

UNITED NATIONS DEVELOPMENT PROGRAMME
and
HIS MAJESTY GOVERNMENT OF NEPAL PROJECT
NEP/86/025

SHALLOW GROUND WATER INVESTIGATIONS IN TERAI

EXECUTING AGENCY: UNITED NATIONS DEPARTMENT
OF TECHNICAL CO-OPERATION FOR DEVELOPMENT

2ND MISSION REPORT
(3-29 NOVEMBER 1987)

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NEP/86/025 - SHALLOW GROUND WATER INVESTIGATIONS IN TERAI

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NEP/86/025 - SHALLOW GROUND WATER INVESTIGATIONS IN TERAI

1. INTRODUCTION

This is the Second Mission Report of the Chief Consultant in the UNDP/Government of Nepal project "Shallow Ground Water Investigations in Terai", with code number NE/86/025. The mission duration was from 3 through 29 November 1987.

Project Objectives. Immediate Objectives are as follows:

(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 required for applying the most effective methods of shallow ground water abstraction in different parts of the Terai.

(3) To enhance the capacity of the Ground Water Resources Development Board (GWRDB) with regard to ground water exploration, assessment and development.

Project Outputs. The following outputs are expected to be achieved by the project:

(1) A computerized data base with 2000 selected shallow tube and dug wells.

(2) 200 project-drilled exploration-observation-test wells (total drilling metrage about 8000 m).

(3) 400 pumping tests.

(4) Hydrographs of 400 observation wells (200 project wells plus 200 existing wells).

(5) 20 mathematical models covering all districts in the Terai.

(6) Water level maps (depth to water, absolute water level contour maps).

(7) Infiltration test reports and evaluation.

(8) Report on drilling methods in the Terai.

(9) Assessment of shallow ground water in the Terai and definition of specific exploitation criteria for different areas.

Activities

- (1) Survey of 2000 well-spaced and representative shallow tube and dug wells in the Terai.
- (2) Preparing a computerized data base with 2000 wells.
- (3) Drilling and construction of 200 exploration-observation-test wells (depth 30-50 m).
- (4) Pump testing 200 project-drilled wells and 200 other wells selected from existing wells.
- (5) Monitoring water levels in 400 wells (200 project and 200 existing ones). Bimonthly measurement during the monsoon period, monthly during the rest of the year.
- (6) Modelling selected ground water system (20 models).
- (7) Infiltration tests.
- (8) Reviewing different indigenous methods of tube well drilling, testing the suitability of PVC pipes and strainers.

The final output shall be: Evaluation of all available data and assessment of the shallow ground water potential of the Terai per district and per area and/or subarea. Indication of the optimal number of wells in each area, their spacing and recommended discharge rates for a prudent exploitation of shallow aquifers in the Terai.

This Mission

This was the second mission of the Chief Consultant in the project. (The first mission was between 9 June - 6 July 1987.) The main activities during the mission were as follows:

(a) Preparation of drilling program in four districts (Rautahat, Nawalparasi, Kapilvastu, Dang-Deukhuri).

(b) Processing of available information on shallow ground water in four districts (Rautahat, Nawalparasi, Kapilvastu, Dang-Deukhuri). Maps showing contour lines of equal depth to ground water in the month of May 1987 were prepared for all districts in which drilling programme will be carried out in the 1988 premonsoon season. (See Appendices.)

(c) Training of GWRDB staff in computer work, notably in using a contouring programme to produce maps of equal depth to water table. Demonstration of dedicated ground water software (pumping test analyses, chemistry, etc.)

Future Missions. The next mission of this consultant is scheduled for January 1988 to coincide with the arrival of UN Associate Expert in the project. The main task to accomplish in January shall be to witness the beginning of field work (drilling project exploration-test-observation wells,

running pumping tests in existing wells, monitoring water levels, initiate surveying of ground surface in selected four districts). This will be done jointly by Chief Consultant and Associate Expert. The January mission shall be of 3 weeks duration.

The time table of missions in 1988 for Chief Consultant is as follows:

2nd January - 3 weeks Witnessing field work and advising Associate Expert

3rd March/April 4-6 weeks Supervision of field work, data transfer, pumping test analysis, staff training in computer work (modelling, hydrographs, etc.)

4th June/July 4-6 weeks Staff training, transfer of drilling data, pump testing and water-level monitoring data into computerized data bases; modelling; Tripartite Project Review; modification of work programme.

5th October/November 4 weeks Preparation of drilling programme for premonsoon season of 1989 (November 1988 - June 1989); technical reporting on 1988 work.

Acknowledgment

The author of this report expresses his sincere thanks to Mr. Vaidya, secretary and member of Ground Water Resources Development Board for his assistance in setting up the project office in Kathmandu. The project is ready for a good start. Office facilities are absolutely sufficient for the work in Kathmandu. Yet, the success of the project shall be measured by the success of field work (drilling observation wells, pump testing, monitoring levels, etc.). So, it is equally important that GWRDB's field staff embarks enthusiastically upon field work. The assistance and support of Mr. Vaidya and his staff, in this sense, shall be indispensable.

2. EQUIPMENT

Almost all major project equipment (UNDP funds) has been either received by the project or delivered to Kathmandu but not cleared through customs.

The equipment received by the project:

- a. One field vehicle (Toyota pick-up)
- b. Transmitter-receiver sets (3)
- c. Motorcycles (10)
- d. One microcomputer (ZENITH 183-92)
- e. Copy machine (MITA)
- f. Power supplies (3), voltage regulators (2) for microcomputers
- g. Water level indicators

The equipment delivered to Kathmandu but still at customs:

- a. Three Toyota station wagons
- b. One IBM AT microcomputer and accessories (mouse, etc.)
- c. One Hewlett-Packard 7574A plotter
- d. One EPSON FX-286 matrix printer

The following equipment has not yet been ordered by DTCD/New York:

- a. One digitizer. Suggested size 60 cm x 60 cm. Software for digitizer.
- b. One letter-quality printer. Suggested make EPSON LQ 1050 with cut sheet feeder and 10 spare ribbons.
- c. One large size plotter. Suggested make Houston Instrument DMP 52.
- d. Chemical field kit.
- e. Surveying equipment (levelling instruments).

Considering that GWRDB, i.e. this project, have at disposal two microcomputers left over by GDC from their recently completed World Bank supported project, it is suggested that one IBM AT microcomputer (at present at customs) be the last microcomputer purchased for this project. With this computer, the project (and GWRDB) shall have a total of 4 microcomputers (two desk top, two portable) which is believed to be quite sufficient for the time being. The money saved can be used for the purchase of another plotter (large-size Houston Instruments DMP 52 or an equivalent Hewlett-Packard model).

In addition to computer hardware, the following software was delivered to the project:

- Microrim's R:BASE System V
- Microrim's R: BASE CLOUT - Conversational Language Option
- WordPerfect v.4.2
- WordPerfect Library- PFS's First Choice integrated software
- LOTUS 1-2-3, release 2.01
- Norton Utilities v. 4.0
- Borland's Turbo Ligthning
- Borland's Word Wizzard
- Borland's Superkey
- Borland's Sidekick
- Borland's REFLEX
- Borland's Reflex Workshop
- Prosoft's Fantasy
- Funk Software: Sideways
- Executive Systems, Inc.: XTREE

3. WORK PLAN FOR PRE-MONSOON SEASON OF 1988 AND IMMEDIATE PROGRAMME

It was agreed that in the premonsoon season of 1988 (December 1987 - June 1988) the field activities shall be mostly concentrated in the following four districts:

(1) **Rautahat District.** Belongs to Central Region. District area 1020 sq.km. Area for irrigation 960 sq.km. Bhabar zone very limited (10 sq.km). According to Tillson (1985), number of potential wells is 4512.

(2) **Nawalparasi District.** Belongs to Western Region. It is a small district (520 sq.km), which is divided into two zones with respect to occurrence of shallow ground water: southwestern and northeastern zones. Area for irrigation 418 sq.km. Bhabar zone 80 sq.km. According to Tillson (1985), number of potential wells is 2037.

(3) **Kapilvastu District.** Belongs also to Western Region. It is the third largest district in the Terai, covering an area of 1500 sq.km. out of which about 1040 sq.km. are available for irrigation. Bhabar zone is very extensive, about 200 sq.km. According to Tillson (1985), number of potential wells is also very high, about 4888.

(4) **Dang District.** This area belongs to Inner Terai. Actually, these are two separated interior valleys between Mahabharat mountain range to the north and Churia hills to the south. As such, this district has not been subject of ground water investigations in the past.

The original proposal of GWRDB for drilling in four districts was as follows:

District	New Wells	Pumping Tests
Rautahat	20	40
Nawalparasi	30	40
Kapilvastu	20	20
Dang	10	20
TOTAL	80	100

The above programme was modified during this mission, although the modifications are rather tentative and subject to field validation. After all presently available information was analyzed and maps of depth-to-water in dug and shallow wells for May 1987 plotted, the proposal for drilling in the period December 1987 - June 1988 is as follows:

District	New Wells	Pumping Tests
Rautahat	15	21
Nawalparasi E	15	15
Nawalparasi W	16	23
Kapilvastu	20	33
Dang	6	9
Deukhuri	5	11
TOTAL	77	112

More specifically, the drilling programme district-wise is as follows:

(1) **Rautahat District** (see Appendices 1,2,3). 15 shallow wells to drill or construct by indigenous methods. Average depth 35 m. Total drilling metrage 525 m. Locations in 3 north-south sections. Existing shallow tube wells (STW) drilled under ADBN (Agricultural Development Bank of Nepal) loans, about 20, should remain between two lines of new (project) wells.

