SPECIFICATIONS, INSTALLATION AND ANALYSIS OF TIPPING BUCKET RAINGAUGE WITH GPRS DATA LOGGER DL-2016

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ABSTRACT: This manual presents detailed user instructions on the installation, operation, and maintenance of an Automatic Raingauge, with the aim of arriving at a cost effective instrument for automatic rainfall recording. The reader is advised to study this manual carefully before starting to work with the instrument. All rain gauges (recording and non-recording) the tipping bucket raingauge is work very efficient, accurate and economic also. For this project selected tipping bucket raingauge with GPRS based data logger DL-2016 for data storage with date. On top of roof constructed block dimensions 1.5*1.5 feet2 and the height 3feet. We constructed the block with the normal bricks dimensions of the bricks is 19*9*9 cm3. On the block we constructed the concrete bed with 6 inches height with m30grade concrete. On the concrete bed we placed two wooden blocks with dimensions of 8*45 cm2 after raingauge is placed on the wooden block. After construct of block and installation of raingauge, have to give power connection to data logger with extended wire. Actually can't place data logger under rainfall. So have to place near to power connection and at same time keep safe place which is away from rainfall. **Hypertrm** software is used to retrieve the rainfall recordings from the GPRS based data logger DL-2016. The user has to perform, however, a number of additional data filtering and processing operations before storing the recordings in the final database. From GPRS based datalogger DL- 2016. Agricultural engineering's, civil engineering's want know rainfall statement and capacity of water for catchment area. Major all industries, irrigation, drinking and municipalities depend on rainfall. In this project, have to select recording type raingauge for determining annual data and install in ABR College. From raingauge will get data for given time to analysis and calibration of rainfall. Calibration and analysis is done by hydrographs in that unit-hydrograph. Draw hydrograph From raingauge for rainfall data in ABR collage catchment we are installing tipping bucket raingauge (recording type raingauge) on top floor with following standards from the data logger we get data in terms of rainfall intensity with time. So from this data we can analyze rainfall in ABR collage catchment area.

Keywords: Tipping bucket raingauge, GPRS based data logger DL-2016 and **Hypertrm** software.

INTRODUCTION

This manual presents detailed user instructions on the nstallation, operation, and maintenance of an Automatic Raingauge. The FAO Nile Basin Water Resources Project has assembled this system by combining individual parts from various suppliers, with the aim of arriving at a cost effective instrument for automatic rainfall recording. The reader is advised to study this manual carefully before starting to work with the instrument. We have worked hard to present the user instructions as concise as possible, without compromising on the necessary detail. Main purpose of the automatic raingauge is to collect continuous high quality data on the duration, intensity, and total amount of rain events. Precipitation is among the dominant forcing parameters of hydrologic processes, and comprehensive knowledge of the rainfall regime is essential for assessing and predicting hydrologic responses.

Rainfall information is also routinely used for:

- Civil – Water resource planning:
- Agricultural planning;
- Irrigation scheduling;
- Climate change assessment, etc.

Apart from providing continuous information, the automatic raingauge also facilitates automated data processing. This results in much simplified procedures for data retrieval, processing, quality control, and storage in a final database.

Gauges which operate on the tipping bucket principle provide a digital output, which simplifies connection to a data logger. The pulses returned during rainfall may be counted over any time interval desired allowing accurate determination of the rainfall rate (this variable, sometimes called 'intensity', is frequently used in soil erosion studies and is relevant to some aspects of crop pathology). When the DATALOGGER is used primarily to measure rainfall rates, the resolution of the gauge may be too coarse to detect the significant changes in rate which normally occur from minute to minute in moderately heavy rain. In this case the gauge may be adjusted to improve the resolution slightly. It is generally much more satisfactory and convenient to improve the resolution by increasing the collecting area of the gauge. This can be achieved by attaching a funnel with a diameter greater than 25.5 cm over the instrument and avoids the need for internal modifications. A tipping bucket gauge responds to discrete quanta of rainfall, and the accuracy and reproducibility of this quantum are determined not only by factors such as friction in the bearings, etc. but also by the rate of fill of the buckets. When the rainfall rate is high, a bucket may start to tip when the necessary volume of water has been collected, but while the bucket is moving away from the funnel outlet, an extra volume will have been collected and lost through spillage. The resulting degradation in accuracy is of the order of 4% at rainfall rates of 25 mm/hr and 8% at 133 mm/hr for most gauges (Perkin et al, 1982). This is important when results from gauges of different designs are compared. These errors worsen when gauge sensitivity is increased. It follows that gauge design is always a compromise between the need for good resolution and good overall accuracy in rainfall totals.

