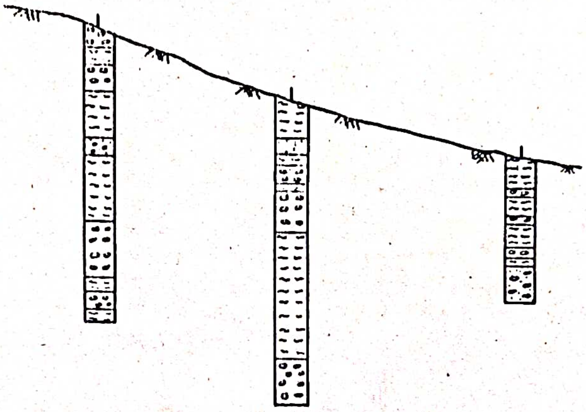
UNITED NATIONS DEVELOPMENT PROGRAMME
AND
HIS MAJESTY's GOVERNMENT OF NEPAL
NEP/86/025

SHALLOW GROUND WATER INVESTIGATIONS IN TERAI

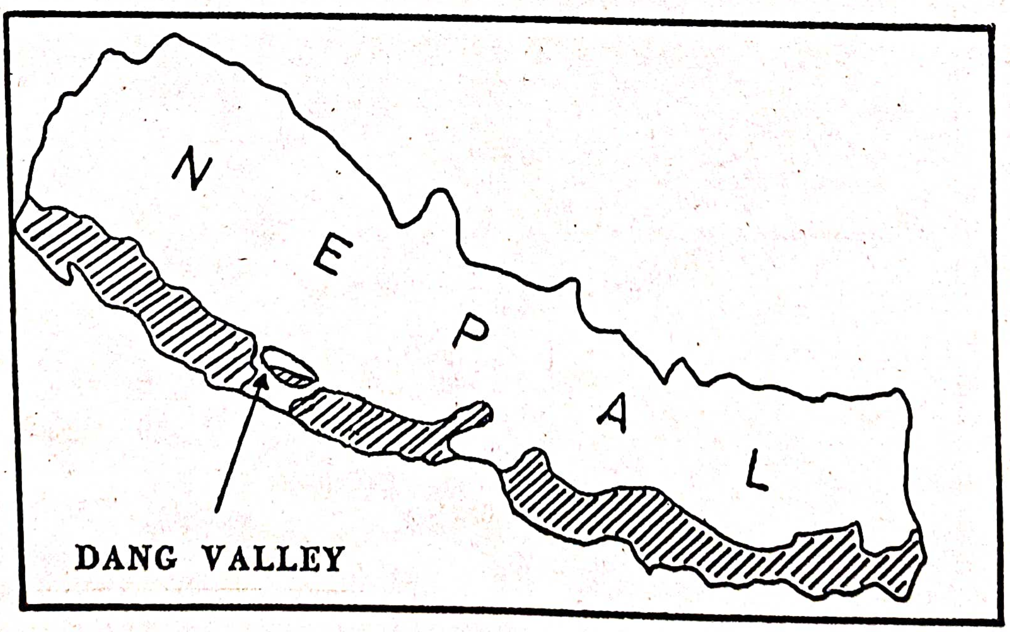
DANG VALLEY

SHALLOW WELLS DRILLING, TESTING AND MONITORING IN 1987/88

BASIC DOCUMENTATION AND PRELIMINARY INTERPRETATION



TECHNICAL REPORT NO.8



KATHMANDU, JUNE 1989

GWRDB-UNDP PROJECT NEP/86/025
SHALLOW GROUND WATER EXPLORATIONS IN TERAI

TECHNICAL REPORT NO. 8

DANG VALLEY

SHALLOW WELLS DRILLING, TESTING AND MONITORING IN 1988/89

BASIC DOCUMENTATION AND PRELIMINARY INTERPRETATION

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

Prepared by:

Suresh R. Uprety, GWRDB Geohydrologist

with assistance of **Dr. J.Karanjac**, Chief Consultant Hydrogeologist

KATHMANDU, JUNE 1989

EARLIER TECHNICAL REPORTS:

1. Bhairawa-Lumbini Ground Water Irrigation System Preliminary Mathematical Modelling. May 1988.

2. Shallow Ground Water Level Fluctuations in the Terai in 1987. Preliminary Report. May 1988.

3. **RAUTAHAT DISTRICT**. Shallow Wells Drilling, Testing and Monitoring in 1987/88. Basic Documentation and Preliminary Interpretation. November 1988.

4. RAUTAHAT DISTRICT. Mathematical Model of Shallow Ground Water System. December 1988.

5. **NAWALPARASI (WEST)**. Shallow Wells Drilling, Testing and Monitoring in 1987-89. Basic Documentation and Preliminary Interpretation. March 1989.

6. NAWALPARASI (WEST). Mathematical Model of Shallow Ground Water System. March 1989.

7. **KAPILVASTU DISTRICT**. Shallow Wells Drilling, Testing and Monitoring in 1987-89. Basic Documentation and Preliminary Interpretation. June 1989.

ABBREVIATIONS:

UN/DTCD - United Nations Department of Technical Co-operation for Development
UNDP - United Nations Development Programme
GWRDB - Ground Water Resources Development Board
GDC - Groundwater Development Consultants (International) Ltd.
ADBN - Agricultural Development Bank of Nepal
ADB - Asian Development Bank
STW - Shallow Tube Well
DW - Dug Well
DTW - Deep Tube Well
MCM - Million Cubic Meters

TABLE OF CONTENT

APPENDICES

1. Project Wells and Pumping Tests Location Map

2. Location Map for Monitoring Network

3. Well Logs and Lithology of Wells (3/1 through 3/29)

4. Lithological Cross-Sections

4.1. Location of Wells for Cross-Sections
4.2. Cross-Section I-I'
4.3. Cross-Section II-II'
4.4. Cross-Section III-III'
4.5. Cross-Section IV-IV'
4.6. Cross-Section V-V'

5. Pumping Tests

5.1 DGSTW 3 - Baibang
5.2 DGSTW 5 - Phachkalwa
5.3 DGSTW 7 - Ammapur
5.4 DGSTW (ADBN) - Bakee
5.5 DGSTW (ADBN) - Baluwa
5.6 DGSTW (ADBN) - Bakhariya
5.7 DGSTW (ADBN) - Malwar
5.8 GW 2 - Tari Gaon
5.9 GW 8 - Bargadwa
5.10 GW 13 - Pakkoi
5.11 GW 15 - Lalpur
5.12 GW 16 - Jaspur

6. Map of Transmissivity of Shallow Aquifer

7. Hydrographs with Rainfall at Selected Wells

8. Depths to Water Table in 1987/1988

8.1. Rise of Water Table from May through October 1987
8.2. June 1988 - Maximum Depth
8.3. August 1988 - Minimum Depth
8.4. Rise of Water Table from June through August 1988
8.5. Depth to Water Table in May 1989

FIGURES

1. BACKGROUND INFORMATION

1.1. 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 field-data collection, establishment of ground water data base, and to assessment of development potentials of shallow aquifers all over the Terai. The government counterpart agency is the Ground Water Resources Development Board (GWRDB) of the Department of Irrigation of the Ministry of Water Resources. The project's activities started in June 1987.

The immediate objectives of the project NEP/86/025 are the following.

(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 capacity of the GWRDB with regard to exploration, assessment and development of ground water.

The following project outputs are anticipated:

(a) Computerized data base with about 2000 shallow water points from all over the Terai. Information on lithology, hydrogeological parameters, water use, etc.
(b) Maps of pre-monsoon (maximum) and post-monsoon (minimum) water depths expressed in relative depths from the land surface and in absolute elevations above mean sea level.
(c) Water level graphs (hydrographs) from selected observation points in a minimum period of one year.
(d) Reports on mathematical modelling.
(e) Report on drilling methods and results in shallow water well drilling in the Terai.

1.2. Basis For This Report

This report is based on the following:

(a) NEP/86/025 project wells (for ease of reference called "project" wells) - 10 newly drilled shallow wells between January and June 1988.
(b) Tube wells drilled for ground water investigations by GWRDB since 1985 to 1987 - 19 wells.
(c) Pumping tests conducted in project wells in 1988.
(d) Pumping tests conducted in GWRDB wells in different times.
(e) Water level observations since May 1987.

(f) Several Mission Reports by Chief Consultant in this project.
(g) Several field trips by NEP/86/025 project staff.
(h) Book "Geology of Nepal" by C.K.Sharma (1977).

Information from GWRDB wells in which upper 70 m are screened is also considered.

1.3 Location, Size and Climate

Dang valley is in Dang district, which belongs to the Mid-Western Region (in addition to Banke and Bardiya districts). The location of Dang valley is shown in Figure 1. This report covers only the drilling activities,lithology and hydrogeological characteristics of the shallow aquifer in the valley covering an area of about 1000 km^2.

The main characteristics of the climate in Dang valley, as well as in the whole Terai, is monsoon rainfall which occurs between June and September and which delivers an average of 85% of the total annual rainfall. For the purpose of this report the data collected in three rainfall stations, Ghorahi, Tulsipur and Nayabasti (Figure 1) are used. It is to be understood that the data are not officially cleared by the HMG Meteorological Service, but rather used in a draft form as an indication for the correlation between shallow water level fluctuation and the rainfall.

Evolution of shallow ground water levels is heavily dependent on the distribution of rainfall. (Most of the recharge to shallow aquifers comes from fan deposits near the Siwalik hills and mountains.) The amounts of rainfall in the years 1987 and 1988 will be discussed in Section 4.2. The mean annual rainfall is about 1900 mm. The major potential surface water source for supplementing natural rainfall is the Babai River which flows from east to west in the southern part of the valley. Unfortunately, the river gauging station is at far outside the valley, its data cannot be used for the present purpose.

2. PROJECT ACTIVITIES IN 1987/89

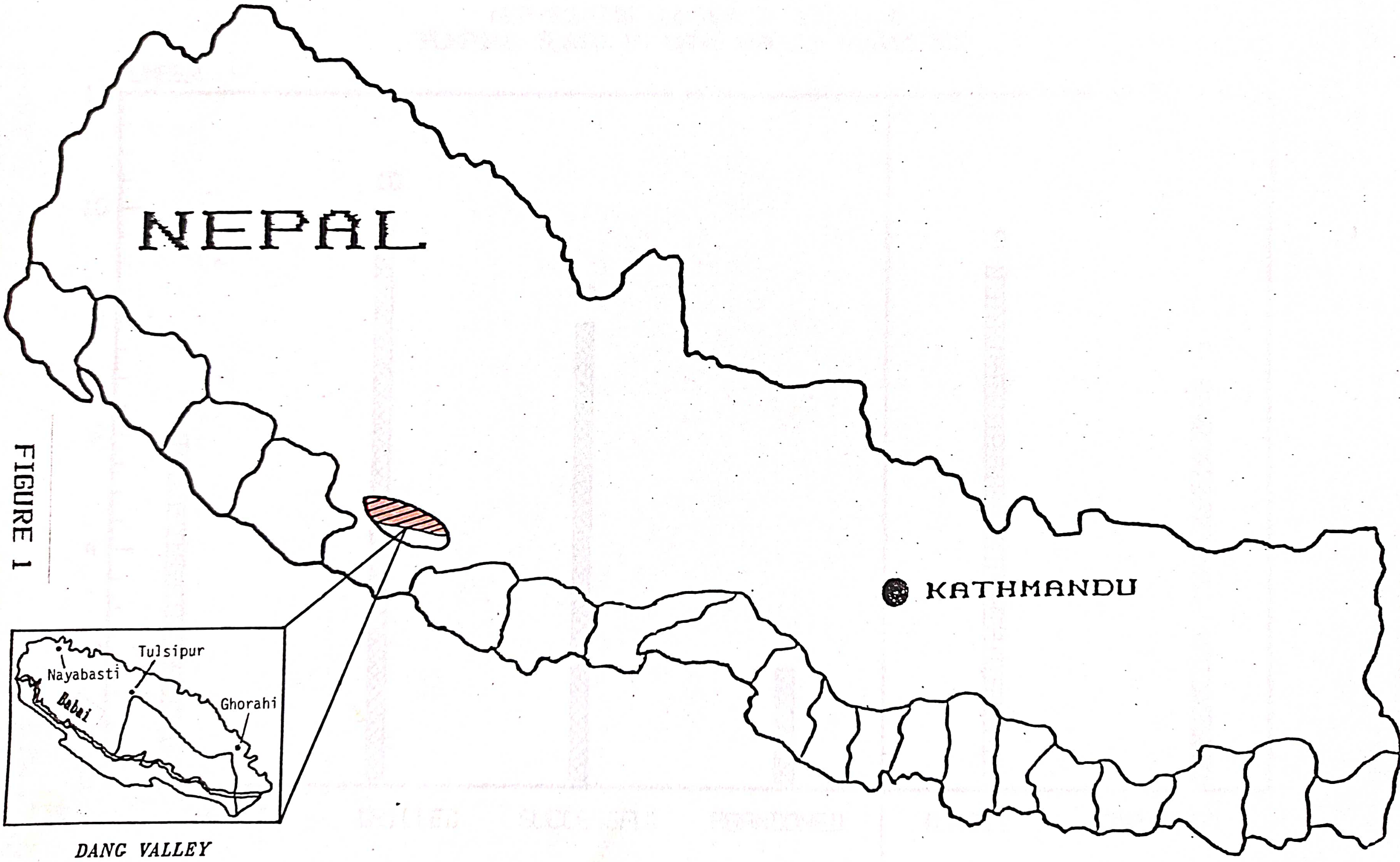
2.1. Drilling

Out of the total planned scope of drilling within this project, which amounts to about 200 shallow wells for the whole Terai, the program of drilling for Dang valley was prepared about a year- and-half ago providing for drilling of 6 wells with an average drilling depth of 40 m. The total drilling metrage in Dang valley was estimated at 240 m. Here below the planned and actual implementation is shown:

Planned: 6 STW Total drilling metrage: 240 m
Actual: 10 STW Total drilling metrage: 299 m

With respect to both, the number of drilled wells and their total drilled metrage, the implementation was better than expected. The implementation compared to the design is illustrated in Figures 2 and 3. The map with locations of all "project" wells is shown in Appendix 1. Twenty nine lithological logs with

FIGURE 1


NEPAL
KATHMANDU
Nayabasti
Tulsipur
Ghorahi
Babai
DANG VALLEY

NEP/86/025 NUMBER OF WELLS &
PUMPING TESTS IN DANG VALLEY (1987/88)

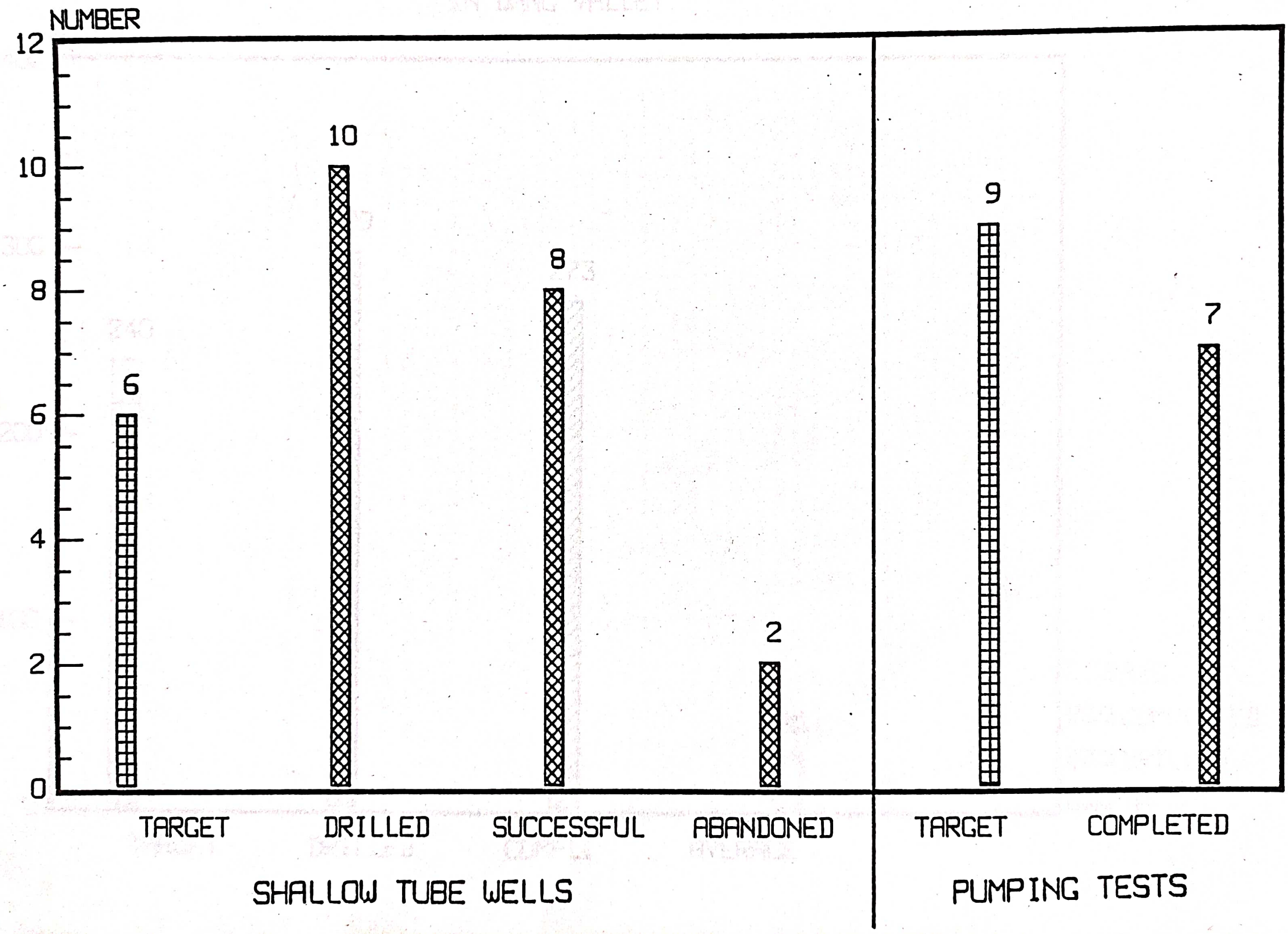


FIGURE 2

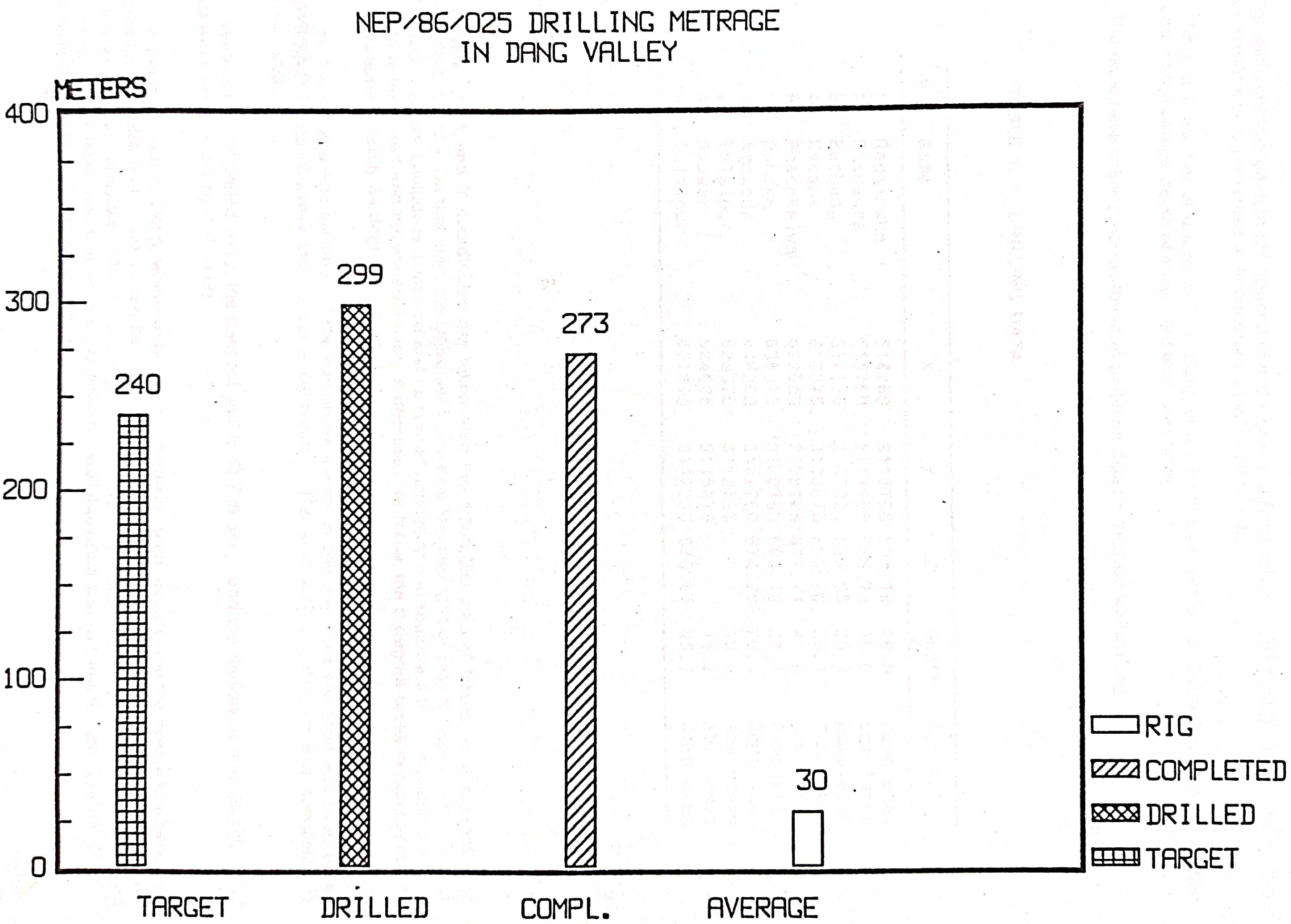

NEP/86/025 DRILLING METRAGE
IN DANG VALLEY
METERS
400
300
200
100
0
240
299
273
30
TARGET
DRILLED
COMPL.
AVERAGE
RIG
COMPLETED
DRILLED
TARGET

FIGURE 3

other well construction data are appended in the group of Appendices 3 (3/1 through 3/29). Lithological cross-sections are presented in Appendices 4 (4/2 through 4/6).

The actual number of drilled wells in Dang valley by this project is 10. Out of this, two wells were abandoned. Average depth of completed wells was 30 m.

The table here below presents the most pertinent data on "project" well drilling.

TABLE 1. DRILLING DATA

No.	Name	X	Y	Z	Depth	Comment
1	Ragaincha	614250	3113750	599.19	29.0	Completed
2	Dhanaura	615750	3111250	565.72	35.0	Completed
3	Baibang	617125	3107000	549.06	25.9	Completed
4	Kataha	616375	3106875	595.70	38.1	Completed
5	Phachkalwa	629500	3108125	617.71	41.0	Completed
6	Dundra	635375	3100750	593.12	38.1	Completed
7	Ammapur	648250	3102750	674.38	20.1	Completed
8	Tulsipur	628375	3112625		10.9	Abandoned
9	Asuwar	624625	3115875		15.2	Abandoned
10	Tulsipur	627875	3112250	676.67	45.7	Completed

Notes. (1) X and Y coordinates are taken from the 1:500,000 map of Nepal, as a composite of LANDSAT imagery. On that map, the Universal Transverse Mercator grid overlay is based on the Everest Geodetic System. Latitude is measured and numbered northward and southward to the equator; and longitude is measured and renumbered every 6 degrees. For Nepal the 6 degree break in numbering occurs at approximately 84 degree East longitude.

(2) Z is the absolute elevation of the well above the mean sea level. The elevation was supplied by SWISSAIR Photo+Surveys Ltd., under a subcontract. The land-surface surveying was completed in April 1989.

Among the completed wells, the deepest well is 45.7 m deep, and the shallowest only 20.1 m. All of 10 wells were drilled by drilling rig.

In the area such as Dang, where water table is normally deep, except near the river, and where large pebbles, cobbles and boulders can be found at any depth and any place, any method of drilling will have to surmount obstacles. Manual, or indigenous, method is probably not suitable here, but, likewise a drilling rig may have problems unless it is powerful, well equipped and well maintained. Diverse drill bits should be readily available when needed.

2.2. Testing Shallow Wells

The program of test pumping recommended the testing of 9 shallow tube wells in total (6 newly drilled and 3 to be selected from existing shallow wells). Out of this, only seven wells had been tested. None of the tests was conducted with observation well. Therefore, storage coefficient could not be known. For the location of all tested wells see Appendix 1 - the location map of all project wells and wells with pumping tests.

Out of 8 newly drilled "project" wells, in five wells the pumping test could not be executed because the static water level at the time of completion was too deep to run a test with a centrifugal pump.

All pumping test interpretations are appended to this report in the group of Appendices 5. The interpretation is based on the proprietary UN/DTCD computer program which includes a measure of appropriate formula fit (standard deviation).

In running pumping tests the following problems have been identified:

(a) Pumping equipment not adequate for all situations. The suction range of centrifugal pump limited to about 7 m below the pump discharge point restricts the possible dynamic depth of pumping. Pump discharge is fluctuating during the test. (Yet, GWRDB earlier test wells were tested with a pump that could lift the water from almost 40 m depth: Lalpur, Pakkoi).

(b) Pump discharge measuring instrumentation unreliable. The match among various methods not always good. The best would have been a 3-in flowmeter with direct reading of the flowrate in liters per second.

(c) Measurements of water level during the pumping and/or recovery periods are sometimes questionable (late, improvised).

In most tested wells the duration of pumping was between 200 and 480 minutes. In only two tests the time of testing was about 20 minutes. Considering that the dynamic levels had stabilized after 3 to 5 hrs, the test duration of four hours seems to be sufficient. It would have been very useful to have had observation wells included in the testing program. For that reason, the "project" wells should have been located nearby existing shallow drilled wells which could then be used as observation wells during the test.

2.3. Monitoring Water Levels

In Technical Report No. 2 three maps from Dang valley were presented showing the maximum and minimum depths to water table in 1987 and the rise of water levels between the minimum and maximum of 1987. In May 1987, water levels were monitored in dug wells. Later, each newly drilled "project" well was included into the monitoring network. The idea was to gradually replace the original network of dug wells with newly drilled wells of which lithology is known, transmissivity eventually calculated and land surface elevation surveyed. This "new" monitoring network is shown in Appendix 2. Fortunately, some of the GWRDB drilled shallow wells are found to be useful for the monitoring purpose. Those wells are also included in the actual monitoring network.

Depth to water levels is observed in either monthly or bimonthly intervals. The evolution of water table in shallow aquifers of the Dang valley is illustrated with several appendices in this report (Appendices 8: depths to water table in June and August 1988, in May 1989; the rise of water table between May and October 1987; the rise of water table between June and August 1988). Individual hydrographs for some of monitored wells are presented in Appendices 10.

3. SHALLOW AQUIFER LITHOLOGY AND AQUIFER PARAMETERS

3.1. Lithology

According to C.K.Sharma (1977), the Dang valley is one of the so-called Dun valleys, formed by a series of reverse faults. Thus, its origin is tectonic. Dang valley is composed of recent deposits which include clay, peat, and conglomerate. As the zone is calcareous in the north of the Dang valley, the sediments of Dang valley derived from that zone are very calcareous.

In Dang the soil is sandy and calcareous and creates "bad land" topography.

Project wells have penetrated through the upper 30 or so meters of an alluvial sequence. GWRDB wells have gone deeper. The valley floor is composed of interlocked alluvial deposits made by the rivers flowing there, and by outwash from hilly sides.

The lithology of the shallow ground water system in Dang valley is known from 10 "project" wells and from 19 wells drilled from 1985 to 1987 by GWRDB. There was no attempt to connect permeable layers in lithological cross sections. The lithology of the upper 30 or so meters is rapidly changing over very small distances. Present-day and past-time rivers have been changing their streambeds; they have been either depositing or eroding sediments, leaving behind either coarse sediments or impermeable fine deposits. Sudden changes in lithology can be noticed from the lithological logs of wells at Bainsa, Tulsipur and Bhojpur.

Out of total 870 meters (drilled metrage in 10 "project" wells of 273 m and taking 30 or so meters lithology of GWRDB wells which is 597), 415 m are sand and gravel deposits. This means that about 48% in an average shallow well is composed of sand and/or gravel. (An "average" well depth considered is 30 m deep, out of which 14.4 m are composed of permeable, and 15.6 m of impermeable deposits.) The average depth of about 30 m is by far insufficient to define the shallow aquifer in Dang valley. In the northern part, the water table is in places deeper than 30 m, so that the upper 30 or so meters are unsaturated, or dry.

In general, while going from north to south the grain size of the formation becomes finer. This can be visualized in the Lithological Cross Sections III-III', IV-IV' and V-V'. But near the Babai River, the grain size becomes again quite coarse. Extremely high transmissivities in some places near the river are probably local occurrences and reflect coarse-river-bed deposits, or maybe some buried river channels.

Considering the lithology of the shallow aquifer in Dang valley, one may conclude that almost everywhere there are chances of getting at least 4 meters of sand and/or gravel deposits within a depth of 30 meters. However, it is questionable whether the first permeable layer will be or remain saturated throughout the year. Due to very steep ground water flow gradient, the water recharged along the northern rim of the valley flows rapidly toward the erosional base, that is the Babai River. In the dry season, quite a high portion of upper permeable layers remain dry (see Appendices 8/2,8/3).

The chances of finding excellent aquifers at shallow depths are tied to locating buried channels in which coarse sediments have been deposited. The chances are better near the Babai River than to the north.

3.2. Hydrogeological Parameters

Hydrogeological parameters of the shallow aquifers were obtained from pumping tests run on 3 "project" wells, four ADBN wells and six GWRDB wells. The wells used in this interpretation are shown in Appendix 6, which is the map of transmissivity. In the same time, this report contains a group of appendices (Appendix 5) with some 13 pumping tests. Each test is interpreted in the same way, using a rather objective computer match between field data and theory. A comparison was made between the classical non-leaky theory of Theis and Jacob with the leaky-aquifer theory of Hantush. The result with lower standard deviation, or a better fit, was accepted. Transmissivities of shallow aquifers are shown in Appendix 6 (Transmissivity map). The map is the creation of a computer contouring program, which interpolates and extrapolates random individual values. This inter-extrapolation process is based on only 13 values which is not sufficient to accurately describe the whole district.

Several more wells are available for testing. After the completion of these tests, the transmissivity distribution will be much more accurate.

The interpretation shall be attempted with information in hands.

TABLE 2. HYDROGEOLOGICAL PARAMETERS

Well		Thickness m	Trans. m2/day	Conduct. m/day	Lithology
DGSTW-3	Baibang	10.9	85	7.8	G
DGSTW-5	Phachkalwa	12.7	495	39.0	G & S
DGSTW-7	Ammapur	11.0	745	67.7	G & S
GW-2	Tari Gaon	45.7	3440	75.3	G
GW-8	Bargadwa	28.1	1035	36.8	G
GW-10a	Bainsa	48.7	35	0.7	G & S
GW-14	Pakkoi	10.9	18	2.3	G
GW-15	Lalpur	44.0	5670	128.9	G & S
GW-16	Jaspur	7.0	2925	417.8	G

Note:- G = Gravel, S = Sand

It is obvious that the whole range of permeabilities and transmissivities can be found in Dang valley. A well can be quite a failure or an excellent producer, depending where exactly it is located. The values of hydraulic conductivity over 30 m/day are what one would expect from sand-and-gravel medium. The value as high as 417.8 m/day in Jaspur is characteristic for the best possible aquifer in loose sedimentary rocks. However, the value of only 0.7 m/day conductivity, that is 35 m^2/day transmissivity in Bainsa, is unexpected. The well is located 5 km north of the river. Its driller's log shows absolute permeable formation from 36.6. m down to 85.3 m, almost 50 meters of gravel and sand. The water level during the pumping test fluctuated within the interval 5.8 m and 26.2 m. The transmissivity of only 35 m^2/day cannot be accepted if the lithology is correctly described. However, one may question the driller's description of lithology. "Gravel" in drill cuttings could be conglomerate fragmented during the drilling operation. And while the gravel deposit is extremely permeable, the permeability of conglomerate is usually very low, tied to fractures. Another explanation is that both aquifer and screen were clogged due to improper well development. The nearby well GW10b, also in Bainsa, confirms good lithology, 8.5 m of gravel between 23.5 and 32 m. Unfortunately, it was not pump tested.

4. FLUCTUATIONS OF SHALLOW WATER TABLE

4.1. Monitoring Network

Dang valley is well covered with observation network. In May 1987, the monitoring of shallow water table started by observing depth to water table in dug wells and is still continuing. After the completion of "project" wells, they were also included in the network. Monitoring of GWRDB drilled wells was being done continuously right from their completion. At this moment, we are recommending to continue with routine observations on all newly drilled project wells, shallow drilled GWRDB wells and in addition on one dug well at Khaira in order to provide for the continuity and correlation of data. This actual monitoring network is shown in Appendix 2.

4.2. Rainfall in Dang valley in 1987/88

To understand better the rise of shallow water levels from the driest month to wettest month (either 1987 or 1988) one should look at rainfall in the June-September period. As shown in Figure 1, there are three rain gauging stations in the Dang valley: Ghorahi in the eastern, Tulsipur in the central and Nayabasti in the western parts. All of these three stations are along the northern foothills.

The mean monthly and annual rainfall values in Dang valley are shown in Figure 4. The annual sum in three stations were as follows.

