A STUDY ON THE WELL-LOSS OF BADC DEEP TUBEWELLS

BY

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In partial fulfilment of the requirements for the Degree of
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18 TH APRIL, 1994

CERTIFICATE

This is to certify that this work has been done by me and neither this project thesis nor any part thereof has been submitted elsewhere for the award of any degree or diploma.

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WE HEREBY RECOMMEND THAT THE PROJECT ENTITLED "A STUDY ON THE WELL LOSS OF BADC DEEP TUBEWELLS" PREPARED BY MD. ZAHIDUL ISLAM BE ACCEPTED AS FULFILLING THIS PART OF THE FULFILMENT FOR THE DEGREEE OF MASTER OF ENGINEERING (WATER RESOURCES)

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ABSTRACT

A study was undertaken to evaluate the extent of well-losses and to track-down the impact of the factors producing the loss. The step draw-down test data of five deep tubewells, constructed under the IDA-II DTW Projects of BADC, were used to determine the well-losses by Jacob-Rorabough method. The extent of impact of the factors on the well-losseswere foundout from the well-characteristics and the aquifer characteristics. These characteristics were determined from the data relating to the tubewell design, constructional details, bore-logs, testing and development records which were collected from BADC. Excessive length of the well-string, arrangement of well components, greater length of the lower well-casing (LWC), placing of strainer at different locations were found to be some of the reasons for the higher well-losses.

It appears from the study that an optimum level of well-loss could be maintained by (i) providing the optimum length of the well-string having properly designed well-screen, (ii) placing the strainers properly at a stretch in a single location, (iii) providing the diameter of the LWC larger than the screens, and (iv) ensuring proper attention to the other factors.

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The Author

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ABBREVIATIONS AND ACRONYMS

BADC	Bangladesh Agricultural Development
DTW	Deep Tube-Well
STW	Shallow Tube-Well
HTW	Hand Tube Well
MPO	Master Plan Organisation
MIT	Massachusetts Institute of Technology
O & M	Operation and Maintenance
ADB	Assian Development Bank
UNDP	United Nations Development Programme
GRP	Glassfibre Reinforced Plastic
NWRDP	North West Rural Development Programme
SFD	Saudi Fund for Development
SSISP	Small Scale Irrigation Sector Project.
IDA	International Development Association
BIADP	Barind Integrated Area Development Project
TCCA	Thana Central Co-operative Association
KSS	Krishak Shamobay Samity
CAD	Command Area Development
CS	Coarse Sand
MS	Medium Sand

FS	Fine Sand
VFS	Very Fine Sand
EC	Electrical Conductivity
PPM	Parts Per Million
UWC	Upper Well Cassing
LWC	Lower Well Casing
SS	Stainless Steel
MS/FS	MS greater than 75% of the sample
MMP	Sir M MacDonald & Partners Ltd.
HTS	Hunting Technical Services Ltd.
ODA	Overseas Development Administration
EPC	Engineering and Planning Consultants Ltd.
PHE	Public Health Engineering
BWDB	Bangladesh Water Development Board
WASA	Water and Sewerage Authority
WJ	Water Jet
RC	Reverse Circulatory
KTCCA	Kotwali Thana Central Co-operative Association
MOSTI	Manually Operated STW Used for Irrigation.

CHAPTER - I

INTRODUCTION

1.1. GENERAL

Bangladesh is a deltaic country and is blessed with vast ground water resources underlying most part of the country. It is also endowed with a huge area of fertile alluvial soils and a plenty of annual rainfall. The average precipitation is estimated to be about 225 cm per year. The temperature and sun-shine favour intensive cultivation and multiple croppings throughout the year. But the intensification is constrained by the fact that about 90% of the total rainfall falls during the monsoon period (May to Sept) and very little rainfall during the dry season (October to April). As a result, during the dry period when the surface water supply is limited, rapid increase in demand for irrigation from groundwater source becomes inevitable.

This necessity initiated the development of the groundwater resources of our country. In the late 1960's attention was focussed to the development of the country's groundwater resources for irrigation. The Second Five Year Plan (1981-85) placed heavy emphasis on the expansion of tubewell irrigation with five time increase in investment in groundwater development over the First Five Year Plan. Under the Third Five Year Plan, irrigation from groundwater was expected to cover 2.26 million hectares but actually contributed to about 1.81 million hectares (Planning Commission: 1990). Master Plan Organization (MPO) estimated the available groundwater potential for use upto the end of Fourth Five Year (1990-95) Plan as 15,460 M_m^3, out of which about 9,000 M_m^3 have already been developed (by operating about 25,000 DTWS, 2,20,000 STWS 3,52,000 HTWS) up to

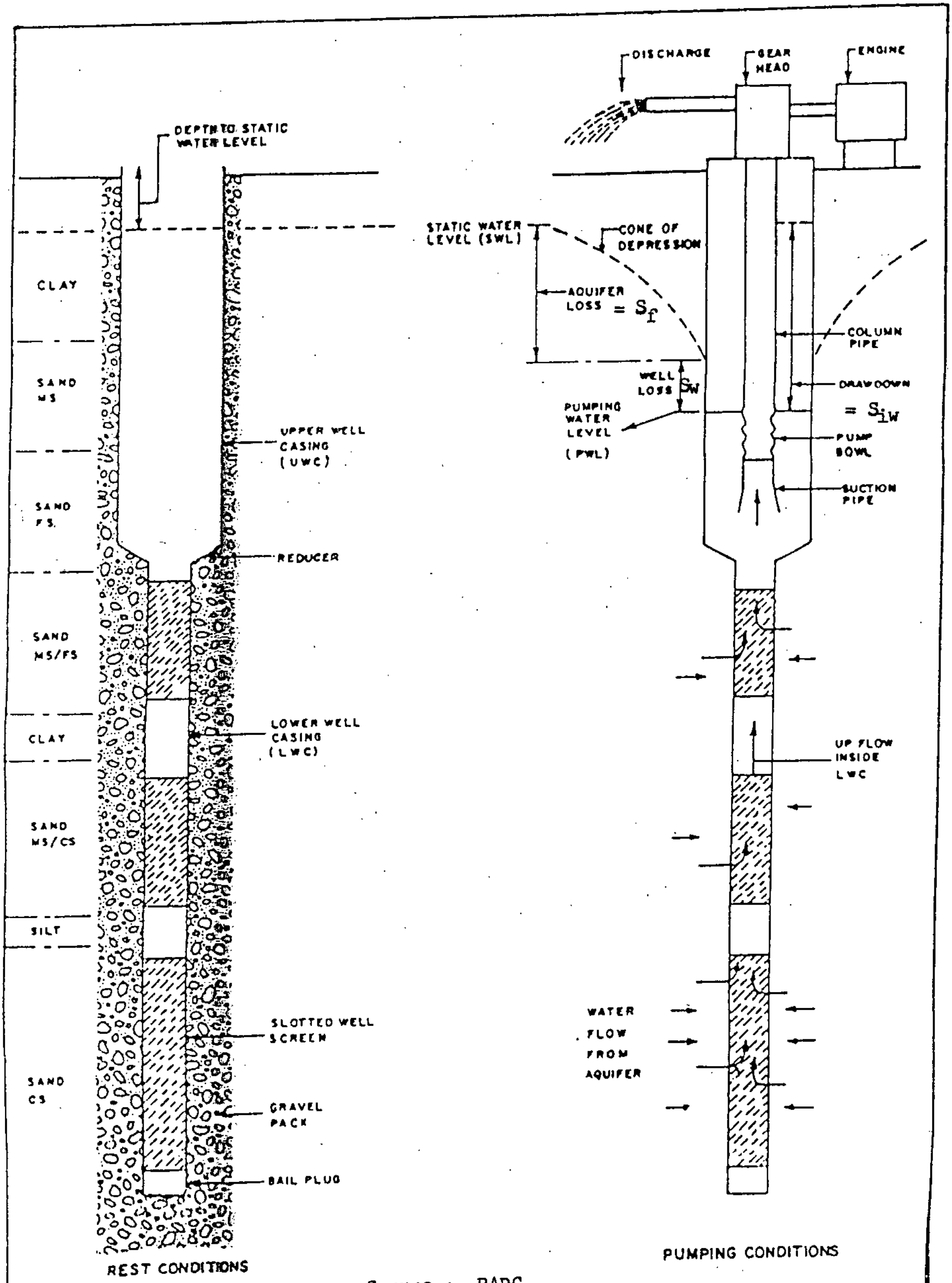
June 1992. MPO further recommends to develop the remaining groundwater potentials of about 7000 Mm^3 during the Fourth Five Year Plan by installing about 1,33,000 STWS, & 25,000 DTWS more throughout the country . MPO also recommends that "the efficiency of the tubewells should have to be increased". This has been made considering the 'resource - constraints' and the escalation of the cost of " energy and irrigation equipments" day by day. The cost of pumping water,in the recent days, has risen sharply not only because the cost of "energy & equipments" have increased, but also because the declining water tables in some major aquifers caused a higher "lift-requirements". As a result, the improvement of 'Well-efficiency'by minimising the " total lift - requirement" was considered as an important(Well-construction) aspect.

Bangladesh Agricultural Development Corporation (BADC) was entrusted with the responsibilities of sinking Deep Tubewells (DTW) for irrigation throughout the country. Since 1967-68 BADC has so far sunk 35,422 DTWs and Commissioned 33,658 DTWs. Out of which 29,462 DTWs are now in operation and an area of about 17,67,720 acres of land has been brought under irrigation(June 1992). BADC DTWs are usually designed for 2 - cusec capacity. But in some special cases 1.2 to 1.5 cusec capacity DTWs are also constructed. These DTWs are mainly commissioned with the prime movers-Engines/Electric motors (the horse-power of which ranges from 20 to 44 hp) and the turbine pumps (the total head of which ranges from 50' to 100ft. head). The cost of commissioning materials ranges from Tk.99,588/- to 3,08,385/-(June/1992). The selection of these pumps and the primemovers mainly depends on the discharge,static-water levels,pumping water levels and draw-downs. The draw-down is the major controlling factor which influences the selection of the pumps and the prime-mover. The draw-down is the summation of aquifer-loss and well-loss as shown in figure 1.1. The aquifer-loss occur due to the laminar flow of water through the aquifer, and the well-loss is the total head-loss due to the flow through the gravel-envelope or developed zone out-side the well-casing and through the screen or openings in the casing as well as the flow inside the well to the pump intake. The aquifer loss can be minimized through a carefull selection of the formation materials, and the well loss can be minimized with the proper design, construction, and development of the wells. For a certain aquifer condition if the well loss is minimum then the drawdown will be less, and consequently the efficiency of the well will also be increased.

Low drawdowns are always desirable as less fuel is required to pump the water. Savings can also be made on the well construction materials. A DTW having less drawdown requires low-powered prime-movers and low-head pumps, and thus the capital cost and the operating costs also become low. The actual cost of BADC DTWs ranges from Tk. 3,33,588/- to Tk. 7,18,385/- (June 1992) depending on the various types of the prime-movers, pumps, tubewell materials and drilling costs. The average cost of one DTW is about 6.5 lac taka and the cost of irrigation per acre is about Tk. 4,155/-.

It has been observed in our country that though the hydrogeologic conditions and aquifer characteristics vary widely from place to place, BADC DTWS are constructed with the same design and specifications for screen, gravel pack and well development. These DTWs

COMPONENTS OF A TYPICAL TUBEWELL



Source : BADC

are being commissioned with the prime-movers & the pumps which are instantly available at hand (in some cases) without considering the technical & economical suitabilites. Interests have been shown only to the maximum volume of water delivered from the well, ignoring the additional costs (capital and O & M) involved due to improper construction of the well. Moreover, there is no monitoring and feedback control of post-constructional performance of the well. As a result, a large number of BADC DTWs are functioning at low-efficiency level incurring a very high cost of construction and operation.

Under the above circumstances, efforts had been made to evaluate the well-loss of some BADC Deep Tubewells and to recommend specific measures to minimise the "total lift-requirements" of the DTWs,keeping the " aquifer-loss and the well loss to an optimum-level so that the total cost(Capital and O & M) of the DTW having proper efficiency become less.

1.2 OBJECTIVES OF THE STUDY :

The objectives of the study are :

(i) To evaluate the well-loss of the BADC deep tubewells;

(ii) To indentify the factors affecting the well-loss;

(iii) To recommend appropriate measures for minimising the well-loss and thereby improve the efficiency of the well.

CHAPTER - II

REVIEW OF LITERATURE

The well-loss phenomenon is associated with the well-characteristics as well as with the aquifer characteristics. In order to facilitate the understandings of this phenomenon the relevant topics are incorporated in this chapter. In our country very little studies have been made on the well-losses of the DTWS. It was observed that some sporadic studies were made in few areas in collaboration with the foreign funding agencies. The available reference studies are cited below to enrich the present studies.

2.1. DEEP TUBEWELL TECHNOLOGY :

A water-well is a hydraulic hole, usually vertical, excavated in the earth for bringing groundwater to the surface. A tubewell is a hydraulic structure which, when properly designed and constructed, permits the economic withdrawal of water from a water-bearing formation.

According to GOB (1985). "Groundwater Management Ordinance-1985" :

Deep Tubewell (DTW) :

Means a tubewell called as such operated by a submersible pump-set or turbine pump coupled with a prime mover capable of pumping ground water when the pumped water level depth is more than 7 meters.

Typical deep tubewells commissioned with diesel engine and electrical motor shown in fig. 2.1 and fig. 2.2 respectively.

2.1.1 COMPONENTS OF A DEEP TUBEWELL AND THEIR FUNCTIONS :

Different parts of a deep tubewell and their functions summerised below :

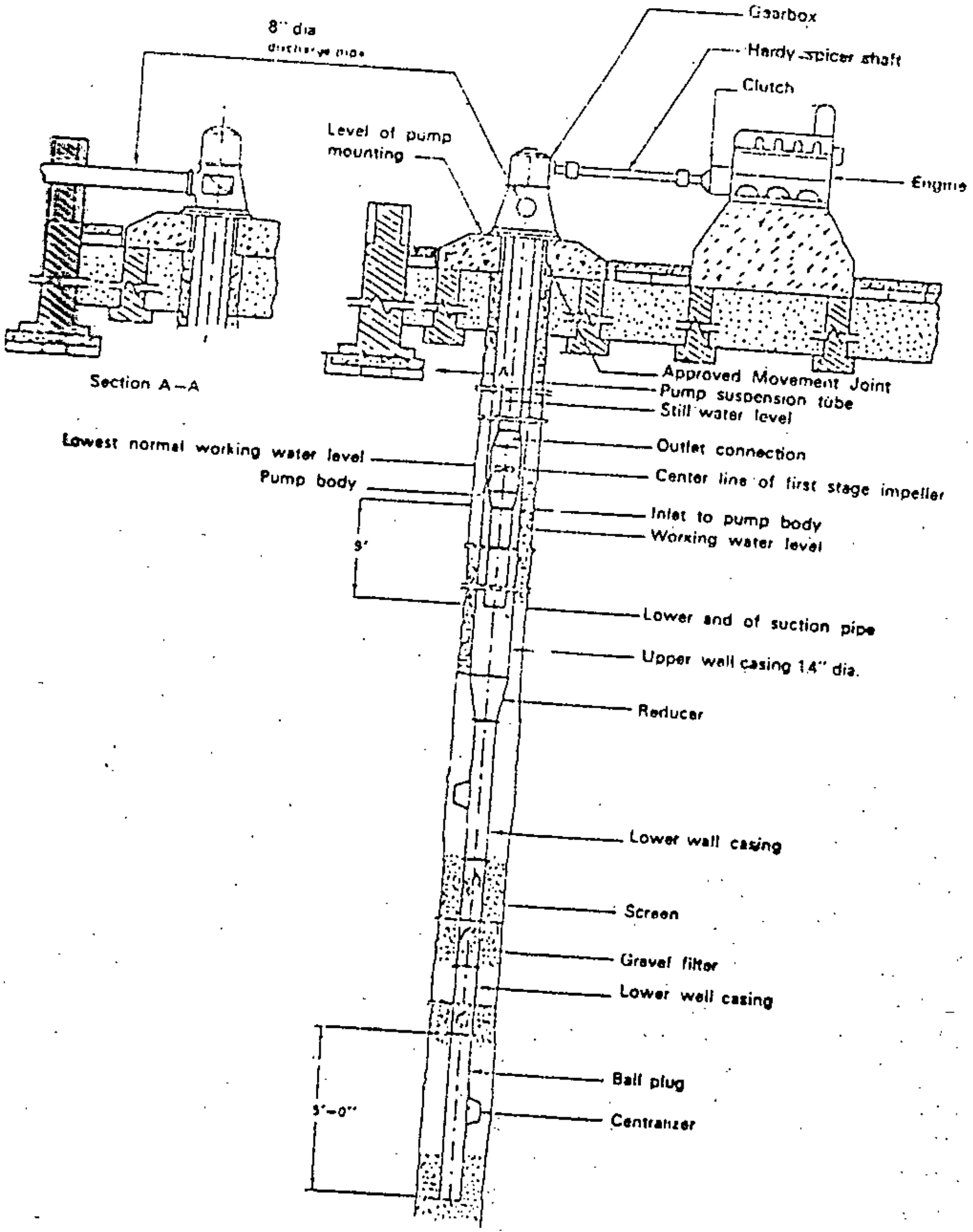
Part	Function	Typical material made of
1. Delivery pipe	It is water conductor from pump to the water course which carries water to the field	G.I.
2. Pump	To lift the water by creating a strong vacuum head under which the water rushes at a high velocity through the strainer into well pipe and further into the delivery pipe.	Steel
3. Motor/Engine	To run the pump.	Steel
4. Housing pipe	It is the upper portion of casing pipe to accommodate the pump.	Steel

Part	Function	Typical material made of
5. Casing	To support the hole temporarily during drilling(in cable-tool method) and subsequently removed or installed afterwards to complete the well assembly.	M.S/G.I.
6. Blind pipe	Serves as a conduit to carry further the water that has entered into the Screen. It is put in the thickness of the impermeable stratum.	M.S/G.I.
7. Strainer	To permit sand-free water entry into the well freely and to support the loose formation materials in unconsolidated formations. It consists of very fine mesh surrounding a slotted or perforated pipe or wire-wound	M.S/G.I. Stainless Steel bronze copper.
8. Bail plug	To close the bottom-most end of the well so that no water enters from the bottom as also to house any sand which has found entry into the well during installation	

Part	Function	Typical material made of
	of well assembly or development for ultimate removal through the water to the surface.	M.S.
9. Impeller	The rotating element producing head. It receives water and impels it to bowel passage. It may be enclosed or semi-enclosed type.	Bronze, Cast iron
10. Air Line	A thin tube installed alongside the pump and submerged in water for the purpose of finding the water level.	Steel galvanised steel or Copper
11. Depth gauge.	It is an instrument for indicating water level. It may be direct or indirect reading type.	Steel

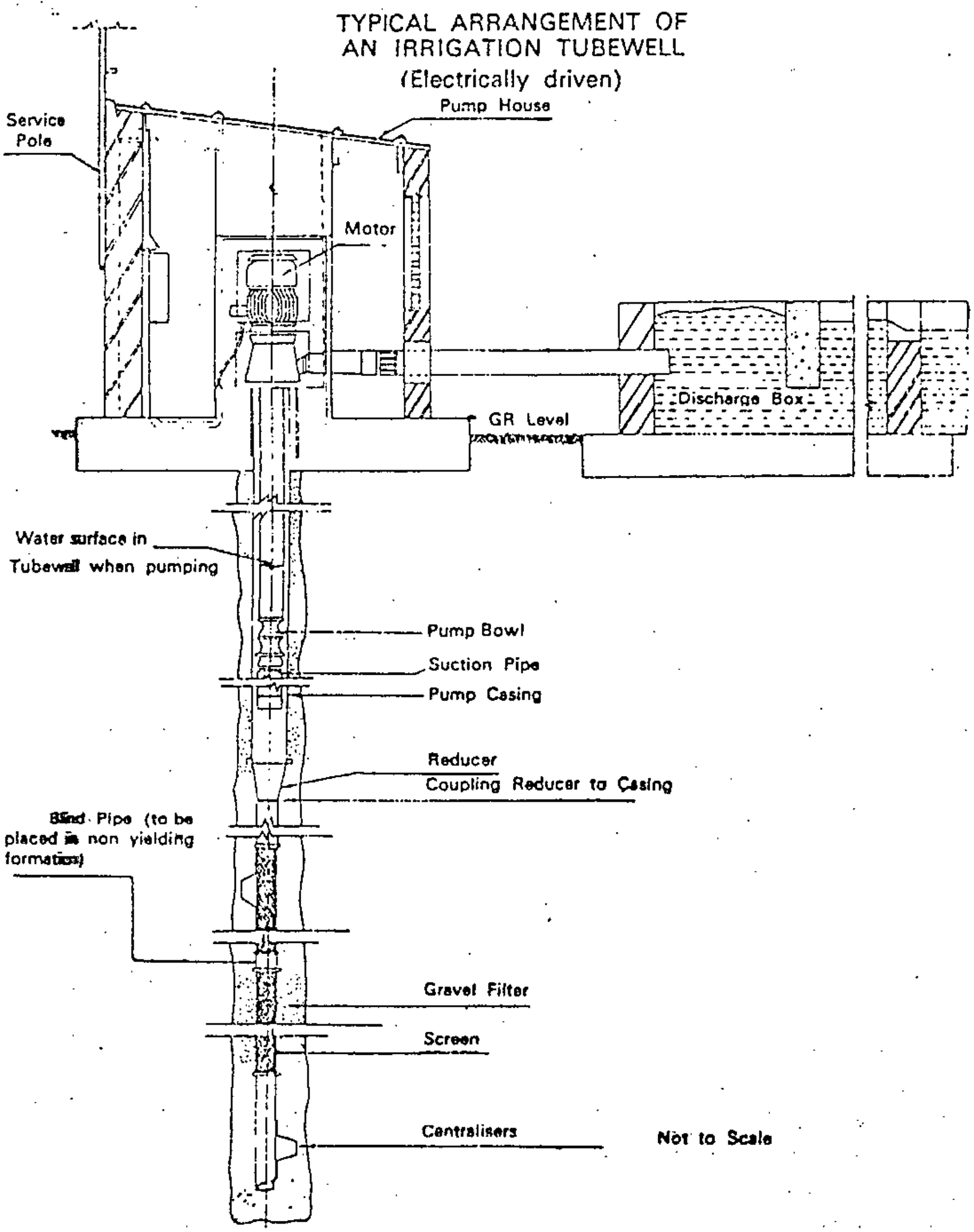
FIG. 2.1

BANGLADESH DEEP TUBEWELLS PROJECT
TYPICAL WELL SECTION
(DIESEL POWERED)



Source : Asaduzzaman, M. (1985). Handbook of Ground Water and Wells.

FIG. 2.2



Source : Asaduzzaman, M. (1985). Handbook of Ground Water and Wells.

2.1.2 Principles of Design and construction of a Deep tubewell

Deep-tubewell design is a progressive process that begins with the need for a well and culminates in the completion and development of a constructed well. Deep Tubewell design involves four steps:

(i) Preliminary design

(ii) Construction

(iii) Final design, and

(iv) Completion and development

Wells are tested immediately after completion to determine initial well performance and pump selection.

(i) Preliminary design :

The initial step in well design involves defining the water requirements, exploration and site selection, preliminary determination of well depth and diameter, cost estimating and bidding, and construction and evaluation of a test hole or pilot hole.

(a) Water Requirements:

The initial determinants in well design are the specific water needs, rate of flow or design capacity, location of delivery and quality of water.

(b) Exploration and site selection :

Many sources of information and several methods can be used to find usable groundwater and to determine the best location for well. Some commonly used information includes topographic maps, logs of existing water or other types of wells, geologic studies, water-level and water-quality records, and test-hole drilling with associated sampling and evaluation techniques. Other techniques, used less commonly in siting individual wells, include surface electrical-resistivity investigations, seismic-refraction studies, aerial photography, and remote sensing. The last two techniques are large in scope and usually beyond economic justification for water wells.

When searching for an optimal well site in an area of known ground water occurrence, well logs usually provide excellent information on the composition and extent of subsurface materials. Other excellent sources of information, which are often based on well-logs , are geologic and hydrogeologic studies, Cross-sections of aquifers, confining beds, and other materials can be delineated such sources and used to identify the occurrence of aquifers.

Other factors affecting specific site selection include (1) accessibility for drilling and service equipment: (2) unfavorable topography, such as low spots that can accumulate surface drainage and contaminate well through leakage; (3) location of nearby wells; and (4) local ordinances or regulations that may limit the proximity of a well to certain other facilities, its depth, completion interval, design rate, or other design parameters.

(c) Preliminary well depth and diameter :

The information used in site selection may also help to determine drilling depth. Estimates of aquifer thickness, transmissivity, areal extent, depth and fluctuations in water level, and water quality will help to establish a preliminary target for well depth and diameter.

(d) Cost estimating, bidding, and contracts :

Before drilling a well, it may be useful to consult with one or more reputable contractors for valuable practical information that can be used in estimating the depth and diameter of a well as well as its cost. In addition, specific cost estimates or bids may be highly desirable.

A contract should include (1) the responsibilities and liabilities of all parties; (2) any guarantees or warranties for well performance, water quality, or equipment; and (3) the method of payment.

(e) Test or pilot hole :

At test or pilot hole explores the composition and depth of the materials at a particular site. Samples and information are gathered continuously to provide the depth and composition of each layer (recorded in the driller's log), the drilling rate, and samples of each material penetrated. When certain drilling techniques are employed, or if specialized equipment is utilized, samples of water can be taken from thetest hole for analysis and tentative determination of groundwater quality.

(ii) Construction :

Construction begins with drilling the test hole and continues through final design, well completion, and development . Understanding well construction methods is essential to achieve proper well contruction at the least cost for a given design capacity and particular drilling conditions.

(a) Drilling Technique :

There are several drilling methods, the more common of which include cable-tool percussion,Hydraulic Rotary or Water Jet & Reverse circulatory method. The advantages and disadvantages of each method must be carefully considered before the right method can be selected for a particular job.

(b) Formation Damage :

Every method of well construction damages the formations penetrated to some extent. The types of formation damage resulting from various methods of well construction include(1) compaction and the reduction of permeability in unconsolidated formations, resulting from the jarring action of tools and the driving of casings in cable-tool drilling; (2) sealing of the borehole face by viscous,drilling-fluid additives in hydraulic rotary drilling;and(3) pentration of fine sand and silt from the drilling fluid into porous materials during hydraulic rotary and reverse-circulation drilling.

(c) Plumbness and Alignment :

Important considerations in well construction are plumbness (verticality) and alignment (adherence of the borehole to a straight line). Of the two factors, alignment is the more important. In general a vertical-shaft-driven pump will operate properly in a well that has good alignment even if it is out of plumb. Submersible pumps can possibly be installed in wells where plumbness or alignment may limit the use of vertical shaft-driven pumps.

(iii) Final Design :

Information developed in the preliminary design phase, including the construction of a test or pilot hole basis for final design of the three components of a well: a pump-housing section, a vertical conduit (casing),and an intake (perforations or screen) section.

(a) Pump housing and vertical conduit :

The pump housing is the upper structural section (casing) of a well into which the pumping equipment will be lowered. The depth and diameter of the pump-housing section must be adequate to accommodate the appropriate pumping equipment over the life of the well. An optimal casing size in this section of the well will provide adequate clearance for the pump and minimal frictional losses, regardles of the type of pump required for the design capacity. The vertical conduit is the section of casing between the well screen and pump housing through which water travels from the intake (well screen or perforations) to the pump housing.

(b) Intake section :

A properly designed intake section ensures hydraulically efficient and sand-free performance . The intake section can be a well screen. Several types of well screens are available. The most common are the continuous-slot screen, the shaped-wire screen,the louvered screen,and the bridge-slot screen. The continuous-slot screen is manufactured by winding cold drawn, triangular-shaped wire around a series of rods. The hydraulic efficiency of a screen depends on the amount of uniform open area available per unit length of screen. The continuous-slot configuration provides significantly greater open area per given length and diameter. In addition to having a large intake area, the continuous-slot screen prevents sand particles from becoming clogged in the openings.

(1) Screen length :

An optimum screen length can be selected after considering the thickness and stratification of the aquifer, the anticipated water-level drawdown in the well,and amount of water required for the job.

(2) Screen slot opening :

In naturally developed wells, the size of the screen slot opening is based on the grain-size distribution. The design of screen slot openings in gravel-packed wells is coordinated with the design of the gravel pack itself.

(3) Screen diameter :

Screen diameter can be selected to satisfy one design principle- to provide sufficient open area that will maintain a desired entrance velocity through the screen. The screen diameter can be varied widely without significantly affecting well yield or specific capacity. Field experience has shown that an entrance velocity of less than 0.1 fps (0.03m/s) through screen openings will result in negligible friction losses and minimal transport of aquifer material and may result in lower rates of encrustation and corrosion, and this design parameter has been widely accepted.

(4) Transmitting capacity:

The transmitting capacity of a well screen is the amount of flow that will pass through the screen slots at a given entrance velocity. It is usually expressed in gallons per minute per foot (litres per metre) of screen length and is the hydraulic capacity of the screen itselt. It is not a measure of the yield or capacity of the aquifer. When aquifer grain size permits large slot openings, screens of smaller diameter may be selected to achieve some cost savings.

(5) Strength, corrosion, and encrustation :

All of these factors warrant consideration in screen design. Even small amounts of corrosion can result in excessive sand production, and encrustation can fill slot openings andresult in reduced transmitting capacity. Careful consideration should be given to proper material selection for particular groundwater conditions.

(6) Gravel pack :

Gravel packing offers the potential of increased screen slot size and open area, cost savings through installation of smaller diameter screen, and increased control over sand production. A gravel pack may allow larger slot sizes, with corresponding increased transmitting capacity while maintaining sand control.

(iv) Completion and development :

Completion of a well includes the installation of the casing and screen in the drilled hole, together with the gravel envelope,grout and other seals as needed. Well development cleans out and removes fine particles around the screen and improves flow into the well.

2.2 INSTALLATION OF DTWS BY BADC IN BANGLADESH

Deep Tubewells were first constructed in Bangladesh to supply fresh water in large quantities to major towns to meet thier domestic and industrial demands. It was in the early sixties that DTWS began to be installed for Irrigation. The first major tubewell project was under taken in the northwest part of the country between 1962 and 1965 by EPWAPDA (Now BWDB) with the assistance of German Government. Under this project 380 four-cusec (113 L/S) electrically operated wells were sunk. In a second pilot project implemented between 1962 and 1970 by KTCCA in east-central Bangladesh,211 two-cusec (57 l/s) diesel powered wells were sunk by using manual drilling techniques (Hanratty,1983). In 1967-68, BADC commenced Deep Tubewell project to install 105 DTWS in Northern districts under the GEC-Milnars project. In 1971,BADC started another IDA financed tubewell project to install 3000 DTWS in the Northwest and in association with Milnars company 5,000 DTWS in the Northeast (MacDonald, 1983). Since 1967-68 BADC has so far sunk 35,422 DTWS throughout the country under the various projects (Such as GEC-Milnars,IDA-I,IDA-II,NWRD,SFD,ADB,DTW phase-I,DTW phase-II, DTW phase-III,DTW phase-iv,BIADP etc).

2.2.1 HYDROGEOLOGIC CONDITIONS OF BANGLADESH

Bangladesh is almost entirely an alluvial,deltaic plain with hills on the northeast, east and southeast margins. Within the alluvial plain there are several slightly elevated areas of older alluvium referred to as terrace areas. The miocene pleistocene and Holocene sediments have been divided into upper and lower aquifer sequences on the basis of differing hydrogeological characteristics. The upper aquifer sequence is a heterogeneous assemblage of sands, silts and clays all essentially in hydraulic continuity. This upper aquifer has three subdivisions:

(a) THE UPPER SILTY CLAY :

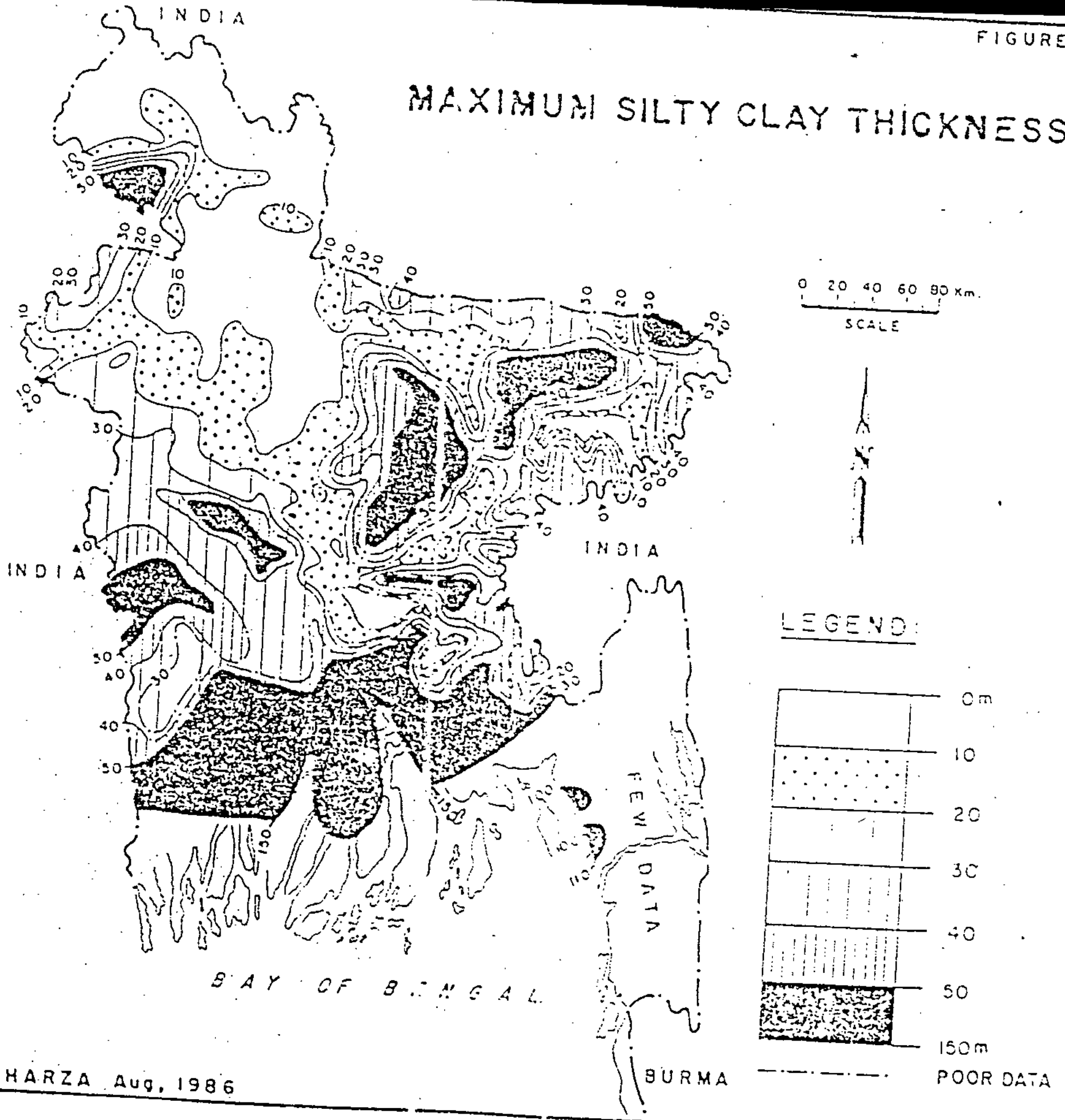
The silty clay cover increases in thickness southwards and towards the northeast from less than 2m in Dinajpur and Rangpur areas to in excess of 100m (as shown in fig. 2.3).Localised thickness is associated with the older alluvium of the Madhupur Tract north of Dhaka, The Lalmai Hills of Comilla, and the High Barind of Rajshahi. The clay composition is highly variable, ranging from heavy to silty clay or clay and sand. Windows of silt or sand occur where rivers have eroded the clay or clay deposits absent.

(b) COMPOSITE AQUIFER :

The top of the aquifer unit, composed primarily of very fine to fine sand is the composite aquifer. It varies in thickness from about 3m in the N/NW to 60m in S/SE part of the country (fig.2.4). Although it is a good aquifer, its irrigation development potential is poor because its sands are too fine for slotted well screens and high discharge rate wells. However it is used as a source of supply for HTWS and MOSTIS.

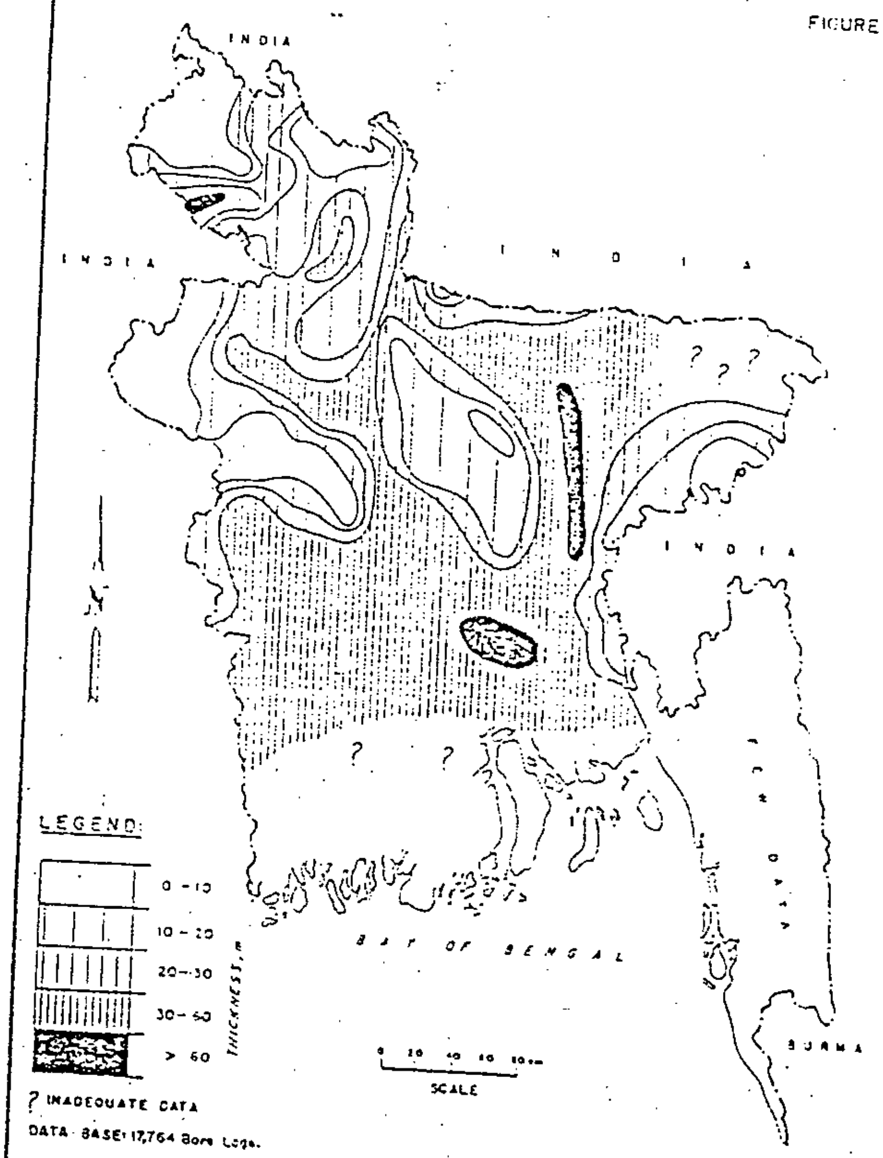
FIGURE 2.3

MAXIMUM SILTY CLAY THICKNESS



MPO/HARZA Aug, 1986

FIGURE 2.4



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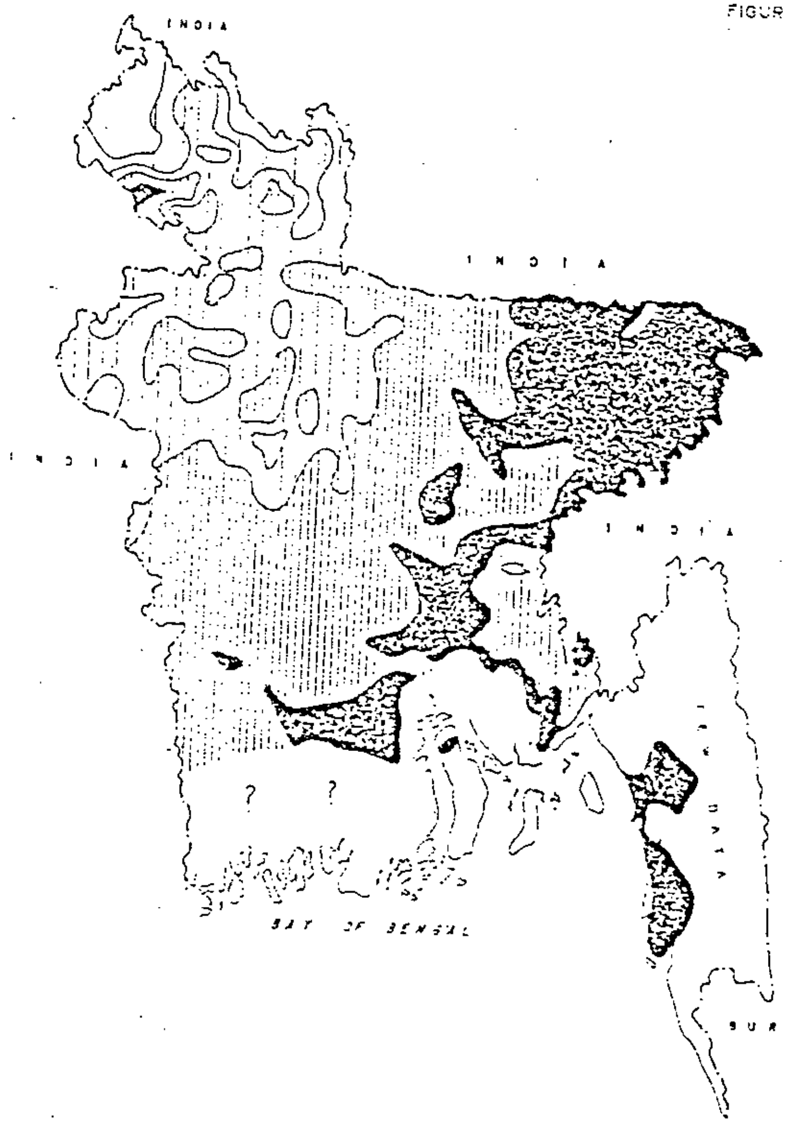
COMPOSITE AQUIFER THICKNESS

FIGURE 2.5



MAXIMUM DEPTH TO THE
TOP OF THE MAIN AQUIFER

(c) MAIN AQUIFER :

Below the composite aquifer is a series of medium to coarse grained sands containing gravel layers with interbedded clay lenses called the main aquifer, Coarse gravel and cobbles occur in the north and northwest and finer grained materials to the south. This aquifer may be reached at depths between 6 and 120m depending on the thickness of the overlying composite aquifer and upper silty clay (fig. 2.5). The coarser grained structure of this aquifer is suitable for large scale groundwater development with screened wells. Most tubewells within the main aquifer, except in Dhaka and the coastal area, are less than 150m deep.

Figure 2.6 shows a typical cross-section of the upper part of the groundwater reservoir. The composite aquifer and main aquifer form one hydraulically interconnected aquifer. Wells placed in either aquifer withdraw water from a common source.

GROUNDWATER OCCURRENCE :

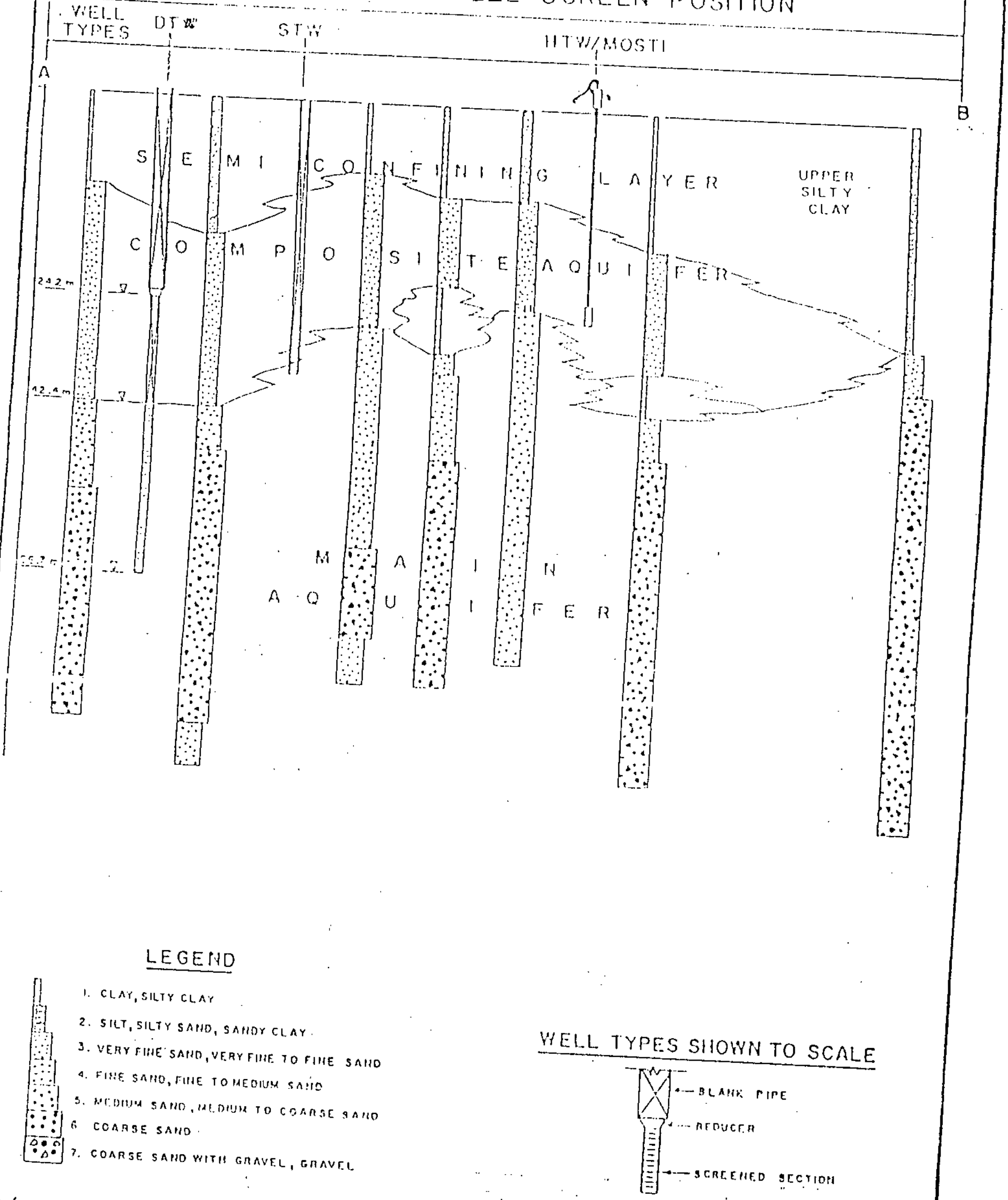
Aquifers suitable for pumping occur in most of Bangladesh. There are two major exceptions:

(1) The area south of a line stretching from Jessore to comilla where groundwater is saline, and

(2) The Eastern and Northern Hill areas, together with adjacent groundwater is eratic (Khan, 1982).In Sylhet the rocky formations in Chattak area and artesian resources encountered during drilling in Habiganj and Moulvi Bazar and occurrence of highly sticky clay in some areas make the sinking of wells quite difficult.