Pumping tests to be conducted in all newly drilled wells (15) plus in several selected STW's (minimum in six).

The drilling locations as shown in Appendix 3 are very tentative. Just before the end of the present mission, field report was received showing locations of shallow tube wells (STW) in which depth to water table was measured in a field campaign between 23 September and 7 October 1987. These wells are shown in Appendices 1,2,3 (blue dots). Fourteen STW are strategically well spread all over the district. It is not clear whether these STW's are the only existing drilled wells, or this is a selection for observation network. The only information received in Kathmandu about these wells is depth-to-water in September/October 1987. The instructions given to project staff are as follows: (a) visit the district, discuss the situation with GWRDB field staff, collect additional information from these wells, (b) modify locations for project wells if some of existing STW's offer the possibility of running pumping tests, or locate project wells close to existing STW's (within 50 m) so that one or the other can be used as observation well during pumping test, (c) continue with bimonthly monitoring water levels in 14 selected STW's (the same ones used for September/October measurements), (d) include newly drilled project wells into the monitoring network immediately after each well is drilled and developed.

Problems to be expected in Rautahat District: (a) drilling in Bhabar zone with deeper water table (deeper than 5 m in May) due to cobble and boulders; (b) sand pumping if wells are constructed without gravel pack.

Ground water in Rautahat District is classified by GDC (Groundwater Development Consultants) in their recently released report (August 1987) (see Appendix 4) as S1/D2 in most of the district, and D2/S2 in its SW part. This means that shallow aquifer is either good (S1) or marginal

(S2) in most of the district. Only in the Bhabar zone, the shallow aquifer is coded with S0, meaning poor aquifer. All over the district, deep aquifer is good (D2) with piezometric surface deeper than 10 m below ground surface.

(2) **Kapilvastu District** (see Appendices 5 and 6). Twenty wells to drill, average depth 40 m, total drilling metrage 800 m. There are many STW's in the district; some are used for monitoring water levels. The drilling programme should be carefully discussed in the field with district hydrogeologists and modifications made accordingly. It is imperative that prior to drilling, project hydrogeologists visit the district, make field trips to various parts of the district, evaluate information that can be collected and used from existing wells. At present, drilling locations are lined in 5 north-south sections. Existing STW's used at present for observations (15) should complete the observation network. Pumping tests for transmissivity, hydraulic conductivity and eventually effective porosity, should be conducted in each newly drilled well (without too much delay after the completion of well construction) plus in some 13 existing observation wells. Wherever possible, include nearby wells into observation programme during pumping tests. This is especially feasible in Harharwa, Bharsarwa where more than one STW exists.

The drilling-and-observation programme in the western part of Kapilvastu district should take into account a statement formed by other consultants (GDC, August 1987) according to which western Kapilvastu has no deep aquifer of any potential and its shallow aquifer may also be marginal. This is displayed in Appendix 7 which is entirely reproduced from the GDC report. The GDC classification S2/D0 in western Kapilvastu means marginal shallow aquifer (with water table less than 5 m) and poor deep aquifer. The symbol S1/D3 to the east implies good shallow aquifer (with water table less than 5 m) and marginal deep aquifer (with self flowing wells). A limited zone near the border with Rupandehi District is coded with S1/D1 which evidently implies good both shallow and deep aquifers. Bhabar zone near Churia hills is represented with symbols S0/D0 and S0/D2, which implies poor shallow aquifer (S0) and either poor deep aquifer (D0) or good aquifer with piezometric surface deeper than 10 m.

(3) **Nawalparasi West** (see Appendices 8,9). Sixteen shallow wells to drill; average depth 50 m; total drilling metrage about 800 m. Locations are lined in 5 sections (NE-SW). As in other districts, locations are tentative and should be verified in the field. Observation network should include all 16 newly drilled (project) wells, plus two hand-pumped dug wells (in Susta and Marchahawa), and eventually some US AID shallow test wells (to be decided after field visit). Pumping tests should include all 16 newly drilled wells, plus 2 dug wells equipped with hand pump, plus some 5 old US AID shallow wells.

According to GDC, in western Nawalparasi shallow aquifer is clearly superior to deep one (see Appendix 7). Most of the area is coded with S1/D0 (good shallow, poor deep aquifer). Restrictions in the sense of drilling to be expected in Bhabar zone are depths to water table (5-6 m in May) and drilling problems with boulders in the alluvial fan.

(4) **Nawalparasi East** (see Appendices 10,11). Fifteen shallow wells to drill; average depth 30 m; total drilling metrage about 450 m. Depth to water in May 1987 in most of Nawalparasi district is below 5 m (see Appendix 10). As it appears from Appendix 10, the project does not have any

information about eventually existing shallow tube wells. The only information at present received by the project is depth-to-water table in May 1987, which is reproduced in Appendix 10. If this is correct, then pumping tests can be run only in newly drilled project wells.

(5) Dang Valley (see Appendices 12,13). Six wells are programmed to be drilled in Dang valley. Average depth of drilling is 40 m, total drilling metrage is 240 m. Water table in most of the Dang valley is deep, deeper than 5 m in May 1987. Drilling problems are expected and drilling programme shall be modified following newly acquired field experience. According to Appendix 12, most of existing wells are deep wells. This is a "virgin" area in the sense of shallow aquifer development and shall be treated as such in this project.

(6) Deukhuri Valley (see Appendices 14,15). It is a narrow elongated valley through which Rapti River flows. Apparently, the river flood plain dominates the valley. Depth to water table in May 1987 is greater than 4 m in most of the valley. Drilling problems are expected. Same as in the case of the Dang valley, the shallow aquifer study shall be a pioneering attempt. A total of 5 shallow wells are programmed to be drilled, with an average depth of 35 m, and total drilling metrage about 175 m. Existing STW's should be included into observation network and pump tested if possible.

4. CONCLUSIONS AND RECOMMENDATIONS

(1) This project is a natural-resources evaluation project. As such, it demands plenty of field data collection. In the period to follow between now and June next, field activities must concentrate on the following:

- drilling project observation wells in four selected districts (Rautahat, Nawalparasi, Kapilvastu, Dang-and-Deukhuri): 77 wells;
- test pumping all to-be-drilled project wells (77), plus about 35 existing ones; if staff, time and equipment potentials permit, test pumping can include some other strategically located existing wells in other districts, as well;
- monitoring on average 20 shallow tube wells and/or dug wells in all districts all over Terai; measuring water levels in monthly or bimonthly intervals;
- field inventories of existing shallow tube wells, clarifying the use of shallow ground water, conditions of wells; collection of all available information from the field (field surveys) and project offices;
- surveying land surface elevation in newly drilled wells, as well as in other wells included into water level monitoring network.

(2) Kathmandu-stationed project staff (Messrs. Shrestha, Uprety) should spend considerable time in the field (in four selected districts) doing the following: (a) selecting drilling sites, (b) preparing drilling specifications, (c) supervising drilling activities (at least at the beginning of

drilling in each of districts), (d) preparing lithological logs of drilled holes, (e) making decisions with respect to gravel packing and/or success of drilling with indigenous methods, selecting zones to be screened, size of screen, deciding on proper well development.

