

Master's thesis

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Inclination Control and Deviation Detection

Create Matlab agents to report wellbore Inclination and Deviation

Master's thesis in Petroleum Engineering (Drilling Specialization)
Supervisor: Pål Skalle
July 2019

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Master's Thesis (TPG 4920)

on

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Deviation

By

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Supervisor: **Pål Skalle**

Trondheim

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Abstract

Inclination or deviation related well problems are well known problems during drilling operation. These problems are like tool failure, stuck pipe, logging problem, casing running challenge and borehole cleaning problem. If they are not diagnosed in their early stage of development, they result into non-productive time (NPT). The use of RTDD and both actual and planned data from survey files were very important for determination of both inclination levels and deviation of the well path. The analysis presented in this master thesis was based on previous literary study and RTDD and/or survey file data computations.

The main objective of this master thesis was to eliminate inclination and deviation related well problems in the future such that it was necessary to create data agents in Matlab which reported both inclination level and deviation using real time drilling data (RTDD) and both actual and planned data from survey files.

From the data analysis using Matlab, estimated inclination, projection of each well in both 2D and 3D, variation of inclination and azimuth with depth, true vertical depth variation with measured depth, dogleg severity variation with measured depth, vertical and horizontal hole deviations at the end of a well and finally both vertical and horizontal hole deviation logs were determined. Moreover, outcomes associated with variation of above parameters were explained.

It was observed that both inclination and deviation calculated from RTDD and survey file data revealed the reality of the models for each wellbore as there were similar trends and nearly equal values of both actual and estimated inclinations. Also some deviation related well problems observed at some depths which have high deviation. Therefore, determination of these parameters during drilling was of vital important in order to take prior measures before installation of casing and other production equipment.

Finally the model selected to estimate inclination was valid as could provide values nearly equal to actual values, the number of loops which were used in inclination classification agent prolonged agent running time and from hole deviation logs created a driller could be able to control deviation during drilling.

Dedication

Present work is dedicated to my family, friends and fellow students for their support throughout my daily routines especially when conducting this work.

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1. Introduction

The inclined and/or deviated well is the one that is not vertical but intentionally drilled away from the vertical direction. These wells may be classified into three different classes depending on the magnitude of an inclination angle (α). Those are high inclination ($\alpha > 60^\circ$), medium inclination ($30^\circ \leq \alpha \leq 60^\circ$) and low inclination ($\alpha < 30^\circ$) wells. These wells may deviate from the plans during drilling process due to different factors involved. The knowledge on how to use the best practices and optimize the drilling process is important when drilling the inclined/deviated wells. The desired information that may prevent problems related to the inclined and deviated wells is of vital importance in order to minimize non-operational time during drilling.

1.1. Research Problem

Different problems are encountered when drilling the inclined or deviated wells. Such problems are like tool failure, stuck pipe, logging problem, casing running challenge and borehole cleaning problem. In the worst case they may lead to an unwanted stop in the drilling operation, sidetracking or abandonment of a well. It is therefore necessary at any time of the operation to know the inclination level and well path deviation from the plan.

1.2. Research Objectives

The main objective of this work is to eliminate the inclination/deviation related well problems in the future. A more specific objective is to be able to predict and detect level of inclination and deviation of the path, automatically to avoid unexpected and unwanted incidents during drilling operations.

1.3. Plan to reach the objectives

To reach the objectives, present master thesis describe the inclined/deviated wells, inclination and/or deviation effects on the different well operations and ways of solving inclination/deviation related well problems in logic steps. Such steps are learning relevant experience from previous publications, develop methods to solve selected problem, build up case data in which Matlab program is proposed to estimate both the inclination and deviation and finally validation of results can be done by comparing the estimated and actual values. Also

deviation of the actual well-path from the plan can be verified by observation of different problems encountered at respective depths which can be the result of unacceptable deviation.

2. Relevant published knowledge

In order to understand the effects of inclination and deviation on wellbore operations, the physics on how these parameters are measured and their behaviors are important. In this chapter the following aspects are discussed:

- Inclination and deviation
- The reasons for drilling inclined/deviated wells
- Well planning
- Factors affecting inclination and/or deviation
- Negative effects of wellbore inclination and deviation on the drilling operation
- Inclined/deviated wellbore problems detection and
- Countermeasures towards inclination/deviation related problems.

2.1. Inclination and deviation

2.1.1. Inclination definition

Inclination is the angle of the deviation of a wellbore from the vertical path. The deviation of a wellbore from the vertical is measured in degrees. Many times wellbores are drilled with an inclination; such drilling is called directional drilling. A directional well profile is the planned well trajectory from the surface to the final drilling depth (Petropedia, 2019).

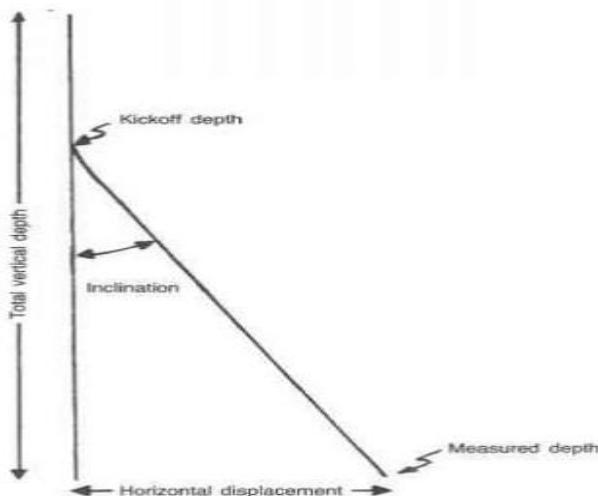


Figure 1: Example of inclination in a well path (Netwasgroup, 2016).

2.1.2. Hole deviation definition

Hole deviation is the unintentional departure of the drill bit from a pre-selected borehole trajectory. Presence of deviation during drilling a straight or curved hole section can lead to drilling problems with associated higher drilling costs (PetroWiki, 2019).

Since the early second half of the twentieth century, many theories have been advanced to explain hole deviation. The significant work has been in drillstring mechanics and has resulted in the design of drillstring to control the rate of change of hole angle for example an advent of steerable rotary directional drilling tools (McLamore, 1971).

Hole deviation provides working knowledge of spatial differences between the actual drilled hole and the planned path of the wellbore. Different components are used to define hole deviation, these are linear and angular differences and the relative changes between the actual drilled hole and the planned path (Stoner, 1999).

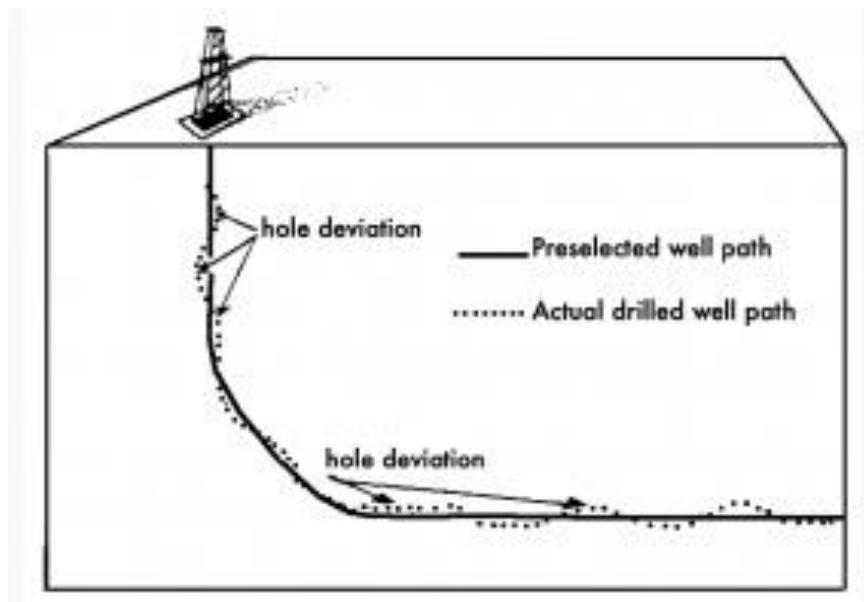


Figure 2: Example of hole deviations (PetroWiki, 2019)

2.1.3. Factors affecting wellbore inclination and deviation

There are many factors that are taken into consideration while observing the trend of wellbore inclination and deviation during drilling of oil and gas well. In this section, factors affecting these parameters while drilling are discussed below:

a) Dip of the formation

Dip. This is the angle between a planar feature such as a sedimentary bed or a fault, and a horizontal plane. True dip is the angle a plane makes with a horizontal plane, the angle being measured in a direction perpendicular to the strike of the plane (Schlumberger2, 2018). Dip of the beds through which the hole is drilled make the bit drill up dip in hard rocks, consequently the direction of drilling is different from the direction of the force on the bit (Lubinski & Woods, 1953).

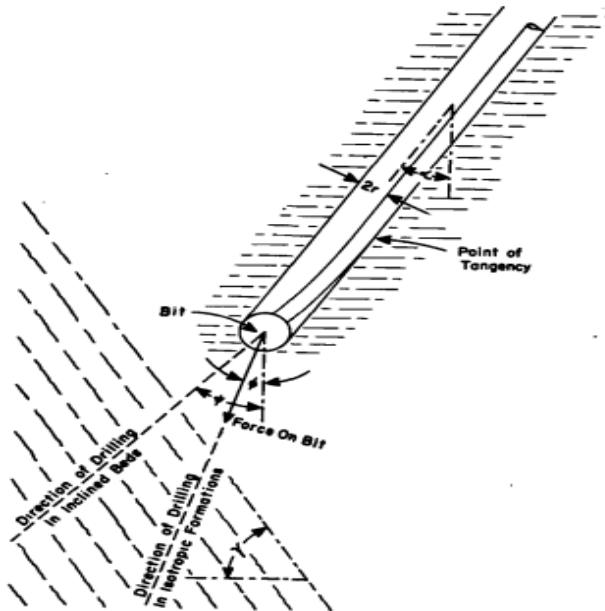


Figure 3: Inclined hole drilled into inclined formation (Lubinski & Woods, 1953)

b) Anisotropic nature of formation

According to (McLamore, 1971), one of the causes of hole deviation is the nature of the rock failure under the bit. When a conventionally shaped wedge penetrates a dipping laminated anisotropic rock, the chips formed on each side of the wedge are not equal in size. This is in contrast with the behavior of the homogeneous and isotropic rocks hence bit departure is created.

c) Hole clearance

In drilling small diameter holes, drill-collars used almost completely fill the hole such that small clearance between the drill-collars and the wall of the hole is observed. In such condition there is small ability of the collar string to deflect in contacting the wall of the hole hence less deviation of borehole as the increases in clearance results in increase in the angle of application of weight on bit which contributes to deviation (Speer & Holiday, 1955).

d) Drill bit type and its basic mechanical design

Different types of bits differ in their ability to drill in the axial and lateral directions. There are a number of different types of drill bits. Steel tooth rotary bits are the most common types of drill bits while Insert bits are steel tooth bit with tungsten carbide inserts, for example Polycrystalline Diamond Compact (PDC) bits which use synthetic diamonds attached to the carbide inserts.



Figure 4: PDC bit (Brechan, Corina, Gjersvik, Sangesland, & Skalle, 2017)

e) Weight on bit (WOB)

WOB has effects on borehole inclination when there is clearance between the drill collar and the hole. Whenever extreme weights are applied to the bit, higher deviation angle for the borehole will be observed resulting from drill collar buckling (Murphey & Cheatham Jr., 1966). Whereas sudden drop of weight on bit reduces inclination angle (Wilson, 1981).

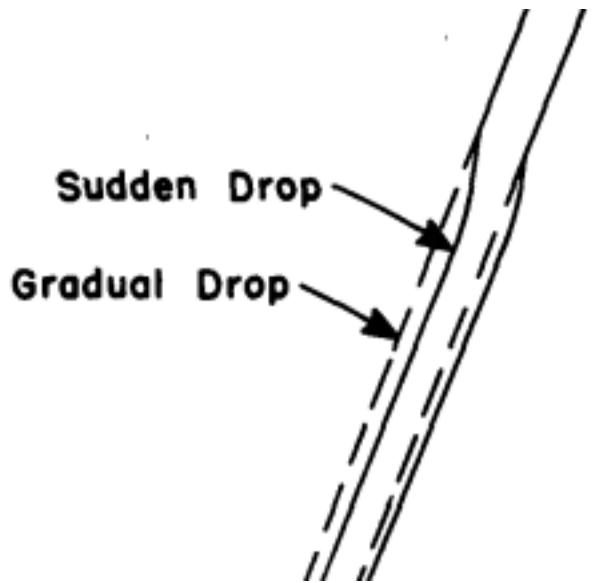


Figure 5: Drop of inclination due to decrease of WOB (Lubinski & Woods, 1953)

f) Drill collar size

During drilling a straight inclined hole, the drill collar string deflects to the low side and contacts the wall of the hole at some point above the bit. When there is no weight on the bit, the force acting on the bit is the resultant weight of the drill collars below the contact point. This force tends to reduce the deviation angle of the borehole back to vertical (Speer & Holiday, 1955). The larger the drill collar diameter used, the heavier the drill-collar string hence large lateral force to increase WOB (Wilson, 1981).

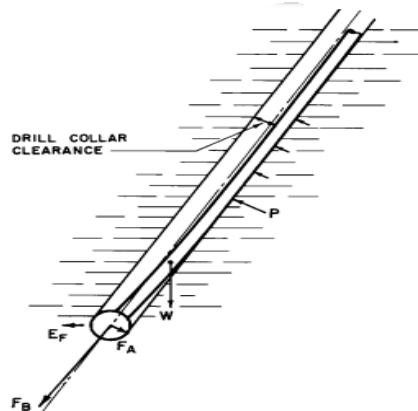


Figure 6: Drill Collar deflected on lower side of the borehole (Speer & Holiday, 1955)

g) Type of circulating medium used (air/gas or fluid)

The use of air as a circulating medium makes the bit more effective in making hole thus it drills crooked faster. Erosion of some formations by turbulent air flow allows the bit to drill crooked and greater shock loads or deflection at the bit are experienced because there is no liquid in the hole to cushion the drill collars (Wilson, 1981).

h) Formation drillability

Due to difference in drilling rates in hard and soft dipping formations, the angle of the hole changes because the bit drills slower in hard formation than in soft. This theory is based on the assumption that the bit weight is distributed uniformly over the bottom of the hole and predicts up-dip deviation when drilling into harder rock and down-dip in softer rock (Murphrey & Cheatham Jr., 1966).

2.1.4. Control of hole deviation

For drilling oil/gas well efficiently under effective cost optimization, different techniques are used to control deviation. Below are some of the deviation control techniques used in oil industry:

a) Application of pendulum assembly

The pendulum assembly makes use of gravity to control hole angle as the weight of drill collars between the fulcrum point and the bit pull the bit back toward vertical when lighter weight is applied to the bit (Wilson, 1981).

b) Packed hole assembly application.

Packed hole assembly uses drill bushings (stabilizers) to force the bit straight ahead in the same direction as the hole already drilled (Wilson, 1981). This is supported by (MacDonald & Lubinski, 1951) who suggested the use conventional stabilizers to permit greater bit weights to be carried without drill collar buckling.

c) Use of heavy metal collars

Since reduction of the weight on bit provides one of the major techniques for controlling or reducing hole angle for straight inclined holes. This results in lower penetration rates and increased drilling costs such that for a driller to maintain required penetration rate, addition of a heavy metal collar to the drill collar string is required to allow more weight to be applied to the bit while maintaining the same hole angle. The increase of hole deviation with increased weight on bit must be resisted by increased lateral force on the bit. This lateral force is supplied by the pendulum behavior of the drill collars. The longer the pendulum length and the heavier the pendulum, the higher the lateral force will be to resist deviation (Bradley, Murphey, McLamore, & Dickson, 1976).

d) Stabilizer positioning

Stabilizer placement with respect to the bit for optimum control of deviation varies with drill collar size, drill collar and stabilizer clearance, hole angle, and weight on bit. For example Optimum stabilizer position for 9 ½-in. drill collars in 10 5/8-in. hole, 10 3/4- in. stabilizer and 35,000 lb +/- weight on bit is approximately 70 ft above the bit (Speer & Holiday, 1955).

e) Minimization of clearance between the drill-collar and the borehole

This can be achieved by means of means of ribs on round drill collars or by use of square drill-collars, for example 7- by 7-in. square drill-collar which has the same stiffness as an 8-in.circular drill-collar. Through this technique, the deflection of drill-collar above the bit is reduced such that can result in the decrease of deviation angle (Murphey & Cheatham Jr., 1966).

2.2. Reasons for drilling Inclined/deviated Wells

Inclined wells are mainly drilled for several purposes basing on production and safety requirements (Wikipedia, 2018).

- a) From production perspective, inclined wells increases the exposed section length through the reservoir by drilling through the reservoir at an angle.
- b) Also drilling into the reservoir where vertical access is difficult or not possible for instance, an oilfield under a town or under a lake.
- c) Allows more wellheads to be grouped together on one surface location to allow fewer rig moves and make it easier and cheaper to complete and produce the wells. For instance an oil platform or jacket offshore, 20 or more wells can be grouped together.
- d) For safety purposes drilling a relief well to relieve the pressure of a well producing without restraint (well with a blowout). In this scenario another well could be drilled starting at a safe distance away from the blowout, but intersecting the troubled wellbore. Then, heavy fluid (kill fluid) is pumped into the relief wellbore to suppress the high pressure in the original wellbore causing the blowout.

2.3. Well Planning

The planning of a directional well is done to design the wellbore path or trajectory to intersect a given target. The initial design should consider the various types of paths that can be drilled economically. Most common types of wellbore paths/profiles are

- a) Build and hold
- b) Build–hold and drop, and
- c) Continuous build.

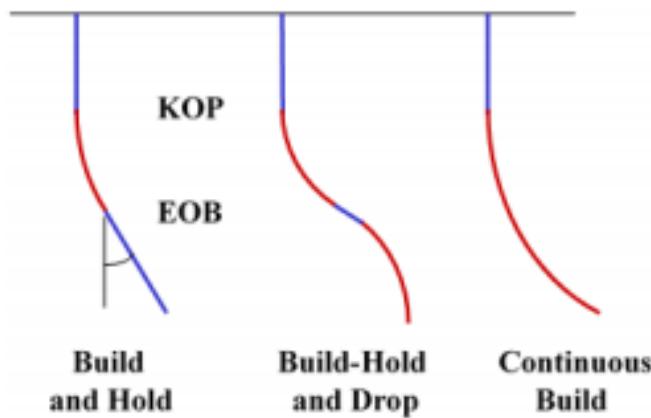


Figure 7: Most common types of wellbore profiles (Brechan, Corina, Gjersvik, Sangesland, & Skalle, 2017).

2.3.1. Parameters defining the well path

There are three specific parameters which must be considered when planning the wellbore profile. These parameters combine to define the trajectory of the well:

- a) **Kick-off point:** This is the long hole measured depth at which a change in inclination of the well is initiated and the well is oriented in a particular direction (in terms of north, south, east and west). In general the most distant targets have the shallowest KOPs in order to reduce the inclination of the tangent section of the well. It is generally easier to kick off a well in shallow formations than in deep formations. The kick-off should also be initiated in formations which are stable and not likely to cause drilling problems such as unconsolidated clays.

- b) Build-up and drop off rate (in degrees of inclination):** These are the rates at which the well deviates from the vertical (usually measured in degrees per 30 m or 100 ft). The build-up rate is chosen on the basis of previous drilling experience in the location and the tools available, but rates between 1° and 3° per 30 m or 100 ft of hole drilled are most common in conventional wells. Build up rates in excess of $3^\circ/30\text{ m}$ are likely to cause doglegs when drilling conventional deviated wells with conventional drilling equipment. The build-up rate is often termed the dogleg severity (DLS).
- c) Tangent angle of the well (or drift angle):** This is the inclination (in degrees from the vertical) of the long straight section of the well after the build-up section of the well. This section of the well is termed the tangent section because it forms a tangent to the arc formed by the build-up section of the well. The tangent angle will generally be between 10° and 60° since it is difficult to control the trajectory of the well at angles below 10° and it is difficult to run wire line tools into wells at angles greater than 60° .

2.3.2. Target and geography

The trajectory of a deviated well must be carefully planned so that the most efficient trajectory is used to drill between the rig and the target location and ensure that the well is drilled for the lowest cost. When planning and drilling the well, the position of all points along the well-path trajectory is considered in three dimensions (Figure 8). The three dimensional system that is generally used to define the position of a particular point along the well path is:

- a) The vertical depth of the point below a particular reference point (TVD).
- b) The horizontal distance traversed from the wellhead in a northerly direction (N).
- c) The distance traversed from the wellhead in an easterly direction (E).

The depth of a particular point on the well path referred to as true vertical depth (TVD) is expressed in meters (feet) vertically below a reference (datum) point. The northerly and easterly displacements of the point horizontally from the wellhead are reported as Northing/easting or latitude/ longitude.

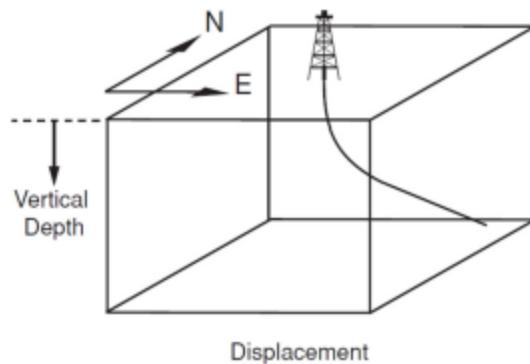


Figure 8: Well planning reference systems

2.3.3. Defining the well path

After fixing the target and the rig position, the next stage is to plan the geometrical profile of the well to reach the target. As stated earlier in section 2.3, there three different types of wellbore profiles but the most common one is the build and hold profile which consists of 3 sections, vertical, build-up and tangent. The trajectory of the wellbore can be plotted when the following points have been defined:

- a) kick-off point(KOP) (selected by engineer)
- b) TVD and horizontal displacement of the end of the build-up section; and
- c) TVD and horizontal displacement of the target (defined by position of rig and target).

In addition to necessary points defined, the driller will only be able to determine the long hole depth of the well such that the following information will also be required:

- a) A long hole depth of the KOP (same as TVD of KOP)
- b) Build up rate for the build-up section (selected by engineer)
- c) Direction in which the well is to be drilled after the KOP in degrees from north (defined by position of rig and target)
- d) A long hole depth (AHD) at end of build (EOB) and the tangent section commences and
- e) A long hole depth (AHD) of the target.

2.3.4. Requirements to Trajectory Planning Models

A well is constructed in several intervals as predetermined casing points are set to support formation pressure and increase wellbore stability. Figure 9 shows a typical well and the different casing points where the red lines illustrate offset or already drilled wells. There are different type of requirements and typical aspects each section haves. Some of these are;

- a) 30" Conductor Casing
- b) 20" Surface Casing
- c) 13 3/8 " Intermediate Casing and
- d) 9 5/8 Production Casing

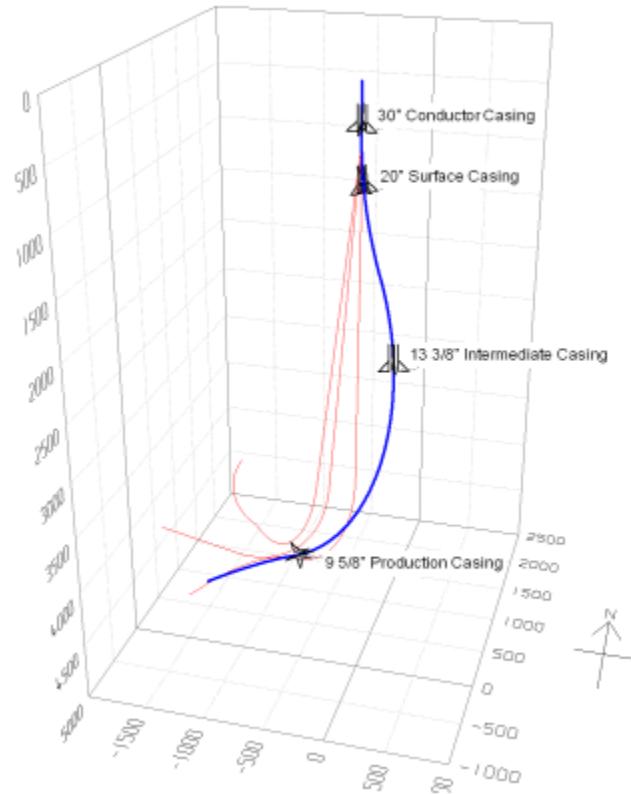


Figure 9: Typical well, Casing Points and Anti-collision (Compass) (Strømhaug, 2014)

2.3.5. Some basics of constructing a well path

2.3.5.1. Inclination measurement

The inclination is measured from zero degrees vertical and upwards to 90 degrees. Figure 10 shows how the well can deviate from the vertical axis creating what is called a deviated well.

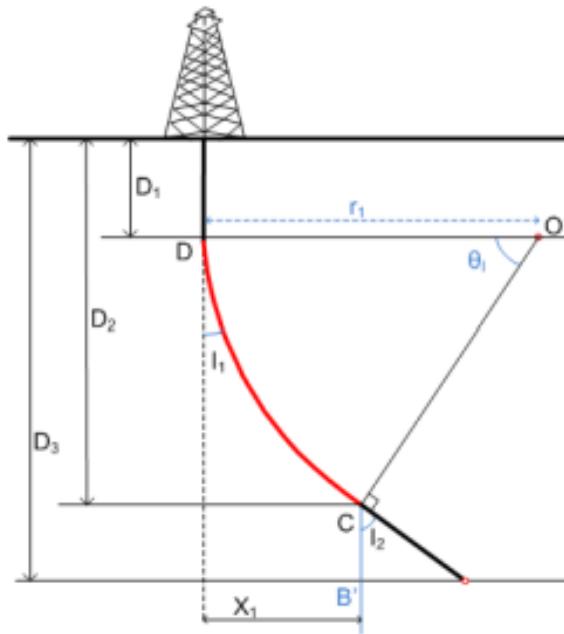


Figure 10: Wellbore Inclination from vertical axis (Strømhaug, 2014)

The amount of change or the degree of how fast the well builds from vertical is given by the build rate. Build rate is given in degrees/30m or 100 ft. This means that if a section has a build rate of 3 deg/30 m, the inclination of the well path would increase with 3 degrees for every 30 m of drilled length or measured depth (MD). The total change in inclination of a section represented as ϕ in figure 10 is called the dogleg of the section. It is simply given by equation 1

$$\phi = I_2 - I_1 \quad (1)$$

The inclination change will follow a circular arc with radius r which is illustrated in figure 10. The relationship between the radius r and the build rate B can be found by referring to circle with radius r and curve length (CL):

$$r = \frac{180 * 30}{\pi * B} \quad (2)$$

The curve length can then be described by:

$$CL = \frac{r * \pi(I_2 - I_1)}{180} \quad (3)$$

2.3.5.2. Azimuth

The borehole can be represented by 360 degrees. By looking down the well it can go in any direction of this 360 degree circle where north is 0 or 360 degrees, directly east 90 degrees and west 270 degrees. This circle compass is now lying flat in the plane of north/south and east/west. This amount of direction change is called the azimuth (A) to show the direction change in the horizontal plane. Figure 11 illustrates how the azimuth or well path is changing in the horizontal plane.

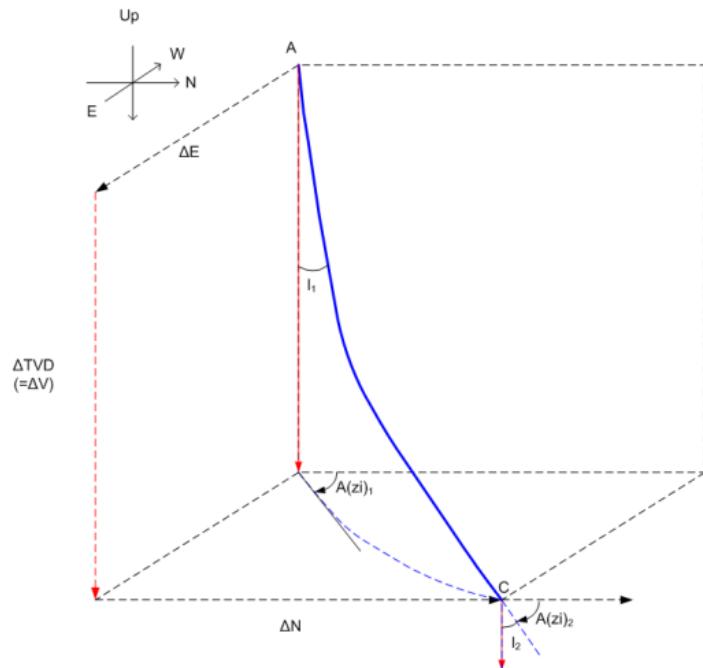


Figure 11: Inclination and Azimuth (Brechan, Corina, Gjersvik, Sangesland, & Skalle, 2017)

2.3.5.3. Dogleg Severity

The dogleg severity is directly connected to dogleg angle and given by equation 4, given in deg/30 m. This is a very important parameter as it describes the curvature of the well path and is directly linked to the bending force of the pipe. As wells curve there will be bending forces on the drill pipe that can cause a number of problems such as drill pipe failure, stuck pipe problems, under drilling, casing wear and wellbore instability. For this reason the dogleg severity will often act as a limitation to what kind of well path can be chosen.

