतहभन्दा माथी छ ?



Dried up.

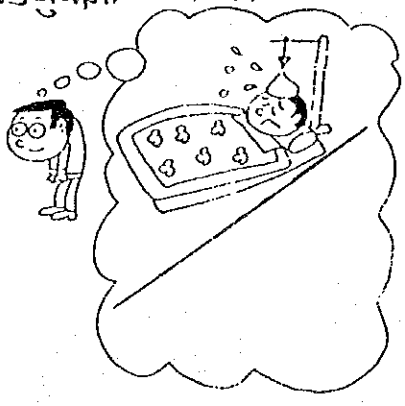
8) Miss a sceduled Measurement पूर्व निर्धारित ताप नलिएमा :

Please ask alternate observer to take measurement if you can not observe due to some reasons, otherwise follow as bellow : आफ रिडिंग लिन आसपास भएमा कुनै अर्को जानिसलाइ रिडिंग लिने अनुरोध गर्ने र त्यो पनि सम्भव नभएको खण्डमा तल अनुसारगर्ने।

Correct (सहि)

When you miss a scheduled measurement, record this in the notebook accordingly

रिडिंग नलिएको दिन र समयलाई फिल्डबुकमा समावेश गर्ने।

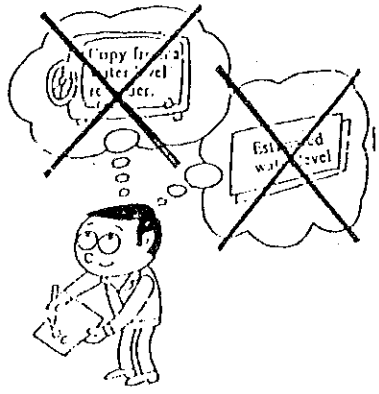


Wrong (गलत)

Don't use estimated value! Your judgement could be mistaken. अन्दाजको आधारमा रिडिंग नलिनुहोला।

There are wrong! → (गलत)

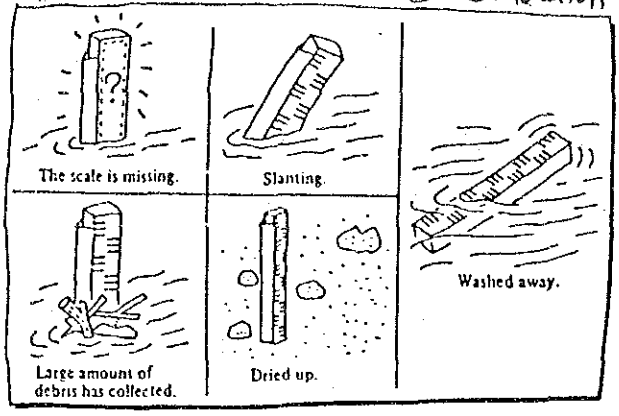
* Estimated value आन्दाजमा गरेको आधार
* Copy from raingauge recorder रेन गेजको रेकर्डबाट सारिएको आधार।



9) Contact the Regional office [निम्न अवस्थामा क्षेत्रीय कार्यालयमा सम्पर्क राख्ने]

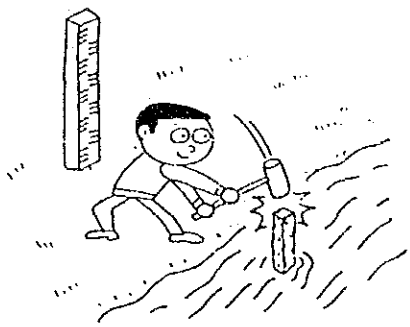
a. Immediately contact the Regional office in any of the following circumstances.

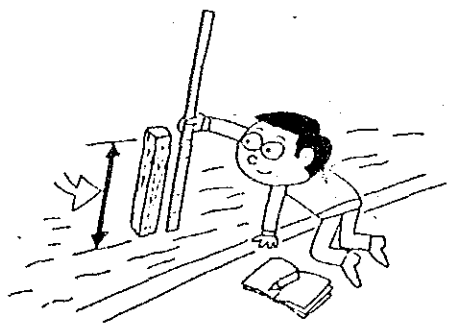
* The scale is missing स्केल (नापलिने वस्तु) हराएको भए।
* Slanting स्याफ गेज बाङ्गोएको भए।
* Large amount of debris has collected फोहोरको ठूलो मात्रा जम्मा भएकोभए।
* Dried up (पानी सुकेको अवस्थामा)
* Washed away स्याफगेजले साइड बगाएर लगेको अवस्थामा।

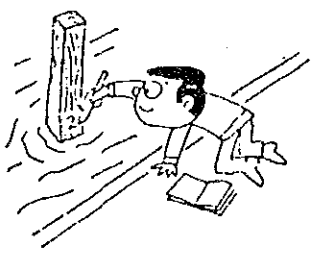


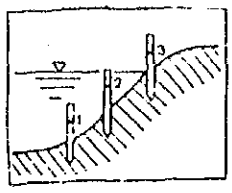
b. Temporary measurement is to be done as possible as you can until recover of damaged staff gauge. बिग्रिएको स्याफगेज गरुन्जेल अस्थाई रुपले नाप लिने विधि;

* Pounding a stake temporarily → अस्थाई रुपमा काठको किलालाई पानीमा गाड्ने।
* Measuring water level by a ruler पानीको सतहलाई स्केलको सहायताले नाप्ने।



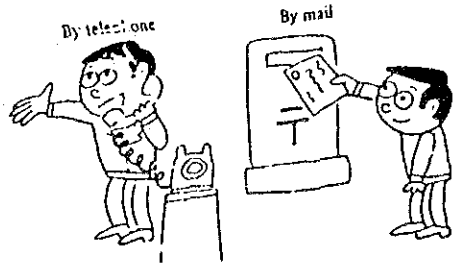






DEPARTMENT OF HYDROLOGY AND METEOROLOGY
WESTERN REGIONAL OFFICE, POKHARE

TELEPHONE : 20299 OR 20448



NATIONWIDE HYDRO-METEOROLOGICAL
DATA MANAGEMENT PROJECT

MANUAL OF RECORDING WATER LEVEL GAUGE FOR OBSERVERS

August, 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

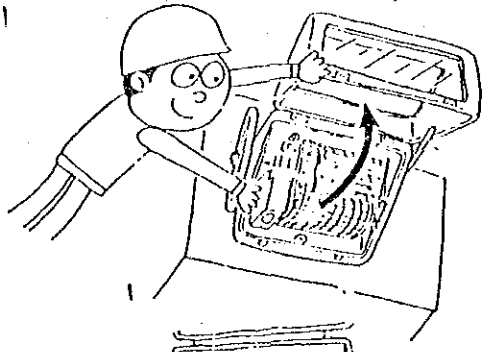
2.2 Observation of Recording water level gauge. रेकर्डिंग वाटर लेभल (पानीको सतह) गेज पढने विधि -

How to change a Recording chart [रेकर्डिंग चार्टलाई कसरि फेर्ने]

A Recording chart is changed once a week, i.e. every Monday morning after ing staff gauge, and simple checking of recording gauge is to be conducted every day after reading of staff gauge : स्टाफ गेज, रिडिंग लिइसकेपछि, प्रत्येक सोमवार रेकर्डिंग चार्ट लाई फेर्ने र रेकर्डिंग गेजलाई चेक गर्ने गर्नु पर्छ।

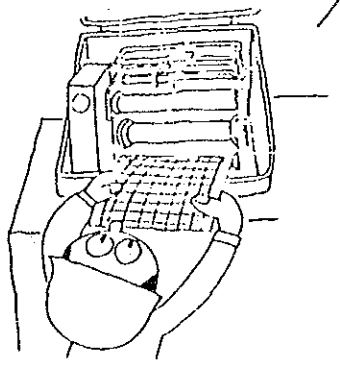
1) Open the cover of the gauge gently.

गेजको ढक्कन लाई बिस्तारै खोल्ने।



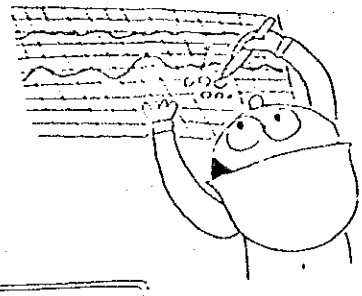
2) Make a mark at the pen's position. Lift the pen and remove the recording chart.

पेन भएको ठाउँमा चिन्हा लगाउने र पेन लाई उचालेर रेकर्डिंग चार्ट झिक्ने।



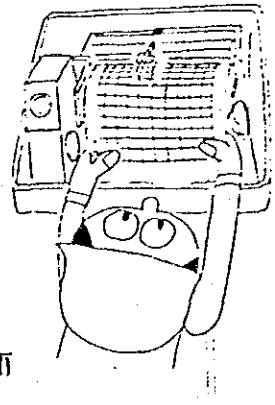
3) Record the data, time, your name and water level and normal staff gauge when the chart is removed.

चार्ट हटाउँदा रिडिंग समय ; आफ्नो नाम र पानीको सतह आदि त्यो चार्टमा लेख्ने।



4) Put in new recording chart.

नयाँ चार्ट राख्ने।

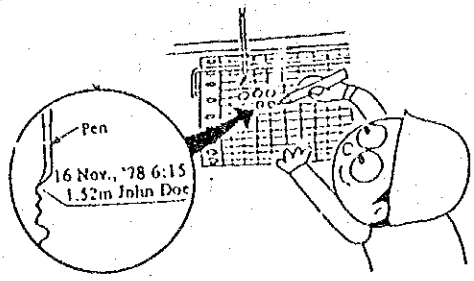


5) If necesarry, adjustment to water level on ordinary staff gauge.

आवश्यक भएको खण्डमा साधारण रेजगेजमा पानीको सतहलाई मिलाउने।

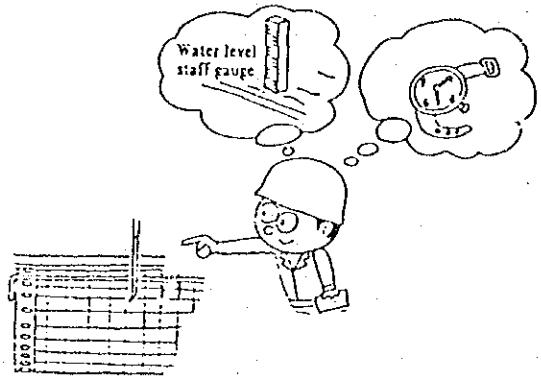
6) Record the data and time of installation, your name and the water level determinded by ordinary staff gauge

साधरण स्टाफगजले देखाएको रिडिंग, स्थापना गरेको समय, आफ्नो नाऊं र पानीको सतह (लेभल) लाई रेकर्ड गर्ने।



7) Start the pen in agreement with the time and the water level as determinded by ordinary staff gauge.

