CASE STUDY CS-(AR) 183

INFILTRATION STUDIES : DUDHNAI SUB-BASIN (ASSAM & MEGHALAYA)

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PREFACE

Infiltration characteristics of an area is of great importance for hydrologic studies of the system. It is a basic parameter for water balance studies in an integrated crop, soil and water management plan. Infiltration affects the soil moisture status and is therefore amenable to vegetation manipulation. Like other parts of the country, NE region also lacks infiltration results in most of its basins and sub-basins. During last Regional Co-ordination Committee meeting with different Govt. agencies held at Guwahti , it was therefore, decided that infiltration tests at various river basins be carried out under overall national objective of NIH to prepare a thematic map of infiltration function for different areas throughout the country.

Keeping this in view, field infiltration tests were carried out, results analyzed and infiltration functions developed at Dudhnai sub-basin which has been taken for long term representative studies by the regional centre. This study, therefore, constitutes component part of the overall study:Representative Studies at Dudhnai. Related to infiltration parameter, soil & water samples were also collected from the sites and laboratory tests were conducted to reflect soil and water quality parameters alongwith infiltration characteristics. This study should be useful for other hydrologic studies of the area and the methodology developed. should be helpful to other agencies as guidance for future studies to be taken up elsewhere.

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ABSTRACT

Determination of infiltration characteristics of an area is essentially required for comprehensive hydrologic studies in an area. The infiltration process that is water entry into the soil affects the water budget in the watershed. In requirement of the long term representative studies taken up at Dudhnai sub-basin, field infiltration tests were carried out in it with double ring cylinder infiltrometer at 23 locations under different soil & land uses. Results are analyzed and infiltration curves developed reflecting land use, soil type and to some extent water quality.

The regression analysis was performed for the field observations using Kostiakov (1932) type infiltration function (also compared with other infiltration models available) through multiple linear regression . The results showed large variation of infiltration rates depending upon various land uses and soil types in Dudhnai sub-basin. While analyzing the results different infiltration models were applied but Kostiakov's equation gave most satisfactory results with correlation coefficients of regression equation ($\log F = b \log T + \log a$) ranging from 0.87 to 0.99 in most cases confirming a good fit of the infiltration function.

1.0 INTRODUCTION :

The process of water entry into the soil is the infiltration. Infiltration by which precipitation water moves down the surface of earth and replenishes soil moisture, is influenced by vegetal cover, temperature, properties of soil etc. Infiltration characteristics are very useful to the agronomists and ecologists who are concerned with the availability of soil moisture in the root zone of crops and plants for assessing the soil moisture deficits and accordingly planning for irrigation and drainage systems. The knowledge of infiltration is also useful to soil scientist to plan for appropriate devices to dissipate the energy of flowing water to minimize soil erosion. Detailed study of infiltration characteristics helps planners, engineers, hydrologists, farmers, agriculture specialists and decision makers in number of ways like: to estimate peak rate and volume of runoff in planning and construction of bridge, dam, culverts etc, to estimate surface runoff and overland flow, to estimate ground water recharge, to plan for watershed management, for planning irrigation and drainage system and so on.

Infiltration studies in India have been carried out by various water resource organizations and academic institutions such as CSWRTI, FRI, Universities, CWC, CWPRS, National Bureau of Soil Survey & Landuse Planning, National Institute of Hydrology (NIH) etc. But all these studies have been extremely scattered and no compiled document on infiltration properties of soil of the country exists. Keeping this in view, NIH has taken up

infiltration studies in the basins & sub-basins throughout the country to preapare a thematic map of infiltration functions. It would help implementation of computer models where information on infiltration is used as a parameter.

Under this broad objective, North Eastern Regional Centre undertook infiltration studies at the inter-state Dudhnai sub-basin in Assam and Meghalaya. Point infiltration tests were conducted at various locations in respect of different land uses. Soil samples were also collected from test sites and tested in laboratory to relate the results to soil types. From the field observations infiltration curves were developed and presented in the report.

The basin with catchment area of about 500 km^2 on the south bank of the river Brahmaputra has also been selected for long term representative basin studies. Therefore, the results of the study would be used in the subsequent hydrologic studies to model the basin.

2.0 METHODOLOGY :

2.1 General :

Infiltration may be defined as the process of water entry into the soil, generally by downward flow through all or part of the soil surface. Water may enter the soil through the entire surface uniformly as under ponding or rain, or it may enter the soil through furrows. Infiltration rate is the volume of water entering the soil profile per unit of soil surface area and time. The maximum rate at which a given soil in a given condition can absorb water is known as **infiltration capacity** or **infiltrability of the soil.**

Infiltration rate and **accumulated infiltration** are the two parameters commonly used in evaluating the infiltration characteristics of soil.

$$F(t) = \int_0^t t\ (\tau)\ d\tau$$

where τ is a dummy variable of time in the integration. Conversely the infiltration rate is the time derivative of thecumulative infiltration :

$$f(t) = \frac{d}{dt} F(t)$$

where F is the cumulative infiltration and f is the ifiltration rate in depth per unit time.

2.2 Theory of Infiltration :

Some of the popular infiltration models are described below:

GREEN & AMPT MODEL

Green and Ampt (1911) developed infiltration equation from a ponded surface in deep homogeneous soil with uniform initial water content based on Darcy type water flux. Infiltration has to be proportional to the total gradient, including suction effect. Therefore,

$$f = \frac{Ks(H + \# + Lf)}{Lf} \qquad (1)$$

Where, f is infiltration rate or capacity (units of velocity), H is a some level of ponding on the surface, # is a suction effect due to dryness at lower levels, Lf is the increasing depth of the water front and Ks is saturated hydraulic conductivity. It is assumed that the wet front moves as piston. If H is assumed small , eqn. 1 can be expressed as

$$f = Ks + \frac{Ks\ S\ \#}{y} \qquad (2)$$

Where y is the total infiltrated water given by (Qs-Qi).Lf = SLf, and S is the initial moisture (as a fraction volume) deficit of the soil column. Haan et al. (1982) have also provided a good summary of results to the Green and Ampt model.

KOSTIAKOVE'S MODEL

Kostiakov (1932) proposed an empirical equation and is generally known as Kostiakov equation (Lewis, 1937, Criddle et al., 1956, Haise et al.,1956). The equation is given as :

$$y = a\,t^{b} \qquad (t \text{ is not } = 0) \qquad (3)$$

Where y is cumulative depth of water infiltrated (cm); t is time elapsed from start of the ponding of the water (hr), a and b are empirical constants.

HORTON'S MODEL

Horton (1933) defined infiltration as the process involved when water soaks into the ground. The rate at which water can enter the soil is called the infiltration capacity. (Horton, 1940 Fleming et al 1975). After a period of 1-2 hours water infiltrates at a slow steady rate. This is called the **basic infiltration rate** . The proposed Horton's equation for infiltration capacity (cm/hr) at time t is :

$$f = fe + (fo - fe)\, e^{-kt} \qquad (4)$$

Where k is a constant representing the rate of decrease in infiltration f; fe is final or equilibrium capacity (cm/hr) ; and fo is initial infiltration.

KLUTE'S MODEL

Klute (1952) defined infiltration into unsaturated soil by differential equation as given under:

$$\frac{dQ}{dt} = \frac{d}{dz}\left(K\frac{dO}{dz}\right) + \frac{d}{dz}(K.g) \qquad (5)$$

(N.B.: d denotes partial differentiation)

Where, Q is the moisture content in volume of water per unit volume of soil, K is the unsaturated hydraulic conductivity (L/T), O is the capillary potential (L) , g is gravitational constant (L/T^2) and z is the vertical co-ordinate (L).

PHILLIP'S MODEL

Philip (1957) suggested the following theoretical infiltration equation based on physical properties of soil and analysis of water penetration into a uniform soil.

$$y = Sp\ t^{0.5} + a\ t \qquad (6)$$

Where , y is cumulative infiltration (cm) at time t , Sp is 'sorptivity' parameter that relates to capillarity or soil matrix forces, and a is soil parameter relating to transmission of water through the soil or gravity force.

SCS MODEL

Soil Conservation Service (1968) empirically obtained run-off over finite areas for various regions in the United States. The equation is:

$$P - y - Ia = Rs = \frac{(P-Ia)^2}{(P - Ia + S)} \qquad (7)$$

$$P \geq Ia$$

$$S \geq Ia + y$$

Where, P is volume of total precipitation, y is volume of total infiltration, Ia is an initial retention volume and S is the potential maximum surface retention. The initial abstraction Ia is commonly taken as Ia = 0.2 S . The retention volume is given by:

$$S\ (\text{inches}) = \frac{1000}{CN} - 10 \qquad (8)$$

Where CN is called curve number , a parameter dependent on soil type , use , and antecedent moisture conditions.

HOLTON'S MODEL

Holton (1971) proposed the following equation for infiltration capacity (cm/hr) at time t,

$$f = ci\ Sa^{n} + t\ fe \qquad (9)$$

Where, i is infiltration capacity per unit of available storage ; Sa is available storage which is the difference between the potential soil moisture storage and the cumulative (cm), n is a coefficient that relates to soil texture ; fe is constant rate of infiltration after prolonged wetting of soil (cm/hr) and the value of c is given as 0.69 for cm (1.0 for inches).

2.3 Factors Affecting Infiltration :

The factors which mostly affect the infiltration capacity are intensity and duration of rainfall, soil characteristics, condition of soil (soil moisture content), vegetal cover, land use, entrapped air, depth of the ground water and weather (temperature) etc.

Infiltration rate is a function of both rainfall intensity and antecedent soil conditions. If the rainfall rate is less than infiltration capacity, infiltration may continue indefinitely at a rate equal to the rainfall rate without ponding at the surface. When rainfall rate is more than the infiltration capacity, the infiltration rate is limited by the capacity of the soil to absorb water. This results in surface ponding and water becomes available for run-off.

The soil texture controls the infiltration rate until the soil behind the wetting front reaches saturation. Water infiltration rate is rapid into large, continuous pores in the soil. It is reduced by anything that decreases either the size or amount of pore space or wettability. Coarse sand permits rapid infiltration. Fine textured soil with large water-stable aggregates (granular structure) has higher infiltration rates than massive (structureless) soils.

Vegetal cover and land use are very important factors for affecting the infiltration rates. Vegetal cover intercepts rain water and facilitates high rate of infiltration which in turn reduces the surface run-off. Mulching greatly improves the infiltration rates by absorbing the raindrop impact and prevents the formation of impervious surface layer.

The entrapped air in the soil mass builds up pressure, which reduces the infiltration rate.

Forest cover renders high infiltration rate. It is relatively more in forested soil as compared to agricultural area and grass lands. Based on the results of some of the infiltration studies carried out, it could be inferred that infiltration rates from arable crop land and grass lands are nearly 30 to 35% and 40-50% respectively of that from forest lands. However, it is drastically affected due to biotic interferences like forest fires, trampling by cattle, removal of leaf liter etc.

The forest cover provides a layer of decaying organic matter associated with deep roots which helps in making the soil structure more conductive to infiltration.

Agricultural practices affect infiltration since the porosity of the soil is changed by cultivation or compaction. Cultivation influences the infiltration rate by increasing the porosity of the surface soil and breaking up the surface seals. The effect of tillage on infiltration usually lasts only until the soil settles back to its farmer condition of bulk density because of subsequent irrigations. In surface Irrigation, increased depth increases initial infiltration slightly but the head has negligible effect after prolonged irrigation.

Due to change in temperature of water its viscosity also changes. This change in viscosity affects infiltration. The viscosity of water roughly double for each 22°C decrease in temperature. For this reason the infiltration of water must decrease as temperature decreases.

Due to man's influence soils are subjected to compaction at unsurfaced roadways, animal trails, heavily pastured areas & feedlots and at other areas with traffic load of heavy machinery. Because of the compaction pore spaces of the soils are reduced which lowers the infiltration rate. The net effect of reduced infiltration from such areas largely depends upon the intensity and areal extent of the compaction.

2.4 Infiltrometer Equipments:

Commonly used methods for determining infiltration capacity are hydrograph analysis and infiltrometer tests. There are many direct & indirect methods available for determining infiltration rate as mentioned below:

- Infiltrometer (Double ring cylinder)
- Observation pits and ponds.
- Placing a catch basin below a laboratory sample.
- Artificial rain simulators.
- Hydrograph analysis.
- Small rainfall simulator.
- Rogers infiltrometer.
- ø-index method.
- W-index method.
- f-ave. method.
- Lysimeters.

For determination of infiltration rate, **double ring infiltrometers** are widely used due to its simplicity and cost-effectiveness besides being quick and giving results reasonably well.

Infiltration rate observed by cylinder infiltrometer are influenced by the cylinder diameter, thickness of cylinder, leveling of the cylinder bottom, the method of driving the cylinder into the soil and the installation depth. The variability of data caused by ring placement could be overcome greatly by leaving the cylinders in place over a long period of time during a series of measurements.

In the earlier studies only a single cylinder was used and many of the data indicated a high degree of variability. The variability was mainly due to the uncontrolled lateral movement of water from the cylinder after the wetting front reached the bottom of the cylinder. After the initiation of infiltration while the wetting front is in the cylinder, the water subsidence rate corresponds to the infiltration rate. When the wetting front passes below the cylinder, a more or less divergence of flow will occur. The lateral movement of water from cylinder is minimized by ponding water in an outer guard cylinder to provide a buffer area around the inner cylinder. Double ring cylinder infiltrometer essentially comprises of the following components:

(a) Inner cylinder of M.S. or G. I. sheet about 2 mm thick, of at least 300 mm internal diameter & 450 mm height.

(b) Outer buffer cylinder of M.S. or G.I. sheet about 2 mm thick of at least 450 mm internal diameter & 450 mm height.

(c) One MS plate & a hammer to drive the cylinders into the ground, a linear scale to measure water level depletion, water bucket for filling & refilling and a stop watch to record elapsed time.

Top outer surface of the cylinders should be collared by 2 mm thick G I or M.S. sheet by continuous welding process upto 4 cm height so that top surface of the cylinders does not distort by hammering during driving. Both inner & outer sides of the cylinders should be painted by water proof paint to prevent corrosion in the long run.

2.5 Experimental Set-up :

1. To examine the test site and record the soil conditions(e.g.texture, structure etc from open soil profile or by visual interpretation), with particular reference to the first 30 cm depth that may influence the rate of water intake, specific land use etc.

2. Selected site should be free from surface soil creeks, floating materials, vegetables or humus. These materials create problems during reading time. The site should not be deep, sloping and undulating.

3. Source of water should be available near the test location, otherwise there should be proper arrangement to carry required quantity of water to the site.

4. To place the measuring inner cylinder on the leveled ground surface and press it firmly into the soil. Then the cylinder is driven uniformly into the ground for a depth of about 15 cm with the help of a driving guide i.e.a wooden plank or a MS plate and a metallic hammer. Then the outer cylinder is driven up to the same depth & level around the inner one.

5. Care should be taken that hammering is done in the middle of the wooden plank and not towards the edge of the cylinder so that hammering impact is equally distributed driving is uniform and there is minimum distortion of the soil mass.

6. A scale touching the side of inner cylinder is inserted to measure water level with respect to time.

7. Enclosed soil surface should be covered with burlap or other puddling protecting device to prevent surface erosion/disturbance during filling. Then both the cylinders should be filled simultaneously up to the top zero reference level(little below the rim) of the vertical scale.

8.Then depletion of water level with time is recorded, initially at very short intervals viz 1,2,3 min, there after at 5,10 or 15 min and finally at large intervals as the infiltration rate slows down till a constant rate is achieved.

9. When water surface goes down by about 12 to 15 cm from top reference point, both the cylinders should be refilled from time up to the point.

10. Finally, a graph drawn with elapsed time on X axis and infiltration rate on Y-axis gives the infiltration function.

2.5.1 Limitations :

The disadvantages of this type of experiment are that the soil structure may be greatly disturbed in driving the cylinder into position. When the soil is not completely protected by vegetation or by a layer of humus, the soil structure may be altered by aggregation of eroded soil particles due to impact of water. However, rain drop impact is not properly simulated in this type of experiment.

However this is one of the simplest methods and works well for practical purposes.

2.5.2 Assumptions:

The following assumptions are made in the experiment:

1. There is no flow of water from inner cylinder to soil when water is filled upto reference point at the starting time.

2. There is no structural change of the soil particles due to hammering vibration while driving the cylinders into soil.

3. There is no lateral movement of water from inner cylinder .

4. There is no evaporation loss during test.

A sample infiltration test data sheet is given for users reference purpose in **Appendix-I.** Also a smple graphical plot of infiltration results with elapsed time of the same test data is given in **Appendix-II** for users reference purpose.

3.0 STATEMENT OF THE PROBLEM :

Infiltration measurements in India have been made in many isolated locations using different methods ranging from simple infiltrometer to rainfall simulator. Many water resources organization and academic institutions have conducted studies to ascertain the infiltration characteristics of various experimental areas. However, there are following gaps regarding infiltration studies conducted so far :

- Infiltration data for many basins are not available.
- Preparation of thematic maps for different basins have not been made.
- Data availability and studies on infiltration at vegetated and snow covered soil surface are very limited.
- The hydrological parametrization of surface run-off have been well achieved, but studies concerning with infiltration process still lag behind.
- The classified studies on infiltration in respect of land use and soil types are very limited.

Keeping in view the various existing gaps National Institute of Hydrology, through its regional centre proposed to conduct field infiltration test at basins & sub-basins throughout the country. The study aims to prepare an Infiltration Map of the country and to determine average cumulative infiltration function from point infiltration measurements. In pursuit of these objective the NE regional centre , Guwahati has carried out field test in several places within Dudhnai Representative Basin.

4.0 STUDY AREA :

The present study was conducted for Dudhnai sub-catchment in states of Assam and Meghalaya, India(Fig-1). It is located between Longitude 90°-40'-33"E to 90°-56'-01"E and Latitude 25°-36'-57"'N to 25°-58'-45" N. It is bounded by the river Brahmaputra in the North, the hill ranges of the Garo Hills in the South, the Kulsi Deosila sub-basin in the East and the Jinary sub-basin in the West. The catchment area of the sub-basin up to the discharge site of NH crossing at Dudhnai is about 500 km^2.

Geology of this area is such that cretaceous sandstones lie on an irregular surface of Shillong quartzites and other metamorphic rocks. The basal bed is conglomerates embedded with sandstone, followed by glyconitic sands and carbonaceous sandstone which contains plant remains. There is much lateral variation and most of the sand stones are unforssiliferous.

In the Western part of the basin, the lowest beds recently termed as Tura stage includes sandstone, and the various out crops of thin coal occurring in and near the Garo Hills. These beds rest with no marked discordance on the Cretaceous but over lap on to the gneiss and other metamorphic rock.

