A Project on

SOFTWARE DEVELOPMENT FOR PLANNING OF EXTENDED REACH WELLS

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A Dissertation Report Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of

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CERTIFICATE

This is to certify that the dissertation report on "Software Development for Planning of Extended Reach Wells" completed and submitted to the University of Petroleum & Energy Studies, Dehradun by Mr. Adit Gupta, in partial fulfillment of the requirement for the award of degree of Bachelor in Technology (Applied Petroleum Engineering), 2003-2007, is a bonafide work carried out by him under my supervision and guidance.

To the best of my knowledge and belief the work has been based on investigation made, data collected and analyzed by him and this work has not been submitted anywhere else for any other university or institution for the award of any degree/diploma.

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My deepest regards and thanks also go to Mrs. Neelu Ahuja for providing me valuable guidance and encouragement during project work.

PREFACE

Extended Reach Drilling (ERD) has become a prime industry methodology for optimization of field development through reduction in the number of drillsites and structures and enabling production from otherwise inaccessible parts of reservoirs.

ERD has always been associated with increased technical risk, high research work and upfront capital expenditure. Thus, it is necessary to have a detailed and a well defined plan for drilling Extended Reach Wells.

The aim of this project is to serve the above defined purpose. This report gives details of the software and how it can act as a tool for planning of extended reach wells.

First four sections of this report deal with the technologies used in ERD, technological differences between drilling of extended reach wells and vertical wells and the general procedure which is adopted for planning of extended reach wells.

The above sections explain the technologies used in ERD and the factors which make ERD a complex procedure.

This is followed by details of software design, software programming and its coding and the output which we can get from the software.

Section on software design gives details about how the software has been structured and how the software can extensively help in planning of ERD.

Details about software programming have also been given to better understand the working of the software.

Thus, I hope that the software will fully serve its purpose and would emerge as a major tool for planning of extended reach wells.

Abbreviations

ERD: Extended Reach Drilling

MWD: Measurement While Drilling

PDC: Polycrystalline Diamond Cutter

IADC: International Association of Drilling Contractors

RSS: Rotary Steerable System

BHA: Bottom Hole Assembly

SET: Solid Expandable Tubular

ECD: Equivalent Circulation Density

MDI: Multiple Document Interface

CLR: Common Language Runtime

MSIL: Microsoft Intermediate Language

JIT: Just-In-Time

SQL: Structured Query Language

DML: Data Manipulation Language

DDL: Data Definition Language

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INTRODUCTION

Introduction

Today we are facing the problem of exponential growth in demand of oil and gas due to which the upstream oil industry is moving towards more challenging areas for hydrocarbon recovery.

Thus, as we drill into deeper harsh areas, the use of efficient and effective technology becomes a necessity not only due to drill the areas successfully, but also to be in accordance with the stringent environmental conditions.

Extended Reach (ERD) Wells have been successful in not only delivering excellent results but also minimize environmental effects. ERD wells are those wells where the wellbore is kicked off from the vertical near the surface, inclination is built to allow sufficient horizontal displacement from the surface to reach the target zone some distance away, and the angle is again built to near horizontal.

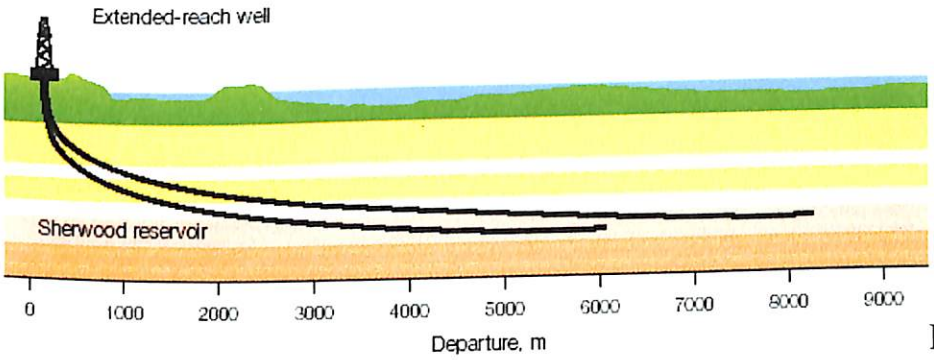


Fig-1

As seen in the above figure, the wellbore is extended horizontally into the reservoir.

In other terms, a well is defined as extended reach if it has a stepout ratio (horizontal displacement divided by TVD at total depth) of 2 or more. ERD wells employ both directional and horizontal drilling techniques so as to achieve greater horizontal departures .Moreover, ERD wells not only provide solutions for restricted reservoir production but also help us to eliminate additional platforms.

Though, ERD wells are considered to be more risky than conventional wells, but with the use of effective technology and personnel experience far better results can be obtained when compared to conventional wells.

Some of the many advantages of using ERD to access reserves are based on the elimination of high capital cost items. For example, in Alaska, ERD can reduce the need for costly drilling and production islands and the inherent logistical problems associated with these. For offshore drilling, such as in the North Sea and the Gulf of Mexico a substantial reduction in subsea equipment, including fewer pipelines, has not only an impact on economics but also on environmental concerns and even permitting. An evolutionary plot is used to show that the most aggressive ERD activity has taken place during the 1990s. Currently, year on year record breaking achievements are being made, The driving force behind drilling such long, costly wells is of course robust economics. These tend to demonstrate, at the planning stage, that drilling and future intervention costs make sense, What is less well understood are the risks of drilling such wells - the probability of encountering significant drilling problems are generally much higher than those experienced in conventional wells.

Methodology

Planning of ER wells takes up to 14-16 months. This involves understanding technologies for ER wells, a review of best practices followed and ways to reduce NPT and hence costs associated with drilling of ER wells.

The software PlanERD has been developed keeping in view the above mentioned points.

The process began with a deep study of the technologies that are associated with ER wells. The efficiency of each technology was noted down. This resulted in identifying the best set of technologies for ER wells.

This was followed by a review of best practices that are followed in drilling of ER wells. A number of fields where studied to identify the best practices. This included fields that were drilled in 1996 up to 2002.

Finally a system was designed which would assist in planning of ER wells.

The following flow chart describes the methodology for this project.

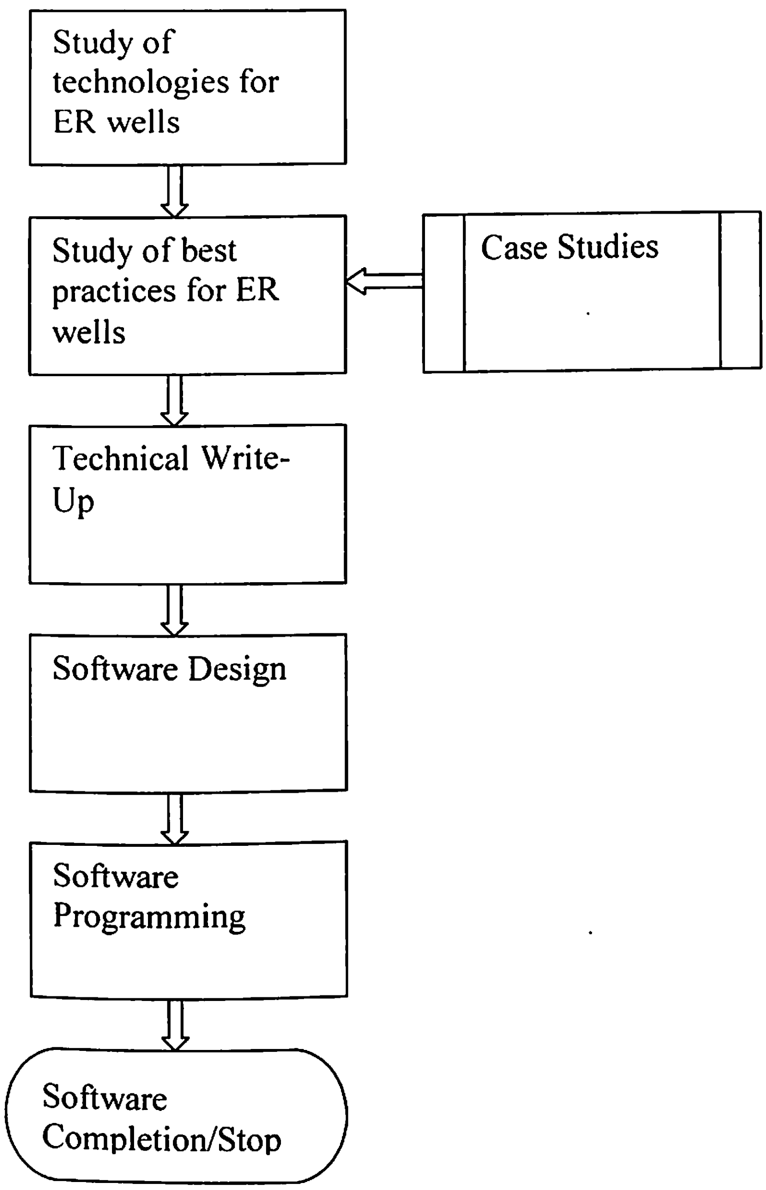


Fig-2

For this Project, study of technologies for ER wells commenced in later half of 2005 which was rigorously taken up in 2006.

Software design started in later half of 2006 and the software was completed in first half of 2007

Target Diagram

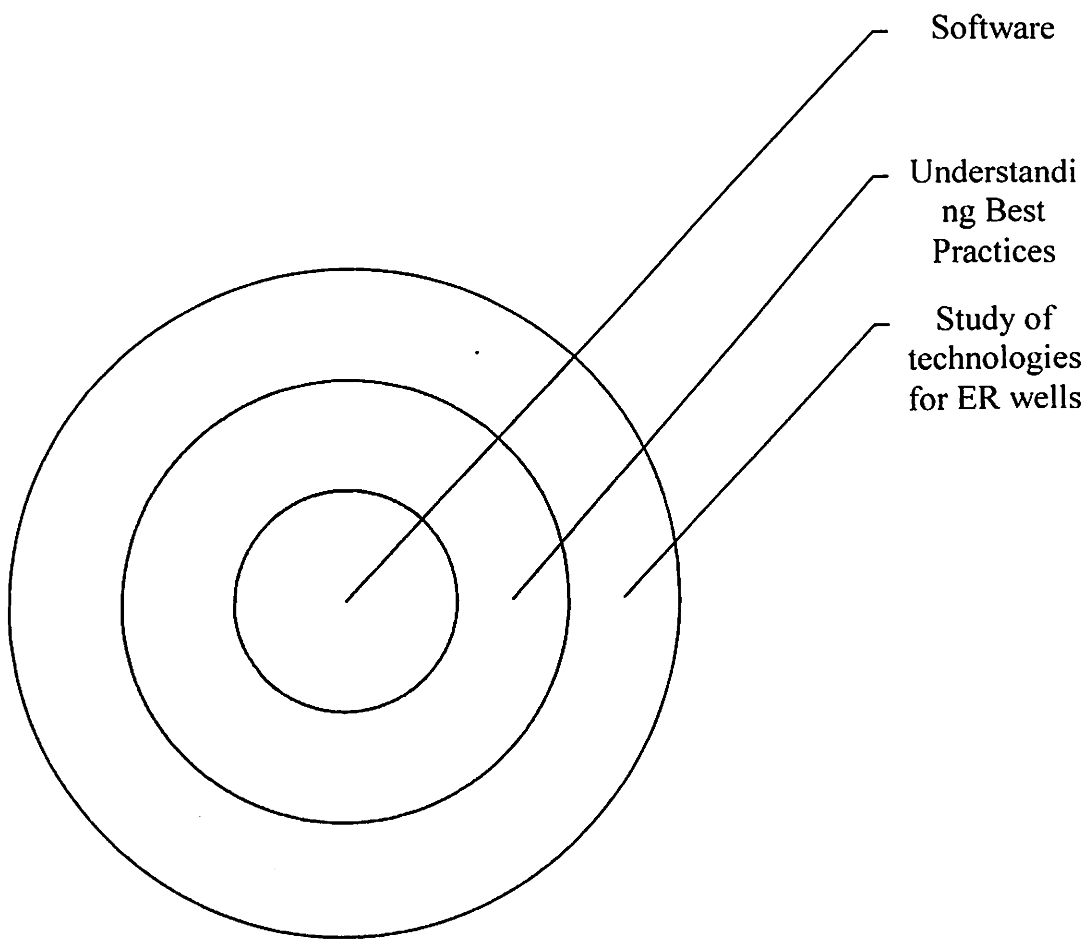


Fig-3

Technology for ERD wells

Rotary steerable systems: Rotary steerable drilling is the technology that enables full three dimensional drilling controls to be performed while drilling with continuous drillstring rotation from surface and thus no slide drilling is necessary. A special BHA component known as rotary steering device is necessary to perform the above-mentioned task. Rotary steerable systems offer the following advantages over the slide drilling:

- Fewer trips are required when using RSS. RSS uses fixed cutter bits unlike the other systems, which used tricone bits for directional control reasons. The longer life of fixed cutter bits results in more footage per bit and thus fewer trips for bit change.
- Continuous rotation at higher speeds results in very efficient hole cleaning.
- RSS can drill nearly all the required section trajectories using a single BHA design. Reduced tripping activity can be measured by comparing the footage drilled vs. the total amount of pipe tripped over the course of the project.

Rotary Steerable Systems: System and Technology

Earlier, **"Push the Bit"** system was used in RSS. These rotary steerable systems rely on non-rotating, stationary pads or stabilizers to provide changes in borehole direction. An inherent weakness with this technique is that it relies on contact with the borehole wall to achieve predictable and consistent directional control. Hole washouts and borehole rugosity can negatively impact the directional performance of these systems. Today the system which is used is known as the **"Point the Bit"** system.

The point-the-bit system can be divided into 3 sub-assemblies. The steering section, electronics and sensor section, and a power generation section. The nucleus of the system, the steering section, contains the point-the-bit mechanism. The steering section contains a universal joint, which transmits torque and weight on bit, but permits the axis of the bit to be at an angular offset from the axis of the tool. The offset allows for the directional drilling tendency of the system to be controlled through traditional 3-point contact with the well bore. The axis of the bit shaft is kept offset by a mandrel, which is maintained geostationary during collar rotation. This is accomplished through the use of a counter rotating electric motor. The feedback/control of the motor is accomplished via the electronics and sensor section. The sensors monitor the rotation of both the collar and motor. This information is utilized to insure feedback for proper control of the system.

These same sensors provide full direction and inclination (D&I) measurement capabilities. Power generation is achieved through a high power turbine and alternator assembly.

