CHALLENGES AND REMEDIAL MEASURES OF WELL DRILLING SITE DEVELOPMENT IN BANGLADESH

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RECOMMENDATION OF THE BOARD OF EXAMINERS

The project titled "**Challenges and Remedial Measures of Well Drilling Site Development in Bangladesh**" submitted by Md. Shahinur Rahman Farazi, Student No.100713025, and Session: October 2007, has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Master of Engineering in Petroleum Engineering.

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It is hereby declared that this paper or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Abstract

Drilling activities can take place in diversified geological and geophysical settings, each posing unique type of challenge. There is no universal methodology to address all the situations. Therefore, each project is tailored on a case by case basis. However, it is possible to analyze the problems and to table the common items to bring them under a systematic procedure. Well site development is the initial stage of a drilling project. It involves mainly Civil Engineering works which includes earthworks, leveling, proper compaction, construction of rig and machinery foundation, well site yard, pipe rack, cat walk, mud pit, ware houses, deep water well with water line, office and personnel accommodation, security fencing/wall, sanitary and drainage works etc. An unplanned or faulty development of a drilling site may cause severe problems which may even jeopardize the entire drilling project.

State-run and international oil companies have so far drilled about 186 wells in different geographical and geological conditions of Bangladesh. Currently, BAPEX and 4 IOC's are conducting the country's drilling activities. In onshore, the North-Eastern territory of the country has offered the most of the oil and gas resources. Besides, a number of wells have been drilled in off shore as well. Despite of having the drilling experiences, it is difficult to get a generalized idea on the drilling issues due to lack of compilation of the individual experiences.

In this study, the challenges and remedial measures of six representative well sites have been analyzed. This study took a closer look at the challenges and remedial measures of the sites as the first attempt of this kind in Bangladesh. It observed the nature of the problems and their reasons; degree of severity which causes time and cost overrun of a project. For example, the cost overrun comes from 5% to 44% and the time overrun comes from 0% to 83% in the same project due to the severity of the problems such as excessive rain, flood etc.

It is revealed that, heavy rainfall during the monsoon and consequent flooding poses the biggest and most common problems for the pre-construction activities before drilling wells. The case-studies showed that the natural constrains caused delay in project implementation, difficulty of logistic movement, raise security issues, damage to

equipments and cost overrun. The terrains are either low lands with seasonal water bodies, popularly known as haors, or hilly areas with dense forest. Both types of lands are susceptible to flooding, landslide or washout.

Construction and maintaining of the approach road is the next biggest challenge, which is also tied to flooding and remoteness of the location. In some cases, scarcity of manpower and proximity to the international border are also problems. It is therefore important that the weather and flood pattern, availability of manpower and proximity to international border from locations should be taken into account to plan the logistic movement.

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Chapter-1

INTRODUCTION

Hydrocarbon may be found in various types of places including the sea, mountains, deserts, rain forests, marshlands, and permafrost regions. The location of a well is dictated primarily by geological and geophysical considerations. Rest of the activities are planned accordingly to address site specific challenges. The drilling site must be prepared carefully to ensure safe operation of the drilling rig and other equipment. It also should address environmental and health issues. As each location may pose a different set of challenges, the remedial measures largely depend on the experience, innovation and the available resources to the site development team [1-5].

State-run and international oil companies have so far drilled about 186 wells in different geographical and geological conditions of Bangladesh. A list of these wells is given in the Appendix, Table A1. Bangladesh Petroleum Exploration and Production Company Ltd. (BAPEX) is the sole state owned company entrusted with the responsibility of hydrocarbon exploration in the country. It has drilled 18 exploratory wells and performed 30 work over activities in different environment of the country. The list of exploratory wells and work over activities are shown in Appendix, Table A2 and Table A3 respectively. Difficulties such as road accessibility, difficult terrain, untimely flood and inundation of the site, landslide etc. were encountered. It is important to review and analyze these events and the remedial measures. It is true that the expertise has grown over the years, but unfortunately the valuable specific site experiences were not systematically compiled. Thus the important lessons from various projects largely remained with individuals and the transfer of knowledge has been limited.

The proposed work aims to conduct case studies on a selected number of wells drilled in different areas of Bangladesh. This may be seen as the first step towards building a knowledge base which should help to formulate guidelines for future hydrocarbon exploration in Bangladesh. It should be emphasized here that the focus of the proposed work is limited to site development only. Therefore, the drilling process itself is excluded. If site development is not done properly, the rest of the drilling activity cannot be carried out safely, and it may jeopardize the entire project. The paper will help to implement the site development work at a new project by pointing out the problems and remedial

measures linked to different areas of Bangladesh. For example, a contractor with a lot of experience in Saudi Arabia wants to drill 4 numbers of gas wells in different territory of Bangladesh. He may not have enough information and experience about Bangladesh. The challenges or difficulties of the projects may be new to him. Also, he may not be familiar with the experienced persons in Bangladesh to gather helpful insight. Thus, this may be useful at the time of bidding as well as site development.

By the help of the knowledge base, one can take preventive approach during implementing a well drilling project. The outcome of this paper can help to prepare a manual of site preparation especially for Bangladesh.

Objectives:

- To analyze the problems encountered and remedial measures taken while preparing well sites for drilling of a selected number of wells in Bangladesh.
- To categorize these problems in different ways such as the frequency of occurrence, degree of difficulty, monetary involvement, hazard level, etc.
- To suggest guidelines for selection and development of well sites for future exploration and development in light of the past experiences.

Outline of Methodology / Experimental Design:

- Collection of all relevant data and information of the exploratory and development wells drilled by various companies in Bangladesh.
- Data collection will include collection of project reports, working papers, site visit, interview of related personnel, etc.
- Analyze the problems whether these were caused due to human error, design error, or unforeseen natural factors, and whether same type of problems occurred recurrently.
- Assess the indicative monetary involvement, time loss, and effectiveness of the remedial steps
- To make suggestions to be adopted for future activities.

Chapter-2

OVERVIEW OF A DRILLING PROJECT

A drilling program is initiated to gain knowledge on the existence and to establish the quality of hydrocarbon deposit. Despite the development and advancement of seismic studies, drilling is the only available method to positively claim the presence or absence of hydrocarbon. It is also the only way to produce hydrocarbon.

A typical on shore drilling project involves the following steps [6]:

1) To select well site location and make site plan
2) To prepare drilling program and estimate well cost
3) To select drilling contractor
4) To procure drilling materials
5) To select services companies
6) To prepare various manuals
7) To prepare well site and access road
8) Receiving of drilling materials
9) To mobilize rig and service companies equipment
10) To drill the well
11) To test/suspend/complete/abandon well
12) To restore the site

2.1 Selecting well site location and making of site plan

The site selection of an oil/gas well depends upon the geological program. A suitable camp location is finalized as close as possible to the working area where future boreholes are likely to be located. While selecting the site or camp location, the basic amenities like availability of water, electricity, transportation from nearby town, market and dispensary must be taken into account. The other factors that play a crucial role in selecting the camp location are proximity to workshop, availability to Petroleum Oil and Lubricant (POL) and communication facilities. If it happens to be a private land an agreement with the land owner is a must. For establishment of camp in a government land necessary approval from local authority is required before commencement of site development. The well site area is to be properly cleaned and leveled, followed by pitching of tent age and erecting of store, POL and vehicle shed. Once a bottom hole target has been selected,

the site inspection will be made to select suitable site in the proposed area. At that time the following matters should be considered:

- Access to site
- Existing utilities
- Proximity of habitation
- Environmental consideration (EIA study)
- Size and shape of site
- Proximity to roads and railways
- Cost including site purchase (or lease), site preparation

The site plan should meet the following criteria:

- To be large enough to accommodate the rig and equipment
- To provide easy access for solid and waste removal
- To allows the placement of production testing equipments
- To provide sufficient solids settling pits
- To provide a safe location for flare line
- To have sufficient room to turn trucks around on site

A typical site plan of an oil and gas exploration well drilling project is shown in Fig: 2.1

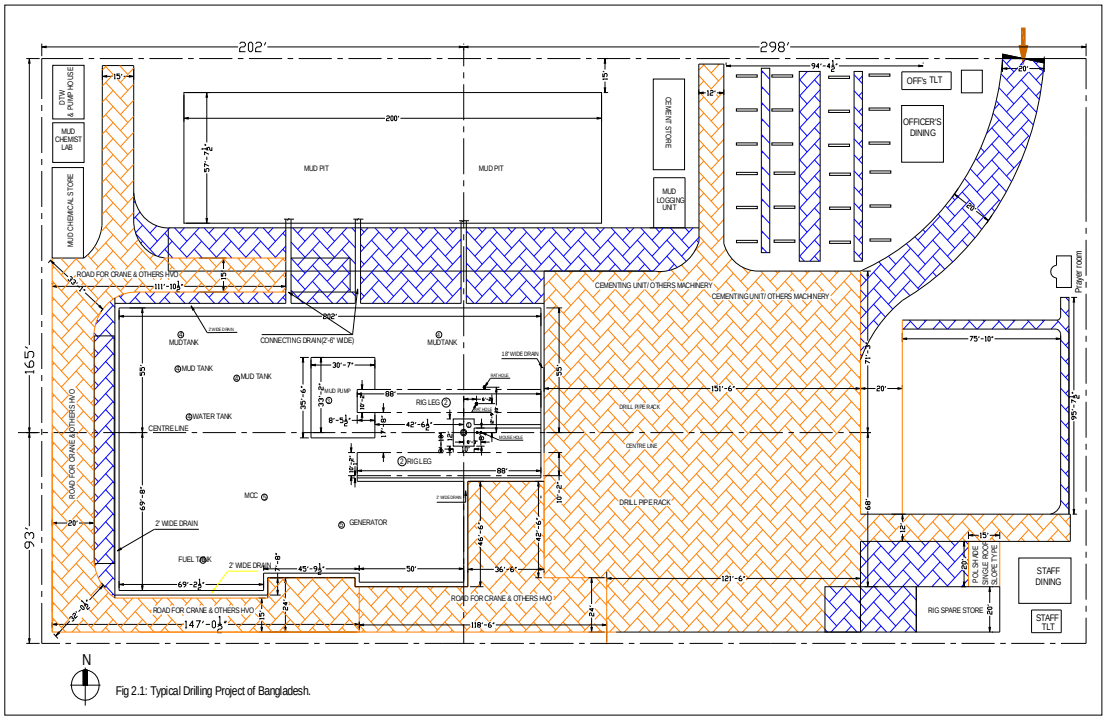

Figure 2.1: Typical lay out plan of an oil and gas well drilling project. (Rupgonj, Narayangonj)

2.2 Preparation of drilling program and estimating well cost

The first step in the promotion of good drilling practices is planning the well. Objective of well planning is to formulate a program from variables for drilling a well. The most important aspect of preparing the well plan is various type of data collection. As data are collected the well can be designed. Well design will include:

- Formation pressure prediction
- Casing program
- Cementing program
- Directional plan
- Bit program
- Mud (Drilling fluid) program
- Wellhead & BOP's
- Logging program
- Coring program
- Completion program

Authorization for expenditure (AFE) is one of the vital parts of a drilling project. Initially, a lump sum cost is estimated. But, it is finalized after gathering of all data and interpretation. Actual cost of a well drilling project is obtained by integrating expected drilling and completion times with the well design.

2.3 Selection of drilling contractor

This step involves preparation of tender document, tender invitation, collection, evaluation and contract. Drilling contract may have the following clauses:

- Agreement and Terms
- Personal, equipment, services & supplies
- Rates of payment
- Quality control or performance Liabilities
- Drilling methods and practices
- Insurance
- Special conditions
- Confidentiality
- Patents

- Assignment of contracts
- Laws
- Arbitration
- Signatures

After preparing the tender documents the tender is invited. After then sorting and evaluating the received tenders, drilling contractor is selected by proper approval of the authority.

2.4 Procurement of drilling materials

This step involves preparation of tender document, tender invitation, collection, evaluation and contract. The following materials generally procured by tendering during a drilling project:

- Wellhead and Christ mass Tree
- Casing and tubing
- Bits
- Mud chemicals
- Cement and cement additives
- Completion materials
- Liner hanger
- Casing accessories

During purchasing the following essential items should be included in a contract:

- Country of origin
- Inspection and testing
- Packing
- Delivery and document
- Payment
- insurance
- Warranty
- Delay's in the suppliers performance
- Termination for default
- Taxes and duties
- Return policy

2.5 Selection of service companies

It involves preparation of tender document, tender invitation, collection, evaluation and contract.

The selection of service companies generally required the following services during an on shore drilling:

- Mud Engineering
- Mud logging
- Cementing
- Wire line logging
- Casing running
- Well Testing
- Directional drilling
- Coring
- Other special services (Liner hanger, fishing)

Then the service tender is invited same as rig tendering.

2.6 Preparation of various manuals

This step involves the preparation of different types of operation manuals, contingency manuals, material list etc. the manuals preparation for the well drilling is done by a group of experts regarding the topography, type of structures, formation criteria etc.

2.7 Preparation of well site and access road

Following is a general outline of site preparation. Details will be discussed in chapter-3.

2.7.1 Drill Site Preparation

To prepare for initial drilling, the lease site is leveled, if necessary, with a bulldozer and/or grader, with careful consideration given to buried pipelines and utilities, as well as proximity to surface water features. The scale and duration of lease site preparation is site specific. On some drilling sites, a cellar may be excavated. This is where the borehole is to be drilled. A reserve pit and settling pits may be excavated and are used for water or drilling fluid (mud) discharges. Besides, rig and machinery foundation, rat hole, mouse hole, ware houses, tube wells, water line etc. are also constructed in a drill site [7].

Tubular are to be stacked above ground and preferably on three supports at the site as well as in the camp named pipe rack. Generally, two stores are required to be constructed named chemical store and general store respectively. The general store contains all drilling spares and the chemical store contains all types of mud chemicals.

Generator and compressor set required for drilling and lighting of the drilling site. The project Engineers used to prepare the foundation to rest on. It should be perfectly leveled (Undulation not more than 5 mm) and should be of sufficient strength to carry both static and dynamic load at operation.

The following generator and compressors are used for a typical drilling site in Bangladesh.

Table 2.1: Generator and compressor set generally used for drilling projects in Bangladesh [16].

Sl No	Name of rig	AC Generator		DC Generator		Generator at camp site		Compressor (120 psi)	Size (L X B)		Weight (Ton)		Remarks
		No's	Capacity (KVA)	No's	Capacity (HP)	No's	Capacity (KVA)		Generator (With skid)	Compressor (With skid)	Generator	Compressor (With skid)	
1	ZJ 70 DBS	4	1500	……	…….	2	312	2	30'X10'	40' X10'	28.0	24.0	
2	ZJ 50 DBS	4	1500			2	250	2	30'X10'	40' X10'	28.0	24.0	Procurement under process
3	IPS Cardwell	2	312	5	904 HP	1	312	3	25'X9'	17'X9'	20.0	10.0	
4	IDECO Gardener Denver	2	650	…..	…….	2	812	3	30'X10'	20'X8'	18.0	15.0	It has 3 additional engines
5	ZJ 40 DBT	3	1875	……	…….	2	312	3	33'X10'	33'X8''	23.0	17.0	
6	P-80	1	312	….	……	…. .	…….	1	5'X5'	N/A	5.0	N/A	It has 1 additional engine

From Table 2.1 it is shown that any one of the above generators or compressors set is widely used at drilling site in Bangladesh. During site preparation it is taken into account to accommodate and the mobilization of the generator and compressor set.

2.7.2 Site preparation for Development well drilling

During a development well drilling the site is to be prepared carefully, if a development well is located adjacent to the existing live (producing) well. The well head and the gathering line are to be protected cautiously. During erection of a rig, shifting, hoisting of bulk material may cause a serious accident to the existing well. Sometime, a number of development wells need to be drilled one after another from a single foundation. It is done by constructing a series of cellar in a single row and shared one leg for every

alternate drill beside the well. In these cases, the next foundation is to be prepared by superimposing with the previous one and the development wells are drilled one after another. It could be very effective when an inaccessible site is required to be developed. It saves a lot of time as well as development cost for the project. The site preparation works for the development wells need extra care to avoid hazardous incident maintaining a live well besides the developing well. The disposal of cuttings may be another challenge for the cluster type of development well. If the development well exists far from the exploratory well, then the site preparation is same as wildcat drilling.

2.8 Receiving of drilling materials

Meanwhile the tender has been processed and a contractor was selected to deliver the materials. At this stage, the contract materials should be received with proper inspection by an inspection committee.