TABLE 3. RAINFALL IN DANG VALLEY

	Annual Rainfall in mm	
Station	1987	1988
Ghorahi	2145	1804
Tulsipur	1500	1848
Nayabasti	1676	1734
AVERAGE:	1774 MM	1795 MM

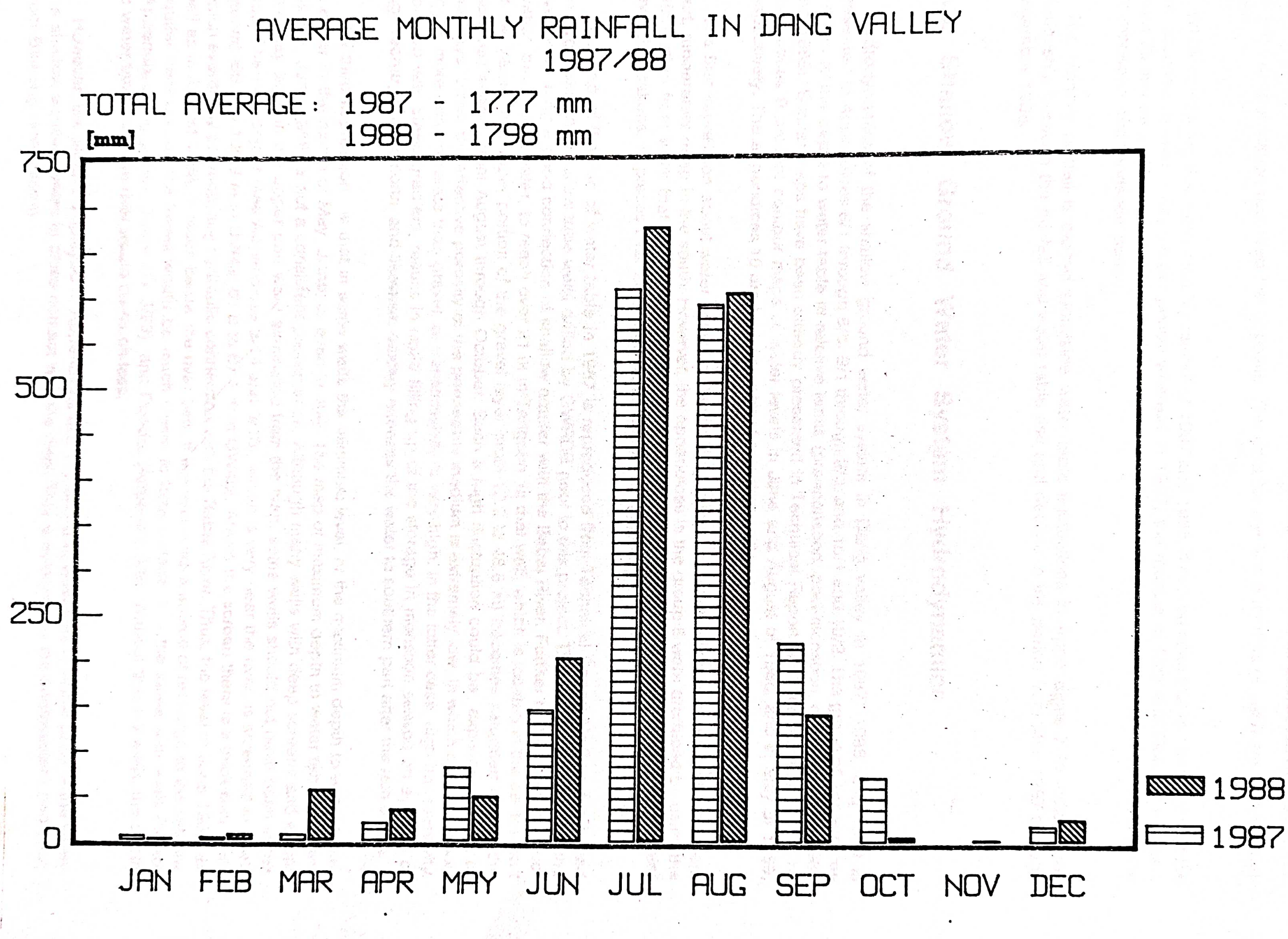

AVERAGE MONTHLY RAINFALL IN DANG VALLEY
1987/88
TOTAL AVERAGE: 1987 - 1777 mm
1988 - 1798 mm
[mm]
750
500
250
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1988
1987

FIGURE 4

but the Tulsipur station recorded the opposite. The data for the first 5 months of 1989 are not yet available!

While comparing the mean monthly rainfall of 1987 and 1988, it can be seen that in 1988, most of the rain occurred in June - September period whereas in 1987, the months of May and October had also about 75 mm each. This monthly distribution may have quite an effect on evolution of water levels in the pre-monsoon and monsoon period.

The monthly rainfall is plotted alongside water table fluctuations in Appendices 7 to indicate the relationship between the rainfall and water table rise and decline in the period from May 1987 through December 1988.

4.3. Shallow Ground Water System Hydrodynamics

Hydrodynamics of the shallow ground water system in Dang valley in 1987, 1988, and 1989 is presented in Appendices 8/1 through 8/5; 9/1 through 9/3; and 10/1 and 10/2. The group of Appendices 8 refers to the depth to water table in relative terms (pre-monsoon, post-monsoon, rise of levels in 1987 and 1988). Similar maps have been already presented in Technical Report No.2 for the year 1987. The appendices 9 present contour maps of water levels in June and August of 1988, and in May of 1989, respectively. The appendices 10 are hydrographs of selected wells.

The first impression about water levels in Dang valley is that the levels are very deep in the northern part, moderately deep in the south. However, the appendices in the group 8 were produced by using the information from wells that do not screen the same horizon. The second impression is very high water level fluctuations, in places over 20 m (see Appendix 10/1, Tarigaon).

The map of the rise of water table in 1987 is reproduced from Technical Report No.2 and is based on dug wells and shallow tube wells drilled by GWRDB prior to this project. The rise is smallest near the river, indicating a good connection of shallow aquifer with the Babai River. Further to the north, the fluctuation becomes greater, to reach over 21 m in Tarigaon. In that well, which is located in the central part of the valley, the upper portion of the gravel layer (from 12.2 to 48.8 m) becomes saturated only in the monsoon season from August through October. Such a high fluctuation could be explained in one of the ways. Either the effective porosity of the permeable medium is extremely low, in which case the lithology is more conglomerate than gravel, or transmissivity is very high. In the latter case, high transmissivity coupled with steep gradient, results in rapid filling up of the storage in monsoon season on account of high recharge in the north, and likewise, quickly releases the water to southern part after the rain stops.

The third impression is that in some wells the minimum level, or the maximum depth to water table, is either in the month of May, June, or even in July. The map of maximum depth to water table (Appendix 8/1, June 1988) is not a consistent presentation. Although many wells with deep screens and extensive clay layer in the upper part were eliminated from the map, some wells should not have been in the map. The well Bojpur (see Appendices 3/14 and 3/15), which is very near the river, is screened in deep interval (66.8 to 108.2 m in GW4a; 61.6 to 67.1 m in GW4b). Above the screen there is a thick clay layer which eventually prevents any hydraulic connection with the Babai River. Thus, the level in June 1988, as well as in August 1988, is much below the river bed. If the river were a source of recharge to the shallow aquifer near Bojpur, the levels would be much closer to land surface. It is the same with wells Pakkoi (Appendix 3/27), Jaspur (Appendix 3/29), and Dundra (Appendix 3/6). Without these 3 wells, the depth to water table near the river would be much less.

However, the picture displayed in Appendices 8/2, 8/3 and 8/5, illustrates in which parts of the valley the shallow aquifer comes in close contact with the river. This is evidently in the northwestern part only, from Baibang downstream.

The deepest water table in the whole valley is in Lalpur, in the central part of the reported area, 37.9 m. There, the upper permeable layer of gravel and sand, between 9.1 and 16.2 m, is all the time unsaturated (see Appendices 3/28 and 10/2). Since the level in the period 1988-89 never rose above the depth of 33 m, the second permeable layer (27.4-45.7) is also partly unsaturated all the time. The transmissivity of that locality is extremely high, indicating that the gravel underneath is extremely permeable and transmissive. Since the flow gradient is also high, about 0.012, which is quite unusual for a ground water system, plenty of water flows through this cross section. There is no "backflow" effect since there is no zone of low transmissivity from Lalpur to the north (see Appendix 6) to stop the flow and create a damming effect. The zone around Lalpur serves as a transient zone in which the water is not accumulated but only released to the south. Quite a similar picture is in May 1989. The levels are very deep in Lalpur, Tarigaon, Bargadi, Jaspur.

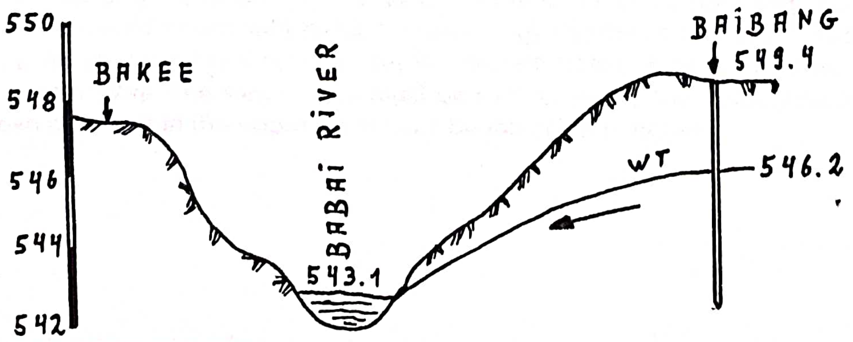
In 1988, the rise of levels started in the month of June as a direct response to June rainfall (Appendix 10). The maximum water levels were established in August and the decline started in September. Correlating the hydrographs with rainfall, it may be concluded that the high August level is the response to rainfall of 1279 mm in July and August and the rainfall in September of 139 mm is not sufficient to keep the water at such high levels and the levels slowly but steadily declined.

Appendices 7 present hydrographs at selected locations correlated with monthly rainfall. The correlation is obvious. There is a similar rise of levels in 1988 and in 1987, because the rainfall in 1988 is nearly equal to that of 1987.

4.4. Water Level Contour Maps in 1988/89

The Appendices 9/1, 9/2, and 9/3 present water level contour maps in June and August 1988, and May 1989, respectively. As mentioned before, the absolute elevations are the real ones, obtained through surveying. There is not so much difference in ground water flow gradients in either of these three maps. The scale of maps is small for details, but the gradient is everywhere very steep. The curvature of contour lines at the place where they intersect the Babai River indicates that the ground water flow parallel to the river. As expected the general direction of ground water flow is from northeast to southwest. In June 1988 the gradient of flow in the western part is about 0.008, or 8 meters per one kilometer. In the eastern part, the gradient is about 0.005, or 5 m/km. From the contour line 600 m in the southeast, the gradient of flow becomes flatter towards west. The change in gradient may be an indication of greater transmissivity of the areas in the southern and central parts. As mentioned above, the steepest gradient is in the central zone between Tarigaon and Lalpur, which may reach as high as 0.015. The map of contours in August 1988 is about the same as the map in June, except that the contour lines are higher everywhere for about 10 m. The flow pattern is the same. There is very little difference between contour maps in June 1988 and May 1989 (Appendices 9/1 and 9/3).

The sketch here below demonstrates the connection between the Babai River and the shallow ground water system at a cross-section between villages Bakee and Baibang. The surveying work near the end of March 1989 included the measurement of absolute elevation of the river water. The water level in early April at Baibang, which is several hundred meters from the river bank, is 3.1 m above the river level. Thus the gradient across such a short distance is very steep.



5. ASSESSMENT OF WATER RECHARGE AND DISCHARGE

5.1. Preliminary Assessment from Basic Documentation

The following conclusions are drawn about the recharge and discharge of the ground water system in reported area.

(1) The recharge comes from local infiltration of rainfall everywhere where more or less permeable surface permits. In Dang valley, the recharge is mostly along the northern fringe of the valley. According to lithological logs about one half of the valley has very permeable surface, with five or more meters of sand and gravel directly underlying it. These are the zones around Rangalcha, Bainsa, Baibang, Beltakura, Kataha, Phachkalwa, Tarigaon, Tari, Amaraiya, Amuwapur, Ammapur, Bargadi. The other half is almost impermeable. Thus the recharge to the shallow aquifer may include an area of about 500 km^2. (2) Although one would expect that the outflow of shallow ground water would be normally towards southwest into the Babai river, and although the water level contour maps confirm this, in many places along the river line the shallow water table is very deep under the river bed, making, thus, any connection unlikely. Actually, the water level contour maps indicate that the shallow ground water flows directly into the river in the western half of the valley, between Baibang and Bhojpur, while in the eastern half, the flow is parallel with the river course.

(3) The outflow into Babai river from Rangaincha to Bhojpur is calculated approximately with gradients from Appendices 9/1, 9/2, 9/3 and transmissivities from Appendix 6. The length of outflow section is about 30 km. The transmissivity is increasing from less than 100 m^2/day from Baibang to more than 6000 m^2/day in Malwar. The gradient of flow in the section between Baibang and Jaspur, where most of water appears to be outflowing into the river, is very high, 40 m per 5 kilometers, or 0.008. Westward and eastward of that section, the gradient is milder, about 0.006, which is still very high. The volume of water that may be outflowing through the section between Baibang and Bhojpur (12 km) with an average gradient of 0.008 and transmissivity of about 3500 m^2/day, could be about 336,000 m^3/day, or 122 MCM per year. With westernmost section from Baibang westwards included, the total outflow into the river in the western half of the valley could be as high as 130 MCM. If all this water must have infiltrated into the system from rainfall, then the infiltration percentage of rainfall comes to be about 14%, which is a correct order of magnitude. The recharge could be even higher, if one proves higher transmissivities in the westernmost part near the river. In other words, the outflow into the Babai River of 130 MCM may be on the conservative side, since the "contribution" of the westernmost 18 km were taken as only 8 MCM/year. There may be also some outflow into the river in the easternmost part, although with depths of water deep below the river bed one can hardly justify that. (4) All water that is recharged into the system from infiltrated rainfall flows very rapidly toward the river, i.e. toward the valley's erosional base.

The ground water system as explained in this report lends itself favourably to extensive ground water exploitation. The potential exists, aquifers are permeable and transmissive. Most of this 130 MCM of water can be abstracted by careful siting of wells, by reversing the gradients creating an extended cone of depression. The only constraint seems to be the economics of pumping, considering the depth of water table. One should count with dynamic (pumping) depths of over 40 m in some places. A typical well would be 80 m deep, with screens set in intervals between 30 and 70 m, and pump installed at some 40 or more meters. The well design must be such to permit the installation of 10 l/sec pump, that is the well screen diameter in the upper 40 m must be minimum 6 inches.

5.2. Assessment of Water Balance by Mathematical Modelling

The volume of data appears to be sufficient to construct a preliminary model of Dang valley. The missing information is in the northwestern part and along the northern rim of the valley. The model, of preliminary nature, may provide quantitative answers to the following:

(a) Recharge from rainfall over the permeable portion of the valley.
(b) The correct order of magnitude of hydrogeological parameters (permeability and transmissivity).
(d) The connection with the Babai River and the volume of outflow across the district boundary into India.
(e) The response of the valley to intensive ground water abstraction in various scenarios of development.

The boundaries of the valley are all natural (Appendix 11). The final outcome of the model could be the amount that can be annually developed by shallow wells considering the recharge, and the salvaged water on account of outflow into the Babai River.

The basis for the model calibration, i.e. for the verification of all system parameters, should be the rise of water levels from June through August 1988, correlated with rainfall, decline of water levels from August 1988 through May 1989, and again the rise of levels from May through September 1989. All three maps of water flow, i.e. in June 1988, August 1988, May 1989, should be matched by the model.

At the end of the modelling study the water balance of the shallow ground water system and its development potential can be formulated. Without a comprehensive evaluation of the whole system, including all its components (recharge-flow-discharge), any quantification of the shallow ground water system behavior and development potential is only a speculation.

The main components of the model shall be the following:

(a) Size. The whole Dang valley shall be modelled. It is a closed basin, and all boundaries must be included into the model. The area involved in the model shall be, along the X axis, from 605000 to 653000, or 48 km in the east-west direction; along the Y axis, the model shall start with 3092000 and end with 3123000, i.e. its Y dimension shall be 31. Thus the model size shall be 48 km by 31 km, or a total of 1488 km^2. The discretization shall be 1000 m in each direction, creating a uniform mesh network of 1 km2 each cell. Thus the model shall have 1488 cells, out of which in active simulation (aquifer) shall be about 1000 cells.

(b) The model shall be two-dimensional. The geometry of the shallow ground water system shall demand the following data input for each cell: (i) land surface elevation, (ii) top of aquifer elevation, (iii) bottom of aquifer elevation, (iv) initial water level elevation. Other input matrices (one value for each cell) shall be the following: hydraulic conductivity of the shallow aquifer, storage coefficient of the shallow aquifer, recharge from rainfall infiltration, discharge through evapotranspiration process. This last process is probably the least important in such a deep water table system as is the Dang.

(c) Model calibration process shall have four stages: (i) steady-state calibration of modelled output in the month of June 1988 (minimum water levels), (ii) unsteady-state calibration of the period June 1988 - August 1988 (the rise of water levels as a consequence of monsoon rains and increased recharge), (iii) unsteady-state calibration of the period August 1988 through May 1989 (the decline of water levels after the end of monsoon), (iv) model verification in the monsoon season from May through September 1989.

(d) The model output shall be the following: (i) improved distribution of aquifer parameters (hydraulic conductivity, storage coefficient), (ii) recharge from rainfall, as well as discharge into the river, (iii) assessment of available shallow water for increased development on account of reducing or eliminating the outflow into the Babai River.

6. CONCLUSIONS AND RECOMMENDATIONS

The objective of this report is to present technical information on the occurrence of shallow ground water in Dang valley. It is given in a form of a basic documentation with some preliminary interpretation.

The drilling program which was formulated about a year ago, was completed according to the expectations. Eight wells were completed with the total drilling metrage of 273 m. The average depth of newly completed wells is 30.0 m. Considering the lithology of shallow ground water system, and especially the depth to water table in static and pumping conditions, this depth is not adequate for the project purpose. All of 8 wells were constructed by drilling rig. In the area such as Dang, where water table is normally deep, except near the river, and where large pebbles, cobbles and boulders can be found at any depth and any place, any method of drilling will have to surmount obstacles. Manual, or indigenous, method is probably not suitable here, but, likewise a drilling rig may have problems unless it is powerful, well equipped and well maintained. Diverse drill bits should be readily available when needed. An average shallow well in Dang valley, to be used for either monitoring water levels or as a producer, should be between 60 and 70 m deep. The upper permeable layers are in most places dry during a portion of year.

In running pumping tests the following problems have been identified:

(a) Pumping equipment not adequate for all situations. The suction range of centrifugal pump limited to about 7 m below the pump discharge point restricts the possible dynamic depth of pumping. Pump discharge is fluctuating during the test. In Dang either electrical submersible pump or vertical turbine pump should be used. To accommodate such a pump, well diameter should be 6 inches.

(b) Pump discharge measuring instrumentation is not always reliable. The best method of testing would be with a 3-in flowmeter with direct reading of the flowrate in liters per second.

(c) Measurements of water level during the pumping and/or recovery periods are sometimes questionable (late, improvised).

(d) Mostly because of deep levels and inadequate pumpingequipment in only seven UN "project" wells pumping test had been run. However, the information presented herein is expanded by making an interpretation of earlier pumping tests conducted by GWRDB several years ago.

The pump testing program in Dang valley should be continued. There are some wells which lend themselves to testing in the period when water levels are within suction lift capacity of centrifugal pump, and in others an adequate pump should be employed. If remaining wells are tested, the wealth of information and knowledge about the district would be improved to some extent. The wells to be tested are as follows: DGSTW 1 Ragaincha, DGSTW 6 Dundra and DGSTW 10 Tulsipur. There are some wells which are not properly developed. It is recommended to redevelop properly and re-test the following wells: DGSTW 3 Baibang, GW 10a Bainsa, and GW 14 Pakkol.

The interpretation of lithology on the basis of driller's log is sometimes difficult. In many logs the description is given as "clay and gravel". Such description has no sense in hydrogeology. Few percents of silty components in otherwise coarse-grained material may make the formation completely impermeable. Thus a large component of gravel has to be proved by pumping tests and matched with transmissivity values. With this in mind, the pumping tests results become the decisive in declaring an area good or bad.

Although, generally, the Dang valley is characterized by high transmissivities of shallow layers, which in places reaches as high as 6,000 m^2/day, several wells did not fit into the picture. One well in the east and two in the west have shown rather poor transmissivities: Pakkoi - 26, Bainsa - 36 and Baibang - 86 m^2/day. In Baibang the lithology shows 11 m of gravel. If the lowermost possible hydraulic conductivity of gravel is considered, the well should have produced at least 440 m^2/day transmissivity. Likewise, in Bainsa, about 50 m of gravel and sand have shown 36 m^2/day and in Pakkoi, 11 m of gravel has produced only 26 m^2/day transmissivity. From this, it can be concluded that either the reported lithology or the construction and/or development of wells are not correct. Considering the location of the well, one can suspect that the wells at Pakkoi and Baibang must have been not properly developed. There is also a possibility that drilled-through layers are composed of conglomerates rather than gravel. The wells in central and southern parts which are mostly along the Babai and Guwar rivers have shown higher transmissivities.

Dang valley is well covered with water-level monitoring network. In the month of February 1989, the network includes 8 project- drilled wells, 10 GWRDB drilled wells and one dug well. It is recommended to continue with the same network, i.e. with 19 wells, on a once-a-month basis.

The hydrogeology of Dang valley can be best described as follows.

(a) The percentage of permeable material (sand, gravel) in the upper 30 or so meters is about 48%. In deeper parts this percentage is either about the same or even higher.

(b) There are several permeable layers, which may be interconnected over a larger distance, but locally they are separated by considerable clay layer (more than 10 m thick).

(c) Water table is generally deep, especially in the northern half of the valley. The deepest water table is close to 30 m. Fluctuations of water levels are generally high, in some places over 20 m. Water table of aquifer at depths 50 to 70 m in some wells in the southeastern part of the valley near the river are deep under the river bed, indicating effective separation between the surface and ground water.

(d) The recharge into the shallow ground water system is from rainfall, and discharge is to the Babai River. The rainfall may contribute the recharge over about 50% of the valley, that is to some 500 km^2. With the average annual rainfall of some 1900 mm, and with the percentage of infiltration of 14 (a result of calculation from flow net), the total input into the shallow ground water system could be about 130 MCM per year.

(e) Although one would expect that the outflow of shallow ground water would be normally towards southwest into the Babai river, and although the water level contour maps confirm this, in many places along the river line the shallow water table is very deep under the river bed, making, thus, any connection unlikely. Actually, the water level contour maps indicate that the shallow ground water flows directly into the river in the western half of the valley, between Baibang and Bhojpur, while in the eastern half, the flow is parallel with the river course.

(f) The outflow into Babai river from Rangaincha to Bhojpur is calculated from the gradient of ground water flow and transmissivities from pumping tests. The gradient all over the valley is very high, on average 40 m per 5 kilometers, or 0.008. The volume of water that may be outflowing through the section between Baibang and Bhojpur (12 km) could be about 336,000 m^3/day, or 122 MCM per year. With westernmost section from Baibang westwards included, the total outflow into the river in the western half of the valley could be as high as 130 MCM. In an average year, in a closed basin such as the Dang, all recharge should be balanced by discharge. Since the evaporation process may have only limited importance, and pumping from wells is at the moment of low significance, the recharge to the system could be at least 130 MCM/year, or higher if one proves higher transmissivities in the westernmost part near the river. In other words, the outflow into the Babai River of 130 MCM may be on the conservative side, since the "contribution" of the westernmost 18 km were taken as only 8 MCM/year. There may be also some outflow into the river in the easternmost part, although with depths of water deep below the river bed one can hardly justify that.

The ground water system as explained in this report lends itself favourably to extensive ground water exploitation. The potential exists, aquifers are permeable and transmissive. Most of this 130 MCM of water can be abstracted by careful siting of wells, by reversing the gradients and by creating an extended cone of depression. The only constraint seems to be the economics of pumping, considering the depth of water table. One should count with dynamic (pumping) depths of over 40 m in some places. A typical well would be 80 m deep, with screens set in intervals between 30 and 70 m, and pump installed at some 40 or more meters. The well design must be such to permit the installation of 10 l/sec pump, that is the well screen diameter in the upper 40 m must be minimum 6 inches.

On the basis of the presented information, the feasibility of shallow ground water development in the reported area is as follows (Appendix 12):

The best area for shallow ground water development by using centrifugal pump is along the Babai river. In the rest of the valley, water table is beyond the suction lift reach of centrifugal pump. This is not to say that shallow ground water development is not feasible in such areas. On the contrary, notably in the central part where transmissivities are higher than 2000 m^2/day, the development potential is very high but other types of pumps should be used, and well diameter should be at least 6 inches. Only in the northwestern part and along the rim of the valley, the development potentials appear to be impaired due to (a) unknown lithology, (b) deep water table, (c) very hard material, (d) rough or "undulating" topography.

It is believed that wells in Dang valley shall be able to pump between 30 and 50 l/sec, from dynamic depths of some 40-50 m. The number of wells, producing on average 150,000 m^3/season, which may be sufficient to irrigate about 10 hectares, could be about 900. These are expensive wells, with expensive pumping equipment, but since each can irrigate at least 10 hectares, the expense may be shared by a group of farmers.

Finally, the following is recommended to be done during future investigations:

(i) Complete pumping tests in existing wells. Use adequate pumping equipment.

(ii) Drill additional test holes between Tari Gaon and Amuwapur, Bainsa and Tulsipur, north of Rangaicha, between Asuwar and Kataha to fill the gap.

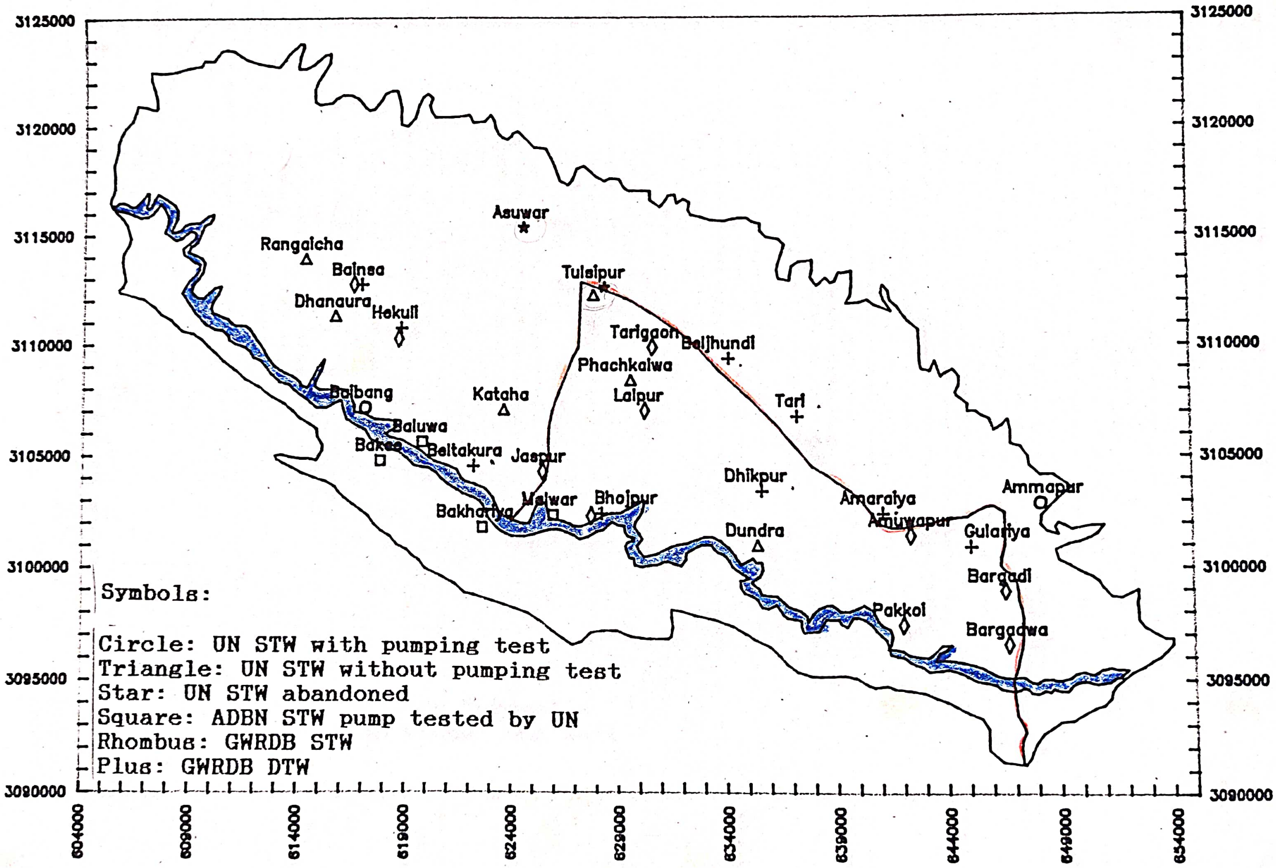
(iii) Construct several 6" size wells nearby already existing 4" size in the areas where water table is always below 7 m and conduct pumping test using 4-in existing wells as observations wells. Make one well 70 m deep, which would be of typical design for future large-scale exploitation (6-in casing in upper 50 m, 4-in in lower part; well screen 4-in and 6-in; drilling diameter 10-in, gravel pack 2-in) and run a long-term pumping test (3 days minimum).

(iv) Continue monitoring of water levels without interruptions. Use all 19 wells.

(v) Make a mathematical model of the whole valley which will quantify the parameters and processes involved in the present ground water flow environment and offer planning and management alternatives for future intensive ground water development.

APPENDICES

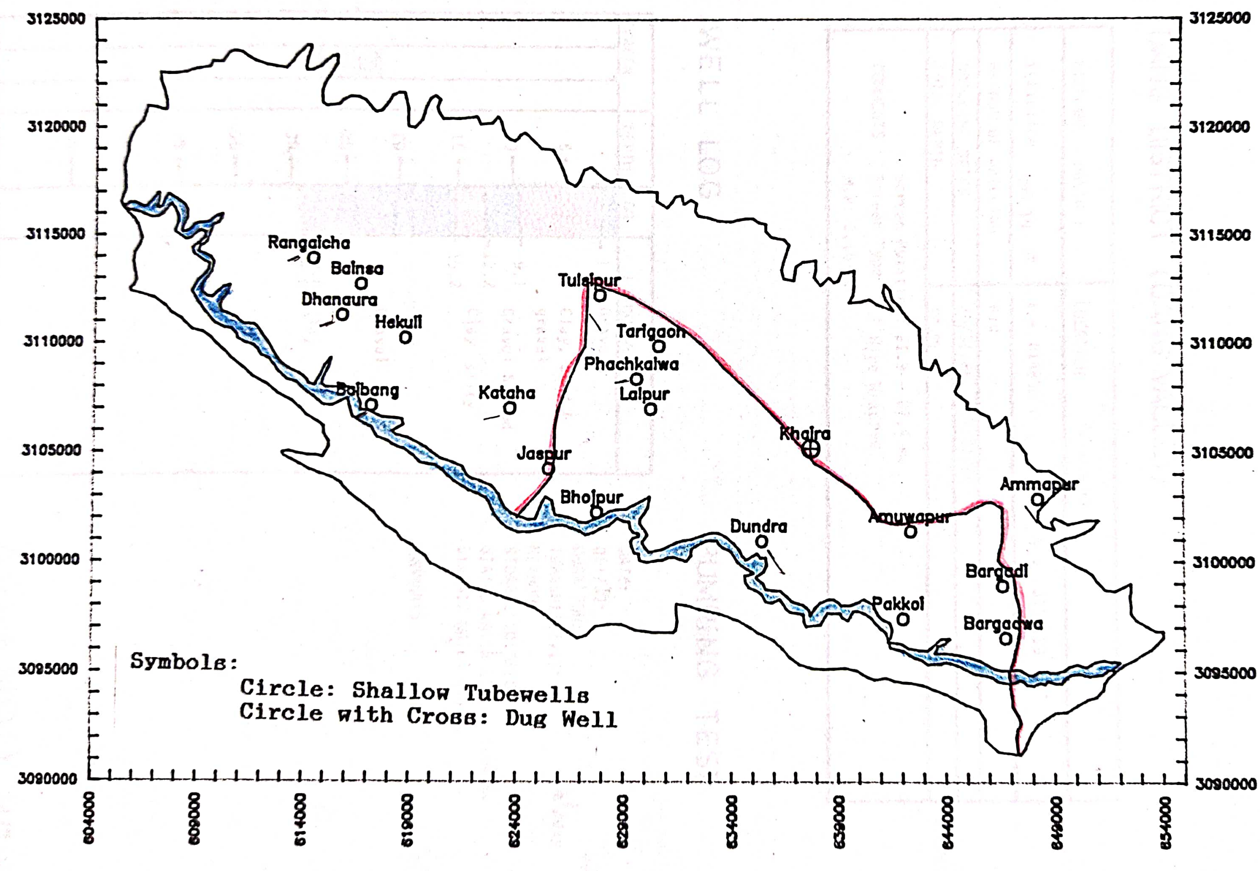
DANG VALLEY – TUBEWELL LOCATION MAP



APPENDIX 1

APPENDIX 2

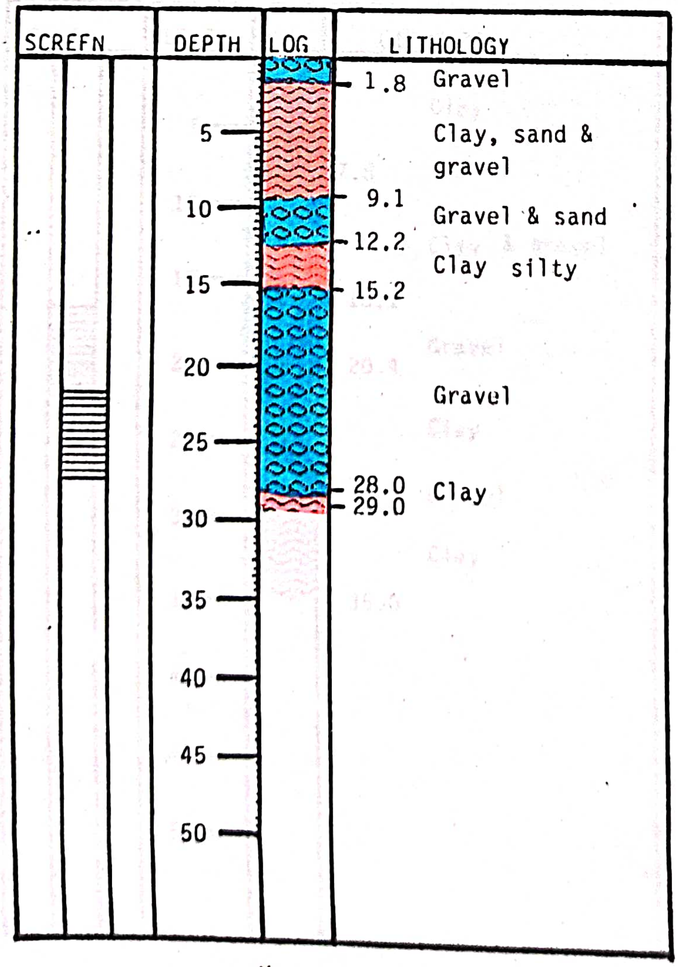
DANG VALLEY – ACTUAL MONITORING NETWORK



DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 1	LOCATION Ragaincha	
ELEVATION 599.19 m	X = 614250	Y = 3113750
METHOD OF DRILLING	Rig	
DRILLING DATES	20/01/88 - 24/01/88	
TOTAL DEPTH	29 m.	
COMMENTS	Screen Position: 21.9 - 27.4 m. Screen Type : Wire Wrapped M.P: 0.15 m.	