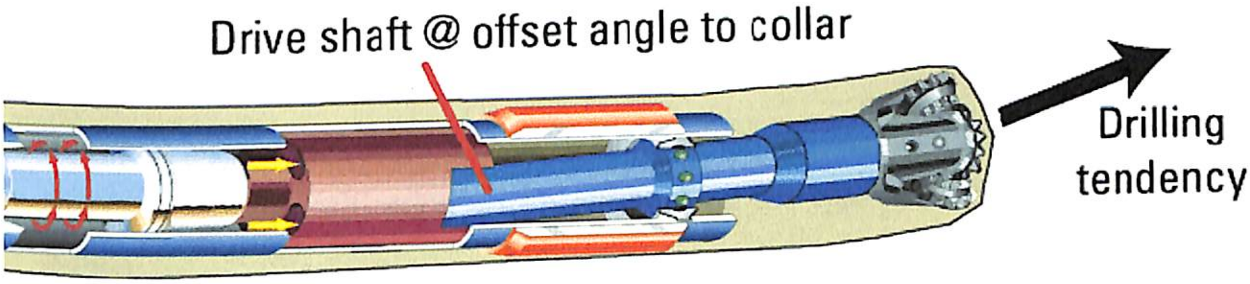


Fig-4

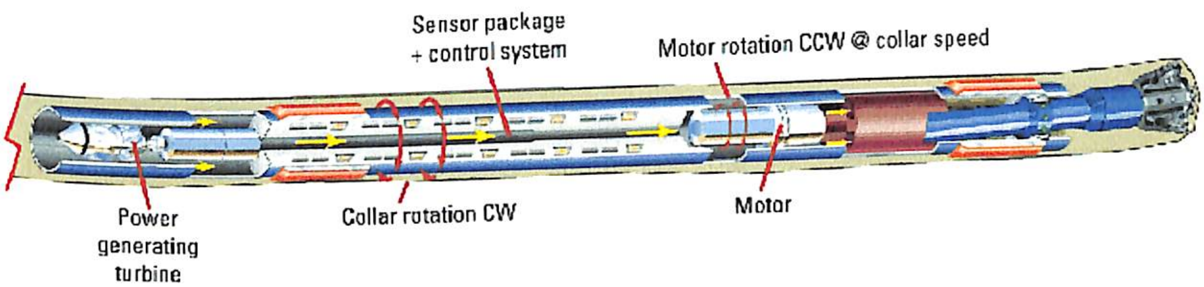


Fig-5

Point the Bit rotary steerable system. Bit shaft is held at an offset to the axis of the tool.

The point the bit system described above is used by one of the service company. In this system, all the drilling parameters are surface controlled. The sensor package and the control system consist of a navigation control until and MWD system. The MWD system sends signal to the surface controller according to which the drill string is directed forward with the help of the navigation counter. Another service company uses hydraulic system to deflect the drive shaft. High pressure fluids are directed to pistons to deflect the drive shaft.

Bit Selection

PDC bits are most commonly used in a rotary steerable system. Bits are selected on the basis of IADC classification which is based on the type of formation which is being drilled.

IADC bit Classification	Formation
1-1	Soft formations having low compressive strength and high drillability
1-2	-do-
5-1	-do-
6-2	-do-
1-3	Soft to medium formations
6-1	-do-
2-1	Medium to medium hard formations
6-2	-do-
2-3	Medium hard abrasive to hard formations
6-2	-do-
3-1	Hard semiabrasive formations
7-2	-do-
3-2	Hard abrasive formations
3-4	-do-
8-1	-do-

Table-1

Drill Pipes

Till now, ERD wells were drilled with either 5-½ in. or 6-5/8 in. or a combination of both. But sue to the problems, which arises due to the above drill pipes, the industry is now turning to 5-7/8 in. drill pipes.

The hydraulic performance of 5-1/2in.drill pipe becomes a major limitation in ERD wells resulting in poor cuttings removal, slow penetration rates and diminished control over well trajectory.

The 6-5/8in.drill pipe is difficult to handle and requires more physical space on the rig. The 5-7/8in. pipe also provides 16% more ID flow area than 5-1/2 in. pipe. Moreover, it is found that pressure losses are reduced upto 28% with the 5-7/8in. pipes.

Solid Expandable Tubular: System and Technology

Drilling and completion of ERD wells is considered as a difficult task due to the many problems associated with ERD wells like high torque and drag, hole cleaning and hole stability.

Solid Expandable Tubular (SET) Technology has two important advantages in ERD wells:

- Favorable drillstring casing geometry is possible which can reduce the tendency for drillstring lockup.
- Use of Larger drilling tubular is possible
- ERD wells extend up to large horizontal distances, which require running additional casing strings. SET is useful in these cases.

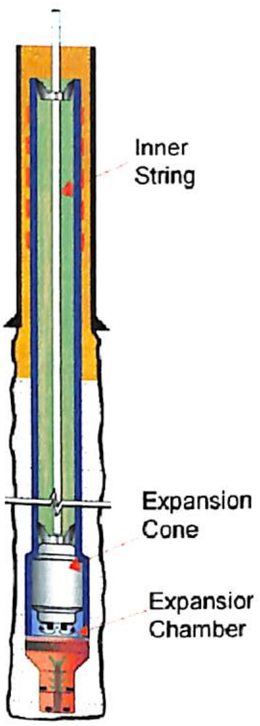
Technology

In SET, the casing is being cold worked to expand it to the required size downhole. Many other technical aspects are taken care of, as cold working is an unstable process for the tubular.

Expansion process: the launcher assembly (launcher + expansion cone) is connected to the liner to be expanded and is run through the rotary table. The required length of the expandable casing is then connected and is run in the wellbore which is followed by running the drillstring concentrically into the liner till it is latched into the expansion cone with the help of a safety thread connection. When the dart gets seated, pressure is exerted below the expansion cone. Expansion is initiated with hydraulic pressure from the drillstring. The expansion process is verified by decrease in the hook load. The progress of the cone through the tubular deforms the steel past its elastic yield limit into its plastic deformation region, but not its ultimate yield strength. Expansions of over 25percent, based on the diameter of the pipe, have been accomplished.

SET are very useful in transversing severely depleted zone especially when the zone lies in an abnormal pressurized environment.

Thus, vertical wells can easily be completed with the conventional casing systems, but for long ERD wells, in some cases, SET become the only option.



Expansion Process for Solid Expandable Tubulars

Fig-6

Casing Floatation: In casing floatation, casing is not filled as each joint is run into the wellbore, as is done in typical casing operations. The goal is to have the casing close to neutrally buoyant, so it becomes virtually weightless in the mud, and drag is minimal. In a long extended-reach section, an entire air-filled casing string can become positively buoyant and resist being pushed farther into the well. Thus, partial casing floatation was taken up and the casing string was divided into two sections; the upper section filled with mud and the lower section filled with air. Thus, double floatation collars were used. The section filled with mud is in the vertical section of the well and provides weight to help push the lower, buoyant casing into the well.

Technological differences between ERD wells and vertical wells

1. ERD wells are characterized by high horizontal departures which results in high torque and drag. As a result, ERD wells are drilled by Rotary Steerable Systems (RSS). In RSS, continuous drillstring rotation is provided from the surface which reduces drag as there is no need to slide the drillstring.Vertical wells can be drilled with normal drilling BHA unlike ERD wells.

2. Completion of vertical wells is comparatively easier to achieve than ERD wells. ERD wells require special technology like casing floatation for completion due to high drag.

3. ERD wells require top drive of higher load capacity when compared to vertical wells.

4. ERD wells require high rig horsepower compared to vertical wells.

Planning of ERD wells

Planning for ERD wells is driven by economical, environmental and technical objectives. In general extended reach drill string design involves:

- Determining expected loads
- Selecting drill string components
- Verifying each components condition
- Monitoring conditions during drilling

Economic issues in drill string planning include availability, logistics and cost. Rig and logistics issues include storage space, accuracy of load indicators, pump pressure/volume capacity, and top drive output torque. Hole issues include hole cleaning, hole stability, hydraulics, casing wear, and directional objectives.

Below is other list a set of considerations that will influence the planning and evaluation of ERD operations. Some of these are related to mechanics, some to operating practices and logistics and others to formation and reservoir characteristics:

- Top Drive: maximum sustainable torque.
- Hydraulics: maximum standpipe pressure.
- Drillpipe: maximum yield stress, make-up torque, fatigue endurance.
- Contact Loads: riser and casing wear.
- Drag: axial friction during sliding operations.
- Buckling: high compressive loading.
- Stuck Pipe: maximum applied overpull.
- Logistics: total length of DP that can be handling large volumes of mud.
- ECD'S: pore pressure and fracture gradients.
- Wellbore Stability: borehole collapse, loss circulation.

SOFTWARE DESIGN

Software Design

The software is a MDI application meaning that it contains a parent form which contains a number of child forms. The software menu consists of three main components:

File

- New
- Exit

Planning

- Rigs and Logistics
- Drilling
- Database Entry
- Industry Envelope
- Case Studies

Help

- Contents
- About

The drilling section is further divided into following components:

Instructions

- Selection of Drill Pipe
- Rigs and Logistics
- ECD Management
- Surge and Swab
- d-Exponent
- Torque and Drag

A flow chart for the process carried out by the software is shown as follows:

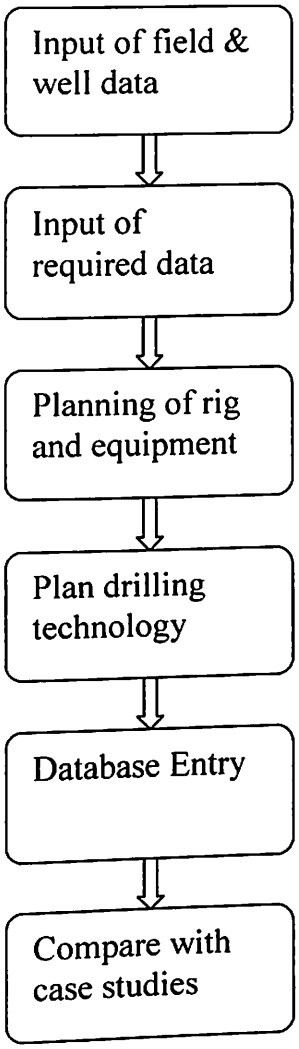


Fig-7

Each of the sections are explained in detail in the report

RIGS AND LOGISTICS

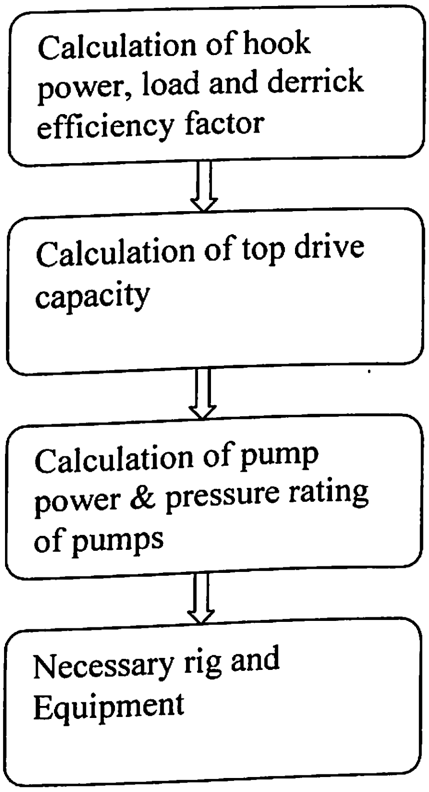
RIGS AND LOGISTICS

Drilling rigs were tradionally built and designed o drill vertical wells. Such rigs and associated tubulars have limitations when drilling ER wells and require modifications when drilling extended reach wells and require medications to give them necessary capacities for drilling ER wells.

In ERD, the factors on which rig sizing depends are as follows:

- Hole Cleaning-To determine the number of mud pumps to be used
- Drilling System- RSS with the top drive system to be used
- Drill Pipe Sizing
- Rig Power
- Environmental Compliance

The software considers all the above factors. The following flow chart demonstrates the working of the software for the Rigs and Logistics section:



DRILLING

Drilling

The drilling section of this software covers nearly all the important parameters which are taken up while drilling of Extended Reach wells.

The section is further divided into following sections:

- Selection of Drill Pipe
- Rigs and Logistics
- ECD Management
- Surge and Swab
- d-Exponent
- Torque and Drag

All the sub sections are explained as follows:

Wellpath Modeling

The immediate objective of a directional survey of a well is to determine the X-Y-Z coordinates of a series of measuring points (stations) along the wellbore based on three things that are known at these points:

- the location of the first point P_0 at surface or tie-in point
- the **measured distance** between any two points along the wellbore
- the wellbore direction (Inclination and Azimuth) at each point

The **Inclination** angle **(φ)** is the angle with respect to the vertical **(0 to 89.5°)**, and the **Azimuth** bearing **(θ)** is the angle in the horizontal plane in a clockwise sense with respect to the North **(0 to 359.5°)**.

The convention followed here is that the **Z**-direction points vertically downwards and the Z-distance give the **True vertical depth**. The **X**-direction aligns with the magnetic North and **Y**-direction points to the East.

Thus, given:

i) the point $P_0 = (X_0, Y_0, Z_0)$

ii) the distance, S_1 between P_0 and P_1

iii) the well direction determined by inclination φ_0 and azimuth θ_0 at P_0, and similarly by φ_1 and θ_1 at P_1,

Find $P_1 = (X_1, Y_1, Z_1)$.

The most widely-used and an accurate method for computing these coordinates is the **Minimum Curvature Method**. According to this method, the solution of the problem is as follows:

$$X_1 = X_0 + S_1\gamma(U_x + V_x)/2$$
$$Y_1 = Y_0 + S_1\gamma(U_y + V_y)/2$$
$$Z_1 = Z_0 + S_1\gamma(U_z + V_z)/2$$
where...
$$V_x = \sin\phi_0 \cos\theta_0$$
$$V_y = \sin\phi_0 \sin\theta_0$$
$$V_z = \cos\phi_0$$
$$U_x = \sin\phi_1 \cos\theta_1$$
$$U_y = \sin\phi_1 \sin\theta_1$$
$$U_z = \cos\phi_1$$
and...
$$\gamma = \frac{2}{\psi}\tan\left(\frac{\psi}{2}\right)$$
where...
$$\cos\psi = U_xV_x + U_yV_y + U_zV_z$$
$$(\gamma = 1 \ldots if \ldots \psi = 0)$$

ECD Management

The equivalent circulation density can be interpreted as the density of a hypothetical fluid, which in static conditions and at any depth produces the same pressure as a given drilling mud in dynamic conditions.

ECD is calculated using the **steady-state model** based on the **Bingham plastic behavior** of drilling mud. The method involves **estimating and summing** the frictional pressure losses arising from the normal circulation of mud outside the drill string. These pressures losses are added to the mud's hydrostatic pressure and converted to density using the true vertical depth.

The annular velocity around the drillpipe is calculated, followed by the critical velocity. If the annular velocity is less than the critical velocity, the laminar pressure losses equation is applied. If otherwise, the turbulent pressure loss equation is applied. The process is then repeated for the drillcollar section. The relevant equations are:

$$n = 3.32 \log \frac{\theta_{600}}{\theta_{300}}$$

$$K = \frac{\theta_{300}}{511^{n}}$$

$$V_c = \left(\frac{38780\,K}{\rho}\right)^{\frac{1}{2-n}} \left(\frac{2.4}{D_h - D_p}\,\frac{2n+1}{3n}\right)^{\frac{n}{2-n}}$$

$$\Delta P_{laminar} = \left(\frac{2.4v}{D_h - D_p}\,\frac{2n+1}{3n}\right)^{n} \left(\frac{KL}{300(D_h - D_p)}\right)$$

$$\Delta P_{turbulent} = \frac{0.000077\,\rho^{0.8} Q^{1.8} PV^{0.2} L}{\left(D_h - D_p\right)^{3} \left(D_h - D_p\right)^{1.8}}$$

< p>

Where:

Q_p = mud circulation rate, gallons/min.