2.9 Mobilization of rig and other equipments

After the contractors are selected, the mobilization schedule will be prepared considering readiness of the site preparation. The mobilization and demobilization are generally performed by the contractor's responsibility in a lump sum payment conducted by the contractor him selves. At the end of this stage, the well is spudded and drilled according to the drilling program.

2.10 Drilling of a well

It involves [7] -

- Drilling rig and equipment mobilization.
- Drilling fluids/mud-testing and recycling.
- Blow out preventer (BOP) installation.
- Surface and intermediate (in some cases) casing cemented into the wellbore.
- Drill cutting samples taken and analyzed (ongoing throughout the drilling process).
- Wellbore drilled to total depth (vertical, directional or horizontal).
- Potential reservoirs (s) identified and evaluated using geophysical logging techniques.

2.11 Restoring the Site

Rig down operation was conducted and the rig was released to another project. For a successful well, the flowing gas processed through a process plant, and then sent to the sales line. For an unsuccessful/dry project, the well is plugged and abandoned by cementing and then the X- mass tree along with the foundation is left by constructing fencing around it. The rest of the land is released to the owner/DC office for further action. Often the soil layers are separated for better soil conservation. Upon completion of the drilling, the soils can then be restored to their original location [8 & 9].

Chapter-3

SITE DEVELOPMENT

This chapter presents a detailed discussion about the site development for a drilling project.

3.1 Site Selection, Feasibility and Costing [10]

After geological and geophysical survey it is the first requirement to select the site. The geological location may be in a pond, top of a hill or in the midst of a river. The appropriate location is to be selected according to the feasibility, ease of communication and cost to develop it. In a densely populated riverrine country like Bangladesh, it is very important to select the proper site.

If the well location is in a deep forest, the site should be selected carefully. It is such that the site is feasible to access with easy communication to nearest locality as well as administration center. The site should be select in such a way that a minimum number of trees are required to be cut down. The trees needs to be uprooted completely and leveled with a minimum cost.

If a well location is in the midst of a flowing watercourse, it is required to be shifted along the seismic line within a possible limit. It may be very difficult to develop the site and there is a chance of changing the path of watercourse.

Well location in the midst of a densely populated area involves social factors as the rehabilitation of the locality is very challenging. The site is to be shifted within a feasible range and the well is to be drilled in a deviated manner.

If the well location is on the hill top, it is not easy to develop the site. The site selection is also a vital issue and then re-shifted the well location to the valley of the hills, so that the development works can easily be done. On the top of some hillocks, the water wells can not be easily installed and the rig can not be moved smoothly. Thus the hill tops required to be cut down and the valley of the hills is filled.

3.2 Land Access Negotiation [10]

According to Bangladeshi constitution clause 143, the Bangladeshi government is the owner of minerals inside any land within the country. The land area may be owned by

somebody and then it can be owned by the Government of Bangladesh in lieu of proper price according to clause 42.

Generally, requisition for the land to be submitted first for 2 years in lieu of crop compensations. After successful drilling and discovery of hydrocarbon, steps are taken to acquire the land permanently. If no hydrocarbon prospect is found the required area is released within a short time after acquiring only the wellhead area. To assess the price of the land, it is the usual practice to take the average price within last 1 year in that locality as the base price. Then it is multiplied by 1.5. The whole requisition or acquisition processes are associated with respective Deputy Commissioner's office and Ministry of land. This process involves quite a bit of time, usually about 8-10 months.

A lengthy requisition process may cause a lot of problems. The project completion time and subsequent project cost may become very high. Moreover, the delay may interrupt the expected supply of gas essential for the country. To avoid such situations, the project officials may consult with the respective land owner of the project area and reach a negotiation within minimum time.

3.3 Topographical Survey and Engineering Design [10]

The design of well sites and associated access tracks varies with respect to the topography of the well site area. If the well site is within hilly area, the approach road must be prepared in slope with minimum grading, maximum drainage facilities and with proper super elevation. The well site should not be prepared at the hill top as most of the hill tops are vulnerable to landslide due to excess rainfall or earthquake in Bangladesh. There is also a scarcity of water on the hill tops, because of unavailability of water table. Again, the preparation of well site is also chaotic on the valley surrounded by a number of hills. This is because of shallow water table at the toe of the hills. Thus, the site is to be prepared by cutting the top of the hills and filling it on the valley. Then after mechanical compaction the site is to be prepared for drilling.

If the well location is in the midst of a flowing watercourse, it is very challenging to prepare the drill site and the approach road. The approach road and the site is to be prepared by earth/sand filling throughout the area. Sometimes, a dam is prepared around the site and the stagnant water is pumped out from the well site area. At that time, the dam is under water pressure and the seepage may occur. This may cause damage to the dam and flooding of the well site area. Similarly, the approach road may

be affected by flood water. Thus, a guide wall should be constructed around the well site and along the approach road. Otherwise, the filled land may be washed out by the flowing water current and rainfall.

Sometimes, a well location may be in a deep forest and remote from the locality. A great challenge associated with the deforestation comes in the frontline. At the time of site preparation, the trees are uprooted completely, so that no tyre bursting may occur during movement of vehicles. The well site may be in a remote place but should be of well communicated to the nearest hospital, local administration, police station, bazaar etc.

Sometimes, the well location may be adjacent to International boarder. The site development adjacent to the International boarder may be very difficult. It is due to the chance of illegal migration, smuggling etc. It can be solved by engaging a lot of securities and developing the law and order situation of the area by the help of local administration.

Sometimes, a well site needs to be developed in a densely populated area by rehabilitating the dwellers from the project area. The site is then prepared cautiously so that, the sound or fumes cannot create a hazard to the local people. At the time of shifting the man and machineries there may be traffic congestion in the locality. As a result, the shipment of the materials can be done during off peak or at mid night.

3.4 Resource consenting [10]

Resource consent is the authorization given to certain activities or uses of natural and physical resources required under a certain law. Under this law (Act), the term 'environmental effect' refers to virtually any imaginable change to the environment at and around the location of the proposed activity. Environmental effects can be:

- Positive or negative.
- Temporary or permanent.
- Past, present or future.
- Cumulative (occurs over time or in combination with other effects).
- Of high probability.
- Of low probability but high impact.

Some examples of environmental effects are: an increase in traffic, soil erosion, and changes to the character of the street or landscape, loss of recreational value, or noise and visual impact.

A Cultural Impact Assessment is a report documenting of cultural values, interests and associations with an area or a resource, and the potential impacts of a proposed activity on these. It is the duty to assessment of the environmental effects and the cultural impact at the time of developing the well site. Generally, the Department of Environment (DoE) assesses the effects. For each project, an Environmental Impact Assessment report to be submitted to the DoE. Then the authority assesses the detail effect and serves the NOC for the project. After then, the way of development is to be found out.

3.5 Geotechnical Investigations and reporting

Geotechnical investigations are performed by geotechnical engineers or engineering geologists to obtain information on the physical properties of soil and rock around a site to design earthworks and foundations for the proposed structures. This type of investigation is called a site investigation. To obtain information about the soil conditions below the surface, some form of subsurface exploration is required. Methods of observing the soils below the surface, obtaining samples, and determining physical properties of the soils and rocks include test pits, trenching (particularly for locating faults and slide planes), boring, and in situ tests. Any of the above tests may be implemented to know the soil condition and to determine the type of foundation required to be constructed for the structures.

3.6 Well Site Design

This is the most vital part of site development phase of a drilling project. Well sites in different terrain needs different pattern of design and different methodology to mitigate the site development hazards. For example: The factors of periodic landslide, excessive rainfall, flood, scarcity of land, labor, seepage of water etc. should be considered as per requirements.

3.7 Preparation of Tender Documentation

Generally, for the development of a well site it will be necessary to construct the following infrastructures:

- Site development by earth cutting or filling,
- Fencing or boundary around the well site
- Site office
- Deep water well, fire hydrant, water network etc.
- Chemical and general store godown
- Rig foundation
- Other machinery foundation
- Well site yard
- Pipe rack, cat walk etc.
- Mud pit
- Personnel accommodation with toilet facilities
- Security posts
- Garages and workshops
- Internal road
- Generator house
- Prayer house etc.

These are common for all types of terrain. For a water flowing zone, the additional works like guide wall, bank protection works, continuous dewatering etc are required. For hilly areas, the extra protection for land slide (guide wall/retaining wall) and sufficient drainage system is necessary. In a deep forest zone, there will be need to plough the entire area to uprooted the trees after removal of all trees. There also need excessive demurrage for trees, extra care for wild life and extra protection for man and machineries. In a densely populated area, the additional steps needed to be taken for well site preparation are widening the roads, maintaining smooth and efficient drainage system, constructing sound barrier etc.

The works required to be constructed are designed and estimated first by the engineers. Then, after proper approval of the authority, the schedules of quantities, specifications and tender documentation are prepared for invitation of tender.

3.8 Management of Tender Process

A tender opening committee (TOC) and a tender evaluation committee (TEC) is formed with due approval. The tenders received on due date are opened in front of the bidders. Thus, at the time of opening the tender, the bidders came to know about their tender

status. Generally, a single envelop bidding system is practiced for the construction of infrastructure in a drilling project. After some checking of the submitted tenders by the TEC, the successful bidders are shorted out accordingly and invited for an agreement. After some formalities, the successful bidder is given the work order to the commencement of the work.

3.9 Management and Supervision

An efficient site development work largely depends on the management and site supervision during the construction works. A group of officers and staff's are required to be engaged in the implementation of the project. Their responsibilities are to implement the project as per specified design and drawings. Without proper monitoring and supervision, the quality of the finished job can not be ensured up to the mark.

3.10 Site set out and surveying

Construction surveying (otherwise known as "lay-out" or "setting-out") is to stake out reference points and markers that will guide the construction of new structures such as internal roads, buildings/ sheds or other infrastructures. These markers are usually staked out according to a suitable coordinate system selected for the project. In Bangladesh, the co ordinate system is widely used for tracking the well location, a certain plot of a real estate project which covered a vast area. Generally, for a drilling project, consisting of a few acres of land, the surveyor follows the master plan/ Layout plan and staked out the infrastructures by measuring the land simply by measuring tape.

3.11 Organizing internal communications

This is the process of organizing internal communications to site, to flare lines, to skimmer pipes and cellar installation. It includes internal roads to site, pipeline to flare, open drain to cellar etc.

3.12 Environmental monitoring

Environmental monitoring describes the processes and activities that need to take place to characterize and monitor the quality of the environment. Environmental monitoring is used in the preparation of environmental impact assessments. A careful planning is an essential preparation for any successful operation, especially an emergency one. Thus,

environmental monitoring and preparation of spill response plan will help to predict the whole environmental risks associated with the project.

3.13 Preparation of management plans [11]

It is very much necessary to prepare the environmental and archeological plan before starting a well site development activity. An Environmental Management Plan (EMP) is a site-specific plan developed to ensure that all necessary measures are identified and implemented in order to protect the environment and comply with environmental legislation. The environmental management plans should be necessarily based on considerations of resource conservation and pollution abatement, some of which are:

- Liquid Effluents
- Air Pollution
- Solid Wastes
- Noise and Vibration
- Occupational Safety and Health
- Prevention, maintenance and operation of Environment Control Systems
- House-Keeping
- Human Settlements
- Transport Systems
- Recovery - reuse of waste products
- Vegetal Cover
- Disaster Planning
- Environment Management Cell

An Archaeological Management Plan (AMP) is an effective tool that supports the implementation of policies and procedures for identifying and conserving archaeological resources. An AMP also supports the intent of the cultural heritage and archaeological objectives. The AMP will contain:

- well-researched mapping
- a comprehensive inventory of all known archaeological resources including sensitive cemeteries and burial grounds, and
- Processes and procedures for managing any identified archaeological resources located within a municipality [12].

3.14 Management of public relations

This is one of the more important phases of the site development activities. A set of manpower is required to be engaged for the management of public relations with land owners and the neighboring parties. A number of bilateral issues may arise at the time of developing the project. For example, in Sunamgonj- Netrokona Exploration well drilling project (Sunetra-1), conflicts arouse with the local people regarding many aspects of the works. Some of them claimed that the construction of boundary/fencing was not done rightly. Some claimed more compensation for land already acquired. Some people claimed that electricity must also be made available to them while setting electric cables. Some other movement for use of heavy vehicles on the pretext that the local roads will be damaged etc. etc. Hence, a set of skilled manpower is required to handle such problem properly.

In summary, it may be said that site development is a time consuming and complicated task often involving both physical and social factors. The success of the drilling project itself largely depends on a well planned and well managed site development. Moreover, the logistics plan is also tied to the season. For example: especially in wet land (locally known as haor) areas like Sunetra, it is a flash flood zone and the flood water comes early in the month of March or mid April. The roads and the entire area is often submerged under water making the movement of vehicles of any kind impossible. Thus, the knowledge of weather pattern and seasonal variation must be obtained and integrated with the shipment plan.

Chapter-4

CASE STUDIES

4.1 Geographical Features of Bangladesh

Bangladesh is a low-lying, riverine country located in South Asia. It has a large marshy jungle coastline of 710 km (441 mi) on the northern littoral of the Bay of Bengal. It is formed by a delta plain at the confluence of the Ganges (Padma), the Brahmaputra (Jamuna), and the Meghna River systems. Straddling the Tropic of Cancer, Bangladesh has a tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures, and high humidity. Natural disasters, such as floods, tornadoes, and cyclones with tidal bores are regular events.

The physical geography of Bangladesh is varied and has an area characterized by two distinctive features: a broad deltaic plain, and a small hilly region crossed by swiftly flowing rivers. The country has an area of 147,570 square kilometers and extends 820 kilometers north to south and 600 kilometers east to west. Bangladesh is bordered on the west, north, and east by a 4,095-kilometer land frontier with India and, in the southeast, by a short land and water frontier (193 km) with Myanmar. On the south is a highly irregular deltaic coastline of about 580 kilometers, covered with the largest mangrove forest in the world, known as the Sundarbans. This forest area is environmentally sensitive, and home to a number of endangered species. It is also recognized as a world heritage site. Thus any kind of exploration activity in this area will add severe restrictions. This area is fissured by many rivers and streams flowing into the Bay of Bengal.

The territorial waters of Bangladesh extend 12 nautical miles (22 km), and the exclusive economic zone of the country is 200 nautical miles (370 km). Roughly 80% of the landmass is made up of fertile alluvial lowland which is part of the Lower Gangetic Plain. Although altitudes up to 105 meters above sea level occur in the northern part, most elevations are less than 10 meters above sea level. About 10,000 square kilometers of the total area of Bangladesh is covered with water, and larger areas are routinely flooded during the monsoon season.

The Chittagong Hills constitute the only significant hill system in the country, which is the western fringe of the north-south mountain ranges of Burma and eastern India. The Chittagong Hills rise steeply to narrow ridge lines, generally no wider than 36 meters,

with altitudes from 600 to 900 meters. The highest elevation in Bangladesh is at Mowdok Mual (1,052 meters) located in the southeastern part of the hills. The other significant geographical features are large water bodies, locally known as haors, located mostly in the eastern part of the country, especially in Sylhet and Sunamgonj districts. Some of these are considered environmentally sensitive, and included in the world heritage sites. These also pose additional restrictions to any exploration activity. Another important geographical feature is the relatively higher plains of the north-western part of the country, known as the Barendra plains.

Most of the oil and gas discoveries exist in the North-eastern part known as the Surma basin. Thus most of the exploration and development activities are concentrated in this area. E & P activities in the other regions of the country have been very limited. Therefore, one is more likely to carry out a project in the Surma Basin and surrounding areas. All the six case studies presented in this report are located in this area. Figure 4.1 shows the six areas under case study. However, those will cover three main types of terrains such as: Wet land/water bodies or Haor, low lying paddy field and hilly regions.

4.2 CASE STUDY-1

Exploration well drilling Project: Sunetra-1

The main objective of the project was to drill an exploration well (Sunetra#1) in the Sunetra Structure at a depth of about 3700 (±300) meters and to conduct well testing and completion (Phase I). Sunetra was named after the names of two adjacent districts, Sunamganj and Netrakona as the structure is stretched between the districts under hydrocarbon blocks 11 and 12. BAPEX planned to drill at least three more development wells in the field following the commercial discovery of oil and gas reserve there.