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 7.59 m.
DYNAMIC WATER LEVEL:

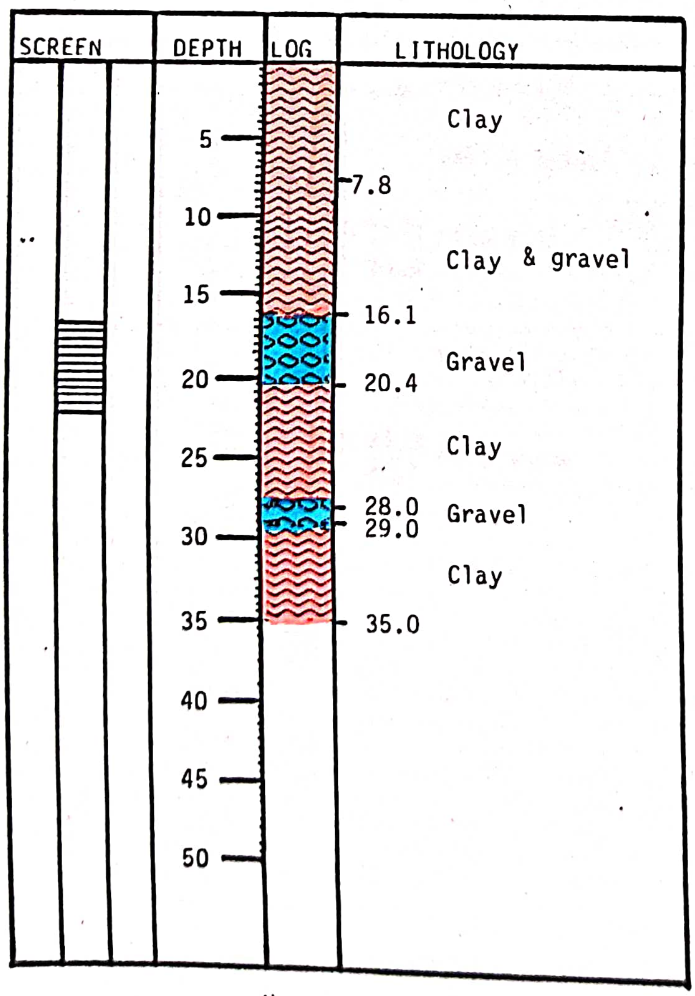
COMMENTS:

APPENDIX 3/1

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 2	LOCATION Dhanaura	
ELEVATION 565.72 m	X = 615750	Y = 3111250
METHOD OF DRILLING	Rig	
DRILLING DATES	3/02/88 - 5/02/88	
TOTAL DEPTH	35.0 m.	
COMMENTS	Screen Position: 16.75 m - 22.25 m. Screen Type : Wire Wrapped M.P: 0.25 m.	

WELL LOG



PUMPING TEST

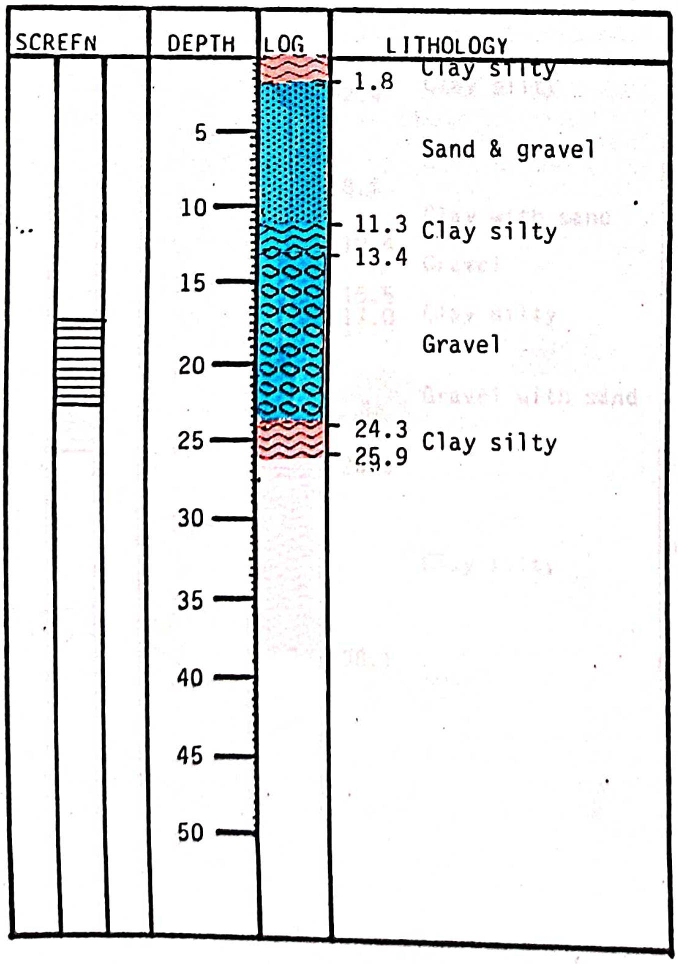
DATE:
Q(1/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 12.75 m.
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 3	LOCATION Baibang
ELEVATION 549.06 m	X = 617125 Y = 3107000
METHOD OF DRILLING	Rig
DRILLING DATES	6/02/88 - 6/02/88
TOTAL DEPTH	25.9 m.
COMMENTS	Screen Position: 17.37 m - 23 m. Screen Type : Wire Wrapped M.P: 0.38 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s): 7
DURATION: 300 min
TRANSMISSIVITY: 85 m^2/day
METHOD: Jacob
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 3.79 m (B.G.L)
DYNAMIC WATER LEVEL: 6.98 m

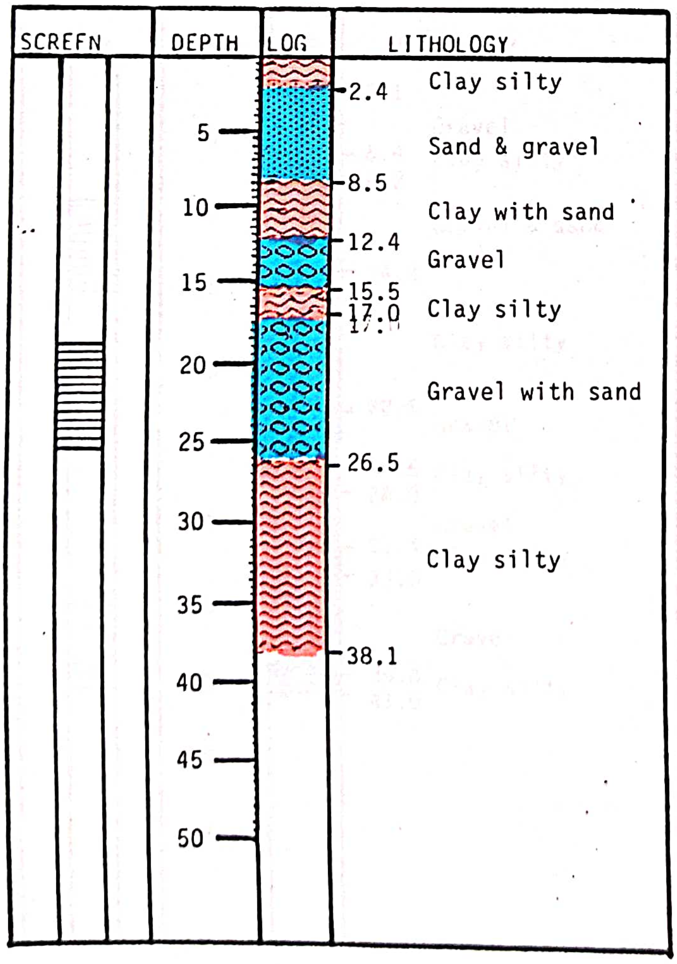
COMMENTS:

APPENDIX 3/3

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 4	LOCATION Kataha
ELEVATION 595.70 m	X = 616375 Y = 3106875
METHOD OF DRILLING	Rig
DRILLING DATES	9/02/88 - 11/02/88
TOTAL DEPTH	38.1 m.
COMMENTS	M.P: 0.26 m. Screen Position: 18.8 m - 25.5 m Screen Type : Wire Wrapped

WELL LOG



PUMPING TEST

DATE:
Q(l/s): 10 (Compressor)
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 10.64 m.
DYNAMIC WATER LEVEL:

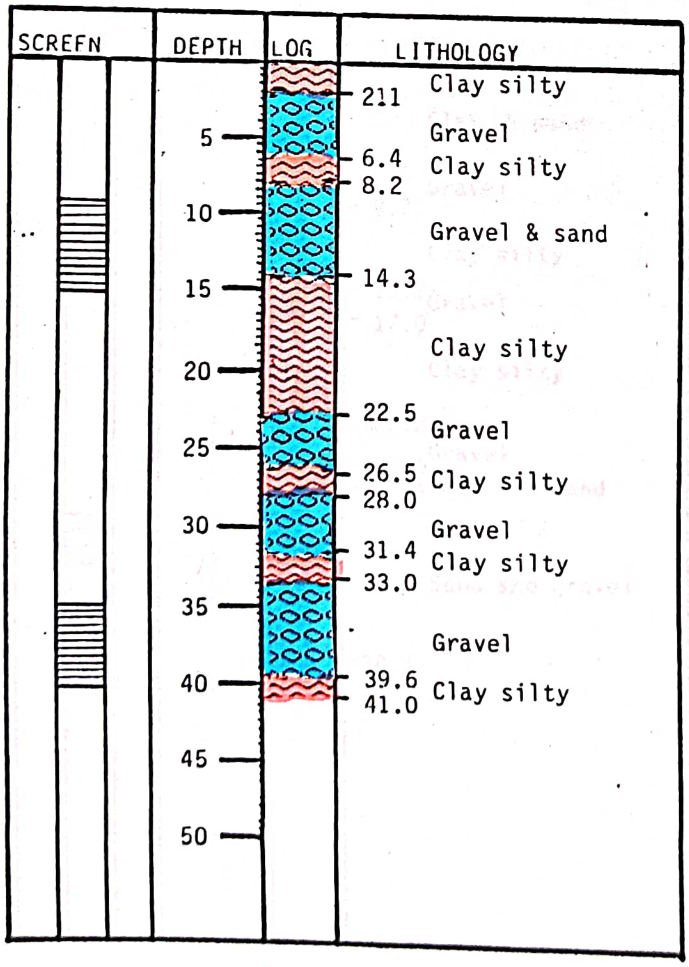
COMMENTS:

APPENDIX 3/4

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 5	LOCATION Phachkalwa
ELEVATION 617.71 m	X = 629500 Y = 3108125
METHOD OF DRILLING	Rig
DRILLING DATES	12/02/88 - 14/02/88
TOTAL DEPTH	41 m.
COMMENTS	Screen Position: 9.7 m - 15.3 m 35 m - 40.6 m Screen Type : Wire Wrapped M.P: 0.03 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s): 23.0
DURATION: 3 hrs. 30 min.
TRANSMISSIVITY: 495 m^2/day
METHOD: Jacob
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 1.08 m (B.G.L)
DYNAMIC WATER LEVEL: 5.27 m

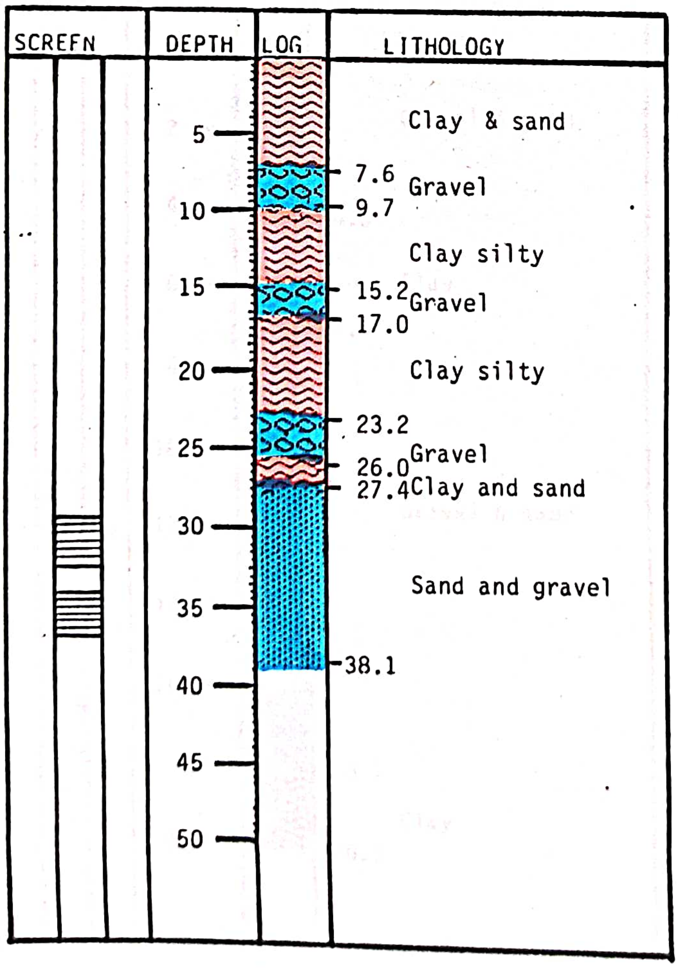
COMMENTS:

APPENDIX 3/5

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 6	LOCATION Dundra
ELEVATION 593.12 m	X = 635375 Y = 3100750
METHOD OF DRILLING	Rig
DRILLING DATES	21/02/88 - 23/02/88
TOTAL DEPTH	38.1 m.
COMMENTS	Screen Position: 29.5 m - 32.5 m. 34 m. - 37 m. Screen Type : Slotted Pipe M.P: 0.24 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 5.0 m.
DYNAMIC WATER LEVEL:

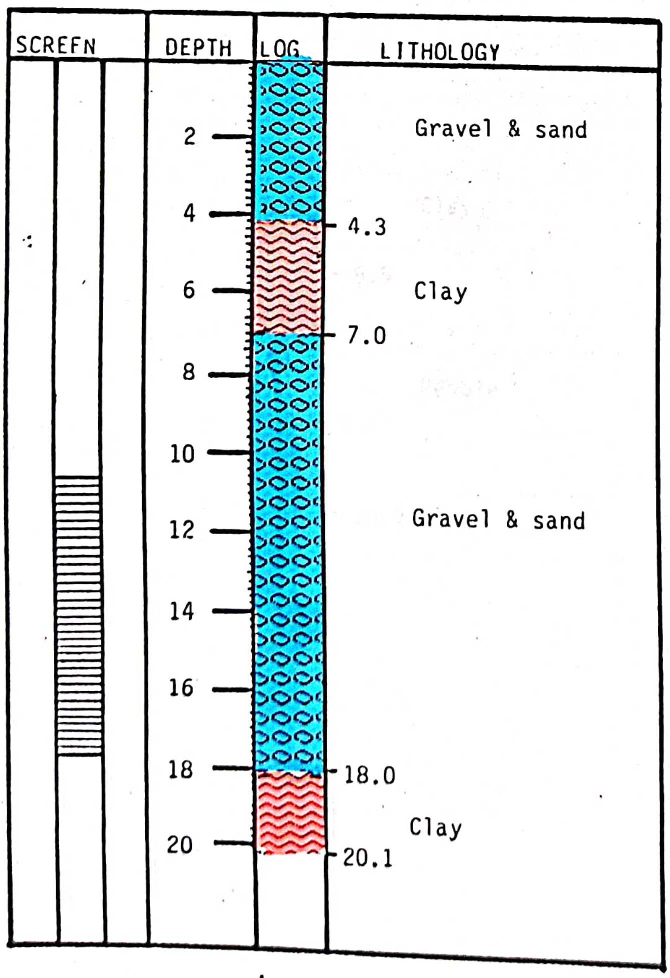
COMMENTS:

APPENDIX 3/6

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 7	LOCATION Ammapur
ELEVATION 674.38 m	X = 648250 Y = 3102750
METHOD OF DRILLING	Rig
DRILLING DATES	27/02/88 - 29/02/88
TOTAL DEPTH	20.1 m.
COMMENTS	Screen Position: 10.7 m - 17.7 m Screen Type : Slotted Pipe M.P: 0.22 m.

WELL LOG



PUMPING TEST

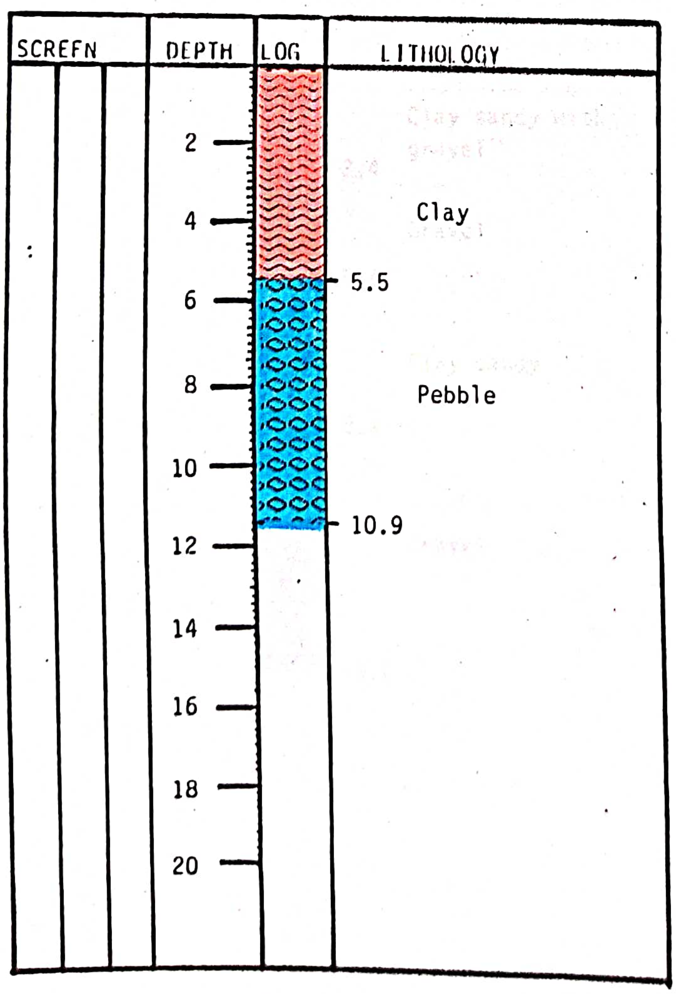
DATE:
Q(l/s): 11
DURATION: 300 min.
TRANSMISSIVITY: 745 m^2/day
METHOD: Jacob
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 3.04 m (B.G.L)
DYNAMIC WATER LEVEL: 7.87 m

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 8	LOCATION Tulsipur	
ELEVATION m	X = 628375	Y = 3112625
METHOD OF DRILLING	Rig	
DRILLING DATES	16/02/88 - 19/02/88	
TOTAL DEPTH	10.9 m.	
COMMENTS Well abandoned		

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL:
DYNAMIC WATER LEVEL:

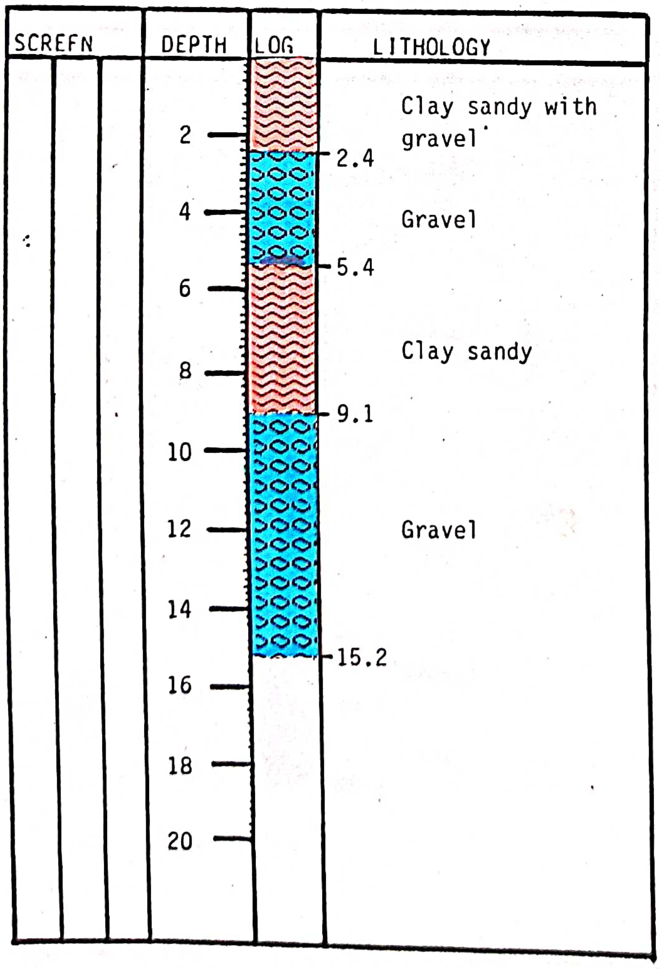
COMMENTS:

GWRDB - UNDP NEP/86/025
SHALLOW GROUNDWATER EXPLORATION IN TERAI

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 9	LOCATION Asuwar
ELEVATION m	X = 624625 Y = 3115875
METHOD OF DRILLING	Rig
DRILLING DATES	25/04/88 - 27/04/88
TOTAL DEPTH	15.2 m.
COMMENTS Well abandoned	

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL:
DYNAMIC WATER LEVEL:

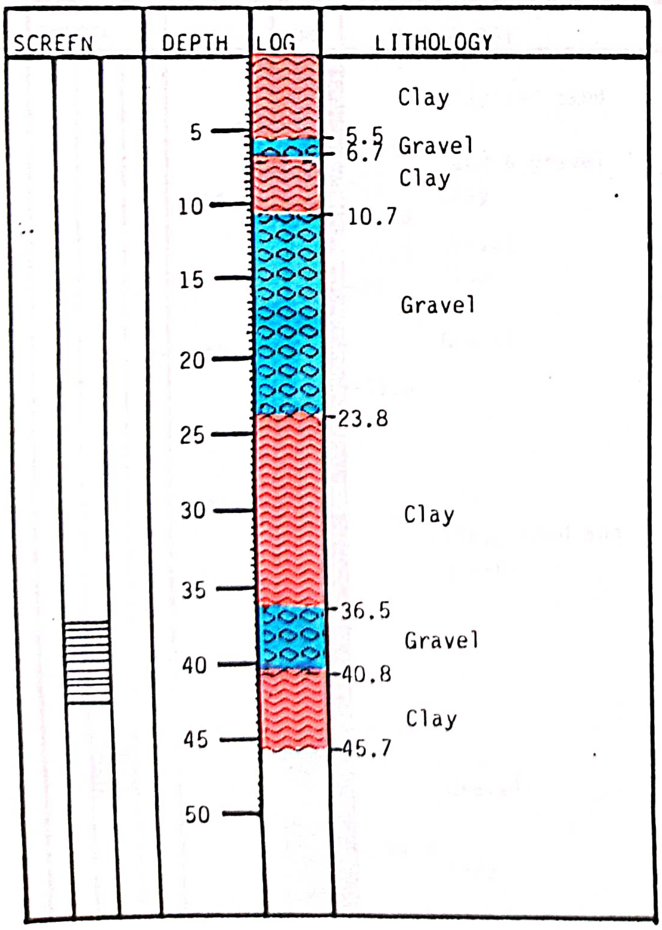
COMMENTS:

APPENDIX 3/9

DANG DISTRICT (DANG VALLEY)

WELL NO. DGSTW 10	LOCATION Tulsipur
ELEVATION 676.67 m	X = 627875 Y = 3112250
METHOD OF DRILLING	Rig
DRILLING DATES	28/04/88 - 8/05/88
TOTAL DEPTH	45.7 m.
COMMENTS	Screen Position: 37.2 m. - 42.7 m. M.P: 0.60 m.

WELL LOG



PUMPING TEST

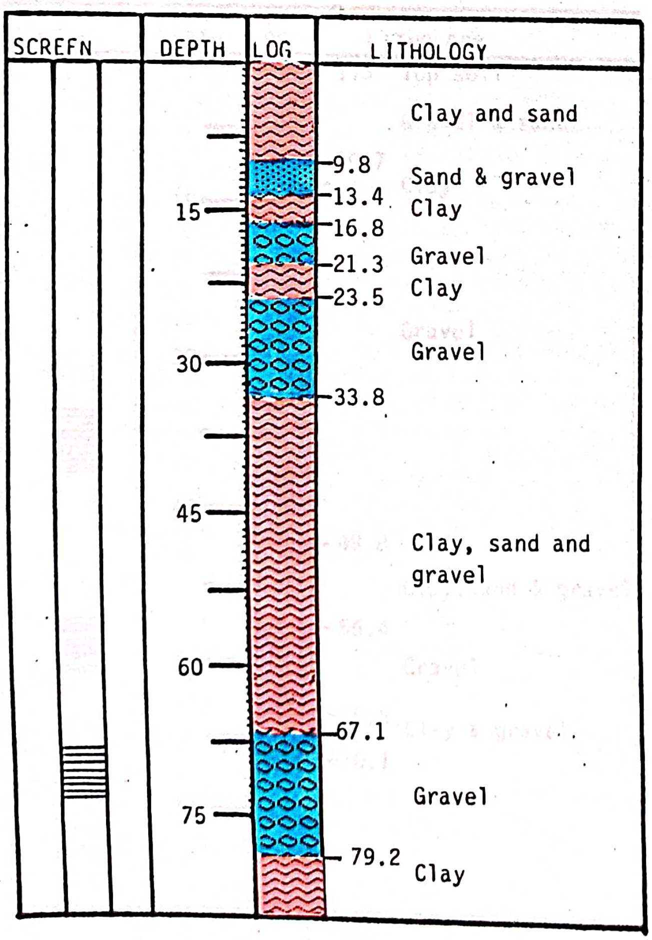
DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 23.56 m.
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW1	LOCATION Dhikpur
ELEVATION 605.04 m	X = 635625 Y = 3103375
METHOD OF DRILLING	Rig
DRILLING DATES	4/01/85 - 18/01/85
TOTAL DEPTH	140.2 m.
COMMENTS	Screen Position: 67.9 - 73.4 m., 104.2 - 115.5 m., 131.2 - 136.7 m. Screen Type : Wire Wrapped M.P: 0.41 m. Well Size : 10"/6"

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 9.60 m.
DYNAMIC WATER LEVEL:

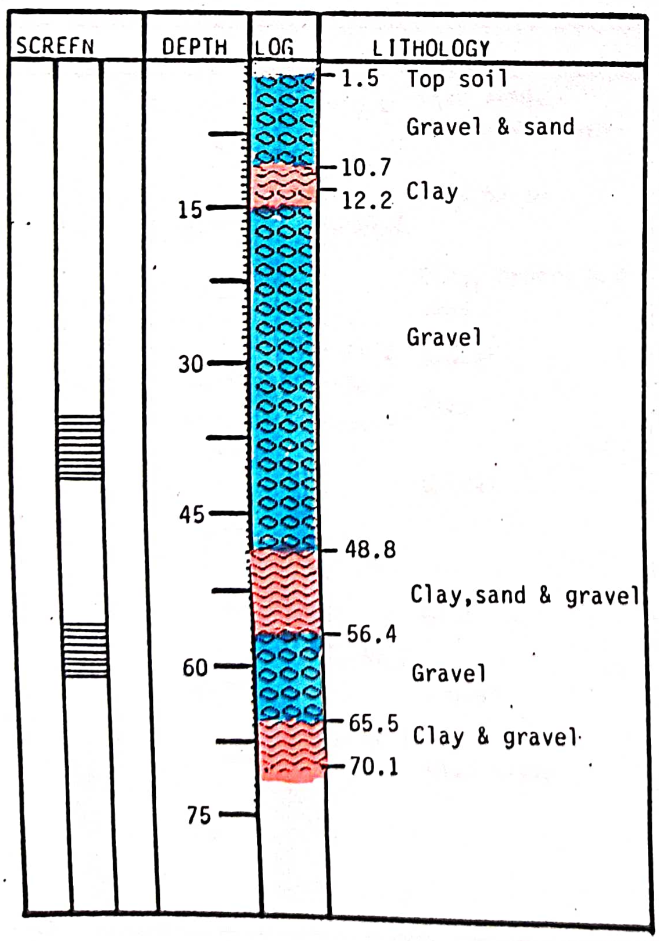
COMMENTS:

APPENDIX 3/11

DANG DISTRICT (DANG VALLEY)

WELL NO. GW2	LOCATION Tari Gaon
ELEVATION 622.74 m	X = 630625 Y = 3109875
METHOD OF DRILLING	Rig
DRILLING DATES	21/01/85 - 01/02/85
TOTAL DEPTH	70.1 m.
COMMENTS	Screen Position: 34.1 - 39.6 m., 55.5 - 61 m. Screen Type : Wire Wrapped Well Size : 6" M.P: 0.07 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s): 16.7
DURATION: 12 hrs.
TRANSMISSIVITY: 3440 m^2/day
METHOD: Jacob
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 15.2 m.
DYNAMIC WATER LEVEL: 16.25 m (B.G.L)

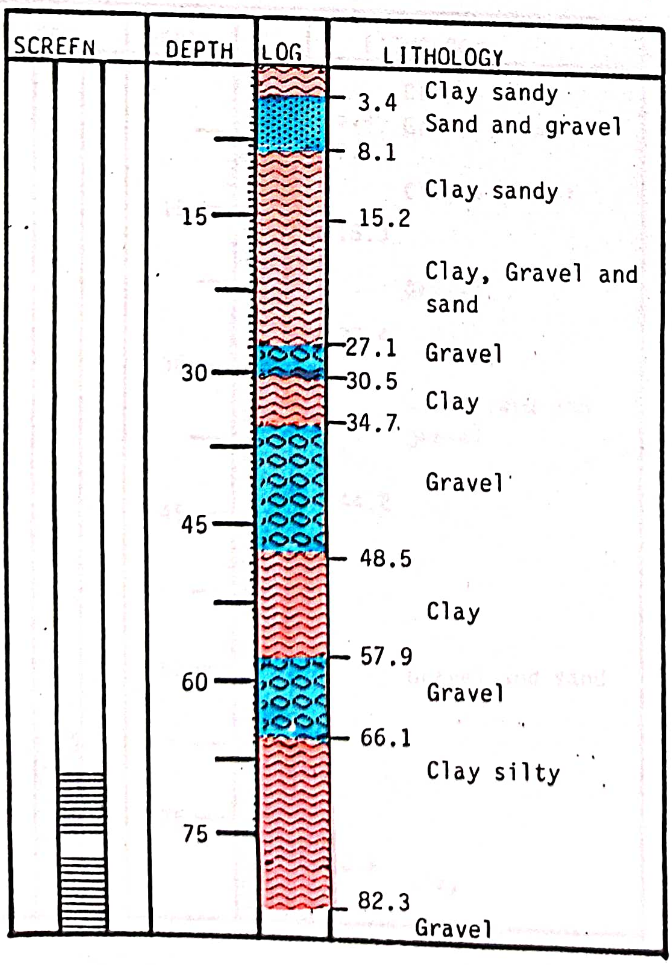
COMMENTS:

APPENDIX 3/12

DANG DISTRICT (DANG VALLEY)

WELL NO. GW3	LOCATION Amaraiya
ELEVATION 626.34 m	X = 641125 Y =3102375
METHOD OF DRILLING	Rig
DRILLING DATES	25/01/85 - 16/02/85
TOTAL DEPTH	149.4 m.
COMMENTS	Screen Position: 69.8 - 75.3m., 77.2 - 83.4 m. Screen Type : Slotted Pipe Well Size : 10"/6" M.P: 0.32 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 13.84 m.
DYNAMIC WATER LEVEL:

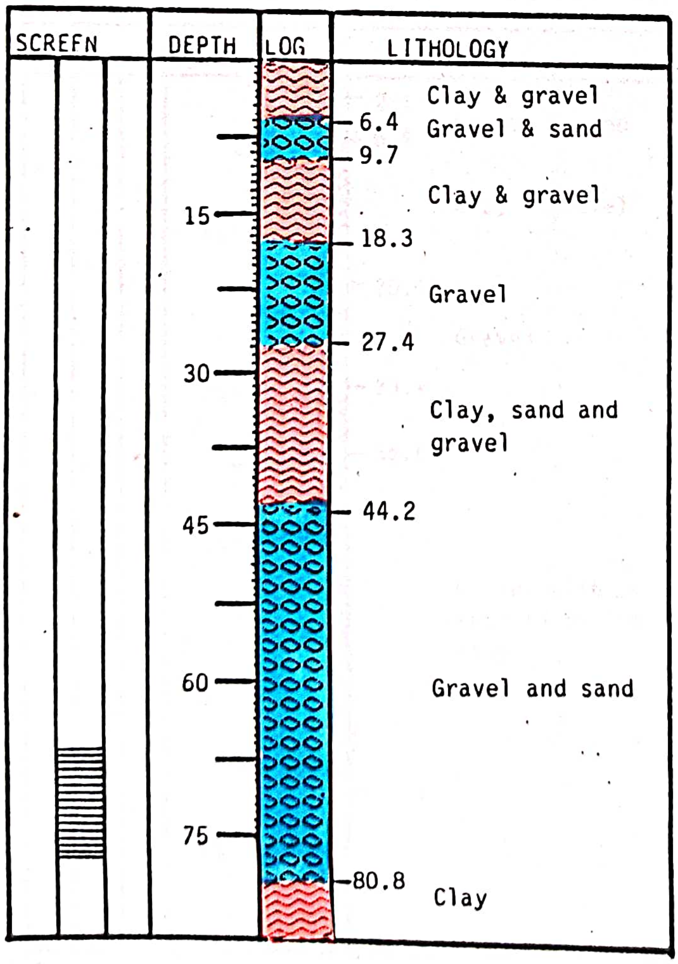
COMMENTS:

APPENDIX 3/13

DANG DISTRICT (DANG VALLEY)

WELL NO. GW4 a	LOCATION Bhojpur	
ELEVATION 582.13 m	X = 628250	Y = 3101876
METHOD OF DRILLING	Rig	
DRILLING DATES	05/02/85 - 22/02/85	
TOTAL DEPTH	117.3 m.	
COMMENTS	Screen Position: 66.8 - 77.7 m., 90.5 - 96 m., 102.7 - 108.2 m. Screen Type : Wire Wrapped Well Size : 10"/6"	M.P: 0.03 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 14.83 m.
DYNAMIC WATER LEVEL:

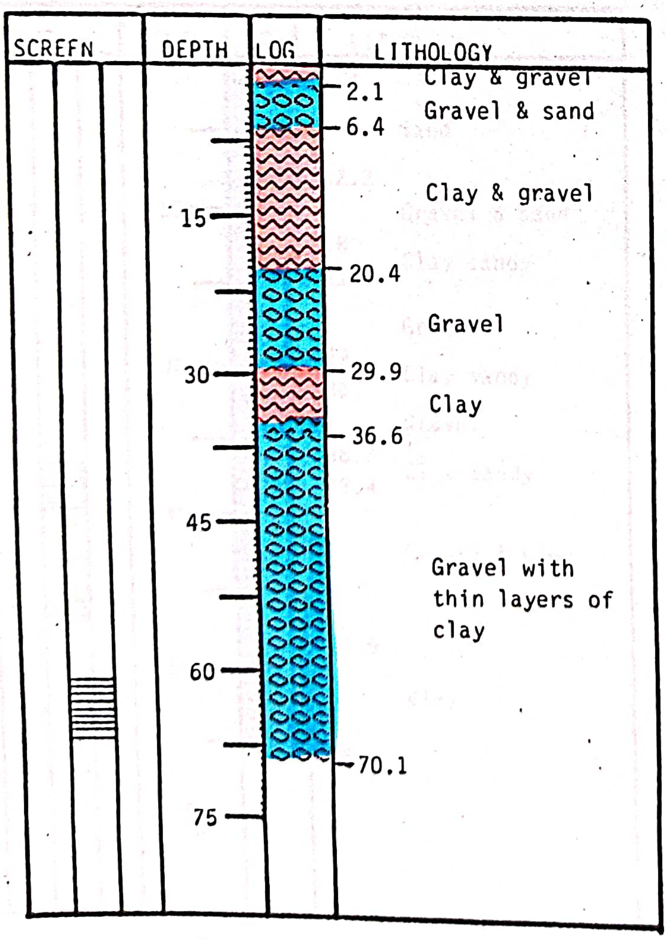
COMMENTS:

APPENDIX 3/14

DANG DISTRICT (DANG VALLEY)

WELL NO. GW4 b	LOCATION Bhojpur
ELEVATION 582.06 m	X = 627375 Y = 3101750
METHOD OF DRILLING	Rig
DRILLING DATES	27/02/85 - 04/03/85
TOTAL DEPTH	70.1 m.
COMMENTS	M.P: 0.34 m. Screen Position: 61.6 - 67.1 m. Screen Type: Wire Wrapped Well Size: 6"

WELL LOG



PUMPING TEST

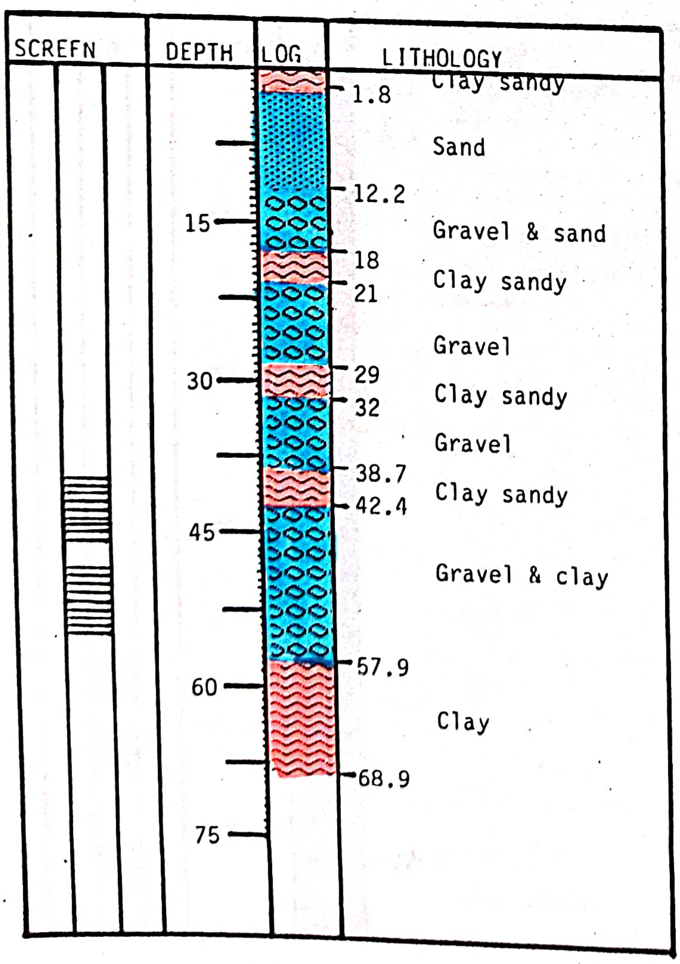
DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 15.5 m.
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW5	LOCATION Amuwapur		
ELEVATION 633.10 m	X = 642375	Y = 3101375	
METHOD OF DRILLING	Rig		
DRILLING DATES	18/02/85 - 02/03/85		
TOTAL DEPTH	68.9 m.		
COMMENTS	M.P: 0.33 m. Screen Position: 41.1 - 46.7, 49.7 - 55.2 m. Screen Type: Wire Wrapped Well Size: 10/6 "		

WELL LOG



PUMPING TEST

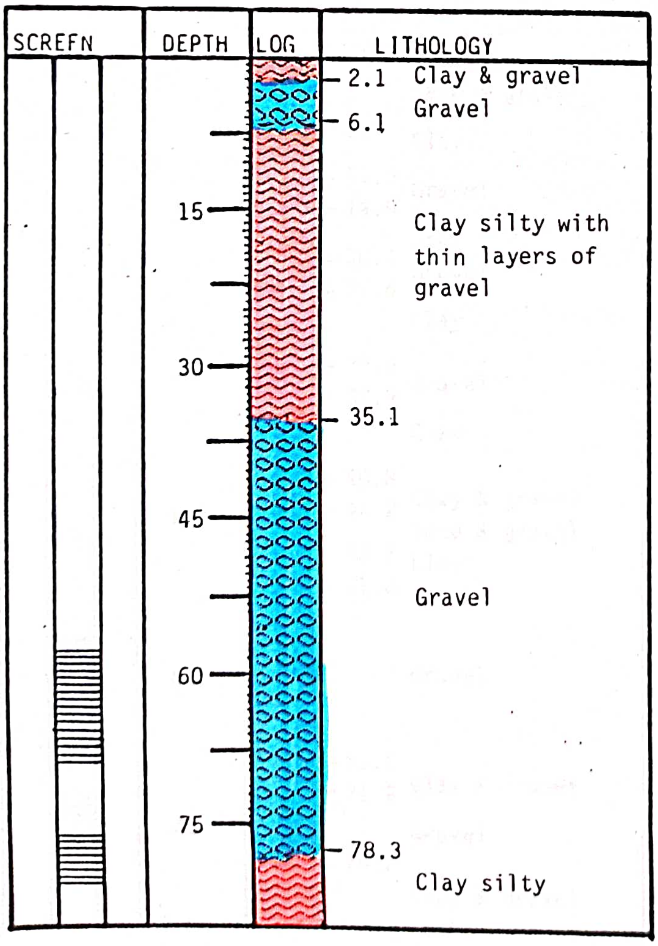
DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 23.77 m.
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW6	LOCATION Beljhundi
ELEVATION 646.11 m	X = 634125 Y = 3109375
METHOD OF DRILLING	Rig
DRILLING DATES	15/03/85 - 01/04/85
TOTAL DEPTH	100.6 m.
COMMENTS	Screen Position: 58-69 m., 76.3-81.2 m., 89.1-94.6 m. Screen Type : Slotted Pipe Well Size: : 10"/6" M.P: 0.28 m.

WELL LOG



PUMPING TEST

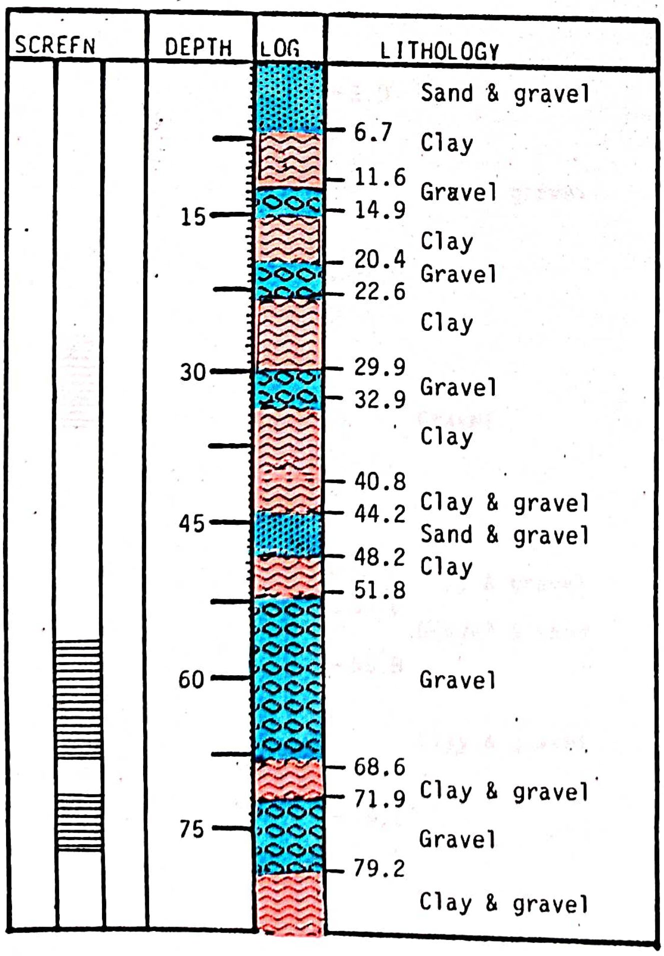
DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 22.68 m.
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW7	LOCATION Beltakura
ELEVATION 578.10 m	X = 622250 Y = 3104500
METHOD OF DRILLING	Rig
DRILLING DATES	08/04/86 - 14/05/86
TOTAL DEPTH	82.3 m.
COMMENTS	Screen Position: 56.7 - 67.7 m., 71.9 - 77.4 m. Screen Type : Wire Wrapped Well Size : 10"/6" M.P: 0.53 m.

WELL LOG



PUMPING TEST

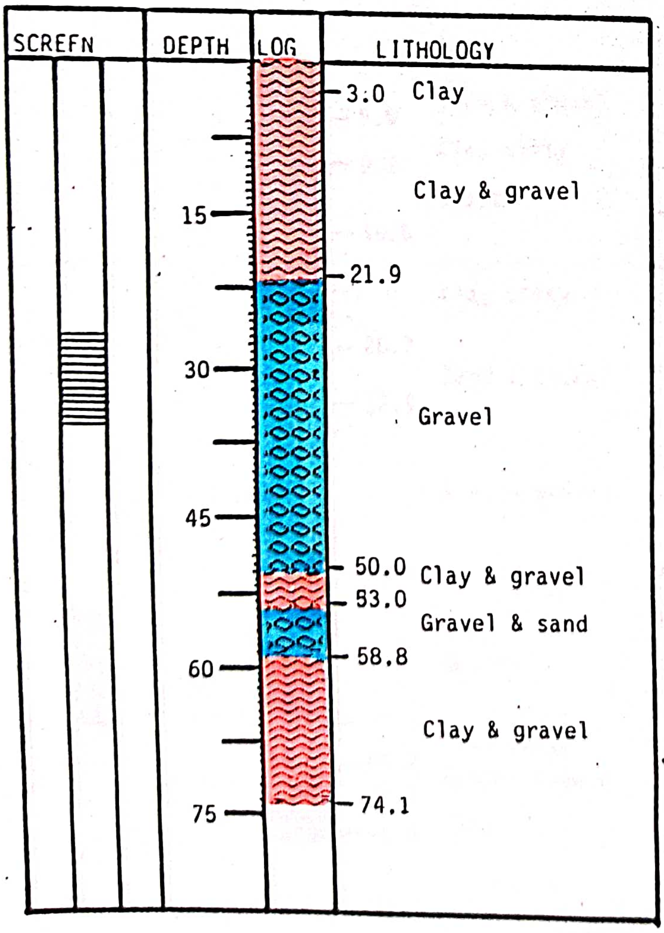
DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 20.12 m.
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW8	LOCATION Bargadwa
ELEVATION 634.49 m	X = 646750 Y = 3096500
METHOD OF DRILLING	Rig
DRILLING DATES	17/04/86 - 24/04/86
TOTAL DEPTH	117.3 m.
COMMENTS	Screep Position: 27.7 - 35.1 m. Screen Type : Slotted Pipe Well Size : 6" M.P: 0.14 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s): 9.5
DURATION: 6 hrs. 30 min
TRANSMISSIVITY: 1035 m^2/day
METHOD: Jacob
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 19.56 m (B.G.L)
DYNAMIC WATER LEVEL: 21.8 m

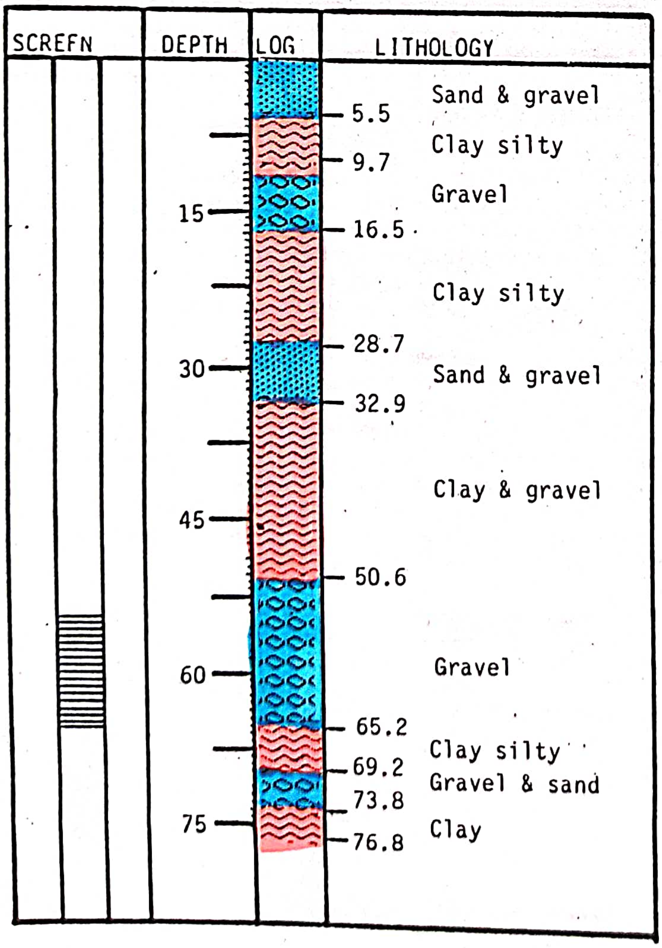
COMMENTS:

APPENDIX 3/19

DANG DISTRICT (DANG VALLEY)

WELL NO. GW9	LOCATION Tari
ELEVATION 627.46 m	X = 637250 Y = 3106750
METHOD OF DRILLING	Rig
DRILLING DATES	06/01/87 - 24/01/87
TOTAL DEPTH	96 m.
COMMENTS	Screen Position: 54.3 - 65.3 m., 80.1 - 91.1 m Screen Type : Wire Wrapped Well Size : 6" M.P: 0.28 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 4.70 m.
DYNAMIC WATER LEVEL:

COMMENTS:

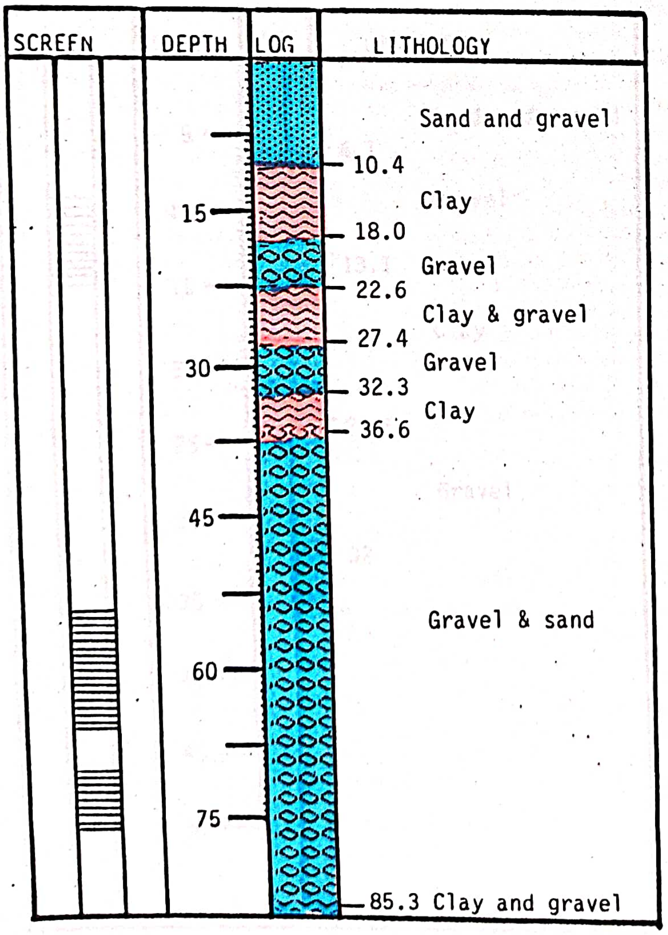
APPENDIX 3/20

GWRDB - UNDP NEP/86/025
SHALLOW GROUNDWATER EXPLORATION IN TERAI

DANG DISTRICT (DANG VALLEY)

WELL NO. GW10 a	LOCATION Bainsa
ELEVATION 602.33 m	X = 617000 Y = 3112750
METHOD OF DRILLING	Rig
DRILLING DATES	22/01/88 - 07/02/87
TOTAL DEPTH	90 m.
COMMENTS	Screen Position: 54-65 m., 70.5 - 76 m. Screen Type : Slotted Pipe Well Size : 6" M.P: 0.45 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s): 9.6
DURATION: 16 hrs.
TRANSMISSIVITY: 35 m^2/day
METHOD: Theis
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 5.77 m (B.G.L)
DYNAMIC WATER LEVEL: 26.19 m

COMMENTS:

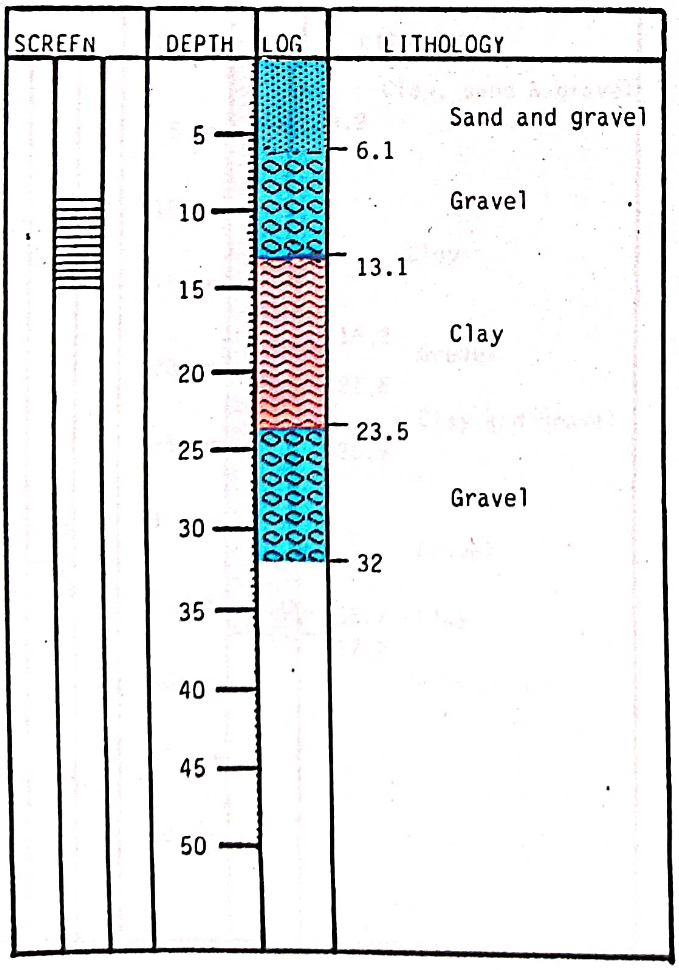
APPENDIX 3/21

GWRDB - UNDP NEP/86/025
SHALLOW GROUNDWATER EXPLORATION IN TERAI

DANG DISTRICT (DANG VALLEY)

WELL NO. GW10 b	LOCATION Bainsa	
ELEVATION 602.14 m	X = 616625	Y = 3112750
METHOD OF DRILLING	Rig	
DRILLING DATES	07/02/87 - 10/02/87	
TOTAL DEPTH	32 m.	
COMMENTS	Screen Position: 9.6 - 15.1 m. Screen Type: Wire Wrapped Well Size: 4"	

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL:
DYNAMIC WATER LEVEL:

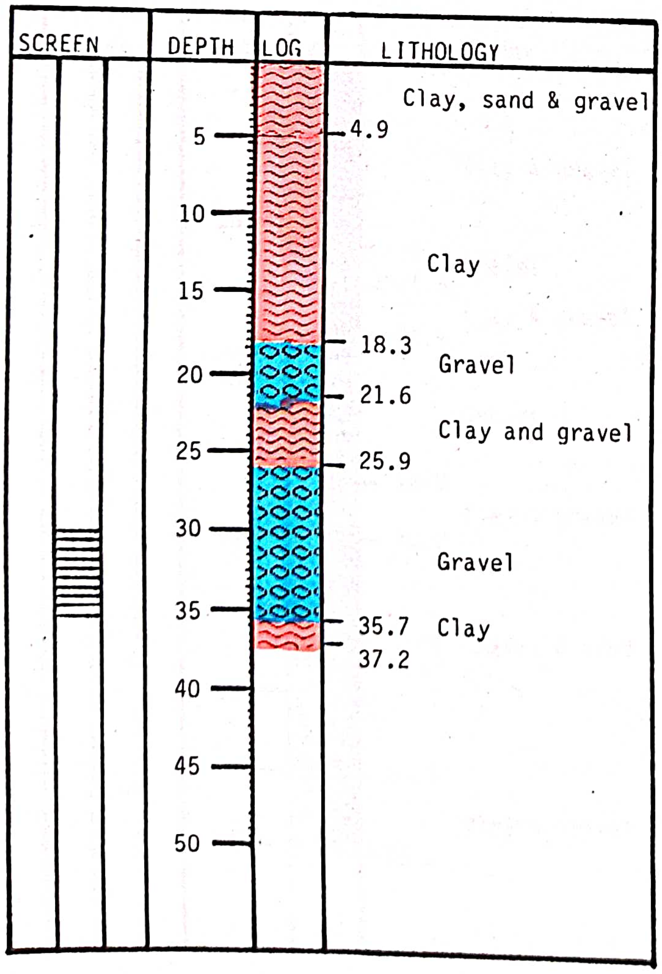
COMMENTS:

APPENDIX 3/22

DANG DISTRICT (DANG VALLEY)

WELL NO. GW11 a	LOCATION Hekuli	
ELEVATION 576.96 m	X = 618750	Y = 3108750
METHOD OF DRILLING	Rig	
DRILLING DATES	03/02/87 - 05/02/87	
TOTAL DEPTH	37.2 m.	
COMMENTS	M.P: 0.39 m. Screen Position: 30.2 - 35.7 m. Screen Type: Wire Wrapped Well Size: 4"	

WELL LOG



PUMPING TEST

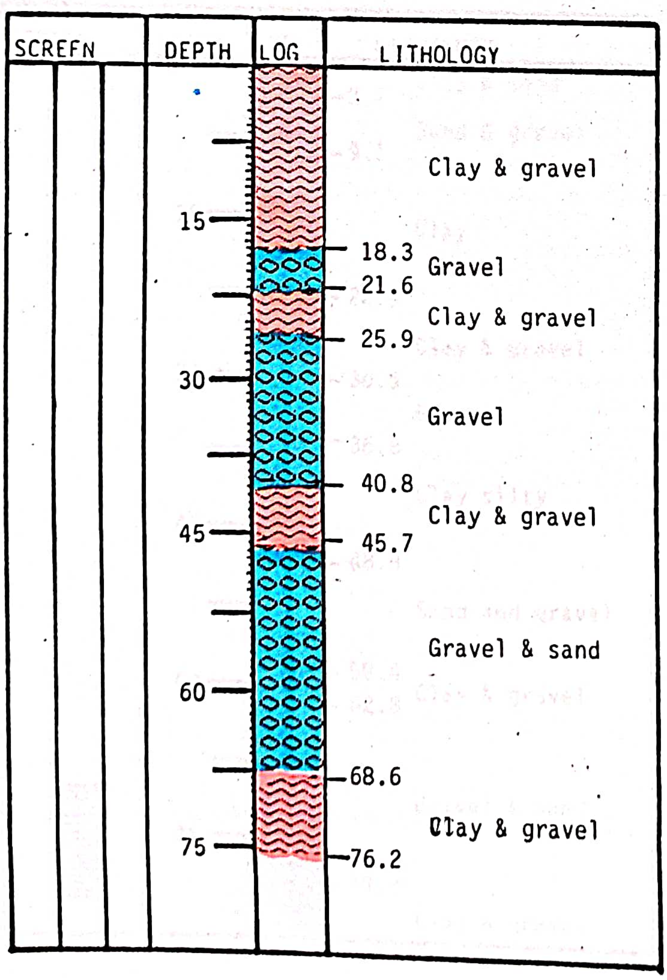
DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL:
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW11 b	LOCATION Hekuli	
ELEVATION 576.99 m	X = 618875	Y = 3110750
METHOD OF DRILLING	Rig	
DRILLING DATES	13/02/87 - 02/03/87	
TOTAL DEPTH	99.4 m.	
COMMENTS	Screen Position: 86.6 - 97.6 m. Screen Type : Wire Wrapped Well Size : 6"	M.P: 0.47 m.

WELL LOG



PUMPING TEST

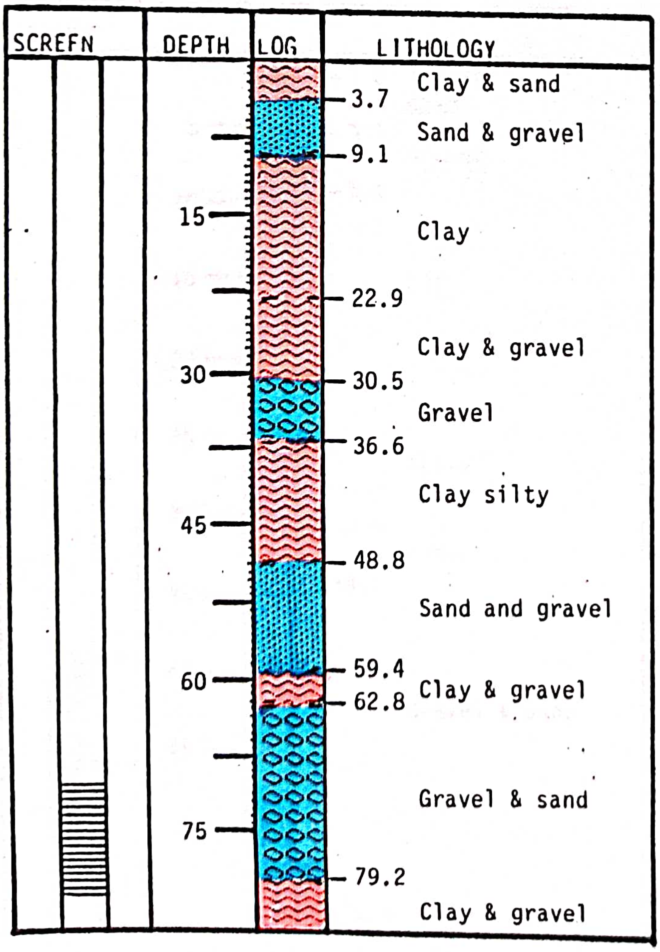
DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 29.77 m.
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW12	LOCATION Gulariya	
ELEVATION 649.39 m	X = 645125	Y = 3100875
METHOD OF DRILLING	Rig	
DRILLING DATES	08/03/87 - 25/03/87	
TOTAL DEPTH	99.1 m.	
COMMENTS	Screen Position: 69.2 - 80.2 m Screen Type : Wire Wrapped Well Size : 6"	M.P: 0.28 m.

WELL LOG



PUMPING TEST

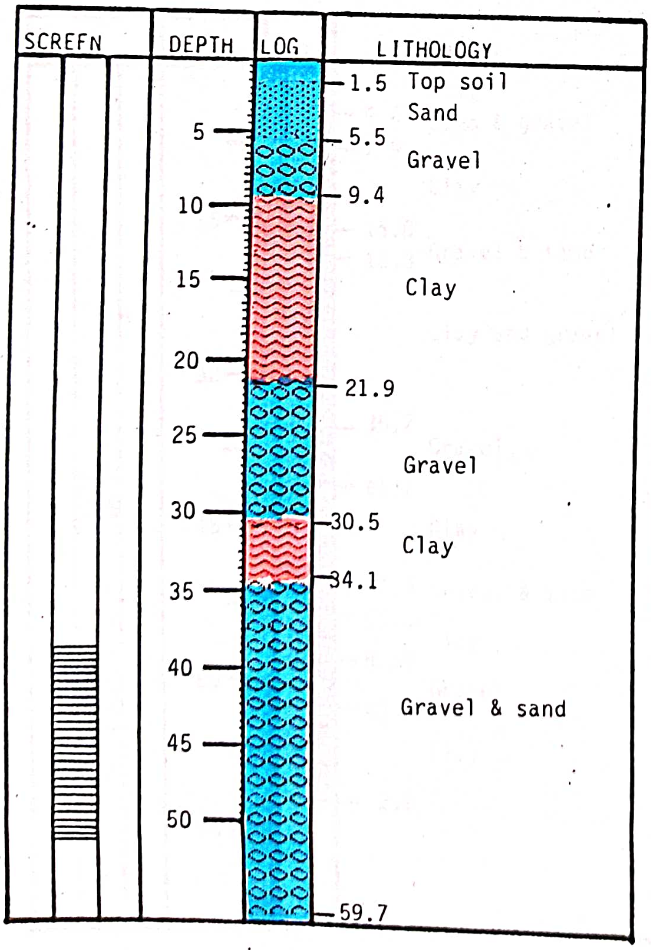
DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 5.10 m.
DYNAMIC WATER LEVEL:

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW13	LOCATION Bargadi	
ELEVATION 655.54 m	X = 646625	Y = 3098875
METHOD OF DRILLING	Rig	
DRILLING DATES	13/06/87 - 20/06/87	
TOTAL DEPTH	59.7 m.	
COMMENTS	Screen Position: 38.7 - 52.2 m. Screen Type : Slotted Pipe Well Size : 6"	M.P: 0.29 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s):
DURATION:
TRANSMISSIVITY: m^2/day
METHOD:
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 30.00 m.
DYNAMIC WATER LEVEL:

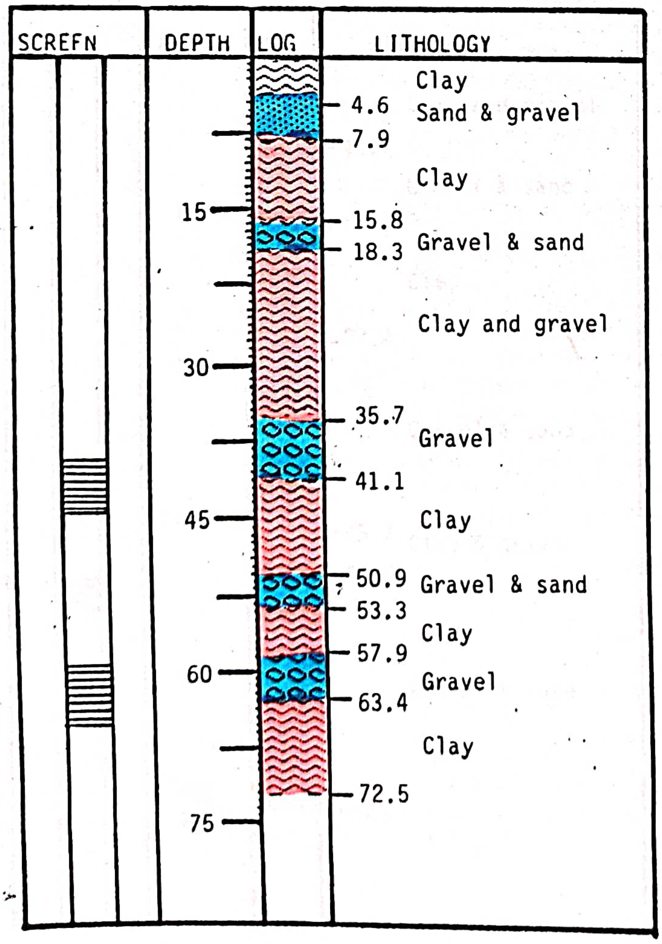
COMMENTS:

APPENDIX 3/26

DANG DISTRICT (DANG VALLEY)

WELL NO. GW14	LOCATION Pakkoi
ELEVATION 616.34 m	X = 642000 Y = 3097375
METHOD OF DRILLING	Rig
DRILLING DATES	17/01/88 - 24/01/88
TOTAL DEPTH	72.5 m.
COMMENTS	Screen Position: 38.7 - 44.2 m., 59.7 - 65.3 m. Screen Type : Wire Wrapped Well Size : 6" M.P: 0.54 m.