The soil in the plain of this sub-basin is mostly new alluvium which are found in the riparian tracts. This formation is caused by deposition of silt due to floods and the soil is mild acidic in character. They are generally sandy loam or silty loam in nature. In the hill portion of the sub basin loam and laterites are found. Results of sieve analysis and plastic limit tests

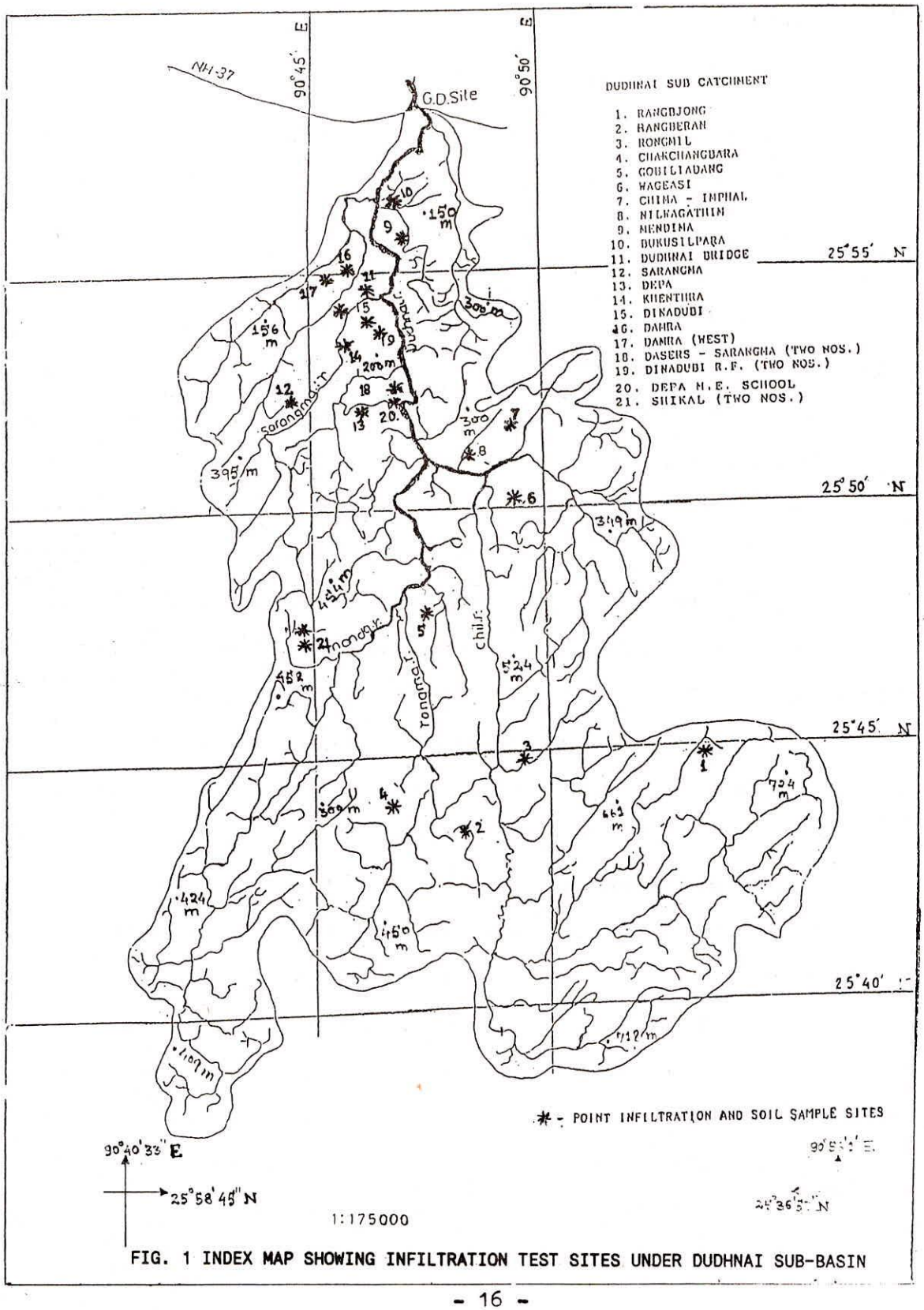


FIG. 1 INDEX MAP SHOWING INFILTRATION TEST SITES UNDER DUDHNAI SUB-BASIN

of the soil samples collected from different sites of the sub-basin are furnished in **Appendix-III.**

The Dudhnai sub basin falls within the climatic zone-1 which comprises North and North-East India and adjoining the parts of Nepal, Bangladesh and North Burma. The average annual rainfall in the plain area of the sub basin is about 1817.20 mm. November to February are dry months of the year for the sub basin. The average annual temperature ranges between 29.5°C to 19.7°C. The temperature starts rising from the beginning of March and reaches maximum in July & August.

The relative humidity in the rainy season (May to Sept) is between 72% to 85%. The non-monsoon period (Feb. to April) is having relative humidity ranging between 50% to 75%

The major part of the sub basin which is in East Garo Hills district of Meghalaya is mostly hilly and Forest covered except some plain areas adjoining the Assam Meghalaya border. Agriculture(Jhum or Shifting cultivation at hill slopes and traditional paddy cultivation at lower plain region) and forest are the main stay of the people in the sub-basin.

4.1 Description of Test Sites :

The rate of infiltration of a given soil mostly affected by the Initial moisture content of the soil, condition of the soil surface, hydraulic conductivity of the soil profile, texture, porosity, degree of swelling of soil collides, vegetative cover. land use pattern, topographic conditions, climatic conditions etc. Therefore, it is necessary to observe these surrounding

For the purpose, a field guide note sheet **(Appendix-I)** was prepared in compact manner to record all types of site information with readings. A brief description of each infiltration sites shown in of the Dudhnai sub-basin shown in **Fig-1** is given below:

CHIKAL VILLAGE (SITE NO 1 & 2) :

Two infiltration tests were conducted at Chikal village, one at harvested paddy field and the other at open grassy field surrounded by Bannana, Bettlenut & Bamboo trees. River Manda is flowing towards north to south about 800 m from the test sites of Chikal. Distance between both the test sites is about 300 m. The elevation of the site is about 500 m above m.s.l. Site 1 has top layer soil (upto a depth of about 50 cm) is made of dark gray sandy loam with matured paddy roots of recent harvest. But at grassy land site 2, soil was in loose state having light yellowish brown colour up to 30 cm below ground surface and after 30 cm it was in reddish dark colour with appearance of stones & spherical kankars like moorum soil. It was covered around 75% by small grasses. No human habitats were present at the test locations.

DASERA SARANGMA (SITE NO 3 & 4) :

3rd & 4th infiltration tests were conducted at Dasera sarangma lying about 2 km from Dudhnai forest rest house. Test No 3 was conducted at dense forest cover of Sal, Teak & Archid. Fourth test was conducted in harvested paddy field at Daresa -Sarangma agricultural seed farm under department of Agriculture, Govt of Maghalaya. The river Manda flows from North to South

direction about 1 km from test sites. Average elevation is about 220 m. Soil of the site No 3 was dark gray sandy-loam type and is characterized with fine pores and fissures. Continuous movement of heavily loaded vehicles were observed about 50m from the site. Top surface soil of the forest cover (site No 4) was sandy loam consisting humus & tree leaves but sub-surface soil was (30 cm BGL) of dark gray colour inter-woven with fully matured tree roots.

DIANADUBI FOREST REST HOUSE (SITE NO 5 & 6) :

Dianadubi Forest rest house is located towards lower end of the basin and is a land mark for the area. The average elevation of this place is about 200 m and test here was conducted in the forest cover of Sal, Teak, Bettlenut and other under-growths.

At site 5, the texture of the surface soil is sandy loam of dark gray colour while it is loamy sand of light yellowish gray at site 6.

RONG-JONG (SITE NO 7) :

This site is near the bank of the river Rong-Jong located at an altitude of about 500 m. The site is on a flat river bank area of grassy land with ground cover of about 30% .

The soil upto a depth of about 50 cm has light brown colour. Test site is surrounded by Bettelnuts, Bamboos & Sal trees. Soil is moderately silty and is characterized by fine pores and fine grass roots.

RONG-BERAM (SITE NO 8) :

This infiltration site is at about 550 m elevation. It is covered with shrubs with 80-90% grass cover. In the surroundings, Banana & Bettlenut trees were seen. River Chichra is flowing towards North to South at about 1 km from the test site. The soil surface upto 50 cm depth is made of light yellowish silty sand and is characterized by fine pores and many medium size plant roots.

RONGMILE (SITE NO 9) :

The 9th infiltration site at an elevation of 500 m in Rong mile is a plain barren land with silty type soil having loamy sand texture . The colour of soil changes from dark gray to light brown after 50 cm BGL.

CHAKJONGDRA (SITE NO 10) :

The elevation of 10th infiltration test site at Chakjongdra is about 350 m located near the basin mouth. It is primarily a shruby land with ground cover of about 80%. Test site is surrounded by Banana & Bettelnut trees . Soil surface upto 50 cm depth is silty sand type and of dark gray colour characterized by fine fissures & many fine plant roots.

GABLIADANG (SITE NO 11) :

This site is situated between Chil & Rongma rivers. This is again a shruby land with 90% ground cover. Test location is situated at foot hill and is surrounded by bamboos.

Soil Texture is silty sand having dark gray colour upto 50 cm depth and below it colour changes to light yellowish gray.

GANDUAL (SITE NO 12) :

The site is on a flat topography on the bank of river Chill with 30% grass cover. Its elevation is about 350 m. The soil is uniformly graded with sandy loam texture upto a depth of 50 cm. Colour of the soil is dark gray at the surface changing to light brown beyond it.

CHIMA IMPHAL (SITE NO 13) :

The site is barren and flat surrounded by mixed land use of Bannana, Sal & Bettlenut trees. Its elevation is about 400 m. The site is devoid of any grass at the surface. Soil is predominantly of fine silty sand uniformly graded and is of light yellow colour.

NILWAGITHIM (SITE NO 14):

This test site is at an elevation of about 410 m from MSL. The land use is barren type and surrounded shrubs were observed. Soil is mainly fine silty sand of uniform grade having light to dark yellowish brown colour.

MONDIMA (SITE NO 15) :

This infiltration test was conducted at the foot hills and it has forest cover of Sal, Teak, Deodar, & Bamboos. Its altitude is about 200 m from MSL. Soil Texture is mainly loamy sand.

BAKSILPARA (SITE NO 16):

It is a plain grassy land site at the plain lower portion of the basin. River Dudhnai is flowing near the test site. Its elevation about is about 150 m from MSL.

Soil Texture is loamy sand medium graded having dark blackish gray to yellowish brown colour. Soil is mainly of sandy nature and characterized by fine pores and many fine grass roots. Grass cover is about 95%.

DUDHNAI (SITE NO. 17):

This site is mainly of shruby land use type and is surrounded by Bettelnut and Bannana trees. Site is situated near Dudhnai river bridge across National Highway. It is about 5 km from Dudhnai forest rest house towards north direction. Average elevation is about 150 m from MSL. Ground cover of Shrubs was about 50%. Soil Texture is mainly silty sand, uniformly graded Colour of soil was dark gray upto 50 cm below ground surface and light brown after 50 cm.

SARANGMA (SITE NO. 18):

The site is shruby land with 80% ground cover. Test location is on a flat topography and surrounded by mixed land use of Banana & Bettlenut trees. Its elevation is about 300 m. Soil is mainly silty sand in nature with dark yellowish brown colour. This test location is situated just near the dudhnai river bridge crossing. The movement of heavy loaded vehicles were also observed nearby the test site.

DEPA (SITE No. 19) :

This is again a shruby land of about 90% ground cover. Test location is just below the hill and in the surroundings, Bananas and dense Sal forest were seen. The elevation is about 350 m. Soil of the site is uniformly graded silty sand having light brown colour.

KHENTARA (SITE NO. 20):

This site is near the bank of the river Sarangma located at an altitude of about 250 m. Soil is well graded sandy loam. Ground cover of grass was almost 90%.

DIANADUBI (SITE NO 21):

The site is about 10 km from the basin mouth with elevation of about 250 m. It has mixed forest cover and well graded sandy loam type soil. Large scale human influence on the forest was visible.

DAMARA, EAST & WEST (SITE NO 22 & 23):

The sites were about 4 km from Dudhnai town at the basin mouth. Tests were conducted in mixed forest covers with surrounding of human habitats and cropped lands. Soils here were also found to be well graded sandy loams.

Laboratory analysis for Textural Analysis and Soil Properties at different sites are furnished in Appendix-III & Appendix-IV respectively.

Plate 1 to 3 shows infiltration test site at Dianadubi, Sarangma Bridge Side and Dasara Sarangma respectively.

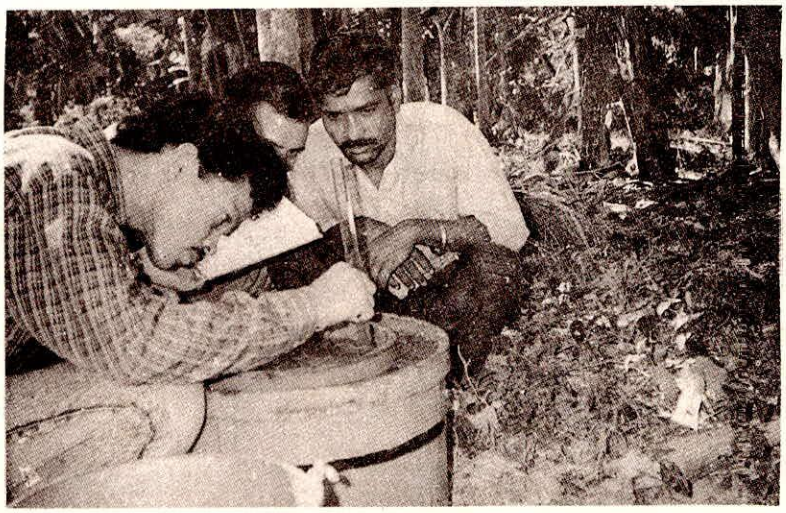


Plate - 1 Infiltration Test at Dudhnai Forest Area

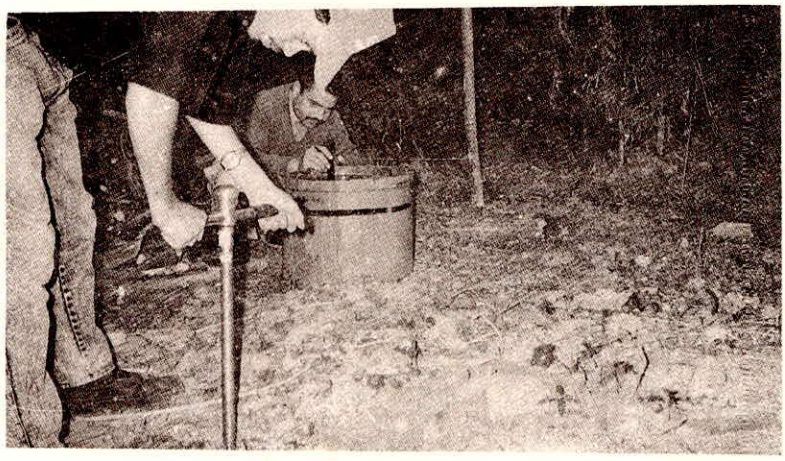


Plate - 2 Infiltration Test & Soil Sampling at Sarangma Bridge Side

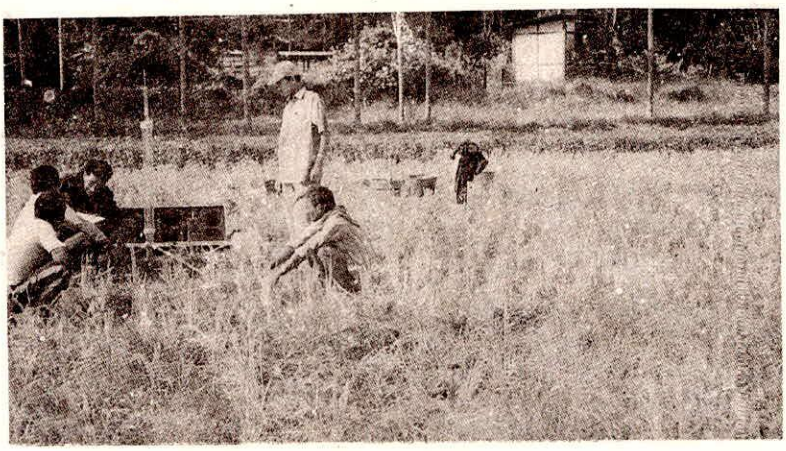


Plate - 3 Infiltration , Guelph Permeameter and Tensiometer Test at Dasera Sarangma Site

5.0 RESULTS AND ANALYSIS :

Based on the Methodology and available infiltration models described in Chapter-2, test data obtained during field experiments at 23 locations of Dudhnai Sub-Basin were analyzed and individual infiltration curves for different land uses, soil types and different properties of soil & soil texture have been developed. Soil samples were collected from the infiltration sites to find out the overall effect of different soil properties on infiltration rates. The samples were tested at laboratory for determination of its porosity, initial moisture content, void ratio, % air voids, effective grain size dia, medium grain size dia, plasticity, degree of saturation and uniformity coefficient. Also to find out the relation between hydraulic conductivity and soil suction, **Guelph Permeameter** tests were conducted at three infiltration sites. Soil suctions were also found in two infiltration sites with the help of **Tensiometer**. Flux potential was obtained with the help of hydraulic conductivity readings. Results of soil tests for textural analysis and properties are furnished in **Appendix-III & Appendix-IV** respectively. Infiltration curves have been plotted for different combination of land uses and soil types. Few water quality parameters have also been reflected in the Tables. Summarized results in this respect have been furnished in **Table-5.1**. Detailed results alongwith infiltration curves are presented in **Table-5.2 to Table-5.8** and **Fig-2 to Fig-8**. This set of results shows infiltration characteristics for a particular land use but for different soil properties at test

sites. Another set of results furnished in **Table-5.9 to Table-5.12 & Fig-9 to Fig-12** show infiltration characteristics for a particular soil type but for different land uses. Due to interference of soil texture & soil properties it is not clearly established everywhere that forest has the higher infiltration rate than the other land uses.

Fig-13 to Fig-15 are the Bar Graph presentation of results to show the infiltration characteristics at different sites under the same soil type & land use and also the total elapsed time the soil is taking to reach the infiltration capacity. The variation of results are attributed to the factors other than land use & soil type as described in Chapter-2. **Fig-16 & Fig-17** is the generalized representation in the form of Bar Graph showing infiltration characteristics under different land use and different soil types respectively.