TYPICAL GEOLOGICAL CROSS SECTION SHOWING TUBEWELL SCREEN POSITION

FIGURE 2.6



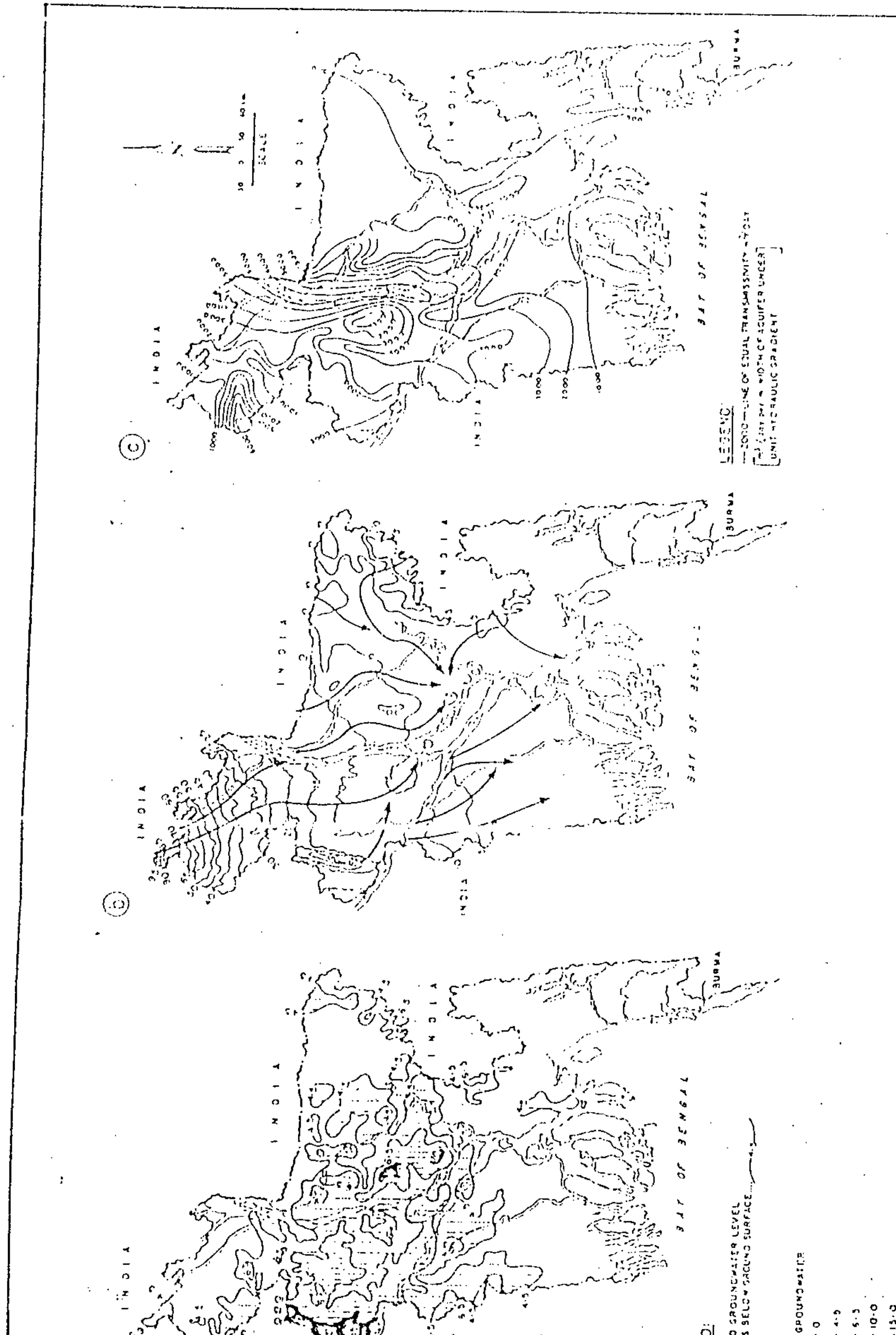
MPO/HARZA July 1986

Except in the Chittagong Hill Tracts, Rajshahi High Barind and the Madhupur Tracts north of Dhaka, groundwater occurs at shallow depth, and groundwater levels are at or near ground level during the period July-October. Flowing artesian wells occur on the coastal plain. The lowest seasonal groundwater levels (April-May) range from three meters below surface in the north to more than 15m in the area of largest groundwater withdrawal northwest of Dhaka district and in Dhaka City. Figure 2.7a shows the depth to groundwater during period of lowest annual level.

The principal shollow aquifers in Bangladesh generally lie within 100m of the surface under a cover of clay that gernerally increases in thickness southward to more than 50m from less than 2m in Dinajpur and Rangpur districts. Deep aquifers are present in much of Bangladesh but occur at depths of 300m or more (BWDB, 1982). It is the shallow aquifer system which has been of interest for groundwater development in the country. These aquifers generally have excellent water storage and transmission properties but their development is constrained by the overlying clay, except where it is thin or absent as in the northern districts, Fig 2.8 shows variations of surface clay layer over the country.

Most tubewells within the country, except in Dhaka and the coastal area, are less than 135m (450 ft.) deep. The top of the aquifer unit is composed primarily of very fine sand to fine sand, sometimes medium sands, with occassional clay layers. This forms the uppermost waterbearing formation often referred to as a composite aquifer. Although it is a good aquifer, because of fine

FIG- 2.7



DEPTH TO GROUNDWATER LEVEL

(April 1983)

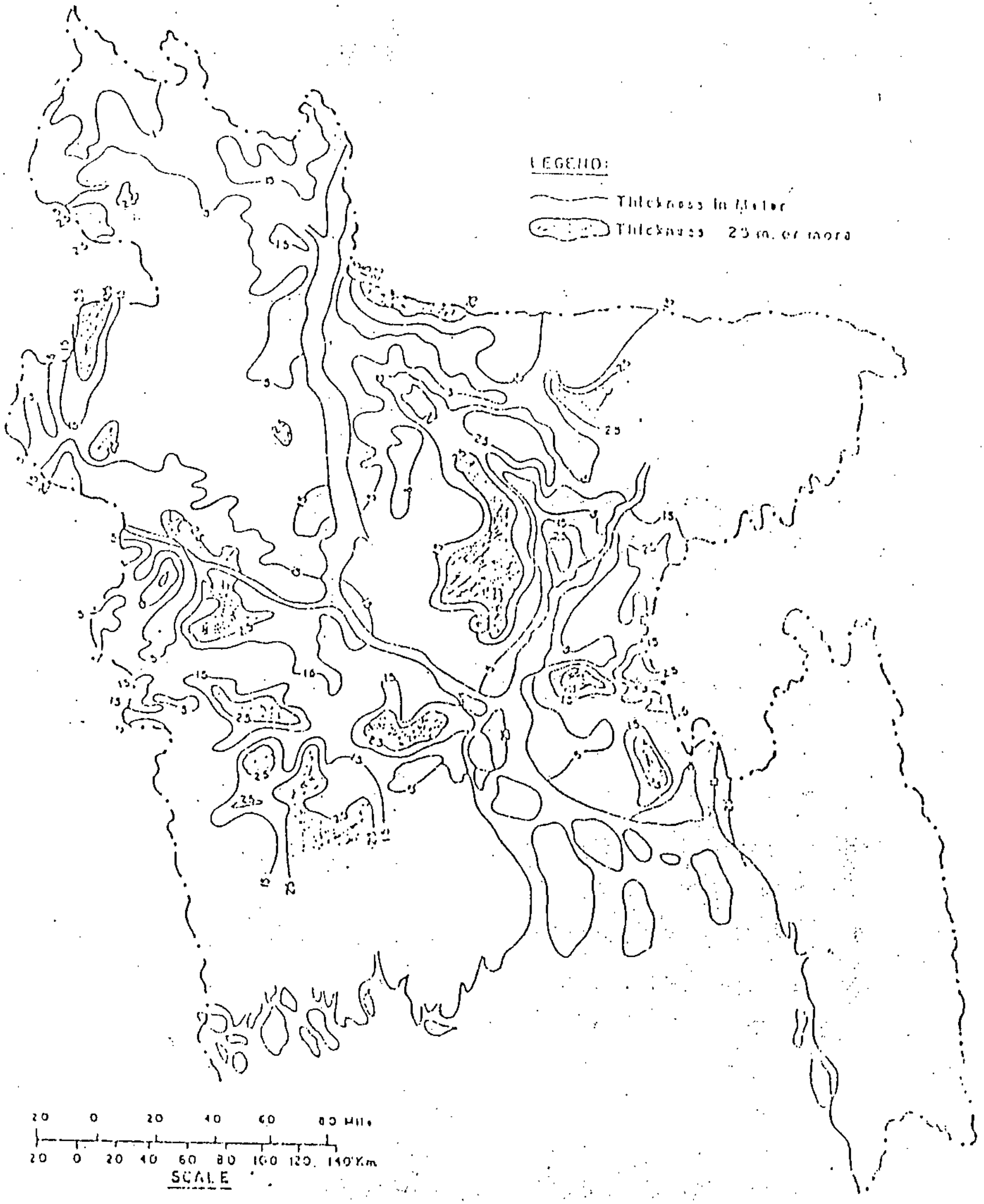
POTENTIOMETRIC SURFACE (WATERTABLE)
MINIMUM ELEVATION APRIL 1983
DATUM MEAN SEA LEVEL (BWDB)

TRANSMISSIVITY OF MAIN ACUIFER

MPO/HARZ July, 1985

FIG. 2.8

THICKNESS OF UPPER CLAY AND SILT



SOURCE: BWDB/UNDTCD: The Hydrogeological Condition of Bangladesh, 1982 sediments it is not suitable for development by large diameter wells of high design discharge considering the constraints on the selection of proper screen size. This aquifer unit, however, can be successfully tapped by low discharge HTWS and STWS.

The main aquifer unit lies below the fine sand aquifer, consists of a series of medium to coarse grained sands containing gravel layers and clay lenses, The thickness of this main aquifer is highly variable may be encountered at depths varying from about 6m to 120m depending on the thickness of the overlying fine sand aquifer and upper surface clay layer. Due to the coarse grain structure this aquifer is highly suitable for groundwater abstruction by screened and gravel packed wells of higher design discharge.

GROUNDWATER MOVEMENT :

The regional groundwater flow in the main aquifer is generally toward the major rivers and the Bay of Bengal. Groundwater gradients vary from 1:1000 in the NW to 1:13000 in the Central Bangladesh and to less than 1:20,000 in the coastal area (fig.2.7b). Groundwater movement to and from rivers is locally important but small compared with the vertical recharge from rainfall and flooding during the rainy season.

The hydraulic conductivity of the composite aquifers ranges from 0.003 to 28.3 m/day whereas that for the main aquifer system ranges from 10 m/day in Sylhet districts to as high as 200 m/ day in Rangpur districts. The transmissivity values obtained from pumping test data range from as low as 100 sq.m/day at the foothills of Chittagong Hill Tracts to as high as 7020 sq.m/day in Rangpur districts in the north. Areas of high transmissivity are found near

Chittagong Hill Tracts and in the older formations in Sylhet areas. Despite the generally high transmissivity, horizontal ground water flow is very small because of the low groundwater gradients. Horizontal flow in the main aquifer between Jamalpur and Joypurhat, for example, is about 0.04 Mm^3/day, aquivalent to 17 DTW pumping for 12-hours per day .

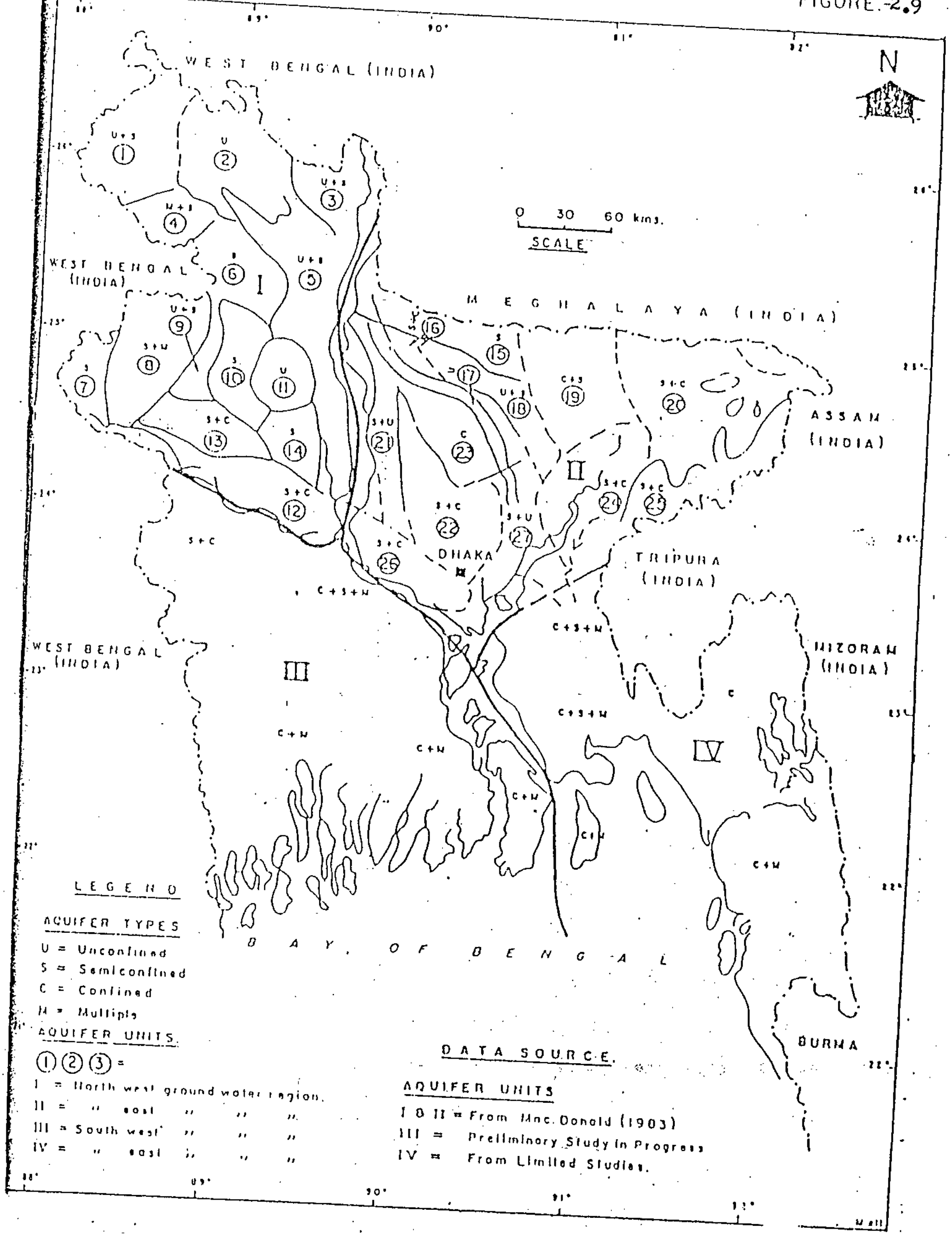
The main source of groundwater in Bangladesh is gravity drainage of the semi-confining layer of unconfined aquifer at the surface as the water table falls. At very high tubewell densities, which now exist in parts of Bangladesh, horizontal recharge is available to wells at the edge of the wellfield. Wells within the wellfield have no access to horizontal recharge because it is captured by the peripheral wells. All the withdrawals by interior wells must be derived from storage within the radius of influence of the well or the cone of depression around the well if the well field is densely developed. Consequently well yields at full development will depend upon the vertical gravity flow of storedwater above a falling water table.

The storavity of the main aquifer system is reported to range from 0. 0005 to 0.0006 with highest values in the NW zone and gradually decreasing towards south and eastern zone.

The regional aquifer types based on as the studies made as far are shown in fig 2.9

REGIONAL AQUIFER TYPES

FIGURE:-2.9



2.2.2 METHODS OF DRILLING DEEP TUBEWELLS

In Bangladesh most Deep Tubewells have been drilled either by the mechanical revers circulation rotary drilling (RC) or by the manual water-jet drilling (WJ) method. The brief descriptions of the these two methods and their comparisons are as follows.

2.2.2.1 Reverse-Circulation Rotary Drilling Method :

The Reverse Circulation Rotary Drilling Method is one of the fastest techniques for drilling large diameter wells through unconsolidated formations, such as those encountered in almost all areas in Bangladesh,where geological conditions are favourable, the cost per foot increase little as diameter increase. The circulation fluid used in this method is mostly clear water directed down the annular space between drill pipe and wall of the hole by quantity. The drilled cuttings and fluid are removed from the hole via the drill pipe by means of a suitable vacuum pump such as the sykes sertes II Univac, Once inside the body of the pump, both cuttings and fluid are discharged into the settling pit. To prevent large gravel damaging the impeller, a stone catcher bucket is fitted to the pump inlet. This drilling method can only be used successfully when the static water level (SWL) is more than 9 ft. and less than 35 ft. below the surface level.

The process is continuous. The hole is not cased during drilling and is prevented from cave-in by the hydrostatic pressure of the drill fluid in the hole and the film of fine-grained material

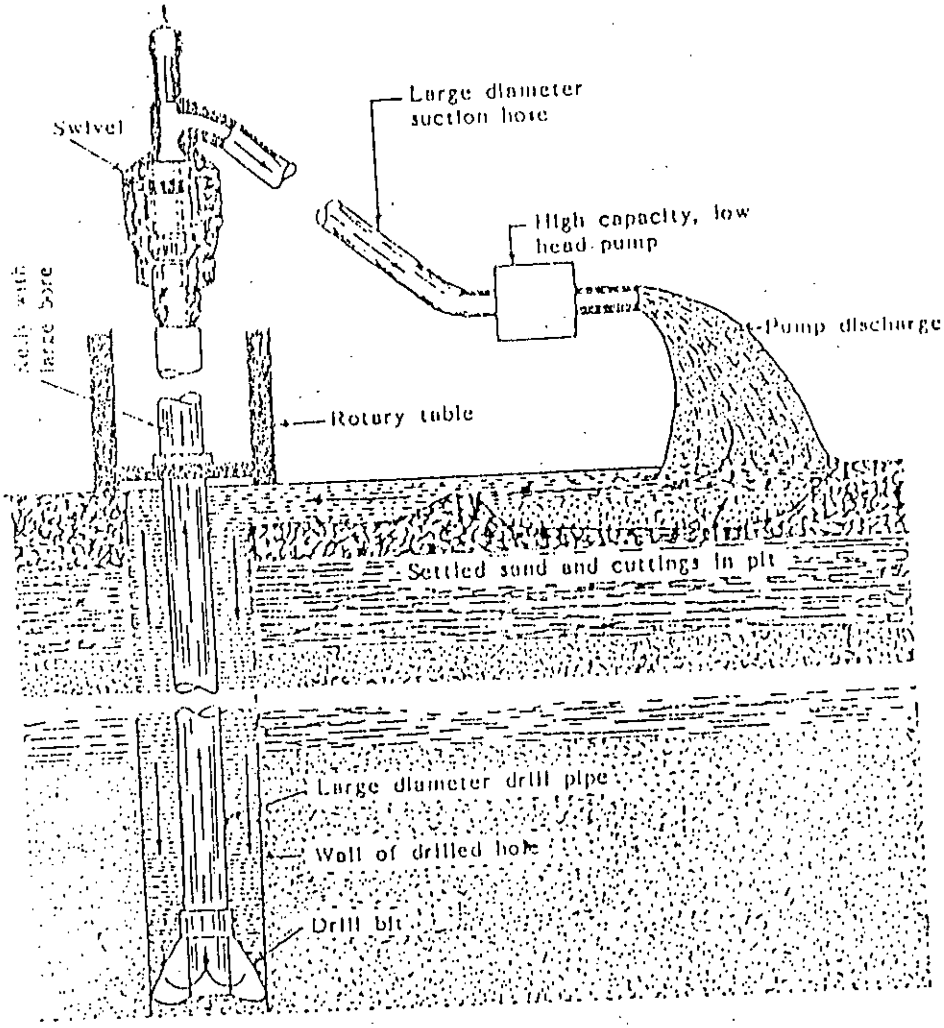


FIG. 2. 10 Schematic sketch illustrating basic principles of reverse rotary drilling.

Source : Michael A.M. (1978) Irrigation Theory and practice.

deposited on the wall of the hole by the circulating water. A considerable supply of water, in the range of 3-9 1/Sec, depending upon the size and depth of the hole, is required from the time drilling is started till the gravel packing of the well has been completed. Mud is added to water if the formation starts to cave-in. The drilling operation has to be carried out round the clock. For drilling deeper holes, up to 300 m or So, compressed air is used for circulating the drilling fluid.

The basic principles of reverse rotary drilling is shown in fig . 2.10

2.2.2.2. Water-Jet Drilling Method :

Manual drilling of large diameter holes in Bangladesh is done by a method popularly known as 'Water-jet' method. The name water-jet is in fact a misnomer as no fluid jet is used in the operation; it would be more appropriate to call it "Manual Direct Circulation Rotary Drilling Method." In this method, the drilling fluid is pumped through a flexible hose pipe down the hollow drill string. The drill string is manually rotated by a team of 4 to 6 persons with the help of chain tongs. This rotation transmitted to the drill bit causes the cutting of the formations. The Water pressure brings the cutting to the surface through the annular space between the drill pipe and the borehole.

The rig used for this manual drilling operation can be easily fabricated locally in about six weeks time at a total cost of Tk. 270,000 (MacDonald, 1983). When erected, the height between ground level and the crown is generally about 10 m. The rig consists of four legs fabricated from 10-cm screwed and socketed steel line pipe bracked and supported by the addition of steel crossmembers. The crown sheaves are supported by two steel 'H' girders bolted across the legs. Hoisting is accomplished with the help of a large manually operated winch. A high discharge lowhead rotary diesel powered pump is used to maintain the circulation at drilling fluid. The drill string consists of 10 cm screwed and sockted line pipe. The drill bit is fabricated from MS plate, with the cutting surfaces hardened by tempering. For harder formations a more robust bit with cutting surfaces hardened by tungsten carbide may be necessary.

Sometimes a working table is constructed using drill pipes and timbers incorporating a rudimentary guide bush. But often the drilling crew providing the rotary action to the drill pipe find it more convenient to work without a working table.

The function of the guide bush is to keep the drill string in the same vertical line during the drilling operation in order to provide verticality of the hole. In the manual chain tong system of providing rotary motion the drill string is liable to shift sideways and also can be subject to torque. As such, it may be desirable to have better guide bush, than the one generally used, with removale slips capable of guiding the drill string more closely and also allowing the drill pipe joints to pass.

The basic principle of Water Jet or Direct Rotary drilling method shown in fig. 2.11.

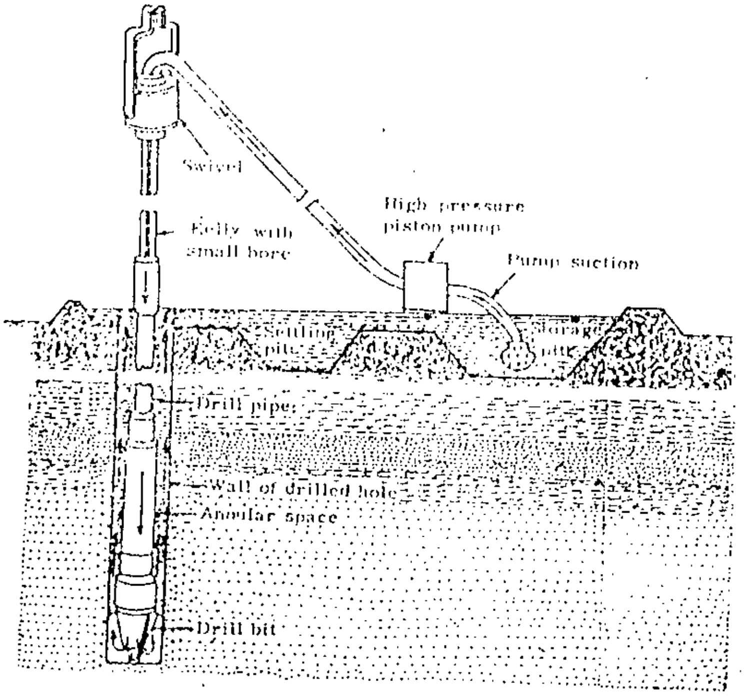


Fig. 2. 11 Schematic sketch illustrating the basic principles of direct rotary drilling.

The formation samples are generally collected by directly catching the overflow from the conductor casing in a bucket. The formation material is allowed to settle in the bottom of the bucket and then the sample collected and identified by the operator. To ensure accurate samples the following procedure should be adopted: A pre-decided interval of sample collection(usually every 5ft. or 1.5 m) is marked over the drill pipe with paint clearly visible even at night. During drilling as each interval mark becomes level with a reference point, the drilling is stopped but circulation is maintained. The drill string is lifted about 10 to 15 cm. The sample is collected and the drilling resumed by lowering the drill string and commencing rotation after the overflow ceases to contain formation cuttings indicating that the borehole is clean. This will minimise the mixing of the samples from different depths.

Inspite of the above care, the samples collected can still be misleading to some extent. For example, some clay or other finer particles can be washed off and the sample collected may not indicate the presence of these particles in the formation. Thin layers of clay could be missed if due care is not taken.

It is recommended that throughout the drilling operation a complete record be kept of the drilling time and borehole washing time for every interval of drilling. They assist in the sample identification for the drilling is easier and faster in the sandy formation than clayee layers, it takes much longer for the borehole to clean when drilling through sandy layers.

2.2.2.3 Comparison of Reverse-Circulation and Water-Jet Methods.

Table-2.1 Comparison between the RC and WJ drilling method

Drilling method	Reverse dirculation	Water-jet
1. Unit description	High technology (imported unit); all operations mechanical	Appropriate technology (local manufacture); manual rotations and hoist.
2. Time for erecting the unit	0.5 day	2.0 days
3. Dismantling time	0.5 day	2.5 days
4. Minimum hole dia	38 cm	23 cm
5. Operational period	dry season (Nov-April)	Also part of monsoon
6. Site access	selected sites	most sites
7. Minimum holes per month	6 to 9	2 to 3
8. Unit cost (Tk.)	Tk. 22,00,000.00	Tk. 2,70,000.00
9. Drilling cost per hole	Tk. 30,000,00	Tk. 26,000.00
10. Spare parts	Imported	Local
11. Drilling conditions	soft,medium,hard[a] boulder[b]	soft,medium,hard

a) with a commercial drilling bit,i.e. tricone or plate type:

b) would require expertise and special equipment.

2.2.3 DTW DESIGN AND CONSTRUCTION PROCEDURE AS PRACTICED IN BADC

During the last 25 yrs BADC adopted almost fixed pattern of tubewell design criteria with some variations in the length of UWC and strainers. The length of UWC varies from 70 ft. to 112 ft. and the length of strainers varies from 77 ft. to about 160 ft. There was no remarkable change in the slot-size of the screens. Different types of strainers such as G.I. core brass strainer, GRP screens, continuous slot-type SS screen etc. Were used. Since the DTWS under study were belongs to the IDA-II project, the procedure followed in the design and construction of the DTWS by the project given below.

2.2.3.1 Components of Tubewell casing :

There are three main types of casing used in a deep tubewell. The upper part (upper well casing, UWC) is of a larger diameter and is used to house the pump. Below this . is a reducer to a smaller diameter connecting the UWC to the rest of the casing which is divided into lower well casing (LWC) and screen. The former consists of blank pipe, whilst the latter contains slots. At the bottom of the lowest screen, a short length of blind pipe is used as a bail plug. These various components are shown in figure 1.1.

2.2.3.2 Materials of Tubewell casing :

For this project the UWC consist of 356mm (14") dia mild steel pipe. This was butt welded together to form a continuous tube. The LWC made of 152mm (6") or 203mm (8") diameter galvanised mild steel pipe with threaded couplings.

The screen made of either stainless steel (SS) or glassfibre reinforced plastic (GRP) with a slot size of 1mm (40 thou). It was also available in diameters of 152mm and 203mm.)

2.2.3.3 Length of Upper Well Casing (UWC)

The length of upper well casing (UWC) is governed by the lowest level at which the intake of the pump is likely to be set. There are five major factors which govern the setting of the pump and these are shown in the following equation:

$$H = AGL + LSWL + PAC + 2.5\ ESD + DA + 1/10\ DA$$

Where :

H = Length of upper well casing.

AGL = Height of pump casing Above Ground Level.
The top of the UWC would be normally be 0.6 metres (2 ft) higher than the ground level or the reported normal flood level whichever is the higher.

LSWL = Lowest Static Water Level
This is the static water level usually observed at the end of dry season around the middle of May, just before any appreciable recharge to the aquifer takes place. This varies between 6.1 and 18.3 metres (20 to 60 ft) below the ground surface in the project Area.

PCA = Pump Clearance Allowance
This represents the length of suction pipe below the base of the pump which normally varies from 1.5 to 2.7 metres (5 to 9 ft).

ESD = Estimated Specific Drawdown

This will range from 0.054 to 0.162 m/1/s (5 to 15 ft/cusec). 2.5 ESD is used in the design calculation as it represents the estimated drawdown at design discharge plus a 25% increase to allow for deterioration in performance of the well with time.

DA = Depletion Allowance

This is an estimate of the effect of the total groundwater abstraction on the water level at the end of the dry season when the project is fully operational.

1/10 DA = This is a factor of safety allowing for a further depletion of the groundwater level in an unusually very dry year. It is 10% of the depletion allowance.

Using the above equation, along with the hydrogeological conditions of the project Area, the required length of 356mm (14") diameter UWC would generally be between 21.3 (70 ft) and 33.5 metres (110 ft) for 56 1/s (2 cusec) discharge.

Therefore, the recommended lengths of UWC are as follows:

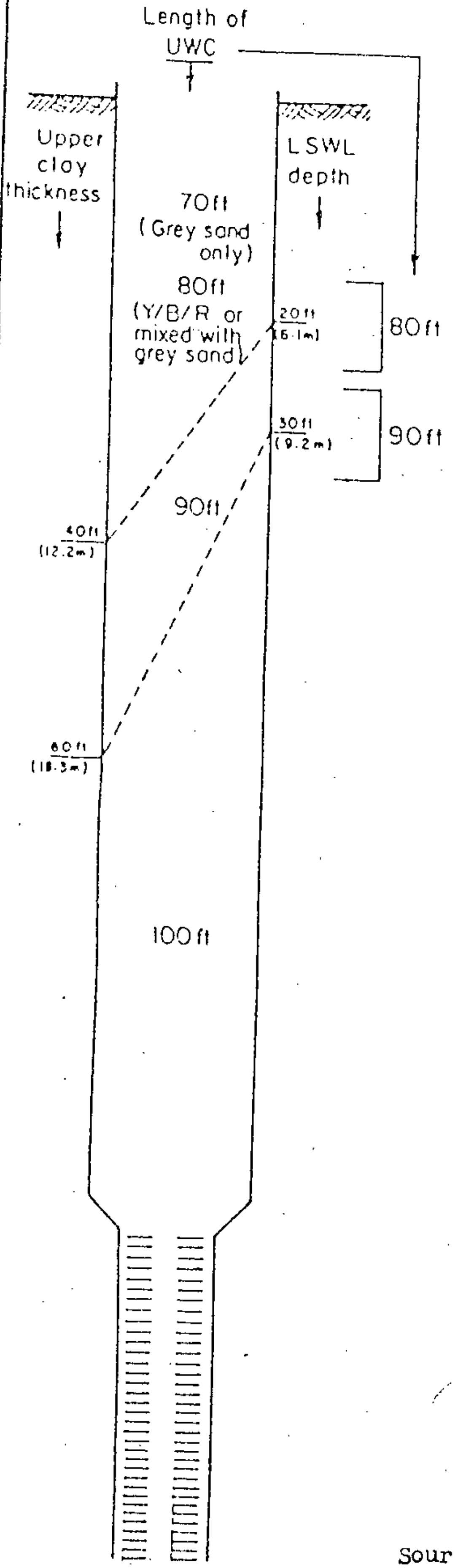
a)	21.3 metres (70 ft)	If the upper clay is less than 12.2 metres (40 ft) thick and also the lowest late dry season static water level is less than 6.1 metres (20 ft) below ground level in a grey sand only sequence.
b)	24.4 metres (80 ft)	i) the same as a), but with yellow/brown/ red sand or a mixture with grey sand .

	ii) If the upper clay is between 12.2 and 18.3 metres (40 to 60 ft) and the LSWL is less than 6.1 metres(20 ft). iii) If the upper clay is less than 12.2 metres (40 ft) and the LSWL between 6.1 and 9.2 metres(20 to 30 ft).
c) 27.4 metres (90 ft)	i) If the upper clay is between 12.2 and 18.3 metres (40 to 60 ft) and also if the LSWL is between 6.1 and 9.2 metres (20 to 30 ft). ii) If the upper clay is greater than 18.3 metres (60 ft) and the LSWL is less than 9.2 metres (30 ft). iii) If the upper clay is less than 18.3 metres (60ft) and the LSWL is greater than 9.2 metres (30 ft).
d) 30.5 metres (100 ft)	Where the upper clay is thicker than 18.3 metres (60 ft) and the lowest late dry season water level is greater than 9.2 metres (30 ft) below ground level.

In generalizing the UWC length into these categories two major factors have been taken into account, that is UWC length of the existing DTW, and specification of the pumping plant to be procured for the project. This is illustrated in Figure 2.1 2

Figure 2.12

UPPER WELL CASING DESIGN



a) 70 ft : (21.3m) Upper clay is <40ft and also LSWL is <20ft in a grey sand only

b) 80ft : (24.4m)
- i) Same as (a), but in Y/B/R or mixed with grey sand
- ii) Upper clay is 40 to 60ft and LSWL is < 20ft.
- iii) Upper clay is <40ft and LSWL is 20 to 30ft.

c) 90ft : (27.4m)
- i) Upper clay is 40 to 60ft and LSWL is 20 to 30ft.
- ii) Upper clay is >60 ft. and LSWL is < 30 ft.
- iii) Upper clay is <60 ft. and LSWL is >30 ft.

d) 100ft : (30.5m) Upper clay is > 60ft and also LSWL is > 30ft.

Source: BADC

2.2.3.4 Lower Well Casing (LWC)

The actual length of the LWC depends upon the thickness of the unscreenable layer or layers. A minimum length of 2 ft offset between the ends of the blank pipe and the beginning end of the unscreenable formation was maintained to prevent mobilisation of the finer materials due to high flow velocities close to the well-screen.

2.2.3.5 Length of strainers

To determine the length of strainers required to produce 56 L/s (2-cusec)of water with an screen entrance velocity of not more than 0.03 m/sec (0.10 ft/sec), the following procedures were followed .

In order to differentiate the unscreenable and screenable aquifer, the penetration factor (h) and the design factor (F) were used. Both of these two factors are the ratios of the estimated permeabilities of aquifers of different grain sizes and colours in relation to that of grey medium to fine sand (MS/FS), which is the finest screenable aquifer material allowable using 1mm (40 thou) slot screen. This grey MS/FS has been given a value of 1.00 and is used as a base for the calculation of values. The design factor (F) applies to the screenable aquifer while the penetration factor(h) applies to the unscreened aquifers. The design and pentration factors per ft thickness of different aquifer materials given in table 2.2

Design Calculation :

To determine the screen length required to produce 56 l/s (2-cusec) of water with an screen entrance velocity of not more than 0.03

TABLE-2.2 DESIGN AND PENETRATION FACTOR

Lithology	Design Factor (F)		Penetration Factor (h)		Remarks
	per 0.3 metre (1ft)				
	Y/B/R	Grey	Y/B/R	Grey	
Clay/Clayish	-	-	-	-	Unscreenable
Silt/Silty	-	-	-	-	with 1mm
VFS	-	-	0.05	0.10	(40 thou)
VFS/FS	-		0.10	0.20	screen
FS/VFS	-	-	0.20	0.40	"
FS	-	-	0.30	0.60	"
FS/MS	-	-	0.40	0.80	"
MS/FS	0.50	1.00	0.50	1.00	Screenable
MS	0.70	1.40	0.70	1.40	with 1mm
MS/CS	0.80	1.60	0.80	1.60	(40 thou)
CS/MS	0.90	1.80	0.90	1.80	screen
CS	1.10	2.20	1.10	2.20	"
CS/Gr	1.00	2.00	1.00	2.00	"
Gr/CS/MS	0.60	1.20	0.60	1.20	"

VFS : very fine sand, FS : fine sand, MS : medium sand CS : coarse sand, Gr: gravel, Y : yellow, B :brown, R : Reddish. The grain sizes first named are predominant to the others.

metres per second (0.1 ft/sec), the following procedures are to be followed in the field, using the design calculation sheet. A completed form is shown in Figure 2.13

i) Transfer the simplified graphic log of the formations encountered from the drilling log onto the design sheet as drilling proceeds.

ii) Determine the length of UWC by following the UWC design procedures before drilling depth reaches around 30 metres (100 ft).

iii) Start marking the position of blank LWC against the unscreenable layers before drilling depth reaches around 46 metres (150 ft) in a grey sand aquifer with thin upper clays or around 76 metres (250 ft) in brown/yellow sand aquifers with thicker upper clays. This will indicate the possible location of the screens. Fit lengths of screens (in multiples of 3 metres (10 ft) in positions bearing in mind the need for a minimum blank casing offset of 0.61 metre (2 ft) at the junction of each unscreenable layer.

iv) Several attempts may be required to determine the lengths and the settings of LWC and screen, bearing in mind that unit length of both LWC and screen are 3 or 6.1 metres (10 or 20 ft).

v) Draw horizontal lines at each formation boundary and at both ends of each screen section.

vi) Under the column of " Screened Aquifer" on the Design Sheet, multiply the thickness (D) of each screened aquifer section by the design factor (F) corresponding to its aquifer classification

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Fig. 2.13

EXAMPLE

CONTRACTOR:

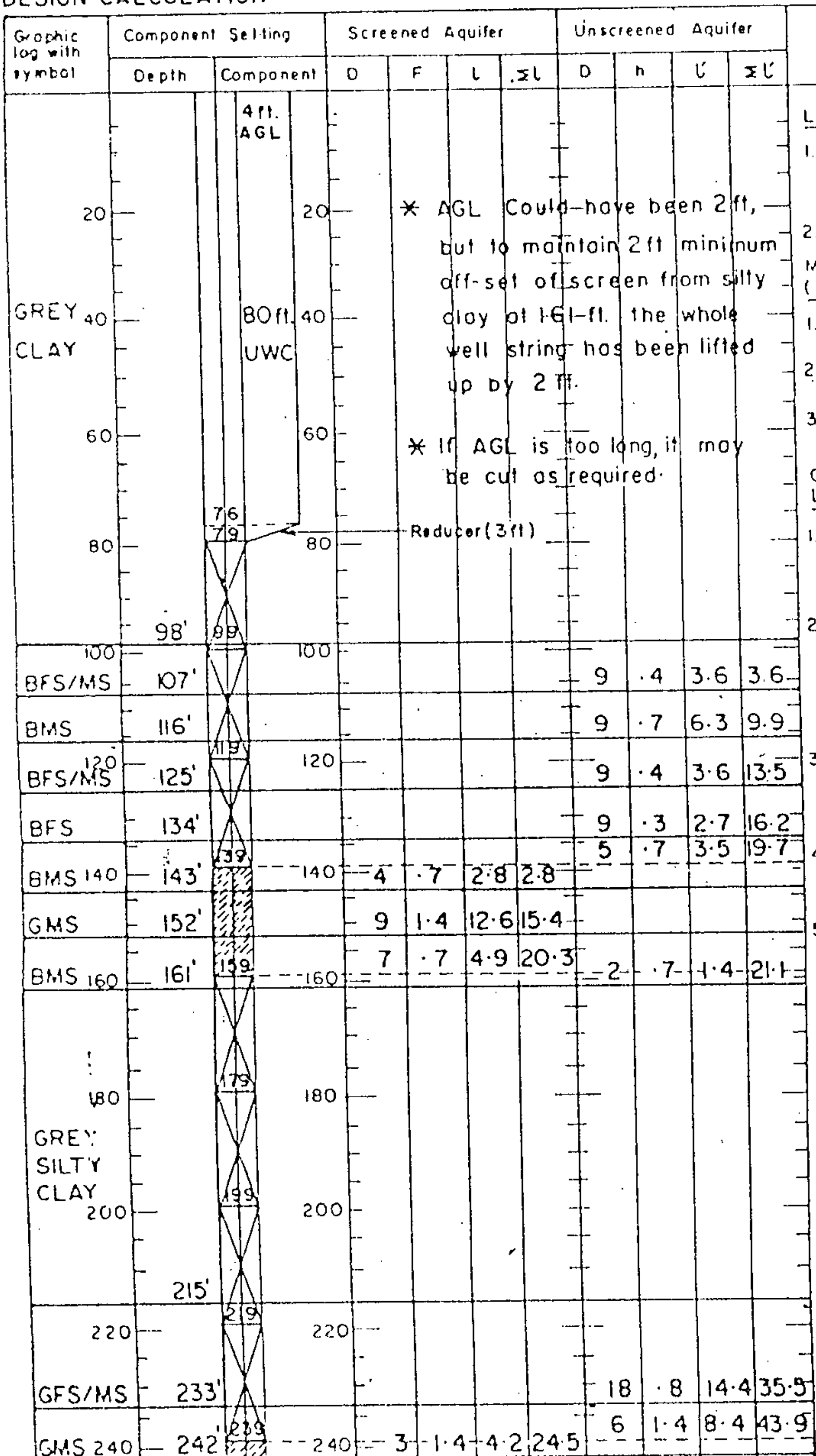
....

DESIGN SHEET

Well No. /

App No ..../ / /

DESIGN CALCULATION



Graphic log with symbol	Component Setting: Depth	Component Setting: Component	Screened Aquifer: D	F	L	ΣL	Unscreened Aquifer: D	h	L'	ΣL'
GREY CLAY	98'	4 ft. AGL 80 ft. UWC 76 79 99								
BFS/MS	107'						9	·4	3·6	3·6
BMS	116'	119					9	·7	6·3	9·9
BFS/MS	125'						9	·4	3·6	13·5
BFS	134'						9 5	·3 ·7	2·7 3·5	16·2 19·7
BMS	143'	139	4	·7	2·8	2·8				
GMS	152'		9	1·4	12·6	15·4				
BMS	161'	159	7	·7	4·9	20·3	2	·7	1·4	21·1
GREY SILTY CLAY	215'	179 199								
GFS/MS	233'	219					18	·8	14·4	35·9
GMS	242'	239	3	1·4	4·2	24·5	6	1·4	8·4	43·9

* AGL Could have been 2 ft, but to maintain 2 ft minimum off-set of screen from silty clay at 161-ft. the whole well string has been lifted up by 2 ft.

* If AGL is too long, it may be cut as required.

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≤ 40 feet thick and lowest late dry season SWL is ≤ 20ft
2. (80ft) : in rest of project area

MINIMUM LENGTH OF SCREEN (≮ 6 in.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft. or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) b relevant F or h and summed in the appropriate column.
3. Drilling may be stopped when ΣL ≥ 100 and ΣL' ≥ 50 are achieved, subject to minimum screen lengths stated above.
4. Final value of L' will be 20ft. multiplied by its relevant h value below lowest screen.
5. If ΣL' including the bottom 20ft. is < 50, although ΣL is ≥ 100, if possible, additional aquifer should be screened to make ΣL + ΣL' ≥ 150, subject to minimum screen length stated above.

KEY

D : Thickness of formation
F : Design factor of formation screened
L : D x F
ΣL : Summation of L values
h : Penetration factor of formation unscreened.
L' : D x h
ΣL' : Summation of L' values

DESIGNER

Signature:..............................

Name....................................

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR:

....

DESIGN SHEET

EXAMPLE

Well No. .... / ....

App No. ..../...../..../......

DESIGN CALCULATION

Graphic log with symbol	Component Setting		Screened Aquifer				Unscreened Aquifer			
	Depth	Component	D	F	L	ΣL	D	h	L'	$\Sigma L'$
		242								
GMS/GR	251'		9	1·2	10·8	35·3				43·9
GMS	259'	259	8	1·4	11·2	46·5				
GMS	269'		10	1·4	14·0	60·5				
GMS	279'	279	10	1·4	14·0	74·5				
GMS	289'		10	1·4	14·0	88·5				
GMS	299'	299	10	1·4	14·0	102·5				
GMS	309'	309	10	1·4	14·0	116·5				
		314 Total 90 ft. screen					20	1·4	28	71·9
GMS	323'	Ball plug								
		Base of hole								

$\Sigma L > 100$ OK

$\Sigma L' > 50$ OK

$\Sigma L + \Sigma L' > 150$

ALL CRITERIA OK

Total depth of fixture: 314 ft.
(Design depth)

Another 5 to 10 ft. may be drilled at descretion of the driller.

Stop drilling at 323 ft.

REMARKS

LENGTH OF UWC

1. 70ft If upper clay is ≦ 40 feet thick and lowest late dry season SWL is ≦ 20ft
2. 80ft. in rest of project area

MINIMUM LENGTH OF SCREEN (⌀ 6 in)

1. 90ft : Grey MS or coarser sands only
2. 110ft : Half mixed grey and brown/yellow/reddish sands
3. 120ft: Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10 ft. or more of clay/silt above topmost screen should be excluded from the calculations
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) b relevant F or h and summed in the appropriate column
3. Drilling may be stopped when $\Sigma L \geqq 100$ and $\Sigma L' \geqq 50$ are achieved, subject to minimum screen lengths stated above
4. Final value of L' will be 20ft multiplied by its relevant h value below lowest screen.
5. If $\Sigma L'$ including the bottom 20ft. is <50, although ΣL is $\geqq 100$, if possible, additional aquifer should be screened to make $\Sigma L + \Sigma L' \geqq 150$, subject to minimum screen length stated above.

KEY

D: Thickness of formation
F: Design factor of formation screened.
L: D x F
ΣL: Summation of L values
h: Penetration factor of formation unscreened.
L': D x h
$\Sigma L'$: Summation of L' values

DESIGNER

Signature.........................

Name.........................

Designation.........................

to derive a value which represent the thickness of the screened aquifer equivalent to grey MS/FS, that is;

$$l = D \times F$$

vii) Progressivly sum all the values, of l in the relevant column which will indicate the total thickness of the screened aquifer equivalent to a grey MS/FS, that is;

$$\Sigma l = \Sigma (D \times F)$$

viii) Likewise, under the column of " Unscreened Aquifer" on the Design Sheet, multiply the thickness (D)of each screened and unscreenable aquifer section by the penetration factor (h) corresponding to its aquifer classification to derive a value which represents the thickness of the unscreened aquifer equivalent to a grey MS/FS, that is;

$$l' = D \times h$$

ix) The final value of l' will be 6.1 metres (20 ft) multiplied by the relevant h value of the aquifer material found below the lowest screen. If the drilling terminates in a clay or silty formation, this final value of l' will be zero.

x) Progressivly sum all the values of l' in the relevant column which will indicate the total thickness of unscreened aquifer equivalent to a grey MS/FS, that is;

$$\Sigma l' = \Sigma (D \times h)$$

xi) Any aquifer underlain by 3 metres (10 ft) or more of a clay or silt above the topmost screen should be excluded from these calculations. Any aquifer bounded above and below by more than 3 metres (10 ft) and not screened should be excluded from these calculations.

xii) Minimum length of screen

24.4 metres: In case of grey MS or coarser sands (80 ft) through the entire well depth, otherwise 27.4 metres(90 ft).

33.5 metres: In case of half mixed grey and B/Y/R (110 ft)
(110 ft) sands

36.6 metres: In case of brown/yellow/reddish sands through-
(120 ft) out the entire well depth.

xiii) Maximum well depth would be 122 metres (400 ft). The maximum length of screen that should be used in any well will be 48.8 metres (160 ft).

xiv) Drilling may be stopped when $\Sigma l = 100$ and $\Sigma l' = 50$ are achieved, subject to the minimum screen lengths and the maximum well depth shown above.

xv) If the value of $\Sigma l'$, including the bottom 6.1 metres (20 ft), is less than 50, although the value of Σl is greater than 100, if possible, additional aquifer should be screened to satisfy the criteria $\Sigma l + \Sigma l' = 150$, subject to the minimum screen lengths and the maximum well depths shown above.

xvi) A tubewell can be designed even if the value of $\sum l$ fails to reach 100, if $\sum l + \sum l' = 150$ is achieved, subject to the minmum screen length and the maximum well depths shown above.

xvii) Where a poor aquifer exists at the bottom of the borehole, and there is little chance of finding a further screenable aquifer by increasing borehole depth, the value of the $\sum l + \sum l'$ can be reduced to 130 in order to complete a tubewell, subject to the minimum screen lengths shown above.

xviii) Once the final design of the well has been established, the top 40% of the LWC must be installed with 203 mm (8") diameter blank pipe and screen. This is to ensure minimum upflow losses, whilst keeping the well costs as low as possible. The design factor is not affected by the increase in screen diameter and no other factors are to be taken into consideration. Thus the final act of well design is to calculate the length of 203mm components that will be installed.

2.2.3.6 Installation of Casing:

After completing the well-design, the bail-plug, screens, blank casing, reducers and UWC were placed in the bore-hole. During installation the head differential of the bore-hole must be maintained to prevent well collapse.

(1) Centralisers :

The centralisers are placed on the outside of the LWC and UWC in order to hold the casing string in the center of the drilled hole. This ensures an even annulus between the casing and borehole side, through which the gravel pack can pass and settle.

(2) Verticality :

Upon successful installation of the casing, the UWC must be checked for verticality. This is to ensure that the pump will hang vertically in the well. The verticality of the hole and of the assembled casing string in it shall be such that;

> both before and after placing the gravel filter, no point on the actual centre line of the upper well casing shall deviate more than 89mm (3.5") from an imaginary plumb line passing through the centre of the top of the upper well casing.

(3) Straightness :

The UWC must also be checked for straightness to ensure that the pump will enter the well. The straightness of the well shall be such that;

> both before and after placing the gravel filter, a cylindrical dolly should pass freely down the full length of the upper well casing.

(4) Gravel Pack :

The gravel pack is used to help prevent the finer materials of the aquifer from entering the well, whilst facilitating the flow of water to the well. The thickness of the gravel pack normally varies from 76mm (3") to 203mm (8"). A thickness of about 152mm (6") of gravel pack below the reducer and 76mm (3") above the reducer are recommended to minimize any difficulties with placing the gravels and the time required for development.

Sufficient gravel should be inserted to ensure that the entire annular space between the tubewell components and the undisturbed formation is filled to the ground level.

The following are the gradings of materials to be used for a screen having a slot size of 1mm (0.040") set in medium/fine sands (i.e. the fine sands are less than 25%). It should be noted that this " gravel pack" contains 67% coarse sand and only 28% gravel and thus could be called a " sand pack"

Table: 2.3 Recommended Gradings of Gravel Pack Materials.