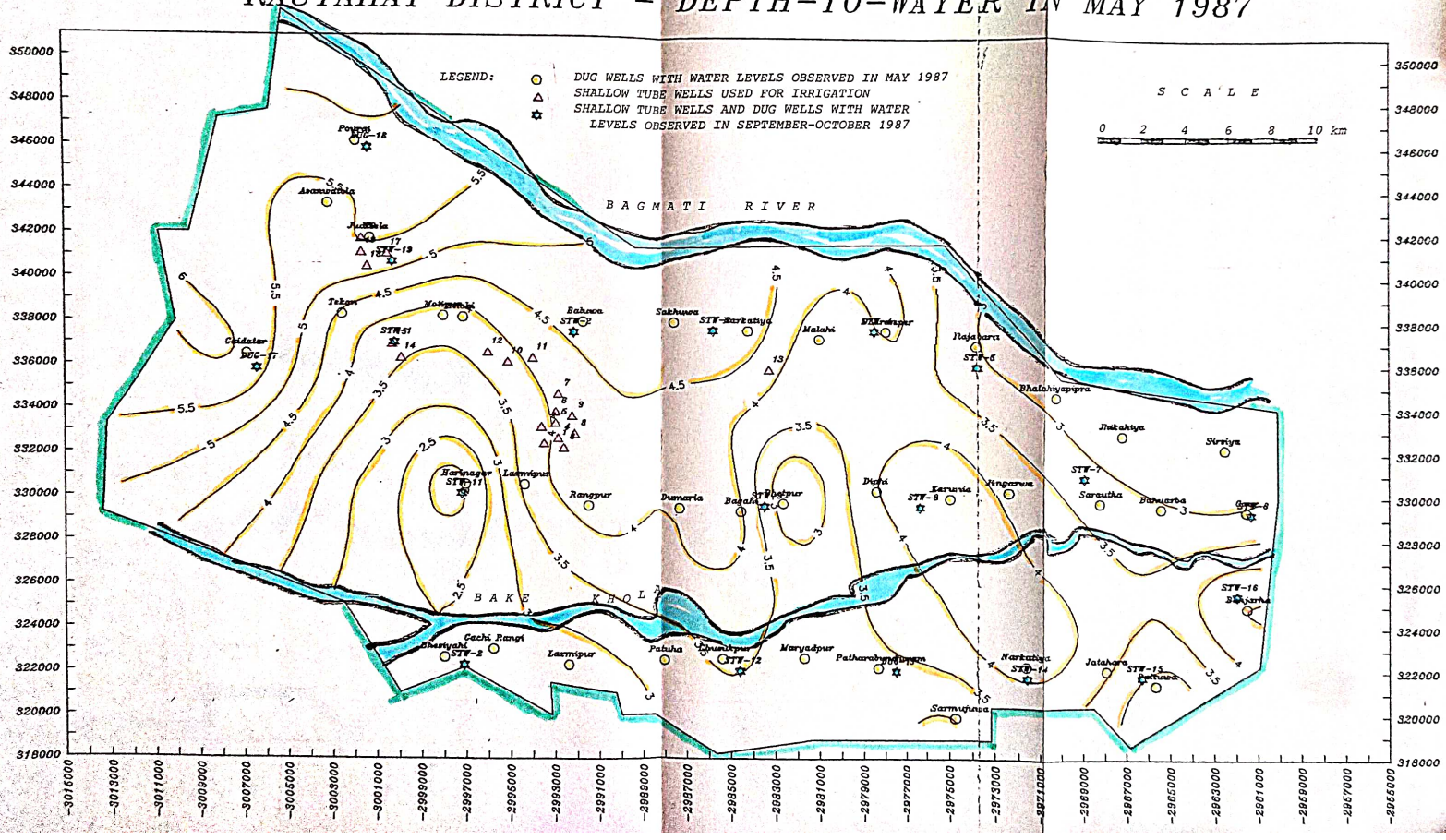
(3) The period between January 1 and June 30 should be mostly field oriented. Data transfer to computers, modelling, plotting maps and hydrographs could be done in the monsoon season (July-October). Yet, every spare period of time (between two field trips) should be used for further processing water level data for all other districts (similar to maps shown in Appendices). This information shall be used in the second half of 1988 for elaborating the programme of field work (drilling, test pumping, monitoring) in districts to be "tackled" a year from now (premonsoon season of 1989).

(4) It is important that all available information on shallow tube wells, use of water, irrigation practices and plans is constantly collected and channelled to the project office. This refers equally to the four district selected for this year field work as well as to all remaining Terai districts. GWRDB's field office staff should be constantly reminded to collect such information.

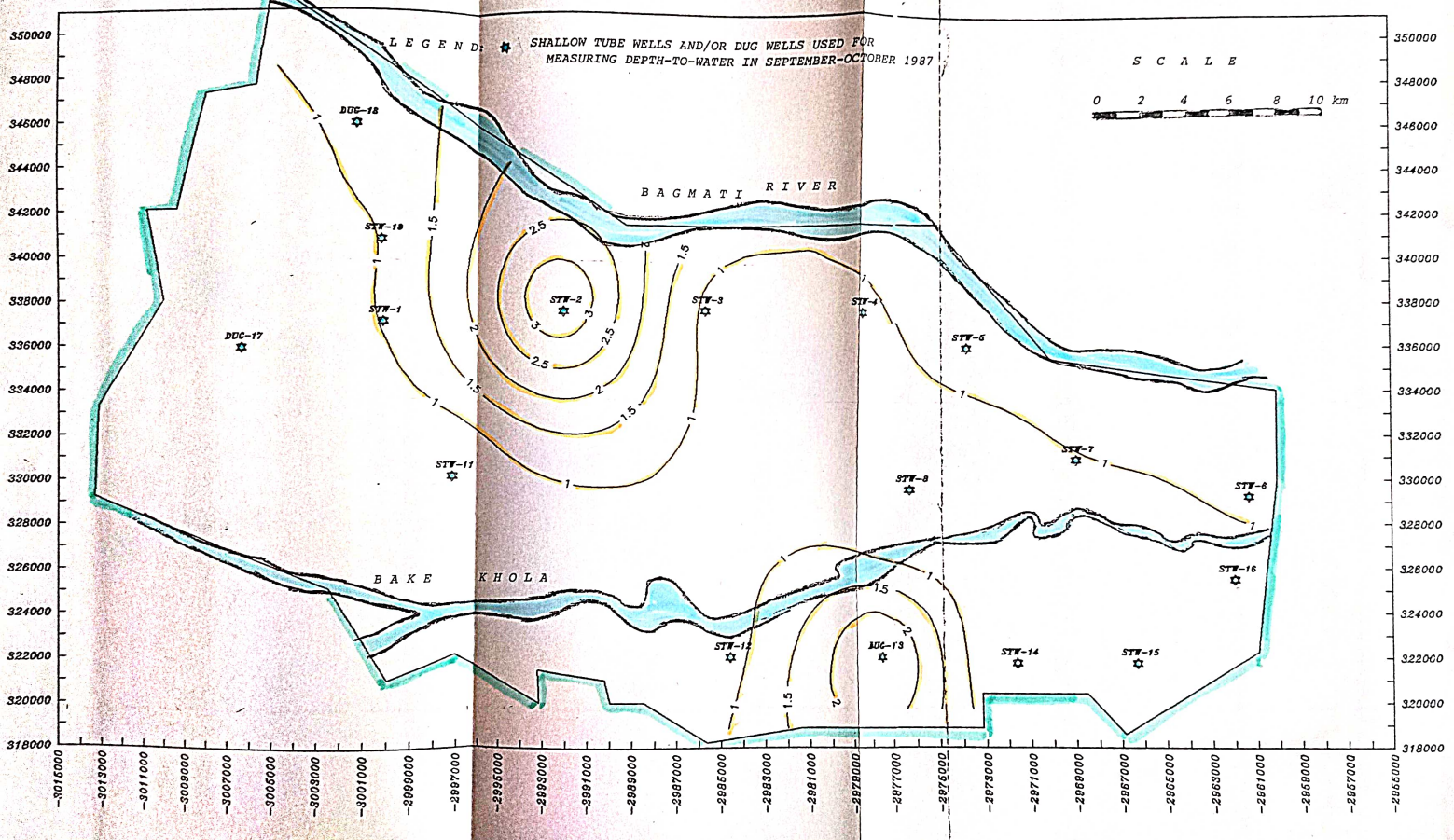
(5) Equipment purchased by the project for the project (vehicles, motorcycles, transmitter-receivers, water level indicators, surveying instruments, etc.) should be sent to the field to be used there. At least one out of four microcomputers should be sent to the field (Bhairawa), to be used by project staff for data collection in Kapilvastu, Rupandehi and Nawalparasi districts. This cannot be done without a prior training-in-depth of project staff in the use of microcomputer, running project software, and like. It is recommended that Mr. Kunwar from Bhairawa office spends some time in Kathmandu working with the computer.

(6) GWRDB has prepared a training programme schedule (fellowship and study tours programme). It has placed an emphasize on number of candidates (12) rather than length of training for each candidate. Excluding a study tour to Madras, India, which is programmed for 3 people 10 days each, it is suggested that other 9 candidates spend between 4 and 8 weeks in Thailand (AIT), Netherlands (ILWR), England (Wallingford) and USA (USGS). This is in a somewhat conflict with the original programme (project document) which suggested extended training of limited number of fellows notably in ground water management (modelling). Both concepts deserve equal attention. Which will be more beneficial to GWRDB and Nepal will depend on availability of qualified and motivated staff to continue working in the project, both in the field and in the Kathmandu office.