Sunetra structure is located in about 59 km south-west of Chattak Gas Field and about 69 km north-west of Bibiyana Gas Field. The structure is situated at the western edge of the Surma Basin. The Indian state Meghalaya is situated about 20-25 km north from the project site. BAPEX selected the project site on the bank of Kangsha river which is flowing through haors, globally known as wetlands. Tanguar Haor, the largest wetland in Bangladesh, is located in Dharmapasha upazilla and its adjacent upazilla Tahirpur. Tanguar haor is one of the world heritage sites [13]. The well site location [14] shown in Figure 4.2.

General Information: The entire Sunetra structure, which stretched between Sunamganj and Netrakona districts, is beneath vast wetland having no regular communication facilities for the movement of drilling equipments and manpower. The area remains submerged at least six months a year due to heavy rainfall and subsequent flash flood in the region.

Northeastern part of Bangladesh, especially Sunamganj, Sylhet and Netrokona districts, are located in the downstream of very steep uplands adjacent to the region in Meghalaya and Assam hills. Meghalaya, the upstream of the Sunetra structure is historically experiences heavy rainfall of about 2,818 mm each year. A number of rivers and canal came from the upstream, which overflow during rainy season. Flash flood is the most significant natural phenomenon in the area which is characterized by sudden and wide variation in water flow due to excessive rainfall. Flash flood occurs when precipitation falls rapidly on saturated soil or dry soil that has poor absorption ability. The floodwater carries a huge amount of sediment originated mainly from the hills. But no authentic data was collected on the highest level of floodwater during monsoon in the area.

Accessible road facility towards the project site ended at Kakura bazaar in Barhatta upazila of Netrakona district, which is five kilometers away from the location. A 4.5-km narrow paved road and a half-a-km earthen road connected the bazaar and the project site. The initial condition of the 5-km road did not allow any vehicle containing drilling materials throughout the year. Besides, it was submerged during monsoon. In recent years, Local Government Engineering Department (LGED) initiated a project for constructing submersible road through the wet lands (i. e haor) connecting the scattered localities. However, none of the roads, running through the haor, were wide enough to accommodate the vehicles which are used for transporting drilling equipments.

Significant Difficulties of the project [15]:

- **Excessive rain and flood:** The civil works wing of the project raised the level of the projects site by filling sandy earth with compaction. The engineers used information on the level of floodwater, collected from local aged people, in estimating the level of the land of the project site to be raised. The project faced first serious difficulty when the floodwater came very close to the site in the beginning of the monsoon in 2011. The developed land of the project site subsided by about nine inches as the sandy earth settled down gaining rainwater and floodwater. It causes the entrance of water

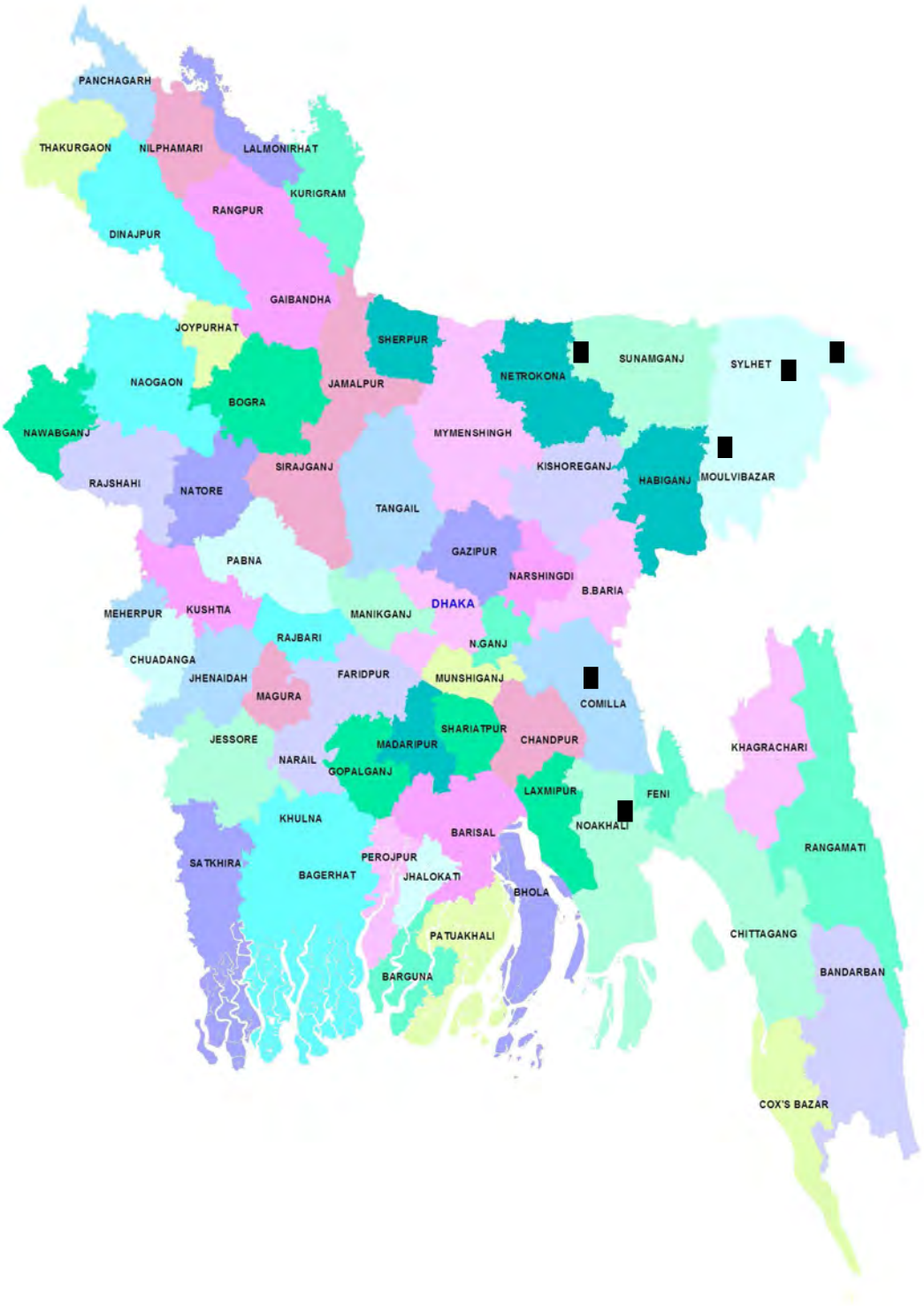

Figure 4.1: Location of the six projects under case study.

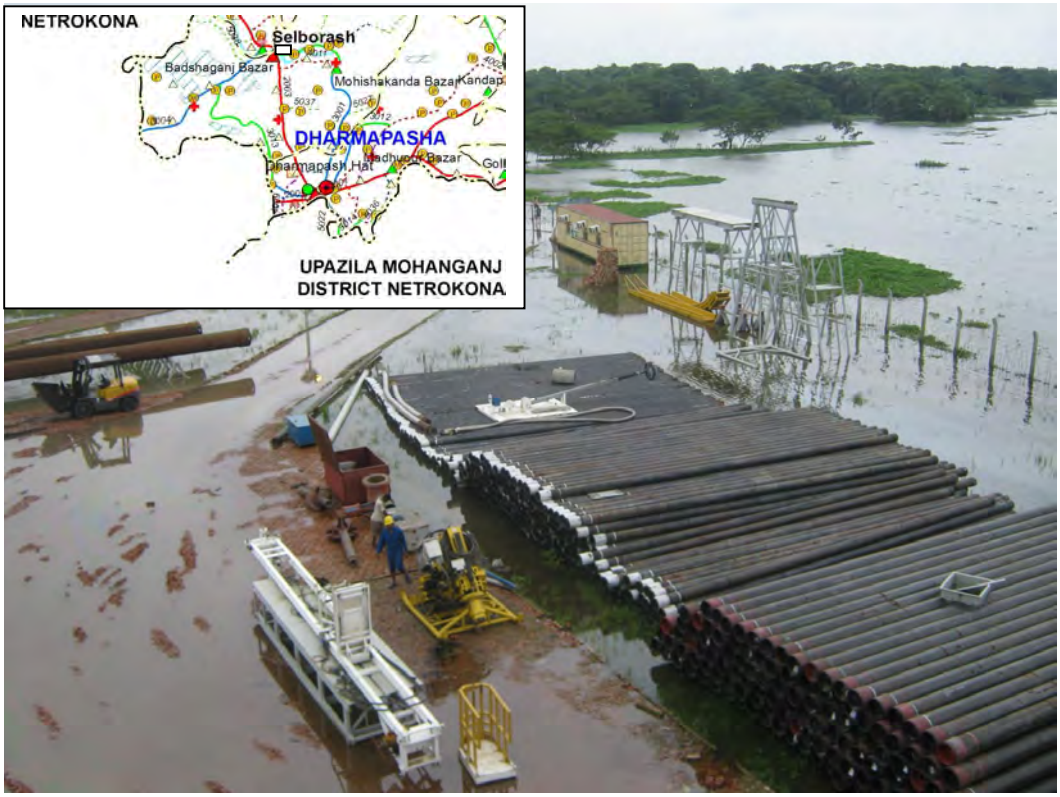

Figure 4.2: Location photograph of Sunetra 1 Exploration well site.

to some areas, disrupted the roadway and delayed the works for about 2-3 months. Figure 4.3 shows the stagnant floodwater in the project site and approach road in the year 2011.

Again, in 2012, the flash flood suddenly struck the site and submerged the site and approach road under water. Merciless rainfall worsened the situation. Later, the local people claimed that they never saw such rainfall and flood in last 40 years. The flood water interrupted the drilling program for about 2 months. Figure: 4.4 shows the drilling interrupted due to flood water in the year 2012.

The filled land of the site was mostly washed out when the floodwater receded. Foundation, prepared for machinery at the backside of the site, was damaged. The bank of mud pit and the machinery foundation were then repaired by palisading and earth work again. It caused a serious loss to the project. The incident could be avoided or mitigated by:

- Developing the project area by considering the highest flood level based on data of about 100 years or more from official sources, such as Water Development board,

Figure 4.3: Flood water enters the project area and disrupting the communication system in year 2011 at Sunetra.

Figure 4.4: Flood water disrupting the drilling in the year 2012 at Sunetra.

Board, LGED or Weather office, instead of local people's testimony.

- Constructing a retaining wall around the project area to protect the site from floodwater. (Same type of retaining wall has constructed to well site at Mobarakpur and semutang gas fields of Bangladesh.
- Providing compaction of the filled soil by means of soil compactor or grader etc to achieve 100% dry density. Otherwise, the loose soil may be washed out or settled down easily. The use of cohesive soil instead of sandy soil may be helpful to mitigate the problem also.

We did not have taken any one of the above precaution. Initially a dam was constructed across the path of floodwater. Laborers stopped working when the water further increased. As a result, the valuable equipments, VFD house, living caravans etc needed to rose by 4 ft. providing wooden block, brick block etc urgently. These involved additional cost, time and extra efforts. If the measures were not taken urgently, the damage to valuable equipments would be serious, and could jeopardize the entire project.

- **Remoteness:** The project area was remote enough to have the supply of electricity, connectivity with roads and other essential supports as there was no habitat in 1.0 kilometer range. It was in the deeper part of the haor. The well site had to be filled by earth, which was carried from a distant area. Owners often refused to transport materials to the project site due to difficulties on the narrow approach road. Sometimes, the heavy materials had to be distributed to lighter vehicles on the road. As a result, additional cost incurred to the shipment of construction materials. The estimated cost was revised to make it rational to both the contractor and to the authority. Sometimes, the rescue operation of the trapped vehicle required a high cost.

During the development of well site, the entire project area was affected by flood twice. All the connecting routes were either submerged or disrupted at that time. Even it was pretty tough to reach to the location in dry season on emergency as no public transports were available. As a result, stand by vehicles were engaged at the site for emergency movement of manpower and machinery.

Besides, an unwanted situation happened in Sunetra once a day. Security issue appeared as a big concern at a remote area like the first drilling site of Sunetra Structure when

some of the construction materials were stolen. The nearest police station was 15 km away. The police men came to the spot after a long time travelling by trawler. This is because of no other vehicles could be moved easily on the road.

- **Inadequate road:** Widening of a 4.5-km road, from 10 feet to 14 feet in width, and construction of a 0.5-km road was a preliminary task for transportation of heavy drilling equipments to the project site. It was also a mandatory part of the site development because no other alternative roads were there available to reach the project area. But strengthening of the 5-km road was delayed by 6 months which caused the transportation of drilling equipments difficult to the site.

The level of difficulty was increased as the equipments were transported at mid-night so that the regular movement of other vehicles might not be interrupted. In a result, the VFD house of Bijoy-10 rig along with the carrier fell out of the track due to inadequate width of the road. A specialized team rushed there immediately. First, the team sought support from the landowners adjacent to the road for using the land to widen the accident spot by about 150 feet to facilitate the rescue operation. Then the road was widened sufficiently by means of palisading, sand filled bags with proper compaction, brick flat soling and HBB works to set up two cranes on the opposite sides of the road. At last, the VFD house was rescued wasting a lot of time and caused wastage of around Tk 10 lakhs. The loss, which was apparently caused by the negligence of the local contractor, also seized vehicular movement as rain and floodwater damaged the existing road from Kakura bazaar to the project site.

The experiences prompted the authority and the local contractor to strengthen the existing road facility immediately. But flood washed out the entire effort. Then in November, a sustainable connectivity was established between the project site and the conventional road at Kakura bazaar.

The authority became more cautious as it employed a team along about 12 km road during transportation of drilling equipments using heavy lorries. The team managed other vehicles not to pass the road during the shipment of the equipment by putting blockeds at Berhatta, 7 kilometers upstream of Kakura bazaar, and at the project site with proper signaling and indication. The team also provides support to the vehicular movement with proper signaling along the connecting road. It took around Tk 185 lakh in addition to

widen and strengthen the 5-km road. Besides, the repair and maintenance of roads and culverts had to be done which kept adding to the project cost.

- **Collapsing of bridges and culverts:** The previous roads and the culverts were designed ("C" category road having 10 ft width) to carry lighter vehicles as estimated by the Local Government Engineering Department (LGED). Heavy vehicular movement of the project damaged the road at different spots and some culverts were collapsed. In a result, the road maintaining agency (LGED) complained. They imposed an obstruction to heavy vehicles on the roads. After some negotiation and assurance of reconstructing the roads and culverts the problem was solved.
- **Scarcity of labor:** As the site was very remote and flash flood prone heavy rainy area of the country, the scarcity of labor was another problem. From outside of Sunetra, nobody agreed to go there for works. Again, the project area was not so densely populated. Thus, a small number of laborers did the entire job consuming a very long time, which delayed the implementation of the project.

Here also the motivational works were imposed to the different parties. The works were distributed among a number of contractors and insisted them to collect laborers from different places of the country.

In summary it is seen that, for the Sunetra-1 case, the location being in a haor area was the main problem, tied with the natural events such as heavy rain and flood. Inadequacy of access roads and remoteness of the location further complicated the situation. Besides safety issues, the cost and time overrun were 5% and 83% respectively. Careful planning with relative information on flood level, weather pattern, construction of access roads and logistics movement is tied to the seasonal weather pattern and proper compaction of the soil could have effectively minimize much of the difficulties of the project.

4.3 CASE STUDY-2

Exploration well drilling project: Beanibazar-1

The main objective of the project was to drill the well Beanibazar-1 to explore hydrocarbon. In 1980, Petrobangla implemented the project employing Parkar drilling company of Germany under Multi-well Drilling Project. The drilling site was located in Sylhet district and about 15 km east of kailashtila gas field [13]. Photograph of the site location is presented in Figure 4.5 [14].

General information: The Beanibazar structure was on the Sonai - Kushiara basin. The first drilling location of the structure was selected beside the river Kusiara. The river often flooded its banks over three months, from June to August, a year due to heavy rainfall and consecutive flashflood. The river carries water from the hills of Assam in India which is adjacent to the Beanibazar structure. Since Assam is one of the great rain prone areas in the world, Beanibazar experiences the rainfall as much as 2850 mm a year.

Figure 4.5: Location photograph of Beanibazar gas field.

A 35-km unpaved road connected the drilling site with the nearest locality at southern end of Sylhet town. There were no electricity supply and telephone line in the project area. The project site was established on 10.8 acres of land, which was owned by the dwellers. The entire project duration was 22 months, of which, the site development completed within 7.5 months battling all difficulties.

Significant Difficulties of the project [16]:

- **Excessive rain and flood:** The project implementing agencies raised the drilling pad, residential and storage-shed areas much higher than the average rise of water-level

during the river Kushiara flooded over. The agencies had completed the land-heightening task before the monsoon came. Thus, the project engineers mitigated the potential threat from flood. But huge rainfall affected the project works for about three months in different intervals. In one hand, the construction of sheds, rig foundation and other relevant infrastructures were interrupted, on the other hand, the unpaved road was inaccessible for transporting manpower and materials. As a result, heavy damp weather with humid subtropical condition always persists there.