पेनलाई फेरि साधरण स्टाफगेजले देखाएको समय र पानीको लेभलबाट सुरु गर्ने।



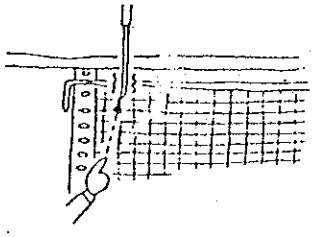
8) Only float-type water level gauge [तैरीनसक्ने किसिमको वाटर लेभलगेज]

Move the pulley, etc. slightly and check whether the pen moves. Particularly in the case of a reverse pen, clock will which direction the pen moves when the water level rises.

पुल्लि लाई अलिकति घुमाउने र पेन चल्छ कि चल्दैन त्यो हेर्ने। पानीको लेभल माथी जाँदा किर्गिस पेन(उल्टो दिशामा राखेको पेन) कुन दिशामा चल्छ त्यो भाग्रो संग हेरेर चेक गर्ने।

9) Wait about three to five minutes after installing the recording paper to check that movement is correct.

नयां रेकर्डिंग पेपर (रिडिंग लेख्ने कागज) को गतिलाई पाँच (५) मिनट समम परेर हेर्ने र त्यसको गतिलाई चेक गर्ने।

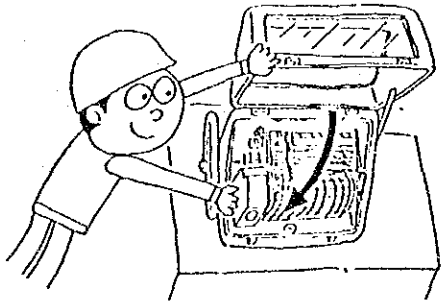


10) Pay attention to the scale and battery remain.

स्केल र बैट्री कति बाँकी छ त्यसमा ध्यान दिने।

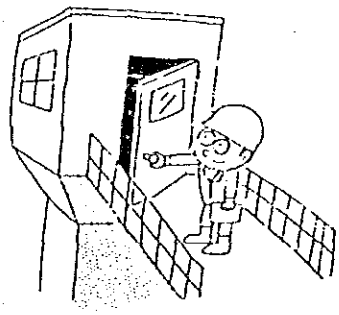
11) Close the cover gently.

ढक्कनलाई बिस्तारै बन्द गर्ने।



12) When leaving, be certain to lock the door of the observation house.

जेजहर, राख्वेको घरबाट बाहिर आउँदा घरमा राम्रो ताला बन्द गर्ने।



13) Caution [सावधानी राख्नु पर्ने कुराहरु]

a) Be gentle with the cover of the gauge when lowering and raising it. जेजको ढक्कनलाई गाथि र तल जेजादा बिस्तारै चलाउने।

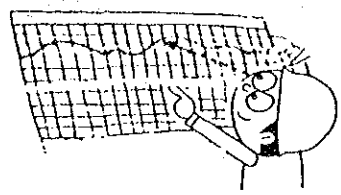
b) Be particularly careful not to leave the cover open. ढक्कन लाइ कुनै हालतमा पान खुल्ला छाड्नु हुदैन।

c) Don't touch mechanic and electric portion of the instrument.

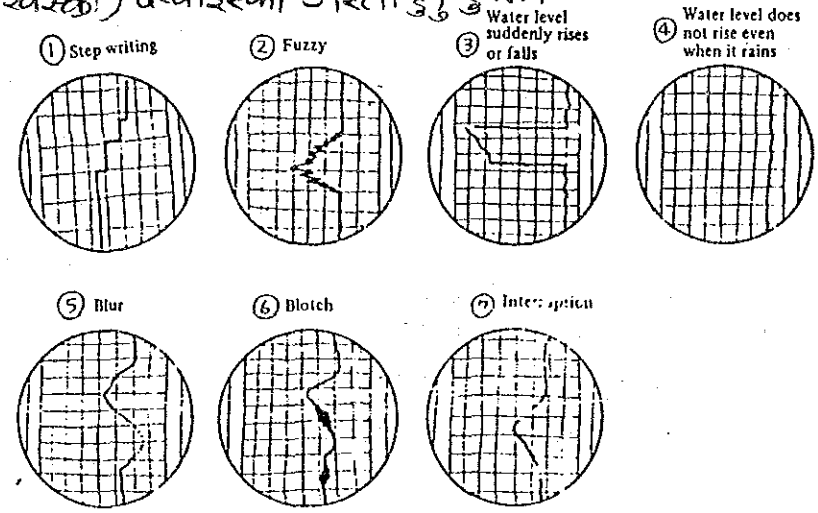
सञ्यन्त्रका यन्त्रिक र विद्युतिय भागहरुलाई छुनु नहाे है।

14) Daily Inspection of the recording water level gauge.
प्रत्येक दिन बिहान वाटरलेभल गेजलाई चेक गर्नु पर्दछ।
After reading of staff gauge, simple checking of the water level gauge is to be conducted every morning as follow :
चेक गर्दा विचार पुर्याउने कुराहरू -

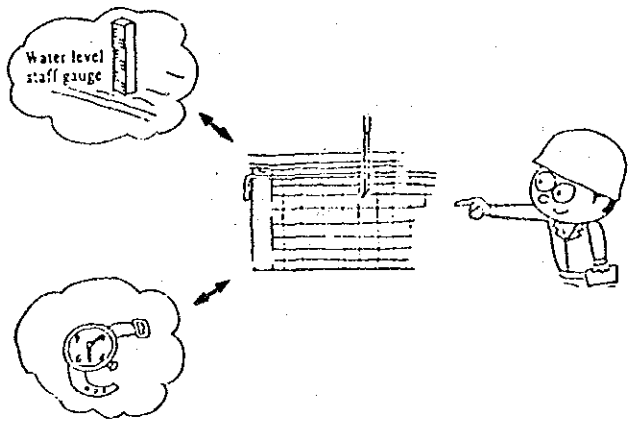
a. Inspection of the recording chart



* No Fuzzy, Blur, Blotch, interruption etc.
रेकर्डिङ चार्टमा कुनै पनि किसिमको अवरुद्ध र रुकावट जस्तै हुन हुँदैन।
तल(लेखिएको) देखाइएको जस्तो हुनु हुँदैन।



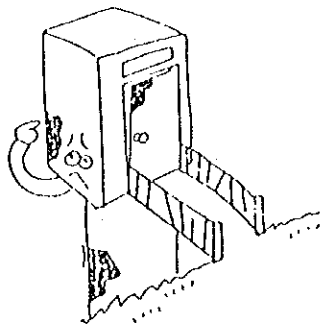
* No big difference between recording and staff gauge reading
स्टाफगेज रिडिंग र रेकर्डिङ रिडिंगमा धेरै अन्तर हुँदैन।



* No big dirrerence of time
समयको पनि धेरै अन्तर हुनु हुँदैन।

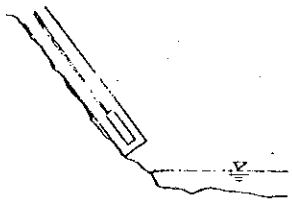
* No stop of clock
घडिलाई रोक्नु हुँदैन।

b. Inspection of the Station
स्टेसनलाई कसरी जाँच गर्ने।

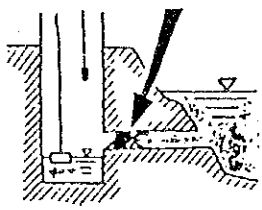


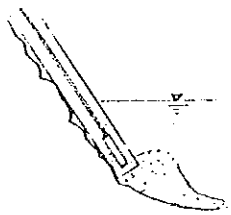
* No damage to the observation station
रिडिंग लिने स्टेशनमा कुनै पनि किसिमको ताडफोड वा खराबी हुन हुदैन।

* Is the pressure sensor under the water level?
के दवाब सेन्सर (प्रेसर सेन्सर) पानी भित्र छ?



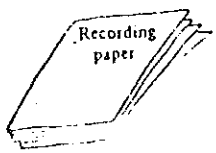
* No blockade of the sensor pipe/water gauge well due to sediment load or debris ?
सेन्सर पाइप वा वाटरगेज मा कुनैपनि किसिमको अवरुद्ध हुन हुदैन।

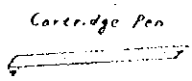




c. Others (अरु)

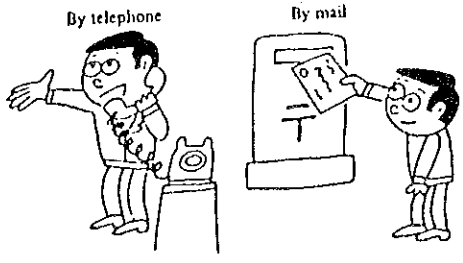
* No shortage of recording charts, pens, field notebook, etc.
रेकर्डिंग चार्ट, पेन र फिल्डबुक को कमी हुन हुदैन।