Discuss about specification of raingauge and GPRS based datalogger DL-2016

1. SPECIFICATIONS OF THE AUTOMATIC RAINGAGE:

The RainWise RAINEW industrial tipping bucket rain gauge is constructed to provide accurate recording of rainfall data at a reasonable price. The tipping bucket causes a reed switch to close with every increment of rainfall. This may be used in a system to determine either rainfall amount or rate. An insect/debris screen is provided.

Fig.1 Rainwise tipping bucket

Housing : High Impact Polypropylene.
Transducer : Tipping bucket of specially formulated plastic for low surface tension
Switch : Dry reed switch.
Signal : Less than 0.1 sec. switch closure.
Electrical Capacit: 6 to 24 VDC @ 500ma
Resolution : 0.5 mm
Accuracy : 2.0% at 25 mm per hour
Collector diamete: 203.2 mm
Sensitivity : One switch closure per tip of 1mm bucket.
Measuring range : Max. rainfall intensity, 600mm/hr
Measuring accuracy : Better than 2% @ 100mm/hr.
Sensor : Tipping bucket (synthetic ceramic coated brass).
Tip Sensitivity : Standard setting 0.25 mm of rain per tip
Typical Accuracy: 98% @ 20 mm/hr
96% @ 50 mm/hr
95% @ 120mm/hr
Maximum Rainfall Rate: 500 mm/hr
(with software correction)
Output : Contact closure at tip
Weight : 1.0 kg
Catalog No. :RGI

OPERATION

Operation of the TE525 Tipping Bucket Rain Gauge is fully automatic and does not require user interventions. Measure a volume of water corresponding to 10mm of rainfall using a rainfall measure and pour it very slowly, over about 15 minutes, into the receiver. This creates a condition of heavy rain striking the ground sufficient to make a pool of water of the ground.

2. SPECIFICATIONS FOR DATA LOGGER TAGV-DL2016

The TAGV-DL2016 Event Logger is a compact GPRS based datalogger DL-2016 that stores momentary contact-closure events. Only one time per event is stored to minimize memory usage. The logger has a capacity of 8,000 events, which is equivalent to 203.2cm of rainfall when connected to a 0.254 mm tipping bucket raingage. The Event Logger includes a compact, weatherproof case that can be mounted inside or outside the rain collector. The instrument is powered by a user-replaceable battery, which lasts 1 year. This replacement 3V lithium battery is similar to those used in calculators. The Event Logger has two memory modes: (1) stop when full, and (2) wrap around when full, also referred to as ring mode. The unit's non-volatile EEPROM memory retains the collected data even if the battery fails.

Fig.2 Block Diagram Of Data Logger

Processor and System

a. Micro Controller Kinetis – K60
   Architecture : 32bit ARM Core Cortex M4
   Code Memory : 512MB
   Date Memory : 128KB
   Speed : 100MHz
b. Data Memory : 32Mbit (5 years @ 1Hr)
c. Operating Voltage: 9V to 15Volts DC
d. Operating Current: Below 120mA @12V
e. Quist Current : 1mA @15V, 2mA @ 9V
f. Op. Temperature : -20° to 60° Degrees
g. Op. Humidity : 0 to 100%

Connectors

a. PC Communication : DB-9 Female
b. Power Supply : 2 PIN Phoenix Male

Analog Inputs

a. Resolution per Channel : 16bit
b. Conversion rate : 480mSec
c. Reference Voltage : 2.5Volts @ ±1ppm
d. Inputs : 4 Channels

Digital Inputs

a. Counter Inputs : 3 Channels
b. RS-485 : 1

GSM/GPRS

a. Network : Dual Band (2G)
b. Communication Server : FTP Protocol

Data logger Pic

Fig.3 Image Of Data Logger

Operation

Operation of the HOBO Event Logger is fully automatic and does not require user interventions. The unit has a red LED (Light Emitting Diode) that blinks every two seconds while it is logging. The LED blinks four times faster when storing an event. Always keep the logger's protective case dry and closed, to avoid rain or moist from affecting the electronics.

INSTALLATION

This chapter discusses about the installation of raingauge in selected place with following of all recommendations. , and collect data from the data logger, draw the hydro-graphs and analyze.