Drill pipes, casings, wellbore stability and safety factors related to stuck pipe often have a set value of tolerated dogleg severity. High build and turn rates will obviously lead to high dogleg severity and that is why sharp turns and builds should be avoided. DLS is given as:

$$DLS = \frac{\phi * 30}{CL} \quad (4)$$

2.4. Negative effects of wellbore inclination and deviation on the drilling operation

Drilling of inclined/deviated wells normally results in the most difficult and costly problems in the drilling industry despite the developments and improvements of drilling tools and technology. Lack of knowledge of the change in wellbore inclination/deviation during and after drilling cause different problems depending on the level of inclination:

a) Wellbore instability

Since borehole-inclination produces alterations in the stress state around the borehole and in the physical properties of the rock such that the strength of the rock is reduced. Therefore inclined wells may be prone to mechanical instability problems associated with the in-situ stresses in the field. For instance when drilling through highly layered formations wellbore tensile failure and plastic shear deformations occurs (Ostadhassan, Jabbari, Zamiran, Osouli, Oster, & Lentz, 2014)

b) Casing running problem

Casing running challenges for extended reach (highly inclined) wells especially for long production casing strings. This is determined as one of the most critical well operations such that failure to reach target depth often has negative impacts on well deliverability and overall cost resulted from non-productive time (NPT) (Bybee, 2004).

c) Logging problem

Logging using coiled tubing for highly inclined wells may be associated with challenges compared to logging in vertical wells. Working in horizontal wells caused the industry to start analyzing the loads on a coiled tubing string for specific well conditions and the challenge is tubing buckling due to the compression arising from the accumulated friction drag in highly deviated sections (Mark Corrigan, C. Hoyer, & C. Gaston, 1991).

d) Stuck pipe

Stuck pipe is one of the major causes of lost time and added cost worldwide. This happens mostly in inclined and deviated wells as the wellbore geometry supports sticking of drill string. Situations like key seating, poor hole cleaning and wall forces cause pipe to get stuck in these wells.

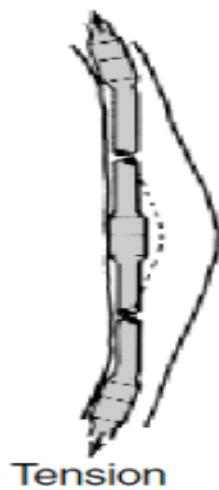


Figure 12: Example of Key seating (Brechan, Corina, Gjersvik, Sangesland, & Skalle, 2017).

e) Poor hole cleaning

During hole cleaning in deviated and/or deviated wells, the fluid velocity has a reduced vertical component so the cuttings will have only small distance to fall before resting on the bottom. This decreases the mud's capability of suspending drilled cuttings and it results in an increased tendency for particles to settle out of suspension.

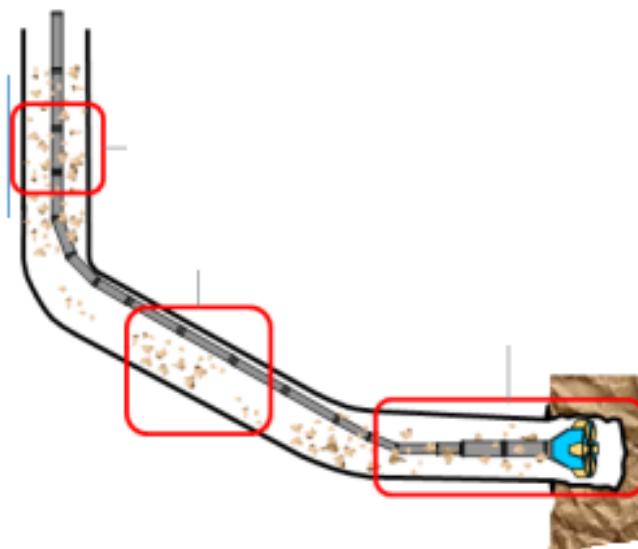


Figure 13: Hole cleaning regimes in inclined well (Brechan, Corina, Gjersvik, Sangesland, & Skalle, 2017)

2.5. Detections of Inclined/deviated wellbore problems

In order to solve wellbore failures/problems associated with inclination or deviation, such problems need to be detected and well understood for better interpretation of them. Practically detection of these problems is done under surveillance through Real-Time Drilling Data (RTDD). During drilling three possible process states are observed by surveillance as illustrated in figure 14. These are Normal state, Error state and failure state (Skalle, 2014).

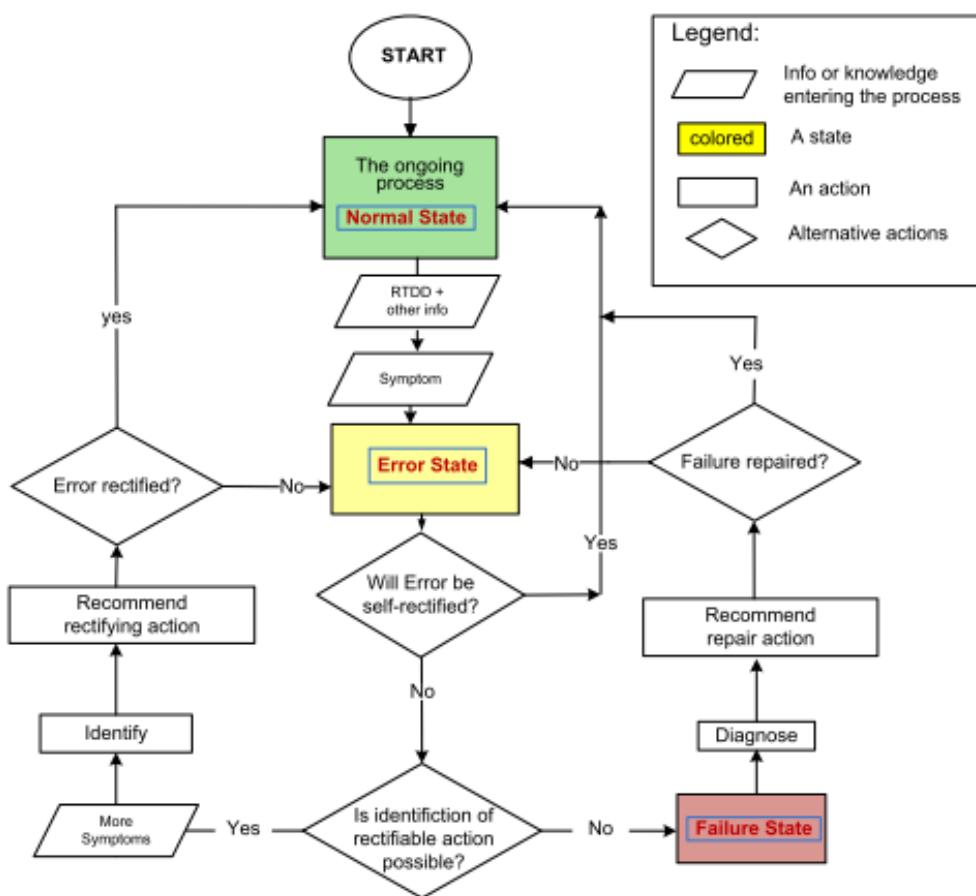


Figure 14: Three possible process states under surveillance during drilling (Skalle, Aamodt, & Swahn, 2016).

2.6. Countermeasures towards inclination/deviation related well-problems

Based on field experiences and previous publications, most oil and gas companies solves inclination and deviation related wellbore problems by developing well known best practices through investigations conducted in the laboratory. Since the drilling cost is of highly concern in oil and gas industry, saving time for solving such problems reduces overall cost resulted from non-productive time (NPT). In this section different methods of solving wellbore problems resulted from both inclination and deviations are analyzed.

- a) Better understanding and analytical design capability to manage the wellbore stability in high in-situ stress field, enables to reduce inclination related instability problems. Through determining the magnitude and orientation of in-situ stresses in the formation by borehole breakout analyses and modified leak off tests, the most stable inclined well trajectory can be designed (Zhou, Hillis, & Sandiford, Mechanical Stability of Inclined Wellbores, 1996).
- b) Systematic collection of quality data and application of best practice techniques help in identifying common factors associated with both casing running success and failure (Bybee, 2004).
- c) Understanding of actual buckling behavior and computer modeling makes easier for the buckling problem to be avoided by extending the application limit. (Mark Corrigan, C. Hoyer, & C. Gaston, 1991).
- d) Proper planning and training on how to reduce stuck pipe. Learning to identify the stuck pipe mechanisms and taking the correct actions immediately contributes to reduction in stuck pipe time significantly (Brechan, Corina, Gjersvik, Sangesland, & Skalle, 2017).
- e) Maintain high cleaning performance by maintaining high flow rate and high RPM of the drillstring, Reaming/circulating only 1 – 2 minutes prior to connections, use low mud viscosity to enhance local turbulence and use mechanical cleaning device (Skalle, 2014).

Based on literary study, different publications have been cited. Some of them are most relevant to the topic under consideration and some others are less. Below is the table to show different publications with their relevance to the topic of concern.

Table 1: Reviewed literatures and their relevance to the present work

Author	Publications	Relevance
Ostadhassan, M., Jabbari, H., Zamiran, S., Osouli, A., Oster, B., & Lentz, N. (2014).	B. Wellbore Instability of Inclined Wells in Highly Layered Rocks.	Most relevant
Lubinski, A., & Woods, H. (1953).	C. Factors affecting the angle of Inclination and Dog-Legging in Rotary Bore Holes	Most relevant
Skalle, P., Aamodt, A., & Swahn, I. (2016).	A. Detection of Failures and Interpretation of Causes During Drilling Operations	Most relevant
Bybee, K. J. (2004).	B. Casing Running Challenges for Extended-Reach Wells	Most relevant
Mark Corrigan, D. S, C. Hoyer, D. S., & C. Gaston, D. S. (1991)	B. Logging on Coiled Tubing: A Proven Technique for Highly Deviated Wells and Other Applications	Most relevant
Speer, J. W., & Holiday, G. H. (1955).	C. Influence of Drill-collar Size and Stabilizers on Deviation Control.	Most relevant

Denotation:

- A Detection methods
- B Consequence challenges/problems & Countermeasures
- C Influencing factors

3. Methodology

3.1. Hypothesis

It may be possible to determine inclination and wellbore deviation from real-time drilling data (RTDD) and survey file data (actual and plan data) for a given well. Using both actual and planned data for the present master thesis it is possible to determine classes of inclination and wellbore deviation during drilling. Different methods/models are suggested to calculate inclination and deviation of the present wells using Matlab as a computing tool.

3.2. Development of methods

As the detection of inclination and wellbore deviation from RTDD(actual data) and planned data is of highly concern, it is vital important to gain great knowledge about real time drilling data and wellbore planning to determine accurately how inclined and/or deviated the well is and know the impacts on drillstring during drilling.

Well planning makes an exact mathematical description of the well path in the three dimensional system, from start point to the target. The suggested calculation models are the mathematical expressions describing how inclined and deviated the well path is. As mentioned earlier, the importance of describing the well path inclination and deviation correctly is the key to prevention of problems related to inclined well drilling and deviation control performance respectively. In order to meet the objectives, present work analysis was done by developing the following models:

- Inclination Estimation Model.
- Mathematical Model of Deviation.

3.2.1. Inclination Estimation Model

The inclination angle (I) can be calculated based on the vertical plane illustrated in figure 15. This angle can be expressed by TVD (z) and the horizontal departure between the current position and the target given in equation 5.

$$I = \tan^{-1} \left(\frac{\sqrt{x^2 + y^2}}{z} \right) \quad (5)$$

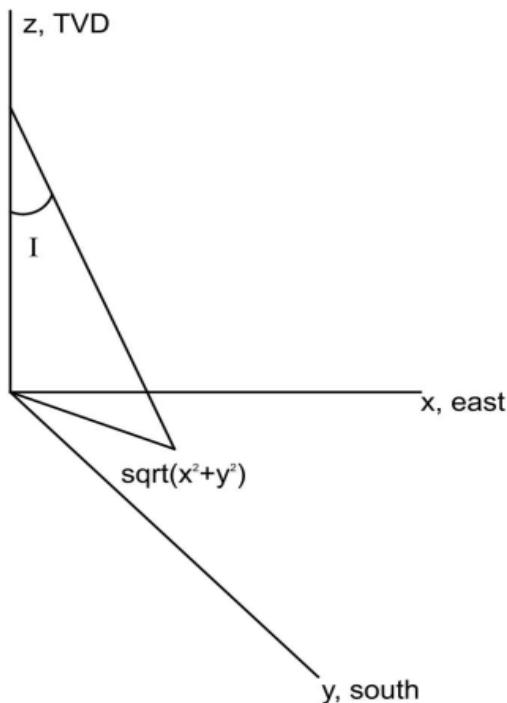


Figure 15: Inclination Alignment (Strømhaug, 2014)

3.2.1.1. Computation of horizontal and vertical departure

Both horizontal (north and east) and vertical departures are calculated based on minimum curvature method. As the balanced tangential method gives errors in wellbore position, the minimum curvature method is an extension of this method. This method projects the well path as a circular arc between the two survey points by applying a ratio factor. Figure 16 below shows the projection (Brechan, Corina, Gjersvik, Sangesland, & Skalle, 2017).

The ratio factor is based on the overall bending between the surveys sections defined as dogleg angle ϕ . The minimum curvature method assumes that the circular arc is wrapped around a sphere with radius R . The minimum curvature method is assumed to be quite accurate and is one of the most adopted for directional survey calculations.

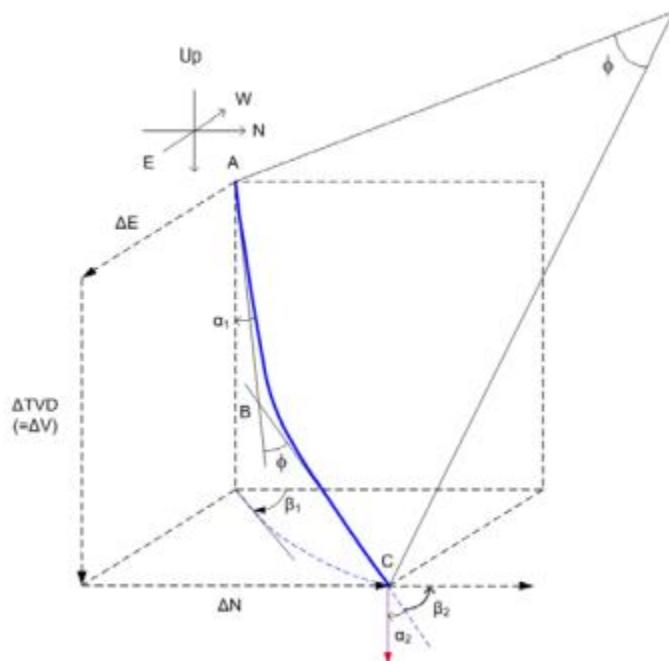


Figure 16: Minimum Curvature method (Brechan, Corina, Gjersvik, Sangesland, & Skalle, 2017)

Below are the final equations for the north, east and vertical depth departure presented.

The dogleg angle can be described as follow:

$$\phi = \cos^{-1}(\cos \alpha_1 \cos \alpha_2 + \sin \alpha_1 \sin \alpha_2 \cos(\beta_2 - \beta_1)) \quad (6)$$

The ratio factor can be described as follow:

$$F = \frac{2}{\phi} * \frac{180}{\pi} * \tan \frac{\phi}{2} \quad (7)$$

With ratio factor calculated the results of changes ΔN , ΔE and ΔTVD , can be calculated as follows:

$$\Delta N = \frac{F \cdot L}{2} (\sin \alpha_1 \cos \beta_1 + \sin \alpha_2 \cos \beta_2) \quad (8)$$

$$\Delta E = \frac{F \cdot L}{2} (\sin \alpha_1 \sin \beta_1 + \sin \alpha_2 \sin \beta_2) \quad (9)$$

$$\Delta TVD = \frac{F \cdot L}{2} (\cos \alpha_1 + \cos \alpha_2) \quad (10)$$

From calculated ΔN , ΔE and ΔV , inclination is estimated using equation 5 and the position of the well in three dimensions can be calculated as a cumulative sum of these changes at every point along the well path.

3.2.2. Mathematical Model of Deviation

The model requires both mathematically defined planned path and real time collected data (actual path) for correct determination of deviation. Both planned and actual paths should parametrically define each Cartesian coordinate, hole inclination and azimuth in terms of measured depth. Using minimum curvature method as suggested in section 3.2.1, both the planned and actual paths are designed and determined respectively. In order to quantify hole deviation sufficiently, eight variables are required (Stoner, 1999). These are:

- a) Vertical Deviation (V) (m)
- b) Horizontal Deviation (H) (m)
- c) Inclinalional Deviation ($\Delta\phi$) (deg)
- d) Azimuthal Deviation ($\Delta\theta$) (deg)
- e) Relative change in vertical deviation (ΔV_r)
- f) Relative change in horizontal deviation(ΔH_r)
- g) Relative change in inclinalional deviation ($\Delta\Delta\phi_r$) (deg/m)
- h) Relative change in azimuthal deviation ($\Delta\Delta\theta_r$) (deg/m)

Mathematical definitions of these variables are:

$$V = (N_a - N_p) \cos \theta_p \cos \phi_p + (E_a - E_p) \sin \theta_p \cos \phi_p - (TVD_a - TVD_p) \sin \phi_p \quad (11)$$

$$H = (E_a - E_p) \cos \theta_p - (N_a - N_p) \sin \theta_p \quad (12)$$

$$\Delta\phi = \phi_a - \phi_p \quad (13)$$

$$\Delta\theta = \theta_a - \theta_p \quad (14)$$

$$\Delta V_r^n = 1000 \frac{V^n - V^{n-1}}{\Delta L^n} \quad (15)$$

$$\Delta H_r^n = 1000 \frac{H^n - H^{n-1}}{\Delta L^n} \quad (16)$$

$$\Delta\Delta\phi_r^n = 100 \frac{\Delta\phi^n - \Delta\phi^{n-1}}{\Delta L^n} \quad (17)$$

$$\Delta\Delta\theta_r^n = 100 \frac{\Delta\theta^n - \Delta\theta^{n-1}}{\Delta L^n} \quad (18)$$

The constants 1000 and 100 for equations 15 to 18 are included for convenience when plotting. Based on mathematical expression provided, vertical and horizontal deviations represent linear differences while inclinational and azimuthal deviations are angular differences. Inclinational ($\Delta\phi$) and azimuthal ($\Delta\theta$) deviations are more difficult to visualize than V and H. $\Delta\phi$ and $\Delta\theta$ are differences in wellbore angles. The relative changes in vertical (ΔV_r), horizontal (ΔH_r), inclinational ($\Delta\Delta\phi_r$) and azimuthal ($\Delta\Delta\theta_r$) deviations are extremely informative. The actual drilled path perfectly follows a planned drilling trajectory over ΔL only if all eight hole deviation components equal zero.

Through interpretation of eight deviation variables, it is better to group them into two constituents. These are vertical and horizontal constituents.

- a) Vertical constituent include: V, $\Delta\phi$, ΔV_r and $\Delta\Delta\phi_r$
- b) Horizontal constituents include: H, $\Delta\theta$, ΔH_r and $\Delta\Delta\theta_r$.

Figure 17 is the example of deviation of the well for +V (actual point at high side of the planned point) and -H (actual point at left side of the planned point)

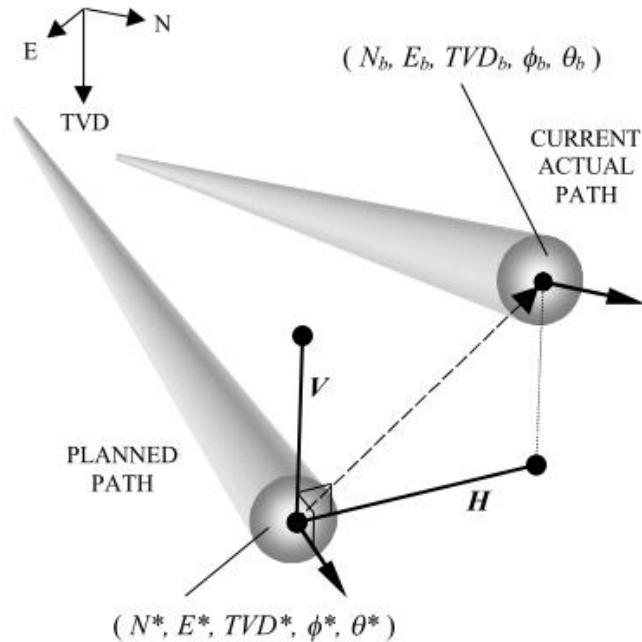


Figure 17: High vertical deviation (V) and left horizontal deviation (H) (Stoner, 1999).

Sorting of planned trajectory points closer to the actual well path

Minimizing the straight line distance between planned trajectory and actual survey points is done by using Euclidean distance formula (equation 19) as used in paper written by (Stoner, 1999). From calculated minimum distances, planned trajectory points closer to the actual well path are obtained for better estimation of eight deviation parameters (See appendix F, section 8.6.1 for detailed computation of minimum straight line distance between the actual and plan trajectory points).

$$\text{Linear distance} = \sqrt{(Na - Np)^2 + (Ea - Ep)^2 + (TVDa - TVDp)^2} \quad (19)$$

3.3. Case Data

The data used in this work were obtained from Equinor. These were the data for drilling of 34/10-C-47 well from Gullfaks field and 15/9-F4, 15/9-F5, 15/9-F10, 15/9-F-11T2, 15/9-F12 and 15/9-F-14 wells from Volve field. The data from 34/10-C-47 well consist of EOW/FWR report together with the actual real time drilling data (RTDD). Whereas data from Volve field wells consists of RTDD and both actual and planned data in survey files. From these data, it was possible to generate two data cases, Case 1 for well from Gullfaks field and Case 2 for wells from Volve field.

3.3.1. Case 1

In this case, well 34/10-C-47 from Gullfaks field was taken into consideration. This section described based on basic geology of Gullfaks field and wellbore description (Well 34/10-C-47)

3.3.1.1. Basic geology of Gullfaks field

3.3.1.1.1. Regional setting

The Gullfaks Field is located on the western flank of the Viking Graben, where it occupies the eastern half of a 10-25 km wide, NNE-SSW-trending fault block named the Gullfaks fault block. The Gullfaks fault block is one of a series of large (first-order) fault blocks that are easily identified on regional seismic lines across the North Sea. The general trend of these larger faults in the northern North Sea is N – S to NNE - SSW, reflecting the overall E-W extension across the rift. The extensional history of the North Sea dates back to the Devonian extensional phase shortly after the Caledonian collision (Fossen & Hesthammer, 1998).

Onshore kinematic studies support the idea of plate-scale divergent movements in the Devonian (Fossen H. , 1992). The main subsequent rifting phases are commonly referred to as the Permo-Triassic and late Jurassic phases (Badley, Price, Dahl, & Agdestein, 1988). Whereas the extension involved in the Permo-Triassic event is significant, the late Jurassic deformation of the Jurassic sequence is more obvious on commercial seismic lines and best known from well data (Fossen & Hesthammer, 1998).

3.3.1.1.2. Structure of the field

The Gullfaks field is characterized by two structurally contrasting compartments. A western domino system with typical domino-style fault block geometry and a deeply eroded eastern horst complex of elevated sub-horizontal layers and steep faults. These two regions are significantly different and treated separately. Between the western and eastern regions is a transitional accommodation zone (graben system) which is identified as a modified fold structure (Fossen & Hesthammer, 1998).

The distribution of these structurally different areas displays an east stepping occurrence of the accommodation zone as one goes from the north to the south. The stepping occurs across E-W transfer faults with high displacement gradients (rapidly decreasing displacement to the west). These E-W faults thus separate domains of contrasting dips.

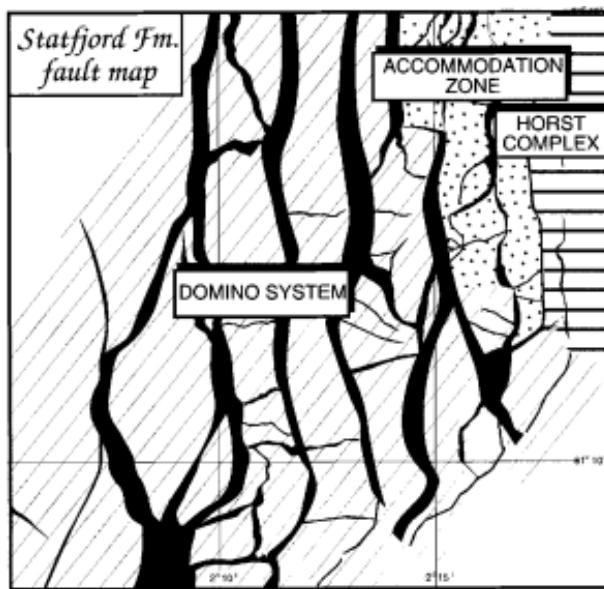


Figure 18: The areal distribution of the domino system, the horst complex and the accommodation zone on the top Statfjord fault map (Fossen & Hesthammer, 1998).

3.3.1.2. Wellbore description (Well 34/10-C-47)

Well 34/10-C-47 is the well located in Gullfaks field in the North Sea-Norway, drilled from Gullfaks C drilling rig under Statoil AS (currently Equinor) as a drilling operator. The well was drilled from 25.11.2005 15:00 to 25.04.2006 16:00 with primary purpose of oil production, then after production time the well changed to become water injector. The well is currently closed (Christophersen, Gjerde, & Valdem, 2007). Below is the map of the Gullfaks field and Coordinates of the well 34/10-C-47 to show its location within the field.

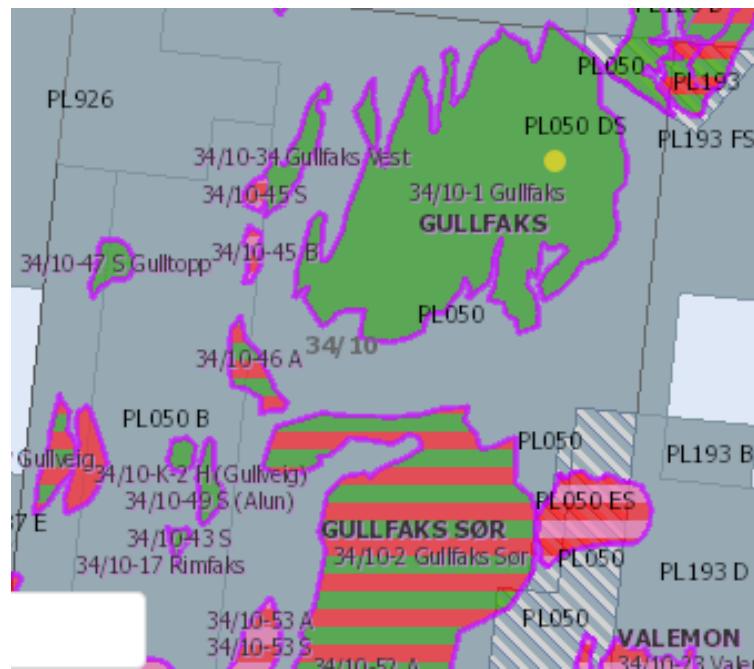


Figure 19: Map of Gullfaks oil field (Norwegian Petroleum Directorate, 2017)

Table 2: Well 34/10 C-47 coordinates at the wellhead level (Christophersen, Gjerde, & Valdem, 2007)

Coordinates at Wellhead Level				
	Structure Centre		Slot Centre	
	Latitude	Longitude	Latitude	Longitude
Geographic:	61° 12' 53.802" N	02° 16' 25.925" E	61°12' 54.941" N	02° 16' 26.394" E
UTM	6787107.3 m N	460990.8 m E	6787142.46 m N	460998.20 m E
Rectangular (from structure centre)	-	-	35.17 m N	7.40 m E

3.3.1.2.1. Important information from EOW/FWR for 34/10-C-47 well

For better determination of inclination and deviation of the wellbore, both final well report and real time drilling data are needed. FWR report consists of field information which provides important aid in calculation of inclination and deviation of the wellbore using both real time data and survey file data. From FWR report the necessary data used in the present work analysis are found. These data includes formation evaluation and deviation data in drilling 34/10-C-47 well,

a) Formation Evaluation Data

Geological field information plays a great role in determining what type of restriction is encountered in maintaining designed path of the well. For example, the hard dipping formation may results into high deviation/inclination of a well as the dip of the beds through which the hole is drilled make the bit drill up dip in hard rocks (Lubinski & Woods, 1953). Anisotropic formation increase deviation tendencies of the well as the chips formed on each side of the wedge penetrating through it are not equal in size (McLamore, 1971).