To find out the functional relationships of each land use with infiltration characteristics available infiltration models have been tested and Kostiakov's model was found to be the best fitted model for correlations. In this model regression analysis were done with the log values of elapsed time & observed cumulative infiltration values. The original Kostiakov's equation is $F=a.T^b$ and its linear equation form after taking log is **log F = log a+ b. log T.** This form of equations have been developed for each land use & soil type. The results are presented in Table-5.13. From the Table, it is evident that the correlation coefficients (r^2) varied from 0.994 to 0.997, 0.894 to 0.973, 0.891 to 0.999, 0.916 to 0.976, 0.870 to 0.948 and 0.914 to 0.943 for paddy farm, grassy land, forest cover, river

bank, shrub land and barren land respectively confirming a good fit of the function.

The water used while conducting infiltration tests were tested to find out its fluid properties like turbidity, pH, Dissolved Oxygen, temperature, Kinematic viscosity and conductivity at site and these results were incorporated with the infiltration results.

Past studies on different land uses show that the average infiltration rate decreases in order of Forest, Grassy land, Barren land and Agricultural land (Harvested Paddy Field). But in the present study at Dudhnai sub-basin average infiltration rate is not clearly showing this order. This may be due to control of soil characteristics and other factors.

From very limited test data at few places, graph between hydraulic conductivity and infiltration rates were plotted and shown in Fig-18. It shows increase in conductivity increases infiltration rates. But on the basis of only few data, it cannot be firmly established. It is necessary to conduct some more Guelph Permeameter tests at the infiltration sites to verify it. Similarly, in Fig-19 & Fig-20 it has been attempted to relate Flux Potential & Soil Suction with infiltration characteristics from few isolated tests which again calls for extension of these works for a definite inference.

TABLE - 5.1

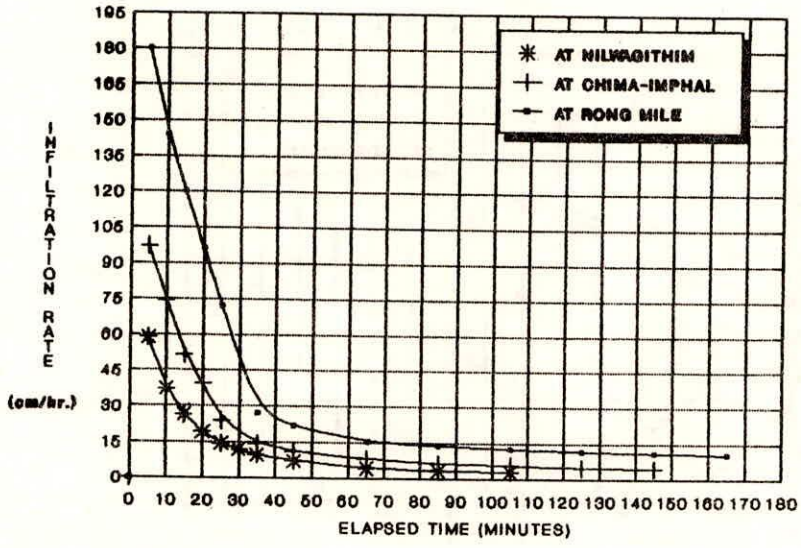
INFILTRATION RATES UNDER DIFFERENT LAND USES WITH SOIL TEXTURES

S. NO.	SITE'S NAME	LAND USE	SOIL TEXTURE	INFILTRATION RESULTS			
				INITIAL INFILTRATION RATE OBSERVED IN (cm/hr)	FINAL INFILTRATION RATE AFTER (cm/hr)	TOTAL CUMULATIVE DEPTH (cm)	TESTING DATE
1	2	3	4	5	6	7	8
1	CHIKAL	HARVESTED PADDY FARM	SANDY LOAM(W G)	0.8 IN 30MIN	0.4 /240 MIN	1.8	27-12-94
2	DASERA SARANGMA	HARVESTED PADDY FARM	LOAMY SAND(M G)	27.6 IN 5 MIN	1.4 /250 MIN	11.2	28-12-94
3	CHIKAL **	GRASSY LAND	SILTY SAND(M G)	180.0 IN 1 MIN	32.0 /112 MIN	107.5	27-12-94
4	BUKSILPARA	GRASSY LAND	LOAMY SAND(W G)	69.6 IN 5 MIN	0.9 /155 MIN	27.2	13-12-94
5	RONG MILE **	BARREN LAND	LOAMY SAND(M G)	180.0 IN 5 MIN	10.5 /165 MIN	84.1	10-12-94
6	CHIMA-IMPHAL	BARREN LAND	LOAMY SAND(W G)	97.2 IN 5 MIN	4.5 /145 MIN	38.0	12-12-94
7	NILWAGITHIM	BARREN LAND	SILTY SAND(U G)	58.8 IN 5 MIN	3.0 /105 MIN	19.5	12-12-94
8	RONG JONG	RIVER BANK	LOAMY SAND(W G)	64.8 IN 5 MIN	4.8 /140 MIN	32.4	10-12-94
9	GANDUAL	RIVER BANK	LOAMY SAND(U G)	79.2 IN 5 MIN	2.0 /180 MIN	42.5	12-12-94
10	KHENTARA	RIVER BANK	SANDY LOAM(W G)	55.2 IN 5 MIN	0.9 /120 MIN	16.5	14-12-94
11	RONG BERAM	SHRUB LAND	SILTY SAND(U G)	90.0 IN 5 MIN	3.0 /130 MIN	29.6	10-12-94
12	CHAKJONGDRA	SHRUB LAND	SILTY SAND(U G)	73.2 IN 5 MIN	2.6 /215 MIN	42.0	11-12-94
13	GABLIADANG	SHRUB LAND	SILTY SAND(U G)	90.0 IN 5 MIN	6.6 /180 MIN	52.4	11-12-94
14	DUDHNAI	SHRUB LAND	SILTY SAND(U G)	76.8 IN 5 MIN	1.5 /165 MIN	40.8	13-12-94
15	SARANGMA	SHRUB LAND	SILTY SAND(U G)	109.2 IN 5 MIN	2.1 /140 MIN	42.1	14-12-94
16	DEPA	SHRUB LAND	SILTY SAND(U G)	87.6 IN 5 MIN	1.2 /140 MIN	29.4	14-12-94
17	DASERA SARANGMA	FOREST COVER (SAL, TEAK & ORCHID)	LOAMY SAND(M G)	120.0 IN 1 MIN	4.6 /356 MIN	58.1	28-12-94
18	DIANADUBI FOREST REST HOUSE(EAST)	FOREST COVER (SAL & TEAK)	LOAMY SAND(W G)	43.2 IN 5 MIN	5.2 /195 MIN	27.9	29-12-94
19	MONDIMA	FOREST COVER (SAL, TEAK & ORCHID)	LOAMY SAND(M G)	126.0 IN 5 MIN	1.6 /185 MIN	57.5	13-12-94
20	DIANADUBI	FOREST COVER (SAL & TEAK)	SANDY LOAM(W G)	72.0 IN 5 MIN	1.2 /140 MIN	20.8	14-12-94
21	DAMARA (WEST)	FOREST COVER (SAL, TEAK & DEVDAR)	SANDY LOAM(W G)	40.8 IN 5 MIN	0.9 /120 MIN	14.5	15-12-94
22	DAMARA (EAST)	FOREST COVER (SAL, TEAK & DEVDAR)	SANDY LOAM(W G)	56.4 IN 5 MIN	1.5 /170 MIN	29.3	15-12-94
23	DIANADUBI FOREST REST HOUSE(WEST)	FOREST COVER (SAL & TEAK)	SANDY LOAM(W G)	21.6 IN 5 MIN	3.8 /255 MIN	21.4	29-12-94

NOTE : (W G) - WELL GRADED; (M G) - MEDIUM GRADED; (U G) - UNIFORM GRADED

** TEST NOT ACCEPTABLE DUE TO BAD SITE CONDITIONS

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION CURVES FOR
BARREN LAND



SOIL TYPE :LOAMY SAND
(MEDIUM TO WELL GRADED) FIG. 2

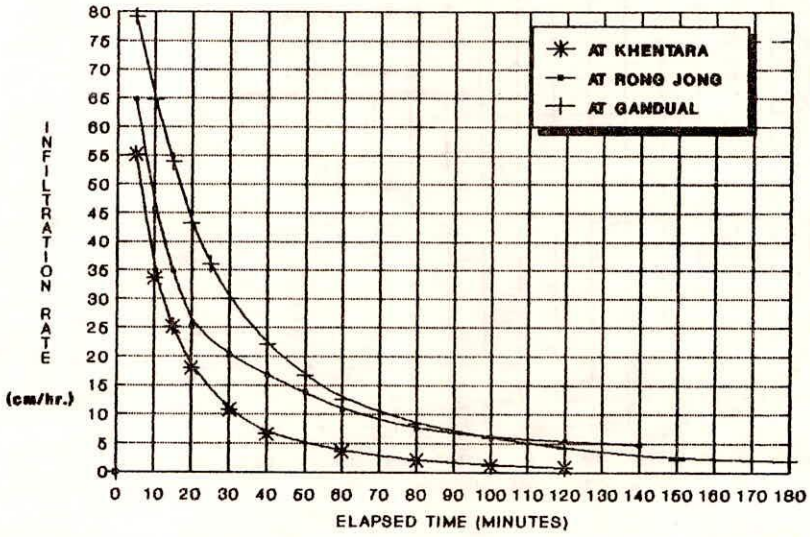
TABLE - 5.2

INFILTRATION CHARACTERISTICS WITH RESPECT TO LAND USE, SOIL PROPERTIES AND WATER QUALITY PARAMETERS

S. NO.	SITE'S NAME / PROPERTIES	RONG MILE	CHIMA IMPHAL	NILWAGITHIM
SOIL PROPERTIES				
1	NATURAL DENSITY (gm/cc)	1.45	1.62	1.38
2	MOISTURE CONTENT (%)	20.5	19.8	20.2
3	VOID RATIO	1.16	0.91	0.88
4	POROSITY (%)	53.7	47.0	46.3
5	AIR CONTENT	0.55	0.40	0.52
6	% AIR VOIDS	29.8	20.3	23.7
7	SATURATED DENSITY (gm/cc)	1.73	1.79	1.60
8	DEGREE OF SATURATION (%)	44.60%	60.05%	47.95%
9	SPECIFIC GRAVITY	2.58	2.51	2.12
10	PLASTIC LIMIT	13.5	34.6	28.7
11	UNIFORMITY COEFFICIENT (Cu)	18.33	9	4.4
12	CURVATURE COEFFICIENT (Cc)	3.79	1.44	1.2
13	NATURAL DRY DENSITY (gm/cc)	1.20	1.34	1.15
WATER QUALITY				
1	pH	6.72	6.42	WATER
2	TEMPERATURE (°C)	22.2	21.6	SAMPLE WAS
3	KINEMATIC VISCOSITY (cm^2/sec)	9.64E-03	9.78E-03	NOT
4	DISSOLVED OXYGEN (ppm)	5.10	6.20	COLLECTED
5	TURBIDITY (% AT 1000 nm)	85.90	87.60	
6	CONDUCTIVITY (ml/mho)	7.80	8.20	
INFILTRATION RECORD				
1	INITIAL INFILTRATION RATE(cm/h)	180.0 FOR 5 min	97.20 FOR 5 min	58.80 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	10.5 AFTER 165min	4.50 AFTER 145min	3.00 AFTER 105min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	84.10	38.00	19.50
	LAND USE	BARREN LAND	BARREN LAND	BARREN LAND
	SOIL TYPE	LOAMY SAND; MEDIUM GRAD.	LOAMY SAND WELL GRADED	SILTY SAND; UNIFORM GRAD

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION CURVES FOR
RIVER BANK (GRASS COVER)

CONDITION OF RIVER BANK - SEMI WET



SOIL TYPE :LOAMY SAND TO SANDY LOAM
(WELL GRADED)

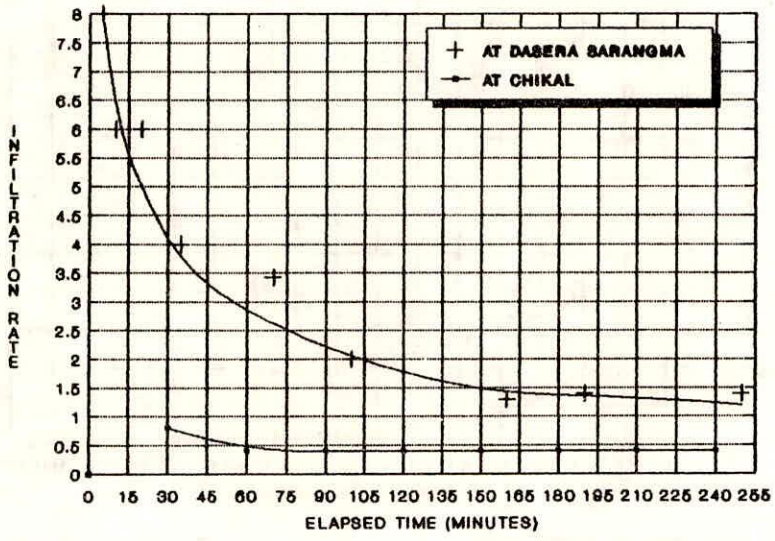
FIG. 3

TABLE - 5.3

INFILTRATION CHARACTERISTICS WITH RESPECT TO LAND USE,
SOIL PROPERTIES AND WATER QUALITY PARAMETERS

S. NO.	SITE'S NAME / PROPERTIES	RONG JONG	GANDUAL	KHENTARA
SOIL PROPERTIES				
1	NATURAL DENSITY (gm/cc)	1.43	1.29	SOIL SAMPLE WAS NOT COLLECTED
2	MOISTURE CONTENT (%)	23.3	22.7	
3	VOID RATIO	0.80	1.23	
4	POROSITY (%)	44.2	54.8	
5	AIR CONTENT	0.39	0.57	
6	% AIR VOIDS	17.4	31.3	
7	SATURATED DENSITY (gm/cc)	1.60	1.58	
8	DEGREE OF SATURATION (%)	60.95%	42.65%	
9	SPECIFIC GRAVITY	2.08	2.31	
10	PLASTIC LIMIT	30.3		
11	UNIFORMITY COEFFICIENT (Cu)	21.25	16.47	
12	CURVATURE COEFFICIENT (Cc)	2.65	2.54	
13	NATURAL DRY DENSITY (gm/cc)	1.16	1.05	
WATER QUALITY				
1	pH	6.80	6.33	WATER SAMPLE WAS NOT COLLECTED
2	TEMPERATURE (°C)	22.1	21.6	
3	KINEMATIC VISCOSITY (cm^2/sec)	9.66E-03	9.78E-03	
4	DISSOLVED OXYGEN (ppm)	6.50	6.10	
5	TURBIDITY (% AT 1000 nm)	84.80	87.00	
6	CONDUCTIVITY (ml/mho)	1.16	9.20	
INFILTRATION RECORD				
1	INITIAL INFILTRATION RATE(cm/h)	64.80 FOR 5 min	79.20 FOR 5 min	55.20 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	4.80 AFTER 140min	2.00 AFTER 180min	0.90 AFTER 120min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	32.40	42.50	16.50
	LAND USE	RIVER BANK; GRASSY LAND	RIVER BANK; GRASSY LAND	RIVER BANK; GRASSY LAND
	SOIL TYPE	LOAMY SAND; WELL GRADED	LOAMY SAND; UNIFORM GRAD	SANDY LOAM; WELL GRADED

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION CURVES FOR
HARVESTED PADDY FIELD



SOIL TYPE :SANDY LOAM TO LOAMY SAND

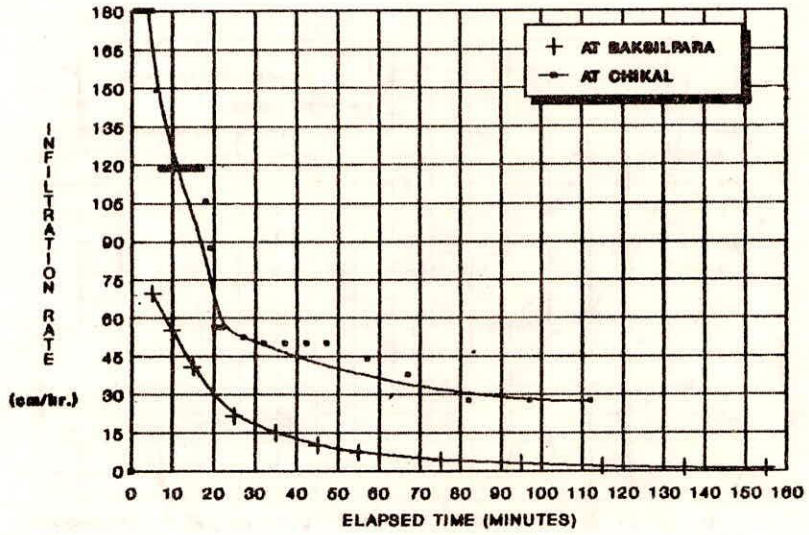
FIG. 4

TABLE - 5.4

INFILTRATION CHARACTERISTICS WITH RESPECT TO LAND USE, SOIL PROPERTIES AND WATER QUALITY PARAMETERS

S. NO.	SITE'S NAME / PROPERTIES	CHIKAL	DASERA SARANGMA
SOIL PROPERTIES			
1	NATURAL DENSITY (gm/cc)	1.56	1.5
2	MOISTURE CONTENT (%)	36.9	16.2
3	VOID RATIO	0.39	0.43
4	POROSITY (%)	28.1	29.7
5	AIR CONTENT	0.05	0.31
6	% AIR VOIDS	1.40	8.53
7	SATURATED DENSITY (gm/cc)	1.00	1.59
8	DEGREE OF SATURATION (%)	95.00%	69.50%
9	SPECIFIC GRAVITY	1.00	1.85
10	PLASTIC LIMIT		
11	UNIFORMITY COEFFICIENT (Cu)	18	12.78
12	CURVATURE COEFFICIENT (Cc)	1.13	2.42
13	NATURAL DRY DENSITY (gm/cc)	1.14	1.29
WATER QUALITY			
1	pH	6.66	WATER
2	TEMPERATURE (°C)	21.0	SAMPLE WAS
3	KINEMATIC VISCOSITY (cm^2/sec)	9.92E-03	NOT
4	DISSOLVED OXYGEN (ppm)	5.98	COLLECTED
5	TURBIDITY (% AT 1000 nm)	81.00	
6	CONDUCTIVITY (ml/mho)	10.64	
INFILTRATION RECORD			
1	INITIAL INFILTRATION RATE(cm/h)	0.80 FOR 30 min	27.60 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	0.4 AFTER 240min	1.40 AFTER 250min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	1.80	11.20
	LAND USE	HARVESTED PADDY FARM	HARVESTED; PADDY FARM
	SOIL TYPE	SANDY LOAM; WELL GRADED	LOAMY SAND; MEDIUM GRAD.