DEPARTMENT OF HYDROLOGY AND METEOROLOGY
WESTERN REGION OFFICE, POKHARA

TELEPHONE : 20299 OR 20448



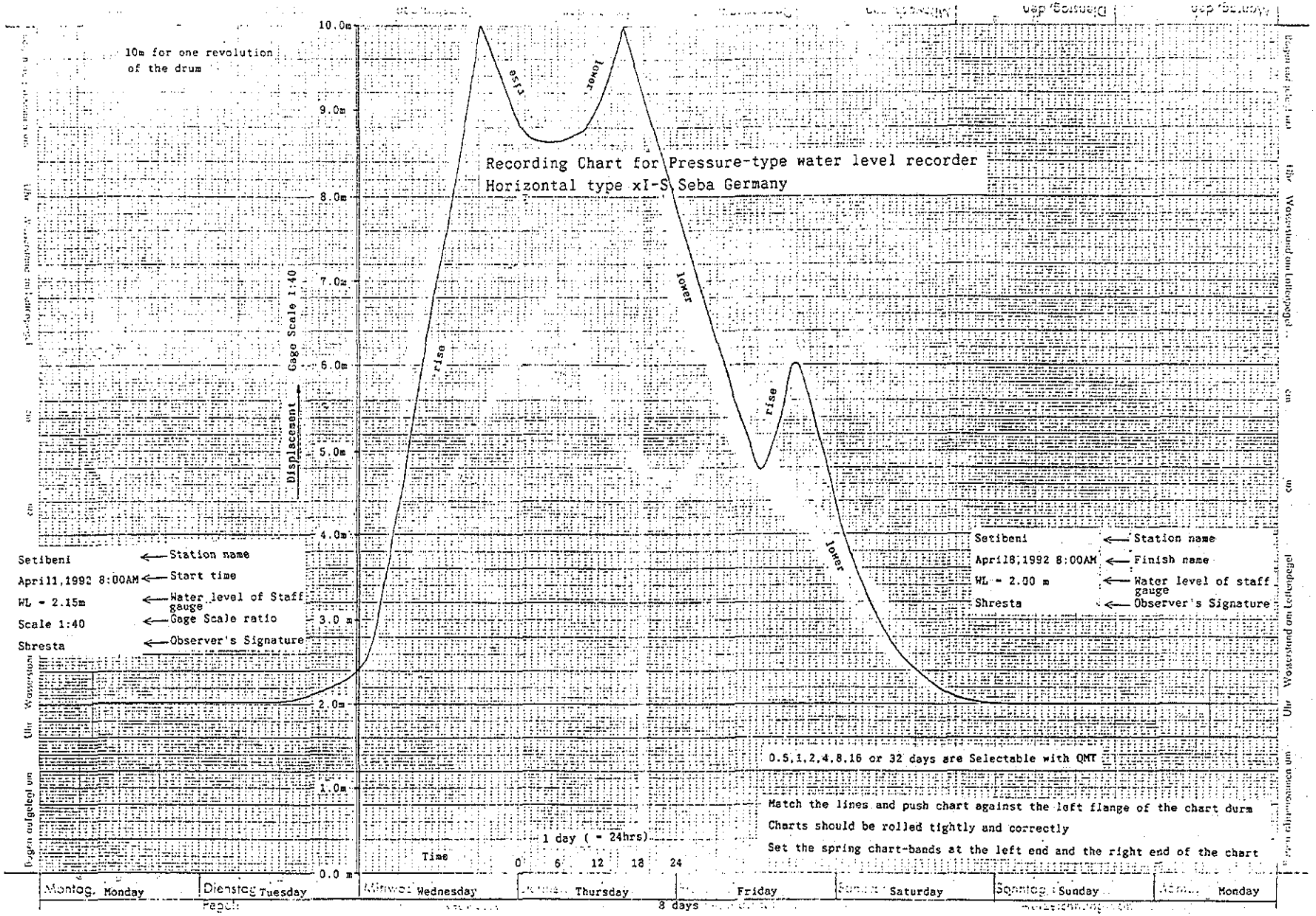


Chart of float-type water level gauge
Scale 1 : 40, 192 hrs.

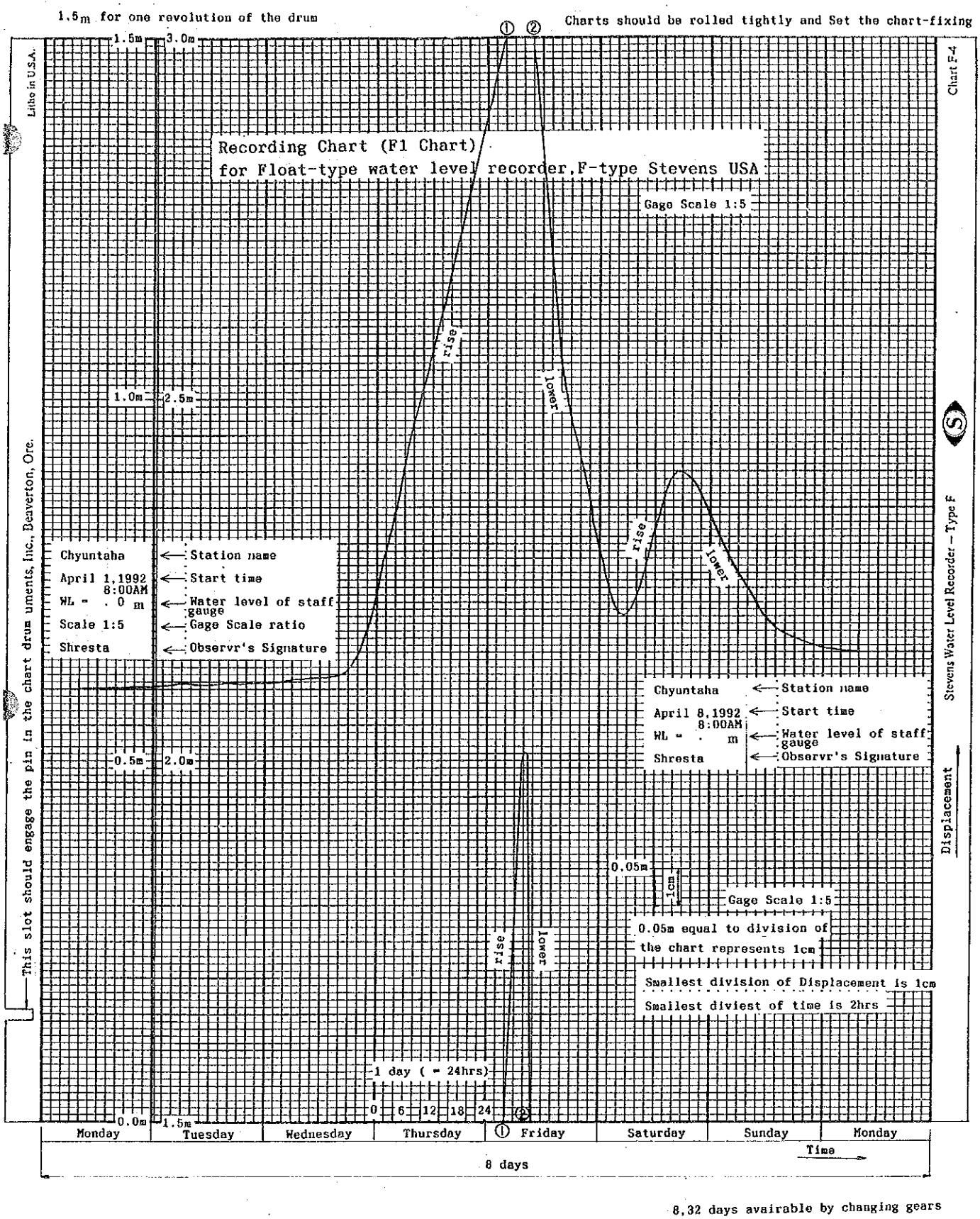


Chart of float-type water level gauge
Scale 1 : 5, 192 hrs.

NATIONWIDE HYDRO-METEOROLOGICAL
DATA MANAGEMENT PROJECT

MANUAL OF INSTALLATION, OPERATION, INSPECTION AND MAINTENANCE FOR INSTRUMENTS AND GAUGING STATIONS

August, 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

PART 1 : INSTALLATION AND OPERATION
PART 2 : INSPECTION AND MAINTENANCE

PART 1

INSTALLATION AND OPERATION

CONTENTS

PART 1 : INSTALLATION AND OPERATION

Page

1. PRECIPITATION OBSERVATION

1.1 General

1.1.1 General Requirement

The amount of precipitation, which reaches the ground is expressed as the vertical depth. Method of measurement is classified into two types; point rainfall measurement such as ordinary and recording raingauge and areal rainfall measurement such as rainfall radar and satellite.

1.1.2 Site Selection

The precipitation is subject to the effect of the wind, i.e. wind speed and wind turbulence. In case of snowfall, this effect is much more pronounced to measure true precipitation. To measure true precipitation, following consideration should be given for the selection of site:

(1) Wind speed at the level of the gauge orifice should be as small as possible:

   (a) The height of the gauge orifice above the ground should be as low as possible, because the wind velocity increases with height.

   (b) Site on a slope or with the ground sloping sharply away in one direction should be avoided.

(2) There should not be any cutting off of rainfall by surrounding objects:

   (a) The angle from the top of the encircling objects to range from at least 30° to no more than 45°.

(3) Accessibility of the site and availability of observers.

1.2 Time and Frequency of Observation

Frequency of observation 1 time per day
Time of observation 8:45 in the morning everyday
(Ordinary raingauge is emptied after measuring water content.)

1.3 Instrument

1.3.1 Ordinary (Manual) Raingauge

Ordinary precipitation gauge consists of over flow can (outer tube), a measuring tube (inner tube), a funnel and three legged support. Water caught by the funnel rim is funnelled down to the inner tube and when it is filled, water overflows to the other tube, then depth of water deposited is measured in the inner tube. The measuring tube has across-sectional area one-tenth that of the collector and precipitation is measured directly by calibrated measuring stick.

This gauge can be used in measuring the water equivalent of snow if its funnel and inner tube are removed.

- Type : Ordinary raingauge
- Collector diameter : 200 mm
- Height : 1 m

1.3.2 Recording Raingauge

(1) Weighing-type Raingauge

This type rainfall gauge weights directly the rainfall and snowfall without heating device which falls into a bucket set on the platform of a spring balance. The recorder shows the accumulation of precipitation.

The automatic recorder is of dual-traverse pen-type, which is rotated by a 8-day spring powered chart drive. Specification is below. (see Fig. 1.1 and 1.2)

- Manufacturer : BELFORT, USA
- Model : NO. 5-780 series universal recording raingauge
- Operating range : 0 to 300mm (accumulation)
- Collector diameter : 8 inch
- Clock work : Mechanical clock
- Accuracy : 1/2 of 1% F.S. (-40 to 120 F)
- Sensitivity : 0.01 inch of precipitation
- Chart period : 8 days
- Chart Record : 6 inch wide 11 1/2 inch long
- Chart number : 5-4046-MM

Least division Range : 1 mm
Time : 2 hours

- Chart timing Accuracy : within 14 minutes/week
- Gauge weight : 25 lbp
- Gauge height : 35 3/8 inch

(2) Tipping Bucket-type Rain Gauge

This type of raingauge consists of a rainfall collector, tipping bucket and electric counter device. The tilting bucket tilts once per 0.1mm of rainfall and the impulses received from it will be digitally stored in the data logger.