B.S.410 Sieve Number	Aperture size mm	(in.)	percentage passing through	Ideal Quantities %	Grain Size
3/16	4.76	(0.1874)	100	0.0	
1/8	3.18	(0.1252)	85 - 95	10.0	FGr
8	2.00	(0.0787)	64 - 80	18.0	FGr
16	1.00	(0.0393)	10 - 30	52.0	CS
25	0.60	(0.0236)	0 - 10	15.0	CS
36	0.425	(0.0167)	0	5.0	MS

During the placement of the gravel pack, the water level in the well must be maintained at ground level. Any drilling fluid removed to assist in gravel emplacement must be returned to the well inorder that well collapse be prevented. Only after final checking of the verticality can the level in the well be allowed to drop to the static water level.

2.2.3.7 WELL DEVELOPMENT

"Over pumping" and " Backwashing" are the simplest development methods used on tubewells in Bangladesh for a long time and are outlined below :

(a) Overpumping :

This involves pumping the well at a much higher rate than its design capacity. On satisfactory completion of the " Preliminary Operation", the discharge is gradually increased to a rate at which the true development work is to be carried out.

The capacity of the pump to be used for this purpose should be not less than 84 1/s (3 cusecs). However even this capacity would be insuffficent for fully developing wells whose capacities are very high in the good aquifers of the project area.

(b) Backwashing :

This method involves alternately pumping and stopping the pump in an attempt to reverse the flow of water inside the well by allowing the water inside the column pipe to run back through the screen and the gravels in to the aquifer. The pump is started and stopped as rapidly as the pumping unit mechanically permits. Thus, inflow and outflow can produce an effective surging action.

When the well is pumped, the fines are removed along with the water, When it is stopped, bridging of the aquifer sands and the gravel pack are broken, and the mud film of the wall of the borehole destroyed by the varying pressure differentials caused by the sudden changes of the head of water in the well. By repeating this operation, the gravel pack and the aquifer sands in the vicinity of the well are progressively rearranged, settle down and become stabilized. Once this has occurred, no further fines will be pumped with water from the well, thus achieving one of the objectives of development.

The pump commonly used for the purpose is a deep well turbine pump without a foot valve. The pump used need not be of a much higher capacity than the design discharge of the well, but its capacity should be no less than this amount.

2.3 WELL-LOSS IN DEEP TUBEWELLS

The well-loss phenomenon was described by the various Authors in different books and papers in a number of ways. The available reference studies described below.

2.3.1 DETERMINATION OF WELL-LOSSES

The methods of determining well-losses were suggested by the various Authors as follows:

2.3.1.1 Well-loss determination by Jacob-Rorabaugh assumptions:

WELL LOSSES :

To determine the total lift for pumping water from well, the distance S_{iw} between the static piezometric surface or water table and the water level in the well (Figure 1.1) must be known. The value of S_{iw} normally is taken as the sum of the drawdown S_f in the aquifer at the well, and the total-head loss S_w incurred when water moves into the well through the developed zone or gravel envelope and the screen or slots in the casing. The loss S_f is called the formation loss because it occurs in the aquifer, While S_w is called the well loss.

Since the flow in the aquifer is laminar, S_f will vary linearly with Q as indicated by the various well-flow equations. Of course S_f also varies with time, but if pumping is continued long enough so that Sf changes only very little, the " final" S_f will be directly proportional to the pumping rate (ignoring the effect of drawdown on transmissivity if the aquifer is unconfined). The flow through the gravel invelope or developed zone outside the well casing and through the screen or other openings in the casing, as well as the flow inside the well itself, however, will usually be turbulent. Thus, S_w can be expected to vary with some power of Q, and the total head loss S_{iw} can be expressed as

$$S_{iw} = C_f Q + C_w Q^n \quad (2.1)$$
$$= Sf + S_w \quad (2.2)$$

Where Cf is the formation constant relating Q to S_f, C_w is the well-loss constant relating Q^n to S_w and n is the exponent due to turbulence. Jacob (1947) Suggested that n=2, while Rorabaugh (1953) concluded that a value of 2.5 may be more appropriate. In actual tests, Lennox (1966) found n values as high as 3.5. Values of n less than 2 may also occur- for example, if Q is relatively low and full turbulence has not yet developed in the entire well-entry flow. For very low values of Q, the flow may even be laminar throughout the system, in which case C_w will be zero. The value of C_f could be calculated from one of the well-flow equations.

The best way to determine C_f, C_w, and n for a given well is by experiment. This can be done with the step-drawdown test where S_{iw} is measured for successively increasing values of Q. The well is pumped at a certain Q until S_{iw} changes only relatively little; Q is then increased, and S_{iw} is measured after the same time interval used for the first flow rate. This process is repeated until S_{iw} is known for about four or five different Q values. The depth of the water level in the well during pumping is usually measured with the bubble-tube technique.

Jacob (1947) developed equations for evaluating C_f and C_w from the increase in S_{iw} due to an increase in Q, assuming n=2. Rorabaugh (1953) presented a graphical procedure where n is evaluated from the test results themselves, as are C_f and C_w. For this purpose, Eq. (2.1) is written as

$$\frac{S_{iw}}{Q} - C_f = C_w Q^{n-1} \qquad (2.3)$$

Taking the logarithm of both sides, this equation becomes

$$\log \left(\frac{S_{iw}}{Q} - C_f\right) = \log C_w + (n - 1) \log Q \qquad (2.4)$$

which shows that a plot of $\left(S_{iw}/Q - C_f\right)$ versus Q on double-logarithmic paper should yield a straight line with slope $(n-1)$ and intercept C_w when $\left(\frac{S_{iw}}{Q} - C_f\right) = 1$. Since C_f is not known however such a plot cennot be constructed. The procedure then is to assume different values of C_f and plotting $\left(\frac{S_{iw}}{Q} - C_f\right)$ versus Q on double-logarithmic paper until a straight line is obtained. Usually, the first C_f value is taken as zero, which yields a concave curve as shown in Figure 2.14. Then, C_f is successively increased until a straight line is obtained (if C_f is too large, a concave curve on the other side of the straight line will be obtained, as in Figure 2.14). The slope of the stright line is equal to $(n-1)$ which yields n. To evaluate C_w the line can be extended until $\left(\frac{S_{iw}}{Q} - C_f\right) = 1$, or C_w can be calculated by substituting C_f, n, and a certain combination of the measured S_{iw} and Q into Eq (2.1)

2.3.1.2 Determination of well-loss by Walton, Jacob and Rorabaugh's procedure

Apart from the drawdown components due to laminar flow of water through the aquifer (aquifer or formation loss S_a), partial penetration of pumped well (s_p), dewatering of aquifer, if any (s_d), and barrier and recharge boundaries (S_b, $- S_r$), deviations from theoretically computed drawdowns occur because of an additional

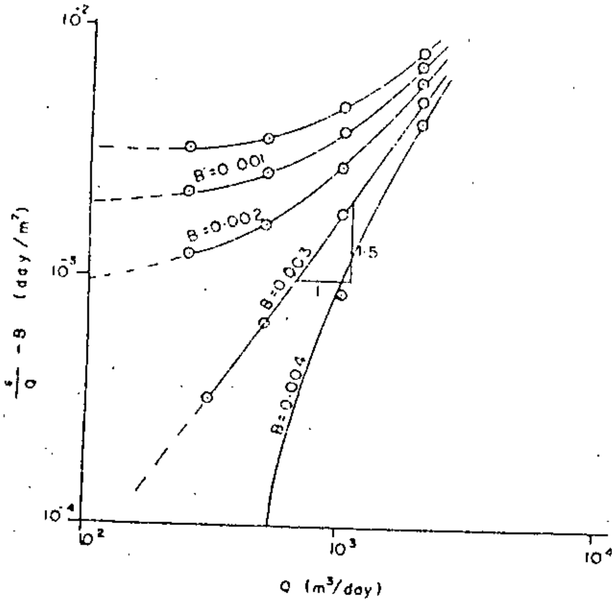


Fig. 2. 14 Double-logarithmic plot of $\frac{s}{Q} - B$ versus Q for different values of B to obtain B yielding straight line

Source : Karanth, K.R. (1987) Ground water Assessment
Development And Management

component designated well loss (S_w), arising from the turbulent flow of water through the screen or well face and inside the casing to the pump intake. Expressed as an equation (Walton, 1962),

$$S = S_a + S_p + S_d + S_b - S_r + S_w \qquad (2.5)$$

Well loss may be represented approximately by the relationship (Jacob, 1946)

$$S_w = CQ^2 \qquad (2.6)$$

Where S_w = well loss, in m

C = well loss constant, in S^2/m^5

Q = discharge, in m^3/s

The value of C may be estimated by conducting a step drawdown test, which consists of increasing the discharge in three or four stages in a step fashion and recording the drawdowns, each step being of the same duration.

Jacob (1947) suggested a graphical solution for separating the drawdown in a pumped well into its components

$$S = BQ + CQ^2 \qquad (2.7)$$

$$\frac{S}{Q} = B + CQ \qquad (2.8)$$

where B is the formation-loss coefficient.

Plotting S/Q, specific drawdown, versus Q the slope of the straight line gives the well-loss coefficient, and the intercept on the Y axis gives the value of B.

Rorabaugh (1953) obtained a more general solution by treating the exponent of Q in the well-loss term as unknown.

$$S = BQ + CQ^n \qquad (2.9)$$

$$\frac{S}{Q} = B + CQ^{n-1} \qquad (2.10)$$

The solution was obtained by assuming different values of B and plotting (s/Q)- B versus Q on a double log paper.

C, as computed by Walton (1962), is given by the equation

$$C = \frac{(\Delta S_i/\Delta Q_i) - (S_{i-1}/\Delta Q_{i-1})}{\Delta Q_{i-1} + \Delta Q_i} \qquad (2.11)$$

where C = well loss coefficient in S^2/m^5

ΔS = increment of drawdown produced by each increase in Q in the rate of pumping, in m

ΔQ = increase in the rate of pumping in each step in m^3/s

For step 1 and 2,

$$C = \frac{(\Delta S_2/\Delta Q_2) - (\Delta S_1/\Delta Q_1)}{\Delta Q_1 + \Delta Q_2}$$

For steps 2 and 3,

$$C = \frac{(\Delta S_3/\Delta Q_3) - (\Delta S_2/\Delta Q_2)}{\Delta Q_2 + \Delta Q_3}$$

and so on.

If the value of C changes during the test, the drawdown is indicated to be influenced by the development or clogging of the pores of the material outside the screen. A decrease in C with increase in Q suggests development during the course of the test, while an increase in C with higher pumping rates suggests clogging of the well screen or well face. Thus, it is possible to assess, from the values of C during a step drawdown test, the stability of a well and the success of rehabilitation work on wells. Walton (1962) suggests the following criteria to appraise the condition of a well:

$C < 5\ s^2/ft^5$ $(C < 1900\ s^2/m^5)$	Well properly designed and developed
C between 5 and 10 s^2/ft^5 (C between 1900 and $3800 s^2/m^5$)	Mild deterioration of well
$C > 10\ s^2/ft^5$ $(C > 3800\ s^2/m^5)$	Severe clogging of well
$C > 40\ s^2/ft^5$ $(C > 15{,}200\ s^2/m^5)$	Condition of well such that it is difficult and sometimes impossible to restore to original capacity

2.3.1.3 Analytical Method of determining Well-loss by Garg and Lal.

The head loss through the screen of a fully penetrating well in a confined aquifer was determined by Garg and Lal (1971) as

$$S_W = \frac{(C_c A_p U_t - U_{ta}) r_w \ln(r_e/r_w)}{K} + \frac{U_t^2}{C_v^2 2g} \qquad (2.12)$$

Where u_t = velocity through screen slots at the top of the aquifer

u_{ta}= velocity near the screen in the top region of the aquifer.

Another equation was derived for flow through the aquifer, through the screen slots and within the screen. These two equations were solved by numerical methods and their validity was verified experimentally. The well losses were seen to depend upon the following parameters:

(i) A dimensionless screen parameter C_sL/D.

(ii) A dimensionles friction parameter fL/D.

(iii) Coefficient of permeability of the aquifer.

(iv) The head loss through the aquifer.

where $C_s = 8\sqrt{2}C_c C_v A_p$ = screen coefficient, dimensionless.

C_e = contraction coefficient, dimensionless, value for square slots = 0.626

C_v = velocity coefficient, dimensionless, usual value = 0.97

A_p = ratio of the slot area to the total area of the screen, dimensionless

L = screen length, in m

D = screen diameter, in m

f = Darcy-Weisbach resistance coefficient in the formula

$$h_f = \frac{4fLV^2}{2gD} \qquad (1.13)$$

for flow within the well screen, Representative values of f are

Brass, copper, lead	0.003
Iron, steel	0.005
Concrete, rivetted steel	0.01

No information is available about the value of f for slotted pipes; it is expected to be higher than the above values.

They found that for low values of the screen parameter C_sL/D the well loss is very high and as the value of the screen parameter increases, the well loss gets progressively reduced, till a value of the screen parameter = 10 is reached, beyondwhich the well loss does not reduce further. In nature about half of the slot area of a screen gets blocked by aquifer grains. In course of time the blockage may further increase due to incrustation and rearrangment of grains. Hence in actual practice the value of C_sL/D was recommended, to be kept more than 60. i.e

$$\frac{8\sqrt{2}\ C_c C_v A_p L}{D} > 60 \qquad (2.14)$$

2.3.1.4 Calculating Well-losses by using Manning's equation for hydraulic Losses in pipe flow

The well-loss was calculated on the basis of some field experiments and using Manning's equation for hydraulic losses in pipe flow.

Manning's equation for hydraulic losses in pipe flow, expressed in terms of hydraulic gradient, can be written, in fps units.:

$$S = \frac{d\,H}{d\,l} = \frac{4.637\ q^2\ n^2}{D^{16/3}} \qquad (2.15)$$

Where S = hydraulic gradient (dimensionless)

H = head or pressure in pipe (length)

l = length of pipe (length)

Q = flow in pipe (length ^{3}/time)

D = pipe internal diameter (length)

n = Manning's co-efficient

For a flow in the pipe, q, varying from zero at the bottom of the well to Q, the total well discharge at the top, the relationship between q and Q might lie between:

$$q = Q\left(\frac{l}{L}\right) \quad \text{and} \quad q = Q\left(\frac{l}{L}\right)^{p} \qquad (2.16)$$

The power, p, is to allow for reduction in unit inflow rate down the well as upflow loss reduces the effective drawdown causing influx. Various values of p were tried and the best compromise considered to be p = 1.25 ; this means the lower 50% of the well only produces 42% of the discharge. Thus :

$$\frac{dH}{dl} = \frac{4.637 \; Q^2 \, n^2 (l/L)^{2.5}}{D^{16/3}} \qquad (2.17)$$

And total upflow head loss, H is :

$$H = \sum \frac{dH}{dl} = \int_{0}^{L} \frac{4.637 \; Q^2 n^2 l^{2.5}}{L^{2.5} \; D^{16/3}} \, dl \qquad (2.18)$$

$$= -\frac{1.325 \; Q^2 n^2 L}{D^{16/3}} \qquad (2.19)$$

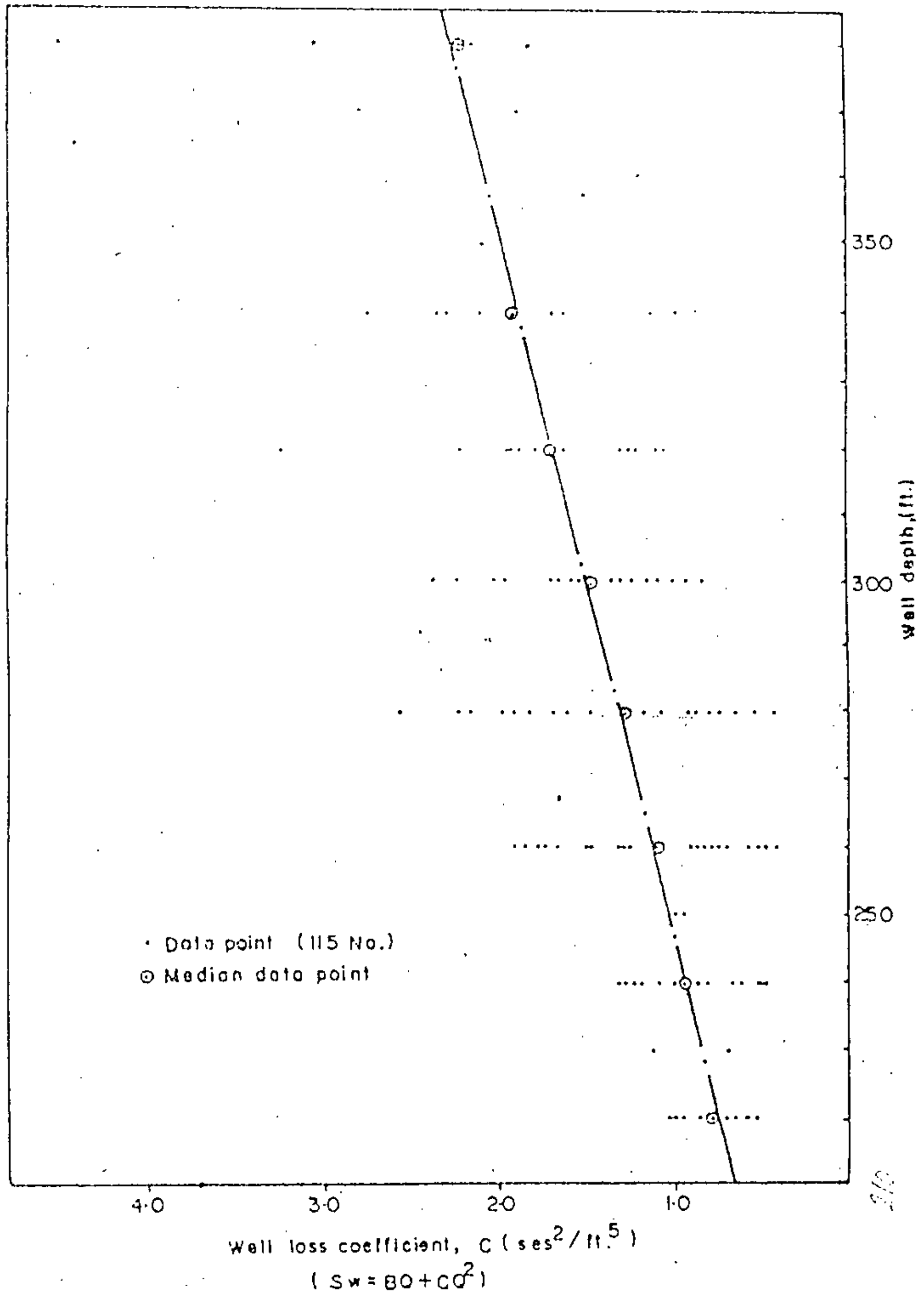
And from the slope of the line in Figure 2.15, n=0.0134.

This is somewhat rougher than the n value that would be expected for uncut, GRP pipe formed on a polished mandrel where the value would be 0.009 . The difference reflects both the roughening effect of the cut slots and the turbulence induced by ' jets ' entering the flow at right angles through slots .

A few calculations, however , show that the significance of these numbers is enormous . It is clear that the great majority of the total loss is upflow loss inside the well and that the true entry loss is insignificant .

Figure 2.15

Well Loss: Depth Relationships



If all results where C is less than about 1.0 are ignored, the loss/depth line changes so that it has an intercept of C = 1.0 at 210 ft depth and a slope such that n = 0.0116. It is unlikely that n could be much lower, this value being only 29% higher than the best value for uncut pipe. A value of n = 0.0116 also comes closest to reproducing entry losses which are equal for all well depths, as they should be for constant screen length, diameter and discharge rate. In terms of the fps units of the analysis, entry loss is estimated to be $0.143Q^2$ ft or 0.57 feet (a value that compares well with 0.2 to $0.25Q^2$ for 8 inch wells in North-west Bangladesh). Entry loss may thus be only 7 to 14% of total well losses with 6 inch screens!

The consequences of these evaluations are considerable. If entry losses were assumed to be proportional to approach flow velocity, then total well losses could be expressed (in fps units)as :

$$\text{Loss} = \frac{8.58\, Q^2}{L_s D}\ (\text{entry}) + \frac{1.325\, Q^2 n^2 L_t}{D^{16/3}}\ (\text{Upflow}) \qquad (2.20)$$

2.3.1.5 Calculation of Entry loss of the Wells.

According to the following equation (William, E.B. 1981) the entry losses of the DTWS could be determined :

" The Screen is commonly visualized as a series of orifices through which the flow 'Jets' into the well, with transformation of potential energy to kinetic energy". Head loss across the orifices is given by

$$h_1 = \left(\frac{1}{Cv^2} - 1 \right) \frac{Ve^2}{2g} . \qquad (2.21)$$

Where, h_1 = head loss

C_v = Co-efficient of velocity

V_e = Screen entrance velocity, and

g = gravitational constant

2.3.2 FACTORS AFFECTING THE WELL-LOSS

Since the water coming out from the well initiates movement through the aquifer and then flows through the developed zone or the gravel-pack, screen-openings and intake section of the well,the factors contributing well-losses can be grouped into two classes. One class comprises those factors associated with the Aquifer-characteristics; and the other class consists of the factors concerned with the well characteristics.

The Aquifer-Characteristics have indirect but dominating impact on the well-Characteristics. As a result, the Aquifer Characteristics had also been taken into properconsideration, during the analysis of the factors affecting the well-loss. So, the related factors may be described as follows:

A. <u>The factors associated with the Aquifer characteristics</u> :

(1) <u>The size, uniformity and arrangement of soil particles of the formation</u>

The grain-size distribution, grain shape and grading of the particles determined the permeabilities of the formation which was indicated the amount of water that could flow through it. Depending on this, the size,length and the location of the strainer in the aquifer were determined which in turn dictated the total depth and the structure of the well. Thus the above factor affected the well-losses .

(2) Formation thickness and permeability

The screenable formation thickness and the permeability, affected the ability of the aquifer to transmit water and thus regulated the size of the slot and the length of the strainer which in turn influences the loss of wells.

(3) The presence of confining beds:

The presence of confining layers/beds affected the storage Co-efficient and the design of the well intakestructure and the performance of the aquifer under the pumping conditions. Thus influences the entry losses and upflow losses of the well.

(4) The degree of consolidation of the formation :

During the construction of the well, a certain degree of compaction of the formation and the reduction of permeability were made due to the jarring action of tools, driving of casings, sealing of borehole-face by viscous drilling fluid and peretration of fine sand and silt from the drilling fluid into the porous materials.

The above action affected the selection of well-casing and screen materials, and thus influence the well-losses of the wells.

(5) The chemical composition of formation materials and ground water :

This factor affects the potential for encrustation and corrosion in the well and thus influenced the well-loss of the DTWS.

A. The factors concerned with the Well-characteristics :

1. Well - site Selection :

Several points, such as accessibility, topography, soil texture & structure, annual fluctuation of ground water levels, geohydrology of the under-ground, existing irrigation facilities etc. were considered during the selection of a DTW site. If the location of one DTW selected within the zone of influence of another DTW, then the drawdown of both the DTWs become very high and thus affected the aquifer loss as well as the well-loss of the DTWs.

2. Well drilling method :

Since the drilling technique, collection of samples, description of samples and the procedure of selecting the proper samples, changes with the method of drilling applied to a particular well, the extent of well-loss also varies accordingly. The individual impact of these factors are as follows.

(i) Drilling Technique :

The technique of drilling a DTW affects the accuracy of the collection and classification of samples, plumbness (verticality), alignment(adherence to a straight line), and maximum yield. Thus influenced the loss of wells.

(ii) Sample collection :

Since the formation sampling was the major source of informations required to determine the underground strata on the basis of which the DTW was designed, the procedure of collection of the sample affects the well-loss.

(iii) Sample descriptions:

The accurate descriptions of the formation samples were very inportant for the successful design of a DTW. The descriptions of the sample include it's colour, type,size,shape and sortings of the grain-size. Depending on which samples are classified as screenable or unscreenable formation and thus dictated the structure of the well.

(iv) Sample Selection :

The proper selection of samples mainly depends on the accuracy with which the formation particles were described. Comparatively well-sorted formation particles having higher permeabilities usually considered as the best sample for screening the aquifer. Less-permeable to impermeable portions of the aquifer were selected as unscreenable portion of the aquifer. This selection of screenable and unscreenable aquifers influenced the configuration of the well and thus affected the loss of wells.

3. Components of well casing:

The arrengement of the components of the well influenced the well-losses of the well due to the friction between the rising water and the LWC.

4. Materials of well casing :

The selection of materials required for the UWC,LWC and reducer,depends on the factors,such as,(i) strength requirements(ii) quality of water, & (iii) potential presence of detrimental bacteria. A properly selected well casing prevents collapse of the hole,entry of undesirable water & escape of good water from the well, and capable of withstanding corrosive action. Materials selected for well-screen should be resistant to corrossion & encrustation and strong enough to withstand column load (vertical compression), tensile load(extending forces) and collapse pressure (horizontal forces). Thus the effectiveness of the well depends on the materials of well-casing.

(5) Design of Well :

The design of a well consists of the design of mainly three essential components;

Namely,(i) a pump housing-section (UWC),(ii) a vertical conduit (casing), and an intake (screen or perforation)section.

(i) Design of Upper-well casing:

An optimal housing-section of a well provides adequate clearance for the pump and minimum frictional losses and thus influenced well-losses.

(ii) Design of lower-well casing:

The lower well-casing serves as a vertical conduit between the well screen and the pump housing (and in some cases between the screens) through which water travels from the intake (screen or perforation) to the pump housing. Since the majority of the total well-loss generally caused due to the " upflow-losses" inside the well, the length and diameter of the lower-well casing greatly influenced the loss of the wells.

(iii) Design of strainer :

A properly designed strainer having optimum entrance velocity, length, diameter, slot-openings, transmitting capacity, strength and resistance to corrosion and encrustation-ensures hydraulically efficient & sand-free performances. A major portion of the well-loss occurred due to the well-screen losses which consist of:

(i) Loss of pressure head at the entrance due to size and shape

(ii) Loss of head attributed to the turbulence of water in passing from the formation to inside the well screen.

(iii) Loss inside the well screen due to turbulence

(iv) Loss of head due to partial perforations.

(v) Loss of head due to pertial penetration

(vi) Loss of head due to entrance (entrance losses).

The entrance velocity,length,diameter,slot-openings,and the transmitting capacity of the strainer-seriously influenced the well-losses of the DTWS. The effectivenes of those parameters are as follows:

(a) Entrance Velocity :

Entrance velocity regulates transport of aquifer material, friction-loss in the screen openings and rate of encrustation and corrosion. Thus influenced the well-losses.

(b) Length of Strainer :

Length of the strainer depends on the thickness & permeabilities of the aquifer,entrance velocities,effective open areas and the discharge of the DTW. It affects entry losses as well as the upflow losses.

(c) Diameter of the strainer:

Diameter of a screen provides sufficient open area to maintain desired entrance velocity. It influences the entry losses and upflow losses.

(d) Screen slot opening :

An over-sized slot causes sand-pumping while an under-sized slot offers resistance to the flow of ground water,resulting in more head losses. An optimum slot size provides sand-free discharge with minimum head loss, by matching the opening with the grain size distribution of the materials surrounding the screen. Thus affects the well-losses.

(e) Transmitting Capacity :

Transmitting capacity of a screen refers to the amount of flow passing through the slot openings at an entrance velocity causing loss of head, and thus influences the well-losses.

6. Installation of Well-Casings:

Installation of well casings refers to the fitting & fixing of the well components (bail plug, screen, blind pipe, reducer & housing pipe), placing of well components in the bore-hole, and an effective gravel packings. Despite a perfect well-design and the use of the best components, an improper installation adversely affects the well-loss as well as the performance of the well.

(i) Verticality :

Verticality affects the frictional-loss and the turbulence within the well, and thus influences the loss of well.

(ii) Straightness:

Straightness influences the friction-loss and the turbulence within the well, and thus affects the loss of wells.

(iii) Gravel Pack :

An effective gravel packing reduced the well-loss by

- increasing the transmitting capacity
- offering the potential of increased screen slot-size and the well.
- increasing the area of contact between the aquifer and the well.
- increasing the effective diameter of the well.
- reducing the entrace velocity of water into the well.
- reducing the entrance friction and excessive head-loss.
- reducing the potential of encrustation.
- preventing the caving-in of the formation material and thus reducing the danger of clogging of the screen.
- providing the sand control.
- increasing the potential of the use of smaller diameter screen.
- increasing the permeabilities around the screen.

7. Well Development :

A successful well-development refers to a sand-free pumping with lowest possible specific-drawdown. A proper well development minimizes the well-losses by -

- increasing the porosity and permeability of the aquifer adjacent to the screen.

- removing the drilling fluid from the well.
- cleaning the inside of the well and the pores of the gravel packs and immediate aquifer.
- breaking down the mud-film formed on the wall of the bore-hole during drilling.
- facilitating the steady flow of water into the well and thereby increasing the effective redius of the screen.
- minimizing entrance friction and excessive head-loss.
- Stabilizing the gravel packs and assisting in grading the filter materials to prevent the further entry of aquifer materials into the well.

2.3.3 FIELD STUDIES ON WELL-LOSS IN BANGLADESH

The available reference studies made on the well-loss of deep tubewells in our country given below.

2.3.3.1 Well-loss of BADC deeptubewells in Greater mymensingh district.

In the year 1982, some studies on the well-losses were carried out in association with Sir MacDonald, M. and Partners ltd. and H.T.S ltd. The DTWs under study were constructed under a turnkey-type of contract by Milner's Tubewells Ltd, in the Greater District of Mymensingh. It was stated that:

"The wells have either 24 or 27m of (355mm) 14-inch internal diameter pump chamber or upper-well casing. Lower casing/screen (GRP) strings are generally 6-inch internal diameter,withscreen lengths varying from 34 to 40m but commonly 37m (120 ft)in a total well depth ranging from 67 to 120m but averaging about 85m. Those DTWs were probably deeper than was necessary."

The well-losses were analysed by using Jacob (1947)assumptions:

Well drawdown=aquifer drawdown + well-losses

Or, $S_{iw} = C_f Q + C_w Q^2$

Where, S_{iw} = drawdown in the well,m.

Q = discharge, in m^3/day.

C_f = formation loss co-efficient d/m^2

C_w = Well-loss co-efficient, d^2/m^5

The test Result of the DTWs under study were summerised in the table 2.4

The study was concluded with the following finding:

(i) The well-loss co-efficient increased linearly with the length of screen and casing string.

(ii) Entry losses may be only 7 to 14% of the total well-losses with 6-inch screens.

(iii) The use of 6 inch (152mm)-diameter screen was completely wrong, considering the higher well-losses.

TABLE - 2.4 WELL-LOSSES OF THE DTWS CONSTRUCTED IN THE GREATER DISTRICT OF MYMENSINGH

Sl. No.	Name of thana	Well Nr.	Depth (m)	Screen(m)		Formation-losses co-efficient, d/m^2	Well-loss Co-efficient, d^2/m^5	Formation loss (m)	Well-loss m	Well efficency
				Length	Depth - interval					
1	2	3	4	5	6	7	8	9	10	11
1.	Muktagacha	Mu 60	73	37	33-70	18.6×10^{-4}	5.09×10^{-8}	9.10	1.20	88%
		Mu 2	85	37	37-82 *	7.5×10^{-4}	6.77×10^{-8}	3.66	1.60	69.5%
		Mu 18	79	37	40-76 *	14.3×10^{-4}	6.72×10^{-8}	7.00	1.60	81.0%
		Mu 38	79	37	40-76 *	10.1×10^{-4}	6.87×10^{-8}	4.94	1.62	75 %
2.	Phulpur	Ph 76	98	37	52-95 *	9.6×10^{-4}	8.30×10^{-8}	4.69	1.98	70 %
		Ph 25	91	34	43-88 *	5.4×10^{-4}	12.37×10^{-8}	2.64	2.94	47 %
		Ph 102	67	37	27-64	3.7×10^{-4}	3.46×10^{-8}	1.81	0.81	69 %
3.	Haluaghat	Ha 31	100	37	69-97 *	7.5×10^{-4}	10.18×10^{-8}	3.66	2.41	60 %
		Ha 35	73	37	33-70	9.6×10^{-4}	6.98×10^{-8}	4.69	1.65	73 %
		Ha 16	67	37	27-64	4.0×10^{-4}	5.30×10^{-8}	1.95	1.26	51 %
4.	Shakhipur	Sa 3	77	37	37-74	2.5×10^{-4}	9.32×10^{-8}	1.22	2.22	35 %
		Sa 44	86	37	46-83	10.6×10^{-4}	4.79×10^{-8}	5.18	1.12	82 %
		Sa 43	79	30	27-73 *	4.4×10^{-4}	3.82×10^{-8}	2.15	0.91	70 %

* The exact depth interval was not shown.

2.3.3.2 Study on the well-loss of (ADB/UNDP) Second deeptubewell Project of BADC

Under the above project some studies on the well-losses of the DTWs sunk at Thana Basail & Shakhipur of Tangail District and Muktagacha Thana of Mymensingh District were conducted in association with MacDonald and Partners & HTS Ltd. The studies were carried out during 1982 to 1983. Fig. 2.16 shows the lithological and constructional details of the three DTWS chosen by the consultants for testing together with the location of samples recovered by a split-spoon sampling device. Step draw-down test data of the DTWS were used to determine the well-losses using equ. (2.7) & (2.8)

The formation - loss co-efficients (C_f) and the well-loss co-efficients (C_w) were determined by plotting the values of specific drawdown ($\frac{S}{Q}$) versus discharge (Q) as shown in fig 2.17 . The Test Results were given in the Table 2.5.

TABLE- 2.5 WELL-LOSSES OF THE DTWS CONSTRUCTED AT BASAIL, SHAKHIPUR AND MUKTAGACHA

Sl. No.	Thana	Formation-loss co-efficient ft^{-2}-Sec	Well-loss co-efficient ft^{-5}-Sec^2	Formation loss (ft)	Well loss (ft)	Well efficiency
1	2	3	4	5	6	7
1.	Basail	2.85	1.20	5.7	4.8	54%
2.	Shakhipur	8.15	1.31	16.3	5.24	75%
3.	Muktagacha	10.00	1.25	20.0	5.00	80%

Borelogs of DTWs Where Step Pumping Tests Were Carried Out (Consultants Logging)

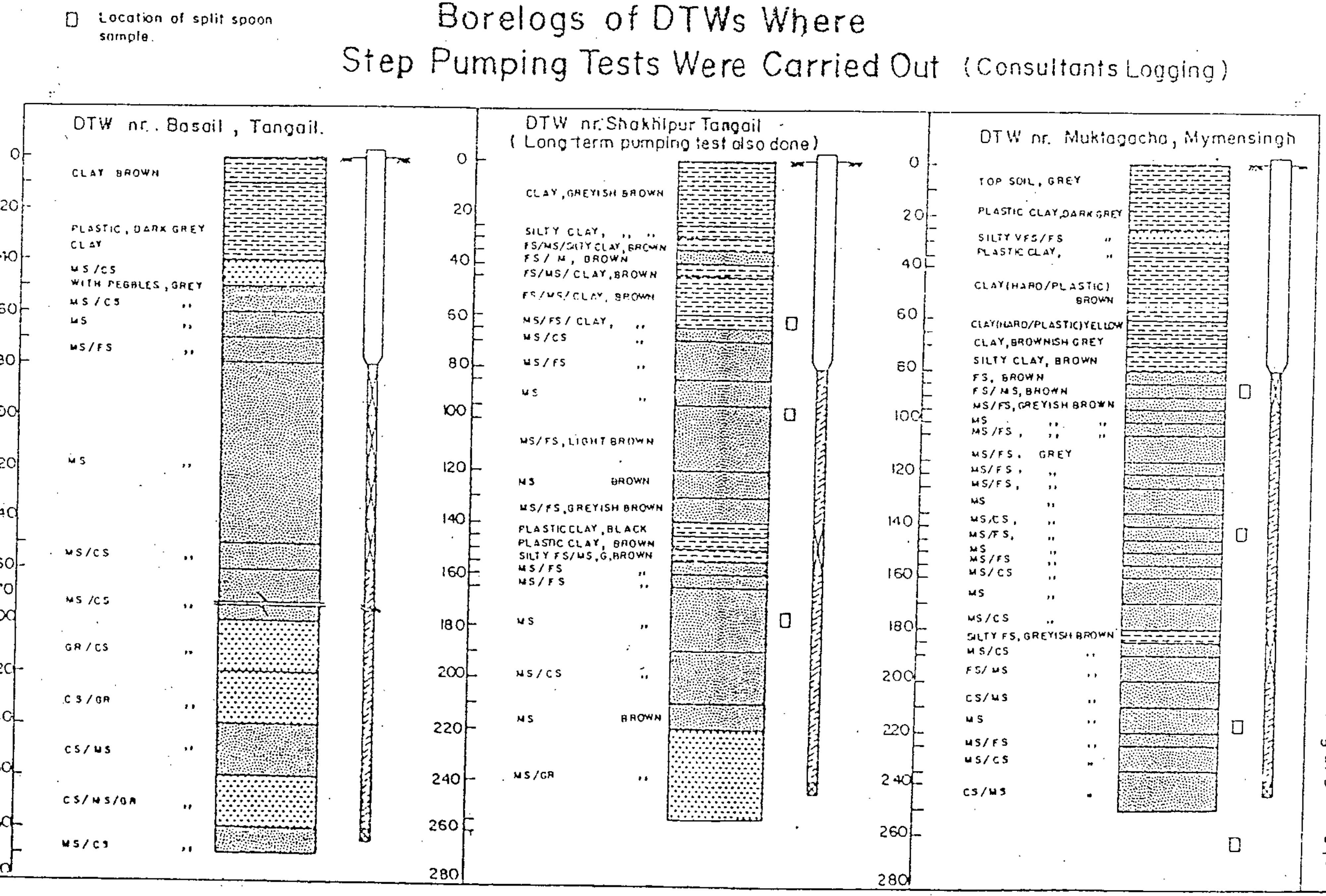
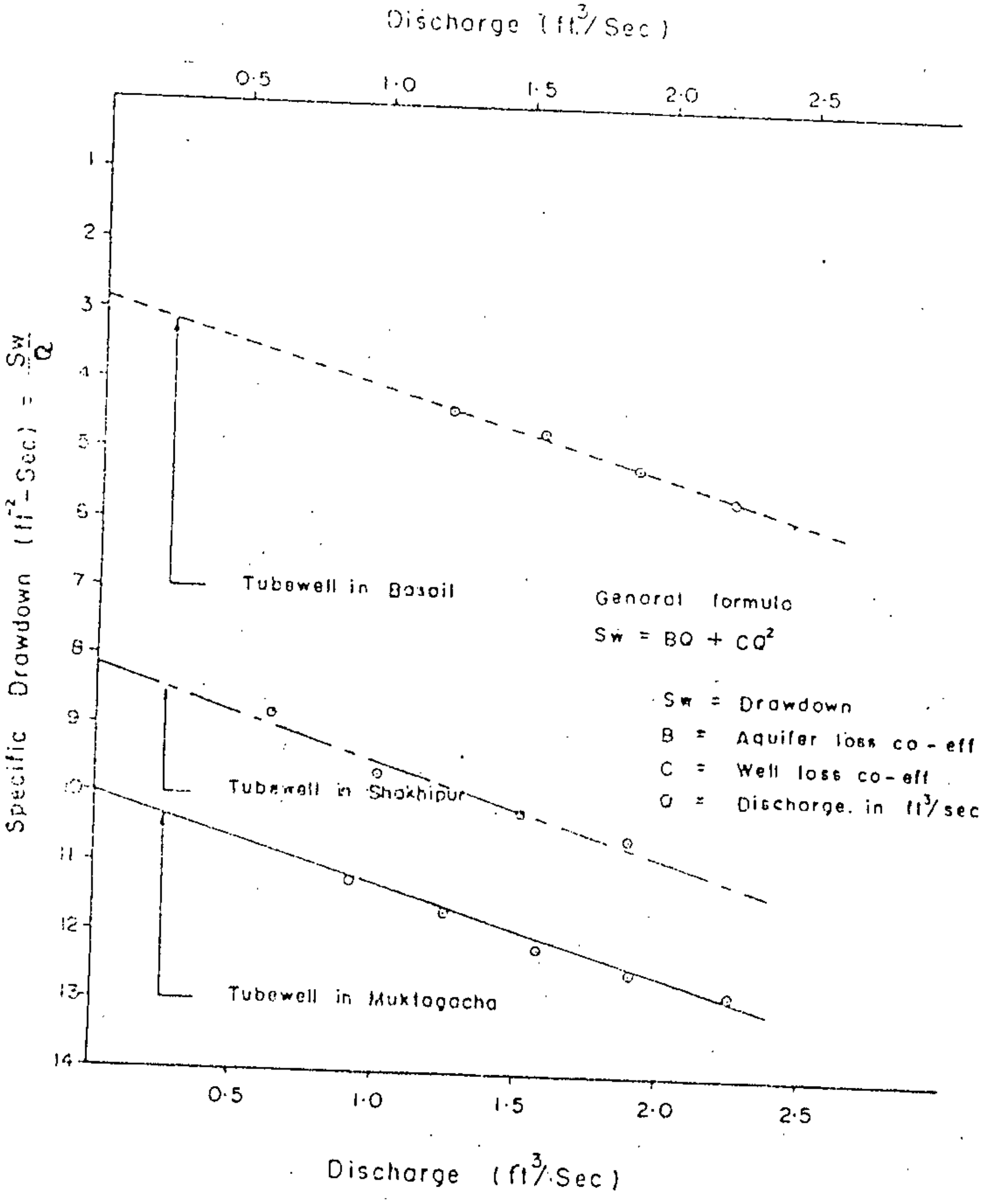


Figure - 2.16

Figure 2.17

Determination of Well Losses



	Basail (Flood plain)	Shakhipur (Madhupur)	Muktagacha (Mymensingh trough)
B =	2.85 ft^{-2} - Sec	8.15 ft^{-2} - Sec	10.0 ft^{-2} - Sec
C =	1.20 ft^{-5} - Sec^2	1.31 ft^{-5} - Sec^2	1.25 ft^{-5} - Sec^2
U.W.C. =	80 ft.	80 ft.	80 ft.
Total well depth =	230 ft.	250 ft.	250 ft.

2.3.3.3 Study on the Well-loss of (ODA/IDA) DTW Project of BADC

In order to ensure the construction of the 2-cusec DTWS having 5 to 10 ft/cusec specific drawdown, several studies were made by the above project in association with the MecDonald, M. and partner Ltd and HTS Ltd. The outcome of the studies were noted as follows:

(i) The well-losses composed of losses due to the entry of water through the gravel pack and screen, and its change in the direction of flow from horizontal (in the aquifer) to vertical (in the lower well casing). In addition, further well-loss was caused by the friction between the rising water and the LWC and the screen. Therefore, by reducing those losses, a decrease in the value of specific drawdown can be achieved.

(ii) Theoretical calculations on the flow of water inside the screen and LWC indicated that by increasing the diameter of the LWC and Screen, a considerable savings in well-loss can be achieved.

(iii) It was recommended that the top 40% of the LWC be increased in diameter to 203mm (8"-inch), whilst the lower 60% remains at 152mm (6"-inch) in diameter. This increaso in diameter of the upper part of the LWC will assist in reducing the up-flow losses, and thus produce a more efficient well.

2.3.3.4 Well-loss studies by BADC in Greater Sylhet Districts.

In the greater Sylhet district, studies on the well-losses were made by BADC in association with MacDonald, M. and Partners Ltd. and HTS Ltd and EPC Ltd., and the results were given in the table-2.6. Step drawdown tests were carried out to determine the well-losses using the graphical solution of equ. (2.8)

At the end of the study, the following comments were made:

(i) Many of the tubewells were hydraulically inefficient when pumping at 2-cusec.

(ii) The causes of large well-losses were not certain but probably relate to the use of all 6-inch diameter lower well components and perhaps more importantly, to the difficulty of developing deep silty aquifers by over pumping and back-washing.

(iii) Development of bore-hole drilled by direct circulation (as opposed to reverse circulation) was likely to be more difficult because formation damage was greater.

TABLE - 2.6 WELL-LOSSES OF THE DTWS CONSTRUCTED IN THE GREATER SYLHET DIST.

Sl. No.	Upazilla	Mouza	Date of Step Test	No. of Steps	Formation co-eff. C_f m/1/s	Well-loss co-effi. C_w	Formation loss m	Well-loss m	Efficiency
1	2	3	4	5	6	7	8	9	10
1.	Jaganathpur	Jatrapasha	26-Jan-88	5	0.152	0.0019	8.512	5.95	59 %
2.	Biswanath	Singerkach	10-Jan-88	4	0.259	0.0012	14.50	3.76	79 %
3.	Sylhet	Hassanpur	14-May-85	5	0.108	0.0016	6.048	5.017	55 %
4.	Gowainghat	Uparhatlihai	10-Apr-86	4	0.285	0.0017	15.96	5.33	75 %
5.	Kanairghat	Durgapur	04-Dec-88	5	0.159	0.0010	8.904	3.13	73 %
6.	Zakiganj	Kazalsar	08-Apr-88	4	0.120	0.0018	6.72	5.64	54 %
7.	Beanibazar	Alipur	16-Feb-88	4	0.312	0.0022	17.47	6.89	71 %
8.	Golapganj	Tikorpara	03-May-86	3	0.335	0.0045	18.76	14.11	57 %
9.	Kulaura	Hajipur	10-Apr-88	4	0.340	0.0045	19.04	14.11	57 %
10.	Moulvibazar	Barbag	21-Apr-87	2	0.360	0.0010	20.16	3.13	86 %
11.	Lakhai	Zarunda	08-Mar-86	5	0.150	0.0033	8.4	10.34	45 %

CHAPTER - III

RESEARCH METHODOLOGY

From the last sixteen years of field experience, it is stated that BADC engineers and DTW-drillers have often shown much more keen interest to the maximum volume of water coming out from the well,rather than giving proper importance to the effect of the "total-lift requirement" of the well. The concerned farmers also feel very proud and happy to see the discharge during the step-drawdown test. Moreover the step-drawdown test was done usually at a stretch for a long time, which reflects the actual performance of the well much better than any other test. As a result, a heavy emphasis has always been given on the step-drawdown test which makes the data comparatively more dependable for research work.

As the success of a research-work mainly depends on the quantity, quality & reliability of the desired data and the methodology adopted, the step-drawdown test data of BADC DTWs were chosen to determine the well-losses.

3.1 METHODOLOGY ADOPTED

Five Deep Tubewells, one from each of the thana Nandail, Phulbari & Bhaluka of district Mymensingh, one from Nabinagar of B.Baria & one from Daudkandi of Comilla ,were selected randomly from among the DTWs having comparatively higher drawdowns for evaluating the well-losses. All of the five DTWs were constructed under IDA-II DTW project. The multiple-step drawdown test data of the DTWs were used to determine the well-losses.

The well-loss was calculated by using the relevant part (well loss) of equ. (2.1) i.e.

$S_w = C_w Q^n$ Where, S_w = Well-loss, in m.

C_w = Well-loss Co-efficient, d^2/m^5

Q = Discharge, in m^3/day.

n = Exponent due to turbulence.

The value of the well-loss Co-efficient C_w was determined using step drawdown test data by Rorabaugh graphical procedure as outlined in article No. 2.3.1.1 The well-losses and formation-losses were calculated by using the equation (2.1).

After evaluating the well-losses, the factors affecting the well-losses were determined from the well-characteristics and the aquifer-characteristics which were found out from the relevant data of the tubewell design & constructional details, bore-logs & development records.

From the above study, recommendations were made for minimising the well-loss.

3.2 SELECTION OF PROJECT FOR EVALUATION

During the last 25 yrs, BADC has undertaken so many DTW projects like NWRDP (North West Rural Development Project), SFD (Saudi Fund for Development), ADB (Asian Development Bank), SSISP (Small scale Irrigation Sector Project), IDA (International Development Association Project)-I, IDA-II, DTW Phase-I, DTW Phase-II, DTW Phase-III, DTW Phase-IV Projects, BIADP (Barind Integrated Area Development Project) etc. Out of these Projects, IDA-II DTW Project was selected for the present study.

3.2.1 Reasons for Selecting the Project:

The following points were considered in selecting the project:

(i) Comparatively dependable and reliable data of tube-well design & constructional details, bore-log, development & testings were available.

(ii) The project envisaged almost all aspects of DTW constructions and preserved the relevant data with care.

(iii) Provisions for training to the BADC engineers and DTW supervisory staffs were made within the purview of the project. But no such provision was made in case of other DTW projects.

(iv) Some working papers (about 56 Nos) were published by the project on the different aspects of " ground water irrigation, Management, Monitoring & Evaluation" — which had enriched & updated our hydrogeological data as well as our technical knowledge.

Considering the above points, the project was selected keeping in mind that a higher value of well-loss of IDA-DTWs would indicate a much more higher value of well-loss prevailing in the comparatively less-cared DTW of other projects.

3.2.2 Brief descriptions of the project :

IDA-II Deep Tubewell project comprises of 60 (sixty) thanas of 11 (eleven) Districts (part of greater Mymensingh, Kishorganj, Dhaka & Comilla). The name of Districts and Thanas are given in Appendix-I. The project was designed by the IDA in 1982, for the commissioning of 4000 DTWs and to provide informations for the improvement of the design of wells.

3.3 COLLECTION OF DATA

In order to evaluate the well-losses, the multiple-step drawdown test data of the folowing 5(five) deeptubewells were collected from BADC and shown in Appendix-II.