Formation evaluation data for 34/10-C-47 well include:

- Well target
- Formation dip and faults penetrated

i) Well 34/10-C-47 target.

The well was planned to be drilled from the Statfjord formation in segment K3 and K2. Primarily the well-targeted to produce from S2/S1 on the eastern flank of the K2 segment (Figure 20). The secondary target was to produce an attic volume in a small horst at top Statfjord (S10) and partly water flooded zones (S9-S3) below in the K3 segment.

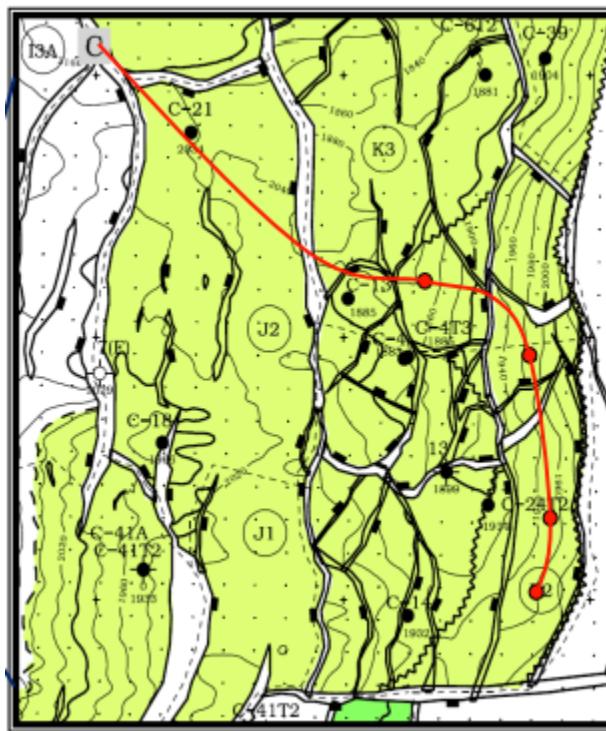


Figure 20: The planned well path going into the Statfjord formation east of well C-13 in the K3 segment and then turning south along the east flank of the K2 segment (Christophersen, Gjerde, & Valdem, 2007).

ii) Formation Dip and Faults penetrated

Based on dip data from density/neutron image data, the formation layers have eastern dip of 5-10 deg. These were confirmed by the seismic signals. In addition to formation dip, also several faults were encountered when drilling the well 34/10-C-47 (Table 3). These faults were interpreted on seismic data (Figure 21).

Table 3: Faults interpreted from well data and seismic data (Christophersen, Gjerde, & Valdem, 2007).

Fault/Formation	Measured Depth (m RKB)	True Vertical Depth (m MSL)
Fault S3 (S5/S3)	3210	1975
Fault S3	3425	1999
Fault S3	3555	1998
Fault S2 (S3/S2)	3810	2000
Fault S2	4080	2005
Fault S2	4150	1999
Fault S3	4350	1985

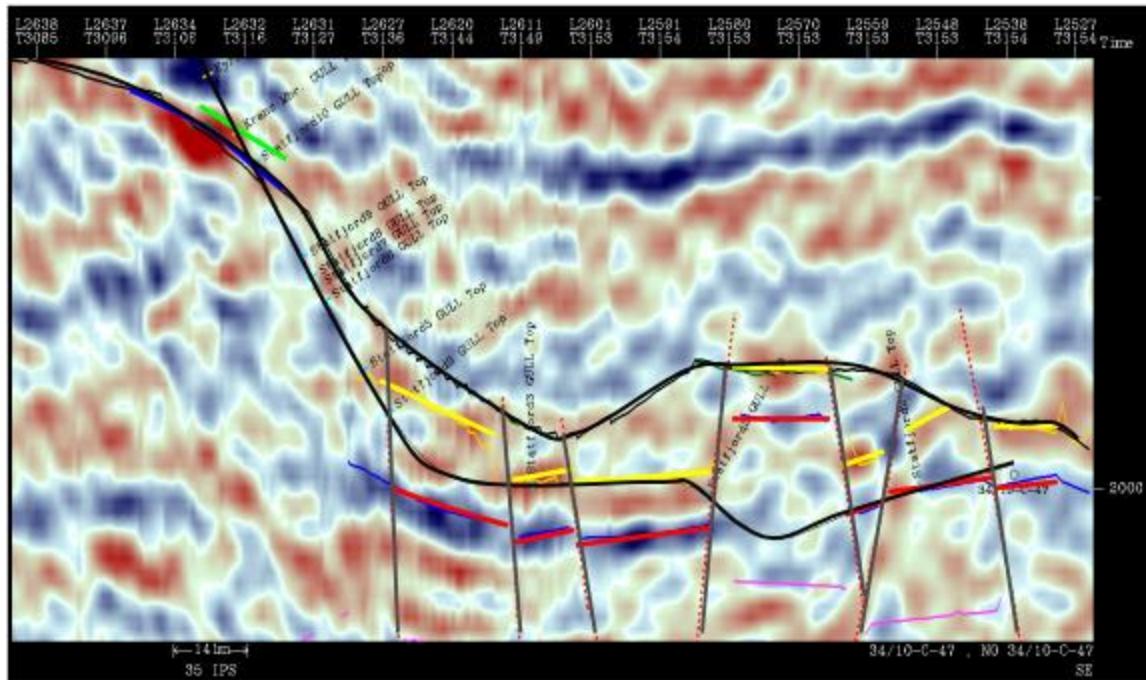


Figure 21: New interpretation on seismic (Christophersen, Gjerde, & Valdem, 2007).

b) Deviation in drilling of well 34/10-C-47

The anisotropic nature of the formation associated with dipping layers and faults, resulted into deviation of the drilling well data from the prognosis. The formation tops were drilled with deviation from the prognosis except sections 24" and 17½" were drilled approximately in accordance with the prognosis. Some of the deviation tendencies observed at the top of some formations (Table 4) supported by figures 22 and 23.

Table 4: Formation tops with depth and deviation from the prognosis (Christophersen, Gjerde, & Valdem, 2007).

Formation	Measured Depth (m RKB)	True Vertical Depth (m MSL)	TVD deviation from prognosis
Top Utsira Formation	995	882	+4
Top sandy Hordaland	1050	927	
Top sand free Hordaland	1655	1282	
Top Balder Formation.	2050	1486	-1
Top List a Formation	2200	1555	
Top Shetland Group.	2411	1655	-6
Top Kyrre Formation	2833	1842	
Top Krans Mb.	2892	1865	+11
Top S10	2929	1878	+13
Top S9	3028	1914	N/A
Top S8	3047	1920	+20
Top S7	3058	1925	N/A
Top S6	3075	1930	N/A
Top S5	3150	1957	N/A
Top S3	3202	1973	N/A
Top S2	3810	2000	+40
Top S2/Base S3	4220	1994	+4
TD	4399	1982	+2

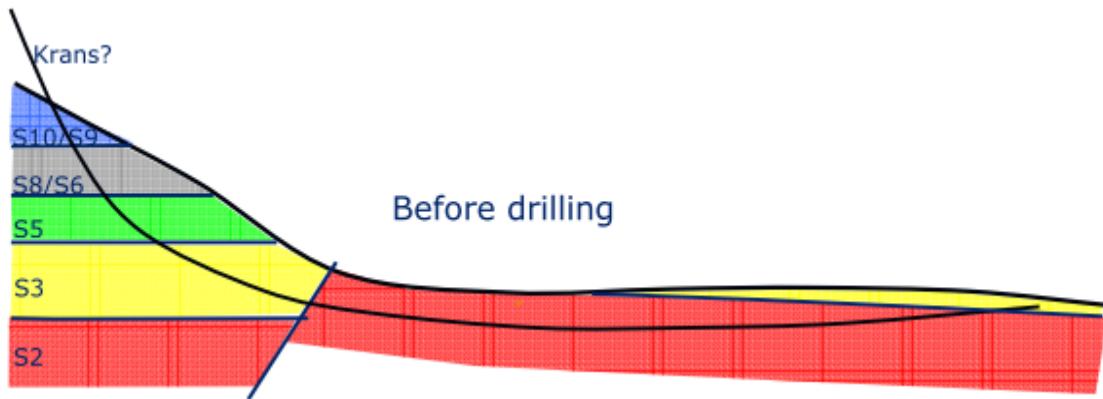


Figure 22: Planned well path and expected stratigraphy before drilling (Christophersen, Gjerde, & Valdem, 2007).

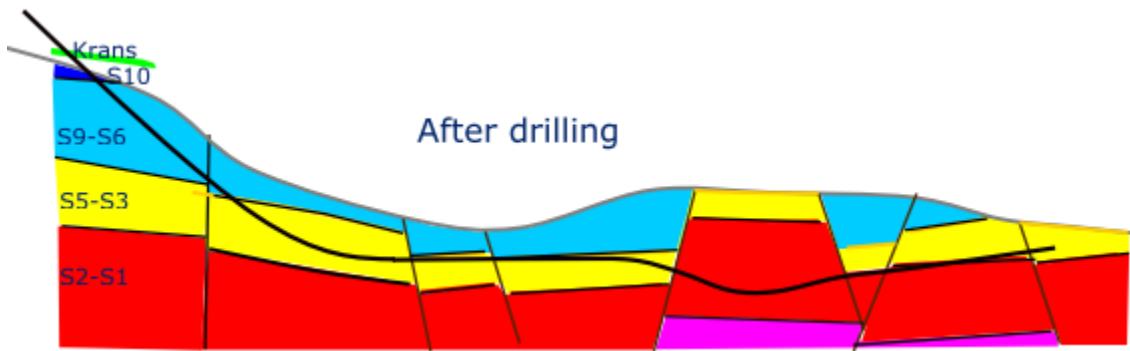


Figure 23: Well path and stratigraphy after drilling (Christophersen, Gjerde, & Valdem, 2007).

3.3.2. Case 2 (Wells from Volvo field)

This case consist 15/9-F4, 15/9-F5, 15/9-F10, 15/9-F-11T2, 15/9-F12 and 15/9-F14 wells from Volvo field. This is an oil field located in the central part of the North Sea, approximately eight kilometers north of Sleipner Øst. The wells in this field drilled using jack-up as processing and drilling facility (Norwegian Petroleum Directorate, 2017). Based on geology of the area, drilling of wells in this field is differently from drilling in Gullfaks field, thus variation of both wellbore inclination and deviation could be different.

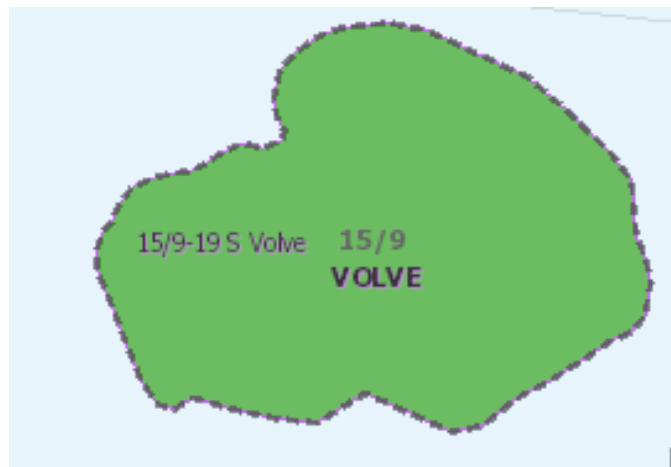


Figure 24: Map of Volvo field (Norwegian Petroleum Directorate, 2017)

3.3.2.1. Geology of Volvo field

The Volvo reservoir contains oil in a combined stratigraphic and structural trap in Jurassic sandstones in the Hugin Formation. The structure of the field is heavily faulted and communication across the faults is uncertain on the western part.

3.3.2.2. Description of wells from Volvo Field

3.3.2.2.1. Well 15/9-F4

Well 15/9-F4 is the development well located in Volvo field in the central part of the North Sea drilled from MAERSK INSPIRER drilling Facility under StatoilHydro ASA (currently Equinor) as a drilling operator. The well was drilled from 13.10.2007 to 09.03.2008 and purposes was for injection. The well is currently Plugged and abandoned (P&A) (Norwegian Petroleum Directorate, 2017). Table 5 show location of well 15/9-F4

Table 5: Well 15/9-F4 coordinates at the wellhead level (Norwegian Petroleum Directorate, 2017).

	Structure Centre	
	Latitude	Longitude
Geographic	58° 26' 29.72" N	1° 53' 14.92" E
UTM	6478560.84 m N	435049.84m E

3.3.2.2. Well 15/9-F5

Well 15/9-F5 is the development well located in Volvo field in the central part of the North Sea drilled from MAERSK INSPIRER drilling Facility under StatoilHydro ASA (currently Equinor) as a drilling operator. The well was drilled from 18.12.2007 to 01.08.2008, for injection. The well is currently Plugged and abandoned (P&A) (Norwegian Petroleum Directorate, 2017). Table 6 show location of well 15/9-F5

Table 6: Well 15/9-F5 coordinates at the wellhead level (Norwegian Petroleum Directorate, 2017).

	Structure Centre	
	Latitude	Longitude
Geographic	58° 26' 29.66" N	1° 53' 14.99" E
UTM	6478558.97m N	435050.94m E

3.3.2.2.3. Well 15/9-F10

Well 15/9-F10 is the development well located in Volve field in the central part of the North Sea drilled from MAERSK INSPIRER drilling Facility under StatoilHydro Petroleum AS (currently Equinor) as a drilling operator. The well was drilled for 64 days from 06.04.2009 to 08.06.2009 and its purpose was for observation of production progress. The well is currently Plugged and abandoned (P&A) (Norwegian Petroleum Directorate, 2017). Table 7 show location of well 15/9-F10

Table 7: Well 15/9-F-10 coordinates at the wellhead level (Norwegian Petroleum Directorate, 2017).

	Structure Centre	
	Latitude	Longitude
Geographic	58° 26' 29.68" N	1° 53' 15.07" E
UTM	6478559.56m N	435052.25m E

3.3.2.2.4. Well 15/9-F-11T2

Well 15/9-F-11T2 is the development well located in Volve field in the central part of the North Sea drilled from MAERSK INSPIRER drilling Facility under Statoil Petroleum AS (currently Equinor) as a drilling operator. The well was drilled for observation using 67 days from 07.03.2013 to 12.05.2013. The well is currently Plugged and abandoned (P&A) (Norwegian Petroleum Directorate, 2017). Table 8 show location of well 15/9-F-11T2

Table 8: Well 15/9-F-11T2 coordinates at the wellhead level (Norwegian Petroleum Directorate, 2017).

	Structure Centre	
	Latitude	Longitude
Geographic	58° 26' 29.96" N	1° 53' 14.87" E
UTM	6478568.28 m N	435049.15 m E

3.3.2.5. Well 15/9-F-12

Well 15/9-F-12 is the development well located (6478574.75m NS, 435050.23m EW) in Volve field in the central part of the North Sea drilled from MAERSK INSPIRER drilling Facility under Statoil Petroleum AS (currently Equinor) as a drilling operator. The well was drilled for production using 75 days from 14.06.2007 to 27.08.2007. The well is currently Plugged and abandoned (P&A) (Norwegian Petroleum Directorate, 2017).

3.3.2.6. Well 15/9-F-14

Well 15/9-F-14 is the development well located (6478562.34m NS, 435052.46m EW) in Volve field in the central part of the North Sea drilled from MAERSK INSPIRER drilling Facility under StatoilHydro AS (currently Equinor) as a drilling operator. The well was drilled for production using 44 days from 05.12.2007 to 17.06.2008. The well is currently Plugged and abandoned (P&A) (Norwegian Petroleum Directorate, 2017).

3.3.3. Available Real Time Drilling Data (RTDD)

More than ten RTDD parameters have been provided for the given wells and some of them were used to calculate the inclination and deviation of the wellbore. These parameters are DMEA, BITI, BITA, DLS, HKL, WOB, TRQ, RPMB, MFI and SPP. Only DMEA, BITI and BITA were used in calculation of both inclination and deviation of the wellbore.

3.3.3.1. Determination of RTDD parameters

In drilling oil and gas wells, different drilling parameters need to be properly understood and being measured accurately for better monitoring and application of them to optimize drilling efficiency. In this section measurements of some parameters are discussed.

a) Weight on Bit (WOB)

WOB is one of important parameter that needs to be properly monitored and applied to optimize drilling efficiency. The industry standard practice is to measure WOB as the difference between surface hook load when the bit is off-bottom and the hook load during drilling (Zha, Ramsay, & Pham, 2018):

$$\text{WOB} = \text{HKL}_{\text{off}} - \text{HKL}_{\text{drill}} \quad (20)$$

b) Hook Load (HKL)

Historically hook load has been measured using the ‘weight indicator’. The weight indicator operates using the signals from the deadline. The hook load ‘w’ displayed by the weight indicator is assumed to be equal to number of lines between blocks (N) times the deadline tension (F_{dl}). This equation does not account for the friction effect hence no consideration is given between static and dynamic conditions (Luke & Juvkam-Wold, 1993)

$$W = F_{dl}N \quad (21)$$

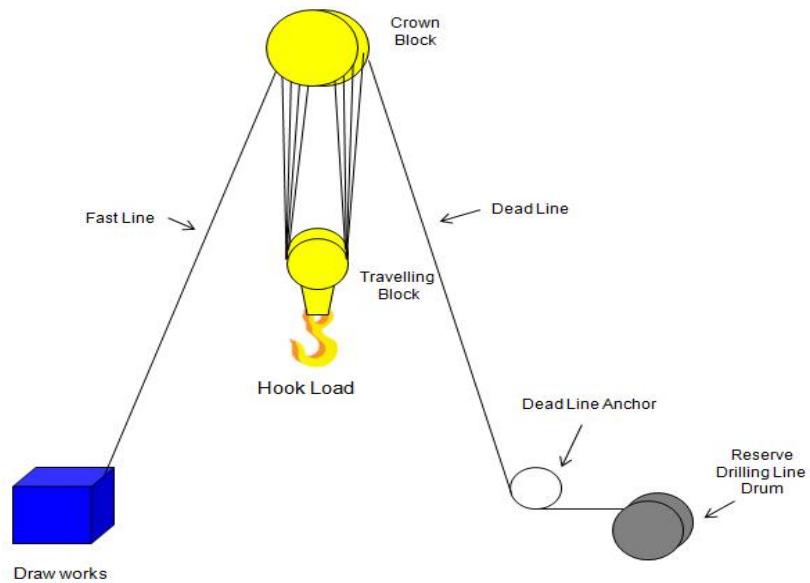


Figure 25: Example of travelling block for hook load measurement (DrillingFormulas, 2013)

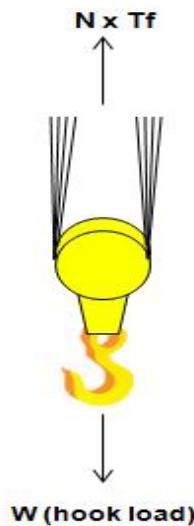


Figure 26: Free Body Diagram on Travelling Block to show measurement of Hook load
(DrillingFormulas, 2013)

c) Measured depth of a well (DMEA)

The measured depth of the wellbore differs from the true vertical depth of the well except for vertical wells. Since the wellbore cannot be physically measured from end to end, the lengths of individual joints of drill pipe, drill collars and other drill string elements like stabilizers are measured with a steel tape measure and added together to obtain total well measured depth.

Effect of drill string elongation should be taken into consideration, as the pipes are measured while lying on a pipe rack, in an unstressed state. When the pipes are screwed together and put into the wellbore, it stretches under its own weights and that of the bottom hole assembly. Hence, the actual wellbore is slightly deeper than the reported depth (Schlumberger1, 2018).

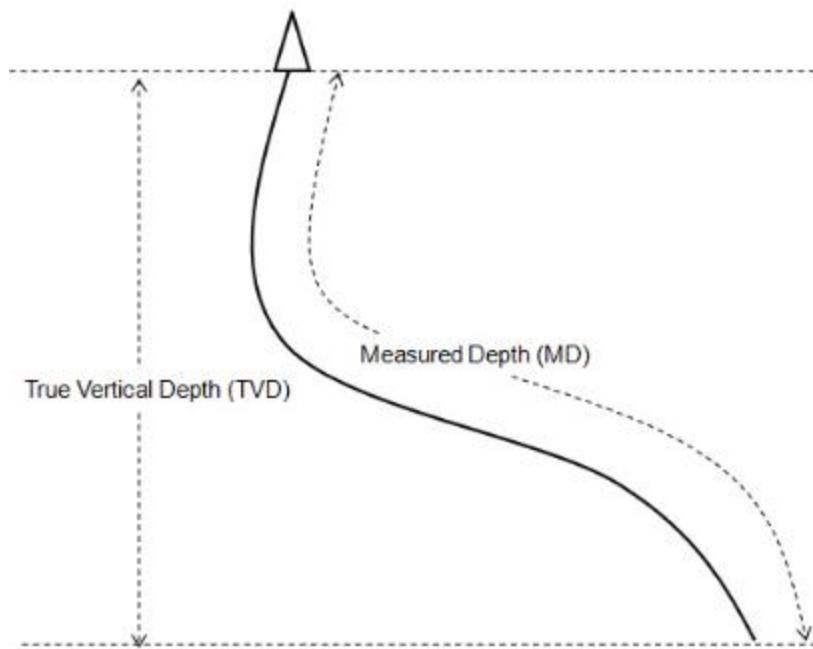


Figure 27: Example of a wellbore to show Measured Depth and True Vertical depth (DrillingFormulas., 2011)

d) Torque (TRQ)

Most drilling rigs are equipped with some simple devices (rotary torque meter) for indicating torque. Most of these devices gives inaccurate reading and are not calibrated to provide readings in useful torque units. Few drilling rigs in the world are equipped with calibrated rotary torque indicators (Johancsik, Friesen, & Dawson, 1984).



Figure 28: Rotary torque indicator (RigChina Group company, 2018)

e) Bit average rotary speed (RPMB)

Currently bit rotation speed can be accurately measured downhole but it cannot be analyzed in real-time. The bit rotation speed is obtained from the radial centrifugal acceleration measured downhole in the proximity of the bit (a_c) and distance of the accelerometer from the vertical axis of rotation (r) using the given equation below (Bernasconi & Vassallo, 2001)

$$\Omega(t) = \sqrt{a_c(t)/r} \quad (22)$$

f) Mud Flow in average (MFI)

Measurement of drilling fluids into the wellbore is carried out by simple counting of pump strokes to calculate the flow rates. The flow rate is calculated by taking pump speed times pump displacement for a single stroke (Engineershandbook, 2004).

$$Q = nd \quad (23)$$

g) Standpipe pressure average (SPP)

Standpipe pressure (SPP) is defined as the total pressure loss in a system that occurs due to fluid friction. It is calculated by the summation of pressure loss in annulus, pressure loss in drill string, pressure loss in bottom hole assembly (BHA) and pressure loss across the bit (Petropedia, 2018).

3.3.3.2. Factors affecting RTDD

There are many factors that are taken into consideration while observing the trend of main parameters during drilling of oil and/or gas wells. In this section five different factors affecting these parameters are discussed

a) Buoyed weight of drill string

During drilling operation, the drill string is submerged in the drilling fluid such that the recorded weight of the drill string suspended by the hook depends on the densities of the drill string and drilling fluid in the borehole. In this case two forces are acting which affects both the hook load (HKL) and weight on bit (WOB). These are gravity and buoyancy forces. Buoyance force is the upward force that exerted by fluid and it opposes the gravity force (Mkuyi, 2016).

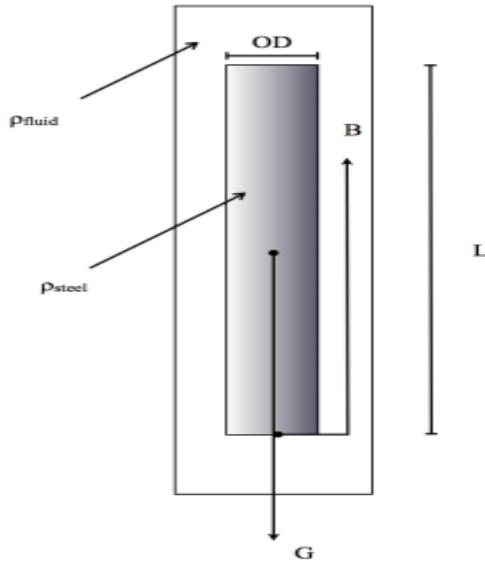


Figure 29: Forces acting on a drill string component submerged in drilling fluid (Glomstad, 2012).

b) Friction force

Friction is defined as the force that resists motion between two surfaces in contact. For most of the extended reach drilling operations, friction is one of the limiting factors affecting both hook load and weight on bit for tangential motion. During rotational motion, torque reading is highly affected due to friction experienced along the length of the drill string (Mkuyi, 2016).

c) Side force

Side forces are defined as normal forces caused by bending and tension of the drill string. These forces are common in deviated wells due to change in azimuth and inclination to meet the drilling target and likely occur at drop and build up sections (Kristensen, 2013). These forces affect hook load, weight on bit and torque readings.

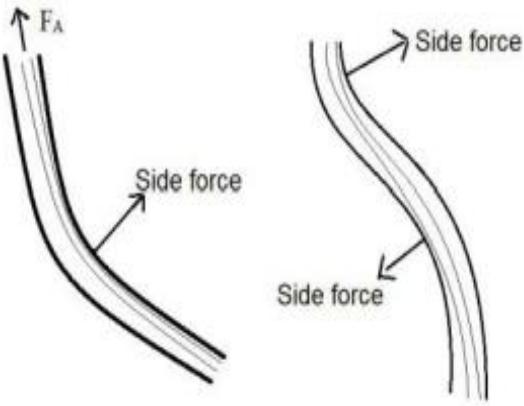


Figure 30: Side forces on drill string component (Kristensen, 2013)

d) Fluid-Drag

Fluid drag is defined as the friction force which occurs in the well as a result of contact between the surface of drill string and the fluid. According to (Sjøberg, 2014), during tripping (in and out), the mud exerts an extra friction affecting hook load measurement hence weight on bit.

e) Drilling mud pump efficiency

Counting of the pump strokes does not account for physical wear on the pump liner, which can cause differences between theoretical and actual pumping rates, hence error in Mud flow in average (MFI) measurement.

3.3.3.3. Importance of RTDD to the drilling industry

Generally, RTDD analysis results into real time decisions during drilling operation. With RTDD many downhole drilling parameters can be captured and transformed into useful information. The availability of the right information available at all stages of well construction helps to minimize non-productive time (NPT) and reduce health safety and environment (HSE) incidents. These are both important in improving cost-efficiency and well delivery in ever more challenging exploration environments (Kongsberg, 2018).

The importance of RTDD analysis and management can therefore be summarized as shown in the list below:

- a) Improved safety drilling
- b) Reduced drilling costs
- c) Proper positioning of the wellbore
- d) Reduces drilling problems such as stuck pipe
- e) Makes drilling process quicker.
- f) Enables proper casing placement and cementing

3.4. Research Validation Plan

By analyzing both RTDD and survey file data using Matlab it was possible to estimate inclination and deviation of the wellbore path. Variation of both inclination and deviation during wellbore drilling can be detected and presented through table and graphs/figures. From these tables and graphs, validation of results/models can be done by comparing estimated results against actuals values for example in inclination estimation. Also relating the computed well deviation parameters and failures/problems due to deviation indicated in FWR at specified depths along the well path enabled easier validation of deviation models.

3.5. Data Analysis

The analysis of available data was done based on different techniques/steps. These techniques are data requirement and collection, data processing, data cleaning, exploratory data analysis, Modeling and Algorithms, data product (Matlab) and communication. Figure 34 represent the process.

3.5.1. Data requirement and collection

Both RTDD and survey file data were required for determination of both inclination and deviation of the wellbore. RTDD always include data collected from sensors, that need to be interpreted in such a way that they can be understandable and informative (Valipour Shokouhi, Skalle, Aamodt, & Sormo, 2009). Planned data are generated based on determination of the expected characteristics and problems to be encountered in the well. A well cannot be planned properly if these environments are unknown.