V_c = critical velocity, ft/min.

v = annular velocity, ft/min

ΔP = pressure loss, psi

ρ = mud weight, ppg

n = derived parameter of mud, dimensionless

K = derived parameter of mud, dimensionless

θ_{300} = 300 viscometer dial reading

θ_{600} = 600 viscometer dial reading

$\theta_{300} = PV + YP$

$\theta_{600} = \theta_{300} + PV$

PV = plastic viscosity of mud, cps

YP = yield point of mud, $lb/100ft^2$

L = length of pipe or collar, ft

TVD = true vertical depth, ft

D_h = hole diameter, inches

D_p = drill pipe or collar OD, inches

The total pressure can be converted to the **equivalent circulation density** via the expression:

$\boldsymbol{\rho_{ecd} = 19.23 * \Delta P_{total} / TVD}$.

Surge and Swab

During tripping, pipe run into the wellbore too fast may generate large surge pressures inside the hole which can lead to lost circulation and formation fracture. On the other hand, when pipe is pulled out too fast, it may generate large swab (negative surge) pressures that can lead to kicks and blowouts.

Surge pressures are generally calculated using the **steady-state model** developed by **Burkhardt**. The method is based on the **Bingham plastic behavior** of drilling mud, and essentially involves **estimating and summing** the frictional pressure losses arising from the normal circulation of mud inside and outside the drill string components. These pressures losses are added to the mud's hydrostatic pressure in the hole to obtain the Surge pressure, and subtracted to obtain Swab pressure. There are 2 string configurations to consider: Closed pipe or Open pipe.

CLOSED-PIPE: Here, the pressure losses due to **annular flow around** the drillpipe and collars are considered. Laminar flow is assumed around the pipe and turbulent flow around the collar. The relevant equations are:

- **drillpipe pressure losses:**

$$V_m = 1.5\left[0.45 + \frac{D_p^2}{D_h^2 - D_p^2}\right]V_p$$

$$n = 3.32\log\frac{\theta_{600}}{\theta_{300}}$$

$$K = \frac{\theta_{300}}{511^n}$$

$$P_s = \frac{3.33K\left(\dfrac{2.4V_m}{D_h - D_p}\right)^n L}{1000(D_h - D_p)}$$

drillcollar pressure losses:

$$P_s = \frac{0.000077\rho^{0.8}\left[\frac{V_m\left[D_h^2 - D_p^2\right]}{24.5}\right]^{1.8} \times PV^{0.2}L}{\left(D_h - D_p\right)^3\left(D_h + D_p\right)^{1.8}}$$

Where:

V_p = pipe velocity, ft/minute

V_m = max pipe velocity, ft/min.

P_s = pressure loss, psi

ρ = mud weight, ppg

n = derived parameter of mud, dimensionless

K = derived parameter of mud, dimensionless

θ_{300} = 300 viscometer dial reading

θ_{600} = 600 viscometer dial reading

$\theta_{300} = PV + YP$;

$\theta_{600} = \theta_{300} + PV$

PV = plastic viscosity of mud, cps

YP = yield point of mud, lb/100ft^2

L = length of pipe, ft

TVD = true vertical depth, ft

D_h = hole diameter, inches

D_p = drill pipe or collar OD, inches

D_i = drill pipe or collar ID, inches

OPEN-PIPE: Here, the relative flow in the annulus and in the drillstring are considered separately. That is, the pressure losses attendant to **a)** annular flow **over** the drillpipe plus collars, and **b)** drillstring flow **through** the pipe plus the collars plus the drillbit nozzles. The **mean** of a) and b), or the **max** (larger) of a) and b) can be considered representative of the surge pressure. Laminar flow is assumed inside and outside the pipe. Turbulent flow is assumed in and outside the collars and also in the nozzles.

The expressions for annular pressure losses is similar to that of the closed-pipe, except that the fluid velocity is now lower and includes the pipe's inner diameter term:

$$V_m = 1.5\left[0.45 + \frac{D_p^2 - D_i^2}{D_h^2 - D_p^2 + D_i^2}\right].$$

The following equations are employed to estimates pressure losses inside the drillstring components:

- **inside drillpipe:**

$$P_s = \left[\frac{1.6V_m}{D_i}\frac{3n+1}{4n}\right]\frac{KL}{300D_i}$$

- **inside drill collars:**

$$P_s = \frac{0.000077\rho^{0.8}\left[\frac{V_m\left[D_i^2\right]}{24.5}\right]^{1.8} \times PV^{0.2}L}{\left(D_i\right)^{4.8}}.$$

- **inside drillbit nozzles:**

$$P_s = \frac{\rho v_n^2}{1120}$$

Surge pressure can be converted to the **equivalent mud weight** increment via the expression:

$\rho = 19.23 * P_{surge} / TVD$.

d-Exponent

This is a factor for evaluating drilling rate and predicting/detecting abnormal pore pressure zones. All things being equal, the d-exponent should increase with depth when drilling in a normal pressure section. A reversal of this trend is an indication of drilling into potential overpressures.

The relevant equation developed by **Jorden & Shirley** is:

$$d = \left(\frac{\log \frac{R}{60N}}{\log \frac{12W}{1000D}} \right) \left(\frac{\rho_n}{\rho_m} \right)^c$$

Where:

R = penetration rate, ft/hr.

N = rotary speed, rev/minute

W = weight on bit, 1000 lb.

D = drillbit diameter, inches

ρ_n = normal pressure gradient, mud-weight equivalent, lb/gal.

ρ_m = mud-weight used, lb/gallon

c = shale compactibility coefficient, dimensionless

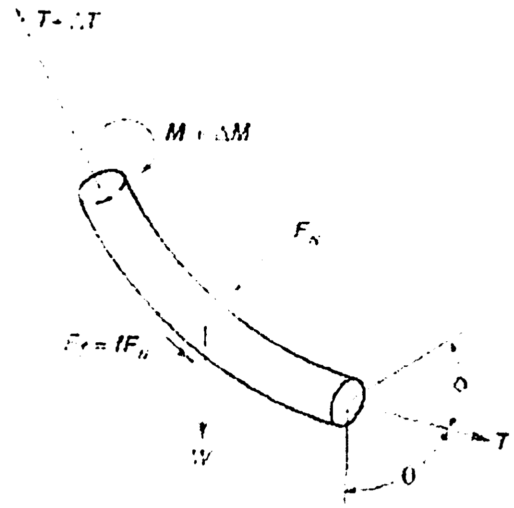
Torque

Torque and drag may be critical factors in determining whether the desired wellpath can actually be drilled and cased. Torque/drag models consider well trajectory, drillstring configuration, doglegs, friction factors, and casing depth to predict torque and drag in the well. Torque-and-drag modeling is used for various purposes, including:

- Evaluating and optimizing wellpaths to minimize torque and drag
- fine-tuning wellpaths to minimize local effects, such as excessive normal loads
- providing normal force loads for inputs into other programs, such as casing wear models
- identifying depth or reach capabilities or limitations, both for drilling' and running casing/tubing
- matching the strength of drillstring components to the loads (axial, torsional, or lateral) in the wellbore
- identifying the hoisting and torque requirements of the drilling rig

The most commonly used torque/drag models are based on the "soft-string" model developed by 10hancsik *et al.*(1983). The drillstring is modeled as a string or cable that is capable of carrying axial loads but not bending moments. Friction is the product of normal forces and a coefficient of friction. The normal force at each calculation node has two components: (1) the buoyed weight of the pipe in drilling fluid, and (2) the lateral reaction force resulting from drillstring tension through curved sections of the wellbore.

A simplified drillstring element, shown in Figure 2-7, has net axial forces and normal forces acting upon it. The Equations are as follows:



$$F_N = [(T\Delta\phi \sin\theta_{avg})^2 + (T\Delta\theta + W \sin\theta_{avg})^2]^{1/2}$$

$$\Delta T = W\cos\theta_{avg} \pm fF_N$$

$$\Delta M = fF_N R$$

$$F_f = fF_N$$

Fig-8

where F is the net normal force, T is the axial tension at the low:; end of the element, W is the buoyed weight. Of drillstring element, fF is the-sliding friction force acting the element, R is the characteristic radius of element, M is the torsion at the lower end of element, θ is the inclination angle at lower end of element, φ *is* the azimuth angle at lower end of element ,f is the coefficient of friction, and $\Delta(T, M \varphi, \theta)$ is the change in those values over the length of the element. The product $fF N$ can be positive or negative, depending on whether the drillstring is advancing into the hole or being pulled out of the hole.

Industry Envelope

Extended Reach Drilling (ERD) has become a prime industry methodology for optimization of field development through reduction in the number of drillsites and structures and enabling production from otherwise inaccessible parts of reservoirs. It has evolved from simple directional drilling to horizontal, lateral, and multi-lateral step-outs. ERD employs both directional and horizontal drilling techniques and has the ability to achieve horizontal well departures beyond conventional experience.

Two ratios; the Aspect and Depth Ratios, are used to determine whether a well can be considered an ERD well. The Aspect Ratio is calculated by dividing the Horizontal Displacement (HD) of the well by its True Vertical Depth, (HD/TVD). Although there is no industry consensus, a well is generally considered to be an ERD well if it has an Aspect Ratio greater than 2.0. The Aspect Ratio has also been used to provide a relative measure of the complexity of an ERD well (i.e. the higher the ratio, the more complex and difficult the well). However, this definition does not fully capture the different types of ERD wells, or the relative complexity they may have. Similarly, the Depth Ratio is also an indicator that is used to describe ERD wells. The Depth Ratio is calculated by dividing the Measured Depth (MD) of the well by its True Vertical Depth, (MD/TVD). The diagram is a plot of the Aspect Ratios (HD/TVD) for many ERD wells. It shows the current ERD drilling envelope and a projection of what may be achievable with technological advancement.

SOFTWARE PROGRAMMING

Software Programming

The software was created in Visual Basic 2005 Express Edition, which is the latest version of Visual Basic. .NET Framework 2.0 was added as the software component.

.NET Framework

The **Microsoft .NET Framework** is a software component that can be added to the Microsoft Windows operating system. It provides a large body of pre-coded solutions to common program requirements, and manages the execution of programs written specifically for the framework. The .NET Framework is a key Microsoft offering, and is intended to be used by most new applications created for the Windows platform.

The pre-coded solutions form the framework's class library and cover a large range of programming needs in areas including: user interface, data access, cryptography, web application development, numeric algorithms , and network communications. The functions of the class library are used by programmers who combine them with their own code to produce applications.

For software developers, the .NET Framework is a significant change. It brings into the operating system features and responsibilities that previously had been provided individually by programming languages and tools from various sources. The incorporation of the features into the operating system is meant to provide a number of advantages, including:

- Assuring the availability of framework features to all programs written in any of the .NET languages.
- Providing to programmers a common means of accessing framework features, regardless of programming language.
- Guarantees of a common behavior within the framework, regardless of programming language.

- Allowing the operating system to provide some guarantees of program behavior that it otherwise could not offer.

- Reducing the complexity and limitations of program-to-program communication, even when those programs are written in different .NET languages.

.NET Framework Architecture

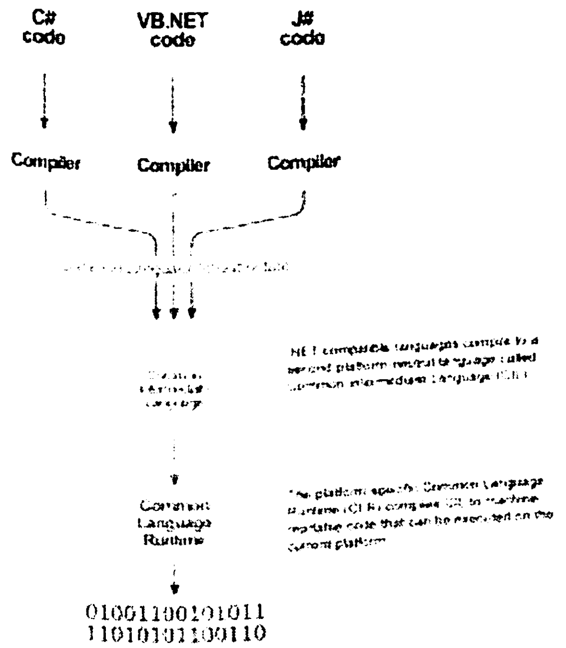


Fig-9

Execution environment for the program code was defined in Common Language Runtime (CLR).

The **Common Language Runtime** (CLR) is the virtual machine component of Microsoft's .NET initiative. It is Microsoft's implementation of the Common Language Infrastructure (CLI) standard, which defines an execution environment for program code. The CLR runs a form of bytecode called the Microsoft Intermediate Language (MSIL), Microsoft's implementation of the Common Intermediate Language.

Developers using the CLR write code in a high level language such as C# or VB.Net. At compile-time, a .NET compiler converts such code into MSIL (Microsoft Intermediate Language) code. At runtime, the CLR's just-in-time compiler (JIT compiler) converts the

MSIL code into code native to the operating system. Alternatively, the MSIL code can be compiled to native code in a separate step prior to runtime. This speeds up all later runs of the software as the MSIL-to-native compilation is no longer necessary.

```
Source code                    Bytecode                Native code


                     C# compiler  ___________
C#  ---------------------->|             |
                           |             |
                           |             |
             VB.NET compiler |           |   CLR
VB.NET ------------------->| MSIL Code   |---------> native code
                           |             |
                           |             |
              other compiler |           |
Other .NET --------------->|             |
language                   |_____________|

\_________________________________/ \____________________________/
                |                                |
                                              runtime
         compile-time
```

Fig-9

Although some other implementations of the Common Language Infrastructure run on non-Windows operating systems, the CLR runs on Microsoft Windows operating systems.

The virtual machine aspect of the CLR allows programmers to ignore many details of the specific CPU that will execute the program. The CLR also provides other important services, including the following:

- Memory management
- Thread management
- Exception handling
- Garbage collection

- Security

Database programming was done in SQL and the data's were connected through SQL Server 2005.

SQL is a set of statements that tell a database engine (such as the ADO .NET engine with Visual Basic 2005) what information the user wants displayed. The engine then processes that set of statements, as it sees fit, to provide the information. SQL statements fall into two categories: data manipulation language (**DML**) and data definition language (**DDL**). DDL statements can be used to define tables, indexes, and database relations. DML statements are used to select, sort, summarize, and make computations on data. We will discuss primarily DML statements.

All major calculations were carried out in Microsoft Excel. Internal web browsers were created to embed web pages that contained excel sheets.