1. Site Selection

Rainfall measurements are intended to be representative of the actual rain falling on a given area. Some of the more important factors which influence the representativeness of a gauge are as follows:

- Site the gauge on level ground where possible. Avoid sloping sites.
- Site should have adequate protection from strong winds.
- Site should be free of large obstructions such as buildings and trees.
- Provide suitable ground surface to avoid splashing into the gauge.

2.Setting Up

- We constructed the block above the fourth floor and 2 feet far from the parapet wall.
- Dimensions of the block : 1.5*1.5 feet^2 and the height 3 feet .
- We constructed the block with the normal bricks dimensions of the bricks is 19*9*9 cm^3
- On the block we constructed the concrete bed with 6 inches height with m30grade concrete.
- On the concrete bed we placed two wooden blocks with dimensions of 8*45 cm^2 after raingauge is placed on the wooden block. Gap between the wooden places from 10 cm above the concrete bed.
- And finally set up of the raingauge instrument from leveling materials.
- Made some slopes between the two wooden blocks for free flow of water after fall from bucket.
- Raingauge is placed on wooden block with four corner screws and have to follow bucket direction of flow below buckets.
- After construction of block and installation of raingauge, have to give power connection to data logger with extended wire.
- Actually can't place data logger under rainfall. So have to place near to power connection and at same time keep safe place which is away from rainfall.
- Finally check all connections and levelling of raingauge.

The installation process clearly shown in the following Figures

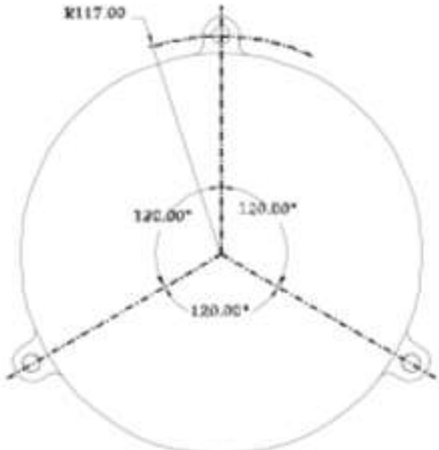

Fig 4 Bottom dimensions of rain gauge



1. **Choice of Site**

Site the gauge carefully, avoiding obvious sources of error such as nearby trees or buildings. A useful 'rule of thumb' is that the distance between the gauge and any obstruction should be at least as great as twice the height of the obstruction above the ground. No two rain gauge designs are ever likely to produce identical results and identical rain gauges can give slightly different catches even when sites within a meter of each other. Research has shown that a rain gauge obstructs the flow of air and that the flow accelerates and turbulence increases over the top of the funnel. This can cause less rain to be collected in the funnel than otherwise would have fallen on the ground. In most cases, this phenomenon is ignored but it may be corrected for arithmetically or overcome physically by placing the gauge in a pit so that the rim of the funnel is level with the ground. The pit is covered by a grating to simulate the aerodynamic roughness of the ground surface while preventing any splash into the funnel. There are obvious advantages with this method, but it is not always practical. The body of the DATALOGGER has a profile which has been designed to reduce drag and turbulence and it can therefore be sited conventionally on exposed sites with some confidence. Further details on the exposure of rain gauges are given in HMSO (1956, 1982) and by Rodda (1967). Another useful text on exposure and associated errors is Painter (1976).

2. **Unpacking**

Unpack the DATALOGGER carefully. The tipping mechanism is immobilised before shipping to prevent damage in transit. To release the mechanism.

1. Remove the funnel of the gauge from its base by unscrewing the three screws.
2. Remove the small piece of tape which secures the balance arm to the central post and check the bucket mechanism for freedom of movement.

3. **Mounting**

The DATALOGGER is a light-weight instrument and it must therefore be bolted down securely. Three mounting holes are provided in the base of the gauge; access to these is gained by simply pulling the inner section upwards (it may be necessary to relieve the strain slightly by pushing a little more cable through the rubber grommet). If you need to mount the DATALOGGER on concrete, we recommend the use of Anchor bolts. Alternatively, a concrete paving slab may be more convenient as a base, in which case through-bolts or screws are suitable. Whichever is chosen, we recommend the use of large washers to spread the load more evenly around the mounting holes in the plastic base. For fast, semi-permanent installations the optional RGB1 leveling base plate can be used.

4. **Levelling**

If the rain gauge is tilted by more than a few degrees, the bucket mechanism may be thrown out of balance, significantly affecting its calibration. Furthermore, during wind-driven rain the response of a gauge with a tilted funnel collector will vary with wind direction. Where a concrete slab is used, add sand underneath the slab to level the gauge. If the gauge is mounted on a concrete base using Anchorbolts, add packing material under the base before tightening the bolts. Use the internal bubble to check that the base of the gauge (with the funnel removed) is level; as an additional check, place a spirit level across the rim of the assembled DATALOGGER.

