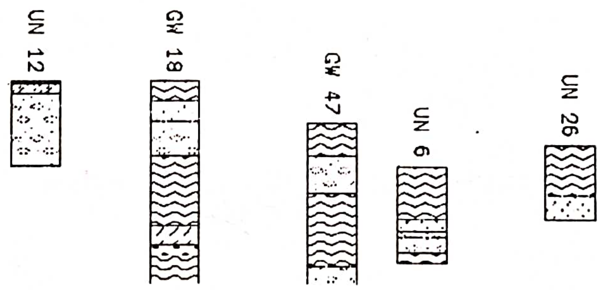
Shallow Ground Water Resources of the Terai
Kailali District
Far Western Development Region, Nepal

Technical Report No. 26

By

SHANMUKHESH CHANDRA AMATYA
Geohydrologist
GWRDB, HMG, Nepal.



United Nations Development Program and
His Majesty's Government of Nepal

NEP/86/025
Shallow Ground Water Investigations in the Terai
January 1992

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Executing Agency:
United Nations Department of Technical Co-operation for Development

Implementing Agency:
Ground Water Resources Development Board HMG, Nepal

January 1992

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ABBREVIATIONS

ADB - Asian Development Bank
ADBN - Agriculture Development Bank of Nepal
DTW - Deep Tube Well
GDC - Groundwater Development Consultants (International) Ltd.
GWRDB - Ground Water Resources Development Board
GWS - Ground Water Software, UN/DTCD.
MCM - Million Cubic Meters
NRSC - National Remote Sensing Center, Nepal/GTZ/World Bank
STW - Shallow Tube Well
UNDP - United Nations Development Program
UN/DTCD - United Nations Department of Technical Co-operation for Development

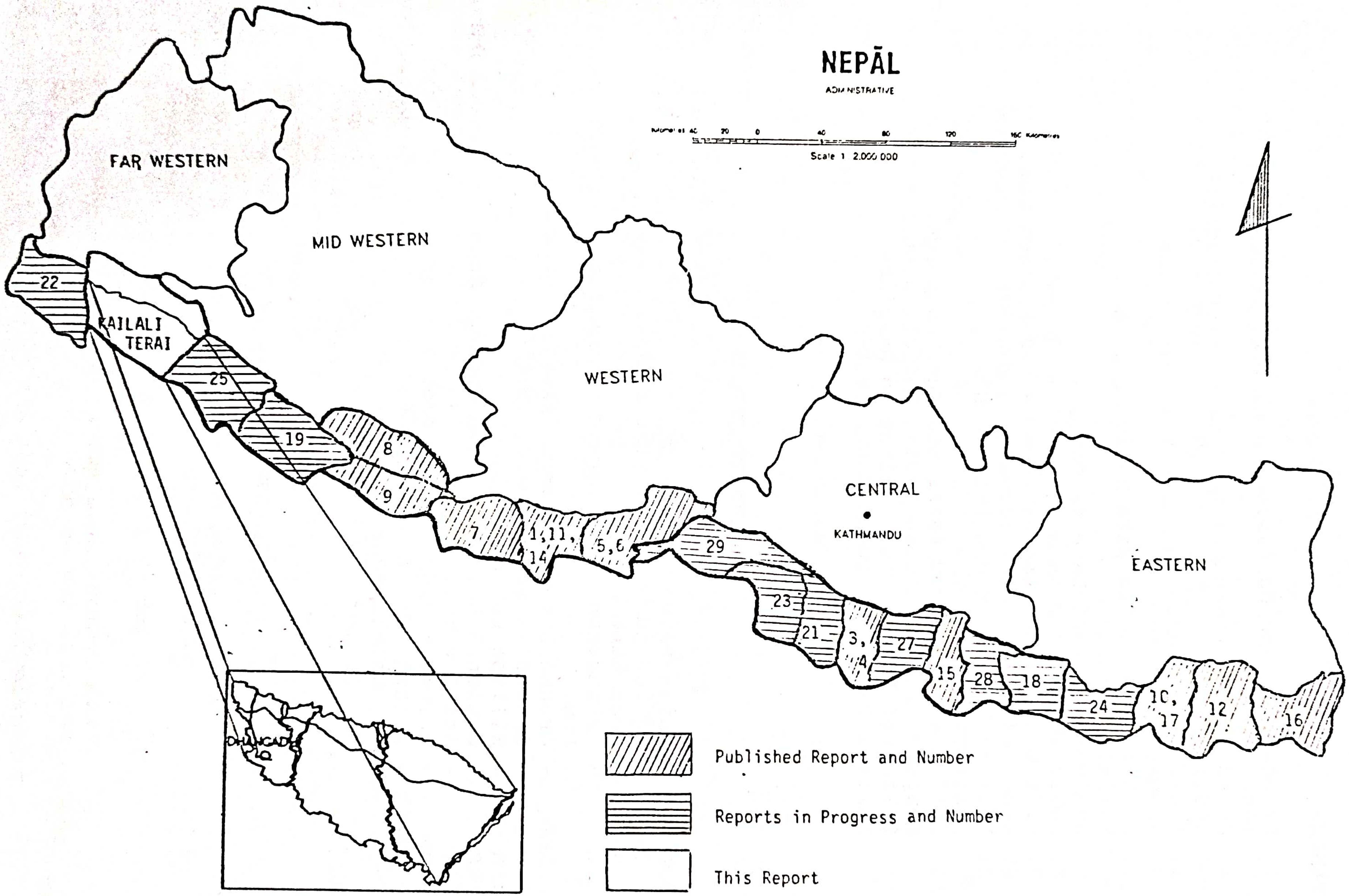


Figure 1. Index map showing present status of Ground water Reports from the shallow Ground water Inestigation in the Terai.

ABSTRACT

Kailali District, which comprises an area of 3200 km^2 in far western Nepal, is about 60% in the Terai and about 40% in the Siwalik Hills physiographic province. The average annual precipitation since 1987 has been about 1619 millimeters of which more than 90% comes during the monsoon. The population in 1981 was 258,000 of which 89% was rural. Agriculture is the dominant economic activity in the district. Approximately 50% of the farm land is irrigated for a single crop and only about 15% for more than a single crop. The aquifer in Kailali has the potential to provide water to irrigate the remaining 85% of unirrigated or single crop irrigated land.

The aquifer is comprised of an indeterminate number of interconnected permeable lenses of sand, gravel and pebbles intercalated with some silts and clays which comprise a very large ground water reservoir. Nineteen pumping tests were done and transmissivities were determined to range from less than 200 to more than 4,000 m^2/day. Yields of existing wells range from less than 5 to 17 liters per second (l/s). The yield potential map indicates the northwestern and eastern parts of the district should yield more than 15 l/s.

Fluctuations observed in the water level change maps are relatively small and are due to seasonal variation and are not due to pumping stress on the aquifer.

Recharge in the district is principally from local precipitation. Estimates of potential recharge vary from about 320 MCM to more than 800 MCM per year. This compares favorably with the estimated ground water outflow to India of 40 MCM per year and a hypothetical pumpage of 171 MCM per year calculated from 1000 wells pumping 20 l/s for six hours each day.

1. INTRODUCTION

1.1 Purpose and Scope

The United Nations Department of Technical Co-operation for Development and the Ground Water Resources Development Board, HMG, Nepal instituted a project in June 1987, NEP/86/025, to investigate the shallow ground water resources of the Terai. Project document information is presented in Appendix A. This report on Kailali District is one of a series of reports from the project. The status of the project is shown in Figure 1.

The purpose of the project is to conduct an orderly and defined investigation of shallow ground water in each Terai district. A major goal of NEP/86/025 is to develop scientific procedures for the collection, interpretation, and presentation of ground water data, throughout the Terai in Nepal. A principal component of this goal is the development of a computerized Ground Water Information System (GWIS) to manage the groundwater information obtained in this project. Eventually the GWIS will become a major tool in many aspects of ground water data storage, retrieval, and dissemination for all ground water information collected by DOI.

A second major goal is to train Nepalese hydrologists to implement the procedures. This will facilitate optimum development of ground water resources of the Terai, in particular, and Nepal in general.

A third major goal is to define the areal extent of each Terai district where a shallow irrigation well (SIW) may be developed. A SIW is defined in Chapter 5, Shallow Ground Water Availability.

Ground water must be utilized in the best possible manner to ensure availability of this most important natural resource now and in the future. Irrigation by wells in Kailali District in the Terai will help Nepal increase agricultural production for an increasing population, for export and for valuable foreign exchange.

This report should be considered in relation to the above goals. Ground water data has been collected, placed in an information system, interpreted and presented. Training takes place during these activities. Finally, a SIW area is defined.

1.2 Location and Extent of Area

Kailali District is the second district from the west border of Nepal with India and borders India on the south lying between the LANDSAT IMAGERY [National Remote Sensing Center (NRSC,1984)] co-ordinates: x=450000 - 52800 and Y=3140000 - 3198000 shown in Figure 1. Bardiya District borders on the east along the Karnali River and Kanchanpur District on the west along the Mohana River. Dhangadhi is the principal city of Kailali. Kailali has an area of about 3200 km^2 (Statistical Pocket Book, Nepal (SPBN), 1986) and the Terai portion has an area of about 1970 km^2 (about 60%) including the Bhabar zone with 475 Km^2 (Tillson, 1985).

1.3 Previous Investigations

Kailali and surrounding districts have been investigated and studied previously by several workers and projects. Reports by these investigators are listed in the Selected References.

1.4 Methods of Investigation

Field work for this report was started in May 1987 and for the most part was completed in May 1990. The work consisted of water level measurements, drilling project wells (started in December 1988 and terminated in May 1990), altitude surveys of land surface at wells, and aquifer tests.

Initial water level measurements were made in a network of 50 existing wells (41 dug wells and 9 private shallow wells). Only 43 wells (36 dug and 7 private shallow wells) have been regularly monitored from December 1988 to date. The monitoring network has become a combination of 36 dug wells, 7 private shallow wells and 32 project drilled shallow tube wells (STW) which cover the district.

1.5 Well Identification System

Wells in this report are identified in several ways: 1) they are numbered sequentially and given a location name; 2) each has a computer file name or number which includes the letters KL for Kailali District and the sequence number; 3) additional identification (ID) is provided by another secondary number to differentiate wells drilled for this project (UN and a sequential number), wells drilled for USAID/GWRDB (US and a sequential number) and wells drilled by GWRDB (GW and sequential number); 4) X and Y coordinates have been digitized from the 1:500,000 LANDSAT imagery map of Nepal and are another ID.

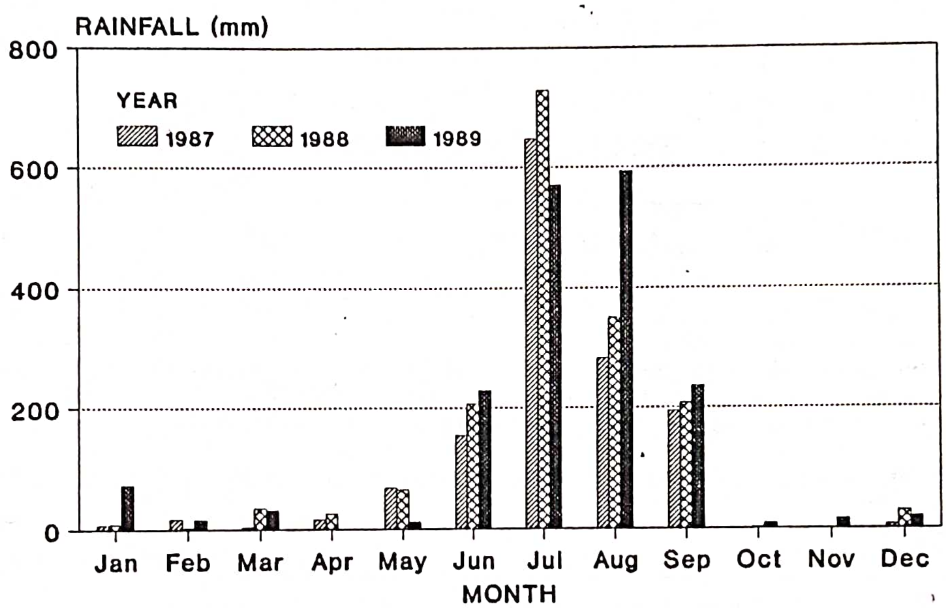
1.6 Topography and Drainage

Kailali District is in the Terai Physiographic Province of Nepal in the south and in the Siwalik Hills Province in the north. Altitudes in Kailali District range from more than 1000 meters in the north to about 100 meters at the border with India.

There are several rivers in Kailali District which flow from north to south. The larger among them are Mohana, Khutiya, Ghuraha, Kanara, and Karnali. The Mohana River forms the west and south boundary with Kanchanpur District and India respectively. The Karnali River forms the east boundary with Bardiya District. The Khutiya, Ghuraha, Kanara are the other major rivers in the Kailali Terai. The stream network formed by these and other streams has an average density of one stream every 10 km^2.

1.7 Climate

The climate of Kailali District is subtropical with a mean monthly temperature of 16°C in January and 30°C in June. High humidity is prevalent except in winter and may be suffocating in summer. Heavy monsoon rains begin in June and end in September. The monsoon provides about 92% of the average precipitation for the year at the Dhangadhi airport. Monthly precipitation is shown on Figure 2. The mean anunual rainfall during the three years from 1987 to 1989 of this investigation is close to 1619 mm at Dhangadhi.



Total Raifall In
1987=1395 mm, 1989=1804 mm, 1988=1657mm
Average Annual Rainfall=1619 mm

Figure 2: Bar Chart of Monthly Rainfall recorded at Dhangadhi, 1987-1989.

1.8 Population

There were about 258,000 people in Kailali District in 1981 giving an average density of about 80 people per km^2 (SPBN). About 11% were living in an urban setting and 89% in a rural setting.

1.9 Agriculture

The crops grown in Kailali District include paddy, maize, millet, wheat, barley, oil seeds, potato, tobacco, sugarcane and pulses. The area, yield and annual average retail price in 1988/89 are given in Table 1 below (Agricultural Statistics of Nepal 1990).

TABLE 1. *Principal crops harvested in 1988/89*

Crop	Area (Ha)	Yield (Kg/Ha)	Production (M.ton)	Annual Ave. Retail Price (Rs./Kg)
Paddy	50200	2200	110440	5.78
Maize	11650	1421	16550	4.73
Millet	1100	1000	1100	5.88
Wheat	20870	1400	29210	5.91
Barley	140	857	120	Not Available
Oilseed	15740	700	11020	13.83
Potato	1010	11307	11420	4.68
Tobacco	40	750	30	55.15
Sugarcane	500	30000	15000	Not Available
Pulse	15800	815	12880	Not Available

Kailali District contains 66,722 Ha of agricultural land (ASN,90) and less than half is irrigated (Table 2). Ground water will provide a large part of the water to irrigate the potential irrigation land.

TABLE 2. *Status of Agricultural Land in Kailali(1988/89)*

Item		Area in Ha
Total Agricultural Land		66722
Land that cannot be irrigated		2610
Potential Irrigation Land		64112
Land being irrigated	By monsoon	20918
	Year round	9437
	Total	30355
Remaining Potential Year Round Irrigation Land		54675

1.10 Acknowledgments

Most of the information compiled and presented in this report came from the Ground Water Resources Development Board office in Dhangadhi. Some wells drilled by GWRDB/Kailali and USAID/GWRDB are also presented in this report. The pumping tests made by GWRDB, Dhangadhi in Kailali District has provided a wealth of valuable information necessary for aquifer evaluation.

The work of the staff engaged in hydrogeological work in Kailali, both in the field and office, is highly appreciated. The author would like to express thanks and sincere appreciation to Mr. Y. L. Vaidya, Deputy Director General, Department of Irrigation, HMG for his support and encouragement to prepare this report. The support and guidelines provided by Dr. R. Tuladhar, National Co-ordinator of the Project NEP/86/025, and the staff at the central office Kathmandu during preparation of this report is much appreciated. Mr. J.M. McNellis, Senior Adviser to NEP/86/025 is acknowledged here for his report preparation assistance.

2. GEOLOGY, LITHOLOGY, AND WATER SUPPLY

Sediments comprising the Terai Plain are thick clastic deposits of Quaternary and Pleistocene age and are accumulating to the present day. The plain is composed of interlocked alluvial deposits of the wider Ganges plain including fans, channels, flood plains of numerous rivers flowing from the Siwalik Range and across the Terai Plain, as well as colluvial deposits at the foothills of the above range. The most permeable portions of the Terai sediments are the coarse fractions and thus sand, gravel and larger fractions will be called aquifer in the succeeding discussion. These aquifers and the underlying and overlying sandy-silts, silts, and clays comprise a very large groundwater reservoir in which ground water is stored until discharged naturally on by pumping.

The deposits are placed in two groups for hydrologic and lithologic purposes, the Bhabar Zone deposits and the Terai Plain deposits. The break down is not easily defined in the subsurface because of the nature of the sedimentation process.

2.1 Lithological Cross Sections:

The well locations and traces of lithological cross sections for Kailali District are presented in Figure 3. The individual cross sections were produced using UN/DTCD Ground Water Software (GWS) (Karanjac, 1989). They are shown in Figures 4 to 11 and followed by descriptions. The vertical axis of the individual cross sections represents elevation above sea level in meters.

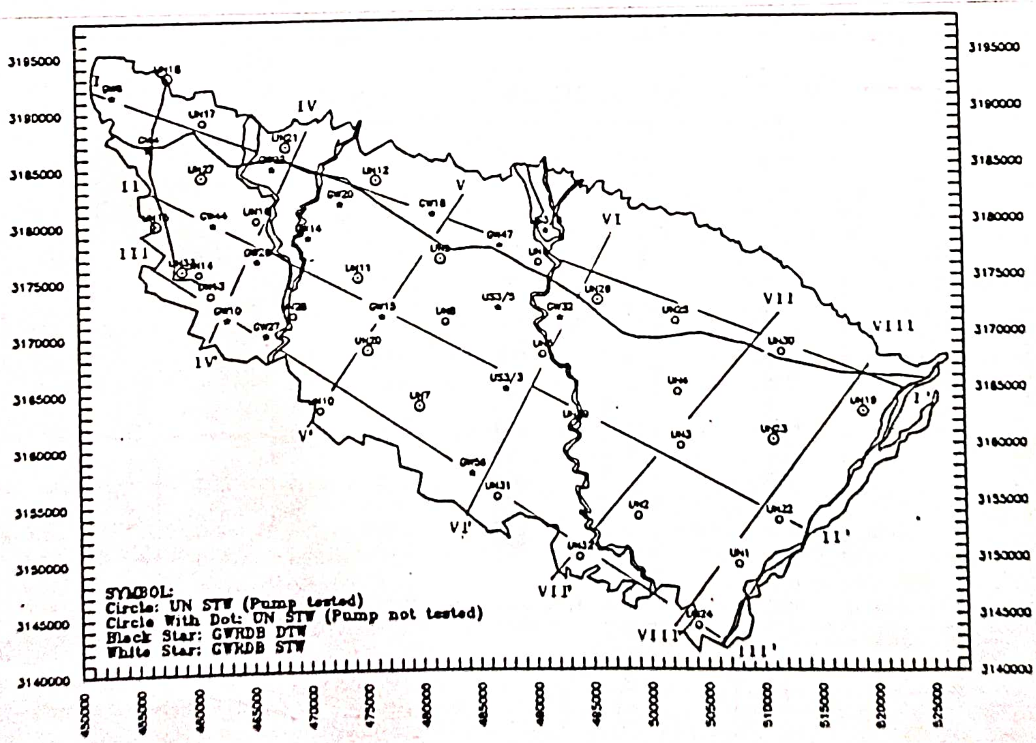


Figure 3: Map showing Location of Wells and Lithological Cross Sections

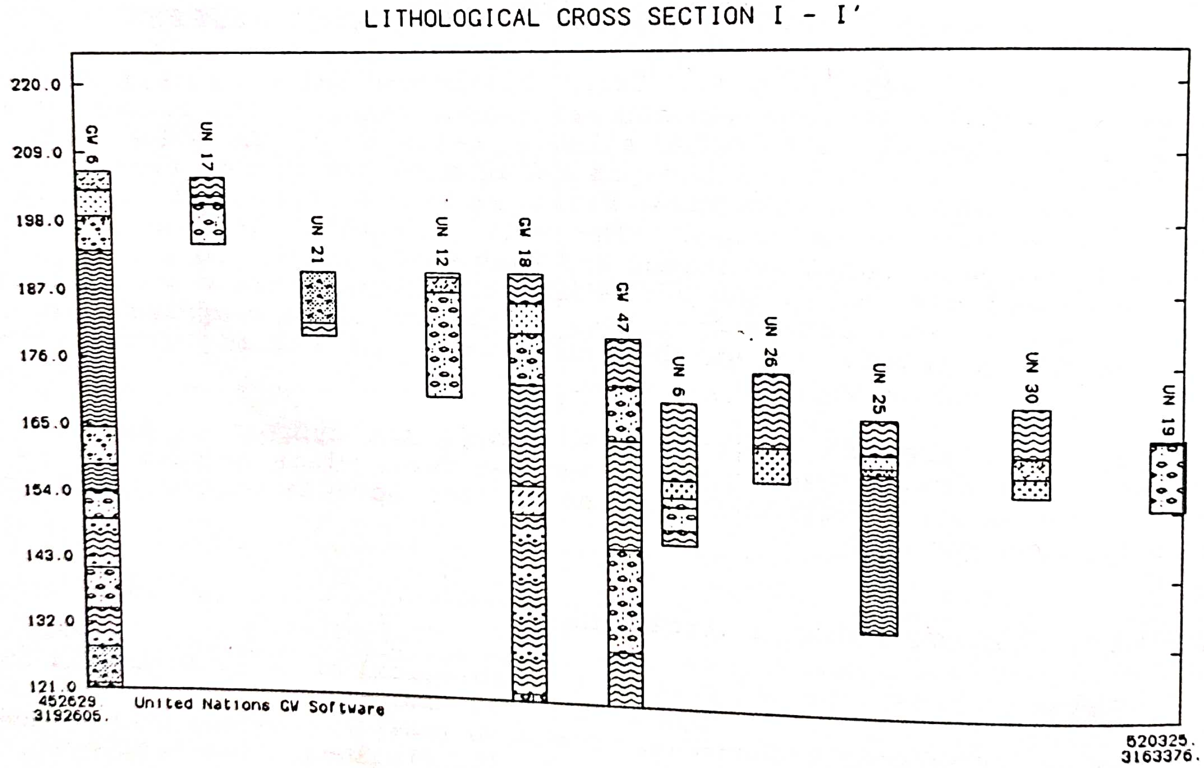


Figure 4: West-East Cross section I - I'

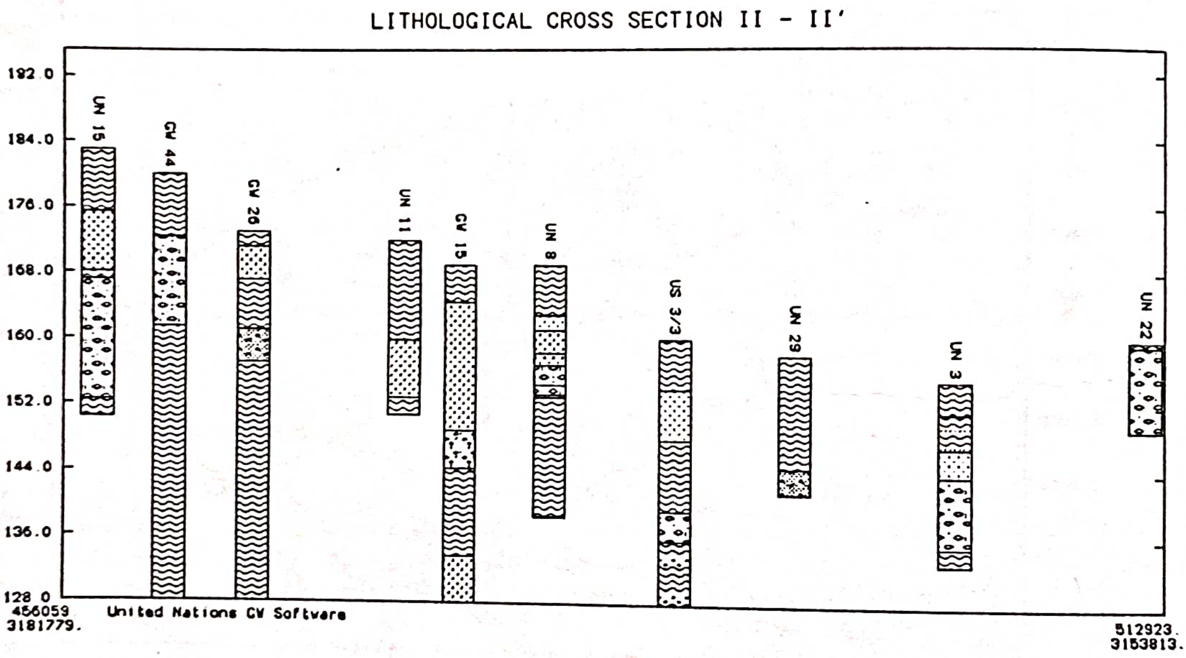


Figure 5: West-East Cross section II - II'

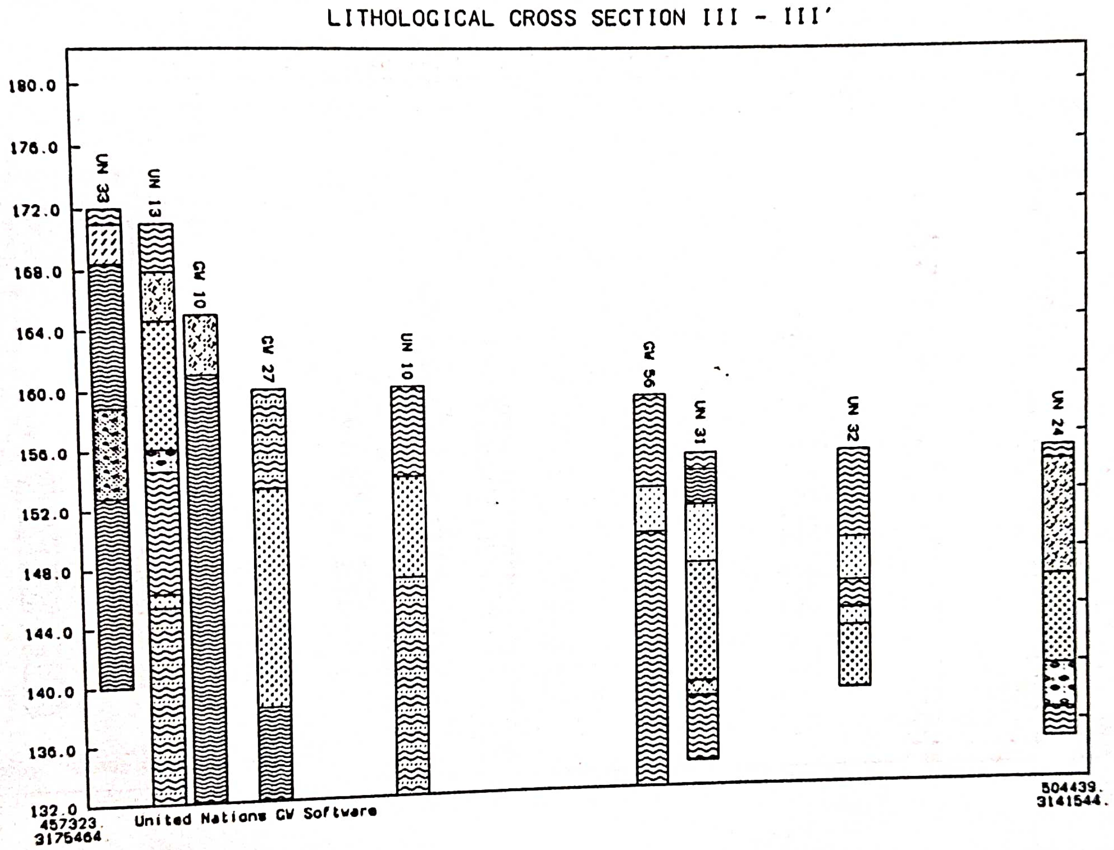


Figure 6: West-East Cross section III - III'

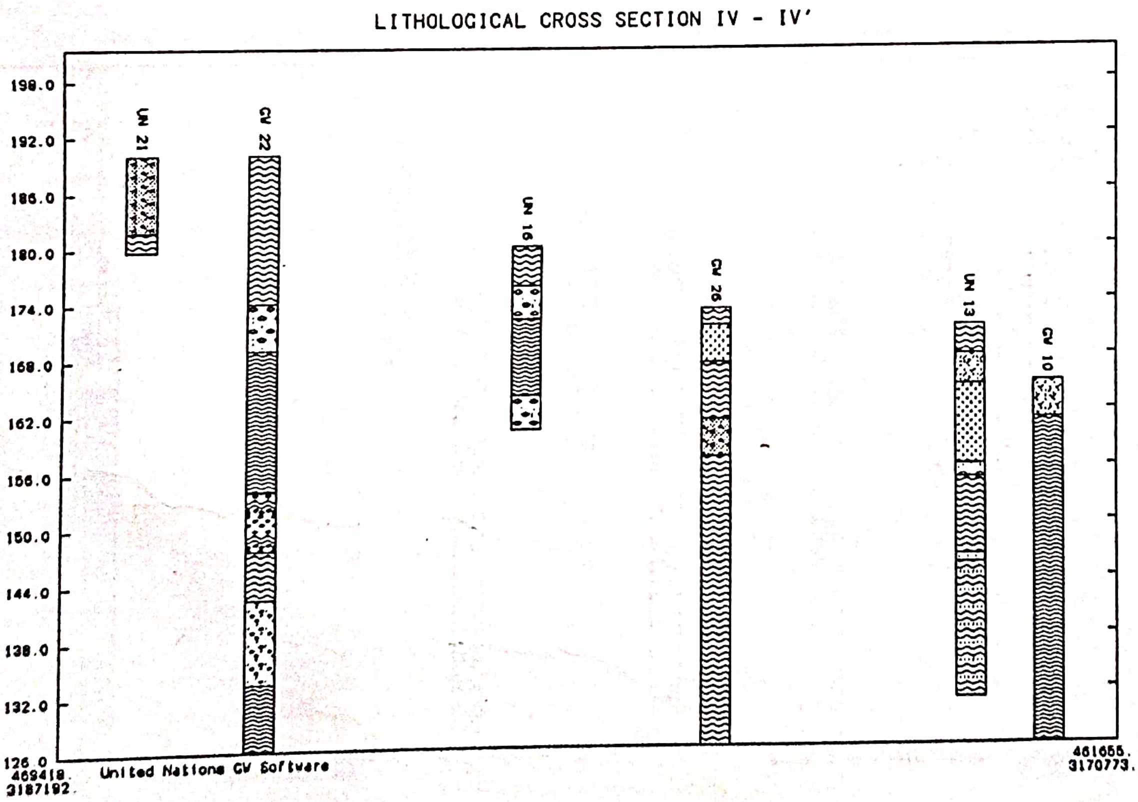


Figure 7: North-South Cross section IV - IV'

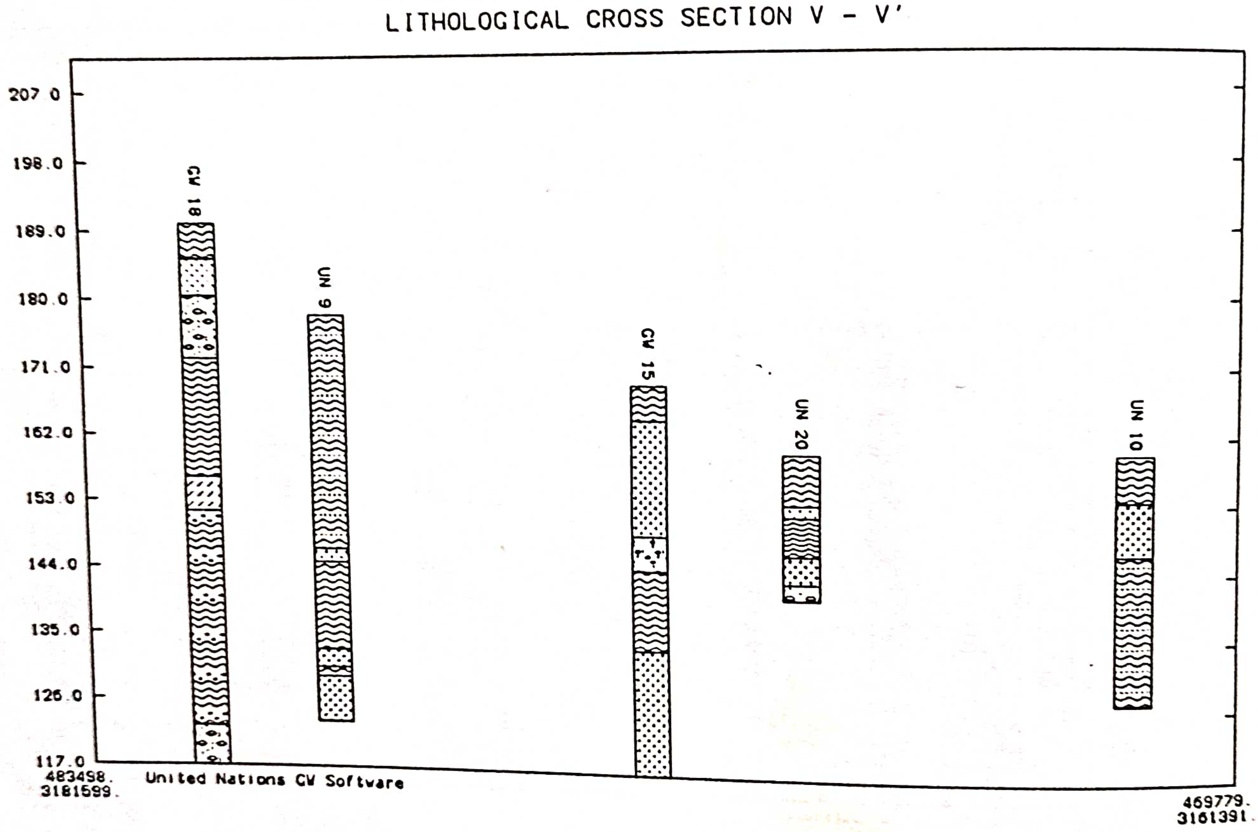


Figure 8: North-South Cross section V - V'

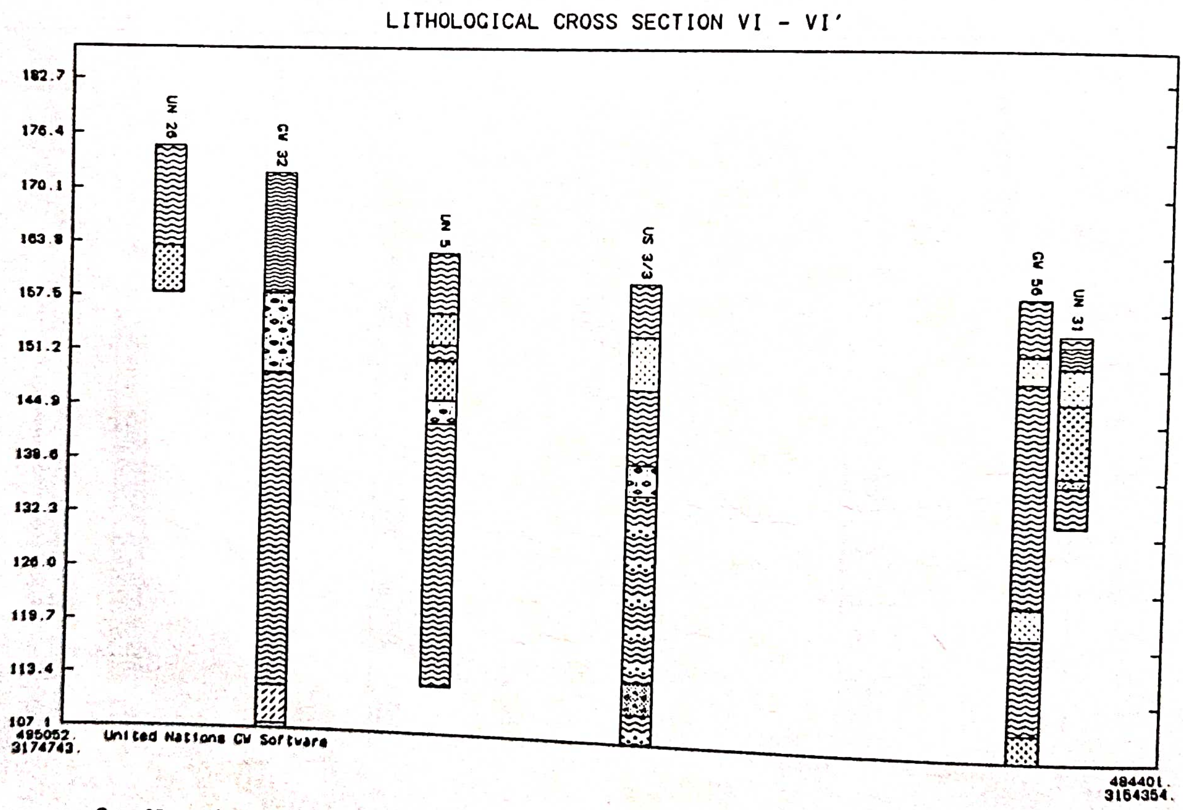


Figure 9: North-South Cross section VI - VI'

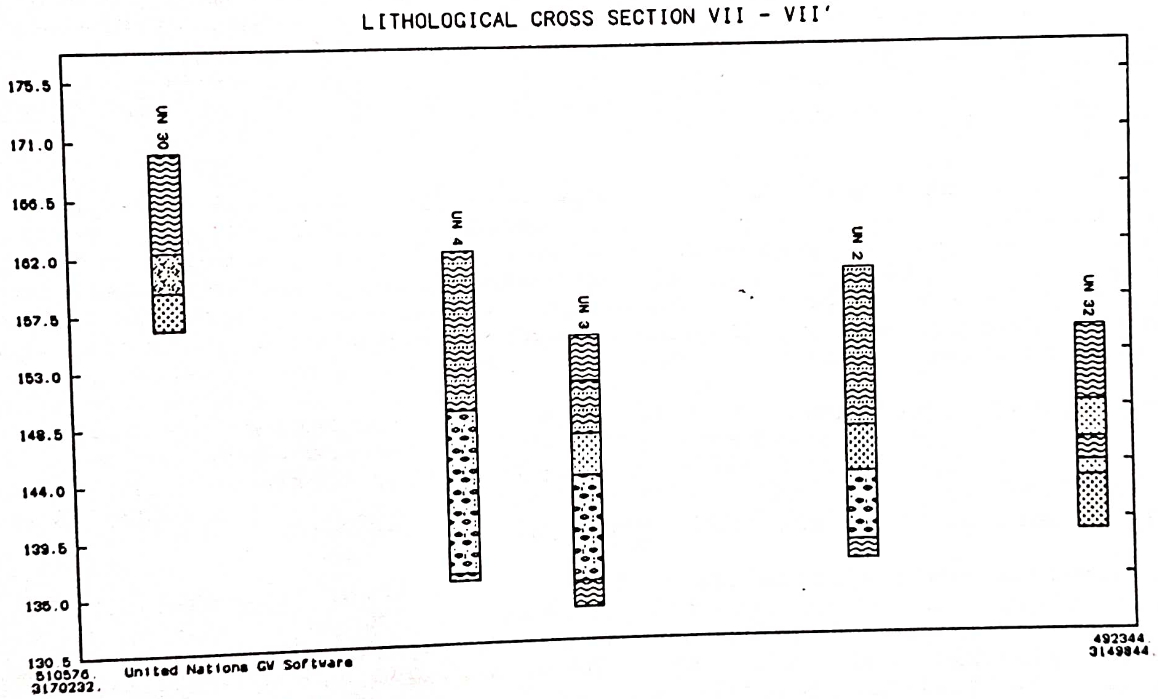


Figure 10: North-South Cross section VII - VII'

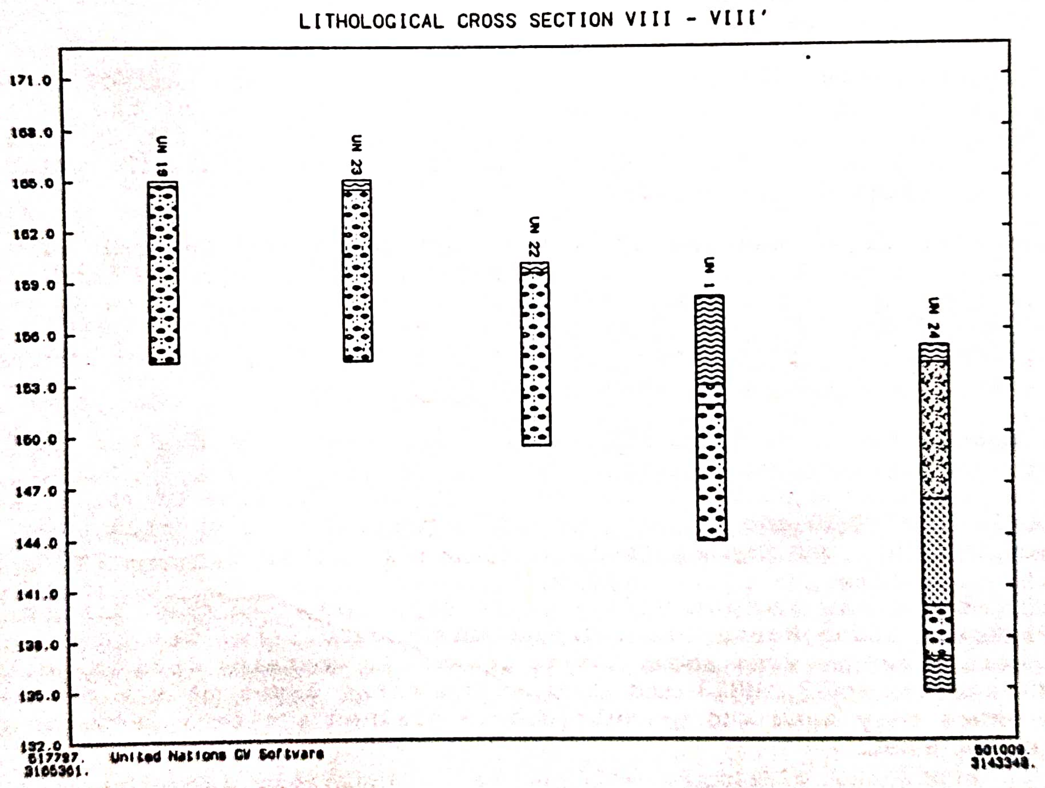


Figure 11: North-South Cross section VIII - VIII'

No attempt has been made to connect permeable layers in the cross sections. This is a "risky" undertaking in Quaternary deposits near the Siwaliks and across the Terai Plain which is cross-cut by many present rivers and buried channels of rivers of the past. The lithology of the sediments changes rapidly over very small distances. Eight cross sections are presented to understand and gain an appreciation for the rapid changes within the subsurface of the Terai area. The descripitions of the cross sections are as follows.

Lithological cross section I - I' cuts the upper part of the District along West-East direction (Figure 4). The elevation of land surface varies from about 165 to 205 m. This section consists of eight UN wells and three GW wells. They are, UN6, UN12, UN17, UN18, UN21, US25, UN26, UN30, GW6, GW18 and GW 47. The wells in the section contain a considerable thickness of sand and gravel. However, this section shows comparatively coarser grain size than the middle and lower (southern) parts.

Lithological cross section II - II' cuts the middle part of the district from West to East direction (Figure 5). The land surface elevation varies from about 155 to 182 m. It consists of six UN wells, three GW wells and one US well. They are, UN3, UN8, UN11, UN16, UN22, UN29, GW15, GW26, GW44, and US3/3. Most of the wells show sand layers.

Lithological cross section III - III' cuts the lower (southern) part of the District along West-East direction (Figure 6). The land surface varies from about 155 to 172 m. It contains six UN wells and three GW wells. They are, UN10, UN13, UN24, UN31, UN32, UN33, GW10, GW27 and GW56. This section shows mostly fine grained aquifer. So, it is obvious that the grain size is decreasing from North to South of Kailali District.

Lithological cross section IV - IV' represents the Far-Western part of the District and cuts along North-South direction (Figure 7). The land surface in this section varies from about 165 to 190 m. It contains three UN wells and three GW wells, which are UN13, UN16, UN21, GW10, GW22 and GW26. The aquifer in the first three wells from North shows coarser grained (sand and gravel) than the other three wells (sand).

Lithological cross section V - V' represents the Western part of the District along North-South direction (Figure 8). The elevation of the wells ranges from about 160 to 189 m. It contains three UN wells and two GW wells, which are UN9, UN10, UN20, GW15 and GW18. The first layer of all the wells in this section shows sand type aquifer.

Lithological cross section VI - VI' represents the Central part of the District and cuts along North-South direction (Figure 9). The land surface in this section varies from about 155 to 175 m. It contains three UN wells, two GW wells and one US well, which are UN5, UN26, UN31, GW32, GW55 and US3/3. The aquifer in the first three wells from North shows coarser grained (sand and gravel) than the other three wells (fine sand).

Lithological cross section VII - VII' represents the Eastern part of the District along North-South direction (Figure 10). The land surface in this section ranges from about 155 to 170 m. It contains five UN wells, which are UN2, UN3, UN4, UN30 and UN32. The middle part of this section shows coarser grained aquifer than the aquifer in the other parts.

Lithological cross section VIII - VIII' represents the most Eastern part of the District along North-South direction (Figure 11). The land surface in this section ranges from about 155 to 165 m. It contains five UN wells, which are UN1, UN19, UN22, UN23 and UN24. The first layer of the Northern four wells shows only sand and gravel (coarse grained aquifer) and the Southern well shows sand.

The grain size of Terai sediments appears to decrease slightly from north to south, according to the cross sections. However, Table 3 indicates that average thickness of permeable or aquifer material within 26 m of the surface does not vary consistently. Lithologic logs of individual wells from the district are presented in Appendix B.

2.2 Bhabar Zone Deposits

2.2.1 Lithology, Distribution, and Thickness

Bhabar Zone deposits are found, but are not continuous (Figure 4, Lithological Cross-section I-I'), at the surface along the base of the Siwalik Hills at the north edge of the Terai and also along major rivers transecting the Terai. The area of Bhabar in Kailali District is estimated at 475 km^2 (Tilson, 1985), and is a principal recharge area for the ground water reservoir of the Kailali Terai. The Bhabar is derived principally from erosion of the Siwalik Formations found in the Siwalik Hills. Streams cut through the Hills, abruptly debauch onto the much flatter Terai which is the north portion of the Ganges plain, and dump their sediment as alluvial fans. Through time these fans combine and are covered with other sediments and comprise the Bhabar. The Bhabar or its equivalent may be found at depth to the south of the current Siwalik Hills.