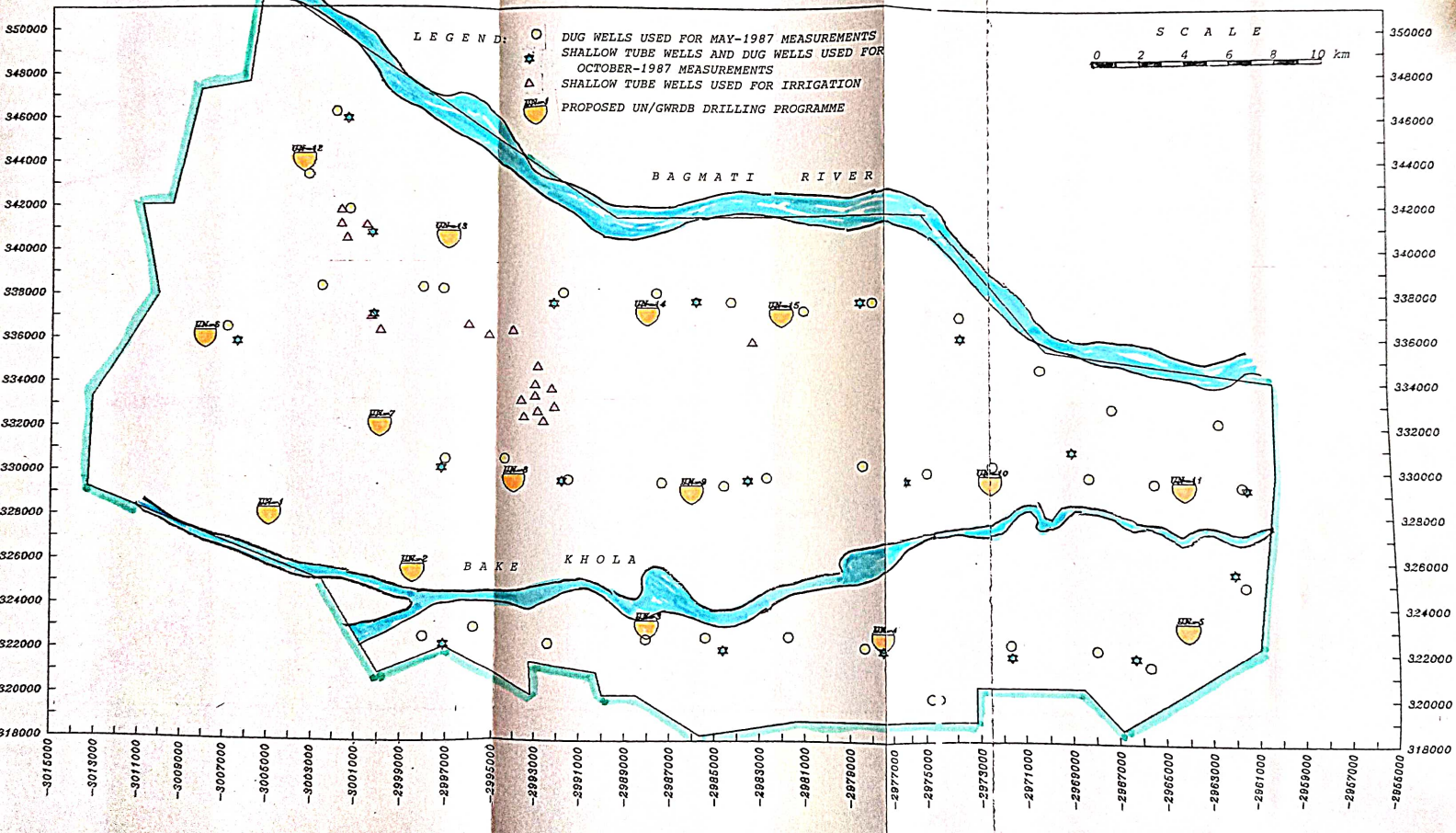
RAUTAHAT DISTRICT - DEPTH-TO-WATER IN MAY 1987



RAUTAHAT DISTRICT - DEPTH-TO-WATER OCTOBER 1987



RAUTAHAT DISTRICT - PROPOSAL FOR DRILLING PROJECT WELLS

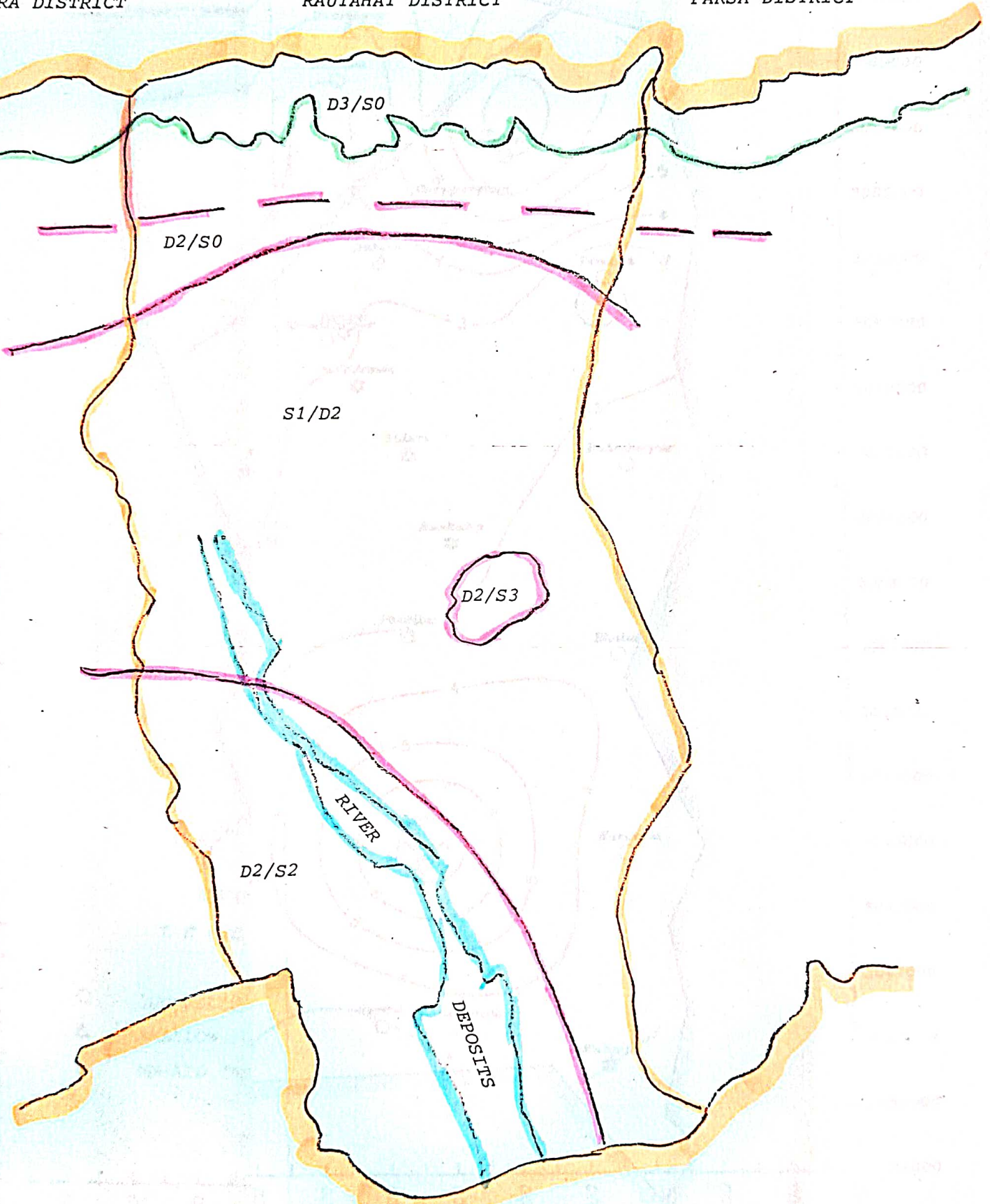


CLASSIFICATION OF GROUND WATER POTENTIAL DEVELOPMENT ZONES
(AFTER GROUNDWATER DEVELOPMENT CONSULTANTS, 1987)