3.5.2. Data processing

Data provided for the present master thesis were in both Matlab and notepad formats. RTDD were given in Matlab format whereas survey files for both actual and planned data were given as text files. According to the strategy used in this thesis, Matlab was used as a computing tool. Therefore the data in notepad files were organized and imported into Matlab.

3.5.2.1. Importation of notepad/text file into Matlab

Importing data in text file into Matlab was done by using importdata function in Matlab (See Appendix F, section 8.6.1). This provide easier clarification of data as the will be found in rows and columns for easier computation of output parameters

Volve F_F-4_F-4_F-4_ACTUAL - Notepad

File Edit Format View Help

SURVEY LIST									
MD	Inc	Azim	TVD	X-offset (E/W)	Y-offset (N/S)	UTM E/W	UTM N/S	DLS	
m RKB	deg	deg	m RKB	m	m	m	m	deg/3	
145.90	0.00	0.00	145.90	-0.190	-2.699	435049.831	6478560.825	0.00	
184.12	0.10	233.25	184.12	-0.216	-2.719	435049.805	6478560.805	0.08	
224.45	0.16	227.58	224.45	-0.286	-2.778	435049.735	6478560.746	0.05	
264.79	0.84	218.68	264.79	-0.512	-3.047	435049.509	6478560.477	0.51	
305.10	1.60	210.39	305.09	-0.982	-3.763	435049.039	6478559.761	0.58	
345.45	2.76	227.92	345.41	-1.988	-4.900	435048.034	6478558.625	0.99	
385.80	5.17	242.27	385.66	-4.318	-6.397	435045.704	6478557.128	1.92	
426.12	7.04	240.40	425.75	-8.075	-8.463	435041.948	6478555.063	1.40	
466.40	8.06	224.23	465.68	-12.192	-11.706	435037.833	6478551.821	1.75	
506.65	8.85	205.85	505.50	-15.511	-16.515	435034.516	6478547.013	2.09	
546.96	8.90	191.34	545.34	-17.476	-22.364	435032.551	6478541.167	1.66	
587.28	8.91	181.74	585.17	-18.184	-28.543	435031.843	6478534.990	1.10	
627.54	9.00	180.61	624.94	-18.312	-34.809	435031.715	6478528.726	0.15	
667.63	9.45	172.33	664.52	-17.907	-41.206	435032.121	6478522.331	1.05	
707.96	9.68	168.40	704.29	-16.783	-47.809	435033.244	6478515.731	0.51	
748.28	11.47	163.50	743.92	-14.962	-54.974	435035.064	6478508.568	1.49	
788.57	13.92	158.60	783.22	-12.056	-63.329	435037.969	6478500.216	1.99	
828.91	15.68	154.79	822.22	-7.963	-72.779	435042.061	6478490.769	1.49	

Figure 31: Available text file for well 15/9-F4 (before importation)

145.90	0.00	0.00	145.90	-0.190	-2.699	435049.831	6478560.825	0.00
184.12	0.10	233.25	184.12	-0.216	-2.719	435049.805	6478560.805	0.08
224.45	0.16	227.58	224.45	-0.286	-2.778	435049.735	6478560.746	0.05
264.79	0.84	218.68	264.79	-0.512	-3.047	435049.509	6478560.477	0.51
305.10	1.60	210.39	305.09	-0.982	-3.763	435049.039	6478559.761	0.58
345.45	2.76	227.92	345.41	-1.988	-4.900	435048.034	6478558.625	0.99
385.80	5.17	242.27	385.66	-4.318	-6.397	435045.704	6478557.128	1.92
426.12	7.04	240.40	425.75	-8.075	-8.463	435041.948	6478555.063	1.40
466.40	8.06	224.23	465.68	-12.192	-11.706	435037.833	6478551.821	1.75
506.65	8.85	205.85	505.50	-15.511	-16.515	435034.516	6478547.013	2.09
546.96	8.90	191.34	545.34	-17.476	-22.364	435032.551	6478541.167	1.66
587.28	8.91	181.74	585.17	-18.184	-28.543	435031.843	6478534.990	1.10
627.54	9.00	180.61	624.94	-18.312	-34.809	435031.715	6478528.726	0.15
667.63	9.45	172.33	664.52	-17.907	-41.206	435032.121	6478522.331	1.05
707.96	9.68	168.40	704.29	-16.783	-47.809	435033.244	6478515.731	0.51
748.28	11.47	163.50	743.92	-14.962	-54.974	435035.064	6478508.568	1.49
788.57	13.92	158.60	783.22	-12.056	-63.329	435037.969	6478500.216	1.99
828.91	15.68	154.79	822.22	-7.963	-72.779	435042.061	6478490.769	1.49

Figure 32: Available data for well 15/9-F4 (after importation in Matlab)

3.5.3. Data cleaning

The processed and organized data may be incomplete, contain duplicates, or contain errors. Based on the way that data are entered and stored in Matlab for computation, some common tasks were done to correct the data (Refer program code in appendix A, section 8.1.1). These tasks include:

- a) Identification of inaccuracy of data and its overall quality
- b) De-duplication using unique function and
- c) Column segmentation.

```
%Create a Matrix B
B=zeros(length(MD), 5);
%Define parameters in Matrix B
B(1:end,1)=BD;          %Bit Measured Depth
B(1:end,2)=MD;          %Measured Depth
B(1:end,3)=IN;          %Wellbore Inclination
B(1:end,4)=AZ;          %Wellbore Azimuth
B(1:end,5)=DLS;         %Wellbore Dogleg Severity
%Define necessary parameters of actual data (RTDD):
I=unique(B(1:end, 3), 'stable'); %Wellbore Inclination
L_q=unique(B(1:end, 2), 'stable'); %Measured Depth
L=L_q(1:length(I));           %Make matrix dimension agree
A_q=unique(B(1:end, 4), 'stable'); %Wellbore Azimuth
A=A_q(1:length(I));           %Make matrix dimension agree
```

Figure 33: Screenshot of Matlab block code to show column segmentation and de-duplication

3.5.4. Exploratory data analysis

This technique was applied to understand the messages contained in the data and see if there are some inaccurate data remained after cleaning such that additional data cleaning or additional requests for data can be done.

3.5.5. Modeling and Algorithms

Mathematical formulas or models and algorithms were applied to the data to identify relationships among the variables. For example, correlation of dogleg angle and ratio factor in determination of wellbore position along the path. The detailed explanation of how models and algorithms used in the program during execution process is given in sub-chapter 3.6.

3.5.6. Data product (Matlab)

Matlab was the main software used for execution of data. The execution done based on models or algorithms used in both inclination and deviation reporting agents. As Matlab takes data inputs and generates outputs, the outputs can be feed back into the drilling environment for improvement of drilling process.

3.5.7. Communication of results

The results were communicated in main chapter 4, using different data visualization techniques such as tables and graphs or figures. Therefore data analysis in present master thesis helped to show how inclined the well was and combining both actual and planned data, it was possible to show how the well is deviating from the planned path during drilling.

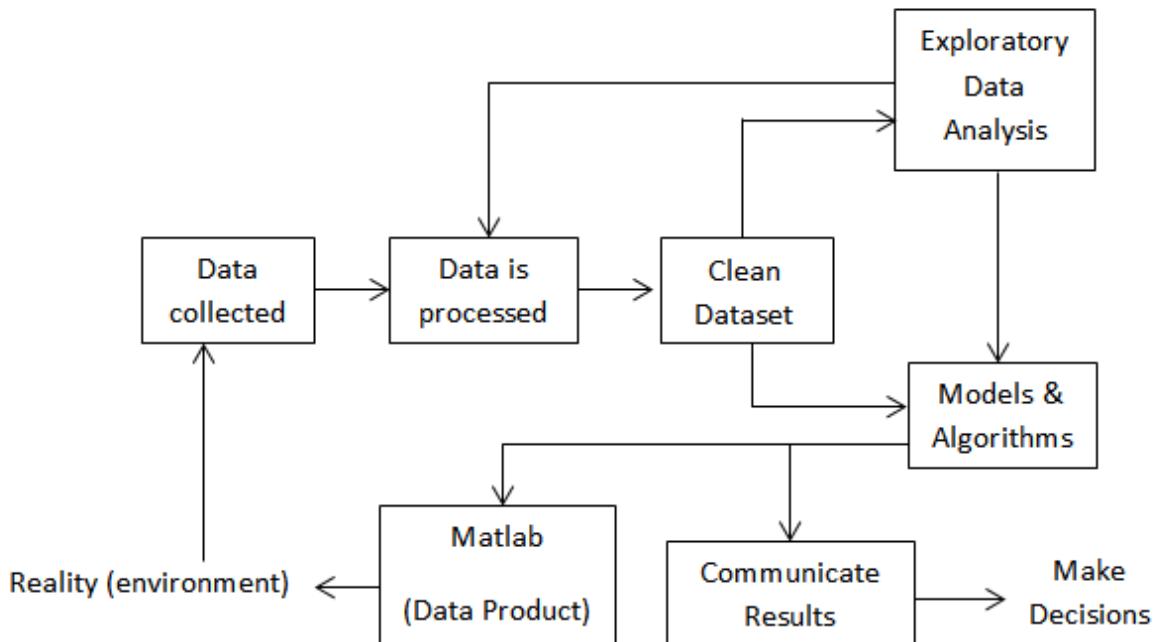


Figure 34: Data Analysis flowchart

3.6. Design of the agents using Matlab

Using mathematical models (equation 5 and equations 11 through 18) and available real time drilling data and both actual and planned data, two different programs to report inclination class and wellbore deviation were developed using the Matlab software. Development of the programs was based on algorithms (Flow charts), inputs and outputs.

3.6.1. Algorithms (Flow Charts)

Referring to the tasks under consideration, two different Matlab data agents were created. These agents are presented through two different algorithms. These are flow chart of inclination reporting agent and flow chart of deviation reporting agent. Figure 35 and Figure 36 shows the flow charts of the inclination reporting agent and deviation reporting agent respectively. A detailed explanation about implementation in each agent is given in section 3.6.4.

3.6.2. Inputs

There are two types of inputs used in present master thesis. There are inputs for inclination and deviation reporting agents.

3.6.2.1. Inputs for inclination reporting agent

From the available real time drilling data, the agent extracts:

- Time (T)
- Measured Depth (DMEA)
- Depth of the bit measured (DBTM)
- Actual Inclination (INC)
- Actual Azimuth (AZI)
- Actual Dogleg Severity (DLS)

3.6.2.2. Inputs for deviation reporting agent

From the available survey file data, the agent extracts both actual and planned parameters. These parameters are:

- Measured Depth (MD)
- Inclination (Inc.)
- Azimuth (Azim)
- True Vertical Depth (TVD)
- UTM-East (E)
- UTM-North (N)
- Dogleg Severity (DLS)

3.6.3. Outputs

Execution of the both agents in Matlab provided outputs as follows:

3.6.3.1. Outputs from inclination reporting agent

These include:

- Table providing estimated inclination and inclination classification at each point with their corresponding measured depth (MD).
- Warning message based on inclination class/level encountered. This sends a message to the driller when inclination changes during drilling process.

3.6.3.2. Outputs from deviation reporting agent

These include:

- Table providing eight deviation parameters at each point at their corresponding measured depths (MD).
- Warning message based on deviation as acceptable or not. This sends a message to the driller when deviation increases beyond the acceptable limit during drilling process.
- Both vertical and horizontal hole deviation logs.

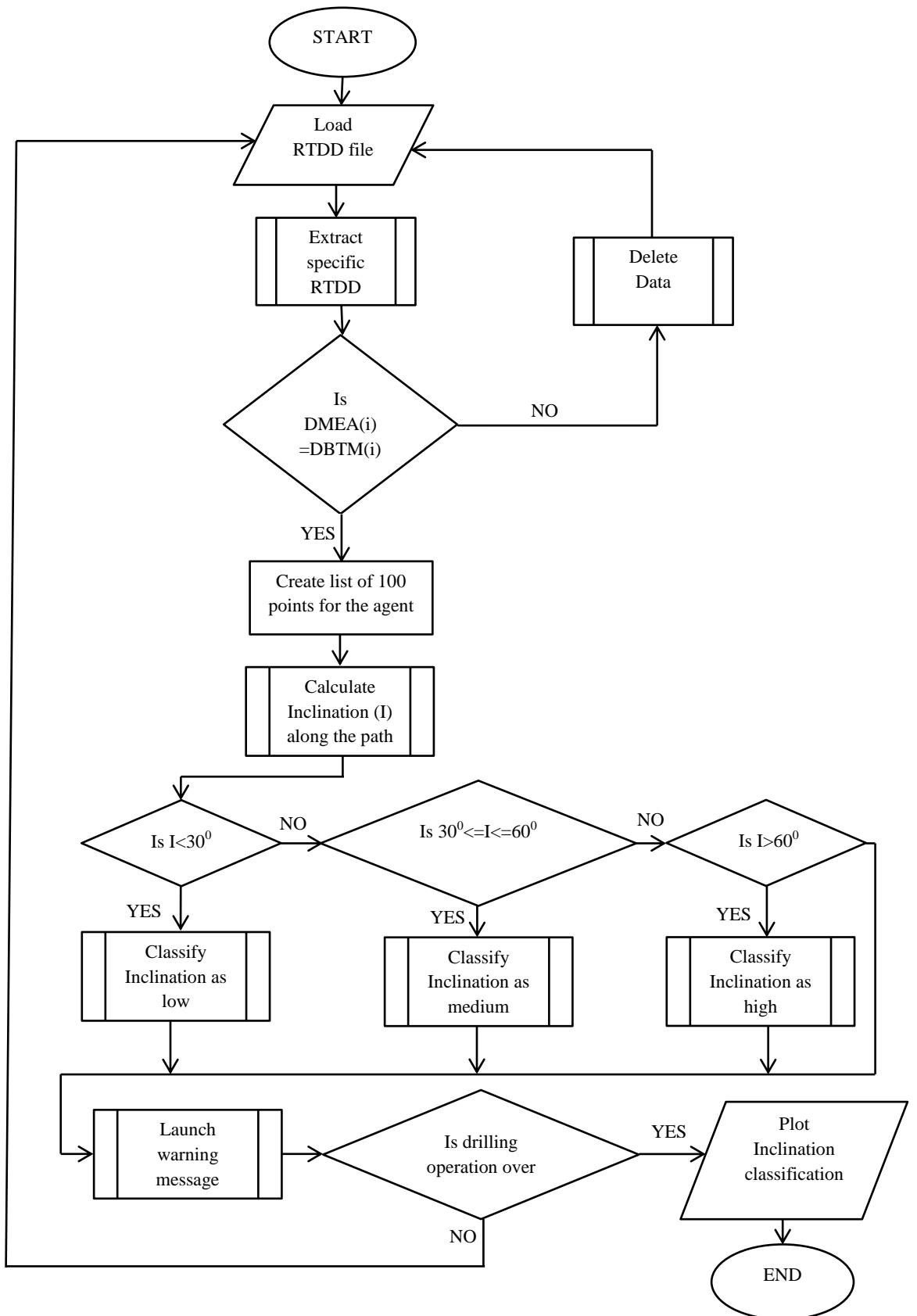


Figure 35: Flow chart of inclination reporting agent

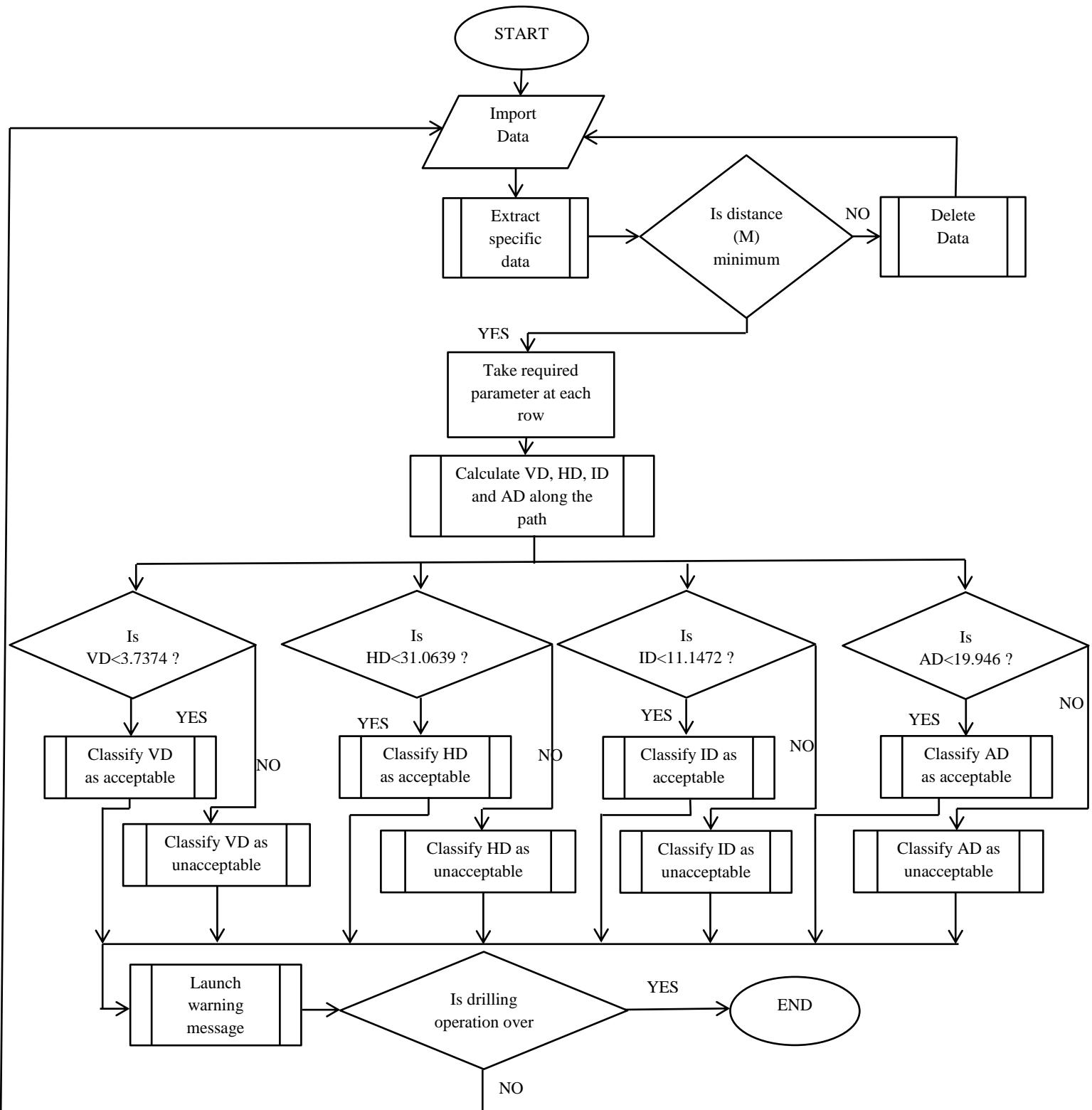


Figure 36: Flow chart of deviation reporting agent

3.6.4. Implementation of the agents in Matlab

Based on designed flow charts for each agent, the coding was done in Matlab accordingly. Appendix A, section 8.1.1 contains the code for inclinational estimation and well projection. Appendix B, section 8.2.3 contains the code reporting whenever inclination of the well path is high, medium or low. Also Appendix F, section 8.6.1 contains the code for calculation of eight parameters of the wellbore deviation including plots to show deviation of the well in 2D and 3D and hole deviation logs.

3.6.4.1. Implementation of inclination reporting agent

For this agent, the data are loaded directly into the Matlab script. Then clean lists of RTDD are created by removing data from non-drilling operations. The agent removes data from non-drilling operation by comparing the depth of the well (DMEA) and the depth of the bit (DBTM). During drilling both DMEA and DBTM have to be the same otherwise the agent delete data recorded and reload the data again. When DMEA equals DBTM (during drilling), the agent load the first 100 points to initialize computation of inclination. Then run its full algorithms and start again until all available data are used.

3.6.4.2. Implementation of deviation reporting agent

For deviation agent created in present master thesis, the actual and planned data available are directly loaded into the Matlab script by using importdata function. The agent runs its full algorithm until all available data are used.

4. Results and Discussion

4.1. Description of Results

Upon execution of different functions in the Matlab codes created in the appendices A, B, E and F, different tables (see appendices C, D and G) and graphs/figures were generated to present the results for different wells under consideration. In this sub-chapter both actual and estimated parameters are presented using figures in sections.

4.1.1. Actual and Estimated Inclination

Using equation 5 presented in section 3.2.1, Inclination was estimated for each point along the well path. Equations 6 through 10 were used to calculate input parameters for inclination for well 34/10-C-47 with data given Matlab format whereas for wells with data in text files, their inclination were estimated directly using equation 5 as TVD, East and North UTM coordinates were provided. Both actual and estimated values obtained were presented in table 09 (appendix C) for well 34/10-C-47 and tables 10 through 12 (appendix D) for wells 15/9-F-4, 15/9-F-5, 15/9-F-10, 15/9-F-11T2, 15/9-F-12, 15/9-F-14. Detailed computations of inclinations for each well are shown in appendices A and B and the comparison between estimated and actual inclinations is illustrated in figures 37 through 40.

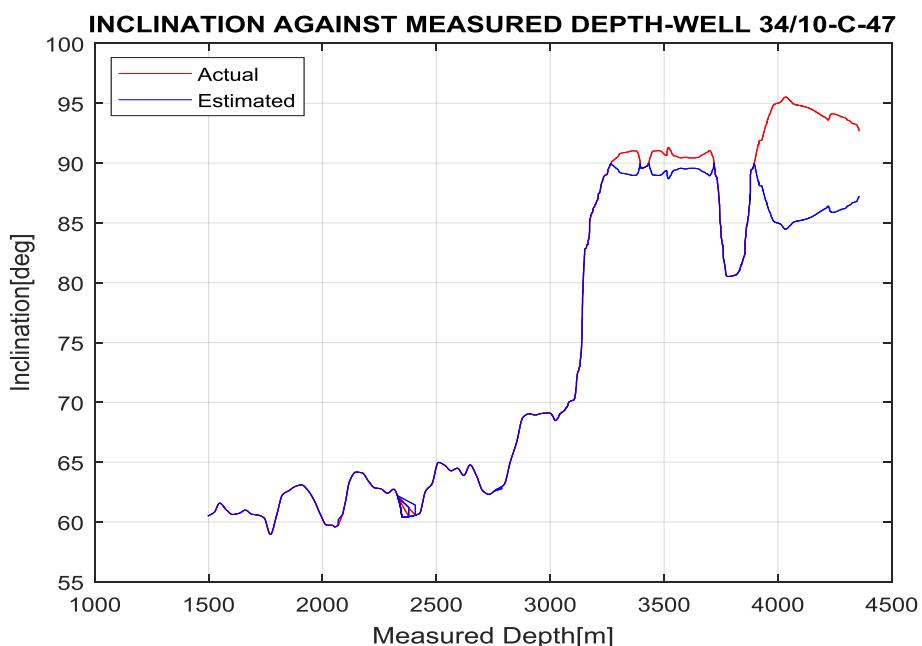


Figure 37: Actual and estimated inclinations for well 34/10-C-47

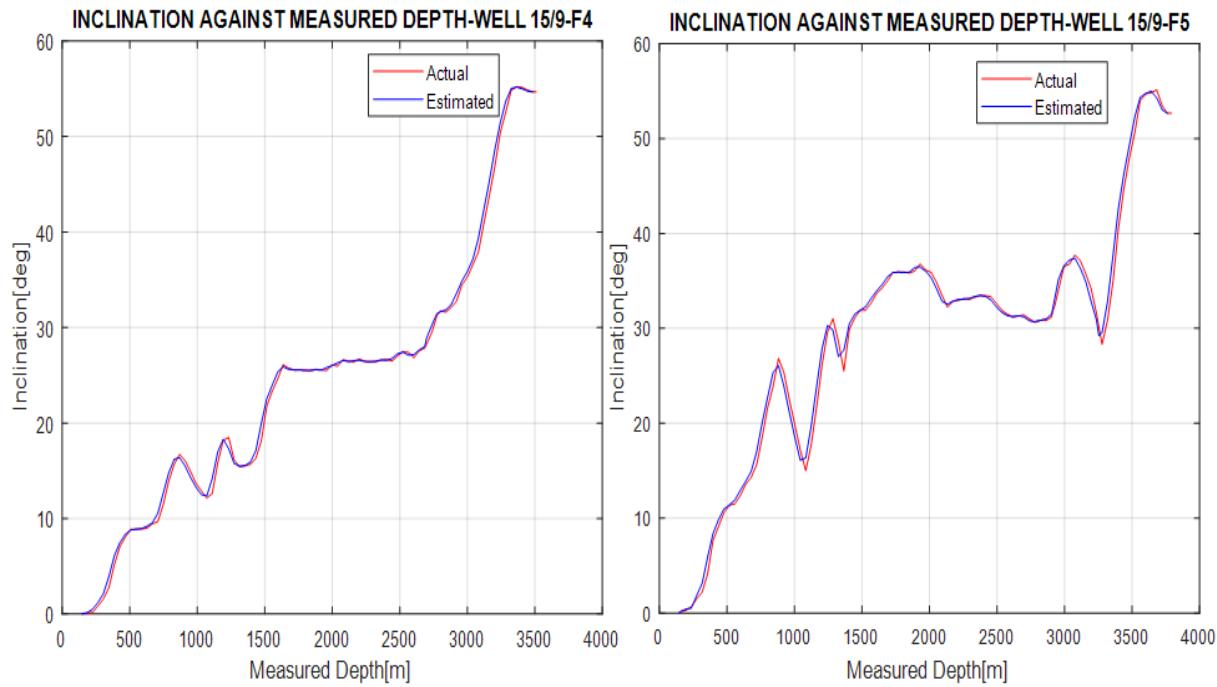


Figure 38: Actual and estimated inclinations for wells 15/9-F-4 and 15/9-F-5

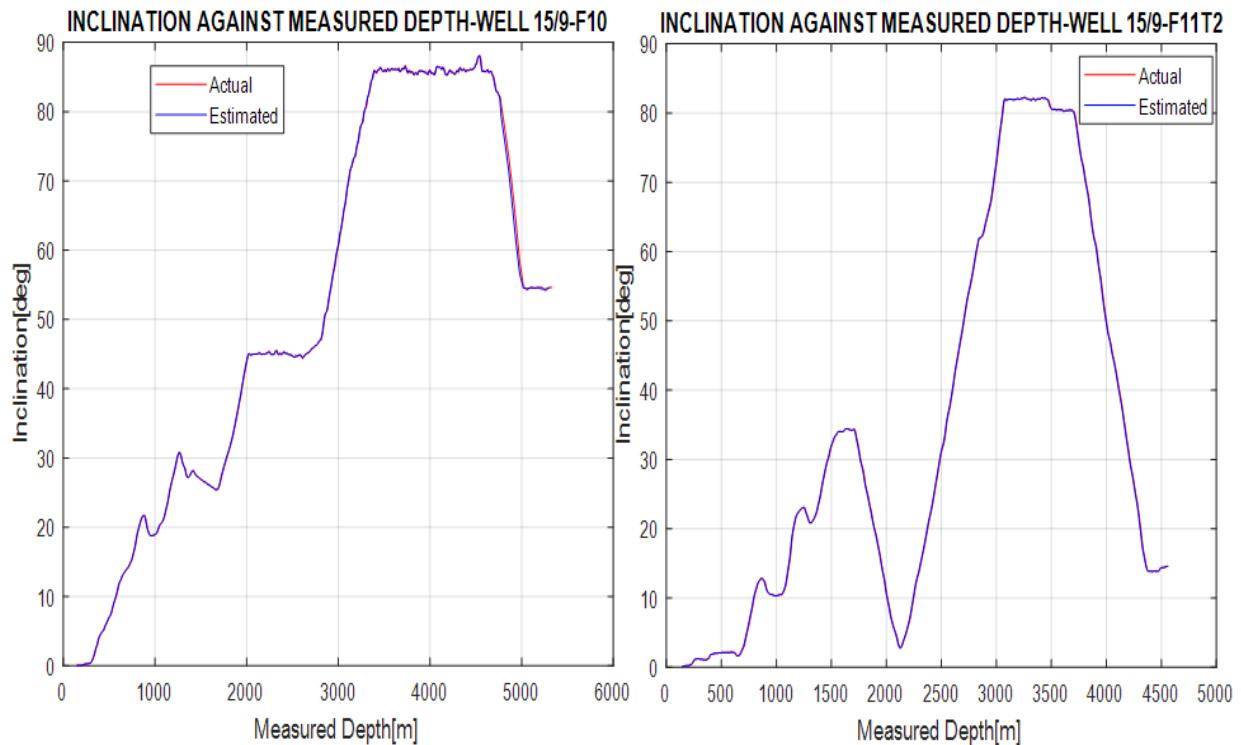


Figure 39: Actual and estimated inclinations for wells 15/9-F-10 and 15/9-F-11T2

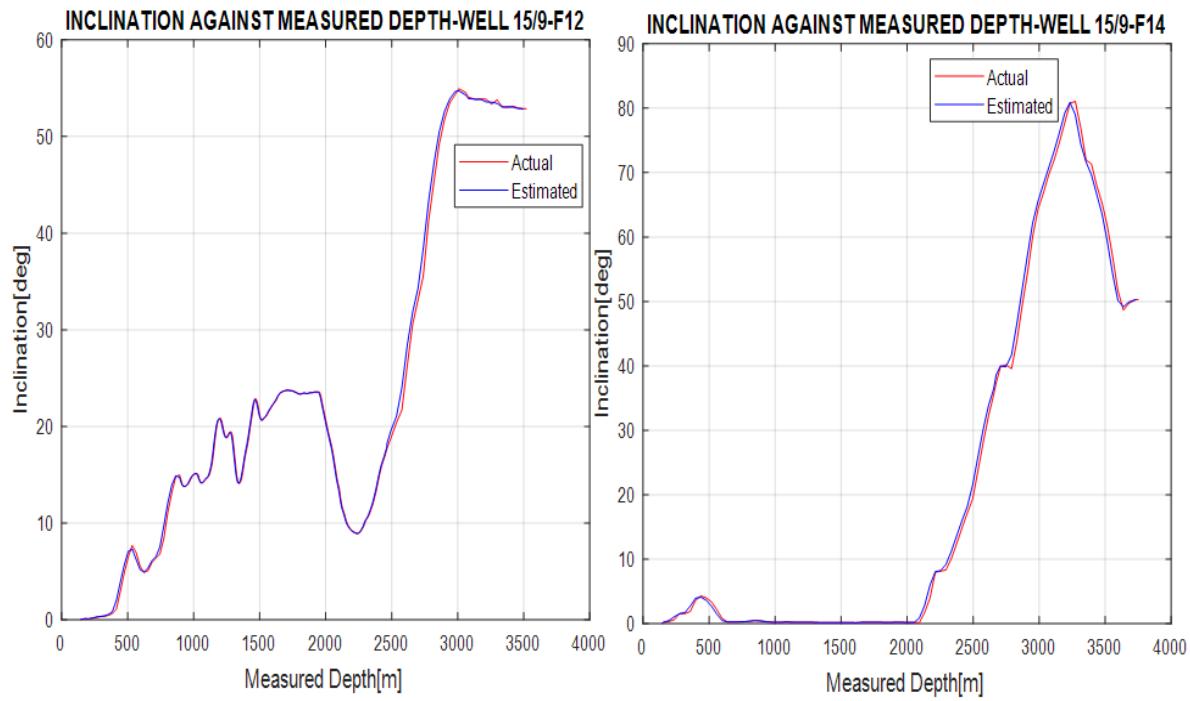


Figure 40: Actual and estimated inclinations for wells 15/9-F-12 and 15/9-F-14

4.1.2. Well Projections

The projection of wells was done by viewing well first in the vertical projection (inclination), then in the horizontal/plan view (Azimuth) and finally in 3D.