The Bhabar is very poorly sorted and contains a large proportion of coarse grained material, ranging in size from sand to boulders. There are intercalated finer sediments as well. Thickness ranges from a few meters to more than a hundred meters.

2.2.2 Water Supply

Wells screened in the Bhabar adjacent to the Siwalik Hills experience water level fluctuations large enough to place water levels below the lifting capability of commonly used centrifugal pumps. Therefore, very few STW obtain water from the Bhabar. Yields from deep tube wells (DTW) in Kailali District which may tap the Bhabar Zone range from about 6 to 30 (l/s). Most DTW are used for irrigation.

2.3 Terai Plain Deposits

2.3.1 Lithology, Distribution, and Thickness

Throughout the Terai a thick sequence of clastic sediments has been and is being deposited. The deposits are called Terai Plain deposits in this report and in project NEP/86/025. These sediments are at the surface except for the outcrop area of the Bhabar Zone and cover about 1495 km^2 (Tillson, 1985) in Kailali District. They are a major recharge area for the ground water reservoir of the Kailali Terai.

These sediments are comprised of rock material eroding from the Siwalik Hills and the mountains to the north. Sediment ranges in size from clay to gravel and the proportions vary widely. However, they generally comprise more clay, silt, and fine sand than sand and gravel. The coarser size fractions appear to be lenticular in litholigical cross-sections I-VIII (Figures 4-11) and are described as sand lenses or sand and gravel lenses contained in finer sediments. Their thickness may exceed 1000 meters along the Indian border.

Lithological cross-sections of Kailali indicate that the sediments of the shallow aquifer becomes somewhat finer from north to south (Figures 4-6, Lithological Cross-sections I-III). However along the east-west direction, there is not much difference in the grading of the aquifer materials. The aquifer material is coarse (gravel and coarse sand) in the eastern and far western parts and comparatively fine (fine to medium sand) in the central and western part. This can be visualized in the lithological cross sections IV-VIII (Figures 7-11).

The regional distribution of shallow permeable thickness in Kailali within 26 m depth (calculated from the UN wells in the cross section and surrounding UN wells) is shown in table 3 below.

TABLE 3. *Regional Aquifer Thickness within ~~26~~ 50 m depth*

Region	Maximum (m)	Minimum (m)	Average (m)	Cross-section No. (Figure #)
Northern	~~16.9~~ 25.1	5.5	13.6 ~~9.2~~	I-I'(Fig. 6)
Central	~~22.0~~ 34.7	7.0	14.6 ~~12.2~~	II-II'(Fig. 7)
Southern	~~12.2~~ 21.6	6.1	11.8 ~~9.0~~	III-III'(Fig. 8)
Far-Western	22.0	7.2	11.2 ~~10.2~~	IV-IV'(Fig.9)
Western	34.7 ~~7.9~~	7.0	15.5 ~~7.3~~	V-V'(Fig.10)
Central	13.4 ~~12.2~~	5.5	9.9 ~~9.6~~	VI-VI'(Fig.11)
Eastern	13.1	8.5	10.1	VII-VII'(Fig.12) VIII-VIII'(Fig.13)

2.3.2 Water Supply

There were 922 STW (780 STW were drilled by ADBN and 142 by GWRDB) reported in Kailali in mid-1986 (GDC, 1987). In addition, there were a large number of dug wells. Some of these wells provide water for drinking or domestic purposes and others, STW in particular, provide irrigation water. Reported yields range from less than five l/s to more than 16 l/s. The pump tested project wells yielded from less than 5 to 17 l/s.

2.4 Drilling:

Lithological logs and other information were collected on 50 drilled wells including 3 DTW drilled by USAID and 14 wells (13 DTW and 1 STW) drilled by GWRDB in the 1970's. This project drilled 33 investigation wells, 32 were successful and 1 was abandoned. The 33 project wells were constructed by manual methods known as Slugger, Bogie or Driven. The maximum and minimum drilled depths of the project wells are 56.4 m and 10.2 m respectively and the average drilling depth is 26 m. The number of project wells and drilling meterage in Kailali are shown on Figures 12 and 13 respectively. The most pertinent data on the project wells and other selected wells are presented in Table 4, including the water levels of pump tested wells. The DTW in the table numbered 34 to 50 only have known lithology. The elevations of land surface at wells were surveyed but were referred to temporary bench marks and are not ready to directly use in this report.

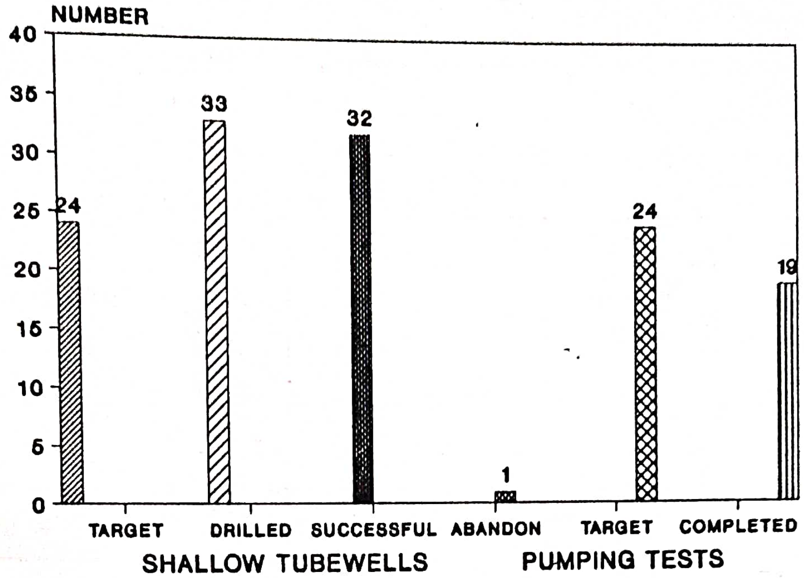


Figure 12: Number of wells and pump tests in Kailali District

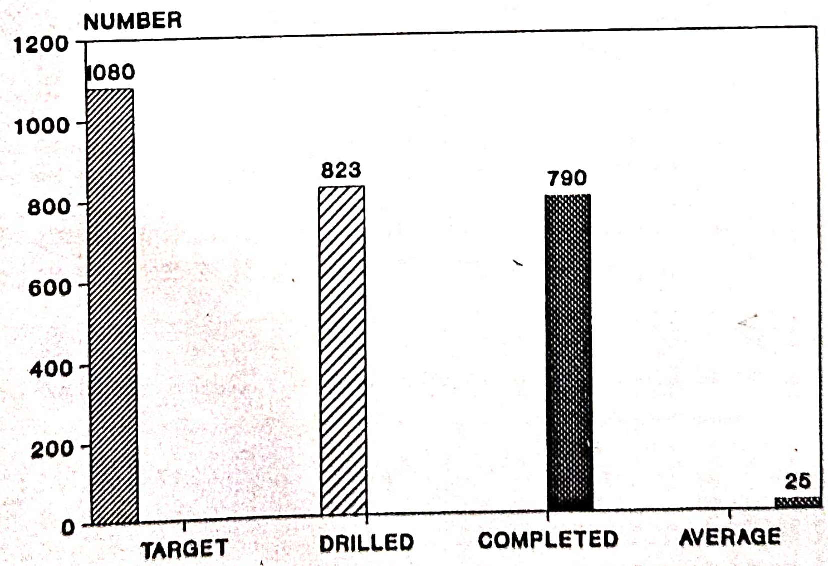


Figure 13: Drilling meterage in Kailali District

TABLE 4. *List of Tube Wells with Basic Data*

S. No.	File Name in Computer	Well Number (1)	Location: Village Name	Location: Landsat Co-ordinates (2) X	Location: Landsat Co-ordinates (2) Y	Elev. from MSL (m) (3)	Depth of Well (m)	Length of Screen used (m)	Screen Position (m)	Screen Type	Permeable Thickness (m)	Permeable Percent of depth (m)	Drilling Date	Well Diameter (inch) (4)	Water Level BGL (m)
1	KLS01.LTH	UN 1*	BISHNUKANTIPUR	507800.	3149300.	158.00	14.30	3.7	10.6-14.3	Perforated	9.1	63.6	01.08.89	4	1.29
2	KLS02.LTH	UN 2*	DHUSI	499000.	3153600.	160.00	23.50	3.7	12.8-16.5	,,	9.2	39.1	02.08.89	4	2.70
3	KLS03.LTH	UN 3*	JOSHIPUR	502800.	3159800.	155.00	21.90	3.7	16.1-19.8	,,	11.9	54.3	01.08.89	4	2.31
4	KLS04.LTH	UN 4*	SIMRI	502600.	3164600.	162.00	26.50	3.7	18.3-21.9	,,	13.1	49.4		4	2.82
5	KLS05.LTH	UN 5*	KOTA	490800.	3168000.	163.00	50.30	6.1	14.0-20.1	Slotted	11.0	21.9	24.03.89	4	5.22
6	KLS06.LTH	UN 6*	THABAI	490500.	3176200.	170.00	22.50	3.6	16.5-20.1	Perforated	7.9	35.1	18.05.89	4	5.32
7	KLS07.LTH	UN 7	BASAUTI	479800.	3163500.	160.00	56.40	1.8	47.0-48.8	,,	2.1	3.7	02.04089	2.5	
8	KLS08.LTH	UN 8*	PRITHIVIPUR N	482200.	3171000.	169.00	30.50	5.5	11.0-16.5	Slotted	10.0	32.8	28.03.89	4	3.00
9	KLS09.LTH	UN 9	UDASHIPUR	481800.	3176600.	178.00	54.90	6.1	48.8-54.9	,,	10.3	18.8	09.03.89	4	
10	KLS10.LTH	UN 10*	PHULBARI	471000.	3163200.	160.00	32.60	4.2	09.8-14.0	Perforated	7.0	21.5	20.12.88	4	4.17
11	KLS11.LTH	UN 11	BHADA	474500.	3175000.	172.00	21.30	6.1	13.1-19.2	Slotted	7.0	32.9	03.01.89	4	
12	KLS12.LTH	UN 12	MAGHI	476200.	3183700.	190.00	19.90	3.7	16.2-19.9	Perforated	16.9	84.7	05.03.89	4	
13	KLS13.LTH	UN 13*	DHANGADHI VILL	461500.	3173700.	171.00	40.00	5.5	10.7-16.2	Slotted	10.9	27.2	Dec.1989	4	4.62
14	KLS14.LTH	UN 14*	DHANGADHI TOWN	460500.	3175600.	171.00	35.60	5.5	10.7-16.2	,,	7.9	22.2	30.01.89	4	3.98
15	KLS15.LTH	UN 15	RAJPUR	456800.	3180000.	183.00	32.60	3.7			22.0	67.5	Dec.1989	4	
16	KLS16.LTH	UN 16*	DHANCHAURI	465600.	3180300.	180.00	19.80	3.0	16.8-19.8	Perforated	7.2	36.6	15.05.89	4	3.11
17	KLS17.LTH	UN 17*	LALPUR	461000.	3189100.	205.00	10.70	3.7	07.0-10.7	,,	6.4	59.8	10.01089	4	2.22
18	KLS18.LTH	UN 18	TEGHARI	458000.	3193100.	250.00	11.90	3.1	08.2-13.1	,,	8.3	69.7	06.06.89	4	
19	KLS19.LTH	UN 19	KATACHHE	519000.	3162800.	165.00	10.70	3.7	07.0-10.7	,,	10.4	97.2	13.01.90	4	
20	KLS20.LTH	UN 20	KHAREITY	475300.	3168500.	160.00	19.20	3.0	16.2-19.2	,,	7.3	38.0	07.02.90	4	
21	KLS21.LTH	UN 21	BANBEHDA	468200.	3186600.	190.00	10.20	2.7	05.5-08.2	,,	8.2	80.4	15.02.90	4	
22	KLS22.LTH	UN 22*	TIKAPUR	511400.	3153200.	160.00	10.70	3.7	07.0-10.7	,,	10.1	94.4	13.12.89	4	2.43
23	KLS23.LTH	UN 23	DURGAULI	511000.	3160300.	165.00	10.70	3.7	07.0-10.7	,,	10.1	94.4	12.12.89	4	2.25
24	KLS24.LTH	UN 24*	CHAUGURDI	504100.	3143900.	155.00	20.20	3.6	14.6-18.2	,,	9.2	45.5	09.12.89	4	4.71
25	KLS25.LTH	UN 25*	NUMUWABOJHI	502500.	3170900.	168.00	33.50	2.7	05.5-08.2	,,	3.0	9.0	02.05.90	4	3.32
26	KLS26.LTH	UN 26	SIMTHALI	495700.	3172800.	175.00	17.10	2.7	13.7-16.4	,,	5.5	32.2	26.04.90	4	
27	KLS27.LTH	UN 27	SRIPUR(School)	460800.	3184200.	188.00	44.00	6.7	10.5-17.2	Slotted	7.5	17.0	26.04.90	4	
28	KLS28.LTH	UN 28*	KANARI	468700.	3171700.	165.00	21.30	2.7	05.5-08.2	Perforated	8.6	40.4	03.02.90	4	2.74
29	KLS29.LTH	UN 29	BIJULIYA	493600.	3161700.	158.00	16.50	3.5	13.0-16.5		3.1	18.8	22.02.90	4	4.13
30	KLS30.LTH	UN 30*	BALIYA	511800.	3168100.	170.00	13.70	3.7	10.0-13.7	Perforated	3.0	21.9	20.11.89	4	2.16

continued from Table 4.

S. No.	File Name in Computer	Well Number (1)	Location: Village Name	Location: Landsat Co-ordinates (2) X	Location: Landsat Co-ordinates (2) Y	Elev. from MSL (m) (3)	Depth of Well (m)	Length of Screen used (m)	Screen Position (m)	Screen Type	Permeable Thickness (m)	Permeable Percent of depth (m)	Drilling Date	Well Diameter (inch) (4)	Water Level (m)
31	KLS31.LTH	UN 31*	RAMPUR	486600.	3155400.	155.00	21.30	5.5	09.7-15.2	,,	12.2	57.3	24.02.90	4	4.99
32	KLS32.LTH	UN 32*	CHHARRA	493800.	3150000.	155.00	16.50	3.6	12.9-16.5	,,	8.5	51.5	14.02.90	4	3.86
33	KLS33.LTH	UN 33	DHANGADHI TOWN	459000.	3175900.	172.00	32.00	6.1	13.1-19.2	Slotted	6.1	19.1	10.04.89	4	
34	KLS37.LTH	GW 4	AUTERIA	456300.	3186900.	195.10	56.10	0.0			3.4	6.1	21.01.74		
35	KLD06.LTH	GW 6	MALAKHETI(1)	453200.	3191500.	206.00	-122.60	18.4			43.9	35.8		10/6	
36	KLD10.LTH	GW 10	MANIHARA	462900.	3171500.	165.00	146.00	20.2			17.7	12.1		10/6	
37	KLD14.LTH	GW 14	URMA (1)	470100.	3178650.	170.00	169.50	12.2			28.8	17.0		10/6	
38	KLD15.LTH	GW 15	SAMACRAURE	476600.	3171500.	169.00	124.40	15.2			64.5	51.8		10/6	
39	KLD18.LTH	GW 18	UDASHIPUR (1)	481150.	3180650.	190.00	134.50	13.2			56.7	42.2		10/6	
40	KLD20.LTH	GW 20	UDASI	473000.	3181650.	190.90	125.30	12.2			56.7	45.3			
41	KLD22.LTH	GW 22	DAMAULIA	467000.	3184900.	190.00	120.70	12.3			55.3	45.8		10/6	
42	KLD26.LTH	GW 26	BOARDING SCHOO	465600.	3176650.	173.00	107.00	9.1			13.8	12.9			
43	KLD27.LTH	GW 27	JUGEDA	466300.	3170000.	160.00	98.80	0.0			39.0	39.5			
44	KLD32.LTH	GW 32	AMBASA	492350.	3171250.	172.00	124.10	0.0			16.9	13.6	29.05.78		
45	KLD44.LTH	GW 44	JHALARI	461800.	3180000.	180.00	99.10	17.4			29.6	29.9	08.08.79	12/8	
46	KLD47.LTH	GW 47	MASURIA	487100.	3177750.	180.00	108.20	18.9			43.7	40.4	24.02.80	12/8	
47	KLD56.LTH	GW 56	BASANTA	484400.	3157500.	159.10	457.50	6.1			23.8	5.2	23.05.74	6/4	
48	KLD58.LTH	US 3/3	BIJAYAPUR	487500.	3165000.	160.00	115.20	6.1			47.5	41.2	15.04.74	6/4	
49	KLD59.LTH	US 3/5	SISAIYA	486900.	3172200.	172.00	352.90	6.1			24.7	7.0	14.04.74	6/4	
50	KLD60.LTH	US 3/8	GANESHPUR	491200.	3179000.	185.00	122.20	4.9			27.6	22.6	18.04.74	6/4	

(m) Meter

(1) Well with pumping tests have an *

(2) X and Y coordinates are taken from the 1:500,000 map of Nepal, a composite of LANDSAT imagery [National Remote Sensing Center (NRSC, 1984)]. The coordinates were read with the help of project-supplied digitizer.

(3) The absolute elevation of the well above is in terms of the mean sea level. The elevations are interpolated from 1:125,000 scale district map.

(4) From S.No. 35 to 50, the last figure indicates reduced diameter of the lowering pipe.

The 50 wells listed in Table 4 are further analyzed to Table 5. The percentage of aquifer (permeable) material found in each well and for all wells is listed in Table 6.

TABLE 5. *Analysis of Well Data in Table 4.*

Item	For UN-STW	For DTW	All together (including one GWRDB STW)
Total no. of wells	33	16	50
Total drilled depth	822.8 m	2528.0 m	3406.9m
Average depth per well	25.9 m	158.0 m	68.1m
Total screen used	133.9 m	172.3 m	306.2m
Average screen used	4.1 m	12.3 m	6.5m
No. of wells with screen	33	14	47
No. of wells without screen	0	2	3

TABLE 6. *Analysis of Permeable Thickness from Table 4.*

Item	For UN-STW		For DTW	All together
Depth of calculation	50.0 m	*57.0 m	50.0 m	50.0 m
Cumulative depth	811.2 m	822.8 m	800.0 m	1661.2 m
Total permeable thickness	286.1 m	291.0 m	224.7 m	514.2 m
Average percent of permeable thickness	35.3%	35.4%	28.1%	31.0%

* Maximum depth drilled by UN project in Kailali is 56.4 m. So, figures in this column are considered.

3. HYDROLOGIC PROPERTIES OF WATER BEARING MATERIALS

The quantity of water available from an aquifer depends on the ability of the aquifer to store and to transmit water. The ability of an aquifer to store water is measured by its storage coefficient (S) and the ability to transmit water by its transmissivity (T). These hydraulic properties are in turn dependent upon the dimensional and geological parameters of the aquifer. Hydrologists have several ways to determine the hydraulic constants of aquifers and for NEP/86/025 the method is called a Pumping Test which is performed to learn aquifer properties of T, S and sometimes leakage(p).

Thirty-two pumping tests were targeted but only 21 were begun of which 19 were nominally successful (Figure 12). The pumping tests are of marginal quality and the numeric results they provide should be used with caution. The hydraulic properties of the project wells determined by aquifer tests on the shallow aquifer in Kailali District are listed in Table 7.

TABLE 7. *Hydraulic Properties of Pump Tested Project Wells.*

Well No.	Transmissivity (m^2/day)	Satu. Aquifer Thickness (m)	Hyd. Condvt. (m/day)	Aquifer Lithology	Storage Coefficient	Discharge (l/s)	Distance from Pumping Well (m)	Static Water Level (m)
UN01	3497	9	389	G	0.12E-01	16.6	50	-1.29
UN02	2483	9	276	GS	.15E-02	17	50	-2.70
UN03	2157	12	180	GS	.17E-02	16	115	-2.31
UN04	1308	13	101	GS	.38E-04	15.8	15.7	-2.82
UN05	439	7.3	40	SG	.54E-02	10.4	72.41	-5.22
UN06	251	8	31	GS	.21E-02	12.86	58.4	-5.32
UN08	737	10	74	GS	-	8.7	0.05	-3.00
UN10	289	7	41	S	.79E-03	8	18	-4.17
UN13	1502	10	137	SG	.82E-03	12	47	-4.62
UN14	264	7	33	G	-	14.2	0.05	-3.98
UN16	821	3.7	117	GS	.32E-05	14.42	2.3	-3.11
UN17	3722	7	532	G	.27E-02	16.3	91	-2.22
UN22	4027	10	403	G	.43E-01	15	47	-2.43
UN24	3575	9	397	GS	.66E-02	12	18.3	-4.71
UN25	156	3	52	SG	.81E-03	2.5	11	-3.32
UN28	4042	6.4	449	SG	.15E-07	4.7	9	-2.74
UN30	2757	3	919	S	.31E-02	14	98.7	-2.16
UN31	2558	10	213	S	.16E-02	7	18.1	-4.99
UN32	3581	5.5	398	S	.24E-02	12.6	31	-3.86

Note: G = Gravel, S = Sand, GS = Gravel with sand,
SG = Sand with gravel

The GWS was used to determine aquifer properties for 19 pump tested wells in Kailali District. UN wells 08 and 14 utilized the pumped well and the rest utilized a nearby observation well for drawdown measurements. Therefore, T was determined on 19 wells but S on only 17 wells.

No information is available about the construction of the observation wells, their depths or their lithologies. A comparison of the non-leaky theory of Theis and Jacob and the leaky-aquifer theory of Hantush was made with GWS. The Theis interpretation gave the best fit except for UN well 14, Dhangadhi Town, where the Jacob fit was better. The graphs of the pump tests are presented in Appendix C.

The pumping test results indicate a confined aquifer based on the storage coefficients. This is unlikely and not to be believed. The aquifer at depth may be confined but not in the project wells. Certainly, the aquifer will behave as unconfined if stressed by pumpage for irrigation.

The T map, Figure 14, was prepared from the 19 pump test results. The map was created using a computer contouring program, part of GWS, which interpolates and extrapolates random individual values. This process is based on only 19 points in the district, there are reservations about the quality and accuracy of the pumping test data, there is no information about the screen in the observation wells and the aquifer zones screened in the pumped wells are not the same. Therefore, the map which shows distribution of T should be utilized with caution.

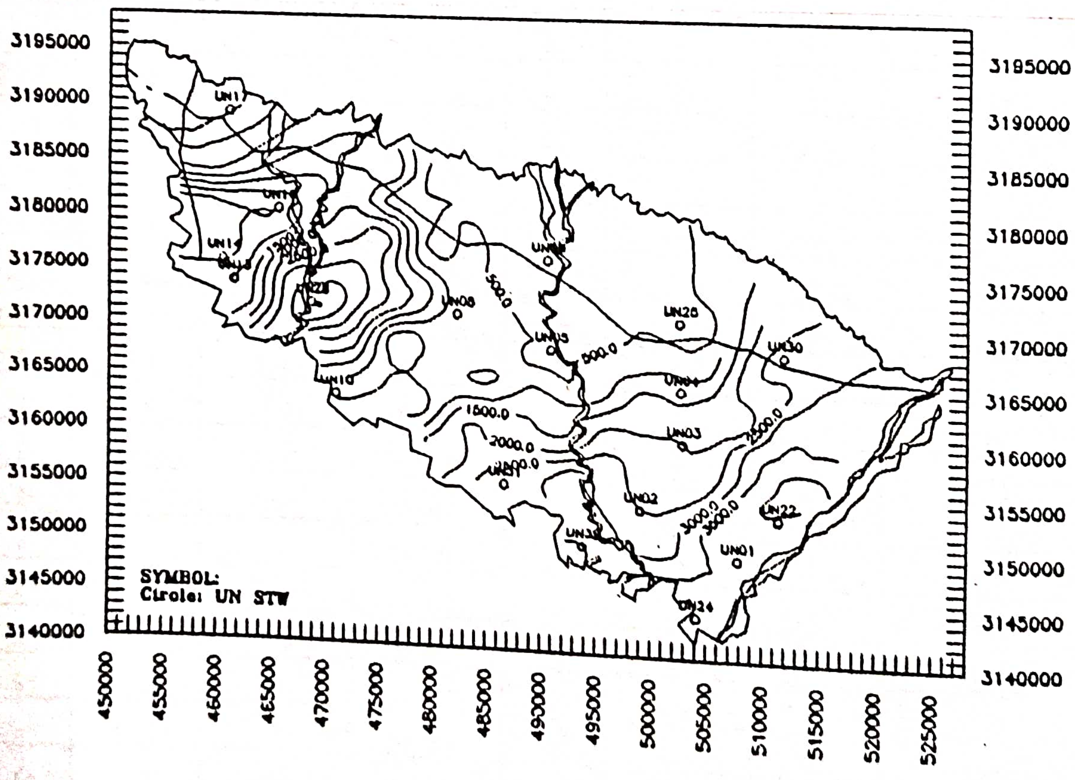


Figure 14: Transmissivity Map (m^2/day)

The highest T is found in UN well 28 at Kanari (4042 m2/day) located in the south west part of the district. The lowest T was found in UN well 25 at Numuwabojhi (156 m2/day) located in the north east part of the district. The higher T zones are in the west and the east parts of the district. Hydraulic conductivity of sand ranges from 4 to 125 m/day, sand and gravel from 8 to 200 m/day and gravel from 40 to 625 m/day. For the most part, the lithologies of the project wells, Table 7, ~~match the~~ are in the range of hydraulic conductivity values above.

The yield potential map for Kailali District presented in Figure 15 was prepared from the discharges of 20 project wells. The map shows four ranges of potential yield in the district plus the location, discharge and static water level in the 20 wells. Areas in the eastern and northwestern parts of Kailali have more than 15 l/s discharge and the largest potential yields. T values are highest in about the same areas.

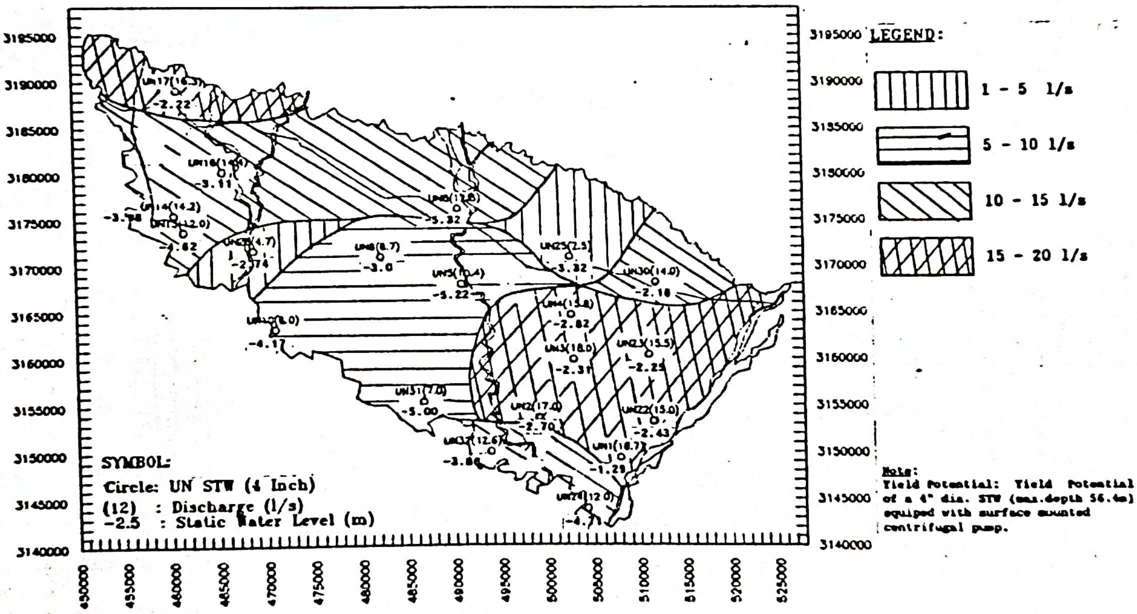


Figure 15: Map showing Zones of Yield Potential

4. GROUND WATER

The discussion on ground water will cover general ground water concepts utilizing the data aquired and interpreted in this ground water investigation in Kailali District as well as in the larger context of project NEP/86/025.

4.1 Source

The primary source of ground water in Kailali District is local precipitation. For example, ground water in the Bhabar Zone and the Terai Plain deposits is derived from precipitation that falls on Kailali and the watersheds of the streams that traverse Kailali, including the Siwalik areas of those watersheds. Ground water consists of precipitation that percolates through the materials on the earth's surface to the water table. Figure 16 illustrates the relationship between precipitation and water levels in selected wells.

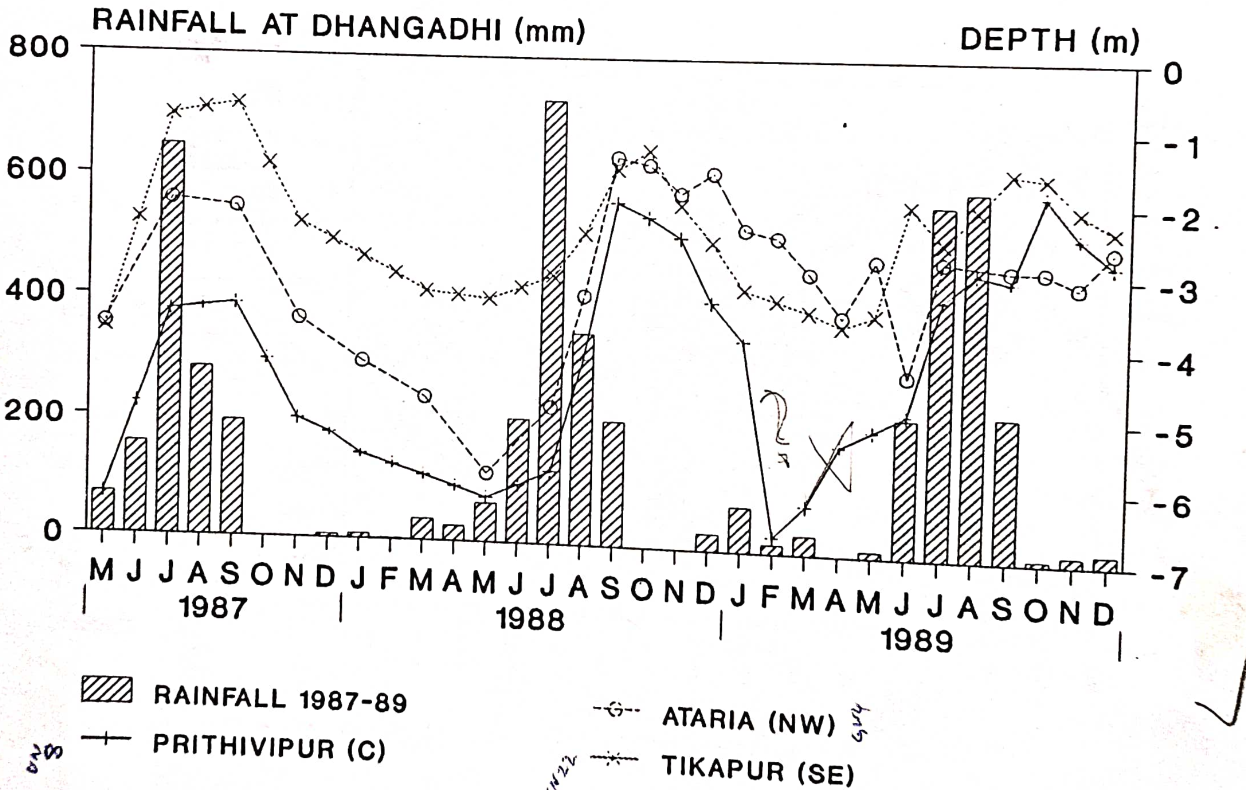


Figure 16: Relation between precipitation and depth to water table in selected wells, 1987-1989.

4.2 Occurrence and Movement

Water in unconsolidated aquifers occurs in the interstices between rock particles. The rate at which water will move through these aquifers depends on the hydraulic gradient and on the shape, size, and interconnection of the contained voids or interstices. The quantity of ground water available to wells depends on the areal extent and the saturated thickness of the aquifer. Interstices in sand and gravel are larger and better connected than interstices in silt and clay, Thus, water will move freely through a coarse gravel under a low hydraulic gradient, but will move with extreme slowness through clay under a high hydraulic gradient.

The shape and slope of the water table in May and August 1990 in Kailali District are shown on Figure 17 and 18, and reflect pre and post monsoon respectively, by contours drawn through points of equal altitude of the water table. Ground water moves down gradient at right angles to the contours. The contours indicate that ground water was moving generally from north to south. The spacing of the contours indicates a hydraulic gradient of about 2 meters per kilometer at the north to 1 meter per kilometer on the south.

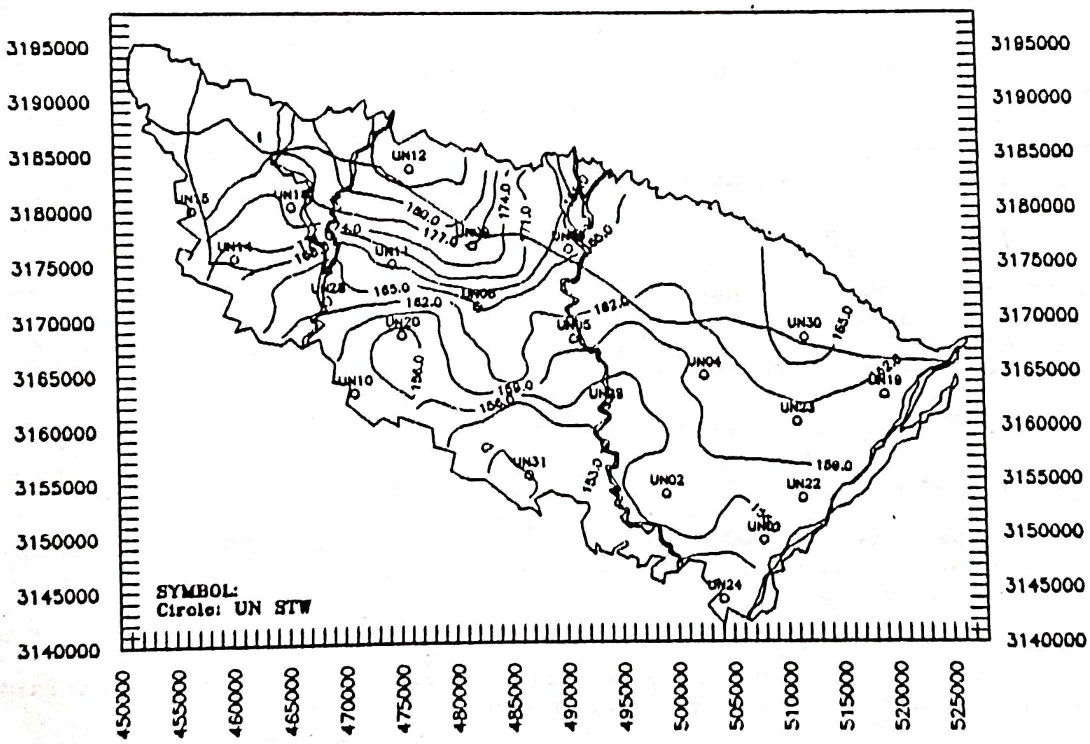


Figure 17: Water Level Contour in May 1990

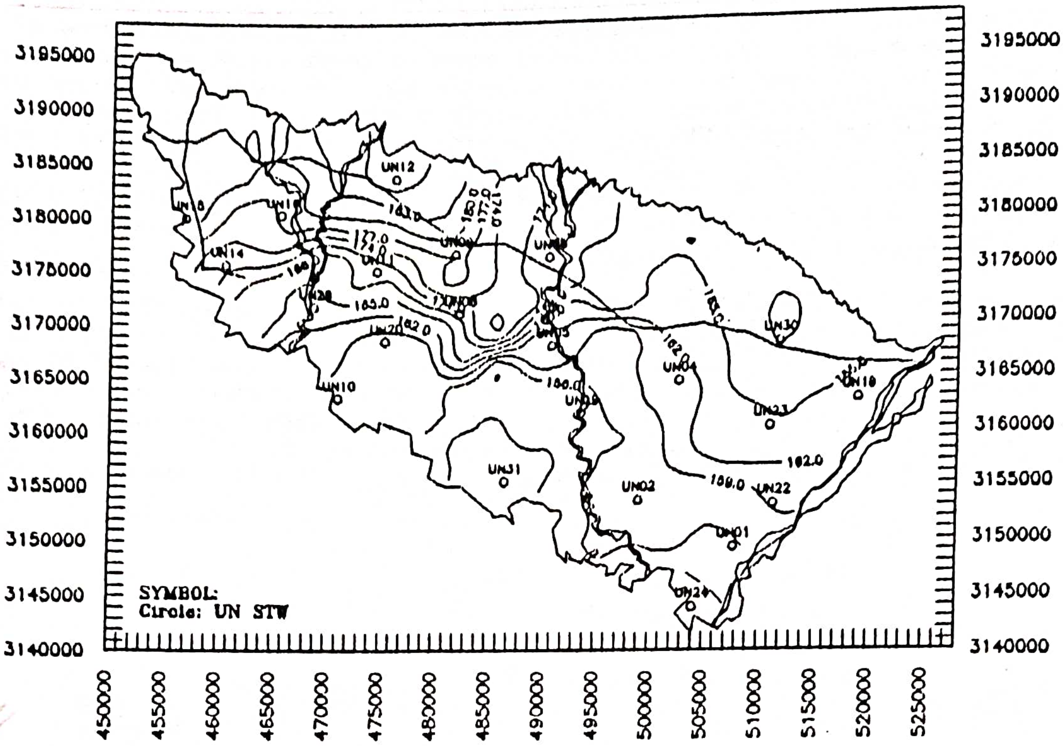


Figure 18: Water Level Contour in Aug 1990

The quantity of water flowing through a given cross-sectional area of an aquifer can be computed by the formula:

$$Q = pAv = KIA = TIL$$

where Q is the quantity of water,
p is the porosity of the aquifer material,
A is the cross-sectional area,
v is the average velocity of ground water,
K is the hydraulic conductivity, and
I is the hydraulic gradient.
T is the transmissivity
L is the length

The approximate rate of movement of ground water through an aquifer is obtained by transposition of the above formula to:

$$v = KI/p$$

An estimate of the quantity of water moving as subsurface outflow to India is calculated using the following assumptions:

Average aquifer saturated thickness is the average % of coarse grained material in the STW, or 35.3% of 50 meters, i.e. 17.7 meters.

Assumed effective porosity for sand and gravel is 15%,
Aquifer width (distance along border with India) 61 km,
Hydraulic gradient is 0.0009 (or 0.9 meter per kilometer,
Transmissivity near Indian border is 2000 m^2/day
Hydraulic conductivity (T/Aqui.thickness) 222 m/day

The volume of water flowing to India
= 109,800 m^3/day
= **40 MCM/year at a rate of 1.3 m/day.**

4.3 Storage

The volume of water in the ground water reservoir in Kailali District is quite large. The total thickness of the Terai sediments and the total thickness of aquifer within the sediments are not known. The volume of drainable water is a function of thickness and specific yield of the aquifer. Information from drilling project wells indicates an average of about 35% or 17.7 meters of aquifer are encountered in a 50 m well. An average specific yield for sediments from a similar depositional environment and similar lithologies, the High Plains aquifer of the United States (Gutentag et.al., 1984), is .15.

The drainable water in storage may be calculated by multiplying aquifer thickness, estimated specific yield and area of the aquifer (1970 km^2):

Storage = 17.7 m * 0.15 * 1970 km2 = 5,230 MCM

The value for volume of drainable water is not to be used as a figure for exploitation but rather to give an appreciation of the very large amount of water stored in the Terai aquifers. All the drainable water in storage cannot be recovered and used. The volume of water that can be removed is site specific and depends on well construction, lithology, saturated thickness, hydraulic conductivity, specific yield and drainage time.

4.4 Changes in Storage

One method of assessing changes in the amount of ground water in an aquifer involves periodic water-level measurements, construction of water-level-change maps from the measurements, and computation of the volume of material and water involved in the change. Unless heavy pumping disturbs natural conditions, the changes in storage in an aquifer reflect seasonal changes in precipitation and evapotranspiration. Water-level-change maps may illustrate, by minor fluctuations and trends, essentially static conditions in a relatively undisturbed aquifer. The range of static water level in pre and post monsoon from 1987 to 1990 for dug wells (DW) and from 1990 for Project STW is shown in Table 8.

TABLE 8. *Range of Static Water Levels in Monitoring Networks*

Region	Range of SWL in Pre-monsoon (May/Apr.) (in meter)		Range of SWL in Post-monsoon (Aug./Sept.) (in meter)	
	Dug well	Project STW	Dug well	Project STW
North-western	3 - 6	3 - 4	0.5 - 4	1 - 2.5
Central	3 - 7	3 - 5	1 - 5	0.5 - 3.5
South-eastern	3 - 6	3 - 4	0.5 - 5	0.5 - 2.5

The tables of water levels in dug wells and private STWs and project STWs are presented in D-1 and D-2 of Appendix D respectively. The fluctuations of the water table in the project wells and dug wells including private STWs in 1990 are presented in D-3 of Appendix D.

The locations of the 32 project STWs and the forty dug wells, including 9 private STWs of the current monitoring network are presented separately in Figures 19 and 20. The list of dug wells and the private STWs is shown in Table 9.

TABLE 9. *List of Monitoring Dug wells and Private STW in Monitoring Network*

S. No	Village Name	X	Y	S. No	Village Name	X	Y	S. No	Village Name	X	Y
1	AMAURA	514125	3164000	18	GOVINDAPURWA	475375	3167630	35	PATHRI	468250	3178000
2	*AMBASA	489375	3172250	19	GULARA	509500	3169250	36	PANCHMURIA	492750	3162750
3	AILANIGARHI	454000	3192500	20	HARAIYA	461875	3187380	37	PHULBARI	471750	3163250
4	ATARIA	456750	3185880	21	HASULIA	481625	3160750	38	*PRATAPPUR	508125	3164630
5	*BADHARA	456500	3175500	22	JOSHIPUR	502875	3159630	39	PRITHVIPUR	482750	3171500
6	BANBEHRA	468375	3186130	23	JHARAUKHA	489250	3176880	40	RAJIPUR	478250	3181000
7	BHADA	474625	3174630	24	JUGERA	464500	3169880	41	RAJPUR	457250	3181000
8	BHAGAURA	514875	3166880	25	KATACHHE	519500	3162750	42	RAMPUR	486750	3155130
9	*BHAJNI	497750	3153380	26	KHAKRAULA	505500	3145500	43	SANDEPANI	498375	3171880
10	BELADEVIPUR	462625	3180750	27	KHURKHURIA	477125	3176630	44	SIMRI	502500	3165380
11	CHARRA	493750	3150880	28	LALBHOJHI	497000	3149880	45	SHIVAPUR	484375	3174130
12	CHAUMALA	472500	3182380	29	LEKMA	483750	3178630	46	SHREEPUR	460875	3183750
13	CHUKA BINAULI	480125	3166630	30	*MAINA POKHARI	500000	3177500	47	TEGHARI	457000	3187500
14	*DHANGARHI	461125	3175750	31	MALAKHETI	453750	3189750	48	*TIKAPUR	513875	3152880
15	*DODODHARA	507750	3168000	32	MUNUWA	507625	3158000	49	URMA	469375	3173130
16	DURGAULI	511250	3159630	33	*NARAYANPUR	505500	3151000				
17	GANJAWA	493750	3157000	34	NIMDI	496125	3168130				

* = Private STW   X and Y = Landsat Co-ordinates

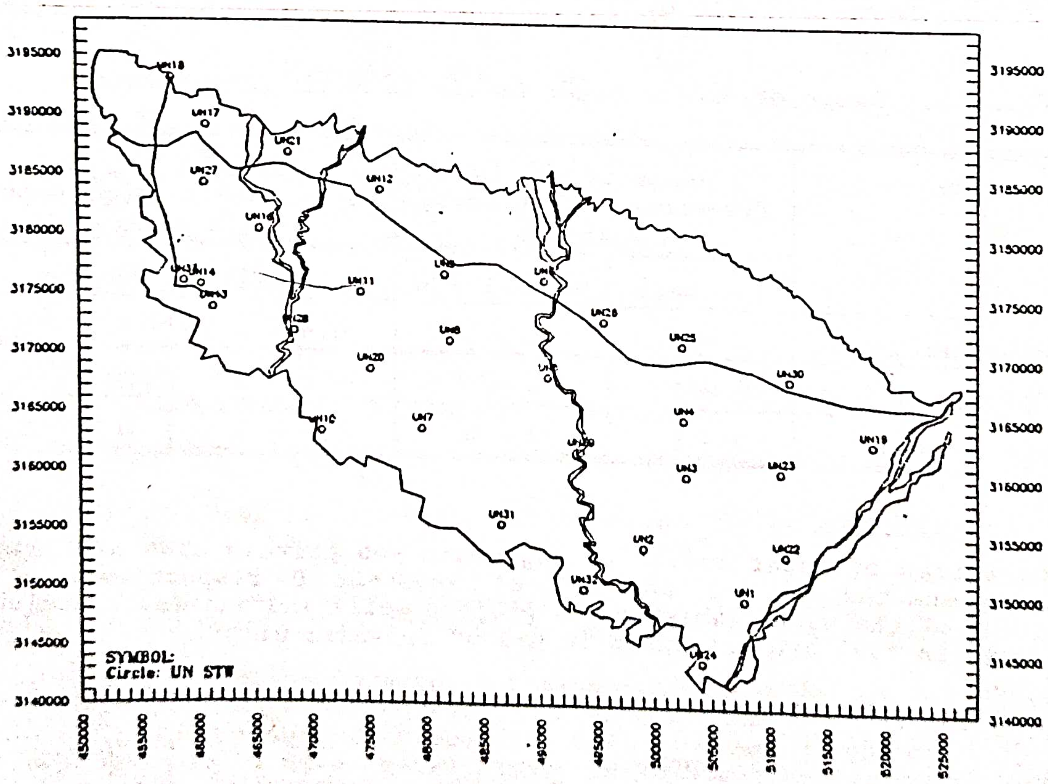


Figure 19 : Monitoring network of project STWs

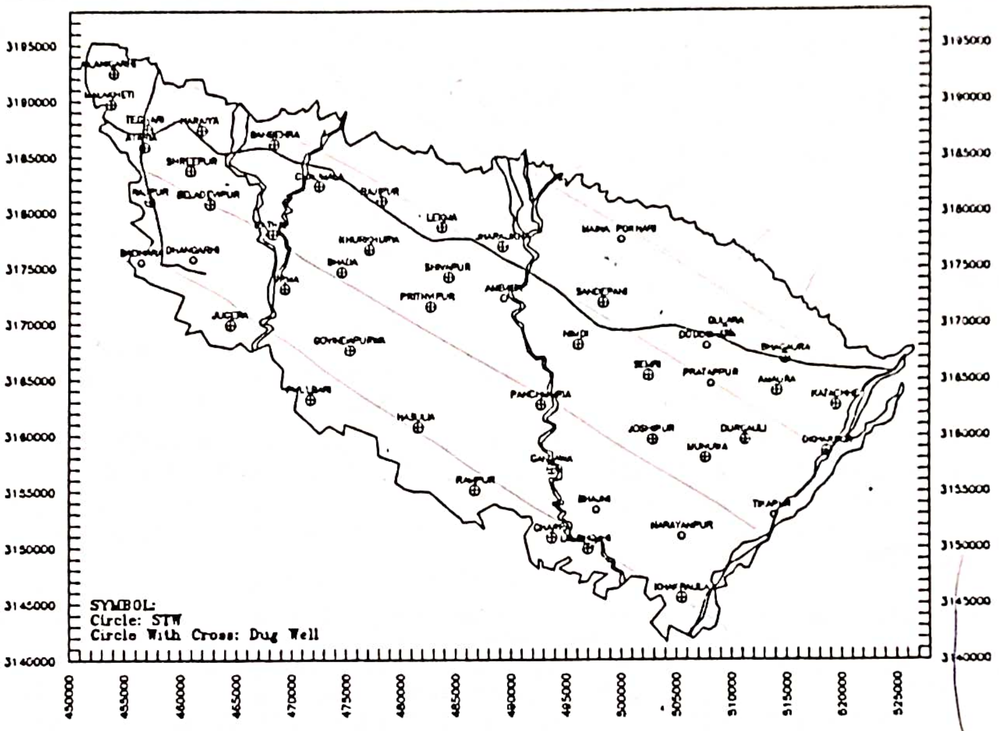


Figure 20 : Monitoring network of dug wells and private STWs

The location map and hydrographs of 27 wells (19 dug wells, 2 private STWs and 6 project STWs) are presented in Appendix E. The 17 dug wells, a private STW and 6 project STWs have a similar responses to the monsoon. The remaining 2 dug wells and a private STW at Katache, Gulara and Maina Pokhari (all three in the North-eastern part of the district) show illogical behavior. Most of the monitored wells showed the maximum depth to water table in the month of May. The quick response of the water level to rainfall is logical and expected.