WELL LOG



PUMPING TEST

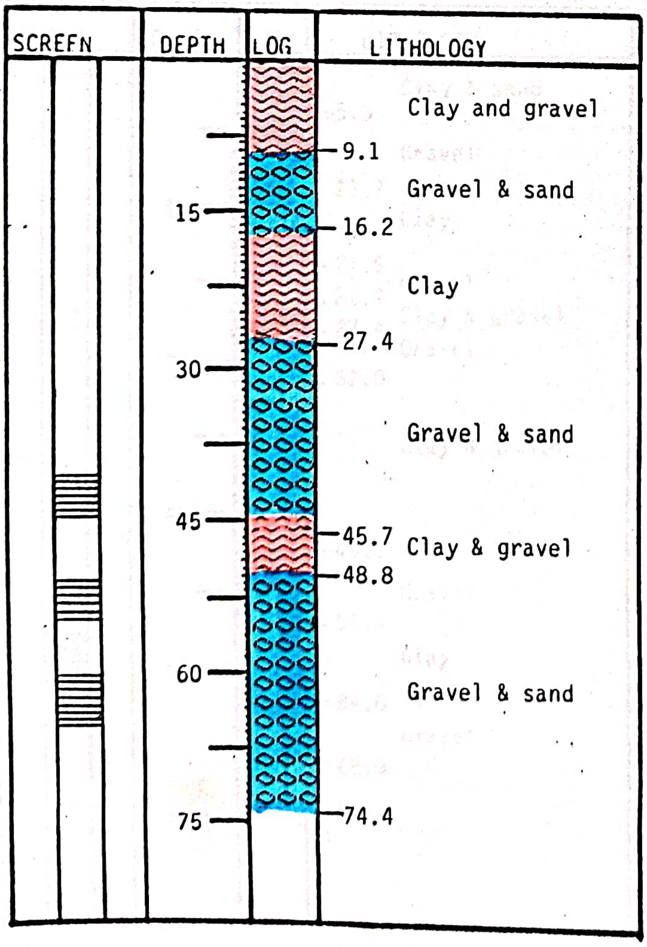
DATE:
Q(l/s): 9.0
DURATION: 8 hrs.
TRANSMISSIVITY: 25 m^2/day
METHOD: Jacob
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 21.16 m
DYNAMIC WATER LEVEL: 39.37 m (B.G.L)

COMMENTS:

DANG DISTRICT (DANG VALLEY)

WELL NO. GW15	LOCATION Lalpur
ELEVATION 613.09 m	X = 630250 Y = 3107000
METHOD OF DRILLING	Rig
DRILLING DATES	31/03/88 -
TOTAL DEPTH	74.4 m.
COMMENTS	Screen Position: 39.3-44.8 m, 49.4-54.9 m, 60.4 - 65.8 m. Screen Type : Wire Wrapped Well Size : 6" M.P: 0.15 m.

WELL LOG



PUMPING TEST

DATE:
Q(l/s): 9.7
DURATION: 5 hrs.
TRANSMISSIVITY: 5670 m^2/day
METHOD: Jacob
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 37.55 m (B.G.L)
DYNAMIC WATER LEVEL: 38.91 m (B.G.L)

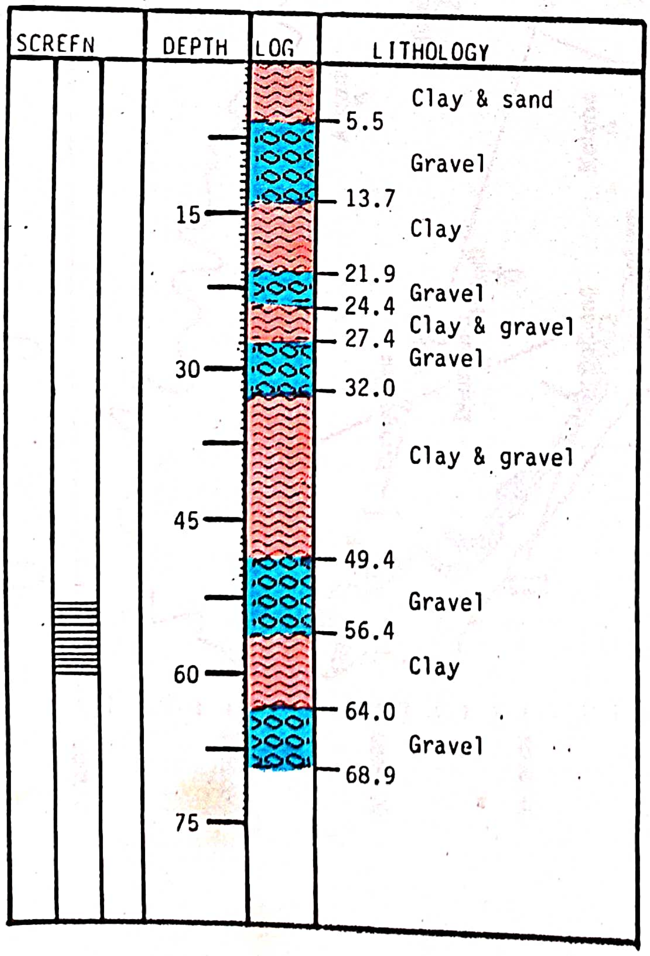
COMMENTS:

GWRDB - UNDP NEP/86/025
SHALLOW GROUNDWATER EXPLORATION IN TERAI

DANG DISTRICT (DANG VALLEY)

WELL NO. GW16	LOCATION Jaspur
ELEVATION 584.40 m	X = 625500 Y = 3104250
METHOD OF DRILLING	Rig
DRILLING DATES	14/04/88 - 24/04/88
TOTAL DEPTH	68.9 m.
COMMENTS	Screen Position: 53.1 - 60.4 m. Screen Type : Wire Wrapped Well Size : 6" M.P: 0.21 m.

WELL LOG



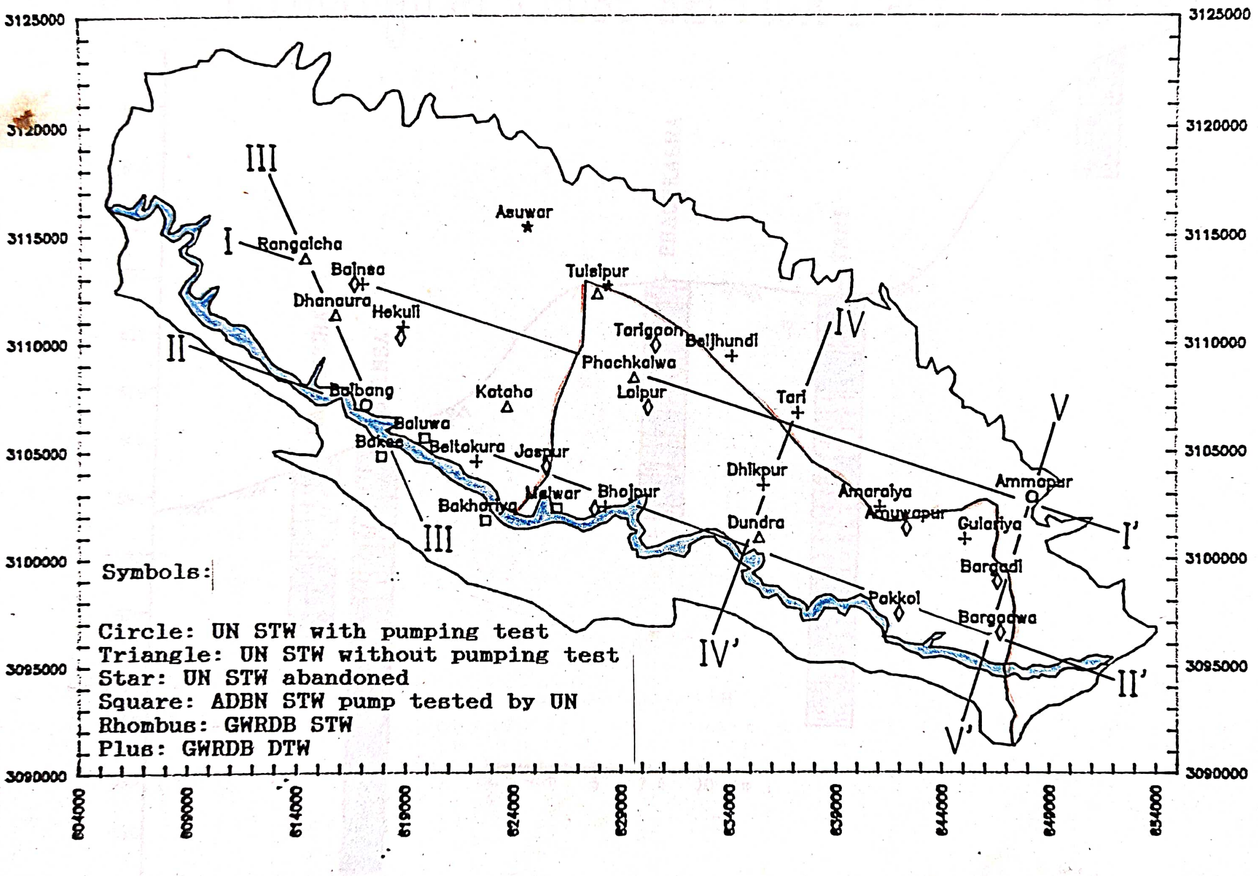
PUMPING TEST

DATE:
Q(l/s): 13.0
DURATION: 9 hrs.
TRANSMISSIVITY: 2925 m^2/day
METHOD: Theis
STORAGE COEFFICIENT:
STATIC WATER LEVEL: 21.16 m (B.G.L)
DYNAMIC WATER LEVEL: 23.00 m

COMMENTS:

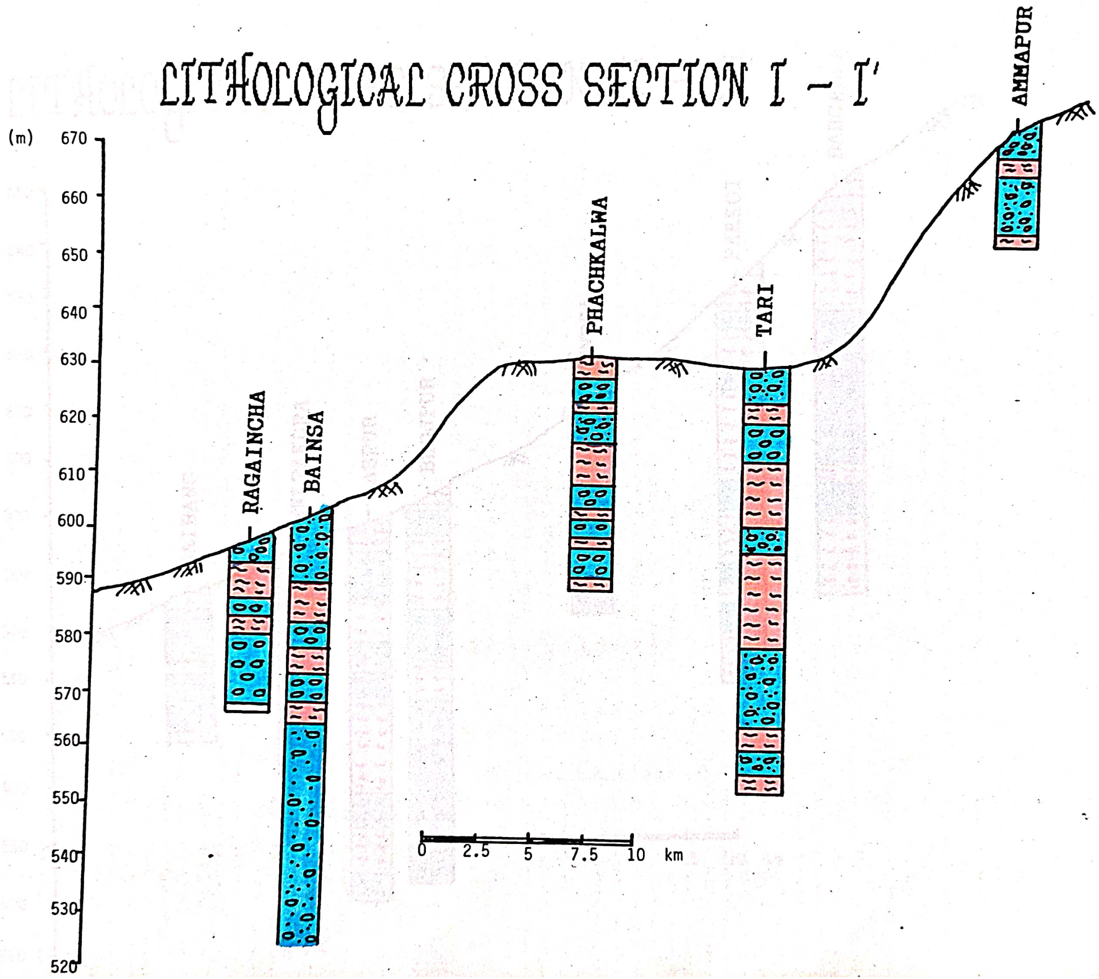
APPENDIX 3/29

DANG VALLEY - LITHOLOGICAL CROSS SECTIONS I - V



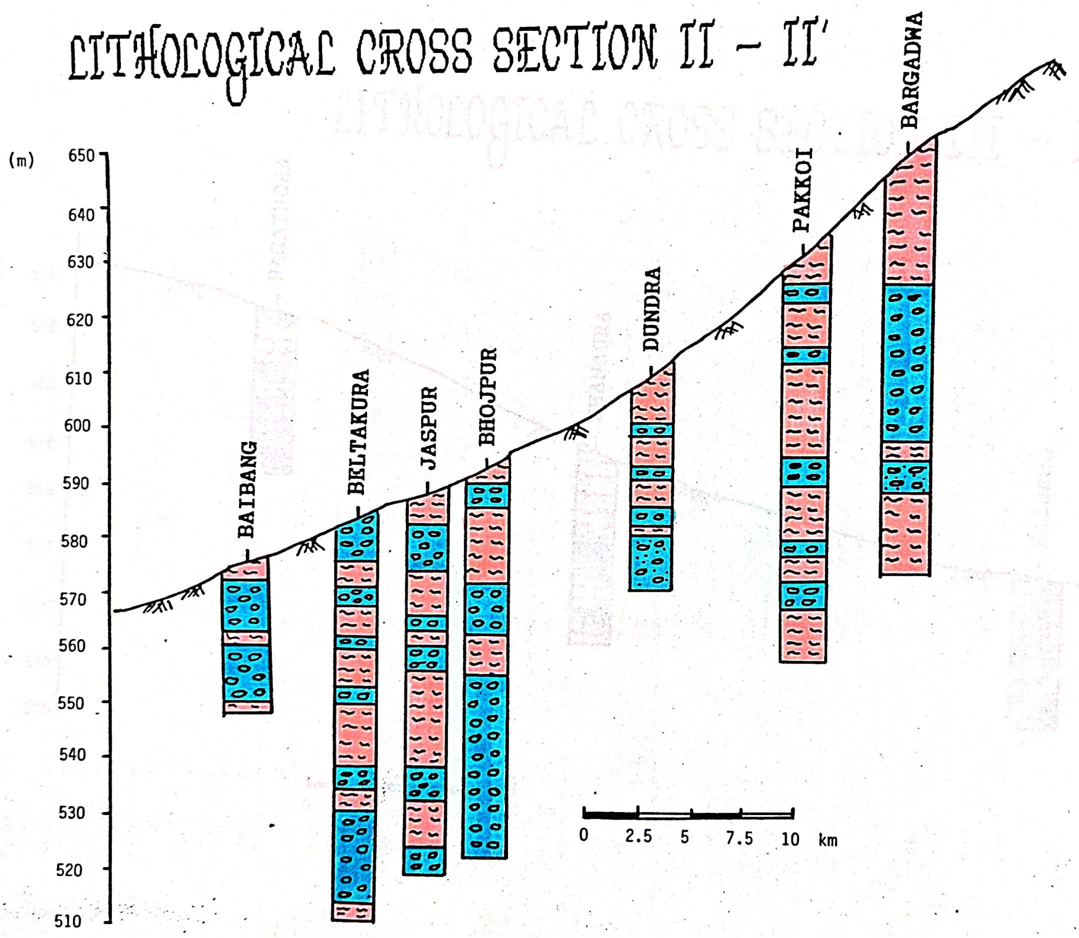
APPENDIX 4/1

LITHOLOGICAL CROSS SECTION I - I'



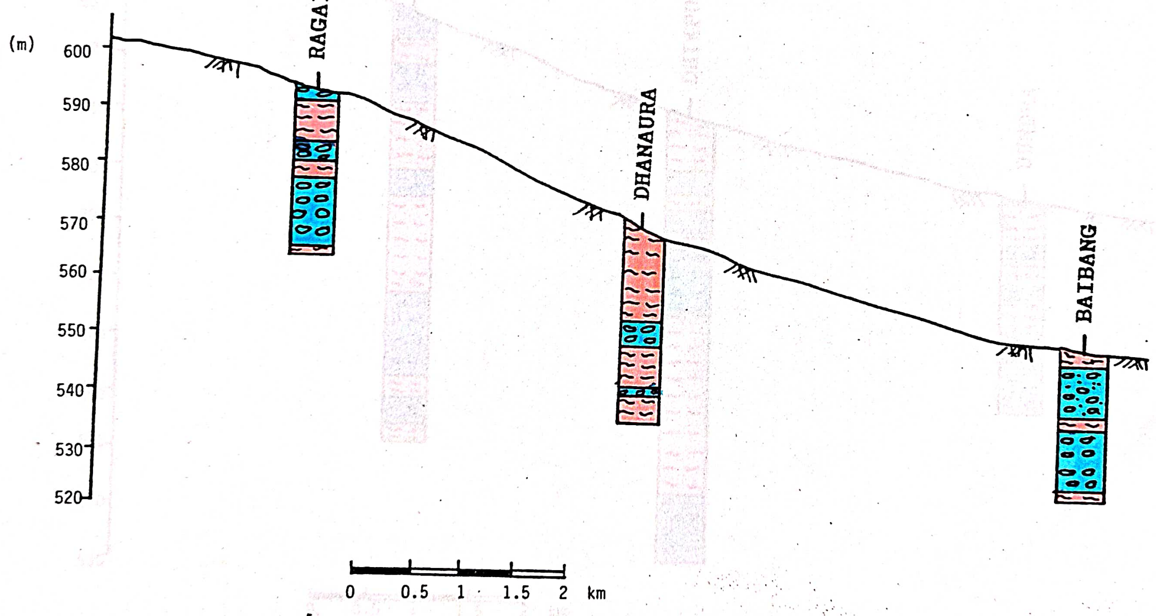
APPENDIX 4/2

LITHOLOGICAL CROSS SECTION II - II'



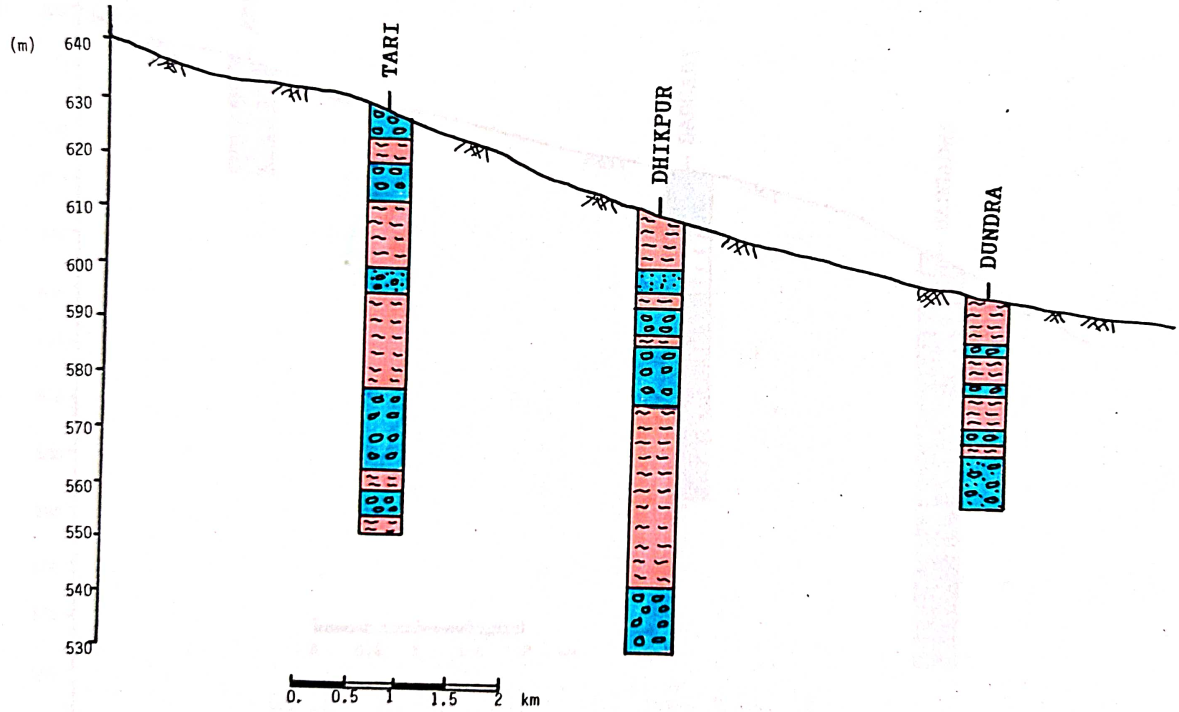
APPENDIX 4/3

LITHOLOGICAL CROSS SECTION III - III'



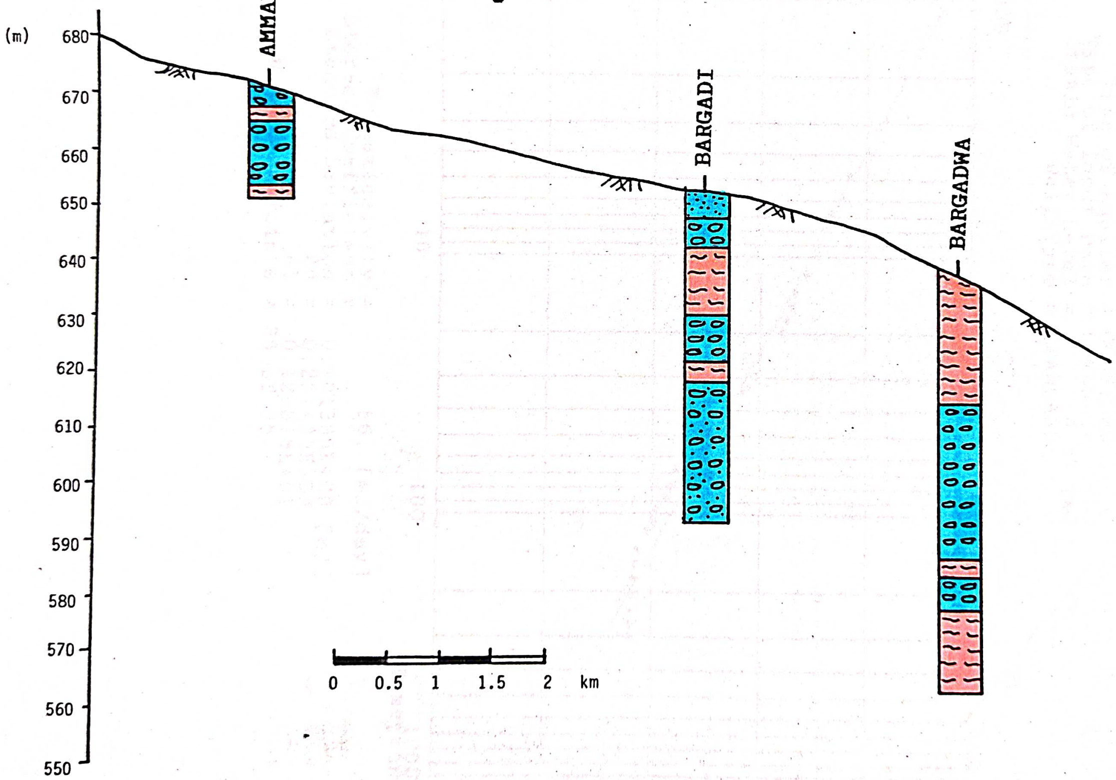
APPENDIX 4/4

LITHOLOGICAL CROSS SECTION IV – IV'



APPENDIX 4/5

LITHOLOGICAL CROSS SECTION V – V'



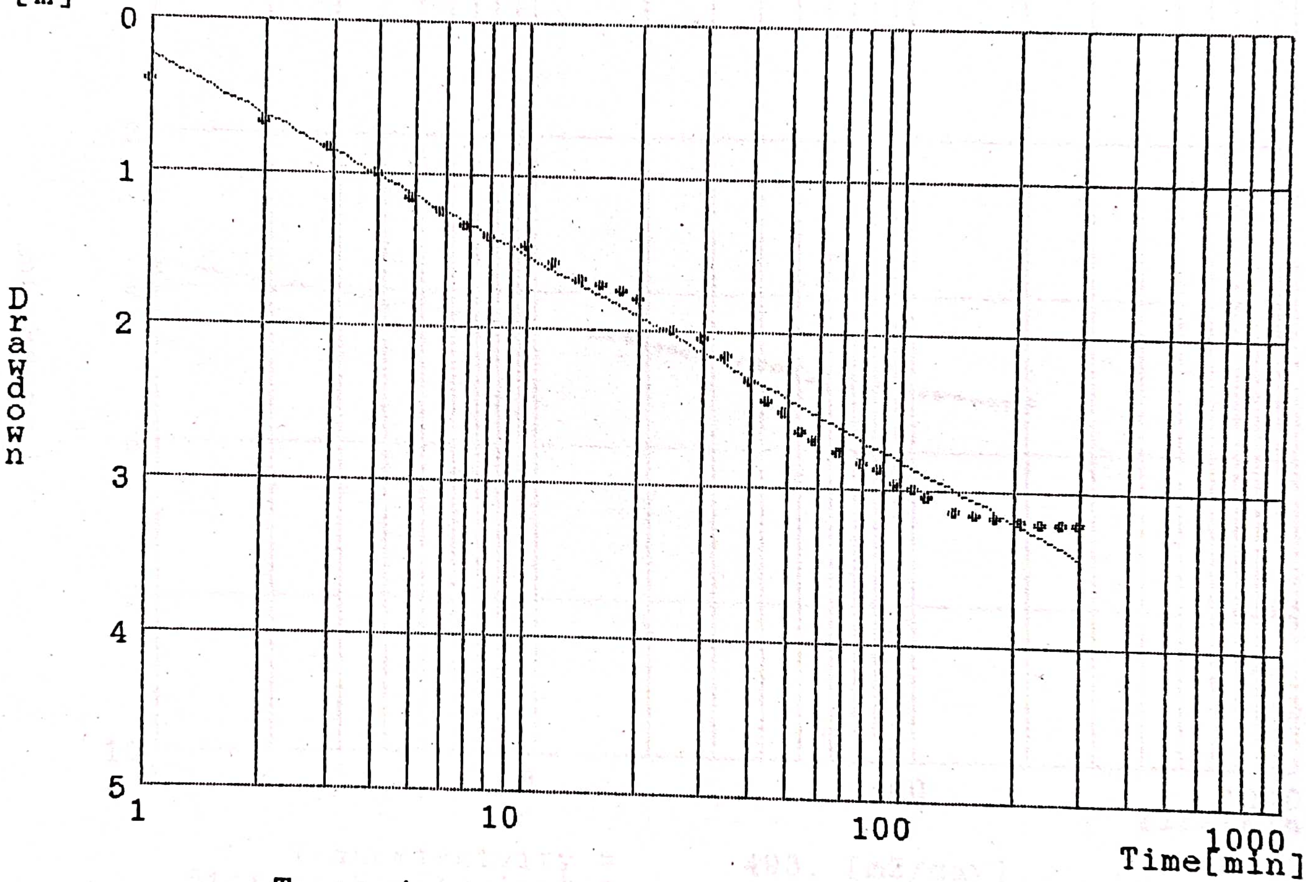
APPENDIX 4/6

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : DGSTW 3 BAIBANG

Constant Pumping Rate = 7.000 [l/s]
Distance from Observation Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -4.17 [m]
Well Type = STANDARD

JACOB METHOD



Transmissivity = 86. [m2/day]
Storage Coefficient =
Standard Deviation = 0.101388E+00 [m]
A0 = 0.231433E+00
A1 = 0.128878E+01
Number of Points = 35 of 35

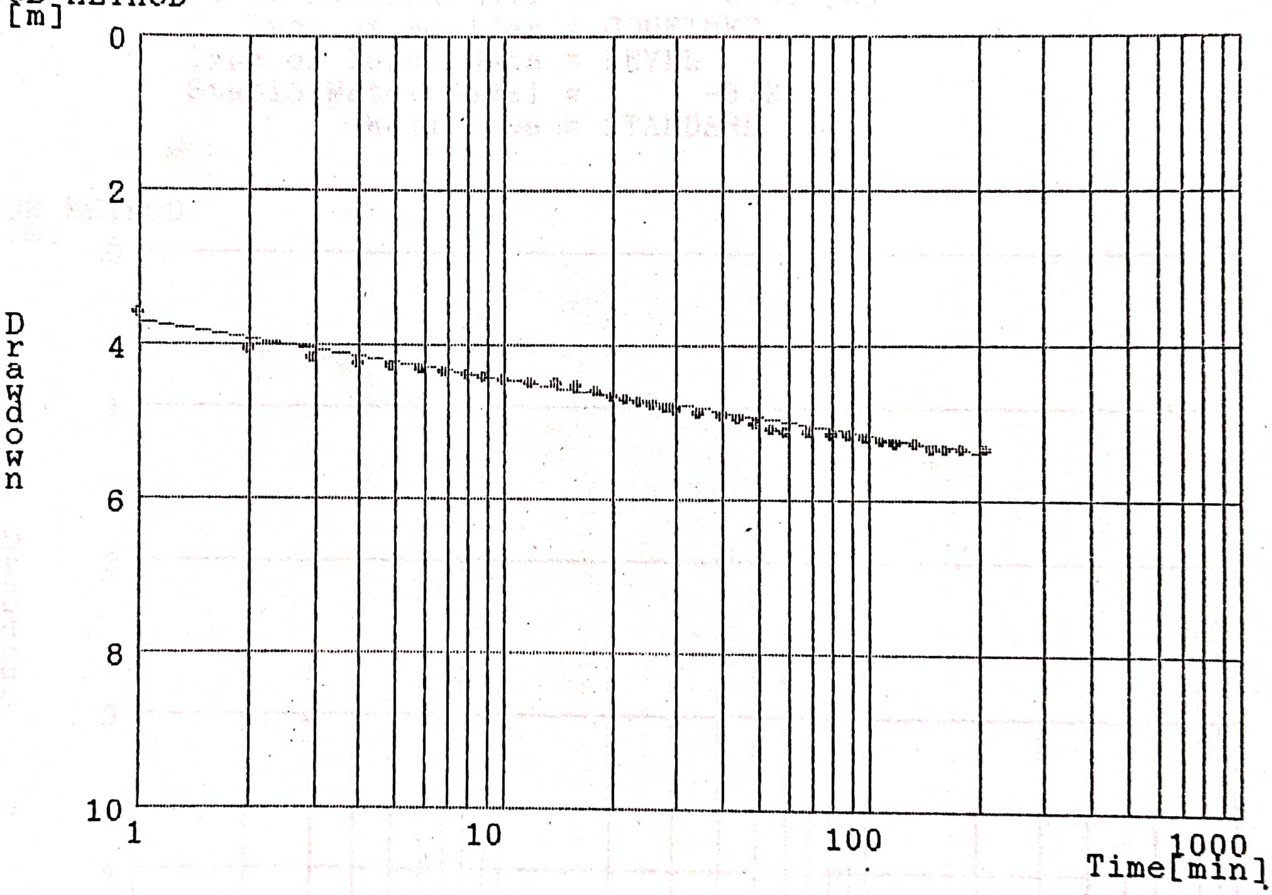
APPENDIX 5/1

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : DGSTW 5 PHACHKALWA

Constant Pumping Rate = 23.000 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -1.11 [m]
Well Type = STANDARD