SOFTWARE CODING

Splash Screen

```
Public NotInheritable Class SplashScreen1

    'TODO: This form can easily be set as the splash screen for the
application by going to the "Application" tab
    '  of the Project Designer ("Properties" under the "Project" menu).


    Private Sub SplashScreen1_Load(ByVal sender As Object, ByVal e As
System.EventArgs) Handles Me.Load
        'Set up the dialog text at runtime according to the
application's assembly information.

        'TODO: Customize the application's assembly information in the
"Application" pane of the project
        '  properties dialog (under the "Project" menu).

        'Application title
        If My.Application.Info.Title <> "" Then
            ApplicationTitle.Text = My.Application.Info.Title
        Else
            'If the application title is missing, use the application
name, without the extension
            ApplicationTitle.Text =
System.IO.Path.GetFileNameWithoutExtension(My.Application.Info.Assembly
Name)
        End If

        'Format the version information using the text set into the
Version control at design time as the
        '  formatting string.  This allows for effective localization
if desired.
        '  Build and revision information could be included by using
the following code and changing the
        '      Version control's designtime text to "Version
{0}.{1:00}.{2}.{3}" or something similar.  See
        '  String.Format() in Help for more information.
        '
        '          Version.Text = System.String.Format(Version.Text,
My.Application.Info.Version.Major,     My.Application.Info.Version.Minor,
My.Application.Info.Version.Build,
My.Application.Info.Version.Revision)

        Version.Text = System.String.Format(Version.Text,
My.Application.Info.Version.Major, My.Application.Info.Version.Minor)

        'Copyright info
        Copyright.Text = My.Application.Info.Copyright
    End Sub

    Private Sub ApplicationTitle_Click(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles ApplicationTitle.Click
        MDIParent1.Show()
```

```
    End Sub

    Private  Sub  MainLayoutPanel_Paint(ByVal  sender  As  System.Object,
ByVal    e     As      System.Windows.Forms.PaintEventArgs)     Handles
MainLayoutPanel.Paint

    End Sub
End Class
```

Parent Form

```
Imports System.Windows.Forms
Imports System.Drawing.Printing
Imports System.Windows.Forms.QueryAccessibilityHelpEventArgs

Public Class MDIParent1

    Private  Sub  ShowNewForm(ByVal  sender  As  Object,  ByVal  e  As
EventArgs) Handles NewToolStripMenuItem.Click
        ' Create a new instance of the child form.
        Dim Form3 As New Form3
        ' Make it a child of this MDI form before showing it.
        Form3.MdiParent = Me

        m_ChildFormNumber += 1
        Form3.Text = "General Data"

        Form3.Show()
    End Sub

    Private Sub OpenFile(ByVal sender As Object, ByVal e As EventArgs)
Handles OpenToolStripButton.Click
        Dim OpenFileDialog As New OpenFileDialog
        OpenFileDialog.InitialDirectory                                =
My.Computer.FileSystem.SpecialDirectories.MyDocuments
        OpenFileDialog.Filter  =  "Text  Files  (*.txt)|*.txt|All  Files
(*.*)|*.*"
        If                 (OpenFileDialog.ShowDialog(Me)              =
System.Windows.Forms.DialogResult.OK) Then
            Dim FileName As String = OpenFileDialog.FileName
            ' TODO: Add code here to open the file.
        End If
    End Sub

    Private  Sub  SaveAsToolStripMenuItem_Click(ByVal  sender  As  Object,
ByVal e As EventArgs)
        Dim SaveFileDialog As New SaveFileDialog
        SaveFileDialog.InitialDirectory                                =
My.Computer.FileSystem.SpecialDirectories.MyDocuments
        SaveFileDialog.Filter  =  "Text  Files  (*.txt)|*.txt|All  Files
(*.*)|*.*"

        If                 (SaveFileDialog.ShowDialog(Me)              =
System.Windows.Forms.DialogResult.OK) Then
            Dim FileName As String = SaveFileDialog.FileName
```

```
        ' TODO: Add code here to save the current contents of the
form to a file.
        End If
    End Sub


    Private Sub ExitToolsStripMenuItem_Click(ByVal sender As Object,
ByVal e As EventArgs) Handles ExitToolStripMenuItem.Click
        Global.System.Windows.Forms.Application.Exit()
    End Sub

    Private Sub CutToolStripMenuItem_Click(ByVal sender As Object,
ByVal e As EventArgs) Handles CutToolStripMenuItem.Click
        ' Use My.Computer.Clipboard to insert the selected text or
images into the clipboard
        Dim form12 As New Form12
        form12.MdiParent = Me
        m_ChildFormNumber += 1
        form12.Text = "Industry Envelope"

        form12.Show()
    End Sub

    Private Sub CopyToolStripMenuItem_Click(ByVal sender As Object,
ByVal e As EventArgs) Handles CopyToolStripMenuItem.Click
        ' Use My.Computer.Clipboard to insert the selected text or
images into the clipboard
        Dim form11 As New Form11
        form11.MdiParent = Me
        m_ChildFormNumber += 1
        form11.Text = "Case Studies"

        form11.Show()
    End Sub
    Private Sub PasteToolStripMenuItem_Click(ByVal sender As Object,
ByVal e As EventArgs)
        'Use My.Computer.Clipboard.GetText() or
My.Computer.Clipboard.GetData to retrieve information from the
clipboard.
    End Sub

    Private Sub ToolBarToolStripMenuItem_Click(ByVal sender As Object,
ByVal e As EventArgs)

    End Sub

    Private Sub StatusBarToolStripMenuItem_Click(ByVal sender As
Object, ByVal e As EventArgs)

    End Sub

    Private Sub CascadeToolStripMenuItem_Click(ByVal sender As Object,
ByVal e As EventArgs)
        Me.LayoutMdi(MdiLayout.Cascade)
    End Sub
```

```
    Private  Sub  TileVerticleToolStripMenuItem_Click(ByVal  sender  As
Object, ByVal e As EventArgs)
        Me.LayoutMdi(MdiLayout.TileVertical)
    End Sub

    Private  Sub  TileHorizontalToolStripMenuItem_Click(ByVal  sender  As
Object, ByVal e As EventArgs)
        Me.LayoutMdi(MdiLayout.TileHorizontal)
    End Sub

    Private  Sub  ArrangeIconsToolStripMenuItem_Click(ByVal  sender  As
Object, ByVal e As EventArgs)
        Me.LayoutMdi(MdiLayout.ArrangeIcons)
    End Sub

    Private Sub CloseAllToolStripMenuItem_Click(ByVal sender As Object,
ByVal e As EventArgs)
        ' Close all child forms of the parent.
        For Each ChildForm As Form In Me.MdiChildren
            ChildForm.Close()
        Next
    End Sub

    Private m_ChildFormNumber As Integer = 0

    Private Sub EditMenu_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles EditMenu.Click

    End Sub

    Private   Sub   UndoToolStripMenuItem_Click(ByVal   sender   As
System.Object,   ByVal   e   As   System.EventArgs)   Handles
UndoToolStripMenuItem.Click


        Dim Form4 As New Form4
        ' Make it a child of this MDI form before showing it.
        Form4.MdiParent = Me

        m_ChildFormNumber += 1
        Form4.Text = "Rigs and Logistics"

        Form4.Show()
        ToolStripStatusLabel.Text = "Done"
    End Sub

    Private  Sub  SurgeAndSwabToolStripMenuItem_Click(ByVal  sender  As
Object,   ByVal   e   As   System.EventArgs)   Handles
SurgeAndSwabToolStripMenuItem.Click
        Dim form7 As New Form7
        form7.MdiParent = Me
        m_ChildFormNumber += 1
        form7.Text = "Surge and Swab Calculations"

        form7.Show()
    End Sub
```

```
    Private Sub ECDManagementToolStripMenuItem_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
ECDManagementToolStripMenuItem.Click
        Dim form8 As New Form8
        form8.MdiParent = Me
        m_ChildFormNumber += 1
        form8.Text = "ECD Management Calculations"

        form8.Show()
    End Sub

    Private Sub ToolStripMenuItem1_Click(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles ToolStripMenuItem1.Click
        Dim form18 As New Form18
        form18.MdiParent = Me
        m_ChildFormNumber += 1
        form18.Text = "Instructions"

        form18.Show()
    End Sub

    Private Sub WellPathToolStripMenuItem_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
WellPathToolStripMenuItem.Click
        Dim form9 As New Form9
        form9.MdiParent = Me
        m_ChildFormNumber += 1
        form9.Text = "WellPath Calculations"

        form9.Show()
    End Sub

    Private Sub PrintToolStripMenuItem_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs)




    End Sub

    Private Sub SaveToolStripMenuItem_Click(ByVal sender As Object,
ByVal e As System.EventArgs)

    End Sub

    Private Sub AboutToolStripMenuItem_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
AboutToolStripMenuItem.Click
        AboutBox1.Show()

    End Sub

    Private Sub ContentsToolStripMenuItem_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
ContentsToolStripMenuItem.Click
```

```
        Dim form17 As New Form17
        form17.MdiParent = Me
        m_ChildFormNumber += 1
        form17.Text = "Contents"

        form17.Show()
    End Sub

    Private Sub ToolStripMenuItem2_Click(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles ToolStripMenuItem2.Click
        ToolStripStatusLabel.Text = "Initializing..."
        Dim form10 As New Form10
        form10.MdiParent = Me
        m_ChildFormNumber += 1
        form10.Text = "Database Entry"

        form10.Show()
        ToolStripStatusLabel.Text = "Done"
    End Sub

    Private     Sub     HelpToolStripButton_Click(ByVal     sender     As
System.Object, ByVal e As System.EventArgs)

    End Sub

    Private Sub ToolStripMenuItem3_Click(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles ToolStripMenuItem3.Click
        PrintDialog1.ShowDialog()

    End Sub


    Private  Sub  DrillPipeSelectionToolStripMenuItem_Click(ByVal  sender
As    System.Object,    ByVal    e    As    System.EventArgs)    Handles
DrillPipeSelectionToolStripMenuItem.Click
        Dim form13 As New Form13
        form13.MdiParent = Me
        m_ChildFormNumber += 1
        form13.Text = "Drill Pipe Selection"

        form13.Show()
    End Sub

    Private   Sub   DexponentToolStripMenuItem_Click(ByVal   sender   As
System.Object,     ByVal     e     As     System.EventArgs)     Handles
DexponentToolStripMenuItem.Click
        Dim form15 As New Form15
        form15.MdiParent = Me
        m_ChildFormNumber += 1
        form15.Text = "d-exponent"

        form15.Show()
    End Sub

    Private Sub ToolStripMenuItem5_Click(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles ToolStripMenuItem5.Click
        Dim form16 As New Form16
```

```
        form16.MdiParent = Me
        m_ChildFormNumber += 1
        form16.Text = "Torque and Drag Analysis"

        form16.Show()
    End Sub
```

General Data

```
Public Class Form3

    Private Sub GeneraldataBindingNavigatorSaveItem_Click(ByVal sender
As System.Object, ByVal e As System.EventArgs) Handles
GeneraldataBindingNavigatorSaveItem.Click
        Me.Validate()
        Me.GeneraldataBindingSource.EndEdit()

Me.GeneraldataTableAdapter.Update(Me.Database1DataSet.generaldata)

    End Sub

    Private Sub Form3_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        'TODO: This line of code loads data into the
'Database1DataSet.generaldata' table. You can move, or remove it, as
needed.

Me.GeneraldataTableAdapter.Fill(Me.Database1DataSet.generaldata)

    End Sub

    Private Sub DataGridView1_CellContentClick(ByVal sender As
System.Object, ByVal e As
System.Windows.Forms.DataGridViewCellEventArgs)

    End Sub

    Private Sub GeneraldataDataGridView_CellContentClick(ByVal sender
As System.Object, ByVal e As
System.Windows.Forms.DataGridViewCellEventArgs) Handles
GeneraldataDataGridView.CellContentClick

    End Sub
End Class
```

Rigs and Logistics

```
Public Class Form4

    Private Sub Form4_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load

        'TODO: This line of code loads data into the
'Database2DataSet1.rigsizing1' table. You can move, or remove it, as
needed.
```

```
    End Sub

    Private Sub Button1_Click(ByVal sender As Object, ByVal e As
System.EventArgs) Handles Button1.Click
        Dim md As Integer = TextBox1.Text

        If md < 3500 Then MsgBox("Lightweight rig")
        If md > 3500 And md < 6000 Then MsgBox("Intermediate Rig")
        If md >= 6000 And md < 8000 Then MsgBox("Heavyweight Rig")
        If md > 8000 And md <= 20000 Then MsgBox("Ultraweight Rig")



    End Sub

    Private Sub Button2_Click(ByVal sender As Object, ByVal e As
System.EventArgs) Handles Button2.Click
        Dim md As Integer = TextBox1.Text
        If md < 3500 Then MsgBox("Total Horsepower Required=650hp")

        If md > 3500 And md < 6000 Then MsgBox("Total Horsepower
Required=1300hp")
        If md >= 6000 And md < 8000 Then MsgBox("Total Horsepower
Required=2000hp")
        If md > 8000 And md <= 20000 Then MsgBox("Total Horsepower
Required=3000hp")




    End Sub

    Private Sub Button3_Click(ByVal sender As Object, ByVal e As
System.EventArgs) Handles Button3.Click
        Dim md As Integer = TextBox1.Text
        If md < 3500 Then GroupBox2.Visible = True
        If md >= 3500 And md < 6000 Then GroupBox3.Visible = True
        If md >= 6000 And md < 8000 Then GroupBox4.Visible = True
        If md >= 8000 And md <= 20000 Then GroupBox5.Visible = True
    End Sub

    Private Sub RadioButton3_CheckedChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
RadioButton3.CheckedChanged
        Dim md As Integer = TextBox1.Text
        If md < 3500 And RadioButton3.Checked = True Then
RichTextBox2.Text = "It is preferrable to use Range 1 or Range 2
drillpipe here"

        If md >= 3500 And md < 6000 And RadioButton3.Checked = True
Then RichTextBox2.Text = "It is preferrable to use Range 2 drillpipe
here"
```

```
        If md >= 6000 And md < 8000 And RadioButton3.Checked = True
Then RichTextBox2.Text = "It is adequate to use Range 3 drillpipe here"
        If md >= 8000 And md <= 20000 And RadioButton3.Checked = True
Then RichTextBox2.Text = "The Well has high measured depth. Thus, it is
adequate to use Range 3 pipes"

    End Sub



    Private Sub RadioButton2_CheckedChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
RadioButton2.CheckedChanged
        Dim md As Integer = TextBox1.Text
        If md < 3500 And RadioButton2.Checked = True Then
RichTextBox2.Text = "It is adequate to use Range 2 drillpipe here"
        If md >= 3500 And md < 6000 And RadioButton2.Checked = True
Then RichTextBox2.Text = "It is adequate to use Range 2 drillpipe here"
        If md >= 6000 And md < 8000 And RadioButton2.Checked = True
Then RichTextBox2.Text = "It is adequate to use Range 2 drillpipe here"
        If md >= 8000 And md <= 20000 And RadioButton2.Checked = True
Then RichTextBox2.Text = "The Well has high measured depth. Thus, it is
advised to use Range 3 pipes.The Rig should also be capable of running
double stands of drill pipe."




    End Sub

    Private Sub RadioButton1_CheckedChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
RadioButton1.CheckedChanged
        Dim md As Integer = TextBox1.Text
        If md < 3500 And RadioButton1.Checked = True Then
RichTextBox2.Text = "It is adequate to use Range 1 drillpipe here"
        If md >= 3500 And md < 6000 And RadioButton1.Checked = True
Then RichTextBox2.Text = "It is preferrable to use Range 2 drillpipe
here"
        If md >= 6000 And md < 8000 And RadioButton1.Checked = True
Then RichTextBox2.Text = "It is preferrable to use Range 2 drillpipe
here"
        If md >= 8000 And md <= 20000 And RadioButton1.Checked = True
Then RichTextBox2.Text = "The Well has high measured depth. Thus, it is
advised to use Range 3 pipes.The Rig should also be capable of running
double stands of drill pipe."

    End Sub

    Private Sub GroupBox8_Enter(ByVal sender As System.Object, ByVal e
As System.EventArgs)

    End Sub
```

```
    Private    Sub    RadioButton4_CheckedChanged(ByVal    sender    As
System.Object,    ByVal    e    As    System.EventArgs)    Handles
RadioButton4.CheckedChanged
        Dim hl As Double = TextBox4.Text
        If   hl   <=   8.5   And   RadioButton4.Checked   =   True   Then
RichTextBox1.Text = " A single pump is adequate for this hole size."
        If   hl   <=   8.5   And   RadioButton5.Checked   =   True   Then
RichTextBox1.Text = " A single pump is adequate for this hole size."
        If   hl   <=   8.5   And   RadioButton6.Checked   =   True   Then
RichTextBox1.Text = " A single pump is adequate for this hole size."
        If   hl   <=   8.5   And   RadioButton7.Checked   =   True   Then
RichTextBox1.Text = " A single pump is adequate for this hole size."
        If hl > 8.5 And hl < 12.25 And RadioButton4.Checked = True Then
RichTextBox1.Text = "2 x 1600hp pumps will be adeqaute for hole size
greater than 8.5. Hole cleaning is an important parameter in Extended
Reach Drilling. A flow rate of about 800-900gpm would be required for
hole cleaning of this hole size. Thus, 2 x 1600hp pumps would be
adequate."
        If   hl   >=   12.25   And   RadioButton4.Checked   =   True   Then
RichTextBox1.Text = "Hole cleaning is an important parameter in
Extended Reach Drilling, For tangent angles of more than 80, a flow
rate of more than 1100gpm would be required. Thus it is advised to go
for 4 x 1600hp pumps for this hole size."
        If hl > 8.5 And hl < 12.25 And RadioButton5.Checked = True Then
RichTextBox1.Text = "3 x 1600hp pumps will be adeqaute for hole size
greater than 8.5. Hole cleaning is an important parameter in Extended
Reach Drilling. A flow rate of about 800-900gpm would be required for
hole cleaning of this hole size. Thus, 3 x 1600hp pumps would be
adequate."
        If   hl   >=   12.25   And   RadioButton5.Checked   =   True   Then
RichTextBox1.Text = "Hole cleaning is an important parameter in
Extended Reach Drilling, For tangent angles of more than 80, a flow
rate of more than 1100gpm would be required. Thus it is advised to go
for 4 x 1600hp pumps for this hole size."
        If hl > 8.5 And hl < 12.25 And RadioButton6.Checked = True Then
RichTextBox1.Text = "2 x 1600hp pumps will be adeqaute for hole size
greater than 8.5. Hole cleaning is an important parameter in Extended
Reach Drilling. A flow rate of about 800-900gpm would be required for
hole cleaning of this hole size."
        If   hl   >=   12.25   And   RadioButton6.Checked   =   True   Then
RichTextBox1.Text = "Hole cleaning is an important parameter in
Extended Reach Drilling, For tangent angles of more than 80, a flow
rate of more than 1100gpm would be required. Thus it is advised to go
for 4 x 1600hp pumps for this hole size."
        If   hl   >=   12.25   And   RadioButton6.Checked   =   True   Then
RichTextBox1.Text = "It is strictly advised to go for 4 x 1600hp pumps
or 2 x 2200 hp pumps for this hole size for efficient hole cleaning"
        If hl > 8.5 And hl < 12.25 And RadioButton7.Checked = True Then
RichTextBox1.Text = "2 x 1600hp pumps will be adeqaute for hole size
greater than 8.5. Hole cleaning is an important parameter in Extended
Reach Drilling. A flow rate of about 800-900gpm would be required for
hole cleaning of this hole size."
        If   hl   >=   12.25   And   RadioButton4.Checked   =   True   Then
RichTextBox1.Text = "Hole cleaning is an important parameter in
Extended Reach Drilling, For tangent angles of more than 80, a flow
rate of more than 1100gpm would be required. Thus it is advised to go
for 4 x 1600hp pumps for this hole size."
```

```
        If   hl   >=   12.25   And   RadioButton4.Checked   =   True   Then
RichTextBox1.Text = "It is strictly advised to go for 4 x 1600hp pumps
or 2 x 2200 hp pumps for this hole size for efficient hole cleaning"


    End Sub

    Private Sub GroupBox7_Enter(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles GroupBox7.Enter

    End Sub

    Private Sub GroupBox6_Enter(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles GroupBox6.Enter

    End Sub

    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs)
        Form5.Show()

    End Sub

    Private Sub RichTextBox3_TextChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs)

    End Sub


    Private Sub ProgressBar1_Click(ByVal sender As System.Object, ByVal
e As System.EventArgs)

    End Sub

    Private Sub Button5_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button5.Click
        Dim md As Integer = TextBox1.Text
        Dim cnv As Integer = CInt(md) * 3.28
        If RadioButton8.Checked = True Then MsgBox(cnv / 60 * 19.5)
        If RadioButton9.Checked = True Then MsgBox(cnv / 60 * 21.9)
        If RadioButton10.Checked = True Then MsgBox(cnv / 60 * 23.4)
        If RadioButton11.Checked = True Then MsgBox(cnv / 60 * 25.2)
    End Sub

    Private Sub Label6_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Label6.Click

    End Sub
End Class
```