- **Remoteness:** Project implementation in an area, having no power supply and telecommunication and having poor road communication, was so risky as it was not possible to get emergency support from law enforcers and fire services in relevent situations. The officials of the project implementing agencies had depnd on building good relationship with the local people. Besides, they built a communication system with the local administrations via Dhaka. A radio networking system was built to keep continuous communications with the head office in Dhaka. At the same time, some scheduled messengers were used throughout the project period to keep communications with the local administrations.
- **Inadequate/poor road condition:** The construction and drilling materials were transported mainly by road. Some of the equipments and a portion of fuel oil were transported by helicopter during emergency shipment. The rest of the fuel was transported by oil lorries. But the river Kushiara created obstacle before reaching the oil supply to the location. The project engineers drew the fuel through a temporary pipeline connecting the lorries and a pillow type rubber tank at the site. Fuel transportation through such a temporary pipeline was so much risky as a little ignition could cause a massive explosion there. Besides, any leakage incident could affect the aquatic life of the area.

The project implementing agencies constructed 5 to 6 kilometers new road, repaired and strengthened of about 3 kilometers for the transportation of machinery and manpower. Besides, two boat ferries were required to cross the Kushiara River for the connectivity with Sylhet. The earlier version of the makeshift ferry (Two boats were tied to build the ferry) was used to carry the man and light vehicles like motor bikes and rickshaw vans. A jetty was constructed at Bairagibazar, down of Shawla, by using an 80'-90' long hired barge.

- **Uneven Terrains with dense jungle:** The project implementing agencies had to clean the jungle and uproot the trees applying a 600-laborforce to leveled the site. Harmful insects and snakes became a big threat for the task. The entire cleaning

operation was carried out with care. The authority had to cut down the top of a number of hillocks to prepare the area for the construction of infrastructures. The engineers prepared the valley of hillocks to construct foundations for installing rig and accommodating machinery, sheds and dug a deep water well.

The uneven terrains, however, helped the engineers to prepare a mud pit by some simple modifications to some hillocks. The gaps of the hillocks, which enclosed a valley, were filled to dump the fluid and cuttings produced during drilling. The authority had to procure the entire land, 10.8 acres, from the local land owners by a ministerial order.

- **Scarcity of labor:** The management had to face severe labor shortage as the area did not produce labor. Besides, it was tough to gather a big number labor force from other regions of the country in a remote area like Beanibazar. Approximately, 600 labors were engaged to uproot the trees from the project area. The authority had to spend beyond its initial to gather the temporary workforce.

In summary, geographical condition of the Beanibazar-1 project site posed the greatest challenge before the authority. Heavy rainfall, floodwater and hillock surface with dense jungle in a basin of two hilly rivers were natural obstacles there for developing the project site for drilling the exploration well. All these obstacles affected the entire activities and created new problems like damaging unpaved road, which affected smooth mobility there. Difficulty of communication with administrative center and company Head Quarter further complicated the situation. This resulted in cost and time overrun by 20% and 25% respectively.

Proper planning of logistics by knowing reliable data on weather pattern, highest water level in river could be effectively minimized the difficulties of the project. Besides, the effective planning on construction of the connecting road and the use of machine (bulldozer, plough) for bamboo deforestation could also be helpful to mitigate the hazards.

4.4 CASE STUDY 3

Exploration Well Drilling Project: Atgram-1

The project name was taken after the village Atgram where the site was selected. Atgram is in Zokiganj upazila of Sylhet district. The village is approximately 35 kilometers east of Sylhet town and 12 km away from Zokiganj. The village lay across the river Surma, which

served as a de facto border, separating Bangladesh from Cachar district of Assam, India [13]. It is about 0.4 km from the international boarder. The location photograph [14] shown in Figure 4.6.

General information: Being employed by Petrobangla, German company Sunmark started developing the site in February 1981 and took 23 months to complete the project.

Figure 4.6: Location photograph of Atgram 1 well drilling project.

Out of 23 months, the German company spent eight months for construction works in preparing the site and connecting roads for drilling the exploration well there. The project location was in a beel surrounded by 4 to 5 hillocks. The valleys of the hills were always in marshy condition. This is due to the existence of water table at shallow depth or adjacent to surface.

It was disconnected from nearby conventional roads and locality having no power supply and telecommunication support. The site was about 12 Km away from the nearby town, Zakiganj. At least, a 2.5-km unpaved-narrow-road was totally unfit for the vehicles carrying heavy materials and equipments related to drilling well. Like any other bordered villages, it was almost beyond the control of the local administrative. Heavy rainfall and

subsequent flashflood is a common phenomenon of the area as it is adjacent and down to India's Assam which is prominent for the phenomenon. The village Atgram stands across the river Surma which lives on rainwater and hilly streams. The river gets high tide due to heavy rainfall in the upstream. Sometimes, the river overflows due to quick rise of floodwater.

Significant Difficulties of the project [16]:

- **Excessive rain and flood:** The village Atgram stands across the river Surma. Specially, at heavy rainfall in the upstream causes high tide to the river. Sometimes, the river overflowed and the flood water rose quickly. The flood interrupted the common movements and activities on the project area. Heavy rainfall and the floodwater delayed the project development works by 2 months. Sometimes, the works were continuing under tarpaulin in rain.
- **Remoteness:** It was not possible to have emergency support from technical team, law enforcers, local administration or fire services as the location's remoteness. A radio messaging system was developed to communicate the head office and thus a via communication was established with the local administrations and law enforcers. At the same time, the authorities engaged some persons to communicate with the local security and administration physically. The necessary support, whenever it required, took long time increasing the overall project duration. A number of vehicles were kept standby for emergency. All the arrangements increased the cost of the project.
- **Inadequate/poor road condition:** The construction engineers constructed a new road of about 2.5 km length to provide a smooth communication to the drilling site. The road from Sylhet town was not suitable for transporting heavy drilling equipment smoothly to the site as well. The engineers repaired and enlarged the road in many places to facilitate the shipment of the drilling equipments. Despite having all efforts to build up a dedicated communication system by road, the river Surma created an unavoidable obstacle in reaching the drilling the site, particularly for the oil lories. The project engineers passed fuel oil through a temporary pipeline connecting the lorries and a pillow type rubber tank at the site. Fuel transportation through such a temporary pipeline was so much risky as a little ignition could cause a massive explosion there. Any leakage incident could affect the aquatic life of the area. There were also chances of hitting the pipeline by fishing and passenger boats in the river. Besides, it was an easy target for the miscreants for sabotage or steal fuel oil. The security as well as inspection

teams, however, handled the shipment of fuel oil through pipeline without a noticeable damage. It incurred an additional cost to the project.

- **Collapsing of bridges/culverts:** There was a bailey bridge of about 150' in length on the way to the location. Once, the bailey bridge collapsed due to the movement of heavy vehicles. Then the engineers constructed a wood-deck bridge. Another 70'-0" was prepared as like as cut off to reduce the width of the river. It required a lot of money wasting a long time.
- **Uneven Terrains:** The project implementing agencies acquired about 9 acres of land by paying the crop compensation to owners, who were local dwellers, under a ministerial order. The engineers had to cut down a number of hillocks to obtain a plane land for the construction of a rig pad and sheds. The waste pit or mud pit was made by creating am artificial ditch by filling the gaps between the hillocks enclosed the area. Other infrastructures like rig and machinery foundation, master drain and deep water well were constructed afterwards.
- **Water entrapping by shallow water table/seepage action:** The construction wing of the project faced difficulties in preparing foundations for drilling rig as they did not compact the base properly. The engineers could not assess the necessary level of compaction of a marshy land like the project site. Same situation arose with wastage of time and extra allocation of money was in construction of an access road for the movement of crane, trailer or other vehicles to install the generator, compressor or other equipments at the periphery of the foundation.

The project faced another problem, the buoyant force in a swamp soil, which resulted in imbalance of foundation. The problem was due to the cut off the path of water table flowing downward of the hills. A number of cross drains were constructed along the slope of the hills to flow the accumulated water. It incurred a huge time and additional expense to the project.

- **Proximity to International boarder:** A number restrictions were imposed on on the activities during drilling of the well due the location's proximity to an international border. The Border Security Force India often visited there to see the activities. They were always worried about the chance of infiltration of Bangladeshi people to Indian territory. Sometimes, loaded helicopter entered into the Indian air space unintentionally due to wind. The drilling authorities along with Bangladeshi administration had to settle the matter with the Indian counterpart. As a result, a number of extra securities (both in

from administration and Petrobangla) were deputed to reduce the chance of infiltration of people to India. They also checked the chance of smuggling.

In summary, the main problem was the terrain being marshy and hilly simultaneously. Continuous seepage at the well site made the compaction of soil difficult, which could compromise the integrity of the rig foundation. Proximity to the Indian boarder further complicated the situation. It results the cost and time overrun by 30% and 30% respectively. Careful planning and preparation of site at comparatively higher land in those areas could minimize the hazards mostly. Besides, efficient drainage system around the site, cross drainage below the foundation, could effectively minimize the problems. Strong liaison with the local administration and time-to-time joint consultation could mitigate the boarder problem.

4.5 CASE STUDY 4

Exploration well drilling Project: Fenchugonj- 2

The Fenchugonj gas field is situated in Kulaura, the largest Upazilla of Moulavibazar. There are Power Plant, Urea Fertilizer factory (first fertilizer factory planted in Asia), tea gardens, rubber gardens, gas field etc. in this area. Though the gas field was named Fenchugonj, it is situated completely in Kulaura, Moulavibazar district. Recently it was named Vatera Gas field by the ministerial order. Kulaura being the largest Upazilla of Moulavibazar has 17 unions. The gas field is in Vatera [13].

General information: The site development started on January 1983 by petrobangla. The well site area was hilly and they were up to 50-150 ft high. There was no connecting road for the movement of man and machineries. The area was devoid of electricity and telephone network. About 22 km road was prepared to implement the project. The man and machineries were carried by road and by helicopter. Though the project took 60 months to complete, the site development lasted for 14 months only. It was the deepest well of Bangladesh. The area is completely scattered from locality and the local administration till now. The well site area (13 acres) was prepared in 3 stages on the hill. One for well site, one for officer's and another for staff's accommodation.

The hills of Fenchugonj were sandy and very loose for stability. To prepare the site it was taken a bulldozer and cutting the hill top in 3 stages. Due to sandy soils, it was risky to prepare the stages of the hills. Each stage was supported by successive guide walls. The

Fenchugonj was a reserve forest. Tea estates and rubber gardens existed there since 19th century.

Significant Difficulties of the project [16, 17 & 18]

4.4.1 Excessive rain and flood: The drilling area was at high level and free from flood. Vatera gas field is situated adjacent to the Indian state Tripura. The well site scenario is shown in Figure: 4.7 [14].

Figure 4.7: Well site scenerio of Vatera 2 (Fenchugonj) gas field, Kulaura, Moulavibazar.

Heavy rainfall in this area created strong current especially during monsoon. The current of the water flows downwards with a lot of sediment from the hills. It also hits the abutments of the bridges and culverts badly. That's why, huge cost incurred for repair and maintenance of the culverts, bridges and approach roads to the project every year.

- **Remoteness:** The well site area was as remote as inaccessible. The Engineers constructed approximately 22 km road towards project area. Sometimes, by pass road and temporary culverts were constructed for the movement of construction materials. Sometimes, it was required to segregate the heavy load into a number of light vehicles to carry the whole load. As a result, additional cost incurred to the shipment of construction materials, ultimately adding more costs to the project.

The Upazilla sadar was about 33 km from the site. Out of which about 22 km was constructing at that time. No other alternate road and public transport were available. Besides, telephone, telegraph etc were not spread out broadly. Petrobangla officials used a radio message system in case of emergency only. Hence, it was very difficult to communicate with the local administration as where necessary. It was done by sent a messenger physically. Also, standby vehicles were required to be arranged for emergency purposes. Those involved a lot of time with additional cost.

- **Inadequate/ Poor road condition:** The drilling equipments were transported by road. Approximately 15.0 km road from Brahmanbazar to Baramchal and 7.0 km road from baramchal to well site area required to be prepared. Rather, the army government used to help the drilling team by helicopter to carry machineries and fuel at that time. A number of (25 Nos.) bridges and culverts were constructed on the canals/Chara to ease the transportation of man and machineries to the site. The road used to fill by mud on a depth of about 1-2 ft. Additional cost and labor was required to be engaged for the removal of the mud. Sometimes, the loaded trucks with drilling/construction materials needed to be boosted up by the working bulldozer, crane etc.

- **Uneven terrain with Reserve/Dense forest:** The project area was in reserve forest. It was very complex task to obtain the permission of Department of Environment (DoE). Besides, there were serious disturbance of beast and the reptiles in the project, even in the residential area. To be safe from such type of hazard, the adjacent bushes were regularly cleaned off. Proper lighting arrangement with proper precaution helped to improve the situation. These incurred more cost with more time. Besides, tea plantation started in the area since 1873. Later on, the rubber garden started and came into production phase. The production life of a tea or rubber plant is more than 50 years. During the development of the site a lot of demurrage due to tea and rubber plants had to be paid. It added up the cost comparative to some other projects.
- **Problem associated with seepage action:** The project area was hilly and accompanied by tea and rubber garden. The approach road was at the valley of the hills and just above the water table. Due to heavy rainfall and seepage action, it was created water logging in this area. If the position of water table in shallow depth couldn't be identified initially, it might be created a channel below the foundation washing out the soil below it. The same scenario was seen at the time of drilling well#4 at that field. The leg of a crane inserted during the erection of the rig due to the existence of water

channel and hollow space below the foundation. The problem was minimized by tracking out the shallow water table, water channel and diverting the path with sufficient cross drain. After the incident, the strength of the foundation raised to 2 Mpa by increasing substantial amount of thickness and reinforcement content.

- **Maintenance of bridge and culverts:** A number of bridges and culverts were constructed on the road. Those were badly affected by heavy current during rainy season. The protection of abutments and wing walls from the current required to be ensured compulsorily. Also, a routine maintenance of existing bridges and culverts needed every year.

In summary, it is clear that the challenges aroused during site development were due to the natural events like heavy rainfall, uneven hilly terrain, inadequacy of access roads and remoteness of the location. The presence of reserve forest further complicated the problem. Due to these hazards, the cost and time overrun were 44% and 56% respectively. Careful planning with reliable information on weather pattern, construction of roadside guide wall cum drain, tracking of the water channel and drained out the seepage water could have effectively minimized the difficulties of the project.

4.6 CASE STUDY-5

Exploration well drilling Project: Srikail- 1

Srikail is located in Muradnagor Upazila under Comilla district. Srikail is 25th gas field of Bangladesh. It is about 100 km from Dhaka by road [11]. The gas from the field discovered in 2004 but it was not commercially extractable. Two other wells have drilled in 2013 and now producing from these wells. The well site scenario is shown in Figure 4.8 [14].

General information: The site development started in May 2003 by BAPEX. The drilling equipments were transported by road. Due to inadequate road width, the road from Companygonj to well site were required to be widened and strengthen by the Engineering team. The project duration was 41 months whereas the site development took only 7 months. The whole area (18.56 acres) was fenced by a dyke of about 7 ft height and the infrastructures were constructed in the enclosed area.

A master drain was constructed at the toe of the dyke. The rain/waste water from the entire area through various link drains came to the master drain. It was then pumped out from the area. The land was taken by requisition in lieu of crop compensation only for 2

years initially. Then the duration of the requisition prolonged up to 2014. The process of permanent acquisition is under process.

Figure 4.8: Location photograph of Srikail 1 well drilling project, Comilla. (Dike is seen ahead)

Significant Difficulties of the project [15 & 16]

- **Excessive rain and flood:** The well site was low lying paddy land of about 3 meters above mean sea level. It is situated partially in the basin of river Gumti and buri. Every year the area gets submerged under water for about 3-4 months. A protective dike was build around the entire project for this reason. However, In the year 2004 the entire district was badly affected by flood. The water height was just about to overflow the dyke. The dyke was already affected by rat holes. Besides, there was a hydrostatic pressure and seepage action due to loose compaction. As a result, the dyke collapsed partially and the entire area was flooded. Figure 4.9 and Figure 4.10 shows the photographs of inundation of rig, generator and other infrastructures under water at Srikail.