4.1.2.1. Vertical Projection

Vertical projections for different wells were created by plotting true vertical depth against horizontal departure of a given well. Horizontal departure was predetermined using both east and north coordinates as indicated by numerator of equation 5 in section 3.2.1.

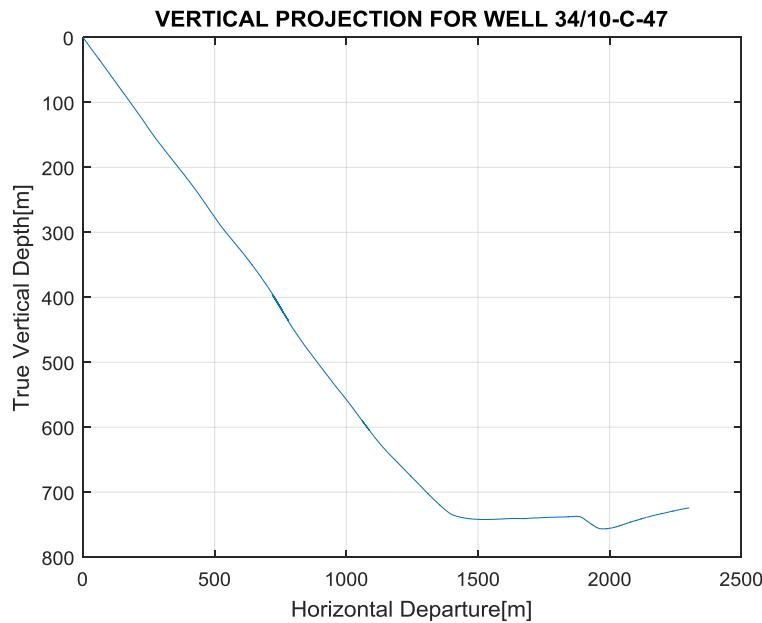


Figure 41: Vertical projection for Well 34/10-C-47

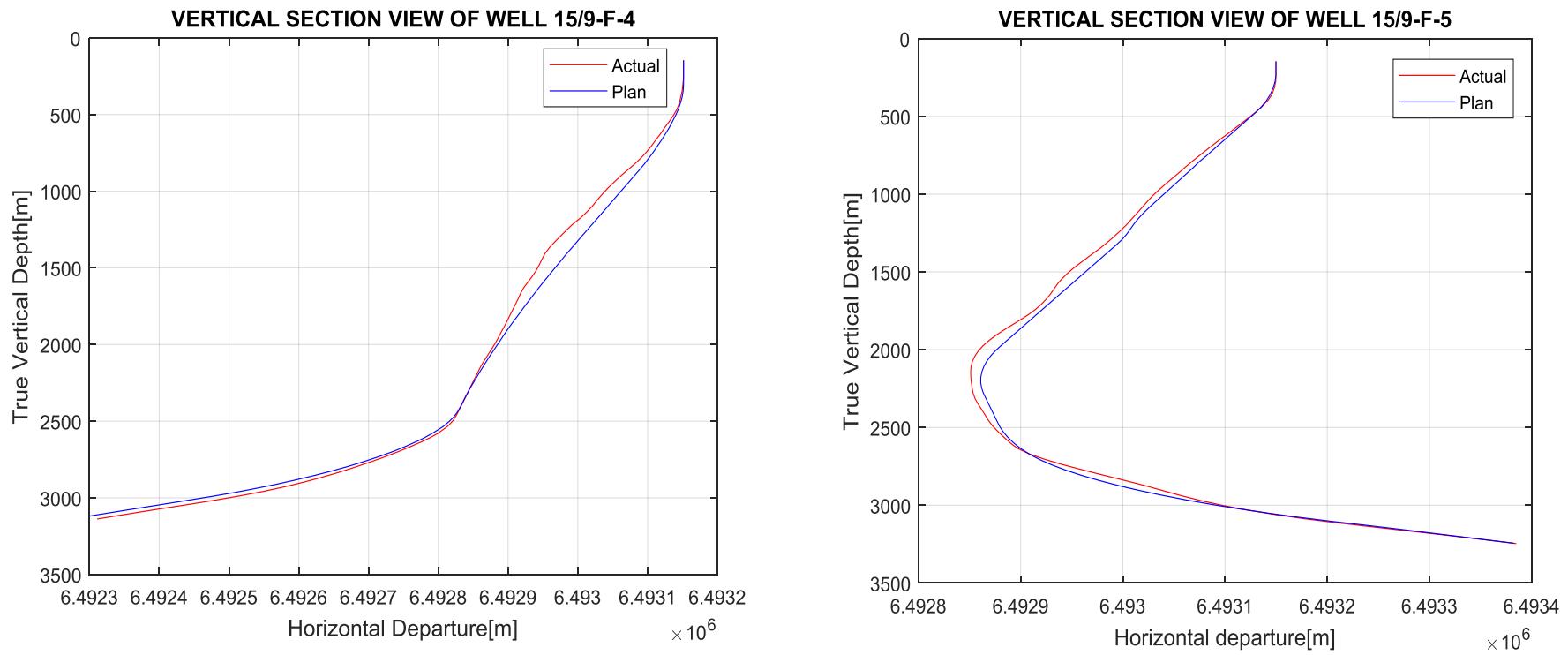


Figure 42: Vertical projection for Well 15/9-F-4 and 15/9-F-5

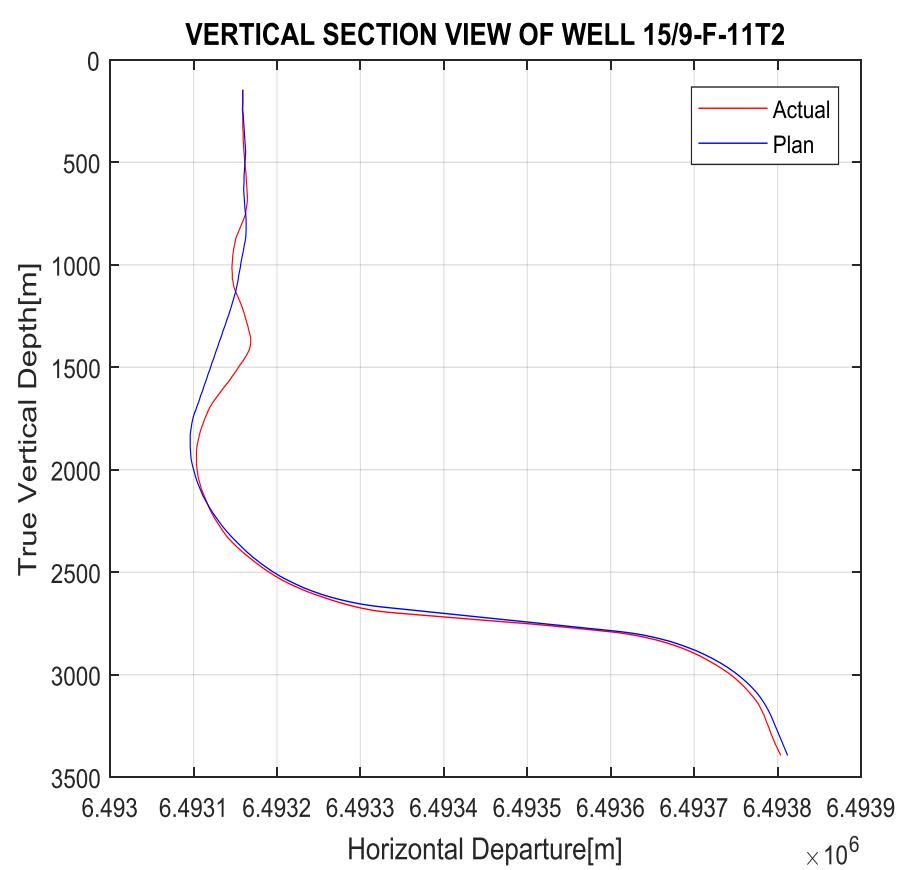
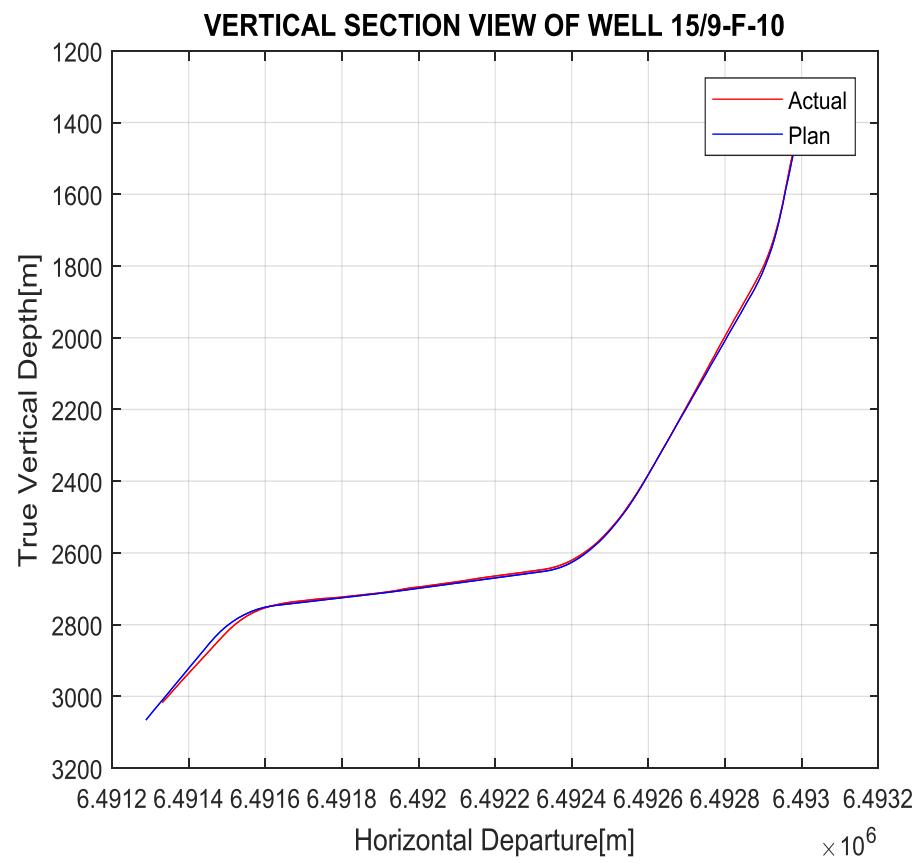


Figure 43: Vertical projection for Wells 15/9-F-10 and 15/9-F-11T2

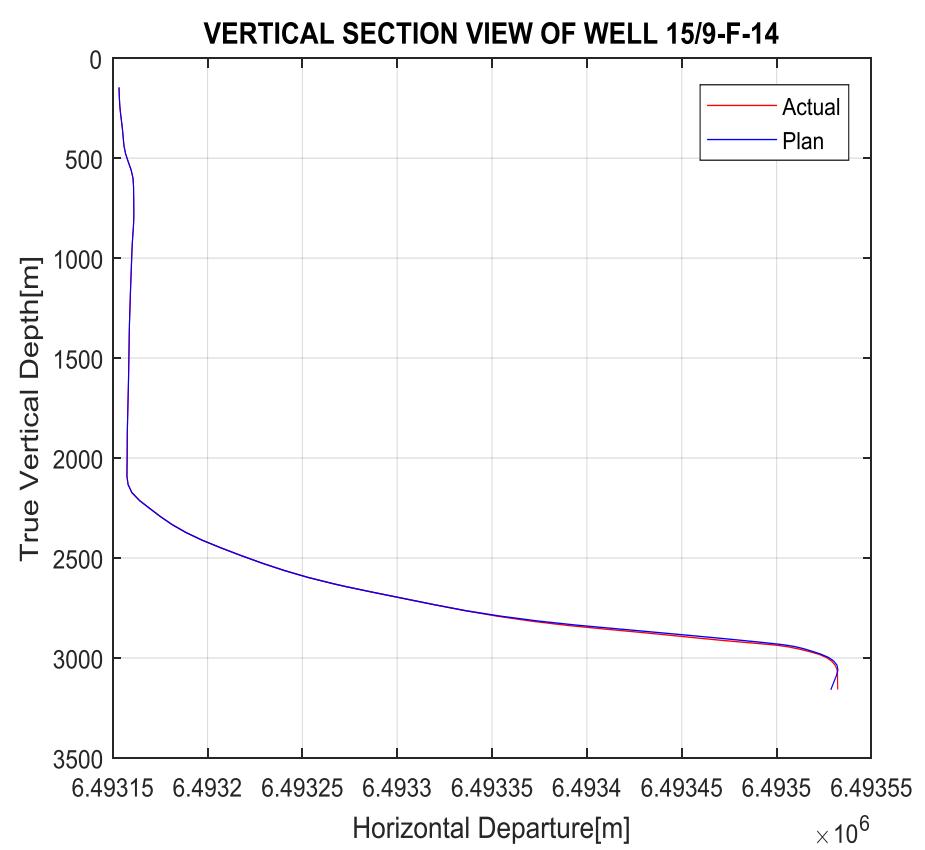
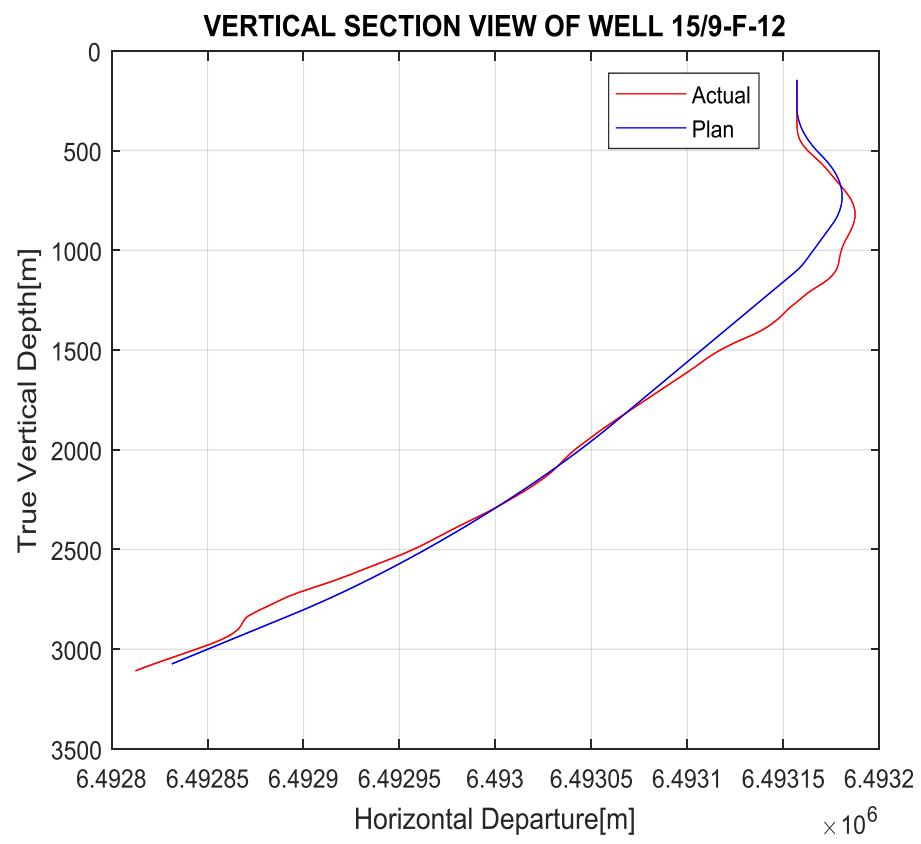


Figure 44: Vertical projection for wells 15/9-F-12 and 15/9-F-14

4.1.2.2. Horizontal Projection

Horizontal projections for different wells were created by plotting North coordinate against East coordinate (see codes in appendices A and F).

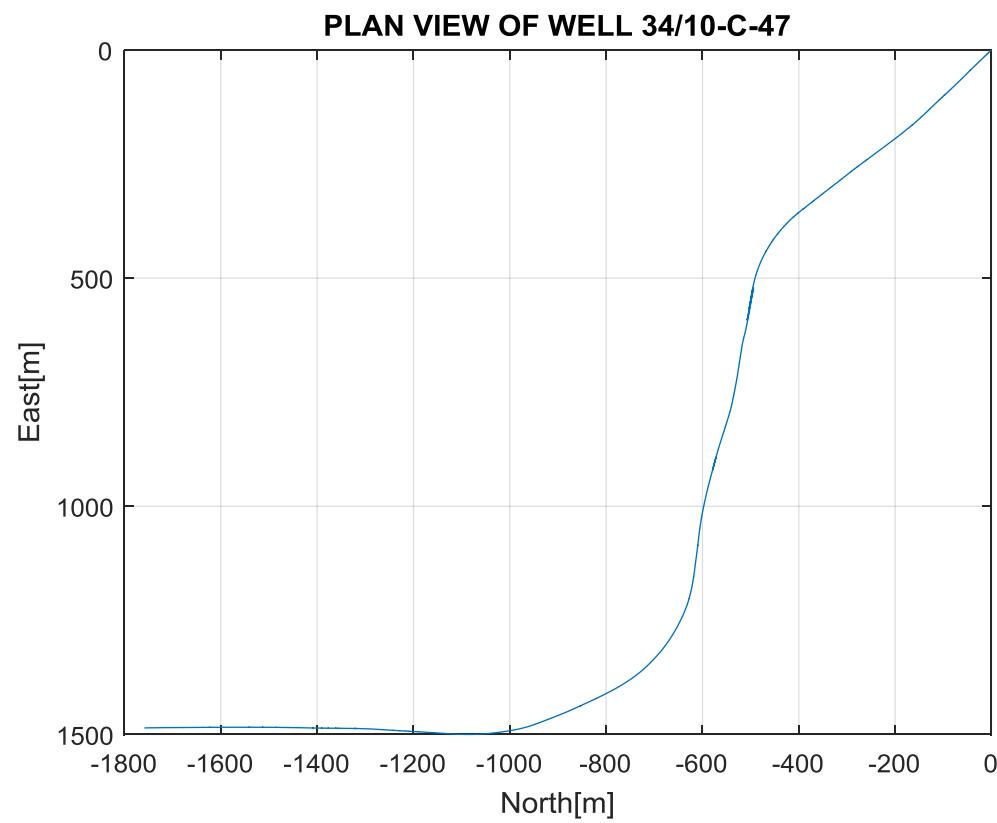


Figure 45: Horizontal projection for Well 34/10-C-47

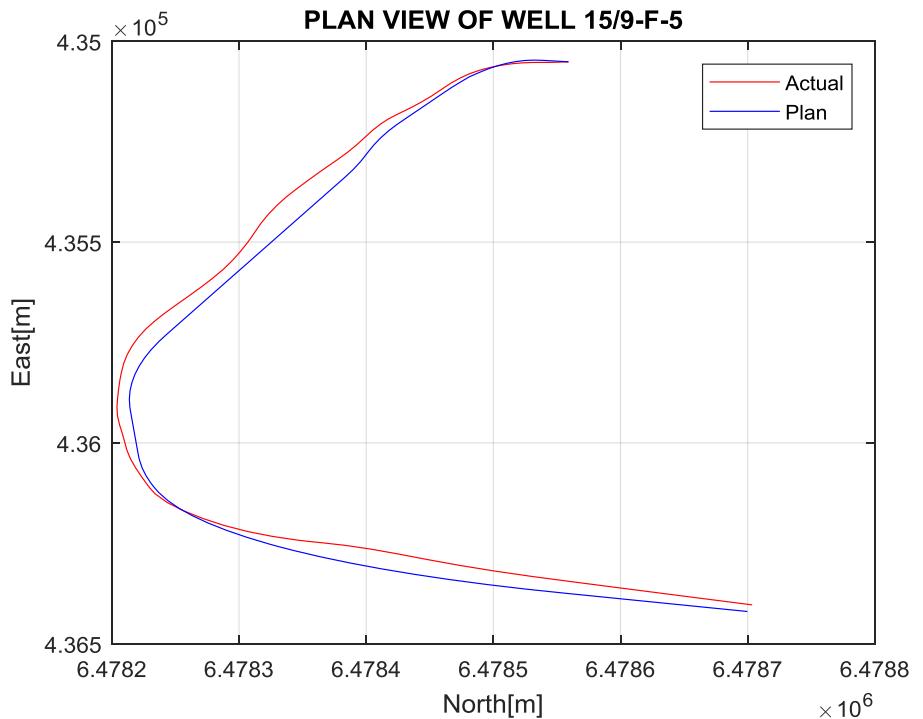
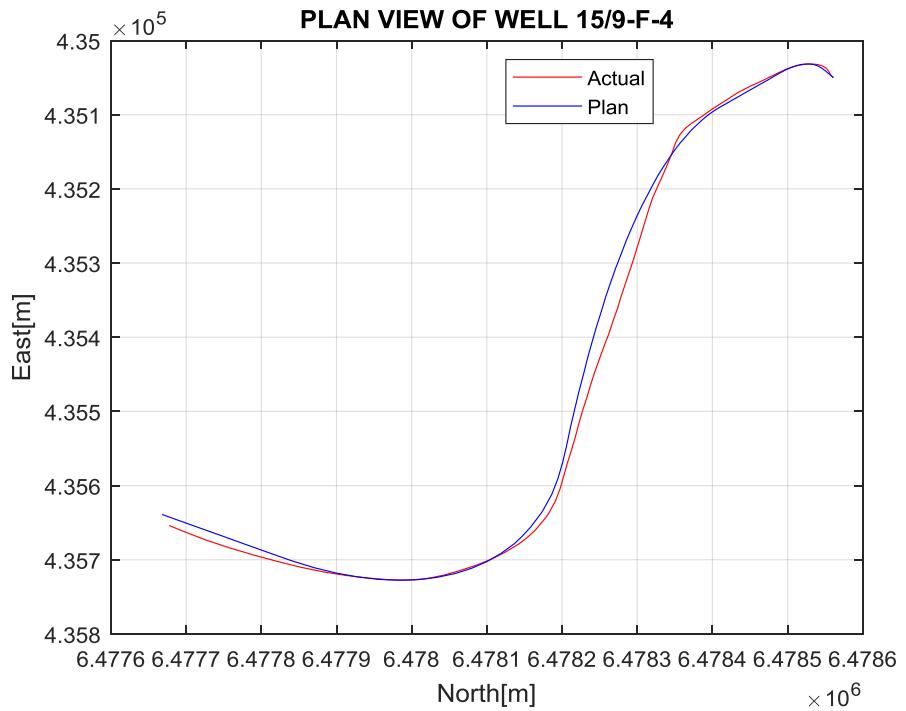


Figure 46: Horizontal projection for wells 15/9-F-4 and 15/9-F-5

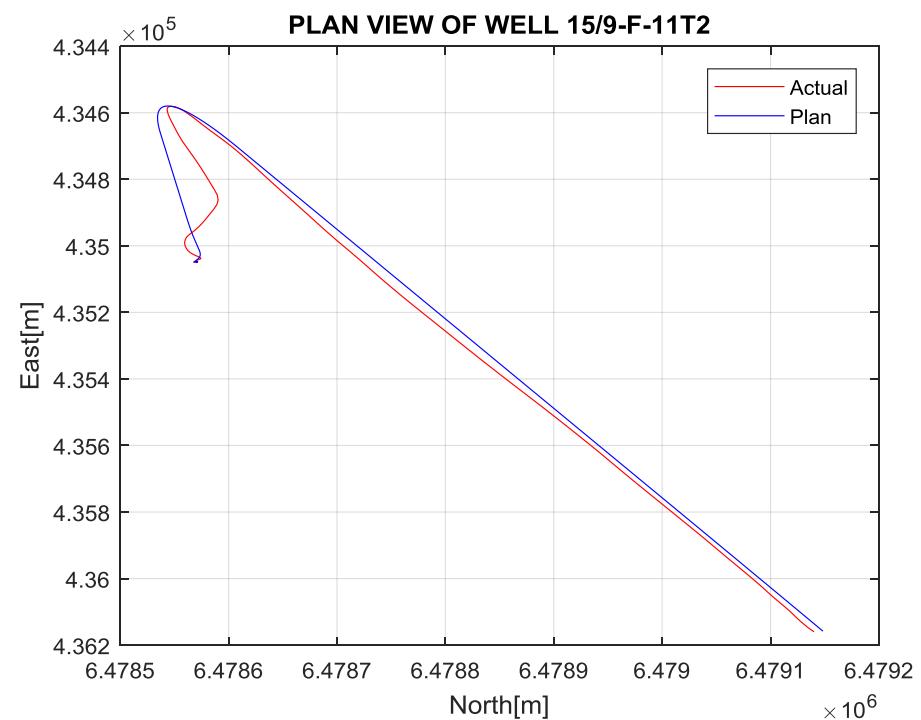
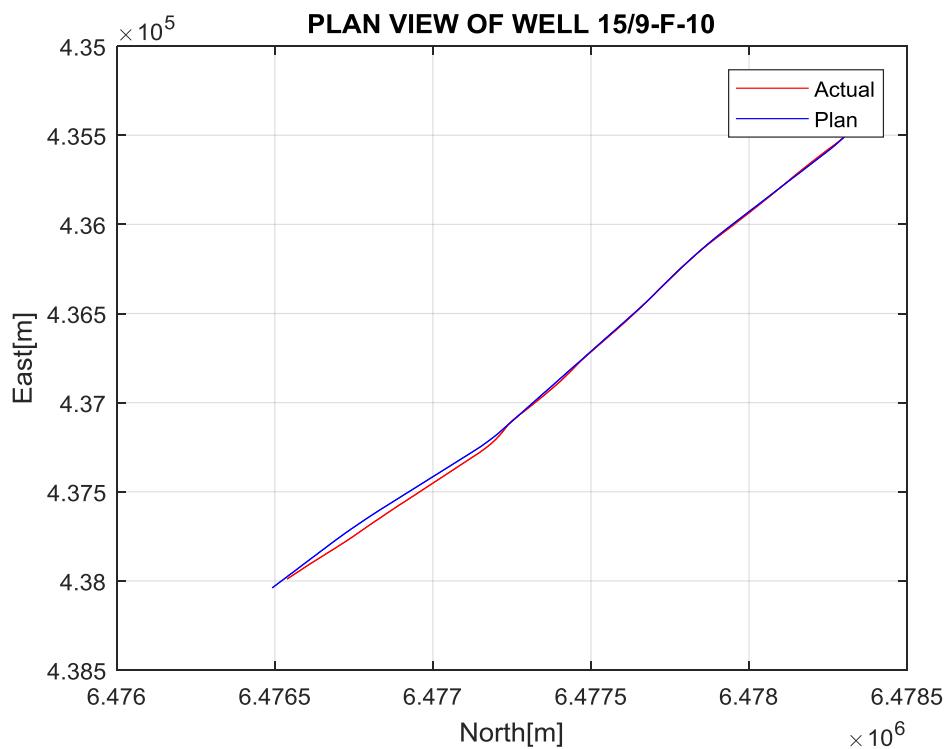