(a) Tipping bucket-type raingauge

- Manufacturer : SEBA HYDROMETRIE, GERMANY
- Model : RG-50
- Collector area : 200 cm^2
- Resolution : 1 pulse / 0.1mm rainfall
- Recording period : depending on the data logger.
- Gauge weight : 3.9 kg
- Gauge height : 346 mm

(b) Data Logger

- Manufacturer : SEBA HYDROMETRIE, GERMANY
- Model : MDS II
- Memory capacity : C-MOS-RAM
  56 Kbyte (30,000 impulses i.e. max 3,000mm rainfall)
- Input channel : 1 channel Digital (impulses)
- Communication : RS232C
- Accuracy of clock : 2 minutes per year
- Operation temperature : -30 to 70°C
- Humidity : 100% not condensing
- Power supply : 10.5 V (7 X 1.5 V)
- Dimension : D 100mm L 300mm

1.4 Installation

1.4.1 Ordinary (Manual) Raingauge

The three-legged support is tucked on the concrete foundation and the rim should be kept on levelled position at specified height.

1.4.2 Recording Raingauge

(1) Weighing-type Raingauge

Installation procedure is as follows:

(a) Imbed the support base in the concrete foundation, then fix the gauge to the support base with bolts.

(b) Remove the collector and catch bucket.

(c) Remove the bucket platform, five(5) screws and washers, and gauge housing from the base.

(d) Install the machined gauge housing shoulder horizontal on the support base and tighten bolts. Level it carefully and accurately.

(e) Remove the shipping tie holding the pen arm to the pen shifter.

(f) Loosen the mechanism locking screw until the top lever is stopped by limit screw.

(g) Remove the stop sleeve.

(h) Set the dashpot between the mechanism frame and fill the dashpot cylinder damping fluid.

(i) Set the bucket on its platform.

(j) Replace the chart drive mechanism.

(2) Tipping Bucket-type Raingauge

Installation procedure is as follows:

(a) After making concrete foundation and installing stand, then fix the gauge to the stand with bolts.

(b) Remove the outside cylinder and install it level and tightly. Carefully and accurately level it so that the tilting bucket is well balanced.

(c) Connect it to the date logger.

(d) Install the outside by cylinder.

1.5 Method of Observation

1.5.1 Ordinary (Manual) Raingauge

A graduated measuring cylinder and a graduated dip rod are in common use for manual rainfall observation. A measuring cylinder should be clear and have low coefficient of expansion. Calibrated measuring lines are marked with the size of the gauge. Dip rods should be made of suitable material which does not absorb water to any appreciable extent.

1) When the water content is less than a full inner tube:

   (a) Remove the funnel before measuring the water content, being careful not to tilt the inner tube.

   for a graduated dip rod

   (b) Dip the measuring stick vertically down into the inner tube.

   (c) Lift the measuring stick and take the recording of the water depth indicted by the wetted portion of the stick.

   for a graduated measuring cylinder

   (b') Keep the cylinder vertical, then read water depth of the cylinder.

   (c') Reading accuracy should be taken to the nearest tenth of millimeter. Write the value on the rainfall card.

   (d') Discard the water thoroughly after it has been measured and reset the raingauge carefully in its stand so that the funnel is properly levelled.

2) When the water content has overflowed the inner tube:

   (a) After carefully removing the funnel, gently lift the inner tube and measure water depth, then discard the tubeful content thoroughly.

   (b) Refill the measuring tube by water deposited in the overflow container (outer tube) and repeat the above procedures.

   (c) Add the results to obtain the total amount and write the value on the record card.

In case that there is less than 0.1mm water in the inner tube, record rainfall amount 'T' mm. In case that there is no water, record rainfall amount '0.0 mm'.

1.5.2 Recording Raingauge

(1) Weighing-type Raingauge

1) Change the chart:

Once a week, 9:00 o'clock every Monday after measuring ordinary rain gauge.

2) Procedure of changing the chart

The undermentioned procedure should be followed to change charts:

(a) Open the sliding access door, and make a short vertical mark (time check) on the chart by lightly touching the bucket platform.
If chart drive has stopped, turn the chart cylinder slightly in both directions to mark the existing pen position.
If the pen is not making a trace, indicate the pen position by a dot enclosed in a circle.

(b) Lift the pen off of the chart by moving the pen shifter.

(c) Remove the collector, and empty the catch bucket.

(d) Remove the chart cylinder thumbnut, and remove the cylinder by lifting it up.

(e) Release the chart clip holding chart, and remove the chart.

(f) Wind the chart drive.

(g) Mount new chart to the cylinder.
Wrap chart snugly around cylinder to that:
- time is read from left to right.
- corresponding rainfall graduations meet.
- the bottom edge of the chart is set to the cylinder flange.
- the folded end of the chart overlaps the opposite end.
- the crease in the fold is at the right-hand edge of the both the notch in the upper edge of the cylinder and slot in the cylinder flange.
Clamp the chart cylinder by placing the clip.

(h) Replace the chart cylinder and thumbnut on the chart drive mechanism spindle.

(i) Push in pen shifter to return the pen almost to the chart surface.

(j) Set the pen to the zero line with coarse and fine adjustment screws.

(k) Set chart to time by first turning the cylinder clockwise past the correct time and then returning it counterclockwise to the correct time.

(l) Push the pen shifter all the way in to put the pen on the chart. Lightly touch the bucket platform to make a time check on the chart.

(m) Close and padlock the access door.

(2) Tipping Bucket-type Raingauge with Data Logger

1) Retrieve the data stored in data logger

Every one or two months is recommended to retrieve stored data. It depends on total amount of accumulating rainfall i.e. in case of more than 3,000 mm rainfall, 56 kbyete memory overflows.

2) Procedure of retrieve/operation of data logger

Start operation of data logger

(a) Connect data logger to the HT-100 (Service, retrieve and operation unit) with connection cable.

(b) Switch on the HT-100

(c) Set the initial data (factor A, B) and time.

(d) Start the measurement.

Retrieve stored data

(a) Connect data logger to the HT-100 (Service, retrieve and operation unit) with connection cable.

(b) Switch on the HT-100 and insert Memory card

(c) Stop measurement

(d) Retrieve data into the Memory card from HT-100

(e) Start measurement

1.5.3 Solid Precipitation

(1) Ordinary (Manual) Raingauge

The water equivalent of snow is measured as follows:

(a) Lift the overflow container and carry it indoors. Add measured hot water in the overflow container where the frozen precipitation is deposited until it is melted.

(b) Pour the melted water into the inner tube and then measure the depth by dipping the measuring stick into the inner tube.

(c) Refill the measuring tube by remaining water in the overflow container and measure the depth as the same procedure.

(d) Add the results to obtain the total amount then minus hot water added.

(2) Weighing-type Recorder Raingauge

(a) Remove the funnel fixed to the bottom of the collector.

(b) Add an antifreeze solution composed of two pints of ethylene glycol and three pints of methyl alcohol. (1 pint = 0.471) Add six ounces of 10W motor oil to retard evaporation.

(c) Do not make any adjustment to the gauge after adding it.

(d) The catch bucket should be emptied and recharged with fresh anti-freeze and oil whenever the gauge level and the prevailing temperatures indicate that freezing of catch is probable.

2. WATER LEVEL OBSERVATION

2.1 General

2.1.1 General Requirement

Records of discharge are computed from the relation between stage and discharge, as defined by periodic discharge measurements and a systematic record of stage, or from a measuring structure, either laboratory or field calibration.

2.1.2 Site Selection

The ideal gauge site should satisfy the following criteria:

(a) The general course of the stream is straight for about 100 meters upstream and downstream from the gauge site;

(b) The total flow is confined to one channel at all stages and no flow bypasses the site as subsurface flow;

(c) The stream-bed is not subject to scour and fill and is free of weeds;

(d) Banks are permanent, high enough to contain floods, and are free of bush;

(e) Unchanging natural controls are present in the form of a bedrock outcrop, other stable riffle for low flow and a channel constriction for high flow - or a falls or cascade that is unsubmerged at all stages;

(f) A pool is present upstream from the control at extremely low stages to ensure a recording of stage at extremely low flow, and to avoid high velocities at the stream ward end of stage recorder intakes during periods of high flow;

(g) The gauge site is far enough upstream from the confluence with another stream or from tidal effect to avoid any variable influence the other stream on the tide may have on the stage at the gauge site;

(h) A satisfactory reach for measuring discharge at all stages is available within reasonable proximity of the gauge site. It is not necessary for low and high flows to be measured at the same stream cross-section;

(i) The site is readily accessible for ease in installation and operation of the gauging station.

2.2 Time and Frequency of Observation

1) Staff gauge reading should be conducted as follows:

Frequency of observation : 3 times per day
Time of observation : 8:00, 12:00 and 16:00

Recording chart should be changed at 8:00 o'clock in every Monday morning after reading staff gauge.

2.3 Instrument

2.3.1 Staff Gauge

Staff gauges are either vertical or inclined. Vertical staff gauge consists of enamelled iron sections, each one meter long and graduated every 10 mm.

2.3.2 Recording Water Level Gauge

(1) Pressure Sensor

Water level is measured as a hydrostatic pressure with semiconductor sensor (piezo resistive pressure transducer).

- Manufacturer : SEBA HYDROMETRIE, GERMANY
- Model : DS type
- Measuring range : 0 to 10 m
- Measuring accuracy : 0.1% of total value
- Operating temperature : -5°C to 70°C

(2) Water level recorder

- Manufacturer : SEBA HYDROMETRIE, GERMANY
- Model : Horizontal water level recorder XI-S
- Measuring accuracy : 0.3% of measuring range
- Power Supply : 9 V (1.5 V X 6)
- Clock work : Mechanical clock
- Interval of meas. : 8 and 32 days, gear changeable
- Operation temperature : -25°C to 70°C
- Dimension of drum : 122 mm dia 250 mm height providing reversing spindle
- Recording weight : 9 kg

(3) Data Logger

– Manufacturer :	SEBA HYDROMETRIE, GERMANY
– Model :	MDS II
– Memory capacity :	C-MOS-RAM 64 Kbyte (approx. 40,000 values)
– Input channel :	1 channel digital
– Communication :	RS 232 C
– Accuracy of clock :	2 minutes per year
– Operation temperature :	-30°C to 70°C
– Humidity :	100% not condensing
– Power supply :	10.5 V (7 x 1.5 V)
– Dimension :	D 100mm L 300mm
– Interval :	from 0.5 sec to 13 days

(4) Float-type water level gauge

The rise and fall of the float with changing water levels turns the drum proportionally, as the time-controlled marker moves across the chart at a constant speed and specification is below: (see Fig. 2.1)

– Manufacturer :	STEVENS, USA
– Type :	F type
– Model :	Model 68
– Measuring range :	Depending on the length of the float line
– Measuring accuracy :	0.6mm
– Operating temperature :	-5°C to 70°C
– Float :	203mm diameter
– Float pulley :	375mm diameter
– Gauge scale :	1 : 5 (Water level change for 1 revolution of drum is 1.5m)
– Recording period :	8 days (1/2 - 1 - 2 - 4 - 8 - 16 - 32 days selectable)
– Chart size :	244mm wide 300mm long (Value of smallest chart division is 2 hours of 8 days, value of smallest chart division is 10mm)
– Clock :	Quartz Multispeed Timer battery driven (6 X 1.5V)
– Clock accuracy :	0.02% maximum variation
– Operation temperature :	-30°C to +50°C
– Recorder weight :	9 kg

2.4 Installation

2.4.1 Staff Gauge

Staff gauge should be installed according to following requirements.