Database Entry

```
Public Class Form10

    Private Sub Case_StudiesBindingNavigatorSaveItem_Click(ByVal sender
As System.Object, ByVal e As System.EventArgs) Handles
Case_StudiesBindingNavigatorSaveItem.Click
        Me.Validate()
        Me.Case_StudiesBindingSource.EndEdit()

Me.Case_StudiesTableAdapter.Update(Me.Database4DataSet1.Case_Studies)

    End Sub

    Private Sub Form10_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        'TODO: This line of code loads data into the
'Database4DataSet2.Case_Studies' table. You can move, or remove it, as
needed.

Me.Case_StudiesTableAdapter1.Fill(Me.Database4DataSet2.Case_Studies)
        'TODO: This line of code loads data into the
'Database4DataSet1.Case_Studies' table. You can move, or remove it, as
needed.


    End Sub

    Private Sub Well_NameTextBox_TextChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs)

    End Sub

    Private Sub Top_Drive_CapacityLabel_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs)

    End Sub

    Private Sub CountryLabel_Click(ByVal sender As System.Object, ByVal
e As System.EventArgs)

    End Sub

    Private Sub CountryTextBox_TextChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
CountryTextBox.TextChanged

    End Sub

    Private Sub Step_Out_RatioLabel_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs)

    End Sub

    Private Sub Drilling_SystemLabel_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs)
```

```
    End Sub

    Private Sub Drilling_SystemTextBox_TextChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
Drilling SystemTextBox.TextChanged

    End Sub
End Class
```

Drill Pipe Selection

```
Public Class Form13

    Private Sub RadioButton1_CheckedChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs)



    End Sub

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button1.Click

        TextBox1.Text = "4 in"
        TextBox2.Text = "25.6 lbm/ft"
        TextBox3.Text = "0.50 in"
        TextBox4.Text = "11458 psi"
        TextBox5.Text = "40544 lbf.ft"
        TextBox6.Text = "14514 psi"
        TextBox7.Text = "51356 lbf.ft"
        TextBox8.Text = "16042 psi"
        TextBox9.Text = "56762 lbf.ft"
        TextBox10.Text = "20510 psi"
        TextBox11.Text = "72979 lbf.ft"
        TextBox12.Text = "The 5 in drillpipe has a capacity of 0.01535
bbl/ft. Hole Cleaning is an important parameter in drilling of Extended
Reach Wells. Surface Hole(17.5 in) and Intermediate Holes require
efficient hole cleaning. The capacity of 5 in drillpipe is not enough
to provide good hole cleaning. ECD Management aldo depends on drillpipe
OD. Less OD will create problems in ECD Management"

    End Sub

    Private Sub Label4_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Label4.Click

    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button2.Click
        TextBox1.Text = "4.778 in"
        TextBox2.Text = "21.9 lbm/ft"
        TextBox3.Text = "0.361 in"
        TextBox4.Text = "5730 psi"
```

```
        TextBox5.Text = "39863 lbf.ft"
        TextBox6.Text = "6542 psi"
        TextBox7.Text = "50494 lbf.ft"
        TextBox8.Text = "6865 psi"
        TextBox9.Text = "55809 lbf.ft"
        TextBox10.Text = "7496 psi"
        TextBox11.Text = "71754 lbf.ft"
        TextBox12.Text = "The 5.5 in drillpipe has a capacity of
0.02172 bbl/ft. Hole Cleaning is an important parameter in drilling of
Extended Reach Wells. Surface Hole(17.5 in) and Intermediate Holes
require efficient hole cleaning. The capacity of 5.5 in drillpipe is
just enough to provide good hole cleaning. However, hydraulic
performance of 5-1/2 in. drill pipe can be a major limitation in
substantial ERD and deepwater wells resulting in poor cuttings removal,
slower penetration rates, diminished control over well trajectory and
more tendency for drill pipe sticking."

    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button3.Click
        TextBox1.Text = "5.153 in"
        TextBox2.Text = "23.40 lbm/ft"
        TextBox3.Text = "0.361 in"
        TextBox4.Text = "5500 psi"
        TextBox5.Text = "37835 lbf.ft"
        TextBox6.Text = "6275 psi"
        TextBox7.Text = "48993 lbf.ft"
        TextBox8.Text = "6472 psi"
        TextBox9.Text = "52782 lbf.ft"
        TextBox10.Text = "7283 psi"
        TextBox11.Text = "70847 lbf.ft"
        TextBox12.Text = "The 5-7/8 in. 23.40 lb/ft pipe provides 16%
more ID flow area than 5-1/2 in. 21.90 lb/ft pipe. Pressure losses are
reduced by approximately 28% with the 5-7/8 in. drill pipe.In addition,
drill pipe sticking tendencies are reduced due to better cuttings
removal, and the directional control of the well path is improved.
Working pressure requirements for the mud circulating system are also
reduced. "
    End Sub

    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button4.Click
        TextBox1.Text = "5.901 in"
        TextBox2.Text = "27.70 lbm/ft"
        TextBox3.Text = "0.362 in"
        TextBox4.Text = "3615 psi"
        TextBox5.Text = "60192 lbf.ft"
        TextBox6.Text = "4029 psi"
        TextBox7.Text = "77312 lbf.ft"
        TextBox8.Text = "4222 psi"
        TextBox9.Text = "85450 lbf.ft"
        TextBox10.Text = "4562 psi"
        TextBox11.Text = "109864 lbf.ft"
        TextBox12.Text = "Hydraulic pressure losses are minimized with
6-5/8 in. drill pipe, but 6-5/8 in. drill pipe is an over-design
solution in many cases. The 6-5/8 in. drill pipe is difficult to
```

```
handle, requires excessive physical space onthe rig, can limit setback
capacity and generally requires significant rig handling equipment
modifications.In addition, 6-5/8 in. drill pipe cannot be used to drill
inside of 9-5/8 in. casing and 8-1/2 in. hole sections."
    End Sub

    Private Sub Button5_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button5.Click
        Form14.Show()

    End Sub
End Class
```

Case Studies

```
Public Class Form11

    Private Sub DataGridView1_CellContentClick(ByVal sender As
System.Object, ByVal e As
System.Windows.Forms.DataGridViewCellEventArgs)

    End Sub

    Private Sub Form11_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        'TODO: This line of code loads data into the
'Database5DataSet.CST1' table. You can move, or remove it, as needed.
        Me.CST1TableAdapter.Fill(Me.Database5DataSet.CST1)

    End Sub


    Private Sub TextBox3_TextChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles TextBox3.TextChanged

    End Sub

    Private Sub TextBox2_TextChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles TextBox2.TextChanged

    End Sub

    Private Sub TextBox1_TextChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles TextBox1.TextChanged

    End Sub

    Private Sub Button1_Click_1(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button1.Click
        TextBox1.Text = "Chirag"
        TextBox2.Text = "A19"
        TextBox3.Text = "BP Exploration"
        TextBox4.Text = "Azerbaijan"
        TextBox5.Text = "2.87(Aspect Ratio)"
        TextBox6.Text = "Rotary Drilling System-Push the Bit"
```

```
        TextBox7.Text = "5.625in S-135"
        TextBox8.Text = "1.45 SG Mud"
        TextBox9.Text = "2 x 2200HP Pumps"
        RichTextBox1.Text = "Derrick Load=940,000lbs with drawworks of 
2000HP.Power Provided=6.4MW"
        RichTextBox2.Text = "A Common Process was launched by the 
operator. The project approach utilises stage gates-Access, Appraise, 
Select, Define, Execute and Operate. This Planned approach was a key 
factor in delievering the best results from the field.Casing Floatation 
was used as the completion technique"



    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As 
System.EventArgs) Handles Button2.Click
        TextBox1.Text = "Chavyo"
        TextBox2.Text = "Z-4,Z-6"
        TextBox3.Text = "Exxon Mobil"
        TextBox4.Text = "Russia"
        TextBox5.Text = "3.6(Aspect Ratio)"
        TextBox6.Text = "Rotary Drilling System-Point the Bit"
        TextBox7.Text = "5.875in S-135(Range 3)"
        TextBox8.Text = "Not Available"
        TextBox9.Text = "4 x 1600HP Pumps(7500psi)"
        RichTextBox1.Text = "Total Rig Horsepower=12000HP with Top 
Drive Capacity of 55,000ft-lbs at 150RPM."
        RichTextBox2.Text = ""
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As 
System.EventArgs)
        PrintPreviewDialog1.ShowDialog()
    End Sub
End Class
```

Databases

Database 1.mdf
Database 2.mdf
Database 3.mdf
Database 4.mdf
Database 5.mdf
Case Studies.mdf

Database Deply Files

Case Studies.mdb.deploy
Database1.mdf.deploy
Database1_log.ldf.deploy
Database2.mdf.deploy

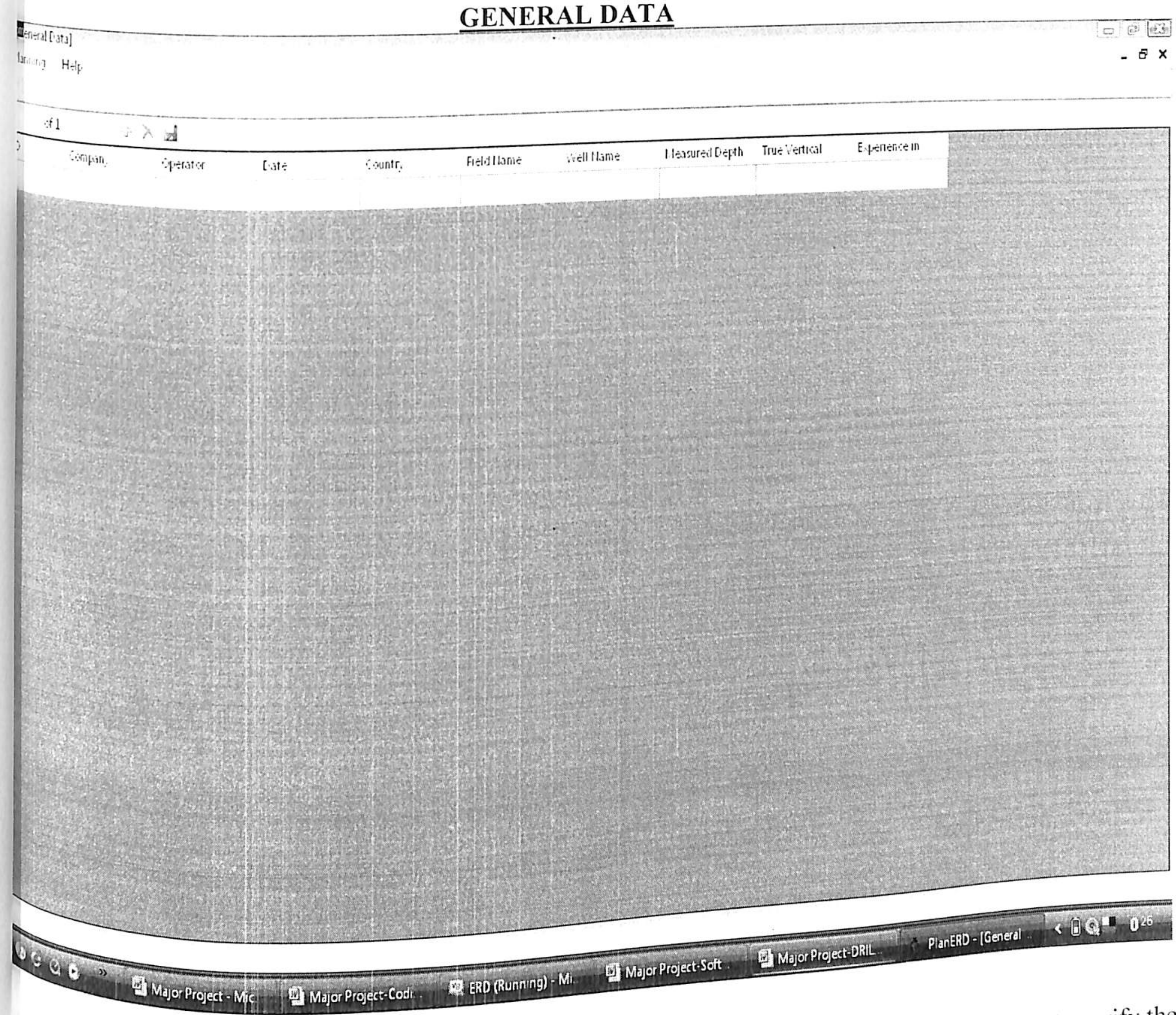
Database2_log.ldf.deploy
Database3.mdf.deploy
Database3_log.ldf.deploy
Database4.mdf.deploy
Database4_log.ldf.deploy
Database5.mdf.deploy
Database5_log.ldf.deploy