4.5 Discharge

Ground water in the Terai of Kailali District is discharged from the aquifer by wells, evapotranspiration, subsurface outflow, and inflow to streams. The subsurface outflow from the district was determined in the section 4.2 occurrence and movement.

4.5.1 Pumping By Wells

Pumpage records for irrigation wells are not available and there is no project for acquisition of pumpage. However, a conservative over estimate of pumpage based on number of irrigation wells, average discharge, and hours pumped is calculated. The number of STW in 1986 was 922 and an increased number is estimated at 1000. In addition there are 100 DTW (GDC, 87). Yields of STW and DTW are estimated at 20 l/s and the number of hours pumped per well per year are estimated at 2160 (6 hrs/day). A conservative figure for pumpage in Kailali is about 171 MCM/year.

4.5.2 Evapotranspiration

Direct evaporation occurs in areas where the water table is near the land surface, such as along stream banks and in stream beds. The potential for evaporation is high during the rice growing season as the paddies are really large bodies of surface water during that time. Finally, during and after the monsoon the water levels are at or near the surface at many places in Kailali. Although no quantitative estimate is made for evaporation in Kailali, it is assumed to be high because of the above circumstances.

Transpiration by plants from the saturated zone is not confined to the water courses where large vegetation may be found. Rather, transpiration is occurring in the forests, and from growing crops as well. No quantitative estimate is made for transpiration in Kailali, but it is assumed to be high because of the opportunities described above.

4.5.3 Inflow To Streams

Stream flow records were not considered and no low flow measurements were made to permit an estimate of the inflow to streams in the district.

4.6 Recharge

The aquifer in Kailali is recharged by subsurface inflow from stream valleys entering the district, by subsurface inflow from the Siwalik Hills, by seepage losses from streams during high flow and perennial flow, and by precipitation percolating directly through the soil and rock materials on the surface to the water table. These four increments of recharge result from local precipitation.

Several previous workers have estimated recharge by different methods with different answers forthcoming. This report will calculate three values based on percolation from rainfall.

4.6.1 Subsurface Inflow

No data were obtained to provide a basis for a quantitative determination of subsurface inflow to the aquifer.

4.6.2 Seepage Losses From Streams

The stream systems in Kailali carry large amounts of surface water in, across and out of the district. Seepage into the aquifer is substantial during high flow. However, no quantitative determination of seepage into the aquifer was attempted.

4.6.3 Percolation From Rainfall

Percolation of precipitation into the aquifer is the primary recharge mechanism in Kailali. The Bhabar is particularly receptive to direct percolation to the water table because of the large size of the particles comprising the deposits. However, the balance of the Terai Plain is also receptive to direct percolation of precipitation to the aquifer. Finally, the Siwalik exposures contribute additional recharge through percolation to the aquifer but no estimates were made.

Three estimates of recharge from precipitation are calculated and they are each above 300 MCM. The first method utilizes data from Duba (1982); the second method assumes 10% (conservatively) of rainfall becomes recharge; the third method assumes a specific yield or effective porosity. Each method uses an area of 1970 km^2 for the Kailali Terai.

Method 1:
Duba (1982) estimated 32.9% of the rain that falls on the Bhabar Zone and 24.3% that falls on the Terai Plain would percolate to the aquifer. No estimate of recharge for the Siwaliks was made. The calculation for recharge using Duba estimates:

Recharge in m^3/year = Annual rainfall in m * area of recharge (Bhabar or Terai Plain) in Km^2 * % of rainfall to aquifer

For Bhabar, recharge = 1.619 m * (475 * 1000 * 1000)m^2 [i.e. 475 Km2] * 0.329
= 253,009,225 m^3/year
= 253 MCM/year (million cubic meters)

For Terai Plain = 1.619 m * (1495 * 1000 * 1000)m^2 [i.e. 1495 Km^2] * 0.243
= 588,158,410 m^3/year
= 588 MCM/year (million cubic meters)

Total Recharge = Recharge in Bhabar + Recharge in Terai Plain
= 841 MCM/year

Method 2:
Application of a 10% (conservatively) percolation for rainfall over the Kailali Terai (Bhabar + Terai Plain) provides the calculation:

Recharge = 1.619 m * (1970 * 1000 * 1000)m^2 * 0.10 = 319 MCM/year

Method 3:
Assume the storage coefficient or specific yield is 0.15 (i.e. assuming 15% for sand and gravel), the percentage of aquifer material is 35.4% from project wells and monsoon water level fluctuation is 3 m over an area of aquifer of 1970 Km. The calculation is:

Recharge = 0.15 * 0.354 * 3 m * 1970 Km2 = 314 MCM/year

These estimates do not take into account rejected recharge due to soil saturation nor the increase of recharge possible if water levels were lowered by pumpage for irrigation below the depth of evapotranspiration loss.

The difference between a potential recharge of more than 300 MCM per year and subsurface outflow into India of about 40 MCM per year is very large. The excess potential recharge is considered to be discharged through evapotranspiration (dominant component), inflow to streams (minor component) and also withdrawals from the aquifer by wells (minor component).

The land surface of Kailali does not have equal permeability. A difference between the north and the south parts is indicated by the project well logs. Thick clays are more prevalent just below the surface in the south and percolation will be much slower there. There will also be lateral flow from north to south as the high permeability Bhabar is in the north.

4.7 Summary of Ground Water System

Recharge (addition of water to the aquifers), storage (retention of water in the aquifers), and discharge (diversion of water from the aquifers) are directly related to each other, in a ground water system. When recharge exceeds discharge, (during the monsoon period) the quantity of water in storage increases and the water table rises. Conversely, when discharge exceeds recharge, (during the dry period) the quantity of water stored decreases and the water table declines. The monsoon raises the water table as the aquifer is recharged by percolation of rain, seepage from streams and by subsurface inflow from the Siwaliks. The dry season lowers the water table as the water is pumped, evapotranspired, and moves in the subsurface toward the south.

The water level change maps reflect the recharge, change in storage and discharge of the Kailali ground water system. The changes in water level appear to be due to seasonal variations. As agricultural practices replace the forests, no discernible effect has been made on seasonal water levels. Therefore, the ground water system in Kailai is maintaining a quasi-equilibrium state.

The storage estimate, recharge estimates, pumpage estimate and outflow to India estimate seem reasonable. Table 10 brings these figures together. The estimate of water in storage is large and only a part would provide water to wells. However, about 523 MCM of ground water could be used if only 10% of the estimated water in storage is available.

TABLE 10. *Estimates of Ground Water Storage, Recharge, Pumpage and Outflow to India in Kailali District.*

Item	Storage	Recharge per year	Discharge per year
Volume of water (Static reserve)	5230 MCM		
Recharge by 3 methods:			
1) Duba's estimate		841 MCM	
2) Conservative estimate (with 10% of rainfall)		319 MCM	
3) Calculation considering effective porosity, % of aq. material & fluctuation of W.T.		314 MCM	
Pumpage			171 MCM
Outflow to India			40 MCM

Information on recharge, storage and discharge of the ground water system in Kailali District is not complete. Several of the data components have not been measured or observed. However, estimates have been made for some major components with the thought that the estimates may be refined as data are collected in the future. Other components are not known nor estimated as their influence will become measurable during development of the ground water system. Table 11 lists the status of data components required to describe the Kailali ground water system.

TABLE 11. *Status of components required to describe Kailali Ground Water System.*

COMPONENT	AVAILABLE	M(measured) E(estimated)	RELIABILITY	AREAL DISTRIBUTION
Siwalik information	No			
Bhabar Zone delineation	No			
Terai Plain delineation	No			
Detailed well inventory	No			
Lithology of wells	Yes	M	Adequate	Adequate
Aquifer tests	Yes	M	Poor	Poor
Storage coefficient	Yes	E		
Transmissivity	Yes	M	Poor	Poor
Leakage	No			
Water level measurements	Yes	M	Adequate	Adequate
Weather records	Yes	M	Adequate	Adequate
Pumpage records	Yes	E		
Stream flow records	No			
Evaporation data	No			
Transpiration data	No			

5. SHALLOW GROUND WATER AVAILABILITY

Areal delineation of feasibility of SIW in an area is a major goal of the project. The criterion defining a SIW are listed below:

1) a water level that does not exceed 7 m in depth in the dry season while pumping
2) a discharge adequate to irrigate an individual farm, as required
3) no deeper than 50 m
4) 100 mm or 4 inches (in) in diameter
5) use a centrifugal pump
6) powered by a diesel or electric motor
7) drilled by indigenous methods, if possible

The definition includes depth, diameter, energy source, type of pump and method of drilling a well all predicated to be within the range of resources a farmer may command.

Figure 21 delineates the area in Kailali District where contours of depth to water table have not exceeded 5 m during the dry season (pre-monsoon) since the project began. The May water levels are used as they reflect the pre-monsoon conditions. The depth to water criterion is the most important hydrologic constraint in the above definition of a SIW. Wells in the Terai will almost always find water but the wells may not yield water to a centrifugal pump during the dry season if the depth to water exceeds 7 m. Thus, the dynamic water level of a well during the dry season should be within the suction limit of lift of a centrifugal pump i.e. water level must be less than 7 m below ground level or more accurately below the pump level. If the 5 m depth to water contour represents the depth to water in most dry seasons there should be 2 m of drawdown to be exceeded before a well would cease to produce irrigation water in the designated areas.

Wells drilled to 50 m should find about 17.7 m of aquifer material, on average in Kailali. This also means that some wells may find practically no aquifer and some wells may find practically all aquifer. In other words, holes will be drilled which will be unsuccessful wells because there is insufficient aquifer at that location.

The practice of drilling test holes to assist in choosing a productive location to place an irrigation well is common and frequently required in many ground water areas in many countries. The depositional environment of the aquifers in the Terai is such that very different lithologies may be encountered in two test holes within relatively few meters of each other.

Discharge of the tube well should be adequate for irrigation, which is considered to be a yield of 3 to 5 l/s or more. The average individual farms in Kailali is 1.7 ha in area in 1981 (SPBN). A well that pumps 5 l/s could cover 1.7 ha with about 5 centimeters (cm) of water in 48 hours. Thus the average farm could be irrigated with such a well. However, it is questionable if average size farms in Kailali are economically viable, even with the technology limited by the SIW definition. The limiting factor, economically, is the average size of a farm.

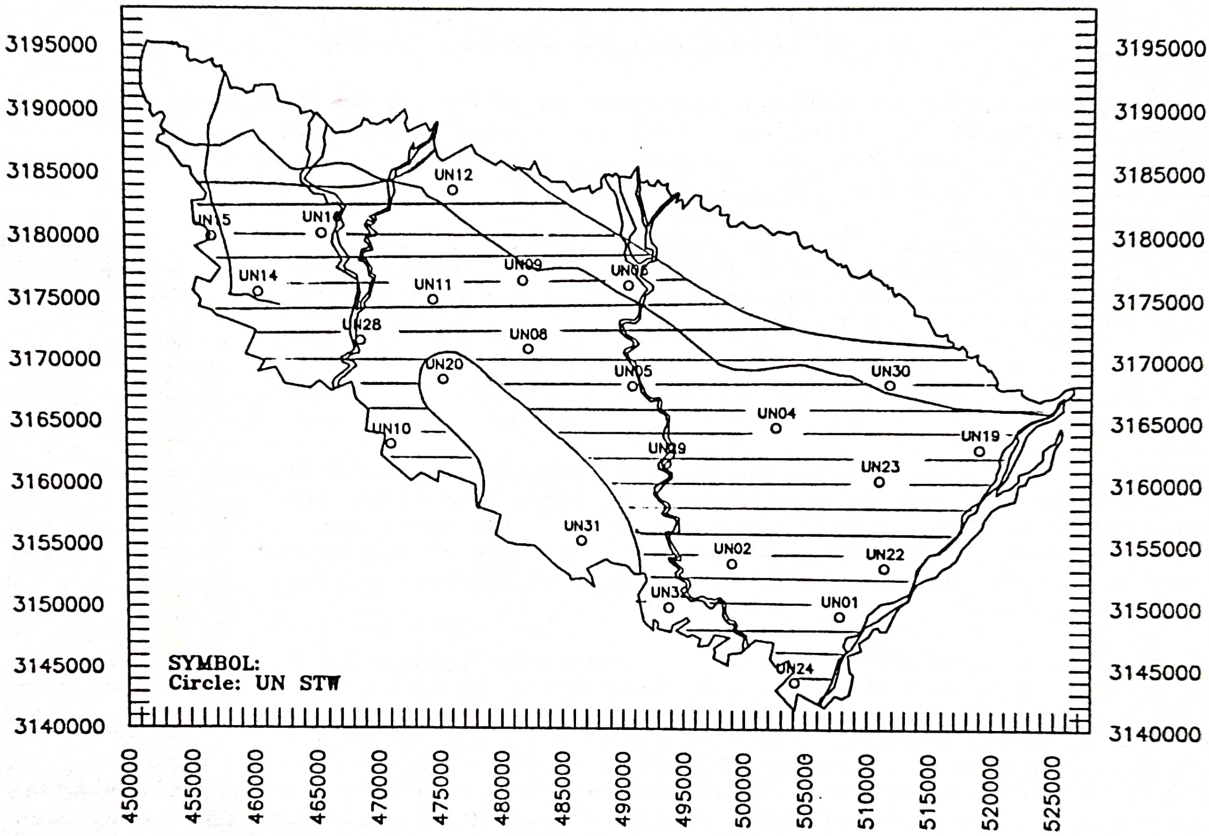


Figure 21: Shaded pattern area shows probable SIW area in Kailali District

6. UTILIZATION OF GROUND WATER

Ground water in Kailali District is utilized by families, villages, towns and schools for drinking water; for watering animals; for business and industrial purposes; but the largest use and the use that seems destined to have a large increase in the future is for irrigation of crops. According to the statistics from Table 2, only 15% of the potential irrigation land in Kailali is irrigated the whole year, leaving 85% or about 55,000 hectares that could be irrigated the whole year. The food requirements of the expanding population of Nepal will require more and more year around irrigation in the Terai and therefore in Kailali.

7. SUMMARY AND RECOMMENDATIONS

7.1 Summary

The study of the shallow ground water resource of Kailali District is part of a study of ground water throughout the Terai. The project, NEP/86/025 is a cooperative effort by the United Nations Department of Technical Co-operation for Development and the Ground Water Resources Development Board, HMG, Nepal.

Field work for this report began in the Spring of 1987 and for the most part was completed in 1989. The work consisted of drilling wells, making water level measurements, lithologic determinations, altitude surveys of land surface at wells, and aquifer tests.

There were 33 manually drilled wells begun and 32 were completed. The average depth of the wells was about 26 meters and the desired depth was 50 meters. Slightly more than 35% of the sediments encountered were sand and gravel and are considered an aquifer. The far-western and the eastern parts of the district provide thicker permeable deposits according to the project wells.

Nineteen of 21 pumping tests were completed and the remaining 11 wells were not tested. The range of transmissivities is from 251 to 4042 m^2/day.

The water level monitoring network progressed from dug wells in 1987 to project STW with some private STW in 1991. As expected, the wells have the deepest water levels just prior to the monsoon and the shallowest water levels just after the monsoon. Water level contour maps indicate the ground water flows from north to south with a gradient of about 2 meters per kilometer in the north and about 1 meter per kilometer at the Indian border.

The aquifer in Kailali is recharged primarily by precipitation percolating directly through the soil and rock materials on the surface to the water table. The Bhabar Zone is particularly receptive to direct percolation to the water table because of the large size of the particles comprising the deposits. However, the Terai Plain is also receptive to direct percolation of precipitation to the aquifer. As much as 800 MCM per year may potentially be available for recharge although a more conservative estimate of about 320 MCM is also calculated. Even the latter estimate compares favorably with the 40 MCM of water flowing to India per year.

The water level change maps reflect the recharge, change in storage and discharge taking place in the Kailali ground water system. The change maps indicate the system is maintaining equilibrium as agricultural practices replace the forests. Put another way, stress on the aquifer, for the short period of record of this project, shows no discernible effect on the water level maps.

7.2 Recommendations

Ground water in Kailali District is utilized by families, villages, towns and schools for drinking water; for watering animals; for business and industrial purposes; but the largest use and the use that seems destined to have a large increase in the future is for irrigation of crops. This report provides valuable data for planning and continuing development of the ground water resource but large scale development in a specific area should include additional investigative wells and properly designed and completed aquifer tests to help maximize success.

8. GLOSSARY OF TERMS

Aquifer: A rock formation, bed, or zone that contains water that is available to wells. An aquifer is sometimes referred to as a water-bearing rock, or water-bearing bed.

Evapotranspiration: The combined total water evaporated by heat energy and transpired by plants into the atmosphere.

Gaining stream: A stream or reach of a stream whose flow is being increased by inflow of ground water. Replaces the term "effluent stream."

Ground water: Water in the saturated zone or water below the water table.

Hydraulic conductivity: A measure of the rate of flow of water through an aquifer, which is dependent primarily on the nature of the interstices within the aquifer. Expressed in units of length per units of time that are consistent and suitable to the problem involved.

Hydraulic gradient: Gradient of the water table measured in the direction of the greatest slope, generally expressed in meters per kilometer.

Inflow: Movement of ground water into an area in response to a hydraulic gradient.

Interstice: An opening or void in a rock. Interstices may be filled with air, gas, oil, water, or some other material, The interstices in an aquifer are filled with water.

Outflow: Movement of ground water from an area in response to a hydraulic gradient.

Percolation: The movement of water through soil and rock to the saturated zone.

Permeability: The capacity of water-bearing rock or soil to transmit water, which is related to the size and interconnection of interstices. Replaced by the term "hydraulic conductivity."

Porosity: The porosity of a rock is its property of containing openings or interstices. Quantitatively, the porosity of a rock is the ratio (usually expressed as a percentage) of the volume of openings in the rock to the total volume of the rock.

Recharge: The process by which water is absorbed and added to the saturated zone. Also used to designate the quantity of water added to the ground-water reservoir.

Runoff: The discharge of water through surface streams. It includes both surface-water runoff and ground-water runoff. Also used to designate the quantity of water discharged as runoff.

Saturated zone: The zone of porous rocks saturated with water. Ground water is contained in this zone.

Specific yield: also called effective porosity (Johnson, 1967), is defined as the ratio of (1) the volume of water that the saturated sediment will yield by gravity drainage to (2) the total volume of saturated rock. Specific yield is expressed as a dimensionless fraction or percentage. Specific yield depends on particle size, shape, sorting, and cementation of the aquifer material and drainage time.

Specific retention: It is the difference between porosity and specific yield and is defined as the ratio of (1) the volume of water retained in the rock after gravity drainage to (2) the total volume of the saturated rock.

Storage: Water stored in openings in the saturated zone is said to be in storage. Discharge of water from an aquifer not replaced by recharge is said to be from storage.

Storage coefficient: The volume of water released from or taken into storage per unit surface area of an aquifer per unit change in the component of head normal to that surface.

Transmissibility: The transmissibility of a rock or soil is its capacity to transmit water under pressure. Replaced by the term "transmissivity."

Transmissivity: The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Expressed in units of length squared per units of time. Replaces the term "coefficient of transmissibility." To convert a value for coefficient of transissibility to an equivalent value of transmissivity, multiply by 0.134.

Water table: The upper surface of the saturated zone where the pressure is atmospheric. The water table is not a plane surface, but has irregularities much like the land surface.

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APPENDIX A

NEP/86/025 PROJECT DOCUMENT DETAILS

The project NEP/86/025 - Shallow Ground Water Investigations in the Terai - is executed by the United Nations Department of Technical Co-operation for Development. It is designed as a four year project primarily oriented to collect field data to establish a ground water data base and to assess the development potential of shallow aquifers all over the Terai. The government counterpart agency is the Ground Water Resources Development Board (GWRDB) under the Department of Irrigation (DOI), Ministry of Water Resources, HMG, Nepal. The project began in June 1987.

The immediate objectives of project NEP/86/025 are:

(1) To generate technical information on the occurrence and potential of shallow ground water resources in the Terai.

(2) To obtain the information regarding drilling and construction of shallow tube wells.

(3) To enhance the technical capacity of GWRDB with regard to exploration, assessment and development of ground water resources.

The following project outputs are anticipated:

(a) Computerized data base with about 2000 shallow water points from all over the Terai. This was expanded in December 1988 to include deep wells. Information on well location, lithology, hydrogeological parameters, water use, water levels, and etc.

(b) Maps of pre-monsoon (maximum) and post-monsoon (minimum) water levels expressed both in relative depths and in absolute elevations above mean sea level.

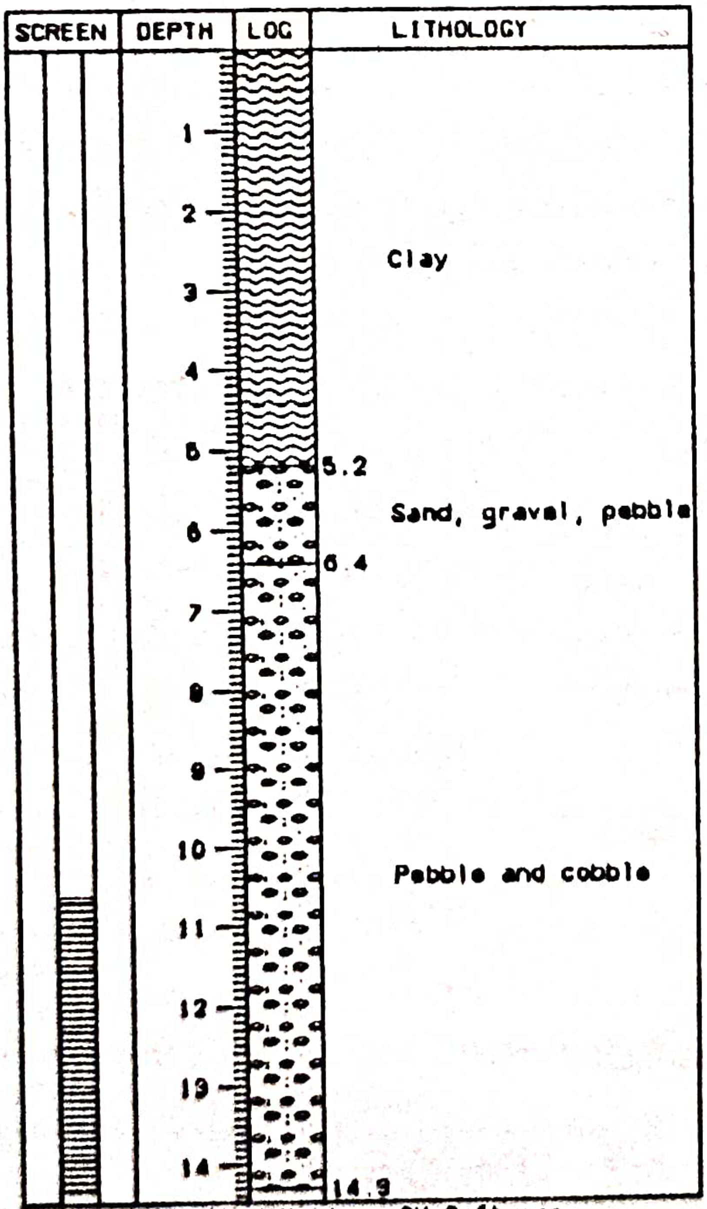
(c) Hydrographs (water level graphs) from selected observation points in a minimum period of eleven months.

(d) Reports on mathematical modelling.

(e) Report on drilling methods and results in shallow water well drilling in the Terai.

Well No. UN 1	Location: BISHNUKANTIPUR
Elevation: 158	X = 507800 Y = 3149300
Method of Drilling: MANUAL	
Drilling Dates : 1.8.89 - 6.8.89	
Total Depth : 14.30	
Comments : Well size: 10 cm Screen position: 10.6 - 14.3 m Screen type: Perforated	

W E L L   L O G



United Nations GW Software

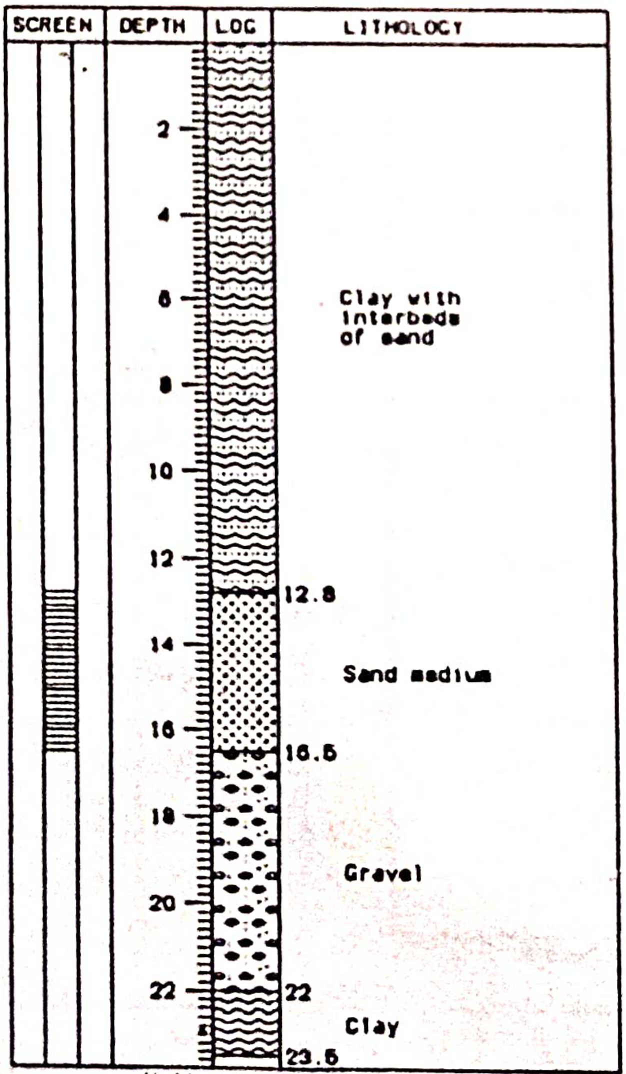
PUMPING TEST

Date: 2.7.89
Capacity: 16.7 l/s
Duration: 70 min
Transmiss.: 3497 m2/day
Method : THEIS
Stor.Coeff.: 0.14E-03
SWL: -1.29 m
DWL: -1.36 m

B-1: Well log of UN 01

Well No. UN 2	Location: DHUSI
Elevation: 160	x = 499000 Y = 3153600
Method of Drilling: MANUAL	
Drilling Dates: 2 8 89 - 11 8 89	
Total Depth: 23 50	
Comments: Well size 10 cm Screen position 12 8 - 16.5 m Screen type Perforated	

WELL LOG



United Nations GW Software

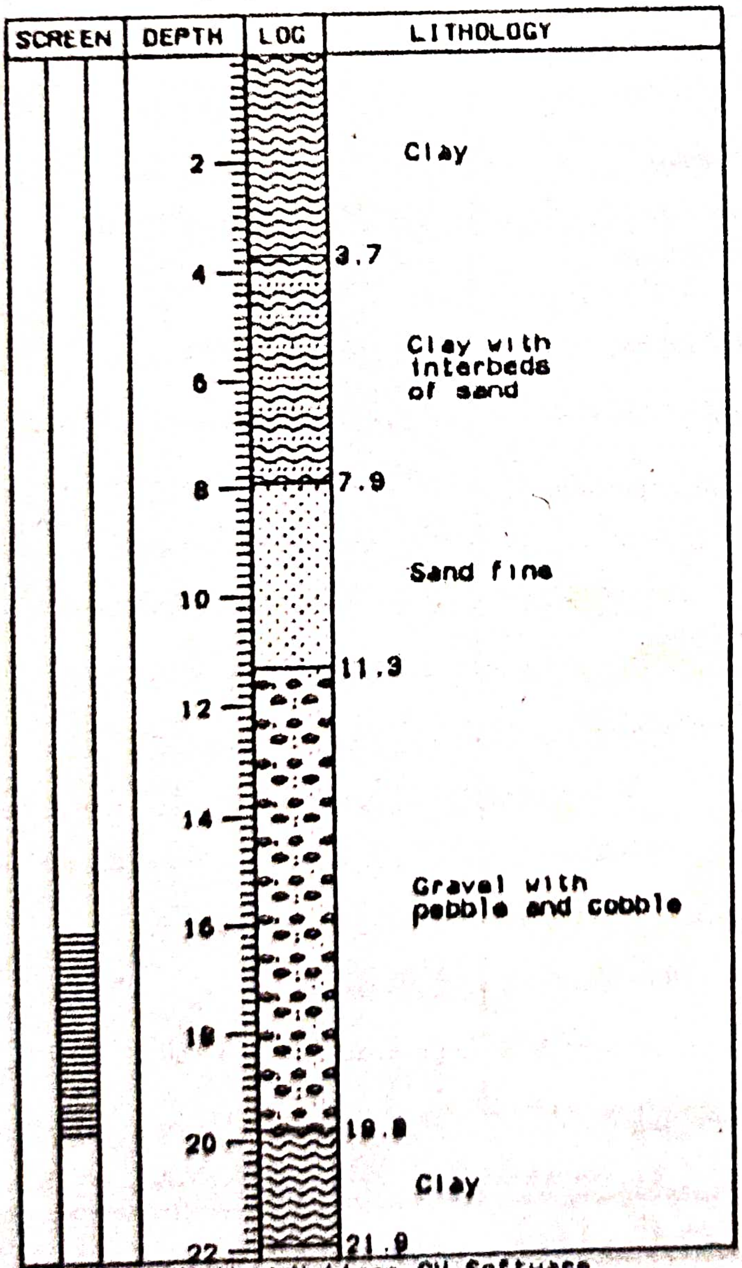
PUMPING TEST

Date: 2.5.90
Capacity: 17 l/s
Duration: 70 min.
Transmiss.: 2483 m2/day
Method : THEIS
Stor.Coeff.: 0.15E-02
SWL: -2.70 m
DWL: -2.88 m

B-2: Well log of UN 02

Well No. UN 3	Location: JOSHIPUR
Elevation: 155	X = 502800 Y = 3159800
Method of Drilling: MANUAL	
Drilling Dates : 1 8 89 - 8 9 89	
Total Depth : 21 90	
Comments : Well size: 10 cm Screen position. 16.1 - 19.8 m Screen type: Perforated	

W E L L   L O G



United Nations GW Software

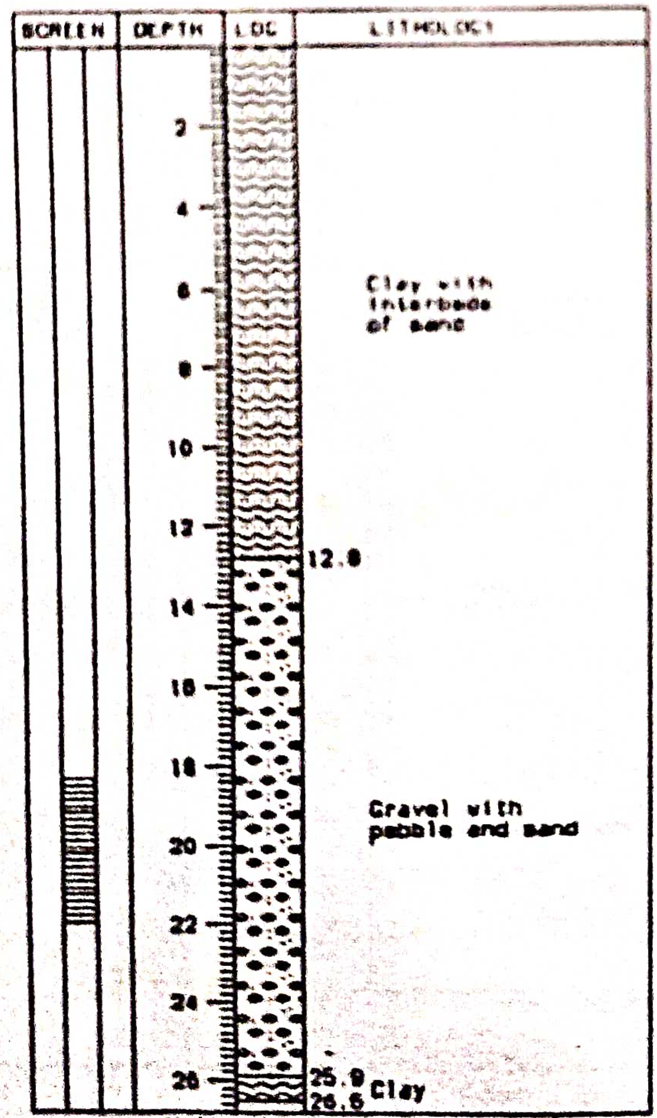
PUMPING TEST

Date: 4.7.89
Capacity: 16 l/s
Duration: 120 min
Transmiss.: 2157 m2/day
Method : THEIS
Stor.Coeff.: 0.17E-02
SWL: -2.31 m
DWL: -2.46 m

B-3: Well log of UN 03

Well No. UN 4	Location: SIMRI
Elevation: 162	x = 502600 y = 3164600
Method of Drilling: MANUAL	
Drilling Dates	
Total Depth: 26.50	
Comments: Well size 10 cm Screen position: 183 - 21.9 m Screen type: Perforated	

WELL LOG



United Nations GV Software

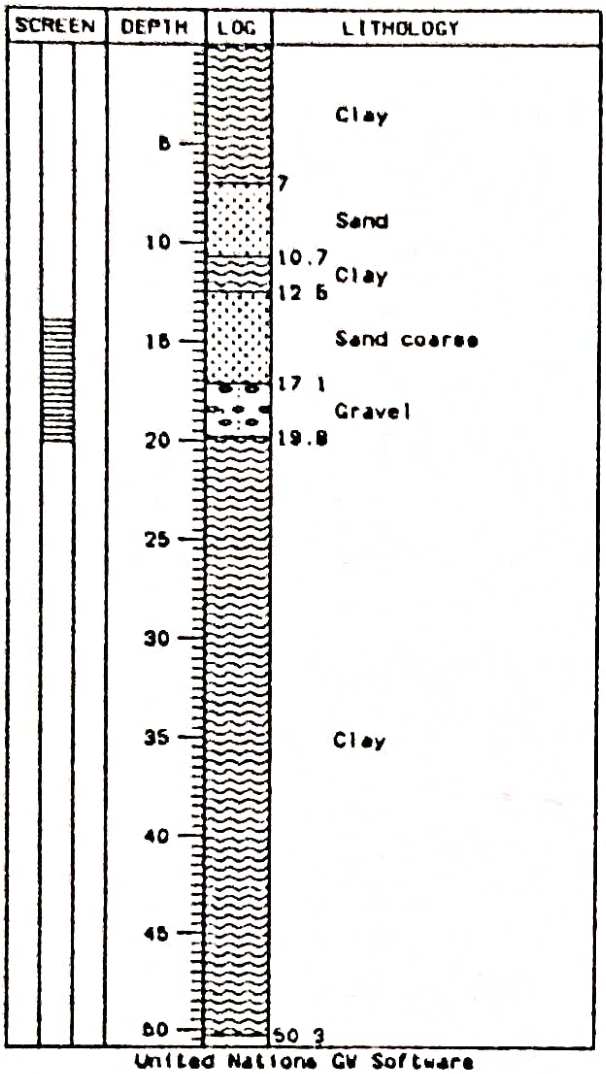
PUMPING TEST

Date: 8.6.89
Capacity: 15.8 l/s
Duration: 220 min.
Transmiss : 1308 m2/day
Method : THEIS
Stor.Coeff.: 0.38E-04
SWL: -2.82 m
DWL: -3.71 m

B-4: Well log of UN 04

Well No UN 5	Location: KOTA
Elevation: 163	x = 490800 y = 3168000
Method of Drilling MANUAL	
Drilling Dates 24 3 89 - 4 5 89	
Total Depth 50 30	
Comments : Well size 10 cm Screen position 14.0 - 20.1 m Screen type Slotted	

W E L L   L O G



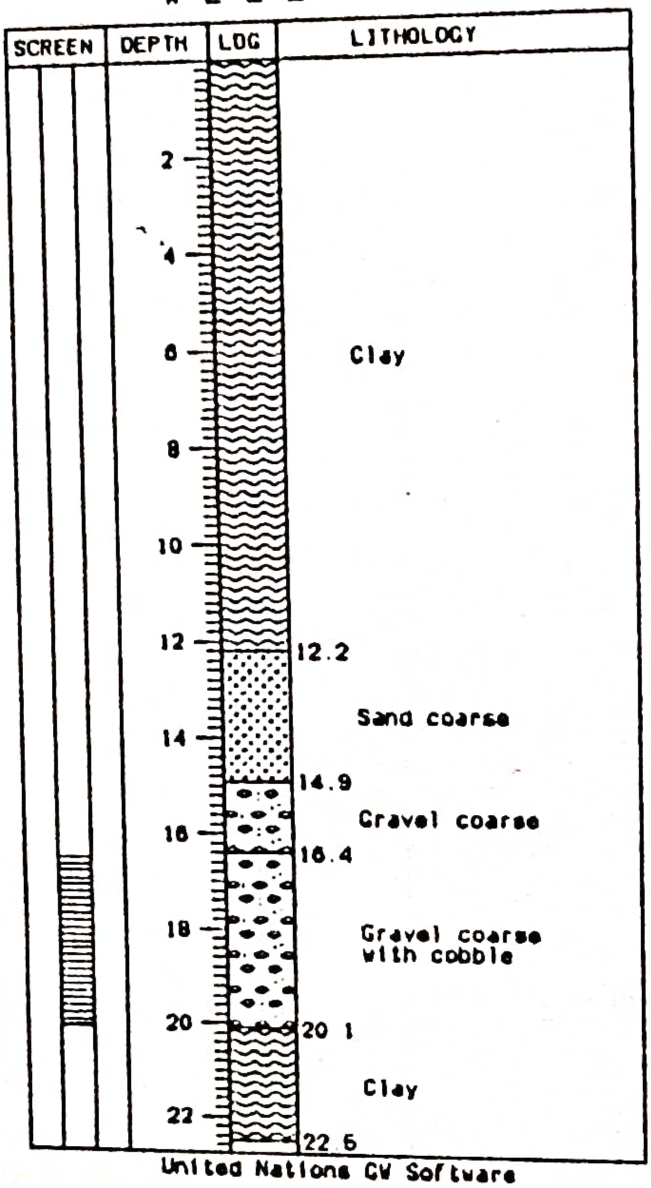
PUMPING TEST

Date. 27.6.89
Capacity. 10.4 l/s
Duration: 160 min
Transmiss · 439 m2/day
Method : THEIS
Stor.Coeff.. 0.54E-02
SWL: -5.22 m
DWL: -6 45 m

B-5: Well log of UN 05

Well No UN 6	Location: THABAI
Elevation: 170	X = 490500 Y = 3176200
Method of Drilling: MANUAL	
Drilling Dates	18 5 89 - 29.5.89
Total Depth :	22.50
Comments :	Well size: 10 cm Screen position. 16 5 - 20.1 m Screen type: Perforated

WELL LOG



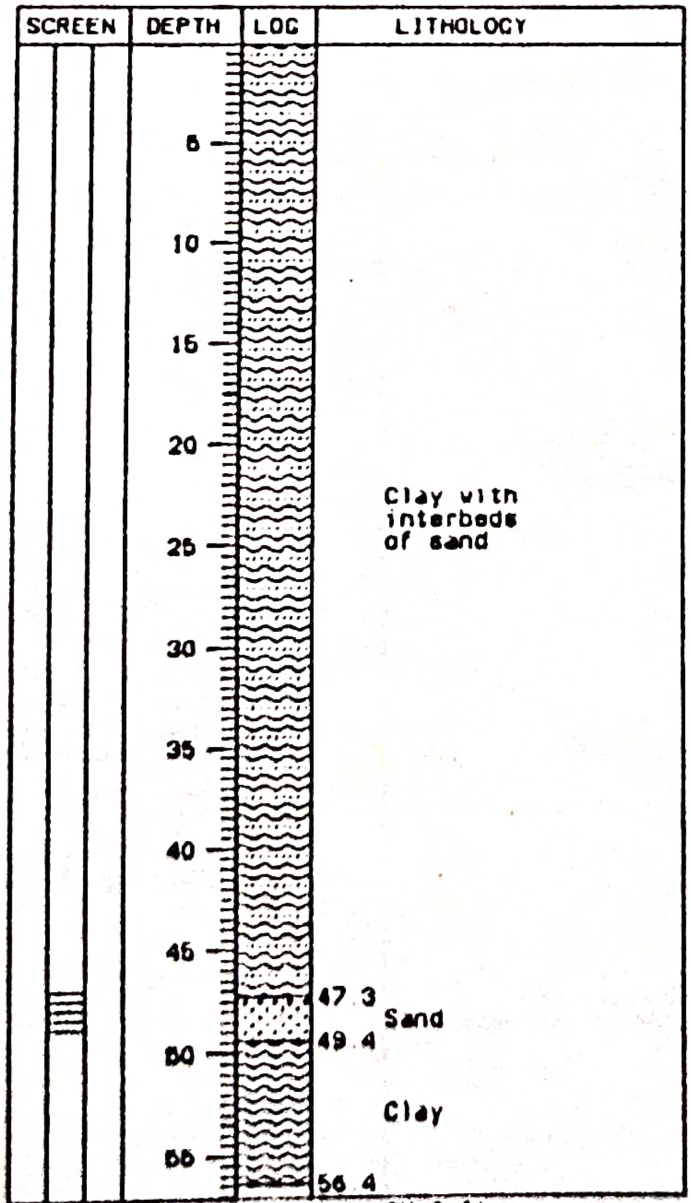
PUMPING TEST

Date. 31.5.89
Capacity: 12.86 l/s
Duration. 100 min.
Transmiss.: 251 m2/day
Method : THEIS
Stor.Coeff.: 0.21E-02
SWL: -5.32 m
DWL: -5.85

B-6: Well log of UN 06

Well No UN 7	Location: BASAUTI
Elevation: 160	X = 479800 Y = 3163500
Method of Drilling: MANUAL (Sludger)	
Drilling Dates 2 4 89 - 12 4 89	
Total Depth 56 40	
Comments: Well size 6 4 cm Screen position. 47.0 - 48.8 m Screen type: Perforated	

W E L L   L O G



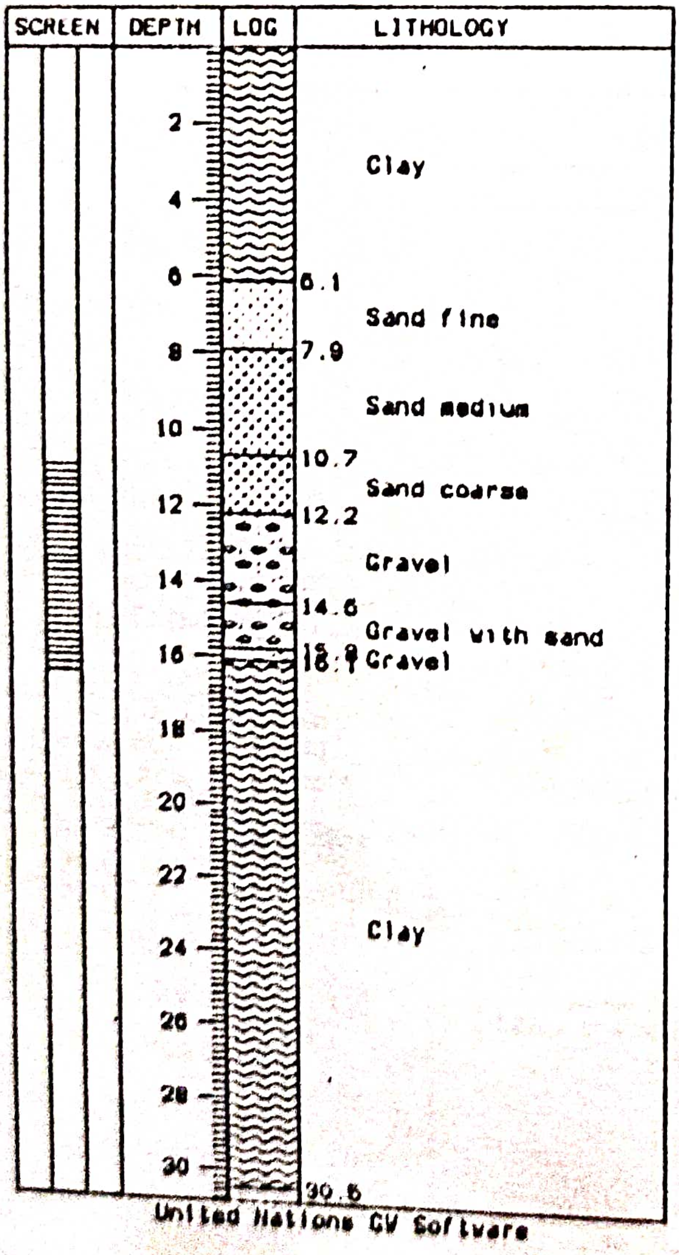
United Nations GW Software

B-7: Well log of UN 07

Well No UN 8	Location: PRITHIVIPUR (N)
Elevation 169	X = 482200 Y = 3171000
Method of Drilling: MANUAL (Sludger)	
Drilling Dates : 28 3 89 - 6 4 89	
Total Depth : 30 50	