(1) Well No.NAN-118
Mouza:Chandipesha
Thana:Nandail
Dist: Mymensingh.

(2) Well No.BHAL-110
Mouza: Shohal
Thana: Bhaluka
Dist: Mymensingh.

(3) Well No.PHUL-160
Mouza: Matichapur
Thana: Phulbari
Dist: Mymensingh.

(4) Well No. NA BI/R-27
Mouza: Shahabazpur
Thana: Nabinagar
Dist: B.Baria.

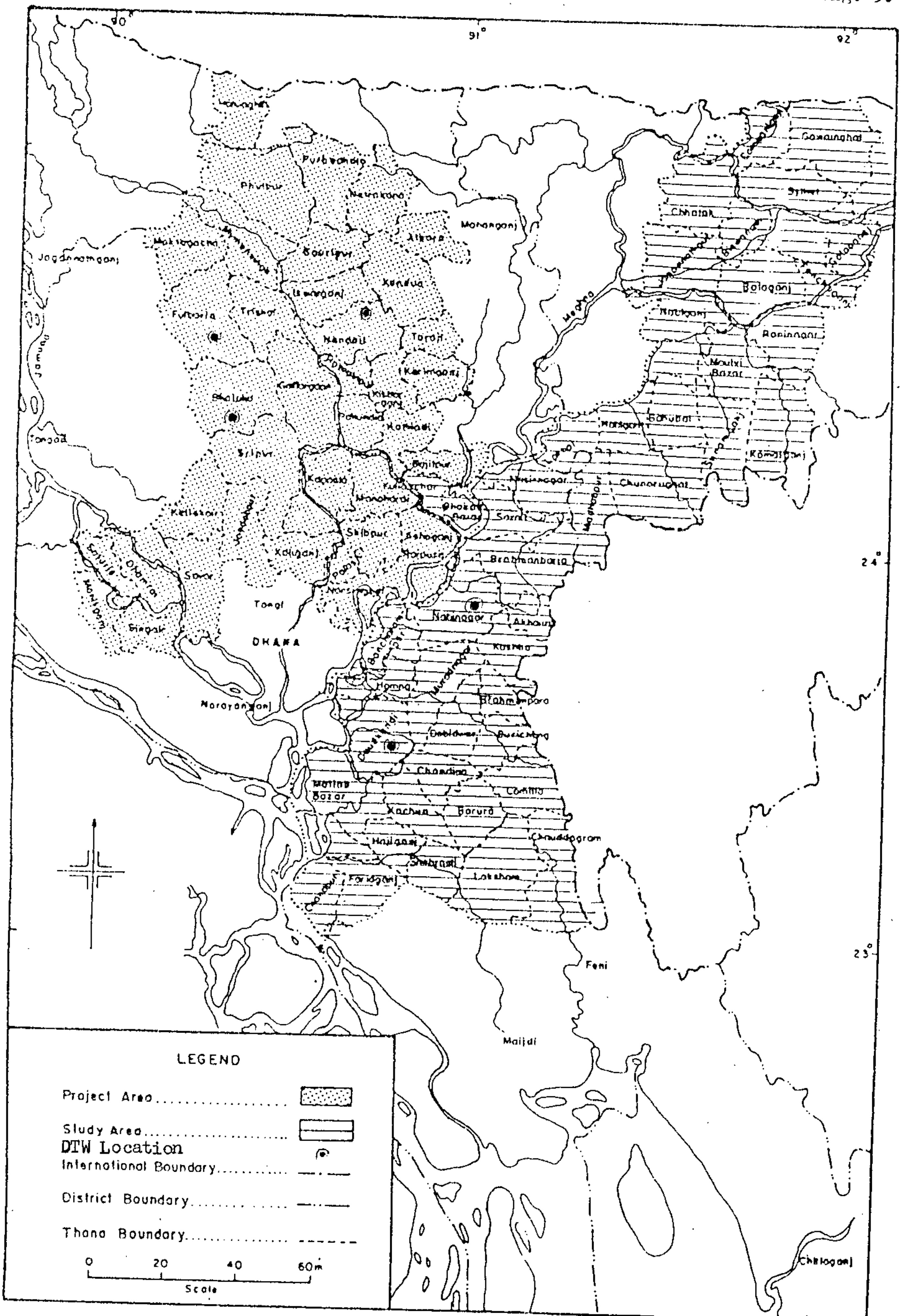
(5) Well No. DAUD-60
Mouza: Naogaon
Thana: Daudkandi
Dist: Comilla

To identify the impact of the factors affecting the well-loss, the relevant data of the well design & constructional details, bore-logs, development & testings of each of the above deeptubewells were collected from BADC and given in Appendix-II

The location of the DTWs under study shown in fig. 3.1

PROJECT LOCATION

Fig. 3.1



CHAPTER - IV

DESCRIPTIONS OF THE SELECTED DTWS AND THEIR WELL-LOSSES

The detail descriptions of the deeptubewells selected for the present Studies were given in Appendix-II. Only the salient features of the deep tubewells mentioned here. The well-losses of the DTWs were determined and the impact of the factors on the well-losses of the DTWS were also noted in this capter.

4.1 DESCRIPTIONS OF THE SELECTED DTWS:

The locations of the selected five DTWS were given in article 3.3. The detail design, construction, bore-log,verticality,development and pumping test record, and water quality test report of the DTWS - NO. NAN - 118, BHAL-110,PHUL-160,NABI-R/27 & DAUD-60 were shown in Appendix-II A (1-7), Appendix-II B (1-8), Appendix-II C (1-7), Appendix-II D (1-9), Appendix-II E (1-7) respectively.

The brief descriptions of the individual DTW described below:

1. DTW No. NAN - 118 :

This DTW was sunk by WJ method in a Leaky or semi-confined aquifer having 334 ft length, consist of 96 ft (14"-dia)UWC, 140'ft

(6"-inch dia)LWC and 90 ft 6"-inch dia(Continuous-slot type) screen. The effective grain-size of the screenable formation was CS/MS, the average permeability of which was 0.00215 ft/Sec. The depth of screenable formation was 102 ft. The EC and P^H of the water were 485mmhocm^{-1} and 7, respectively. The DTW was gravel packed and was deviated 1.81 inch from vertical and the specific drawdown was 20.86 ft/cusec. The screen was placed at single location. The slot-size was 1mm and the entrance velocity was 0.043 ft/Sec.

2. DTW NO. BHAL - 110

This DTW was sunk by WJ drilling method in a leaky or semi-confined aquifer having 459.25 ft length, consist of 112 ft UWC (14"-dia), 195 ft (8"-dia 70 ft and 6"-dia 125 ft) LWC and 144.33 ft (6"-dia) screen. The effective grain size of the screenable formation was MS/ CS, the average permeability of which 0.00124 ft/Sec. The depth of screenable formation 206 ft. The EC and P^H of the water were 380 mmho Cm^{-1} and 7, respectively. The DTW was gravel-packed and deviated 0.68 inch from the vertical and the specific drawdown was 33.20 ft/cusec. The screens were placed at three different locations. The slot-size 1 mm and the entrance velocity was 0.027 ft/Sec.

3. DTW NO. PHUL - 160 :

This DTW was sunk by RC drilling method in a leaky or semi-confined aquifer having 301 ft length, consist of 100 ft.(14"-dia)UWC 75 ft (6"-dia) LWC, and 118 ft (6"-dia) screens. The effective grain size of the screenable formation was MS and the average permeability of the which was 0.00176 ft/Sec. The depth of screenable formation was 145 ft. The EC and P^H of the water were 490 mmho cm^{-1} and 7, respectively. The DTW was gravel-packed and was deviated 2.75 inch from the vertical, and the specific drawdown was 15.41 ft/cusec. The slot size of the screen was 1 mm and the entrance velocity was 0.033 ft/Sec. The screens were placed at two different locations.

4. DTW NO. NABI- R/27 :

This DTW was sunk by WJ drilling method in a leaky or semiconfined aquifer, having 457 ft length, consist of 98 ft (14"-dia) UWC,210 ft (8"-dia 180 ft & 6"-dia 30 ft) LWC,and 140 ft (8"-dia-60 ft and 6"-dia 80 ft) screens (Placed at six different locations). The effective grain size of the screenable formation was MS/FS, the average permeability of which was 0.0011 ft/Sec. The depth of screenable formation was 226 ft. The EC and P^H of the water were 500 mmho cm^{-1} and 7, respectively. The DTW was gravel packed and was deviated 2.7 inch from the vertical. The specific drawdown was 23.45 ft/cusec. The slot-size was 1 mm and the entrance velocity was 0.024 ft/Sec.

5. DTW NO. DAUD-60 :

This DTW was sunk by WJ method in a leaky or semi-confined aquifer, having 299 ft string length, consists of 90 ft(14"-dia) UWC, 100 ft (8"-dia) LWC and 100 ft (8"-dia) screens (placed at two different locations). The effective grain-size of the screenable formation was MS, the average permeability of which was 0.00202 ft/Sec. The depth of screenable formation was 117 ft. The EC and P^H of the water were 625 mmho cm^{-1} and 7, respectively. The DTW was gravel-packed and was deviated 2.15 inch from the vertical. The specific drawdown was 19.16 ft/Cusec. The slot-size was 1 mm and the entrance velocity was 0.029 ft/ Sec.

4.2 DETERMINATION OF WELL-LOSSES OF THE DTWS :

The Well-loss of the DTWS under study were determined using the multiple-step drawdown test data (of the respective DTWS) by Jacob-Rorabaugh graphical procedure as mentioned in article 2.3.1.1. The calculations of the well-losses of the DTWS described as follows.

1. WELL-LOSS OF DTW NO. NAN - 118 :

The incremental discharges and corresponding drawdown of DTW NO.NAN-118 were recorded in Table-4.1. The value of well-loss co-efficient (C_w) was determined by plotting $(\frac{S_{iw}}{Q} - C_f)$ versus Q on double-logarithmic paper by assuming different values of C_f, until a straight line was obtained as shown fig-4.1. The slope of the straight line was equal to (n-1) which Yields the value of n=1.02. From fig.4.1 the value of C_f was obtained as 0.001. C_w was the intercept. The value of C_w , conveniently was determined using the value of C_f,n and a certain combination of the measured Q (4942.07 m^3/day) and S_{iw} (12.80m) in eqn. (2.1), which was, $C_w = 1.34 X 10^{-3}$.

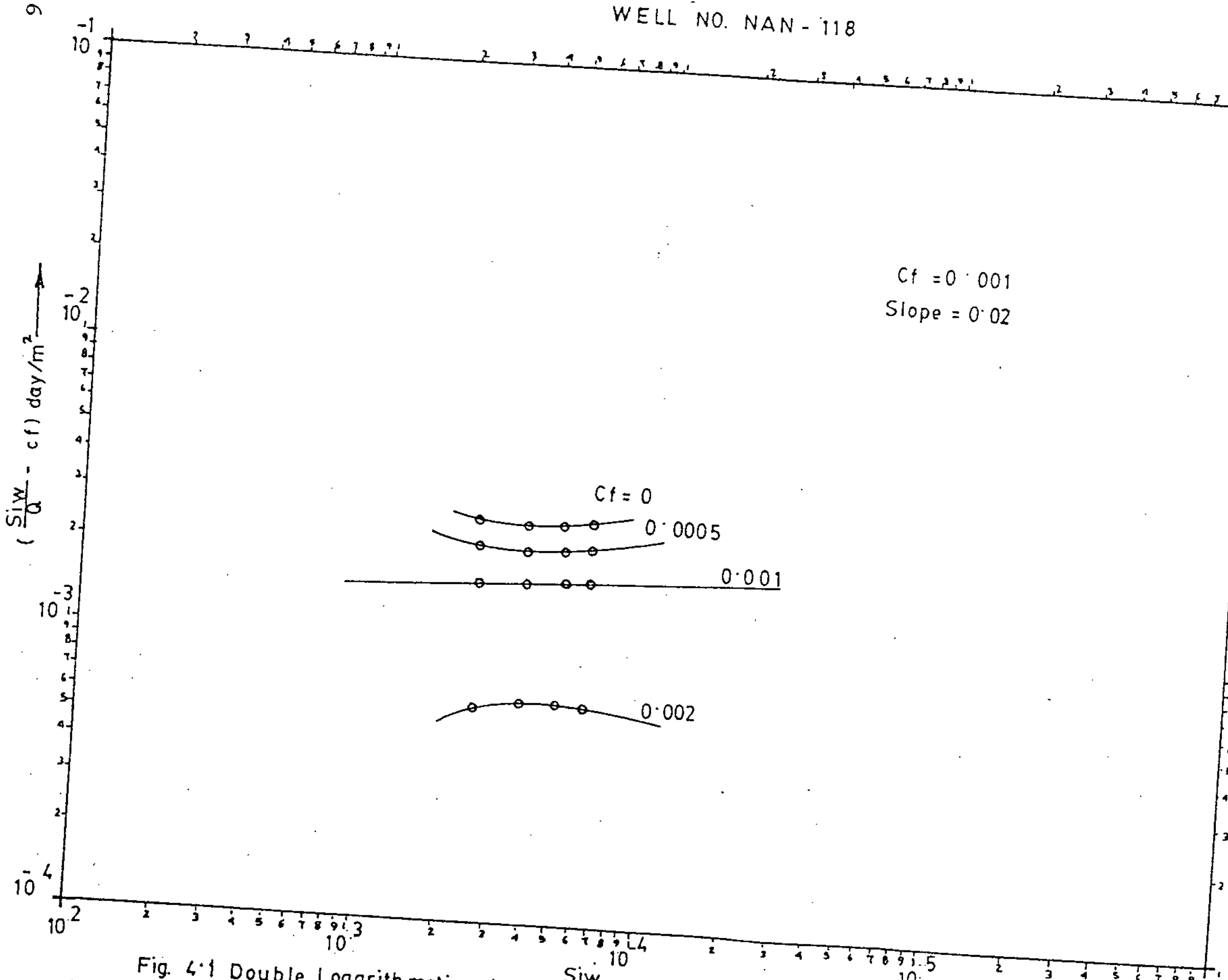


Fig. 4·1 Double Logarithmatic plot of$(\frac{Siw}{Q} - cf)$ Versus Q for different values of cf (on the curves) to obtain cf yielding straight line of DTW No. NAN-118

TABLE-4.1 DISCHARGE-DRAWDOWN DATA OF DTW NO.MN-118 TO FIND OUT THE VALUES OF C_f, C_w & n.

Q (Cusec) m^3/day	S_{iw} (ft) m	$\frac{S_{iw}}{Q}$ day/m^2	Cf day/m^2	$\left(\frac{S_{iw}}{Q} - C_f\right)$ day/m^2
(1.02Cusec) 2495.50	(21ft) 6.4 m	2.56×10^{-3}	0	0.00256
			0.0005	0.00206
			0.001	0.00156
			0.002	0.00056
(1.5 Cusec) 3669.86	(31.16 ft) 9.49 m	2.58×10^{-3}	0	0.00258
			0.0005	0.00208
			0.001	0.00158
			0.002	0.00058
(2.02 Cusec) 4942.07	(42 ft) 12.80 m	2.59×10^{-3}	0	0.00259
			0.0005	0.00209
			0.001	0.00159
			0.002	0.00059
(2.5 Cusec) 6116.43	(52.16 ft) 15.89 m	2.60×10^{-3}	0.	0.00260
			0.0005	0.00210
			0.001	0.00160
			0.002	0.00060

From figure 4.1, the values of Cf= 0.001 day/m^2

the slope = n-1 = 0.02 and n=1.02

$$S_{iw} = C_f Q + C_w Q^n$$

$$12.80 \text{ m} = 0.001 \times 4942.07 + C_w (4942.07)^{1.02}$$

$$= 4.95 \text{ m} + 1.34 \times 10^{-3} (5858.51) \text{ m}$$

$$= \underbrace{4.95\text{m}}_{\text{Formation loss}} + \underbrace{7.85 \text{ m}}_{\text{Well loss}}$$

$$\therefore \text{Well efficiency} = \frac{\text{Formation loss}}{S_{iw}} = \frac{4.95 \times 100}{12.80} = \boxed{38.67 \%}$$

The value of well-loss at the design capacity (2-cusec) of the well=7. 85m and formation loss = 4.95m. The efficiency of the well = 38% only.

2. WELL - LOSS OF DTW NO. BHAL - 110 :

The discharge-drawdown data of multiple step test of DTW NO. BHAL - 110 given in TABLE- 4.2.

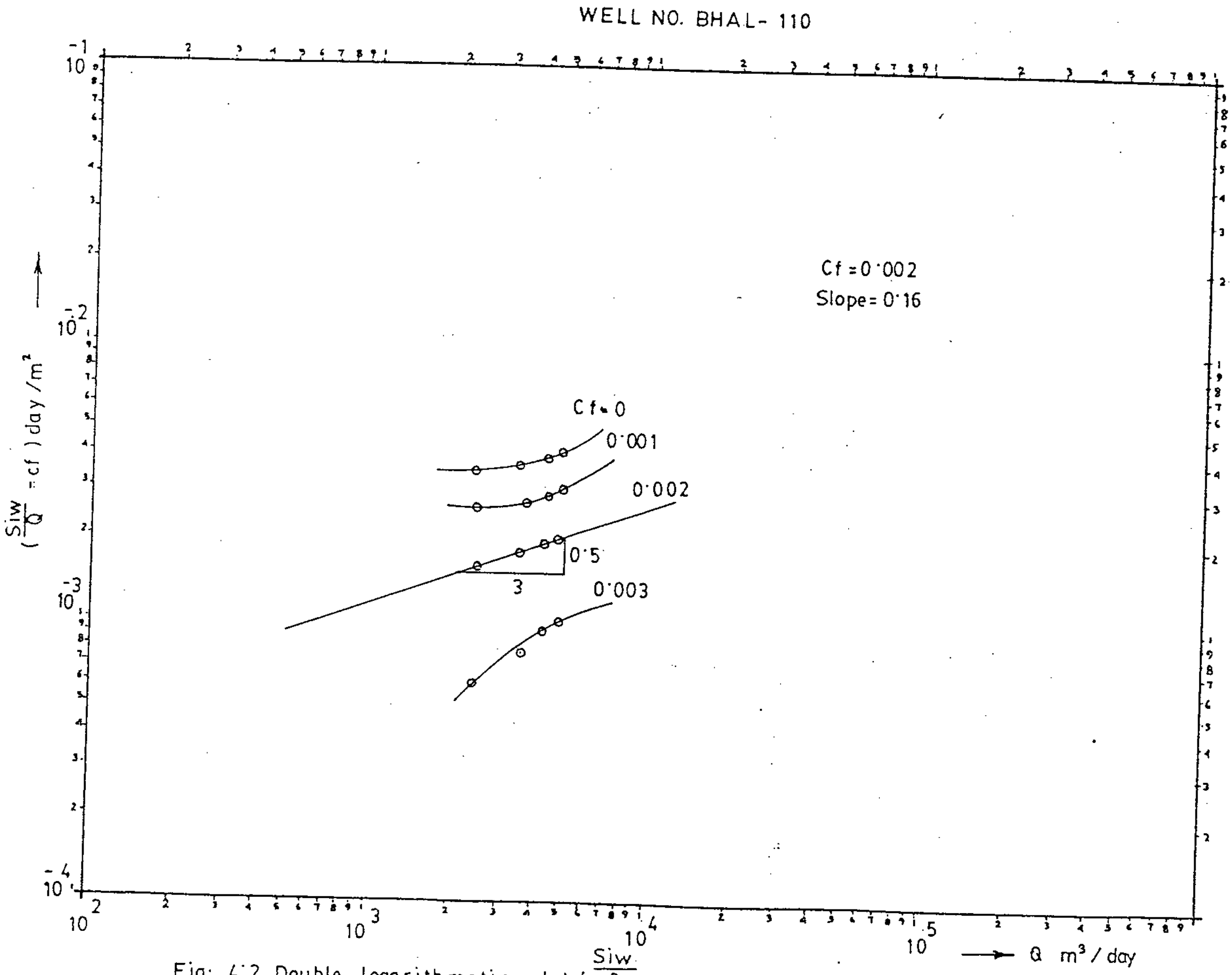
The value of well-loss at the design-capacity (2 cusec) of the well was calculated following the similar procedure as mentioned above. The values of C_f =0.002 and n=1.16 were obtained from fig. 4.2. The value of $C_W=5.29\times10^{-4}$ was calculated using the value of C_f, n and a certain combination of the measured Q (4893.68 m^3/day) and S_{iw} (19.88m) in equ.. (2.1)

The well loss = 10.089 m and the formation loss = 9.787 m and efficiency of the Well = 49%.

3. WELL-LOSS OF DTW NO. PHUL -160 :

The discharge-drawdown data of multiple-step test of DTW NO.PHUL -160 plotted in the TABLE- 4.3 .

The value of well-loss at the design-discharge (2 cusec) of the well was determined as stated before. The value of C_f=0.0008 and n=1.227 were obtained form the figure 4.3. The value of



Fig· 4·2 Double logarithmatic plot ($\frac{Siw}{Q}$ - cf) Versus Q for different values of cf (on the curves) to obtain cf yielding straight line of DTW No. BHAL-110

TABLE-4.2 DISCHARGE-DRAWDOWN DATA OF DTW NO.BHAL-110 TO FIND OUT THE VALUES OF C_f, C_w & n.

Q (Cusec) m^3 /day	S_{iw} (ft) m	$\frac{S_{iw}}{Q}$ day/m^2	Cf day/m^2	($\frac{S_{iw}}{Q}$ $-C_f$)day/m^2
(1.0)	(29'-0")			
2446.57	8.83m	$3.6X10^{-3}$	0	0.0036
			0.001	0.0026
			0.002	0.0016
			0.003	0.0006
(1.5)	(45.75)			
3669.85	13.94m	$3.79x10^{-3}$	0	0.00379
			0.001	0.00279
			0.002	0.00179
			0.003	0.00079
(1.75)	(55.67)			
4281.50	16.96m	$3.96x10^{-3}$	0	0.00396
			0.001	0.00296
			0.002	0.00196
			0.003	0.00096
(2.0)	(65.25)			
4893.14	19.88m	$4.06x10^{-3}$	0	0.00406
			0.001	0.00306
			0.002	0.00206
			0.003	0.00106
			0.004	0.00006

From figure 4.2, the values of C_f=0.002 day/m^2 and, the slope=n-1 = 0.16 and n=1.16

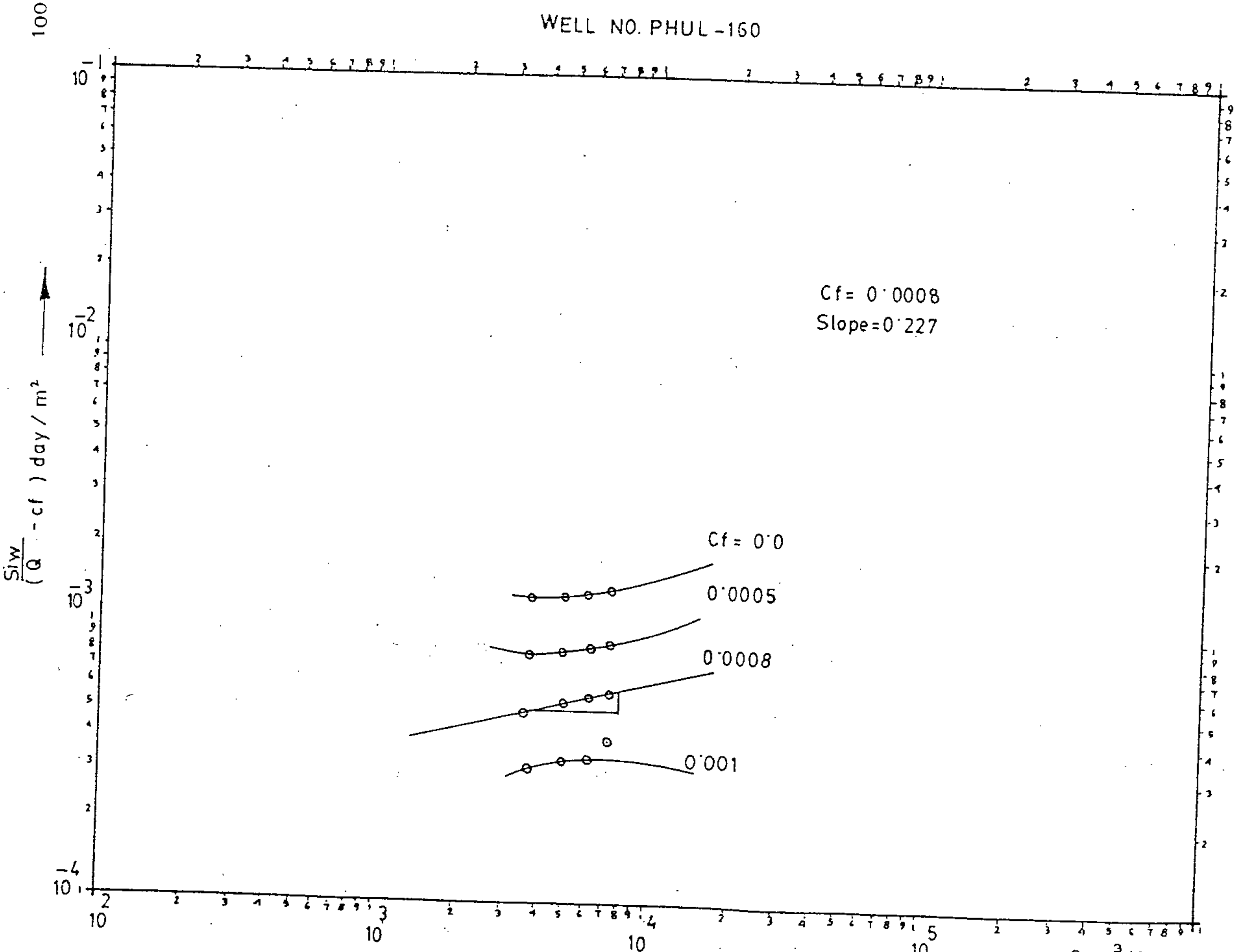
$S_{iw} = C_fQ + C_wQ^n$

19.88m = 0.002 x 4893.14 + C_w (4893.14) $^{1.16}$

= 9.786m + $5.29x10^{-4}$ (19051.17) m

= $\underset{\text{Formation loss}}{\underline{9.786m}}$ + $\underset{\text{Well-loss}}{\underline{10.094m}}$

$\therefore$ well efficiency = $\frac{9.786}{19.88}$ x 100 = 49.22 %



Fig· 4·3 Double logarithmatic plot of $\left(\frac{Siw}{Q} - cf\right)$ versus Q for different values of cf (on the curves) to ob-tain cf yielding straight line of DTW No. PHUL-160

TABLE-4.3 DISCHARGE-DRAWDOWN DATA OF DTW NO.PHUL-160 TO FIND OUT THE VALUES OF C_f, C_w & n .

Q (Cusec) m^3/day	S_{iw} (ft) m	$\frac{S_{iw}}{Q}$ day/m^2	C_f day/m^2	($\frac{S_{iw}}{Q}$ $-C_f$)day/m^2
(1.5) 3669.85	(15.83ft) 4.82m	$1.31x10^{-3}$	0	0.00131
			0.001	0.00031
			0.0005	0.00081
			0.0008	0.00051
(2.0) 4893.14	(21.5ft) 6.55m	$1.33x10^{-3}$	0	0.0013
			0.001	0.00033
			0.0005	0.00083
			0.0008	0.00053
(2.5) 6116.42	(27.37ft) 8.34m	$1.36x10^{-3}$	0	0.00136
			0.001	0.00036
			0.0008	0.00056
			0.0005	0.00086
(3.0) 7339.71	(33.5ft) 10.21m	$1.39x10^{-3}$	0	0.00139
			0.001	0.00039
			0.0008	0.00059
			0.0005	0.00089

From figure 4.3, the values of C_f = 0.0008 day/m^2

the slope = n-1 = 0.227 and n=1.227

$$S_{iw} = C_f Q + C_w Q^n$$

$$6.55m = 0.0008 (4893.14) + C_w (4893.14)^{1.227}$$

$$= 3.91 \text{ m} + 7.82 \times 10^{-5} (33660.769) \text{ m}$$

$$= \underset{\text{Formation Loss}}{\underline{3.91 \text{ m}}} + \underset{\text{Well loss}}{\underline{2.64 \text{ m}}}$$

$$\therefore \text{Well efficiency} = \frac{3.91}{6.55} \times 100 = \boxed{59.69\%}$$

$C_W = 7.82 \times 10^{-5}$ was calculated using the value of C_f, n and a certain combination of the measured Q (4893.68m^3/day) and S_{iw} (6.55m) in equ. (2.1)

The well-loss = 2.632 m and the formation loss = 3.91m and the efficiency of the well = 59.69%.

4. WELL-LOSS OF DTW NO. NABINAGAR-R/27

The discharge- drawdown data of multiple-step test of DTW No. NABINAGAR-R/27 entered in the TABLE-4.4.

The value of well-loss at the design-capacity (2-cusec) was calculated as outlined before. The value of C_f=0.0005 and n=1.17 were obtained from the figure 4.4. The value of $C_W = 4.34 \times 10^{-4}$ was calculated using the value of C_f, n and a certain combination of the measured Q(4893.68 m^3/day) and S_{iw} (11.45m) in equ. (2.1)

The well-loss=9.0 m and the formation-loss = 2.446 m and the efficiency of the DTW = 21%

5. WELL - LOSS OF DTW NO DAUD-60:

From the multiple-step drawdown test of the DTW NO.DAUD-60, the discharge-drawdown data plotted in the TABLE-4.5 .

At the design- capacity, the value of well-loss was calculated in the same procedure as outlined before. The value of C_f=0.0005 day/m^2 and n=1.07 were determined from the fig.4.5. The value of $C_W = 6.88 \times 10^{-4}$ was calculated using the value of C_f, n and a certain combination

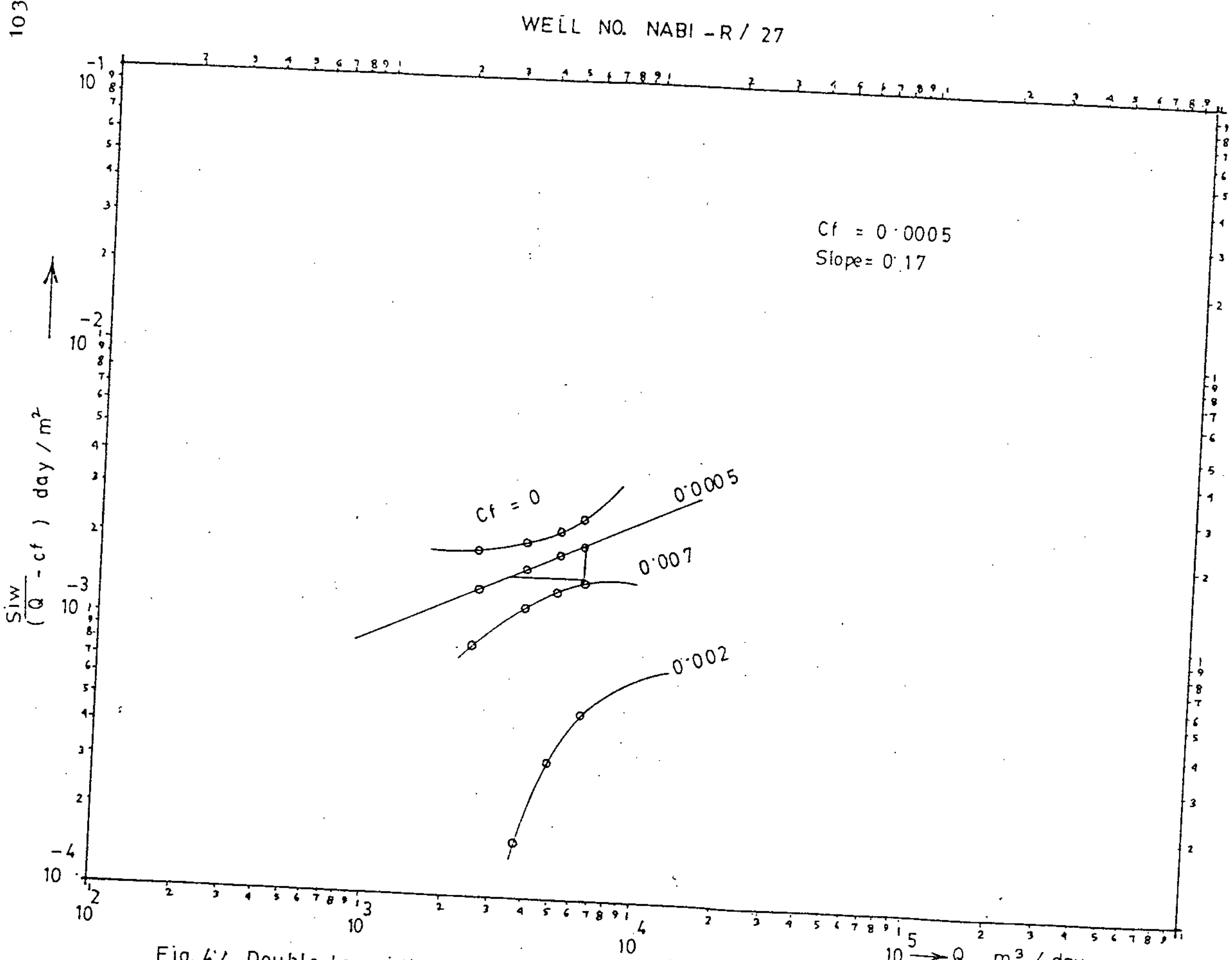


Fig. 4·4 Double logarithmatic plot (Q - cf) versus Q for different values of cf (on the curves) to obtain cf yielding straight line of DTW No. NABI-R/ 27.

TABLE-4.4 DISCHARGE-DRAWDOWN DATA OF DTW NO. R/27 TO FIND OUT THE VALUES OF C_f, C_w & n .

Q (Cusec) m^3 /day	S_{iw} (ft) m	$\frac{S_{iw}}{Q}$ day/m^2	C_f day/m^2	$(\frac{S_{iw}}{Q} - C_f)$day/m^2
(1 Cusec) 2446.57	(14.83ft) 4.52m	$1.84\text{x}10^{-3}$	0	0.00184
			0.0005	0.00134
			0.001	0.00084
(1.5 Cusec) 3669.85	(26.08ft) 7.94m	$2.16\text{x}10^{-3}$	0	0.00216
			0.0005	0.00166
			0.001	0.00116
			0.002	0.00016
(2Cusec) 4893.14	(37.58ft) 11.45m	$2.34\text{x}10^{-3}$	0	0.00234
			0.0005	0.00184
			0.001	0.00134
			0.002	0.00034
(2.5) 6116.42	(49.91) 15.21m	$2.48\text{x}10^{-3}$	0	0.00248
			0.0005	0.00198
			0.001	0.00148
			0.002	0.00048

From figure 4.4, the value of C_f = 0.0005 day/m^2 and ,
the slope = (n-1) = 0.17 and n= 1.17

$$S_{iw} = C_f Q + C_w Q^n$$

$$11.45\text{m} = 0.0005 \times 4893.14 + C_w \; (4893.14)^{1.17}$$

$$= 2.45\text{m} + 4.34 \times 10^{-4} \; (20740.42)$$

$$= \underset{\text{Formation loss}}{\underline{2.45\text{m}}} + \underset{\text{Well-loss}}{\underline{9.00 \text{ m}}}$$

$$\therefore \text{ Well- Efficiency} = \frac{2.45}{11.45} \times 100 = 21.39\%$$

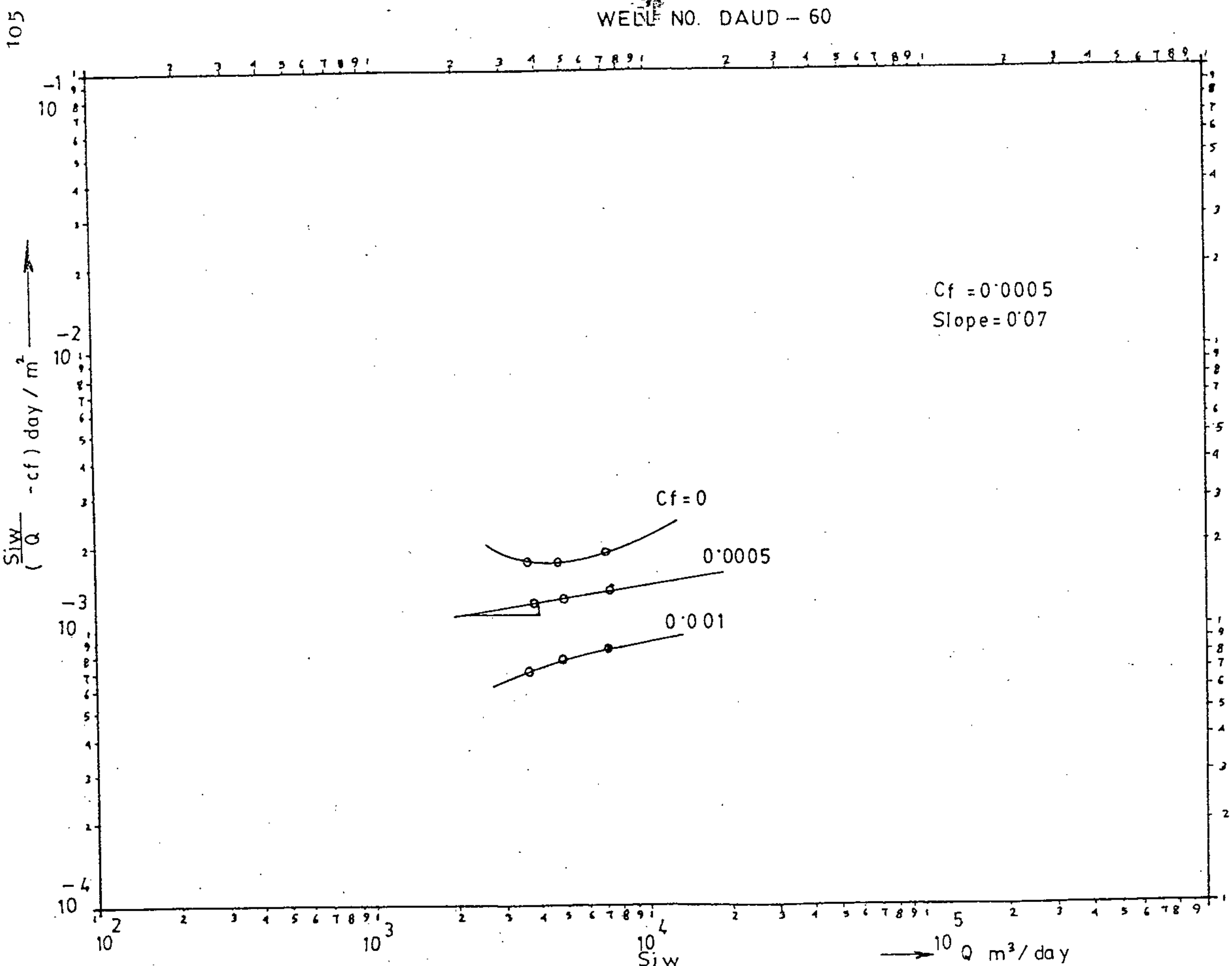


Fig. 4·5 Double logarithmatic plot of $(\frac{S_{iw}}{Q} - cf)$ versus Q for different values of cf (on the curves) to obtain cf yielding straight line of DTW No. DAUD-60

TABLE-4.5 DISCHARGE-DRAWDOWN DATA OF DTW NO. DAUD-60
TO FIND OUT THE VALUES OF C_f, C_w & n.

Q (Cusec) m^3 /day	S_{iw} (ft) m	$\frac{S_{iw}}{Q}$ day/m^2	Cf day/m^2	$(\frac{S_{1w}}{Q} - C_f)$day/m^2
(1.5Cusec) 3669.85	(20.5ft) .24m	1.70×10^{-3}	0.	0.00170
			0.0005	0.00120
			0.001	0.00070
(1.99 Cusec) 4868.67	(27.91ft) 8.5m	1.75×10^{-3}	0	0.00175
			0.0005	0.00125
			0.001	0.00075
(3.0 Cusec) 7339.71	(44.41ft) 13.53m	1.84×10^{-3}	0	0.00184
			0.0005	0.00134
			0.001	0.00084
(0.85 Cusec) 2079.58	(11.58ft) 3.52m	1.69×10^{-3}	0	0.00169
			0.0005	0.00119
			0.001	0.00069

From figure 4.5 the value of C_f = 0.0005 day/m^2
the slope = (n-1) = 0.07 and n= 1.07

$$S_{iw} = C_f Q + C_w Q^n$$

$$8.5m = 0.0005 \times 4868.67 + C_w (4868.67)^{1.07}$$

$$= 2.43m + 6.88 \times 10^{-4} (8821.22)$$

$$= \underset{\text{Formation loss}}{\underline{2.43m}} + \underset{\text{Well -loss}}{\underline{6.07 m}}$$

$\therefore$ Well Efficiency = $\frac{2.43}{8.5} \times 100$ = 28.58%

of the measured Q (4869.21 m^3/day) and S_{iw} (8.5 m) in equ. (2.1)

The well-loss = 6.07 m and formation loss = 2.43 m and the efficiency of the well = 28.58%

4.3 IMPACT OF THE FACTORS ON THE WELL-LOSSES OF THE DEEP TUBEWELLS

The impact of the factors contributing the well-losses varies with the aquifer-characteristics as well as with the Well-characteristics of the respective DTWS. Some of the dominant factors affects the measured well-losses seriously, while some moderate factors contributed

the significant loss of the DTWS. Some other factors had shown very little or no influence on the measured well-losses.

The aquifer characteristics and well-characteristics of the deep tubewells revealed the effectiveness of the factors on the loss of the respective DTWS as shown in Table 4.6.

TABLE - 4.6 SALIENT FEATURES OF THE AQUIFER AND WELL-CHARACTERISTICS AND THE FACTORS AFFECTING THE WELL-LOSSES

Sl. No.	Item	DTW NO. NAN-118	DTW NO. BHAL-110	DTW NO. PHUL-160	DTW NO. NABI-R/27	DTW NO. DAUD-60
1	2	3	4	5	6	7
1.	Salient features of the <u>aquifer characteristics:</u>					
(i)	Type of aquifer	Leaky or semi-confined aquifer.	Leaky or semi-confined aquifer	Leaky or semi-confined aquifer	Leaky or semi-confined aquifer	Leaky or semi-confined aquifer
(ii)	Depth of screenable formation	102 ft.	206 ft.	145'-0" ft	226 ft.	117 ft.
(iii)	Effective grain size of the screenable formation	CS/MS	MS/CS	MS	MS/FS	MS
(iv)	Average permeability	0.00215 ft/Sec.	0.00124 ft/Sec	0.00176ft/Sec	0.0011 ft/Sec	0.00202 ft/Sec
(v)	Aquifer loss	4.95 m	9.78 m	3.91 m	2.45 m	2.43 m

1	2	3	4	5	6	7
	(vi) quality of water					
	(a) EC (mmhe-Cm^{-1})	485	380	490	500	625
	(b) P^{H}	7	7	7	7	7
	(c) Impact	Free from salinity and acidity but slightly harmful to permeability.	Free from salinity and acidity but harmful to permeability.	Free from salinity and acidity but slightly affected the permeability.	Free from salinity and acidity and Suitable for irrigation .	Free from salini & acidity and good for irrigation.
2.	Salient features of the Well-characteristics:					
	(i) Total length of well-string	334 ft.	459.25 ft.	301 ft.	457 ft.	299 ft.
	(ii) Upper well casing (UWC) (14"-dia)	96 ft.	112 ft	100 ft.	98 ft.	90 ft.
	(iii) Lower well casing (LWC)	6-inch dia 140ft.	8"dia 70ft 6"dia 125ft } 195ft	6"-dia 75 ft.	8"dia 180ft 6"dia 30 ft } 210'	8"-dia 100ft.
	(iv) Lenght of screen	6-inch dia 90ft.	6" dia 144.33ft	6"dia 118ft.	8"dia 60ft 6"dia 80ft } 140'	8"dia 100ft.

1	2	3	4	5	6	7
(v)	Placement of screen	Single location	at three different locations.	at two different locations.	at six different locations.	at two different locations.
(vi)	Size of slot	1 mm	1 mm	1 mm	1 mm	1 mm
(vii)	Entrance Velocity	0.043 ft/Sec (optimum 0.065 ft/Sec)	0.027 ft/Sec (Optimum 0.0492 ft/Sec)	0.033 ft/Sec (Opt 0.0656 ft/Sec)	0.024ft/Sec (Optimum 0.0492 ft/Sec)	0.029ft/Sec (Optimum 0.0656 ft/Sec)
(viii)	Methods of drilling	Water Jet	Water Jet	Reverse cirulation Rotory	Water Jet	Water Jet
(ix)	Verticality	1.81 inch deviation	0.68 inch deviation	2.75 inch deviation	2.70 inch deviation	2.15 inch deviation
(x)	Well development	Very poor development	Very poor	Satisfactory	Very poor	poor development
(xi)	Specific drawdown	20.86 ft/Cusec	33.20 ft/Cusec	15.41 ft/Cusec	23.45 ft/Cusec	19.16 ft/Cusec
(xii)	Measured Well-loss	7.85 m	10.089 m	2.63 m	9.0 m	6.07 m
(xiii)	Well-efficiency	38%	49%	59.69%	21%	28.58%

1	2	3	4	5	6	7
3.	Dominant (major) factor Causing Well-losses.	(a) greater length of LWC	(a)Execessive length of the well string	(a)Placing of strainers at two different locations.	(a)Excessive length of well string	(a) Arrangement of well components
		(b)smaller size of slots (in relation to the effective grain size)	(b)Placing of strainers at three locations	(b)Length of well string	(b)Placing of strainers at six different locations	(b)Placing of strainers at two different locations
		(c)Water Jet drilling method	(c)Water Jet drlling method	(c)Diameter of the lower well casing	(c)Water Jet drilling technique	(c)Water Jet drilling technique
		(d)sample collection.	(d)sample collection.	(d)Verticality	(d)sample collection.	(d)sample collection.
		(e)sample descriptions.	(e)sample descriptions.	(e)Gravel packs	(e)sample descriptions	(e)sample descriptions
		(f)gravel packs	(f)gravel packs		(f)gravel packs	(f)Verticality
		(g)Verticality	(g)Verticality		(g)Verticality	(g)Gravel packs
		(h)Well-development	(h)Well-development		(h)Well-development	(h)Well development

1	2	3	4	5	6	7
4.	Moderate (minor) factors Contributing well-losses	(a) Confining layers/beds (b) Transmitting capacity (c) quality of water	(a) Confining layers/beds (b) Consolidation of the formation (c) Chemical composition of water (d) Diameter of lower-well casing. (e) Design of UWC	(a) Confining layers/beds (b) Chemical composition of water (c) Design of UWC	(a) Confining layers/beds (b) Consolidation of the formation.	(a) Presence of confining layers/beds. (b) Consolidation of the formation.
5.	Factors which had very little or no effect on the well-losses.	(a) Well site selection (b) Materials of well casing (c) Design of UWC (d) Entrance Velocity	(a) Well site selection (b) Materials of well casing (c) Entrance velocity (d) Diameter of screen	(a) Well site selection (b) Materials of well casing (c) Entrance velocity (d) Diameter of screen	(a) Well site selection (b) quality of water (c) Diameter of screen (d) screen slot-size	(a) quality of Water (b) Well site selection. (c) Diameter of screen (d) screen slot-size.

1	2	3	4	5	6	7
		(e)Diameter of screen	(e)Screen slot-size	(e)screen slot-size	(e)Transmitting capacity	(e)Transmitting capacity
		(f)Placing of strainers	(f)Transmitting capacity	(f)Transmitting capacity	(f)Straightness	(f)Straightness
		(g)Straightness	(g)Straightness	(g)Straightness		
				(h)Well development		
				(i)Drilling method		

CHAPTER - V

MEASURES FOR MINIMIZING THE WELL-LOSSES

The values of the well-losses determined from this study were found in compatible with the influence of the contributory factors as outlined before. Fixed design-pattern was used in the construction of the DTWS under study and the well-losses were found to vary considerably according to the individual aquifer and well-characteristics.

In the design-criteria of these DTWS it was mentioned that a length of 120 ft of 6"-inch (152 mm) dia screen having 1 mm slot-size would be required to obtain a discharge of 56 l/sec (2-cusec) from an aquifer consisting of grey medium to fine sand. The length of strainer was determined considering the screen entrance velocity of not more than 0.03 m/s (0.1 ft/sec). But there was no lower limit mentioned in the design-criteria. In fact, it was observed that the length of the screens were determined in such a way that the screen entrance velocities remain at about 57% to 76% less than the upper limit (of 0.1 ft/sec). As a result the excess length (and in some cases the multiple locations) of the screen dictates the excessive length of total well-string. So, there was lot of scope for taking an optimum value of screen entrance velocity closer to the permissible upper limit on the basis of the permeaibilities of the screenable formation.

It was also understood from the study that since the entrance velocities of the DTWS were very low as compared to the upper permissible limit, the entry losses were found less significant. However, careful attention should have to be made on the minimization of upflow-losses.

The appropriate measures for reducing the Well-losses of the selected DTWS might be divided into two categories : namely,

(i) Specific measures - needed for the particular well under certain conditions, and

(ii) The general measures - essential for each well to keep the well-loss at an optimum-level.