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION CURVES FOR
PLAIN GRASSY LAND



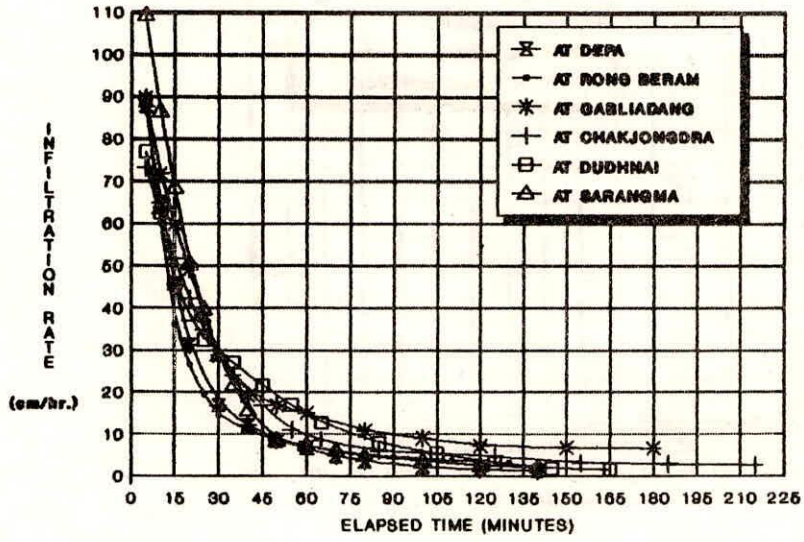
SOIL TYPE :SANDY TO LOAMY SAND
(MEDIUM TO WELL GRADED) FIG. 6

TABLE - 5.5

INFILTRATION CHARACTERISTICS WITH RESPECT TO LAND USE, SOIL PROPERTIES AND WATER QUALITY PARAMETERS

S. NO.	SITE'S NAME / PROPERTIES	CHIKAL	BUKSILPARA
SOIL PROPERTIES			
1	NATURAL DENSITY (gm/cc)	1.38	1.37
2	MOISTURE CONTENT (%)	27.5	15.8
3	VOID RATIO	0.88	0.79
4	POROSITY (%)	46.8	44.1
5	AIR CONTENT	0.37	0.61
6	% AIR VOIDS	17.2	26.7
7	SATURATED DENSITY (gm/cc)	1.55	1.61
8	DEGREE OF SATURATION (%)	63.30%	39.25%
9	SPECIFIC GRAVITY	2.03	2.09
10	PLASTIC LIMIT	15.5	3.7
11	UNIFORMITY COEFFICIENT (Cu)	6.25	30
12	CURVATURE COEFFICIENT (Cc)	1.56	1.7
13	NATURAL DRY DENSITY (gm/cc)	1.08	1.19
WATER QUALITY			
1	pH	WATER	6.92
2	TEMPERATURE (°C)	SAMPLE WAS	20.6
3	KINEMATIC VISCOSITY (cm^2/sec)	NOT	1.00E-02
4	DISSOLVED OXYGEN (ppm)	COLLECTED	7.90
5	TURBIDITY (% AT 1000 nm)		81.80
6	CONDUCTIVITY (ml/mho)		6.50
INFILTRATION RECORD			
1	INITIAL INFILTRATION RATE(cm/h)	180.0 FOR 1 min	69.60 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	32.0 AFTER 112min	0.90 AFTER 155min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	107.50	27.20
	LAND USE	GRASSY LAND	GRASSY LAND
	SOIL TYPE	SILTY SAND; MEDIUM GRAD.	LOAMY SAND; WELL GRADED

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION CURVES FOR
SHRUB LAND



SOIL TYPE :SILTY SAND (UNIFORM GRADED)

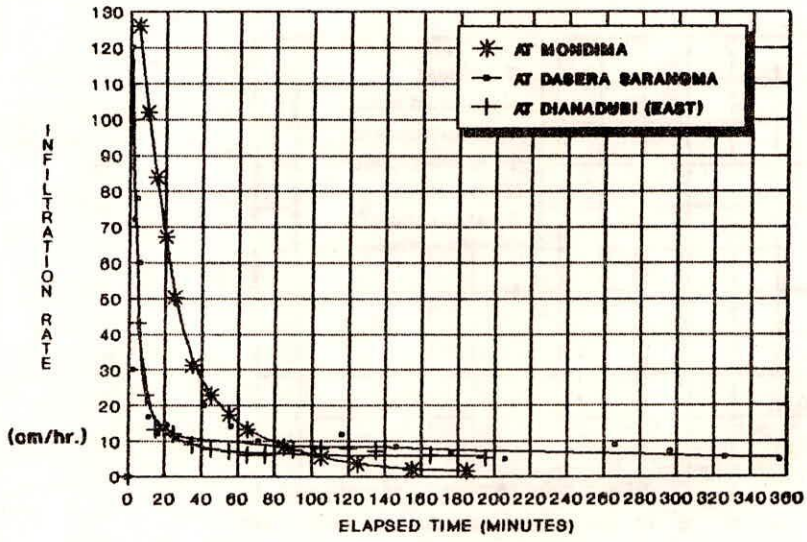
FIG. 6

TABLE - 5.6

INFILTRATION CHARACTERISTICS WITH RESPECT TO LAND USE,
SOIL PROPERTIES AND WATER QUALITY PARAMETERS

S. NO.	SITE'S NAME / PROPERTIES	RONG BERAM	CHAKJONGDRA	GABLIADANG	DUDHNAI	SARANGMA	DEPA
SOIL PROPERTIES							
1	NATURAL DENSITY (gm/cc)	1.33	1.70	1.28	1.39		SOIL
2	MOISTURE CONTENT (%)	15.5	21.9	18.2	27.7		SAMPLE WAS
3	VOID RATIO	1.02	0.75	1.12	1.06	SOIL	NOT
4	POROSITY (%)	50.5	42.2	52.8	51.4	SAMPLE WAS	COLLECTED
5	AIR CONTENT	0.69	0.27	0.63	0.43	NOT	
6	% AIR VOIDS	34.8	12.2	33.2	21.6	COLLECTED	
7	SATURATED DENSITY (gm/cc)	1.51	1.81	1.60	1.59		
8	DEGREE OF SATURATION (%)	31.00%	73.05%	36.95%	57.30%		
9	SPECIFIC GRAVITY	2.04	2.40	2.27	2.22		
10	PLASTIC LIMIT	29.7	10.8	4.7			
11	UNIFORMITY COEFFICIENT (Cu)	11.27	4.82	3.75	5.83		
12	CURVATURE COEFFICIENT (Cc)	0.023	1.35	0.67	1.07		
13	NATURAL DRY DENSITY (gm/cc)	1.00	1.40	1.08	1.09		
WATER QUALITY							
1	pH	7.49	7.18	5.94	WATER	6.33	WATER
2	TEMPERATURE ($^{\circ}$C)	22.2	22.3	21.6	SAMPLE WAS	21.6	SAMPLE WAS
3	KINEMATIC VISCOSITY (cm^2/sec)	9.64E-03	9.62E-03	9.78E-03	NOT	9.78E-03	NOT
4	DISSOLVED OXYGEN (ppm)	5.90	6.30	6.80	COLLECTED	6.10	COLLECTED
5	TURBIDITY (% AT 1000 nm)	87.80	88.30	88.50		87.00	
6	CONDUCTIVITY (ml/mho)	10.40	6.90	7.80		9.20	
INFILTRATION RECORD							
1	INITIAL INFILTRATION RATE(cm/h)	90.00 FOR 5 min	73.20 FOR 5 min	90.00 FOR 5 min	76.8 FOR 5 min	109.20 FOR 5 min	87.60 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	3.00 AFTER 130min	2.60 AFTER 215min	6.60 AFTER 180min	1.50 AFTER 165min	2.10 AFTER 140min	1.20 AFTER 140min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	29.60	42.00	52.40	40.80	42.10	29.40
	LAND USE	SHRUB LAND	SHRUB LAND	SHRUB LAND	SHRUB LAND	SHRUB LAND	SHRUB LAND
	SOIL TYPE	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION CURVES FOR
FOREST COVER



SOIL TYPE :LOAMY SAND(MEDIUM GRADED)

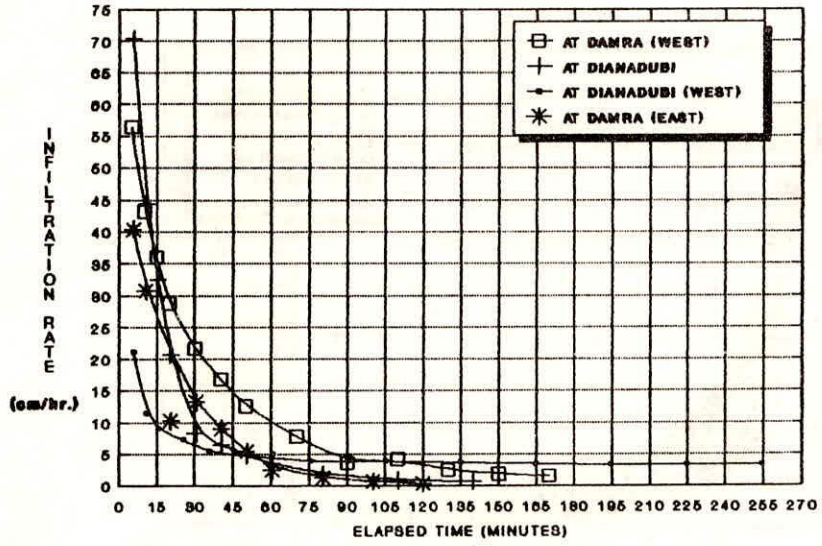
FIG. 7

TABLE - 5.7

INFILTRATION CHARACTERISTICS WITH RESPECT TO LAND USE,
SOIL PROPERTIES AND WATER QUALITY PARAMETERS

S. NO.	SITE'S NAME / PROPERTIES	DASERA SARANGMA	DIANADUBI FOREST GUEST HOUSE (EAST)	MONDIMA
SOIL PROPERTIES				
1	NATURAL DENSITY (gm/cc)	1.3	1.5	1.46
2	MOISTURE CONTENT (%)	16.2	16.1	18.3
3	VOID RATIO	0.60	0.79	0.74
4	POROSITY (%)	33.2	44.1	41.8
5	AIR CONTENT	0.40	0.56	0.50
6	% AIR VOIDS	15.9	24.7	20.4
7	SATURATED DENSITY (gm/cc)	1.45	1.64	1.64
8	DEGREE OF SATURATION (%)	59.90%	44.00%	49.90%
9	SPECIFIC GRAVITY	1.74	2.15	2.10
10	PLASTIC LIMIT	18.7	5.0	22.4
11	UNIFORMITY COEFFICIENT (Cu)	7.78	39.28	13.33
12	CURVATURE COEFFICIENT (Cc)	1	2.92	2.9
13	NATURAL DRY DENSITY (gm/cc)	1.13	1.36	1.24
WATER QUALITY				
1	pH	6.15	WATER	6.42
2	TEMPERATURE (°C)	20.0	SAMPLE WAS	21.6
3	KINEMATIC VISCOSITY (cm^2/sec)	1.02E-02	NOT	9.78E-03
4	DISSOLVED OXYGEN (ppm)	6.85	COLLECTED	6.20
5	TURBIDITY (% AT 1000 nm)	87.00		86.30
6	CONDUCTIVITY (ml/mho)	10.39		8.20
INFILTRATION RECORD				
1	INITIAL INFILTRATION RATE(cm/h)	120.0 FOR 1 min	43.20 FOR 5 min	126.0 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	4.60 AFTER 356min	5.20 AFTER 195min	1.60 AFTER 185min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	58.10	27.90	57.50
	LAND USE	FOREST COVER	FOREST COVER	FOREST COVER
	SOIL TYPE	LOAMY SAND; MEDIUM GRAD.	LOAMY SAND; WELL GRADED	LOAMY SAND; MEDIUM GRAD.

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION CURVES FOR
FOREST COVER



SOIL TYPE :SANDY LOAM (WELL GRADED)

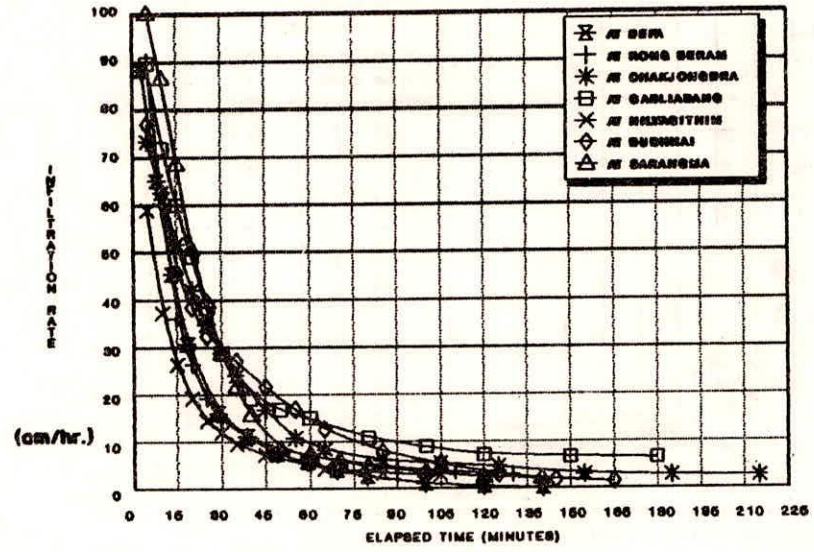
FIG. 8

TABLE - 5.8

INFILTRATION CHARACTERISTICS WITH RESPECT TO LAND USE,
SOIL PROPERTIES AND WATER QUALITY PARAMETERS

S. NO.	SITE'S NAME / PROPERTIES	DIANADUBI	DAMRA (EAST)	DAMRA (WEST)	DIANADUBI FOREST GUEST HOUSE (WEST)
SOIL PROPERTIES					
1	NATURAL DENSITY (gm/cc)	1.70	SOIL	SOIL	1.4
2	MOISTURE CONTENT (%)	28.2	SAMPLE WAS	SAMPLE WAS	15.6
3	VOID RATIO	0.90	NOT	NOT	0.93
4	POROSITY (%)	47.4	COLLECTED	COLLECTED	48.2
5	AIR CONTENT	0.39			0.65
6	% AIR VOIDS	18.7			31.3
7	SATURATED DENSITY (gm/cc)	1.56			1.56
8	DEGREE OF SATURATION (%)	60.60%			35.00%
9	SPECIFIC GRAVITY	2.07			2.09
10	PLASTIC LIMIT	27.1			40.3
11	UNIFORMITY COEFFICIENT (Cu)	41.67			46.67
12	CURVATURE COEFFICIENT (Cc)	3.75			3.81
13	NATURAL DRY DENSITY (gm/cc)	1.55			1.28
WATER QUALITY					
1	pH	5.96	WATER	WATER	4.69
2	TEMPERATURE (°C)	21.6	SAMPLE WAS	SAMPLE WAS	20.6
3	KINEMATIC VISCOSITY (cm^2/sec)	9.78E-03	NOT	NOT	1.00E-02
4	DISSOLVED OXYGEN (ppm)	5.50	COLLECTED	COLLECTED	6.08
5	TURBIDITY (% AT 1000 nm)	88.10			78.00
6	CONDUCTIVITY (ml/mho)	7.60			9.58
INFILTRATION RECORD					
1	INITIAL INFILTRATION RATE(cm/h)	72.00 FOR 5 min	40.80 FOR 5 min	56.4 FOR 5 min	21.60 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	1.20 AFTER 140min	0.90 AFTER 120min	1.50 AFTER 170min	3.80 AFTER 255min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	20.80	14.50	29.30	21.40
	LAND USE	FOREST COVER	FOREST COVER	FOREST COVER	FOREST COVER
	SOIL TYPE	SANDY LOAM; WELL GRADED	SANDY LOAM; WELL GRADED	SANDY LOAM; WELL GRADED	SANDY LOAM; WELL GRADED

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION TEST CURVES OF
SOIL TYPE vs INFILTRATION RATE



(CONSIDERING SOIL TYPE INFORMATION ONLY)
SOIL TYPE :SILTY SAND (UNIFORM GRADED)

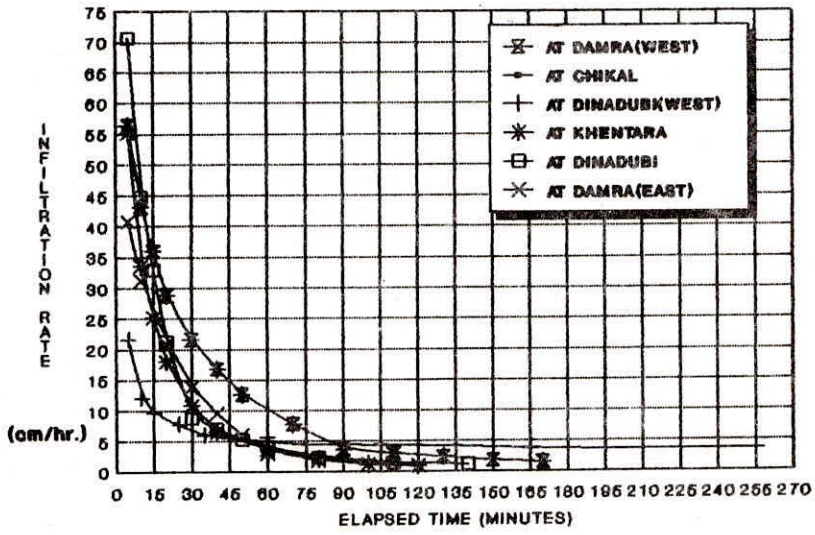
FIG. 8

TABLE - 5.9

INFILTRATION CHARACTERISTICS WITH RESPECT TO LANDUSES, SOIL PROPERTIES AND WATER QUALITY PARAMETERS FOR THE SAME SOIL TEXTURE