Comments : Well size: 10 cm
Screen position 11.0 - 16.5 m
Screen type: Slotted pipe

WELL LOG



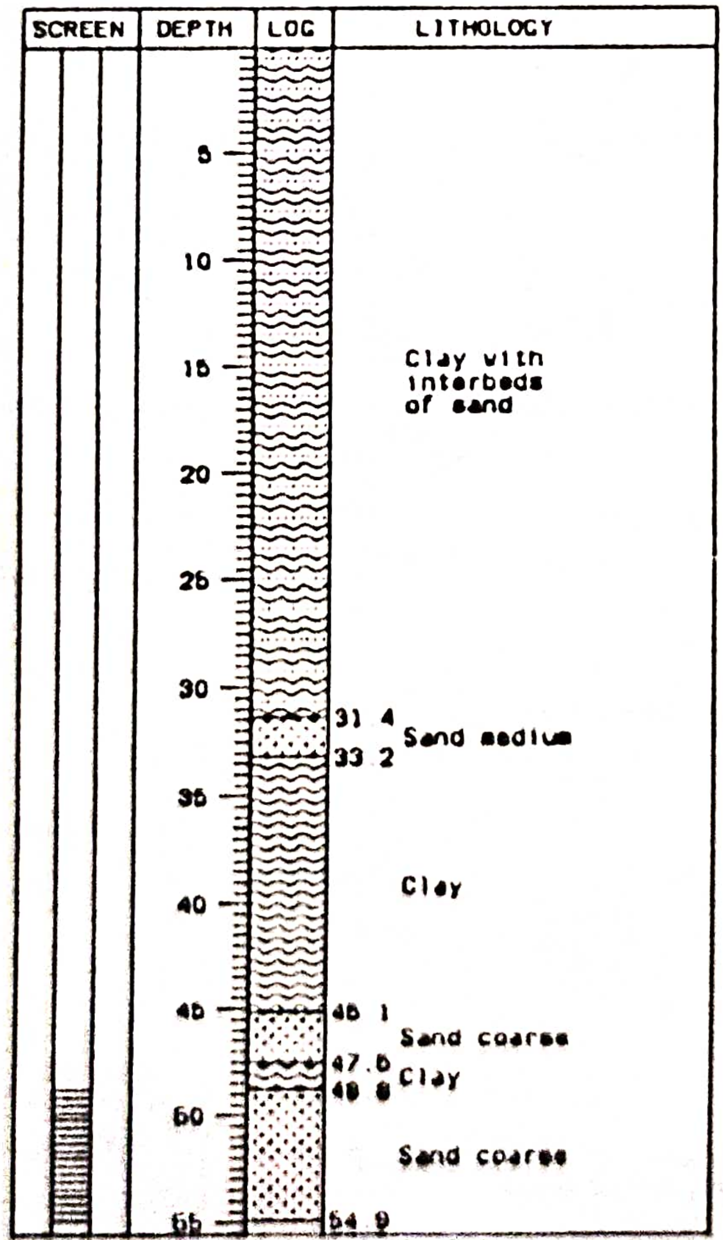
PUMPING TEST

Date: 31.5.89
Capacity: 8.7 l/s
Duration: 40 min
Transmiss.: 737 m2/day
Method : THEIS
SWL: -3.0 m
DWL: -6.7 m

B-8: Well log of UN 08

Well No UN 9	Location: UDASHIPUR
Elevation: 178	X = 481800 Y = 3176600
Method of Drilling: MANUAL (Sludger)	
Drilling Dates : 9 3 89 - 27 3 89	
Total Depth : 54 90	
Comments : Well size 10 cm Screen position 48.8 - 54.9 m Screen type Slotted	

W E L L L O G

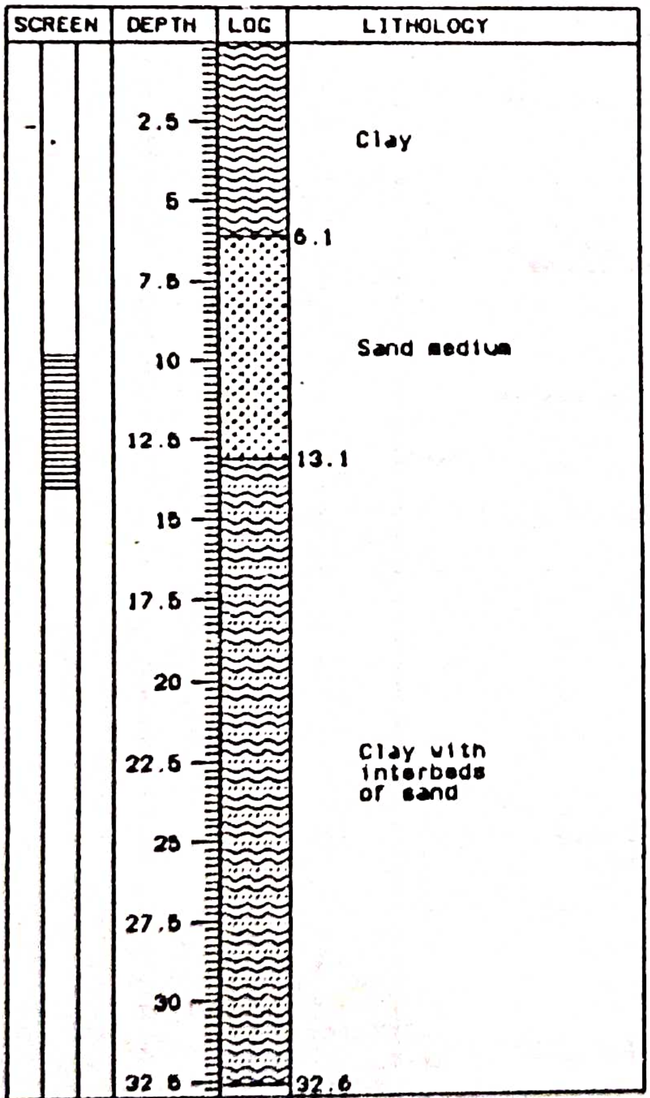


United Nations GV Software

B-9: Well log of UN 09

Well No. UN 10	Location: PHULBARI
Elevation: 160	X = 471000 Y = 3163200
Method of Drilling: MANUAL	
Drilling Dates : 20.12.88 - 30.12.88	
Total Depth : 32.60	
Comments : Well size 10 cm Screen position: 9.8 - 14.0 m Screen type: Perforated	

WELL LOG



United Nations GW Software

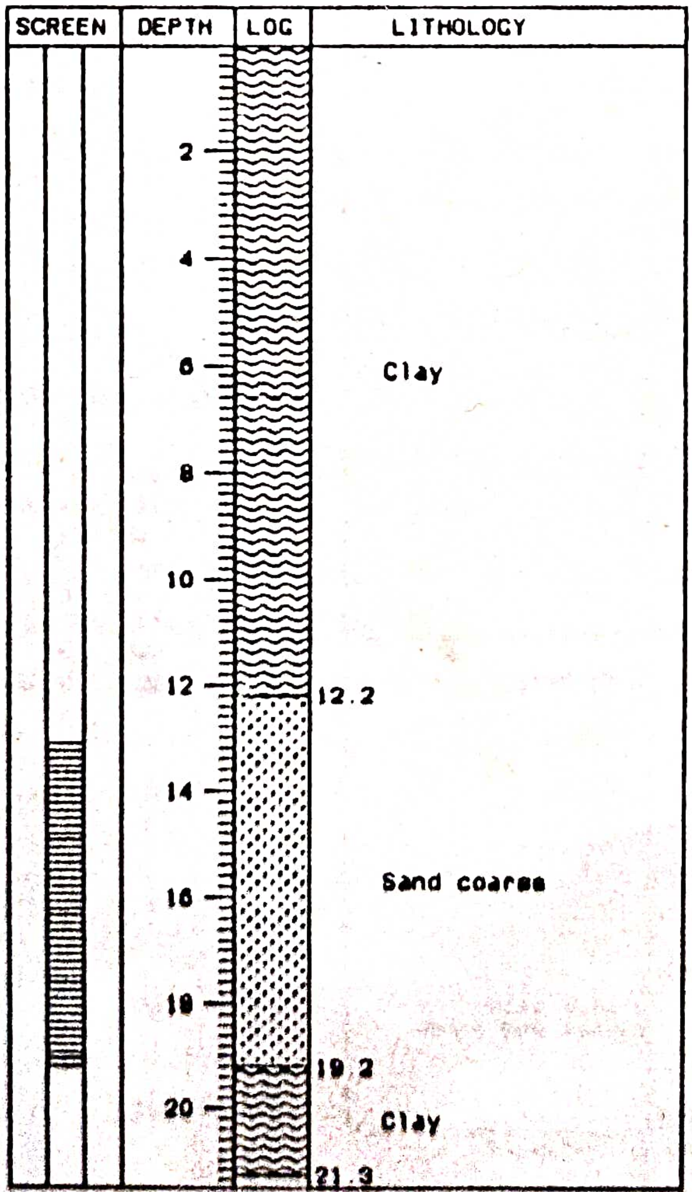
PUMPING TEST

Date: 20.6.89
Capacity: 8.0 l/s
Duration: 170 min.
Transmiss.: 289 m2/day
Method : THEIS
Stor.Coeff.: 0.79E-03
SWL: -4.17 m
DWL: -5.23 m

B-10: Well log of UN 10

Well No. UN 11	Location: BHADA
Elevation: 172	X = 474500 Y = 3175000
Method of Drilling: MANUAL	
Drilling Dates : 3.1.89 - 13.1.89	
Total Depth : 21.30	
Comments : Well size: 10 cm Screen position. 13.1 - 19.2 m Screen type:Slotted	

W E L L   L O G

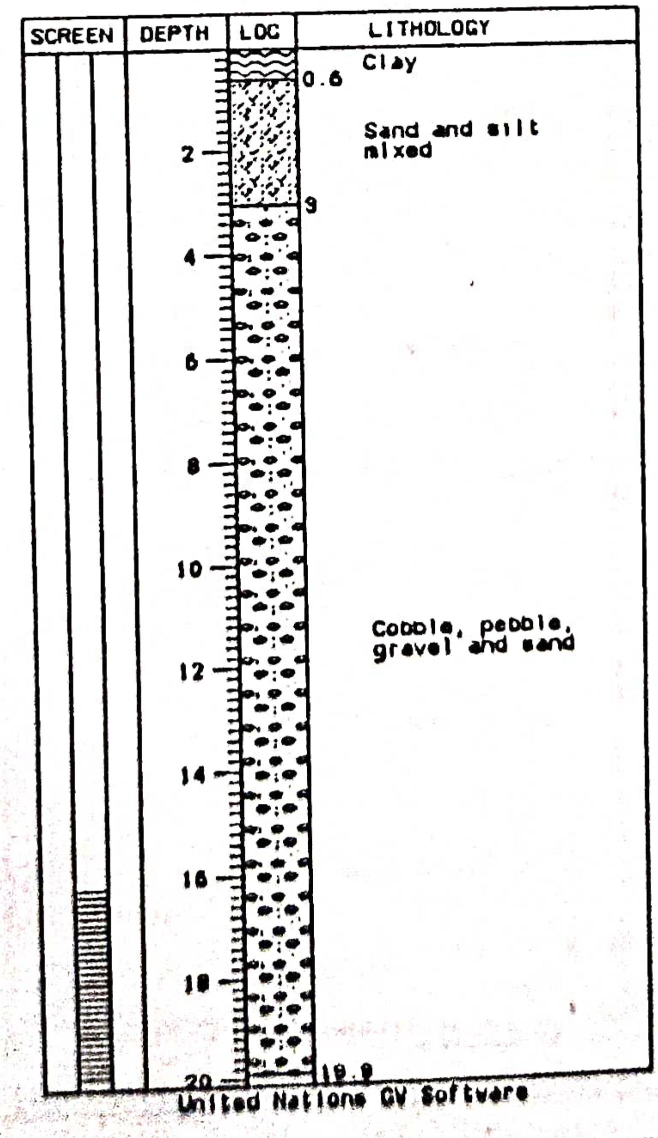


United Nations GW Software

B-11: Well log of UN 11

Well No. UN 12	Location: MAGHI
Elevation: 190	X = 476200 Y = 3183700
Method of Drilling: MANUAL	
Drilling Dates : 5 3 89 - 8.3.89	
Total Depth : 19 90	
Comments : Well size: 10 cm Screen position: 16.2 - 19.9 m Screen type: Perforated	

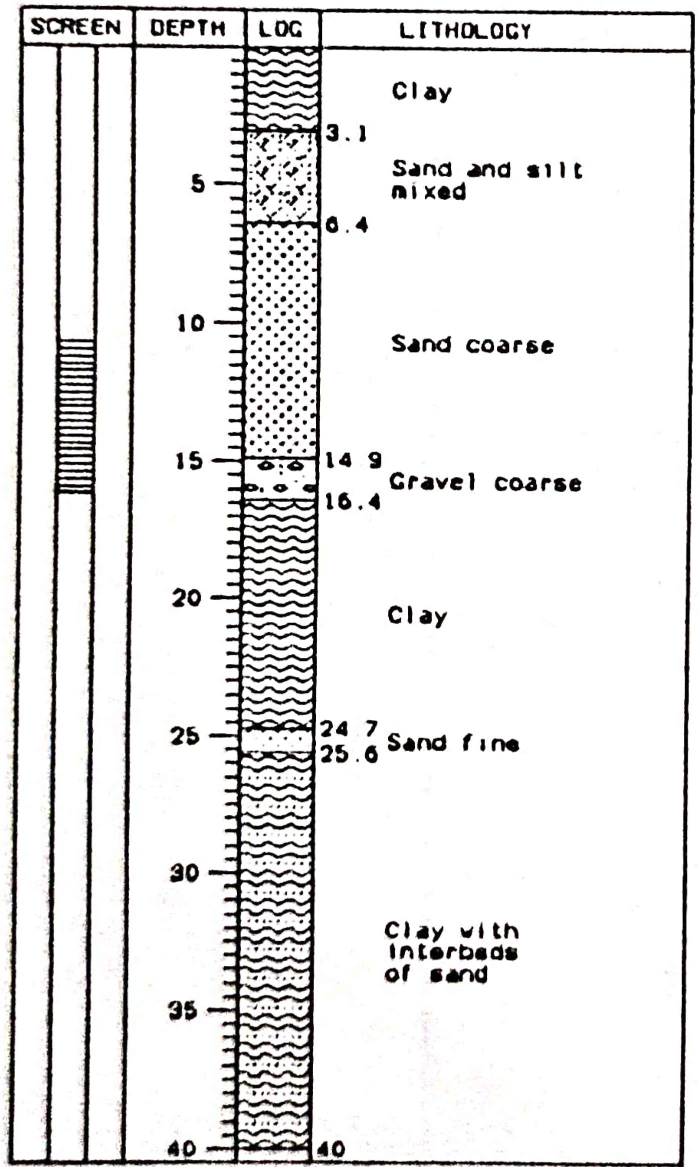
WELL LOG



B-12: Well log of Un 12

Well No UN 13	Location: DHANGADHI VILLAGE
Elevation: 171	X = 461500 Y = 3173700
Method of Drilling: MANUAL	
Drilling Dates: Dec 1988	
Total Depth: 40 00	
Comments: Well size 10 cm Screen position: 10.7 - 16.2 m Screen type: Slotted pipe	

W E L L   L O G



United Nations GW Software

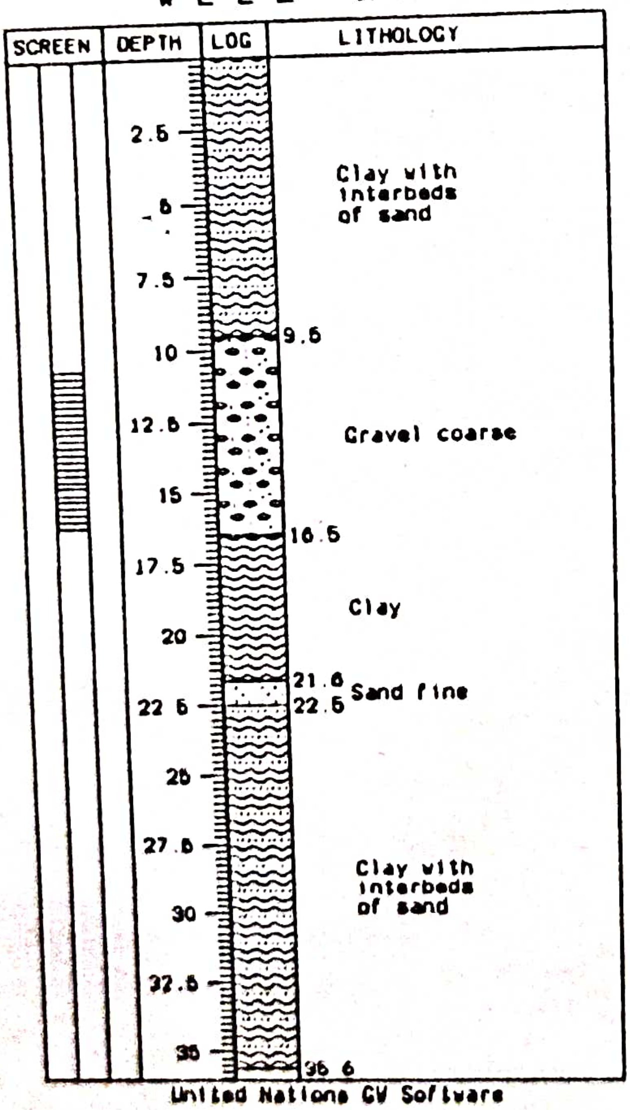
PUMPING TEST

Date: 7.7.89
Capacity: 12 l/s
Duration: 150 min
Transmiss.: 1502 m2/day
Method: THEIS
Stor.Coeff.: 0.82E-03
SWL: -4.62 m
DWL: -4.90 m

B-13: Well log of UN 13

Well No UN 14	Location: DHANGADHI (TOWN)
Elevation 171	x = 460600 Y = 3176100
Method of Drilling: MANUAL	
Drilling Dates : 30 1 89 - 8 2 89	
Total Depth : 35 60	
Comments : Well size 10 cm Screen position: 10.7 - 16.2 m Screen type: Slotted	

W E L L   L O G



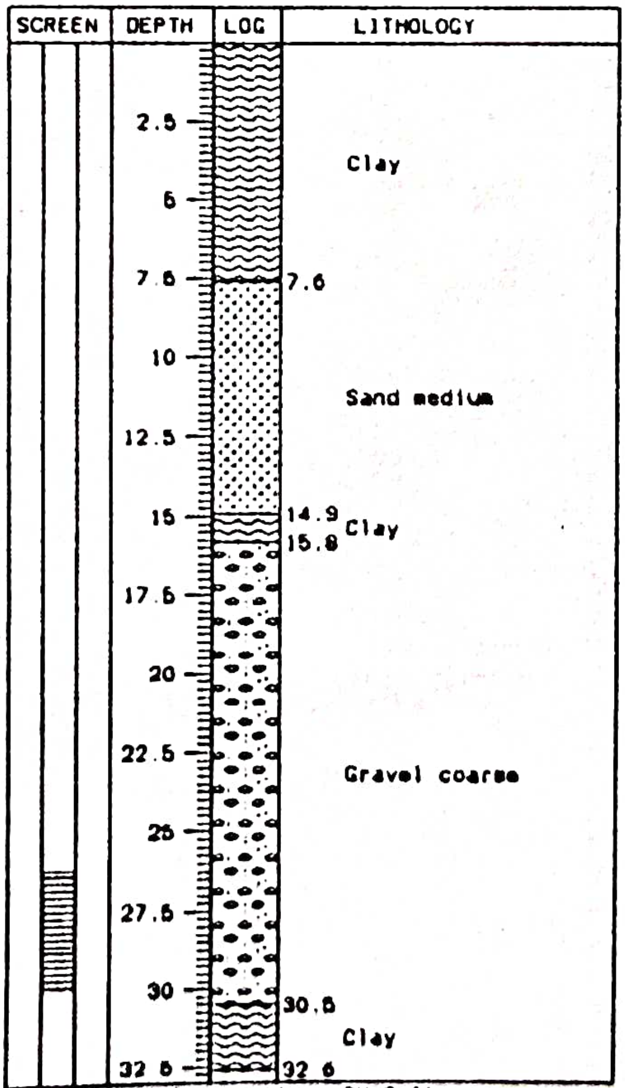
PUMPING TEST

Date, 9.2.89
Capacity: 14.2 l/s
Duration 140 min
Transmiss.: 264 m2/day
Method : JACOB
SWL: -3.98 m
DWL: -6.88 m

B-14: Well log of UN 14

Well No. UN 15	Location: RAJPUR
Elevation: 183	X = 456800 Y = 3180000
Method of Drilling: MANUAL	
Drilling Dates : Dec 1988	
Total Depth : 32 60	
Comments : Abandoned	

W E L L L O G



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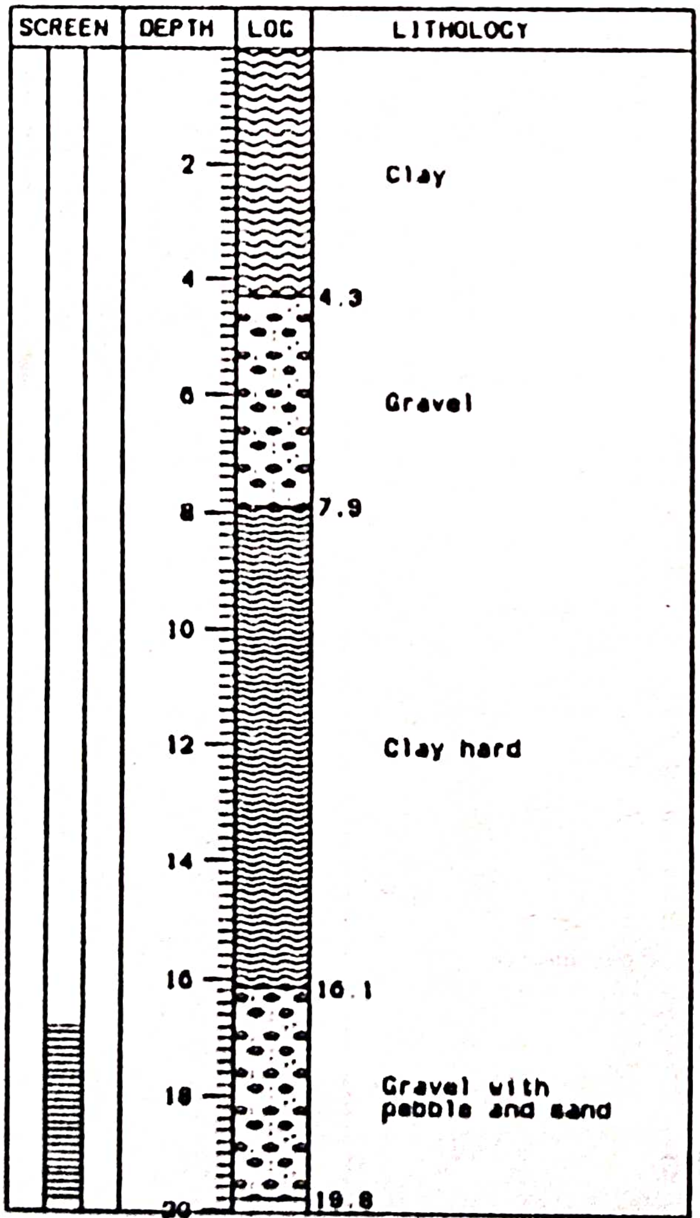
B-15: Well log of UN 15

Well No UN 16	Location: DHANCHAURI
Elevation: 180	X = 465600 Y = 3180300
Method of Drilling: MANUAL	
Drilling Dates : 15.5.89 - 29.5.89	
Total Depth : 19.80	
Comments : Well size: 10 cm Screen position: 16.8 - 19.8 m Screen type: Perforated	

WELL LOG



United Nations GW Software

PUMPING TEST

Date: 1.7.89
Capacity: 14.42 l/s
Duration: 110 min.
Transmiss.: 821 m2/day
Method : THEIS
Stor.Coeff.: 0.32E-05
SWL: -3.11 m
DWL: -5.05 m

B-16: Well log of UN 16

Well No UN 17	Location: LALPUR
Elevation: 205	x = 461000 y = 3189100

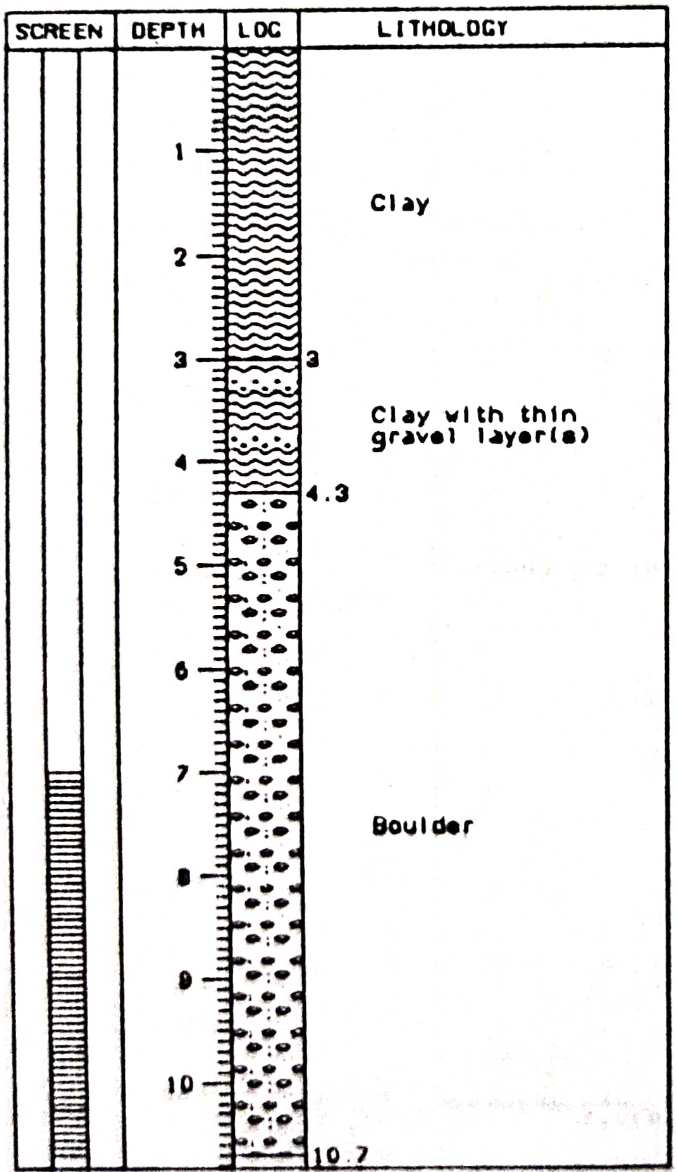
Method of Drilling: MANUAL

Drilling Dates : 10 1 89 - 25 1.89

Total Depth : 10.70

Comments : Well size: 10 cm
Screen position: 7.0 - 10.7 m
Screen type: Perforated

WELL LOG



United Nations GW Software

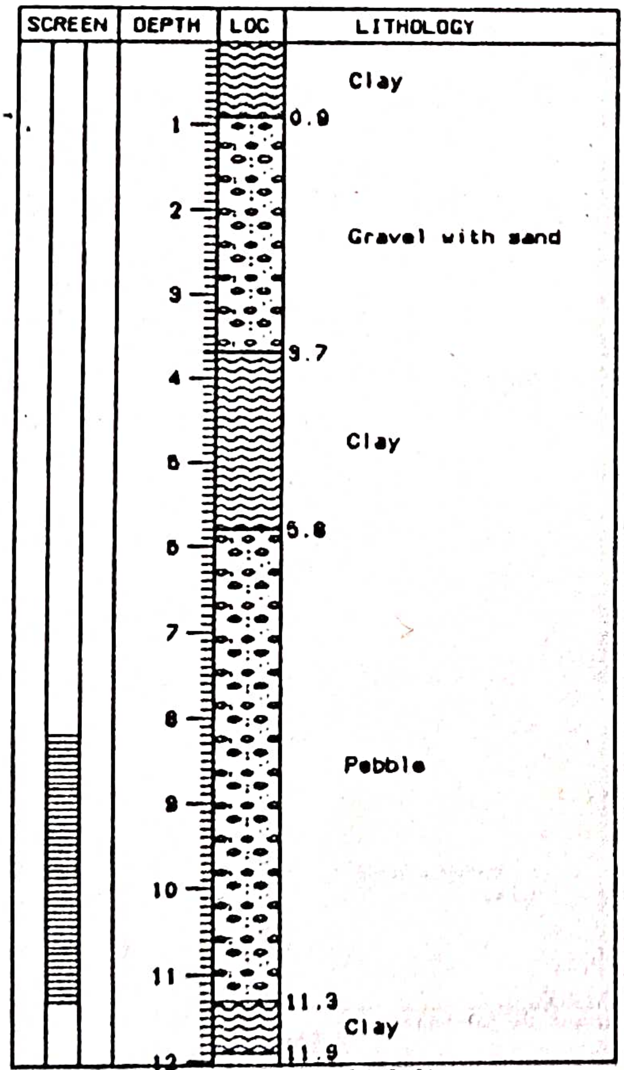
PUMPING TEST

Date: 16.2.89
Capacity: 16.28 l/s
Duration: 160 min
Transmiss.: 3722 m2/day
Method : THEIS
Stor.Coeff.: 0.27E-02
SWL: -2.22 m
DWL: -2.94 m

B-17: Well log of UN 17

Well No. UN 18	Location: TECHARI
Elevation: 250	x = 458000 Y = 3193100
Method of Drilling: MANUAL	
Drilling Dates : 6 6 89 - 6 7 89	
Total Depth : 11.90	
Comments : Well size: 10 cm Screen position: 8.2 - 11.3 m Screen type: Perforated	

WELL LOG

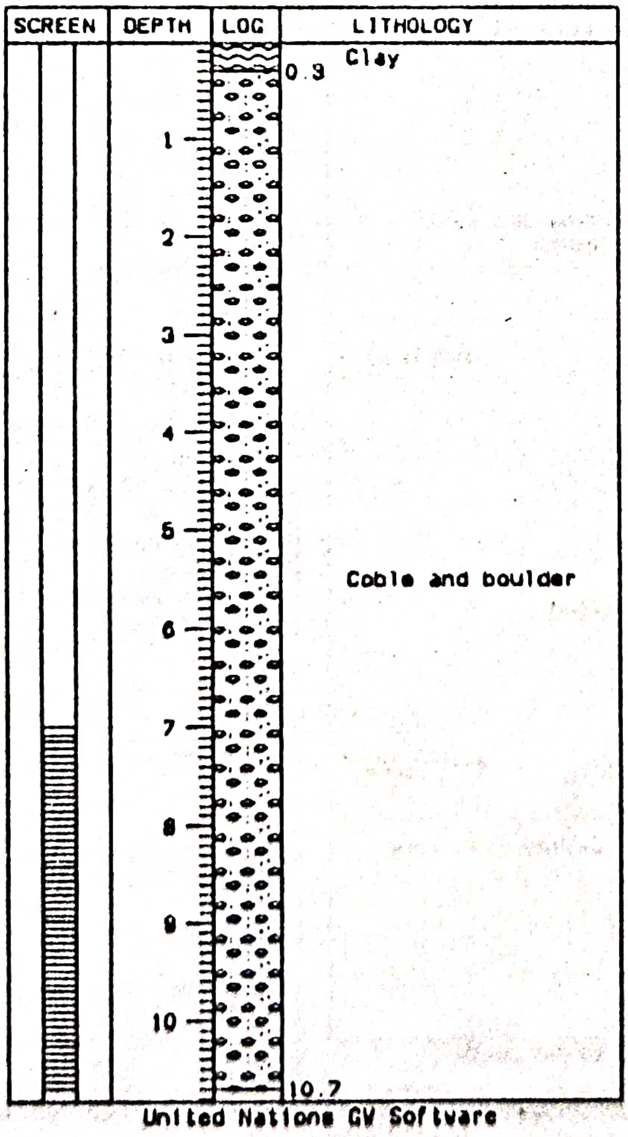


United Nations GW Software

B-18: Well log of UN 18

Well No. UN 19	Location: KATACHHE
Elevation: 165	X = 519000 Y = 3162800
Method of Drilling: MANUAL (Driven)	
Drilling Dates : 13.1.90 - 16.1.90	
Total Depth : 10.70	
Comments : Well size: 10 cm Screen position: 7.0 - 10.7 m Screen type: Perforated	

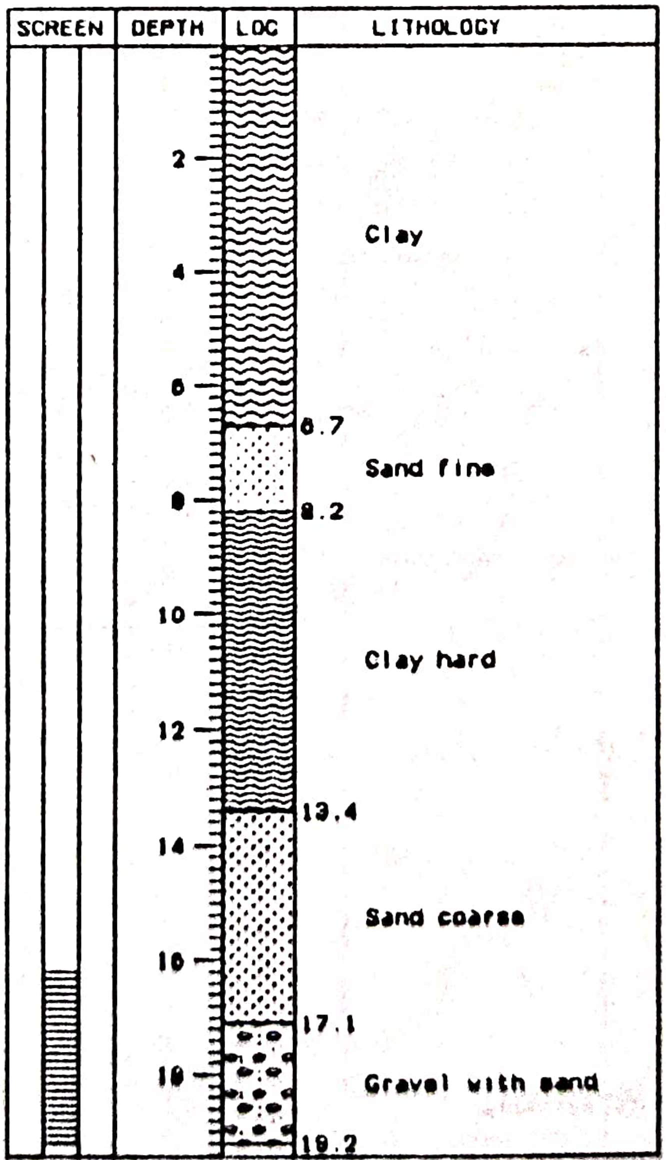
W E L L   L O G



B-19: Well log of UN 19

Well No UN 20	Location: KHAREITY
Elevation: 160	X = 475300 Y = 3168500
Method of Drilling: MANUAL (Bogie)	
Drilling Dates : 7.2.90 - 12.2.90	
Total Depth : 19.20	
Comments : Well size: 10 cm Screen position: 16.2 - 19.2 m Screen type: Perforated	

WELL LOG

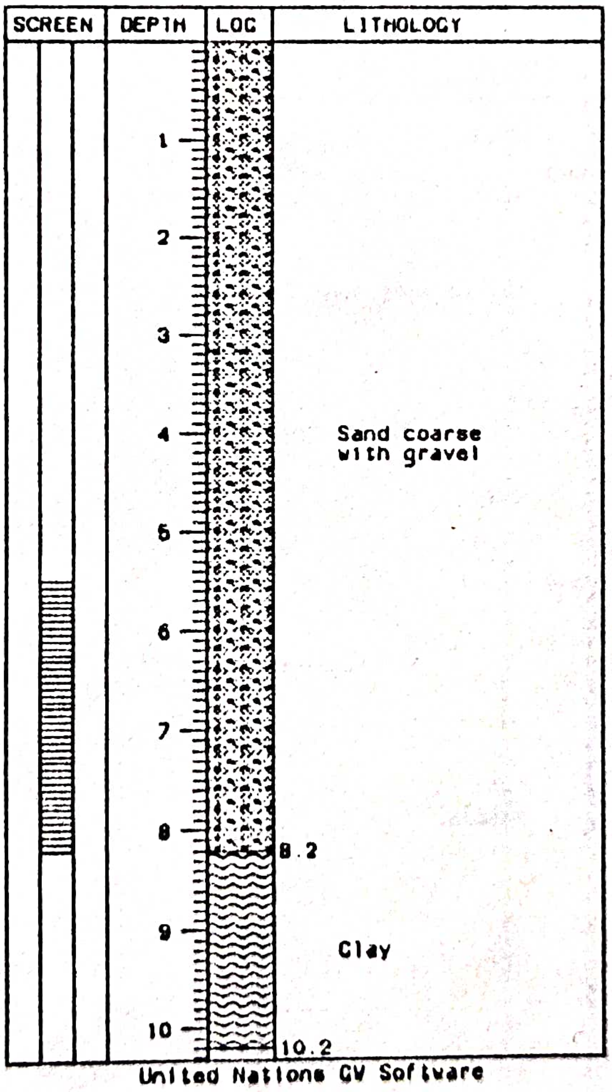


United Nations GW Software

B-20: Well log of UN 20

Well No. UN 21	Location: BANBEHDA
Elevation: 190	x = 468200 y = 3186800
Method of Drilling: MANUAL (Driven)	
Drilling Dates : 15 2 90 - 17 2 90	
Total Depth : 10.20	
Comments : Well size: 10 cm Screen position: 5.5 - 8.2 m Screen type: Perforated	

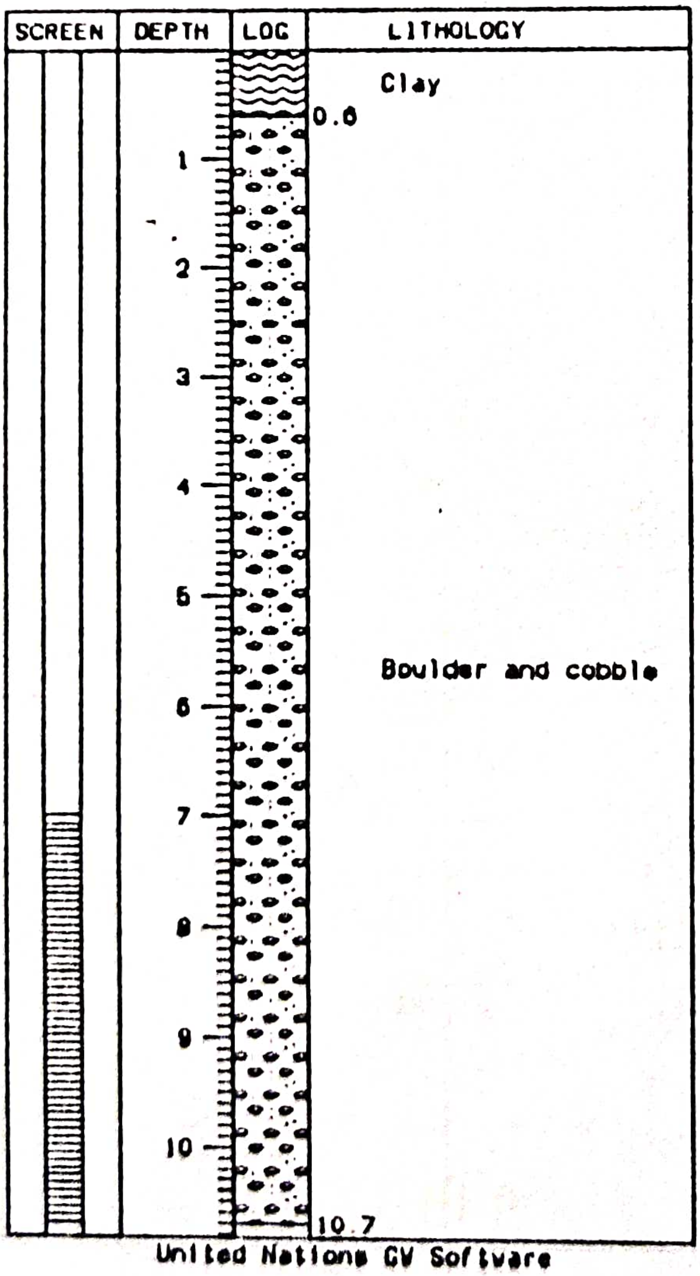
W E L L L O G



B-21: Well log of UN 21

Well No UN 22	Location: TIKAPUR
Elevation: 160	X = 511400 Y = 3153200
Method of Drilling: MANUAL (Driven)	
Drilling Dates : 13.12.89 - 18.12.89	
Total Depth : 10.70	
Comments : Well size: 10 cm Screen position: 7.0 - 10.7 m Screen type: Perforated	

W E L L   L O G



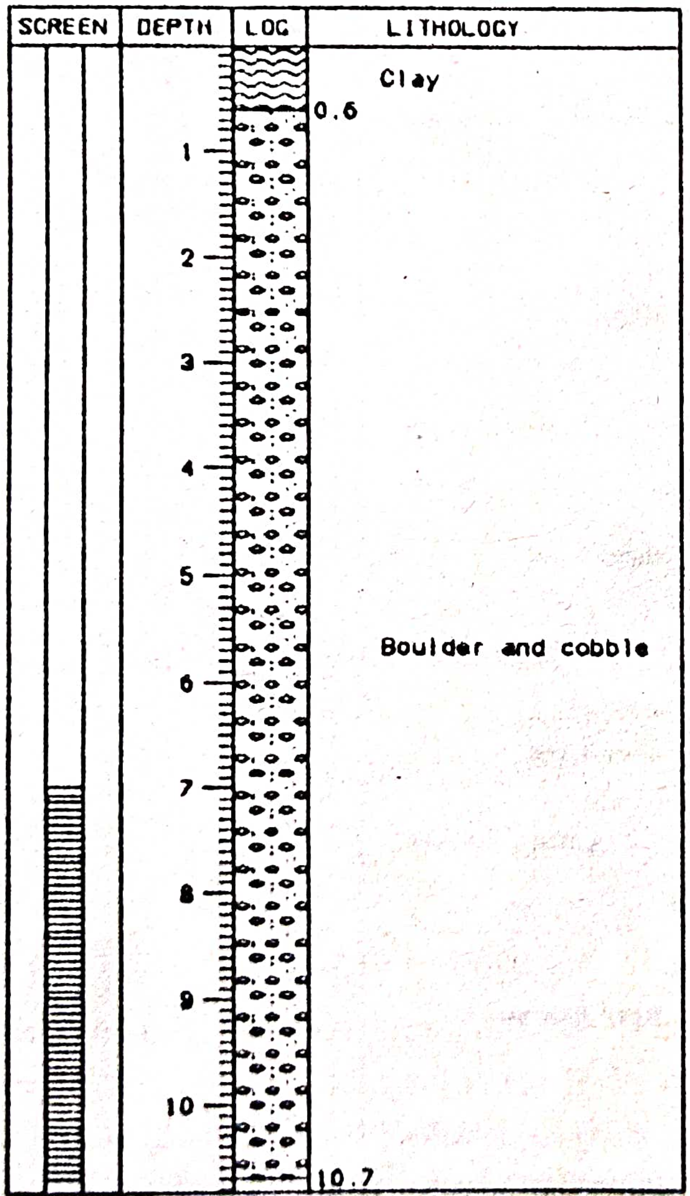
PUMPING TEST

Date: 4.5.90
Capacity: 15 l/s
Duration: 110 min.
Transmiss.: 4027 m2/day
Method : THEIS
Stor.Coeff.: 0.43E-01
SWL: -2.43 m
DWL: -2.49 m

B-22: Well log of UN 22

Well No. UN 23	Location: DURGAULI
Elevation: 165	X = 511000 Y = 3160300
Method of Drilling: MANUAL (Driven)	
Drilling Dates: 12 12 89 - 16 12 89	
Total Depth: 10 70	
Comments: Well size 10 cm Screen position: 7.0 - 10.7 m Screen type: Perforated	

W E L L   L O G



United Nations GV Software

PUMPING TEST

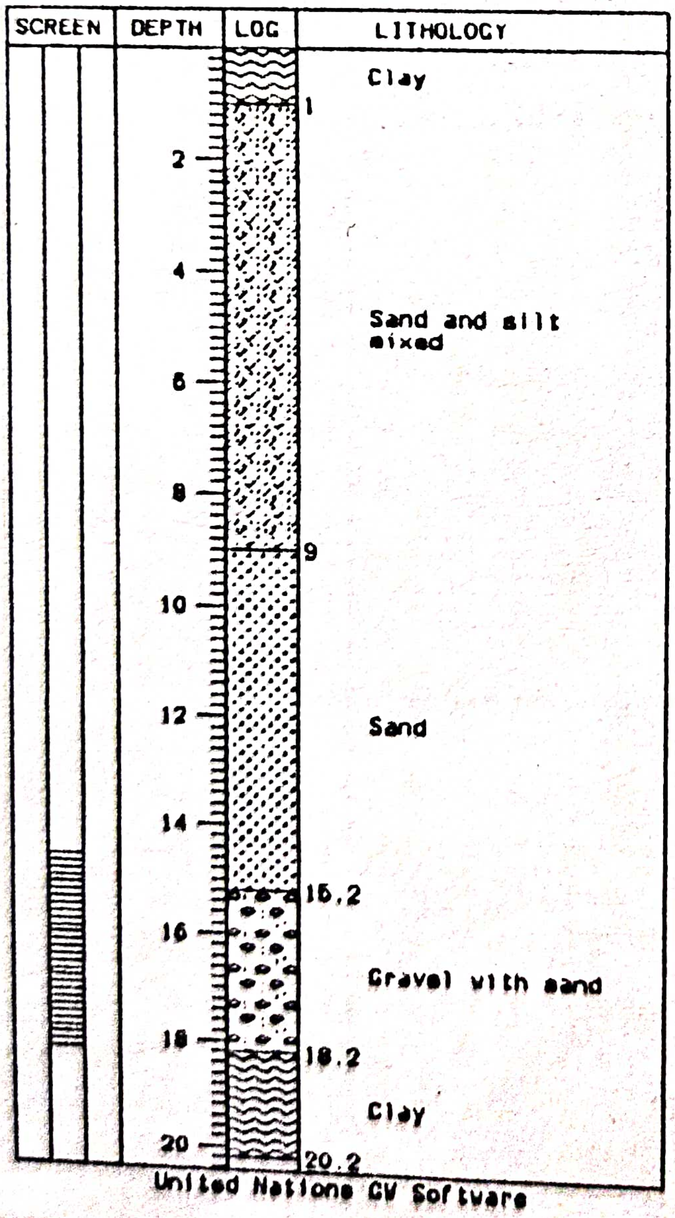
Date: 5.5.90
Capacity: 15.5 l/s
Duration: 40 min.
SWL: -2.25 m

Pumping test was stopped due to no drawdown in the obs. hand pump located at 57.8 m away from the P.Well. The nearby river might have been recharging the P.Well.