5.1 SUGGESTED SPECIFIC MEASURES FOR MINIMIZING THE WELL-LOSSES OF THE SELECTED DEEP TUBEWELLS

The following specific measures were suggested for minimizing the well-losses of the deeptubewells. But the actual reduction in well-loss from the following recommendation could be measured only from the field test - which was beyond the scope of this study. So, for getting a theoretical rough approximation of it the equation No (2.20) and (2.21), were used (with some limitations).

An analysis of well-lossess of the existing deep-tubewells under study and their corresponding recommended deep tubewells are shown in Appendix - XII-C.

1. DTW NO. NAN - 118

The well-loss of this DTW could be minimized by determining the length of the strainer in accordance with the optimum screen velocities based on the permeabilities of the screenable formation. The average permeability of the screenable formation was 0.00215 ft/Sec (0.0655 cm/Sec), at which WALTON'S recommended value of optimum screen entrance velocity (as shown in Appendix - V) was 2 cm/Sec (0.0656 ft/Sec). Since this suggested entrance velocity was lower than the upper permissible limit (of 0.10 ft/Sec), this could be used to determine the length of the strainer by using the equation (Walton, 1962),

$$L = \frac{Q}{Ao\ Ve}, \qquad (5.1)$$

Where, L = length of screen, in ft.

Q = maximum expected discharge, in ft^3/Sec.

Ao = effective area per foot length of screen, ft^2

Ve = Screen entrance velocity, ft/Sec.

Then the length of the 6"-inch dia continuous slot-type screen of 1 mm slot-size having 33% open area, would be

$$L = \frac{2}{0.518 X 0.0656} = 58.58 \text{ ft.}$$

But in case of gravel-packed wells, some investigators suggested the average values of the hydraulic conductivity of the aquifer and of the gravel-pack to determine the entrance velocity. In such a case WALTON also suggested to determine the length of the screen using eque. (5.1) having factor of safety 2 to 5. So, Considering a factor of safety 2, the length of strainer having same specification would be-

$$L = \frac{2 \times 2}{0.518 \times 0.1} = 77.22 \text{ ft}$$

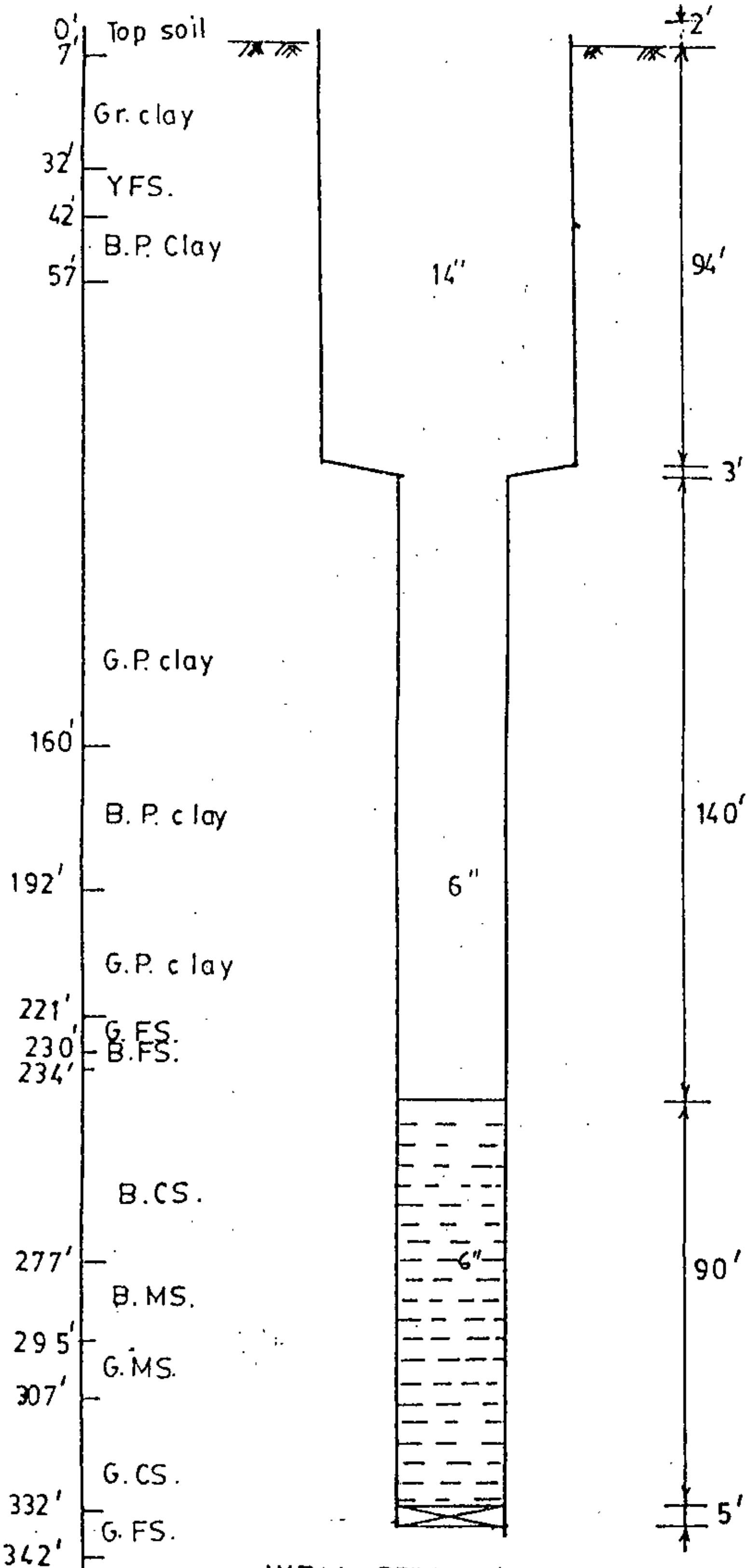
$$\approx 80 \text{ ft.}$$

Now if we recommend the use of 80 ft strainer without any remarkable change in all other design parameter, then the design of the DTW would be as shown in fig. 5.1(b), where the length of the well-string become 96+3+139+1+80+5 = 324 ft. This reduction in the total length of the well-string would not only save the considerable cost but also minimized the well-loss to about 42 % less than the existing one. The cost of the DTW also become Tk.5,18,780/- only, which was about 7.6% - less than the cost of the existing DTW (Tk.5,61,625/-) incurred during the construction of the well, as shown in Appendix-VIII(A&B).

2. DTW NO. BHAL - 110

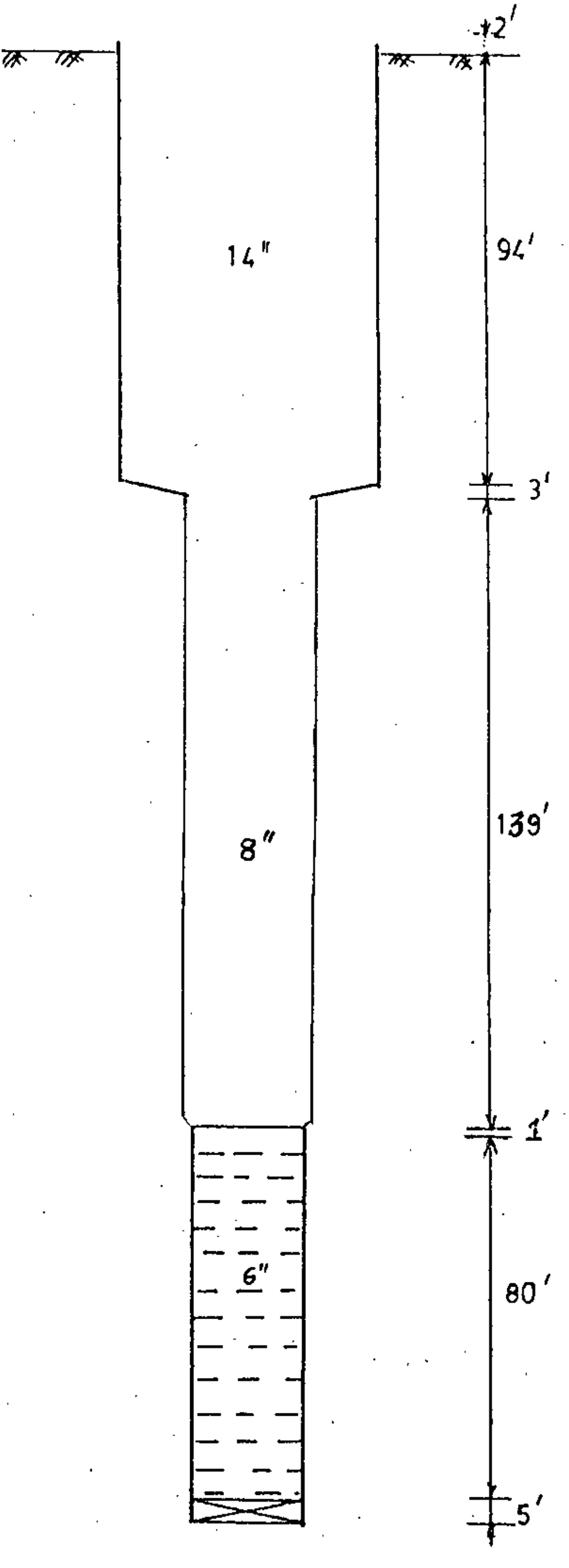
The well-loss of this well could be minimized by designing the DTW in compatible with the lithology of the well. It was observed that a length of about 70' ft screen was placed in the screenable portion (form 270 to 350 ft) of the aquifer. The effective grain-size of that formation was brown MS/CS where the average permeability was 0.00128 ft/Sec (0.039 cm/Sec). According to the WALTON'S recommendation, the optimum screen entrance velocity at that average permeability (0.00128 ft/Sec) was 1.5 cm/Sec (0.0492 ft/Sec). Considering this optimum entrance velocity, the optimum length of the screen (having 1 mm slot-size 6"-inch diameter) would be 78.47 ft. But, Since the length of the screenable portion of the aquifer was only 80 ft, for a greater factor of safety, another alternative screen of 8"-dia(having 1 mm slot-size and 33 percent open area) could be used. In this case, the optimum length of the screen would be 60 ft only. So, it was evident that the total length of the well - string could be

DTW NO. NAN-118



WELL STRING = 334 ft.

FIG. 5.1 (a) Existing DTW NO. NAN - 118.



WELL STRING = 324 ft.

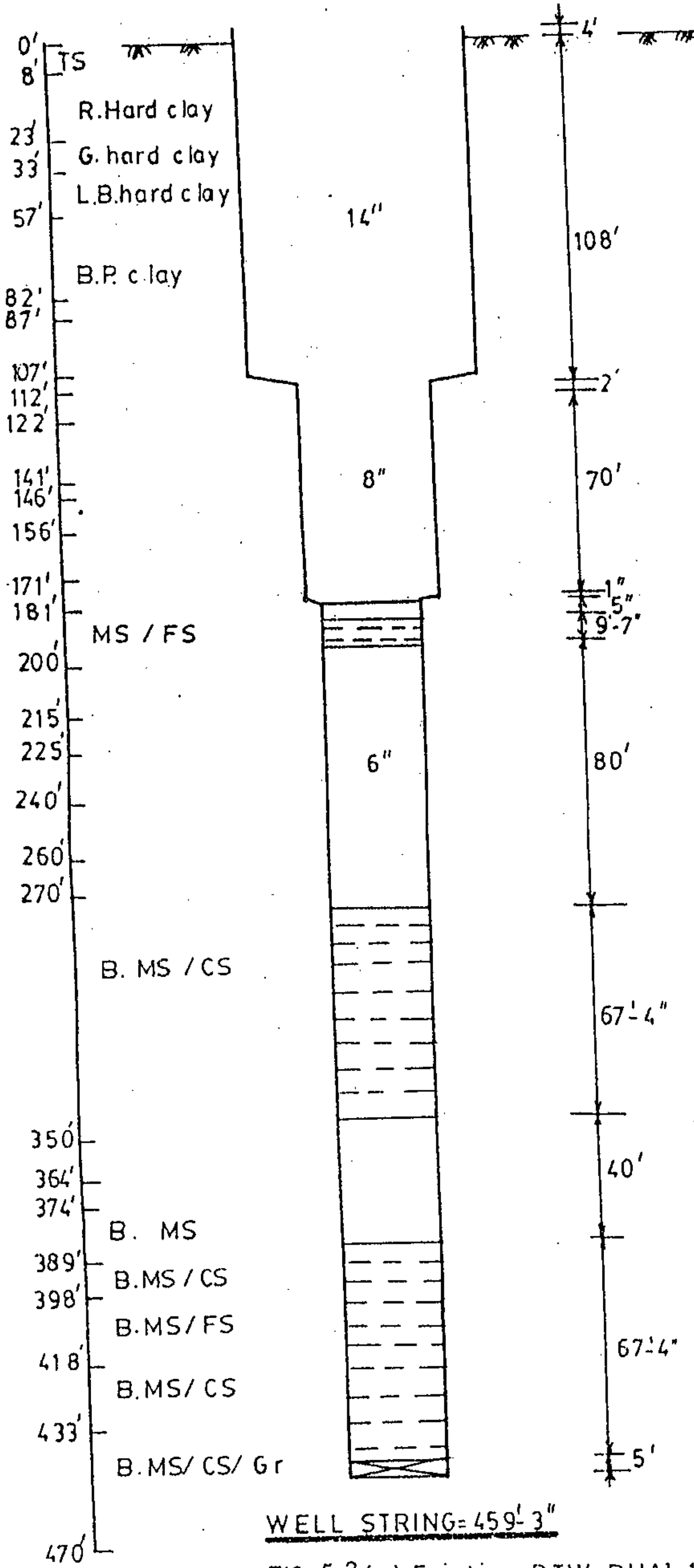
FIG. 5.1 (b) Recommended DTW Against DTW NAN - 118 reduced to 349 ft (100+3+180+60+1+5) instead of 459.25 ft. The recommended design of the DTW shown in fig. 5.2 (b). This reduction in length of the well string, and increase in diameter of the 60 ft screen and 110 ft blind pipe (from 6" to 8"), significantly minimized the well-losses (about 64 % less) and thus would reduce the considerable cost (about 21.64% less) of the DTW (from Tk. 6,91,256.55 to about Tk.5,41,625/-), as shown in Appendix - IX (A & B).

3. DTW NO. PHUL - 160

It was observed that the well-loss of this DTW was minimum among all the five DTWs under study. The efficiency of this DTW was 59.69%. But still, there was lots of scope to improve the performance of this well by reducing the well-loss of the well, at a reasonable cost (less than the actual cost of this well). This could be done by designing & constructing the well in conformity with the desired capacities as well as the aquifer characteristics.

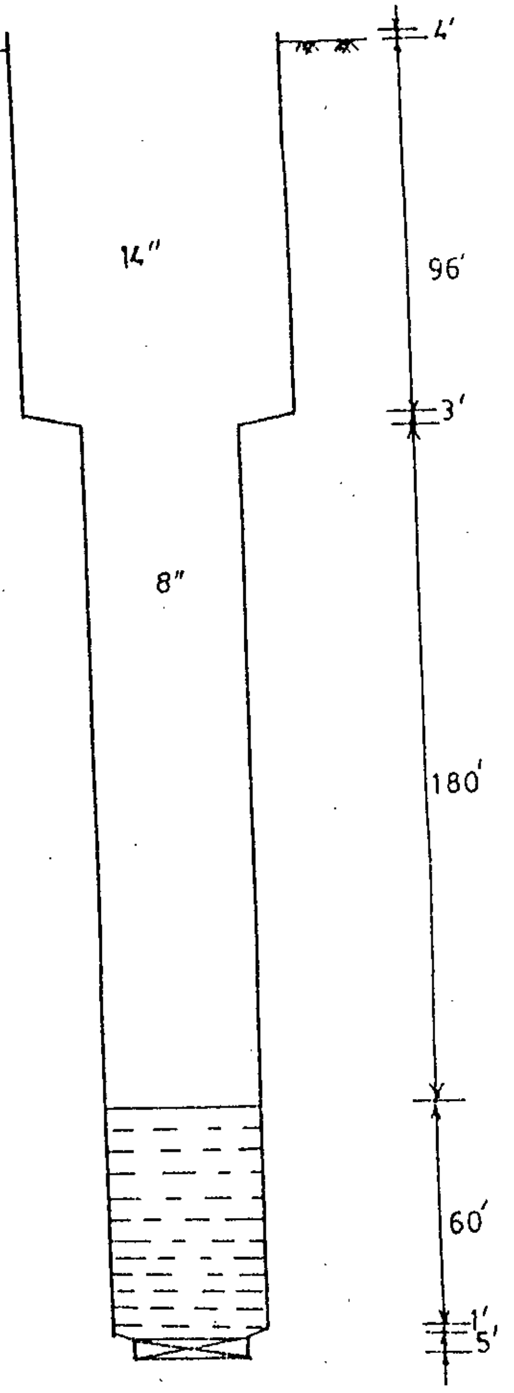
Since the entrance velocity of this well (0.033 ft/Sec) was less than the optimum entrance velocity (0.0656 ft/Sec), the length of the screen could be reduced and be placed at a single location. As for example, if the 6"-dia screen of 33% open area haveing 1 mm slot-opening was used, then the required length of the screen would be 80 ft only, which could be placed at a stretch (from 207 to 287 ft). The length of the upper well

DTW NO. BHAL-110



WELL STRING= 459'-3"

FIG. 5.2 (a) Existing DTW-BHAL-110



WELL STRING = 349'

FIG. 5.2 (b) Recommended DTW Against DTW-BHAL- 110.

casing could be reduced to 90 ft only. Then the total length of the well-string would be (90+3+116+1 +80 +5') = 295 ft only. The suggested design of the DTW shown in fig. 5.3 (b). In this arrangement, since the diameter of the LWC was increased to 8" from 6" and the strainer was placed at a single location the well losses would be reduced to about 18.56%. . As a result, the minimum well-loss would reduce the cost (about 10.41% less) of the well (from Tk. 5,57,430/- to about 4,99,390/-) as shown in Appendix - X (A & B).

4. DTW NO. NABI-R/27

The well-loss of this well could be reduced to a large extent by designing the well with careful considerations of the aquifer characteristics. It was observed from the lithology and constructional details of the well that there was no reasonable justification of placing the strainers at six different locations. The placing of blind pipes at depths-295 to 315 ft, 336 to 346 ft and 386 to 406 ft, was also completely wrong. There was found no vindicable ground of making the well-string to such an excessive long-configuration. Only some ill-motive might be active behind that undesirable workmanship.

According to the lithology, the length of the well-string could be limited to 366 ft only. The screenable portion of the aquifer (from 270 to 360 ft) consists of brown MS/FS, at which

DTW NO.-PHUL-160

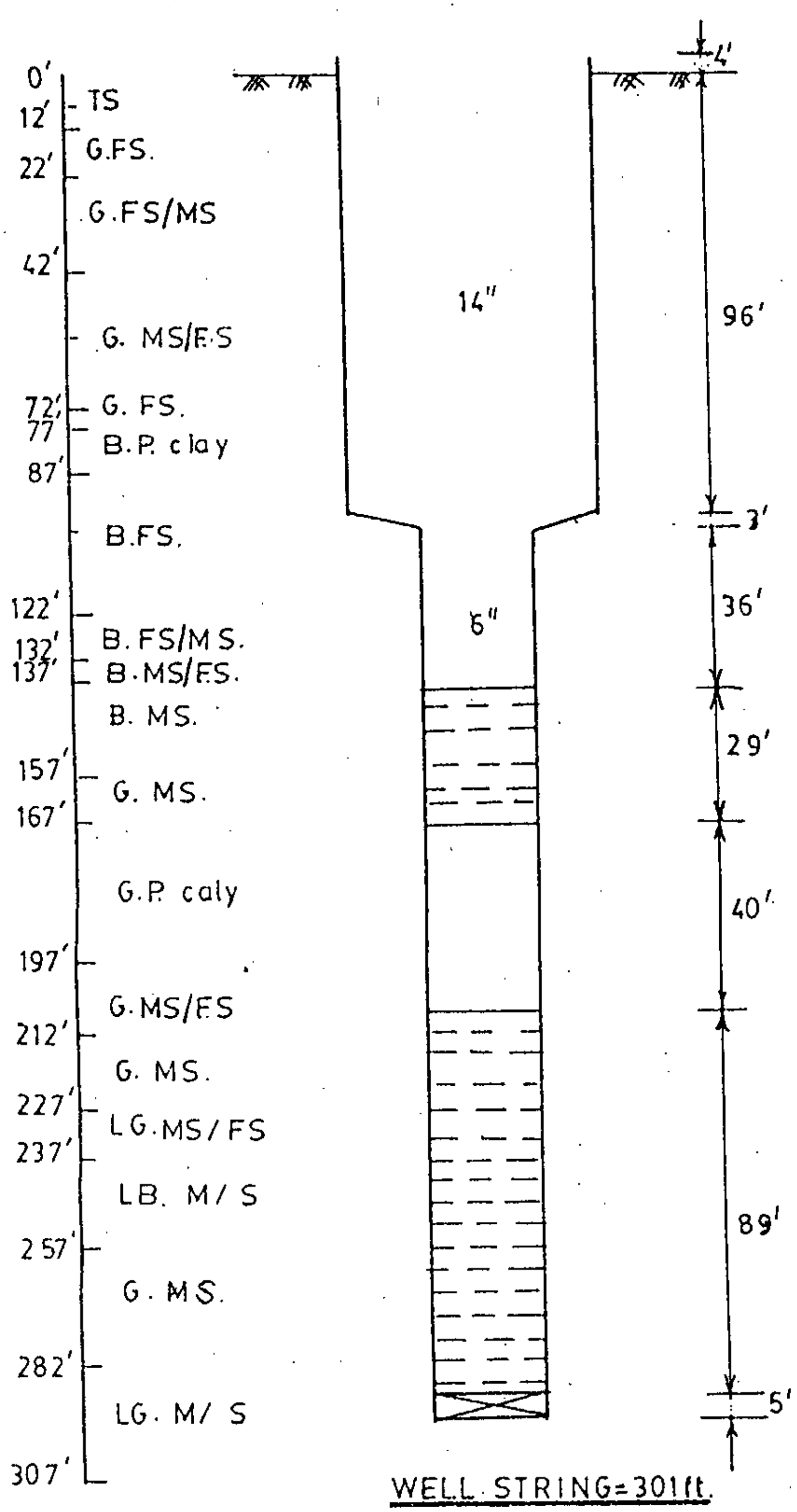


FIG. 5.3 (a) Existing DTW- PHUL-160

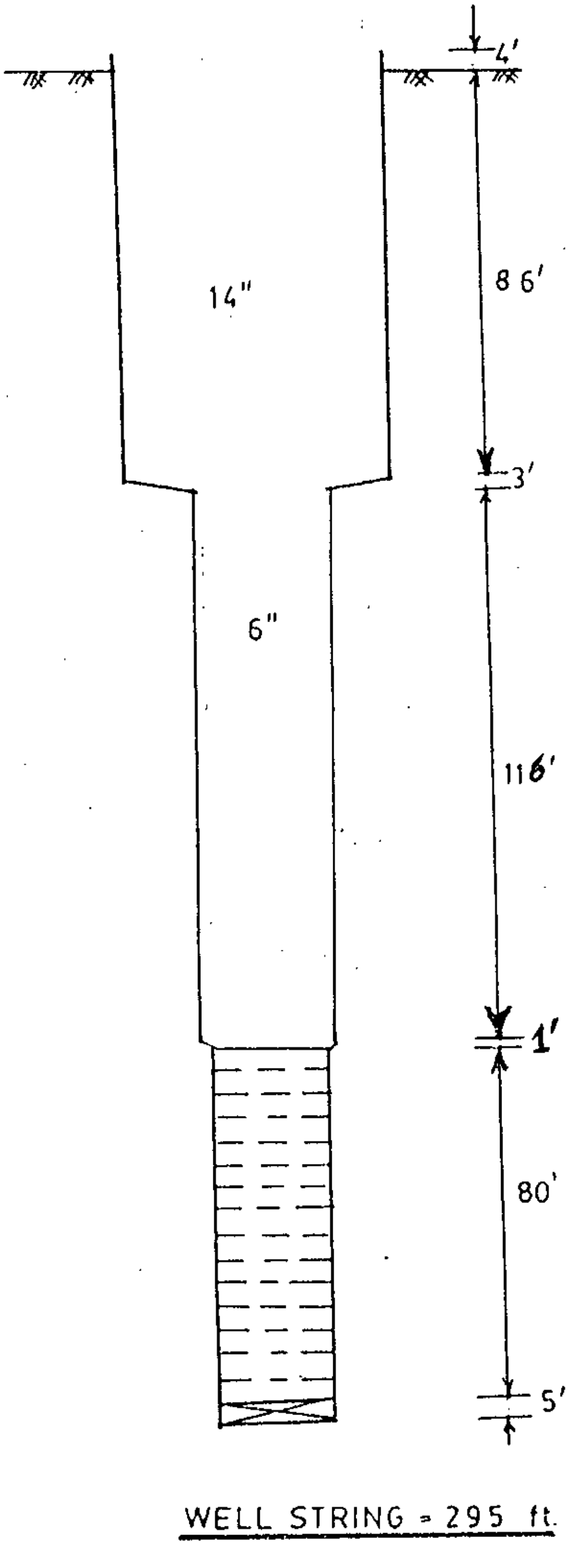


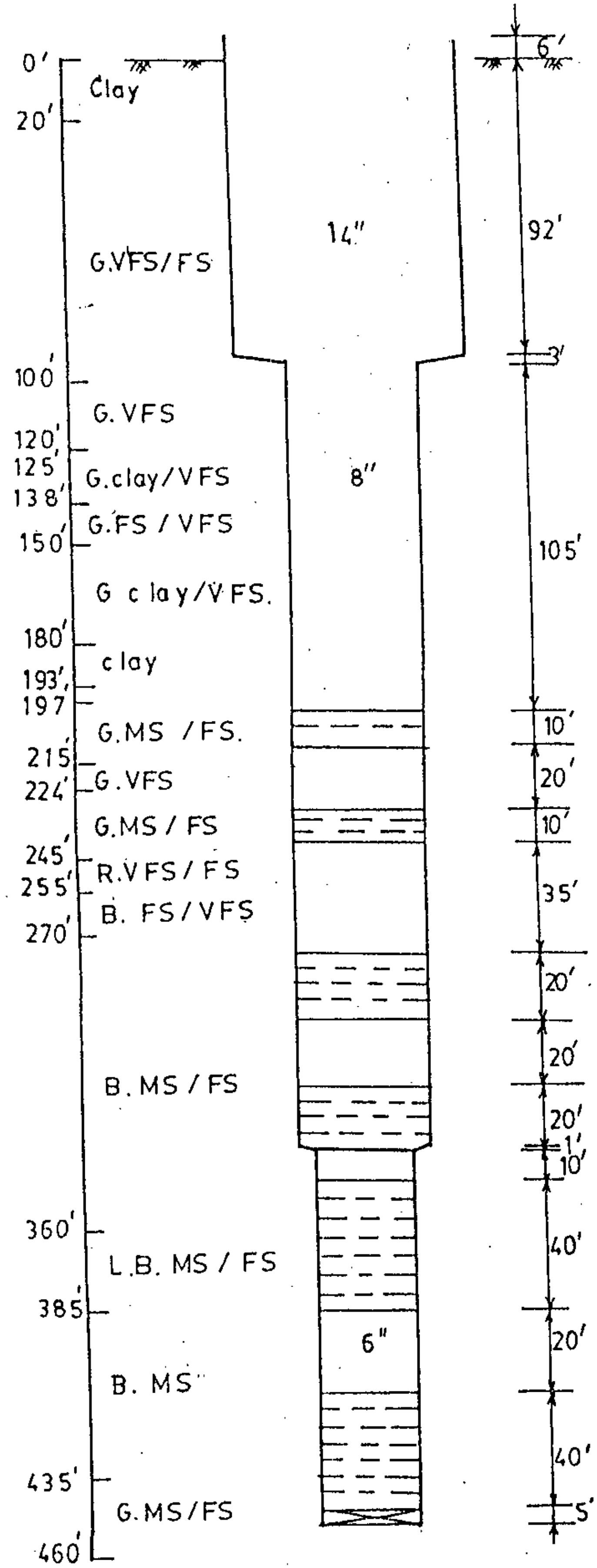
FIG. 5.3 (b) Recommended DTW Against DTW-PHUL- 160

the average permeability was 0.0008 ft/Sec (0.024 cm/Sec). At this permeability, WALTON suggested an optimum screen entrance velocity of 1.5 cm/Sec (0.0492 ft/Sec). Considering this optimum entrance velocity, the optimum length of the screen (having 6"-inch dia 1 mm slot size & 33% percent open area) would be 80 ft only. This 80 ft strainer could be placed at a single location (275 to 355 ft depth). If it was done, then the total length of the well-string would be 366 ft (98'+3'+179'+1'+80'+5') only, where the 8"-inch diameter 179 LWC would be placed above the 6"-inch dia screen through a reducer (8" to 6"). The suggested design of the DTW shown in fig. 5.4(b). This arrangement would significantly reduce the upflow loss which in turn reduce the well-loss to about 17.13% less . As a result, the cost of the DTW would be reduced from Tk. 6,77,800/- to Tk.5,52,540/-, which was about 18.48% percent less than the cost incurred during the construction of this well, as shown in Appendix - XI (A & B).

5. DTW NO.DAUD - 60

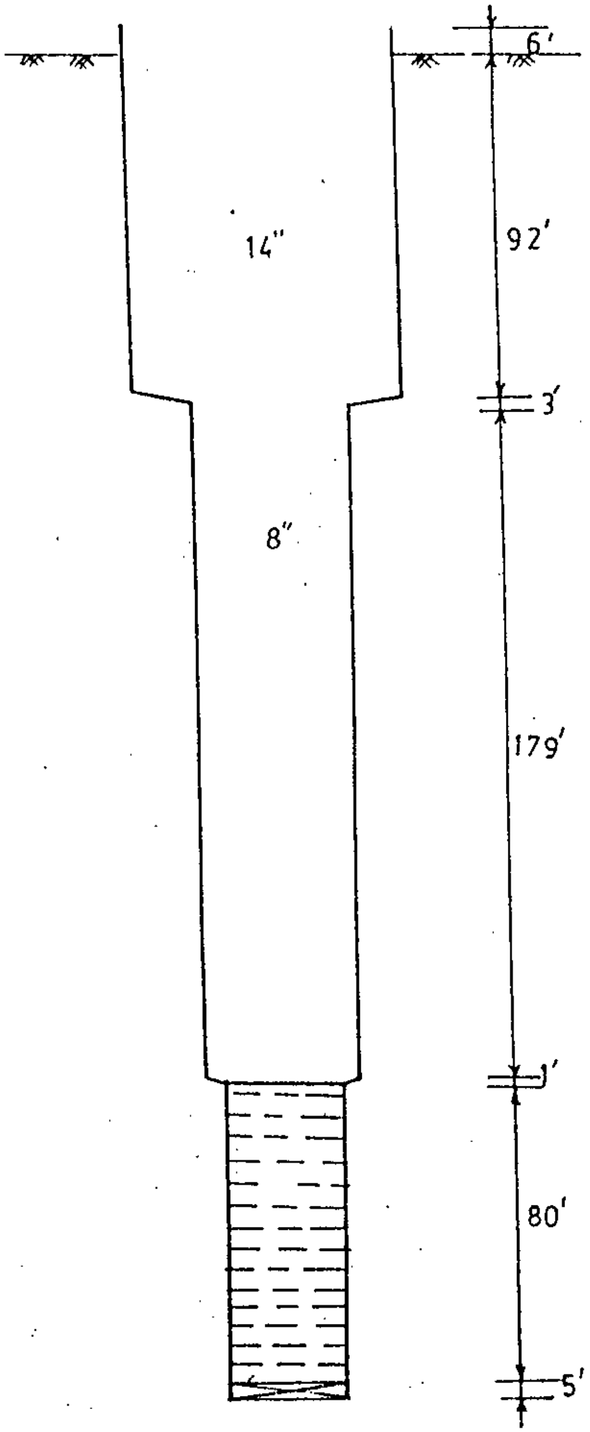
The well-loss of this well could be minimized by designing the well in accordance with the average permeabilities of the screenable portion of the aquifer (227 to 295 ft depth). The average permeability of that formation was found 0.00207 ft/Sec (0.06309 cm/Sec). To obtain the design discharge of 56 litre/Sec the optimum length of the 6"-inch dia screen (having 1 mm slot-

DTW NO.-NABI-R/27



WELL STRING = 457'

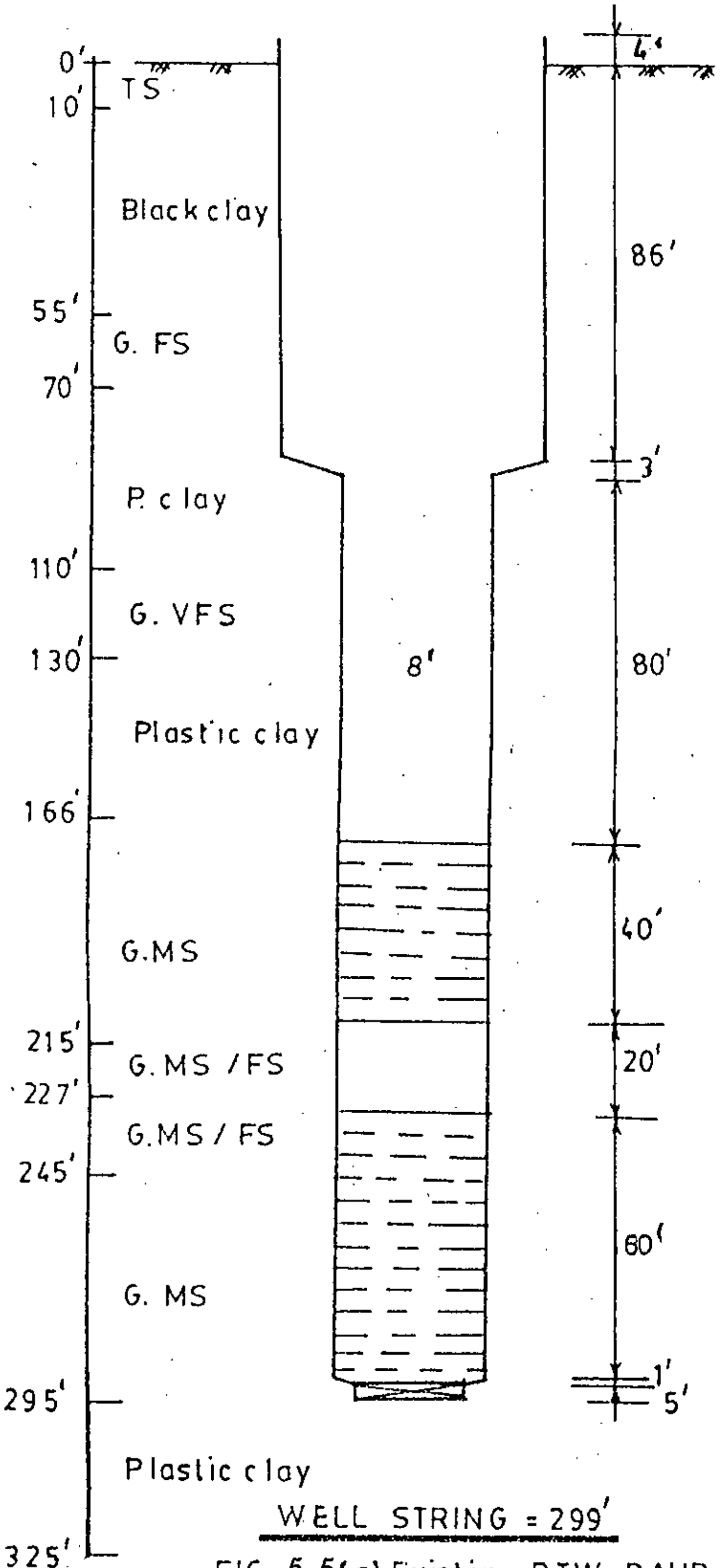
FIG. 5.4.(a) Existing DTW-NABI-R/27



WELL STRING = 366'

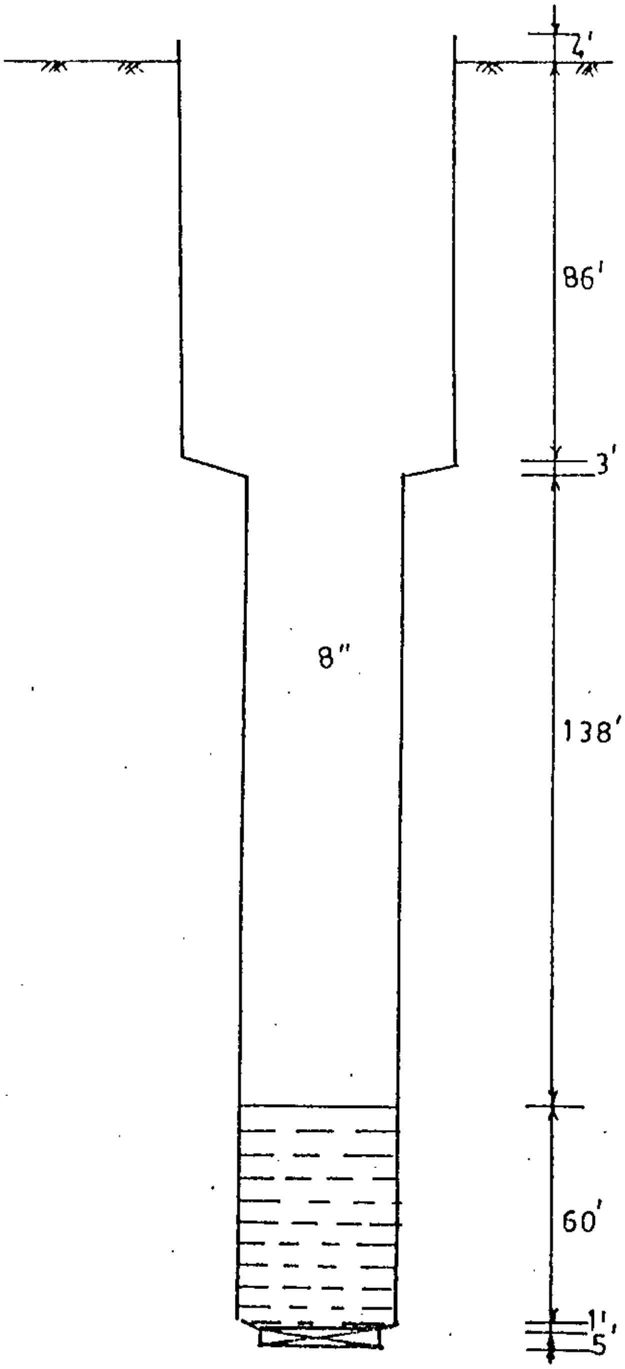
FIG. 5.4(b) Recommended DTW Against DTW-NABI-R-/ 27 size and 33% open area) would be only 60 ft. This 60 ft strainer could be placed at a stretch in a single location (229 to 289 ft depth). Then the modified configuration of the well would become (from top to bottom) 90 ft housing (14"-dia), 3 ft reducer (14" to 8"), 138 ft lower well casing (8"-dia), 1 ft reducer (8" to 6"), 60 ft strainer (6"-dia) and 5 ft bail plug (6"-dia). The total length of the well-string (90'+3'+138'+1'+60'+5') would be 297 ft. The recommended disign of the DTW shown in fig.5.5(b). Since the lithology of this well did not permit any further shortening of the well-string, the placing of strainer at single location would reduce the well-loss to some extent . This effort would not only minimize the well-losses, but also reduce the total cost of the well from Tk. 5,75,200/- to Tk. 5,07835 /-, (which was about 11.71 % percent less than the cost incurred during the construction of the well) as shown in Appendix - XII (A & B).

DTW NO. DAUD- 60



WELL STRING = 299'

FIG. 5.5(a) Existing DTW DAUD-60



WELL STRING = 297'

FIG. 5.5 (b) Recommended DTW Against DTW NO. DAUD - 60

5.2 THE GENERAL MEASURES FOR REDUCING THE WELL-LOSSES OF THE DTWS

The general measures recommended for reducing the well-losses are given below :

1. During the application of "Water Jet drilling method" the sample collection and sample description should have to be made with great care, to ensure the " accurate sampling".

2. Gravel packs should have to be designed on the basis of the grain-size analysis of the formation particles. The placement of gravels should have to be made with great care to ensure the uniform and desired placings of the gravels in the annular space between the well string and the wall of the bore-hole (from top to bottom).

3. The plumbness and straightness of the well-string must have to be ensured to avoid additional turbulence and friction losses during the upward flow of water.

4. The optimum length, diameter and effective open area of the screen should beselected in conformity with the well characteristics as well as the aquifer characteristics.

5. The permeabilities of the screenable formations should be considered as the basis for the optimum length of the screen which in turn dictate the total length and the configuration of the well.

6. The Reverse Circulatory Rotary Drilling method should be preferred over the water jet drilling method.

7. Proper importance should be given on the " total-lift requirements" of the DTWS.

8. The total length of the well-string should be as minimum as possible.

9. The diameter of the lower-well-casing should be larger than the diameter of the screen.

10. The placing of strainers should be made (as far as possible) at a stretch in a single location.

11. The well-site should be selected in such a way that the zone of influence of one DTW does not interfare with another one.

12. The length of the upper well casing should be determined on the basis of the lowest static water level, estimated

specific drawdown, depletion allowance and pump clearance allowance. The diameter of the upper well casing should provide adequate clearance for the pump and minimum friction-less.

13. The well-development must have to be made to ensure sandfree discharge at lowest possible specific drawdown (5-10 ft/cusec).

14. After the Well-construction, the operational monitoring should have to be continued for the timely repair & maintenance of the well to ensure the efficient performance of the well.

5.3 LIMITATIONS OF THE STUDY :

The well-loss phenomenon, some-what critical and complicated in nature is usually beyond our direct-eye vision. It needs deepest and comprehensive perceiveness. So, it was not possible to include all the aspects in a single study or in a single report. None-the-less, sincere efforts had been made to include all the essential elements to make this study as a fruitful one. However, the following points should have to be considered while evaluating this study :

(i) Barrier and recharge boundaries were not strictly considered during the calculation of formation-loss and well-loss.

(ii) Dewatering of the aquifer was not taken into account during the determination of the well-loss and aquifer loss.

(iii) Assumed fully penetrated well (partial penetration was not considered).

(iv) Contributions of all the factors were measured collectively instead of individual measurement.

(v) The factors were not fully depicted, only the relevant portions were mentioned here.

(vi) All the data used for the studywere belong to the newly constructed well ohly.

CHAPTER - VI

CONCLUSIONS AND RECOMMENDATIONS

From the study on the well-loss of some BADC deep tubewells, the following conclusions are drawn along with some recommendations for further study.

6.1. CONCLUSIONS

1. The excessive length of the well string, the arrangement of well components, greater length of LWC, placing of strainers at different locations, the use of water jet drilling Technique, sample collection and selection, gravel packs, verticality and well development, were found as the major dominating factors causing the higher values of the well-losses.

2. The length of the strainer provided was much more than that actually needed, which in turn dictated the excessive length of the well-string and caused the higher well-losses as well as the excessive cost of the well. Placing of the strainer at more than one locations also increased the length of well string.

3. The size of the slots of the strainer used in all the DTWs under study was 1 mm, which was designed considering the "medium to fine sand" as the effective grain-size

of the formation. But the screenable formation of the DTW No. NAN-118, consisted of coarse sand and hence the well-loss of this DTW could have been minimised by providing larger open area.

4. The well-loss could be minimized by reducing the upflow losses by providing the optimum arrangement of the well-components.

5. Not only the well characteristics but also the aquifer characteristics have significant impacts on the well-losses. So, the aquifer characteristics should be taken into proper consideration while selecting the tubewell sites to reduce the well loss.

6. The DTWS having poor development have shown a comparatively higher values of well-losses.

7. Verticality (the plumbness and straightness) of the UWC influenced the upflow losses and thus affected the well-losses.

8. The "total-lift requirement" as well as the total cost of the tubewell could be reduced by ensuring appropriate measures for minimizing the well-losses.

9. Since the sample collections and selections are some what difficult in "Water jet drilling method", it associated with the risk of higher well-losses.

10. The entrance velocities of the DTWS were found less than the optimum entrance velocities due to the use of the excessive length of the screens. This minimized the entry-losses but enhanced the total cost of the well to a large extent.

6.2 RECOMMENDATIONS :

The following recommendations are made for further study :

1. Since a large number of DTWs have already beeen sunk in our country by the various departments/organisations (such as BADC, BWDB, WASA etc.), study should be conducted to utilize the hydrogeologic data relating to these DTWS for formulating a guide-line for the design of the 'location-specific DTWS'.

2. Considering the different optimum screen entrance velocities suggested by the various authors, it is suggest that study should be made to have better idea about optimum screen entrance velocity in relation to the permeability of the formation.

3. Even though the water jet drilling method enhances the risk of higher well-losses, its use should be continued considering its advantages. To make its use more advantageous study should be conducted to reduce the well loss associated with this method.

4. Study should be made to find out the impact of the major individual factors on the well-losses.

Appendix - I

LIST OF UPAZILA/THANA UNDER IDA DTW- II PROJECT

1. Mymensingh District.

1. Bhaluka
2. Gaffargaon
3. Phulbaria
4. Trisal
5. Nandail
6. Iswargonj
7. Kotwali
8. Muktagacha
9. Phulpur
10. Haluaghat
11. Gouripur

Sub-Total : 11

2. Netrokona District

1. Purbadhala
2. Netrokona
3. Atpara
4. Kendua
5. Kalmakanda
6. Barhatta
7. Mohanganj

Sub-Total: 7

3. Kishoregonj District

1. Tarail
2. Karimganj
3. Hossainpur
4. Pakundia
5. Katiadi
6. Bajitpur
7. Kishoregonj
8. Bhairab

Sub-Total : 8

4. Comilla District

1. Daudkandi
2. Debidar
3. Brahmanpara
4. Muradnagar

Sub-Total : 4

5. Dhaka District

1. Dhamrai
2. Savar
3. Nawabgonj
4. Keranigonj

Sub-Total : 4

6. Manikgonj District

1. Saturia
2. Manikgonj
3. Singair
4. Shibalaya
5. Ghior
6. Harirampur
7. Daulatpur

Sub-Total : 7

7. Narsingdi District

1. Narsingdhi
2. Shibpur
3. Balash
4. Belabo
5. Monohordi
6. Raipur

Sub-Total : 6

8. Gazipur District

1. Kapasia
2. Kaligonj
3. Joydebpur
4. Sreepur
5. Kaliakoir

Sub-Total : 5

9. Narayangonj District

1. Sonargaon
2. Rupgonj

Sub-Total : 2

10. Munshigonj District

1. Sreenagar

Sub-Total : 1

11. B.Baria District

1. Bancharampur
2. B. Baria
3. Kasba
4. Nabinagar
5. Sarail

Sub-Total : 5

Note: Besides the above area, the Upazilas covered under Barind Project would also be considered as the project area of IDA DTW-II project. However, if it is found that the project components cannot be absorbed by the original project area, only then Barind area would be utilized.

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT- II

CONTRACTOR:

Luna Technical Enterprise Ltd.

CONTRACT IDA/P-II/I

DRILLING LOG

Well No. NAN / 118.

App. No. 1 / 9 / 105 / 184

RIG No. Mouza: Chandipasha)

(SHEET. 1 of 2)

Date Started 27 . 2 . 19 91 . Date Completed. 28 . 2 . 19 91

Logged by Md. Mukarram Hossain . Depth ordered below OGL 332 ft.

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS(ft.)		GRAPHIC LOG
ROD.No.	FROM	TO		FROM	TO	
			Top soil	0	7	≈
			Grey clay	7	32	▨
			Yellow FS	32	42	⋯
			Brown plastic clay	42	57	▨
			Grey plastic clay	57	160	▨
			Brown plastic clay	160	192	▨
			Grey plastic clay	192	221	▨
			Grey FS	221	230	⋯
			Brown FS	230	234	⋯
			Brown CS	234		⋯

প্রতিস্বাক্ষরিত

(নাম)

নির্বাহী প্রকৌশলী

বি.এ.ডি.সি, আই.ডি.এ, রিজিয়ন

ময়মনসিংহ।

(MD. KHALILUR RAHMAN)
Asstt. Engineer (DTW) BADC
IDA Region, Mymensingh.

Records checked by: Signature

Name/Designation Senior Sub-Asstt. Engineer (DTW)
BADC, IDA, Region, Mymensingh.

Date . . 19

For Luna Technical Enterprises Ltd.

Form Nr
IDA DTW-II/01

A.I

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No.	NAN / 118
App No.	1 / 9 / 105 / 184

CONTRACTOR :

CONTRACT IDA/P-II/I

Luna Technical Enterprise Ltd.

DRILLING LOG

RIG NO. Mouza-Chandipasha

SHEET 2 of 2

Date Started 27 - 2 - 19 91 Date Completed 28 - 2 - 19 91

Logged by Md. Mukarram Hossain Depth ordered below OGL 332 ft.