BARA DISTRICT

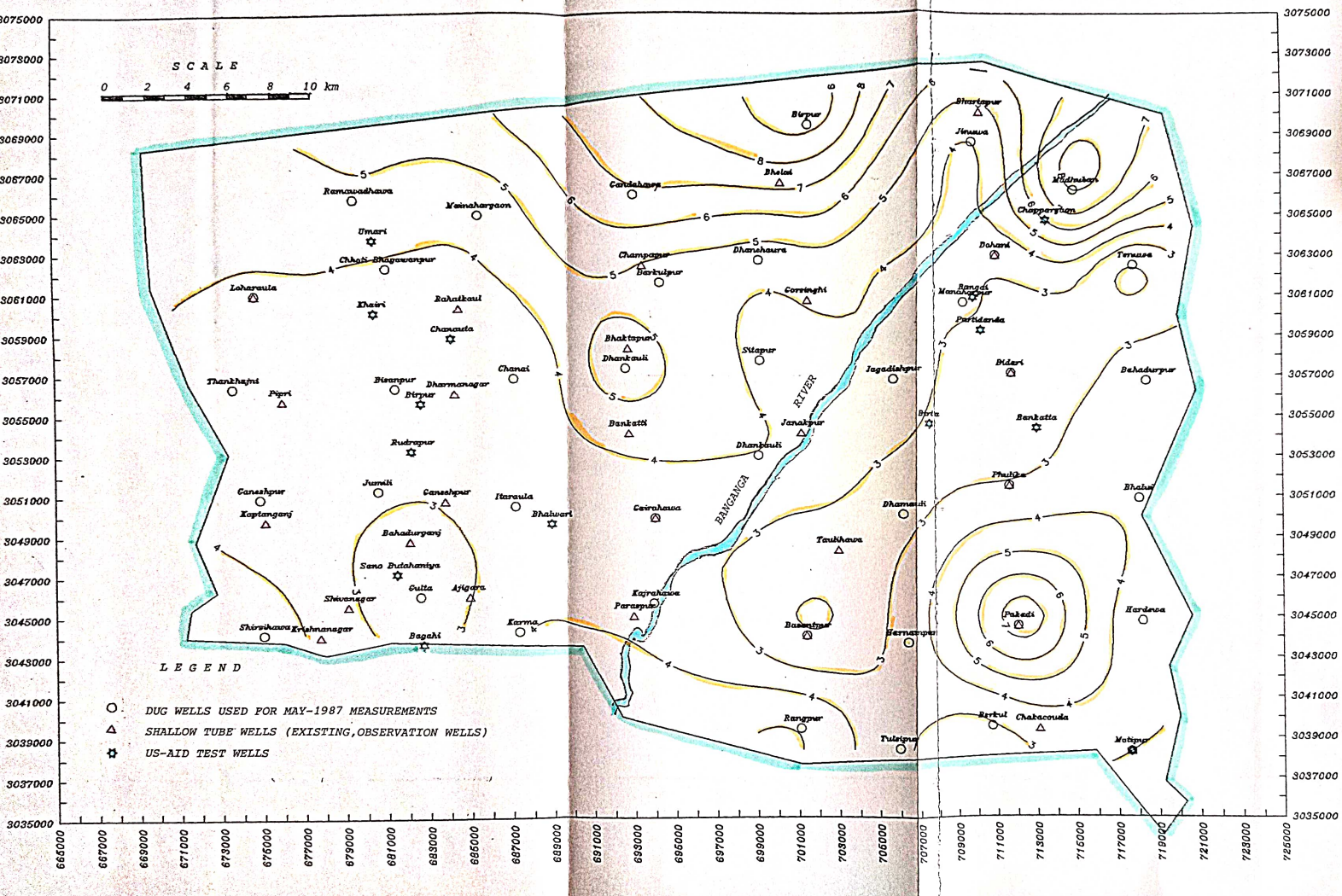
RAUTAHAT DISTRICT

PARSA DISTRICT

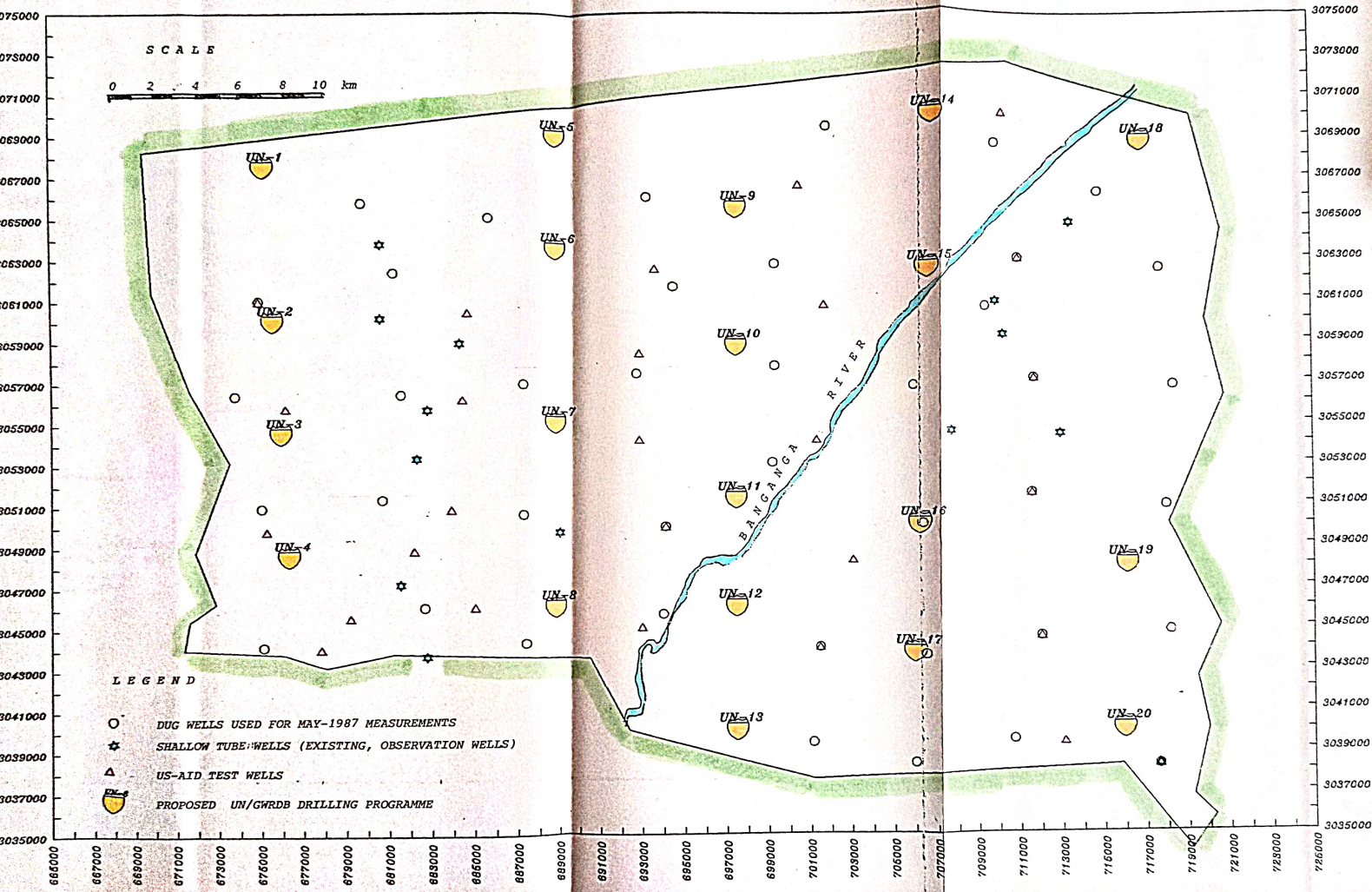


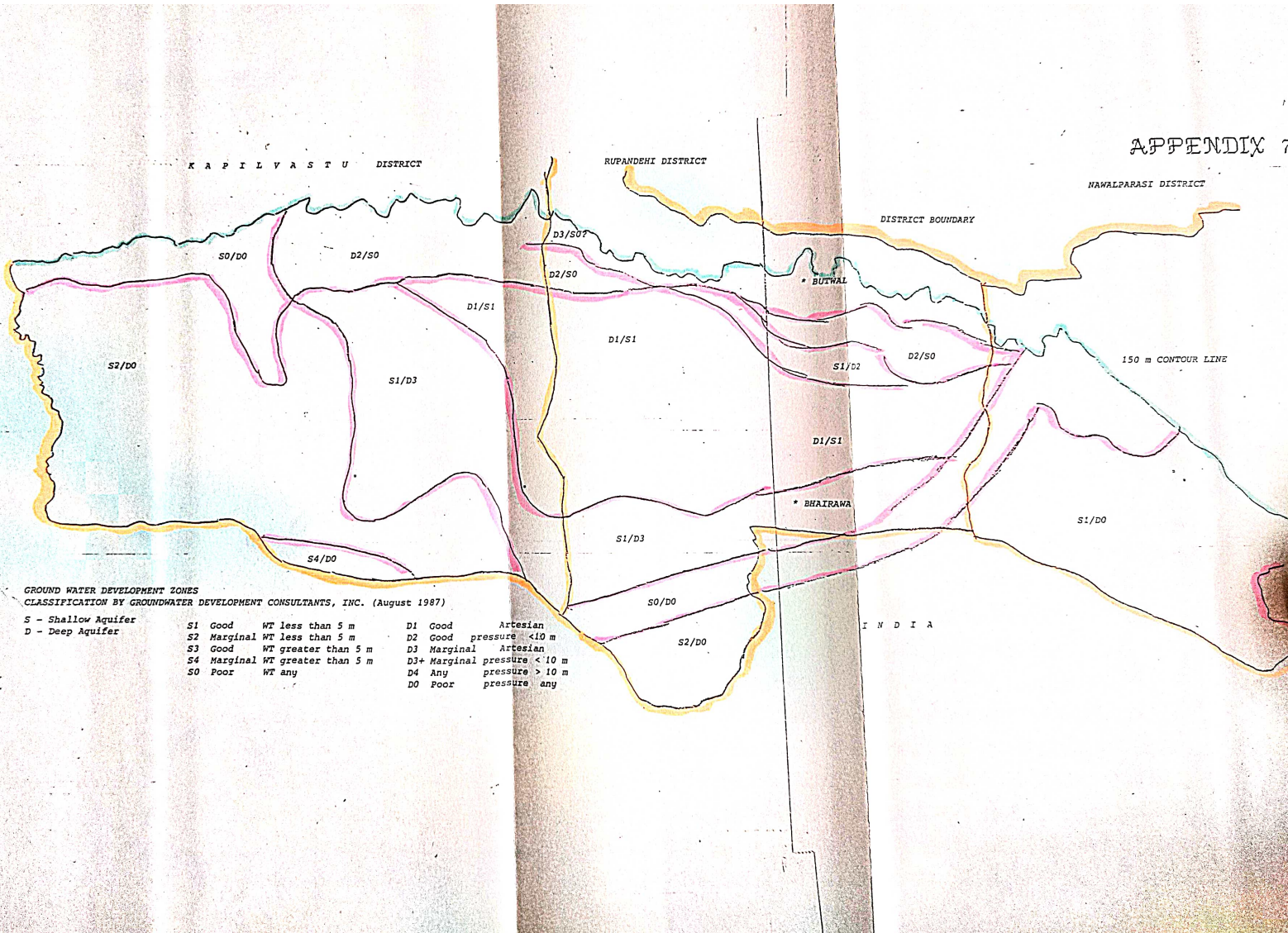
KAPILVASTU DISTRICT (TERAI) - DEPTH-TO-WATER IN MAY 1987

APPENDIX 5



KAPILVASTU DISTRICT (TERAI) - PROPOSAL FOR DRILLING PROJECT WELLS



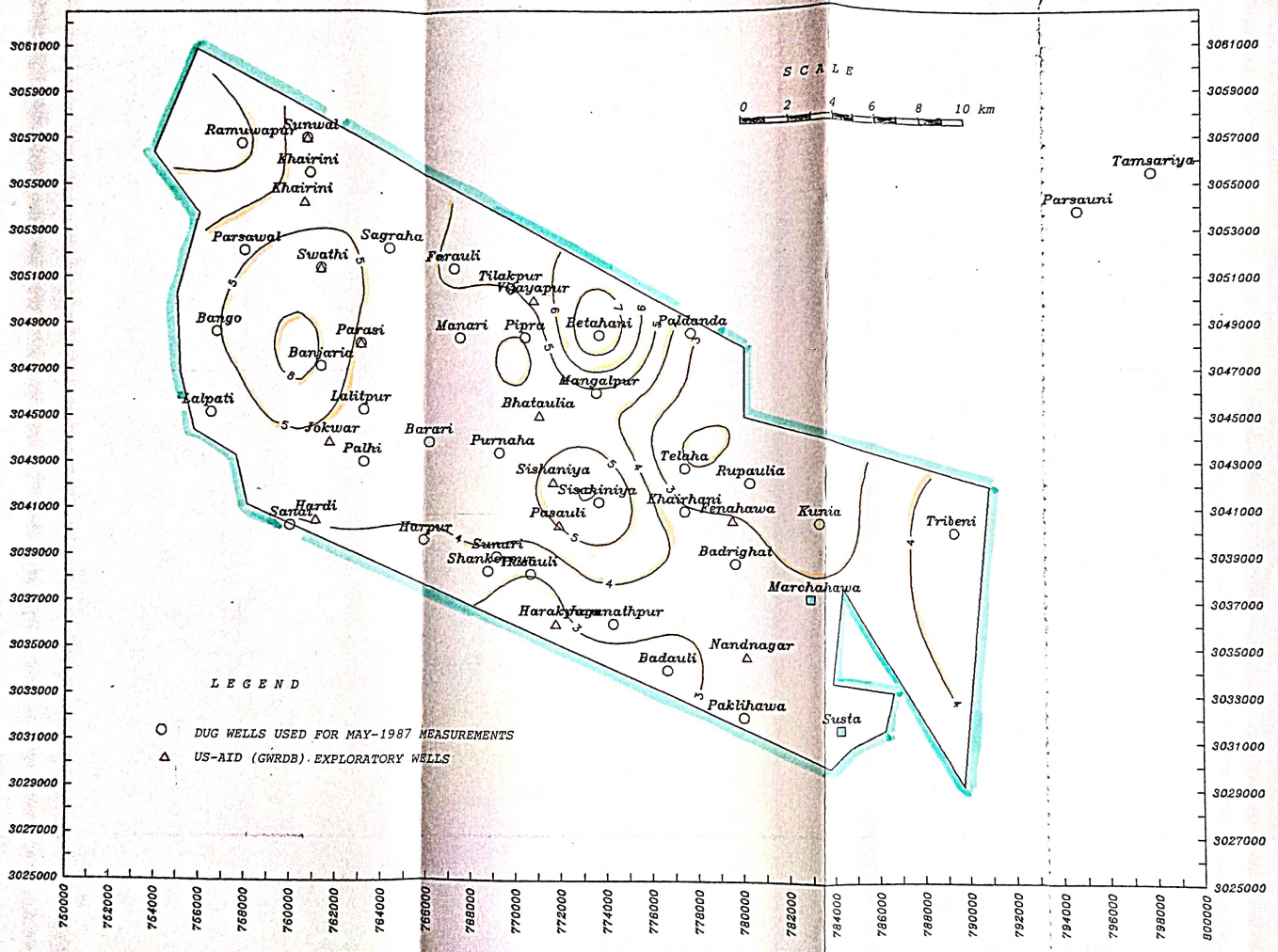


GROUND WATER DEVELOPMENT ZONES