4.2 Wiring

The rain gauge is supplied with custom cable length at the time of order. For most applications the DATALOGGER may be connected directly to a pulse counting input on the datalogger as shown in Figure 4-1. For a long cable, a significant capacitance can exist between the conductors, which discharges across the reed switch as it closes. As well as shortening the life of the switch, a voltage transient may be induced in any other wires which run close to the rain gauge cable each time the gauge tips. A 100□□resistor is fitted inside the gauge to protect the switch from arcing and prevent transients.

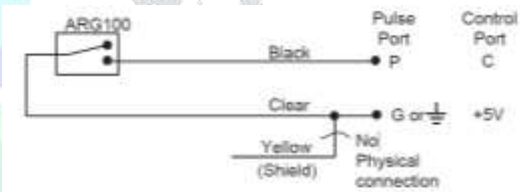

Fig.5 Power connection of GPRS data logger DL-2016

1. **Wiring to a Pulse Channel**

When Short cut software is used to generate the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

Table1 Wiring for pulse channel Input

Colour	Description	CR800 CR1000 CR3000 CR5000	CR500 CR510 CR10(X)	21X CR7 CR23X	CR200(X) Series
Black	Signal	Pulse Channel	Pulse Channel	Pulse Channel	P_SW
White	Signal Return	⏚	G	⏚	⏚
Clear	Shield	⏚	G	⏚	⏚

2. **Wiring to a Control Port**

Dataloggers listed in Table 4-2 have the capability of counting switch closures on some of their control ports. When a control port is used, the return from the rain gauge switch must be connected to +5 volts on the datalogger.

Table.2 Wiring for Control port Input

Colour	Description	CR800 CR1000 CR3000	CR500 CR510	CR10(X)	CR23X
Black	Signal	Control Port	C2/P3	Control Port	Control Port
White	Signal Return	5 V	5 V	5 V	5 V
Clear	Shield	⏚	G	⏚	⏚

DATA AND ANALYSIS

Collect data from datalogger

Hypertrm software is used to retrieve the rainfall recordings from the GPRS based datalogger DL-2016. The user has to perform, however, a number of additional data filtering and processing operations before storing the recordings in the final database. These steps are discussed in this chapter. The final product is a time series, at the desired time resolution. In view of the wide variety of existing database structures, it is left to the user to convert this output.

The data retrieved from the various GPRS based datalogger DL-2016 on location require transfer to a PC. To this end, connect the GPRS based datalogger DL-2016 to the PC using the interface cable. Hypertrm and select GPRS based datalogger DL-2016 Readout from the Logger menu. Follow the instructions on screen and watch the progress bar until data offloading is complete. Use the Save As dialoge to name the data file according to the conventions of your organization. This completes the data retrieval process.

Step 1: Install software hypertrm with supporting files (SilLabs) and after installation, can display icons regarding software and can easily access the following is the icon of the our analysis.

Step 2: Right-click on icon click open, then one dialogue box will appear about **connection description** with details of name of location and work.

Step 3: After giving name as ABRCET and Click ok, then next displays on asking about location, Area code, Phone number and connection (COM1, COM3).

Step 4: After Click ok, then next displays on asking about COM3 properties like Bits per second, Data bits, Parity, Stop bits and Flow control and Click on Restore Defaults then Displays. Click on Ok, Then Displays Dialogue box with information about rainfall with GPRS based datalogger DL-2016.

Use **logs** command for used stored data from GPRS based datalogger DL-2016 as following Fig 6

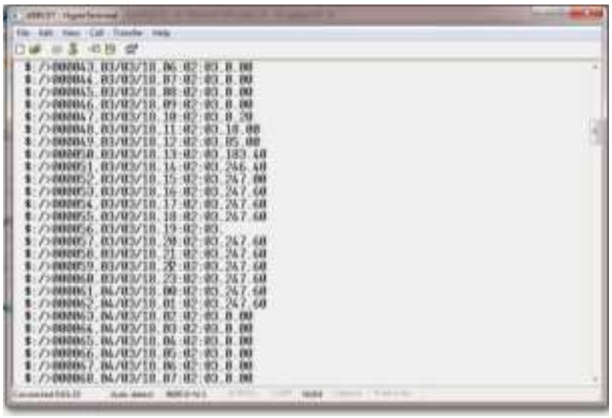

Fig.6 Stored data from GPRS based datalogger DL-2016

Step 5: After got data, select data and can copy the data and paste in excel for analyzing and draw the hydrographs, estimation of peak flood and rainfall in over a period.