Figure 47: Horizontal projection for well 15/9-F-10 and 15/9-F-11T2

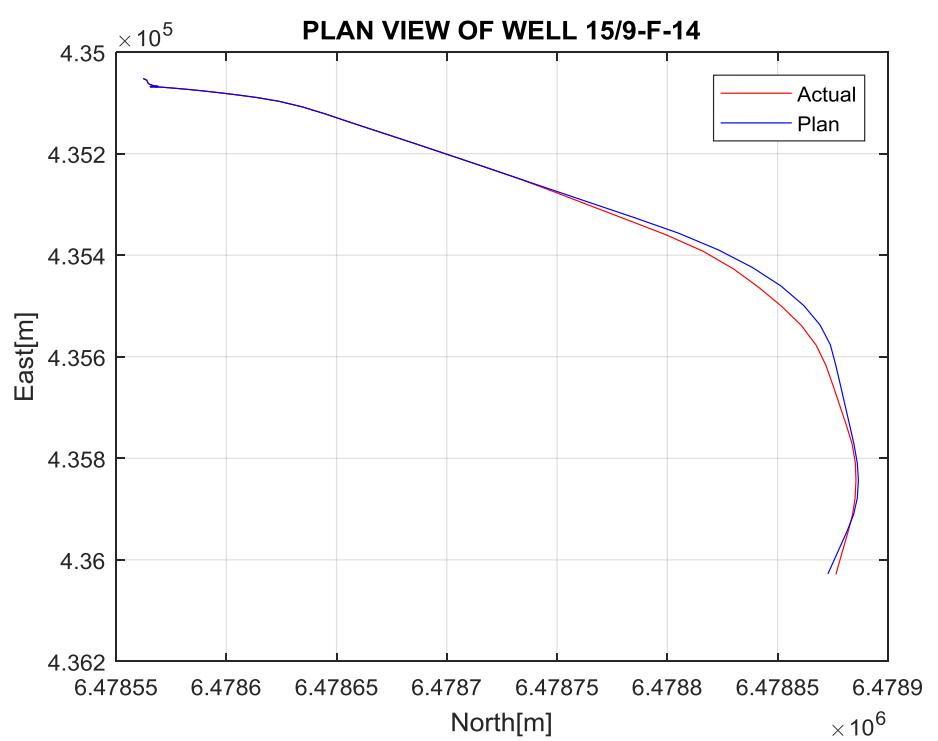
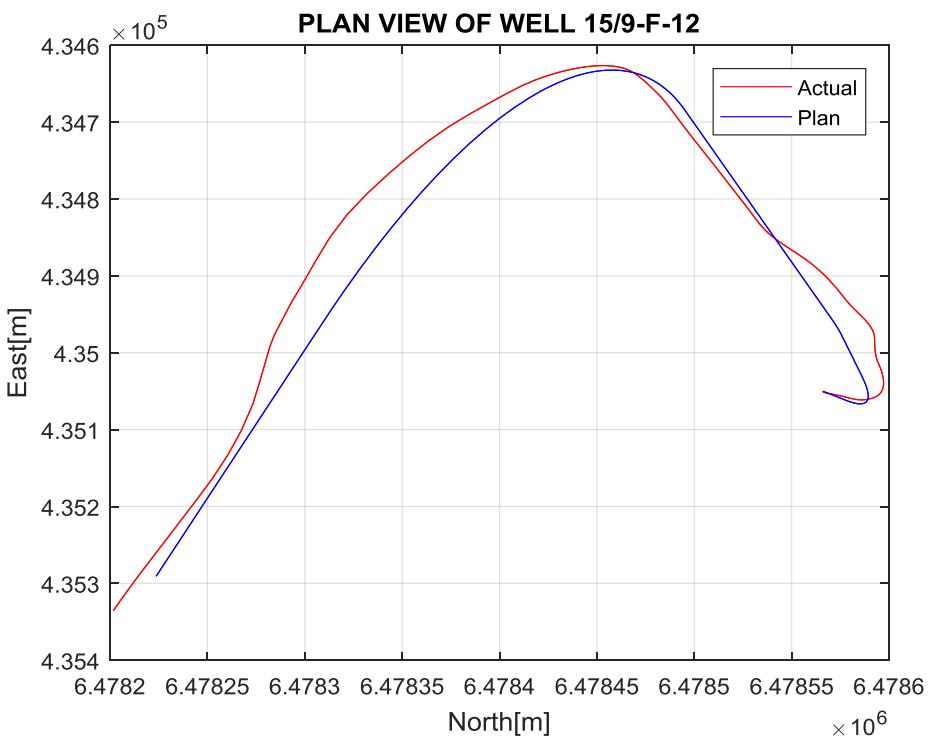


Figure 48: Horizontal projection for wells 15/9-F-12 and 15/9-F-14

4.1.2.3. Three dimensional view (3D)

3D views for different wells were created by plotting true vertical depth against east and north coordinates of the well. Coding done in appendices A and F shows the plotting for seven wells under consideration

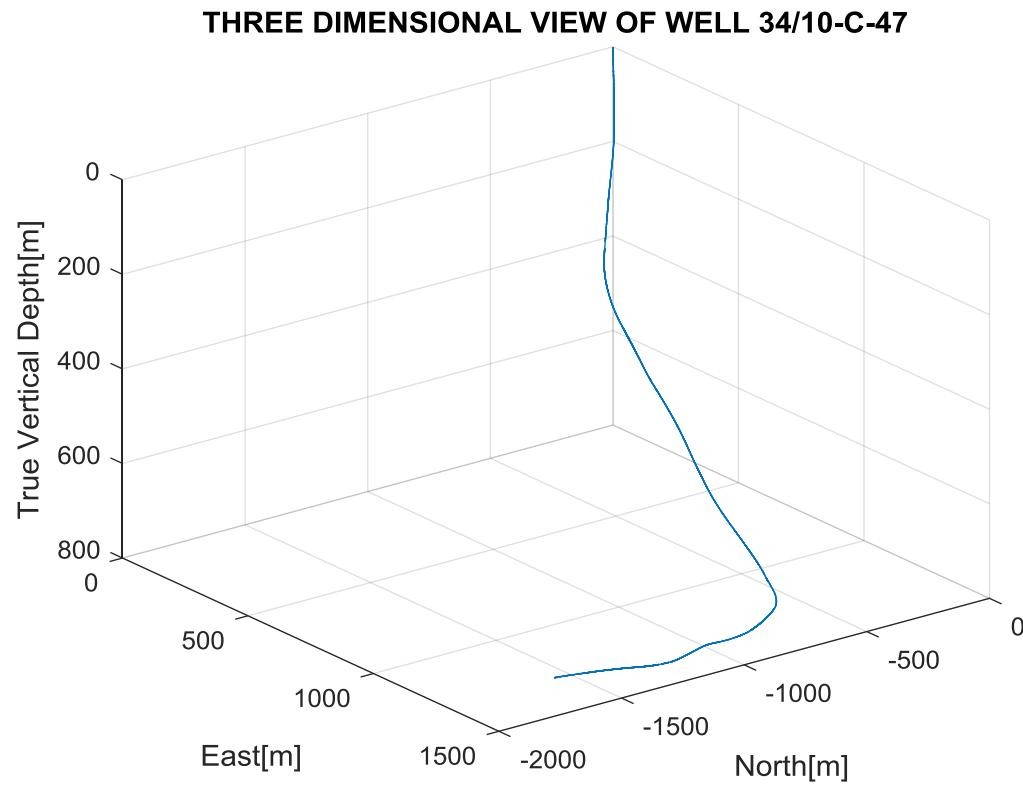


Figure 49: 3D view for well 34/10-C-47

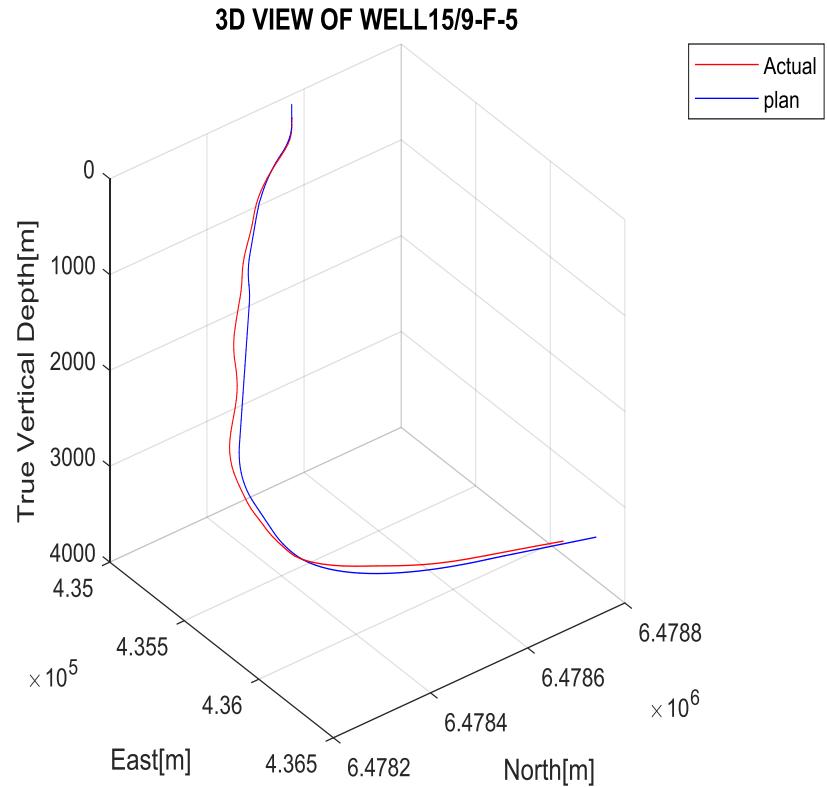
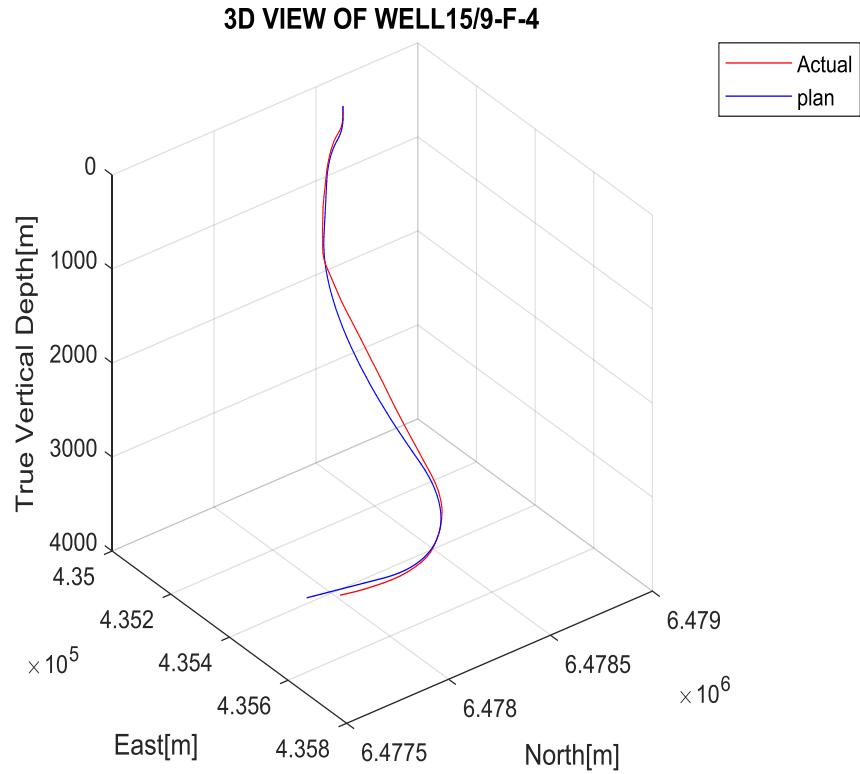


Figure 50: 3D view for wells 15/9-F-4 and 15/9-F-5

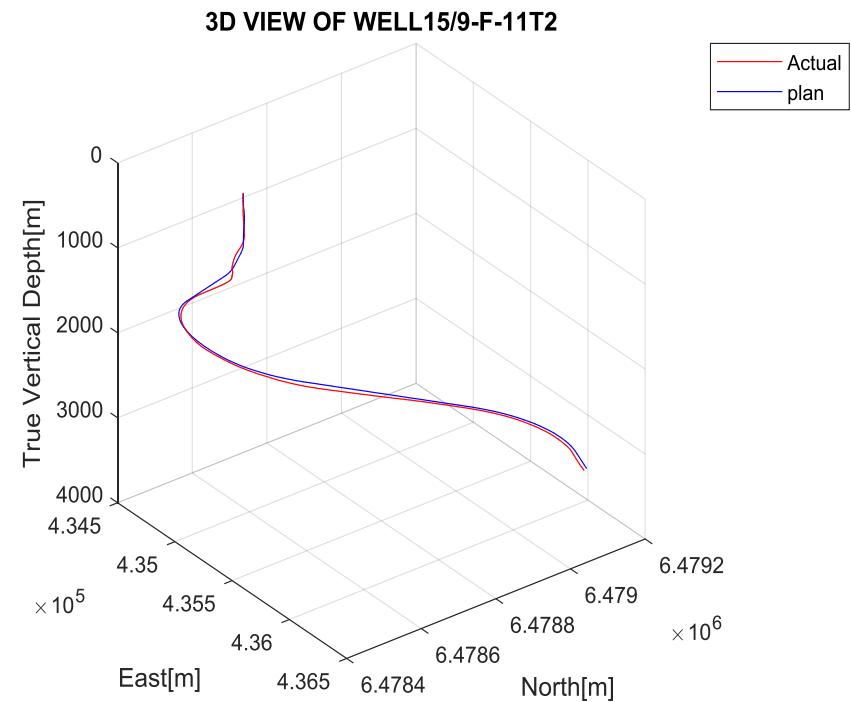
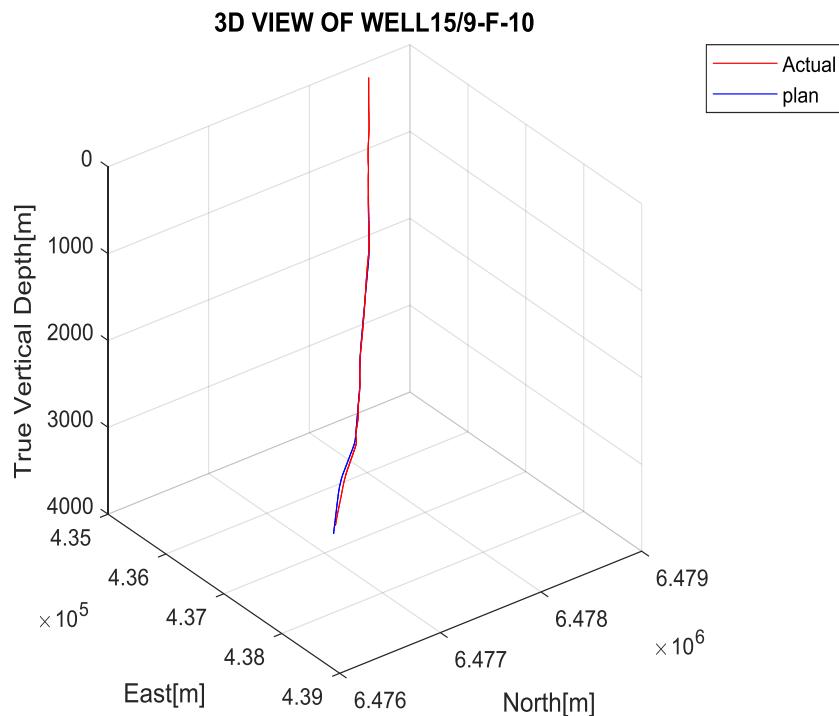


Figure 51: 3D view for wells 15/9-F-10 and 15/9-F-11T2

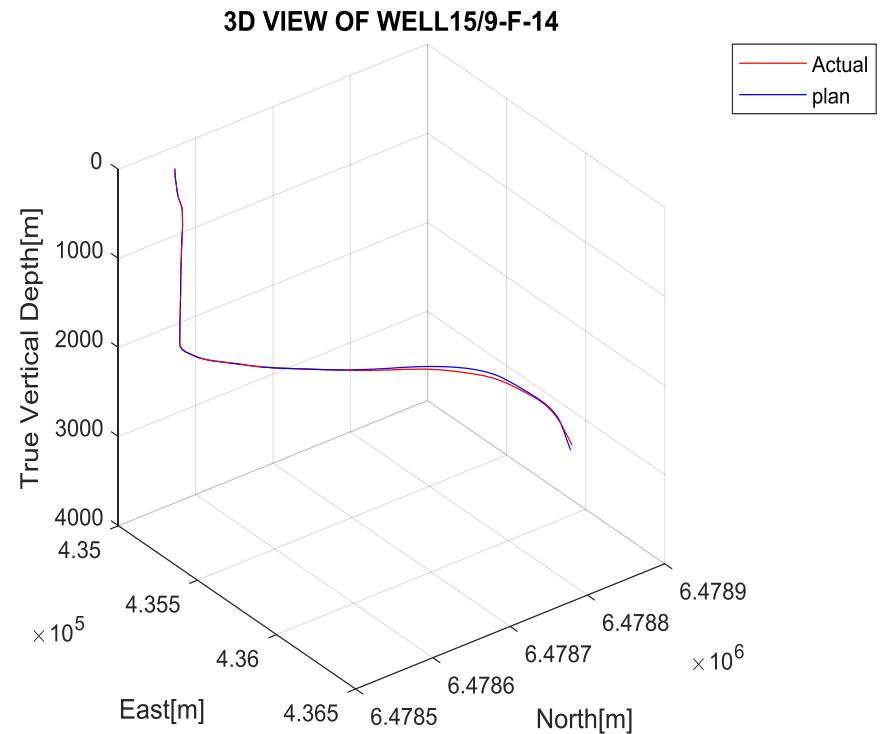
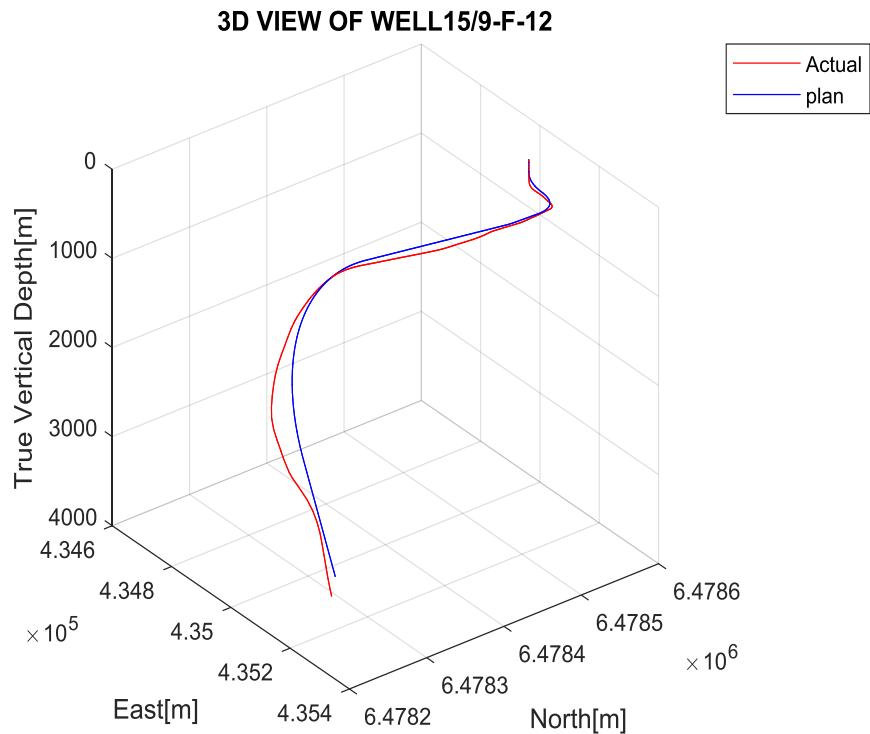


Figure 52: 3D view for wells 15/9-F-12 and 15/9-F-14

4.1.3. Variation of True Vertical Depth with Measured Depth

Plotting of true vertical depth against measured depth was done for each well in order to see the trend and variation of them during drilling operation. Below are figures of TVD variation with MD.

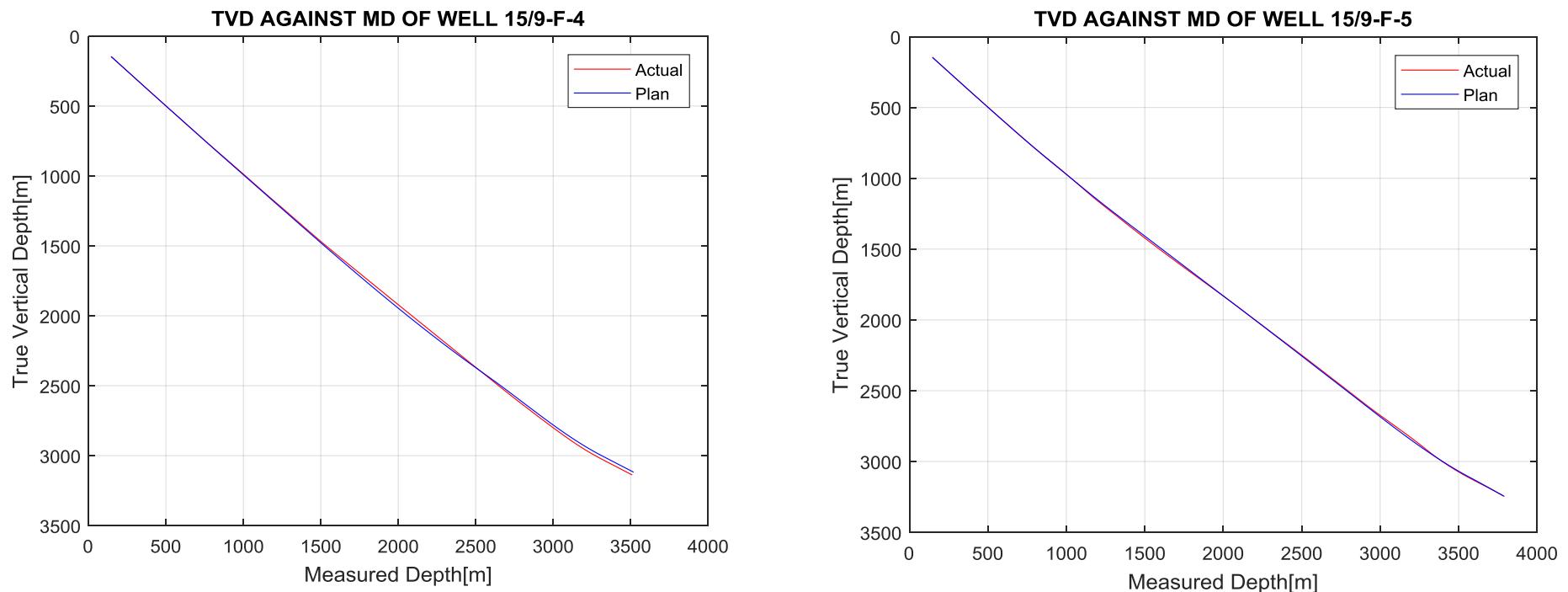


Figure 53: TVD versus MD for wells 15/9-F-4 and 15/9-F-5

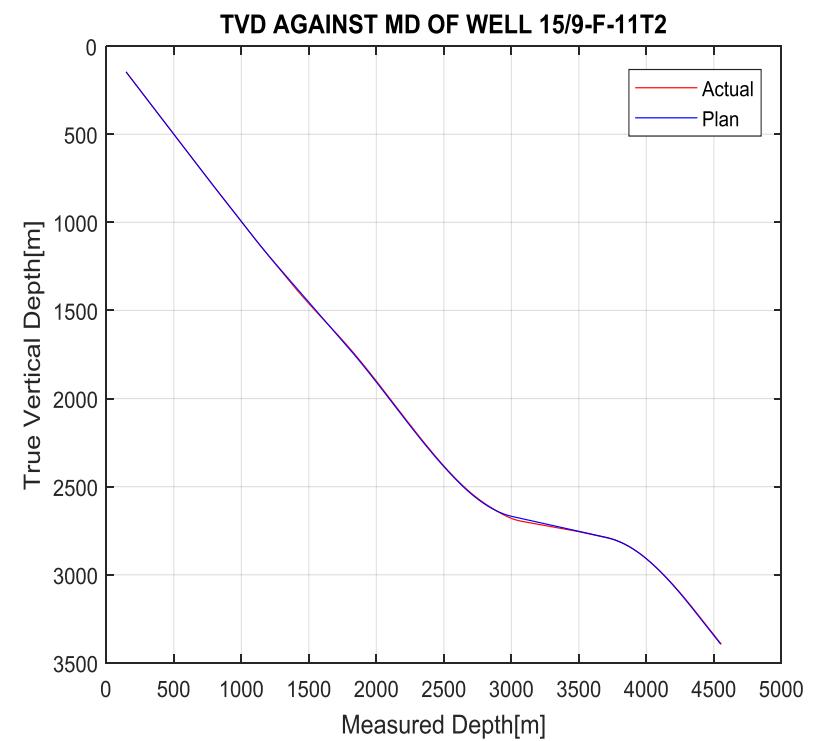
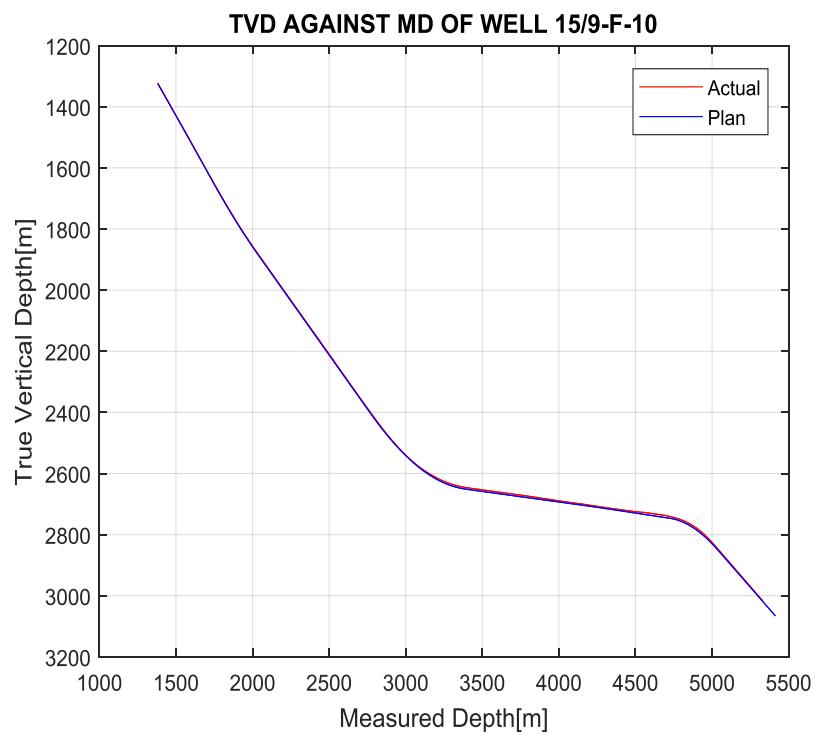