There was nothing to do but to wait for dewatering the area. The sudden flood damaged the mud pump, water pump, generator, living caravans, storage godowns and other

infrastructures. To repair and maintenance of these, an additional cost of about 200 lakh was incurred.

Figure 4.9: Inundation of whole drilling area under flood water at Srikail 1.

Figure 4.10: Inundation of rig, generator and other infrastructures under flood water at Srikail 1.

- **Inadequate/ poor road condition:** Initially, the approach road was constructed by LGED. It was about 10 ft wide. But, the road should have to wide up to 16-20 ft along with shoulder at the time of material shipment. For the reason, the approach road of about 7km and 2 bridges were required to be widened and strengthen at the time of vehicle movement of the project. During the entire project period, routine maintenance

was done to ensure the road at serviceable condition. This kept adding to the project cost.

- **Compulsory maintenance to pumps, dyke etc:** There were about 25 pump used for discharging the entrapped water. During the rainy season, the amount of entrapped water was more and the pumps were running for up to 20 hours per day. The non stop operation often caused the pumps to be burned out. Besides, during winter, only 5-10 nos. of pumps were required to be run. The other pumps required to be pick up and to overhaul them. Due to prolonged running, continuous repair, maintenance as well as the wear and tear of the pumps increased. The fuel consumption of the pumps was an auditable item also. For transparency of fuel consumption, each pump was associated with a log book and those were maintained properly.

The continuously maintaining and repairing/overhauling needed extra manpower which incurred the additional time and cost. Again, due to safety-security and the risk of sabotage, the surrounding dyke was under close monitoring by a group of personnel throughout the year. It was associated with additional manpower which incurred additional cost.

In summary, it can be said that, for srikail-1 project, the main problem came from flooding. The dike failed to protect the drilling site. It created the cost and time overrun by -7.5% and 40% respectively. This perhaps could be avoided by compacting the filled soil properly. Besides, close monitoring of the physical condition of dyke and increasing the elevation to some selected spots, it could be overcome. Finally, to completely fill up of project area instead of dyke could have mitigated the hazard safely.

4.7 CASE STUDY-6

Exploration well drilling Project: Sundalpur- 1

Sundalpur is located in companygonj Upazila under Noakhali district. Sundalpur is 24th gas field of Bangladesh. it is about 200 km from Dhaka by road [13]. The location photograph of Sundalpur gas field is shown in Figure: 4.11 [14].

General information: The site development was started in July 2008 by BAPEX. It was low lying paddy land of about 4m high from mean sea level. The well site area was about 2 ft (average) down and the residential area was about 5 ft down from the adjacent road level. The project area connected the paved road and there were electricity and town

facilities available also. The total project was 48 months (July 2008 – June 2012) and the site was developed by 6 months only. The drilling equipment and fuel were transported

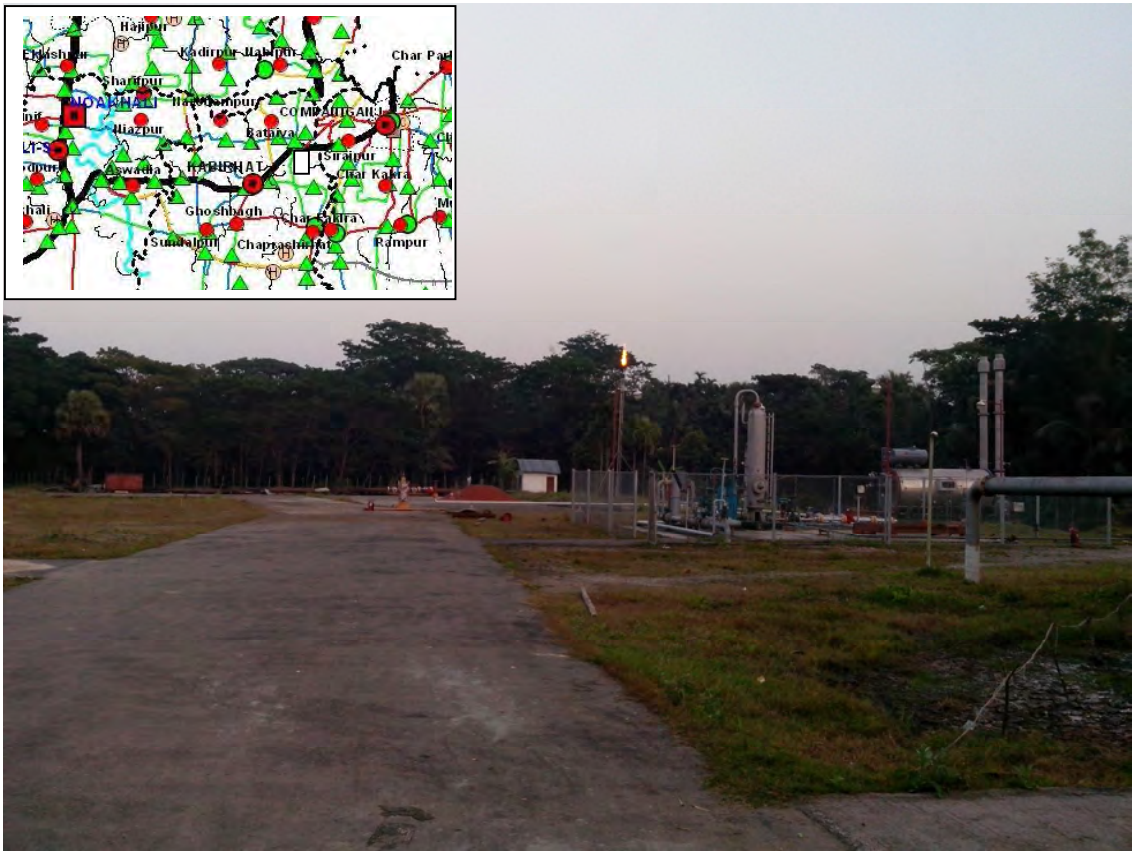

Figure 4.11: Location photograph of Sundalpur gas field, Companygonj, Noakhali.

by road. The dwellers owned the land. The land (3.68 acres) was taken by requisition in lieu of crop compensation only for 2 years. Then the duration of the requisition period prolonged up to 2013. Now, the process of permanent acquisition is under process. The residential area was about 500 meter apart from the well site area. Both the area were prepared by filling the excavated earth and then leveled with bulldozer.

Figure 4.12 and Figure 4.13 Shows the Excavator and bulldozer used in site development at Sundalpur. The leveled soil was then compacted by chain bulldozer and roller to achieve maximum compaction. Figure: 4.14 shows the roller used to compact the soil in both the sites as well as carpeting in the road.

After proper compaction, the required infrastructures such as rig and machinery foundation, warehouses, deep water well, personnel accommodation etc was constructed to the sites.

Figure 4.12: Excavator used in Sundalpur 1 well site construction.

Figure 4.13: Buldozer used in Sundalpur 1 well site construction.

Figure 4.14: Roller used in road at Sundalpur 1 well drilling project.

Significant Difficulties of the project [15 & 16]

- **Excessive rain and flood:** The project area was free from flood. Greater Noakhali is a rain prone area. The average precipitation occurs 3302 mm annually, whereas, the yearly average rainfall in Bangladesh is 2666 mm. The development works started during rainy season. As a result, the construction works delayed and the on going works remain suspended. It causes time and cost overrun to the project. At the time of casting the rig foundation, it was raining mercilessly and we had to use tarpaulin. The construction works continued in rain at sundalpur shown in Figure 4.15 and Figure 4.16.

Scarcity (excessive price) of labor: Practically, we observed that, the people of the area were comparatively richer than the people of other places of the country. As a result, the cost of labor is more as compared to other areas. It was a great problem to the Engineers and also to the contractors who were willing to works there. The situation affected the progress of the work, completion period as well as the project cost. As, no other alternatives were possible to impose, i. e negotiation of the quality of a work and revision of the estimated cost, the above problem was solved by counseling with the contractor and arranged some subsidiary works to compensate them.

Figure 4.15: Rig foundation construction progresses in rain at Sundalpur 1 well drilling project.

Figure 4.16: Construction works in rain at Sundalpur 1 well drilling project.

- **Scarcity (excessive price) of local construction materials:** Soil and bricks are the basic items for any construction work. The actual rate of the materials was about doubled to that of scheduled rate in the project area. The fact was that the soil of that area was used to build bricks. And the bricks were exported in neighboring country at high rate. The bricks were also had a high demand to construction works of Dhaka-Chittagong 4 lane highway at that time. As a result, the contractors required to collect the soil and the bricks at a high rate, especially 20-30% above of the scheduled rate. The authority realizes the matter and made it rationale to implement the project in time.

- **Water entrapped by rain:** The well site area was not filled up to the road level. As a result, rain water entrapped. Due to insufficient drainage; it could not be drained out. An access road always needs for the movement of crane, trailer or other vehicles to install the generator, compressor or other equipment at the periphery of the foundation. Besides, the road was also used to carry the mud or other chemicals. Due to adjacent water, the soil of the road was bumping up and was impossible to compact and construct the road. The site Engineers made an artificial canal around the well site to discharge the water. In order to prepare the road around the foundation, broken bricks were dumped with sufficient thickness to make it stable. Providing of broken bricks incurred additional costs to the project. Figure 4.17 and Figure 4.18 shows the maintenance of artificial canal and the use of broken bricks below the brick flat soling.

Scarcity of land: The project area was in the midst of a locality. The land available for the project was not sufficient (Only 3.68 acres). The land of Noakhali is more costly than other part of the country. As a result, the requisition cost was higher as compared to other projects. As a result, we could not provide the proper sized mud pit to retain the mud water. Besides, the rain water also spilled up the pit shortly. The neighbors of the project often came to complain for mud water and noise associated with drilling equipments.

Shifting of the well apart from the locality, the public complain, area constraint can be minimized. As, it was not possible suddenly, the Drilling in Charge (DIC) used to manage the social problem by counseling with the local people and tried to engage them in some relevant job.

In summary, it can be said that the main problem was untimely working schedule of the project. Improper drainage, proximity to habituated locality, high price of land, soil and

Figure 4.17: Artificial canal/ drain preparation and maintenance to drain out the entrapped water at Sundalpur 1 well drilling project.

Figure 4.18: Providing brick bats beneath the brick soling of drilling site road.

bricks further complicated the situation. These problems resulted in time and cost overrun by 19% and apparently 0% respectively. The terrain itself did not create any special problem, no more than what would happen in any flat land of Bangladesh during rainy season. Moreover, shifting of well site might have helped to mitigate the local problems and the constraint of areas.

Chapter-5

DISCUSSIONS

The challenges associated with the drilling site development are not the same in all projects. They do vary due to a variety of reasons such as location of the site, its topography, drilling season, regime of development, method of development etc. Details of six selected cases were presented in the previous chapter. In this chapter the various information will be compared and analyzed. From the case studies, some specific challenges are identified which have adversely affected the projects. These are summarized in Table 5.1.

Table 5.1: **Categorization in the light of frequency of occurrences.**

Sl. No.	Terrain	Name of the project						Chance of Hazard occurrence (%)	Degree of frequency
		Sunetra 1	Beanibazaar 1	Atgram 1	Fenchugonj 2	Srikail 1	Sundalpur 1		
		Deep Haor	Tilla	Marsh Land	Hilly	Paddy land	Paddy Land		
	Duration (Year)	2011-13	1980-81	1980-81	1983-88	2003-05	2007-08		
	Occurrence of hazard								
1	Excessive Rain and flood	Yes	Yes	Yes	Yes	Yes	Yes	100	Most frequent
2	Inadequate or poor road condition	Yes	Yes	Yes	Yes	Yes	No	83	More frequent
3	Remoteness	Yes	Yes	Yes	Yes	No	No	67	Moderately Frequent
4	Scarcity of labor	Yes	Yes	No	No	No	Yes	50	Moderately Frequent
5	Water entrapping by shallow water table/rain/ Seepage	No	No	Yes	Yes	No	Yes	50	Moderately Frequent
6	Risky shipment of fuel	No	Yes	Yes	No	No	No	33	Less frequent
7	Collapsing of bridges and culverts	Yes	No	Yes	No	No	No	33	Less frequent
8	Dense/Reserve forest	No	Yes	No	Yes	No	No	33	Moderately frequent
9	Compulsory maintenance to site/materials etc.	No	No	No	Yes	Yes	No	33	Moderately Frequent
10	Proximity to International boarder	No	No	Yes	No	No	No	17	Less frequent
11	Scarcity of locally available const. materials	No	No	No	No	No	Yes	17	Less frequent
12	Scarcity of land	No	No	No	No	No	Yes	17	Less frequent

≥90 = Most frequent 30-49 = Moderately frequent

70-89 = More frequent 10-29 = Less frequent Chance of hazard occurrence = $\frac{\Sigma(\text{yes})}{6}$

50-69 = Frequent ≤9 = Least Frequent.

From Table 5.1, it is seen that, excessive rain or flooding is the most common challenge for site development of the projects. As Bangladesh has a long monsoon period, heavy rain during certain time of a year is an inevitable event which cannot be stopped or avoided. Flooding is directly related to rainfall in the regions. However, with careful planning the hazards arising out of rain and flood can be minimized. The planning on logistic movement in dry season, maintaining authentic Highest Flood Level (HFL) of drilling area can effectively minimize the hazards.

The next difficulty is the remoteness of the site, nature and quality of access road. Generally, the oil and gas wells are in remote areas of Bangladesh. The road condition in remote areas is not strong enough to the frequent movement of man and machineries of a drilling project. The remoteness and the road hazard imposes cost and time overrun to almost every drilling project. In remote areas, access roads may be narrow, may have sharp turning, pot holes etc or may be damaged which may be inaccessible to emergency movement. Careful planning and construction of access roads along with ancillaries can mitigate the risk mostly.

The moderately frequent hazards related to hilly terrain are involved in most of the North-East (NE) areas of Bangladesh. Most of the hydrocarbon potential areas of Bangladesh are hilly and covered with forest. The drilling site may be situated on the hills or enclosed by hills. The well sites may have the chance to be entrapped with water from seepage, shallow water table, rainfall etc. Sites on hilltops may be vulnerable to land slide, resulting in serious damage to the rig foundation. Also, such areas of Bangladesh are likely to have sarcity of labor. Effective planning and execution of some engineering measures like construction of guide walls, cross drainage surrounding and below the foundation, mechanical use of deforestation, routine maintenance to various infrastructures can minimize the problems.

It is seen that, now a days, fuel shipment to the site is not a big problem in Bangladesh. The less frequent hazards are the collapsing of bridges and culverts on access road, scarcity of land and locally available construction materials. Although rare case, proximity to international boarders can also give rise to additional problems. The scarcity of land will not be less hazardous in the near future. Thus, proper planning, inspection, monitoring and adopting some engineering measures can minimize the difficulties mostly. Table 5.2 shows the same challenges in light of the degree of difficulty caused by them.

Table 5.2: **Categorization in the light of difficulty to overcome.**

Sl. No.	Name of the well							
	Challenges overcome	Sunetra 1	Beanibazar 1	Atgram 1	Fenchugonj 2	Srikail 1	Sundalpur 1	Degree of difficulty to Overcome
1	Excessive Rain and flood	Yes	Yes	Yes	Yes	Yes	Yes	Most difficult
2	Inadequate or poor road condition	Yes	Yes	Yes	Yes	Yes	No	Difficult
3	Remoteness	Yes	No	No	Yes	No	No	More difficult
4	Scarcity of labor	Yes	Yes	No	No	No	Yes	Difficult
5	Water entrapping by shallow water table/rain/ Seepage	No	No	Yes	Yes	No	Yes	Difficult
6	Risky shipment of fuel	No	Yes	Yes	No	No	No	Difficult
7	Collapsing of bridges and culverts	Yes	No	Yes	No	No	No	More difficult
8	Dense/Reserve forest	No	Yes	No	Yes	No	No	Difficult
9	Compulsory maintenance to site/materials etc.	No	No	No	Yes	Yes	No	Less difficult
10	Proximity to International boarder	No	No	Yes	No	No	No	More difficult
11	Scarcity of locally available const. materials	No	No	No	No	No	Yes	Difficult
12	Scarcity of land	No	No	No	No	No	Yes	Difficult

From Table 5.2, it can be said that, excessive rain and flood are the factor which make the projects most difficult. Therefore, the factors must be taken into account at the time of planning the projects. Logistic movement, road construction etc. activities may be timed carefully to avoid the heavy monsoon period. Collection of weather/ climate data from authentic sources should aid the process.