(a) Staff gauge should be set so that only one datum for the gauge height record is used for the life of the station.

(b) The gauge should be set so that a reading of zero is below the lowest anticipated stage to avoid negative reading, so stable riverbed should be selected.

(c) Two or three bench marks should be established to control the staff gauge.

2.4.2 Recording Water Level Gauge

(1) Float-type Water Level Gauge

This type of instrument is placed inside a stilling well to criminate movement carried by surface waves and other transitory effects. Following consideration should be taken into account for the establishment of float-type gauge.

(a) The stilling well should be long enough for its bottom below the minimum anticipated stage and its top preferably above the estimated flood stage.

(b) The inside of the well should be large enough to permit free operation of float; normally 1.2 m dia or inside dimension 1.2 m by 1.2 m, minimum 0.5 m inside diameter available.

(c) The intake pipe should be properly located and sized to minimize surge and continue to operate against silt deposit; most common 0.1 m diameter pipe and vertical intervals of about 0.5 m, at right angles to the direction of flow and to be level. For the prevention of blockage of the pipe flushing system should be applied.

(2) Pressure-type Water Level Gauge

This type gauge may be used to take advantage of existing natural or artificial features in a stream without costly excavation for well or intake and without need for any external structural support. This gauge is especially well suited for short-term installation.

Following consideration should be taken into account for installation of pressure-type gauge:

(a) Pressure sensor should be placed at least 0.15 - 0.20 m below the lowest anticipated stage and the recorder house should be located above the reach of flood.

(b) The electric cable connecting the sensor and recorder should be encased in a metal pipe or conduit, or buried to protect it from the animals, vandalism and flowing boulders under water.

(c) The sensor should be safe for flowing boulders and debris. The sensor should not be buried in sand and mud.

Staff gauge should be established in close to the recording gauge for checking the gauge height indicated by the recording gauge.

2.5 Method of Observation

2.5.1 Staff Gauge

Following proper observation is necessary for accurate and reliable observation.

(a) Read the water level from a position near the mark and from a horizontal position.

(b) Read the water level from the exact middle of the water mark.

(c) When the water surface is surging rapidly as a result of wave action record the mean of the elevation of the peak and trough of the wave.

(d) When the water line is difficult to read under the conditions of poor light and/or clean water, use some floatable materials against the gauge.

(e) Check the proper staff gauge height regularly and every after flood with bench mark.

2.5.2 Recording Water Level Gauge

(1) Float-type Water Level Gauge

It is essential for proper operation of this recording gauge to compare the water level indicated by recording gauge in the well with outside water level from staff gauge, because some possible sources of error such as faulty intake operation i.e. blockage

of the pipe, accumulation of sediment in the well, float leakage, float tape slippage where it joints the float etc. exist.

1) Change the chart:

Once a week, 9:00 o'clock on every Monday, adjustment of water level from outside staff gauge and set of correct time are conducted. (See Fig. 2.2)

2) Procedure of changing the chart

The undermentioned procedure should be followed when changing charts:

(a) Open the cover of the recorder gently.

(b) Make a mark at the pen's position by rotating a chart drum, then lift the pen and remove the chart drum.

(c) Write the date, time, your name and water level from staff gauge reading at the time of removal.

(d) Set the new recording chart on the drum tightly and properly.

(e) Place the chart drum at proper position and adjust the present time by rotating the drum. If necessary, adjust water level to staff gauge reading at present.

(f) Write the date, time of installation, your name and water level from staff gauge at the time of installation.

(g) Start the pen in agreement with the time and water level as determined by ordinary staff gauge.

(h) Wait about a few minutes after setting the chart to confirm proper operation.

(i) Check battery or wind a clock.

(j) Close the cover of the recorder gently.

(2) Pressure-type Water Level Gauge

It is also important for proper operation of this recording gauge to compare the recording water level with staff gauge reading and find such error sources as sediment deposition in the sensor pipe, the leak of the cable and joint.

The time intervals of recording are usually 10 to 15 minutes. The short-term intervals or continuous operation require at flashy stream and flood events and the long-term intervals require at large stream.

1) Change the chart

See the same chapter of float-type water level gauge.

2) Retrieve data from data logger

Frequency of data retrieval depends on intervals of recording. 64 kbyte memory is available for about 40,000 data i.e. 10 minutes intervals for about 6 months.

3) Procedure of changing the chart

See the same chapter of float-type water level gauge.

4) Procedure of operation and data retrieve from data logger.

See the same chapter of tipping bucket-type rain gauge with data logger.

3. DISCHARGE MEASUREMENT

3.1 General

3.1.1 General Requirement

Discharge can be measured by several different methods and the choice of methods depends on the conditions encountered at a particular site.

Many discharge measurements are necessary at a new station to define the STAGE-DISCHARGE relation, then periodic measurements are necessary to follow the changes in the STAGE-DISCHARGE relation.

In low level water with slow flowing velocity, wading rod and boat with a current meter are used. Cable suspended current meter in combination with single-drum or double-drum winch cable way is effective for measurements in deep water and high flowing velocity such as flood. Bridge may be used to carry out discharge measurements by using handline, a sounding reel supported by a bridge board or portable crane to suspend the current meter and sounding reel.

3.2 Schedule of Discharge Measurement

Factors to be considered in scheduling the number and distribution of discharge measurements include:

(a) Stability of stage-discharge relationship and
(b) Seasonal discharge characteristics and variability

Frequent discharge measurement at new stations to define the stage-discharge relationship throughout the entire range of stage and periodic measurements at existing stations to follow the changes in the stage-discharge relations are required.

Also adequate definition of discharge during flood is of prime importance.

Recommended frequency of discharge measurements is a minimum of ten (10) discharge measurements per year.

3.3 Instrument

3.3.1 Double-Drum Winch

Double-drum winch is applied for the bank operation, one drum for the two cable for hauling the trolley with the current meter, the other for the suspension conduction cable for raising and lowering the current meter. (see Fig. 3.1 and 3.2)

The horizontal and vertical position of the current meter can be read off by two counters, depth and distance counter of the double-drum winch as illustrated in Fig. 3.3 and specification is mentioned below:

– Manufacturer :	A. OTT, Germany
– Type :	Type SK50 Cable way suspended current meter : 100 kg Width of span : 300 m in maximum
– Maximum load of winch :	120 kg
– Dimension of winch :	H 900mm W 400mm L 940mm
– Weight of winch :	120 kg
– Accessories :	Manual float drop device and vertical angle protractor (improvement by study team)

3.3.2 Current Meter

(1) Propeller-type Current Meter

This type current meter counts impulses generated after each propeller revolution by water-tight magnetic contact system. This type is better suited to the river with turbulent and shifting streams.

This current meter applies for both cable suspended and fixing rod use.
Specification of this meter is mentioned below:

– Manufacturer :	A. OTT, GERMANY
– Type :	C31 Universal Current Meter
– Accuracy :	1% of measuring range
– Measuring range :	Depending on the type of propeller and weight as follow:

Propeller size		maximum flow velocity (m/sec)	starting speed (m/sec)	range of component effect	material
125 mm dia.	0.25m pitch	5.0	0.025	5	brass
125 mm dia.	0.25m pitch	5.0	0.035	5	plastic
125 mm dia.	0.50m pitch	6.0	0.040	5	brass
125 mm dia.	0.50m pitch	6.0	0.060	5	plastic
125 mm dia.	1.00m pitch	10.0	0.055	5	brass
80 mm dia.	0.125m pitch	3.0	0.040	5	brass
100 mm dia.	0.125m pitch	2.5	0.030	45	brass
100 mm dia.	0.25m pitch	5.0	0.035	15	aluminum

Type of weight	flow velocity
sinker 5 kg	0.03 to 1.0m/s
sinker 10 kg	ditto
middle piece 25 kg	0.03 to 3.0m/s
middle piece 50 kg	0.03 to 3.5m/s
middle piece 100 kg	0.03 to 6.0m/s

Digital Counter Set for A. OTT current meter

The Z 215 counter set serves, together with A. OTT current meter, for determination of the flow velocity.

- Manufacturer : A. OTT, GERMANY
- Type : Z 215 Counter set
- Maximum pulse sequence : 50 per sec.
- Measuring range :
  presetting of time 0.1...999.9 sec in intervals of 0.1 sec
  presetting of number of pulses 1...9999 pulses
- Accuracy :
  At present time : pulse period +/-0.5 pulse
  At present of number of pulses : time error +/-0.1 sec
- Operating temperature : -20 to +60 Degree centigrade
- Power supply : battery 6 V
- Battery life : 250hrs without buzzer
  100hrs with buzzer
- Weight : approx 1.1 kg

(2) Price-type Current Meter

This type current meter counts the number of clicks generated by intermittently close of electrical circuit after each revolution. The number of clicks is counted by both a headphone and a digital indicator.

Both a cable suspended instrument and fixing one on the rod are available. Specification of the meter is shown below:

- Manufacturer : TELEDYNE GURLEY, USA
- Type : MODEL 622
- Measuring range : 0.2 to 23 ft/sec
- Measuring Accuracy : +/- 2%
- Circuit closing : each/each fifth revolution

Digital indicator for Price current meter

Automatic computation of flow velocities for the MODEL 622 and 625 meter is provided. In addition, an averaging feature is incorporated into the MODEL 1100 to smooth out flow velocity variations.

– Manufacturer :	TELEDYNE GURLEY, USA
– Type :	NO. 1100 Digital Indicator
– Connection :	MODEL 622 or MODEL 625
– Velocity range :	0 to 25 ft/sec
– Sample time :	4 sec (automatic mode) 16 sec (averaging mode)
– Power supply :	9 V battery
– Battery life :	alkaline approx. 100hrs
– Weight :	approx 400 grm

(3) Pygmy Price-type Current Meter

This type current meter is used for measuring flow of water in shallow stream where the depth of water is small or the velocity is low.