B-23: Well log of 23

Well No. UN 24	Location: CHAUGURDI
Elevation: 155	X = 504100 Y = 3143900
Method of Drilling: MANUAL	
Drilling Dates : 9 12 89 - 15 12 89	
Total Depth : 20 20	
Comments Well size 10 cm Screen position. 14.6 - 18.2 m Screen type Perforated	

WELL LOG



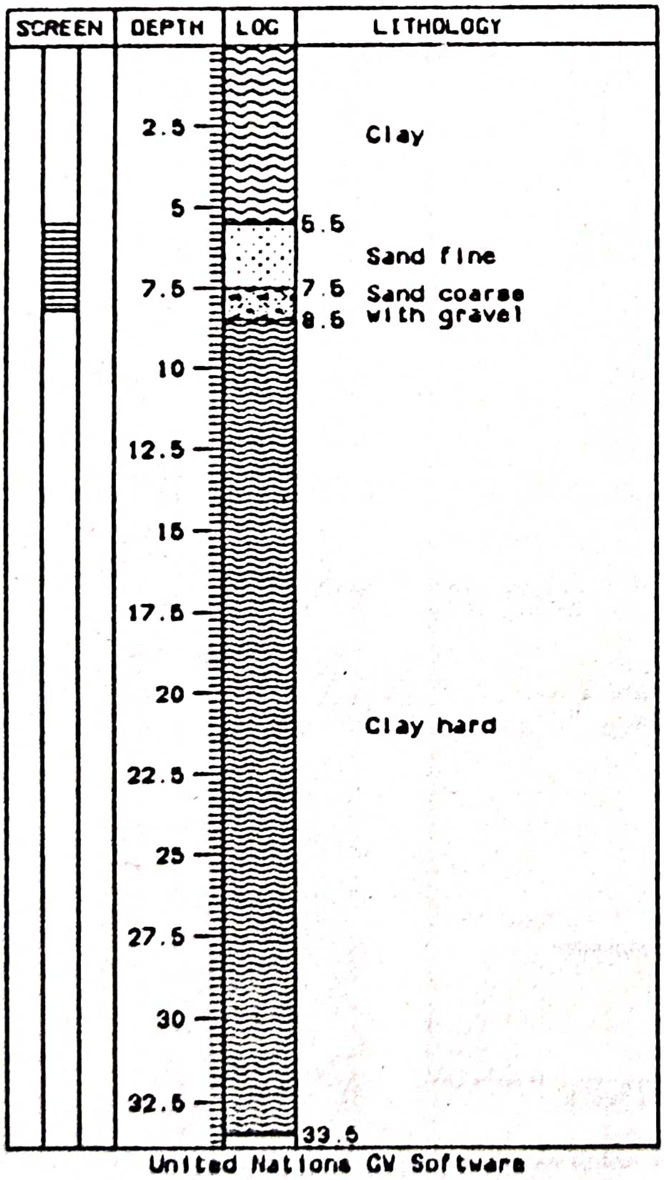
PUMPING TEST

Date: 3.5.90
Capacity: 12 l/s
Duration: 45 min.
Transmiss.: 3575 m2/day
Method : THEIS
Stor.Coeff.: 0.66E-02
SVL: -4.71 m
DVL: -4.82 m

B-24: Well log of UN 24

Well No UN 25	Location: NUMUWABOJHI
Elevation: 168	X = 502500 Y = 3170900
Method of Drilling: MANUAL (Sludger)	
Drilling Dates : 2 5 90 - 6 5 90	
Total Depth : 33 50	
Comments : Well size 10 cm Screen position. 5.5 - 8.2 m Screen type: Perforated wrapped with nylon screen	

WELL LOG



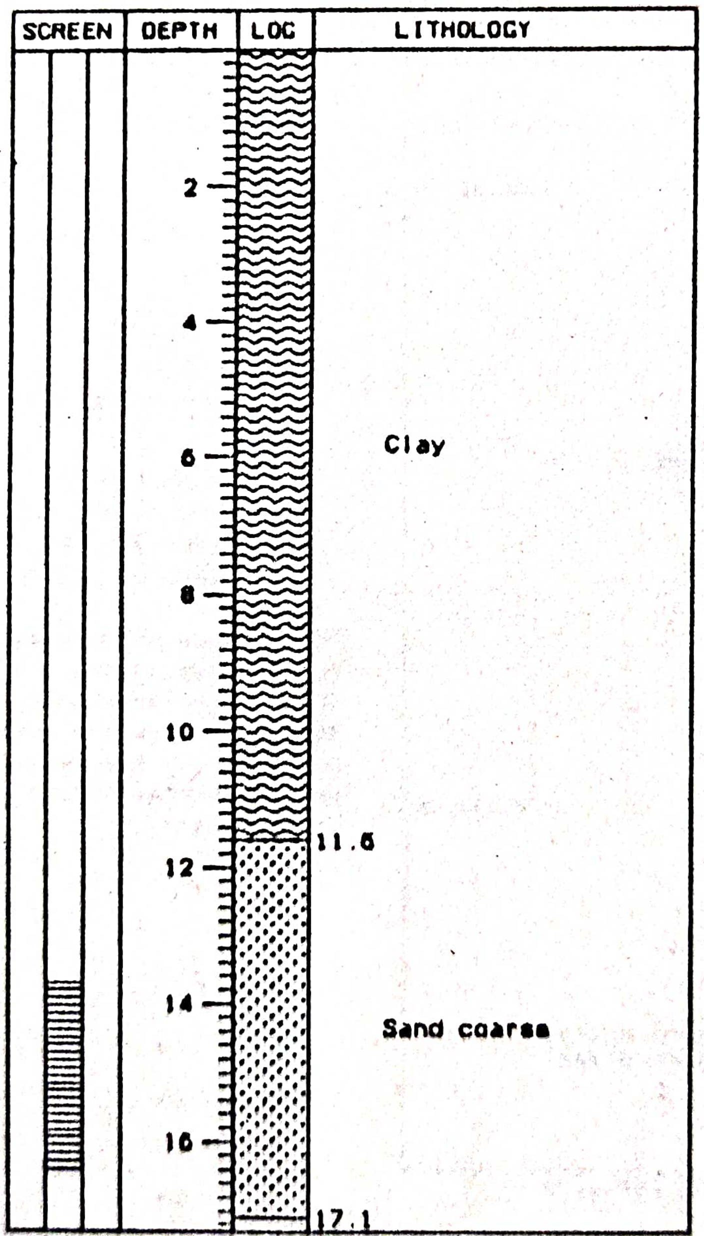
PUMPING TEST

Date: 2.6.90
Capacity: 2.5 l/s
Duration: 90 min
Transmiss.: 156 m2/day
Method : THEIS
Stor.Coeff.: 0.81E-03
SWL: -3.32 m
DWL: -3.90 m

B-25: Well log of UN 25

Well No. UN 26	Location: SIMTHALI
Elevation: 175	X = 495700 Y = 3172800
Method of Drilling: MANUAL (Sludger)	
Drilling Dates : 26.4.90 - 2.5.90	
Total Depth : 17.10	
Comments : Well size: 10 cm Screen position: 13.7 - 16.4 m Screen type: Perforated Drilling could not be run bellow 17.1 m due to boulder	

W E L L   L O G

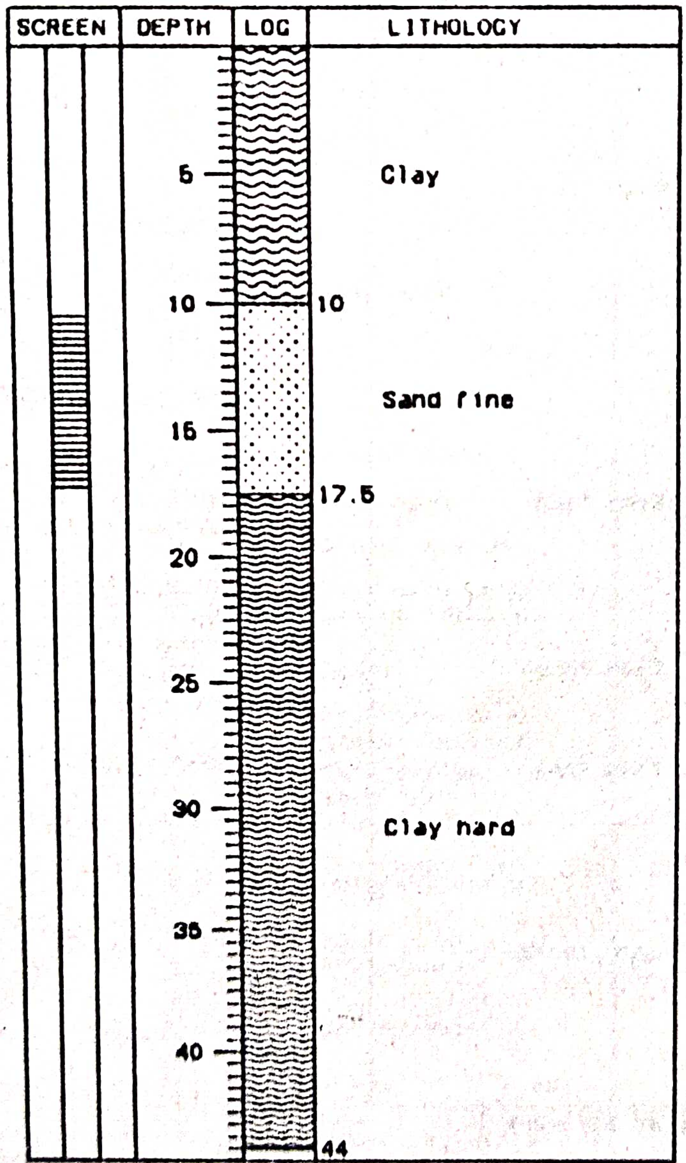


United Nations GW Software

B-26: Well log of UN 26

Well No. UN 27	Location: SRIPUR (School)
Elevation: 188	X = 460800 Y = 3184200
Method of Drilling: MANUAL (Sludger)	
Drilling Dates : 26 4 90 - 1 5.90	
Total Depth : 44 00	
Comments : Well size: 10 cm Screen position: 10.5 - 17.2 m Screen type Slotted	

WELL LOG

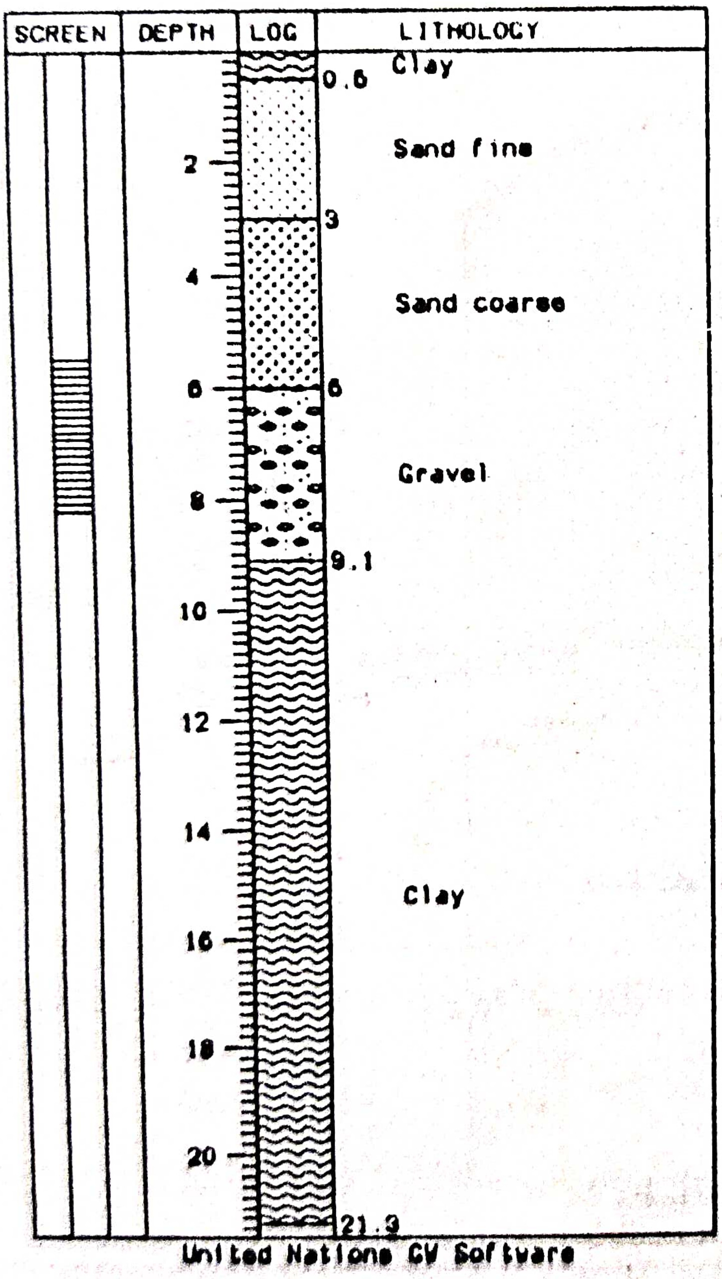


United Nations GW Software

B-27: Well log of UN 27

Well No. UN 28	Location: KANARI
Elevation: 165	X = 468700 Y = 3171700
Method of Drilling: MANUAL (Bogie & Sludger)	
Drilling Dates : 3.2.90 - 6.2.90	
Total Depth : 21.30	
Comments : Well size: 10 cm Screen position: 5.5 - 8.2 m Screen type: Perforated wrapped with nylon screen	

WELL LOG



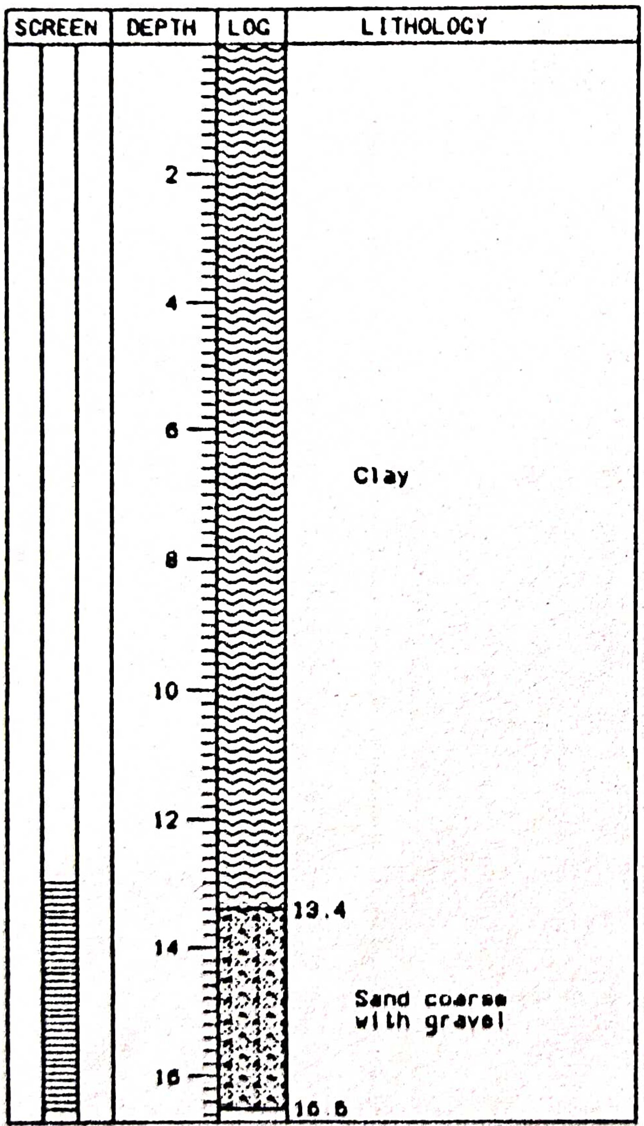
PUMPING TEST

Date: 9.2.90
Capacity: 4.7 l/s
Duration: 22 min.
Transmiss.: 3347 m2/day
Method : THEIS
Stor.Coeff.: 0.17E-06
SWL: -2.74 m
DWL: -2.89 m

B-28: Well log of UN 28

Well No. UN 29	Location: BIJULIYA
Elevation: 158	X = 493600 Y = 3161700
Method of Drilling: MANUAL (Bogie)	
Drilling Dates : 22.2.90 - 29.2.90	
Total Depth : 16.50	
Comments : Well size: 10 cm Screen position: 13.0 - 16.5 m	

WELL LOG



United Nations GW Software

PUMPING TEST

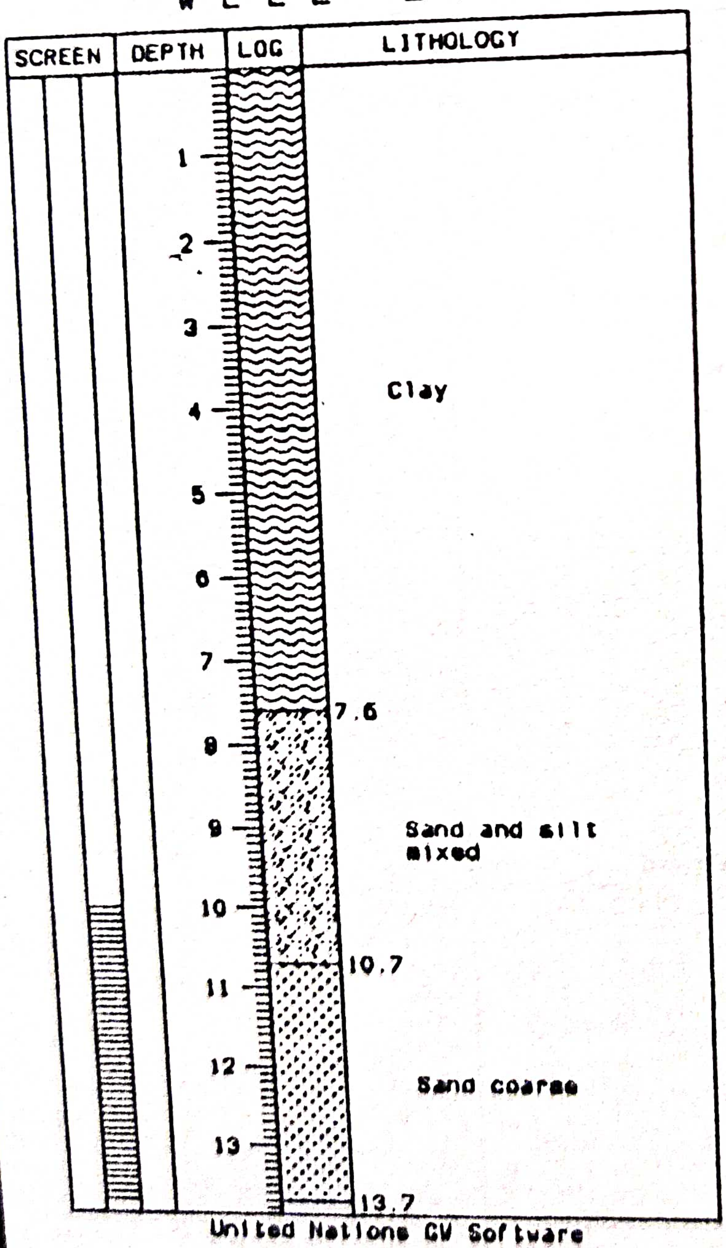
Date: 1.5.90
Capacity: 0.45 l/s
Duration: 30 min.
SWL: -4.13 m

Pumping was stopped due to no drawdown in the observation hand pump located 45 m away from the pumping well. It was due to very poor discharge in the pumping well.

B-29: Well log of UN 29

Well No. UN 30	Location: BALIYA
Elevation: 170	X = 511800 Y = 3168100
Method of Drilling: MANUAL (Driven)	
Drilling Dates : 20.11.89 - 26.11.89	
Total Depth : 13.70	
Comments : Well size: 10 cm Screen position: 10.0 - 13.7 m Screen type: Perforated	

WELL LOG



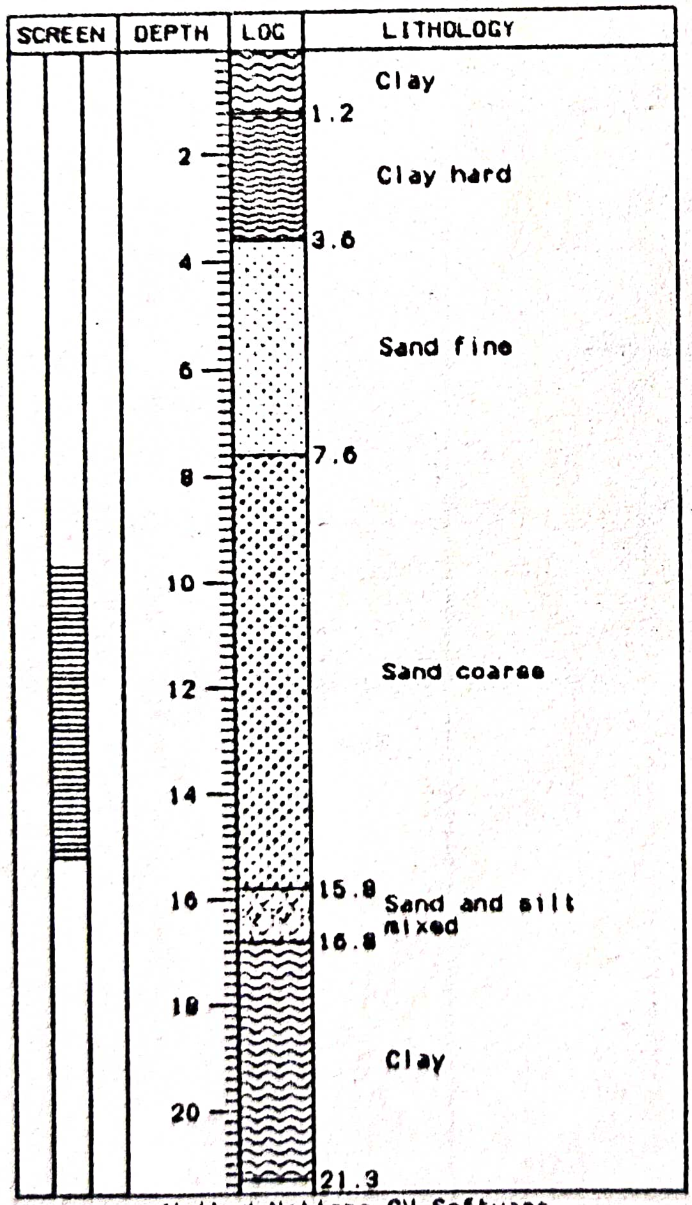
PUMPING TEST

Date: 30.6.90
Capacity: 14 l/s
Duration: 160 min
Transmiss.: 2757 m2/day
Method : THEIS
Stor.Coeff.: 0.31E-02
SWL: -2.16 m
DWL: -2.27 m

B-30: Well log of UN 30

Well No UN 31	Location: RAMPUR (Police station)
Elevation: 155	X = 486600 Y = 3155400
Method of Drilling: MANUAL	
Drilling Dates : 24 2 90 - 26 2 90	
Total Depth : 21 30	
Comments : Well size 10 cm Screen position 9.7 - 15.2 m Screen type Perforated wrapped with nylone srceen	

WELL LOG



United Nations GW Software

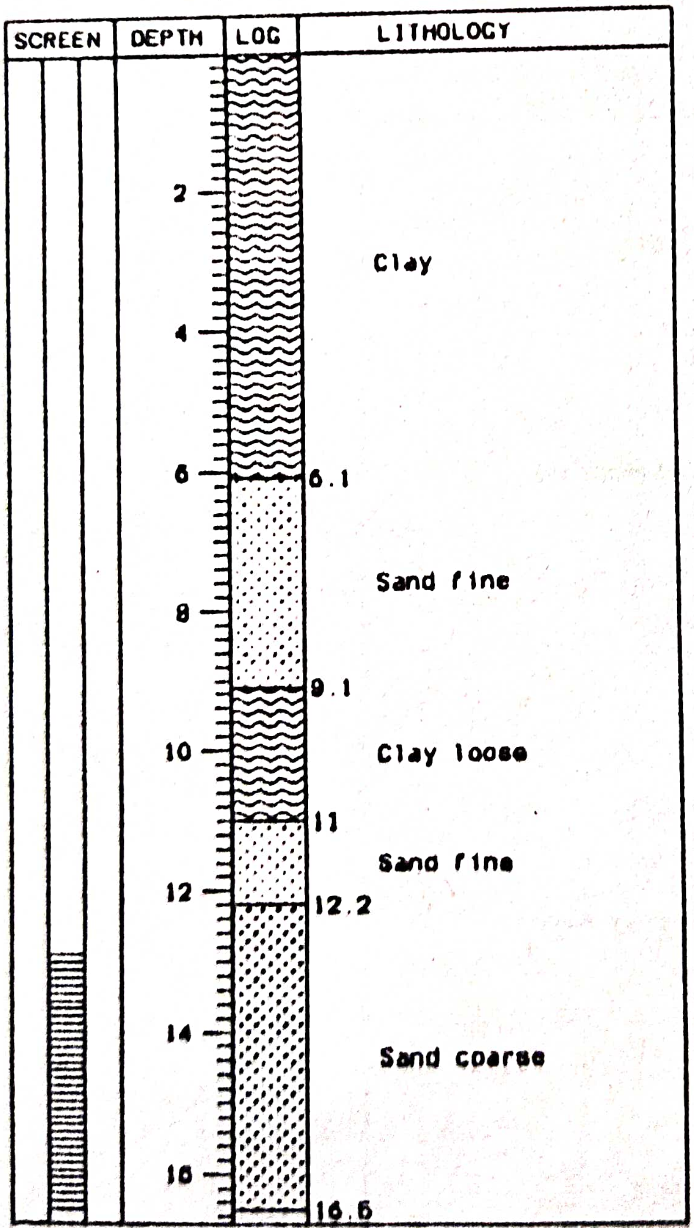
PUMPING TEST

Date: 22.3.90
Capacity: 7 l/s
Duration: 80 min
Transmiss.: 2558 m2/day
Method : THEIS
Stor.Coeff.: 0.16E-02
SWL: -4.99 m
DWL: -5.12 m

B-31: Well log of UN 31

Well No UN 32	Location: CHHARRA (Prithivipur S)
Elevation: 155	X = 493800 Y = 3150000
Method of Drilling: MANUAL (Bogie)	
Drilling Dates : 14 2 90 - 21 2 90	
Total Depth : 16 50	
Comments : Well size. 10 cm Screen position. 12.9 - 16.5 m Screen type. Perforated wrapped with nylon screen	

W E L L   L O G



United Nations GW Software

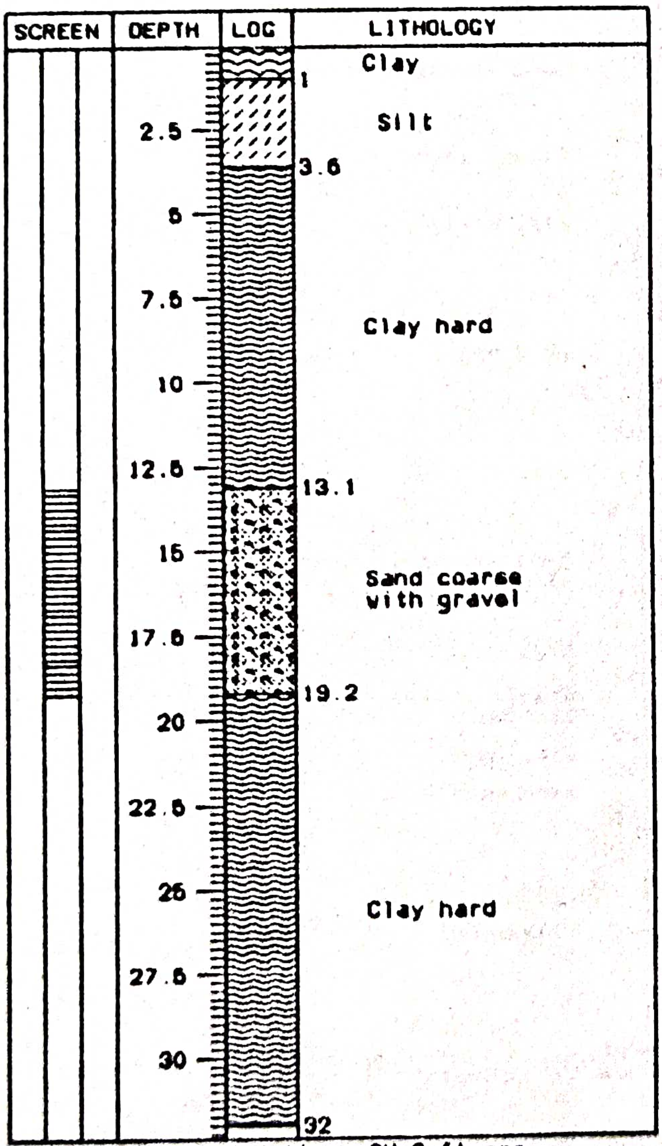
PUMPING TEST

Date: 22.3.90
Capacity: 12.6 l/s
Duration: 100 min.
Transmiss.: 3581 m2/day
Method : THIES
Stor.Coeff.: 0.24E-02
SWL: -3.86 m
DWL: -3.99 m

B-32: Well log of UN 32

Well No. UN 33	Location: DHANGADHI TOWN (W)
Elevation: 172	X = 459000 Y = 3175900
Method of Drilling: MANUAL (Sludger)	
Drilling Dates : 10.4.89 - 19.4.89	
Total Depth : 32.00	
Comments : Well size: 10 cm Screen position: 13.1 - 19.2 m Screen type: Slotted	

WELL LOG

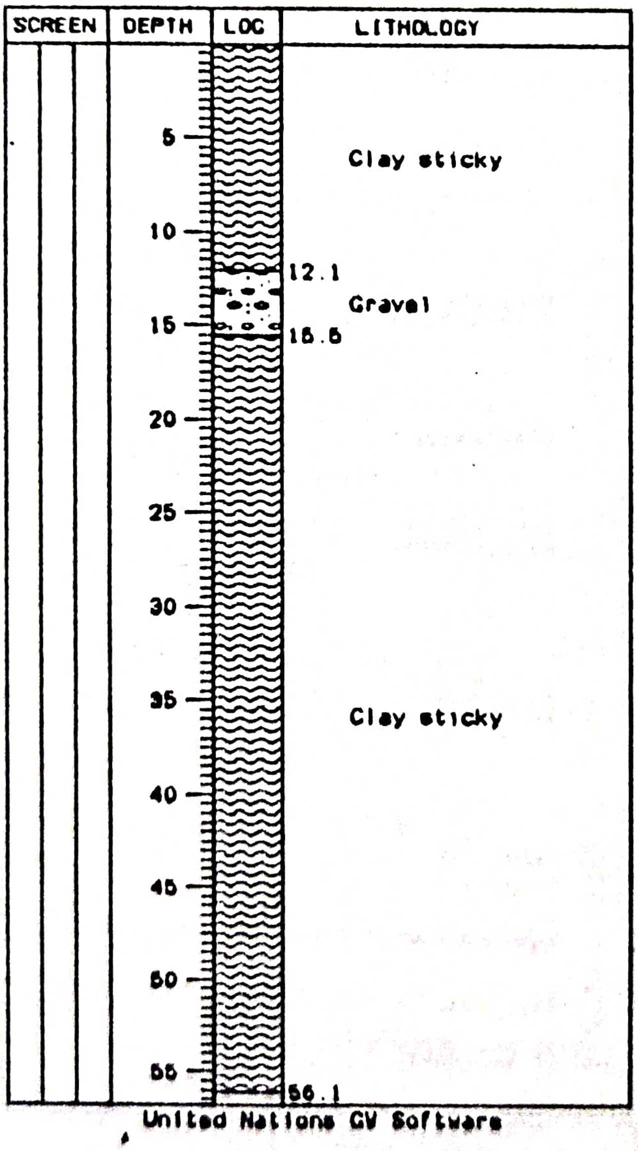


United Nations GW Software

B-33: Well log of UN 33

Well No. GW 4	Location: AUTERIA
Elevation: 195.1	X = 456300 Y = 3186900
Method of Drilling:	
Drilling Dates : 21.1.74 - 25.1.74	
Total Depth : 56.10	
Comments : Drilled under Hydrology Department	

WELL LOG

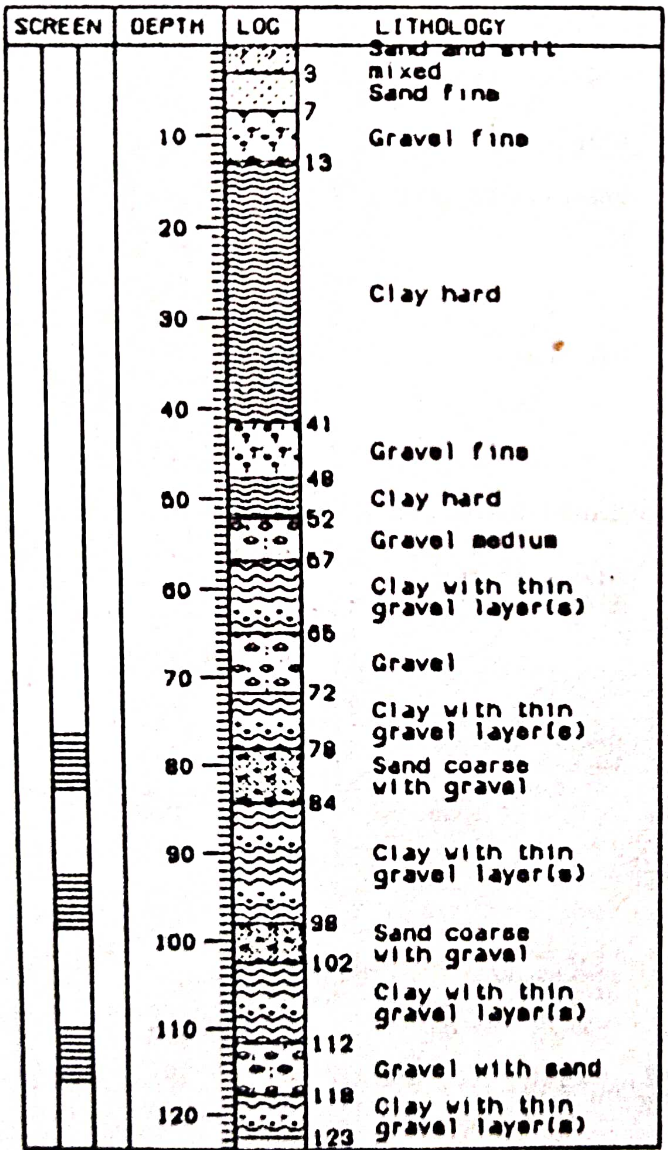


B-34: Well log of GW 04

Well No. GW 6	Location: MALAKHETI(1)
Elevation: 206	X = 453200 Y = 3191500
Method of Drilling: RIG	
Drilling Dates:	
Total Depth: 122 60	

Comments: Well Size: 10"/6"
Screen Position. 76.5 - 82.6 m
92.4 - 98.5 m
110.0 - 116.2 m
Drilled under GWRDB/USAID Project

W E L L L O G



United Nations GW Software

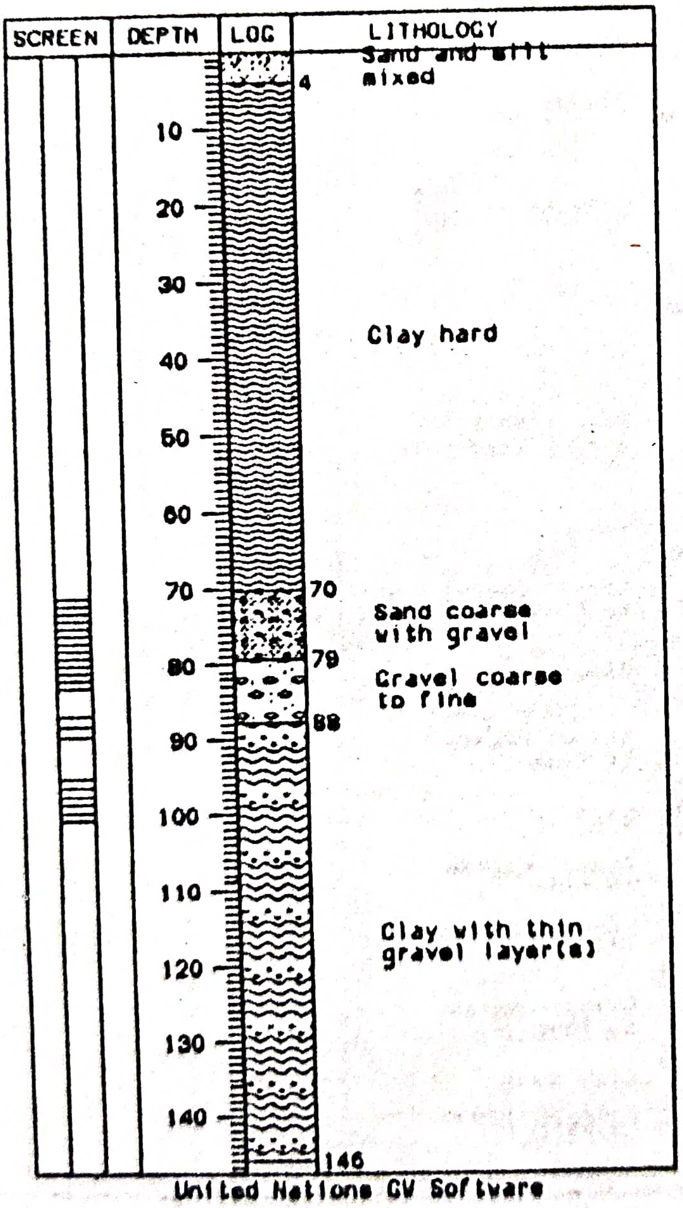
PUMPING TEST

Capacity: 28.1 l/s

B-35: Well log of GW 06

Well No. GW 10	Location: MANIHARA
Elevation: 165	X = 462900 Y = 3171500
Method of Drilling: RIG	
Drilling Dates :	
Total Depth : 146.00	
Comments : Well Size: 10"/6" Screen Position: 71.0 - 82.9 m 86.6 - 89.4 m 95.1 - 100.6 m Drilled under GWRDB/USAID Project	

WELL LOG



PUMPING TEST

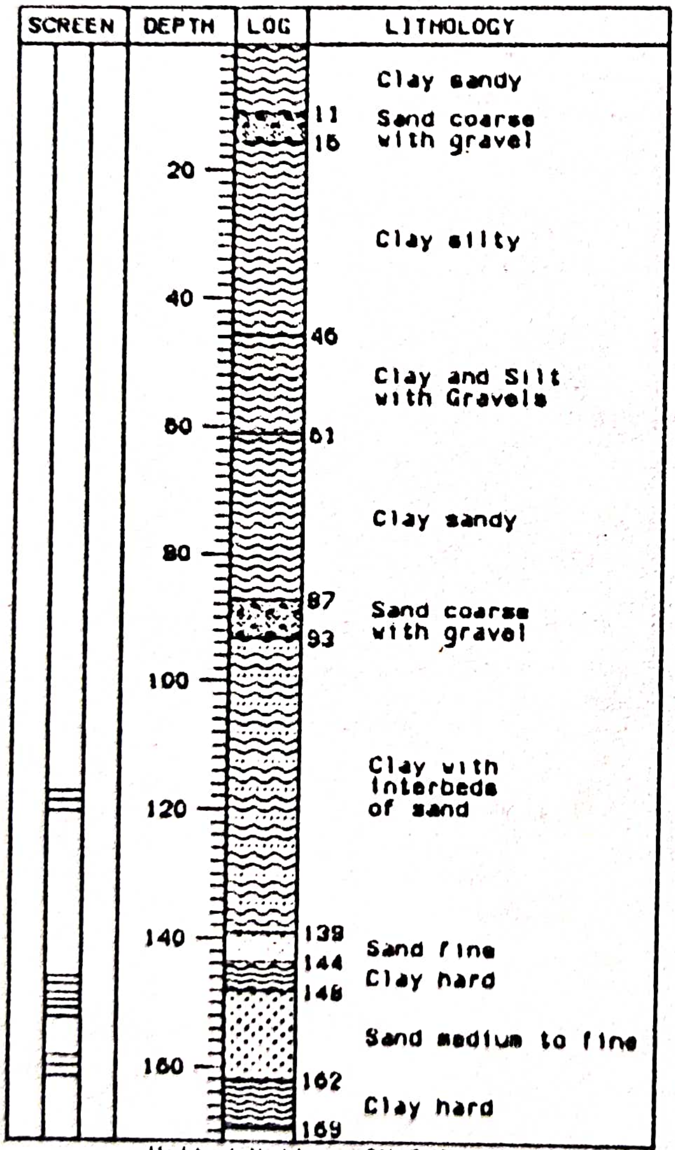
Capacity: 23.4 l/s

B-36: Well log GW 10

Well No GW 14	Location: URMA (1)
Elevation: 170	X = 470100 Y = 3178650
Method of Drilling: RIG	
Drilling Dates :	
Total Depth : 169 50	

Comments : Well Size 10"/6"
Screen Position. 117.4 - 120.4 m
146.3 - 152.4 m
158.5 - 161.6 m
Drilled under GWRDB/USAID Project

W E L L   L O G



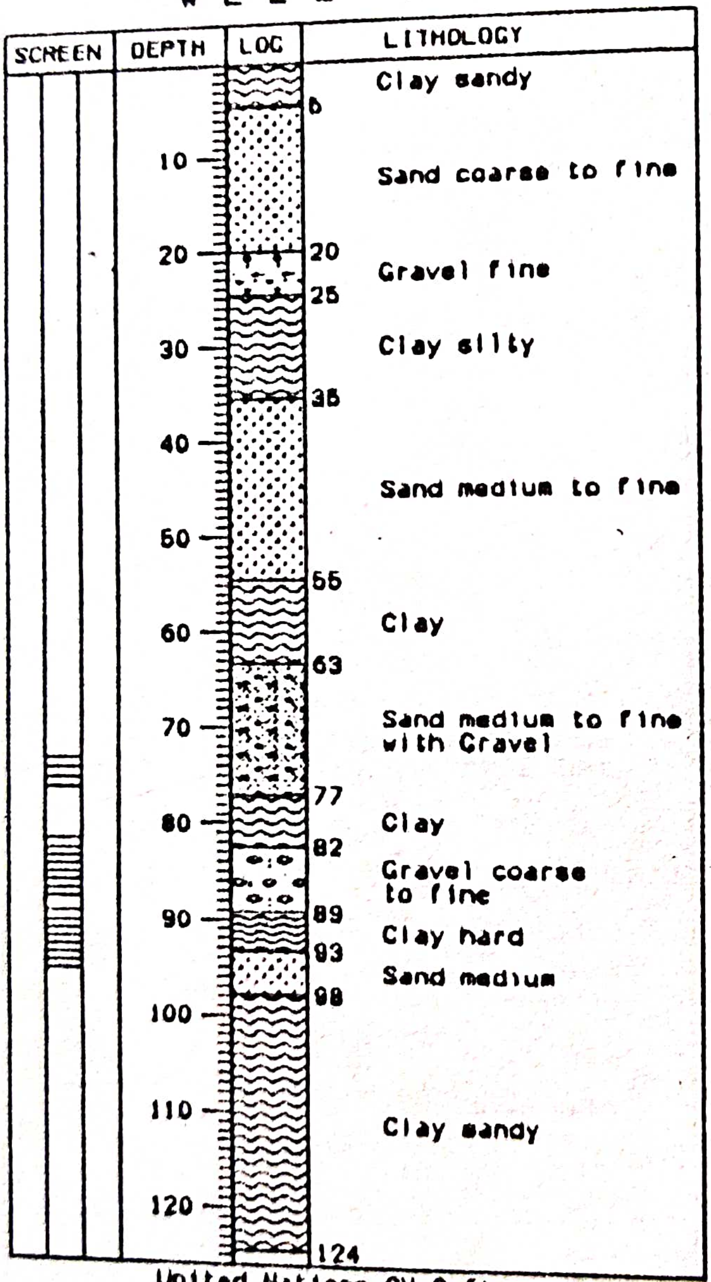
United Nations GW Software

B-37: Well log of GW 14

Well No. GW 15	Location: SAMACRAURE
Elevation: 169	X = 476600 Y = 3171500
Method of Drilling: RIG	
Drilling Dates :	
Total Depth : 124.40	

Comments : Well Size: 10"/6"
Screen Position: 73.2 - 76.2 m
81.7 - 87.8 m
89.3 - 95.4 m
Drilled under GWRDB/USAID Project