The remoteness, proximity to International boarder and collapsing of bridges or culverts are the factors more difficult to overcome. Those also need to be taken into account for successful development of a project. Also, the engineering measures need to be adopted to overcome seepage or stagnant rain water. Besides, to overcome scarcity of labor, land and the constructing materials, proper measures should be taken. Existence of reserve forest and the risky shipment of fuel are also factors difficult to overcome.

Some less difficult factors like maintenance of infrastructures for site development etc. also needed to be overcome. Some typical cautiousness, some planning and imposing some engineering measures the difficulties can be avoided easily. Proximity to International boarder and scarcity of construction materials is not a difficult matter now a day. Monetary involvement to mitigate the hazards arising at the time of site development may not be determined accurately. But, it can be noticed that, a more

hazardous site involves higher cost overrun. Table 5.3 shows the cost and time overrun due to the site development challenges.

Table 5.3: **Cost and time overrun scenario to overcome the challenges** [17 & 18]**.**

Sl. No.	Project Name	Terrain	Implementation period	Estimated cost (Lakh)	Final cost (Lakh)	Cost overrun (%)	Estimated time (M)	Req. time (M)	Time overrun (%)	Remarks
1	Sunetra 1	Haor	Jan'11 - Oct'13	878	921.61	5	06	11	83	Though it shows the cost overrun is only 5%, the hazard was not trivial. It may not reflect the true picture as the initial estimate might be too high.
2	Beanibazar 1	Tilla	Jan'80 - Oct'81	5	6	20	06	7.5	25	-
3	Atgram 1	Marsh land	Feb'81 - Dec'82	6	8	33	06	08	33	-
4	Vatera 2	Hilly	Jun'83 - May'88	8	11.5	**44**	09	14	**56**	Maximum cost and time overrun occurred
5	Srikail 1	Paddy land	May'03 - Oct'06	816	754.38	-7.5	05	07	40	Probably, the initial estimate was too high w.r.to required cost. Actually, more than tk. 50 lac additionally incurred to site development due to flood.
6	Sundalpur 1	Paddy land	July'08 - Jun'12	344	408.76	**19**	06	06	**0**	-

N.B: 1. Column 4 indicates the total project Period, not the stipulated time for site development.

2. The cost in column 5 & 6 are the cost for site development, not the cost of the entire drilling project.

Although item wise breakdown could not be done, the overall effect is expressed in terms of cost and time overrun for each project. From Table 5.3, it is seen that, Fenchugonj-2 exploration well drilling project suffered the most. From the case studies, the reasons become obvious. Of 12 items discussed in Table 5.1 and Table 5.2, we see that, most of the hazardous items were associated to that project. On the other extreme, the least suffered project was Sundalpur. This is due to the reasons stated in case studies and Table 5.1 and Table 5.1. Only, excessive rain and scarcity to land and labor was the relevant factors. The overall damage to the project minimized. Table 5.4 Summarizes the remedial measures for the problems discussed before.

Chapter-6

CONCLUSIONS AND RECOMMENDATIONS

From this study, following conclusions can be made:

- Due to the diversity of existing conditions such as geological, geophysical, weather pattern, social and surrounding etc, the challenges related to drilling projects, are quiet varied. There is no unique solution to address all situations.
- Case studies locations are either in low land or in hilly areas. In both types of terrain rain and flooding created the major difficulties. The problems could be largely avoided by proper planning such as scheduling of logistics movement in the dry season.
- Accessibility is also a major problem which makes it difficult for logistics movement. It often requires widening the roads, sometimes constructing new roads along with bridges and culverts.
- The hilly areas are often covered with dense forest which created additional problem of clearing the forests and leveling the ground. In the basin of hills it can be strongly affected by seepage of water.
- The low lands like haor areas are prone to flash flood due to rainfall in the catchment areas upstream.
- Proximity to any international boarder also create a different set of challenges. Movement of man and machinery to the areas are often restricted.
- Due to problems, of six case studies incurred the cost overrun from 5% to 44% and the time overrun from 0% to 83% in the same project due to the severity of the problems.
- All remedial actions seen to be ad-hoc type. There is no cohesive way of addressing them.

Based on the study following recommendations can be made:

- Every drilling project should be well documented, which can be archived and later retrieved easily while considering a new project in a similar terrain. Thus duplication of hazards may be avoided using prior knowledge.

- Weather reports such as rainfall pattern and flooding pattern must be collected from authentic sources and incorporated during the planning phase.
- Drainage, retaining walls etc. should be more carefully designed so that the ad-hoc nature of the remedial actions is removed, and an well planned methodology is implemented instead. Same recommendation can be made for all other activities for site development.
- The scope of the study can be widened to incorporate more case studies so that the knowledgebase is more comprehensive.
- A learning/ training session may be conducted after each project to evaluate the hazards and effectiveness of the remedial measures. This should help in formulating future strategies.
- Knowledge transfer to other teams, especially to the fresher's must be ensured.
- A manual may be prepared by the experiences from more projects.

References

1. Kennedy, John. L., Fundamentals of Drilling- Technology ad Economics, Penn Well Books, Tulsa, Oklahoma, 1983.
2. Ben C. Gerwick (1974): Preparation of Foundations for Concrete Caisson Sea Structures Offshore Technology Conference, 6-8 May, Houston, Texas
3. O. Loset , K. Schroder (1994): Special Challenges In Design And Construction of Concrete Structures In Shallow Water And Soft Soil, The Fourth International Offshore and Polar Engineering Conference, 10-15 April, Osaka, Japan
4. W.F. Herbert ,H.E. Anderson (1937): Foundations for Marsh Operations, Drilling and Production Practice, 1 January, 1937. American Petroleum Institute, New York, New York
5. P.G. Watson ,C. Humpheson (2007): Foundation Design And Installation Of The Yolla A Platform, OFFSHORE SITE INVESTIGATION AND GEOTECHNICS, Confronting New Challenges and Sharing Knowledge, 11-13 September, London, UK
6. Technical Seminar, "Introduction to Drilling Engineering and Operations". Jointly organized by Japan Oil Engg Co. Ltd (JOE) and Bangladesh Petroleum Institute (BPI).
7. Paper on Understanding well construction and surface footprint, Canadian society for Unconventional Resources (CSUR)
8. Reis C John, Environmental Control in Petroleum Engineering, Gulf Publishing Company, Houston, Texas, 1996.
9. Gerding Mildred, Fundamentals of Petroleum, Petroleum Extension Service, Division of Continuing Education, The University of Texas at Austin, Austin, Texas in cooperation with Association of Desk and Derrick clubs, Tulsa, Oklahoma, 1986.
10. http://www.btwcompany.co.nz/wellsite-development.php, Dated: 03 October 2013.
11. www.landcom.com/downloads/file/forpartners/EMPBrochureR1.pdf, dated: 02 October 2013.
12. http://www.mah.gov.on.ca/Page7302.aspx, Dated: 05 October 2013
13. http://en.wikipedia.org, Dated: 02 October 2013
14. Digital map of Upazilla, LGED website www.lged.gov.bd, Dated: 02 October 2013
15. Construction site visit to Sunetra, Srikail, Sundalpur and Fenchugonj.
16. Interview with the concerned personnel.
17. Project Completion report of various projects.
18. Individual files of various construction works.
19. Petrobangla website, www.petrobangla.org.bd. Dated: 02 October 2013
20. BAPEX website, www.bapex.com.bd, Dated: 02 October 2013
21. BGFCL website, www.bgfcl.org.bd, Dated: 02 October 2013
22. SGFL website, www.sgfl.org.bd, Dated: 02 October 2013
23. Daily production report of Sylhet Gas Fields Company Ltd, Dated: 12 October 2013

24. Daily Production report of BAPEX, Dated: 12 October 2013
25. Daily Production of BGFCL, Dated: 12 October 2013
26. Daily production report of Chevron, Dated: 12 October 2013
27. Daily production report of Santos, Dated: 12 October 2013
28. Daily production report of Tullow, Dated: 12 October 2013
29. MIS report, Petrobangla, October 2013.

Acronyms

Acronyms	Description
AC	Alternating Current
AMP	Archaeological Management Plan
BAPEX	Bangladesh Petroleum Exploration and Production Company
Bbls	Barrels
BCF	Billion Cubic Feet
BHA	Bottom Hole Assembly
BOP	Blow Out Prevention
CBL-VDL	Cement Bond Log
DC	Direct Current
DC	Drill Collar
DoE	Department of Environment
DP	Drill Pipe
DST	Drill Stem Test
EMP	Environmental Management Plan
EMW	Equivalent Mud Weight
GIIP	Gas Initially In Place
GOB	Government Of Bangladesh
HBB	Herring Bone Bond
HP	Horse Power
KVA	Kilo Volt Ampere
MSC	Marcellus Shale Coalition
PHPA KCL	Partially-Hydrolyzed Poly-Acrylamide Potassium(k) Chloride(Cl)
POL	Petroleum Oil Lubricants
PSC	Production Sharing Contract
psi	Pound Per Square Inch
R/A	Residential Area
Sg	Specific Gravity
SSSV	Sub Surface Safety Valve
TCF	Trillion Cubic Feet
TD	Total Depth
TEC	Tender Evaluation Committee
TOC	Tender Opening Committee
VFD	Variable Frequency Drive
VSP	Vertical Seismic Profile

APPENDIX

Table A1: **Chronological list of Exploration / Development wells in Bangladesh** [19, 20 - 29]

Sl No.	Year of drilling	Well Name	Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
1	1910-1914	Sitakund 1	Sitakund	Hilly	Exp.	763	Dry	IPPC	.....	1st drill
2	.....	Sitakund 2	Sitakund	Hilly	Exp.	.....	Dry	IPPC	.....	
3	.....	Sitakund 3	Sitakund	Hilly	Exp.	.....	Dry	IPPC	.....	
4	 1914	Sitakund 4	Sitakund	Hilly	Exp.	1024	Dry	BOC	.....	
5	1933	Patharia 1	Patharia	Hilly	Exp.	876	Dry, Oil show	BOC	.....	
6	1933	Patharia 2	Patharia	Hilly	Exp.	1047	Dry, Oil show	BOC	.....	
7	03.51 - 12.51	Patharia 3	Patharia	Hilly	Exp.	1650	Dry, 2bbl oil with 25 bbl water	PPL	.....	
8	11.51 - 02.53	Patharia 4	Patharia	Hilly	Exp.	830	Dry	PPL	.....	
9	04.52 - 09.53	Patiya 1	Patiya		Exp.	3104	Dry	PPL	.....	
10	01.55 - 05.55	Sylhet 1	Haripur	Hilly	Exp.	2377	Blow out & loss of rig	PPL	.....	
11	05.56 - 10.56	Sylhet 2	Haripur	Hilly	Appr.	2818	Gas Disc.	PPL	.....	1st Disc.
12	05.57 - 07.57	Sylhet 3	Haripur	Hilly	Appr.	1675	Dry	PPL	.....	
13	09.57 - 02.58	Lalmai 1	Lalmai	Hilly	Exp.	3014	Dry	PPL	.....	
14	01.59 - 04.59	Chatak 1	Chatak	Hilly	Exp.	2133	Gas Disc.	PPL	.....	
15	02.59 - 06.59	Kutchma 1	Kuchma	Hilly	Exp.	2875	Dry	SVOC	.....	
16	12.59 - 02.60	Bogra 1	Bogra	Plain	Exp.	2187	Dry	SVOC	.....	
17	03.60 - 04.60	Fenchugonj 1	Fenchugonj	Hilly	Exp.	2439	Dry	PPL	.....	
18	03.60 - 07.60	Rashidpur 1	Rashidpur	Hilly	Exp.	3861	Gas Disc.	PSOC	Producing	
19	03.60 - 09.60	Haripur 1	Haripur	Hilly	Exp.	3816	Dry	SVOC	.....	

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
20	05.60 - 10.60	Lalmai 2	lalmai	plain	Exp.	4115	Dry	PSOC/PPL	.....	
21	11.60 - 06.61	Rashidpur 2	Rashidpur	Hilly	Appr.	4596	Appr.	PSOC	.....	
22	08.61 - 03.62	Kailashtila 1	Kailashtila	Plain	Exp.	4139	Gas Disc.	PSOC	Producing	
23	11.04.62 - 16.04.62	Sylhet 4	Haripur	Hilly	Appr.	314	Appr, Mild blow out	PPL	.....	
24	06.62 - 08.62	Titas 1	Titas	Plain	Exp.	3758	Gas Disc.	PSOC	Producing	
25	11.62 - 01.63	Titas 2	Titas	Plain	Appr.	3224	Dev.	PSOC	Producing	
26	12.62 - 03.63	Sylhet 5			Appr.	575	Obs.	PPL	.....	
27	03.63 - 05.63	Habigonj 1	Habigonj	Hilly	Exp.	3509	Gas Disc.	PSOC	.....	
28	05.64 - 07.64	Sylhet 6	Haripur	plain	Appr.	1405	Dev.	PPL	.....	
29	11.64 - 03.65	Jaldi 1	Jaldi	Tilla	Exp.	2300	Dry	OGDC	.....	
30	05.65 - 11.66	Jaldi 2	jaldi	Tilla	Exp.	3361	Dry	OGDC	.....	
31	04.11.67 - 14.11.67	Habigonj 2	Habigonj	Hilly	Appr.	1539	Dev.	PSOC	.....	
32	05.67 - 05.69	Semutang 1	Semutang	Hilly	Exp.	4088	Gas Disc.	OGDC	.....	
33	02.68 - 05.70	Jaldi 3	Jaldi	hilly	Exp.	4500	Dry	OGDC	.....	
34	08.68 - 08.69	Titas 3	Titas	Plain	Appr.	2839	Dev.	PSOC	.....	
35	09.68 - 06.69	Bakhrabad 1	Bakhrabad	Plain	Exp.	2837	Gas Disc.	PSOC	Producing	
36	12.68 - 03.69	Cox's bazar 1	Cox'sbazar	Off shore	Exp.	3698	Dry	PSOC	.....	1st Offshore drilling
37	09.69- 10.69	Titas 4	Titas	Plain	Appr.	2850	Dev.	PSOC	Producing	

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
38	03.70 - 05.70	Semutang 2	Semutang	Hilly	Appr.	1539	Appr.	OGDC	.....	
39	08.70 - 10.70	Semutang 3	Semutang	Hilly	Appr.	1552	Appr.	OGDC	.....	
40	12.70 - 01.71	Semutang 4	Semutang	Hilly	Appr.	1464	Appr.	OGDC	.....	
41	05.75 - 12.76	Muladi 1	Muladi		Exp.	4732	Dry	P Bangla	.....	
42	10.75 - 03.76	BODC 1	Offshore well	Off shore	Exp.	4598	Dry	BODC	.....	
43	01.76 - 01.77	Begumgonj 1	Begumgonj	Plain	Exp.	3656	Gas Disc.	P Bangla	.....	
44	02.76 - 03.76	ARCO 1	Offshore well	Off shore	Exp.	3904	Dry/Off shore well	ARCO	.....	
45	03.76 - 06.76	BODC 2	Offshore well	Off shore	Exp.	4435	Dry/Off shore well	BODC	.....	
46	03.76 - 05.76	BINA 1	Offshore well	Off shore	Exp.	4095	Dry/Off shore well	INA	.....	
47	..... - 03.76	UNION 76-1	Offshore well	Off shore	Exp.	233	Dry, P & A	UNION	.....	
48	07.12.76 - 01.77	Kutubdia 1	Kutubdia	Off shore	Exp.	3504	Gas Disc.	UNION	.....	1st offshore Discovery
49	25.12.76 - 03.77	BINA 2	Offshore well	Off shore	Exp.	4294	Dry	INA	.....	
50	12.77 - 03.78	BODC 3	Offshore well	Off shore	Exp.	4503	Dry	BODC	.....	
51	03.78 - 08.78	Begumgonj 2	Begumgonj	Plain	Appr.	3577	Dry	P Bangla	.....	
52	02.79 - 01.81	Muladi 2	Muladi	Plain	Exp.	4569	Dry	P Bangla	.....	
53	06.80 - 08.81	Feni 1	Feni	Plain	Exp.	3200	Gas Disc.	P Bangla	.....	
54	07.80 - 04.81	Singra 1	Singra	plain	Exp.	4100	Dry	P Bangla	.....	
55	10.80- 01.81	Titas 5	Titas	Plain	Dev.	3291/ 2981	Dev.	BGFCL	Producing	