Figure 54: TVD versus MD for wells 15/9-F-10 and 15/9-F-11T2

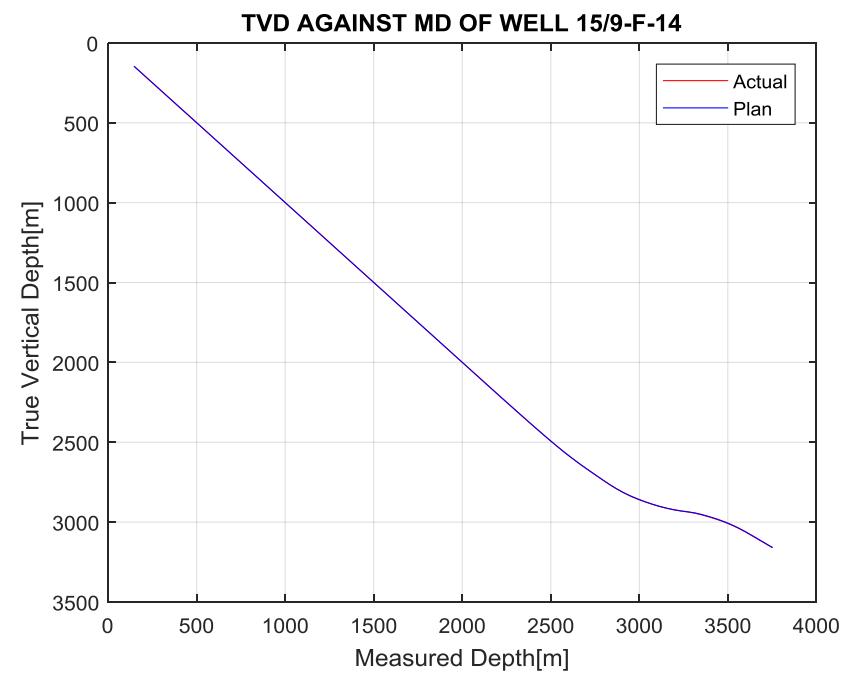
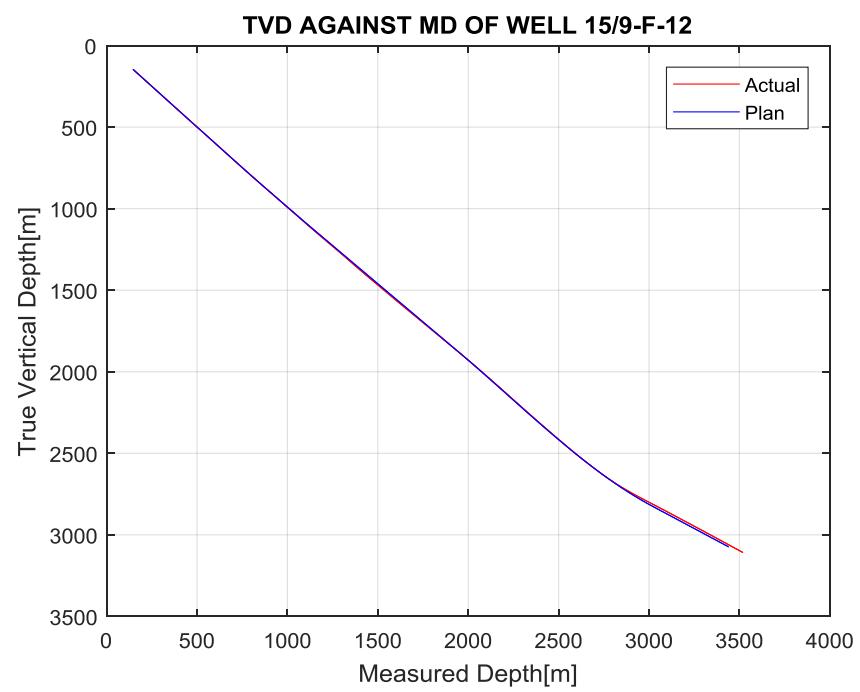


Figure 55: TVD versus MD for wells 15/9-F-12 and 15/9-F-14

4.1.4. Variation of inclination and azimuth with depth

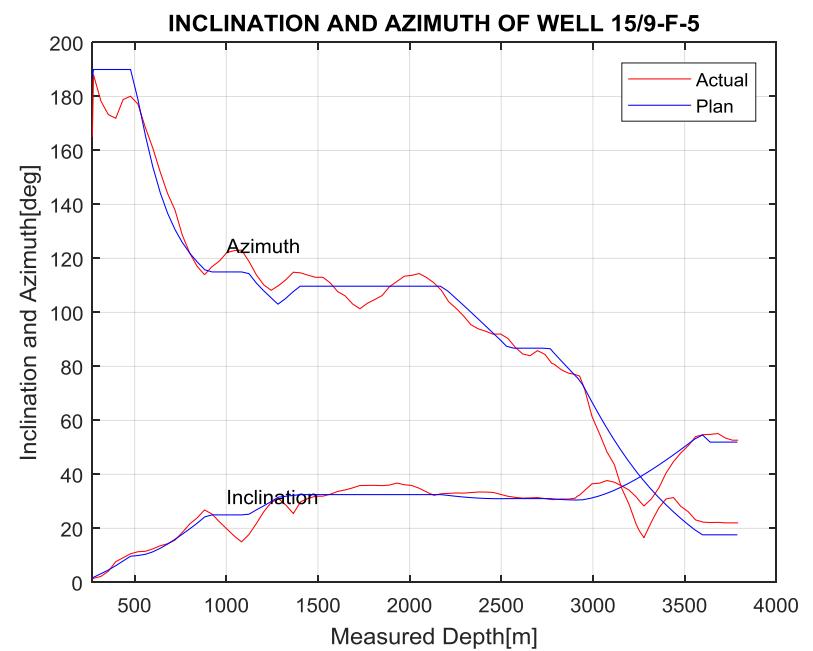
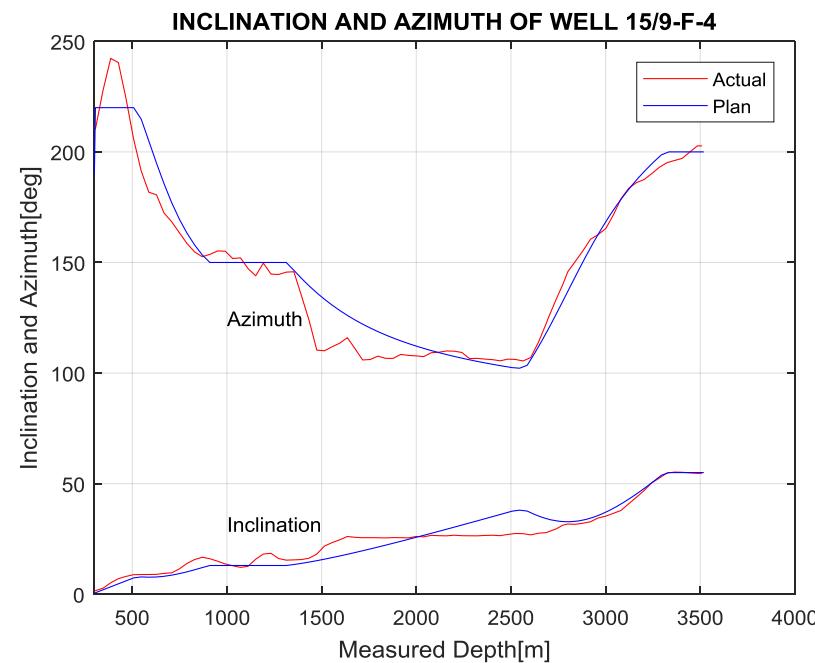


Figure 56: Azimuth and Inclination variation with depth for wells 15/9-F-4 and 15/9-F-5

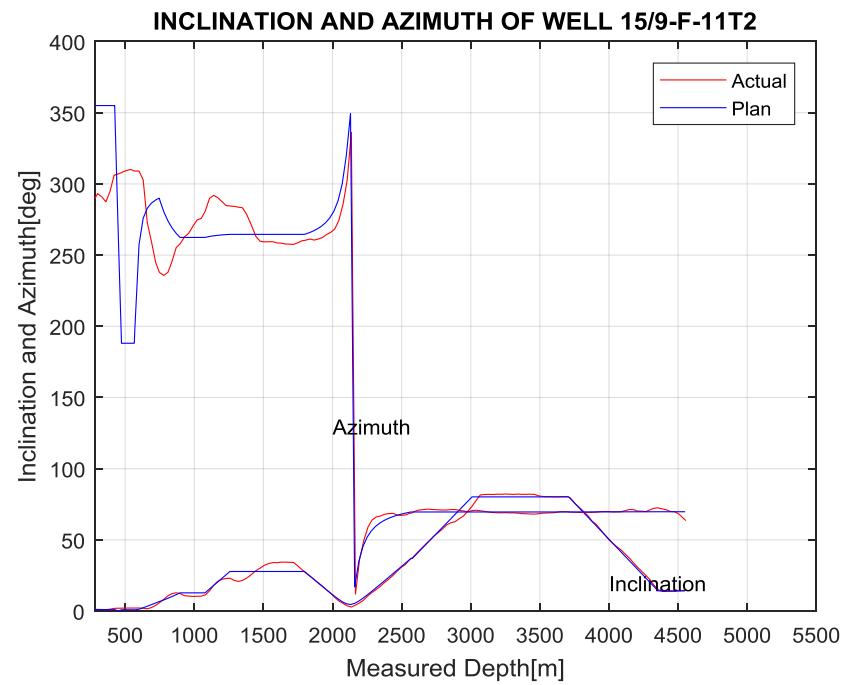
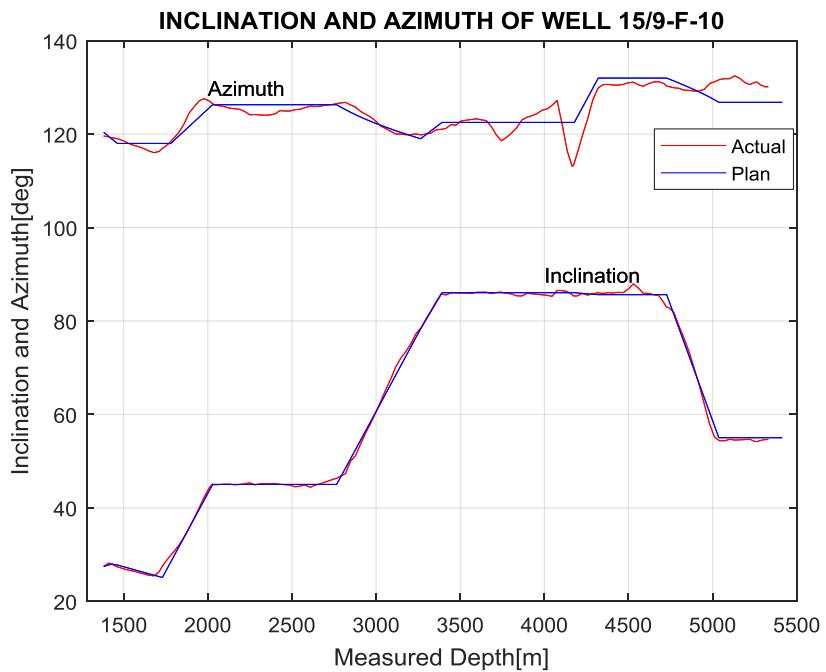


Figure 57: Azimuth and Inclination variation with depth for wells 15/9-F-10 and 15/9-F-11T2

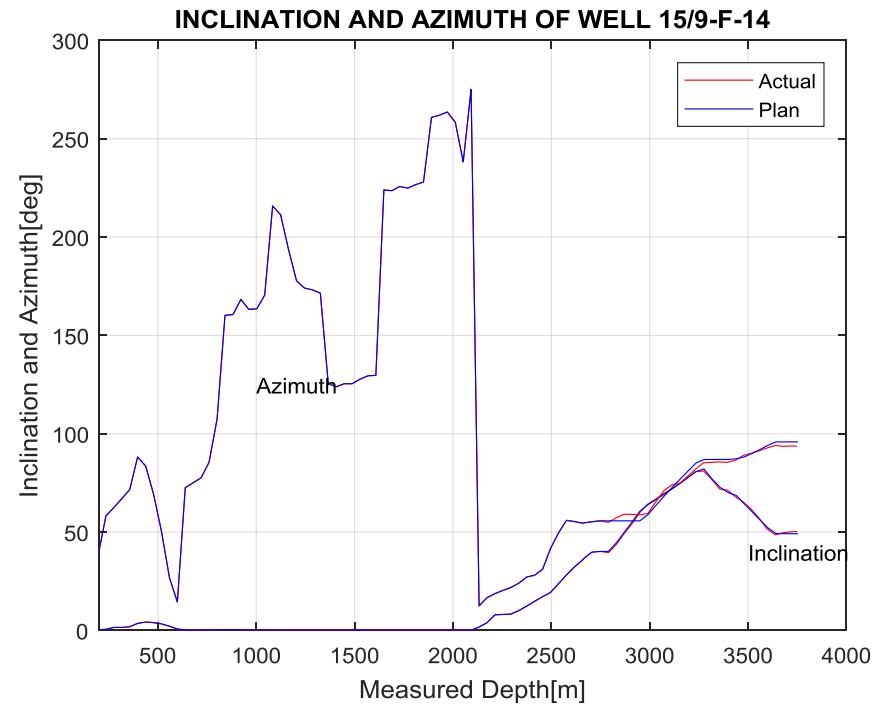
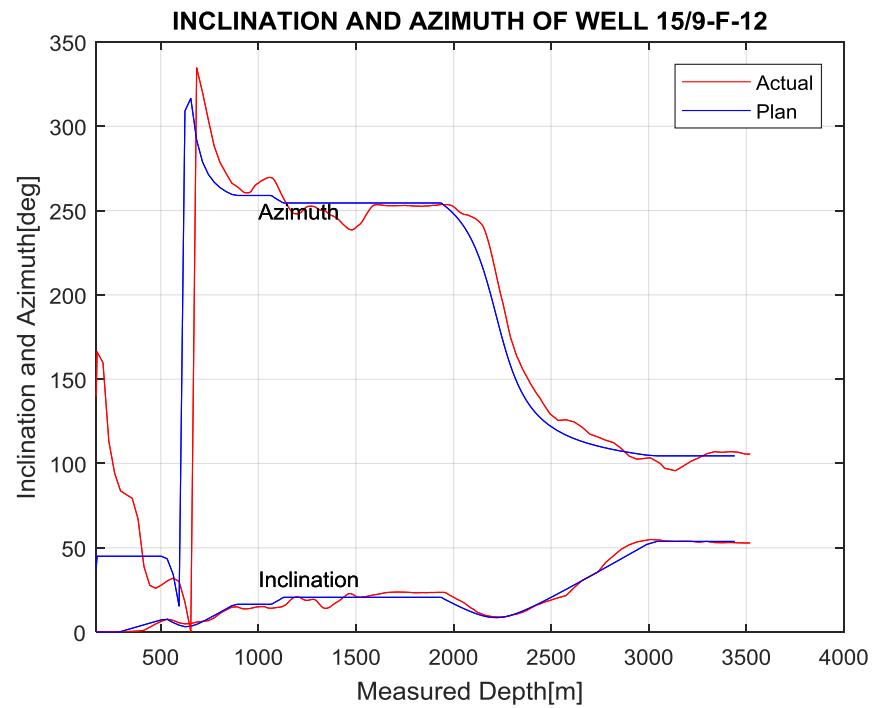


Figure 58: Azimuth and Inclination variation with depth for wells 15/9-F-12 and 15/9-F-14

4.1.5. Variation of dogleg severity with depth

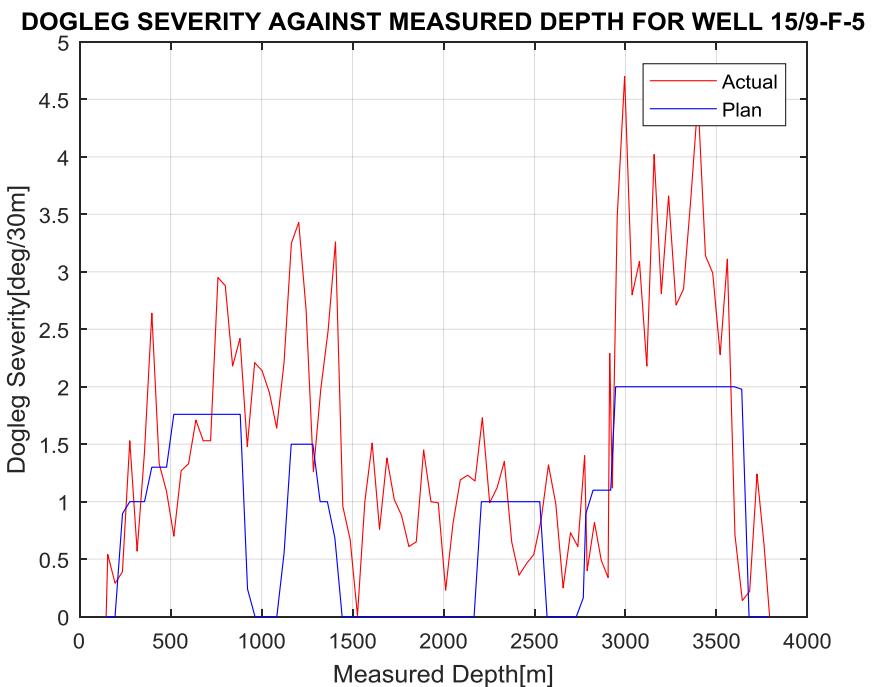
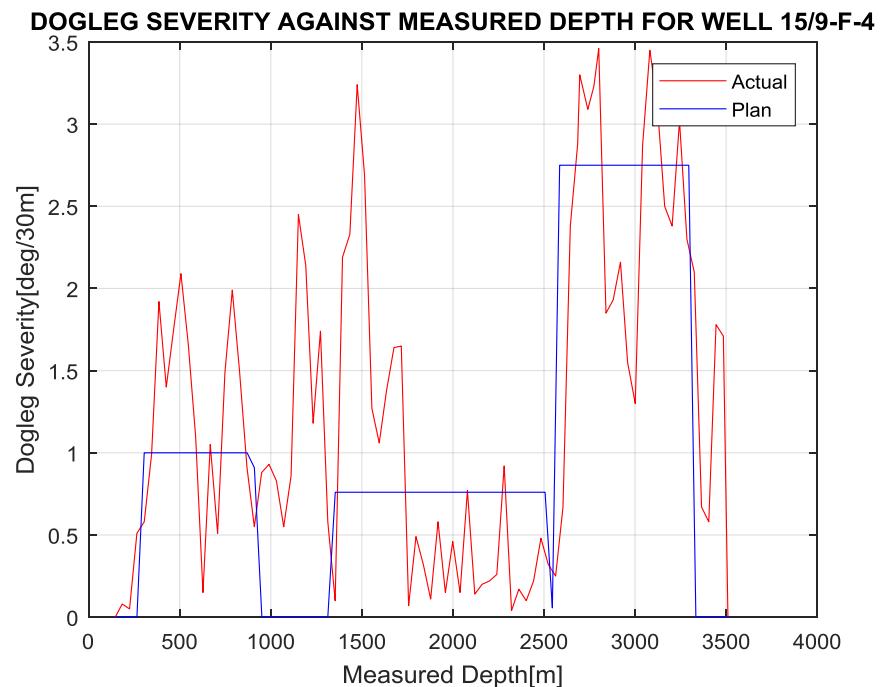


Figure 59: DLS variation with MD for wells 15/9-F-4 and 15/9-F-5

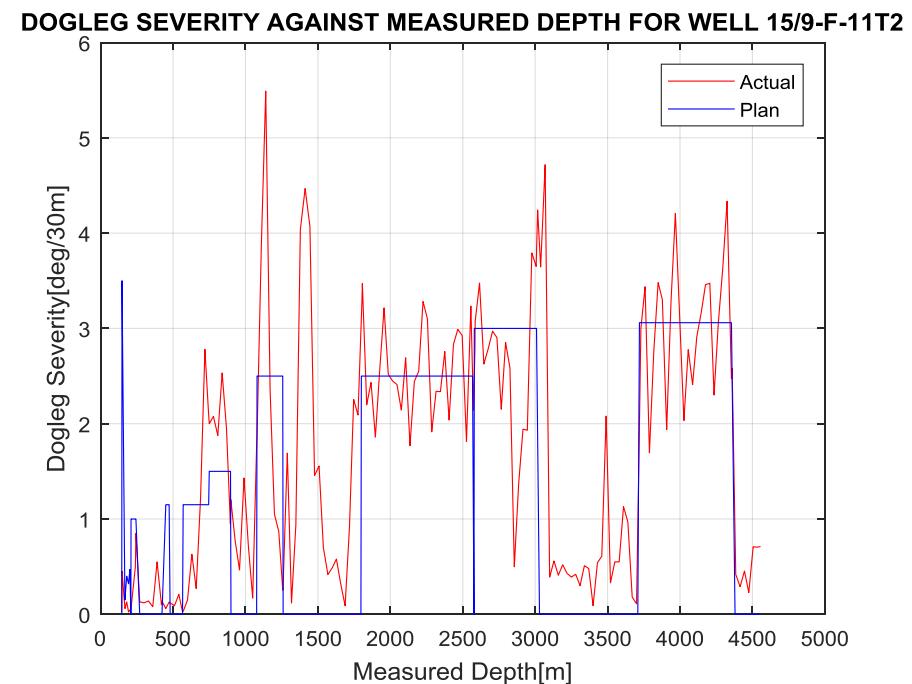
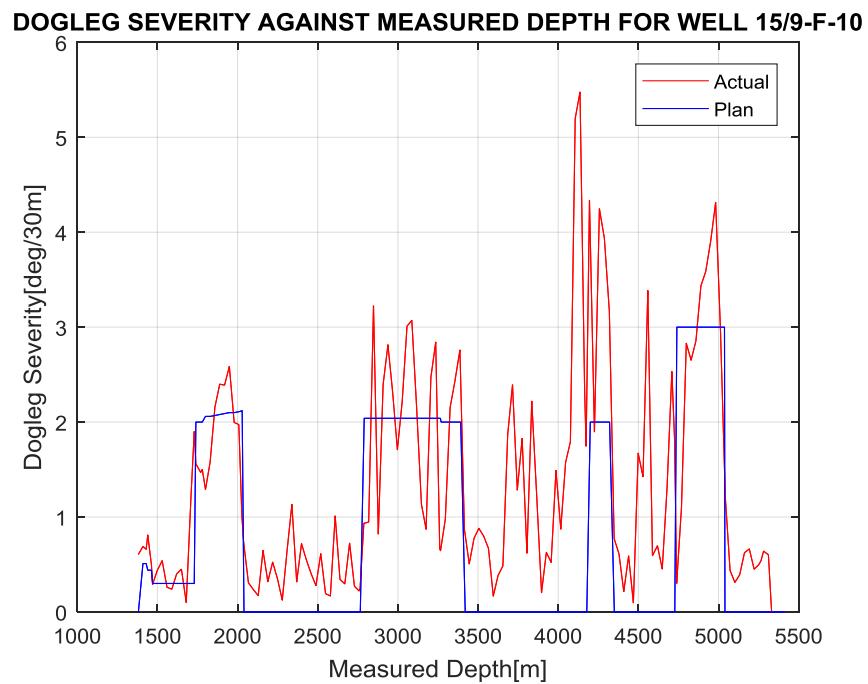


Figure 60: DLS variation with MD for wells 15/9-F-10 and 15/9-F-11T2

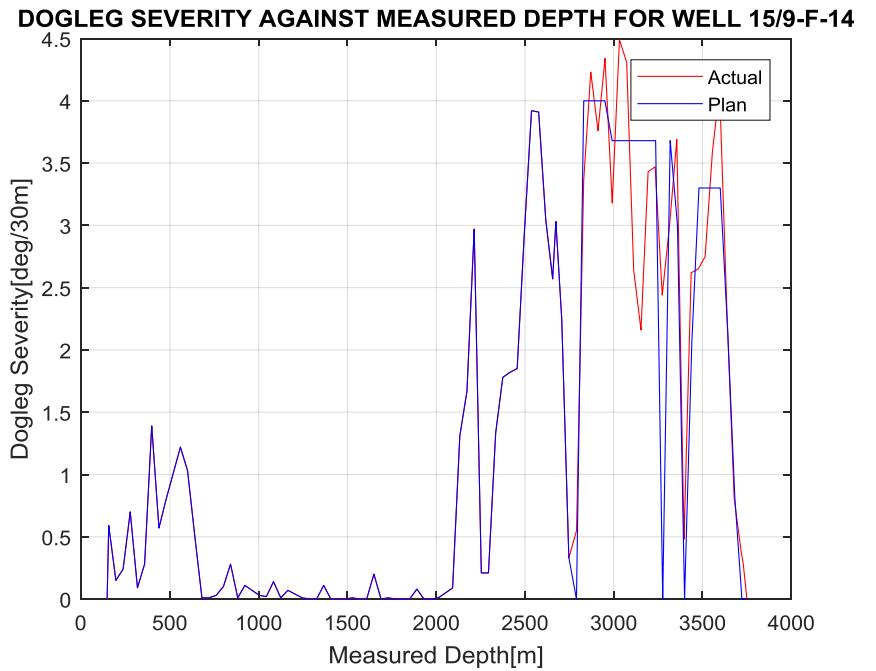
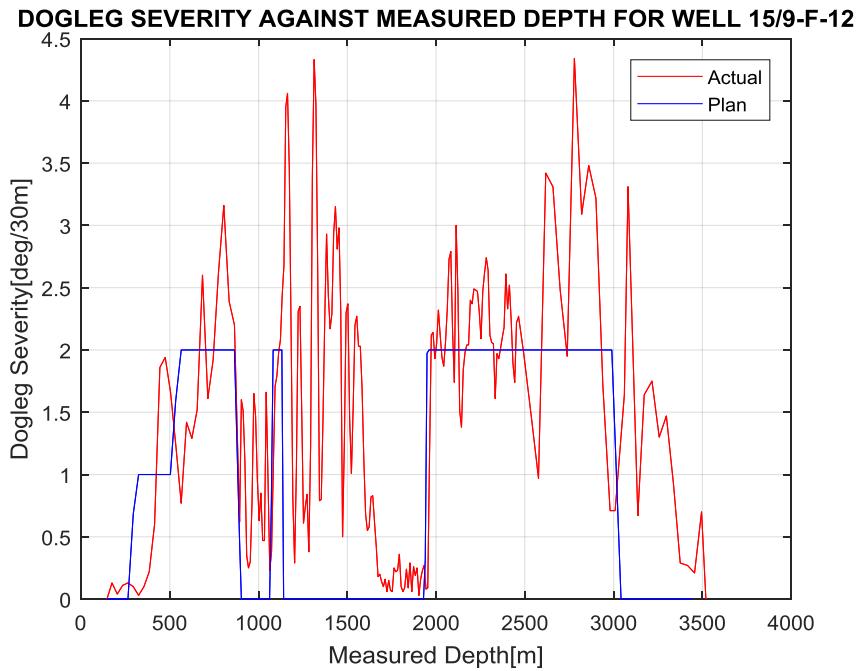