WELL LOG

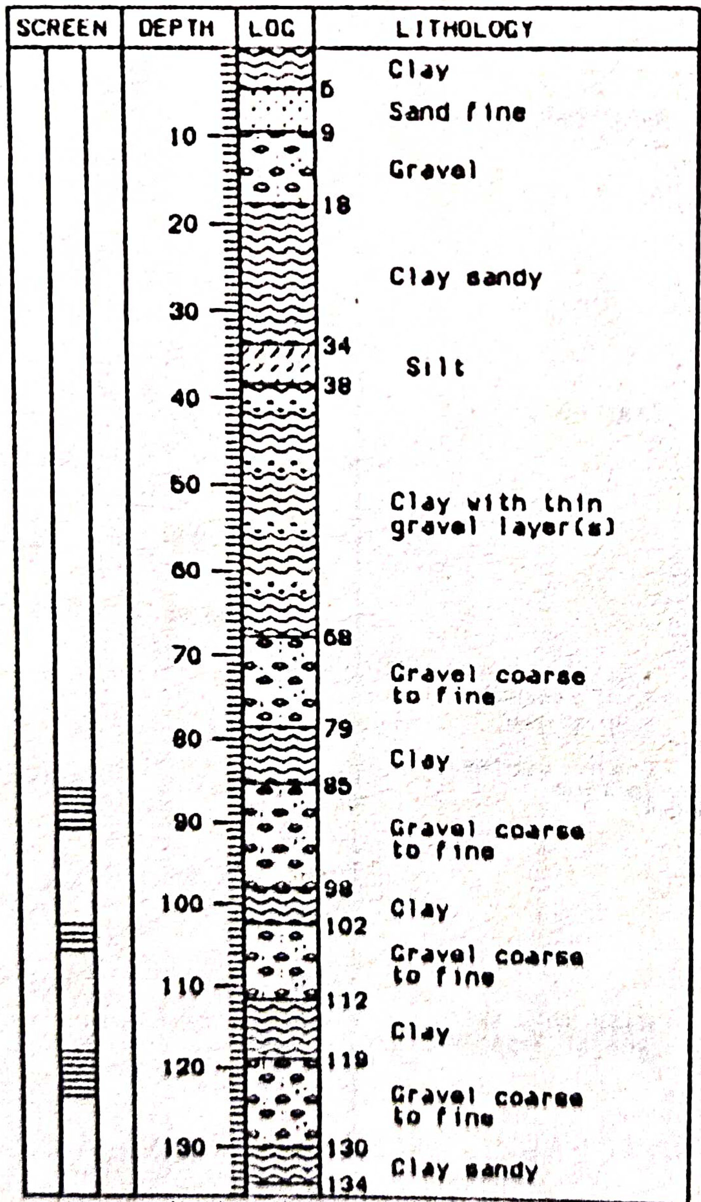


United Nations GW Software

B-38: Well log of GW 15

Well No. GW 18	Location: UDASHIPUR (1)
Elevation: 190	X = 481150 Y = 3180650
Method of Drilling: RIG	
Drilling Dates :	
Total Depth : 134 50	
Comments : Well Size 10"/6" Screen Position 86.3 - 90.9 m 102.7 - 105.8 m 118.3 - 123.8 m Drilled under GWRDB/USAID Project	

WELL LOG



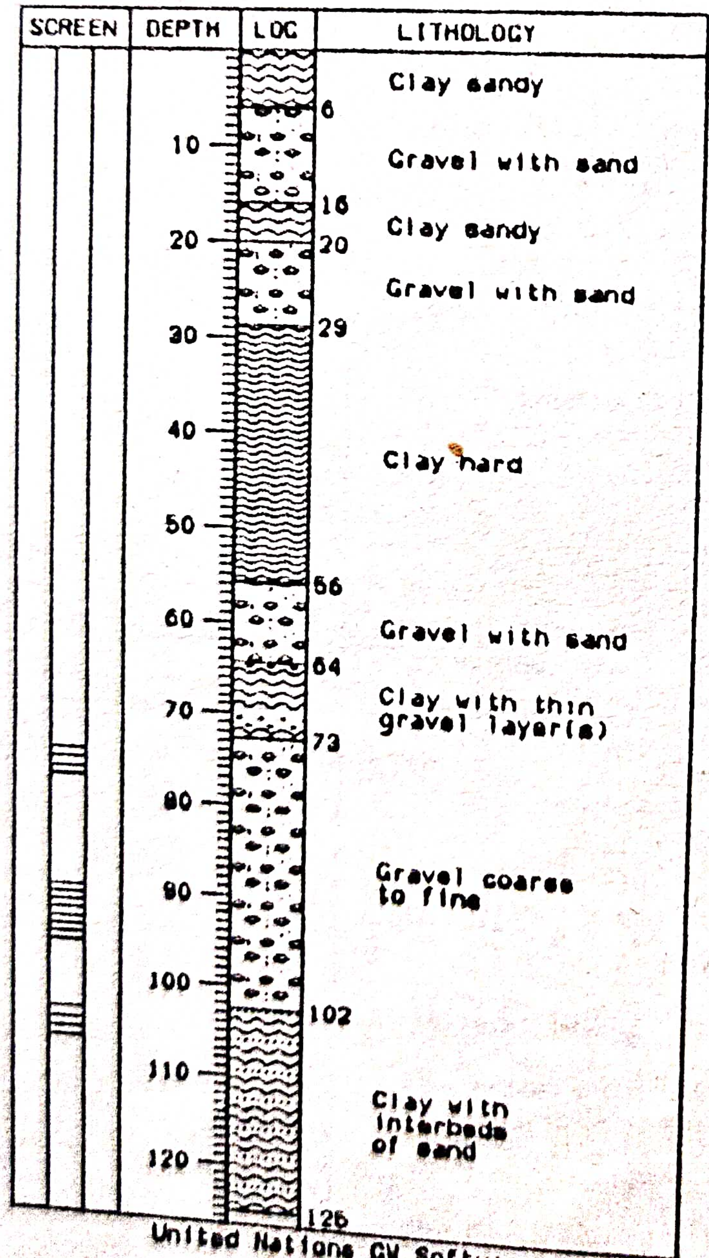
United Nations GW Software

B-39: Well log of GW 18

Well No. GW 20	Location: UDASI
Elevation: 190.9	X = 473000 Y = 3181650
Method of Drilling: RIG	
Drilling Dates :	
Total Depth : 125.30	

Comments : Screen Position 74.7 - 77.7 m
89.9 - 96.0 m
103.6 - 106.7 m
Drilled under GWRDB/USAID Project

WELL LOG



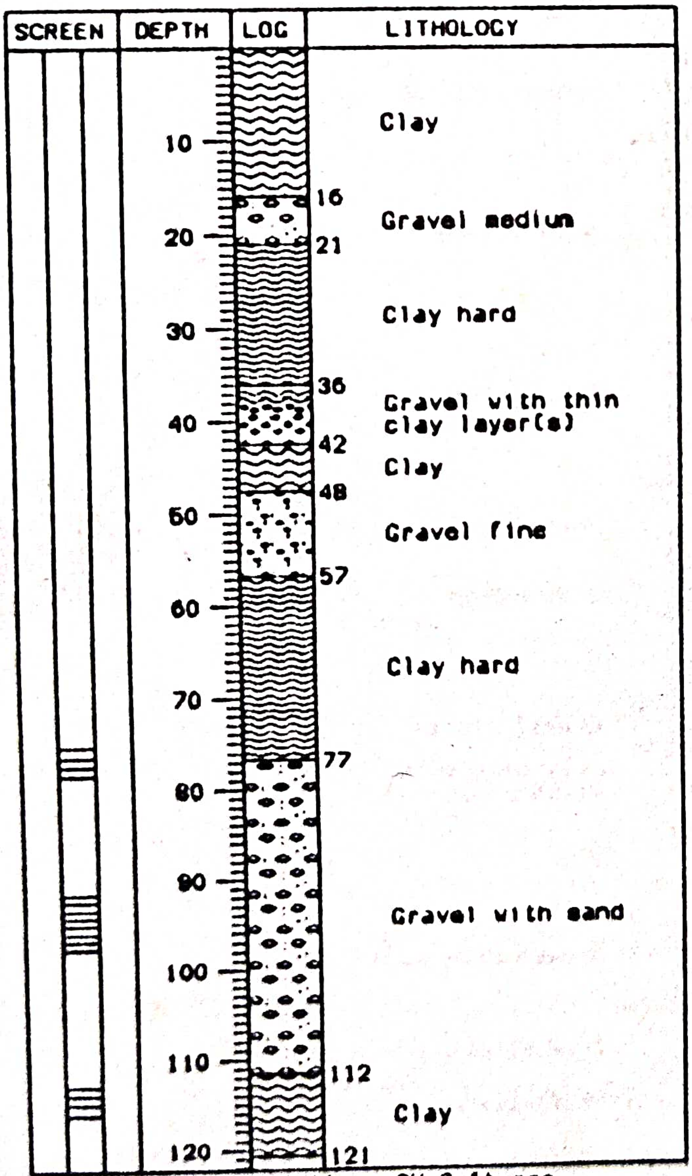
United Nations GW Software

B-40: Well log of GW 20

Well No GW 22	Location: DAMAULIA
Elevation: 190	x = 467000 Y = 3184900
Method of Drilling: RIG	
Drilling Dates :	
Total Depth : 120.70	

Comments : Well Size: 10"/6"
Screen Position: 75.3 - 78.4 m
91.5 - 97.6 m
112.8 - 115.9 m
Drilled under GWRDB/USAID Project

W E L L L O G

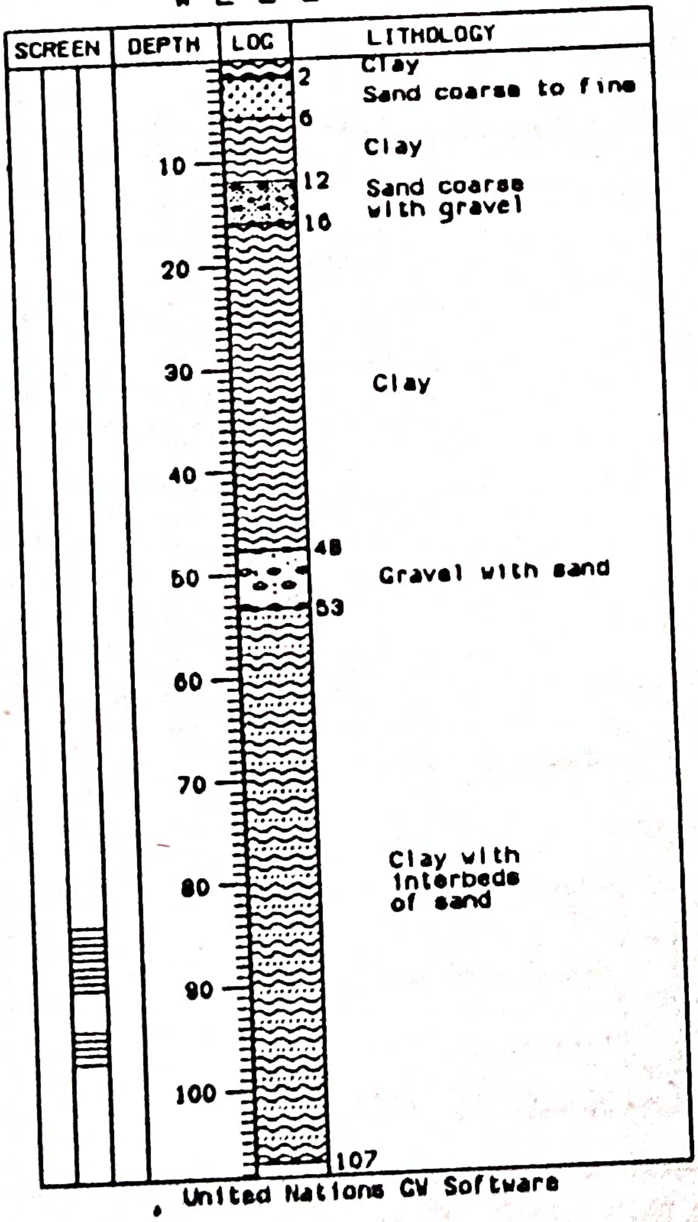


United Nations GW Software

B-41: Well log of GW 22

Well No GW 26	Location: BOARDING SCHOOL
Elevation: 173	X = 465600 Y = 3176650
Method of Drilling: RIG	
Drilling Dates :	
Total Depth : 107.00	
Comments : Screen Position: 83.8 - 89.9 m 93.9 - 96.9 m Drilled under GWRDB/USAID Project	

W E L L   L O G

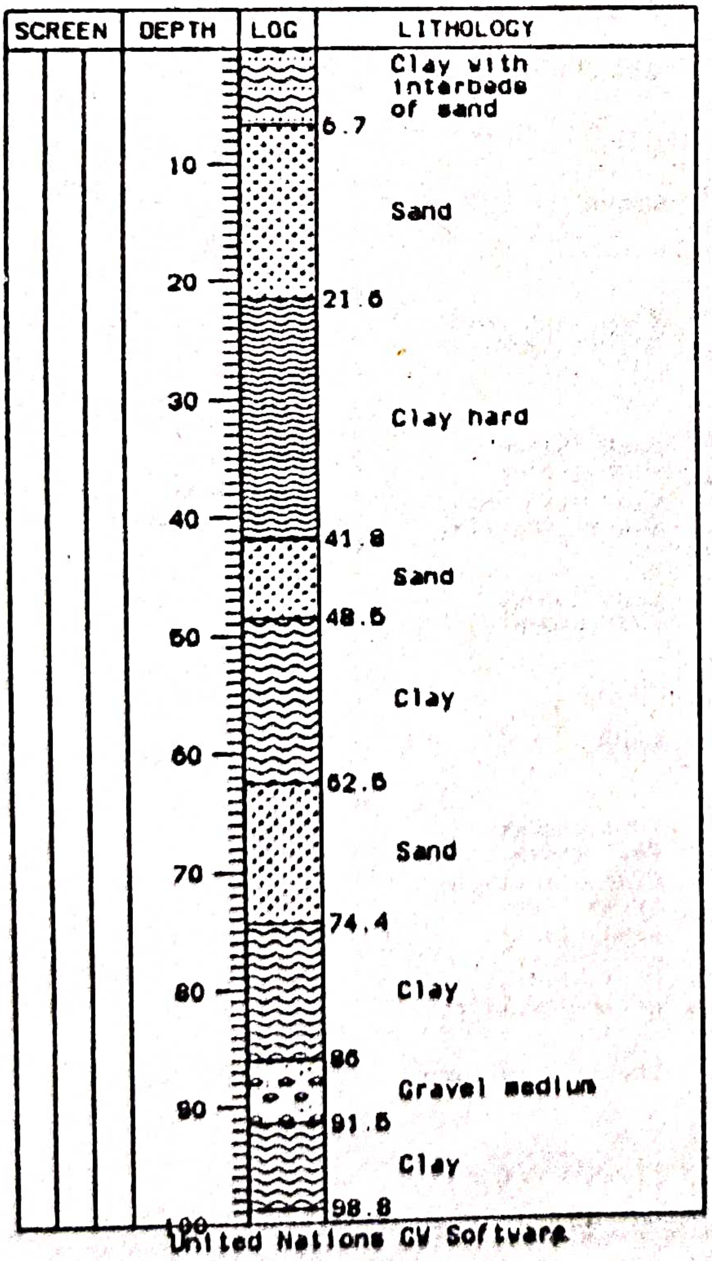


United Nations GW Software

B-42: Well log of GW 26

Well No GW 27	Location: JUGEDA
Elevation: 160	X = 466300 Y = 3170000
Method of Drilling: RIG	
Drilling Dates :	
Total Depth : 98.80	
Comments : Drilled under GWRDB/USAID Project	

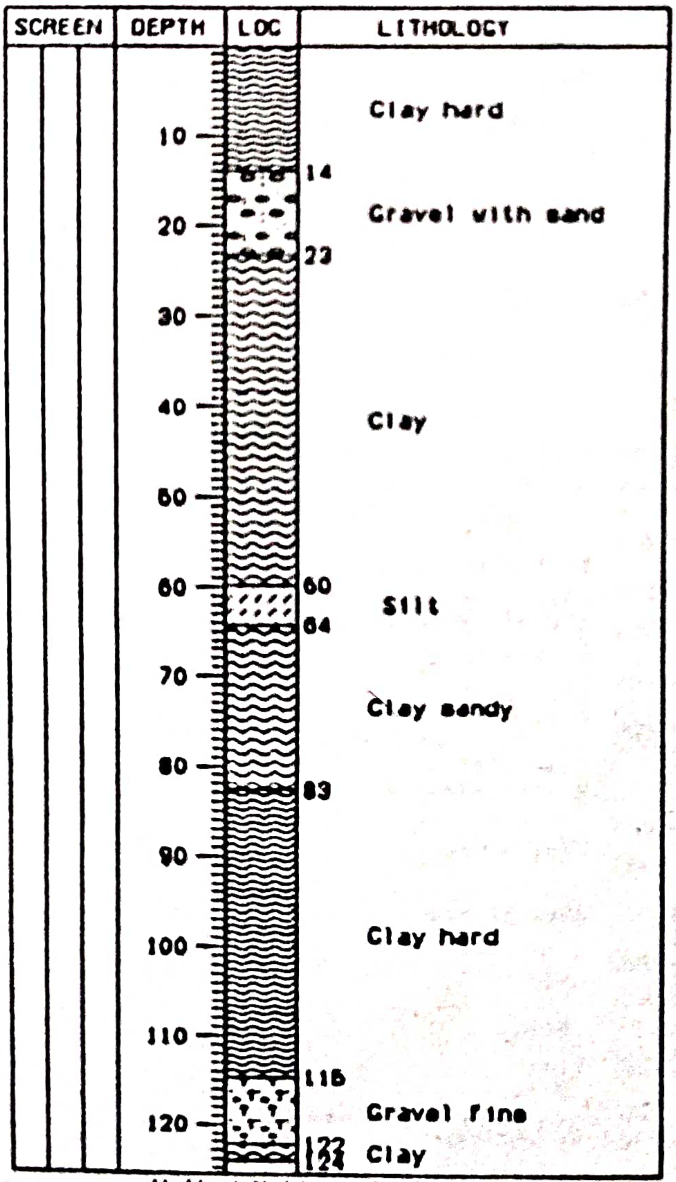
W E L L   L O G



B-43: Well log of GW 27

Well No. GW 32	Location: AMBASA
Elevation: 172	X = 492350 Y = 3171250
Method of Drilling: RIG	
Drilling Dates : 29 5 78 - 3 6 78	
Total Depth : 124 10	
Comments : Drilled under GWRDB/USAID Project	

WELL LOG

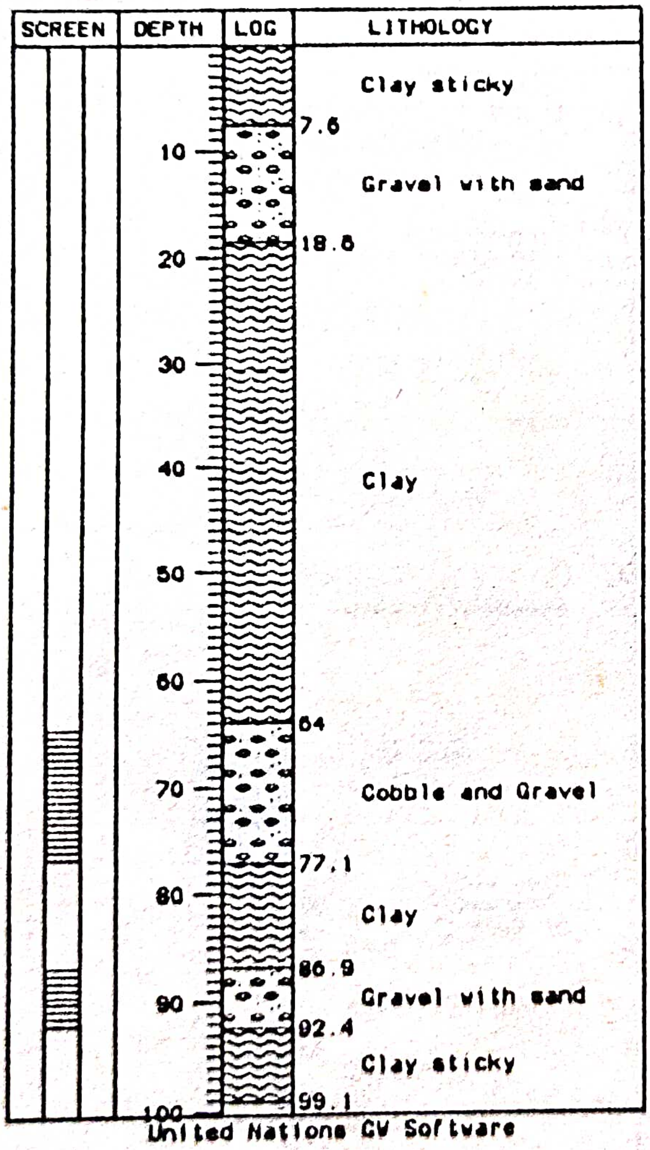


United Nations GW Software

B-44: Well log of GW 32

Well No. GW 44	Location: JHALARI
Elevation: 180	X = 461800 Y = 3180000
Method of Drilling: RIG	
Drilling Dates : 8 8 79 - 19 8 79	
Total Depth : 99 10	
Comments : Well Size: 12"/8" Screen Position. 64.6 - 76.8 m 86.9 - 92.1 m Drilled under GWRDB/USAID Project	

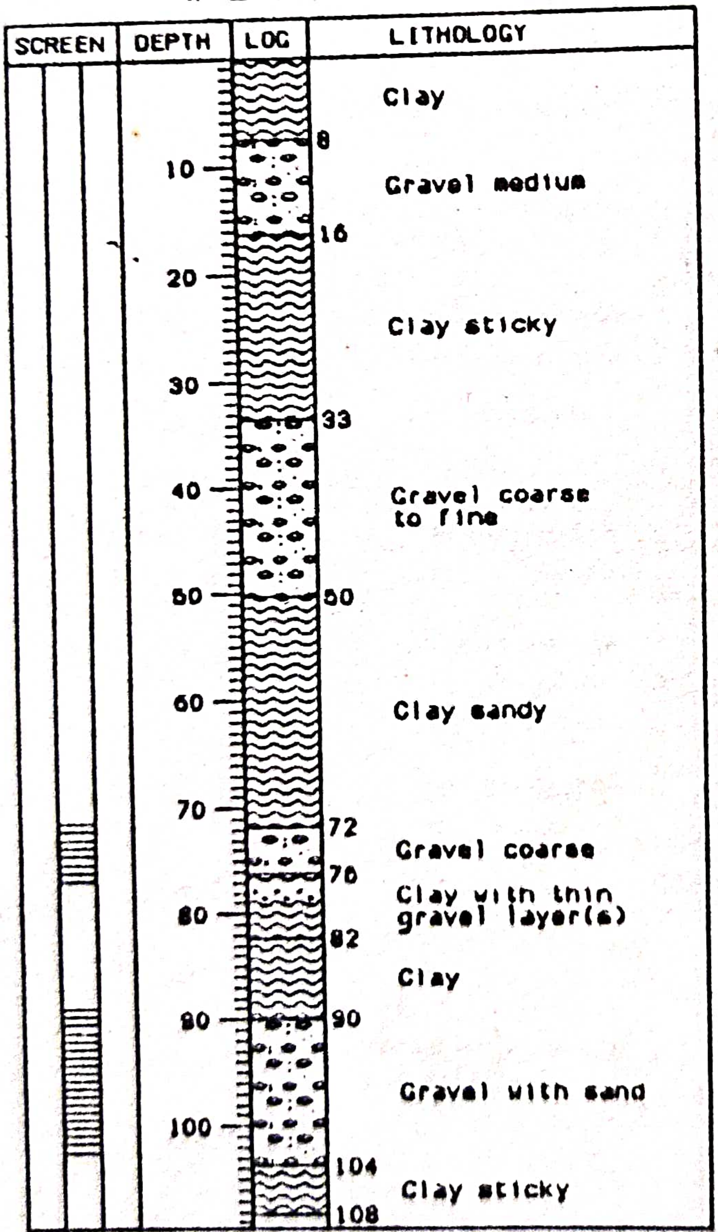
W E L L   L O G



B-45: Well log of GW 44

Well No. GW 47	Location: MASURIA
Elevation: 180	X = 487100 Y = 3177750
Method of Drilling: RIG	
Drilling Dates : 24 2 80 - 2 3 80	
Total Depth : 108 20	
Comments : Well Size: 12"/8" Screen Position: 71.3 - 76.8 m 89 0 - 102.4 m Drilled under GWRDB/USAID Project	

W E L L   L O G



United Nations GW Software

B-46: Well log of GW 47

Well No. GW 56

Location: BASANTA

Elevation: 159 1

X = 484400 Y = 3157500

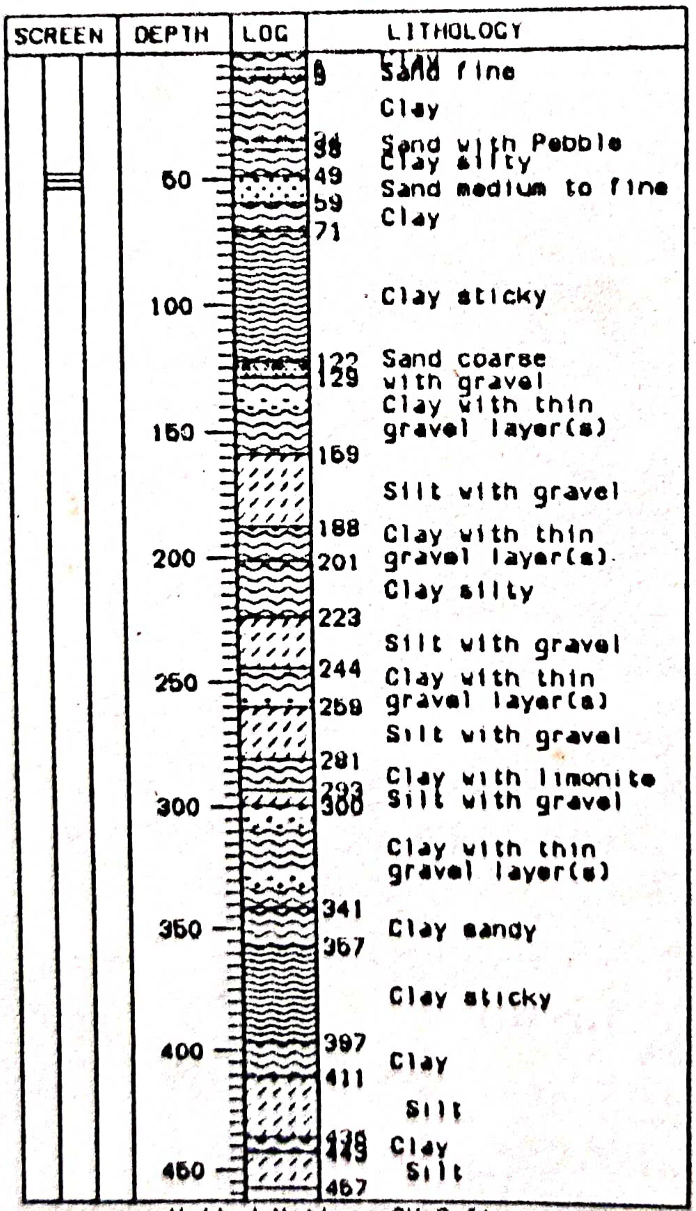
Method of Drilling: RIG

Drilling Dates : 23 5 74 - 29 3 74

Total Depth : 457 50

Comments : Well Size 6"/4"
Screen Position: 47.3 - 53.4 m
Drilled under N.B. Tubewells

WELL LOG

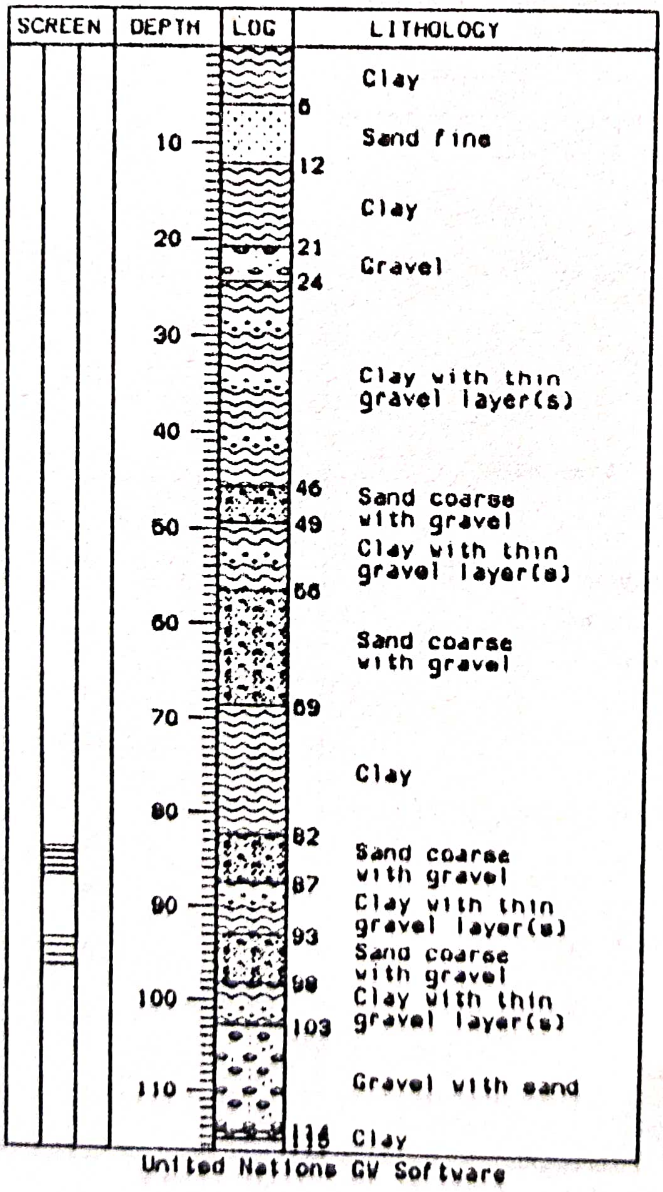


United Nations GW Software

B-47: Well log of GW 56

Well No. US 3/3	Location: BIJAYAPUR
Elevation: 160	X = 487500 Y = 3165000
Method of Drilling: RIG	
Drilling Dates : 15 4 74 - 17 4 74	
Total Depth : 115.20	
Comments : Well size 6/4" Screen position: 83.8-86.9, 93.6-96.6 m Drilled under USAID/HMG Project	

WELL LOG



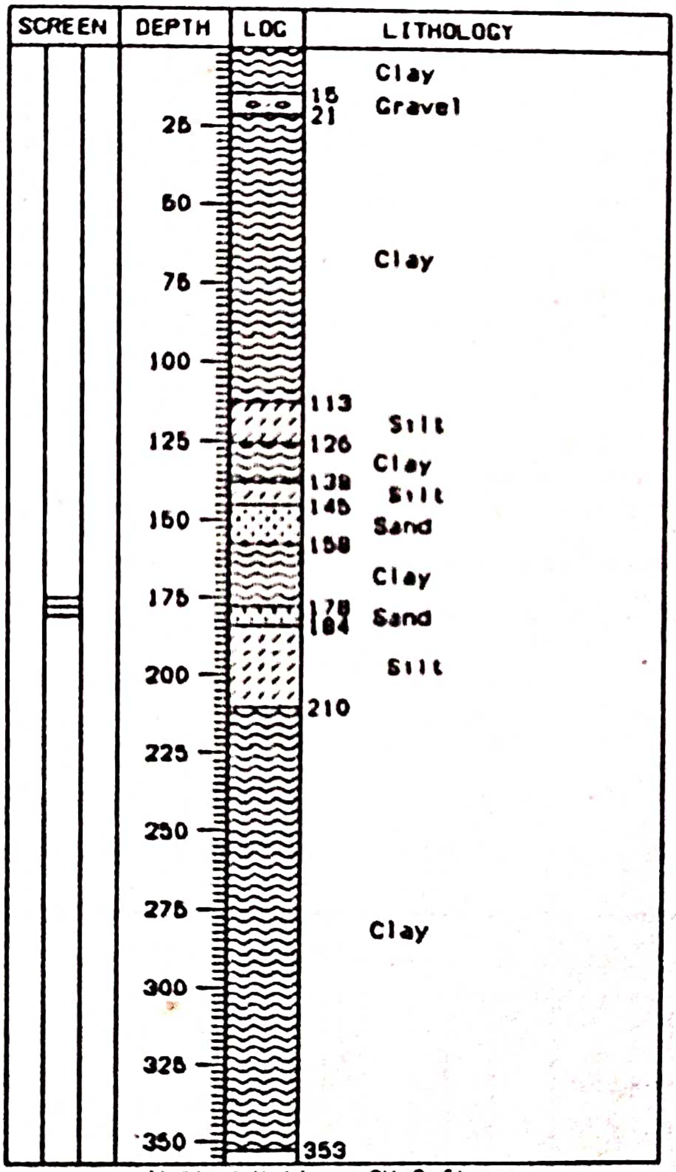
PUMPING TEST

Capacity: 4.3 l/s
SWL. -1.8 m

B-48: Well log of US 3/3

Well No. US 3/5	Location: SISAIYA
Elevation: 172	X = 486900 Y = 3172200
Method of Drilling: RIG	
Drilling Dates: 14 4 74 - 19 4 74	
Total Depth: 352 90	
Comments: Well size: 6/4" Screen position 175.3 - 181.4 m Drilled under USAID/HMG Project	

W E L L   L O G



United Nations GW Software

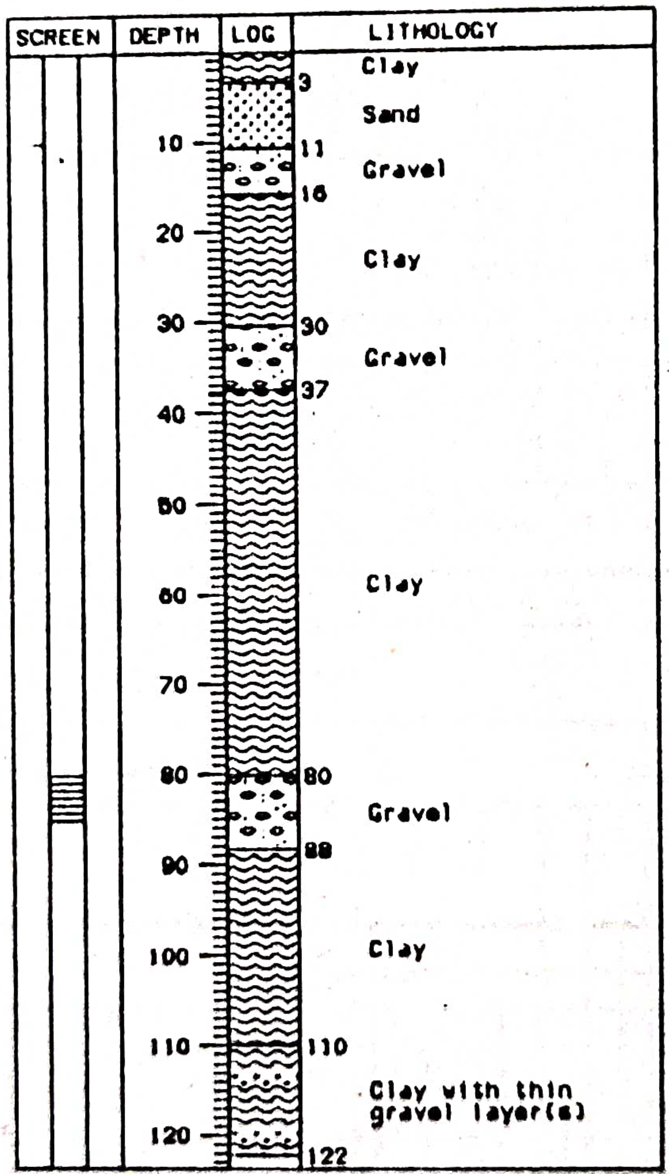
PUMPING TEST

Capacity: 4.7 l/s
SWL: +13.5 m

B-49: Well log of US 3/5

Well No. US 3/8	Location: GANESHPUR
Elevation: 185	X = 491200 Y = 3179000
Method of Drilling: RIG	
Drilling Dates : 18 4 74 - 21 4 74	
Total Depth : 122 20	
Comments : Well size 6/4" Screen position 80.2 - 85.1 m Drilled under USAID/HMG Project	

WELL LOG



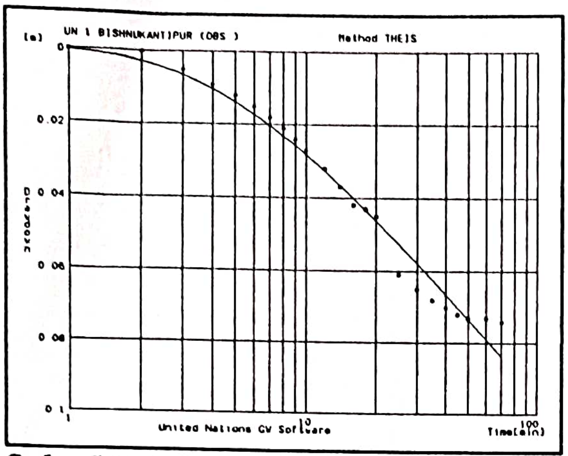
United Nations GW Software

PUMPING TEST

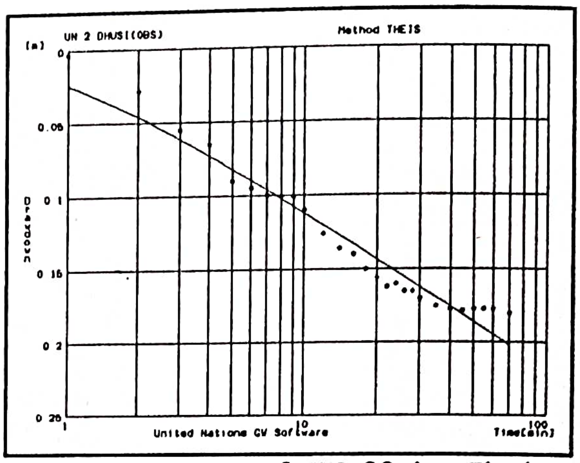
Capacity. 12.2 l/s
SWL. +18.6

B-50: Well log of US 3/8

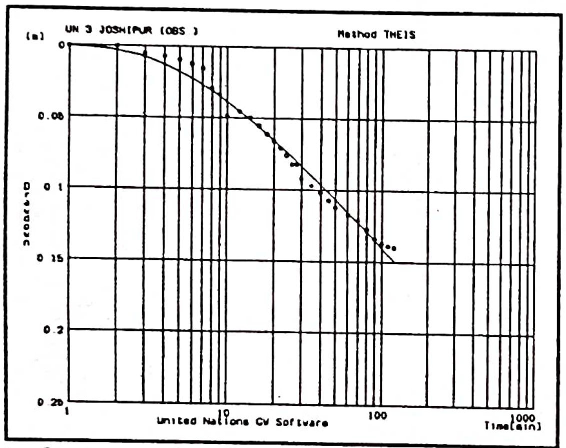
APPENDIX C
PUMPING TEST GRAPHS



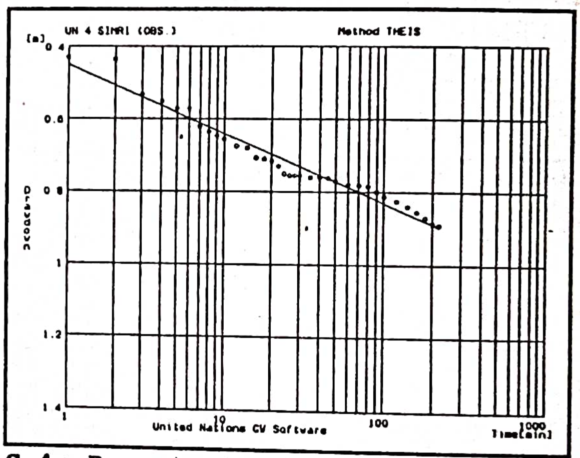
C-1: Pump test of UN 01 by Theis



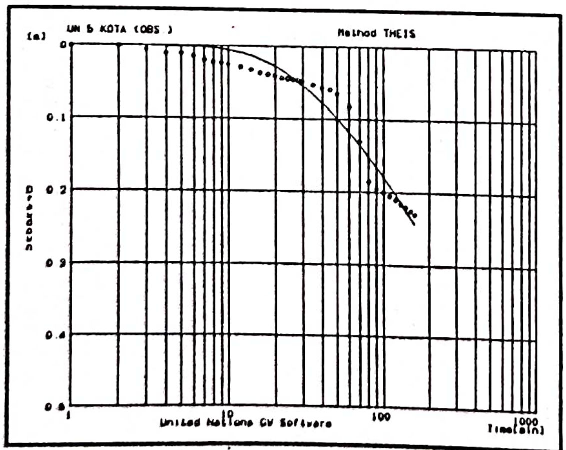
C-2: Pump test of UN 02 by Theis



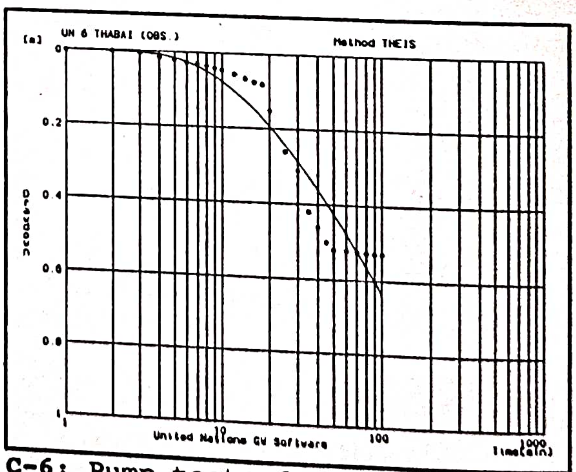
C-3: Pump test of UN 03 by Theis



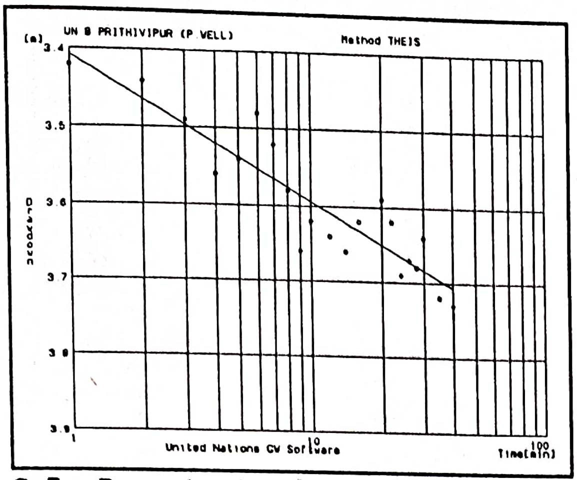
C-4: Pump test of UN 04 by Theis



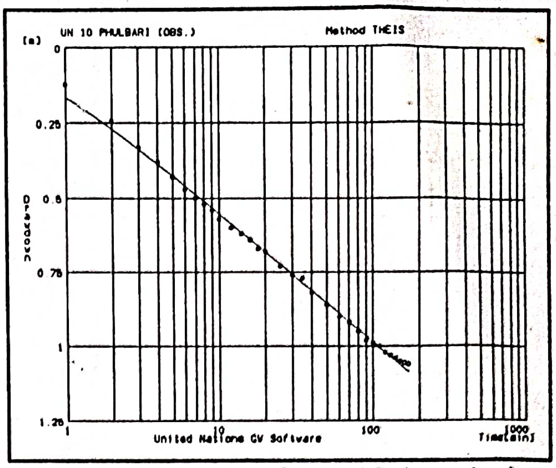
C-5: Pump test of UN 05 Theis



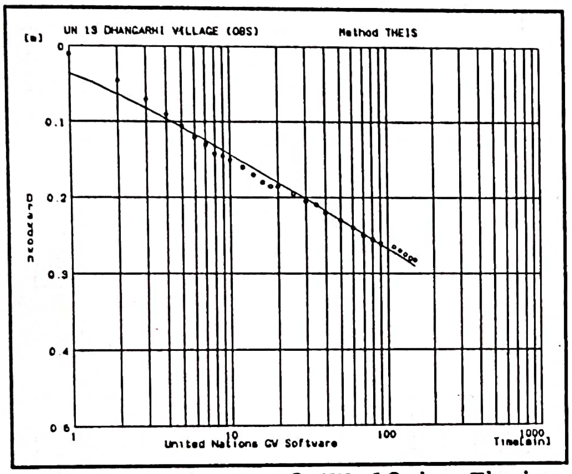
C-6: Pump test of UN 06 by Theis



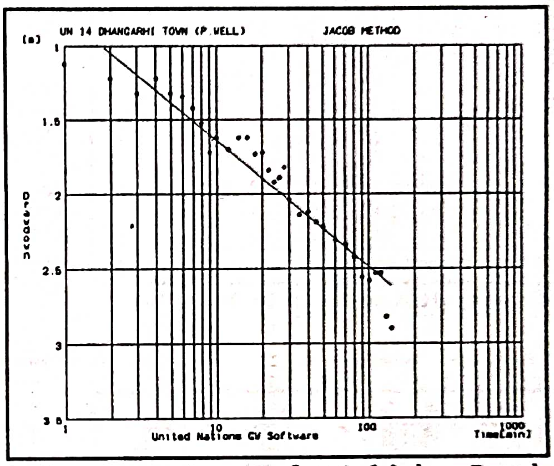
C-7: Pump test of UN 08 by Theis



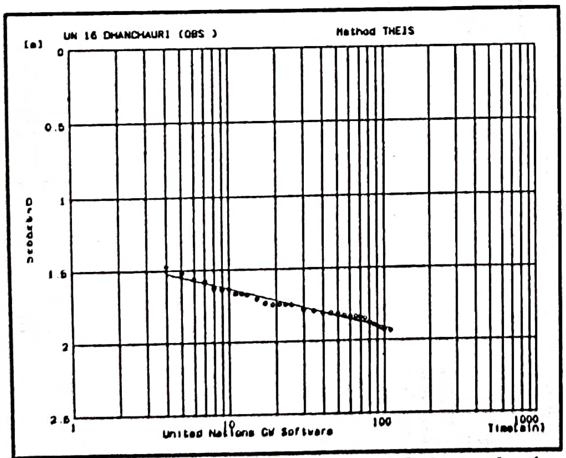
C-8: Pump test of UN 10 by Theis



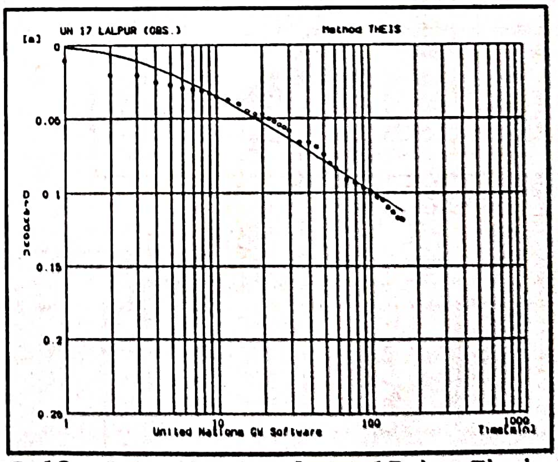
C-9: Pump test of UN 13 by Theis



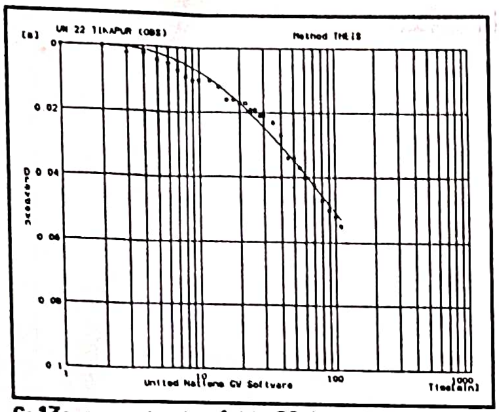
C-10: Pump test of UN 14 by Jacob



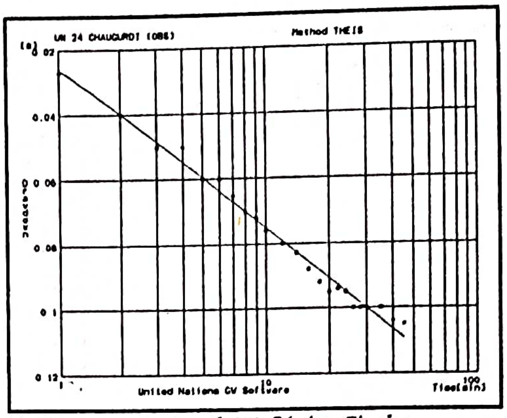
C-11: Pump test of UN 16 by Theis



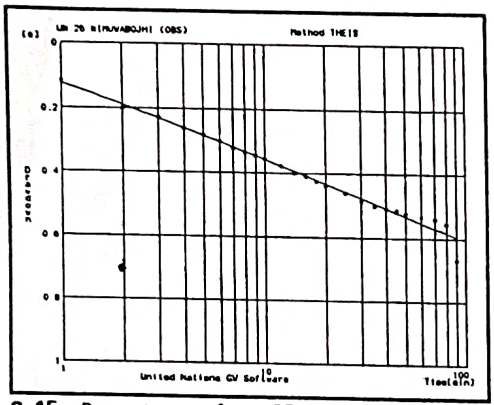
C-12: Pump test of UN 17 by Theis



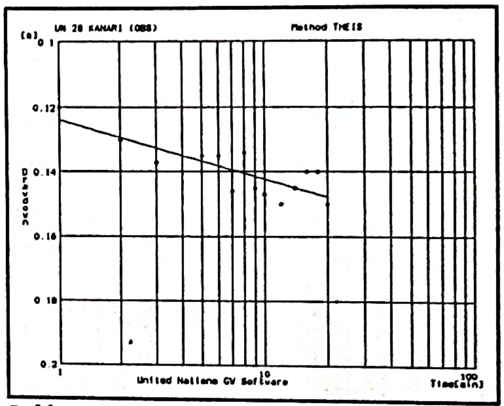
C-13: pump test of UN 22 by Theis



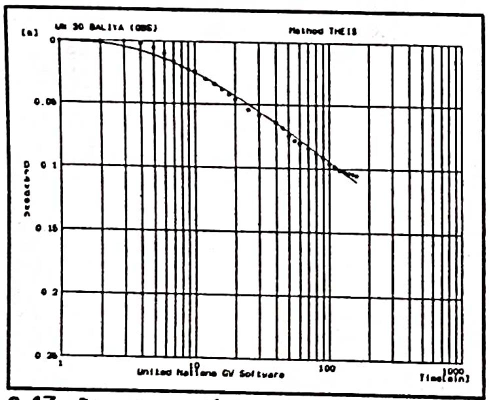
C-14: Pump test of UN 24 by Theis



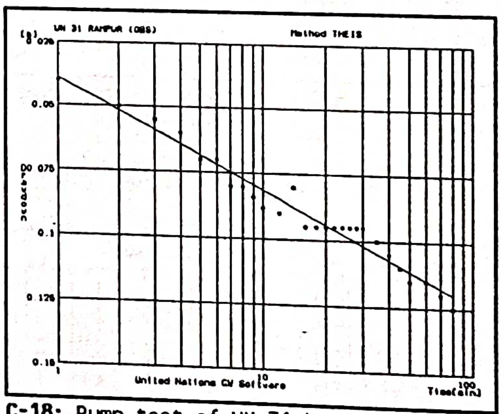
C-15: Pump test of UN 25 by Theis



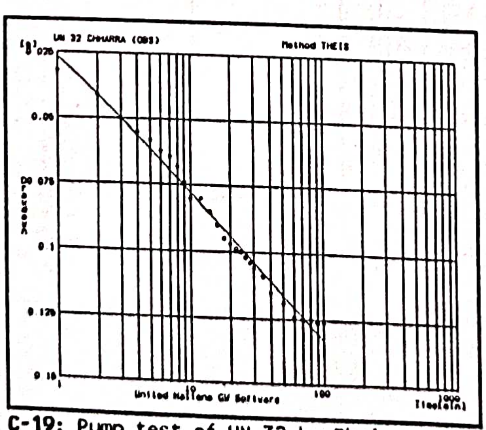
C-16: Pump test of UN 28 by Theis



C-17: Pump test of UN 30 by Theis



C-18: Pump test of UN 31 by Theis



C-19: Pump test of UN 32 by Theis

APPENDIX D

D-1: Monthly Water Level Measurement Data in Dug wells and Private STWs in Kailali District