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
56	11.80 - 05.81	Beanibazar 1	Beanibazar	Small hillok	Exp.	4107	Gas Disc.	P Banga	Producing	
57	05.81 - 10.81	Bakhrabad 2	Bakhrabad	Plain	Dev./ appr	2604	Dev, Deviated well	BGSL	Producing	
58	10.81 - 06.82	Atgram 1	Atgram	tilla	Exp.	4959	Dry.	P Bangla	.....	
59	10.81 - 03.82	Kamta 1	Kamta	Plain	Exp.	3614	Gas Disc.	P Bangla	.....	
60	12.81 - 04.82	Baklhrabad 3	Bakhrabad	Plain	Dev./ Appr.	2846	Dev, deviated well	BGSL	Producing	
61	04.82 - 06.82	Bakhrabad 4	Bakhrabad	Plain	Dev./ Appr.	2874	Dev. Deviated well	BGSL	.....	
62	06.82 - 08.82	Bakhrabad 5	Bakhrabad	Plain	Dev./ Appr.	2948	Dev.	BGSL	.....	Deviated well
63	04.83 - 01.88	Sitakund 5	Sitakund	Hilly	Exp.	4005	Dry.	P Bangla	.....	
64	05.83 - 10.83	Titas 6	Titas	Plain	Dev./ Appr.	3070	Dev.	BGFCL	Producing	
65	07.84 - 08.84	Habigonj 3	Habigonj	Plain	Dev./ Appr.	1610	Dev.	BGFCL	Producing	
66	09.84 - 01.85	Habigonj 4	Habigonj	Plain	Dev./ Appr.	1600	Dev.	BGFCL	Producing	
67	12.84 - 01.85	Titas 7	Titas	Plain	Dev./ Appr.	3355	Dev.	BGFCL	Producing	
68	01.85 - 04.88	Fenchugong 2	Fenchugonj	Hilly	Exp.	4977	Gas Discovery	P Bangla	.....	Deepest well of Bangla desh
69	05.85 - 09.85	Titas 8	Titas	Plain	Dev./ Appr.	3583	Dev.	BGFCL	Producing	
70	09.86 - 01.87	Sylhet 7	Haripur	plain	Dev./ Appr.	2066	Dev, 1st oil discovery	P Bangla	Producing	
71	09.87 - 12.87	Titas 9	Titas	Plain	Dev./ Appr.	3610/ 3183	Dev.	BGFCL	Producing	
72	02.88- 04.88	Titas 10	Titas	Plain	Dev./ Appr	3700	Dev.	BGFCL	Producing	
73	03.88- 07.88	Beanibazar 2	Beanibazar	Hillock	Dev./ Appr.	3672	Dev	P Bangla	Producing	

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
74	05.88 - 06.88	Salbanhat 1	Salbanhat	Plain	Exp.	2516	Dry	Shell	.....	
75	06.08.88 - 10.88	Kailashtila 2	Kailashtila	Plain	Dev./ Appr.	3262	Dev.	P Bangla	Producing	
76	24.08.88 - 12.88	Sitapahar 2	Sitapahar	Hilly	Exp.	1560	Dry	Shell	.....	
77	25.08.88- 01.89	Habigonj 5	Habigonj	Plain	Dev./ Appr.	3521/ 2935	Dev.	BGFCL	Producing	Deviated well
78	10.88 - 01.89	Kailashtila 3	Kailashtila	Plain	Dev. Appr.	3526	Dev.	P Bangla	Producing	Deviated well
79	11.88 - 02.89	Bakhrabad 6	Bakhrabad	Plain	Dev./ Appr.	2677/ 2335	Dev.	BGSL	.....	Deviated well
80	12.88 - 02.89	Bogura 2	Bogra	plain	Exp.	2100	Dry	P Bangla	.....	
81	04.89 - 06.89	Bakhrabad 7	Bakhrabad	Plain	Dev./ Appr.	2590/ 2258	Dev	BGSL	Producing	Deviated well
82	04.89 -	Surma 1A	Haripur		Dev./ Appr.	2503/ 2183	Appr.	SCH	Producing	
83	04.89 - 05.89	Rashidpur 3	Rashidpur	Hilly	Dev./ Appr.	2957	Dev.	P Bangla	Producing	
84	..... - 06.89	Surma 1	.....		Exp.	2253	Gas Show	Scimitar	.....	
85	06.07.89 - 10.89	Rashidpur 4	Rashidpur	Hilly	Dev./ Appr.	3071	Dev.	P Bangla	Producing	
86	25.07.89 - 09.89	Bakhrabad 8	Bakhrabad	Plain	Dev./ Appr.	2694/ 2345	Dev	BGSL	Producing	Deviated well
89	07.89 - 11.89	Jalalabad 1	Jalalabad	Plain	Exp.	2876/ 2626	Gas Disc.	SCH	Producing	
90	11.89 - 07.92	Patharia 1	Patharia	Hilly	Exp.	3438/ 3356	Dry	BAPEX	.....	
91	12.89 - 01.90	Habigonj 6	Habigonj	Plain	Dev./ Appr.	1681	Dev.	P Bangla	Producing	
92	02.90 - 03.90	Titas 11	Titas	Plain	Dev	3186	Dev	P Bangla	Producing	
93	05.90 - 06.90	Meghna (BK-9)	Meghna	plain	Exp.	3069	Dev.	P bangla	Producing	

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
94	08.90 - 09.90	Narshingdi (BK-10)	Narshingdi	plain	Exp.	3450	Gas Producing	P Bangla	Producing	
95	12.93 - 11.95	Shahbazpur 1	Shahbazpur	Plain	Exp.	3750/ 3342	Gas Disc.	BAPEX	Producing	
96	04.94 - 12.94	Feni 2	Feni	Plain	Dev./ Appr.	3087/ 2812	Dev.	BGFCL	....	
97	12.95 - 01.96	Sangu 1	Sangu	Off shore	Exp.	3500 (3464)	Gas Disc.	Cairn	....	
98	02.96 - 03.96	Sangu 2	Sangu	Off shore	Dev./ Appr.	3980 (3945)	Appr/ Dry	Cairn	....	
99	07.96 - 10.96	Saldanadi 1	Salda	Slight hillocks	Exp.	...../ 2511	Gas Disc.	BAPEX	....	
100	08.96 - 11.96	Kailashtila 4	Kailashtila	Plain	Dev./ Appr.	3320	Dev	SGFL	Producing	
101	03.97 - 07.97	Sangu 3/3Z	Sangu	Off Shore	Dev./ Appr.	3888 (3342)	Appr+Dev	Cairn	....	
102	06.97 (Blow out)	Moulavibazar 1	Moulavibazar	Hilly	Exp.	841	Blow out	Oxydental	....	
103	05.97 - 10.97	Semutang 5	Semutang	Hilly	Dev./ Appr.	3029 (2844)	Exp/Appr.	Cairn	Producing	
104	08.97 - 08.98	Sangu 4	Sangu	Off Shore	Dev./ Appr.	3882 (3354)	Appr+Dev	Cairn	....	
105	09.97 - 10.98	Sangu 5	Sangu	Off Shore	Dev./ Appr.	657 (3306)	Appr+Dev	Cairn	....	
106	11.97 - 01.98	Sangu 6	Sangu	Off Shore	Dev./ Appr.	4180 (3142)	Appr+Dev Dry	Cairn	....	Dry, P&A
107	01.98 - 06.98	Halda 1	Halda	Plain	Exp.	4519 (4406)	Dry	Cairn	....	
108	01.98 - 07.98	Bibiyana 1	Bibiyana	Plain	Exp.	4041 (3807)	Gas Disc.	Oxydental	Producing	
109	02.98 - 03.98	Sonadia 1	Sonadia	Off shore	Exp.	4028 (4000)	Dry	Cairn	....	
110	03.98 - 05.98	Jalalabad 2	Jalalabad	Plain	Dev./ Appr.	2950 (2734)	Dev/Appr.	Oxydental	Producing	
111	03.98 - 08.98	Jalalabad 3	Jalalabad	Plain	Dev./ Appr.	2711 (2448)	Dev/Appr.	Oxydental	Producing	

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
112	03.98 - 10.98	Jalalabad 4	Jalalabad	Plain	Dev./ Appr.	3053 (....)	Dev/ Appr.	Oxydental	Producing	
113	05.98 - 07.98	Habigonj 9	Habigonj	Plain	Dev./ Appr.	1600	Dev	BGFCL	.....	
114	11.98 - 01.99	Bibiyana 2	Bibiyana	Plain	Dev./ Appr.	4276	Dev.	Oxydental	Producing	
115	12.98 - 02.99	Habigonj 8	Habigonj	Plain	Dev./ Appr	1609	Dev.	BGFCL	.....	
116	....- 02.99	Jalabad 5	Jalalabad	Plain	Dev./ Appr.	3356	Appr.	Oxydental	.....	Water disposal
117	01.99 - 04.99	Rashidpur 5	Rashidpur	Hilly	Dev./ Appr.	2984	Dev.	SGFL	.....	
118	03.99 - 06.99	Habigonj 7	Habigonj	Plain	Dev./ Appr.	3121	Dev.	BGFCL	Producing	
119	04.99 - 11.99	Saldanadi 2	Saldanadi	Hilly	Dev./ Appr.	2458/2323	Dev./ Appr.	BAPEX	.....	
120	04.99 - 07.00	Rashidpur 7	Rashidpur	Hilly	Dev./ Appr.	2892	Dev.	SGFL	Producing	
121	05.99 - 06.99	Kapna 1	Kapna	Hilly	Exp.	3149	Dry	Unocal	.....	
122	06.99 - 08.99	Titas 12	Titas	Plain	Dev.	3010/2909	Dev	BGFCL	Producing	
123	07.99 - 09.99	Rashidpur 6	Rashidpur	Hilly	Dev./ Appr.	2860	Dev.	SGFL	.....	
124	07.99 - 08.99	Habigonj 10	Habigonj	Plain	Dev./ Appr.	1565	Dev.	BGFCL	Producing	
125	08.99 - 11.99	Moulavibazar 2	Moulavibazar	Hilly	Exp.	3510	Gas Disc.	Unocal	Producing	
126	08.99 - 12.99	Titas 13	Titas	Plain	Dev.	3502/3108	Dev.	BGFCL	Producing	
127	09.99 - 02.00	South Sangu 1	Sangu	Off shore	Exp.	4664	Appr/ Expl. P/A	Shell	.....	
128	11.99 - 11.99	Moulabazar 3	Moulavibazar	Hilly	Dev./ Appr.	2400	Appr.	Unocal	Producing	
129	12.99 - 01.00	Reju 1	Not av.	Off shore	Exp.	4450	Dry	Aucland	.....	

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Field / Structure	Terrain Type	Type of Well	Depth (m)	Outcome	Operator	Current Status	Remarks
130	12.99 - 03.00	Titas 14	Titas	Plain	Dev.	3355/ 3217	Dev	BGFCL	Producing	
131	07.99 - 01.00	Ratna	Not av.	Not av.	Exp.	3835	Dry	Unocal	.....	
132	2000 - 2011	Moulabazar 4	Moulavibazar	Hilly	Dev./ Appr.	2400	Appr.	Chevron	Producing	
133		Moulabazar 5	Moulavibazar	Hilly	Appr.	2400	Exp.	Chevron	Producing	New gas zone discovered
134		Moulabazar 6	Moulavibazar	Hilly	Dev./ Appr.	2400	Appr.	Chevron	Producing	
135		Moulabazar 7	Moulavibazar	Hilly	Dev./ Appr.	2400	Appr.	Chevron	Producing	
136		Moulabazar 8	Moulavibazar	Hilly	Dev./ Appr.	2400	Appr.	Chevron	....	
137		Moulabazar 9	Moulavibazar	Hilly	Dev./ Appr.	2400	Appr.	Chevron	Producing	
138	08.00 - 10.00	Sandweep	Sandweep	offshore	Exp.	3696	Dry	Shell	.....	
139	 2001	South Sangu 2	South Sangu	offshore	Exp.	3850	Dry, P&A	Shell/ Cairn	.....	
140	12.03 - 02.04	Rasulpur 1	Rasulpur	plain	Exp.	3295	Dry	Tullow	.....	
141	02.04 - 04.04	Lalmai 3	Lalmai	plain	Exp.	2800	Gas Disc.	Tullow	.....	
142	06.04 - 07.04	Bangura 1	Bangura	Plain	Exp.	3635	Gas Disc.	Tullow	Producing	
143	04.04 - 12.04	Srikail 1	Srikail	Plain	Exp.	3583	Gas Disc.	BAPEX	.....	
144	2004	Fenchugonj 3	Fenchugonj	Hilly	Dev.	.....	Dev.	BAPEX	Producing	
145	2005	Titas 16	Titas	Plain	Dev.	.....	Dev.	BGFCL	Producing	
146	2005	Titas 15	Titas	Plain	Dev.	.....	Dev.	BGFCL	Producing	
147	2006	Kailashtila 5	Kailashtila	Plain	Dev.	.....	Dev.	SGFL	Producing	
148	2007	Kailashtila 6	Kailashtila	Plain	Dev.	.....	Dev.	SGFL	Producing	
149	2007	Narshingdi 2	Narshingdi	Plain	Dev.	.....	Dev.	BFGCL	Producing	
150	2007	Habigonj 11	Habigonj	Tilla	Dev.	.....	Dev.	BGFCL	Producing	
151	..... - 02.07	South Sangu 3	Sangu	Off shore	Exp.	3510	Gas Show, P&A	Shell/ Cairn	.....	
152	11.04 - 06.05	Sangu 7	Sangu	Off shore	Dev.	3383	Dry	Cairn	.....	

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Field / Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
153	11.04 - 03.05	Sangu 8	Sangu	Off shore	Dev.	3415	Dry	Cairn	.....	
154	11.04 - 03.05	Sangu 9	Sangu	Off shore	Dev.	3964	Dry	Cairn	.....	
155	2011	Sangu 10	Sangu	Off shore	Dev.	.....	Dry	Cairn	.....	Spud date and total depth could not be obtained
156	2012	Sangu 11	Sangu	Off shore	Dev.	.....	Dev.	Cairn	Producing	
157	2005 - 2013	Bangura 2	Bangora	Plain	Dev./ Appr.	.....	Dev.	Tullow	Producing	
158		Bangura 3	Bangora	Plain	Dev./ Appr.	.....	Dev.	Tullow	Producing	
159		Bangura 4	Bangora	Plain	Dev./ Appr.	.....	Gas show, P&A	Tullow	.....	
160		Bangura 5	Bangora	Plain	Dev./ Appr.	.....	Dev.	Tullow	Producing	
161	01.08	Magnama 1	Magnama	Off shore	Exp.	4003	Gas Show, P&A	Shell/ Cairn	.....	
162	2008	Shahbazpur 2	Shahbazpur	Plain	Dev./ Appr.	.....	Dev.	BAPEX	.....	
163	2008	Bibiyana 3	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
164	..... - 02.08	Hatia 1	Hatia	Off shore	Exp.	3850	Dry, P&A	Cairn	.....	
165	..... - 10.11	South sangu 4	Sangu	Off shore	Exp.	3486	Dry, P&A	Cairn	.....	
166	..... - 12.11	North east sangu	Sangu	Off shore	Exp.	2776	Dry, P&A	Cairn	.....	
167	2009-2013	Bibiyana 4	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	Spud date and total depth could not be obtained
168		Bibiyana 5	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
169		Bibiyana 6	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
170		Bibiyana 7	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
171		Bibiyana 8	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
172		Bibiyana 9	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
173		Bibiyana 10	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
174		Bibiyana 11	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
175		Bibiyana 12	Bibiyana	Plain	Dev./ Appr.	.....	Dev	Chevron	Producing	
176	2011	Sundalpur 1	Sundalpur	Plain	Exp.	1400	Gas Disc.	BAPEX	Producing	Spud date could not be obtained

Table: A1 (Contd.)

Sl No.	Year of drilling	Well Name	Field / Structure	Terrain Type	Type of well	Depth (m)	Outcome	Operator	Current Status	Remarks
177	03.04 - 04.11	Kajal 1	Kajal	Plain	Exp.	4413	Dry	Chevron	.....	
178	2011	Fenchugonj 4	Fenchugonj	Hilly	Dev.	.....	Dev.	BAPEX	Producing	Spud date could not be obtained
179	2012	Saldanadi 3	Salda	Tilla	Dev.	.....	Dev.	BAPEX	Producing	
180	2012	Kapasia 1	Kapasia	Plain	Exp.	3301	Dry	BAPEX	.....	
181	2012	Srikail 2	Srikail	Plain	Dev.	3214	Dev.	BAPEX	Producing	
182	2013	Sunetra 1	Sunetra	Haor	Exp.	4500	Dry	BAPEX	.....	
183	2013	Srikail 3	Srikail	Plain	Dev.	.....	Dev.	BAPEX	Producing	Drilled by GAZPROM
184	2013	Titas 17	Titas	Plain	Dev.	.....	Dev.	BGFCL	Producing	
185	2013	Titas 20	Titas	Plain	Dev.	.....	Dev.	BGFCL	Producing	Drilled by GAZPROM
186	2013	Titas 18	Titas	Plain	Dev.	.....	Dev.	BGFCL	Producing	

Table A2: **Exploration activities of BAPEX and its predecessors** [20].