JACOB METHOD



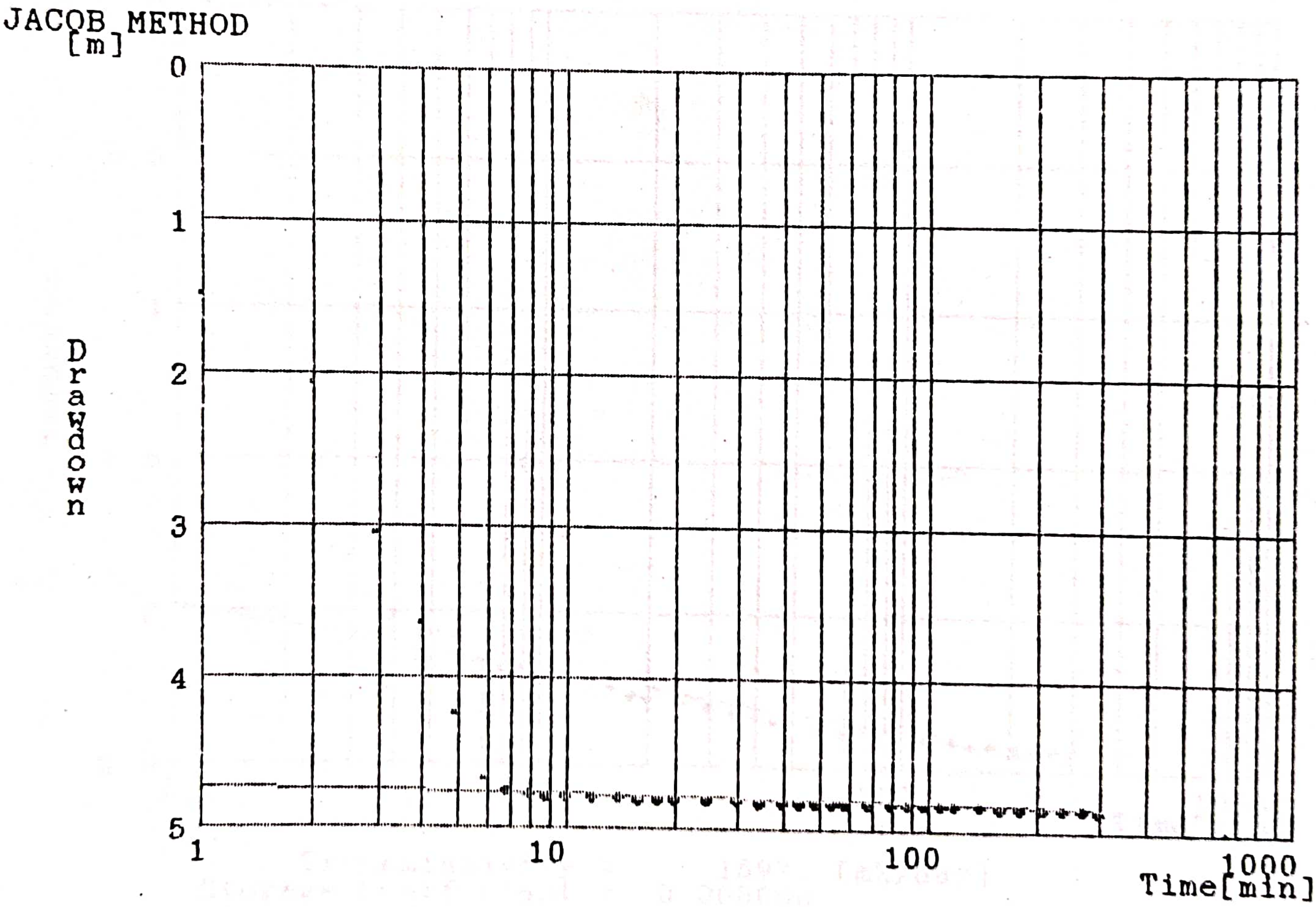
Transmissivity = 493. [m2/day]
Storage Coefficient =
Standard Deviation = 0.0543 [m]
A0 = 0.368303E+01
A1 = 0.738322E+00
Number of Points = 37 of 37

APPENDIX 5/2

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : DGSTW 7 AMMAPUR

Constant Pumping Rate = 11.000 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -3.26 [m]
Well Type = STANDARD



Transmissivity = 747. [m2/day]
Storage Coefficient = 0.00000000
Standard Deviation = 0.0060 [m]
A0 = 0.473187E+01
A1 = 0.427481E-01
Number of Points = 30 of 36

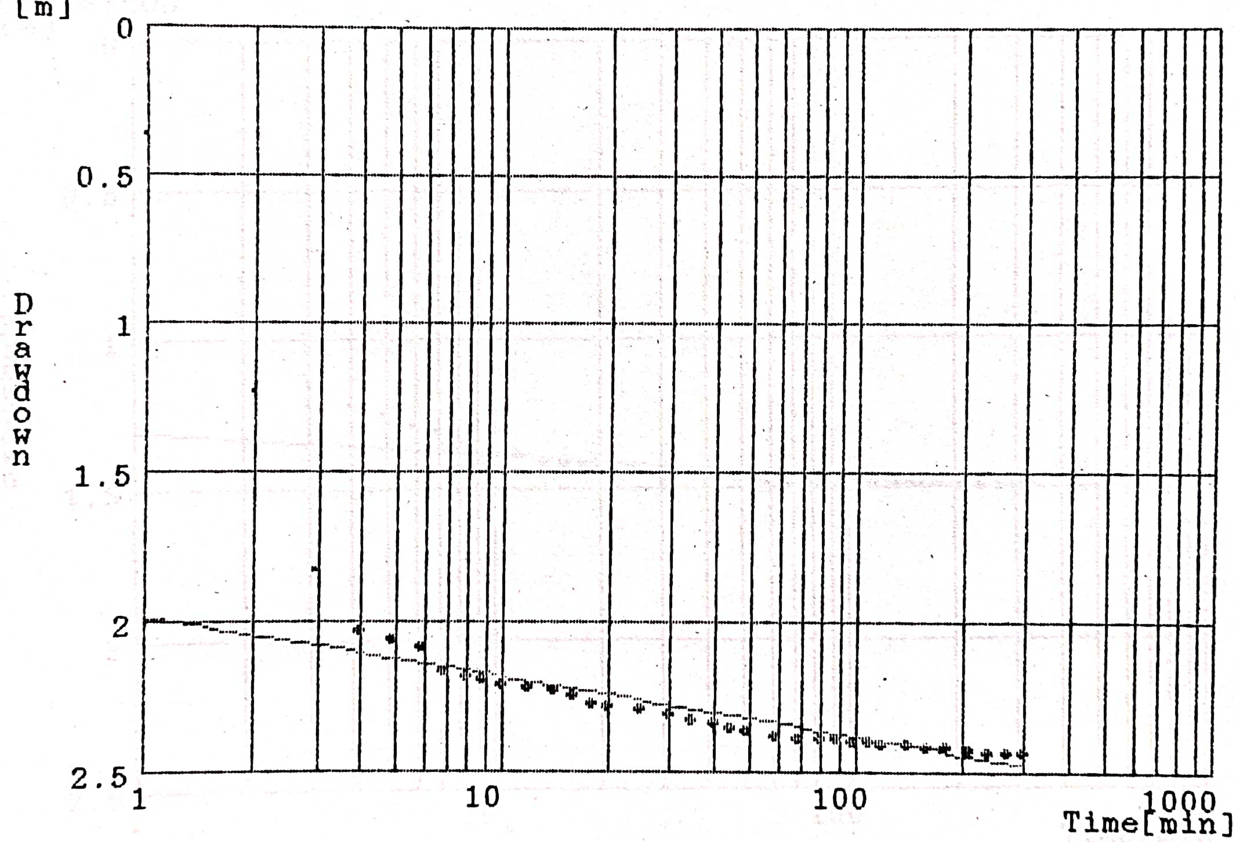
APPENDIX 5/3

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : DGSTW (ADBN) BAKEE

Constant Pumping Rate = 20.000 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -3.86 [m]
Well Type = STANDARD

JACOB METHOD



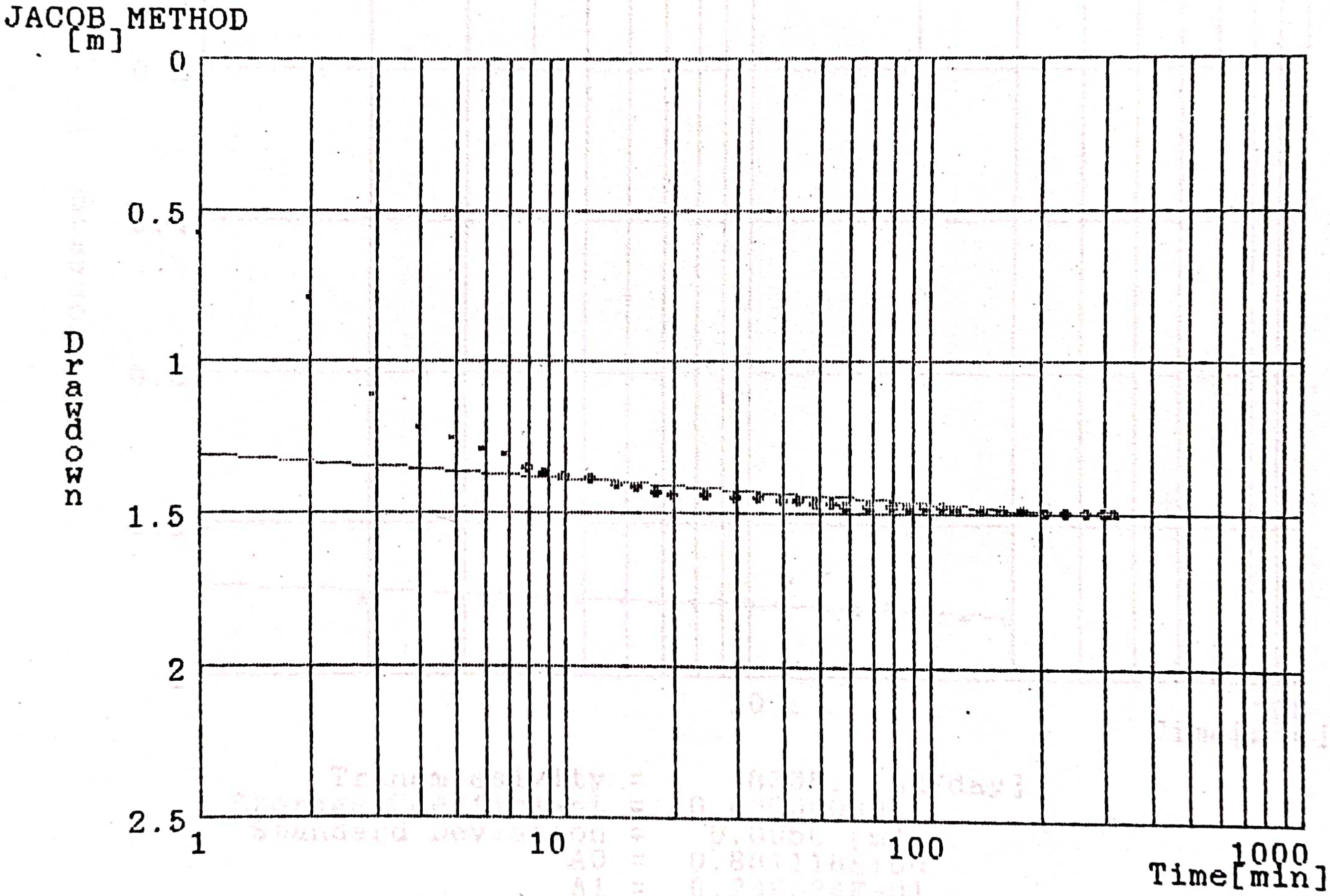
Transmissivity = 1597. [m2/day]
Storage Coefficient = 0.000000
Standard Deviation = 0.0321 [m]
A0 = 0.198351E+01
A1 = 0.198057E+00
Number of Points = 32 of 35

APPENDIX 5/4

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : DGSTW (ADBN) BALUWA

Constant Pumping Rate = 17.000 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -3.81 [m]
Well Type = STANDARD



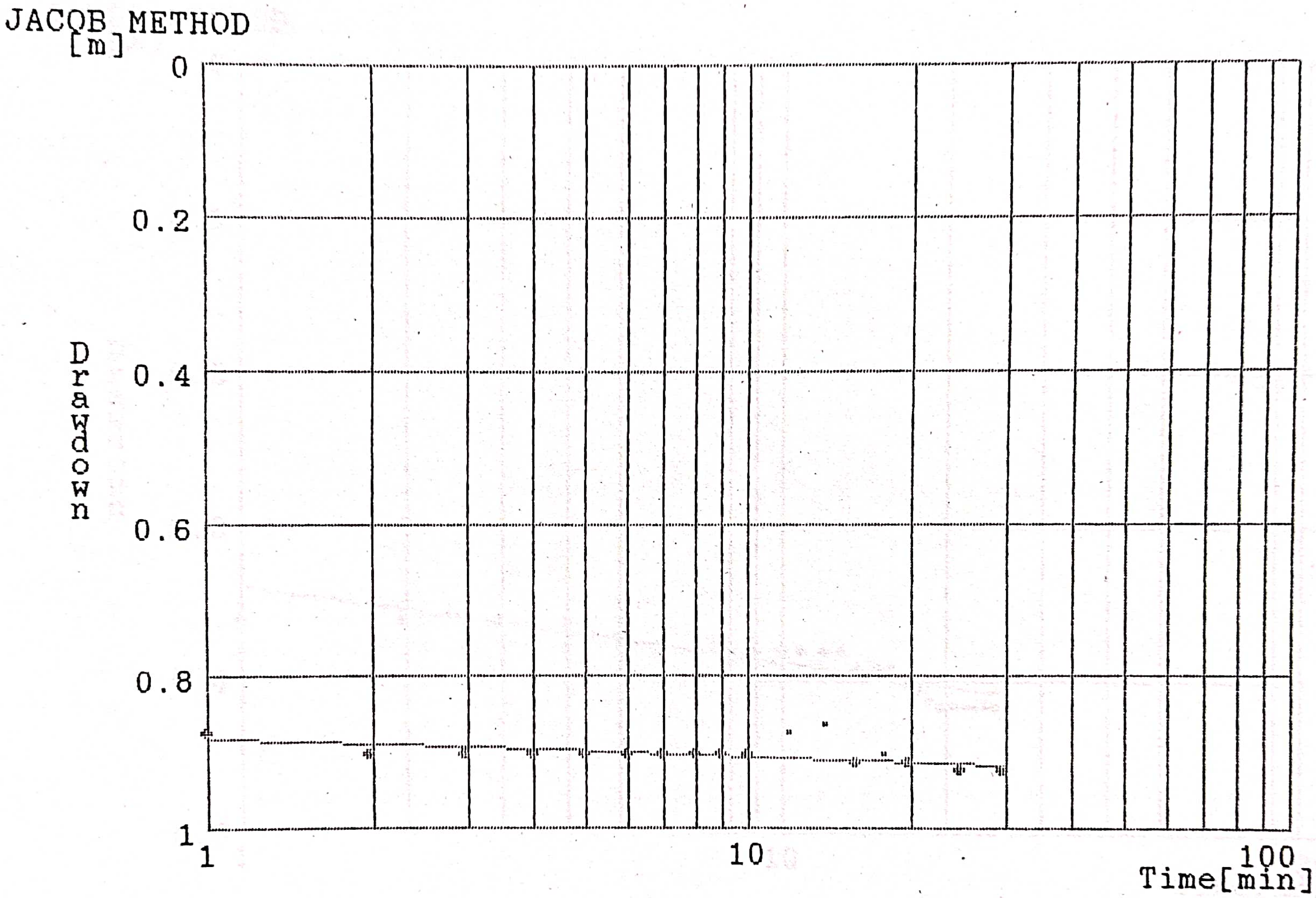
Transmissivity = 3349. [m2/day]
Storage Coefficient = 0.00000000
Standard Deviation = 0.0139 [m]
A0 = 0.130732E+01
A1 = 0.802486E-01
Number of Points = 30 of 37

APPENDIX 5/5

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : DGSTW (ADBN) MALWAR

Constant Pumping Rate = 13.000 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -6.55 [m]
Well Type = STANDARD



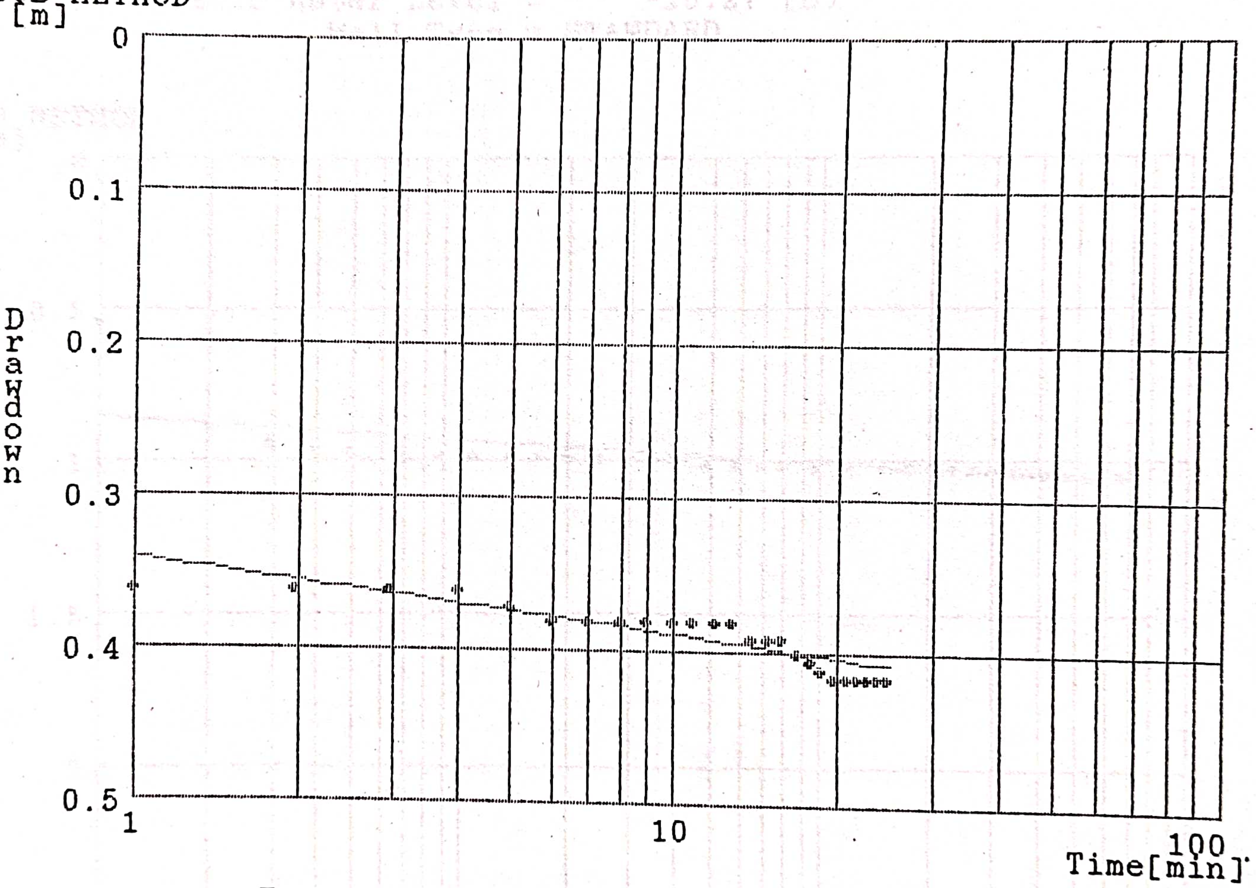
Transmissivity = 8338. [m2/day]
Storage Coefficient = 0.00000000
Standard Deviation = 0.0056 [m]
A0 = 0.881118E+00
A1 = 0.246524E-01
Number of Points = 14 of 17

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : DGSTW (ADBN) BAKHARIYA

Constant Pumping Rate = 11.600 [l/s]
Distance from Observation Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -3.74 [m]
Well Type = STANDARD

JACOB METHOD



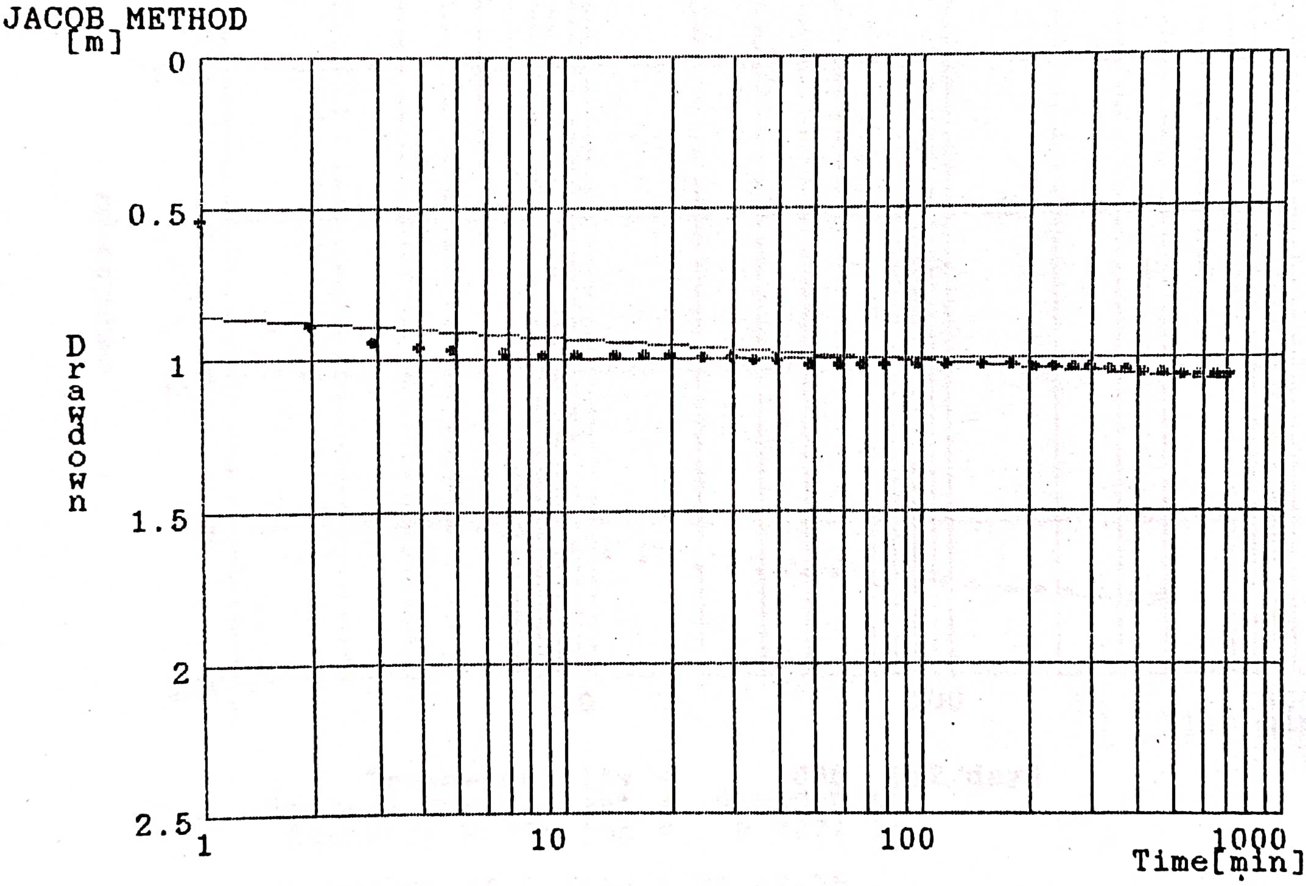
Transmissivity = 3802. [m2/day]
Storage Coefficient =
Standard Deviation = 0.875605E-02 [m]
A0 = 0.340386E+00
A1 = 0.482457E-01
Number of Points = 25 of 25

APPENDIX 5/7

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : GW2 TARI GAON

Constant Pumping Rate =	16.700 [1/s]
Distance from Pumping Well =	0.05 [m]
Type of Aquifer =	CONFINED
Type of Input Data =	LEVEL
Static Water Level =	-15.27 [m]
Well Type =	STANDARD



Transmissivity =	3442. [m2/day]
Storage Coefficient =	0.0000000
Standard Deviation =	0.0612 [m]
A0 =	0.853619E+00
A1 =	0.767167E-01
Number of Points =	35 of 35

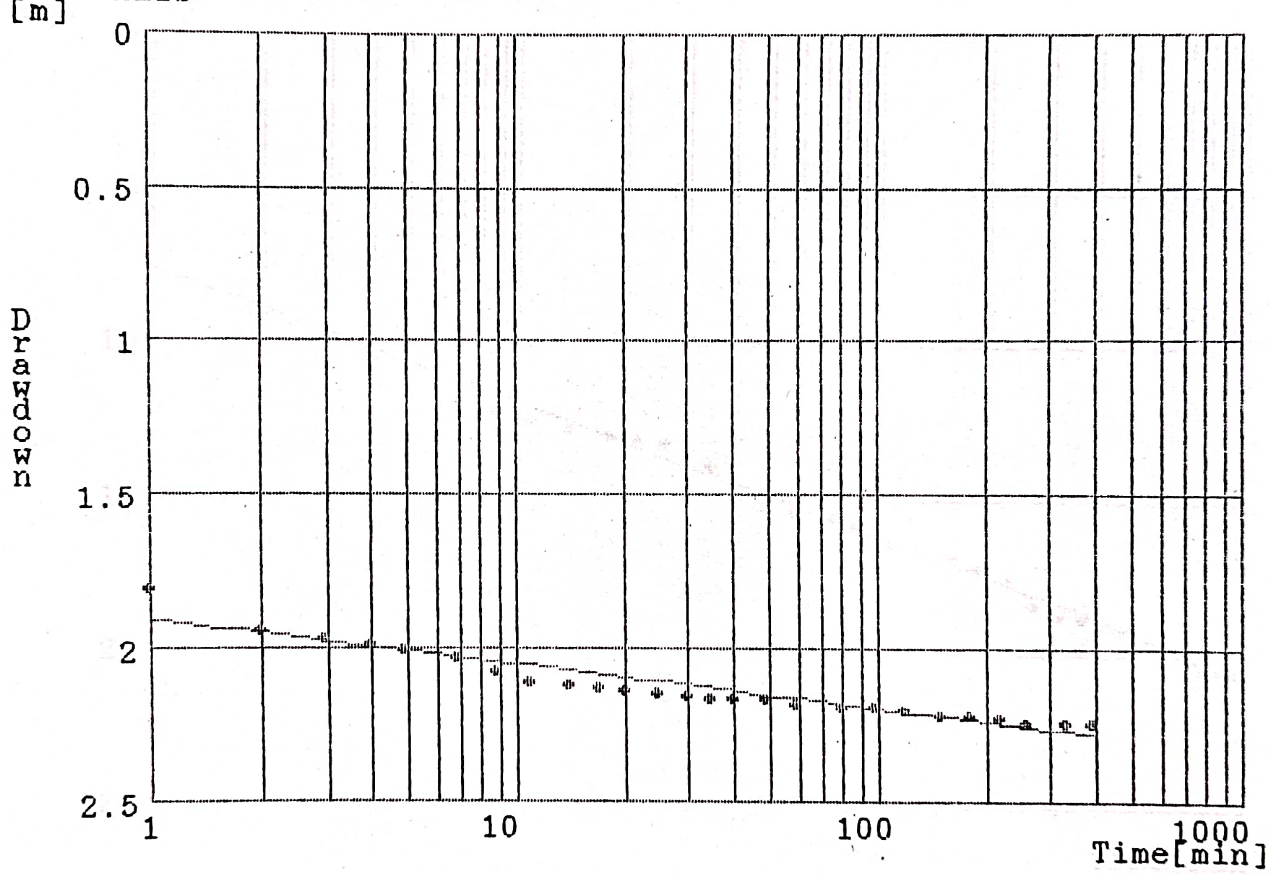
APPENDIX 5/8

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : GW 8 BARGADWA

Constant Pumping Rate = 9.500 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -19.70 [m]
Well Type = STANDARD

Method THEIS



Transmissivity = 1036. [m2/day]
Storage Coefficient = 0.00000000
Standard Deviation = 0.0321 [m]

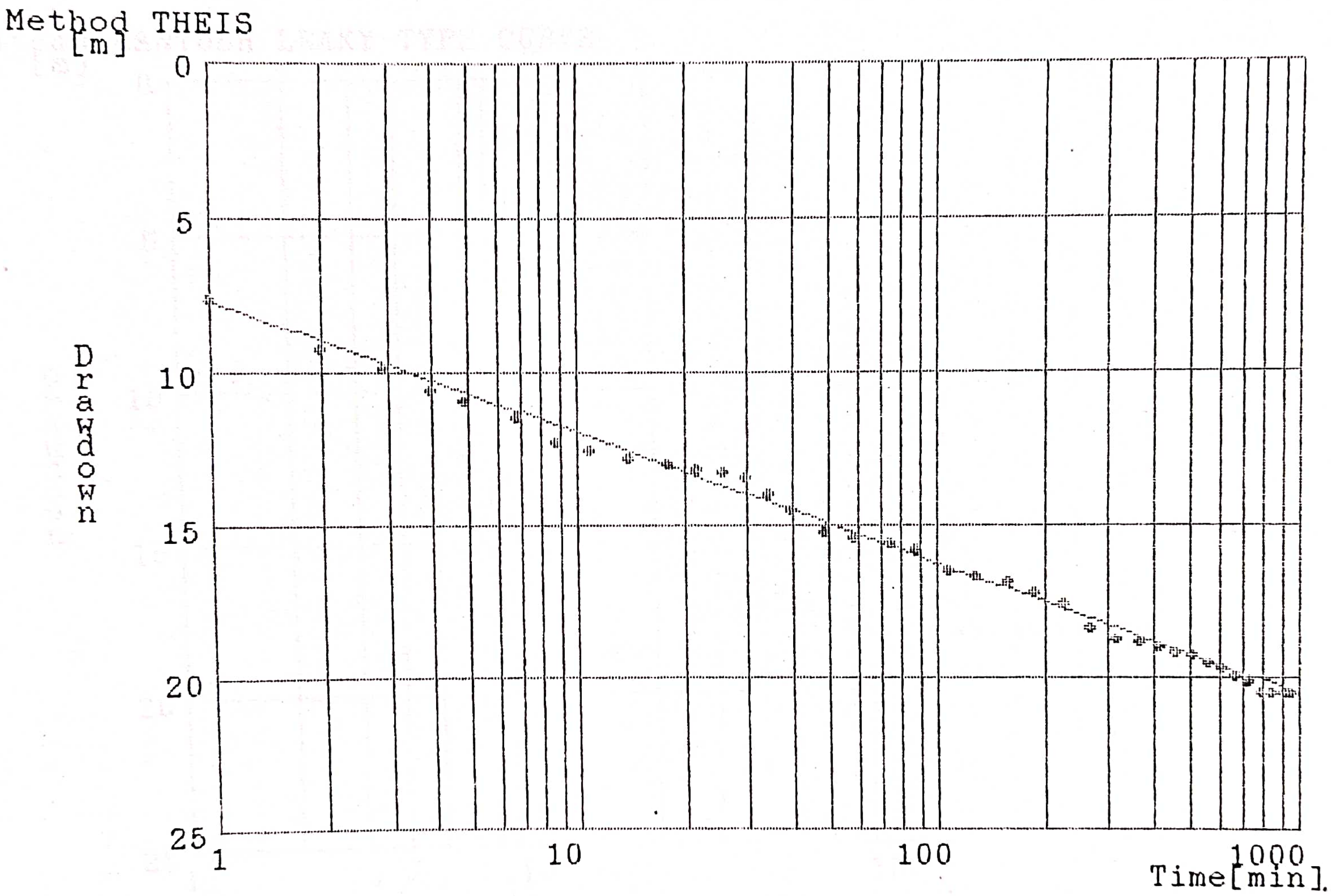
Number of Points = 26 of 26

APPENDIX 5/9

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : GW 10a BAINSA

Constant Pumping Rate = 9.600 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -6.22 [m]
Well Type = STANDARD



Transmissivity = 36. [m2/day]
Storage Coefficient =
Standard Deviation = 0.2414 [m]

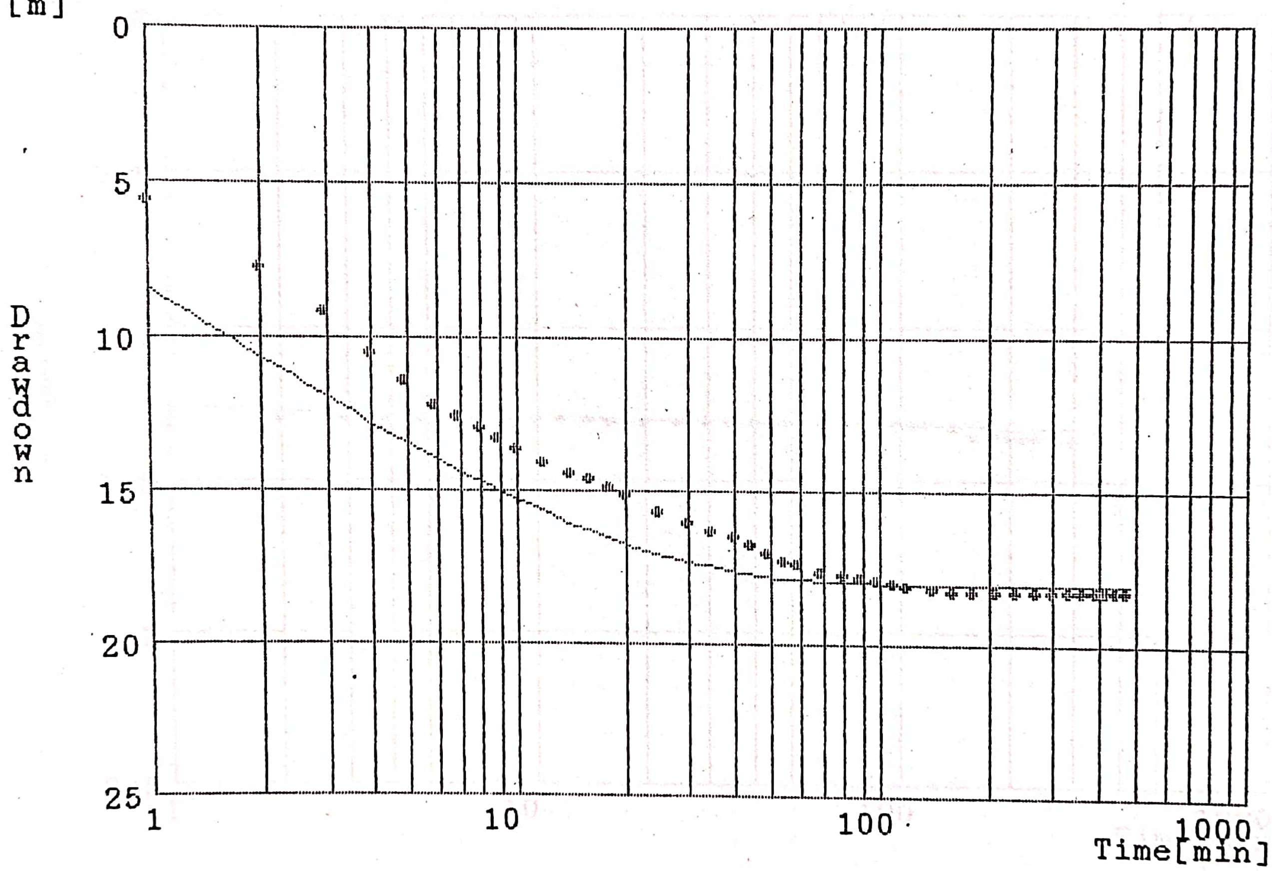
Number of Points = 38 of 38

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : GW 14 PAKKOI

Constant Pumping Rate = 9.000 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -21.70 [m]
Well Type = STANDARD