S. NO.	SITE'S NAME / PROPERTIES	DEPA	RONG BERAM	CHAKJONGDRA	GABLIADANG	NILWAGITHIM	DUDHNAI	SARANGMA
SOIL PROPERTIES								
1	NATURAL DENSITY (gm/cc)	SOIL	1.33	1.70	1.28	1.38	1.39	
2	MOISTURE CONTENT (%)	SAMPLE WAS	15.5	21.9	18.2	20.2	27.7	
3	VOID RATIO	NOT	1.02	0.75	1.12	0.88	1.06	SOIL
4	POROSITY (%)	COLLECTED	50.5	42.2	52.8	46.3	51.4	SAMPLE WAS
5	AIR CONTENT		0.69	0.27	0.63	0.52	0.43	NOT
6	% AIR VOIDS		34.8	12.2	33.2	23.7	21.6	COLLECTED
7	SATURATED DENSITY (gm/cc)		1.51	1.81	1.60	1.60	1.59	
8	DEGREE OF SATURATION (%)		31.00%	73.05%	36.95%	47.95%	57.30%	
9	SPECIFIC GRAVITY		2.04	2.40	2.27	2.12	2.22	
10	PLASTIC LIMIT		29.7	10.8	4.7	28.7		
11	UNIFORMITY COEFFICIENT (Cu)		11.27	4.82	3.75	4.4	5.83	
12	CURVATURE COEFFICIENT (Cc)		0.023	1.35	0.67	1.2	1.07	
13	NATURAL DRY DENSITY (gm/cc)		1.00	1.40	1.08	1.15	1.09	
WATER QUALITY								
1	pH	WATER	7.49	7.18	5.94	WATER	WATER	6.33
2	TEMPERATURE (°C)	SAMPLE WAS	22.2	22.3	21.6	SAMPLE WAS	SAMPLE WAS	21.6
3	KINEMATIC VISCOSITY (cm^2/sec)	NOT	9.64E-03	9.62E-03	9.78E-03	NOT	NOT	9.78E-03
4	DISSOLVED OXYGEN (ppm)	COLLECTED	5.90	6.30	6.80	COLLECTED	COLLECTED	6.10
5	TURBIDITY (% AT 1000 nm)		87.80	88.30	88.50			87.00
6	CONDUCTIVITY (ml/mho)		10.40	6.90	7.80			9.20
INFILTRATION RECORD								
1	INITIAL INFILTRATION RATE(cm/h)	87.60 FOR 5 min	90.00 FOR 5 min	73.20 FOR 5 min	90.00 FOR 5 min	58.80 FOR 5 min	76.8 FOR 5 min	109.20 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	1.20 AFTER 140min	3.00 AFTER 130min	2.60 AFTER 215min	6.60 AFTER 180min	3.00 AFTER 105min	1.50 AFTER 165min	2.10 AFTER 140min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	29.40	29.60	42.00	52.40	19.50	40.80	42.10
	LAND USE	SHRUB LAND	SHRUB LAND	SHRUB LAND	SHRUB LAND	BARREN LAND	SHRUB LAND	SHRUB LAND
	SOIL TYPE	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD	SILTY SAND; UNIFORM GRAD

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION TEST CURVE OF
SOIL TYPE vs INFILTRATION RATE



(CONSIDERING SOIL TYPE INFORMATION ONLY)
SOIL TYPE :SANDY LOAM (WELL GRADED)

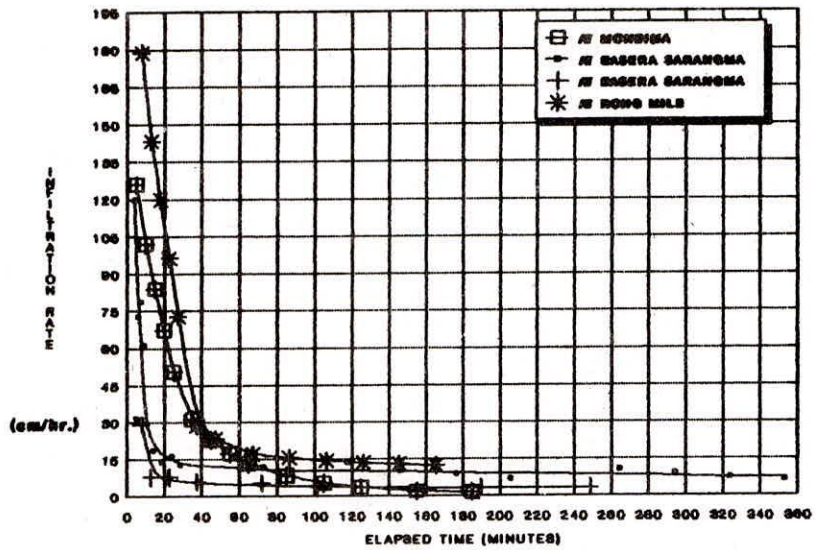
FIG. 10

TABLE - 5.10

INFILTRATION CHARACTERISTICS WITH RESPECT TO LANDUSES, SOIL PROPERTIES AND WATER QUALITY PARAMETERS FOR THE SAME SOIL TEXTURE

S. NO.	SITE'S NAME / PROPERTIES	DAMRA (WEST)	DIANADUBI FOREST GUEST HOUSE (WEST)	KHENTARA	DIANADUBI	DAMRA (EAST)
SOIL PROPERTIES						
1	NATURAL DENSITY (gm/cc)	SOIL	1.4	SOIL	1.70	SOIL
2	MOISTURE CONTENT (%)	SAMPLE WAS	15.6	SAMPLE WAS	28.2	SAMPLE WAS
3	VOID RATIO	NOT	0.93	NOT	0.90	NOT
4	POROSITY (%)	COLLECTED	48.2	COLLECTED	47.4	COLLECTED
5	AIR CONTENT		0.65		0.39	
6	% AIR VOIDS		31.3		18.7	
7	SATURATED DENSITY (gm/cc)		1.56		1.5€	
8	DEGREE OF SATURATION (%)		35.00%		60.60%	
9	SPECIFIC GRAVITY		2.09		2.07	
10	PLASTIC LIMIT		40.3		27.1	
11	UNIFORMITY COEFFICIENT (Cu)		46.67		41.67	
12	CURVATURE COEFFICIENT (Cc)		3.81		3.75	
13	NATURAL DRY DENSITY (gm/cc)		1.28		1.55	
WATER QUALITY						
1	pH	WATER	4.69	WATER	5.96	WATER
2	TEMPERATURE (°C)	SAMPLE WAS	20.6	SAMPLE WAS	21.6	SAMPLE WAS
3	KINEMATIC VISCOSITY (cm^2/sec)	NOT	1.00E-02	NOT	9.78E-03	NOT
4	DISSOLVED OXYGEN (ppm)	COLLECTED	6.08	COLLECTED	5.50	COLLECTED
5	TURBIDITY (% AT 1000 nm)		78.00		88.10	
6	CONDUCTIVITY (ml/mho)		9.58		7.60	
INFILTRATION RECORD						
1	INITIAL INFILTRATION RATE(cm/h)	56.4 FOR 5 min	21.60 FOR 5 min	55.20 FOR 5 min	72.00 FOR 5 min	40.80 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	1.50 AFTER 170min	3.80 AFTER 255min	0.90 AFTER 120min	1.20 AFTER 140min	0.90 AFTER 120min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	29.30	21.40	16.50	20.80	14.50
	LAND USE	FOREST COVER	FOREST COVER	RIVER BANK; GRASSY LAND	FOREST COVER	FOREST COVER
	SOIL TYPE	SANDY LOAM; WELL GRADED	SANDY LOAM; WELL GRADED	SANDY LOAM; WELL GRADED	SANDY LOAM; WELL GRADED	SANDY LOAM; WELL GRADED

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION TEST CURVES OF
SOIL TYPE vs INFILTRATION RATE



(CONSIDERING SOIL TYPE INFORMATION ONLY)
SOIL TYPE : LOAMY SAND (MEDIUM GRADED)

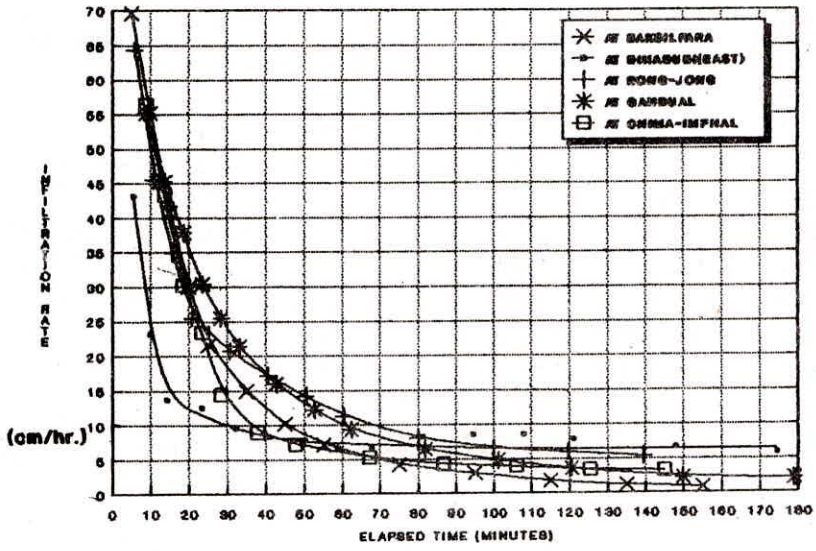
FIG. 11

TABLE - 5.11

INFILTRATION CHARACTERISTICS WITH RESPECT TO LANDUSES, SOIL PROPERTIES AND WATER QUALITY PARAMETERS FOR THE SAME SOIL TEXTURE

S. NO.	SITE'S NAME / PROPERTIES	MONDIMA	DASERA SARANGMA	DASERA SARANGMA	RONG MILE
SOIL PROPERTIES					
1	NATURAL DENSITY (gm/cc)	1.46	1.3	1.5	1.45
2	MOISTURE CONTENT (%)	18.3	16.2	16.2	20.5
3	VOID RATIO	0.74	0.60	0.43	1.16
4	POROSITY (%)	41.8	33.2	29.7	53.7
5	AIR CONTENT	0.50	0.40	0.31	0.55
6	% AIR VOIDS	20.4	15.9	8.53	29.8
7	SATURATED DENSITY (gm/cc)	1.64	1.45	1.59	1.73
8	DEGREE OF SATURATION (%)	49.90%	59.90%	69.50%	44.60%
9	SPECIFIC GRAVITY	2.10	1.74	1.85	2.58
10	PLASTIC LIMIT	22.4	18.7		13.5
11	UNIFORMITY COEFFICIENT (Cu)	13.33	7.78	12.78	18.33
12	CURVATURE COEFFICIENT (Cc)	2.9	1	2.42	3.79
13	NATURAL DRY DENSITY (gm/cc)	1.24	1.13	1.29	1.20
WATER QUALITY					
1	pH	6.42	6.15	WATER	6.72
2	TEMPERATURE ($^{\circ}$C)	21.6	20.0	SAMPLE WAS	22.2
3	KINEMATIC VISCOSITY (cm^2/sec)	9.78E-03	1.02E-02	NOT	9.64E-03
4	DISSOLVED OXYGEN (ppm)	6.20	6.85	COLLECTED	5.10
5	TURBIDITY (% AT 1000 nm)	86.30	87.00		85.90
6	CONDUCTIVITY (ml/mho)	8.20	10.39		7.80
INFILTRATION RECORD					
1	INITIAL INFILTRATION RATE(cm/h)	126.0 FOR 5 min	120.0 FOR 1 min	27.60 FOR 5 min	180.0 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	1.60 AFTER 185min	4.60 AFTER 356min	1.40 AFTER 250min	10.5 AFTER 165min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	57.50	58.10	11.20	84.10
	LAND USE	FOREST COVER	FOREST COVER	HARVESTED; PADDY FARM	BARREN LAND
	SOIL TYPE	LOAMY SAND; MEDIUM GRAD.	LOAMY SAND; MEDIUM GRAD.	LOAMY SAND; MEDIUM GRAD.	LOAMY SAND; MEDIUM GRAD.

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION TEST CURVES OF
SOIL TYPE vs INFILTRATION RATE



(CONSIDERING SOIL TYPE INFORMATION ONLY)
SOIL TYPE :LOAMY SAND(WELL GRADED)

FIG. 12

TABLE - 5.12

INFILTRATION CHARACTERISTICS WITH RESPECT TO LANDUSES, SOIL PROPERTIES AND WATER QUALITY PARAMETERS FOR THE SAME SOIL TEXTURE

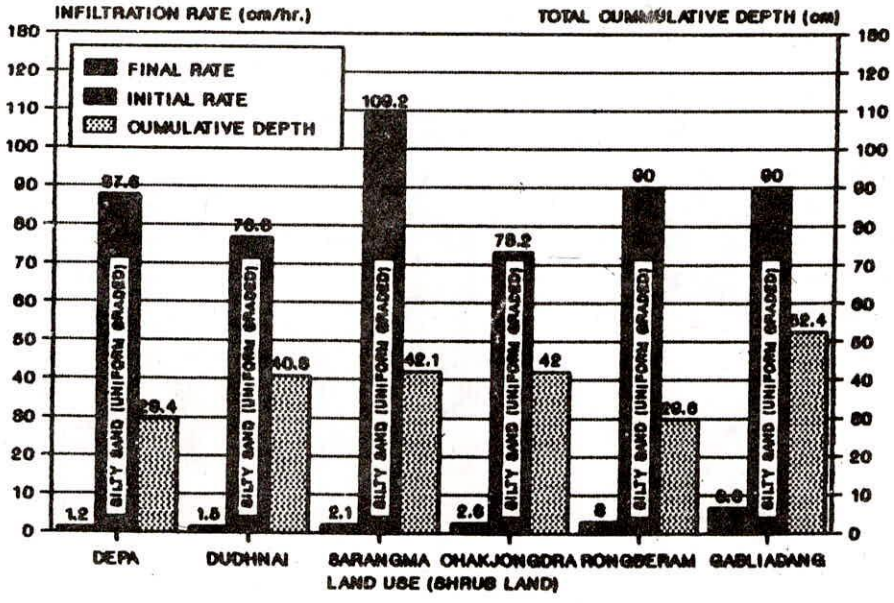
S. NO.	SITE'S NAME / PROPERTIES	BUKSILPARA	DIANADUBI FOREST GUEST HOUSE (EAST)	RONG JONG	GANDUAL	CHIMA IMPHAL
SOIL PROPERTIES						
1	NATURAL DENSITY (gm/cc)	1.37	1.5	1.43	1.29	1.62
2	MOISTURE CONTENT (%)	15.8	16.1	23.3	22.7	19.8
3	VOID RATIO	0.79	0.79	0.80	1.23	0.91
4	POROSITY (%)	44.1	44.1	44.2	54.8	47.0
5	AIR CONTENT	0.61	0.56	0.39	0.57	0.40
6	% AIR VOIDS	26.7	24.7	17.4	31.3	20.3
7	SATURATED DENSITY (gm/cc)	1.61	1.64	1.60	1.58	1.79
8	DEGREE OF SATURATION (%)	39.25%	44.00%	60.95%	42.05%	60.05%
9	SPECIFIC GRAVITY	2.09	2.15	2.08	2.31	2.51
10	PLASTIC LIMIT	3.7	5.0	30.3		34.6
11	UNIFORMITY COEFFICIENT (Cu)	30	39.28	21.25	16.47	9
12	CURVATURE COEFFICIENT (Cc)	1.7	2.92	2.65	2.54	1.44
13	NATURAL DRY DENSITY (gm/cc)	1.19	1.36	1.16	1.05	1.34
WATER QUALITY						
1	pH	6.92	WATER	6.80	6.33	6.42
2	TEMPERATURE ($^{\circ}$C)	20.6	SAMPLE WAS	22.1	21.6	21.6
3	KINEMATIC VISCOSITY (cm^2/sec)	1.00E-02	NOT	9.66E-03	9.78E-03	9.78E-03
4	DISSOLVED OXYGEN (ppm)	7.90	COLLECTED	6.50	6.10	6.20
5	TURBIDITY (% AT 1000 nm)	81.80		84.80	87.00	87.60
6	CONDUCTIVITY (ml/mho)	6.50		1.16	9.20	8.20
INFILTRATION RECORD						
1	INITIAL INFILTRATION RATE(cm/h)	69.60 FOR 5 min	43.20 FOR 5 min	64.80 FOR 5 min	79.20 FOR 5 min	97.20 FOR 5 min
2	FINAL INFILTRATION RATE(cm/h)	0.90 AFTER 155min	5.20 AFTER 195min	4.80 AFTER 140min	2.00 AFTER 180min	4.50 AFTER 145min
3	TOTAL CUMMULATIVE DEPTH OF WATER (cm)	27.20	27.90	32.40	42.50	38.00
	LAND USE	GRASSY LAND	FOREST COVER	RIVER BANK; GRASSY LAND	RIVER BANK; GRASSY LAND	BARREN LAND
	SOIL TYPE	LOAMY SAND; WELL GRADED	LOAMY SAND; WELL GRADED	LOAMY SAND; WELL GRADED	LOAMY SAND; WELL GRADED	LOAMY SAND WELL GRADED

TABLE - 5.13

REGRESSION EQUATION WITH CORRELATION COEFFICIENT FOR DIFFERENT SITES

S. NO.	SITE'S NAME	LAND USE	EQUATION F=CUMULATIVE INFILTRATION (cm) T=ELAPSED TIME (MIN.)	CO-RRELATION COEFFICIENT (r^2)	
1	CHIKAL	HARVESTED PADDY FARM	LOG F = 0.731 T - 1.5045	0.994	
2	DASERA SARANGMA	HARVESTED PADDY FARM	LOG F = 0.415 T + 0.0509	0.997	
3	CHIKAL	GRASSY LAND	LOG F = 0.723 T + 0.6523	0.973	
4	BUKSILPARA	GRASSY LAND	LOG F = 0.405 T + 0.6241	0.894	
5	DASERA SARANGMA	FOREST COVER	LOG F = 0.566 T + 0.3131	0.993	
6	DIANADUBI REST HOUSE (WEST)	FOREST COVER	LOG F = 0.621 T - 0.1816	0.999	MAX.
7	DIANADUBI REST HOUSE (EAST)	FOREST COVER	LOG F = 0.545 T + 0.1711	0.995	
8	DIANADUBI	FOREST COVER	LOG F = 0.343 T + 0.6484	0.891	
9	DAMRA (EAST)	FOREST COVER	LOG F = 0.448 T + 0.2984	0.944	
10	DAMRA (WEST)	FOREST COVER	LOG F = 0.491 T + 0.4489	0.940	
11	MONDIMA	FOREST COVER	LOG F = 0.433 T + 0.8741	0.894	
12	RONG JONG	RIVER BANK	LOG F = 0.518 T + 0.4465	0.976	
13	KHENTARA	RIVER BANK	LOG F = 0.377 T + 0.4942	0.916	
14	GANDUAL	RIVER BANK	LOG F = 0.490 T + 0.6182	0.923	
15	CHAKJONGDRA	SHRUB LAND	LOG F = 0.462 T + 0.6331	0.907	
16	GABLIADANG	SHRUB LAND	LOG F = 0.500 T + 0.6521	0.948	
17	RONG BERAM	SHRUB LAND	LOG F = 0.386 T + 0.7045	0.939	
18	DUDHNAI BRIDGE	SHRUB LAND	LOG F = 0.507 T + 0.5722	0.943	
19	SARANGMA	SHRUB LAND	LOG F = 0.415 T + 0.8226	0.870	MIN.
20	DEPA	SHRUB LAND	LOG F = 0.381 T + 0.7221	0.901	
21	RONG MILE	BARREN LAND	LOG F = 0.429 T + 1.0200	0.914	
22	CHIMA IMPHAL	BARREN LAND	LOG F = 0.407 T + 0.7480	0.923	
23	NILWAGITHIM	BARREN LAND	LOG F = 0.432 T + 0.4714	0.943	