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS (ft.)		GRAPHIC LOG
ROD No.	FROM	TO		FROM	TO	
			Brown CS		277	⁘
			Brown MS	277	295	⁘
			Grey MS	295	307	⁘
			Grey CS	307	332	⁘
			Grey FS	332	342	⁘
			Grey plastic clay	342	392	▨

280 300 320 340 360 380 400 420 440 460 480 500 520

MD. KHALILUR RAHMAN
Asstt. Engineer (DTW) BADC
IDA Region, Mymensingh.

Records checked by : Signature. Senior Sub-Asstt. Engineer (DTW)

Name / Designation BADC, IDA Region, Mymensingh.

Date

For Luna Technical Enterprises, Ltd.

A. 2

Form Nr
IDA DTW-II/01

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR :

Luna Technical Enterprise Ltd. DESIGN SHEET

Well No. NAN / 118

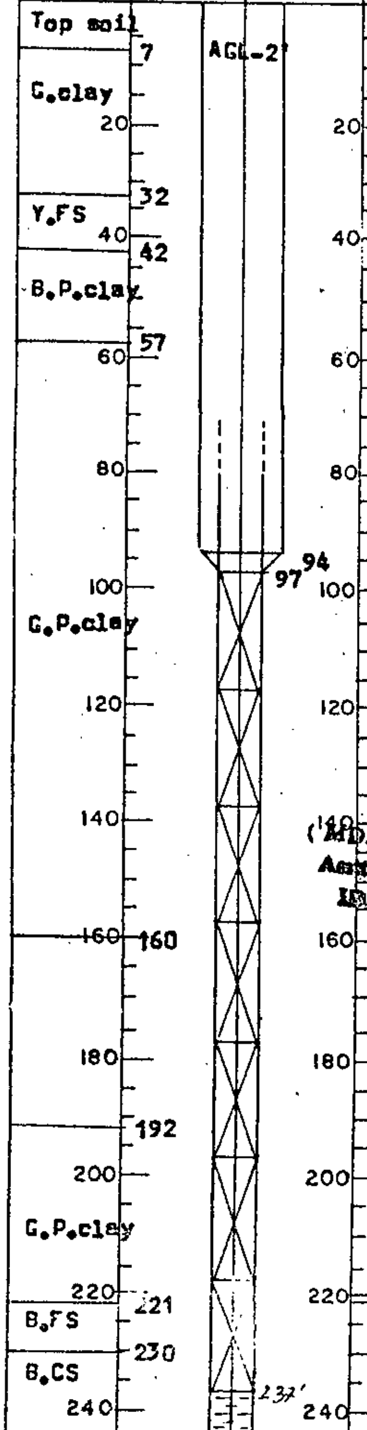
App No. 1 / 9 / 105 / 184

Mouza- Chandipasha

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)		Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/Yellow	Grey	Brown/Yellow	Grey		Brown/Yellow	Grey	Brown/Yellow	Grey
Clay/Clayish	–	–	–	–	MS/FS	0·50	1·00	0·50	1·00
Silt/Silty	–	–	–	–	MS	0.70	1·40	0.70	1.40
VFS	–	–	0·05	0·10	MS/CS	0·80	1·60	0·80	1.60
VFS/FS	–	–	0·10	0·20	CS/MS	0·90	1·80	0·90	1.80
FS/VFS	–	–	0·20	0·40	CS	1.10	2·20	1.10	2·20
FS	–	–	0·30	0.60	CS/Gr	1.00	2·00	1.00	2·00
FS/MS	–	–	0·40	0.80	Gr/CS/MS	0·60	1·20	0·60	1·20

DESIGN CALCULATION



Graphic log with symbol	Component Setting		Screened Aquifer				Unscreened Aquifer				REMARKS
	Depth	Component	D	F	L	ΣL	D	h	L'	ΣL'	
Top soil	7	AGL-2'									
G.clay	32										
Y.FS	42										
B.P.clay	57										
G.P.clay	97 94										
	160										
G.P.clay	192										
B.FS	221						9	0.3	2.7	2.7	
B.CS	230	237'					7	1.1	7.7	10.4	

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (ক্ষুদ্র)
বি,এ,ডি,সি আই. ডি. এ. রিজিয়ন
ময়মনসিংহ।

(MD. KHALILUR RAHMAN)
Asst. Engineer (DTW) BADC
IDA Region, Mymensingh.

Luna Technical Enterprises Ltd.

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≦ 40 feet thick and lowest late dry season SWL is ≦ 20ft.
2. 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 in.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column.
3. Drilling may be stopped when ΣL ≧ 100 and ΣL' ≧ 50 are achieved, subject to minimum screen lengths stated above.
4. Final value of L' will be 20ft. multiplied by its relevant h value below lowest screen.
5. If ΣL' including the bottom 20ft. is <50, although ΣL is ≧ 100, if possible, additional aquifer should be screened to make ΣL + ΣL' ≧ 150, subject to minimum screen length stated above

KEY

D : Thickness of formation.
F : Design factor of formation screened.
L : D x F
ΣL : Summation of L values
h : Penetration factor of formation unscreened.
L' : D x h.
ΣL' : Summation of L' values.

Senior Sub-Asstt. Engineer (DTW)
BADC, IDA, Region, Mymensingh

DESIGNER
Signature..........
Name..........
Designation

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR :

Luna Technical Enterprise Ltd. DESIGN SHEET

Well No .... NAN ..... / 118

App No .... 1 .. / 9 ...... /105 ... / 184

Mouza= Chendipasha

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)		Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/yellow	Grey	Brown/yellow	Grey		Brown/yellow	Grey	Brown/yellow	Grey
Clay/Clayish	—	—	—	—	MS/FS	0·50	1·00	0·50	1·00
Silt/Silty	—	—	—	—	MS	0·70	1·40	0·70	1·40
VFS	—	—	0·05	0·10	MS/CS	0·80	1·60	0·80	1·60
VFS/FS	—	—	0·10	0·20	CS/MS	0·90	1·80	0·90	1·80
FS/VFS	—	—	0·20	0·40	CS	1·10	2·20	1·10	2·20
FS	—	—	0·30	0·60	CS/Gr	1·00	2·00	1·00	2·00
FS/MS	—	—	0·40	0·80	Gr /CS/MS	0·60	1·20	0·60	1·20

DESIGN CALCULATION

Graphic log with symbol	Component Setting		Screened Aquifer				Unscreened Aquifer			
	Depth	Component	D	F	L	ΣL	D	h	L′	ΣL′
B.CS	277		40	1.1	44.0	44.0				
B.MS	295		18	0.7	12.6	56.6				
G.MS	307		12	1.4	16.8	73.4				
G.CS	332	327	20	2.2	44.0	117.4				
G.FS	337	332					5	2.2	11.0	21.4
G.P.clay	392						5	0.6	3.0	24.4

El+El'=117.4@24.4=141.8(O.K.)

মঞ্জুরিত

নির্বাহী প্রকৌশলী (ক্ষুদ্র সেচ)
বি,এ,ডি,সি, আই,ডি,এ রিজিয়ন
ময়মনসিংহ।

(MD KHALILUR RAHMAN)
Asstt. Engineer (DTW) BADC
IDA Region, Mymensingh.

For Luna Technical Enterprises Ltd.

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≦ 40 feet thick and lowest late dry season SWL is ≦ 20ft.
2. 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 in.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft. or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of L and L′ are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column
3. Drilling may be stopped when ΣL ≧ 100 and ΣL′ ≧ 50 are achieved, subject to minimum screen lengths stated above.
4. Final value of L′ will be 20ft. multiplied by its relevant h value below lowest screen.
5. If ΣL′ including the bottom 20ft. is <50, although ΣL is ≧ 100, if possible, additional aquifer should be screened to make ΣL + ΣL′ ≧ 150, subject to minimum screen length stated above

KEY

D: Thickness of formation
F: Design factor of formation screened
L: D x F
L: Summation of L values
h: Penetration factor of formation unscreened
L′: D x h
ΣL′: Summation of L′ values

DESIGNER

Signature S.E. Asstt. Engineer (DTW)
Name BADC, IDA Region, Mymensingh
Designation.................

DA DEEPTUBEWELL PROJECT-II

ONTRACTOR:

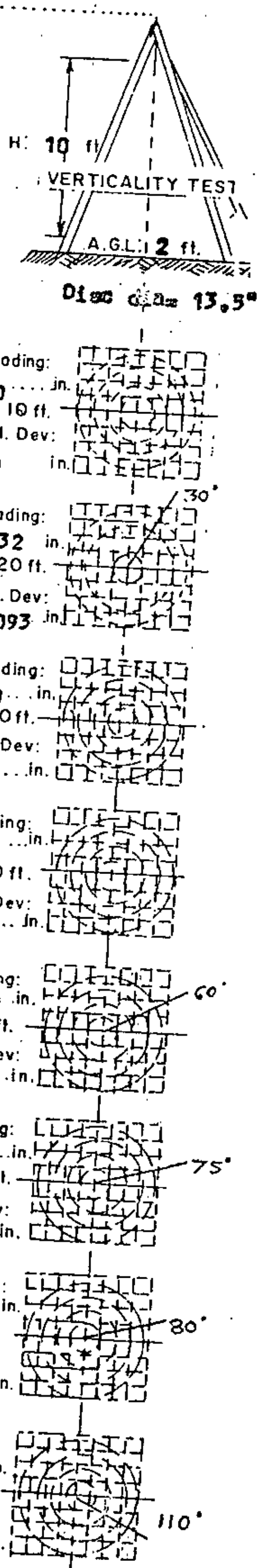
Luna Technical Enterprise Ltd.

Well No	NAN / 118
App No	1 / 9 / 105 / 184

Mouza: Chandipasha

RIG No.

CONTRACT IDA / P – II/I
TUBEWELL CONSTRUCTION DETAILS



Disc dia: 13.5"

Reading: 0 in. 10 ft. Col. Dev: 0 in.

Reading: 1/32 in. 20 ft. Col. Dev: 0.093 in.

Reading: 0 in. 30 ft. Col. Dev: 0 in.

Reading: 0 in. 40 ft. Col. Dev: 0 in.

Reading: 3/32 in. 50 ft. Col. Dev: 0.56 in.

Reading: 4/32 in. 60 ft. Col. Dev: 0.87 in.

Reading: 4/32 in. 70 ft. Col. Dev: 1.0 in.

Reading: 5/32 in. 80 ft. Col. Dev: 1.40 in.

DRILLED HOLE DETAILS

Diameter 20 in.

epth ordered below O.G.L 333 ft. Depth drilled below O.G.L 392 ft.

ength of temporary casing 10 ft. Depth to SWT below O.G.L ft in.

UPPER WELL CASING DETAILS

Diameter / material: 14 in / MS

Height of UWC above OGL 2 ft. in. Total length of UWC 96

Depth of UWC below OGL 94 ft. Reducer (R)/Material: 3 ft. / MS

LOWER WELL CASING & SCREEN DETAILS

	Diameter (in)	Material	Depth below UWC top (ft.)			LWC		Screen	
						No of 10 ft.	No of 20 ft.	No of 10 ft.	No of 20 ft.
LWC	6"	GI	99	to	239	–	7	–	–
Screen	6"	SS	239	to	329	–	–	1	4
LWC				to					
Screen				to					
LWC				to					
Screen				to					
LWC				to					
Screen				to					
LWC				to					
Screen				to					
LWC				to					
Screen				to					
LWC				to					
Screen				to					
				Total		–	7	1	4

[illegible]
নির্বাহী প্রকৌশলী ([illegible])
বি,এ,ডি,সি, আই ডি.এ, রিজিয়ন,
ময়মনসিংহ।

(MD. KHALILUR RAHMAN)
Asstt. Engineer (DTW) BADC
IDA Region, Mymensingh.

+ Material: GRP, SS (Stainless steel) or MS (Mild steel).

Depth to bottom of bail plug below OGL 332 ft.

Gravel quantity (appox) 830 cft.

Total Length of LWC 140 ft.

Total Length of Screen (S) 90 ft.

Bail plug (BP) 5 ft.

TOTAL LENGTH OF WELL STRING (UWC + R + LWC + S + BP) 334 ft.

Signed for the Engineer

Name

Designation Senior Sub-Asstt. Engineer (DTW)
BADC, IDA Region, Mymensingh.

Recoile , , 19

Signed for the Contractor

Name For Luna Technical Enterprises Ltd.

Designation

Date , , 19

90ft=5/32"=1.55in. = 115°

Max. Deviation 1.81 in.

at Depth 90 ft.

Add. Disc allowance .25

Form: IDA – II/3

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

ONTRACTOR :

Luna Technical Enterprise Ltd.

CONTRACT IDA/P-II/I
DEVELOPMENT RECORD

Well No. NAN / 118

App No 1 / 9 / 105 / 184

Mouza: Chandipasha

'atic Water level from top of UWC 23 ft 9 in

eight of top of UWC above O.G.L. 02 ft 0 in

evelopment started at 0800 hrs, 10, 3, 1991

ethod of Development Over pumping & back washing

Diameter of Orifice 6 in.

Diameter of Approach pipe 8 in.

Development Completed at 1725 hrs, 10, 3, 1991

Time elapsed (mins)	Clock time		Discharge (cusec)	Water level from UWC top (m, ft.)	Sand content (ppm)	Remarks
	From	To				
30	0800	0830	0.70	41-5	–	1. Hammering the top of UWC (about 1 minute in every 15 minutes) is needed throughout the development period. 2. Sand content test is not essential during the first two hours. 3. Water levels should be measured just before the changes of discharge rates and at the end of continued OP & BW operation.
15	0830	0845	0.85	43-1	–	
15	0845	0900	1.00	44-9	–	
15	0900	0915	1.24	47-4	–	
15	0915	0930	1.50	54-11	–	
15	0930	0945	1.76	57-9	–	
15	0945	1000	2.02	65-2	–	pumping stopped at 10-00
30	1005	1035	2.02	65-9	27	sampling from 30 sec for 2mins 30 sec.
60	1140	1240	2.25	68-6	-	OP & BW operation.
5	1245	1250	-	-	26	sampling from 25 sec for 2mins 20 sec.
60	1255	1355	2.40	70-4	-	OP & BW operation.
5	1400	1405	-	-	22	sampling from 30 sec for 2mins 25 sec.
90	1420	1550	2.5	75-1	-	OP & BW operation.
5	1555	1600	-	-	22	sampling from 25 sec for 2mins 25 sec.
60	1615	1715	2.5	75-11	-	OP & BW operation.
5	1720	1725	-	-	20	sampling from 30 sec for 2mins 25 sec.

(MD. KHALILUR RAHMAN)
Asstt. Engineer (DTW) BADC
IDA Region, Mymensingh.

Records checked by Signature
Senior Sub-Asstt. Engineer (DTW)
BADC, IDA, Region, Mymensingh.
Name / Designation

For Luna Technical Enterprise, Ltd.

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT- II

Well No. NAN / 118
App. No. 1 / 9 / 105 / 184
Mouza-Chandipasha

CONTRACTOR:
Luna Technical Enterprise Ltd.

CONTRACT IDA/P-II/I
PUMPING TEST RECORD

Static Water table depth from top of UWC 25 ft. 9 in. Diameter of Orifice 6 in.
Height of top of UWC above G.G.L. 2 ft. 0 in. Diameter of Approach pipe 8 in.
Development completed at 1725 hrs. 10 . 3 . 19 91 . Test started at 1000 hrs. 11 . 3 . 19 91 .
Test completed at 1640 hrs. 11 . 3 . 19 91 .

PUMPING TEST READINGS

Step	Time Elapsed (min.)	Water Level from UWC top (ft.)	Drawdown (ft.)	Gauge Reading (in.)	Discharge (cusec)	Specific Drawdown (ft/cusec)	Step	Time Elapsed (min)	Water Level from UWC top (ft.)	Drawdown (ft.)	Gauge Reading (in)	Discharge (cusec)	Specific Drawdown (ft/cusec)
1 st.	0.5	43-2	19-5				3rd.	0.5	64-0	40-3			
	1	-5	-8					1	-2	-5			
	2	-6	-9					2	-4	-7			
	3	-7	-10					3	-6	-9			
	4	-8	-11					4	-7	-10			
	5	-9	20-0					5	-9	41-0			
	7	-10	-1					7	-10	-1			
	10	44-0	-3					10	65-0	-3			
	15	-1	-4					15	-1	-4			
	20	-2	-5					20	-2	-5			
	25	-3	-6					25	-3	-6			
	30	-4	-7					30	-4	-7			
	40	-5	-8					40	-5	-8			
	50	-6	-9					50	-6	-9			
	60	-7	-10					60	-7	-10			
	30	-8	-11					80	-8	-11			
	100	-9	21-0	8"	1.02	20.58		100	-9	42-0	33"	2.02	20.79
2nd.	0.5	53-3	29-6				4th.	0.5	74-4	50-7			
	1	-5	-8					1	-6	-9			
	2	-7	-10					2	-9	51-0			
	3	-8	-11					3	-10	-1			
	4	-10	30-1					4	75-0	-3			
	5	54-0	-3					5	-1	-4			
	7	-1	-4					7	-2	-5			
	10	-2	-5					10	-3	-6			
	15	-3	-6					15	-5	-8			
	20	-4	-7					20	-6	-9			
	25	-5	-8					25	-7	-10			
	30	-6	-9					30	-8	-11			
	40	-7	-10					40	-9	52-0			
	50	-8	-11					50	-10	-1			
	60	-9	31-0					60	-10½	-1½			
	80	-10	-1					80	-11	-2			
	100	-11	-2	18"	1.5	20.77		100	-11	-2	54"	2.5	20.86

(MD. KHALILUR RAHMAN)
Asstt. Engineer (DTW) BADC
IDA Region, Mymensingh.

TESTS

	1st step			2nd step			3rd step			4th step				Remarks
Time elapsed (min)	2	5	50	2	5.	50	2	5	50	2	5	50	100	
Sand content (ppm)	20	19	18	18	16	15	15	14	13	13	8	8	8	. Byimhof oone.
EC (m mho cm^{-1})	☒	☒	500	☒	☒	495	☒	☒	490	☒	☒	485		
PH	☒	☒	6.8	☒	☒	6.8	☒	☒	6.9	☒	☒	7.0		

Records checked by: Signature
N
Designation
D
Sub-Asstt. Engineer (DTW)
BADC, IDA, Region, Mymensingh.

For Luna Technical Enterprise,

Form Nr.
IDA DTW-II/06

APPENDIX-II- B

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT- II

Well No ... BHAL / 110 (R)
App.No . 1 / 1 / 267 / 61

CONTRACTOR:
M/s.Bangladesh Engineers(Pvt)Ltd.

CONTRACT IDA/P-II/

DRILLING LOG

RIG No .. Mouza Shohal ....)
(SHEET ... 1 ... of ... 2 ...)

Date Started .... 27 ..., ... 4 ..., 19 .. 91 . Date Completed ... 29 .... 4 . 19 ... 91 .
Logged by . Md.Abdur Rashid .... Depth ordered below OGL ... 455'-3" .... ft.

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS(ft.)		GRAPHIC LOG
ROD.No	FROM	TO		FROM	TO	
			Topsoil	0	8	
			Redish hard clay	8	23	
			Grey hard clay	23	33	
			Light Green hard clay	33	57	
			Brown plastic clay	57	82	
			Very black plastic clay	82	87	
			Light Grey plastic clay	87	107	
			Brown plastic clay	107	112	
			Grey plastic clay	112	122	
			Brown plastic clay	122	141	
			Brown sand/clay	141	146	
			Light Brown VFS/FS/clay	146	156	
			Grey FS/MS/clay ball	156	171	
			Grey MS/clay ball	171	181	
			Grey MS/FS	181	200	
			Brown MS/FS/clay ball	200	215	
			Brown MS/CS/clay ball	215	225	
			Brown MS/FS/clay ball	225	240	
			Brown MS/ clay ball	240	260	

সহকারী প্রকৌশলী
বিএডিসি, ক্ষুদ্রসেচ বিভাগ
ময়মনসিংহ।

Records checked by: Signature 09/9/91
Name/Designation (Md. A. RASHID)
Sr. SAE (DTW) B. DO.
Date .... IDA, Bhaluka,
Mymensingh.

For Bangladesh Engineers (Pvt.) Ltd.

Form: IDA-II/01

P.T.

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No. BHAL / 110 (R)
App No. 1 / 1 / 267 / 51

CONTRACTOR :
M/s, Bangladesh Engineers(Pvt)Ltd

CONTRACT IDA/P-II/1

DRILLING LOG

RIG NO. Mouzee Shohel
SHEET 2 of 2

Date Started 27 , 4 , 19 91 Date Completed 29 , 4 , 19 9
Logged by Md. Abdur Rashid Depth ordered below OGL 455'-3" f

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS(ft.)		GRAPHIC LOG
ROD No.	FROM	TO		FROM	TO	
			Brown MS/FS/clay ball	260	270	
			Brown MS/CS	270	350	
			Brown silty clay	350	364	
			Brown FS/MS/silty clay	364	374	
			Brown MS	374	389	
			Brown MS/CS	389	398	
			Brown MS/FS	398	418	
			Brown MS/CS	418	433	
			Brown MS/CS/gravels.	433	470	

For Bangladesh Engineers (Pvt.) Ltd.

Records checked by : Signature ... (I.W.) B.D.G.
Name / Designation ... IDA, Bhaluka, Mymensingh.
Date

P-2

Form Nr.
IDA DTW-II/01

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR :

M/s.Bangladesh Engineers(Pvt)Ltd.

DESIGN SHEET

Well No........BHAL../...110 (R)..

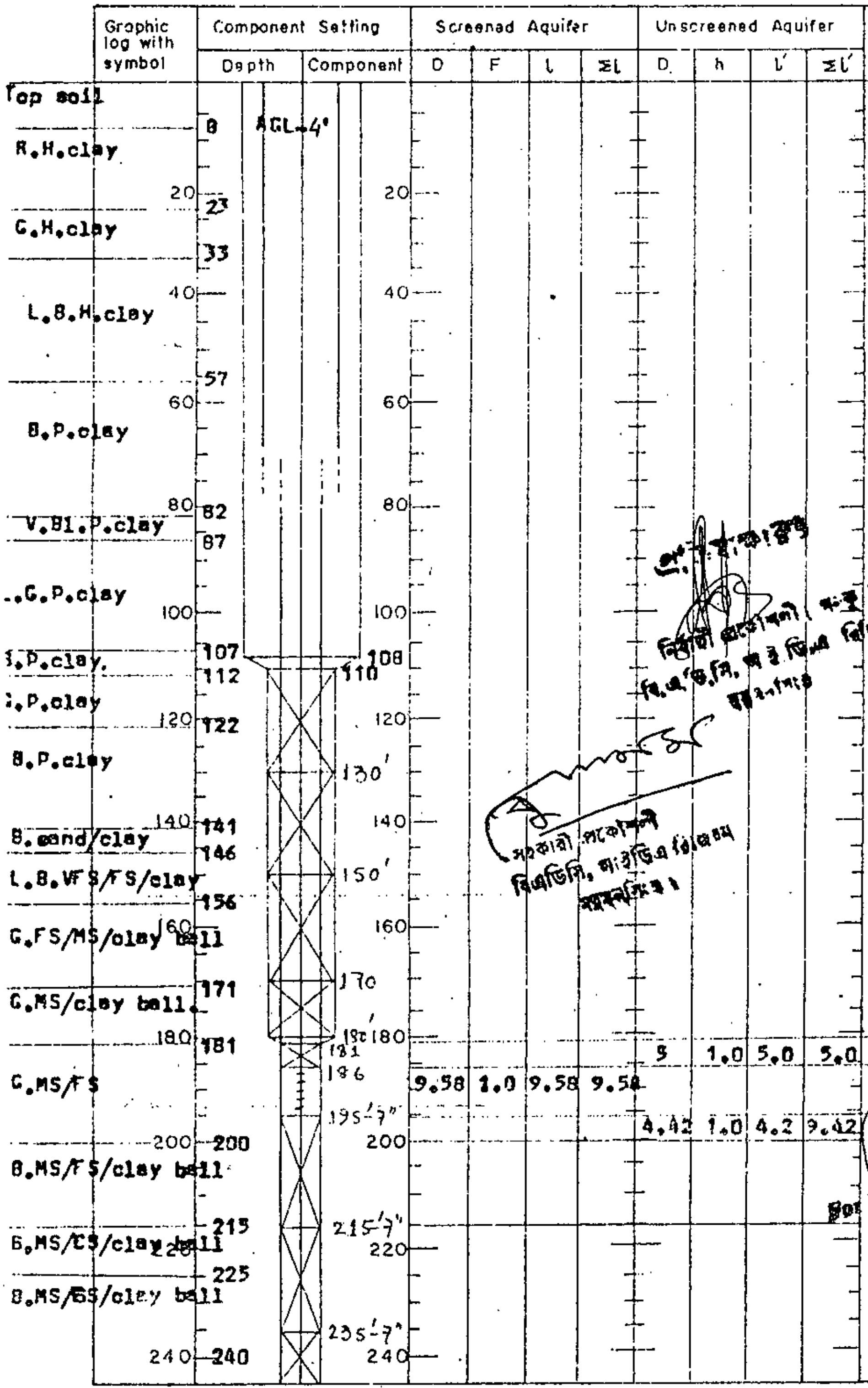
App No.....1../.1...../.267./..61..

Mouza= Shahal

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)		Lithology	Design Fac. (F)		Penetration Factor (h)	
	Brown/Yellow	Grey	Brown/Yellow	Grey		Brown/Yellow	Grey	Brown/Yellow	Grey
Clay/Clayish	–	–	–	–	MS/FS	0·50	1·00	0·50	1·00
Silt/Silty	–	–	–	–	MS	0·70	1·40	0·70	1·40
VFS	–	–	0·05	0·10	MS/CS	0·80	1·60	0·80	1·60
VFS/FS	–	–	0·10	0·20	CS/MS	0·90	1·80	0·90	1·80
FS/VFS	–	–	0·20	0·40	CS	1·10	2·20	1·10	2·20
FS	–	–	0·30	0·60	CS/Gr	1·00	2·00	1·00	2·00
FS/MS	–	–	0·40	0·80	Gr/CS/MS	0·60	1·20	0·60	1·20

DESIGN CALCULATION



Graphic log with symbol	Depth
Top soil	
R.H.clay	8
G.H.clay	23
L.B.H.clay	33
B.P.clay	57
V.Bl.P.clay	82
..G.P.clay	87
3.P.clay.	107
:.P.clay	112
B.P.clay	122
B.sand/clay	141
L.B.VFS/FS/clay	146
G.FS/MS/clay ball	156
G.MS/clay ball.	171
G.MS/FS	181
B.MS/FS/clay ball	200
B.MS/CS/clay ball	215
B.MS/CS/clay ball	225
	240

Component Setting: Component
AGL-4'
108
110
130'
150'
170
18c 180
181
186
195-7"
215-7"
235-7"

Screened Aquifer				Unscreened Aquifer			
D	F	l	Σl	D	h	l'	Σl'
				5	1.0	5.0	5.0
9.58	1.0	9.58	9.5				
				4.42	1.0	4.2	9.42

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≦ 40 feet thick and lowest late dry season SWL is ≦ 20ft.
2. 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 in.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft. or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of l and l' are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column.
3. Drilling may be stopped when Σl ≧ 100 and Σl' ≧ 50 are achieved, subject to minimum screen lengths stated above.
4. Final value of l' will be 20ft. multiplied by its relevant h value below lowest screen.
5. If Σl' including the bottom 20ft. is <50, although Σl is ≧ 100, if possible, additional aquifer should be screened to make Σl + Σl' ≧ 150, subject to minimum screen length stated above

KEY

D: Thickness of formation.

F: Design factor of formation screened.

l: D x F

Σl: Summation of l values

h: Penetration factor of formation unscreened.

l': D x h.

Σl': Summation of l' values.

For Bangladesh Engineers (Pvt.) Ltd.

DESIGNER

Signature.........................

Name......(Er. S.A.B RASHID)

Designation.....(SAE/M BADC) IDA, Bhaluka, Mymensingh./

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR:

M/s. Bangladesh Engineers (Pvt) Ltd.

DESIGN SHEET

Well No........BHAL / 110 (R)....

App No... 1 / 1 / 267 / 61 ...

Mouza = Shohal

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/yellow	Grey	Brown/yellow	Grey
Clay/Clayish	—	—	—	—
Silt/Silty	—	—	—	—
VFS	—	—	0·05	0·10
VFS/FS	—	—	0·10	0·20
FS/VFS	—	—	0·20	0·40
FS	—	—	0·30	0·60
FS/MS	—		0·40	0·80

Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/yellow	Grey	Brown/yellow	Grey
MS/FS	0·50	1·00	0·50	1·00
MS	0·70	1·40	0·70	1·40
MS/CS.	0·80	1·60	0·80	1·60
CS/MS	0·90	1·80	0·90	1·80
CS	1·10	2·20	1·10	2·20
CS/Gr	1·00	2·00	1·00	2·00
Gr/CS/MS	0·60	1·20	0·60	1·20

DESIGN CALCULATION

Graphic log with symbol	Component Setting		Screened Aquifer				Unscreened Aquifer			
	Depth	Component	D	F	L	ΣL	D	h	L'	ΣL'
3. MS/clay ball										
260 B. MS/FS/ clay ball	260 270	255'-7" 260								
280		275'-7" 280					5.58	.8	4.46	13.88
B. MS/CS 300		294'-10" 300	67.33	.8	53.86	63.44				
320		314'-1" 320								
340		333'-1" 342'-11" 340					[illegible]	.8	3.66	19.34
B. S. clay	350									
360 B. FS/MS silty clay	364 374	362'-11" 360								
B. MS 380		382'-11" 380					8.92	.7	6.24	25.7
B. MS/CS	389		6.08	.7	4.25	57.69				
			9	.8	7.2	74.89				
400 B. MS/FS	398	402'-2" 400	10	.5	10	84.89				
420 B. MS/CS	418	421'-5" 420	15	.8	12.0	96.89				
440	433	440'-8" 440	17.25	.8	13.8	110.69				
B. MS/CS/gr. 460		450-3 455-3 460								
							20	.8	16	41.78
480		480	ΣL+ΣL'=110.69+41.78= 152.67(O.K.)							

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≦ 40 feet thick and lowest late dry season SWL is ≦ 20ft.
2. 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 In.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft. or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column
3. Drilling may be stopped when ΣL ≧ 100 and ΣL' ≧ 50 are achieved, subject to minimum screen lengths stated above.
4. Final value of L' will be 20ft. multiplied by its relevant h value below lowest screen.
5. If ΣL' including the bottom 20ft. is <50, although ΣL is ≧100, if possible, additional aquifer should be screened to make ΣL + ΣL' ≧ 150, subject to minimum screen length stated above.

KEY

D : Thickness of formation

F : Design factor of formation

L : D x F

ΣL : Summation of L values

h : Penetration factor of formation unscreened.

L' : D x h

ΣL' : Summation of L' values

For Bangladesh Engineers

DESIGNER

Signature............

Name............ IDA, Bhaluka,

Designation............

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEPTUBEWELL PROJECT—II

)NTRACTOR:

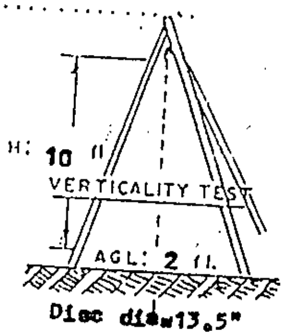
M/s.Bangladesh Engineers(Pvt)Ltd.

Well No.... BHAL . . / . 110 (R) . .
App No. . 1 . / . . 1 . . / . . 267 / . 61 .
Mouza= Shohal
RIG. No. . . . .

CONTRACT IDA /P-II/I
TUBEWELL CONSTRUCTION DETAILS

ILLED HOLE DETAILS

pth ordered below O.GL 455-3 . . ft.
Diameter . . 26/20 . . In.
ngth of temporary casing . 160 . . . ft.
Depth drilled below OGL . . . . . . 470 . . . ft.
Depth to SWT below OGL . . . . . ft. . . . . In.



Disc dia=13.5"

PPER WELL CASING DETAILS

Diameter / material: 14 In./MS . . . .
ight of UWC above OGL . . . 4 . ft. . . In.
Total length of UWC . 112 . . . .
pth of UWC below OGL . 108 . . . . ft.
Reducer(R)/Material: 3 ft /MS . . .

OWER WELL CASING & SCREEN DETAILS

	Diameter (In.)	Material	Depth below UWC top (ft.)	LWC		Screen	
				No. of 10 ft.	No. of 20 ft.	No. of 10 ft.	No. of 20 ft.
LWC	8"	GI	114 to 184	1	3	-	-
Screen			to				
LWC	6"	GI	185 to 190	0.5	-	-	-
Screen	6"	SS	190 to 199-7"	-	-	1	-
LWC	6"	GI	199-7" to 279-7"	-	4	-	-
Screen	6"	SS	279-7" to 346-11"	-	-	1	3
LWC	6"	GI	346-11" to 386-11"	-	2	-	-
Screen	6"	SS	386-11" to 454-3"	-	-	1	3
LWC			to				
Screen			to				
LWC			to				
Screen							
LWC							
Screen			to				
			Total	1.5	9	3	6

নির্বাহী প্রকৌশলী (গভীর) [illegible]
বি.এ.ডি.সি., [illegible] বিভাগ
ময়মনসিংহ

সহকারী প্রকৌশলী
বিএডিসি, [illegible] বিভাগ
ময়মনসিংহ

* Material: GRP, SS (Stainless steel) or MS (Mild steel).

Depth to bottom of bail plug below OGL . . . . 455-3" . . ft.

Total length of LWC . . . . 195 . . . . . ft.

Gravel quality (approx.) . . 1365 . . . . . .

Total length of Screen (S) . 144-4 . ft.

Bail plug (BP) . . . . 5 ft.

TOTAL LENGTH OF WELL STRING (UWC OR + LWC + S + BP) 459-3" ft.

Excess gravels should [illegible] date wise [illegible]

Signed for the Engineer

Name . . . . (M. A. RASHID)

Designation . . . . Sr. SAE, DTW, BADC

Date . . . . 30/4/91 , 19 . .

IDA, Bhaluka, Mymensingh

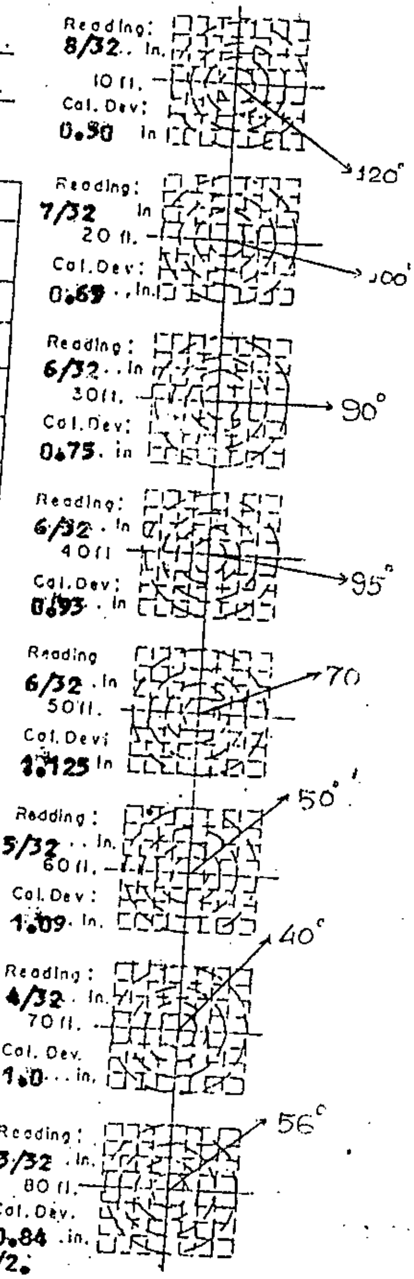
Signed for the Contractor

Name

For Bangladesh Engineers (Pvt.) Ltd.

Designation . . . .

Date . . . . , ... , 19 . . . .



Contd.p/2.

Max. Deviation . . . . In.
at Depth . . . . ft.

Form Nr. IDA DTW-II/03

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEPTUBEWELL PROJECT—II

NTRACTOR:

M/s.Bangladash Engineers(Pvt)Ltd.

Well No.	BHAL / 110 (R)
App No.	1 / 1 / 267 / 61

Mouza. Shohel

RIG. No. ....

CONTRACT IDA/P-II/1
TUBEWELL CONSTRUCTION DETAILS

ILLED HOLE DETAILS

Diameter. 26/20 ... in.

pth ordered below O.GL A55.3 .. ft.

Depth drilled below OGL....... 470 .. ft.

ngth of temporary casing........ ft.

Depth to SWT below OGL......ft......in.

PER WELL CASING DETAILS

Diameter / material: 14 in./ ....

ight of UWC above OGL.... : ft... in.

Total length of UWC...............

pth of UWC below OGL......... ft.

Reducer(R)/Material: 3 ft / ......

OWER WELL CASING & SCREEN DETAILS

	Diameter (in.)	Material	Depth below UWC top (ft.)	LWC		Screen	
				No. of 10 ft.	No. of 20 ft.	No. of 10 ft.	No. of 20 ft.
LWC			to				
Screen			to				
LWC			to				
Screen			to				
LWC			to				
Screen			to				
LWC			to				
Screen			to				
LWC			to				
Screen							
LWC							
Screen							
LWC			to				
Screen			to				
			Total				

সহকারী প্রকৌশলী
বিএডিসি, আইডিএ ডিটি
ময়মনসিংহ

* Material: GRP, SS (Stainless steel) or MS (Mild steel).

Depth to bottom of Bail plug
below OGL .... ft.

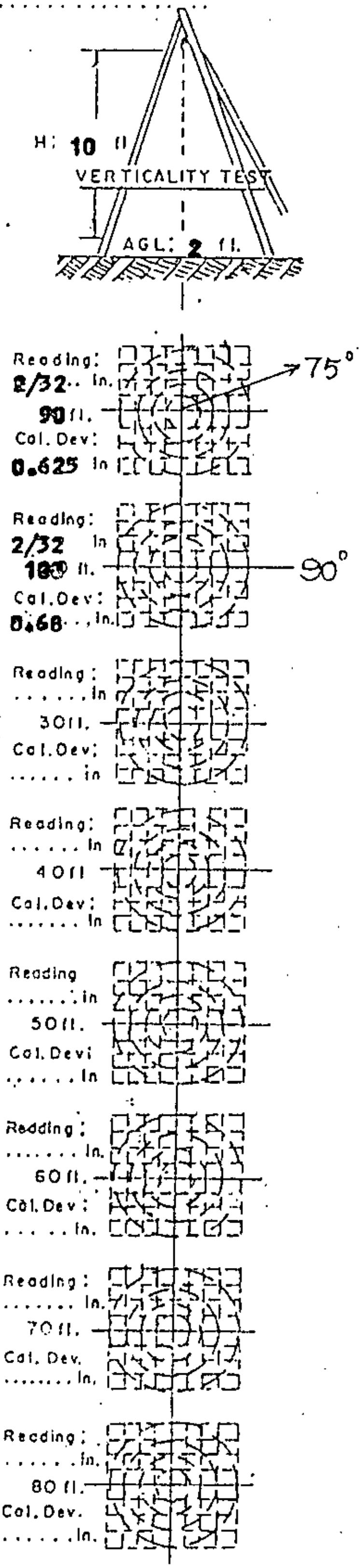
Total Length of LWC.................. ft.

Total Length of Screen. (S)......... ft.

Gravel quantity (approx.)............. cft.

Bail plug (BP)...................... 5 ft.

TOTAL LENGTH OF WELL STRING (UWC+R+LWC+S+BP) ft.



Reading: 2/32 .. in.
90 ft.
Col. Dev: 0.625 in

Reading: 2/32 in
100 ft.
Col.Dev: 0.68 ... in.

Reading: ...... in
30 ft.
Col.Dev: ...... in

Reading: ...... in
40 ft
Col.Dev: ...... in

Reading ...... in
50 ft.
Col.Dev: ...... in

Reading: ...... in.
60 ft.
Col.Dev: ..... in.

Reading: .... in.
70 ft.
Col. Dev. .... in.

Reading: ...... in.
80 ft.
Col. Dev. ...... in.

Signed for the Engineer
Name 30/4/91
Designation .... (M A RASHID) S.A.E. DTW, DO IDA, Bhaluka, Mymensingh.
Date........ , ..., 19

Signed for the Contractor
Name ....
Designation.... For Bangladesh Engineers (Pvt.) Ltd.
Date........., ..., 19 ....

Max. Deviation.. 1.375 . in.
at Depth. ..... 50 ...... ft.

Add.Diac allowance.25

Form Nr. IDA DTW-II/03

AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR :

M/s.Bangladesh Engineers(Pvt)Ltd.

CONTRACT IDA/P-II/I
DEVELOPMENT RECORD

Well No. BHAL / 110 (R)
App. No. 1 / 1 / 267 / 61

Mouza- Shahal

Static Water level from top of UWC 26 ft 3 in

Height of top of UWC above O.G.L 2 ft 0 in

Development started at 0600 hrs, 3 . 5 , 19 91

Method of Development Over pumping & back washing

Diameter of Orifice 6

Diameter of Approach pipe 8

Development Completed at 1540 hrs, 3 , 5, 1991

Time elapsed (mins)	Clock time		Discharge (cusec)	Water level from UWC top (m, ft.)	Sand content (ppm)	Remarks
	From	To				
30	0600	0630	0.70	43-½	–	
15	0630	0645	0.85	50-4	–	1. Hammering the top of UWC (about 1 minute in every 15 minutes) is needed throughout the development period.
15	0645	0700	1.00	55-0	–	2. Sand content test is not essential during the first two hours.
15	0700	0715	1.24	62-6	–	3. Water levels should be measured just before the changes of discharge rates and at the end of continued OP & BW operation
15	0715	0730	1.50	71-0	–	
15	0730	0745	1.76	80-3	–	
15	0745	0800	2.02	90-11	–	
						pumping stopped at 08-00
40	0805	0845	1.50	69-4½	22	sampling from 30 sec for 2mins15 sec.
60	0900	1000	2-2.25	90-8	-	OP & BW operation.
3	1005	1008	2.25	-	20	sampling from 30 sec for 2 minis ~~SUxxxx~~.
60	1100	1200	2-2.25	91-4	-	OP & BW operaion.
4	1205	1209	1.5	-	15	sampling from 30 sec for 2mins 15 sec.
90	1230	1400	2-2.25	91-11	-	OP & BW operation.
5.	1403	1408	2.25	-	10	sampling from 25 sec for 2mins.
60	1430	1530	2-2.25	92-8	-	OP & BW operation.
5	1535	1540	1.50	-	6	sampling from 30 sec for 2 [illegible]

বিএডিসি, আইডিএ [illegible]
ময়মনসিংহ।

[illegible] (প-কু)
বি.এ.ডি.সি, আই.ডি.এ [illegible]
ময়মনসিংহ

For Bangladesh Engineers (Pvt.) Ltd.

Records checked by Signature

Name / Desig. [illegible] RASHID)
[illegible] (W) B. DO

Date

IDA, Bhaluka,
Mymensingh.

Form Nr
IDA DTW-II/05

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT- II

Well No	BHAL / 110 (R).
App. No.	1 / 1 / 267 / 61.

Mouzas Shohal

CONTRACTOR :

M/s.Bangladesh Engineers(Pvt.)Ltd.

CONTRACT IDA/P-II/I
PUMPING TEST RECORD

Static Water table depth from top of UWC 26 ft. 4 in. Diameter of Orifice 6 in.
Height of top of UWC above O.G.L. 2 ft. 0 in. Diameter of Approach pipe 8 in.
Development completed at 1540 hrs, 3, 5, 19 91. Test started at 1000 hrs, 4, 5, 19 91.
Test completed at 1640 hrs, 4, 5, 19 91.

PUMPING TEST READINGS

Step	Time Elapsed (min.)	Water Level from UWC top (ft.)	Drawdown (ft.)	Gauge Reading (in.)	Discharge (cusec)	Specific Drawdown (ft/cusec)	Step	Time Elapsed (min)	Water Level from UWC top (ft.)	Drawdown (ft.)	Gauge Reading (in)	Discharge (cusec)	Specific Drawdown (ft/cusec)
1 st.	0.5	53-2	26-10				3rd.	0.5	79-80	53-6			
	1	-5	27-1					1	80-0	-8			
	2	-8	-4					2	-2	-10			
	3	-10	-6					3	-4	54-0			
	4	54-0	-8					4	-6	-2			
	5	-1	-9					5	-7	-3			
	7	-3	-11					7	-810	-6			
	10	-5	28-1					10	81-0	-8			
	15	-6	-2					15	-2	-10			
	20	-8	-4					20	-4	55-0			
	25	-10	-6					25	-6	-2			
	30	55-0	-8					30	-8	-4			
	40	-1	-9					40	-9	-5			
	50	-2	-10					50	-810	-6			
	60	-3	-11					60	-11	-7			
	80	-3½	-11½					80	82-0	-8			
	100	-4	29-0	8"	1.0	29.0		100	-½	-8½	25"	1.75	31.81
2nd.	0.5	69-8	43-4				4th.	0.5	89-1	62-9			
	1	-10	-6					1	-3	-11			
	2	70-0	-8					2	-6	63-2			
	3	-3	-11					3	-8	-4			
	4	-6	44-2					4	-10	-6			
	5	-8	-4					5	90-0	-8			
	7	-10	-6					7	-3	-11			
	10	-11	-7					10	-5	64-1			
	15	71-0	-8					15	-6	-2			
	20	-2	-10					20	-8	-4			
	25	-4	45-0					25	-10	-6			
	30	-6	-2					30	91-0	-8			
	40	-8	-4					40	-1	-9			
	50	-10	-6					50	-3	-11			
	60	-11	-7					60	-5	65-1			
	80	72-0	-8					80	-6	-2			
	100	-1	-9	18"	1.5	30.5		100	-7	-3	33"	2.0	32.62

TESTS

	1st step			2nd step			3rd step			4th step				Remarks
Time elapsed (min)	2	5	50	2	5.	50	2	5	50	2	5	50	100	
Sand content (ppm)	-	26	25	-	14	12	-	12	10	-	8	5	2	By imhoff cone.
E.C (m.mho cm⁻¹)	☒	☒	395	☒	☒	390	☒	☒	385	☒	☒	380	-	By EC meter.
PH	☒	☒	6.7	☒	☒	6.7	☒	☒	6.8	☒	☒	7.0	-	BY PH meter.

Records checked by : Signature (M. A. RASHID)
Name/Designation Sr. SAE (DTW) IDA, Bhaluka, Mymensingh.
Date

For Bangladesh Engineers (Pvt.) Ltd.

Form No.
IDA DTW-II/06

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

APPENDIX-II-C

IDA DEEP TUBEWELL PROJECT-II

Well No. PHUL / 160
App No. 1 / 10 / 65 / 211
Daura-[illegible]

CONTRACTOR:
M/s.Purbachal Drillers Ltd.

CONTRACT IDA/P-II/1

DRILLING LOG

RIG No.
(SHEET 1 of 2)

Date Started 29, 01, 19 91 Date Completed 30, 1, 19 91
Logged by Md.Sirajuddin Depth ordered below OGL 297 ft

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS (ft.)		GRAPHIC LOG
ROD. No.	FROM	TO		FROM	TO	
			Top soil	0	12	
			Grey FS	12	22	
			Grey FS/MS	22	42	
			Grey MS/FS	42	72	
			Grey FS	72	77	
			Brown plastic clay	77	87	
			Brown FS	87	122	
			Brown FS/MS	122	132	
			Brown MS/FS	132	137	
			Brown MS	137	157	
			Grey MS	157	167	
			Grey plastic clay	167	197	
			Grey MS/FS	197	212	
			Grey MS	212	227	
			Light Grey MS/FS	227	237	
			Light Brown MS	237	257	

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (গঃকূ)
বি,এ,ডি,সি, আই ডি,এ, [illegible]

(মোঃ [illegible])
[illegible]

Records checked by: Signature
Name/Designation Md.Siraj-co... Assistant Regional ...
Date ...
Su ...
EADC, IDA,
Mymensingh.

For Purbachal Drillers Ltd.
Asstt. Project. Engineer.

Form : IDA - II/1

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No PHUL / 160
App No 1 / 10 / 65 /211
RIG NO Mauza=Matichapur
SHEET 2 of 2

CONTRACTOR
M/s.Purbachal Drillers Ltd.

CONTRACT IDA/P-II/1
DRILLING LOG

Date Started 29 , 1 , 19 91
Date Completed 30 , 1 , 19 91
Depth ordered below OGL 297 ft
Logged by Md.Sirajuddin

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No)	THICKNESS (ft)		GRAPHIC LOG
ROD No	FROM	TO		FROM	TO	
			Grey MS	257	282	
			Light Grey MS	282	307	

280
300
320
340
360
380
400
420
440
460
480
500
520

For Purbachal Drillers Ltd.
Asstt. Project. Engineer.

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (গঃকূ)
বি,এ,ডি,সি, আই,ডি,এ, রিজিয়ন
ময়মনসিংহ।

(মোঃ [illegible])
সহকারী প্রকৌশলী [illegible]
[illegible] রিজিয়ন, ময়মনসিংহ।

Records checked by: Signature
Name / Designation (Md.Sirajuddin)
Sub-Assistant Engr.
BADC, IDA Region
Mymensingh.
Date

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR :

M/s.Purbochol Drillers Ltd.

DESIGN SHEET

Well No........PHUL /..160.....