 CLASSIFICATION BY GROUNDWATER DEVELOPMENT CONSULTANTS, INC. (August 1987)

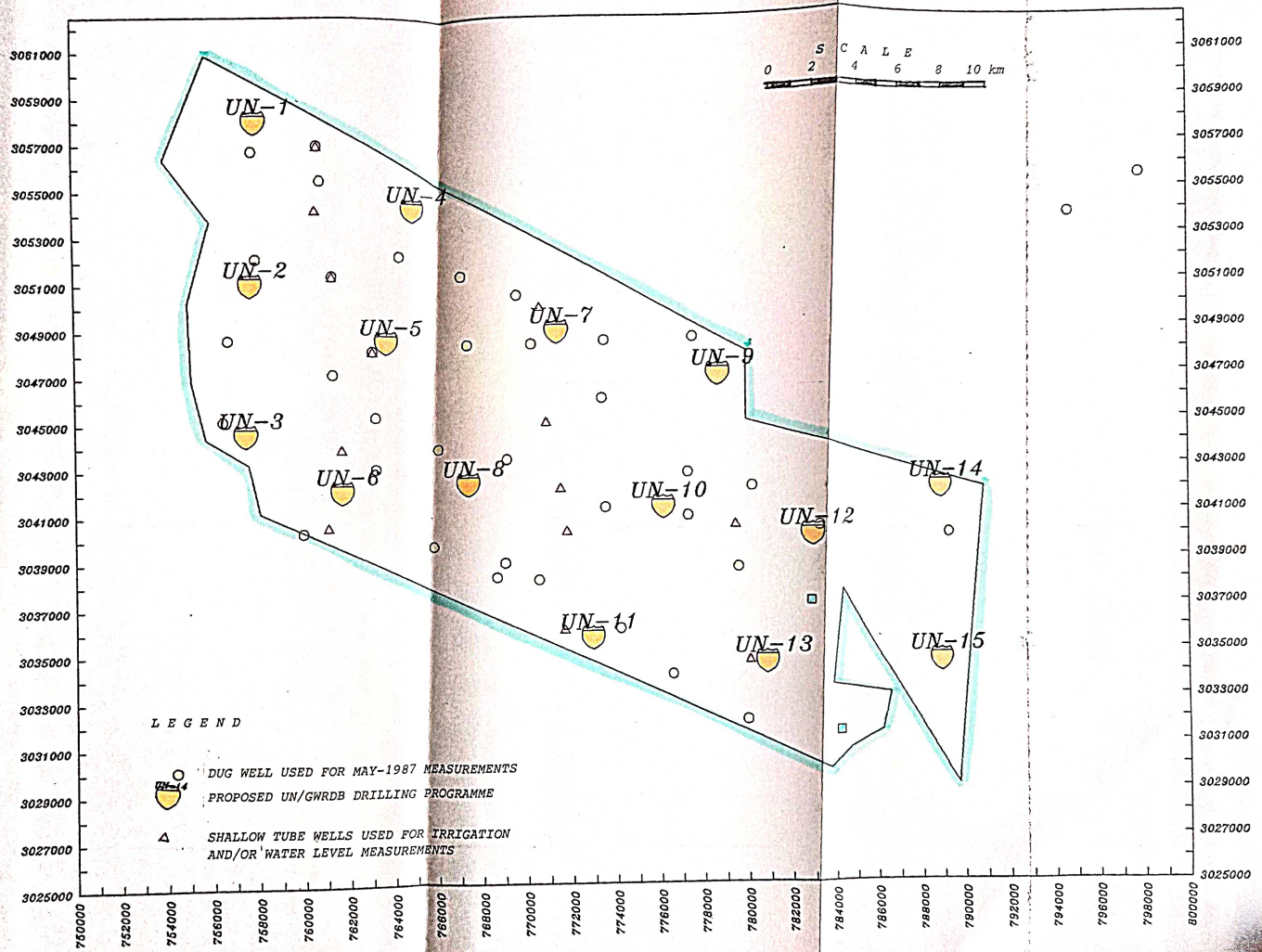
S - Shallow Aquifer
 D - Deep Aquifer

S1 Good WT less than 5 m	D1 Good Artesian
S2 Marginal WT less than 5 m	D2 Good pressure <10 m
S3 Good WT greater than 5 m	D3 Marginal Artesian
S4 Marginal WT greater than 5 m	D3+ Marginal pressure < 10 m
S0 Poor WT any	D4 Any pressure > 10 m
	D0 Poor pressure any