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION TEST RESULTS FOR
SHRUB LAND OF SILTY SAND TYPE SOIL



BAR REPRESENTATION OF THE ELAPSED TIME
TO REACH FINAL INFILTRATION RATE FROM
INITIAL INFILTRATION RATE

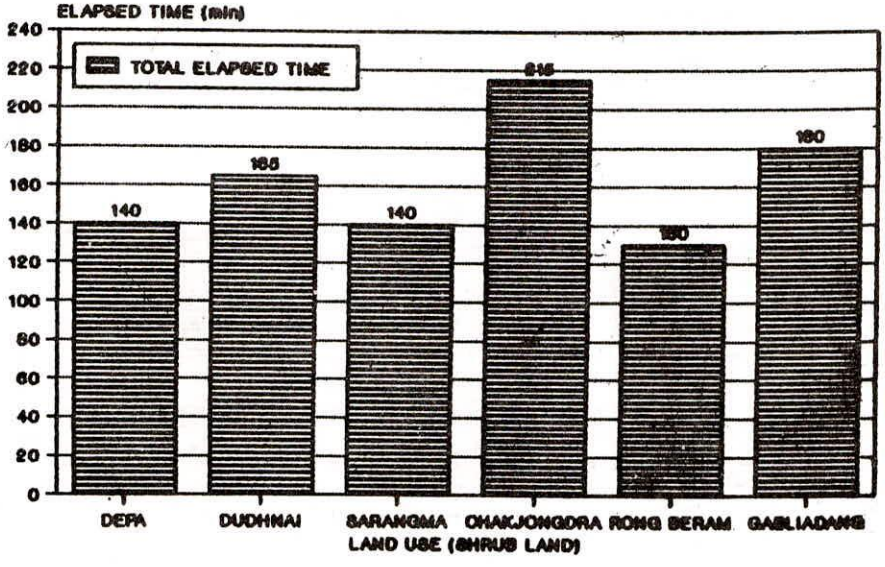
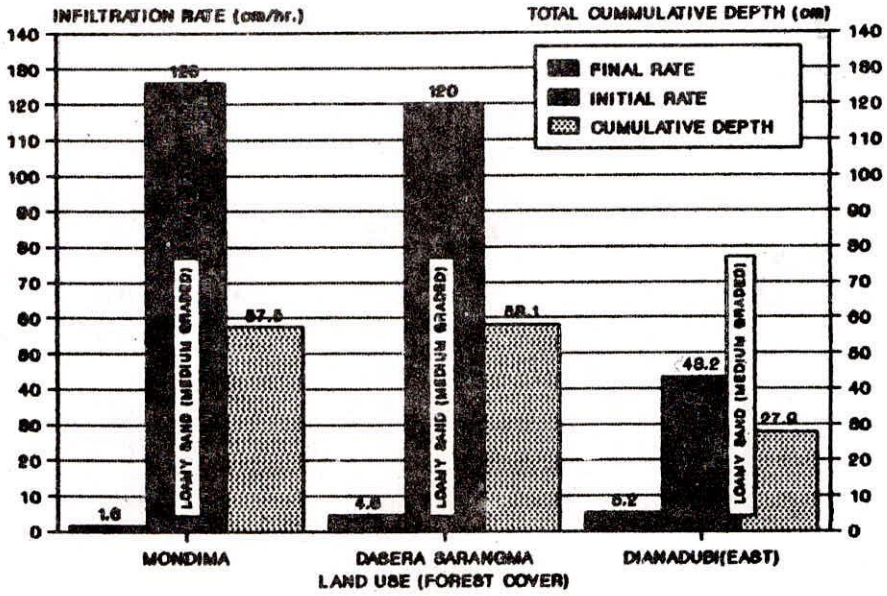


FIG. 19

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION TEST RESULTS FOR FOREST
COVER LAND OF LOAMY SAND TYPE SOIL



BAR REPRESENTATION OF THE ELAPSED TIME
TO REACH FINAL INFILTRATION RATE FROM
INITIAL INFILTRATION RATE

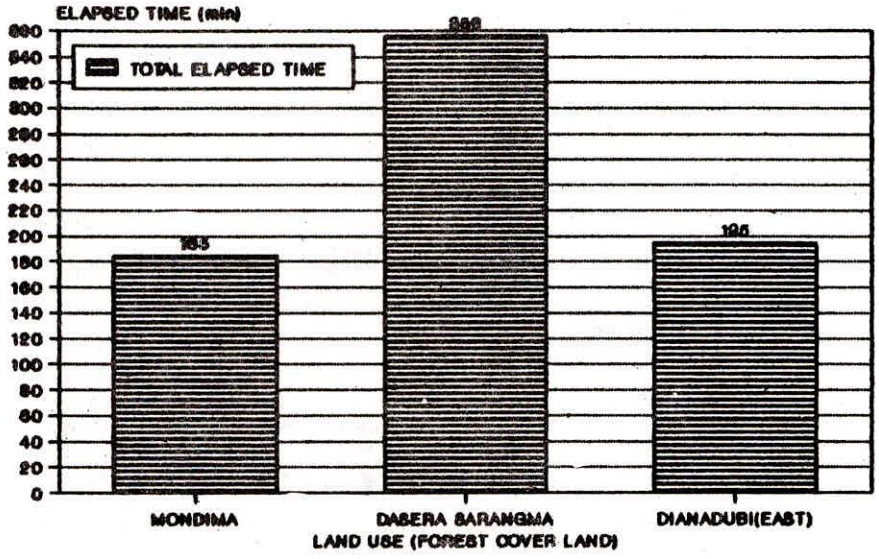
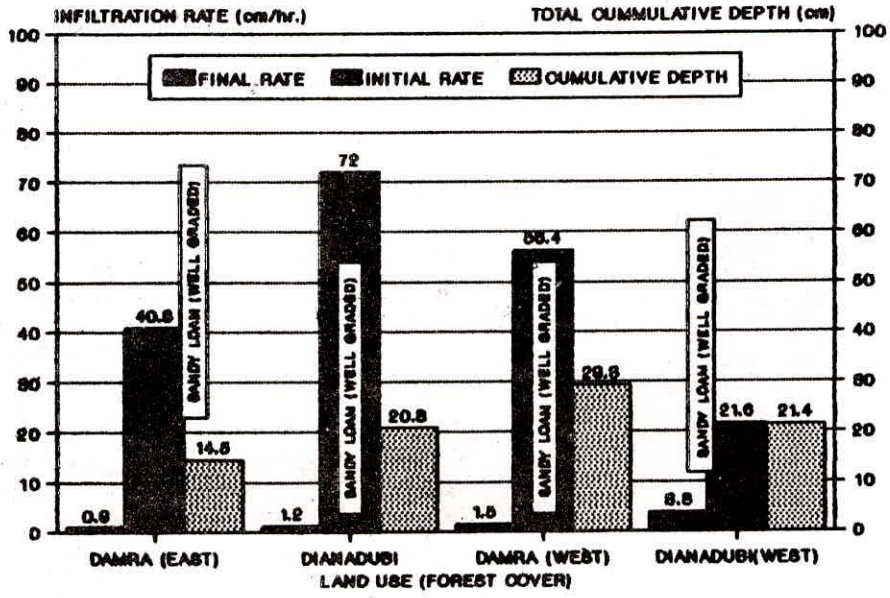


FIG. 14

DUDHNAI REPRESENTATIVE BASIN
INFILTRATION TEST RESULTS FOR FOREST
COVER LAND OF SANDY LOAM TYPE SOIL



BAR REPRESENTATION OF THE ELAPSED TIME
TO REACH FINAL INFILTRATION RATE FROM
INITIAL INFILTRATION RATE

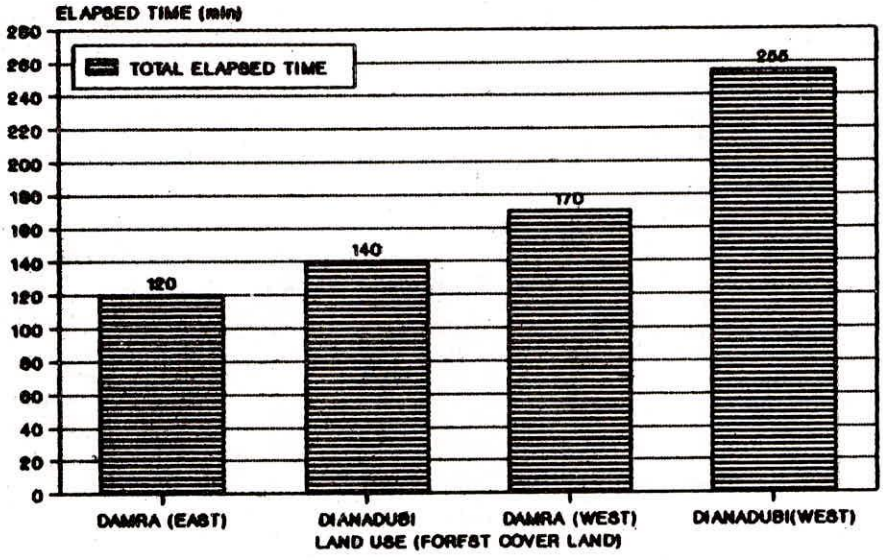
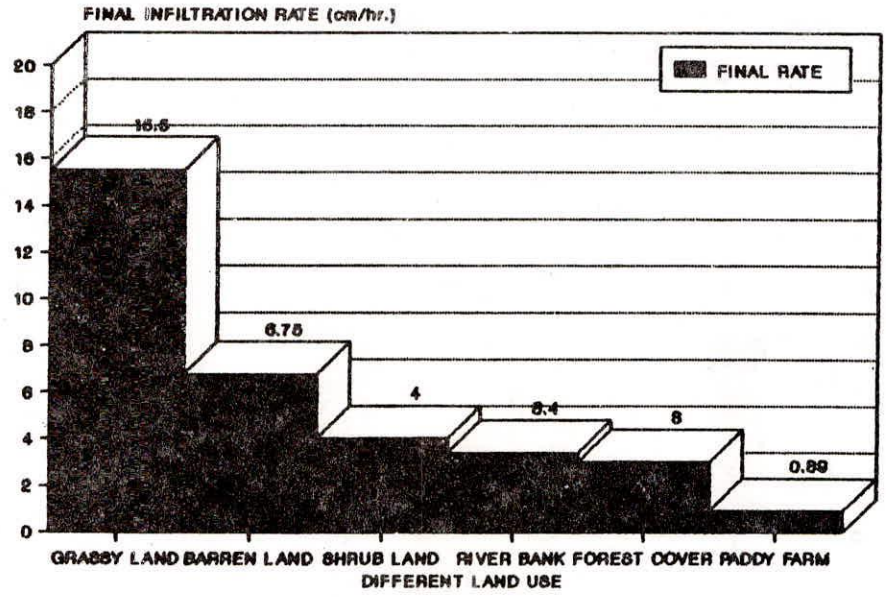


FIG. 16

DUDHNAI REPRESENTATIVE BASIN
BAR REPRESENTATION OF DIFFERENT LAND USE
vs INFILTRATION TEST RESULTS



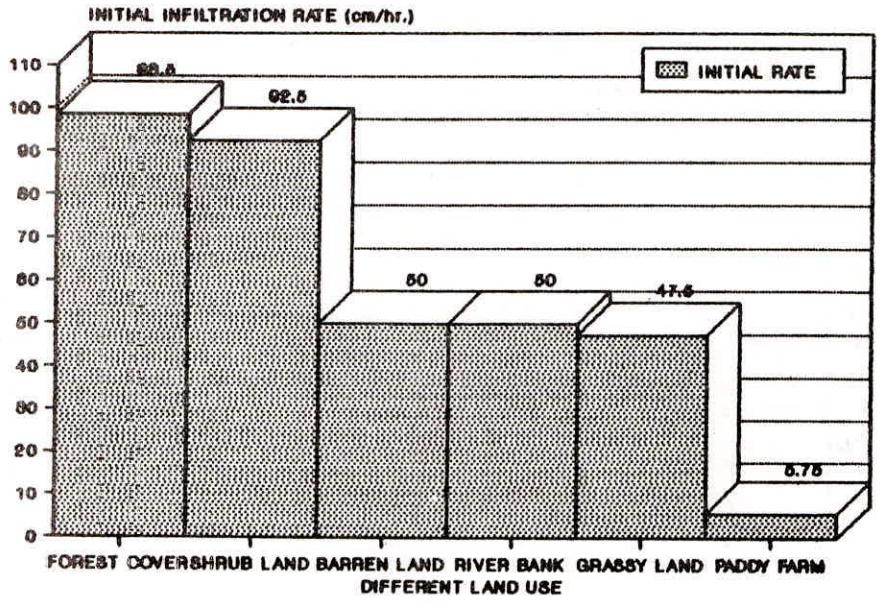
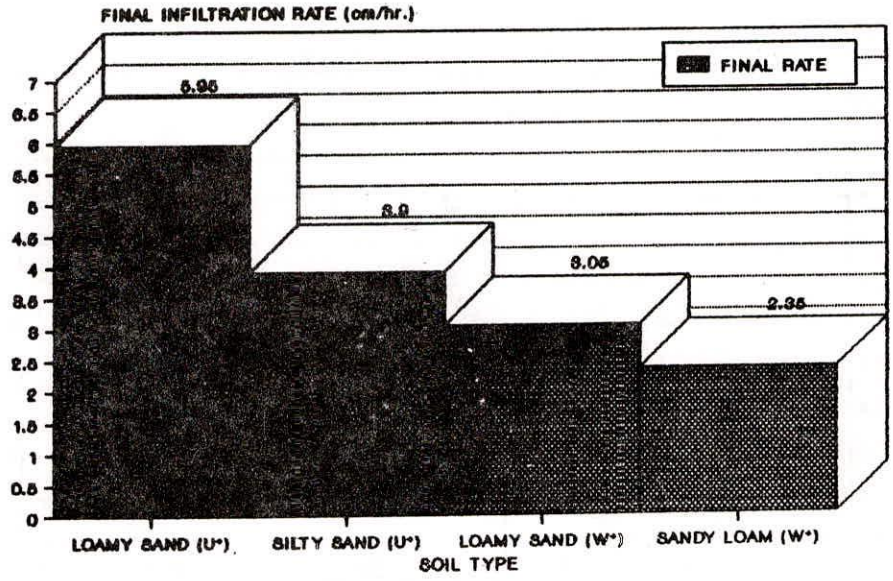
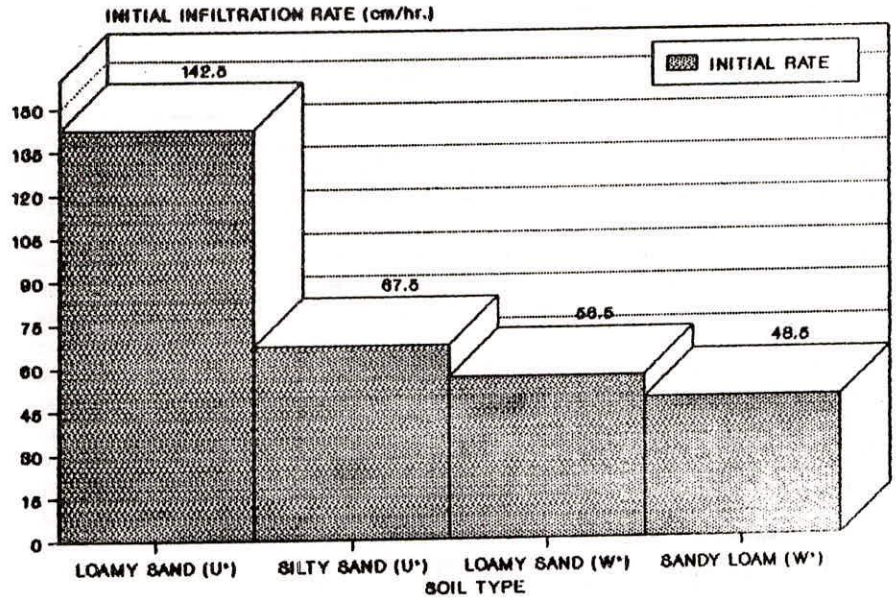


FIG. 16

DUDHNAI REPRESENTATIVE BASIN
BAR REPRESENTATION OF DIFFERENT SOIL
TYPE vs INFILTRATION TEST RESULTS



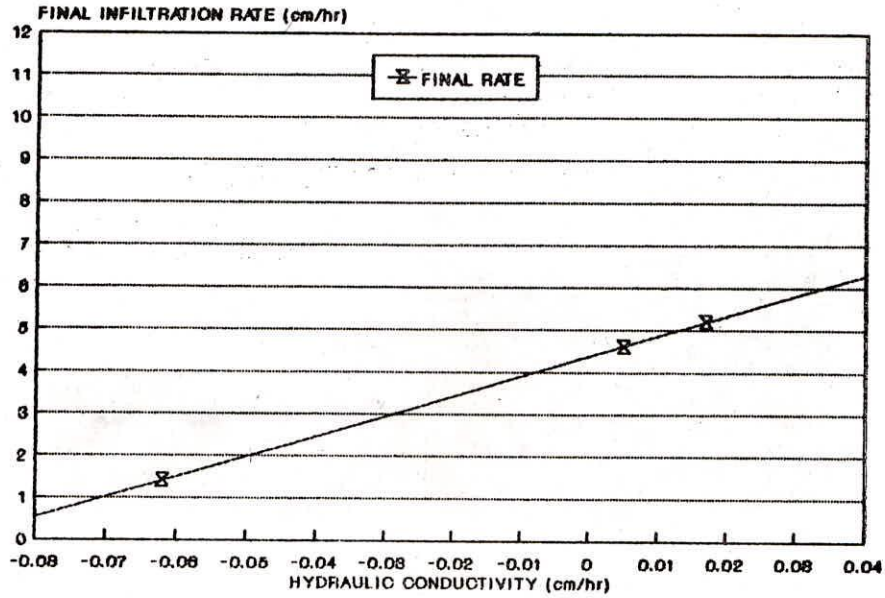
NOTE : (U*) - UNIFORM GRADED SOIL
(W*) - WELL GRADED SOIL