The construction is similar to the standard No. 622 model except for the smaller size. *There is no provision for cable suspended measurement.*

– Manufacturer :	TELEDYNE GURLEY, USA
– Type :	MODEL 625
– Measuring range :	0.05 to 3 ft/sec
– Measuring Accuracy : :	+/- 2%
– Circuit closing :	each revolution

3.4 Installation

3.4.1 Double-drum Winch Cable Way

Procedure of installation is given below and illustrated in Fig. 3.4:

(a) Election of bearing pole.

(b) Fix the angle bucket for track cable and pulley block to the winch post.

(c) Fix the angle bucket and guide pulley to the opposite post.

(d) Spread the track cable and tension it to the desired cable sag (L/70, where L : span of cable way)

(e) Fix the double-drum winch to the winch post

(f) Using auxiliary cable, hauling the towing cable across the river from the bank of the winch post, then run the towing cable back to the winch post and arrange it on the pulley block and wind it around the winch.

(g) Place trolley and cable support pulley and attach lower half of tow cable to the trolley.

(h) Arrange suspension conduction cable over the guide pulley and fasten it to the suspension current meter.

3.5 Method of Measurement

3.5.1 Discharge Measurement by Current Meter

(1) Selection of Verticals

Accuracy of a discharge measurement depends on number of verticals at which observation depth and velocity are obtained. The number of verticals to be measured depends on:

- regularity of flow
- shape of the profile (shallow, deep, or irregular)
- available time (less at rapidly changing water levels during flash floods)

In general, it is recommended that the number of verticals in a cross section is such that:

(a) the interval between any two verticals should not be greater than 1/20 of the total width.

(b) the discharge per section does not exceed 10% of the total discharge.

However, it might be necessary at deeper parts of the cross section to take the vertical at closer distances than in the shallow parts. For very accurate measurements the number of vertical should be increased. In practice that normally some 10 to 20 verticals are required.

(2) Measuring Points in Vertical

The velocity distribution in a vertical can often be approximated by a parabolic, elliptic or other curve. Based on this assumption the mean velocity can be found by limited number of points and evaluating the results arithmetically. The number and depth of the measuring points in one vertical should be chosen such that the arithmetic average of the velocities in these points most closely approximates the true average velocity in the vertical.

The two-points method is used where the velocity distribution is normal and depth is greater than about 60 cm. The one-point method is used for shallower depths. Other methods are used depending on the stream condition and the accuracy desired.

The mean flow velocities can be approximated by measuring the velocity at the following depth:

water depth (d) (m)	Number of flow measurements in vertical	Depth of measurements
< 1.0	1	0.6 d
> 1.0	2	0.2 d & 0.8 d

Typical vertical velocity is given in Fig. 3.5. Mean vertical velocity is calculated by means of following manners:

(a) Vertical velocity curve
(b) Two points (0.2 and 0.8)
(c) Six-tenths depth (one point)
(d) Three points (0.2, 0.6 and 0.8)
(e) Two tenth depth (one point, high velocity)
(f) Sub-surface velocity (one point, at least 0.60cm)
(g) Surface velocity (one point, only an optical current meter)
(h) Integrated
(i) Five points (surface, 0.2, 0.6, 0.8 and bed)
(j) Six points (surface, 0.2, 0.4, 0.6, 0.8 and bed)

(3) Measuring Time

The minimum time of measurement should be taken such as to average out the short time variations in flow velocity. On the other hand, the measuring time should be kept short enough in order to limit the total time for current metering. A normal measuring time is in the order of 40 to 70 seconds.

(4) Air/Wet Line Correction

If the weight is not sufficient when the velocity of the flow is high, the sounding line will show a deviation from the vertical. The depth counter on the winch shows a depth which is more than the actual depth. Therefore, a correction should be applied. The angle between the true vertical and the suspension/conductor cable has to be measured during current metering.

The accuracy of the measurement is increased if deviation from the vertical can be limited by using a sufficient weight.

The relation between the correct depth (d) and the observed depth (d_{ob}) based on the observed angle (φ) is given below:

$$d = [d_{ob} - X (\sec \varphi - 1)] [1 - k]$$

where,

- d: correct depth
- d_{ob}: observed depth
- φ: the angle between the line and the vertical
- X: the distance from the water surface to the point of suspension of the sounding line.
- k: Coefficient factor (See the following table)

The angle (φ) should not exceed 30 degree because the uncertainties in this estimation are such that significant errors may be introduced.

Coefficient factor k for given value of φ

φ	k	φ	k	φ	k
4	0.0006	14	0.0098	24	0.0296
6	0.0016	16	0.0128	26	0.0350
8	0.0032	18	0.0164	28	0.0408
10	0.0050	20	0.0204	30	0.0472
12	0.0072	22	0.0248		

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On the other hand, the correction for measuring error of depth has the air correction and wet line correction as shown in Fig. 3.6. The air correction and wet line correction are shown in Table 3.1.

(5) Computation of Discharge

Discharge should be computed either arithmetically (mid-section or mean-section method) or graphically (depth-velocity integration or velocity-counter method). The mid section method is simpler to compute and a slightly more accurate procedure than the mean-section method and in common use.

1) Mid-section Method

In the mid-section method of computing a current meter measurement it is assumed that the velocity sample at each vertical represents the mean velocity in a partial rectangular area. The area extends laterally from half the distance from the preceding observation vertical to half the distance to the next and vertically, from the water surface to the sounding depth.

The partial discharge is computed for any partial section at vertical x as

$$Q_I = V_I \frac{b_{(x+1)} - b_{(x-1)}}{2} d_I$$

where,

Q_I	=	discharge through partial section x
V_I	=	mean velocity at vertical x
bx	=	distance from initial point to vertical x
$b_{(x-1)}$	=	distance from initial point preceding vertical
$b_{(x+1)}$	=	distance from initial point to next vertical
d_I	=	depth of water at vertical x

The preceding vertical at the beginning of the cross-section is coincident with vertical 1; the next vertical at the end of the cross-section is considered coincident with vertical n.

Thus,

$$Q_1 = V_1 \frac{b_2 - b_1}{2} d_1 \qquad \text{and}$$

$$Q_n = V_n \frac{b_n - b_{(n-1)}}{2} d_n$$

The summation of the discharge for all the partial sections is the total discharge of the stream as illustrated in Fig. 3.7.

2) Mean-section Method

Partial discharge is computed for partial sections between successive observation verticals. The velocity and depth at successive vertical are each averaged, and the section extends laterally from one observation vertical are each averaged. Discharge is the product of the average of two mean velocity, the average of two depths.

(6) Operation of OTT Z215 Counter (propeller type current meter, A. OTT)

By the Z215 counter set together with A. OTT current meters, the propeller revolutions per unit of time are measured for determination of the flow velocity. The following measuring range can be chosen:

(a) Measurement with present number of pulses
switch position "Imp"

(b) Measurement with present number of time
switch position "Time"

(c) Integration measurement
switch position "Int"

(d) Integration Measurement with ground feeler
switch position "+ 6 sec."
This type of measurement is especially intended for cable suspended current meter with a ground feeler. Cable suspended current meter is lowered with constant speed. When touching the ground, the feeler stops measurement.
After having lifted the middle piece and pressing the key, the current-meter pulses are counted anew for 6 sec repeatedly.

(e) Integration Measurement with adjustable remaining-term
switch position "+ Time"
After having lifted the middle piece and pressing the key, the current-meter pulses are counted anew for input remaining-term repeatedly.

(f) Integration Measurement with fixed time interval
switch position "+ Time"
For current meter measurements, the number of propeller revolutions per sec. is calculated as follows:

$$n = \frac{\text{number of pulses X propeller revolution per pulse}}{\text{measuring time in sec.}}$$

Then calculate the velocity by calibration equation or rating table shown in Table 3.2.

(7) Operation of Model 1100 Digital Indicator
(Price type current meter, Teledyne Gurley)

(a) Automatic Operation procedure

Press the button once for the type of meter being used and the desired units, then Every four(4) seconds the updated flow velocity is shown.

(b) Automatic Operation - Averaging mode Procedure

Press the button twice for the type of meter being used and the desired units, then Every sixteen(16) seconds the updated flow velocity averaged over four(4) of the standard automatic samples is shown.

(c) Manual operation Procedure

Press RESET button to enter manual operation. Then press START/STOP button once to start counting revolutions and elapsed time. To stop counting and freeze elapsed time press START/STOP button a second time. The stored number of revolutions and elapsed time can be read by using FUNCTION/SELECTION button.

For manual operation, the number of clicks is counted for a time varying from 40 to 70 seconds.

For current meter measurements, the number of revolutions per sec. is calculated as follows:

$$n = \frac{\text{number of pulses X revolution per pulse}}{\text{measuring time in sec.}}$$

Then, calculate the velocity by calibration equation or rating table shown in Table 3.3.

(d) Quantization error

This error can be considerable at very low velocities where only a couple of pulses are obtained during the sampling period, i.e. 4 sec.

It is possible for the meter to have made some portion of a revolution that does not get recorded at the end of sample period.

It should be apparent that at very low velocities it is advantageous to use the manual mode, so very large sample times can be used.

3.5.2 Measurement by Double Drum Winch Cable Way

A cable way installation consists of a track and tow cable stretched between two bearing posts on either side of the river, suspension conduction cable connected with a current meter, bearing posts and double drum winch.

On the track cable, a trolley can be moved from which the current meter can be lowered or raised to the desired depth by means of a double drum winch.

The horizontal movement of the trolley is controlled by a 6mm thick tow cable and the horizontal distance from the trolley to the winch can be read from the counter which is connected to the coupling shaft of the winch. The depth of the current meter is recorded by a depth counter. Both of counters can be zeroed by depressing a lever.

There is no general rule for the choice of the sinker weight. The ISO - STANDARD Handbook gives the following approximate formula:

$$m = 5 V d$$

where : m = mass of sounding weight (kg)
V = mean flow velocity (m/sec)
d = depth of the river (m)

However, from another source the following data were obtained:

Sinker weight (kg)	Velocity (m/sec)	Depth (m)
5 & 10	< 1.0	< 2.0
25	< 3.0	< 5.0
50	< 3.5	< 7.0
100	< 5.0	< 15.0

– Reference

EQUIPMENT LIST FOR DISCHARGE MEASUREMENT

(a) Current meter

(b) Counter set for current meter and connection cable

or

Headphone, Stopwatch and connection cable

(c) Winch
or
Sounding reel
or
Rod

(d) Sounding weight

(e) Last discharge measurement record and cross section

(f) Discharge measurement form

(g) H/Q curve

(h) repair tools

(i) Batteries for counter

(j) Calculator

(k) Velocity table for individual current meter

(l) Watch

(m) Measuring Tape

(n) Rope

(o) Pencil

Following procedure should be taken for discharge measurement:

INSPECTION BEFORE DEPARTURE

(a) Prepare all necessary equipments according to the check list.