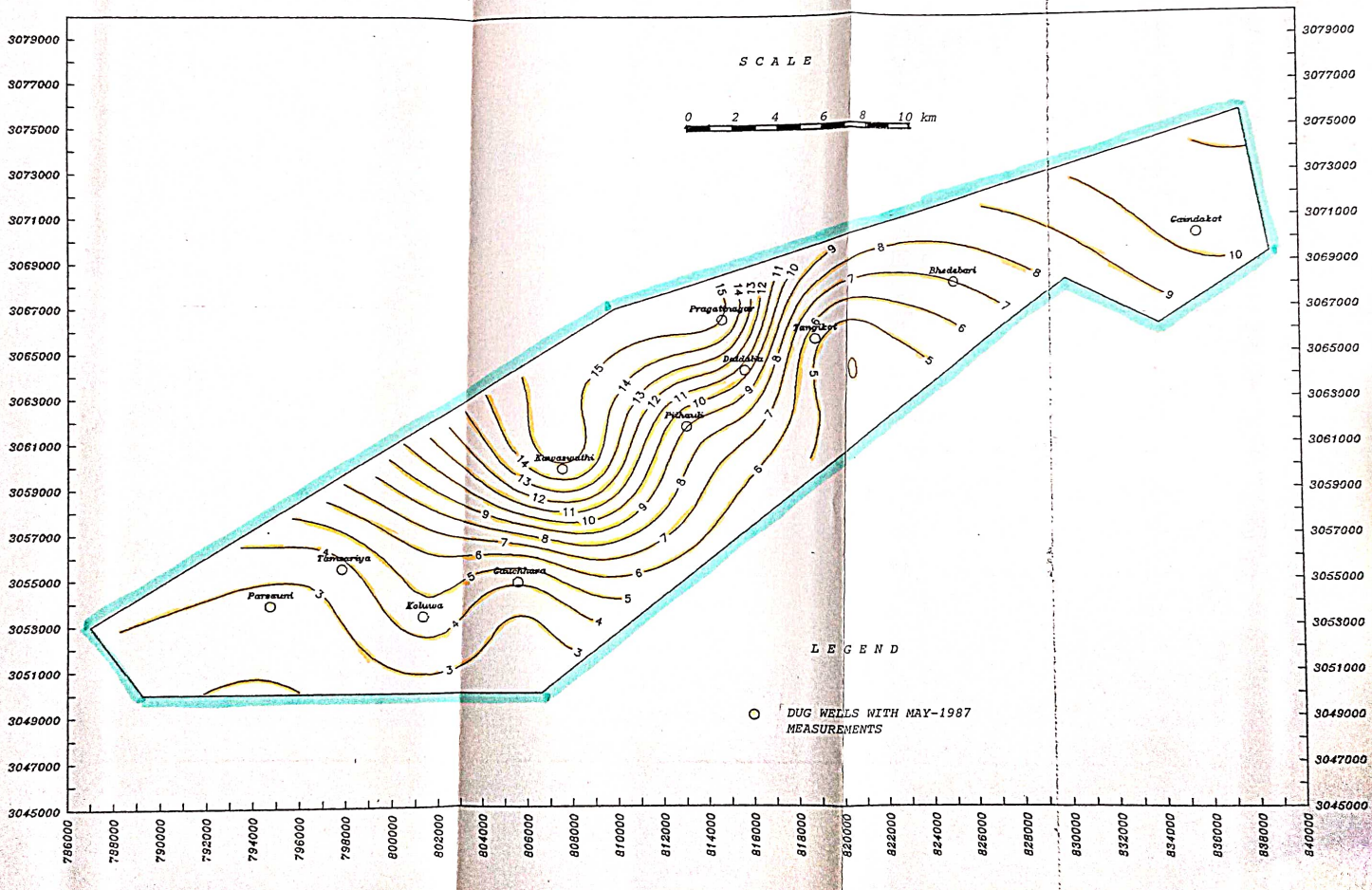
NAWALPARASI DISTRICT SW (TERAI) - DEPTH-TO-WATER IN MAY 1987