ANALYISING WITH HYDROGRAPH

Form 1HR hydrographs on x-axis as time durations with 1hr

On y-axis as Discharge(m^3/sec)

From GPRS based datalogger DL-2016, get rain fall with 1hr (mm/hr), calculate discharge with multiplication of catchment area (km^2). The following table is the information about rainfall data to draw hydrographs.

Table 3 The information about rainfall data to draw hydrographs

S.No	Time(Durations-1hr)	Rainfall instensity(mm/hr)	Area(mm^2)	Discharge(m^3/sec)
1	0	0	32412.84	0
2	1	45	32412.84	5.30
3	2	81	32412.84	9.45
4	3	120	32412.84	14.00
5	4	183.4	32412.84	21.40
6	5	220	32412.84	25.67
7	6	247	32412.84	28.82
8	7	247.6	32412.84	28.89
9	8	247.6	32412.84	28.89

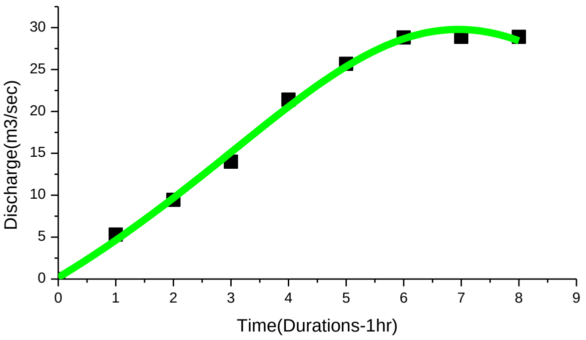

Fig .7 Typical 1-hr Unithydrograph

Estimation peak Rainfall and peak discharge

Estimation peak Rainfall and peak discharge from hydrograph

The unit hydrograph technique can be used to predict the peak- flood hydrograph if the rainfall producing the flood, infiltration characteristics of the catchment and the appropriate unit hydrograph are available. For design purposes, extreme rainfall situations are used to obtain the design storm, viz. the hydrograph of the rainfall excess causing extreme floods. The known or derived unit hydrograph of the catchment is then operated upon by the design storm to generate the desired flood hydrograph.

Effective rainfall (also known as Excess rainfall) (ER) us that part of the rainfall that becomes direct runoff at the outlet of the watershed. It is thus the total rainfall in a given duration from which abstractions such as infiltration and initial losses are subtracted. As such, ER could be defined as that is neither retained on the land surface nor infiltrated into the soil.

The problem of predicting the flood hydrograph resulting from a known storm in a catchment has received considerable attention. A large number of methods are proposed to solve this problem and of them probably the most popular and widely used method is the unit hydrograph method. This method was first suggested by Sherman in 1932 and has undergone many refinements since then.

A unit hydrograph is defined as the hydrograph of direct runoff resulting from one unit depth of rainfall excess occurring uniformly over the basin and at a uniform rate for a specified duration (D hours). The term unit here refers to a unit depth of rainfall excess which is usually taken as 1 cm. The duration, being a very important characteristics, is used as a prefix to a specific unit hydrograph. Thus , one has a 1-h unit hydrograph, 2-h unit hydrograph, etc. and in general a D-h unit hydrograph applicable to a given catchment. The definition of a unit hydrograph implies the following:

1. The unit hydrograph represents the lumped response of the catchment to a unit rainfall excess of D-h duration to produce a direct-runoff hydrograph. It relates only the direct runoff to the rainfall excess. Hence the volume of water contained in the unit hydrograph must be equal to the rainfall excess.
2. The rainfall is considered to have an peak discharge of 1/D cm/h for the duration D-h of the storm.
3. The distribution of the storm is considered to be uniform all over the catchment. The Figure.7 shows a typical 1-h unit hydrograph

Peak discharge =28.89m^3/sec (from table 3)

Estimation peak Rainfall and peak discharge from S-Curve

This S-curve is due to a D-h unit hydrograph. It has an initial steep portion and reaches a maximum equilibrium discharge at a time equal to the time base of the first unit hydrograph. The average intensity of ER producing the S-curve is 1/D cm/h and the equilibrium discharge,

$$Q_s = \left(\frac{A}{D} \times 10^4\right) \text{ m}^3/\text{h},$$

Where A = area of the catchment in km^2 and D = duration in hours of ER of the unit hydrograph used in deriving the S- curve. Alternatively,

$$Q_s = 2.778 \ \frac{A}{D} \text{ m}^3/\text{s}$$

Where A is the km^2 and D is in h. The quantity Q_s represent the maximum rate at which an ER intensity of 1/D cm/h can drain out of a catchment of area A. In actual construction of an S-curve, it is found that the curve oscillates in the top portion at around the equilibrium value due to magnification and accumulation of small errors in the hydrograph.