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
    <configSections>
    </configSections>
    <connectionStrings>
        <add
name="WindowsApplication1.My.MySettings.Database1ConnectionString"
            connectionString="Data
Source=.\SQLEXPRESS;AttachDbFilename=|DataDirectory|\Database1.mdf;Inte
grated Security=True;User Instance=True"
            providerName="System.Data.SqlClient" />
        <add
name="WindowsApplication1.My.MySettings.welldataConnectionString"
            connectionString="Provider=Microsoft.Jet.OLEDB.4.0;Data
Source=|DataDirectory|\welldata.mdb"
            providerName="System.Data.OleDb" />
        <add
name="WindowsApplication1.My.MySettings.Database2ConnectionString"
            connectionString="Data
Source=.\SQLEXPRESS;AttachDbFilename=|DataDirectory|\Database2.mdf;Inte
grated Security=True;User Instance=True"
            providerName="System.Data.SqlClient" />
        <add
name="WindowsApplication1.My.MySettings.Database3ConnectionString"
            connectionString="Data
Source=.\SQLEXPRESS;AttachDbFilename=|DataDirectory|\Database3.mdf;Inte
grated Security=True;User Instance=True"
            providerName="System.Data.SqlClient" />
        <add
name="WindowsApplication1.My.MySettings.Database4ConnectionString"
            connectionString="Data
Source=.\SQLEXPRESS;AttachDbFilename=|DataDirectory|\Database4.mdf;Inte
grated Security=True;User Instance=True"
            providerName="System.Data.SqlClient" />
        <add
name="WindowsApplication1.My.MySettings.Case_StudiesConnectionString"
            connectionString="Provider=Microsoft.Jet.OLEDB.4.0;Data
Source=&quot;|DataDirectory|\Case Studies.mdb&quot;"
            providerName="System.Data.OleDb" />
        <add
name="WindowsApplication1.My.MySettings.Database5ConnectionString"
            connectionString="Data
Source=.\SQLEXPRESS;AttachDbFilename=|DataDirectory|\Database5.mdf;Inte
grated Security=True;User Instance=True"
            providerName="System.Data.SqlClient" />
```

Wellpath Modeling, ECD Management, Surge and Swab, d-exponent and Torque and Drag were created in Excel and then embedded in a web page. The web page was then connected to the internal browser of the software.