Method HANTUSH LEAKY TYPE CURVE



Transmissivity = 18. [m2/day]
Storage Coefficient = 00000000
Standard Deviation = 1.3528 [m]
Leakance = 49.7299 [1/DAY]

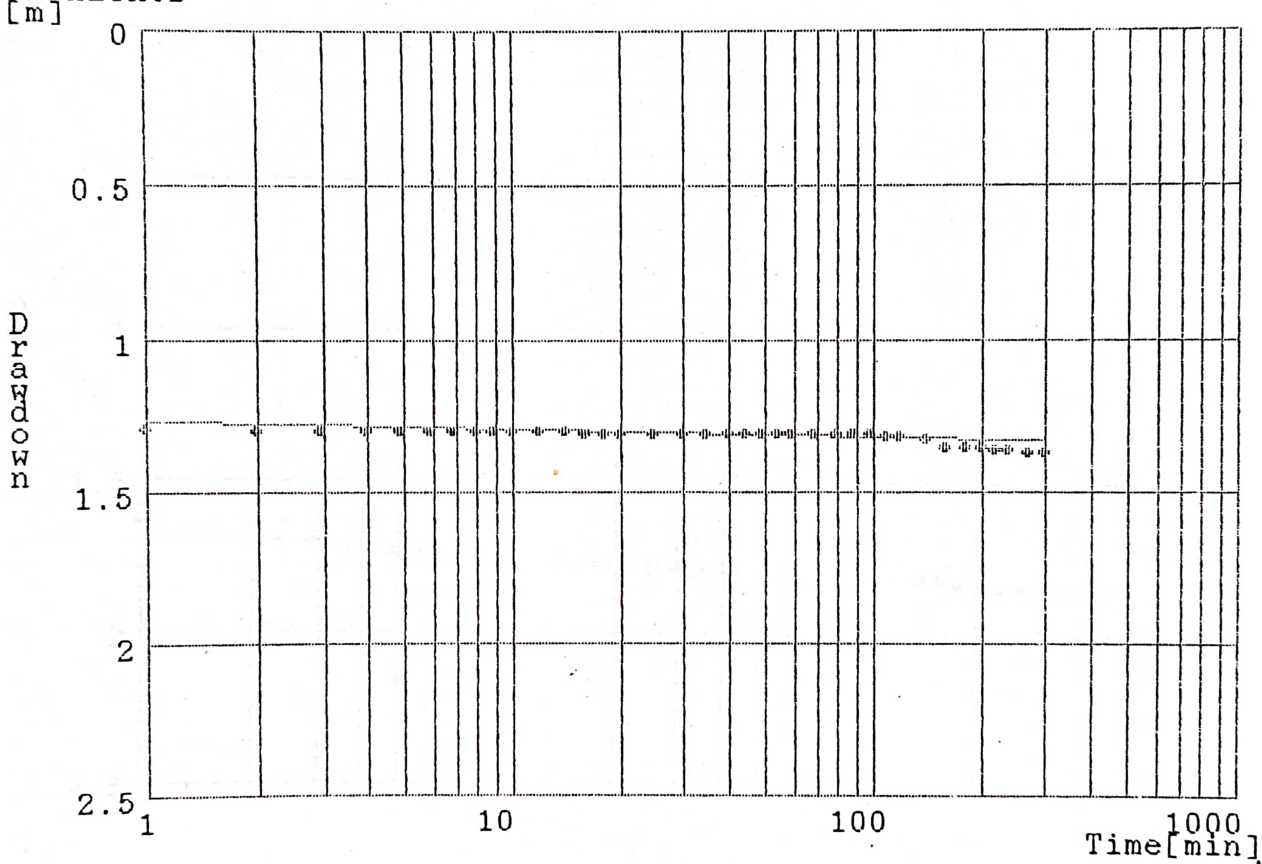
Number of Points = 42 of 42

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : GW 15 LALPUR

Constant Pumping Rate = 9.700 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -37.70 [m]
Well Type = STANDARD

JACOB METHOD



Transmissivity = 5672. [m2/day]
Storage Coefficient = 0.00000000
Standard Deviation = 0.0128 [m]
A0 = 0.126598E+01
A1 = 0.270417E-01
Number of Points = 37 of 37

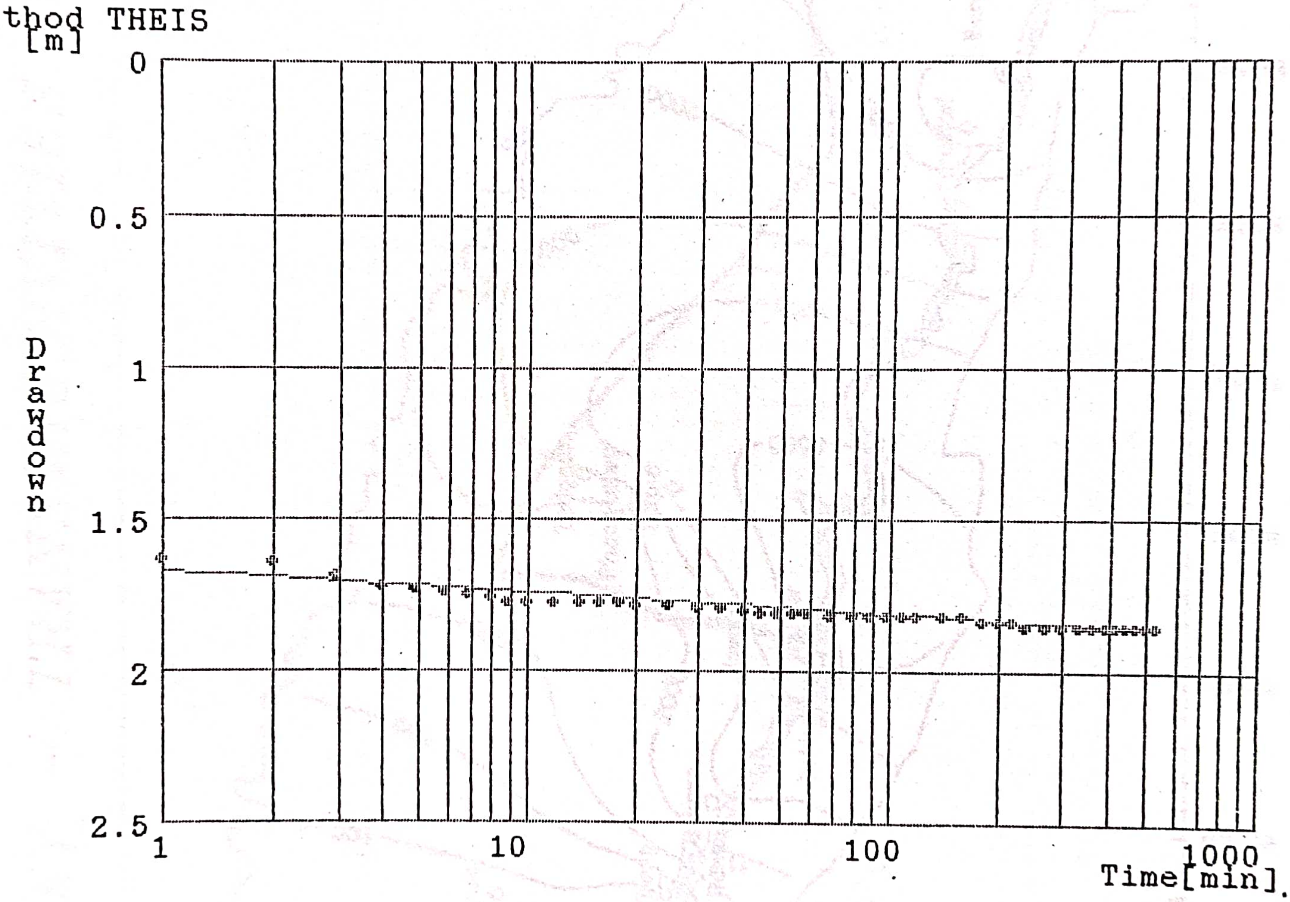
APPENDIX 5/12

Project : NEP/86/025 (DANG)
Organization : UNDP/GWRDB

Test : GW 16 JASPUR

Constant Pumping Rate = 13.000 [l/s]
Distance from Pumping Well = 0.05 [m]
Type of Aquifer = CONFINED
Type of Input Data = LEVEL
Static Water Level = -21.37 [m]
Well Type = STANDARD

Method THEIS

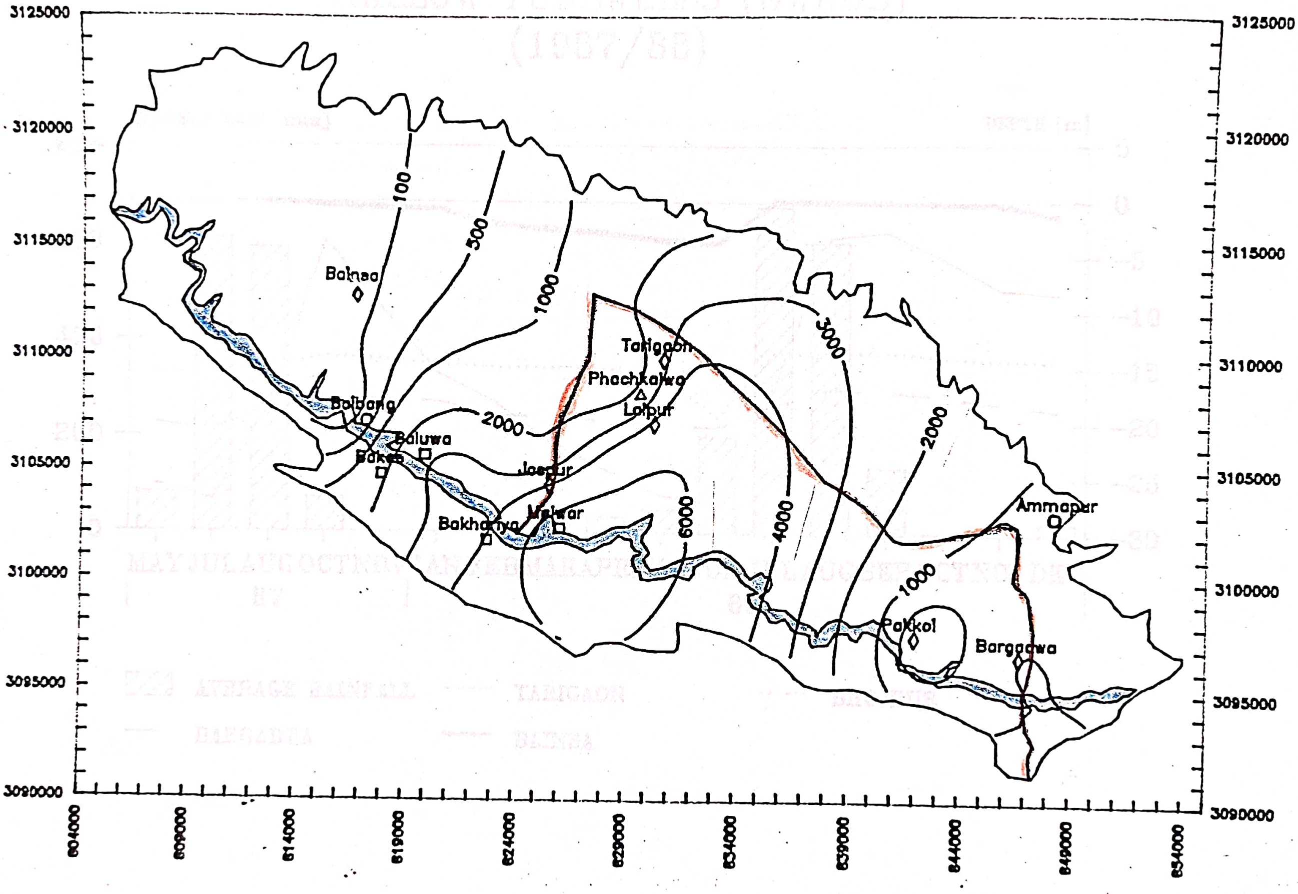


Transmissivity = 2926. [m2/day]
Storage Coefficient = 0.00000000
Standard Deviation = 0.0162 [m]

Number of Points = 45 of 45

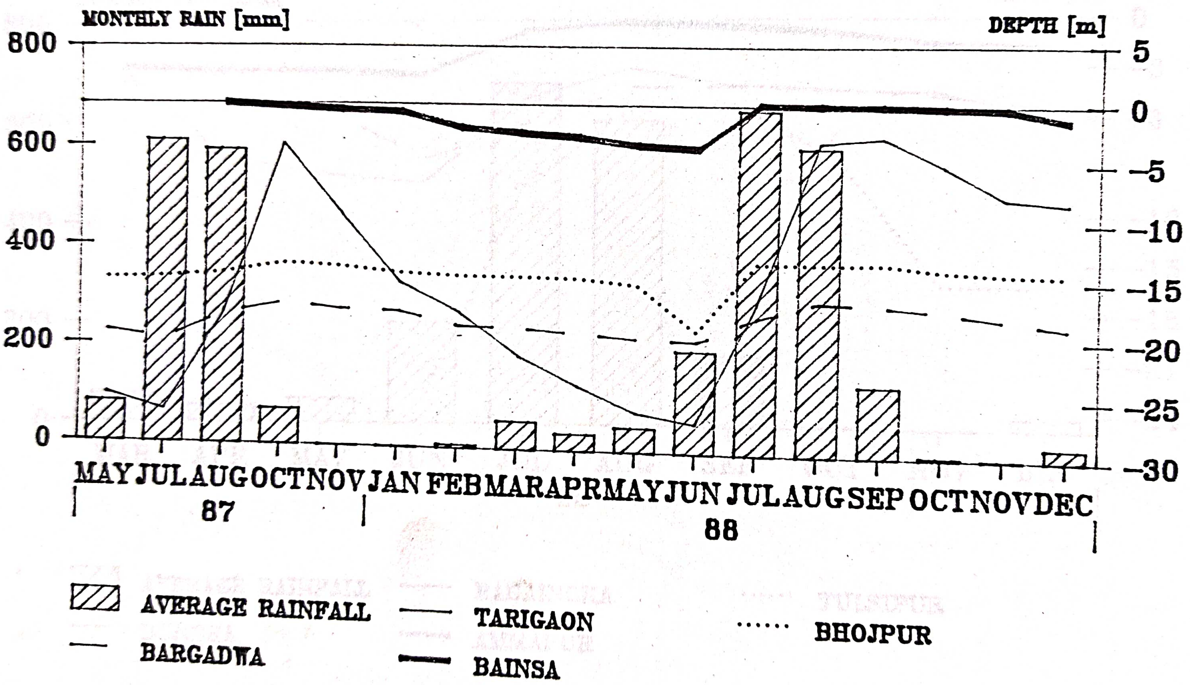
APPENDIX 5/13

DANG VALLEY – TRANSMISSIVITIES (M2/DAY)



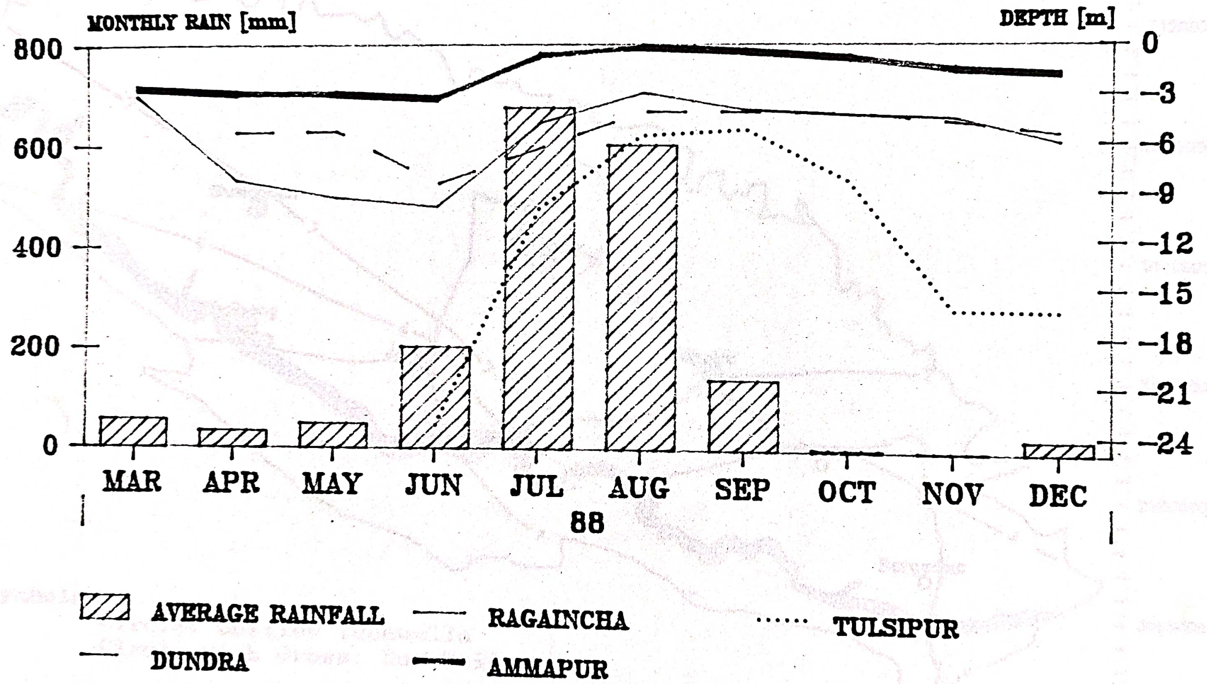
APPENDIX 6

DEPTH TO WATER TABLE & RAINFALL
SHALLOW TUBEWELLS (GWRDB)
(1987/88)



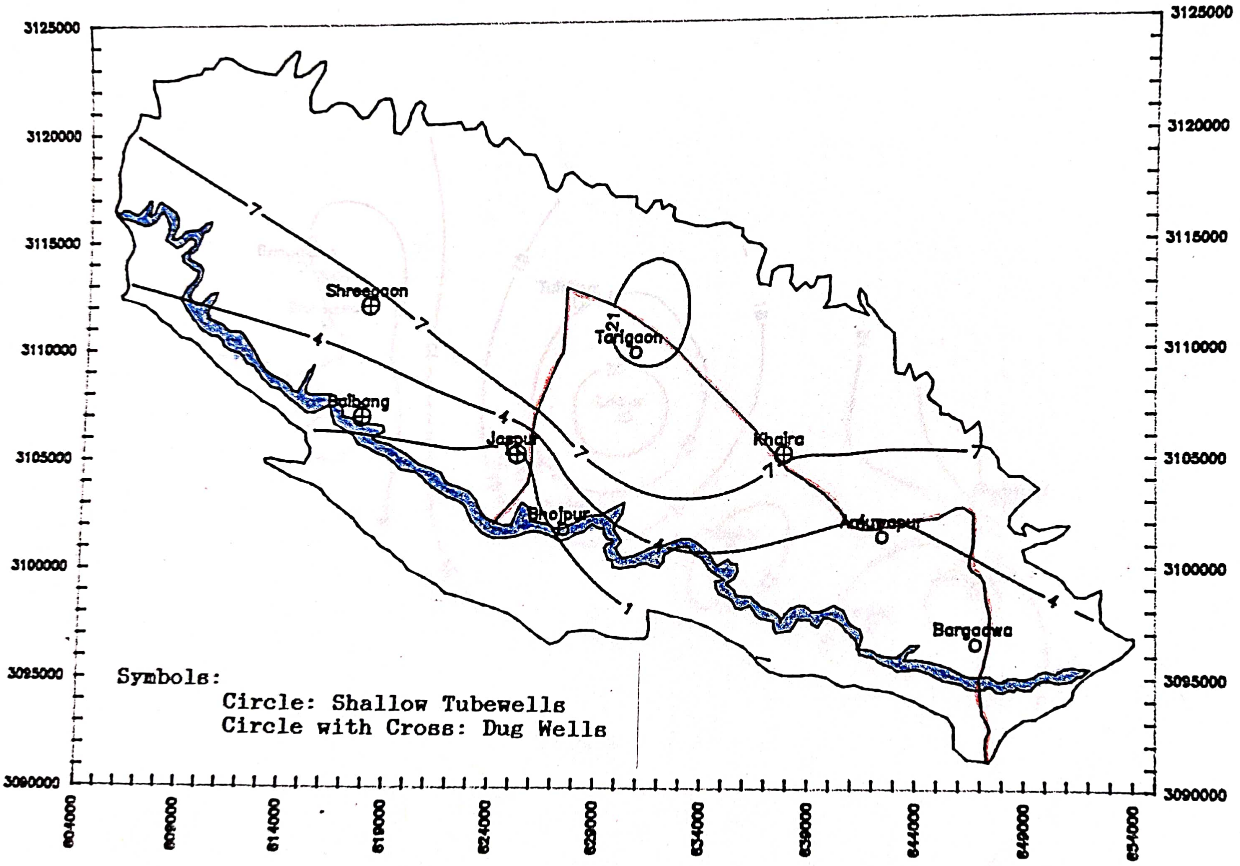
APPENDIX 7/1

DEPTH TO WATER TABLE & RAINFALL
SHALLOW TUBEWELLS (UN)
(1988)



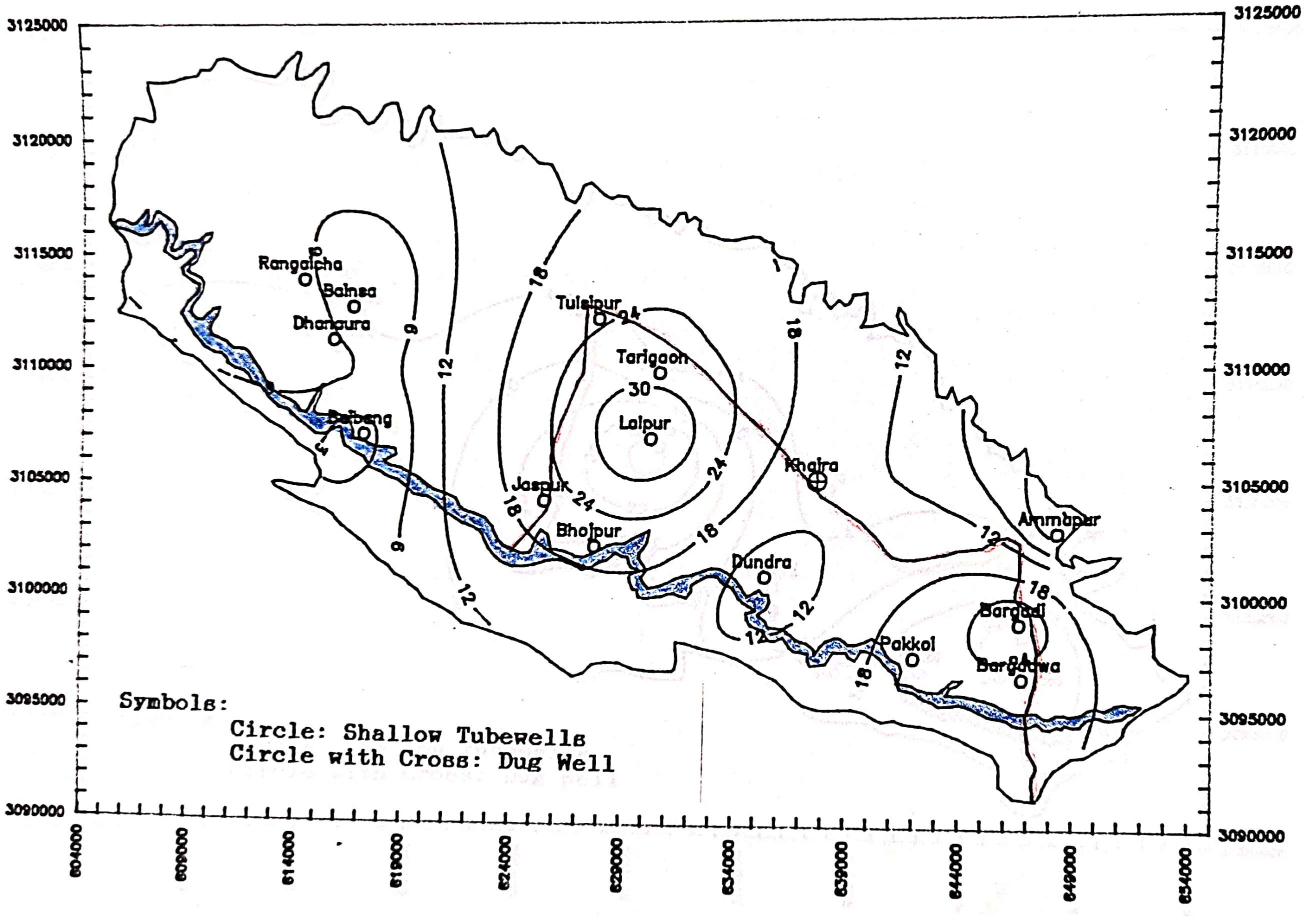
APPENDIX 7/2

DANG VALLEY - RISE OF WATER TABLE MAY - OCT 1987



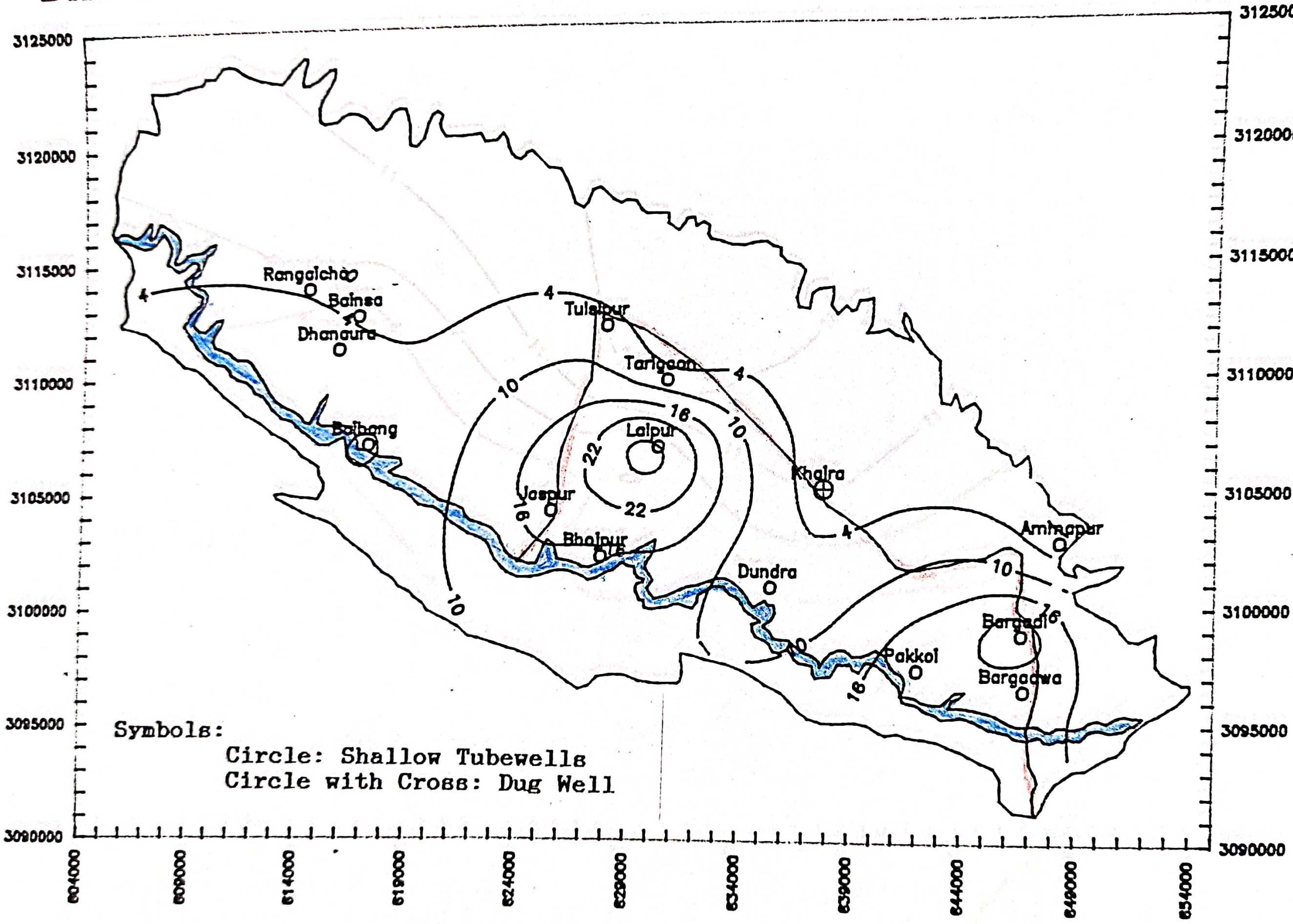
APPENDIX 8/1

DANG VALLEY - DEPTH TO WATER TABLE JUN 1988



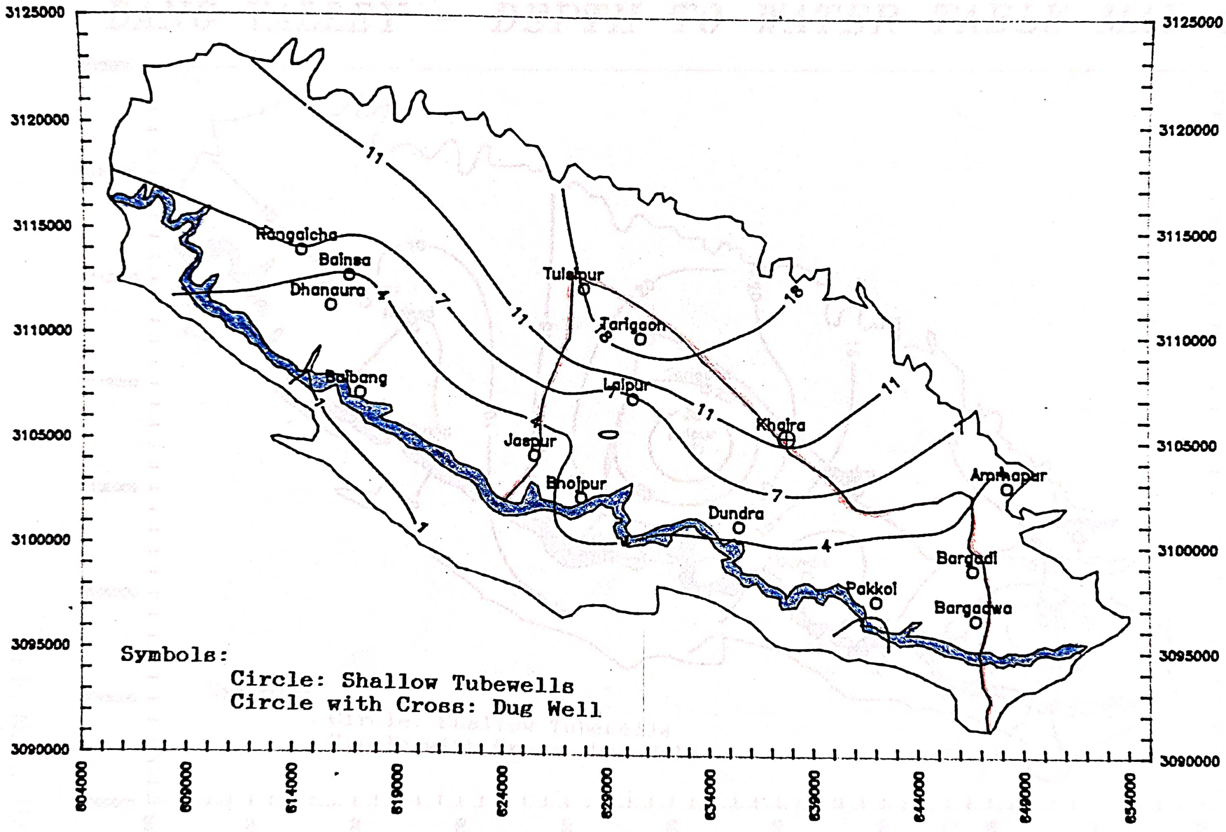
APPENDIX 8/2

DANG VALLEY - DEPTH TO WATER TABLE AUG 1988



APPENDIX 8/3

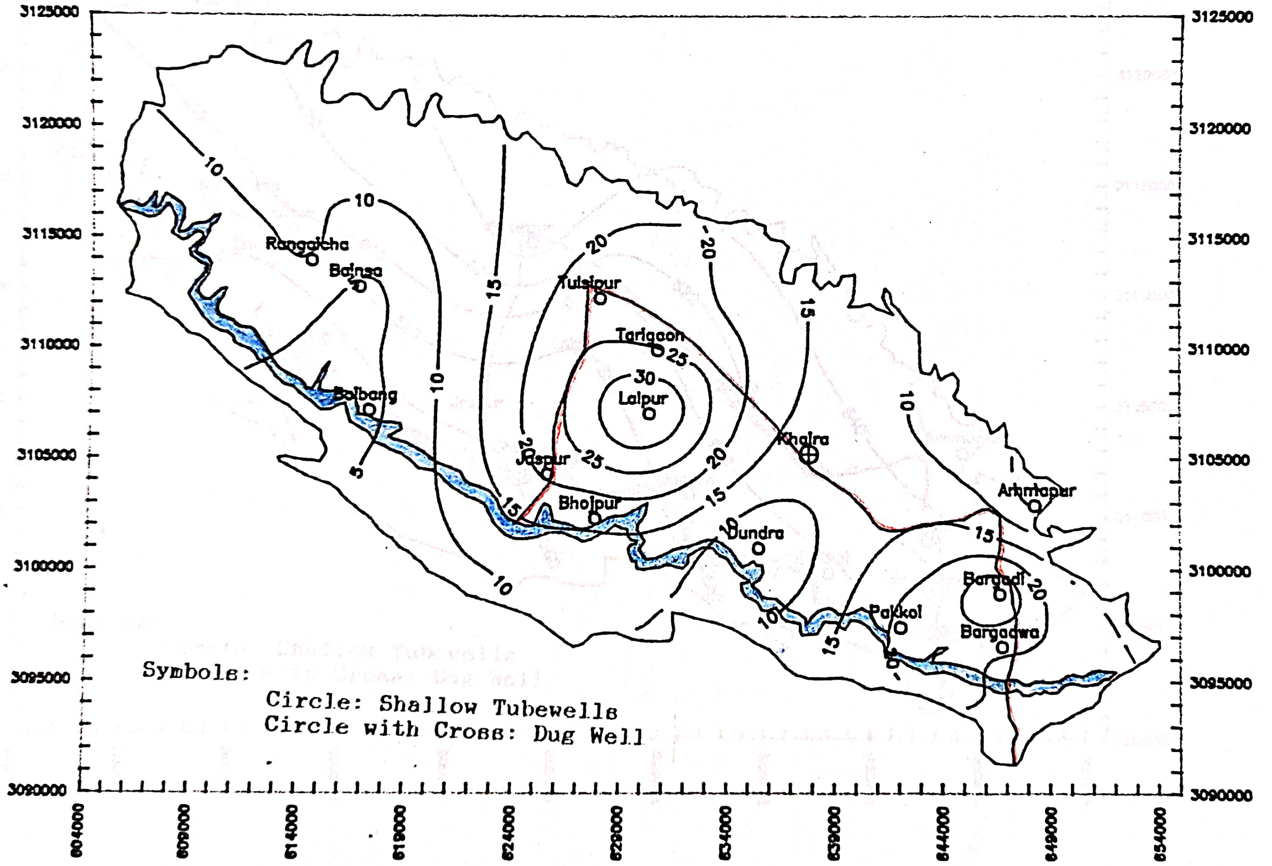
DANG VALLEY - RISE OF WATER TABLE JUN - AUG 1988