S. No	Village Name	X	Y	Elev. MSL (m) #	M.P. (m)	Year	Water Level Measurements in meters (BGL)											
							JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	AMAURA	514125	3164000	165	0.80	1987							2.8				3.7	
						1988			4.7		5.0		4.7	4.3	3.8	3.1	2.7	2.7
						1989	3.4	2.8	3.3	4.6	4.1	2.9	3.1	2.7	2.1	2.7	2.8	3.0
						1990	3.1	3.1	3.1	3.2	3.2	2.2	1.2					
2	*AMBASA	489375	3172250	172	0.25	1987							4.0		2.2		4.1	
						1988	4.6		5.1		5.4		5.5	4.0	3.0	3.9	4.3	
						1989				4.2								
3	AILANIGARHI	454000	3192500	220		1987							12.4		9.0		10.8	
						1988	11.6		12.4		12.6		12.2	10.4	8.9	8.7	9.3	
4	ATARIA	456750	3185880	190	0.80	1987					3.9		2.1		2.2		3.8	
						1988	4.4		4.9		6.0		5.0	3.4	1.4	1.5	1.9	1.6
						1989	2.4	2.5	3.0	3.6	2.8	4.4	2.8		2.9	2.9	3.1	2.6
						1990	3.9			4.3	4.5	4.4	3.1	2.7	3.0	3.2		4.0
						1991		4.2	4.3	4.4	4.5	4.6	3.8	2.9	3.0	3.2	3.6	
5	*BADHARA	456500	3175500	171	0.60	1987							3.1		3.3		3.8	
						1988	4.2		4.4		4.2		4.4	3.8	2.8	2.9	3.2	3.5
						1989								1.3	2.8	3.4	3.6	3.7
						1990	3.6		4.1	4.3	4.4	4.0	2.6	2.4	2.7	2.8		3.7
						1991	4.0	4.0	4.3	4.4	4.5	4.5	3.7	2.6	2.6	2.7	3.1	
6	BANBEHRA	468375	3186130	192	0.65	1987							0.9		0.8		1.1	
						1988			1.6		1.7		0.0	1.2	0.9	0.8	1.1	
						1989												
7	BHADA	474625	3174630	171	0.90	1987					6.4		0.7		0.9		1.8	
						1988	2.3		2.7		3.0		2.6	1.2	0.9	1.4	1.8	
						1989		2.8				1.6			1.1	1.2	1.8	1.9
						1990	2.1	1.8	1.7	2.5	2.6	2.3						
8	BHAGAURA	514875	3166880	178	0.65	1987							4.8		3.4		4.2	
						1988			4.2		4.4		4.2	3.9	3.1	3.4	3.6	4.6
						1989	5.3	5.1	5.5	6.1	6.0	5.7	5.3	4.8	4.2	4.3	4.5	4.5
						1990	4.7	4.5	5.1	5.4	5.1	5.6	4.4		2.6	3.2	3.9	4.4
						1991	4.5	4.2	4.7	4.7	5.1		4.9	3.8		3.8	4.1	
9	*BHAJNI	497750	3153380	152	0.80	1987					3.1		3.2		4.0		4.3	
						1988	4.7		4.6		4.8		2.1	2.1	2.4	2.6	1.9	2.3
						1989	3.0	2.3	2.5	2.8	2.4	1.5	1.0	0.6	0.4	4.8	1.3	1.5
						1990	1.6	1.4	1.4	1.7	1.6	1.5	0.4	0.3	0.7	0.8		
10	BELADEVIPUR	462625	3180750	182	0.90	1987							1.9		1.8		2.2	
						1988	2.6		3.1		3.4		3.8	2.8	1.2	1.4	1.6	2.3
						1989	2.9	3.8	4.3	4.4	4.0	2.3	2.0		1.1	2.8	3.3	
						1990	3.6	6.5	4.2	2.5	2.4	2.4	2.0	1.3	2.5	1.6	2.5	2.4
						1991	2.0	2.9	3.1	3.2	3.9	3.9	2.4	1.5	0.6	2.2	2.9	
11	CHARRA	493750	3150880	150	0.85	1987												
						1988					5.6		6.0	4.5	3.3	3.6	4.0	6.0
						1989			5.9	6.4	4.7	5.7	5.5	3.0	4.5	3.2	3.8	4.2
						1990	4.3	4.5	4.8	5.2	5.2	5.3	4.2	4.1	2.7	3.0		
12	CHAUMALA	472500	3182380	190	0.75	1987					7.0		3.4		4.9		6.3	
						1988	6.8		7.2		7.3		6.2	5.8	5.2	5.0	5.4	
						1989		7.3	5.7	7.6		7.2	6.0	5.6	5.2	5.9	6.1	6.2
						1990	6.4	7.2	6.6	6.7	6.5	6.3	5.4					

* = Private STW, X & Y = Landsat Coordinates, m = meter, # = elev. from topomap BGL = Bellow ground level

App. D-1...cont.

S. No	Village Name	X	Y	Elev. MSL (m)	M.P. (m)	Year	Water Level Measurements in meters (BGL)											
							JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
13	CHUKA BINAULI	480125	3166630			1987							2.8		2.0		3.0	
						1988	3.6		4.0		4.3		4.3	3.8	3.0	2.2	3.1	
						1989												
14	*DHANGARHI	461125	3175750	171		1987							2.3		2.6		4.2	
						1988			4.1		5.0		4.7	3.3	2.1	2.7	4.2	
						1989									2.5	3.4	4.0	4.2
						1990	4.5	4.4	4.8	5.1	5.1	5.2	3.5		3.8	4.0	4.4	4.6
15	*DODODHARA	507750	3168000	178	0.55	1987							0.7		1.7		3.0	
						1988	3.4		3.9		4.8		4.4	3.7	3.5	3.2	2.8	4.4
						1989	5.9		3.7	3.8	3.7	2.6	3.2	2.9	2.1	2.6	2.8	3.1
						1990	3.5	1.6	2.5	2.6	2.9	3.4	2.0					
16	DURGAULI	511250	3159630	162	0.85	1987					4.0		3.8		2.0		3.9	
						1988			4.2		4.3		4.1	2.9	1.9	1.6	3.2	4.2
						1989	4.8	4.2	4.4	4.6	3.5	2.3	3.4	2.5	2.4	3.0	3.1	3.4
						1990	3.6	3.6	3.4	3.5	3.5	3.4	2.2					
17	GANJAWA	493750	3157000	155	0.80	1987							4.1		5.6		7.2	
						1988	7.3		8.2		8.4		8.3	6.3	3.7	3.9	5.1	5.1
						1989	5.8	7.5	7.0	5.4	7.4	7.3	3.9	5.2	2.8	2.9	4.3	4.8
						1990	5.3	5.6	6.6	6.6	6.7	6.6	5.2					
18	GOVINDAPURWA	475375	3167630	160	0.70	1987							3.0		2.8		3.6	
						1988	4.0		4.2		4.3		4.1	3.0	1.4	1.8	2.6	
						1989		4.8				3.4			2.8	2.9	3.2	3.5
						1990	3.8	4.3	3.8	4.0	4.1	4.2		2.2	2.7	3.1	3.4	3.5
						1991	3.6	3.8	4.2	4.0	4.1	4.2	2.3	2.2	2.4	2.5	2.9	
19	GULARA	509500	3169250	185	1.11	1987							0.5		2.8		5.2	
						1988	6.1		6.2		6.4		5.8	3.2	2.9	4.3	5.1	6.3
						1989	7.1		6.3	4.2	5.8	5.9	5.1	4.7	4.1	4.6	5.3	5.4
						1990	5.5	5.4	4.0	5.5	5.5	5.5	3.0		5.0	5.8	5.8	5.8
						1991	6.0	6.0										
20	HARAIYA	461875	3187380	205	0.90	1987					3.7		2.6		2.7		2.9	
						1988	3.3		3.5		3.7		3.4	2.9	2.1	2.2	2.4	2.5
						1989	3.4	4.0	4.5	4.8	4.2	3.1	2.4		0.5	2.5	2.6	2.7
						1990	2.9		2.9	3.3	3.4	3.3	2.3	2.1	2.2	2.3		2.4
						1991	2.9	3.0	2.9	3.0	3.5	3.6	2.7	2.2	2.2	2.3		
21	HASULIA	481625	3160750	155	1.05	1987					4.5		1.2		1.0		2.1	
						1988	3.4		3.7		3.0		3.6	3.1	2.1	2.5	3.1	2.8
						1989	3.4	3.6			3.5	3.4			2.1	2.1		2.9
						1990	3.0	2.0	2.4	2.6	2.7	2.7		2.2	2.3	2.9	3.9	2.7
						1991		3.3	3.3	3.2	3.6	3.4	2.8	1.9	2.1	2.2	2.7	
22	JOSHIPUR	502875	3159630	158	0.55	1987					4.0		2.3		2.6		3.3	
						1988	3.8		4.4		4.6		4.5	3.9	1.9	2.0	2.3	3.5
						1989	4.3	3.6	3.8	3.9	3.8	3.4	1.6	1.1	0.7			3.3
						1990	3.4	3.2	3.3	3.7	3.8	3.7	2.5					3.2
23	JHARAUKHA	489250	3176880	178	0.05	1987							2.1		1.2		1.5	
						1988	1.8		2.5		2.7		2.5	1.8	1.6	0.3	0.7	1.4
						1989	2.1	2.2	3.1		3.8	1.2	3.0	2.6	1.7	2.0	2.3	
						1990	3.0	3.2	3.3	3.4	3.1	3.1	1.5					
24	JUGERA	464500	3169880	165	0.85	1987					5.2		3.2		1.1		2.0	
						1988	2.6		3.1		3.2		3.1	2.7	2.0	1.5	1.8	2.4
						1989	2.7				4.1	3.1	2.9		0.8	1.0		1.8
						1990	2.0	1.5	1.9	2.3	2.4	2.4	1.6	1.4	1.5	1.6	1.7	1.8
						1991		2.4	2.5	2.6	2.8	2.9	1.7	1.4	1.4	2.5	1.6	

* = Private STW, X & Y = Landsat Coordinates, m = meter, # = elev. from topomap BGL = Bellow ground level

App. D-1...cont.

S. No	Village Name	X	Y	Elev. MSL (m)	M.P. (m)	Year	Water Level Measurements in meters (BGL)											
							JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
25	KATACHHE	519500	3162750	175	0.55	1987							1.4		2.4		4.1	
						1988			5.3		5.4		5.3	3.2	2.3	2.8	4.2	4.9
						1989	5.8	5.3	5.3	5.4	5.4	3.8	4.2	3.8	3.3	3.5	4.3	4.8
						1990	5.0	4.9	4.5	4.4	4.2	2.9	1.5					
26	KHAKRAULA	505500	3145500	148	1.05	1987					3.7		1.9		2.1		3.1	
						1988			3.8		5.0		3.9	3.5	3.2	2.8	2.3	2.8
						1989	3.5	4.3	4.4	4.5	4.1	2.0	3.2		2.4	1.4		2.1
						1990	2.3	3.0	3.0	3.6	1.9	1.8	1.4					
27	KHURKHURIA	477125	3176630	175	1.10	1987					4.6		2.3		2.3		3.1	
						1988	3.5		3.8		4.0			2.4	2.0	3.1	3.4	
						1989		6.7				2.1			1.5	1.8	2.6	3.0
						1990	3.4	3.1	3.5	3.9	3.2	3.6		2.0	2.3	2.7	2.8	2.9
						1991	3.3	3.6	3.7	3.8	3.9	4.3	3.6	2.1	2.3	2.5	2.9	
28	LALBHOJHI	497000	3149880	150	0.80	1987							4.7		2.7		5.4	
						1988	6.1		6.3		6.5			4.3	3.4	2.7	5.2	6.4
						1989	7.1		6.1	6.4	6.0	5.8	5.1	4.2	3.6	4.8	5.3	5.7
						1990	5.9	6.0	5.8	5.8	5.5	5.6	4.2					
29	LEKMA	483750	3178630	180	0.90	1987					6.1		1.6		2.2		3.9	
						1988	4.3		4.6		4.8		5.7	4.6	2.0	1.9	3.1	4.1
						1989	4.7	5.3	5.6	6.1		5.4	4.3	3.8	3.1	2.7	3.0	3.8
						1990	4.0	4.3	4.4	4.4	4.3	4.1	4.0	3.4	2.7	3.6	2.0	4.1
30	*MAINA POKHARI	500000	3177500	205	0.35	1987							2.9		4.0		5.3	
						1988	6.1		6.7		7.5		6.8	5.3	4.0	4.0	4.6	4.7
						1989	5.7	5.1	5.3	4.0	6.1	5.6	3.5	3.6	2.7	3.1	3.3	3.3
						1990	2.1	2.1	2.2	2.3	2.3	2.4	0.7					
31	MALAKHETI	453750	3189750	206	0.65	1987					3.6		4.9		2.2		2.7	
						1988	3.6		4.0		3.7		3.4	2.6	1.2	1.4	1.8	2.6
						1989	3.1	3.7	4.5	4.3	3.9	3.3	2.4		1.5	0.6	2.3	3.1
						1990	3.0		3.3	3.5	3.7	3.6	2.5	2.3	2.2	2.3		3.0
						1991	4.0	3.2	4.3	3.4	3.5	3.6	2.8	1.9	2.1	2.3		
32	MUNUWA	507625	3158000	156	1.05	1987							1.4		1.8		2.9	
						1988			3.0		3.2		3.0	2.5	2.0	1.7	2.8	2.7
						1989	3.2		4.0	4.2	3.5	2.2	2.7	2.4	2.0	2.6	2.9	3.1
						1990	3.2	3.3	3.3	3.4	3.4	3.5	2.0					
33	*NARAYANPUR	505500	3151000	152	0.65	1987							0.8		1.1		2.4	
						1988			3.6		3.9		3.8	3.3	3.0	2.4	2.7	3.1
						1989	3.8		3.8	3.7	3.6	2.5	2.8	2.4	2.4	1.8	2.3	2.5
						1990	2.7	3.3	3.4	3.5	3.0	2.5	2.2					
34	NIMDI	496125	3168130	168	0.65	1987							2.7		2.6		4.2	
						1988	4.7		5.1		5.3		5.1	3.3	1.5	5.3	4.9	3.7
						1989	4.4	5.7	6.2	7.3	7.2	5.1		4.4	5.2	4.9	5.1	5.1
						1990	5.3	5.2	4.2	3.9	4.0	3.9	2.4	2.5	2.8	2.9	3.1	3.5
						1991	3.6	3.9	3.9	5.0	5.5		5.4	4.4	2.6	3.6	4.4	
35	PATHRI	468250	3178000	176	0.75	1987							1.4		1.5		2.4	
						1988	2.8		3.2		3.5		3.3	2.7	1.5	1.2	1.8	
						1989		4.3				2.7			2.0	1.8	2.3	2.5
						1990	2.9	2.5	2.9	3.0	3.2	3.0	1.5	1.3	1.6	1.7	1.8	2.0
						1991	2.1	2.2	2.3	2.4	2.7	2.9	2.3	1.4	1.6	1.7		
36	PANCHMURIA	492750	3162750	160	0.95	1987							4.4		4.2		5.6	
						1988	6.0		6.3		6.6		6.4	5.3	4.6	4.9	5.2	5.9
						1989	6.4	6.2	6.2	6.2	5.7	5.4	4.9	3.4	3.6	3.7	4.8	5.6
						1990	6.1	6.2	4.5	4.6	4.4	4.3	3.1	3.0	1.7	1.8	3.5	3.5
						1991	3.7	3.9	4.1	4.3			4.7	4.1	0.8	0.9	3.3	

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App. D-1...cont.

S. No	Village Name	X	Y	Elev. MSL (m)	M.P. (m)	Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
							Water Level Measurements in meters (BGL)											
37	PHULBARI	471750	3163250	158	0.80	1987					6.7		3.2		2.8		3.0	
						1988	3.8		4.2		4.5		4.7	3.6	2.5	1.3	1.4	3.0
						1989	3.6	4.2			5.8	5.0			1.1	2.0		2.8
						1990	3.2	2.9	3.1	3.4	3.5	3.7						
38	*PRATAPPUR	508125	3164630	165	0.80	1987							1.9		2.4		3.1	
						1988			4.3		4.5		4.2	4.0	3.7	3.2	3.7	4.2
						1989	4.9		4.5	4.9	4.6	3.4		3.5	3.2	3.2	3.6	3.7
						1990	3.9	3.8	3.7	3.8	4.5	4.5	3.4		2.6	2.8	4.1	4.1
						1991	4.0	4.0	4.2	4.4	4.6		4.8	4.2	2.4	2.9	3.7	
39	PRITHVIPUR	482750	3171500	168	1.05	1987					6.4		3.7		3.6		5.3	
						1988	5.8		6.1		6.4		5.9	4.3	2.1	2.3	2.5	3.4
						1989	4.0	6.8	6.3	5.4		5.0	3.3	3.0	3.1	1.9	2.4	2.8
						1990	3.1	3.2	3.2	3.2	6.8	3.1	1.4	1.3	1.2	0.3		
40	RAJIPUR	478250	3181000	184	0.65	1987					4.6		1.7		1.7		2.8	
						1988	3.2		3.4		3.5		3.4	2.6	1.8	1.5	2.1	
						1989		3.6				2.4			1.8	2.0	2.6	3.0
						1990	3.1	2.4	3.0	3.2	3.4	3.5		2.1	2.3	2.5	2.6	2.8
						1991	2.9	3.1	3.2	3.3	3.4	3.7	3.2	2.2	2.3	2.3	2.7	
41	RAJPUR	457250	3181000	180	0.95	1987					4.0		1.5		1.6		2.7	
						1988	4.0		4.3		4.1		4.1	2.2	1.9	2.1	2.7	2.5
						1989	3.1	3.9			3.9	3.4			1.4	1.8	2.5	2.7
						1990	2.9	3.1	3.1	3.2	3.4	3.2	1.2	0.9	1.6	2.1		
						1991			2.1									
42	RAMPUR	486750	3155130	152	1.00	1987							2.9		2.5		3.9	
						1988	4.3		4.9		5.2		4.9					3.5
						1989	4.1	4.8			5.1	4.4			3.2	3.0	3.3	3.4
						1990	3.6	3.0	2.9		1.7	1.7						
43	SANDEPANI	498375	3171880	178	0.95	1987					6.4		1.4		2.1		3.3	
						1988	4.1		4.6		4.9		4.7	3.5	1.8	2.0	2.4	3.1
						1989	3.8	4.5	5.9	5.7			4.1		2.7	2.8	3.0	3.1
						1990	3.3	3.4	3.4	3.5	3.5	3.3	2.3	2.1	1.7	1.8	1.8	2.2
						1991	2.3	2.6	2.8	3.6	4.5		3.4	3.1	1.4	2.4	3.6	
44	SIMRI	502500	3165380	162	0.35	1987					2.7		0.1		0.7		0.4	
						1988	0.4		1.0		1.5		1.3	1.0	0.6	0.9	1.0	3.1
						1989	4.3		5.3	5.5	5.5	0.1	0.9	3.9	3.4	2.8	0.4	
						1990			0.9									
45	SHIVAPUR	484375	3174130	173	0.26	1987					7.0		3.7		3.4		4.1	
						1988			4.8		5.1		5.9	5.9	4.3	3.6	3.9	
						1989		4.6										
46	SHREEPUR	460875	3183750	188	0.90	1987					3.3		0.9		1.0		1.4	
						1988	2.4		2.7		3.0		2.9	2.4	1.1	1.1	1.5	2.9
						1989	3.5	2.3	2.6	2.9	2.2	2.2	0.4		0.5	2.8		1.2
						1990	2.3	0.9	1.3	1.6	1.6	1.3	1.1	0.5	0.6	1.0	1.1	1.3
47	TEGHARI	457000	3187500	202	0.80	1987					3.9		2.3		2.4		3.1	
						1988	3.7		3.9		3.9		3.5	2.4	1.6	1.7	1.9	2.9
						1989	3.6	4.0	4.3	4.6	4.2	3.2			1.4	2.1	2.4	3.3
						1990	2.3	2.5	2.9	3.3	3.4	3.4	2.2	2.2	2.3	2.4		
48	*TIKAPUR	513875	3152880	158	0.63	1987					4.0		0.9		0.7		2.4	
						1988			3.4		3.5		3.1	2.5	1.6	1.3	2.1	2.6
						1989	3.3	3.4	3.5	3.7	3.6	2.0	2.5	2.1	1.6	1.6	2.1	2.0
						1990	2.8	2.8	2.0	2.6	2.2	2.1	0.7	0.6				
49	URMA	469375	3173130	170	0.60	1987					2.4		1.6		1.4		2.6	
						1988	3.0		3.4		3.5		3.4	2.7	2.0	1.0	1.9	
						1989						3.0		1.1	2.4	3.4	3.6	3.7
						1990	3.7	3.8	4.1	4.8	4.9	4 8	2.8	2.4	2.7	2.9	2.3	2.6
						1991	2.7	2.9	3.9	3.1	3.3	3.4	2.6	2.1	2.1	2.3	2.3	

* = Private STW, X & Y = Landsa Coordinates, m = meter, # = elev. from topomap BGL = Bellow ground level

D-2: Monthly Water Level Measurement Data in Project STWs in Kailali District

Well No.	Village Name	X	Y	Elev. MSL (m) #	M.P. (m)	Year	Water Level Measurements in meters (BGL)											
							JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
UN 01	BISHNUKANTIPUR	507800	3149300	158		1989												
						1990	3.3	3.4	3.3	3.4	2.9	2.9	2.4	2.4	2.4	2.4	3.4	3.5
						1991	3.6	3.7	3.7	3.8								
UN 02	DHUSI	499000	3153600	160		1989												2.3
						1990	2.7	2.5	2.5	2.9	2.5	2.4	2.7	1.9	2.1	2.1	2.5	2.6
						1991	2.6	2.7	2.7	2.9	2.8		2.8	2.2	1.7	2.2	2.6	
UN 03	JOSHIPUR	502800	3159800	155		1989												2.7
						1990	2.7			3.1								
						1991				4.3		2.9	1.8		1.2			
UN 04	SIMRI	502600	3164600	162	0.42	1989							1.3	1.0	0.9	0.4	0.8	1.1
						1990	6.1	2.6	1.2	1.6	1.8	1.7	1.1	0.5	0.1	0.1	0.7	0.8
						1991	0.9	1.1	1.2	1.2	1.8	2.7	2.7	1.8	0.3	0.8	1.0	
UN 05	KOTA	490800	3168000	163	0.30	1989												
						1990			1.2		2.6	3.2						
						1991												
UN 06	THABAI	490500	3176200	170	0.12	1989						5.1	3.0	2.8	2.1	2.7	1.2	3.6
						1990	4.0	4.4	4.2	4.3	4.5	4.5	2.9	1.5	1.7	2.4	3.4	3.6
						1991	3.8	4.0	4.1	4.3	4.3		3.9	3.4	1.7	2.7	3.4	
UN 07	BASAUTI	479800	3163500	160		1989												
						1990												
						1991												
UN 08	PRITHIVIPUR	482200	3171000	169		1989											3.5	1.6
						1990	2.3	2.5	4.2	1.7	4.2	1.8				2.2		
						1991	3.0	3.1	3.4	3.3	3.6		3.6	2.9	2.3	3.0	3.3	
UN 09	UDASHIPUR	481800	3176600	178		1989												2.1
						1990	2.5	0.7	2.9	3.0	0.2	0.3	0.1	0.1	0.2	0.2	0.2	
						1991												
UN 10	PHULBARI	471000	3163200	160		1989						4.0			1.1	1.6	2.0	2.3
						1990	2.5	2.0	2.2	4.2	2.7	3.1		1.3	1.6	1.8	2.1	2.5
						1991	2.5	3.0	3.2	3.3	3.5	3.8	2.9	1.8	1.3	2.0	2.3	
UN 11	BHADA	474500	3175000	172		1989						2.5				1.3	1.9	2.1
						1990	2.2		1.0	1.5	1.8	1.7		1.0	1.1	1.2	1.3	1.6
						1991	1.7	1.7		2.0	2.1	2.2	1.5	1.1	1.1	1.3	1.6	
UN 12	MAGHI	476200	3183700	190		1989						4.7			3.4	3.7	4.3	5.4
						1990	5.3	4.3	4.4	4.4	4.5	4.2	3.7	3.1	3.4	4.0		
						1991												
UN 13	DHANGADHI VILL	461500	3173700	171		1989												
						1990												
						1991												
UN 14	DHANGADHI TOWN	460500	3175600	171	-0.40	1989									0.5	1.3	1.6	2.1
						1990	1.8	0.7	1.7	1.0	2.4	1.8	0.9	0.9	1.3	1.3	1.7	1.1
						1991	1.8											
UN 15	RAJPUR	456800	3180000	183		1989									0.4	0.9	1.3	1.7
						1990	2.1		2.7	2.9	3.2	4.2	0.7	0.3	0.7	1.3	1.8	2.1
						1991	2.6	2.8	3.0	3.1	3.3	3.4		0.7	0.3	0.8	0.8	
UN 16	DHANCHAURI	465600	3180300	180	0.90	1989												3.7
						1990	4.9		4.0		4.6	4.5	2.4	1.7	2.9	2.7	3.3	3.5
						1991	4.2	4.4		4.5	4.9	5.1	3.4	1.8	2.0	2.6	3.4	

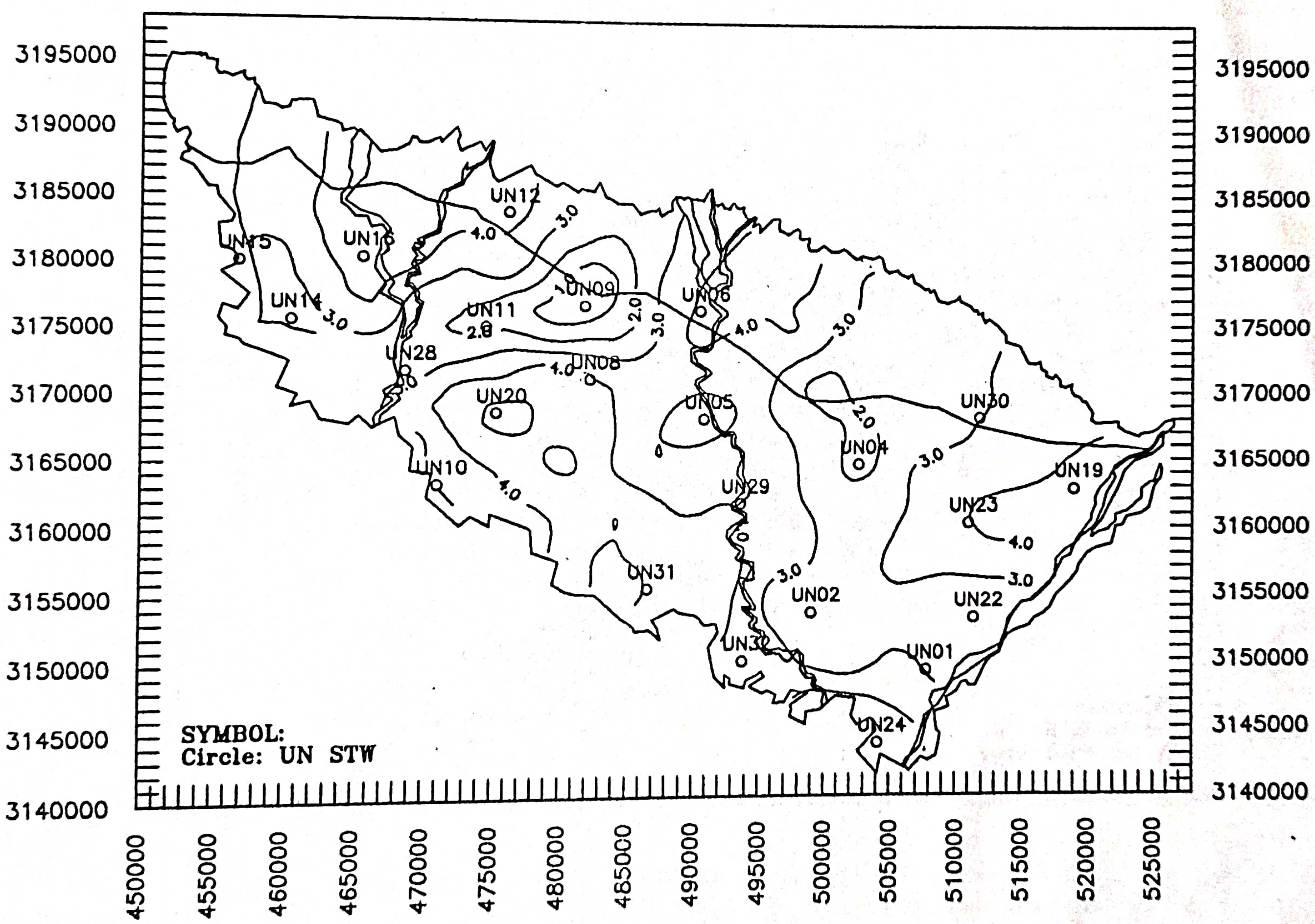
App. D-2 ...cont.

Well No.	Village Name	X	Y	Elev. MSL (m) #	M.P. (m)	Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
							Water Level Measurements in meters (BGL)											
UN 17	LALPUR	461000	3189100	205		1989						1.8	1.8	1.8	1.7	2.3	2.5	2.6
						1990	5.3	2.8	2.3									
						1991												
UN 18	TEGHARI	458000	3193100	250		1989												
						1990												
						1991												
UN 19	KATACHHE	519000	3162800	165	0.15	1989												
						1990	3.6	4.0		3.6	4.3	1.9	1.6	1.1	2.2	3.1		
						1991												
UN 20	KHAREITY	475300	3168500	160		1989												
						1990			5.3	5.5	5.6	5.5		2.9	3.2	3.8	4.7	5.1
						1991	5.1	5.4	5.6	5.7	5.9	6.0	5.1					
UN 21	BANBEHDA	468200	3186800	190		1989												
						1990									1.2	1.2		
						1991	1.3	1.4	1.4	1.5	1.5	1.4	1.0	0.8	1.3	1.3	1.4	
UN 22	TIKAPUR	511400	3153200	160		1989												2.6
						1990	2.8	3.0	2.6	2.6	2.1	0.9	0.7	0.6	0.9	1.7	1.9	2.8
						1991	3.0	3.2	3.3	3.5	3.0		3.0	2.2	0.7	1.9	2.6	
UN 23	DURGAULI	511000	3160300	165		1989												2.1
						1990	2.3	2.5	3.9	3.2	4.4	0.8	1.4	0.3	0.4	2.2	2.0	2.1
						1991	2.2	2.3	2.3	2.6	2.1		2.1	1.2	0.3	1.7	2.0	
UN 24	CHAUGURDI	504100	3143900	155		1989												4.7
						1990		5.0	5.0	5.3	5.0	4.8	3.9		2.7	2.8	4.3	4.6
						1991	4.7	4.4	4.4	4.5	4.5		3.7	4.0		1.1	1.5	
UN 25	NUMUWABOJHI	502500	3170900	168		1989												
						1990							2.4	1.0	0.7	0.7	1.9	2.2
						1991	2.3	2.6	2.7	3.1	3.2	3.6	3.9	3.2	0.2	2.1	2.1	
UN 26	SIMTHALI	495700	3172800	175		1989												
						1990							4.7	3.7	3.9	4.4	5.0	5.1
						1991	5.1	5.2	5.3	5.4	5.4		5.3	4.7	4.5	4.6	5.1	
UN 27	SRIPUR	460800	3184200	188		1989												
						1990								0.9	1.0	1.0	1.4	1.7
						1991		2.0	2.5									
UN 28	KANARI	468700	3171700	165		1989												
						1990					3.0	3.0		2.0	1.7	2.1	2.8	2.7
						1991	2.8	3.0	3.2	3.2	3.3	3.2	2.1	1.2	1.6	2.3	2.5	
UN 29	BIJULIYA	493600	3161700	158		1989												
						1990				4.3	4.2	3.8	3.5	3.5	2.9	3.0	3.8	3.8
						1991	3.9	4.0	4.0	4.1	4.3		4.3	3.8			3.6	
UN 30	BALIYA	511800	3168100	170		1989												2.2
						1990	6.7	3.0	2.4	2.7	3.0	3.3	2.4			0.2	0.7	1.0
						1991												
UN 31	RAMPUR	486600	3155400	155		1989												
						1990			4.9		5.1	5.0		3.0		3.5	4.5	
						1991			4.7	4.7	4.8	5.0	4.1	2.9	2.0	2.3	2.5	
UN 32	CHHARRA	493800	3150000	155		1989												
						1990				3.8	3.8	4.4				0.3	3.3	2.9
						1991												

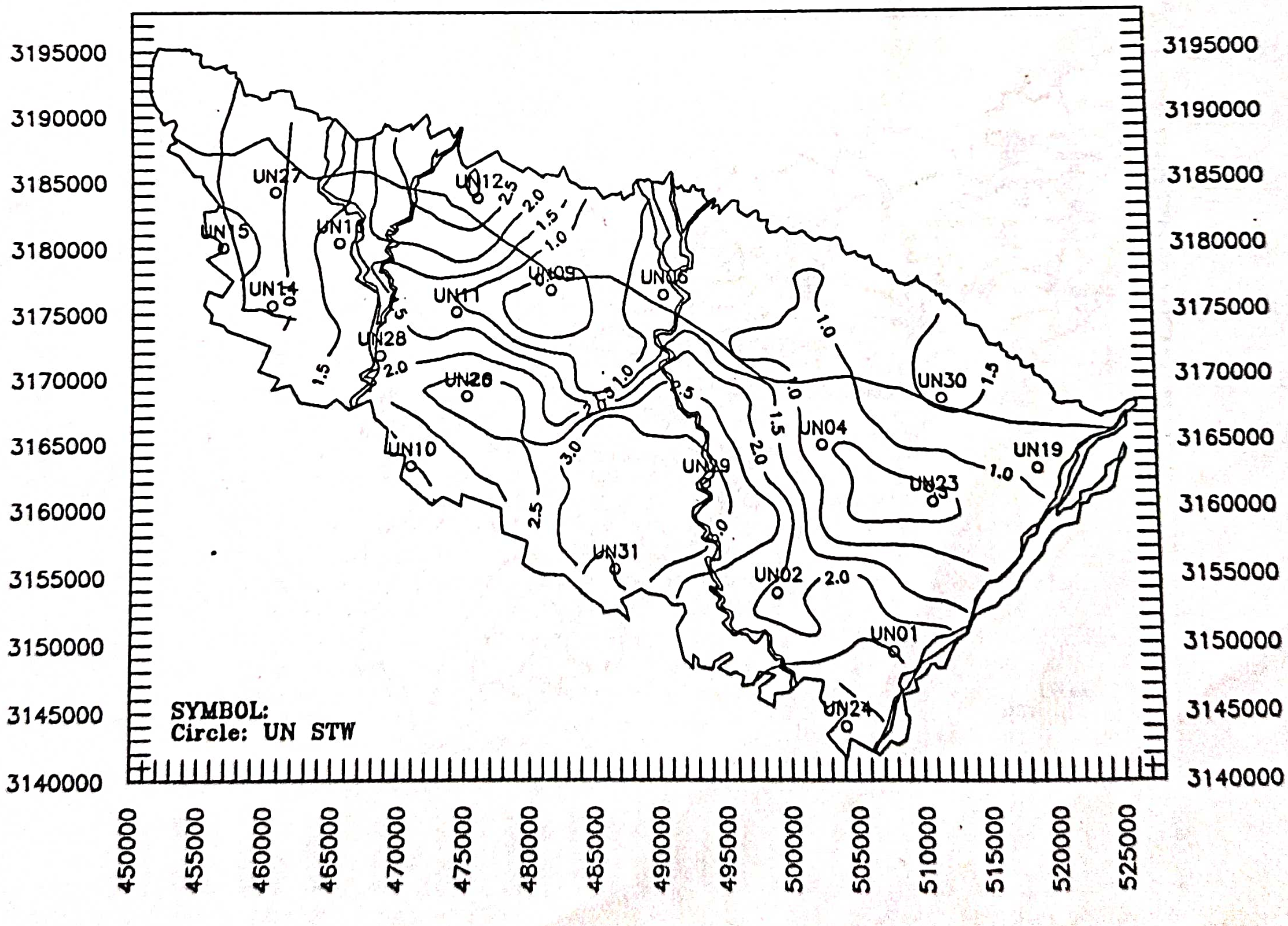
& Y = Landsat Coordinates, m = meter, # = elev. from topomap BGL = Bellow ground level

D-3: Water Level Fluctuation Maps in 1990

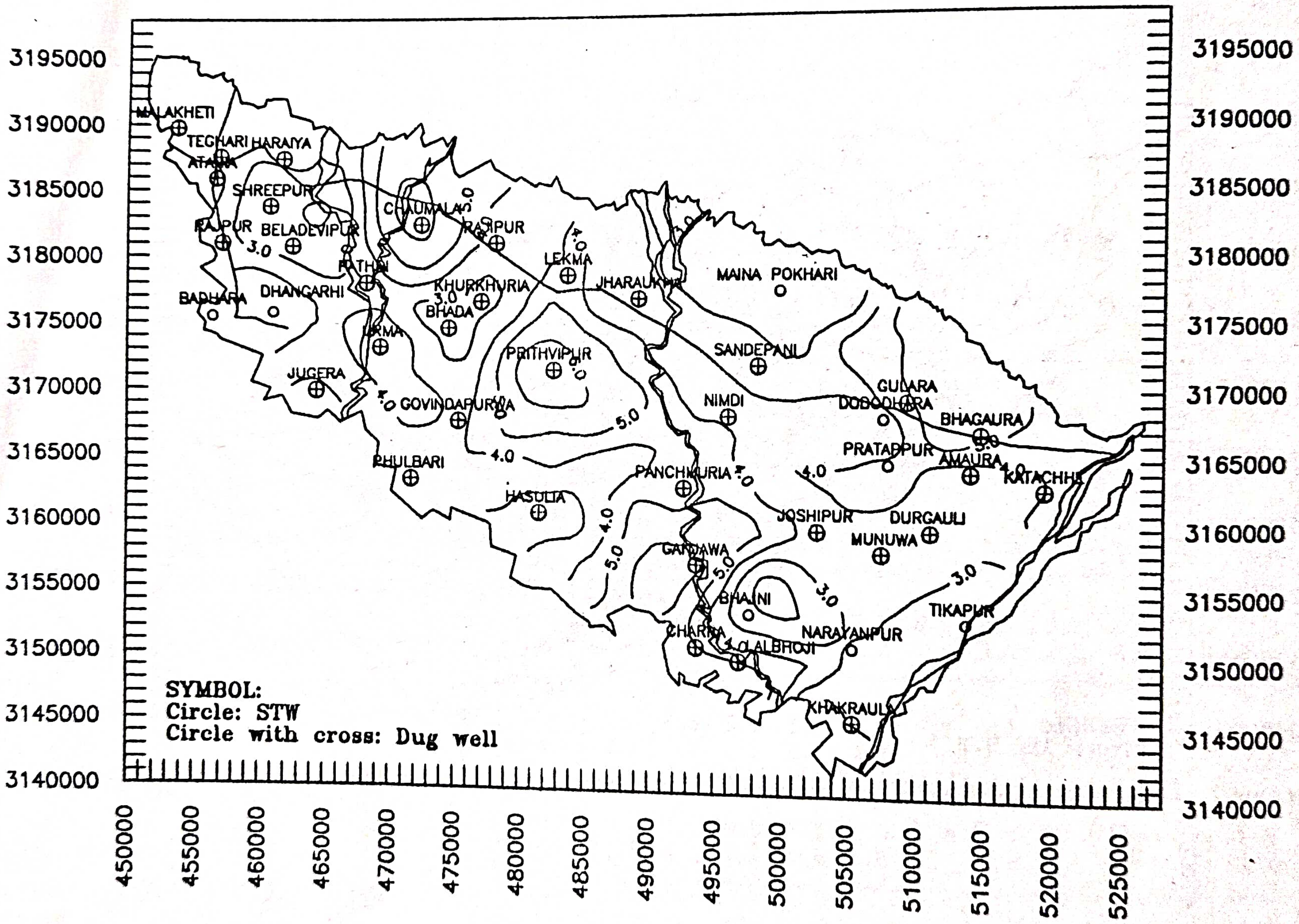
KAILALI - DEPTH TO WATER TABLE IN MAY 1990