(b) Inspect current meter operation according to the check list.

(c) Investigate the latest Stage-Discharge curve and check empty areas on the chart.

(d) Make effective schedule.

(e) Check health condition of technicians.

OBSERVATION PROCEDURE

(a) Assemble the current meter properly.

(b) At the start of measurement, record the water level at the staff gauge along with name of station, date, time, observer's name and required item etc.

(c) Determine the measurement points (number and spacing of vertical) according to the last measurement result so that:
   1) the interval between any two verticals should not be greater than 1/20 of the total width.
   2) the discharge per section does not exceed 10% of the total discharge.

(d) After measuring a water depth of the measurement line, determine the measuring depth in the following manner:

Water depth (d) (m)	Number of flow measurements in vertical	Depth of measurements
< 1.0	1	0.6 d
> 1.0	2	0.2 d & 0.8 d

(e) After the meter is placed at the proper operating depth, start the measurement by means of electric counter or stopwatch.

(f) With a direct reading meter, read it when the needle is stable. Meanwhile with the electric sound or audio device, one measurement time should be around 40 to 70 seconds.

(g) Move to the next vertical and repeat this procedure until the entire cross section.

(h) After measurement, compute the total discharge in site by means of Mean-section method and plot the result on the latest Stage-Discharge (H-Q) chart to confirm accuracy. Sample of discharge measurement notes calculated by means of the mid section method is given in Table 3.4.

(i) If there is some large discrepancy, carry out the measurements once again.

PRECAUTION

(a) During the measurement, the water level should be in the same condition.

(b) The measuring unit of a stopwatch should be one-tenth of a second.

(c) If large amounts of debris are flowing during a measurement, raise the meter up to the safety position.

(d) When applying wading method, stand downstream from the current meter not to affect the current.

(e) If the weight on the sounding line is not sufficient to keep the line within 5 degree of perpendicular to the water surface, correct the observed depth by the vertical angle.

(f) Keep the wading rod vertical and the meter parallel to the direction of flow.

(g) When it is raining during the measurement, don't get the counter, stopwatch, audio device etc wet.

3.5.3 Flood Measurement

(1) Measurement with Float (Float Method)

1) General

The measurement with float is made at the time of high water level, when the measurement with current meter will meet the difficulty.

The float is thrown down on the river from the float projection device attached to cable way or a bridge within a distance between two cross sections predetermined for the float measurement.

The river velocity will be obtained from the time required for the float passing through between two sections. It is desirable that in order to avoid the drift current caused by curve and bad river bed shape, the proposed channel for the measurement of velocity will be selected at the straight river portion where the almost same sectional shape can be expected.

The cross-sectional areas must be measured after the flood has subsided.

2) Selection of Sections

Three sections (A, B and C) will be considered as the sections for measurement of velocity with floats.

Section A:

Section A is the starting section of the float. When the float is put on the river from the cable way or a bridge, the start sign is sent to Section B. Starting point and time are recorded.

Section B:

When the float passes the line of Section B, the sign is sent to Section C by a watchman standing on the point of Section B. Passing time of the float and water level at Section B are recorded.

Section C:

A watchman starts to measure the time by stopwatch immediately on receiving the sign at Section B and C. For the estimation of velocity from this time record, the exact distance between Section B and C shall be obtained in advance.

A travel time of about 20 sec is recommended for measurement. In general, it is recommended that preliminary distance for obtaining a constant velocity is about 30 m and distance for measurement is more than 50 m.

3) Number of Float Measurement

If the flood occurs, the float measurement shall be started before the water level will reach the peak level. The measurement will be continued to the time when the flood is not seen.

The current measurement line is set up along the current of the first cross section. The proportion of water surface width to the distance of float current measurement line is as follows:

Distribution of float measurement line

– For standard

water surface width	< 20 m	20 - 100 m	100 - 200 m	> 200 m
Number of line	5	10	15	20

– For urgent (during flood period)

water surface width	< 50 m	50- -100m	100 -200m	200 -400m	400 -800m	> 800m
Number of line	3	4	5	6	7	8

Source : the River Bureau of the Ministry of Construction, JAPAN

4) Computation of Velocity

The length of floats depends upon the water depth. Table below shows the regulation of the River Bureau of the Ministry of Construction, Japanese Government, about the use of floats. According to this regulation, five (5) kinds of floats will be prepared in accordance with the depth of water.

Length of Float and Coefficient

float	1	2	3	4	5
Water depth (m)	< 0.7	0.7 - 1.3	1.3 - 2.6	2.6 - 5.2	> 5.2
Depth of Draft (m)	surface float	0.5	1.0	2.0	4.0
Coefficient	0.85	0.88	0.91	0.94	0.96

Source : the River Bureau of the Ministry of Construction, JAPAN

On the other hand, the coefficient to be applied to the float-measured velocity should be determined in WMO Guide book as follows:

Float velocity adjustment factor F as function of R

R	F
0.10 or less	0.86
0.25	0.88
0.50	0.90
0.75	0.94
0.95	0.98

R: the ratio of the immersed depth of float to depth of water

Source : GUIDE TO HYDROLOGICAL PRACTICE, WMO

The mean velocity of flow in the panel is equal to the float velocity multiplied by a coefficient which is based on the shape of the vertical velocity profile and relative depth of immersion of the float. Then the mean velocity by float measurement is obtained from the following expression:

$$Vm = \frac{\text{Distance between Section B and C (m)}}{\text{Time when float passes between Sec. B and C (sec)}} \text{ X Coef}$$

5) Preparation of Float

The float can be made of bamboo with a proper length and a diameter of about 4 cm. The knot of the bamboo is taken off by an iron bar, and weight material such as the iron, lead, pebble etc is put into the bamboo. It is better that the unsubmerged portion on the surface is painted white to ease the watch the running float.

For the preparation of the surface float, the circular wood block with a diameter about 30 cm will be provided, and on the center of it, a small flag will be settled.

6) Organization of measurement

Following organization should be established to perform float measurement and their allocation of duties is shown as follows:

One (1) Group leader	All direction concerning the measurement and all responsibility for safety
One (1) Float man	Lower floats into water

One (1) First observer	Signals to second observer when the floats pass the first observation line
One (1) Second observer	Measure the time
One (1) Water level man	Measure the water level during measurement period

– Reference

EQUIPMENT LIST FOR FLOAT MEASUREMENT

(a) Float (The type of floats used should conform to the water depth)
(b) Stopwatch (available one tenth of a second unit)
(c) Watch
(d) Field notebook (data form)
(e) Flags
(f) Rope
(g) Procedure Manual
(h) Latest cross section
(i) Pencil

Following procedure should be taken for observation with floats:

INSPECTION BEFORE DEPARTURE

(a) Before departure, check the tools for float measuring according to the check list.

(b) Make a cross section diagram so that floats can be easily selected to fit the water level and make sure the quantity of the predetermined floats.

(c) Investigate the cross sections of observation lines.

OBSERVATION PROCEDURE

(a) Group leader makes plan and gives instruction to observers for measurement.

(b) Measure the water level before observation at the staff gauges of each observation line.

(c) Float man lowers float into water so as to avoid up and down movement and records measurement time, number of measurement line, number of floats, flowing condition etc.

(d) First observer signals to the second observer when the floats pass the first observation line and records measurement time, number of measurement line, number of floats, flowing condition etc.

(e) When the floats pass the second observation line, second observer presses the stop button and records measurement time, number of measurement line, number of floats, flowing condition etc.

(f) Repeat the above procedure.

(g) After series of measurements, the group leader inspects the observation records.

PRECAUTION

(a) When there is a considerable difference between the flowing courses of the floats, note this in the field note.

(b) Take measures to prevent the floats, stopwatch, notebook etc from getting wet.

(2) Slope-Area Method

1) General

The Slope-area method is one of the most common types of indirect discharge measurements and particularly useful for determining the discharge when it can not be measured directly by using some type of current meter in case of flood, rapid rising or falling flow, flow with ice or debris etc. Estimated discharge of streams is computed on the basis of an uniform flow equation involving representative cross-sectional characteristics, water-surface slope and a coefficient of channel roughness. The drop in water-surface profile for a uniform reach of channel represents energy losses caused by bed and bank roughness.

2) Equation of Uniform Flow

There have been developed and published a large number of practical uniform flow formulas. The best known and most widely used formulas are the Chezy and Manning formulas.

In applying the slope-area method, the Manning equation is preferred in most countries because it is simple to apply and many years of experience in its use has shown that it produces reliable results.

The discharge is computed by using distance between two sections, elevations of flood water and cross section of streams along with a coefficient of roughness. The Manning equation in terms of discharge, Q is given as follows:

$$Q = \frac{1}{n} AR^{\frac{2}{3}} S_f^{\frac{1}{2}} \quad \text{or} \quad Q = KS_f^{\frac{1}{2}}$$

where:

Q = river discharge (m^3/sec)
A = cross sectional area (m^2)
R = hydraulic radius = A/P
P = wetted perimeter (m)
Sf = *friction slope*
n = Manning roughness coefficient
K = the conveyance

The Manning equation was developed under the condition of uniform flow in which the water surface profile and energy gradient are parallel to the stream bed and the area, hydraulic radius, and depth remain constant throughout the reach.

3) Field Procedure

Ideal selection of a reach of channel is the most important step to obtain reliable results. The nearer the reach to an uniform channel the better. During major floods an observer measures height of each staff gauge at the same time at appropriate and frequent intervals.

Under the worst condition such that access roads are blocked or cable ways and bridges are washed out etc., the evidence of the highest stage left by the flood being made of debris, stains, foam line and score marks should be surveyed after the floods.

Requirements to obtain reliable results of the slope-area method are as follows:

(i) Selecting a representative reach of river channel

(a) The length of the reach should be at least 75 times the mean depth in the channel.

(b) The fall in the reach should be equal to or greater than the velocity head or at least 0.50 foot.

(ii) Defining channel cross sections:

(a) A minimum of three (3) cross sections is recommended.

(iii) Measuring the water surface slopes from observed high water marks:

(a) Average the elevation on both banks at each cross section.

(iv) Selecting a suitable roughness coefficient

4) Computing Discharge by Slope-Area Method

In applying the Manning equation, the greatest difficulty lies in determination of the roughness coefficient.