Assume A=10km^2
D=1hr

$$\mathbf{Q_s = 2.778*(10/1) = 27.78 \text{ m}^3/\text{s}}$$

ESTIMATION MAXIMUM FLOOD DISCHARGE FROM EMPIRICALFORMULAE

The empirical formulas used for the estimation of the flood peak are essentially regional formulae based on statistical co relation of the observed peak and important catchment properties. To simply the form of the equation, only a few of the many parameters affecting the flood peak are used. For example, almost all formulae use the catchment area as a parameter affecting the flood peak and most of them neglect the flood frequency as a parameter. In view of these, the empirical formulae are applicable only in the region from which they were developed and when applied to other areas they can at best give approximate values.

Ryves Formula (1884)

$$Q_p = C_R A^{2/3}$$

Where Q_p = maximum flood discharge (m^3/s)
A = catchment area (km^2)
C_R = Ryves coefficient

This formula originally developed for the Tamil Nadu region, is in use in Tamil Nadu and Parts of Karnataka and Andhra Pradesh. The values of C_R recommended by Ryves for use are
C_R = 6.8 for area within 80 km from the east coast
= 8.5 for areas which are 80-160km from the east coast
= 10.2 for limited areas near hills

$$Q_p = C_R A^{2/3}$$

Assume A=10 km^2

C_R = 6.8 for area within 80 km from the east coast

Maximum flood discharge Q_p =*31.56* **m^3/s**

CONCLUSIONS

Based on discussion of experimental test results, a few of major conclusions can be listed with regards to the installation, operation and analysis of tipping bucket raingauge.

- Among all raingauges (recording and non-recording) the tipping bucket raingauge is work very efficient, accurate and economic also. For this project selected tipping bucket raingauge with GPRS based data logger DL-2016 for data storage with date.
- The installation of raingauge on the location under guidelines of Indian standard, the location is on roof of 4th floor, there is no obstacles to stop catching rainfall in catchment of raingauge.
- On top of roof constructed block dimensions 1.5*1.5 feet^2 and the height 3feet. We constructed the block with the normal bricks dimensions of the bricks is 19*9*9 cm3. On the block we constructed the concrete bed with 6 inches height with m30grade concrete. On the concrete bed we placed two wooden blocks with dimensions of 8*45 cm2 after raingauge is placed on the wooden block. Gap between the wooden places from 10 cm above the concrete bed. Finally set up of the raingauge instrument from leveling materials. Made some slopes between the two wooden blocks for free flow of water after fall from bucket. Raingauge is placed on wooden block with four corner screws and have to follow bucket direction of flow below buckets. After construction of block and installation of raingauge, have to give power connection to data logger with extended wire. Actually can't place data logger under rainfall. So have to place near to power connection and at same time keep safe place which is away from rainfall.
- **Hypertrm** software is used to retrieve the rainfall recordings from the GPRS based data logger DL-2016. The user has to perform, however, a number of additional data filtering and processing operations before storing the recordings in the final database. From GPRS based datalogger DL-2016, get rain fall with 1hr (mm/hr), calculate discharge with multiplication of catchment area (km^2). The following table is the information about rainfall data to draw hydrographs.
- The unit hydrograph technique can be used to predict the peak- flood hydrograph if the rainfall producing the flood, infiltration characteristics of the catchment and the appropriate unit hydrograph are available. For design purposes, extreme rainfall situations are used to obtain the design storm, viz. the hydrograph of the rainfall excess causing extreme floods. The known or derived unit hydrograph of the catchment is then operated upon by the design storm to generate the desired flood hydrograph. Peak discharge =28.89m^3/sec, Maximum flood discharge Q_p =*31.56* m^3/s.

SCOPE OF FUTURE WORK

- Flood frequency analysis to find maximum possible flood for a given return period.
- Application of storm water management models.
- Rainfall-runoff modeling
- Development of rainfall-runoff simulation models for estimating flood peaks for small basins.
- Analysis of rainfall data in annual with GPRS based data logger DL-2016

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