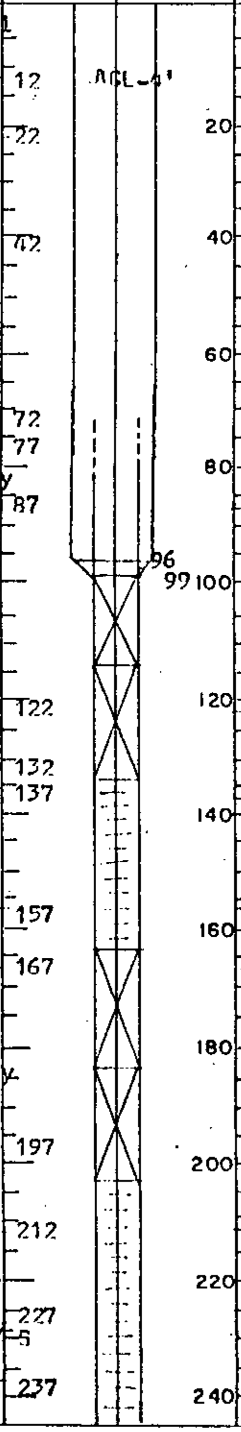
App No .....1 /..10../.65.../..211.

Mouza-Matichapur

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)		Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/Yellow	Grey	Brown/Yellow	Grey		Brown/Yellow	Grey	Brown/Yellow	Grey
Clay/Clayish	–	–	–	–	MS/FS	0·50	1·00	0·50	1·00
Silt/Silty	–	–	–	–	MS	0·70	1·40	0·70	1·40
VFS	–	–	0·05	0·10	MS/CS	0·80	1·60	0·80	1·60
VFS/FS	–	–	0·10	0·20	CS/MS	0·90	1·80	0·90	1·80
FS/VFS	–	–	0·20	0·40	CS	1·10	2·20	1·10	2·20
FS	–	–	0·30	0·60	CS/GR	1·00	2·00	1·00	2·00
FS/MS	–	–	0·40	0·80	Gr/CS/MS	0·60	1·20	0·60	1·20

DESIGN CALCULATION



Graphic log with symbol	Component Setting		Screened Aquifer				Unscreened Aquifer			
	Depth	Component	D	F	l	Σl	D	h	l'	Σl'
Top soil	12	ACL-4'								
G.FS	22									
G.FS/MS	42									
G.MS/FS	72									
G.FS	77									
B.P.clay	87									
B.FS	122	96 99					35	.3	10.5	10.5
B.FS/MS	132						10	.4	4.0	14.5
B.MS/FS	137		3	.5	1.5	1.5	2	.5	1.0	15.5
B.MS	157		20	.7	14.0	15.5				
G.MS	167		6	1.4	8.4	23.9	4	1.4	5.6	21.1
G.P.clay	197									
G.MS/FS	212		9	1.0	9.0	32.9	6	1.0	6.0	27.1
G.MS	227		15	1.4	21.0	53.9				
L.G.MS/FS	237		10	1.0	10.	63.9				

Depth scale: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (ক্ষুদ্র)
বি,এ,ডি,সি, আই ডি,এ, ময়মনসিংহ।

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≦ 40 feet thick and lowest late dry season SWL is ≦ 20ft.
2. 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 in.)

1. 90ft : Grey MS or coarser sands only
2. 110ft : Half mixed grey and brown/yellow/reddish sands
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer undertain by 10ft or more of clay/silt above topmost screen should be excluded from the calculations
2. For each aquifer section values of l and l' are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column
3. Drilling may be stopped when Σl ≧ 100 and Σl' ≧ 50 are achieved, subject to minimum screen lengths stated above
4. Final value of l' will be 20 multiplied by its relevant value below lowest screen
5. If Σl' including last 20ft is <50, although Σl is ≧ 100, if possible, additional aquifer should be screened to make Σl + Σl' ≧ 150 subject to minimum screen length stated above

For Purbochol Drillers Ltd.
Asstt. Project. Engineer.

KEY

D : Thickness of formation
F : Design factor of formation screened
l : D x F
Σl : Summation of values
h : Penetration factor of formation unscreened
l' : D x h.
Σl' : Summation of l' values

DESIGNER

Signature (Md.Sirajuddin)
Name ... Sr. Su... Assistant Engr.
Designation BADC, IDA Region
Mymensingh.

Form: 100

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR

M/s.Purbachal Drillers Ltd.

DESIGN SHEET

Well N PHUL / 160
App No 1 / 10 / 65 / 211
Mouza= Matichapur

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/yellow	Grey	Brown/yellow	Grey
Clay/Clayish	–	–	–	–
Silt/Silty	–	–	–	–
VFS		–	0·05	0 10
VFS/FS	–	–	0·10	0 20
FS/VFS	–	–	0 20	0·40
FS		–	0 30	0 60
FS/MS	–		0 40	0 80

Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/yellow	Grey	Brown/yellow	Grey
MS/FS	0 50	1 00	0 50	1 00
MS	0 70	1 40	0 70	1 40
MS/CS	0 80	1 60	0 80	1 60
CS/MS	0 90	1 80	0 90	1 80
CS	1 10	2 20	1 10	2 20
CS/Gr	1 00	2 00	1 00	2 00
Gr/CS/MS	0 60	1·20	0 60	1 20

DESIGN CALCULATION

Graphic log with symbol	Component Setting		Screened Aquifer				Unscreened Aquifer			
	Depth	Component	D	F	L	ΣL	D	h	L'	ΣL'
L.B.MS			20	0.7	14.0	77.9				
260	257	260								
G.MS			25	1.4	35.0	112.9				
280	282	280								
L.G.MS		292 297	10	1.4	14.0	126.9	20	1.4	28	55.1
300		300								
	312									
320		320								
340		340								
360		360								
380		380								
400		400								
420		420								
440		440								
460		460								
480		480								

E1+E1'=126.9+55.1=182.0(O.K.)

REMARKS

LENGTH OF HWC

1. 70ft – If upper clay is > 40 feet thick and lowest late dry season SWL is < 20ft
2. 80ft – in rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 in)

1. 30ft – Grey MS or coarser sands only
2. 40ft – Half mixed grey and brown/yellow/reddish sands
3. [illegible] Brown/yellow/reddish sands

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft or more of clay/silt [illegible] excluded from the calculations
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) × relevant F or h and summed in the appropriate column
3. Drilling may be stopped when ΣL ≥ 100 and ΣL' ≥ 50 are achieved, subject to minimum screen lengths stated above
4. Final value of L' will be 20ft multiplied by its relevant h value below lowest screen.
5. If ΣL' including the bottom 20ft is < 50, although ΣL is ≥ 100, if possible, additional aquifer should be screened to make ΣL + ΣL' ≥ 150, subject to minimum screen length stated above

i.e.

D = Thickness of formation
F = Design factor of formation screened
L = D × F
[illegible] Penetration factor of formation not screened
[illegible]

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (গনকূ)
বি,এ,ডি,সি, আই ডি,এ, রিজিয়ন
ময়মনসিংহ।

For Purbachal Drillers Ltd.
Asstt. Project Engineer.

(মোঃ [illegible])
সহকারী প্রকৌশলী [illegible]
[illegible] ময়মনসিংহ।

DESIGNED
Signature
Name (Md.Sirajuddin)
Designation Sr. Sub Assistant Engr.
BADC, IDA Region
Mymensingh.

BANGLADESH AGRICULTURAL DEV

IDA DEEPTUBEWELL PROJECT - II

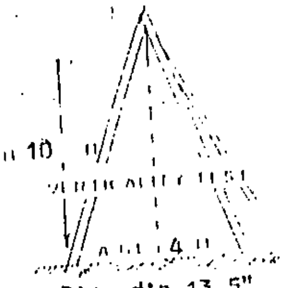
Well No PHUL / 160
App No 1 10 / 65 / 211

CONTRACTOR

M/s.Purbachal Drillers Ltd.

Rig No

CONTRACT IDA / P 11/1
FOR WELL CONSTRUCTION DETAILS



Disc dia=13.5"

DRILLED HOLE DETAILS

Diameter 20 in

Depth drilled below OGL 312 ft

Depth ordered below OGL 297 ft

Depth to SWL below OGL 8 ft 3 in

Length of temporary casing 6 ft

UPPER WELL CASING DETAILS

Diameter / material 14 in / MS

Height of UWC above OGL 4 ft in

Total length of UWC 100

Depth of UWC below OGL 96 ft

Reducer (R)/Material 3 ft /MS

LOWER WELL CASING & SCREEN DETAILS

	Diameter (in)	Material	Depth below UWC Top (ft)		LWC		Screen	
					No of 10 ft	No of 20 ft	No of 10 ft	No of 20 ft
LWC	6"	GI	103	to 138	1.5	1	-	-
Screen	6"	SS	138	to 167	-	-	1	12'-0" 1
LWC	6"	GI	~~167~~	to 207	-	2	-	-
Screen	6"	SS	207	to 296	-	-	1	19.75 x4
LWC				to				
Screen				to				
LWC				to				
Screen				to				
LWC				to				
Screen				to				
LWC				to				
Screen				to				
LWC				to				
Screen				to				
				Total	1.5	3	2	5

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (ক্ষুদ্র)
বি,এ,ডি,সি, আই ডি,এ, বিভিন্ন
ময়মনসিংহ

(মোঃ [illegible])
সহকারী প্রকৌশলী [illegible]
বাএডিসি, [illegible]

Reading 0 in	10 ft	Col Dev 0 in	
Reading 2/32 in	20 ft	Col Dev 0.43 in	65°
Reading 1/32 in	30 ft	Col Dev 0.37 in	130°
Reading 2/32 in	40 ft	Col Dev 0.56 in	110°
Reading 4/32 in	50 ft	Col Dev 1.0 in	120°
Reading 6/32 in	60 ft	Col Dev 1.56 in	125°
Reading 7/32 in	70 ft	Col Dev 2.0 in	126°
Reading 8/32 in	80 ft	Col Dev 2.5 in	115°

Material GI, SS (Stainless steel) or MS (Mild steel)

Total Length of LWC 75 ft

Depth of bottom of Bail plug below OGL 297 ft

Total Length of Screen (S) 118 ft

Gravel quantity (approx) 690 cft

Bail plug (BP) 5 ft

TOTAL LENGTH OF WELL STRING (UWC + R + LWC + S + BP) 301 ft

8/32=90ft=2.75

Signed for the Engineer

Name: Md.Sirajuddin)

Designation Sr S. Assistant E. S.
BADC, IDA Region
Mymensingh.

Date

Signed for the Contractor

Name For Pu[illegible] Drillers Ltd.

Designation Asstt. Project Engineer.

Date

Max. Deviation 2.75 in

at Depth 90 ft

Add.Dinc allowance.25

Form IDA 11/3

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No. PHUL / 160
App. No. 1 / 10 / 65 / 211
Mouza= Matichapur

ONTRACTOR :
M/s.Purbachal Drillers Ltd.

CONTRACT IDA/P-II/I
DEVELOPMENT RECORD

atic Water level from top of UWC ... 8 ... 5 ... ft
ight of top of UWC above O.G.L. ... 4 ... ft ... 0 ... In
velopment started at ... 0830 ... hrs, 3 , 2 , 19 91
thod of Development ... Over pumping & back washing

Diameter of Orifice ... 6 ... In
Diameter of Approach pipe ... 8 ... In
Development Completed at ... 1740 ... hrs, 3 , 2 , 19 91

Time lapsed (mins)	Clock time		Discharge (cusec)	Water level from UWC top (m, ft)	Sand content (ppm)	Remarks
	From	To				
30	0830	0900	0.80	16-10	-	1. Hammering the top of UWC (about 1 minute in every 15 minutes) is needed throughout the development period.
15	0900	0915	0.85	17-4	-	2. Sand content test is not essential during the first two hours
15	0915	0930	1.00	19-0	-	3. Water levels should be measured just before the changes of discharge rates and at the end of continued OP & BW operation
15	0930	0945	1.24	21-6	-	
15	0945	1000	1.50	24-3	-	
15	1000	1015	1.76	27-0	-	
15	1015	1030	2.02	30-2	-	Centinoous Pumping stopped at 10-30
32.	1040	1112	2.0	29-10	9.0	sampling from 30 sec for 2mins 15 sec.
					2.0	sampling from 30 sec for 2mins.
60	1140	1240	2--3	34-8	-	OP & BW operation.
4	1245	1249	3	-	3.0	sampling from 20 sec for 2mins 45 sec.
60	1305	1405	2--3	37-10	-	OP & BW operation.
3	1410	1413	2	-	2.0	sampling from 30 sec for 2mins
90	1430	1600	2--3	40-6	-	OP & BW operation.
5	1605	1610	3	-	1.0	sampling from 20 sec for 2mins.
60	1630	1730	2--3	39-3	-	OP & BW operation.
5	1735	1740	-2	-	1.0	sampling 30 sec for 2mins 30 sec.

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (গনস্থ)
বি,এ,ডি,সি, আই ডি,এ, রিজিয়ন.
ময়মনসিংহ।

For Purbachal Drillers Ltd.
Asstt. Project Engineer.

checked by: Signature (Md.Sirujuddin)
~~Name~~/Designation Assistant Engr.
Sr. Su
Date
BADC, IDA Region
...ensingh.

(মোঃ [illegible] রহমান)
সহকারী প্রকৌশলী গভীর [illegible]
বিএডিসি, আইডিএ রিজিয়ন, ময়মনসিংহ।

Form No
IDA DTW- II/05

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No. PHUL / 160
App. No. 1 / 10 / 65 /211

Mouza-Matichapur

CONTRACTOR :

M/s. Purbachol Drillers Ltd.

CONTRACT IDA/P-II/I
PUMPING TEST RECORD

Static Water table depth from top of UWC ... 8 ft. 6 in. Diameter of Orifice ... 6 in.

Height of top of UWC above O.G.L. ... 4 ft. 0 in. Diameter of Approach pipe ... 8 in.

Development completed at 1740 hrs. 3 , 2 , 19 91. Test started at 1100 hrs. 4 , 2 , 19 91.

Test completed at 1740 hrs. 4 , 2 , 19 91.

PUMPING TEST READINGS

Step	Time Elapsed (min.)	Water Level from UWC-top (ft.)	Drawdown (ft.)	Gouge Reading (in.)	Discharge (cusec)	Specific Drawdown (ft/cusec)	Step	Time Elapsed (min)	Water Level from UWC top (ft.)	Drawdown (ft.)	Gouge Rending (in)	Discharge (cusec)	Specific Drawdown (ft/cusec)
1 st.	0.5	22'-6"	14'-0"				3rd.	0.5	34'-4"	25'-10"			
	1	-8½"	-2½"					1	-5½"	-11½"			
	2	-10"	-4"					2	-7"	26'-1"			
	3	-11½"	-5½"					3	-8"	-2"			
	4	23'-1"	-7"					4	-9½"	-3½"			
	5	-2"	-8"					5	-11"	-5"			
	7	-3"	-9"					7	35'-0"	-6"			
	10	-5"	-11"					10	-1"	-7"			
	15	-6"	15'-0"					15	-2"	-8"			
	20	-7½"	-1½"					20	-3"	-9"			
	25	-9"	-3"					25	-4"	-10"			
	30	-10"	-4"					30	-5½"	-11½"			
	40	-11½"	-5½"					40	-6½"	27'-½"			
	50	24'-½"	-6½"					50	-8"	-2"			
	60	-2"	-8"					60	-9"	-3"			
	80	-3"	-9"					80	-10"	-4"			
	100	-4"	-10"	18"	1.5	10.55		100	-10½"	-4½"	53"	2.5	10.94
2 nd.	0.5	28'-3"	19'-9"				4th.	0.5	40'-5"	31'-11"			
	1	-5"	-11"					1	-7"	32'-1"			
	2	-7"	20'-1"					2	-8½"	-2½"			
	3	-8"	-2"					3	-9½"	-3½"			
	4	-9"	-3"					4	-11	-5"			
	5	-10"	-4"					5	41'-0"	-6"			
	7	-11"	-5"					7	-1"	-7"			
	10	29'-½"	-6½"					10	-2"	-8"			
	15	-2"	-8"					15	-3"	-9"			
	20	-3½"	-9½"					20	-4"	-10"			
	25	-4½"	-10½"					25	-5½"	-11½"			
	30	-6"	21'-0"					30	-6½"	33'-½"			
	40	-7"	-1"					40	-8"	-2"			
	50	-8½"	-2½"					50	-9"	-3"			
	60	-9½"	-3½"					60	-10½"	-4½"			
	80	-11"	-5"					80	-11½"	-5½"			
	100	30'-0"	-6"	33"	2.0	10.75		100	42'-0"	-6"	70"	3.0	11.16

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (গনক)
বি.এ.ডি.সি, আই ডি.এ. রিজিয়ন.
ময়মনসিংহ।

TESTS

	1st step			2nd step			3rd step			4th step				Remarks
Time elapsed (min)	2 to 5		50	2 to 5.		50	2 to 5		50	2 to 5		50	100	
Sand content (ppm)	-	10	8		7	6	-	5	4	-	3	1	-	By imhoff cone.
EC (m mho cm^{-1})	X	X	495	X	X	495	X	X	490	X	X	490		
PH	X	X	6.8	X	X	6.8	X	X	6.9	X	X	7.0		

Records checked by : Signature
Name/Designation (Md. Sirajuddin)
Date
Sr. Su. Assistant Engr.
BADC, IDA Region
Mymensingh.

For Purbachol Drillers Ltd.
Asstt. Project Engineer.

Form No.
IDA DT N- II /06

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

APPENDIX-II-D

IDA DEEP TUBEWELL PROJECT- II

CONTRACTOR: M/S Joy Enterprise.

CONTRACT IDA/P-II/11/89-90

TEST DRILLING LOG

Well No NABI /B-27
App.No 4 / 8 / 39 /1995
RIG No Mauzai-Shahabaz pur.
(SHEET 1 of 2)

Date Started 5 3 1991
Logged by Sr.S.A.E.(Irri) Nabi Nager
Date Completed 7 3 1991.
Depth ordered below OGL 500 ft.

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS(ft.)		GRAPHIC LOG
ROD.No.	FROM	TO		FROM	TO	
			Gray Clay (No-1)	0	20	▤
			Gray VFS/FS. (No-2)	20	98	░
			Gray VFS (No-3)	98	125	░
			Gray FS./Clay. (No-4)	125	140	▤
			GrayFS (No-5)	140	151	░
			Gray Clay/FS. (No-6)	151	180	▤
			Clay (No-7)	180	190	▤
			Gray MS/FS. (No-8)	190	220	░
			Gray VFS. (NO-9)	220	225	░
			Gray MS/FS. (No-10)	225	240	░
			Rediah FS.(No-11)	240	260	░

প্রতিস্বাক্ষর
নির্বাহী প্রকৌশলী (সেচ)
বিএডিসি [illegible]
[illegible]

Records checked by: Signature
Name/Designation
Date

JOY ENTERPRISE

উপসহকারী প্রকৌশলী (সেচ)
বিএডিসি, নবীনগর ইউনিট—১
[illegible]

সহকারী প্রকৌশলী (সেচ)
বিএডিসি, নবীনগর, [illegible]

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No. NABI / R-27.
APR No. 4 / 8 / 59 / 1995

CONTRACTOR: M/S JOY ENTERPRISE.

CONTRACT IDA/P-II/11 89-90
TEST DRILLING LOG

Mauza:-SHAHABAZPUR.
RIG NO.
SHEET 2 of 2

Date Started 5, 3, 1991 Date Completed 7, 3, 19 91
Logged by Sr.S.A.E.(Irri),Nabinagor. Depth ordered below OGL 500 ft.

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS(ft.)		GRAPHIC LOG
ROD.No.	FROM	TO		FROM	TO	
			Brown FS.(No-12)	260	272	░
			Brown MS/FS. (No-13)	272	365	░
			Light Brown MS/FS. (No-14)	365	392	░
			Brown MS. (No-15)	392	440	░
			Gray MS/FS. (No-16)	440	465	░
			Gray FS. (No-17)	465	490	░
			Gray Clay.	490	500	▤

280 300 320 340 360 380 400 420 440 460 480 500 520

প্রতিস্বাক্ষর
নির্বাহী প্রকৌশলী (সেচ)
বিএডিসি বি-বাড়ীয়া রিজিয়ন
ব্রাহ্মণবাড়ীয়া।

Records checked by : Signature উর্ধ্বতন সহকারী প্রকৌশলী (সেচ)
Name / Designation বিএডিসি, নবীনগর ইউনিট-১.
Date নবীনগর, বি. বাড়ীয়া।

JOY ENTERPRISE

সহকারী প্রকৌশলী (সেচ)
বিএডিসি, ব্রাহ্মণবাড়ীয়া

Form : IDA-II/01

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT- II

Well No NABI/ / R-27
App.No 4 / 8 / 59 / 1995

CONTRACTOR:
M/s. Joy Enterprise

CONTRACT IDA/P-II/I/ DRILLING LOG 89-90

Mouza : Shahabazpur
RIG No ( )
(SHEET 1 of 2)

Date Started 10 3 19 1991. Date Completed 13 3 19 91
Logged by Sr. S.A.E(Irri) Nabinagar Depth ordered below OGL 451 ft.

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS(ft.)		GRAPHIC LOG
ROD.No.	FROM	TO		FROM	TO	
		20	Clay	0	20	
		40 60 80	Gray VFS/FS	20	100	
		100	Gray VFS	100	120	
		120	Gray FS/VFS	120	125	
			Gray Clay/VFS	125	138	
		140	Gray FS/VFS	138	150	
		160	Gray Clay/VFS	150	180	
		180	Clay	180	193	
			Gray FS/MS(No-1)	193	197	
		200	Gray MS/FS(No-2).	197	215	
		220	Gray VFS (No-3)	215	224	
		240	Gray MS/FS(No-4)	224	245	
			Redish FS/VFS(No-5)	245	255	
		260		255		

প্রতিস্বাক্ষর
নির্বাহী প্রকৌশলী (সেচ)
বিএডিসি বি-বাড়ীয়া বিভাগ
ব্রাহ্মণবাড়ীয়া।

Records checked by: Signature
Name/Designation উর্ধ্বতন উপ-সহকারী প্রকৌশলী (সেচ), বিএডিসি, নবীনগর ইউনিট, নবীনগর, বি; বাড়ীয়া।
Date

JOY ENTERPRISE

সহকারী প্রকৌশলী (সেচ)

Form: IDA-II/01

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No. NABI / R-27
APR No. 4 / 8 / 59 / 1995

CONTRACTOR:
M/s. Joy Enterprise

CONTRACT IDA/P-II/11/
DRILLING LOG 89-90

Mouza : Shahabazpur.
RIG NO.
SHEET 2 of 2

Date Started 10, 3, 1991 Date Completed 13, 3, 1991
Logged by Sr.S.A.E(Irri)Nabinagar Depth ordered below OGL 451 ft.

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS(ft.)		GRAPHIC LOG
ROD No.	FROM	TO		FROM	TO	
			Brown FS/VFS (No.6)		270	
			Brown MS/FS (No-7)	270	360	
			Light Brown Ms/FS(No-8)	360	385	
			Brown Ms(No-9)	385	435	
			Gray Ms/FS (No-10)	435	460	
			Gray VFS (No-11)	460	483	

প্রতিস্বাক্ষর
নির্বাহী প্রকৌশলী (সেচ)
বিএডিসি [illegible] রিজিয়ন
ব্রাহ্মণবাড়ীয়া।

Records checked by : Signature
Name / Designation
Date 19

JOY ENTERPRISE

সহকারী প্রকৌশলী (সেচ)

Form: IDA-II/01

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR : CONTRACT IDA/P-II/

M/S Joy Enterprise. ....

DESIGN SHEET

Well No.....NABI..../..R2-27......

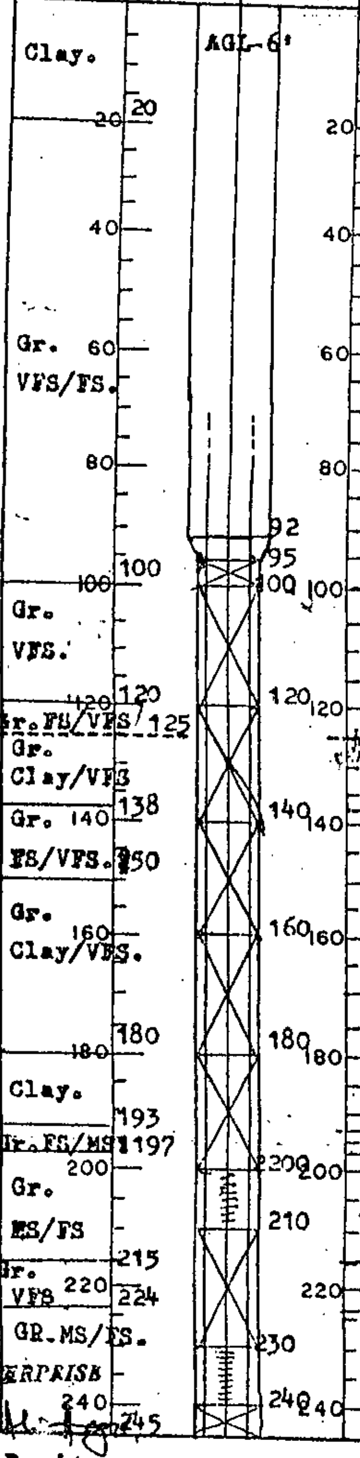
App. No...4../..8../.59../1995

Mauza:-Shahabazpur.

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)		Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/Yellow	Grey	Brown/Yellow	Grey		Brown/Yellow	Grey	Brown/Yellow	Grey
Clay/Clayish	–	–	–	–	MS/FS	0.50	1.00	0.50	1.00
Silt/Silty	–	–	–	–	MS	0.70	1.40	0.70	1.40
VFS	–	–	0.05	0.10	MS/CS	0.80	1.60	0.80	1.60
VFS/FS	–	–	0.10	0.20	CS/MS	0.90	1.80	0.90	1.80
FS/VFS	–	–	0.20	0.40	CS	1.10	2.20	1.10	2.20
FS	–	–	0.30	0.60	CS/Gr	1.00	2.00	1.00	2.00
FS/MS	–	–	0.40	0.80	Gr/CS/MS	0.60	1.20	0.60	1.20

DESIGN CALCULATION



Graphic log with symbol	Depth	Screened Aquifer D	F	L	ΣL	Unscreened Aquifer D	h	L'	ΣL'
Clay.	0–20								
Gr. VFS/FS.	20–100								
Gr. VFS.	100–120								
Gr.FS/VFS	120–125								
Gr. Clay/VFS	125–138								
Gr. FS/VFS.	138–150								
Gr. Clay/VFS.	150–180								
Clay.	180–193								
Gr.FS/MS	193–197					4	0.80	3.2	3.20
Gr. MS/FS	197–200					3	1.0	3.00	6.20
	200–210	10	1.00	10.0	10.00				
	210–215					5	1.0	5.00	11.20
Gr. VFS	215–224					9	0.10	.90	12.10
GR.MS/FS.	224–230					6	1.0	6.0	18.10
	230–240	10	1.0	10.0	20.00				
	240–245					5	1.0	5.0	23.10

প্রতিস্বাক্ষর
নির্বাহী প্রকৌশলী (ক্ষুদ্র)
বিএডিসি ক্ষু-সেচ বিভাগ
ব্রাহ্মণবাড়ীয়া।

সহকারী প্রকৌশলী (ক্ষুদ্র)
বিএডিসি নবীনগর জোন
নবীনগর, ব্রাহ্মণবাড়ীয়া।

JOY ENTERPRISE

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≤ 40 feet thick and lowest late dry season SWL is ≤ 20ft.
2. 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 in.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft. or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column.
3. Drilling may be stopped when ΣL ≥ 100 and ΣL' ≥ 50 are achieved, subject to minimum screen lengths stated above.
4. Final value of L' will be 20ft. multiplied by its relevant h value below lowest screen.
5. If ΣL' including the bottom 20ft. is <50, although ΣL is ≥ 100, if possible, additional aquifer should be screened to make ΣL + ΣL' ≥ 150, subject to minimum screen length stated above

KEY

D: Thickness of formation.
F: Design factor of formation screened.
L: D x F
ΣL: Summation of L values
h: Penetration factor of formation unscreened.
L': D x h.
ΣL': Summation of L' values.

DESIGNER

Signature
Name
Designation

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR : CONTRACT IDA/P-II/11/89-90

M/S Joy Enterprise.

DESIGN SHEET

Well No. NABI / R-27

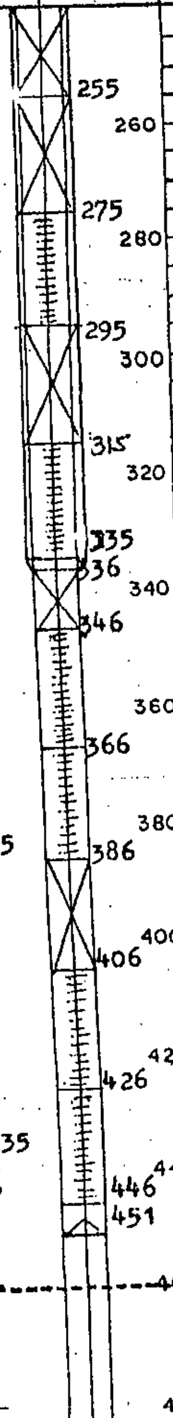
App No. 4 / 8 / 59 / 1995

Mauza:-Shahabazpur.

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)		Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/yellow	Grey	Brown/yellow	Grey		Brown/yellow	Grey	Brown/yellow	Grey
Clay/Clayish	—	—	—	—	MS/FS	0·50	1·00	0·50	1·00
Silt/Silty	—	—	—	—	MS	0·70	1·40	0·70	1·40
VFS	—	—	0·05	0·10	MS/CS.	0·80	1·60	0·80	1·60
VFS/FS	—	—	0·10	0·20	CS/MS	0·90	1·80	0·90	1·80
FS/VFS	—	—	0·20	0·40	CS	1·10	2·20	1·10	2·20
FS	—	—	0·30	0·60	CS/Gr	1·00	2·00	1·00	2·00
FS/MS	—		0·40	0·80	Gr/CS/MS	0·60	1·20	0·60	1·20

DESIGN CALCULATION



Graphic log with symbol	Component Setting		Screened Aquifer				Unscreened Aquifer			
	Depth	Component	D	F	L	ΣL	D	h	L'	ΣL'
Redish FS/VFS	255	255					10	0.20	2.0	25.10
Brown FS/VFS	260 270	260					15	0.20	3.0	28.10
		275					5	0.50	2.5	30.60
BR. MS/FS	280	280	20	0.50	10.00	30.00				
	300	295 300					20	0.50	10.0	40.60
	320	315 320	20	0.50	10.0	40.00				
	340	335 336 340					11	0.50	5.50	46.10
		346	14	0.50	7.0	47.00				
Light Br.MS/FS.	360	360 366	25	0.50	12.5	59.50				
Br.MS.	380 385	380 386	1	0.70	.70	60.20				
	400	400 406					20	.70	14.0	60.10
	420	420 426	29	0.7	20.3	80.50				
Gr.MS/FS.	435 440	440	11	1.0	11.0	91.50				
		446 451					14	1.0	14.0	74.10
Gr.VFS.	460	460					6	0.10	0.60	74.70
	480	480								

ΣL+ΣL' = =91.50 + 74.70

=166.20. OK.

প্রতিস্বাক্ষর

নির্বাহী প্রকৌশলী (সেচ)
বিএডিসি বি-বাড়ীয়া রিজিয়ন
ব্রাহ্মণবাড়ীয়া।

সহকারী প্রকৌশলী (সেচ)
বিএডিসি, নবীনগর, জোন
নবীনগর, বি. বাড়ীয়া।

NTERPRISE

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≦ 40 feet thick and lowest late dry season SWL is ≦ 20ft.
2. 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 in.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft. or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column
3. Drilling may be stopped when ΣL ≧ 100 and ΣL' ≧ 50 are achieved, subject to minimum screen lengths stated above.
4. Final value of L' will be 20ft. multiplied by its relevant h value below lowest screen.
5. If ΣL' including the bottom 20ft. is <50, although ΣL is ≧ 100, if possible, additional aquifer should be screened to make ΣL + ΣL' ≧ 150, subject to minimum screen length stated above

KEY

D: Thickness of formation
F: Design factor of formation screened
L: D x F
L: Summation of L values
h: Penetration factor of formation unscreened.
L': D x h
ΣL': Summation of L' values

DESIGNER

Signature............

Name.............

Designation.............

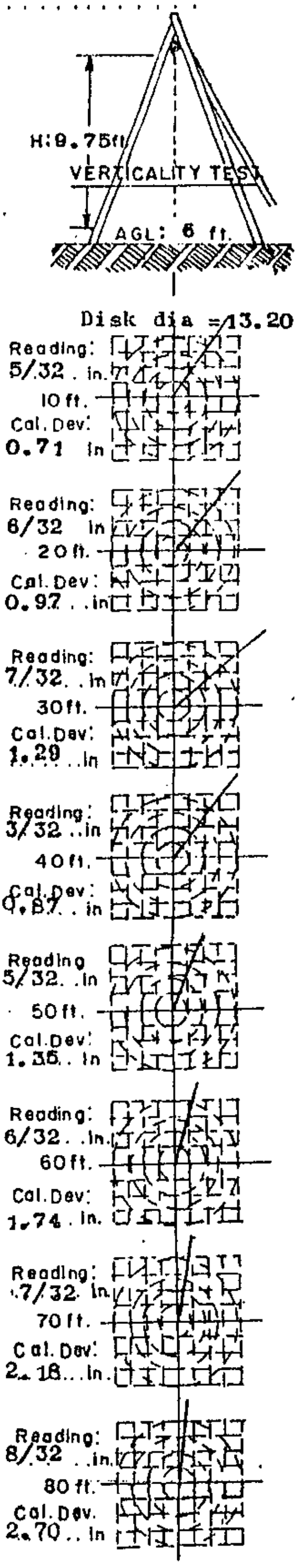
BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEPTUBEWELL PROJECT—II

CONTRACTOR:
M/s. Joy Enterprise

Well No. NABI / R-27
App No. 4 / 8 / 59 / 1995
Mouza : Shahabazpur.
RIG No.

CONTRACT IDA/P-II/ 11/89-90
TUBEWELL CONSTRUCTION DETAILS



DRILLED HOLE DETAILS Diameter 20 in.

Depth ordered below O.G.L. 451 ft. Depth drilled below OGL 483 ft.

Length of temporary casing 70 ft. Depth to SWT below OGL ft. in.

UPPER WELL CASING DETAILS Diameter / material: 14 in./ MS

Height of UWC above OGL 6 ft. in. Total length of UWC 98

Depth of UWC below OGL 92 ft. Reducer(R)/ Material: 3 ft./MS/1ftSS

LOWER WELL CASING & SCREEN DETAILS

	Diameter (in.)	Material	Depth below UWC top (ft.)	LWC		Screen	
				No of 10 ft.	No of 20 ft.	No of 10 ft.	No of 20 ft.
LWC	8	G.I.	95 to 200		5.25	-	-
Screen	8	S.S.	200 to 210	-	-	1	-
LWC	8	G.I.	210 to 230	-	1	-	-
Screen	8	S.S.	230 to 240	-	-	1	-
LWC	8	G.I.	240 to 275	-	1.75	-	-
Screen	8	S.S.	275 to 295	-	-	-	1
LWC	8	G.I.	295 to 315	-	1	-	-
Screen	8	S.S.	315 to 335	-	-	-	1
LWC	6	G.I	336 to 346	1	-	-	-
Screen	6	S.S.	346 to 386	-	-	-	2
LWC	6	G.I.	386 to 406	-	1	-	-
Screen	6	S.S.	406 to 446	-	-	-	2
LWC			to				
Screen			to				
			Total	1	10	2	6

* Material: GRP, SS (Stainless steel) or MS (Mild steel).

Depth to bottom of ball plug below OGL 451 ft.

Total Length of LWC 210 ft.

Total Length of Screen (S) 140 ft.

Gravel quantity (appox.) 1250 cft.

Ball plug (BP) 5 ft.

Excess Gravel used due to Cavitation

TOTAL LENGTH OF WELL STRING (UWC+R+LWC+S+BP) 457 ft.
(98+4+210+140+5)

Signed for the Engineer
Name উর্ধ্বতন উপ-সহকারী প্রকৌশলী (সেচ)
Designation বিএডিসি, নবীনগর ইউনিট—১
নবীনগর, বি, বাড়ীয়া।
Date ,19

Signed for the Contractor
Name Cal. Dev. 8/32 at 95ft=3.42(Same direction
Designation JOY ENTERPRISE
Date
Proprietor.

Max. Deviation 3.42 in.
at Depth 95 ft.

প্রতিস্বাক্ষর
10/11/03

সহকারী প্রকৌশলী (সেচ)

নির্বাহী প্রকৌশলী (সেচ)

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No. NABI / R-27
App. No. 4 / 8 / 59 / ~~1998~~

CONTRACTOR:
M/s. Joy Enterprise

CONTRACT IDA/P-II/11/89-90
DEVELOPMENT RECORD

Mouza : Shahabazpur.

Static Water table from top of UWC 16 ft. 10 in.
Diameter of Orifice 6 in.
Height of top of UWC above O.G.L. 6 ft. in.
Diameter of Approach pipe 8 in.
Development started at 9 hrs, 2 . 4. 1991
Development Completed at 17 hrs, 2 ,4 .'1991
Method of Development Over Pumping & Back Washing.

TIME (clock)		Gauge Reading (in.)	Discharge (cusec)	Water Level from UWC top (ft.)	Drawdown (ft.)	TIME (clock)		Gauge Reading (in.)	Discharge (cusec)	Water Level from UWC top (ft.)	Drawdown (ft.)
From	To					From	To				
9.00	9.20	5-6	Below 1.00			14.03	14.08	54	2.50	58'-1"	
9.20	9.40	7				14.11	14.16	"	"		
9.40	10.00	8	1.00	29'-0"	12'-2"	14.19	14.24	"	"		
						14.27	14.32	"	"		
10.03	10.08	18	1.50	35'-1"		14.35	14.40	"	"		
10.11	10.16	"	"			14.43	14.50	"	"		
10.19	10.24	"	"			14.53	15.00	"	"	61'-3"	44'-5"
10.27	10.32	"	"			15.03	15.08	"	"		
10.35	10.48	"	"			15.11	15.16	"	"		
10.52	11.00	"	"	36'-5"	19'-7"	15.19	15.24	"	"		
11.03	11.08	"	"			15.27	15.32	"	"		
11.19	11.24	"	"			15.35	15.40	"	"		
11.27	11.32	"	"			15.43	15.50	"	"		
11.35	11.40	"	"			15.53	16.00	"	"	62'-11"	46'-1"
11.43	11.48	"	"			16.03	16.08	"	"		
11.53	12.00	"	"	38'-6"	21'-8"	16.11	16.16	"	"		
						16.19	16.24	"	"		
12.03	12.08	33	2.00	45'-9"		16.27	16.32	"	"		
12.11	12.16	"	"			16.35	16.40	"	"		
12.19	12.24	"	"			16.43	16.50	"	"		
12.32	12.40	"	"			16.53	17.00	"	"	63'-7"	46'-9"
12.52	13.00	"	"	47'-3"	30'- 5"						
13.03	13.08	"	"								
13.11	13.16	"	"								
13.19	13.24	"	"								
13.27	13.32	"	"								
13.35	13.40	"	"								
13.43	13.48	"	"								
13.52	14.00	"	"	49'-10"	33'-0"						

প্রতিস্বাক্ষর
নির্বাহী প্রকৌশলী (সেচ)
বিএডিসি বি-বাড়ীয়া রিজিয়ন
ব্রাহ্মণবাড়ীয়া।

SAND CONTENTS

Time elapsed(min)	2	5	10	30	60	90	120	150	180	240	320
Sand content (ppm)	-Muddy	-	-	290	185	120	65	50	20	12 -	6

Records checked by: Signature
ঊর্ধতন উপ-সহকারী প্রকৌশলী (সেচ)
বিএডিসি, নবীনগর ইউনিট—১
Name/Designation নবীনগর, বি; বাড়ীয়া।
Date , 19.

JOY ENTERPRISE

Form : IDA-II/05

সহকারী প্রকৌশলী (সেচ)
বিএডিসি, নবীনগর

D.8

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT- II

Well No . NABI . . / R - 27 .
App. No. 4 / 8 / 59/1990

CONTRACTOR :
M/s. Joy Enterprise.

CONTRACT IDA/P-II/11/89-90
PUMPING TEST RECORD

Mouza : Shahabazpur.

Static Water table depth from top of UWC ..16.. ft.. 6.. in. Diameter of Orifice ... ... 6... ... ... in

Height of top of UWC above O.G.L. ...6 ... ...ft. ... in. Diameter of Approach pipe ... ...8... ... ... in.

Development completed at..9... hrs,.2...,.4.., 1991.... Test started at......10...hrs,...3...,.4., 19.91..

Test completed at.17.40 hrs,..3...,..4, 1991....

PUMPING TEST READINGS

Step	Time Elapsed (min.)	Water Level from UWC top (ft.)	Drawdown (ft.)	Gauge Reading (in.)	Discharge (cusec)	Specific Drawdown (ft/cusec)	Step	Time Elapsed (min)	Water Level from UWC top (ft.)	Drawdown (ft.)	Gauge Reading (in)	Discharge (cusec)	Specific Drawdown (ft/cusec)
1 st.	0.5	28-0		8	1.00		3rd.	0.5	51-4		33	2.00	
	1	1		"	"			1	5		"	"	
	2	2		"	"			2	6		"	"	
	3	3		"	"			3	7		"	"	
	4	4		"	"			4	8		"	"	
	5	5		"	"			5	9		"	"	
	7	7		"	"			7	11		"	"	
	10	10		"	"			10	52-1		"	"	
	15	29-2		"	"			15	3		"	"	
	20	4		"	"			20	5		"	"	
	25	6		"	"			25	7		"	"	
	30	8		"	"			30	9		"	"	
	40	30-0		"	"			40	53-0		"""	"	
	50	3		"	"			50	3		"	"	
	60	6		"	"			60	6		"	"	
	80	11		"	"			80	9		"	"	
	100	31-4	14-10	"	"	14.83		100	54-1	37-7	"	"	18.79
2 nd.	0.5	38-9		18	1.50		4th.	0.5	63-6		54	2.50	
	1	10		"	"			1	7		"	"	
	2	11		"	"			2	8		"	"	
	3	39-0		"	"			3	9		"	"	
	4	1		"	"			4	10		"	"	
	5	2		"	"			5	11		"	"	
	7	4		"	"			7	64- 1		"	"	
	10	7		"	"			10	3		"	"	
	15	10		"	"			15	5		"	"	
	20	40-1		"	"			20	8		"	"	
	25	4		"	"			25	11		"	"	
	30	8		"	"			30	65-2		"	"	
	40	41-0		"	"			40	5		"	"	
	50	4		"	"			50	8		"	"	
	60	9		"	"			60	66-0		"	"	
	80	42-2		"	"			80	2		"	"	
	100	42-7	26-1	"	"	17.38		100	66-5	49-11	"	"	19.96

TESTS

	1st step			2nd step			3rd step			4th step				Remarks
Time elapsed (min)	2	5	50	2	5	50	2	5	50	2	5	50	100	
Sand content (ppm)	-	15	10	15	10	7	8	5	4	5	3	3	3	
EC (m.mho cm^{-1})	☒	☒	490	☒	☒	490	☒	☒	500	☒	☒	500	510	
PH	☒	☒	6.6	☒	☒	6.7	☒	☒	6.8	☒	☒	7.0		

Records checked by : Signature..........

Name/Designation

Date . . . . . , . . .

JOY ENTERPRISE

প্রতিস্বাক্ষর
নির্বাহী প্রকৌশলী (সেচ)
বিএডিসি [illegible]
ব্রাহ্মণবাড়ীয়া .

সহকারী প্রকৌশলী (সেচ)
বিএডিসি, নবীনগর, জোন

Form : IDA-II/06

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR: M. A. Quader Ltd.

CONTRACT IDA/P-II/I

DRILLING LOG

Well No. DAUD 60/
Apr No. 4/4/334/354
RIG No. Mouza:- Nongoan
(SHEET 1 of 2)

Date Started 20, 3, 1991 Date Completed 22, 3, 1991
Logged by Mr. Jamal uddin Sr. SAE Depth ordered below OGL 325 ft

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No.)	THICKNESS (ft.)		GRAPHIC LOG
ROD No	FROM	TO		FROM	TO	
			Top Soil	0	10	▨
			Black Clay	10	55	≡
			Grey FS	55	70	⁘
			Plastic Clay	70	110	≈
			Grey VFS	110	130	⁘
			Plastic Clay	130	166	≈
			Grey MS	166	215	⁘
			Grey FS/Ms	215	227	⁘
			Grey MS/FS	227	245	⁘

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (সেচ)
বি.এ.ডি.সি, কুমিল্লা রিজিয়ন
কুমিল্লা।

সহকারী প্রকৌশলী (সেচ)
বি এ ডি সি, [illegible]
কুমিল্লা।

সিনিয়র সহকারী প্রকৌশলী [illegible]
বি.এ.ডি.সি. (সেচ) [illegible]
[illegible] কুমিল্লা।

Records checked by: Signature

Name/Designation

FOR M/S. M.A. QUADER LTD.
(Syed. Md. Ali)
Supervisor

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

Well No. DAUD 66 /
App. No. 4 / 4 /334 /354

CONTRACTOR:

M.A. Quader Ltd.

CONTRACT IDA/ P-II/1

DRILLING LOG

RIG NO. Mouza:- Noagoan
SHEET 2 of 2

Date Started 20, 3, 1991 Date Completed 22, 3, 1991
Logged by Mr. Jamal Uddin Sr. SAE Depth ordered below OGL 325 ft.

DRILLING TIME LOG			DESCRIPTION OF FORMATION (With Sample No)	THICKNESS (ft.)		GRAPHIC LOG
ROD No.	FROM	TO		FROM	TO	
			Grey MS		295	
			Plastic Clay	295	325	

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (সেচ)
বি,এ,ডি,সি, কুমিল্লা রিজিয়ন-২
কুমিল্লা।

সহকারী প্রকৌশলী (সেচ)
বি এ ডি সি, [illegible], জোন
কুমিল্লা।
Records checked by Signature

[illegible]
বি,এ,ডি,সি, (সেচ) [illegible]
[illegible] কুমিল্লা।

FOR M/S. M.A. QUADER LTD.
(Syed. A.d. Ali)
Supervisor

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

ONTRACTOR :

M.A. Quader. Ltd.

DESIGN SHEET

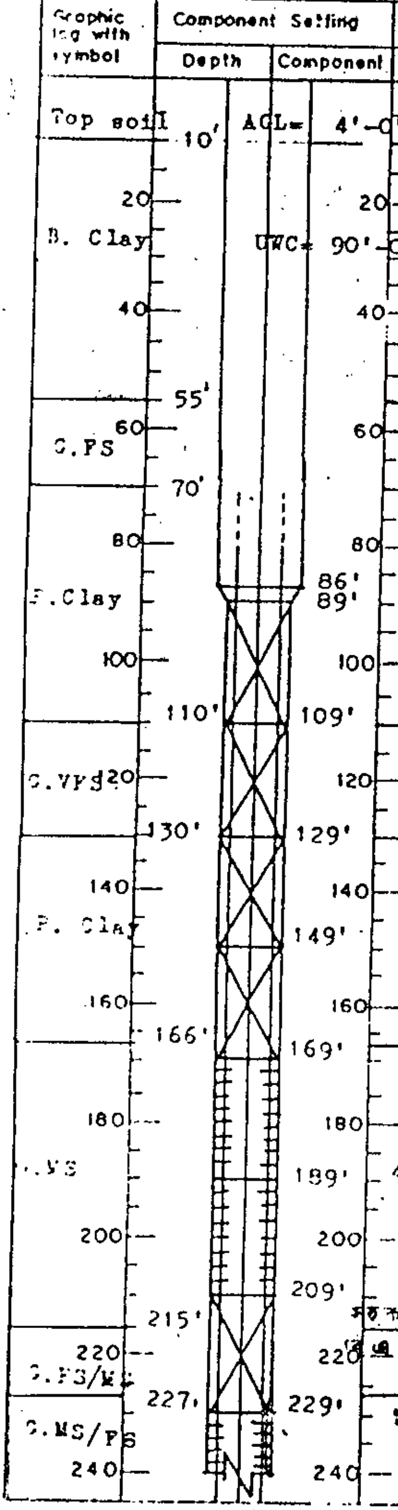
Well No DAUD 60 /
App No. 4 / 4 / 334 / 354

Mouza :-Noagoan

EY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)		Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/Yellow	Grey	Brown/Yellow	Grey		Brown/Yellow	Grey	Brown/Yellow	Grey
lay/Clayish	–	–	–	–	MS/FS	0.50	1.00	0.50	1.00
ilt/Silty	–	–	–	–	MS	0.70	1.40	0.70	1.40
VFS	–	–	0.05	0.10	MS/CS	0.80	1.60	0.80	1.60
VFS/FS	–	–	0.10	0.20	CS/MS	0.90	1.80	0.90	1.80
FS/VFS	–	–	0.20	0.40	CS	1.10	2.20	1.10	2.20
FS	–	–	0.30	0.60	CS/Gr	1.00	2.00	1.00	2.00
FS/MS	–	–	0.40	0.80	Gr/CS/MS	0.60	1.20	0.60	1.20

ESIGN CALCULATION



Depth	Screened Aquifer D	F	L	ΣL	Unscreened Aquifer D	h	L'	ΣL'
169'					3	1.4	4.2	4.2
189'	40	1.4	5600	5600				
215'					6	1.4	8.4	12.6
220					12	.8	9.6	22.2
229'	16	1.0	1600	72.6	2	1.0	2.0	24.2

প্রতিস্বাক্ষরিত
নির্বাহী প্রকৌশলী (সেচ)
বি.এ.ডি.সি, কুমিল্লা রিজিয়ন-২
কুমিল্লা।

সহকারী প্রকৌশলী (সেচ)
বি এ ডি সি, [illegible], কুমিল্লা।

উপ-সহকারী প্রকৌশলী
বি.এ.ডি.সি. (সেচ) [illegible]

REMARKS

LENGTH OF UWC

1 70ft : If upper clay is ≰ 40 feet thick and lowest late dry season SWL is ≰ 20ft.