(a) Friction slope (Sf)

The friction loss is computed as follows (See Fig. 3.8).

$$Sf = \frac{hf}{L} = \frac{\Delta h + \Delta hv - k\,(\Delta hv)}{L}$$

where:

L	=	length of the reach (m)
Δh	=	the difference (fall) in water-surface elevation at two sections (m)
Δhv	=	the upstream velocity head minus the downstream velocity head (m)
$k\,(\Delta hv)$	=	energy loss due to acceleration or deceleration in a contracting or expanding reach
k	=	energy loss coefficient k = 0 : contracting reach k = 0.5 : expanding reach

For contracting reach that becomes:

$$Sf = \frac{\Delta h + \Delta hv}{L}$$

For expanding reach that becomes:

$$Sf = \frac{\Delta h + \Delta hv/2}{L}$$

(b) Velocity head (hv)

Velocity head is computed as follows:

$$hv = \frac{\alpha V^2}{2g}$$

where:

α = the velocity head coefficient
V = the mean velocity in the section (m/sec)
g = acceleration of gravity (m/s^2)

(c) Velocity head coefficient (α)

A velocity-head coefficient represents the ratio of the true velocity head to the velocity head computed on the basis of the mean velocity. It is assumed equal to 1.0, if the cross section is not subdivided. For subdivided sections α is computed as follows:

$$\alpha = \frac{\Sigma \left(\frac{k_i^3}{a_i^3} \right)}{\frac{K_T^3}{A_T^3}}$$

where:

k and a : the conveyance and area of the subsection indicated by the subscript i

K and A : the conveyance and area of the entire cross section

$$K = \frac{1}{n} \cdot A \cdot R^{\frac{2}{3}}$$

R : the hydraulic radius (m)

n : the Manning roughness coefficient

(d) Manning roughness coefficient (n)

The roughness coefficient is a measure of the resistance to flow in a channel. The magnitude of the resistance to flow is influenced by the character of the bed materials, cross section, irregularities, depth of flow, vegetation and alignment of a channel. The most important factors which affect the selection of a n value are the type and size of the materials that compose the bed and banks of a channel and the shape of the channel. Cowan developed a procedure for

estimating these factors to determine the value of n for a channel. In this procedure the value of n may be computed by the followings:

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)\, m_5$$

where:

n_0 = a base value of n for a straight, uniform, smooth channel in natural materials
n_1 = a value added to correct for the effect of channel-bed irregularities
n_2 = a value for variations in shape and size of the channel cross section
n_3 = a value for obstructions
n_4 = a value for vegetation and flow conditions, and
m_5 = a correction factor for channel meandering

Proper values of n_0 to n_4 and m_5 may be selected from Table 3.5 according to the given condition.

Table 3.6 gives a list of n value for channels of various kinds. This table will be found very useful as a guide to quick selection of the n value.

Photographs of a number of typical channels, accompanied by brief descriptions of the channel conditions and the corresponding n values are shown in Fig. 3.10.

(e) Discharge equation

Discharge equations for slope-area computations developed from the above basic equations are presented here.

Two (2) sections:

$$Q = k_2 \sqrt{\frac{\Delta h}{\frac{K_2}{K_1}L + \frac{K_2^2}{2gA_2^2}\left[-\alpha_1\left(\frac{A_2}{A_1}\right)^2(1-k)+\alpha_2(1-k)\right]}}$$

Three (3) sections:

$$Q = K_3\sqrt{\frac{\Delta h}{\frac{K_3}{K_2}\left(\frac{K_3}{K_1}L_{1\text{-}2}+L_{2\text{-}3}\right)+\frac{K_3^2}{2gA_3^2}\left[-\alpha_1\left(\frac{A_3}{A_1}\right)^2(1-k_{1\text{-}2})+\alpha_2\left(\frac{A_3}{A_2}\right)^2(k_{2\text{-}3}-k_{1\text{-}2})+\alpha_3(1-k_{2\text{-}3})\right]}}$$

Multiple sections (n = number of sections):

$$Q = K_n\sqrt{\frac{\Delta h}{A + B}}$$

where:

$$A = K_n^2\frac{L_{1\text{-}2}}{K_1K_2} + K_n^2\frac{L_{2\text{-}3}}{K_2K_3} \text{ ----- } + K_n^2\frac{L_{(n-2)\text{-}(n-1)}}{K_{(n-2)}K_{(n-1)}} + K_n^2\frac{L_{(n-1)\text{-}n}}{K_{(n-1)}K_n}$$

$$B = \frac{K_n^2}{An^2 2g}\left[-\alpha_1\left(\frac{A_n}{A_1}\right)^2(1-k_{1\text{-}2})+\alpha_2\left(\frac{A_n}{A_2}\right)^2(k_{2\text{-}3}-k_{1\text{-}2})+\alpha_3\left(\frac{A_n}{A_3}\right)^2(k_{3\text{-}4}-k_{2\text{-}3})+\right.$$

$$\left. \text{----- } \alpha_{(n-1)}\left(\frac{A_n}{A_{(n-1)}}\right)^2(k_{(n-1)\text{-}n}-k_{(n-2)\text{-}(n-1)})+\alpha_n(1-k_{(n-1)\text{-}n})\right]$$

A check should be made for critical or super critical flow conditions at each section.

Sample of computation form of slope-area method is shown in Fig. 3.9.

(3) Optimized Current Meter Measurement

1) General

Shortened and optimized procedures by using current meter should be conducted during flood period.

2) Method

To shorten procedures following one-point measurement should be conducted and the number of verticals should be reduced.

(a) Six-tenths depth
(b) Two-tenth depth
(c) Sub-surface velocity (at least 0.60cm)
(d) Surface velocity (only an optical current meter)

4. SUSPENDED SEDIMENT OBSERVATION

4.1 General

The total amount of sediment transported in the river may be divided into two parts: wash load and bed material load. The wash load moves entirely in suspension while the bed material load may move either as temporary suspended load or as bed load. Suspended load is the sediment which moves in suspension in water under the influence of turbulence.

4.2 Time and Frequency of Sampling

A common feature of rivers on which the floods are produced mainly by rain storms is the non-uniformity of both water and sediment flow. A sufficient number of measurements during flood is needed to follow sediment and water discharge. Therefore, the following frequency of measurement is recommended:

(1) Regular Sampling:

1)	Dry season	:	once a week
2)	Monsoon season	:	once a day

(2) Flood Sampling : hourly sampling (frequent sampling)

4.3 Instrument

There are many samplers which differ in structural design, type of suspension, sampling volume, nozzle size etc.

4.3.1 Depth Integration Sampler

(1) USD or USDH Series

Basic feature	:	Pressure adjusted by chamber
Sampling volume	:	0.471 liter
Depth limitation	:	4.5 m round trip

4.3.2 Point Integration Sampler

(1) USD Series

Basic feature	:	Pressure adjustable open and close by valve
Sampling volume	:	0.941 liter
Depth limitation	:	25 - 40 m

4.4 Method of Sampling

Conventional methods used to measure suspended concentration in a vertical are sampling by point integration and depth integration.

In point integration method, sampling is taken at the point which is decided on the basis of the depth of the river, the grain size of the suspended sediment and the shape of distribution curve.

On the other hand, in the depth integration method sampling is taken continuously while the sampler is moving at a constant transient rate along the vertical. The sediment concentration of the sample should be representative of the average concentration in the vertical.

(1) Selection of measuring points in a vertical; common simplified methods are as follows:

   (a) One point at depth 0.5 or 0.6
   (b) Two points at relative depth 0.2 and 0.8. Samples may be combined with a proportion of 1 : 1.
   (c) Three points, at relative depth 0.2, 0.5 and 0.8. Samples may be combined with the proportions 2 : 1 : 1 or 1 : 1 : 1.

(2) Sampling by depth integration in a vertical sampling may be carried out by round trips of lifting and lowering or only by a single trip from the surface to the bottom or from bottom to surface.

(3) Selection of Sampling Verticals

   The number of vertical required for sediment discharge measurement depends on the size distribution and concentration distribution of the sediments, as well as on the desired accuracy for data acquisition. Following simplified methods are recommended:

(a) Regular sampling : Three (3) verticals such as one in the main current, two on both sides

(b) Flood sampling : One (1) vertical located near the main current

4.5 Sediment Analysis

4.5.1 General

Commonly, evaporation, filtration or displacement methods are used in the laboratory to determine the suspended sediment concentration. In general, the evaporation method is suitable for use with low concentration. The filtration method may be used for samples of medium and high concentration. The displacement method, however, is suitable only for high concentration.

4.5.2 Method of Analysis

(1) Evaporation Method

The procedure of this method is as follows:

(a) Weigh a sediment sample with sampling bottle
(b) Weigh a dried sampling bottle and evaporation dish
(c) Transfer the wet sediment sample to evaporation dish after withdrawal of clean water from the vessel
(d) Dry it at an even temperature of 110°C
(e) Weigh a dried sediment with evaporation dish

(2) Filtration Method

The procedure of this method is almost as same as evaporation method except using filter materials. The quality of the filter material influences the accuracy of this method.

(3) Weighing

In general, a balance with sensitivity of 1/100 to 1/10,000 is used at stations where the concentration is greater than 1g/1.A balance with a sensitivity of 1/1,000 must be used for a concentration of less than 1 g/l.

5. DATA LOGGER SYSTEM

5.1 General

The recorded data memorized in data logger are collected at the observation station by using service/operation unit or portable personal computer (IBM or compatible). Then at the office data processing is made with personal computer (IBM or compatible). Processing is effected with individual software packages.

5.2 Instrument and Software

(1) Service, retrieve and operational unit

This unit provides following functions and specification:

* Control of instantaneous value, data and time
* Battery control of MDS II
* Retrieve of memorized data
* Transfer data to Personal Computer
* Recalibration of MDS II
* Input of control values

–	Manufacturer :	SEBA HYDROMETRIE, GERMANY
–	Model :	HT 100
–	Interface port :	2 - RS 232 C
–	Indication :	LCD-display, 4 lines, illuminated
–	Power supply :	Accumulator (reachargeable)
–	Memory :	Memory card Rams, changeable 64 Kbyte 3,000 mm accumulating rainfall is available for tipping-bucket type rain gauge RG-50 4,000 times of water level records is available for pressure type gauge
–	Humidity :	100 %
–	Size :	W 115mm L 220mm H 55mm
–	Weight :	1520 g

(2) Software for data logger

Following programmes of data logger are provided by the Manufacturer.

(a) Operation and retrieve software, TTERM
(b) Listing MDS-file, LIMDS
(c) Graphic diagram of MDS-files, PLMDS
(d) Rainfall listing with MDS-files, REMDS
(e) Raifall graphical representation of MDS-files, PLREMDS