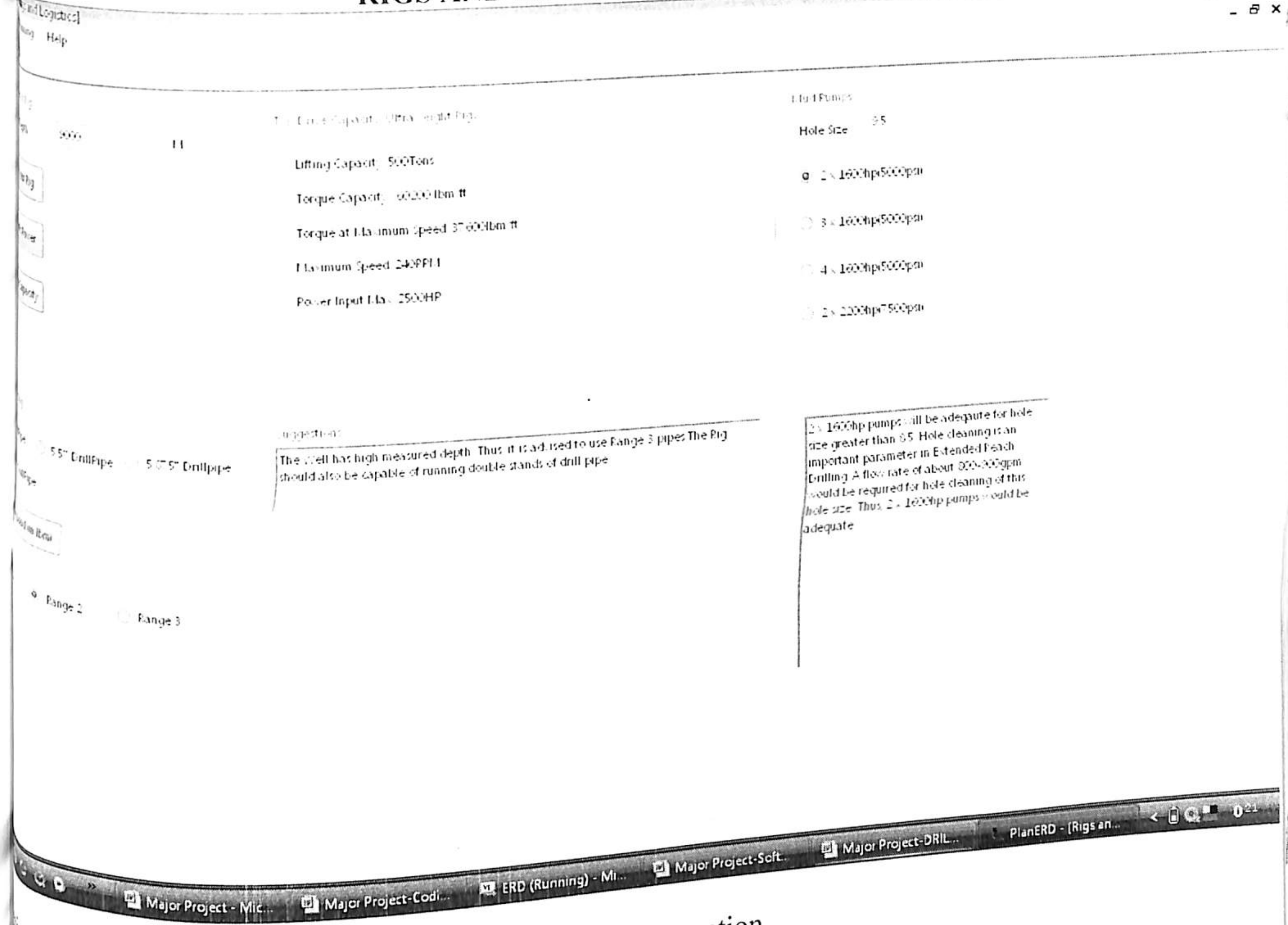
INPUT AND OUTPUT

GENERAL DATA



n enter general data about his well. He can then commit it to the database. However it is important to verify the e connection first. This can be done by checking the SQL Server/ODBE Properties in the control panel. The vould be set to active if then database connection is working.

RIGS AND LOGISTICS



ion shows the input and output for the Rigs and Logistics section.
entered 9000 Meters as the measured depth.
ggested to have an Ultraweight rig with minimum drawworks power of 3000 hp.

drive capacity was given as:

apacity: 500 Tons
Capacity: 60200 lbm/ft
Maximum Speed: 37600 lbm/ft
Sped: 240 RPM
put Max: 2500HP

e Sizing

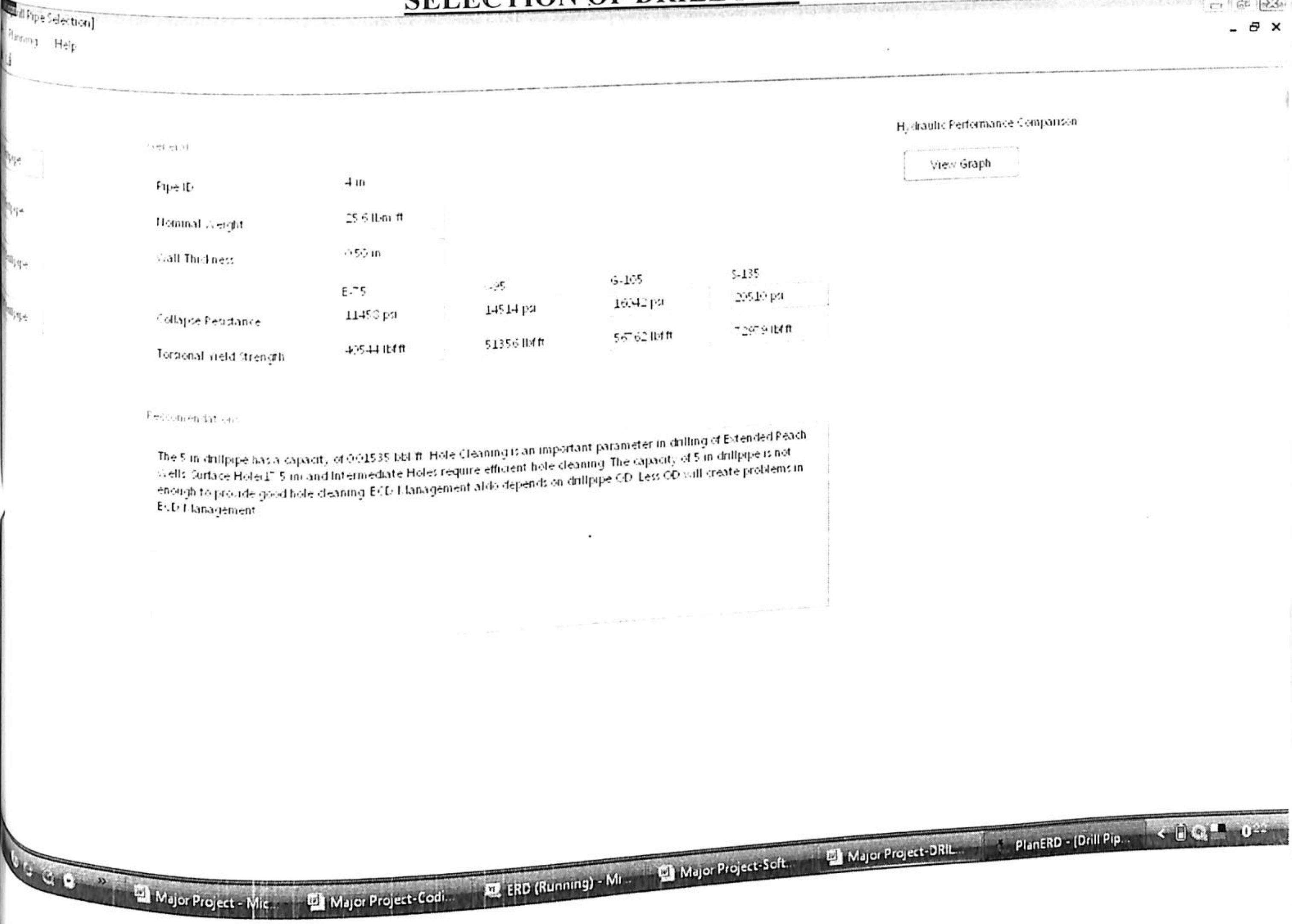
ered 5.5" range 2 drill pipe
d Load: 10774.8 lbm
ns: The well has high measured depth. Thus, it is advised to use range 3 pipes. The rig should also be capable
double stands of drill pipe.

...mps

...ered 9.5" as the hole size and 2 x 1600 HP mud pumps

...ons: 2 x 1600hp pumps will be adeqaute for hole size greater than 8.5. Hole cleaning is an important ...er in Extended Reach Drilling. A flow rate of about 800-900gpm would be required for hole cleaning of this .... Thus, 2 x 1600hp pumps would be adequate.

SELECTION OF DRILL PIPE

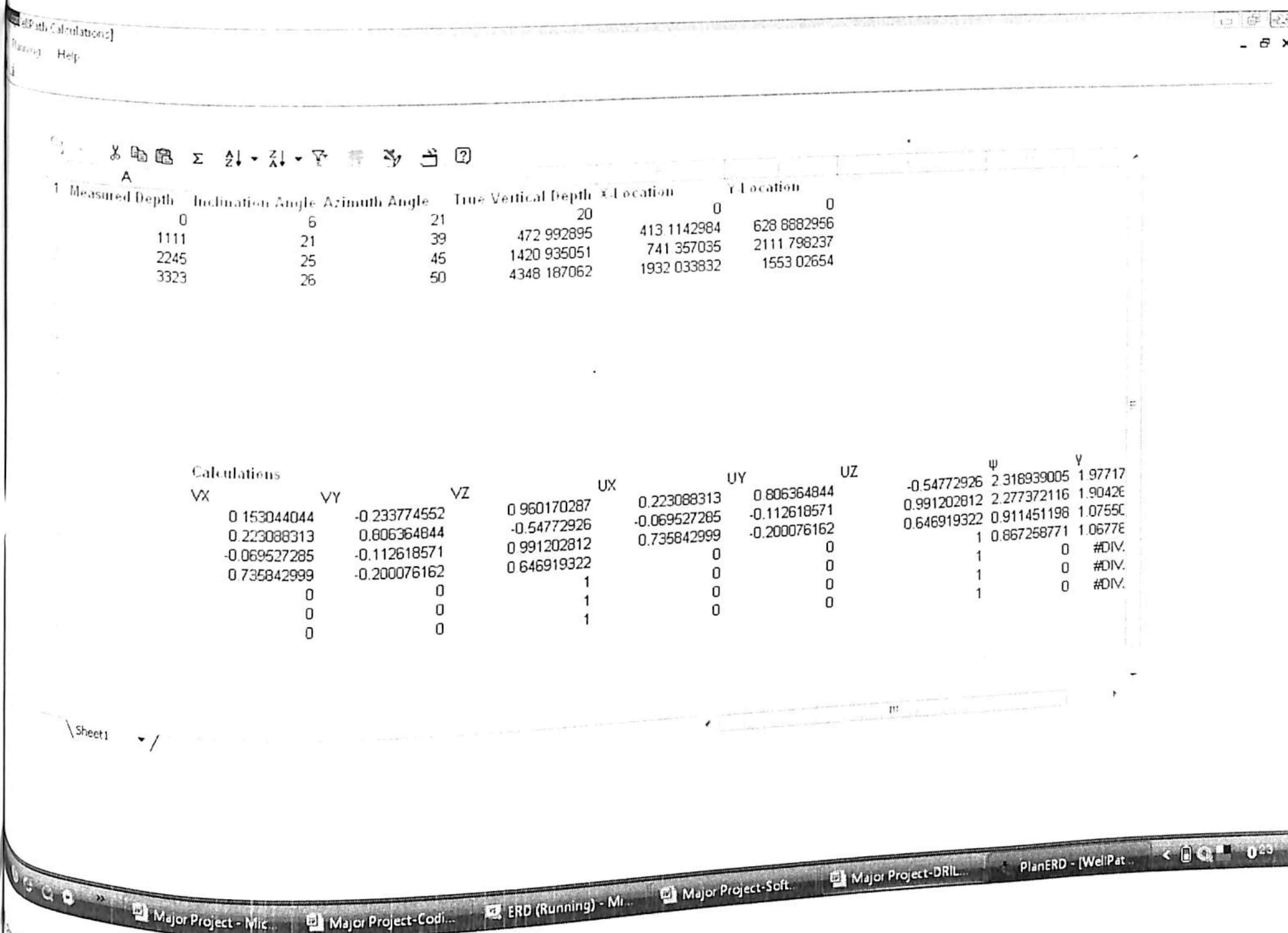


...icked on 5" drill pipe

...al Properties about the pipe were given as shown above.

...mendations: The 5 in drillpipe has a capacity of 0.01535 bbl/ft. Hole Cleaning is an important parameter in ...g of Extended Reach Wells. Surface Hole(17.5 in) and Intermediate Holes require efficient hole cleaning. The ...ity of 5 in drillpipe is not enough to provide good hole cleaning. ECD Management aldo depends on drillpipe OD. ...D) will create problems in ECD Management

WELLPATH MODELING



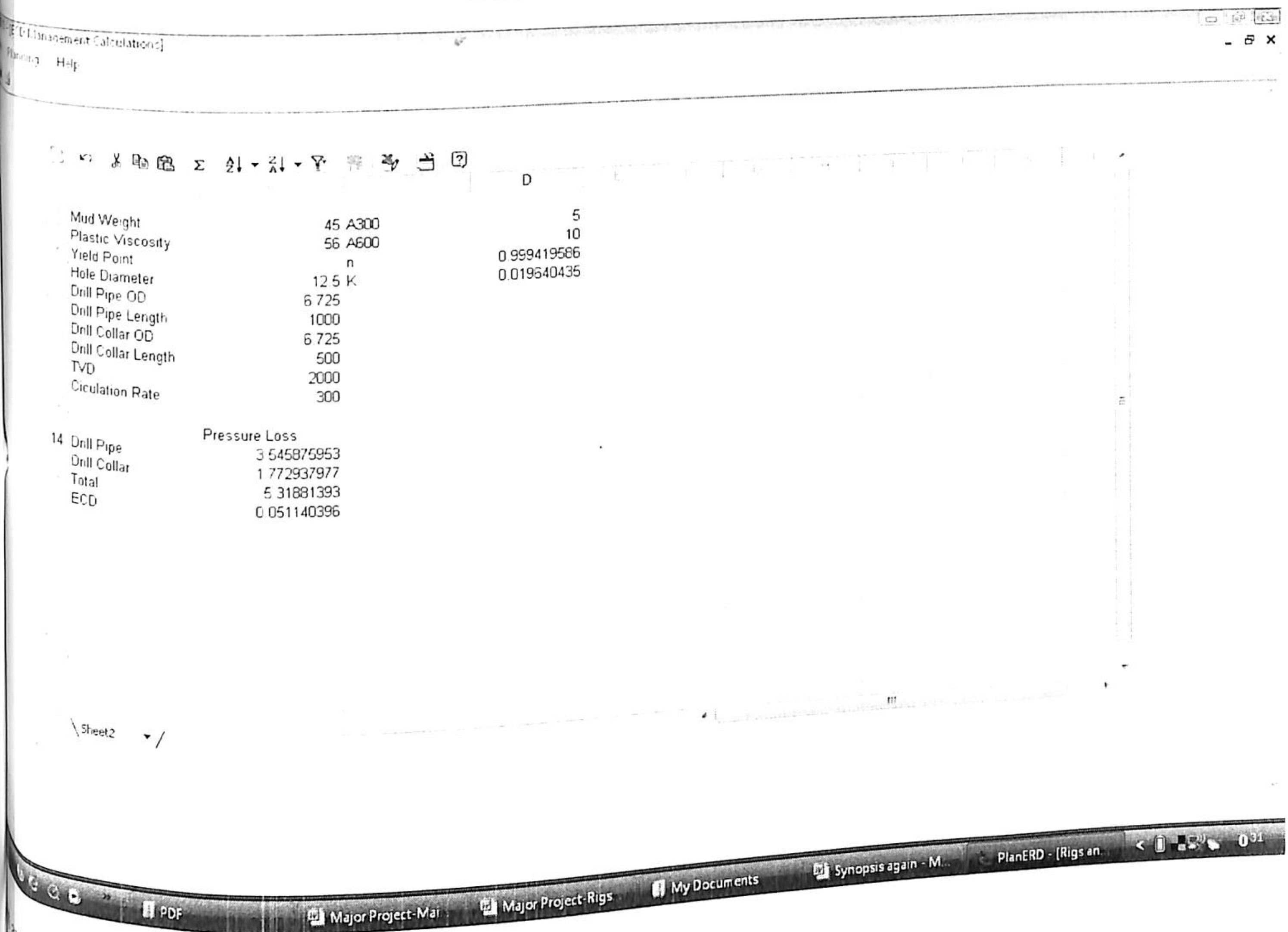
Measured Depth	Inclination Angle	Azimuth Angle	True Vertical Depth	X Location	Y Location
0	6	21	20	0	0
1111	21	39	472 992895	413 1142984	628 8882956
2245	25	45	1420 935051	741 357035	2111 798237
3323	26	50	4348 187062	1932 033832	1553 02654