NAWALPARASI DISTRICT SW (TERAI) - PROPOSAL FOR DRILLING WELLS

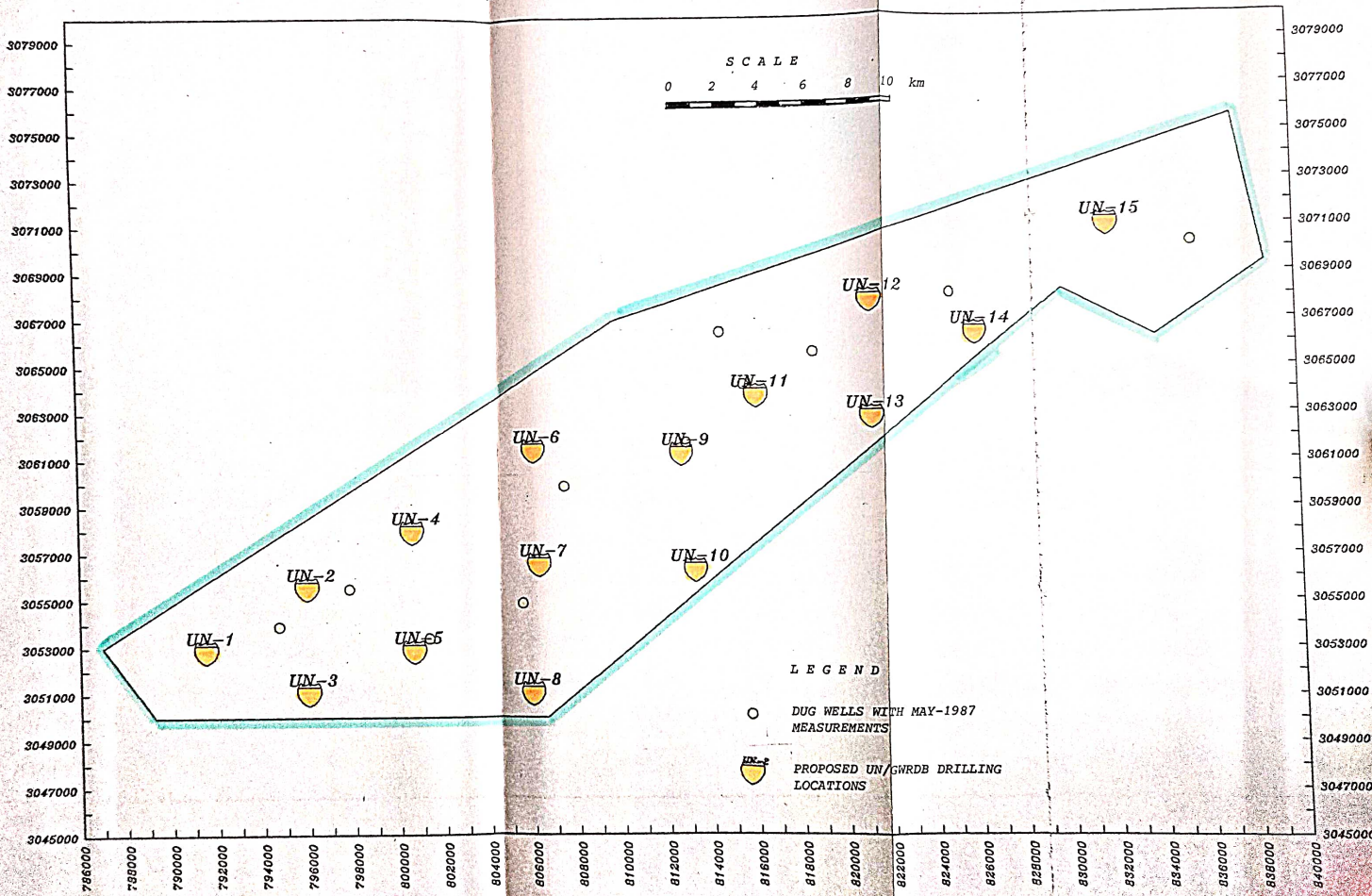


NAWALPARASI NE (TERAI) - DEPTH-TO-WATER IN MAY 1987

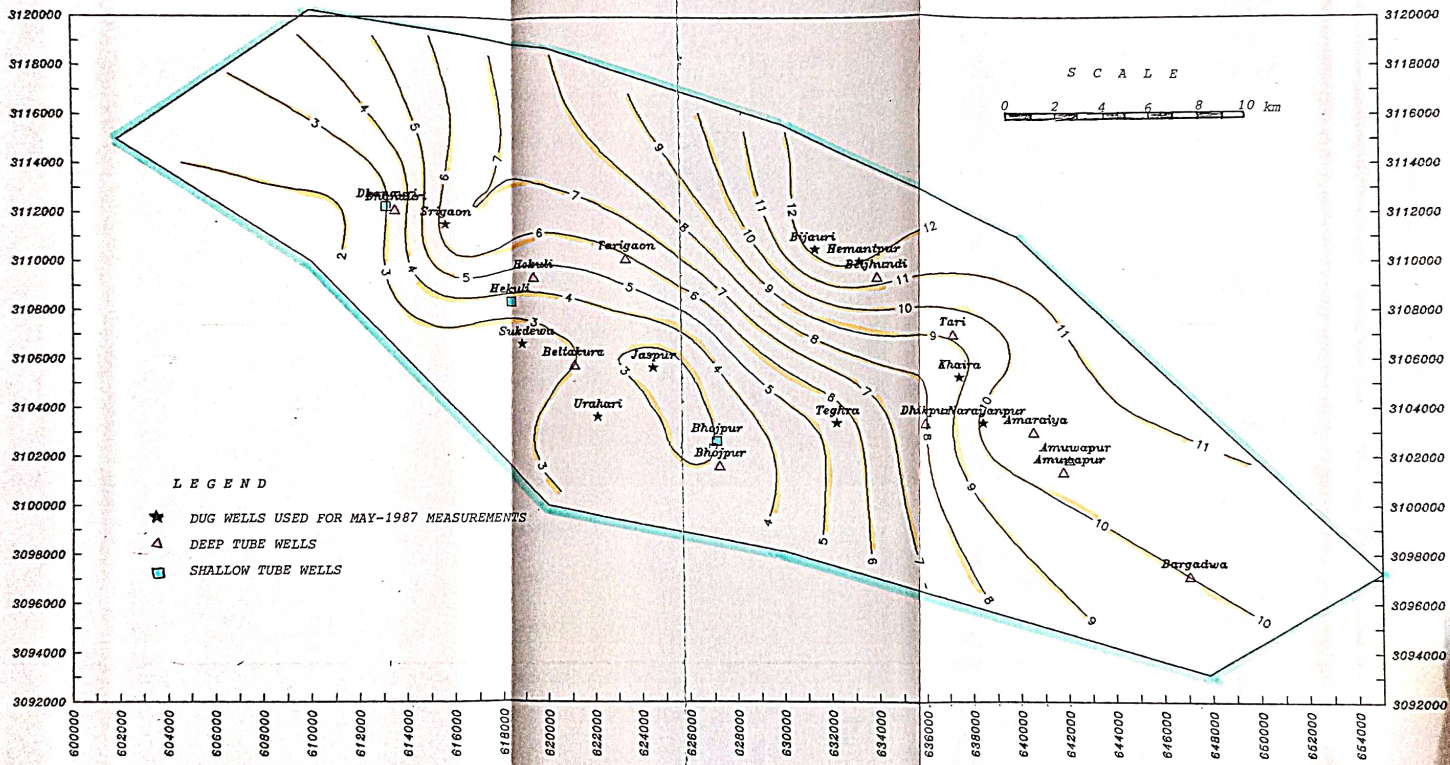


APPENDIX 11

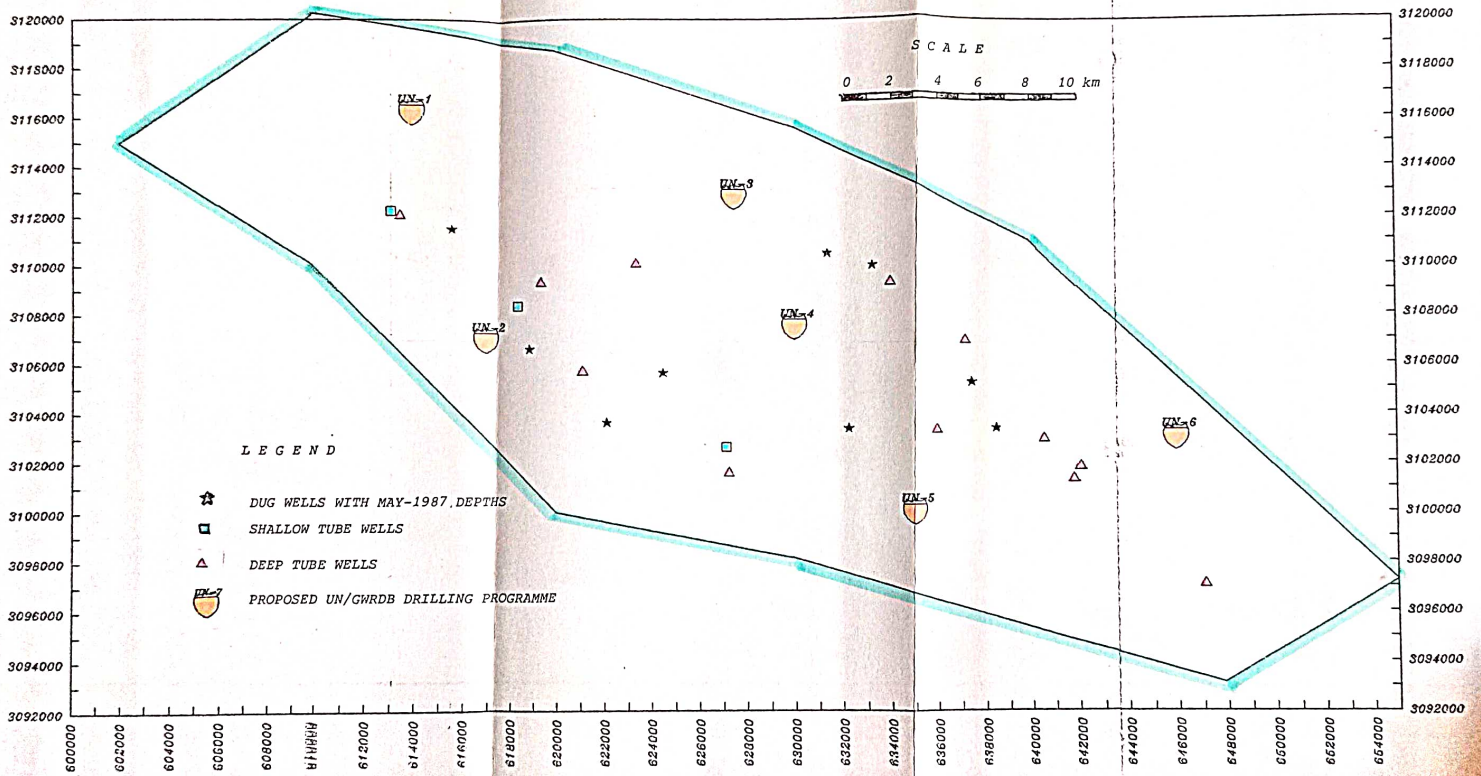
NAWALPARASI NE (TERAI) - PROPOSAL FOR DRILLING PROJECT WELLS



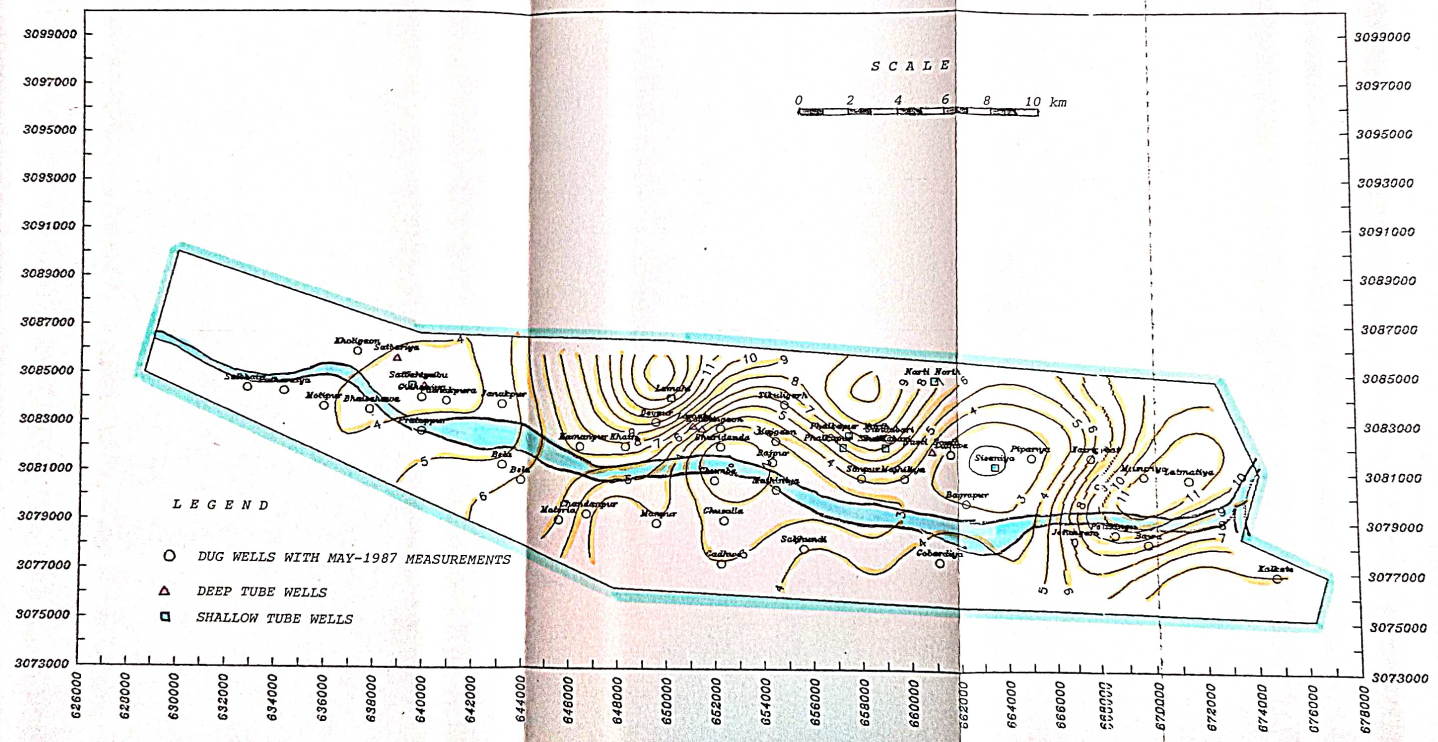
DANG INNER TERAI - DEPTH-TO-WATER IN MAY 1987



DANG INNER TERAI - PROPOSAL FOR DRILLING PROJECT WELLS



DEUKHURI INNER TERAJ - DEPTH-TO-WATER IN MAY 1987



DEUKHURI INNER TERAI - PROPOSAL FOR DRILLING PROJECT WELLS