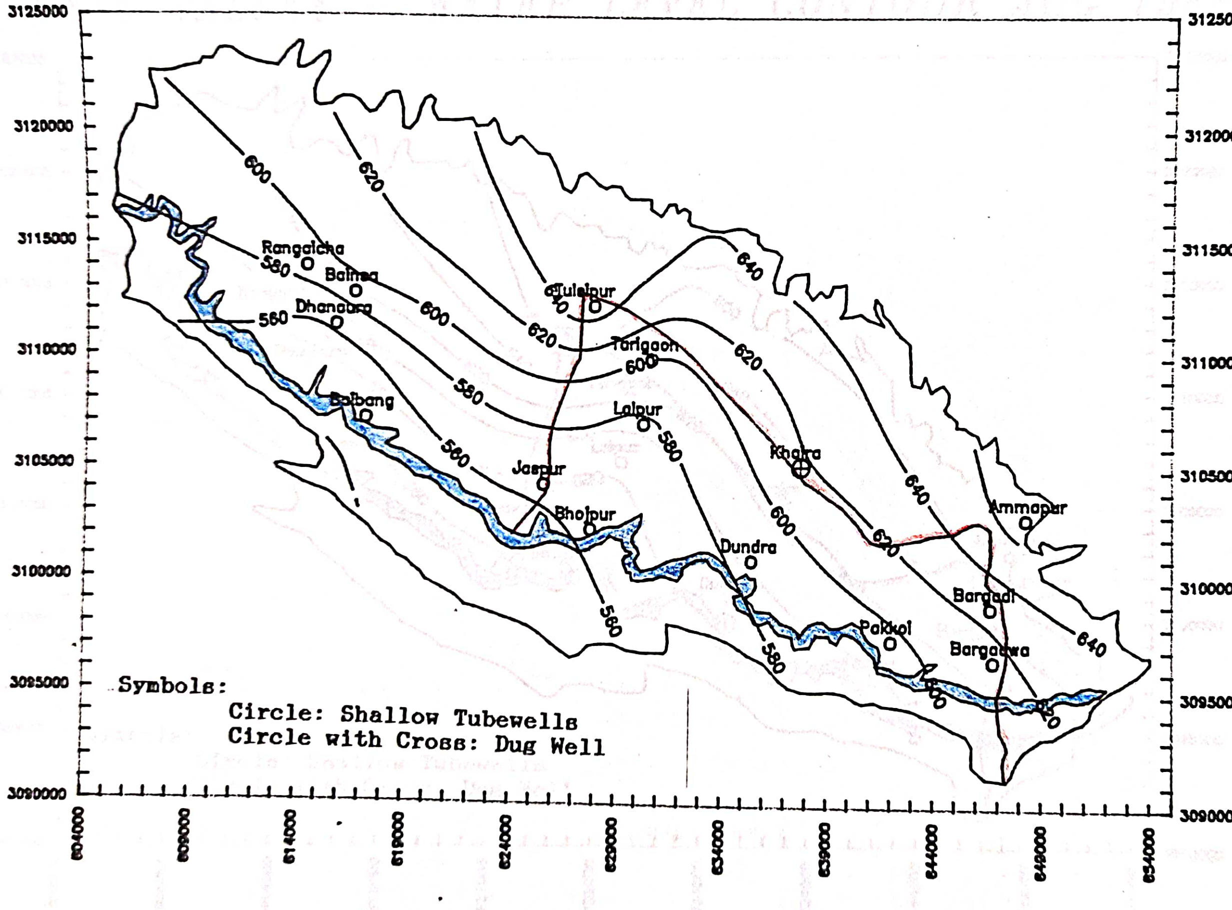
APPENDIX 8/4

APPENDIX 8/5

DANG VALLEY – DEPTH TO WATER TABLE MAY 1989

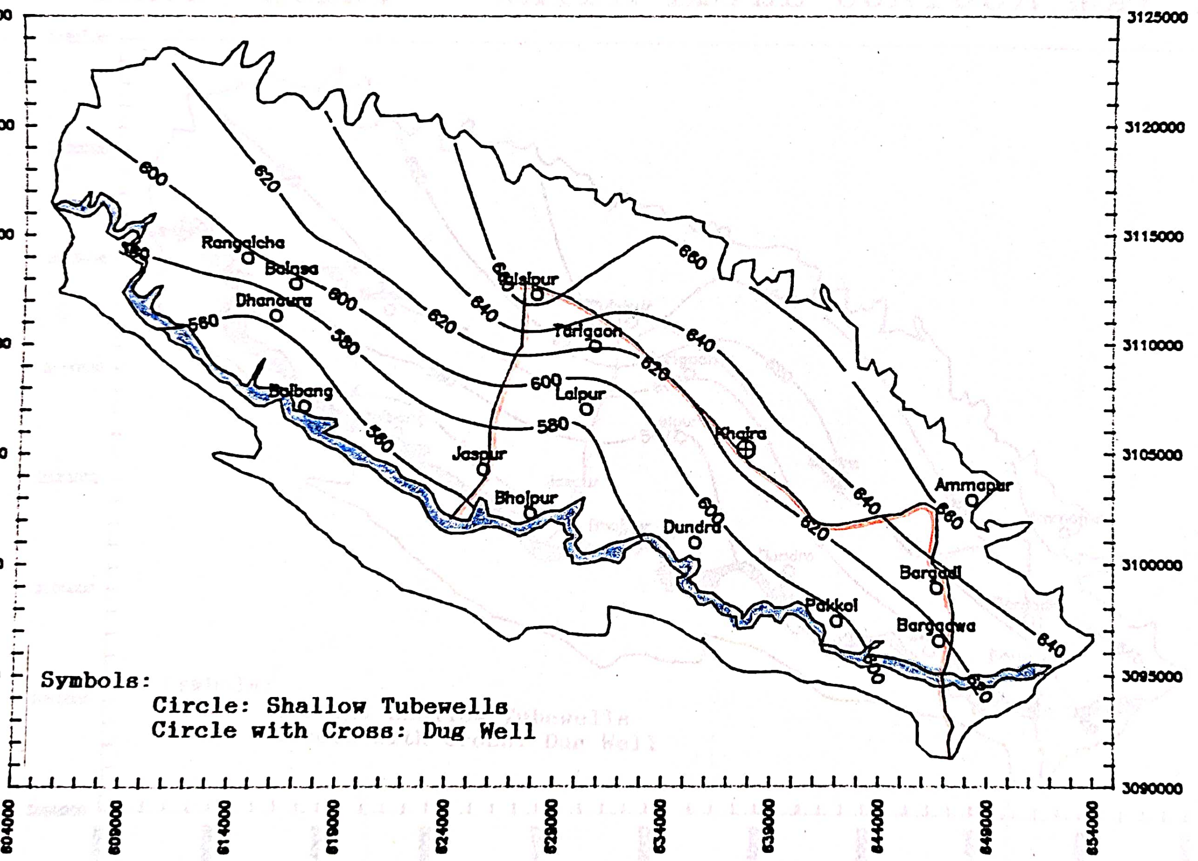


DANG VALLEY - WATER LEVEL CONTOUR JUN 1988



APPENDIX 9/1

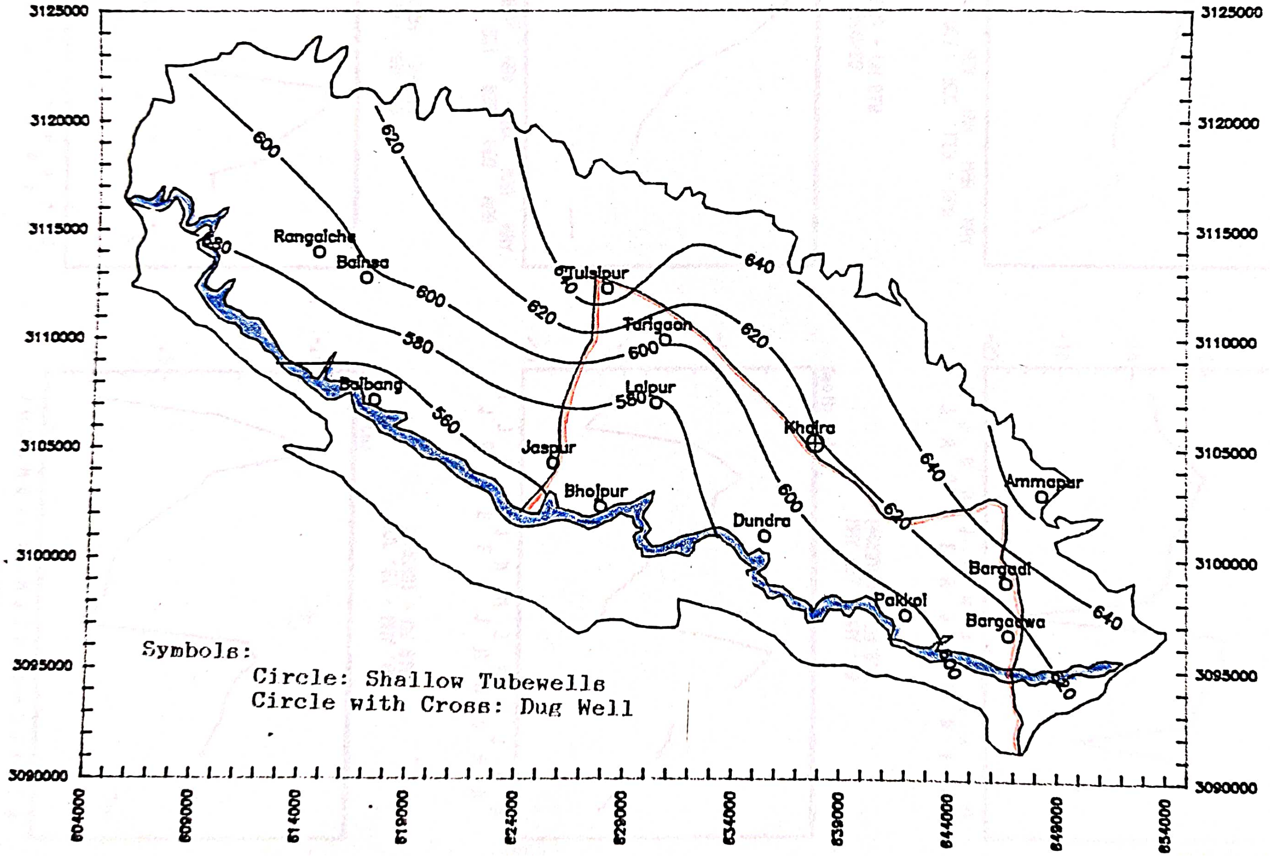
DANG VALLEY - WATER LEVEL CONTOUR AUG 1988



APPENDIX 9/2

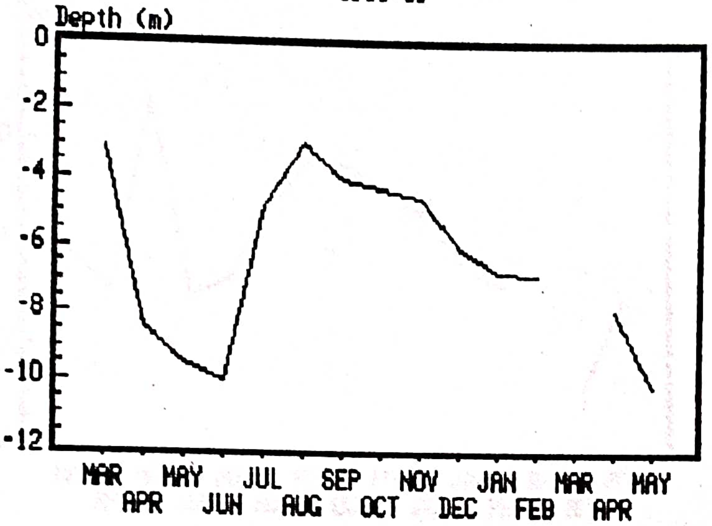
APPENDIX 9/3

DANG VALLEY – WATER LEVEL CONTOUR MAY 1989

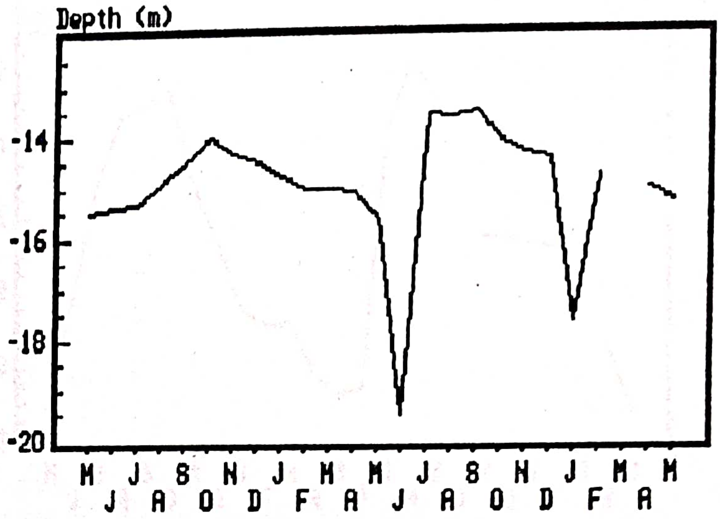


HYDROGRAPHS

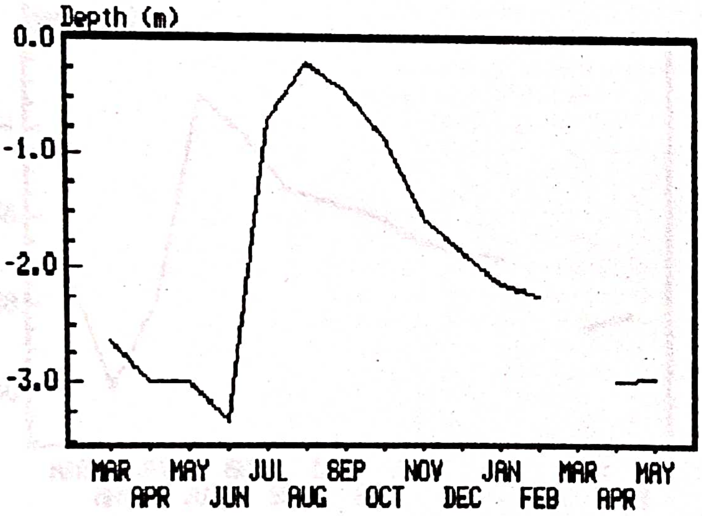
RAGAINCHA - UN STW
1988/89



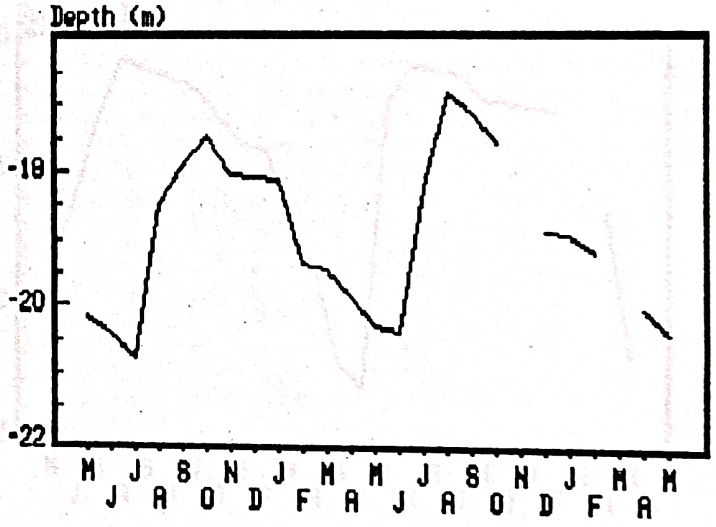
BHOJPUR - GW STW
MAY '87 - MAY '89



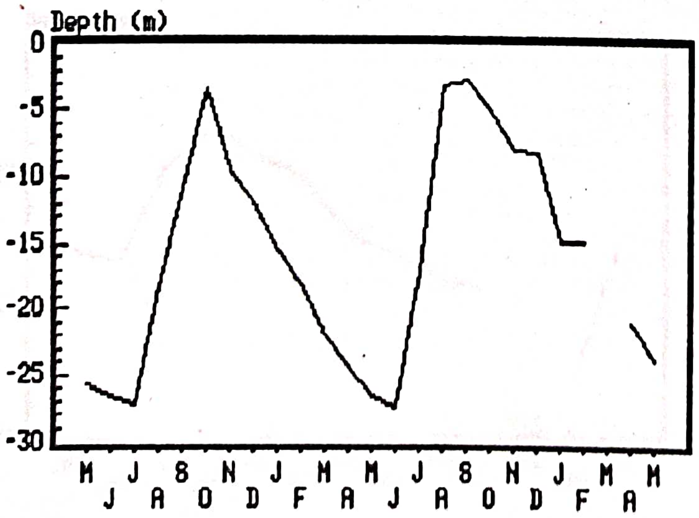
AMMAPUR - UN STW
1988/89



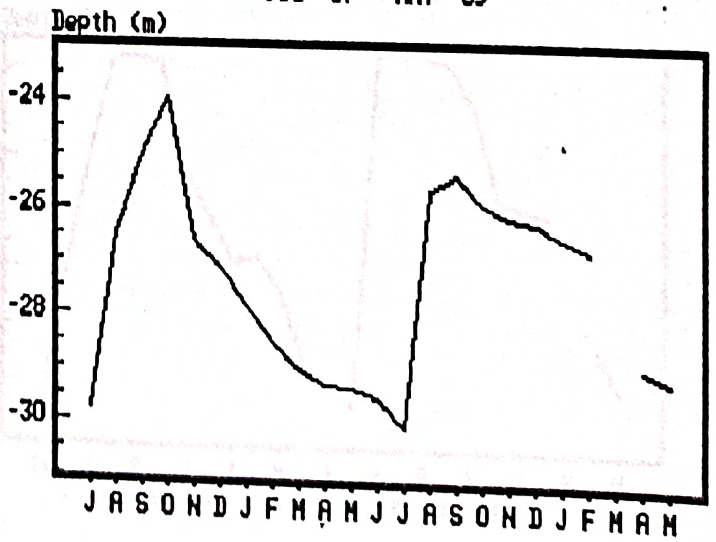
BARGADWA - GW STW
MAY '87 - MAY '89



TARIGAON - GW STW
MAY '87 - MAY '89



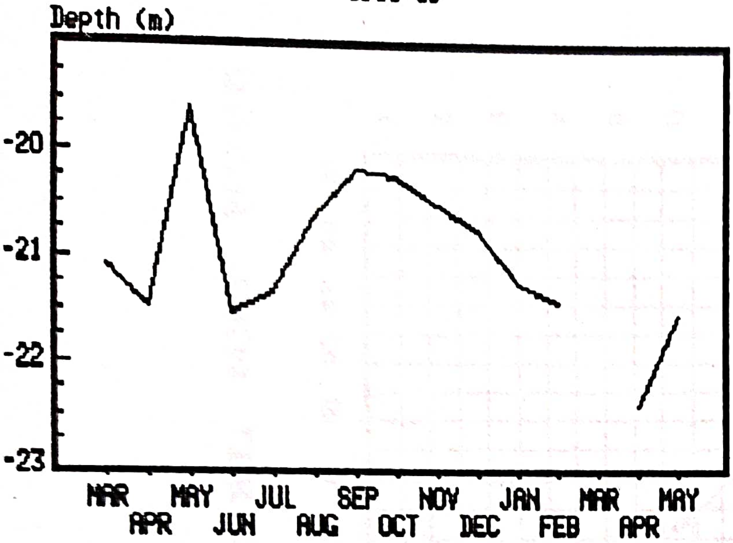
BARGADI - GW STW
JUL '87 - MAY '89



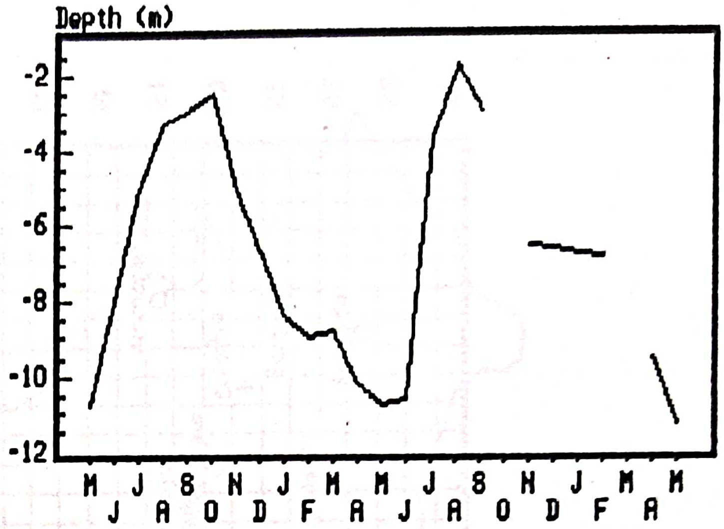
APPENDIX 10/1

HYDROGRAPHS

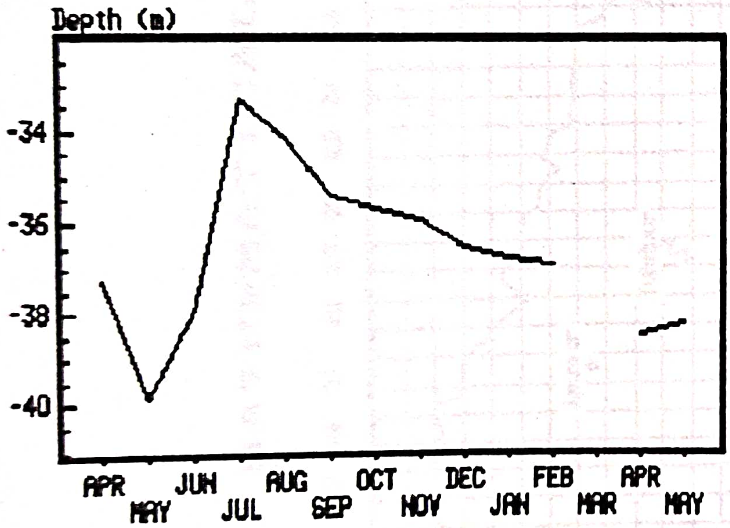
PAKKOI - GW STW
1988/89



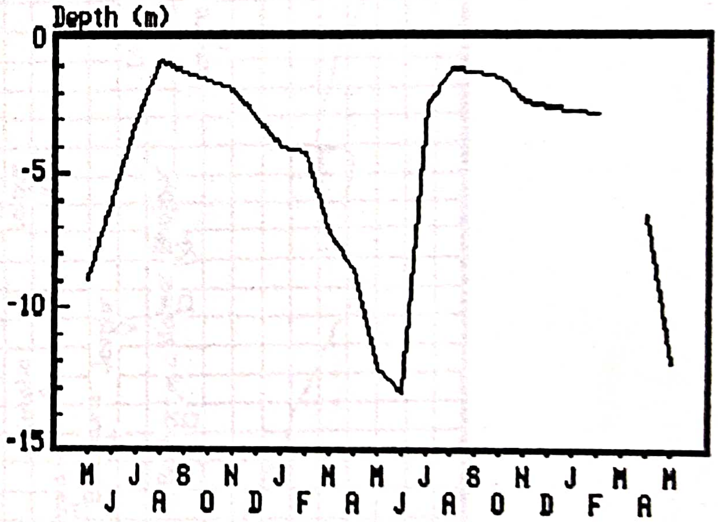
AMUWAPUR - DUG WELL
MAY '87 - MAY '89



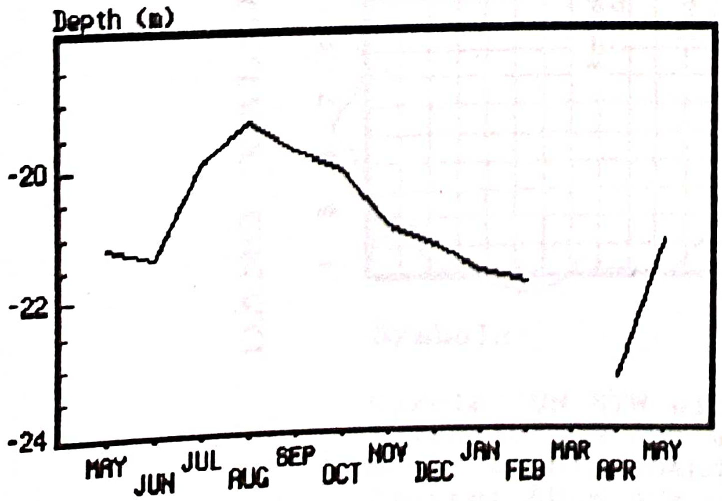
LALPUR - GW STW
1988/89



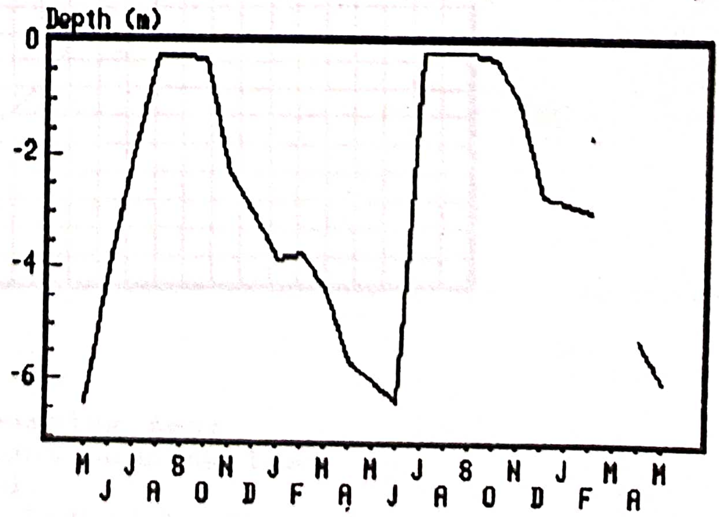
KHAIRA - DUG WELL
MAY '87 - MAY '89



JASPUR - GW STW
1988/89



SHREE GAON - DUG WELL
MAY '87 - MAY '89

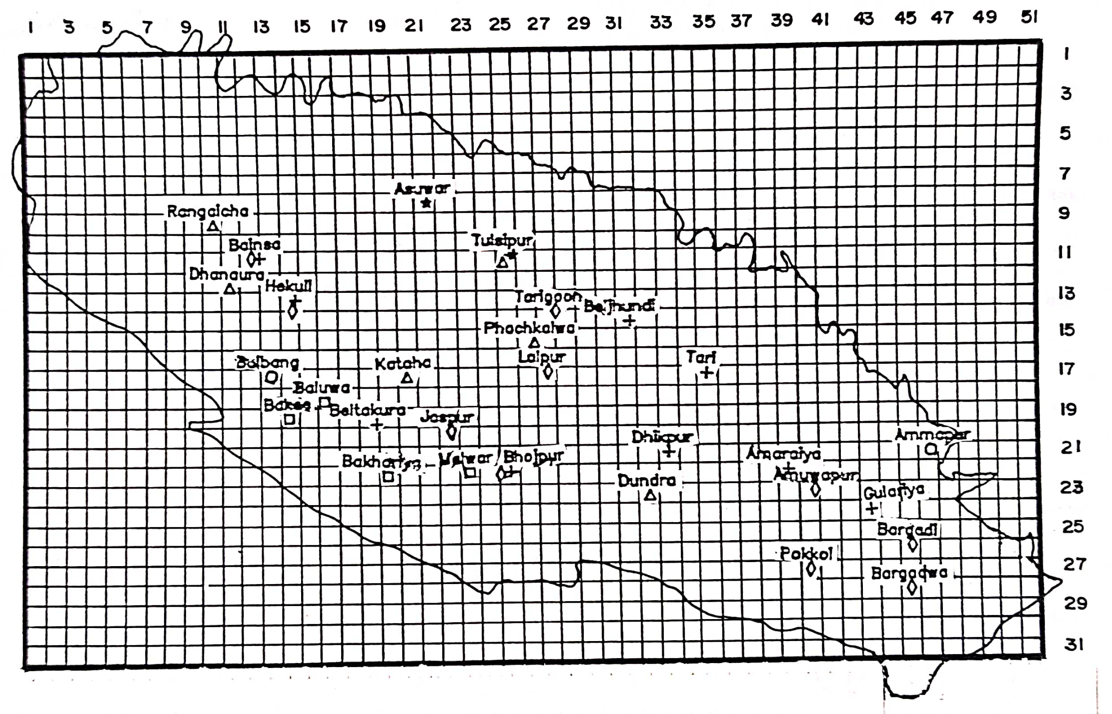


APPENDIX 11

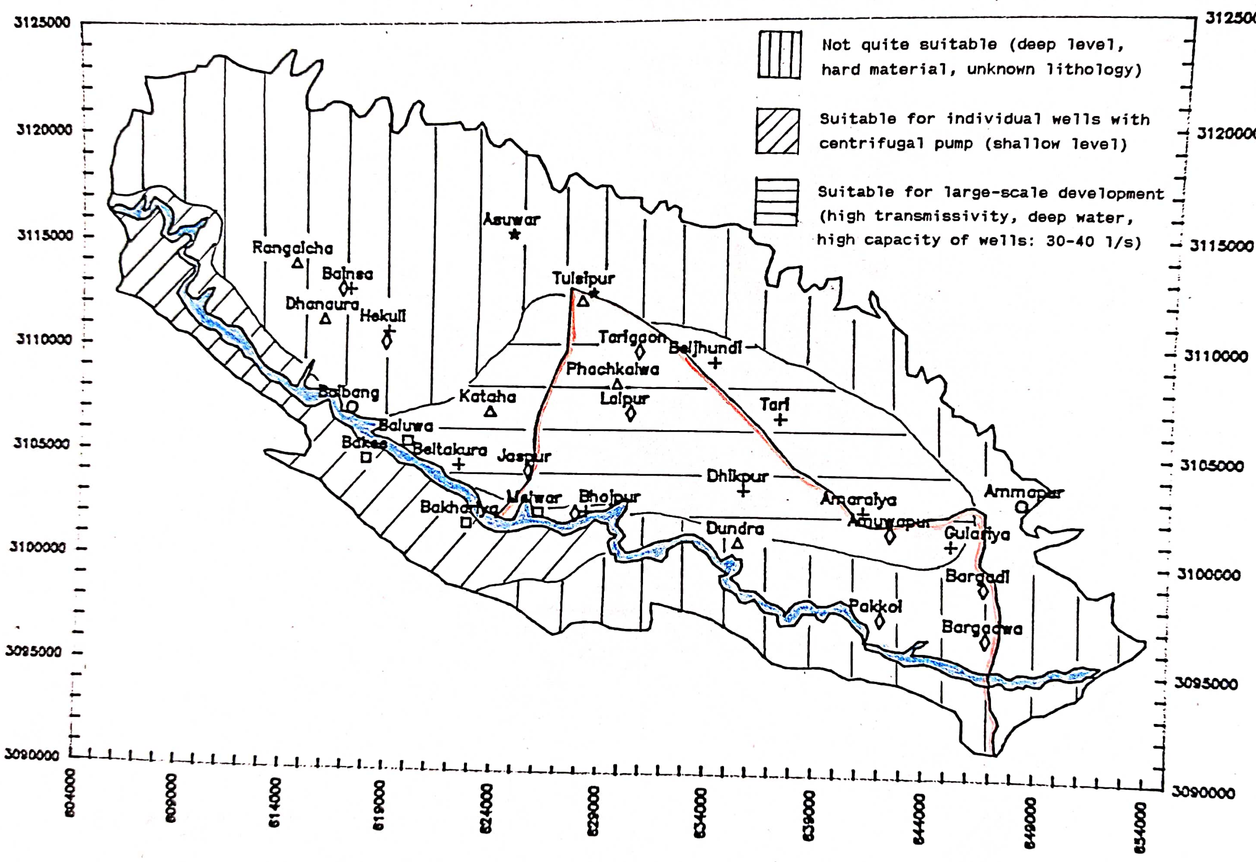
Symbols:

Circle: UN STW with pumping test
Triangle: UN STW without pumping test
Star: UN STW abandoned
Square: ADBN STW pump tested by UN
Rhombus: GWRDB STW
Plus: GWRDB DTW

DANG VALLEY – MATHEMATICAL MODEL NET WORK



FEASIBILITY FOR GROUND WATER DEVELOPMENT



APPENDIX 12