Calculations

VX	VY	VZ	UX	UY	UZ	ψ	γ
0 153044044	-0 233774552	0 960170287	0.223088313	0 806364844	-0.54772926	2 318939005	1 97717
0.223088313	0.806364844	-0.54772926	-0.069527285	-0.112618571	0.991202812	2.277372116	1.9042E
-0.069527285	-0.112618571	0 991202812	0.735842999	-0.200076162	0.646919322	0.911451198	1.0755C
0 735842999	-0.200076162	0 646919322	0	0	1	0.867258771	1.0677E
0	0	1	0	0	1	0	#DIV.
0	0	1	0	0	1	0	#DIV.
0	0	1	0	0	1	0	#DIV.
			0	0	1		

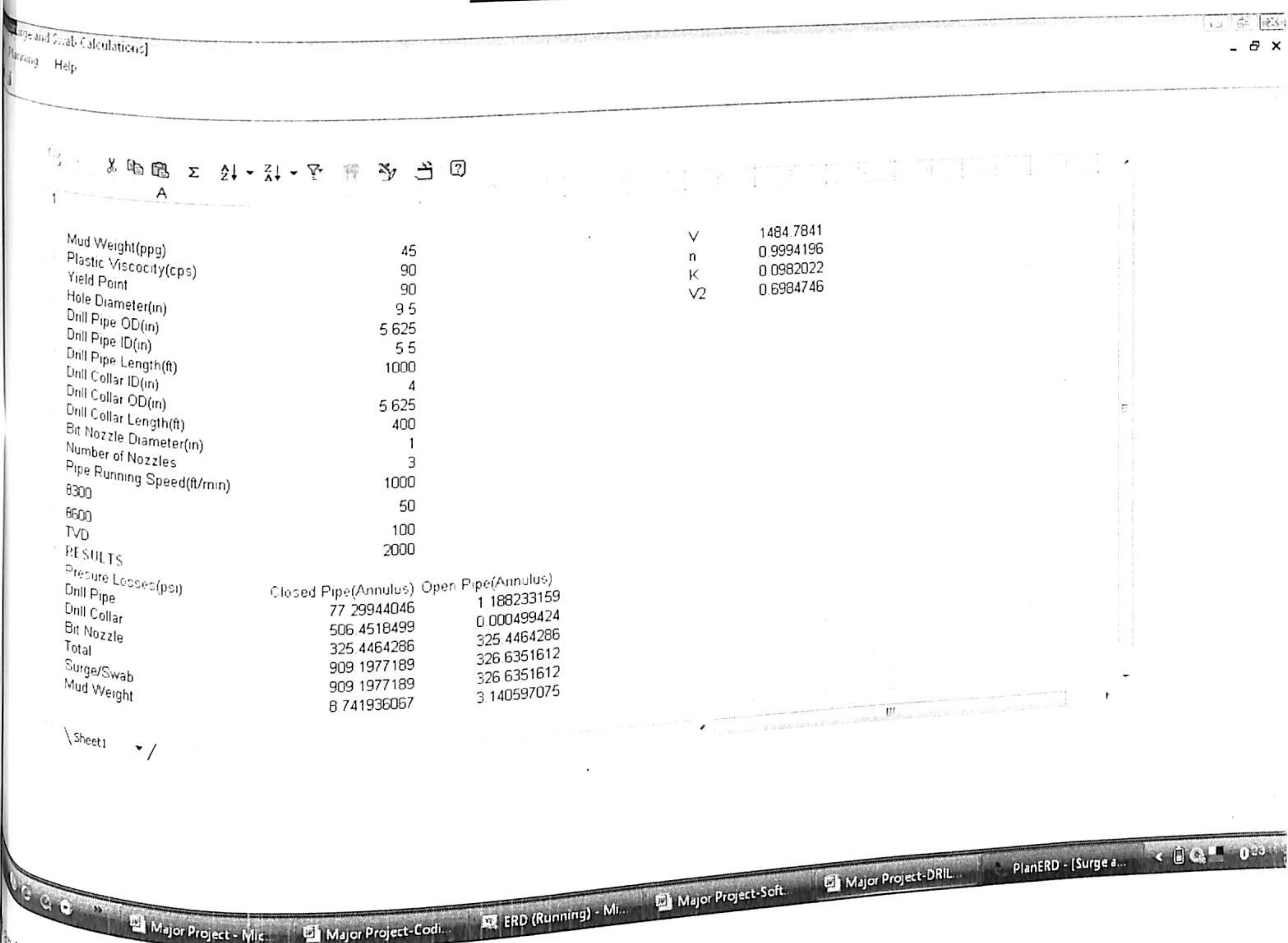
...d Output are shown above.

ECD MANAGEMENT



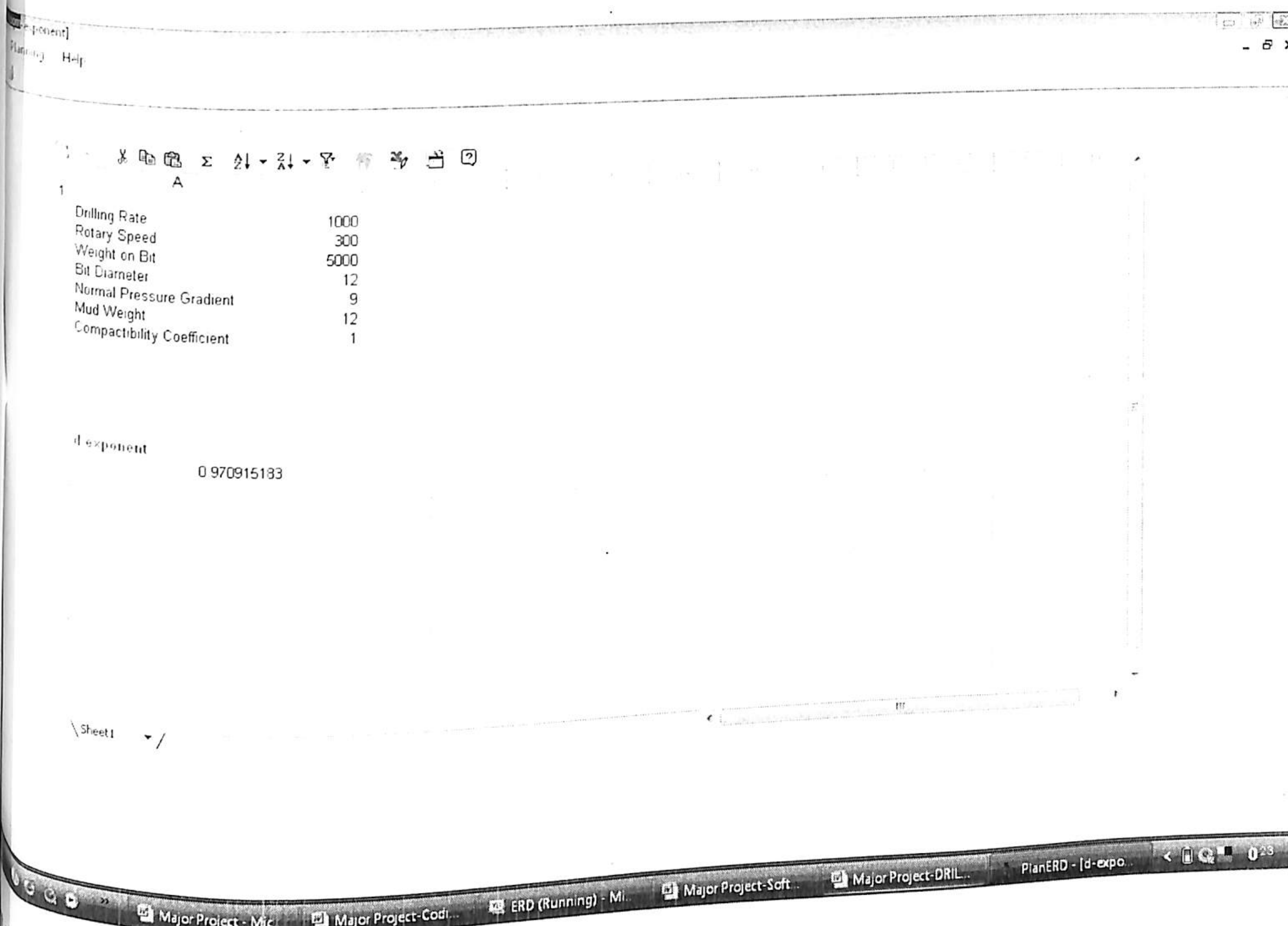
nd Output are shown above.

SURGE AND SWAB



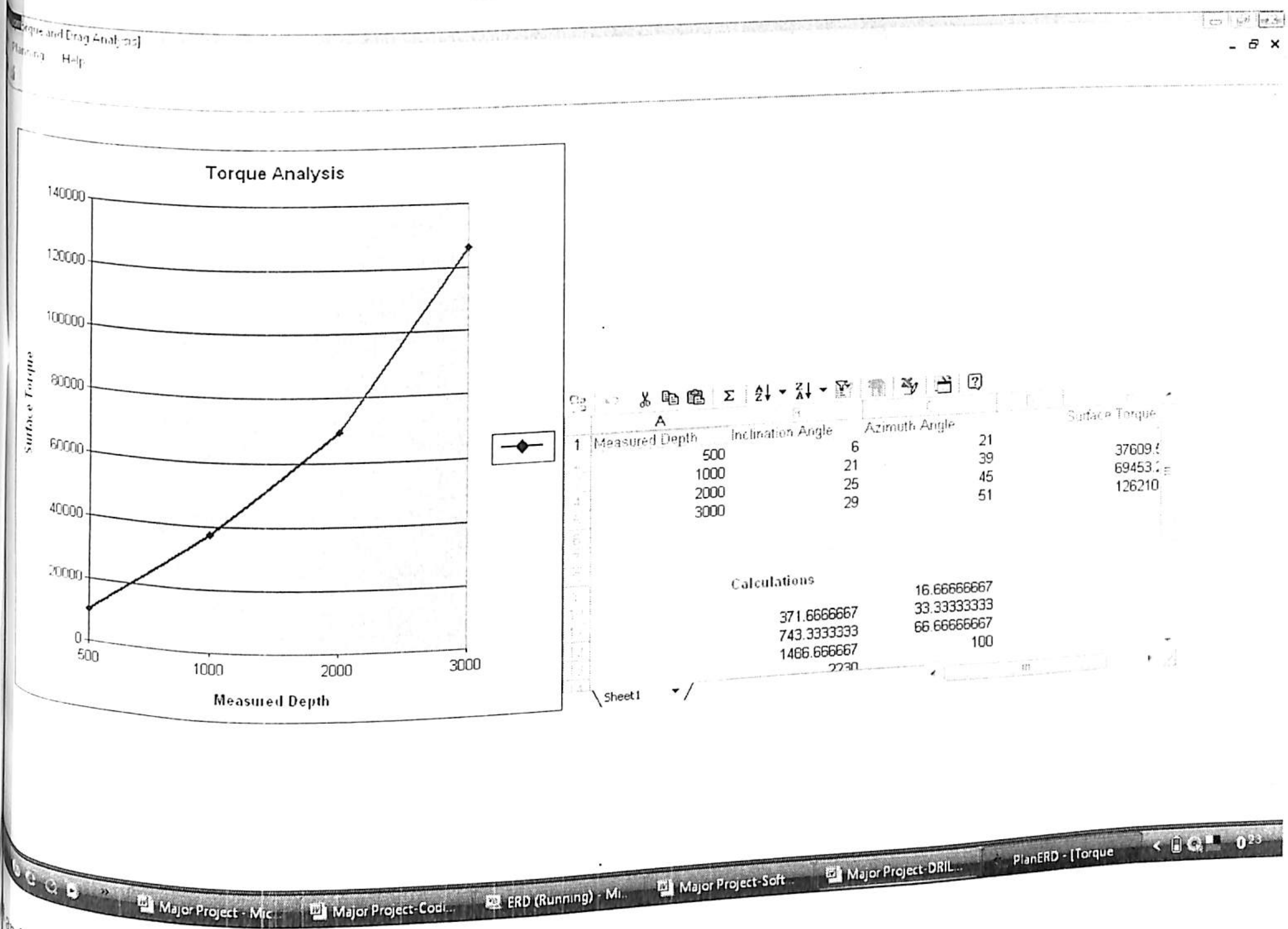
...nd Output are shown above.

d-EXPONENT



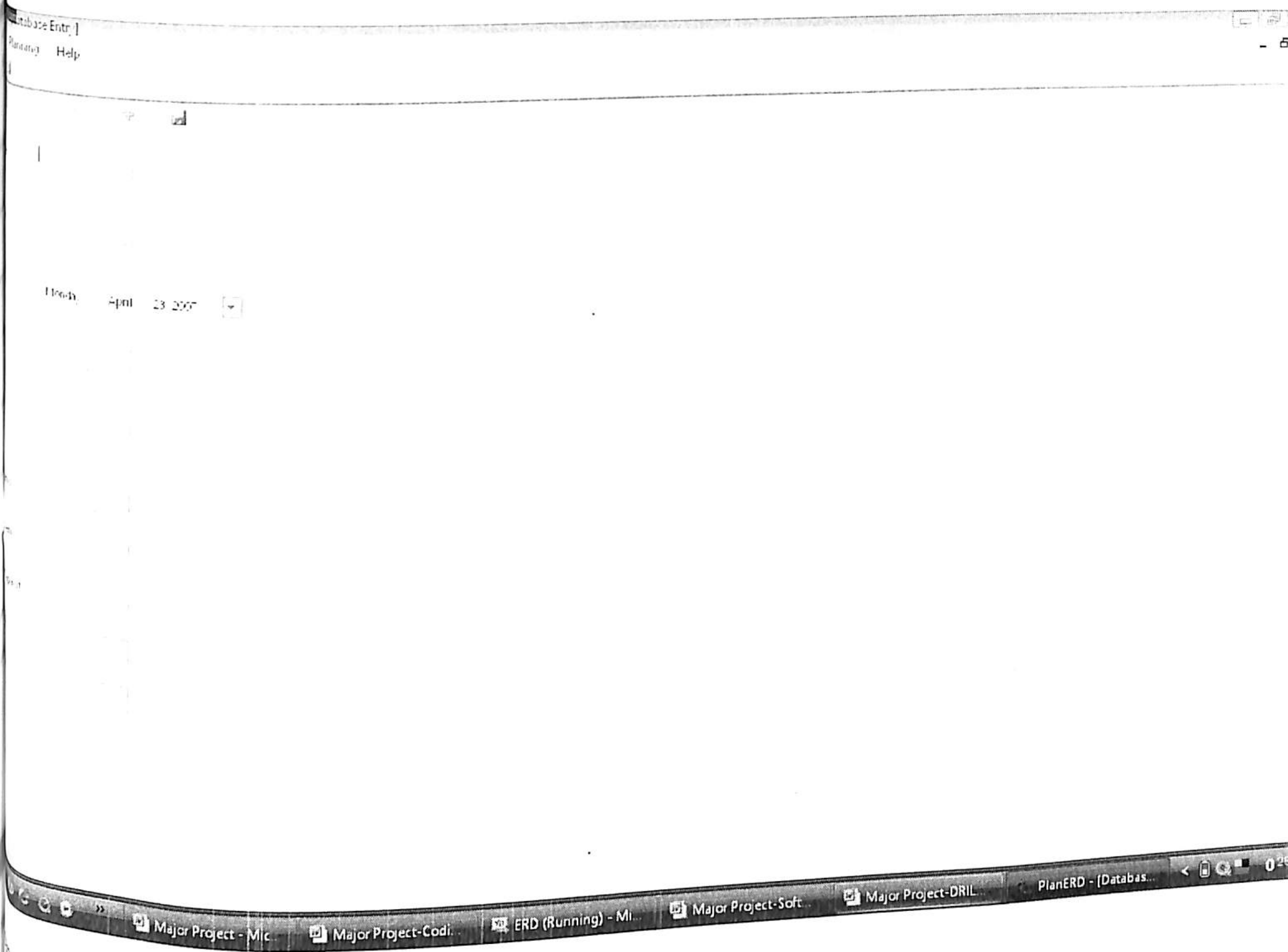
...nd Output are shown above.

TORQUE AND DRAG



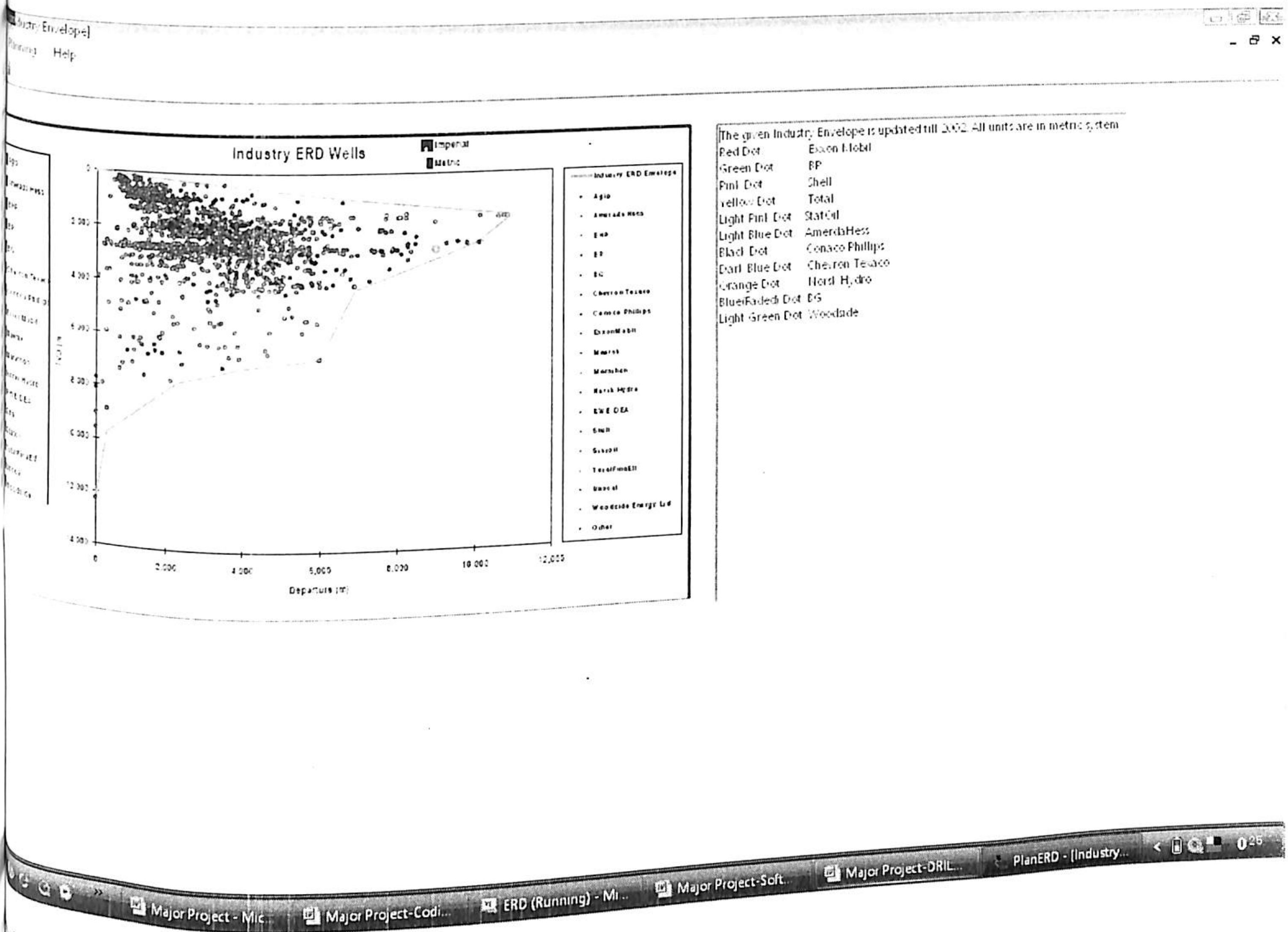
and Output are shown above.

DATABASE ENTRY



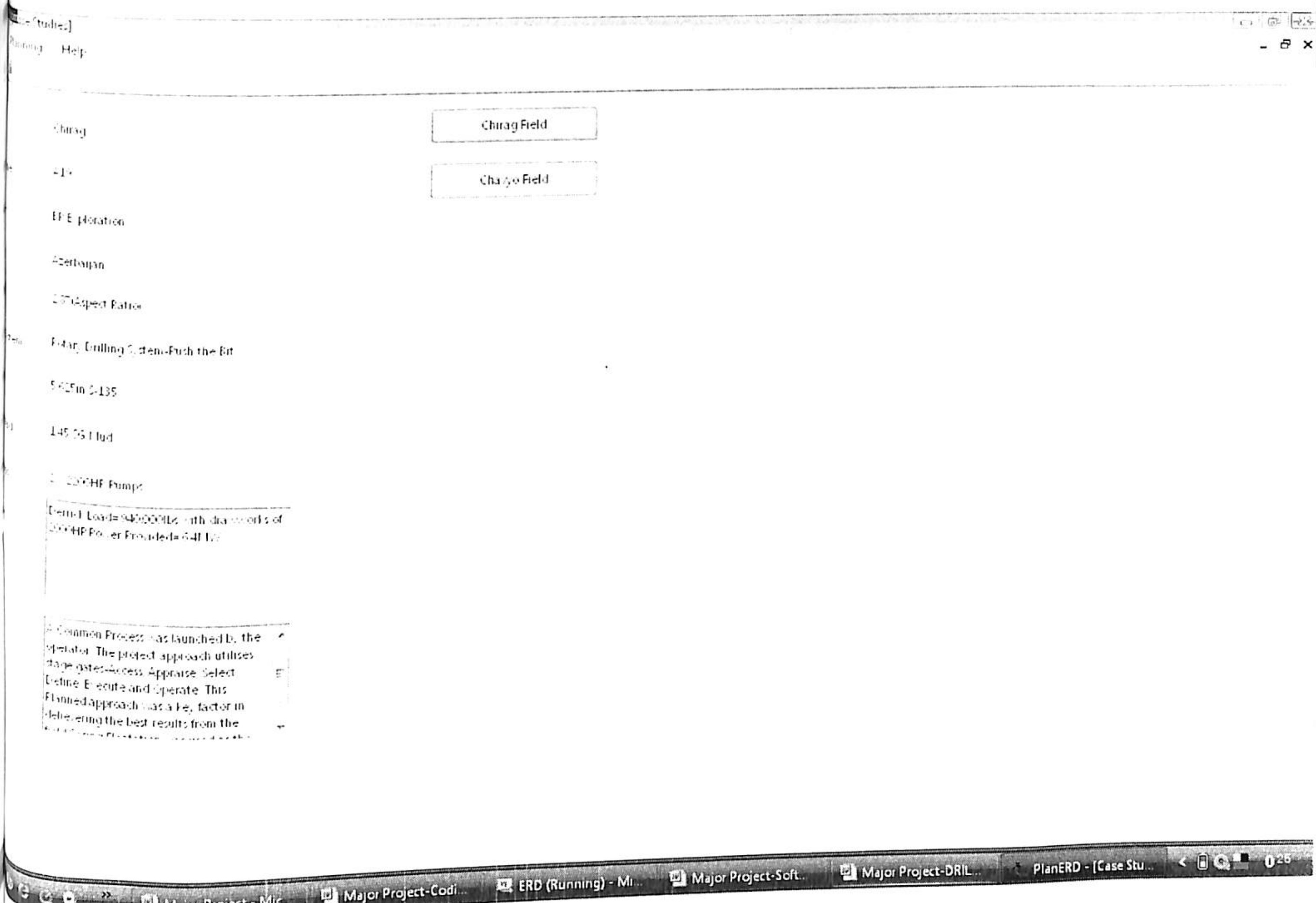
enter the data generated by the software here to commit it to the database.

INDUSTRY ENVELOPE



Envelope of ER wells.

CASE STUDIES



also learn from case studies.

CONCLUSION

ERD is a pivotal industry activity which has already provided major financial impact on a number of projects world-wide. ERD capabilities are expanding rapidly and limits for ERD with current technology remain undefined. ERD opportunities are growing rapidly. Dedicated effort will be required to access and implement expanding ERD technologies. Today oilfields are being discovered in harsh environment with the most complex conditions. Thus, it is extremely necessary to have a well planned approach for drilling the well.

Henceforth, it is necessary that the oil industry should have the best technologies and software's for handling complex situations. This software is just a step taken to achieve the above mentioned goal

With the advent of smart fields, all the systems would be automated and rigs would become man less. We should prepare ourselves for this major shift in the oil industry so that we can get the maximum of the natural resource which god has gifted to us.

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