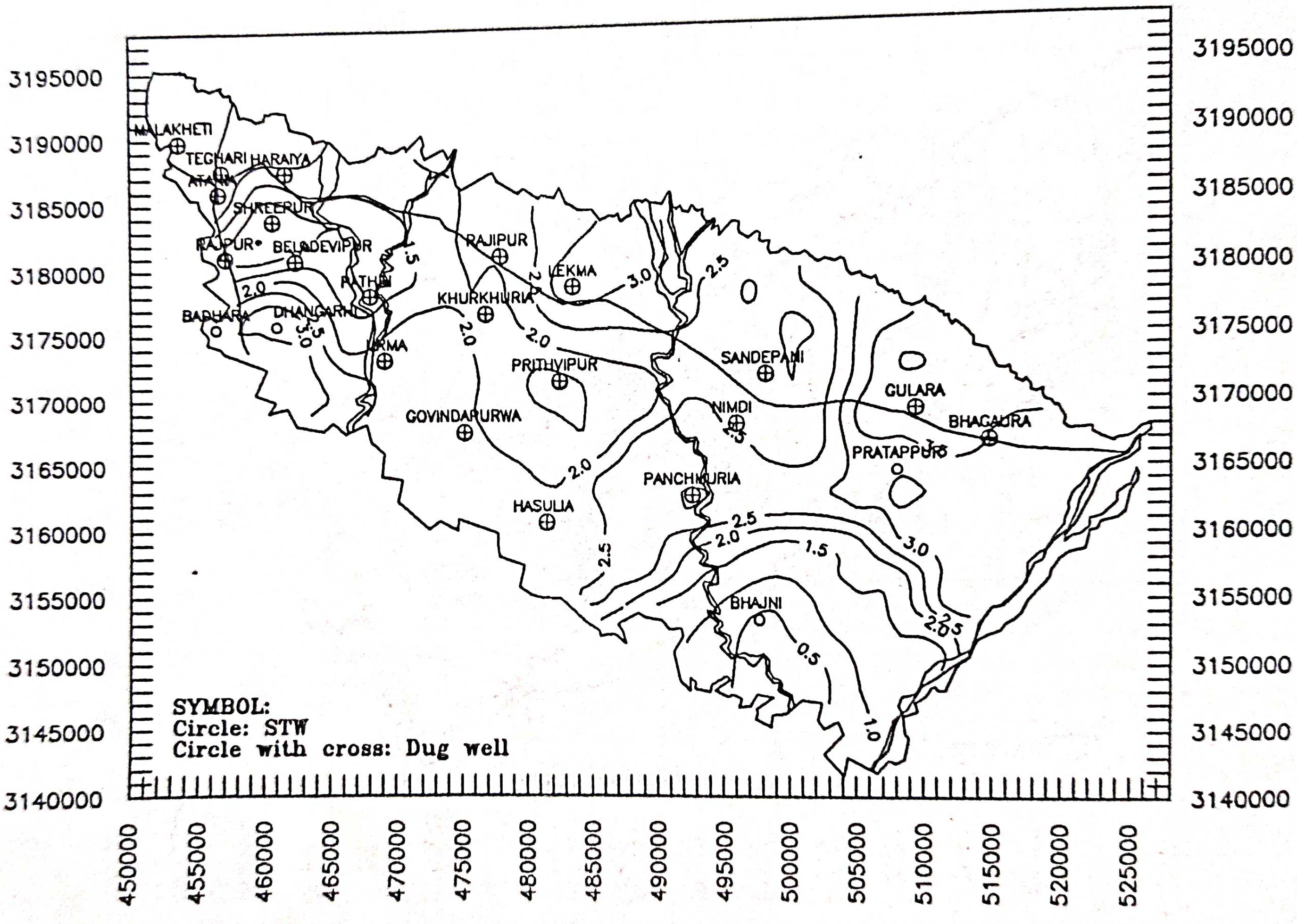
KAILALI - DEPTH TO WATER TABLE IN AUG 1990



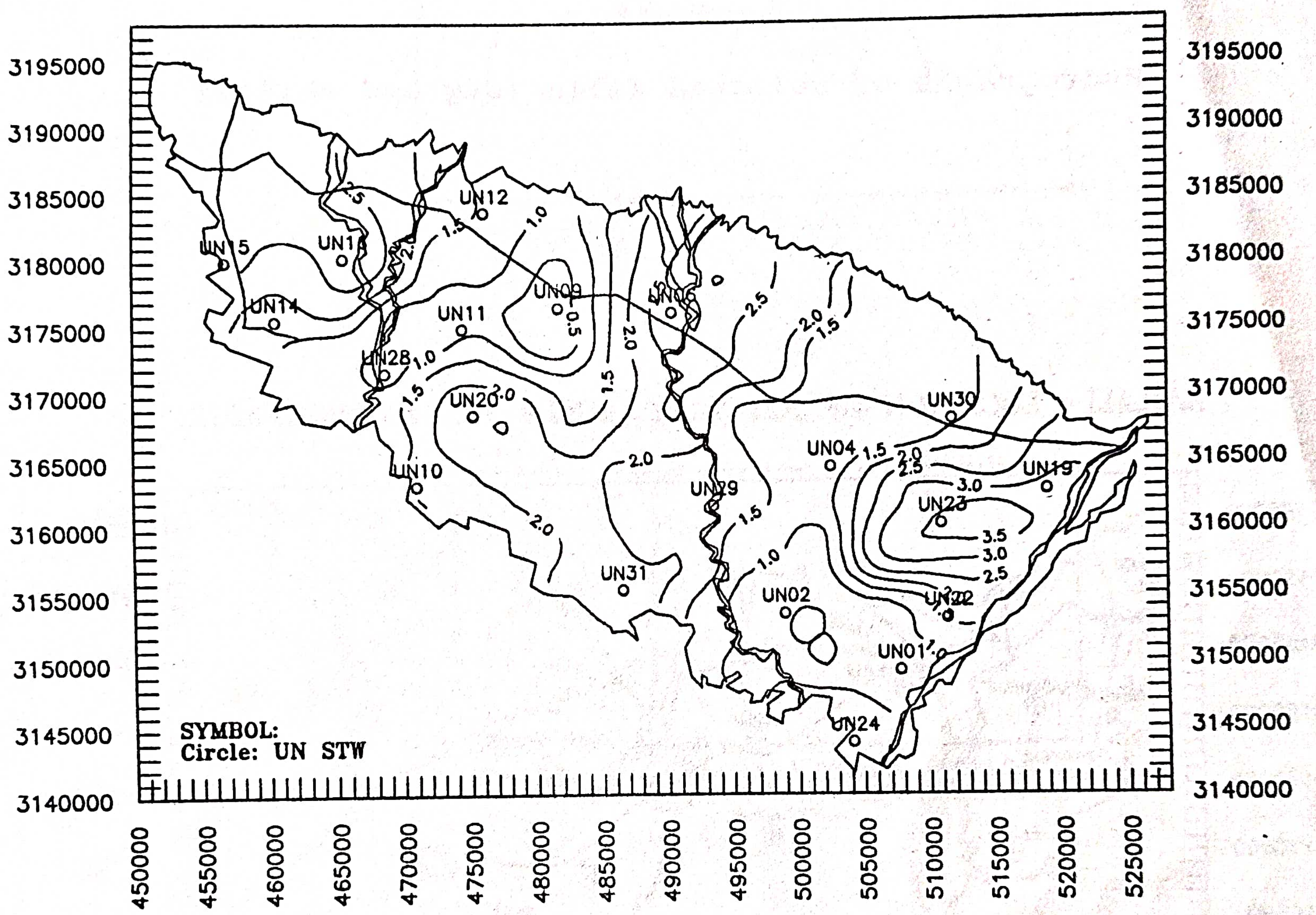
KAILALI - DEPTH TO WATER TABLE IN MAY 1990



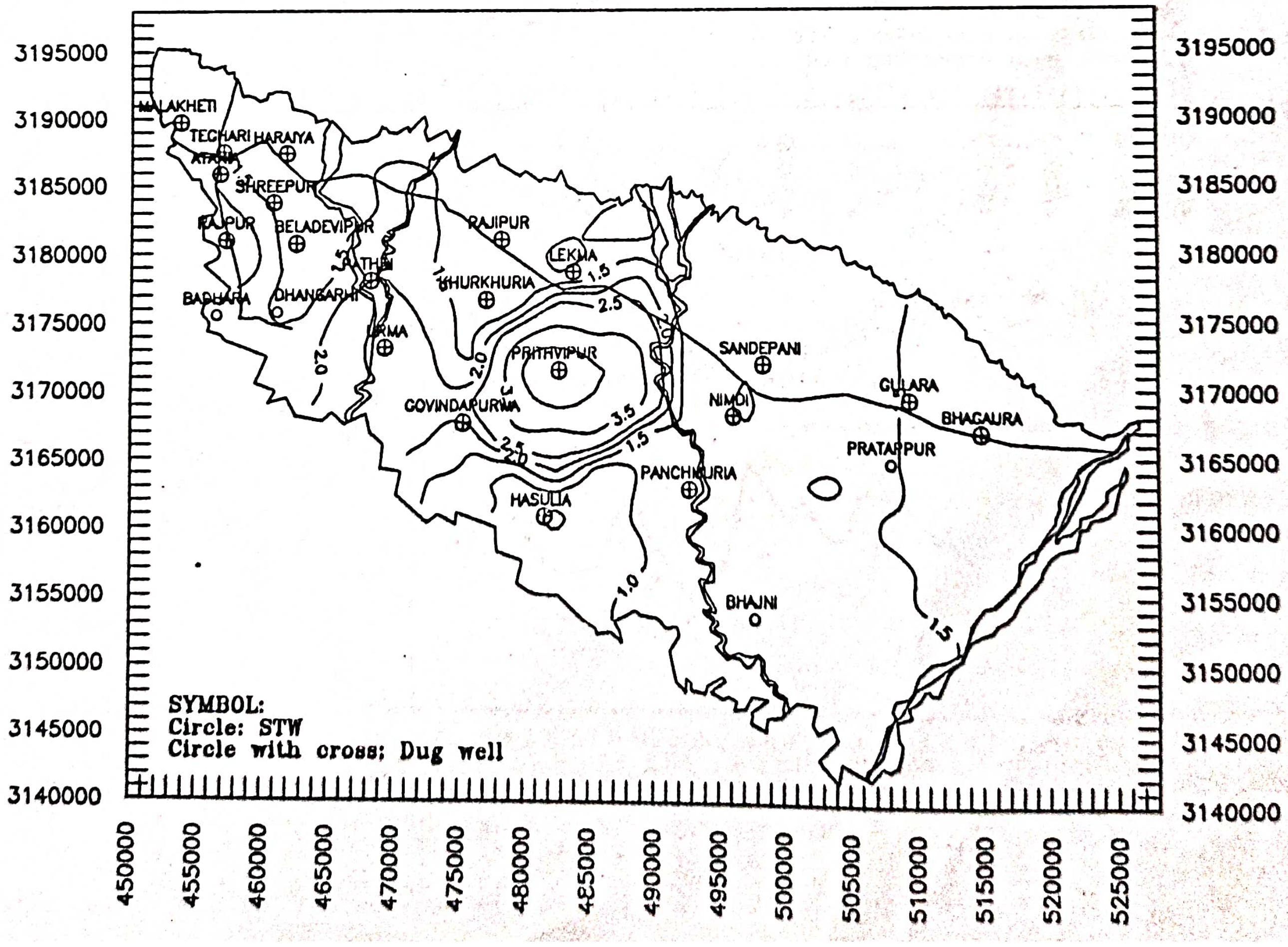
KAILALI - DEPTH TO WATER TABLE IN AUG. 1990



KAILALI - RISE OF WATER TABLE IN MAY-AUG. 1990



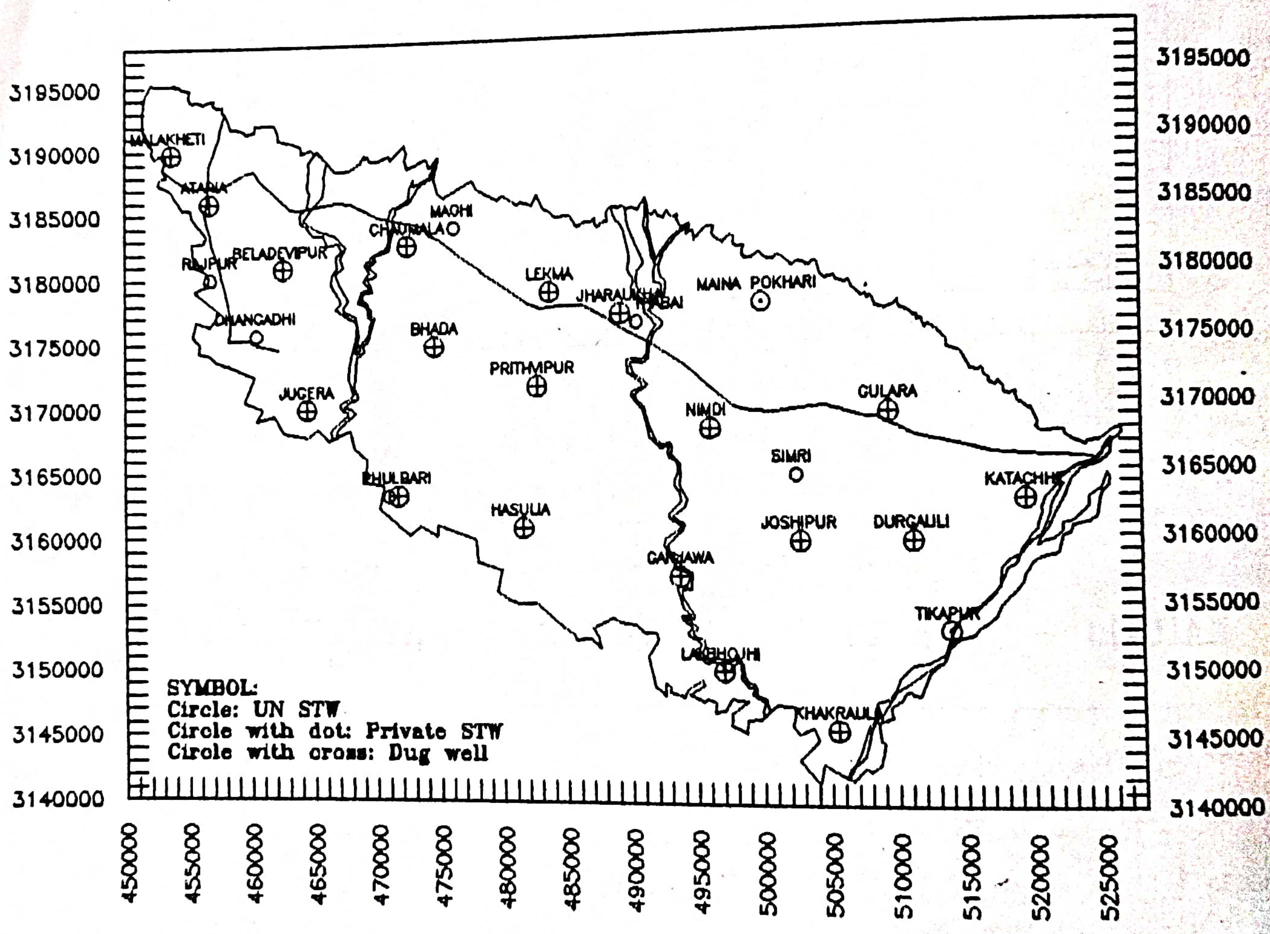
KAILALI - RISE OF WATER TABLE IN MAY-AUG. 1990

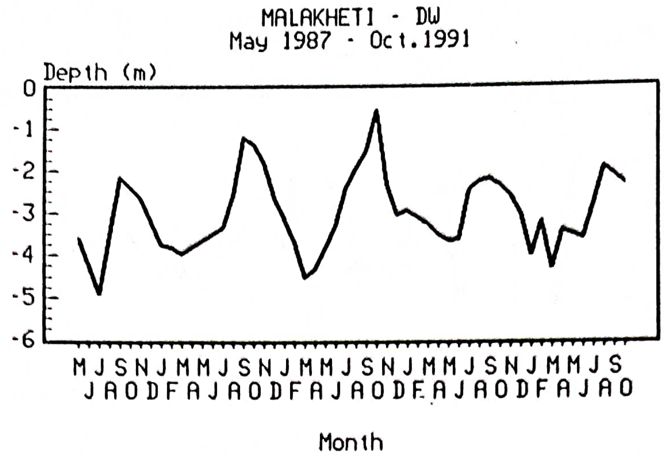


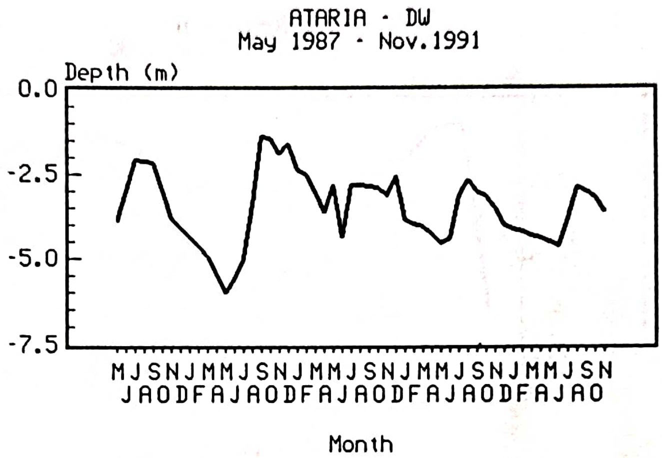
APPENDIX E

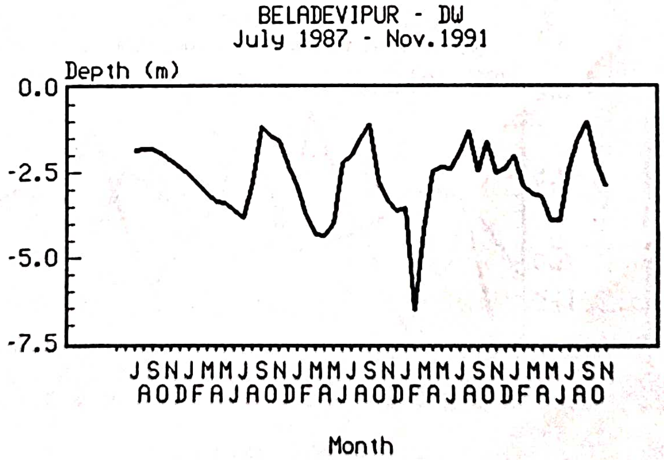
Hydrographs of Selected Wells (dug and shallw)

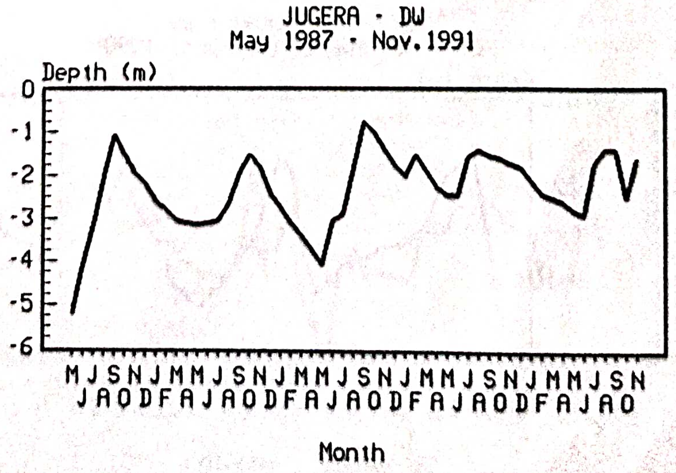
KAILALI- LOCATION OF SELECTED WELLS FOR HYDROGRAPHS



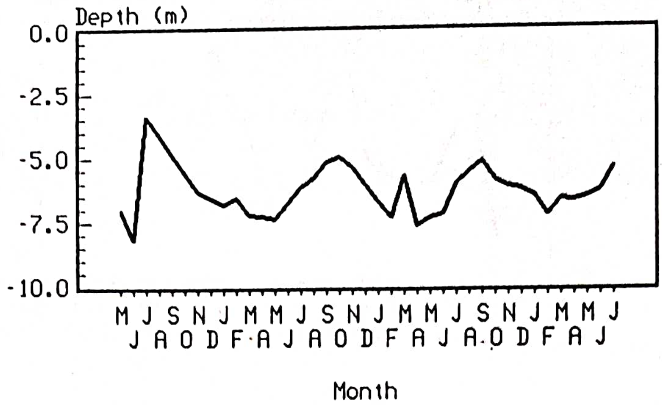

MALAKHETI - DW
May 1987 - Oct.1991
Depth (m)
0
-1
-2
-3
-4
-5
-6
M J S N J M M J S N J M M J S N J M M J S N J M M J S
J A O D F A J A O D F A J A O D F A J A O D F A J A O
Month


ATARIA - DW
May 1987 - Nov.1991
Depth (m)
0.0
-2.5
-5.0
-7.5
M J S N J M M J S N J M M J S N J M M J S N J M M J S N
J A O D F A J A O D F A J A O D F A J A O D F A J A O
Month

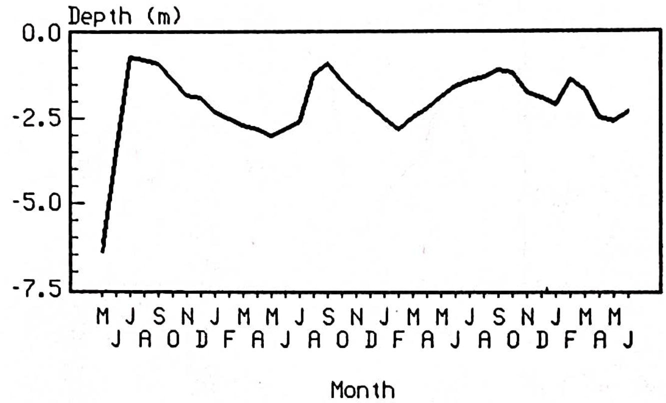

BELADEVIPUR - DW
July 1987 - Nov.1991
Depth (m)
0.0
-2.5
-5.0
-7.5
J S N J M M J S N J M M J S N J M M J S N J M M J S N
A O D F A J A O D F A J A O D F A J A O D F A J A O
Month


JUGERA - DW
May 1987 - Nov.1991
Depth (m)
0
-1
-2
-3
-4
-5
-6
M J S N J M M J S N J M M J S N J M M J S N J M M J S N
J A O D F A J A O D F A J A O D F A J A O D F A J A O
Month

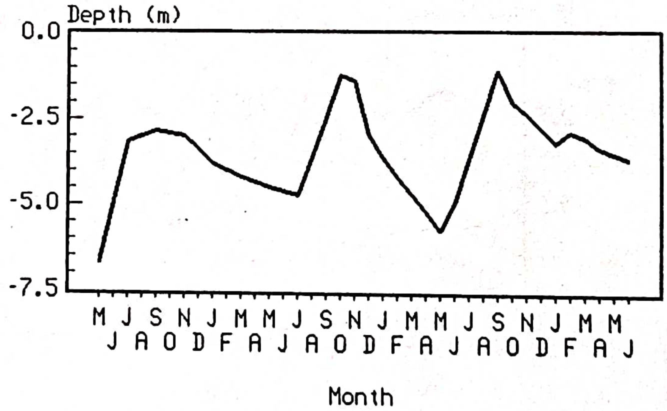
CHAUMALA - DW
May 1987 - July 1990



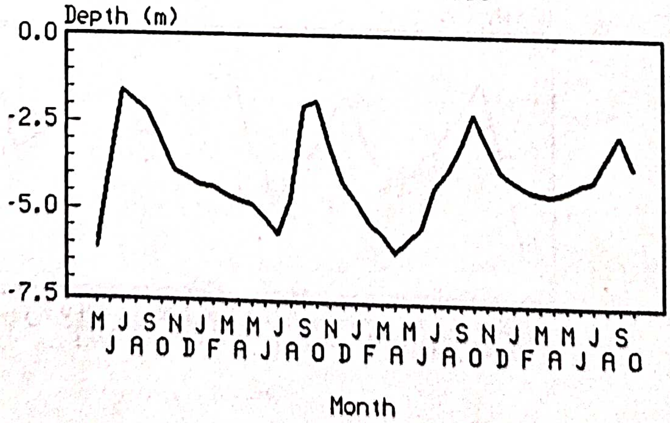
BHADA - DW
May 1987 - Jun 1990

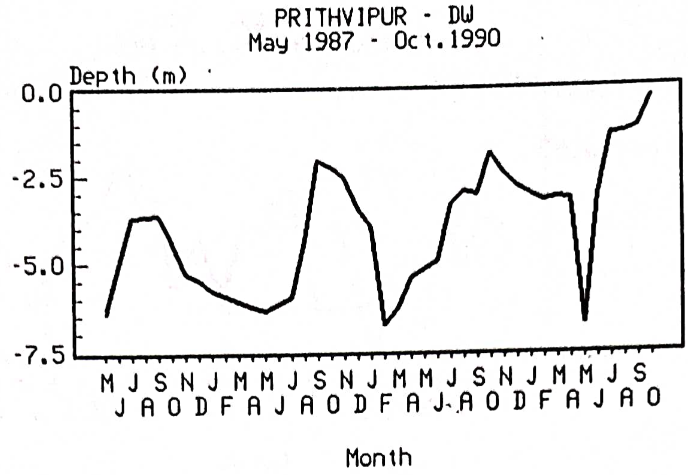


PHULBARI - DW
May 1987 - Jun 1990



LEKMA - DW
May 1987 - Oct. 1990




PRITHVIPUR - DW
May 1987 - Oct.1990
Depth (m)
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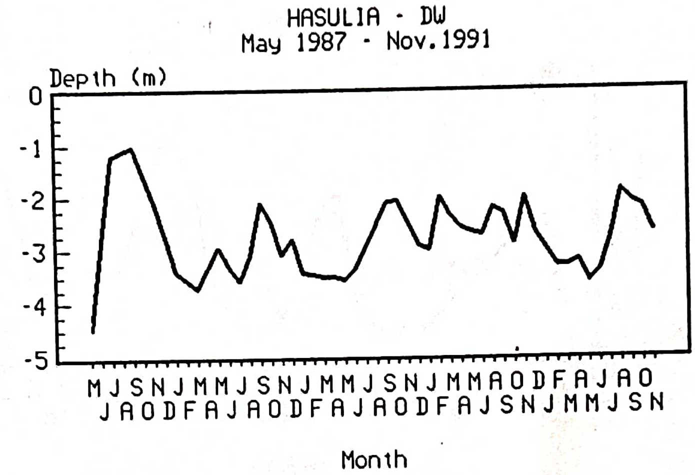
-2.5
-5.0
-7.5
M J S N J M M J S N J M M J S N J M M J S
J A O D F A J A O D F A J A O D F A J A O
Month


HASULIA - DW
May 1987 - Nov.1991
Depth (m)
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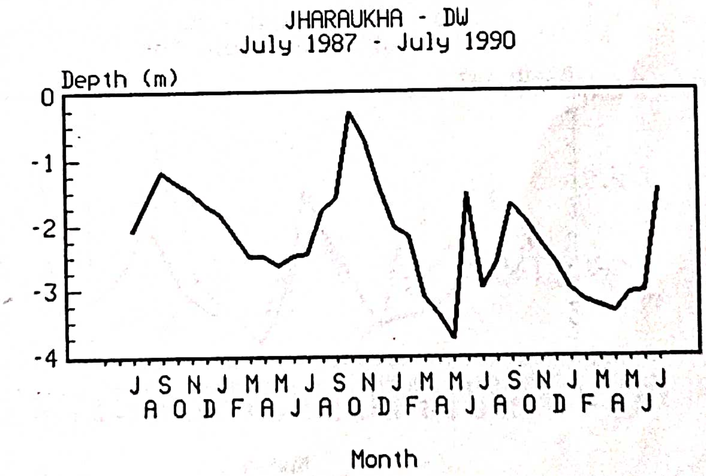
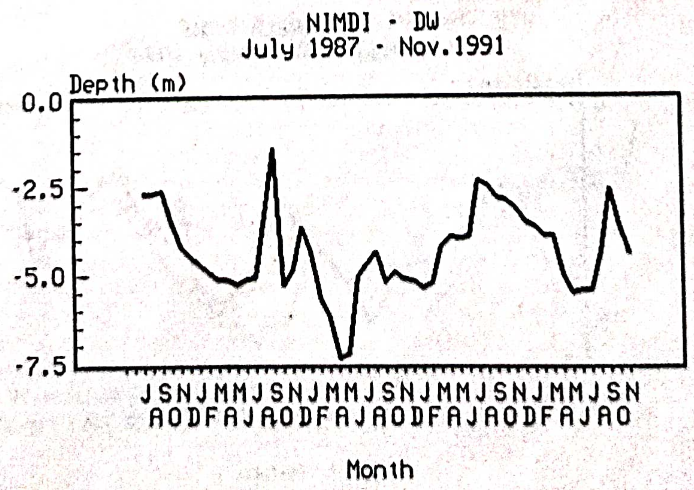
-1
-2
-3
-4
-5
M J S N J M M J S N J M M J S N J M M A O D F A J A O
J A O D F A J A O D F A J A O D F A J S N J M M J S N
Month


JHARAUKHA - DW
July 1987 - July 1990
Depth (m)
0
-1
-2
-3
-4
J S N J M M J S N J M M J S N J M M J
A O D F A J A O D F A J A O D F A J
Month


NIMDI - DW
July 1987 - Nov.1991
Depth (m)
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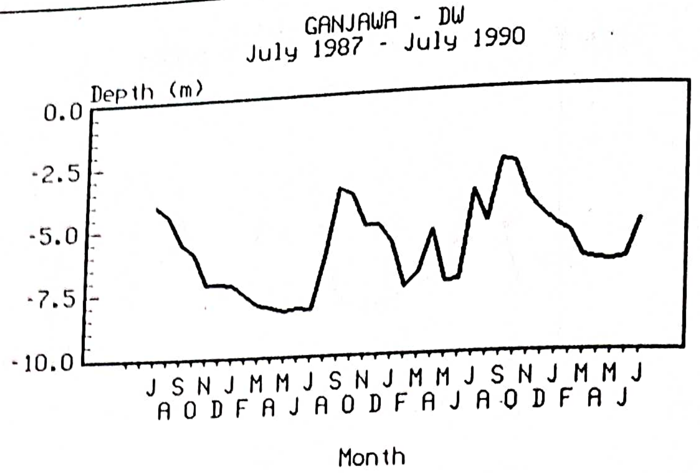
-2.5
-5.0
-7.5
J S N J M M J S N J M M J S N J M M J S N J M M J S N
A O D F A J A O D F A J A O D F A J A O D F A J A O
Month


GANJAWA - DW
July 1987 - July 1990
Depth (m)
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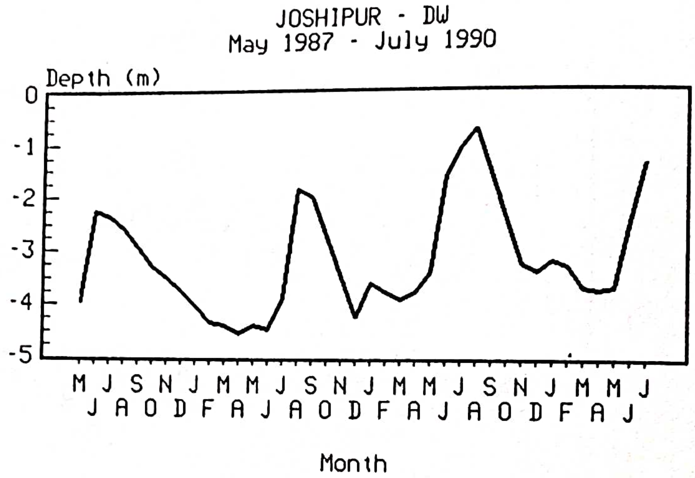
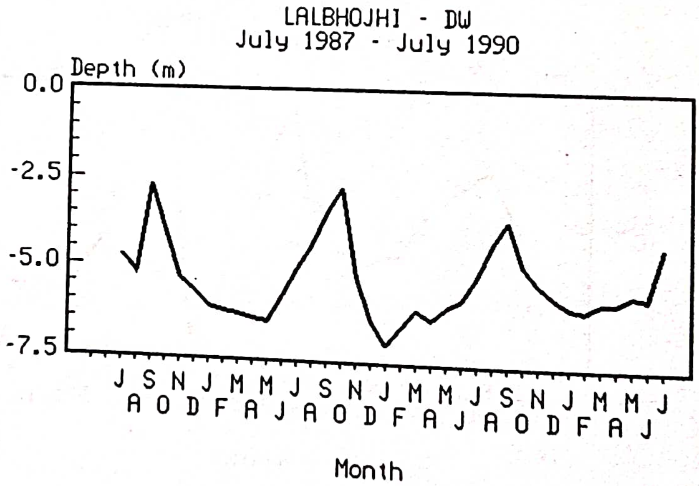
-2.5
-5.0
-7.5
-10.0
J S N J M M J S N J M M J S N J M M J
A O D F A J A O D F A J A O D F A J
Month


JOSHIPUR - DW
May 1987 - July 1990
Depth (m)
0
-1
-2
-3
-4
-5
M J S N J M M J S N J M M J S N J M M J
J A O D F A J A O D F A J A O D F A J
Month


LALBHOJHI - DW
July 1987 - July 1990
Depth (m)
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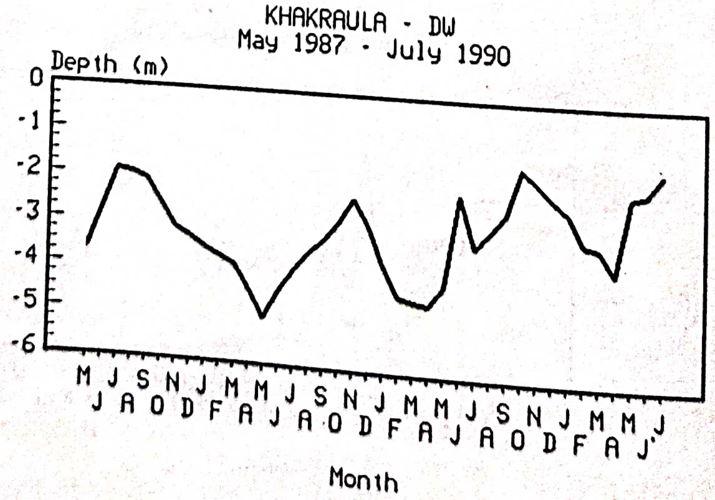
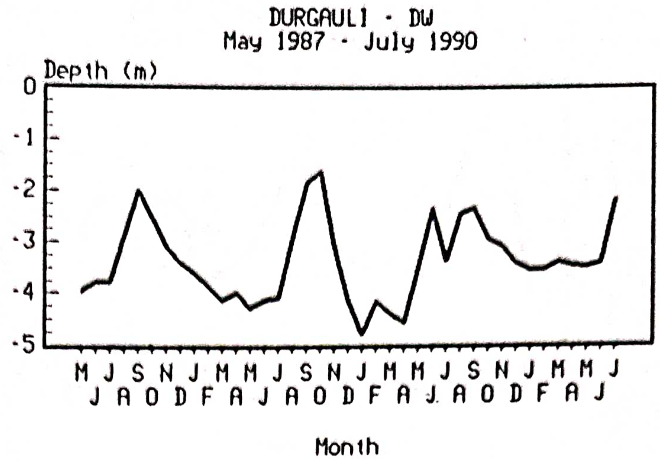
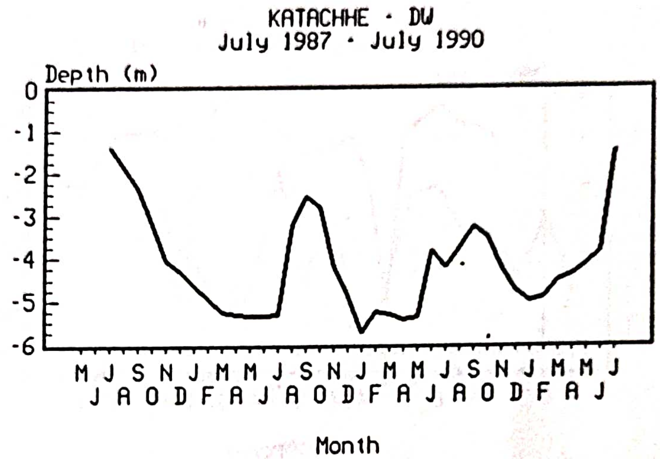
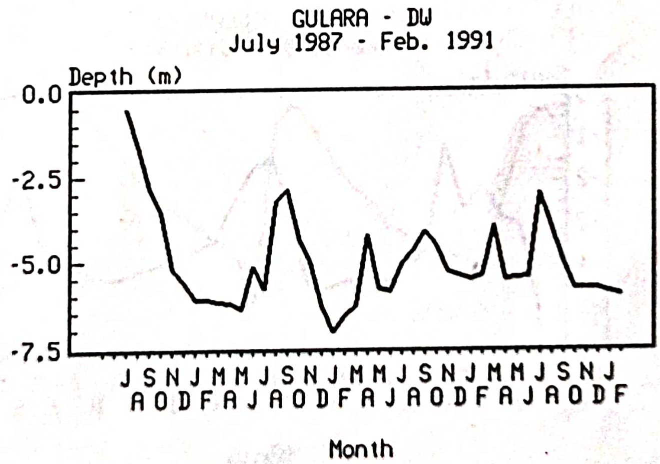
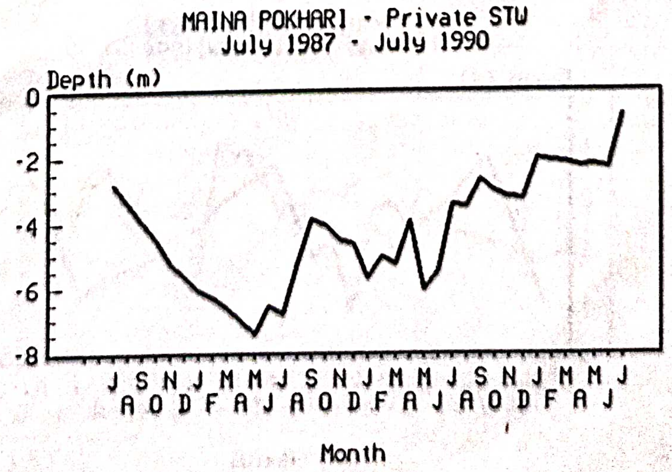
-2.5
-5.0
-7.5
J S N J M M J S N J M M J S N J M M J
A O D F A J A O D F A J A O D F A J
Month


KHAKRAULA - DW
May 1987 - July 1990
Depth (m)
0
-1
-2
-3
-4
-5
-6
M J S N J M M J S N J M M J S N J M M J
J A O D F A J A O D F A J A O D F A J
Month

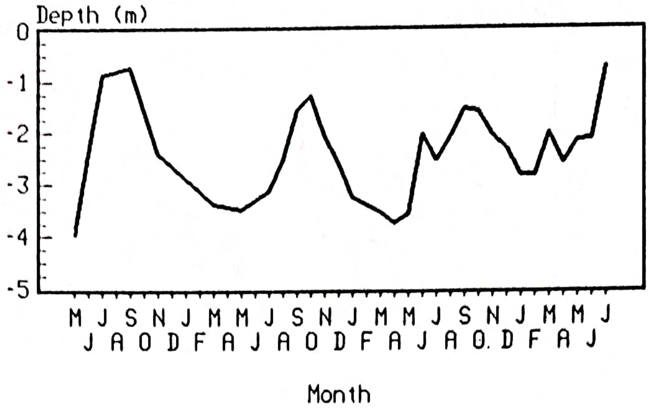

DURGAULI - DW
May 1987 - July 1990
Depth (m)
0
-1
-2
-3
-4
-5
M J S N J M M J S N J M M J S N J M M J
J A O D F A J A O D F A J A O D F A J
Month


KATACHHE - DW
July 1987 - July 1990
Depth (m)
0
-1
-2
-3
-4
-5
-6
M J S N J M M J S N J M M J S N J M M J
J A O D F A J A O D F A J A O D F A J
Month

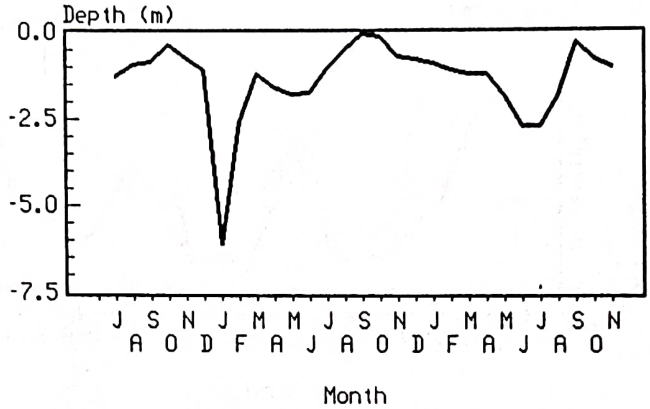

GULARA - DW
July 1987 - Feb. 1991
Depth (m)
0.0
-2.5
-5.0
-7.5
J S N J M M J S N J M M J S N J M M J S N J
A O D F A J A O D F A J A O D F A J A O D F
Month


MAINA POKHARI - Private STW
July 1987 - July 1990
Depth (m)
0
-2
-4
-6
-8
J S N J M M J S N J M M J S N J M M J
A O D F A J A O D F A J A O D F A J
Month

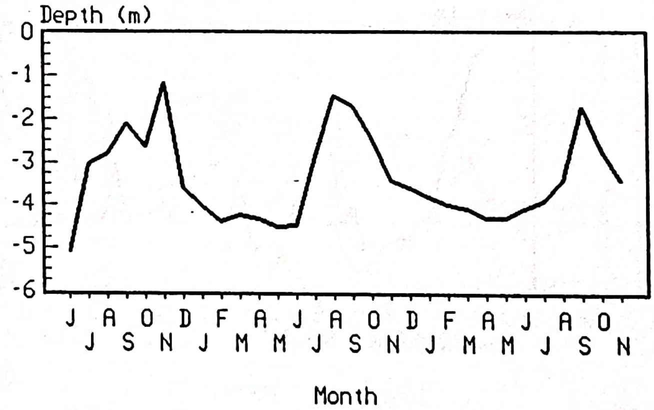
TIKAPUR - Private STW
May 1987 - July 1990



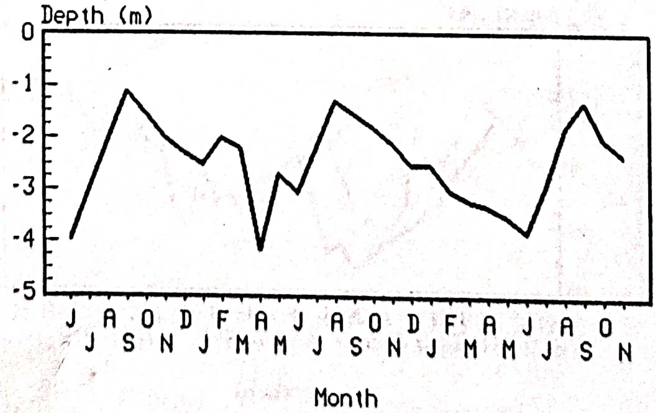
SIMRI - UN04 STW
July 1989 - Nov.1991

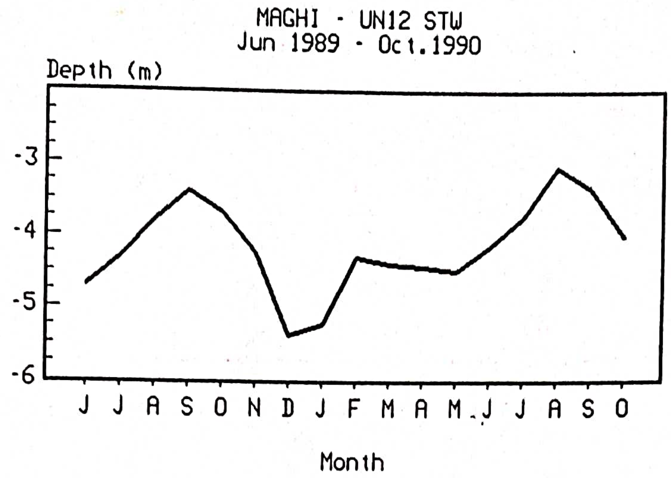


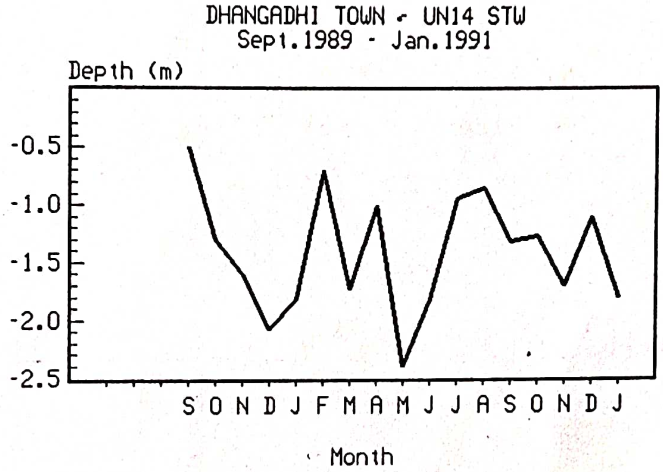
THABAI - UN06 STW
Jun 1989 - Nov.1991

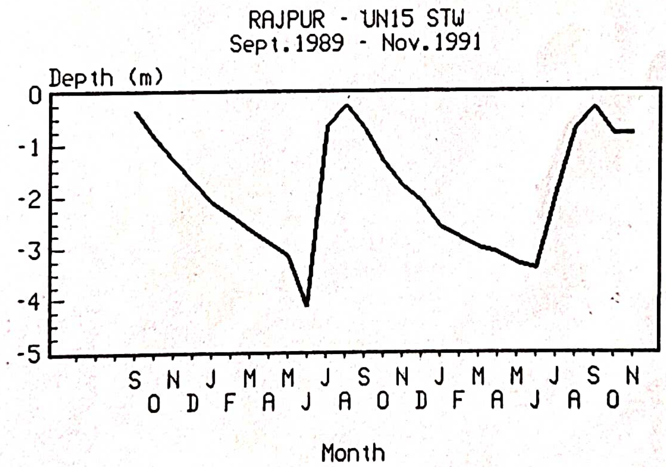


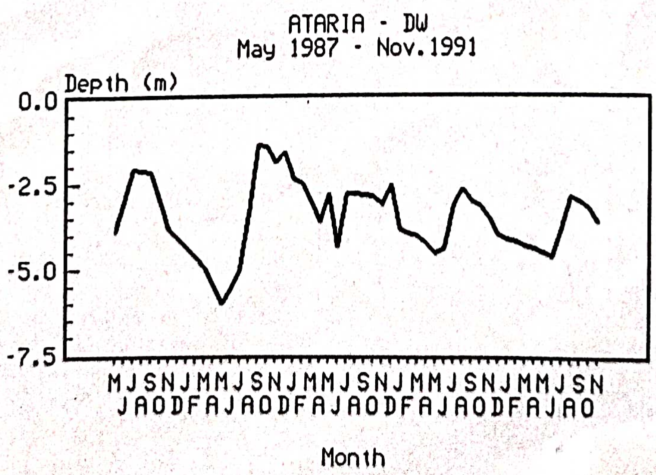
PHULBARI - UN10 STW
Jun 1989 - Nov.1991




MAGHI - UN12 STW
Jun 1989 - Oct.1990
Depth (m)
-3
-4
-5
-6
J J A S O N D J F M A M J J A S O
Month


DHANGADHI TOWN - UN14 STW
Sept.1989 - Jan.1991
Depth (m)
-0.5
-1.0
-1.5
-2.0
-2.5
S O N D J F M A M J J A S O N D J
Month


RAJPUR - UN15 STW
Sept.1989 - Nov.1991
Depth (m)
0
-1
-2
-3
-4
-5
S N J M M J S N J M M J S N
O D F A J A O D F A J A O
Month


ATARIA - DW
May 1987 - Nov.1991
Depth (m)
0.0
-2.5
-5.0
-7.5
MJSNJMMJSNJMMJSNJMMJSNJMMJSN
JAODFAJAODFAJAODFAJAODFAJAO
Month