Sl No.	Year of drilling	Structure and name of well	Rig used	Terrain	Depth (m)	Out Come GIIP, BCF	Operator	Re marks
1	1964-65	Jaldi- 1	Uralmash-A-42	Hilly	2300	Dry	OGDC	
2	1965-66	Jaldi- 2	Uralmash-A-42	Hilly	3361	Dry	OGDC	
3	1968-70	Jaldi- 3	Uralmash-A-42	Hilly	4500	Dry	OGDC	
4	1967-69	Semutang- 1	Uralmash-3D-61	Hilly	4088	Gas Disc, 227	OGDC	
5	1975-76	Muladi- 1	Uralmash-3D-61	plain	4732	Dry	P Bangla	
6	1979-81	Muladi- 2	Uralmash-3D-61	plain	4569	Dry	P Bangla	
7	1976-77	Begumgonj- 1	Uralmash-A-42	Plain	3656	Gas Disc, 46.7	P Bangla	
8	1980-81	Feni-1	Uralmash-A-42	Plain	3200	Gas Disc, 185.2	P Bangla	
9	1980-81	Singra- 1	F-400,4-DH	Plain	4100	Dry	P Bangla	
10	1980-81	Beanibazar- 1	Rental, MDP	Hilly	4107	Gas Disc, 243.1	P Bangla	
11	1981-82	Atgram- 1	Rental, MDP	Hilly	4959	Dry	P Bangla	
12	1981-82	Kamta- 1	Uralmash-3D-61	Plain	3614	Gas Disc,78.8	P Bangla	
13	1983-88	Sitakund- 1	F-400,4-DH	Hilly	4005	Dry	P Bangla	
14	1985-88	Fenchugonj- 2	IDECO H-1700	Hilly	4977	Gas Disc. 404	P Bangla	
15	1988-89	Bogura- 1	Uralmash-3D-61	Plain	2100	Dry	P Bangla	
16	1989-92	Patharia- 1	IDECO H-1700	Hilly	3438/ 3356	Dry	BAPEX	
17	1990	Meghna- 1	Challenger (PIU)	Plain	3069	Gas Disc, 170.6	P Bangla	
18	1990	Narsingdi- 1	Challenger (PIU)	Plain	3450	Gas Disc, 307.2	P Bangla	
19	1993-95	Shahbazpur- 1	IDECO H-1700	Plain	3750/ 3342	Gas Disc. 513	BAPEX	
20	1996	Saldanadi- 1	IDECO H-1700	Tilla	2511	Gas Disc. 230	BAPEX	
21	2004	Srikail- 1	IDECO H-1700	Plain	3583	Gas Disc. 300	BAPEX	
22	2011	Sundalpur- 1	IDECO H-1700	Plain	1400	Gas Disc. 41	BAPEX	
23	2012	Kapasia- 1	IDECO H-1700	Plain	3301	Dry	BAPEX	
24	2013	Sunetra- 1	Bijoy-10 (ZJ70BDS)	Haor	4683	Dry	BAPEX	

Ref: BAPEX website, www.bapex.com.bd

Table A3: **Development activities of BAPEX and its predecessors** [20]**.**

Sl No.	Year of drilling	Structure and no. of well	Rig used	Terrain	Depth (m)	Current Status	Operator	Re marks
1	1970	Semutang- 2	Uralmash-3D-61	Hilly	1539	Dry	OGDC	
2	1970	Semutang- 3	Uralmash-3D-61	Hilly	1552	Dry	OGDC	
3	1971	Semutang- 4	Uralmash-3D-61	Hilly	1464	Dry	OGDC	
4	1978	Begumgonj- 2	Uralmash-A-42	Plain	3577	Dry	P Bangla	
5	1994	Feni- 2	Gardener Denver	Plain	.....	Dry	BAPEX	
6	1995	KTL- 4	Gardener Denver	Plain	.....	Producing	BAPEX	
7	1999	Saldanadi- 2	IDECO H-1700	Tilla	.....	Suspended	BAPEX	
8	2004	Fenchugonj- 3	Gardener Denver	Hilly	.....	Producing	BAPEX	
9	2005	Titas- 16	Gardener Denver	Plain	.....	Producing	BAPEX	
10	2005	Titas- 15	Gardener Denver	Plain	.....	Producing	BAPEX	
11	2006	KTL- 5	IDECO H-1700	Plain	.....	Producing	BAPEX	
12	2007	KTL- 6	IDECO H-1700	Plain	.....	Producing	BAPEX	
13	2007	Narsingdi- 2	Gardener Denver	Plain	.....	Producing	BAPEX	
14	2007	Habigonj- 11	Gardener Denver	Plain	.....	Producing	BAPEX	
15	2008	Shahbazpur- 2	IDECO H-1700	Plain	.....	Suspended	BAPEX	
16	2011	Saldanadi- 3	Gardener Denver	Tilla	.....	Producing	BAPEX	
17	2011	Fenchugonj- 4	Bijoy-10 (ZJ70BDS)	Tilla	.....	Producing	BAPEX	
18	2012	Srikail- 2	Gardener Denver	Plain	3214	Producing	BAPEX	
19	2012	Titas- 17	Gardener Denver	Plain	.....	Producing	BAPEX	
20	2013	Titas- 18	Gardener Denver	Plain	.....	Producing	BAPEX	

Ref: BAPEX website, www.bapex.com.bd

Table A4: **Completed Work over operation conducted by BAPEX in Bangladesh [20].**

Sl. No.	Year	Name of well	Rig used	Work over job description
1	1982	Kailashtila 1	P-80 workover Rig (Mechanical)	Fished out cemented tubing and completed as a dual gas producing well
2	1986	Kamta Well-1	P-80 workover Rig (Mechanical)	Completed as a gas producing well.
3	1986	Chatak Well-1	P-80 workover Rig (Mechanical)	Checked wet production and cleaned sand fill to bring the well back into production.
4	1987	Titas Well-1	P-80 workover Rig (Mechanical)	Changed leaking tubing and recompleted as a gas producing well
5	1987	Titas Well-3	P-80 workover Rig (Mechanical)	Changed leaking tubing and recompleted as a gas producing well
6	1988	Feni Well-1	P-80 workover Rig (Mechanical)	Changed drill string, well head and completed as a gas producing well with new completion string.
7	1992	Titas Well-4	P-80 workover Rig (Mechanical)	Operation completed as per contract with BGFCL.
8	1993	Bakhrabad Well-4	P-80 workover Rig (Mechanical)	Checked wet production and cleaned sand fill to bring the well back into production.
9	1993	Bakhrabad Well-5	P-80 workover Rig (Mechanical)	Checked wet production and cleaned sand fill to back bring the well into production
10	1997	Kailashtila Well-1	P-80 workover Rig (Mechanical)	Worked over by removing packers
11	2004	Shahbajpur Well-1	P-80 workover Rig (Mechanical)	Completed as a gas producing well
12	2005	Sylhet Well-7	P-80 workover Rig (Mechanical)	Converted into gas well from oil well
13	2006	Kailashtila Well-3	P-80 workover Rig (Mechanical)	Isolation of middle zone and produce gas from the top zone of the well
14	2007	Kailashtila Well-4	P-80 workover Rig (Mechanical)	Isolation of lower gas zone and produce gas from the middle gas zone of the well
15	2008	Fenchuganj well-2	P-80 workover Rig (Mechanical)	Squeezing upper zone and produce gas from bottom zone of the well
16	2009	Bakhrabad Well-5	P-80 workover Rig (Mechanical)	No remarkable production
17	2009	Bakhrabad Well-2	P-80 workover Rig (Mechanical)	Completed as a gas producing well
18	2009	Titas-14	IPS Cardwell (Elec.)	Completed as a gas producing well
19	2009	Bangora-3	IDECO- H-1700 (Mechanical)	Completed as a gas producing well
20	2010	Sylhet Well-7 (2_{nd})	P-80 workover Rig (Mechanical)	Completed as a gas producing well
21	2010	Titas Well-4 (2_{nd})	IPS Cardwell (Elec)	Completed as a gas producing well

Table: A4 (Contd.)

Sl. No.	Year	Name of well	Rig used	Work over job description
22	2010	Hobiganj-11	IDECO- H-1700 (Mech)	Completed as a gas producing well
23	2010	Megna-1	P-80 Workover Rig (Mechanical)	Completed as a gas producing well
24	2010	Titas Well-12	IPS Cardwell (Elec)	Completed as a gas producing well
25	2010	Kailashtila Well-5	Wireline Unit	Completed as a gas producing well
26	2011	Semutang-5	P-80 Workover Rig (Mechanical)	Completed as a gas producing well
27	2012	Kailashtila-4	P-80 Workover Rig (Mechanical)	Completed as a gas producing well
28	2013	Salda 1	ZJ40DBS	No remarkable production
29	2013	Fenchugonj 2	P-80 Workover Rig (Mechanical)	Completed as a gas producing well
30	2013	Salda 2	ZJ40DBS	No remarkable production

Ref: BAPEX website, www.bapex.com.bd

Table 5.4: **Remedial measures taken to overcome the challenges at well site development.**

Sl. No.	Challenges	Sunetra 1		Beanibazar 1		Atgram 1		Fenchugonj 2		Srikail 1		Sundalpur 1		Re marks
		Remedial measures	**Effectiveness**	**Remedial measures**	**Effectiveness**	**Remedial measures**	**Effectiveness**	**Remedial measures**	**Effectiveness**	**Remedial measures**	**Effectiveness**	**Remedial measures**	**Effectiveness**	
1	Excessive Rain and flood	Initially constructed a dam to resist water. But, finally failed. Then raised the VFD house and residential caravans by 4ft.	No effective measures could be possible against flood except raising the Variable Frequency Drive (VFD) house and all caravans. It saved approx. tk. 40.0 Crore.	No remedial steps were possible to take against heavy rain. The full construction area was covered by tarpaulin.	Work was running under tarpaulin without having much interruption.	Due to sudden flood, no remedial action could be possible. Tarpaulin were used to work at rain.	Works were possible to be continued under tarpaulin at rain.	No action could be possible against rain. But providing a lot of drainage helped to pass the current shortly.	At heavy rain no works could be possible. But after rain the site was ready to work shortly.	No action could be possible. After flood, the dyke was repaired and maintained, monitored periodically	Due to periodic maintenance and monitoring the next 2 years it was not flooded	Providing Tarpaulin and urgent drainage system helped to continue to works at rain.	It did not create time overrun to the project.	During site development at Sunetra, VFD house was moved to site. Retaining wall was constructed atMobarakpur & Semutang after the incident.
2	Inadequate or poor road condition	Widened and strengthened 5.0 km access road and built a relationship to local people as well as concerned departments.	Construction and drilling materials could be transported easily and comfortably.	Widened and strengthened about 3 km and paved about 5 km of road. Arranged 80 ft long barge to cross the river	Man and machineries could be transported easily and comfortably.	Constructed about2.5km new road. Besides, repaired and enlarged different spots of the existing road	Without constructing the new road, drilling couldn't be possible.	Approximate, 22 km of road and 25 culverts were constructed.	The project was impossible to carry on without constructing the infrastructures.	About 7-8 km road and 2 bridges were widened and strengthened.	It was helpful to conduct the shipment of man and machineries.	N/A	N/A	
3	Remoteness for site development	Temporary road was prepared to conduct the site development works.	The site development was done easy and saved approximate tk. 80 lac.	Arranged standby messenger, transport and radio message system.	Emergency needs ware conducted easily.	Arranged standby messenger, transport and radio message system.	It was easily possible to conduct all emergency	By pass road and temporary culverts were constructed to cross the chara/ canal. Also, the created mud was removed time to time.	The site development was not possible without such by pass or mud management.	N/A	N/A	N/A	N/A	Through radio, one read a written statement at site, another one write the same in Dhaka. Then deliver to the concern

Table: 5.4 (Contd.)

Sl. No.	Challenges	Sunetra 1		Beanibazar 1		Atgram 1		Fenchugonj 2		Srikail 1		Sundalpur 1		Remarks
		Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	
4	Scarcity of labor	Motivation to different parties and segregation of the works	Effectively minimized the problem.	Motivation to different parties to collect the labor and the wage rate was relaxed	Effective-ly mini-mized the problem.	N/A	N/A	N/A	N/A	N/A	N/A	Social motivation and arranged subsidiary to the contractor.	Effectively minimized the problem and remark-ably progress was happened	It was not Engg problem, but affected the Engg tasks. Thus, Engrs should planned effectively.
5	Water entrapping by shallow water table/rain/ Seepage	N/A	N/A	N/A	N/A	A number of cross drain were provided across the path of seepage water even at below the foundation.	Effectively removed the marshy ness of the site.	Sufficient cross drainage was constructed to drain out the seepage water.	Effective-ly reduced the chance of unpleas-ant situation	N/A	N/A	A lot of surface drain was made and cleared the existing drains.	It was possible to remove entrapped water and to make peripheral road.	After collapsing the foundation at FGF#4 due to seepage channel, the strength and thickness was also increased
6	Risky shipment of fuel	N/A	N/A	Tried to use helicopter or engaged a special team at the time of fuel shipment.	Using Helicopte r was the best way. But, security, team effectivel y reduced the risk.	Tried to use helicopter or engaged a special team at the time of fuel shipment.	The Use of helicopte r was an Intl. concern. So, security team Effective ly reduced the risk.	N/A	N/A	N/A	N/A	N/A	N/A	It was not an Engg issue. But important to implement the project. So, careful planning needed to this item.

Table: 5.4 (Contd.)

Sl. No.	Challenges	Sunetra 1		Beanibazar 1		Atgram 1		Fenchugonj 2		Srikail 1		Sundalpur 1		Re marks
		Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	
7	Collapsing of bridges and culverts	Reconstruction of the damaged culverts and providing M.S checkered plate (as necessary) for easy movement of vehicle.	Without constructing the culverts, it was impossible to shipment of construction materials as well as drilling equipments.	N/A	N/A	Construction of a 80'-0" wood decked bridge. The span was reduced by filling the 2 sides of the river	The project was impossible to complete without the bridge.	N/A	N/A	N/A	N/A	N/A	N/A	The culverts were casted in 2 parts, maintaining uninterrupted vehicle movement.
8	Dense/Reserve forest	N/A	N/A	A number of daily labor, security guard and proper lighting arrangement were ensured.	No incident was happened regarding jungle	N/A	N/A	A lot of demurrage had to pay. Besides, a huge no. of security and lighting arrangement were ensured.	Effectively minimized the hazardous incident.	N/A	N/A	N/A	N/A	In reserve forest, it was difficult to obtain the permission from DoE also.
9	Compulsory maintenance to site/materials etc.	N/A	N/A	N/A	N/A	N/A	N/A	Close monitoring, repair and routine maintenance need to be ensured.	It effectively minimized the other hazards.	Compulsory maintenance of dyke, pumps and other machineries were ensured.	Next 2 yrs there were no flood happened in the site.	N/A	N/A	
10	Proximity to International boarder	N/A	N/A	N/A	N/A	Bilateral discussions were conducted. Also, ensuring proper Security to resist infiltration.	Effectively solved the problem.	N/A	N/A	N/A	N/A	N/A	N/A	Though it was not an Engg. Issue, It was very important to conduct the project.

Table:5.4 (Contd.)

Sl. No.	Challenges	Sunetra 1		Beanibazar 1		Atgram 1		Fenchugonj 2		Srikail 1		Sundalpur 1		Re marks
		Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	Remedial measures	Effectiveness	
11	Scarcity of locally available const. materials	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	The office ensured the availability, quantity and rate of the items being rationale to both the parties.	Effectively minimized the problem. Otherwise, it could jeopardize the project	Though it was not an Engg. Issue, It was very important to conduct the project.
12	Scarcity of land	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Due to the midst of a locality, Counseling with the concerned people regarding the disturbances were ensured.	It was the best solution. Otherwise, it may jeopardize to the project.	Though it was not an Engg. Issue, It was very important to conduct the project.