NOTE : (U*) - UNIFORM GRADED SOIL
(W*) - WELL GRADED SOIL

FIG. 17

DUDHNAI REPRESENTATIVE BASIN
GRAPH BETWEEN HYDRAULIC CONDUCTIVITY
AND INFILTRATION RESULTS



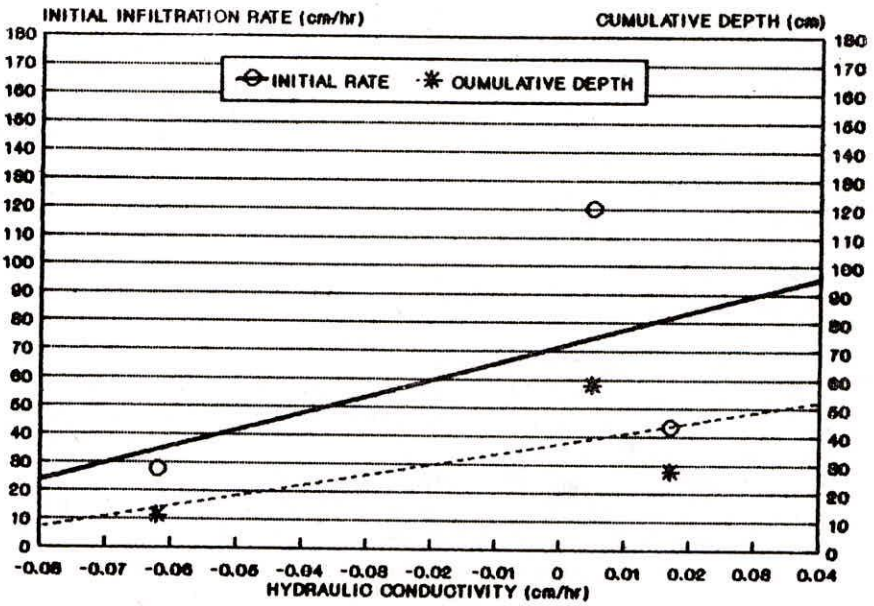
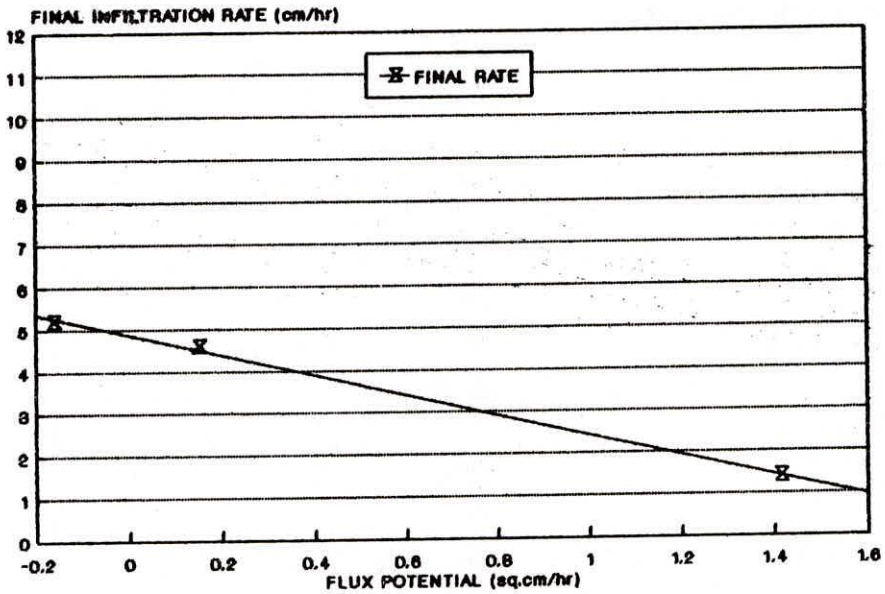


FIG. 18

DUDHNAI REPRESENTATIVE BASIN
GRAPH BETWEEN FLUX POTENTIAL
AND INFILTRATION RESULTS



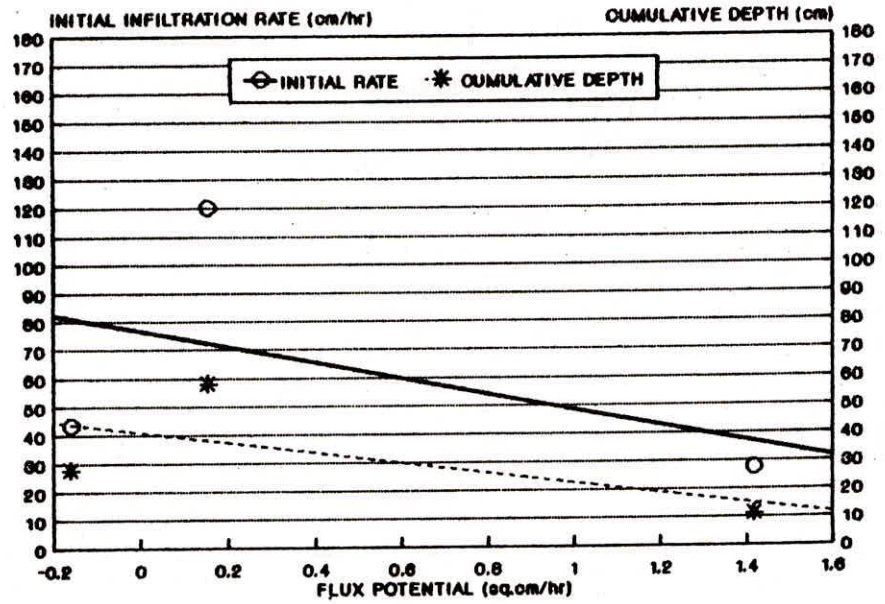
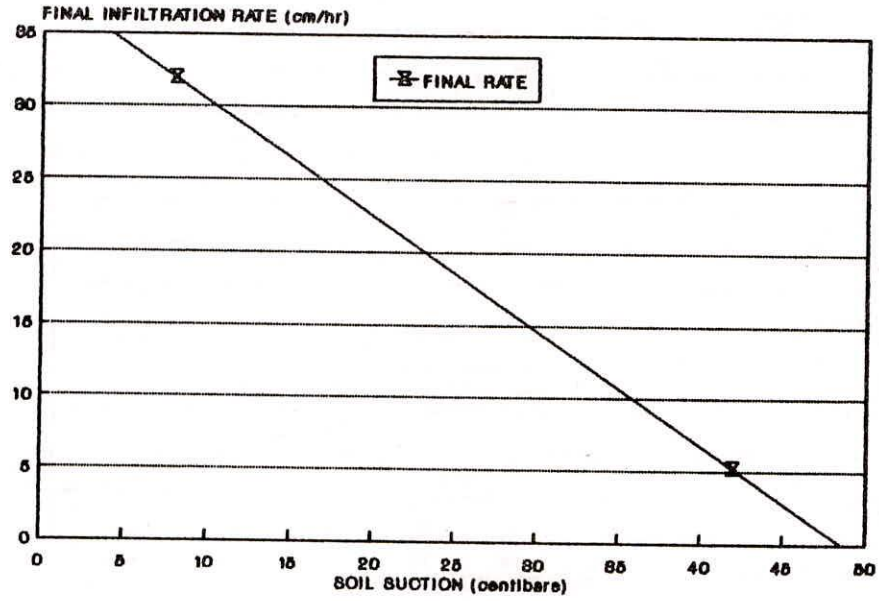


FIG. 19

DUDHNAI REPRESENTATIVE BASIN
GRAPH BETWEEN SOIL SUCTION
AND INFILTRATION RESULTS



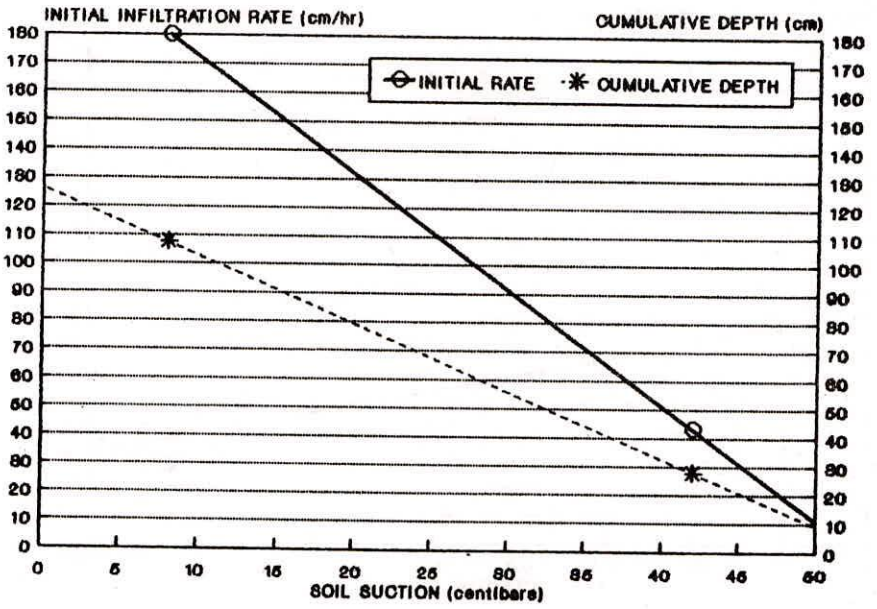


FIG. 20

6.0 CONCLUDING REMARKS :

Based on the results and discussions given in Chapter - 5, following major conclusions can be derived from the present study:

- Regional Infiltration results are required to be developed for various river basins considering land uses, soil types and all other factors.
- While comparing the infiltration results with soil textures information regarding grading of the soil is necessary to define better controls of soil types over infiltration characteristics.
- By observing the large variation on infiltration results by considering land use effect it is necessary to report the infiltration results with land uses & soil types.
- It is necessary to collect the information regarding different soil properties, water quality parameters, soil textures, land uses, climatic conditions, geological information from the test sites to define proper relationship of these parameters on infiltration results.
- It is also necessary to prepare a thematic map of the infiltration results for each river basin & sub-basin.

Scope for Future Studies :

Based on the experience gathered in the present study following are recommended:

1. Such standard relationship can be worked out for other river basins.

2. The developed standard curves can be further refined by collecting and incorporating results of more field experiments.

3.Soils should also be tested for porosity and porosity based model can be tested to verify the control of porosity on infiltration results.

4. To define relationship between hydraulic conductivity and soil suction with infiltration characteristics such tests should be conducted at more sites alongwith infiltration tests.

5. To define the control of land slope over run-off, infiltration test should be conducted on a selected hilly region under same hydrologic conditions towards hill top to foot of the hill.

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****

TEST NO. : 5
DATE: 29-12-94

SAMPLE RECORD SHEET OF INFILTROMETER TEST BY DOUBLE RING CYLINDER METHOD

SITE'S NAME : dudhnai sub-basin
LOCATION : dainedubi forest guest house campus (WEST)
DISTRICT : east garo hills
STATE : meghalaya

LATITUDE : 50°54'30" N
LONGITUDE: 90°46'30" E
ALTITUDE : 220.0 m (FROM MSL)

SOIL SAMPLER NO.: 15 , 5
DEPTH (cm) BGL : AT GL ,50.0
CYLINDER SET NO.: 2

WATER TABLE DEPTH (BGL): 15 ft.

SOIL TYPE & COLOUR : sandy loam of light yellowish grey colour

LAND USE: forest cover

SITE'S NATURE: sal & teak forest, medium dense

PENETRATION DEPTH OF INNER CYLINDER : 15.00 cm BGL
PENETRATION DEPTH OF OUTER CYLINDER : 15.00 cm BGL

AVE. INNER DIA. OF THE INNER CYLINDER: 30.0 cm
INNER CROSS SECTIONAL AREA OF THE CYLINDER: 706.85 cm^2

S. NO.	CLOCK TIME (am/pm) (1)	ELAPSED TIME T (min) (2)	DISTANCE OF WATER SURFACE FROM REFERENCE POINT: BEFORE FILLING (cm) (3)	DISTANCE OF WATER SURFACE FROM REFERENCE POINT: AFTER FILLING (cm) (4)	INFILTRATION DURING PERIOD: DEPTH (cm) (5)	INFILTRATION DURING PERIOD: INFILTRATION RATE (cm/hr) (6)	CUMULATIVE INFILTRATION F (cm) (7)	FOR KOSTIAKOV MODEL ANALYSIS: LOG(T) (8)	FOR KOSTIAKOV MODEL ANALYSIS: LOG(F) (9)	REMARKS
1	09:15 AM			35.0 *			0.00			* REFERENCE POINT IS FIXED AT 35.00 cm
2	09:20 AM	5.0	36.80		1.80	21.60	1.80	0.699	0.255	
3	09:25 AM	10.0	37.80		1.00	12.00	2.80	1.000	0.447	
4	09:30 AM	15.0	38.60		0.80	9.60	3.60	1.176	0.556	
5	09:40 AM	25.0	39.90		1.30	7.80	4.90	1.398	0.690	
6	09:50 AM	35.0	40.90		1.00	6.00	5.90	1.544	0.771	
7	10:00 AM	45.0	41.90		1.00	6.00	6.90	1.653	0.839	
8	10:15 AM	60.0	43.30		1.40	5.60	8.30	1.778	0.919	
9	10:30 AM	75.0	44.40		1.10	4.40	9.40	1.875	0.973	
10	10:45 AM	90.0	45.50	35.0 *	1.10	4.40	10.50	1.954	1.021	* REFILLED UPTO 35.00
11	11:00 AM	105.0	36.10		1.10	4.40	11.60	2.021	1.064	TIME TAKEN FOR REFILLING UPTO
12	11:30 AM	135.0	38.20		2.10	4.20	13.70	2.130	1.137	REF. POINT IS 45 SEC.
13	12:00 PM	165.0	40.20		2.00	4.00	15.70	2.217	1.196	
14	12:30 PM	195.0	42.10		1.90	3.80	17.60	2.290	1.246	
15	01:00 PM	225.0	44.00		1.90	3.80	19.50	2.352	1.290	
16	01:30 PM	255.0	45.90	**	1.90	3.80	21.40	2.407	1.330	**TEST COMPLETED
17										
18										
19										
20										
21										
22										
23										

OTHER INFORMATION RELATED TO TEST SITE

WATER QUALITY RELATED

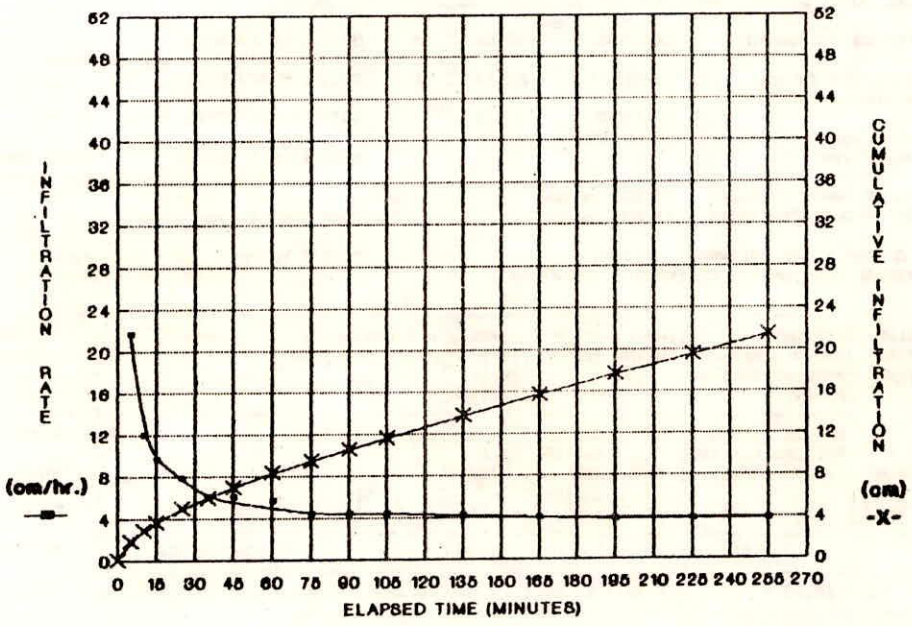
1. SAMPLER NO. : 144
2. SOURCE : dug well
3. pH OF WATER : 4.69
4. TEMP. (C) : 20.60
5. VISCOSITY : 1.0E-02 (KINEMATIC cm^2/sec)
6. TURBIDITY : 78.00 (% AT 100 nm)

OTHER

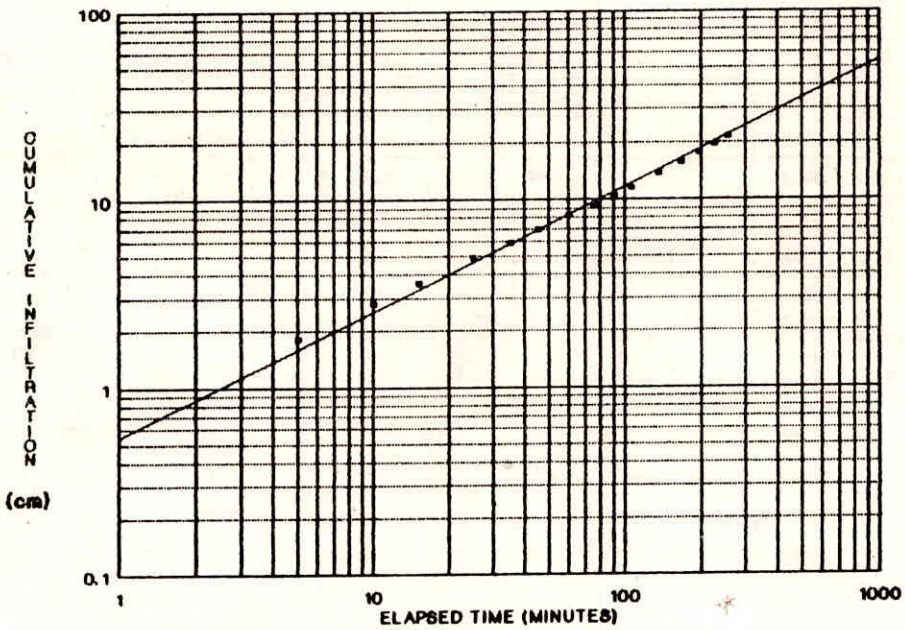
1. SEASON : post monsoon
2. CLIMATE : cold foggy
3. HYDRAULIC CONDUCTIVITY (IF ANY) cm/hr.: 0.017
4. SOIL SUCTION (IF ANY): 42 centibars/150 min
5. SOIL TEMP. : not measured C (IF ANY)
6. GEOLOGICAL INFORMATION (IF ANY) : not collected
7. SOIL SURFACE AND SUB-SURFACE INFORMATION : soil is characterised with fine pores, fine fissures and many fine roots. mainly fine sandy clayey silt type texture.