2 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (ø 6 In.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column.
3. Drilling may be stopped when ΣL ≧ 100 and ΣL' ≧ 50 are achieved, subject to minimum screen lengths stated above
4. Final value of L' will be 20ft. multiplied by its relevant h value below lowest screen.
5. If ΣL' including the bottom 20ft. is <50, although ΣL is ≳ 100, if possible, additional aquifer should be screened to make ΣL + ΣL' ≳ 150, subject to minimum screen length stated above

KEY

D: Thickness of formation
F: Design factor of formation screened.
L : D x F
ΣL : Summation of L values
h : Penetration factor of formation unscreened
L': D x h
ΣL': Summation of L' values

DESIGNER

Signature FOR M/S. M.A. QUADER LTD.
Name
Designation
(Syed. Md

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR.

M.A. Quader Ltd.

DESIGN SHEET

Well No.....DAUD.60./...............

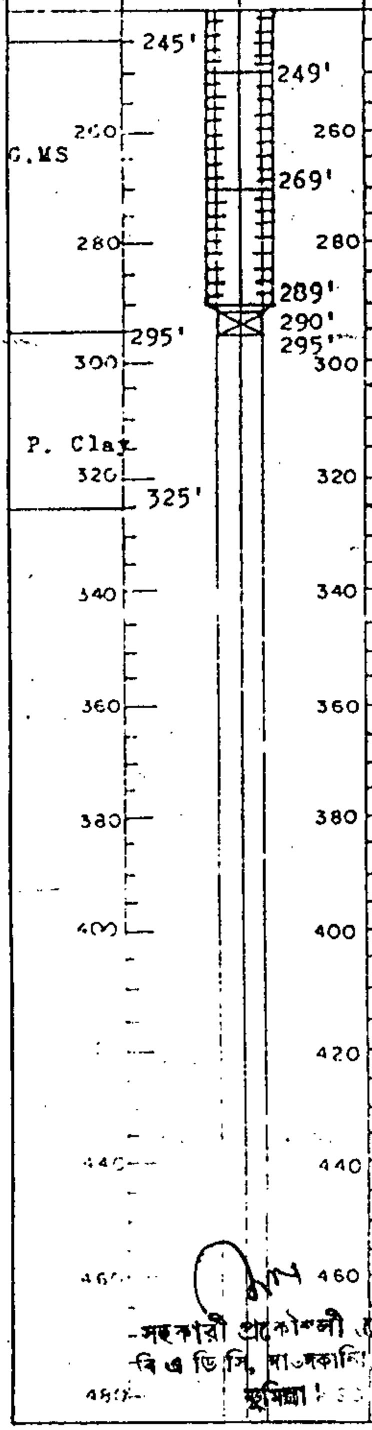
App No.4..../.4..../..334./354..

Mouza:- Noagoan

KEY FACTORS USED TO DETERMINE SCREEN LENGTH

Lithology	Design Factor (F)		Penetration Factor (h)		Lithology	Design Factor (F)		Penetration Factor (h)	
	Brown/yellow	Grey	Brown/yellow	Grey		Brown/yellow	Grey	Brown/yellow	Grey
[illegible]	—	—	—	—	MS/FS	0·50	1·00	0·50	1·00
[illegible]	—	—	[illegible]	—	MS	0·70	1·40	0·70	1·40
[illegible]	—	—	0·05	0·10	MS/CS.	0·80	1·60	0·80	1·60
FS/FS	—	—	0·10	0·20	CS/MS	0·90	1·80	0·90	1·80
[illegible]/VFS	—	—	0·20	0·40	CS	1·10	2·20	1·10	2·20
FS	—	—	0·30	0·60	CS/Gr	1·00	2·00	1·00	2·00
FS/MS	—		0·40	0·80	Gr/CS/MS	0·60	1·20	0·60	1·20

DESIGN CALCULATION



Screened Aquifer				Unscreened Aquifer			
D	F	L	ΣL	D	h	L'	ΣL'
44	1.4	61.6	133.6				
				6	1.4	8.4	32.6

$\Sigma l = 133.6$ $\Sigma l' = 32.6$

$\Sigma l + \Sigma l' = 133.6 + 32.6$

$= 166.2 > 150$

Hence the designe is Ok.

প্রতিস্বাক্ষরিত

নির্বাহী প্রকৌশলী (যন্ত্র)
বি,এ,ডি,সি, কুমিল্লা রিজিয়ন-২
কুমিল্লা।

সহকারী প্রকৌশলী (যন্ত্র)
বি এ ডি সি, দাউদকান্দি জোন
কুমিল্লা।

সিনিয়র সাব-এসিসট্যান্ট ইঞ্জি[illegible]
বি,এ,ডি,সি, (যন্ত্র) দাউদকান্দি
উপজেলা, কুমিল্লা।

REMARKS

LENGTH OF UWC

1. 70ft : If upper clay is ≤ 40 feet thick and lowest late dry season SWL is ≤ 20ft.
2. 80ft : In rest of project area

MINIMUM LENGTH OF SCREEN (⌀ 6 in.)

1. 90ft : Grey MS or coarser sands only.
2. 110ft : Half mixed grey and brown/yellow/reddish sands.
3. 120ft : Brown/yellow/reddish sands.

CALCULATING SCREEN LENGTH

1. Any aquifer underlain by 10ft. or more of clay/silt above topmost screen should be excluded from the calculations.
2. For each aquifer section values of L and L' are calculated by multiplying aquifer thickness (D) by relevant F or h and summed in the appropriate column
3. Drilling may be stopped when ΣL ≧ 100 and ΣL' ≧ 50 are achieved, subject to minimum screen lengths stated above.
4. Final value of L' will be 20ft. multiplied by its relevant h value below lowest screen.
5. If ΣL' including the bottom 20ft. is <50, although ΣL is ≧ 100, if possible, additional aquifer should be screened to make ΣL + ΣL' ≧ 150, subject to minimum screen length stated above

KEY

D: Thickness of formation
F: Design factor of formation screened
L: D x F
ΣL: Summation of L values
h: Penetration factor of formation unscreened.
L': D x h
ΣL': Summation of L' values

DESIGNER

FOR MR. M.A. QUADER LTD.
Name.......
Designation.......(Syed [illegible])
Supervisor

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

IDA DEEPTUBEWELL PROJECT - II

Well No DAUD 60 /

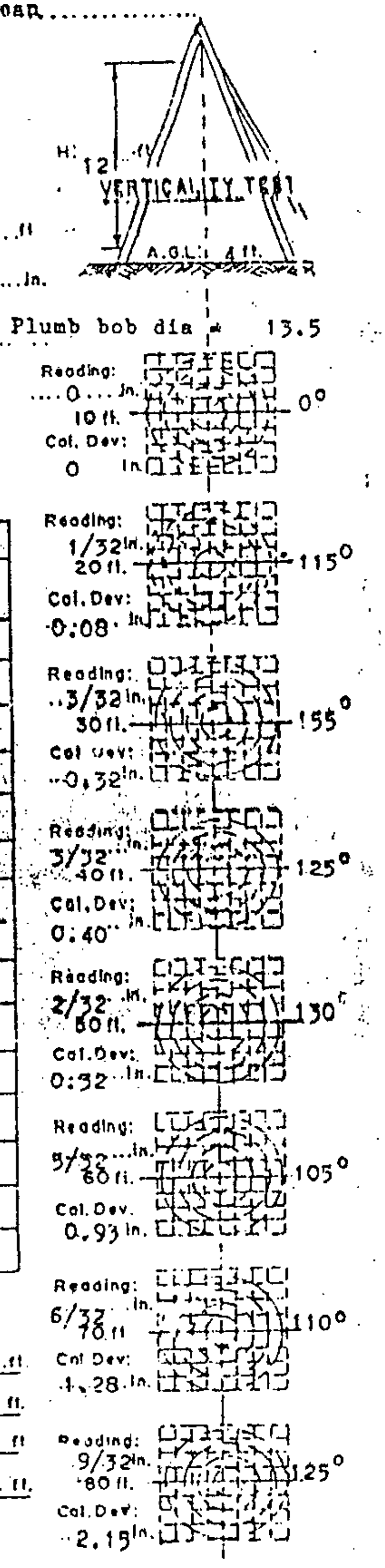
App No 4 / 4 / 334 / 354

TRACTOR

M.A. Quader Ltd .

Mouza :- Hosgoan

CONTRACT IDA / P - II/I
TUBEWELL CONSTRUCTION DETAILS



Plumb bob dia = 13.5

Reading: 0 in. 10 ft. Col. Dev: 0 in.

Reading: 1/32 in. 20 ft. Col. Dev: 0.08 in.

Reading: 3/32 in. 30 ft. Col. Dev: 0.32 in.

Reading: 3/32 in. 40 ft. Col. Dev: 0.40 in.

Reading: 2/32 in. 50 ft. Col. Dev: 0.32 in.

Reading: 5/32 in. 60 ft. Col. Dev. 0.93 in.

Reading: 6/32 in. 70 ft Col Dev: 1.28 in.

Reading: 9/32 in. 80 ft. Col. Dev: 2.15 in.

ED HOLE DETAILS

Diameter 22 in.

pth drilled below O.G.L. 296 ft.

Depth drilled below O.G.L 325 ft

ength of temporary casing 10 ft.

Depth to SWT below O.G.L 23 ft 2 in.

PPER WELL CASING DETAILS

Diameter / material: 14 in / MS

ight of UWC above OGL 4 ft. 0 in.

Total length of UWC 90

h of UWC below OGL 87 ft.

Reducer (R)/Material: 3 ft. / GI

LOWER WELL CASING & SCREEN DETAILS.

	Diameter (in)	Material	Depth below UWC top (ft.)	LWC		Screen	
				No of 10 ft.	No of 20 ft.	No of 10 ft.	No of 20 ft.
LWC	8"	GI	89 to 169	-	4	-	-
Screen	8"	S.S.	169 to 209	-	-	-	2
LWC	8"	G.I.	209 to 229	-	1	-	-
Screen	8"	S.S.	229 to 289	-	-	-	3
LWC			to				
Screen			to				
LWC			to				
Screen			to				
LWC			to				
Screen			to				
LWC			to				
Screen			to				
LWC			to				
Screen			to				
			Total	-	5	-	5

প্রতিস্বাক্ষরিত

নির্বাহী প্রকৌশলী (সেচ)
বি,এ,ডি,সি, কুমিল্লা জোন-২
কুমিল্লা।

Material GRP, SS (Stainless steel) MS (Mild steel)

to bottom of bail plug below OGL 295 ft

Total Length of LWC 100 ft.

Total Length of Screen (S) 100 ft.

Gravel quantity (appox) 740 cft

Bail plug (BP) 5 ft

TOTAL LENGTH OF WELL STRING (UWC + R + LWC + S + BP) = 299 ft.

(90+3+1+100+100+5)

Signed for the Engineer

Name

Designation

সহকারী প্রকৌশলী (সেচ)
বিএডিসি, [illegible]
কুমিল্লা।

Signed for the Contractor

Name

Designation

FOR M/S. M.A. QUADER LTD.

(Syed. Md. Ali)
Supervisor

উপসহকারী প্রকৌশলী (সেচ) [illegible]
(বি,এ,ডি,সি, [illegible]) [illegible]
[illegible], কুমিল্লা।

Max. Deviation 2.40 in.

at Depth 80 ft.

Form IDA - II/3

IDA DEEP TUBEWELL PROJECT-II

RACTOR :

M.A. Quader Ltd.

CONTRACT IDA/P-II/I
DEVELOPMENT RECORD

Well No DAUD 60 /
App. No 4 / 4 / 334 / 354

water level from top of UWC 22 ft 0 In
of top of UWC above O G L 4 ft 0 In
ment started at 8-00 hrs, 27, 3, 1991
of Development Over pumping and Backwashing operation

Diameter of Orifice 6 In
Diameter of Approach pipe 8 In
Development Completed at 18-45 hrs, 27, 3, 1991.

Time elapsed (min)	Clock time From	Clock time To	Discharge (cusec)	Water level from UWC top (m, ft.)	Sand content (ppm)	Remarks
30	8-00	8-30	0·60	26'-4"	–	1. Hammering the top of UWC (about 1 minute in every 15 minutes) is needed throughout the development period.
15	8-30	8-45	0 85	27'-9"	–	2 Sand content test is not essential during the first two hours
15	8-45	9-00	1 00	29'-11"	–	3 Water levels should be measured just before the changes of discharge rates and at the end of continued OP & BW operation
15	9-00	9-15	1·24	32'-0"	–	
15	9-15	9-30	1·50	35'-1"	–	
15	9-30	9-45	1·76	37'-6"	–	
15	9-45	10-00	2·02	41'-3"	–	Continuous pumping stoped at 10-00 AM
90	10-15	11-45	2.2.50	47'-7"	–	
5	11-48	11-53	2.5	–		OP & BW Operation
					35	Sampling form 45 secs. for 2 mins 40 secs.
60	12-00	13-00	2-2.75	53'-4"	–	
5	13-05	13-10	2.65	–		OP & BW operation .
					22	Sampling from 55 secs for 2 mins. 50 secs.
90	13-30	15-00	2-2.75	58'-10"		
5	15-05	15-10	2.5	–		OP & BW operation.
					12	Sampling from 40 secs for 2 mins 50 secs.
90	15-15	16-45	2-2.75	60'-1"	–	
5	16-50	16-55	2.5	–		OP & BW Operation
					5	Sampling from 45 secs. for 2 mins, 45 secs.
60	17-00	18-00	2-2.75	64'-6"	–	
5	18-05	18-10	2.5	–		OP & BW operation.
					3	Sampling from 45 secs. for 2 mins 50 secs.
30	18-15	18-45	2-3	66'-1"	–	
	18-45	18-50	3	–	2	OP & BW operation, Sampling from 40 secs. for 2 mins, 50 secs.

প্রতিস্বাক্ষরিত

নির্বাহী প্রকৌশলী (সেচ)
বি,এ,ডি,সি, কুমিল্লা বিভাগ-২
কুমিল্লা।

সহকারী প্রকৌশলী (সেচ)
বি এ ডি সি, [illegible]
কুমিল্লা।

Checked by Signature

Name/Designation [illegible]

Date [illegible]

FOR M/S. M.A. QUADER LTD.
(Syed. Md. Ali)

Form No
IDA DTW II/05,
3/1

IDA DEEP TUBEWELL PROJECT-II

CONTRACTOR
M.A. Quader Ltd.

CONTRACT IDA / P-II/1
PUMPING TEST RECORD

Well No. DAUD 60/
App. No. 4/A/334/354
Mouza :- Noagoan

Static water table depth from top of UWC 22 ft. 0 in. Diameter of Orifice 6 in.
Height of top of UWC above O.G.L. 4 ft. in. Diameter of Approach pipe 8 in.
Development completed at 18-45 hrs. 27. 3. 19.91. Test started at 8-00 hrs. 28. 3. 19.91.
Test completed at 17-30 hrs. 28. 3. 19.91.

PUMPING TEST READINGS

Step	Time Elapsed (min)	Water Level from UWC top (ft)	Drawdown (ft)	Gauge Reading (in)	Discharge (cusec)	Specific Drawdown (ft/cusec)	Step	Time Elapsed (min)	Water Level from UWC top (ft)	Drawdown (ft)	Gauge Reading (in)	Discharge (cusec)	Specific Drawdown (ft/cusec)
1st	0.5	33'-7"	11'-7"	5	.85	13.44	3rd	0.5	49'-11"	27'-11"	33	1.99	14.03
	1	-8"						1	50'-1½"				
	2	-9½"						2	-4"				
	3	-11"						3	-6"				
	4	34'-0"						4	-7½"				
	5	-0"						5	-9"				
	7	-½"						7	-11"				
	10	-1"						10	51'-1"				
	15	-1"						15	-2½"				
	20	-1½"						20	-3½"				
	25	-1½"						25	-5"				
	30	-2"						30	-7"				
	40	-2"						40	-9½"				
	50	-2½"						50	52'-0"				
	60	-3"						60	-2"				
	80	-3½"						80	-3½"				
	100	34'-4"	12'-4"			14.49		100	52'-5"	30'-5"			15.29
2nd	0.5	42'-6"	20'-6"	18	1.50	13.66	4th	0.5	66'-5"	[illegible]	78	3.00	14.48
	1	-7½"						1	-7"				
	2	-9"						2	-10"				
	3	-10"						3	67'-0"				
	4	-11½"						4	-2"				
	5	43'-1"						5	-5"				
	7	-3"						7	-8"				
	10	-4"						10	-9½"				
	15	-5½"						15	-11"				
	20	-6½"						20	68'-0"				
	25	-8"						25	-1½"				
	30	-9½"						30	-3"				
	40	44'-0"						40	-4½"				
	50	-2"						50	-5½"				
	60	-4"						60	-6"				
	80	-6"						80	-7"				
	100	44'-8"	22'-8"			15.09		100	68'-8"	46'-8"			15.57

মোঃ [illegible]
উপ-সহকারী প্রকৌশলী (সেচ)
বি,এ,ডি,সি, কুমিল্লা
কুমিল্লা।

TESTS

	1st step			2nd step			3rd step			4th step				Remarks
Time elapsed (min)	½	5	50	2	5	50	2	5	50	2	5	50	100	
Sand content (ppm)	5	–	4	–	4	–	–	–	3	–	2	2	2	By Imhoff cone
EC (m mho cm $^{-1}$)	☒	☒	625	☒	☒	625	☒	☒	625	☒	☒	625	625	By Ec metre.
PH	☒	☒	6.7	☒	☒	6.7	☒	☒	6.9	☒	☒	7.0		

Tests checked by Signature

Name / Designation.

Date

সহকারী প্রকৌশলী (সেচ)
বি এ ডি সি, দাউদকান্দি (সেচ)

উপজেলার সাব-এসিসট্যান্ট ইঞ্জিনিয়ার
বি, এ, ডি, সি, (সেচ) দাউদকান্দি [illegible]
দাউদকান্দি, কুমিল্লা।

FOR, M/S. M.A. QUADER LTD.
(Syed. Md. Ali)
Supervisor

APPENDIX-III

GUIDE TO WATER QUALITY TOLERANCES

Parameter	Units	None	Problems increasing	Severe
EC				
(Salinity)	micrombos/cm	< 750	750 - 3000	>3000
(Permeability)	Micrombos/cm	> 500	500 - 200	< 200
TDS	ppm	< 560	560 - 2250	>2250
Chloride	mg/1	< 140	140 - 350	>350
SAR	meq/1	< 6	6 - 9	> 9
Iron	mg/1	< 5	5 - 20	>20
Boron	mg/1	< 0.3	0.3 - 3	>3

Note : (Salinity) affects crop water availability
(permeability) affects infiltration into the soil

APPENDIX - IV

MIT GRAIN SIZE CLASSIFICATION

Description	Grain size (mm)			
Gravel	Coarse	20.0	-	60.0
	Medium	6.0	-	20.0
	Fine	2.0	-	6.0
Sand	Coarse	0.6	-	2.0
	Medium	0.2	-	0.6
	Fine	0.06	-	0.2
Silt	Coarse	0.02	-	0.06
	Medium	0.006	-	0.02
	Fine	0.002	-	0.006
Clay		0.002	and	below

WALTON'S recommended values of optimum screen entrance velocities in relation to the permeabilities of the formation materials given by Sichardt.

Coefftcient of permeability (cm/sec0)	Optimum screen entrance velocities (cm/sec)	Velocity outside the screen according to Sichardt(cm/Sec)
0.28	6.0	0.18
0.26	5.5	0.18
0.24	5.0	0.17
0.19	4.5	0.15
0.14	4.0	0.13
0.12	3.5	0.12
0.09	3.0	0.10
0.07	2.5	0.09
0.05	2.0	0.07
0.03	1.5	0.05
0.01	1.0	0.05

APPENDIX-VI

Permeabilities of Different Grain Sizes determined from pumping tests and laboratory tests given by IDA DTW Project.

Lithology	Permeability x .001 m/sec		Permeability x .001 ft/Sec	
	Y/B/R	Grey	Y/B/R	Grey
Clay/Clayish	-	-	-	-
Silt/Silty	-	-	-	-
VFS	0.024	0.049	0.08	0.16
VFS/FS	0.049	0.098	0.16	0.32
FS/VFS	0.098	0.195	0.32	0.64
FS	0.146	0.293	0.48	0.96
FS/MS	0.195	0.390	0.64	1.28
MS/FS	0.244	0.488	0.80	1.60
MS	0.293	0.683	1.12	2.24
MS/CS	0.390	0.780	1.28	2.56
CS/MS	0.439	0.878	1.44	2.88
CS	0.536	1.073	1.76	3.52
CS/Gr	0.488	0.975	1.60	3.20
Gr/CS/MS	0.293	0.585	0.96	1.92

VFS: very fine sand, FS : fine sand, MS : medium sand CS: coarse sand, Gr : gravel, Y : yellow, B : Brown, R : red. The grain sizes first named are predominant to the others.

APPENDIX- VII

RECOMMENDED GRADINGS OF GRAVEL PACK MATERIALS

B.S.410 Sieve Number	Aperture size mm	(in.)	Percentage Passing through	Ideal Quantities (%)	Grain size
3/16	4.76	(0.1874)	100	0.0	
1/8	3.18	(0.1252)	85 - 95	10.0	FGr
8	2.00	(0.0787)	64 - 80	18.0	FGr
16	1.00	(0.0393)	10 - 30	52.0	CS
25	0.60	(0.0236)	0 - 10	15.0	CS
36	0.425	(0.0167)	0	5.0	MS

APPENDIX-VIII-A

COST OF THE CONSTRUCTED DTW NO. NAN -118

Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
1.	UWC:- 14" dia Housing pipe	96 ft	rft	Tk.400/-	38,400/-
2.	LWC:- 6" dia G.I. Pipe	140 ft	rft	Tk.230/-	32,200/-
3.	Reducer:- (14" to 6")	1	L.S.	Tk.1200/-	1,200/-
4.	S.S.Strainer: 6" dia	90 ft	rft	Tk1000/-	90,000/-
5.	Bail plug: 6" dia	5'-0"	L.S.	Tk.1250/-	1,250/-
6.	Couplings with key	2 Nos	per No.	Tk. 350/-	700/-
7.	Centralizer	15 Nos	-do-	Tk. 150/-	2,250/-
8.	Test boring (With chemical analysis of water)	390ft	rft	Tk. 30/-	11,700/-
9.	Mobilisation & transportation of drilling equipment	1	L.S	-	28,000/-
10.	Drilling cost:-				
	From 0 to 100 ft	100 ft	per rft	Tk.135/-	13,500/-
	100 to 200 ft	100 ft	per rft	Tk. 120/-	12,000/-
	200 to 250 ft	50 ft	per rft	Tk. 90/-	4,500/-
	250 to above	84 ft	per rft	Tk. 75/-	6,300/-

Cont....2

APPENDIX-VIII.A

Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk)
11.	Installation of Tubewell fixture:-				
	(a) Bail plug (6")	1	L.S.	Tk. 200/-	200/-
	(b) Strainer (6")	90 ft	rft	Tk. 35/-	3,150/-
	(c) blind pipe(6")	140 ft	rft	Tk. 20/-	2,800/-
	(d) Connection with reducer (between housing and blind pipe)	1	L.S.	Tk.400/-	400/-
	(e) 14" dia housing pipe	96 ft	rft	Tk. 50/-	4,800/-
	(f) Placing of Centralizer (approx.at 15ft interval)	15 Nos	each	Tk. 25/-	375/-
12.	Gravel packing	830	cft	Tk. 30/-	24,900/-
13.	Well development	1	L.S.	Tk.10000/-	10,000/-
14.	Pump house construction	1	L.S.	Tk.48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk.12000/-	12,000/-
16.	Turbine pump(80ft head)	1	each	Tk.80000/-	80,000/-
17.	Engine	1	each	Tk.110000/-	110,000/-
18.	Gear head	1	each	Tk.20000/-	20,000/-
19.	10 ft Discharge pipe 6" dia	1	each	Tk.3000/-	3,000/-
	Total Cost:-				Tk.5,61,625/-

APPENDIX - VIII-B

COST OF THE RECOMMENDED DTW AGAINST THE DTW NO.NAN-118

Sl. NO.	Description	Quantity	Unit	Rate	Amount (Tk.)
1.	UWC:- 14" dia Housing pipe	90 ft	rft	Tk.400/-	36,000/-
2.	LWC:- 8" dia G.I. pipe	139 ft	rft	Tk.250/-	34,750/-
3.	Reducer:- (14" to8")	1	L.S.	Tk.1200/-	1,200/-
	(8" to 6")	1	L.S.	Tk. 200/-	200/-
4.	S.S.Strainer:- 6" dia	80 ft	rft	Tk1000/-	80,000/-
5.	Bail plug:- 6" dia	5'-0"	L.S.	Tk.1250/-	1,000/-
6.	Couplings (with key)	2 nos	per No.	Tk.350/-	700/-
7.	Contralizer	13 Nos	per No.	Tk.150/-	1,950/-
8.	Test boring(with chemical analysis of water)	315	rft	Tk. 30/-	9,450/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.	-	28,000/-
10.	Drilling cost :-				
	From 0 to 100 ft	100 ft	per rft	Tk. 135/-	13,500/-
	100 to 200 ft	100 ft	per rft	Tk. 120/-	12,000/-
	200 to 250 ft	50 ft	per rft	Tk. 90/-	4,500/-
	250 to above	65 ft	per rft	Tk. 75/-	4,875/-

Cont...P/2

APPENDIX -VIII.B

Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
11.	Installation of Tubewell fixture:-				
	(a) Bail Plug (6")	1	L.S.	Tk.200/-	200/-
	(b) Strainer (6")	80 ft	rft	Tk. 35/-	2,800/-
	(c) blind pipe (8")	139 ft	rft	Tk. 20/-	2,780 /-
	(d) Connection with reducer (between housing and blind pipe)	1	L.S.	Tk.400/-	400/-
	(e) 14" dia housing pipe	90 ft	rft	Tk. 50/-	4,500/-
	(f) Placing of Centralizer approx. at 15ft internal	13 Nos	each	Tk. 25/-	325/-
12.	Gravel packing	555	cft	Tk. 30/-	16,650/-
13.	Well development	1	L.S.	Tk.10000/-	10,000/-
14.	Pump house construction	1	L.S	Tk.48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk. 12000/-	12,000/-
16.	Turbine pump (70ft head)	1	each	Tk.70000/-	70,000/-
17.	Engine	1	each	Tk.100000/-	100,000/-
18.	Gear head	1	each	Tk.20000/-	20,000/-
19.	10 ft Discharge pipe 6"dia	1	each	Tk. 3000/-	3,000/-
	Total Cost:-				5,18,780/-

APPENDIX - IX - A

COST OF THE CONSTRUCTED DTW NO-BHAL - 110

Sl. NO.	Description	Quantity	Unit	Rate	Amount
1.	UWC:- 14" dia Housing pipe	112 ft.	rft	Tk. 400/-	44,800/-
2.	LWC:- 8" dia G.I. blind pipe	70 ft.	rft	Tk. 250/-	17,500/-
	6" dia G.I. Pipe	125 ft.	rft	TK. 230/-	28,750/-
3.	Reducer: (14" to 8")	1	L.S.	TK. 1500/-	1,500/-
	(8" to 6")	1	L.S.	Tk. 300/-	300/-
4.	S.S.Strainer: 6" dia	144.33ft.	rft	Tk. 1000/-	1,44,330/-
5.	Bail Plug 6" dia	5'-0"	L.S.	Tk. 1250/-	1,250/-
6.	upling with Key	6 Nos.	per No.	Tk. 350/-	2,100/-
7.	Centralizer	18 Nos	each	Tk. 150/-	2,700/-
8.	Test boring(with chemical analysis of water)	470 ft.	rft	Tk. 30/-	14,100/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.	-	28,000/-
10.	Drilling cost :-				
	From 0 to 100 ft.	100ft.	per rft	Tk. 135/-	13,500/-
	100 to 200 ft.	100 ft.	per rft	Tk. 120/-	12,000/-
	200 to 250 ft.	50 ft.	per rft	Tk. 90/-	4,500/-
	250 to above	205	per rft	Tk. 75/-	15,375/-

Cont...P/2

Sl. NO.	Description	Quantity	Unit	Rate	Amount (Tk)
11.	Installation of Tubewell fixture :-				
	(a) Bail plug (6")	1	L.S.	Tk. 200/-	200/-
	(b) Strainer (6")	144.33	rft	Tk. 35/-	5,051/55
	(c) blind pipe(6"or8")	195 ft.	rft	Tk. 20/-	3,900/-
	(d) Connection with reducer (between housing and blind pipe)	1	L.S.	Tk. 400/-	400/-
	(e) 14" dia housing pipe	112	rft	Tk. 50/-	5,600/-
	(f) Placing of Centralizer approx. at 15ft interval	18 Nos	each	Tk. 25/-	450/-
12.	Gravel packing	1365	cft	Tk. 30/-	40,950/-
13.	Well development	1	L.S.	Tk. 10000/-	10.000/-
14.	Pump house construction	1	L.S.	Tk.48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk. 12000/-	12,000/-
16.	Turbin e pump(100ft.head)	1	each	Tk. 100000/-	100,000/-
17.	Engine	1	each	Tk. 110000/-	1,10,000/-
18.	Gear head	1	each	Tk.20000/-	20,000/-
19.	10 ft Discharge pipe 8"-dia	1	each	Tk. 4000/-	4,000/0
	Total Cost:-				Tk. 6,91,256/55

APPENDIX - IX - B

COST OF THE RECOMMENDED DTW AGAINST DTW NO.BHAL-110

Sl. NO.	Description	Quantity	Unit	Rate	Amount (Tk)
1.	UWC :- 14" dia Housing pipe	100 ft	rft	Tk.400/-	40,000/-
2.	LWC:- 8" dia G.I. blind pipe	180 ft	rft	Tk.250/-	45,000/-
3.	Reducer:(14" to 8") 3'	1	L.S.	Tk.1500/-	1,500/-
	(8" to 6") 1'	1	L.S.	Tk.300/-	300/-
4.	S.S.Strainer : 8" dia	60ft	rft	Tk.1200/-	72,000/-
5.	Bail Plug : 6" dia	5'-0"	L.S.	Tk.1250/-	1,250/-
6.	Couplings with Key	2 Nos	Per No.	Tk.350/-	700/-
7.	Centralizer	12 Nos	each	Tk.150/-	1,800/-
8.	Test boring (with chemical analysis of water)	345 ft	rft	Tk. 30/-	10,350/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.	-	28,000/-
10.	Drilling cost :-				
	From 0 to 100 ft	100 ft	per rft	Tk. 135/-	13,500/-
	100 to 200 ft	100 ft	per rft	Tk. 120/-	12,000/-
	200 to 250 ft	50 ft	per rft	Tk 90/-	4,500/-
	250 to above	95 ft	per rft	Tk. 75/-	7,125/-

Cont.... P/2

Sl. No.	Description	Quanity	Unit	Rate	Amount (Tk)
11.	Installation of Tubewell fixture:-				
	(a) Bail plug (6")	1	L.S.	Tk. 200/-	200/-
	(b) Strainer (8")	60 ft	rft	Tk. 35/-	2,100/-
	(c) blind Pipe (8")	180	rft	Tk. 20/-	3,600/-
	(d) Connection with reducer (between housing and blind pipe)	1	L.S.	Tk. 400/-	400/-
	(e) 14" dia housing pipe	100 ft	rft	Tk. 50/-	5,000/-
	(f) placing of Centralizer approx. at 15ft internal	12 Nos	each	Tk. 25/-	300/-
12.	Gravel packing	600	cft	Tk. 30/-	18,000/-
13.	Well development	1	L.S.	Tk. 10000/-	10,000/-
14.	Pump house construction	1	L.S.	Tk. 48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk. 12000/-	12,000/-
16.	Turbine Pump (80 ft head)	1	each	Tk. 80000/-	80,000/-
17.	Engine	1	each	Tk. 100000/-	100,000/-
18.	Gear head	1	each	Tk. 20000/-	20,000/-
19.	10 ft Discharge pipe 8" dia	1	each	Tk. 4000/-	4,000/-
	Total Cost :-				5,41,625/-

COST OF THE CONSTRUCTED DTW NO. PHUL -160

Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
1.	UWC:- 14" dia Housing Pipe	100 ft.	rft	Tk.400/-	40,000/-
2.	LWC:- 6" dia G.I. Pipe	75 ft.	rft	Tk.230/-	17,250/-
3.	Reducer: (14" to 6")	1	L.S.	Tk. 1200/-	1,200/-
4.	S.S.Strainer: 6" dia	118 ft.	rft	Tk. 1000/-	118,000/-
5.	Bail Plug: 6" dia	5'-0"	L.S.	Tk. 1250/-	1,250/-
6.	Couplings with key	4 Nos	per No.	Tk.250/-	1,400/-
7.	Centralizer	13 Nos	Each	Tk. 150/-	1,950/-
8.	Test boring(With chemical analysis of water)	310 ft.	rft	Tk.30/-	9,300/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.	-	28,000/-
10.	Drilling Cost:-				
	From 0 to 100 ft	100 ft.	per rft	Tk.135/-	13,500/-
	100 to 200 ft	100 ft.	per rft	Tk.120/-	12,000/-
	200 to250 ft	50 ft.	per rft	Tk. 90/-	4,500/-
	250 to above	51 ft.	per rft	Tk. 75/-	3,825/-

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Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
11.	Installation of Tubewell fixture:-				
	(a) Bail Plug	1	L.S.	Tk.200/-	200/-
	(b) Strainer (6")	118ft.	rft	Tk. 35/-	4,130/-
	(c) blind pipe (6")	75 ft.	rft	Tk. 20/-	1,500/-
	(d) Connection with reducer (between housing and blind pipe)	1	L.S.	Tk.400/-	400/-
	(e) 14" dia housing pipe	100 ft.	rft	Tk. 50/-	5,000/-
	(f) Placing of contralizer approx at 15ft internal	13 Nos	each	Tk. 25/-	325/-
12.	Gravel packing	690	cft	Tk. 30/-	20,700/-
13.	Well development	1	L.S.	Tk.10000/-	10,000/-
14.	Pump house construction	1	L.S.	Tk48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk.12000/-	12,000/-
16.	Turbine pump(80 ft head)	1	each	Tk.80000/-	80,000/-
17.	Engine	1	each	Tk.100000/-	100,000/-
18.	Gear head	1	each	Tk. 2000	12,000
19.	10 ft Discharge pipe:- 6" dia	1	each	Tk.3000/-	3,000/-
	Total Cost:-				5,57,430/-

APPENDIX - X -B

COST OF THE RECOMMENDED DTW AGAINST DTW NO.PHUL-160

Sl. No.	Description	Quantity	Unit	Rate	Amount(Tk.)
1.	UWC:- 14" dia Housing pipe	90 ft	rft	Tk.400/-	36,000/-
2.	LWC:- 8" dia G.I. Pipe	116 ft	rft	Tk.250/-	29,000/-
3.	Reducer :- (14" to 6")	1	L.S.	Tk.1200/-	1,200/-
	(8" to 6")	1	L.S.	Tk. 300/-	300/-
4.	S.S.Strainer:- 6" dia	80 ft.	rft	Tk 1000/-	80,000/-
5.	Bail blug:- 6" dia	5'-0"	L.S.	Tk. 1250/-	1250/-
6.	Couplings with Key	2 Nos	per No.	Tk.350/-	700/-
7.	Centralizer	12 Nos	each	Tk. 150/-	1,800/-
8.	Test boring (With chemical analysis of water	295	rft	Tk. 30/-	8,850/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.	-	28,000/-
10.	Drilling cost:-				
	From 0 to 100 ft	100 ft	per rft	Tk.135/-	13,500/-
	100 to 200 ft	100 ft	per rft	Tk.120/-	12,000/-
	200 to 250 ft	50 ft	per rft	Tk. 90/-	4,500/-
	250 to above	42 ft	per rft	Tk. 75/-	3,150/-

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APPENDIX-X·B

Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
11.	Installation of Tubewell fixture:-				
	(a) Bail Plug (6")	1	L.S.	Tk.200/-	200/-
	(b) Strainer (6")	80ft.	rft	Tk. 35/-	2,800/-
	(c) blind pipe (8")	11^{6} ft	rft	Tk. 20/-	2,340/-
	(d) Connection with reducer (between housing and blind pipe)	1	L.S.	Tk.400/-	400/-
	(e) 14" dia housing pipe	90 ft	rft	Tk. 50/-	4,500/-
	(f) Placing of centralizer approx. at 15ft internal	12 Nos	each	Tk. 25/-	300/-
12.	Gravel packing	520	cft	Tk. 30/-	15,600/-
13.	Well development	1	L.S.	Tk.10000/-	10,000/-
14.	Pump house construction	1	L.S.	Tk.48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk.12000/-	12,000/-
16.	Turbine Pump (70 ft head)	1	each	Tk.70000/-	70,000/-
17.	Engine	1	each	Tk.90000/-	90,000/-
18.	Gear head	1	each	Tk.20000/-	20,000/-
19.	10 ft Discharge pipe 6" dia	1	each	Tk.3000/-	3,000/-
	Total Cost:-				4,99,390/-

COST OF THE CONSTRUCTED DTW NO NABI- R/27

Sl. No.	Description	Quantity	Unit	Rate	Amount(Tk.)
1.	UWC:- 14" dia Housing pipe	98 ft	rft	Tk.400/-	39,200/-
2.	LWC :-8" dia G.I. blind pipe	180ft	rft	Tk.250/-	45,000/-
	6" dia G.I. pipe	30 ft	rft	Tk.230/-	6,900/-
3.	Reducer : (14" to 8")	1	L.S.	Tk.1500/-	1,500/-
	(8" to 6")	1	L.S.	Tk.300/-	300/-
4.	S.S.Strainer : 8" dia	60 ft	rft	Tk.1200/-	72,000/-
	6" dia	80 ft	rft	Tk.1000/-	80,000/-
5.	Bail plug: 6" dia	5'-0"	L.S.	Tk.1250/-	1,250/-
6.	Couplings with key	12 Nos	per No.	Tk.350/-	4,200/-
7.	Centralizer	23 Nos	each	Tk. 150/-	3,450/-
8.	Test boring(With chemical analysis of water	460ft	rft	Tk.30/-	13,800/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.		28,000/-
10.	Drilling cost:-				
	From 0 to 100 ft	100 ft	rft	Tk.135/-	13,500/-
	100 to200 ft	100 ft	per rft	Tk. 120/-	12,000/-
	200 to 250 ft	50 ft	per rft	Tk. 90/-	4,500/-
	250 to above	207 ft	per rft	Tk. 75/-	15,525/-

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APPENDIX-XI.A

Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
11.	Installation of Tubewell fixture :-				
	(a) Bail Plug (6")	1	L.S.	Tk.200/-	200/-
	(b) Strainer (6" or 8")	140ft	rft	Tk.35/-	4,900/-
	(c) blind pipe(6"or8")	210ft	rft	Tk.20/-	4,200/-
	(d) Connection with reducer (between housing and blind pipe)	1	L.S.	Tk.400/-	400/-
	(e) 14" dia housing pipe	98 ft	rft	Tk. 50/-	4,900/-
	(f) Placing of Centralizer approx.at 15ft internal	23	each	Tk. 25/-	575/-
12.	Gravel packing	1250	cft	Tk. 30/-	37,500/-
13.	Well development	1	L.S.	Tk.10000/-	10,000/-
14.	Pump house construction	1	L.S.	Tk 48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk.12000/-	12,000/-
16.	Turbine pump (80ft head)	1	each	Tk.80000/-	80,000/-
17.	Engine	1	each	Tk110000/-	110,000/-
18.	Gear head	1	each	Tk.20000/-	20,000/-
19.	10 ft Discharge pipe 8"-dia	1	each	Tk.4000/-	4,000/-
	Total Cost :-				6,77,800/-

APPENDIX - XI-B

COST OF THE RECOMMENDED DTW AGAINST DTW NO. NABI-R/27

Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
1.	UWC :- 14" dia Housing pipe	98 ft	rft	Tk.400/-	39,300/-
2.	LWC :- 8" dia G.I. blind pipe	179 ft	rft	Tk.250/-	44,750/-
3.	Reducer: (14" to 8")	1	L.S.	Tk.1500/-	1,500/-
	(8" to 6")	1	L.S.	Tk.300/-	300/-
4.	S.S.Strainer: 6" dia	80 ft	rft	Tk.1000/-	80,000/-
5.	Bail plug: 6" dia	5'-0"	L.S.	Tk.1250/-	1,250/-
6.	Couplings with dey	2 Nos	per No.	Tk.350/-	700/-
7.	Centralizer	16 Nos	each	Tk.150/-	2,400/-
8.	Test boring(With chemical analysis of water)	370ft	rft	Tk. 30/-	11,100/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.	-	28,000/-
10.	Drilling cost:-				
	From o to 100 ft	100 ft	per rft	Tk.135/-	13,500/-
	100 to 200 ft	100 ft	per rft	Tk.120/-	12,000/-
	200 to 250 ft	50 ft	per rft	Tk. 90/-	4,500/-
	250 to above	116	per rft	Tk. 75/-	8,700/-

APPENDIX -XI-B

Sl. NO.	Description	Quantity	Unit	Rate	Amount (Tk.)
11.	Installation of Tubewell fixture:-				
	(a) Bail plug (6")	1	L.S.	Tk.200/-	200/-
	(b) Strainer (6")	80 ft	rft	Tk. 35/-	2,800/-
	(c) Bling pipe (8")	179ft	rft	Tk. 20/-	3,580/-
	(d) Connection with reducer (between housing and blind pipe)	1	L.S.	Tk.400/-	400/-
	(e) 14" dia housing pipe	98 ft	rft	Tk. 50/-	4,900/-
	(f) Placing of centralizer approx. at 15ft internal	16	each	Tk. 25/-	400/-
12.	Gravel packing	612	cft	Tk. 30/-	18,360/-
13.	Well development	1	L.S.	Tk.10000/-	10,000/-
14.	Pump house construction	1	L.S.	Tk.48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk.12000/-	12,000/-
16.	Turbine pump (80 ft head)	1	each	Tk.80000/-	80,000/-
17.	Engine	1	each	Tk.100000/-	100,000/-
18.	Gear head	1	each	Tk.20000/-	20,000/-
19.	10 ft Discharge pipe: 8"-dia	1	each	Tk.4000/-	4,000/-
	Total Cost:-				5,52,540/-

COST OF THE CONSTRUCTED DTW NO.DAUD-60

Sl. No.	Description	Quantity	Unit	Rate	Amount(Tk.)
1.	UWC :- 14" dia Housing pipe	90 ft	rft	Tk.400/-	36,000/-
2.	LWC :- 8" dia G.I. blind pipe	100 ft	rft	TK.250/-	25,000/-
3.	Reducer : (14" to 8")	1	L.S.	Tk.1500/-	1,500/-
	(8" to 6")	1	L.S.	Tk.300/-	300/-
4.	S.S.Strainer : 8" dia	100 ft	rft	Tk. 1200/-	120,000/-
5.	Bail Plug : 6" dia	5'-0"	L.S.	Tk.1250/-	1,250/-
6.	Couplings with key	4 Nos	per No.	Tk.350/-	1,400/-
7.	Centralizer	13 Nos	each	Tk.150/-	1,950/-
8.	Test boring(with chemical analysis of water)	300 ft	rft	Tk. 30/-	9,000/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.	-	28,000/-
10.	Drilling cost :-				
	From 0 to 100 ft	100 ft	per rft	Tk.135/-	13,500/-
	100 to 200 ft	100 ft	per rft	Tk.120/-	12,000/-
	200 to 250 ft	50 ft	per rft	Tk. 90/-	4,500/-
	250 to above	49 ft	per rft	Tk. 75/-	3,675/-

APPENDIX- XII - A

Sl. No.	Description	Quantity	Unit	Rate	Amount(Tk.)
11.	Installation of Tubewell fixture:-				
	(a) Bail Plug (6")	1	L.S.	Tk.200/-	200/-
	(b) Strainer (8")	100 ft	rft	Tk.35/-	3,500/-
	(c) Blind pipe (8")	100 ft	rft	Tk.20/-	2,000/-
	(d) Counection with reducer (between housing and blind pipe)	1	L.S.	Tk.400/-	400/-
	(e) 14" dia housing pipe	90 ft	rft	Tk.50/-	4,500/-
	(f) Placing of Centralizer approx. at 15ft internel	13	each	Tk.25/-	325/-
12.	Gravel packing	740	cft	Tk.30/-	22,200/-
13.	Well development	1	L.S.	Tk.10000/-	10,000/-
14.	Pump house construction	1	L.S.	Tk.48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk.12000/-	12,000/-
16.	Turbine pump (80 ft head)	1	each	Tk.80000/-	80,000/-
17.	Engine	1	each	Tk.110000/-	110,000/-
18.	Gear head	1	each	Tk.20000/-	20,000/
19.	10 ft Discharge pipe:				
	8"- dia	1	each	Tk.4,000/	4,000/
	Total Cost :-				5,75,200/-

APPENDIX-XII-B

COST OF THE RECOMMENDED DTW AGAINST THE DTW NO.DAUD -60

SL. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
1.	UWC:- 14" dia Housing pipe	90 ft	rft	Tk.400/-	36,000/-
2.	LWC :-8" dia G.I. blind pipe	138 ft	rft	Tk.250/-	34,500/-
3.	Reducer: (14" to 8")	1	L.S.	Tk.1500/-	1,500/-
	(8" to 6")	1	L.S.	300/-	300/-
4.	S.S.Strainer: 8" dia	60 ft	rft	Tk.1200/-	72,000/-
5.	Bail Plug : 6" dia	5'-0"	L.S.	Tk.1250/-	1,250/-
6.	Couplings with dkey	2 Nos	per No.	Tk.350/-	700/-
7.	Centralizer	12 Nos	each	Tk.150/-	1,800/-
8.	Test boring(with chemical analysis of water)	300	rft	Tk.30/	9,000/-
9.	Mobilisation & transportation of drilling equipment	1	L.S.	-	28,000/-
10.	Drilling cost:-				
	From 0 to 100 ft	100ft	per rft	Tk.135/-	13,500/-
	100 to 200 ft	100 ft	per rft	Tk.120/-	12,000/-
	200 to 250 ft	50 ft	per rft	Tk. 90/-	4,500/-
	250 to above	47 ft	per rft	Tk. 75/-	3,525/-

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Sl. No.	Description	Quantity	Unit	Rate	Amount (Tk.)
11.	Installation of Tubewell fixture:-				
(a)	Bail Plug (6")	1	L.S.	Tk.200/-	200/-
(b)	Strainer (8")	60 ft	rft	Tk.35/-	2,100/-
(c)	Blind pipe (8")	138	rft	Tk.20/-	2,760/-
(d)	Connection with reducer (between housing and blind pipe)	1	L.S.	Tk.400/-	400/-
(e)	14" dia housing pipe	90 ft	rft	Tk. 50/-	4,500/-
(f)	Placing of Centralizer approx.at 15ft internal	12	each	Tk. 25/-	300/-
12.	Gravel packing	500	cft	Tk. 30/-	15,000/-
13.	Well development	1	L.S.	Tk.10000/-	10,000/-
14.	Pump house construction	1	L.S.	Tk.48000/-	48,000/-
15.	Commissioning	1	L.S.	Tk.12000/-	12,000/-
16.	Turbine pump (70 ft head)	1	each	Tk.70000/-	70,000/-
17.	Engine	1	each	Tk.100000/-	100,000/-
18.	Gear head	1	each	Tk.20000/-	20,000/-
19.	10 ft Discharge pipe 8"-dia	1	each	Tk.4000/-	4,000/-
	Total Cost:-				5,07,835/-

APPENDIX - XII - C

ANALYSIS OF WELL-LOSSES OF EXISTING AND RECOMMENDED DTWS

Sl. No.	DTW NO.	Entry Loss, ft	Upflow Loss,ft	Total Well Loss, ft	Entrance Velocity (ft/Sec)	Remarks
1.	NAN - 118	3.29	22.34	25.63	0.043	
	Reco. DTW	3.64	10.99	14.63	0.048	
2.	BHAL - 110	2.10	30.27	32.37	0.027	
	Reco. DTW	4.63	6.83	11.46	0.048	
3.	PHUL - 160	2.57	6.21	8.78	0.033	
	Reco. DTW	3.68	3.47	7.15	0.048	
4.	NABI - R/27	2.23	26.81	29.04	0.024	
	Reco. DTW	3.68	20.38	24.06	0.048	
5.	DAUD - 60	2.82	16.82	19.64	0.029	Reco. based on cost analysis
	Reco. DTW	4.63	16.14	20.77	0.048	

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