TESTED BY :

SAMPLE GRAPHICAL PRESENTATION OF INFILTRATION TEST AT SITE



PLOT OF INFILTRATION TEST DATA PRESENTED IN TEST NO. 5



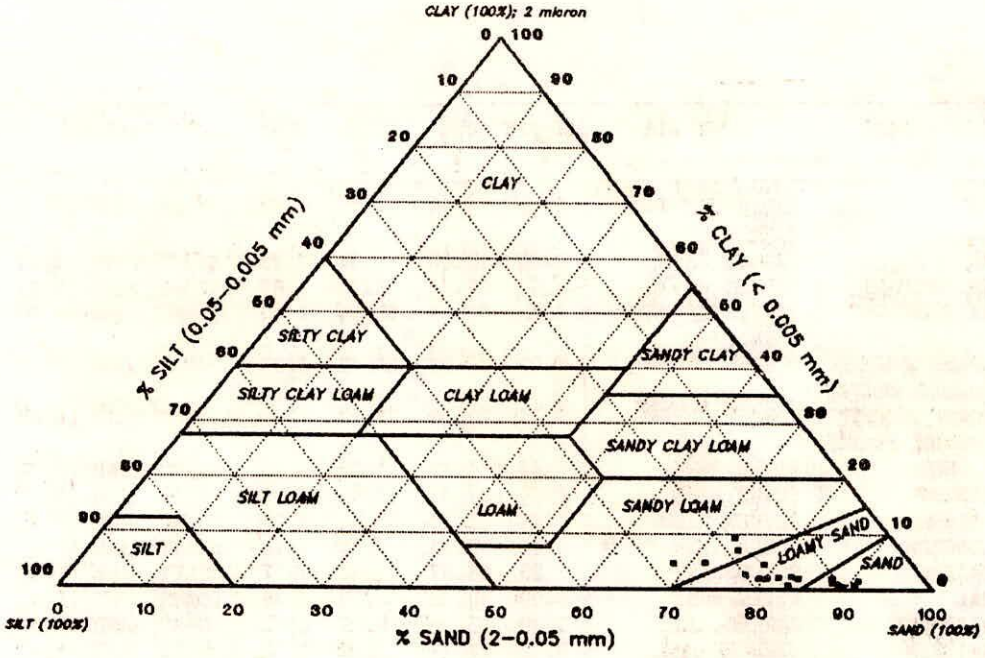
TEXTURAL ANALYSIS OF SOIL AT DUDHNAI SUB-BASIN

S. NO.	SITE'S NAME	LAND USE	GRAVEL %	SAND %	SILT %	CLAY %	SOIL TEXTURE
1	CHIKAL	HARVESTED PADDY FARM	0.00	68.08	27.35	4.56	SANDY LOAM (W G)
2	CHIKAL	GRASSY LAND	0.00	90.86	7.31	1.46	SILTY SAND (M G)
3	DASERA SARANGMA	FOREST COVER	8.61	83.16	6.75	0.67	LOAMY SAND (M G)
4	DASERA SARANGMA	HARVESTED PADDY FARM	4.83	73.25	20.04	1.69	LOAMY SAND (M G)
5	DIANADUBI FOREST REST HOUSE (WEST)	FOREST COVER	0.00	74.23	17.42	6.97	SANDY LOAM (W G)
6	DIANADUBI FOREST REST HOUSE (EAST)	FOREST COVER	0.00	79.19	16.20	1.95	LOAMY SAND (W G)
7	RONG JONG	RIVER BANK	1.44	75.21	19.06	4.27	LOAMY SAND (W G)
8	RONG BERAM	SCRUB LAND	1.30	87.55	8.61	1.96	SILTY SAND (W G)
9	RONG MILE	BARREN LAND	2.13	82.83	12.25	2.29	LOAMY SAND (W G)
10	CHAKGONGDRA	SCRUB LAND	3.42	88.01	5.88	1.18	SILTY SAND (U G)
11	GABLIADANG	SCRUB LAND	3.25	88.87	6.53	0.77	SILTY SAND (U G)
12	GANDUAL	RIVER BANK	0.00	80.10	17.50	1.98	LOAMY SAND (U G)
13	CHIMA IMPHAL	BARREN LAND	0.00	81.37	16.27	2.01	LOAMY SAND (W G)
14	NILWAGITHIM	BARREN LAND	0.80	90.77	7.32	0.73	SILTY SAND (U G)
15	MONDIMA	FOREST COVER	3.68	83.75	10.57	1.90	LOAMY SAND (M G)
16	BUKSILPARA	GRASSY LAND	0.17	77.38	19.14	2.74	LOAMY SAND (W G)
17	DUDHNAI	SCRUB LAND	3.22	89.58	6.29	0.46	SILTY SAND (U G)
18	SARANGMA	SCRUB LAND	0.00	0.00	0.00	0.00	SILTY SAND (U G)
19	DEPA	SCRUB LAND	0.00	0.00	0.00	0.00	SILTY SAND (U G)
20	KHENTARA	RIVER BANK	0.00	0.00	0.00	0.00	SANDY LOAM (W G)
21	DIANADUBI	FOREST COVER	1.18	78.54	14.90	4.44	SANDY LOAM (W G)
22	DAMARA (EAST)	FOREST COVER	0.00	0.00	0.00	0.00	SANDY LOAM (W G)
23	DAMARA (WEST)	FOREST COVER	0.00	0.00	0.00	0.00	SANDY LOAM (W G)

NOTE: (W G) - WELL GRADED ; (M G) - MEDIUM GRADED; (U G) - UNIFORM GRADED

Cont..

DUDHNAI REPRESENTATIVE BASIN
SOIL TEXTURAL CLASSIFICATION(TRIANGULAR)
AS PER U.S. PUBLIC ROAD ADMINISTRATION



SOIL TEST RESULTS FOR SOIL PROPERTIES
(SAMPLES WERE COLLECTED IN NOV-DEC 1994)

S. NO.	SITE'S NAME	LAND USE	SOIL TYPE	SOIL PROPERTIES																
				SAMPLE DEPTH at GL or 50 cm BGL	NATURAL DENSITY gm/cc	MOISTURE CONTENT (%)	VOID RATIO	POROSITY (%)	AIR CONTENT	% AIR VOIDS	SATURATED DENSITY gm/cc	DEGREE of SATURATION (%)	SPECIFIC GRAVITY	PLASTIC LIMIT	HYDRAULIC CONDUCTIVITY cm/hr.	FLUX POTENTIAL cm²/hr	SOIL SUCTION centibars	UNIFORMITY COEFFICIENT Cu	CURVATURE COEFFICIENT Cc	NATURAL DRY DENSITY gm/cc
1	CHIKAL	HARVESTED PADDY FARM	SANDY LOAM (WELL GRADED)	AT GL	1.56	36.9	0.39	28.1	0.05	1.40	1.00	95.00%	1.00							1.14
				50 BGL																
				AVG.	1.56	36.9	0.39	28.1	0.05	1.40	1.00	95.00%	1.00					18	1.13	1.14
2	CHIKAL	GRASSY LAND; SURROUNDED BANANA AND BAMBOO	SILTY SAND (MEDIUM GRADED)	AT GL											-0.008	0.78	8 c.bars in 60 min			
				50 BGL	1.38	27.5	0.88	46.8	0.37	17.2	1.55	63.30%	2.03	15.5						1.08
				AVG.	1.38	27.5	0.88	46.8	0.37	17.2	1.55	63.30%	2.03	15.5			at 50 cm BGL	6.25	1.56	1.08
3	DASERA SARAN-GMA FOREST	DENSE FOREST SAL, TEAK & ORCHID	LOAMY SAND (MEDIUM GRADED)	AT GL	1.40	10.0	0.20	16.7	0.25	4.1	1.43	75.50%	1.51		0.0053	0.153				1.27
				50 BGL	1.21	22.4	0.99	49.7	0.56	27.7	1.48	44.30%	1.96	18.7						0.99
				AVG.	1.3	16.2	0.60	33.2	0.40	15.9	1.45	59.90%	1.74	18.7				7.78	1	1.13
4	DASERA SARAN-GMA (SEED FARM)	HARVESTED; PADDY FARM	LOAMY SAND (MEDIUM GRADED)	AT GL	1.62	20.6	0.54	35.1	0.21	7.4	1.69	79.00%	2.07		-.0615	1.415				1.34
				50 BGL	1.38	11.8	0.32	24.2	0.40	9.7	1.48	60.00%	1.63							1.23
				AVG.	1.5	16.2	0.43	29.7	0.31	8.53	1.59	69.50%	1.85					12.78	2.42	1.29
5	DIANA-DUBI FOREST HOUSE (WEST)	FOREST COVER (SAL & TEAK)	SANDY LOAM (WELL GRADED)	AT GL	1.26	15.6	0.93	48.2	0.65	31.3	1.56	35.00%	2.09	41.3	0.017	-0.16	42 c.bars in 150 min			1.09
				50 BGL	1.47									39.3						1.47
				AVG.	1.4	15.6	0.93	48.2	0.65	31.3	1.56	35.00%	2.09	40.3			at 50 cm BGL	46.67	3.81	1.28
6	DIANA-DUBI FOREST HOUSE (EAST)	FOREST COVER (SAL & TEAK)	LOAMY SAND (WELL GRADED)	AT GL	1.52									1.5						1.52
				50 BGL	1.39	16.1	0.79	44.1	0.56	24.7	1.64	44.00%	2.15	8.4						1.20
				AVG.	1.5	16.1	0.79	44.1	0.56	24.7	1.64	44.00%	2.15	5.0				39.28	2.92	1.36

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S. NO.	SITE'S NAME	LAND USE	SOIL TYPE	SOIL PROPERTIES														
				SAMPLE DEPTH at GL or 50 cm BGL	NATURAL DENSITY gm/cc	MOISTURE CONTENT (%)	VOID RATIO	POROSITY (%)	AIR CONTENT	% AIR VOIDS	SATURATED DENSITY gm/cc	DEGREE of SATURATION (%)	SPECIFIC GRAVITY	PLASTIC LIMIT	UNIFORMITY COEFFICIENT Cu	CURVATURE COEFFICIENT Cc	NATURAL DRY DENSITY gm/cc
7	RONG - JONG	RIVER BANK; GRASSY LAND SURROUNDED (SAL AND BETELNUT)	LOAMY SAND (WELL GRADED)	AT GL	1.44	22.2	0.68	40.5	0.36	14.5	1.58	64.30%	1.97	30.3			1.18
				50 BGL	1.41	24.3	0.92	47.9	0.42	20.3	1.61	57.60%	2.18				1.13
				AVG.	1.43	23.3	0.80	44.2	0.39	17.4	1.60	60.95%	2.08	30.3	21.25	2.65	1.16
8	RONG - BERAM	SCURB LAND; SURROUN- DED FOREST (SAL AND BETELNUT)	SILTY SAND (UNIFORM GRADED)	AT GL	1.15	15.5	1.02	50.5	0.69	34.8	1.51	31.00%	2.04				1.00
				50 BGL	1.50									29.7			
				AVG.	1.33	15.5	1.02	50.5	0.69	34.8	1.51	31.00%	2.04	29.7	11.27	2.30	1.00
9	RONG - MILE	BARREN LAND; (PLAIN SURFACE)	LOAMY SAND (MEDIUM GRADED)	AT GL	1.80	24.2	0.69	40.8	0.15	6.1	1.84	85.00%	2.42	34.6			1.45
				50 BGL	1.43	15.4	1.14	53.3	0.65	34.6	1.75	35.10%	2.60				1.24
				AVG.	1.62	19.8	0.91	47.0	0.40	20.3	1.79	60.05%	2.51	34.6	9	1.44	1.34
10	CHAK - JONG - DRA	SCURB LAND; SURROUNDE FOREST ; SAL,BANANA & BETELNUT)	SILTY SAND (UNIFORM GRADED)	AT GL	1.82	20.6	0.57	36.3	0.14	5.1	1.88	86.00%	2.38	0.3			1.51
				50 BGL	1.58	23.1	0.93	48.2	0.40	19.2	1.74	60.10%	2.42	21.3			1.28
				AVG.	1.70	21.9	0.75	42.2	0.27	12.2	1.81	73.05%	2.40	10.8	4.82	1.35	1.40
11	GABLI- ADANG	SCURB LAND; SURROUNDE SAL & BAMBOO TOP OF HILL	SILTY SAND (UNIFORM GRADED)	AT GL	1.35	24.4	1.14	53.3	0.50	26.6	1.62	50.00%	2.34	4.7			1.09
				50 BGL	1.21	11.9	1.10	52.4	0.76	39.9	1.58	23.90%	2.21				1.08
				AVG.	1.28	18.2	1.12	52.8	0.63	33.2	1.60	36.95%	2.27	4.7	3.75	0.67	1.08
12	GAN- DUAL	RIVER BANK; GRASSY LAND (FOOT OF HILL)	LOAMY SAND (UNIFORM GRADED)	AT GL	1.18	20.1	1.07	51.7	0.62	32.0	1.49	38.00%	2.02				0.98
				50 BGL	1.40	25.2	1.38	58.0	0.53	30.6	1.67	47.30%	2.59				1.12
				AVG.	1.29	22.7	1.23	54.8	0.57	31.3	1.58	42.65%	2.31		16.47	2.54	1.05

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S. NO.	SITE'S NAME	LAND USE	SOIL TYPE	SOIL PROPERTIES													
				SAMPLE DEPTH at GL or 50 cm BGL	NATURAL DENSITY gm/cc	MOISTURE CONTENT (%)	VOID RATIO	POROSITY (%)	AIR CONTENT	% AIR VOIDS	SATURATED DENSITY gm/cc	DEGREE of SATURATION (%)	SPECIFIC GRAVITY	PLASTIC LIMIT	UNIFORMITY COEFFICIENT Cu	CURVATURE COEFFICIENT Cc	NATURAL DRY DENSITY gm/cc
13	CHIMA-IMPHAL	BARE LAND	LOAMY SAND (WELL GRADED)	AT GL	1.42	12.8	1.18	54.1	0.70	37.9	1.81	30.00%	2.77				1.26
				50 BGL	1.47	28.1	1.14	53.3	0.41	21.7	1.66	59.20%	2.40	13.5			1.15
				AVG.	1.45	20.5	1.16	53.7	0.55	29.8	1.73	44.60%	2.58	13.5	18.33	3.79	1.20
14	NILWA-GITHIM	BARE LAND COVERED BY SMALL GROWING GRASS (NATURALLY)	SILTY SAND (UNIFORM GRADED)	AT GL	1.36	14.0	0.71	41.5	0.60	24.9	1.60	40.00%	2.03	28.7			1.19
				50 BGL	1.40	26.4	1.04	51.0	0.44	22.5	1.59	55.90%	2.20				1.11
				AVG.	1.38	20.2	0.88	46.3	0.52	23.7	1.60	47.95%	2.12	28.7	4.4	1.2	1.15
15	MON-DIMA	FOREST COVER; (SAL, TEAK & ORCHID) HILL'S FOOT	LOAMY SAND (MEDIUM GRADED)	AT GL	1.50	10.8	0.57	36.3	0.60	21.8	1.71	40.00%	2.11	43.8			1.35
				50 BGL	1.42	25.7	0.90	47.4	0.40	19.0	1.58	59.80%	2.09	1.0			1.13
				AVG.	1.46	18.3	0.74	41.8	0.50	20.4	1.64	49.90%	2.10	22.4	13.33	2.9	1.24
16	BUK-SIL-PARA	PLAIN GRASSY LAND	LOAMY SAND (WELL GRADED)	AT GL	1.51	10.2	0.76	43.2	0.68	29.4	1.79	32.00%	2.38	3.7			1.37
				50 BGL	1.22	21.3	0.82	45.1	0.54	24.1	1.43	46.50%	1.79				1.01
				AVG.	1.37	15.8	0.79	44.1	0.61	26.7	1.61	39.25%	2.09	3.7	30	1.7	1.19
17	DUDH-NAI	SCRUB LAND; SURROUNDED BANANA & BETEL NUT	SILTY SAND (UNIFORM GRADED)	AT GL	1.28	19.6	0.97	49.2	0.57	28.1	1.57	43.00%	2.13				1.07
				50 BGL	1.50	35.7	1.15	53.5	0.28	15.2	1.61	71.60%	2.31				1.11
				AVG.	1.39	27.7	1.06	51.4	0.43	21.6	1.59	57.30%	2.22		5.83	1.07	1.09
18	SARAN-GHA	SCRUB LAND; SURROUNDED SAL & DEVDAR HILL'S FOOT	SILTY SAND (UNIFORM GRADED)	AT GL				SAMPLES WERE NOT COLLECTED									
				50 BGL													
				AVG.													

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S. NO.	SITE'S NAME	LAND USE	SOIL TYPE	SOIL PROPERTIES													
				SAMPLE DEPTH at GL or 50 cm BGL	NATURAL DENSITY gm/cc	MOISTURE CONTENT (%)	VOID RATIO	POROSITY (%)	AIR CONTENT	% AIR VOIDS	SATURATED DENSITY gm/cc	DEGREE of SATURATION (%)	SPECIFIC GRAVITY	PLASTIC LIMIT	UNIFORMITY COEFFICIENT Cu	CURVATURE COEFFICIENT Cc	NATURAL DRY DENSITY gm/cc
19	DEPA	SCRUB LAND; SURROUNDED BETELNUT & BANANA	SILTY SAND (UNIFORM GRADED)	AT GL				SAMPLES WERE NOT COLLECTED									
				50 BGL													
				AVG.													
20	KHENTARA	RIVER BANK; NATURAL GROWING GRASS COVER	SANDY LOAM (WELL GRADED)	AT GL				SAMPLES WERE NOT COLLECTED									
				50 BGL													
				AVG.													
21	DIANA-DUBI	FOREST COVER (SAL & TEAK)	SANDY LOAM (WELL GRADED)	AT GL	2.06								2.20	27.1			2.06
				50 BGL	1.34	28.2	0.90	47.4	0.39	18.7	1.49	60.60%	1.93				1.05
				AVG.	1.70	28.2	0.90	47.4	0.39	18.7	1.56	60.60%	2.07	27.1	41.67	3.75	1.55
22	DAMARA (EAST)	FOREST COVER (SAL, TEAK & DEVDAR)	SANDY LOAM (WELL GRADED)	AT GL				SAMPLES WERE NOT COLLECTED									
				50 BGL													
				AVG.													
23	DAMARA (WEST)	FOREST COVER (SAL; TEAK & DEVDAR)	SANDY LOAM (WELL GRADED)	AT GL				SAMPLES WERE NOT COLLECTED									
				50 BGL													
				AVG.													

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