Figure 61: DLS variation with MD for wells 15/9-F-12 and 15/9-F-14

4.1.6. Minimum distance between the planned and actual trajectory points

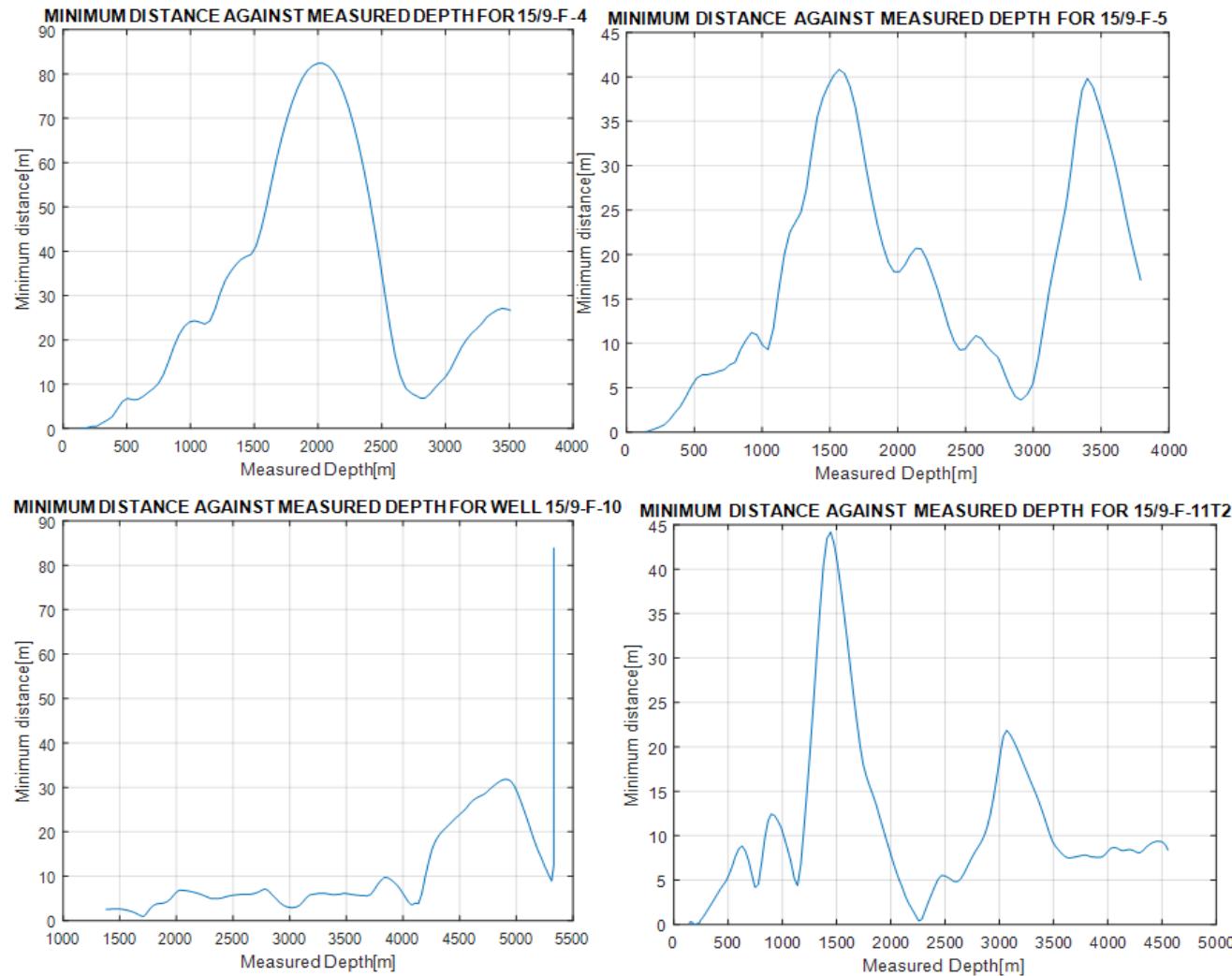


Figure 62: Variation of minimum distance between the planned and actual trajectory points with depth for well 15/9-F-4, 15/9-F-5, 15/9-F-10 and 15/9-F-11T2

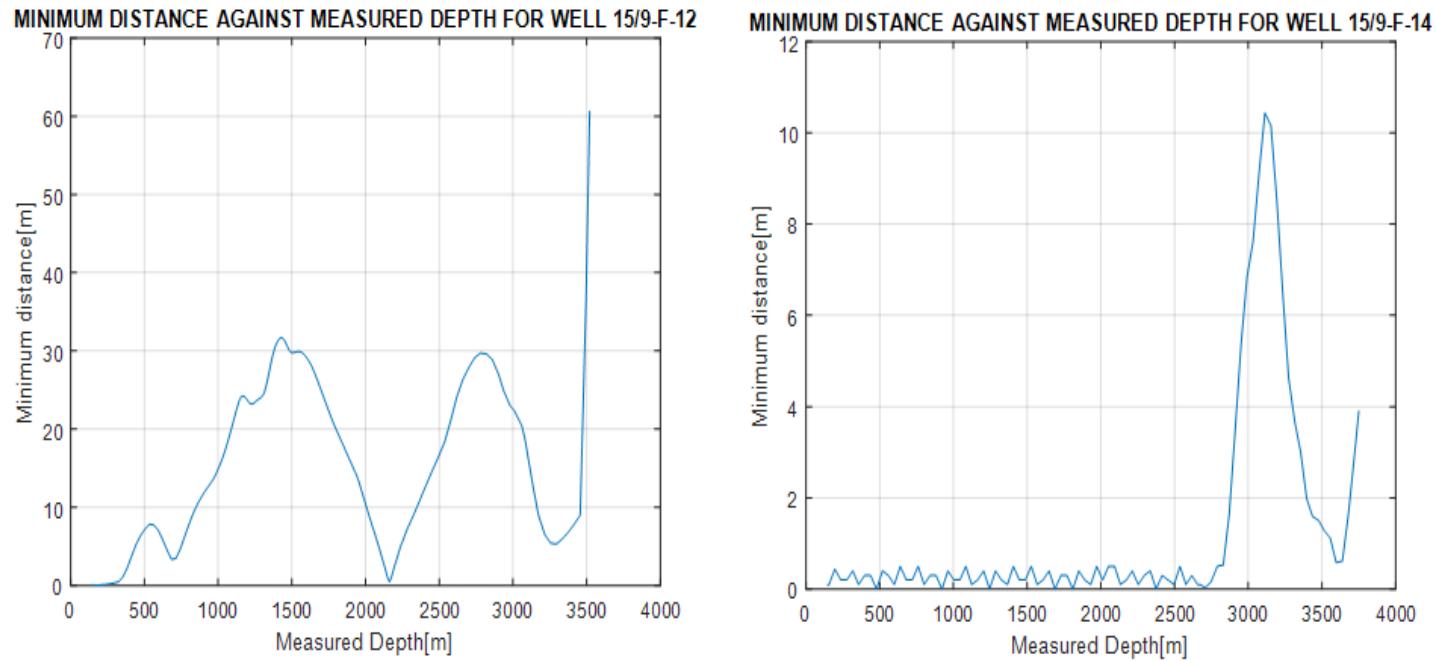


Figure 63: Variation of minimum distance between the planned and actual trajectory points with depth for well 15/9-F-12 and 15/9-F-14

4.1.7. Difference in minimum distance before and after interpolation

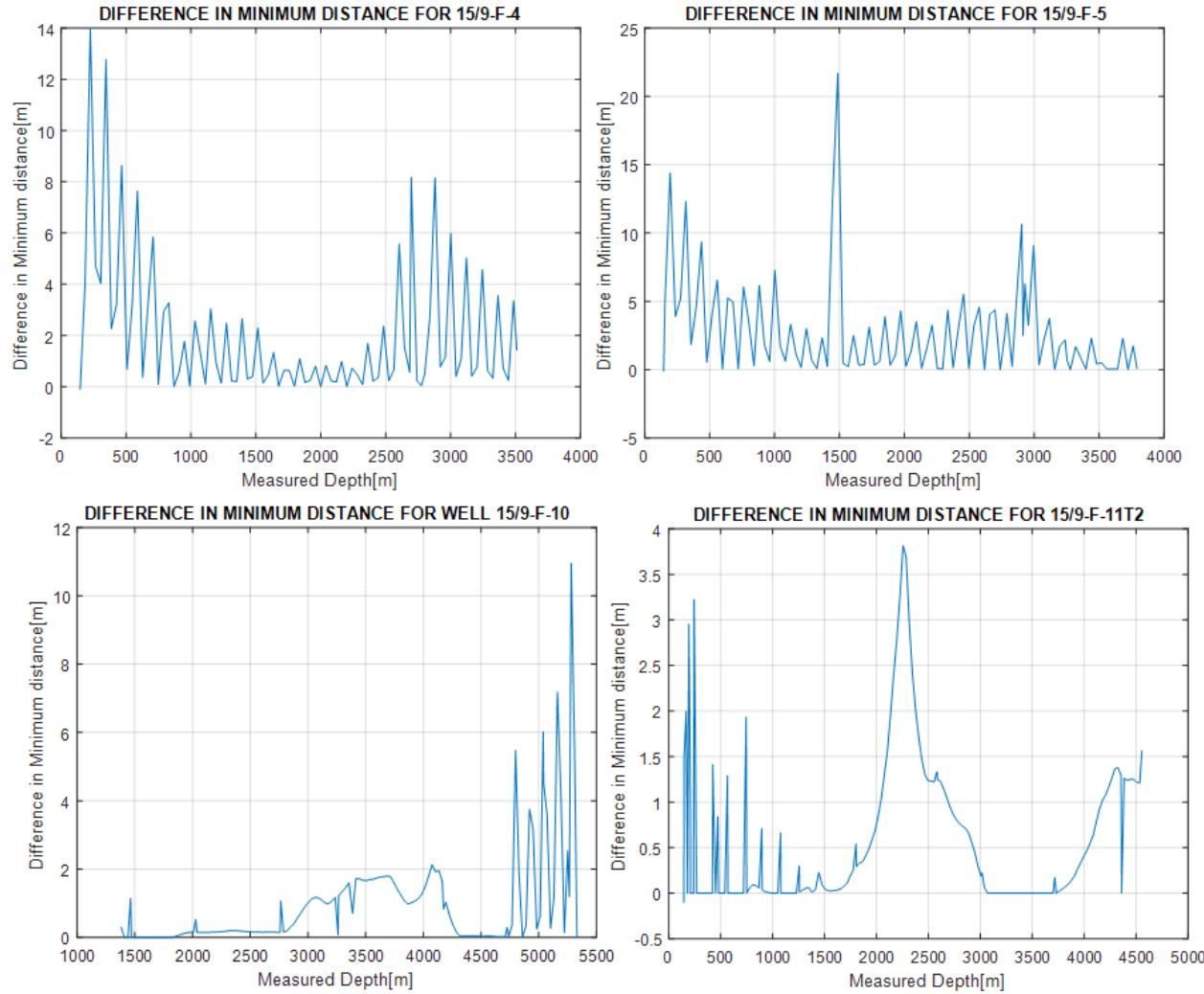


Figure 64: Difference in minimum distance between actual and planned trajectory points before and after interpolation for wells 15/9-F-4, 15/9-F-5, 15/9-F-10 and 15/9-F-11T2

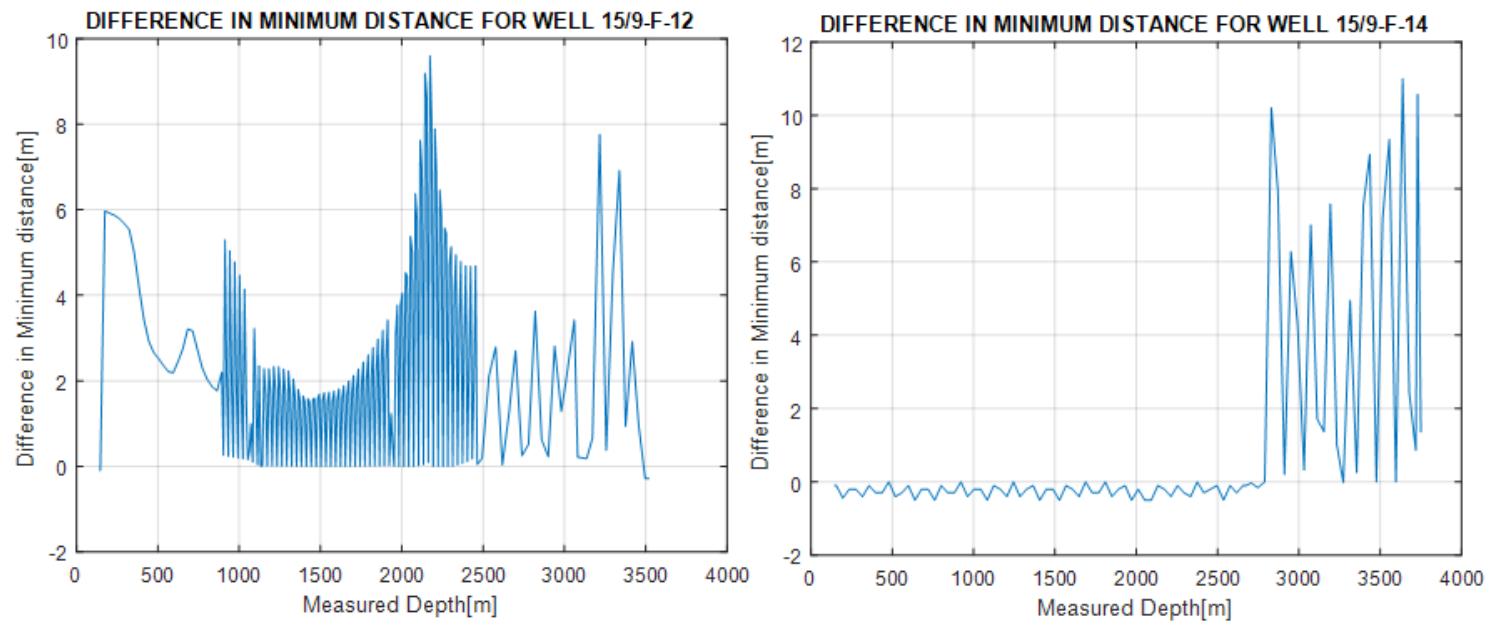


Figure 65: Difference in minimum distance between actual and planned trajectory points before and after interpolation for wells 15/9-F-12 and 15/9-F-14

4.1.8. Horizontal and Vertical deviation of the wells

Different figures to depict both vertical and horizontal deviation have been constructed (see appendix F, section 8.6.1). These illustrate how the wells deviated at the end during drilling.

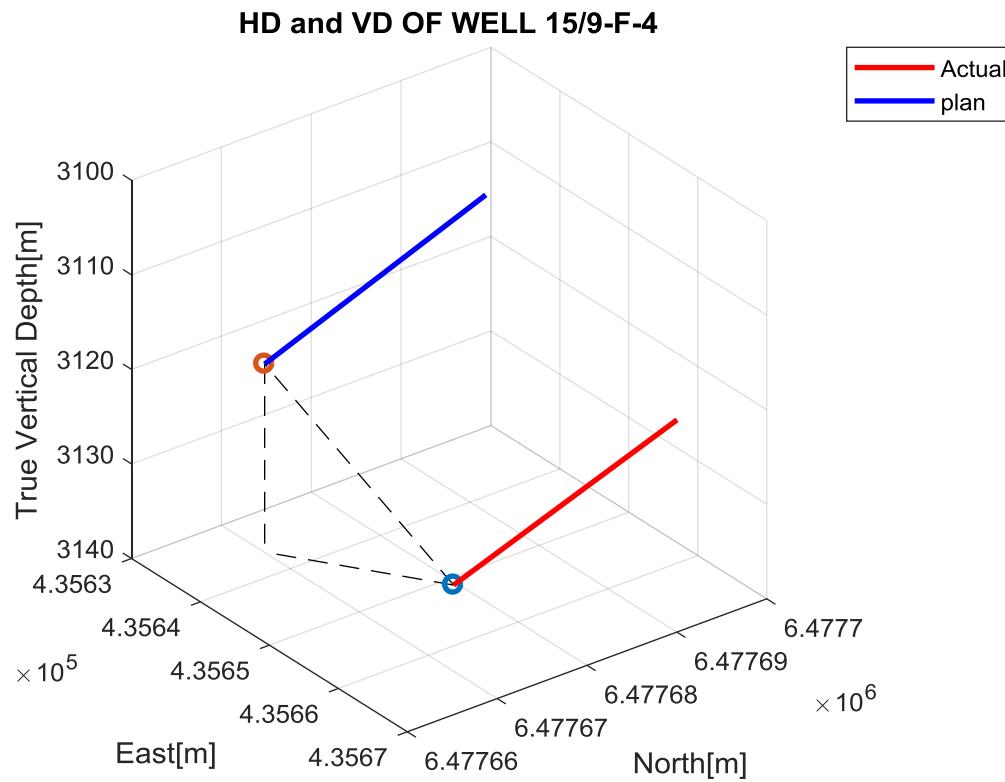


Figure 66: Sketch depicting low vertical deviation (V) and left horizontal deviation (H) at the end of well 15/9-F-4

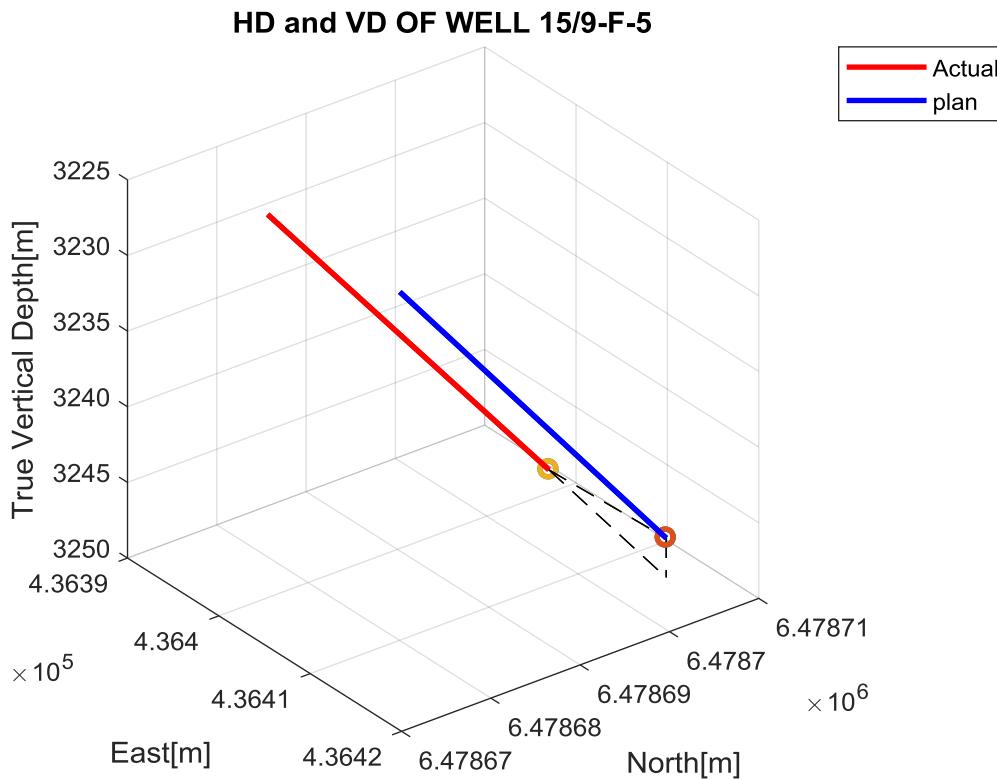


Figure 67: Sketch depicting low vertical deviation and left horizontal deviation at the end of well 15/9-F-5

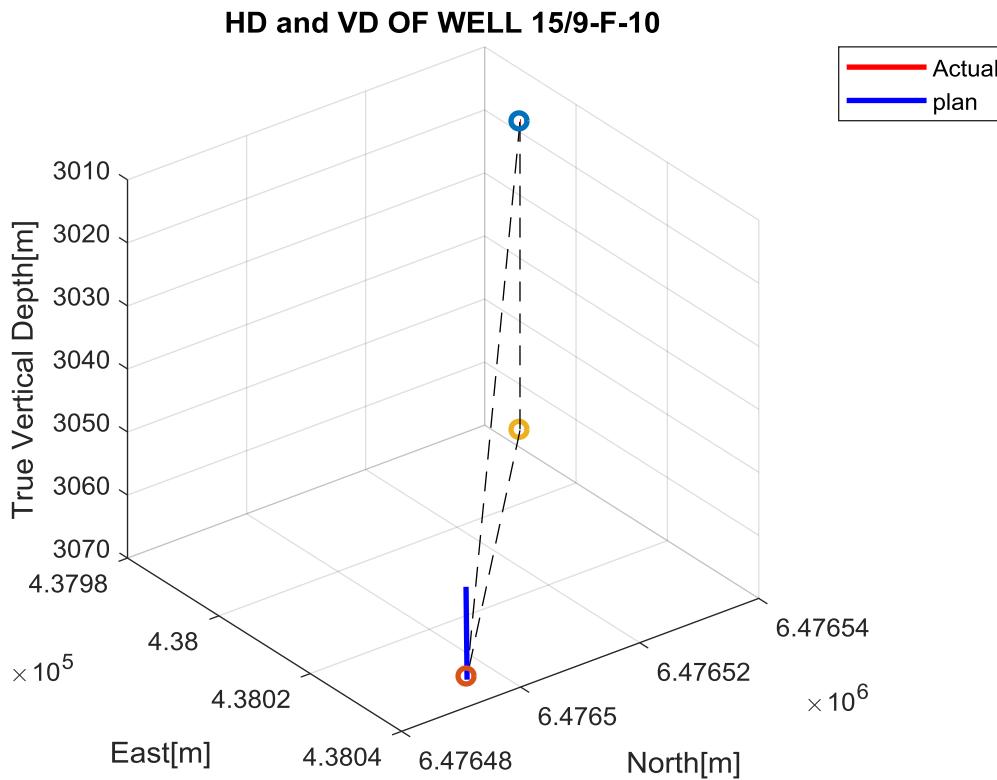


Figure 68: Sketch depicting high vertical deviation and left horizontal deviation at the end of well 15/9-F-10

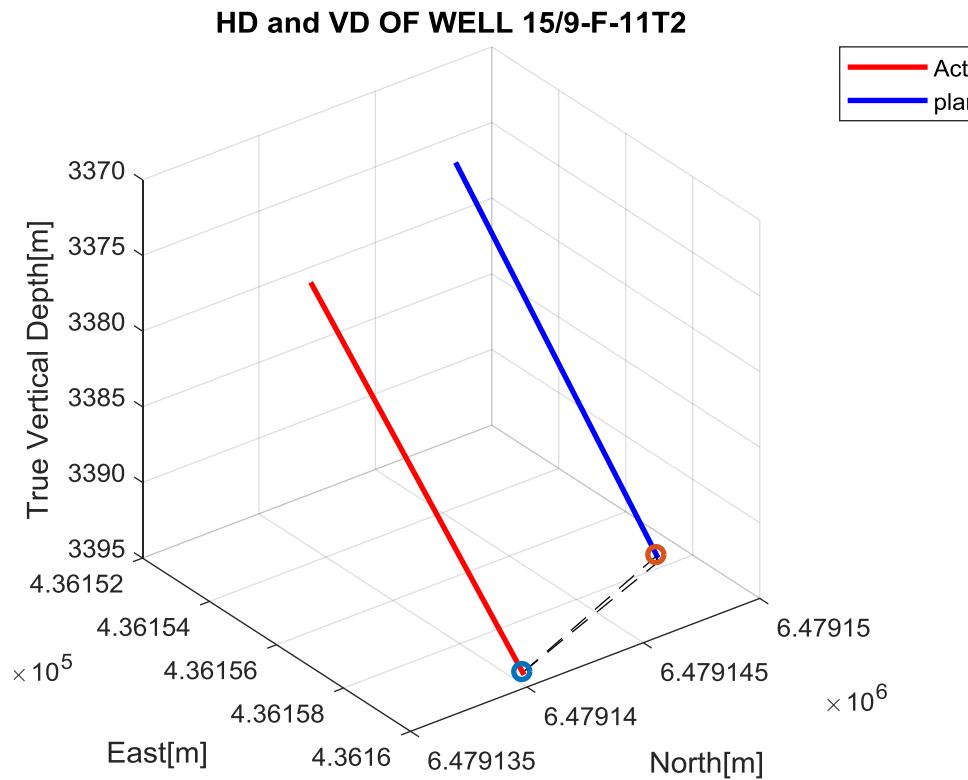


Figure 69: Sketch depicting low vertical deviation and right horizontal deviation at the end of well 15/9-F-11T2

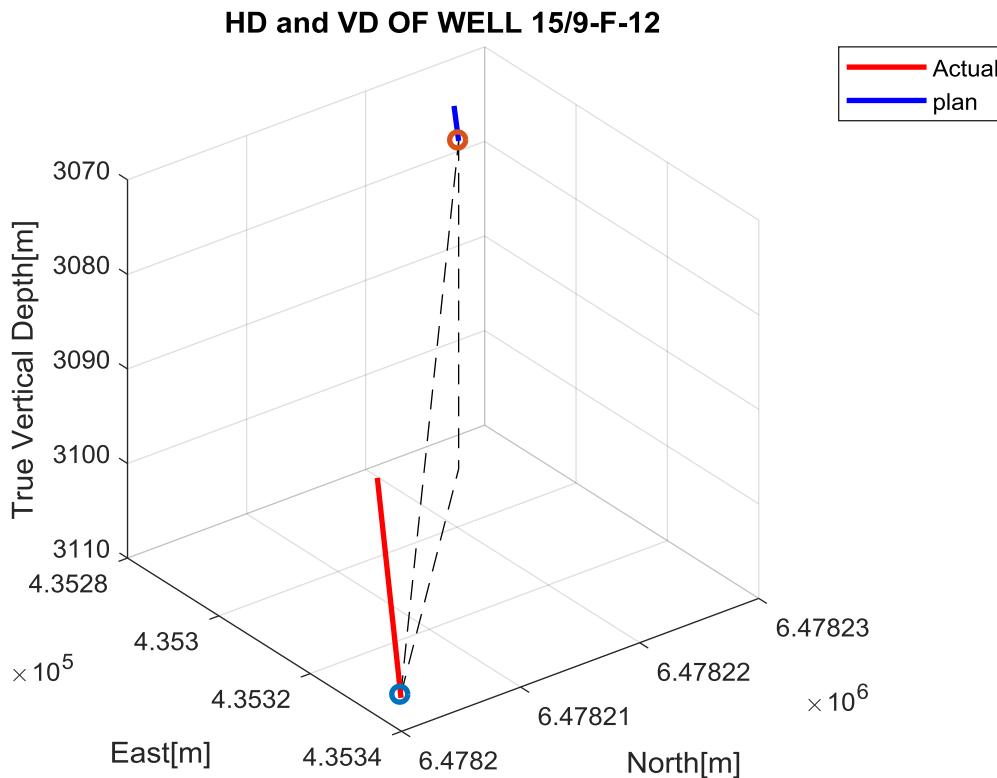


Figure 70: Sketch depicting low vertical deviation and right horizontal deviation at the end of well 15/9-F-12

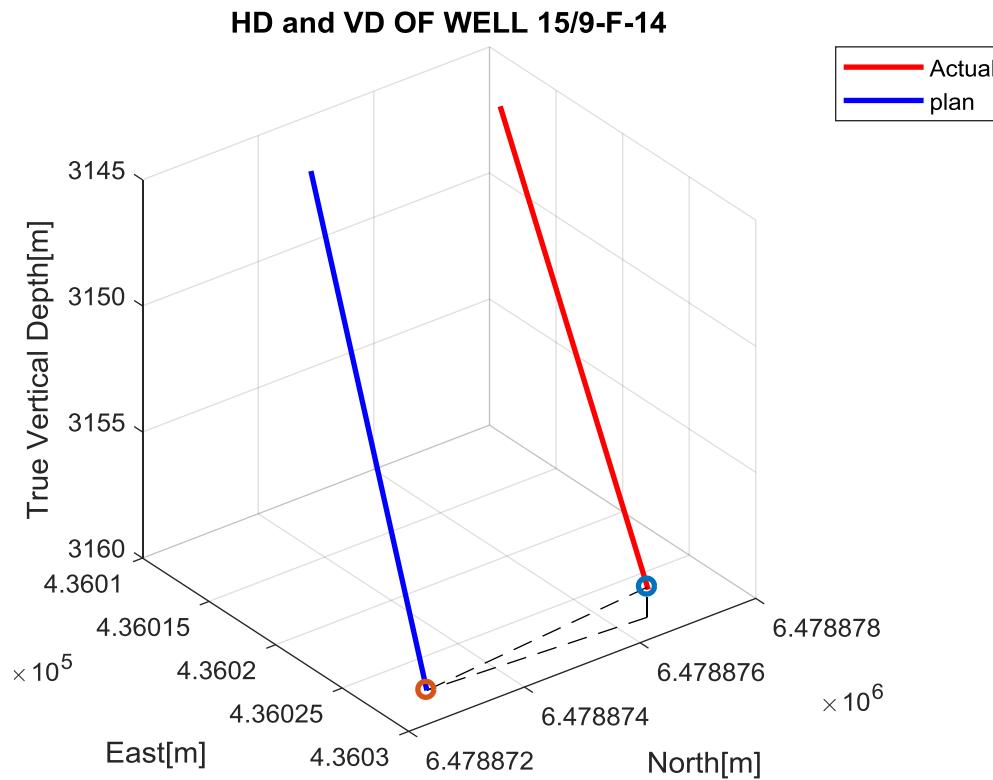


Figure 71: Sketch depicting high vertical deviation and left horizontal deviation at the end of well 15/9-F-14

4.1.9. Vertical and horizontal hole deviation logs of the wells

Using equations 11 through 18 as presented in section 3.2.2, eight deviation parameters were calculated for each point along the well path. No available planned data were available for calculation of deviation parameters in well 34/10-C-47 such that its deviation could not be determined mathematically, instead deviation of formation tops was used for discussion whereas for wells 15/9-F-4, 15/9-F-5, 15/9-F-10, 15/9-F-11T2, 15/9-F-12 and 15/9-F-14, both planned and actual data were provided for computation of deviation. Detailed computations of deviation parameters for each well are shown in appendix F, section 8.6.1 with results presented in tables (appendix G). From eight computed deviation parameters the deviation logs for each well were drawn.

4.1.9.1. Deviation logs for well 15/9-F-4

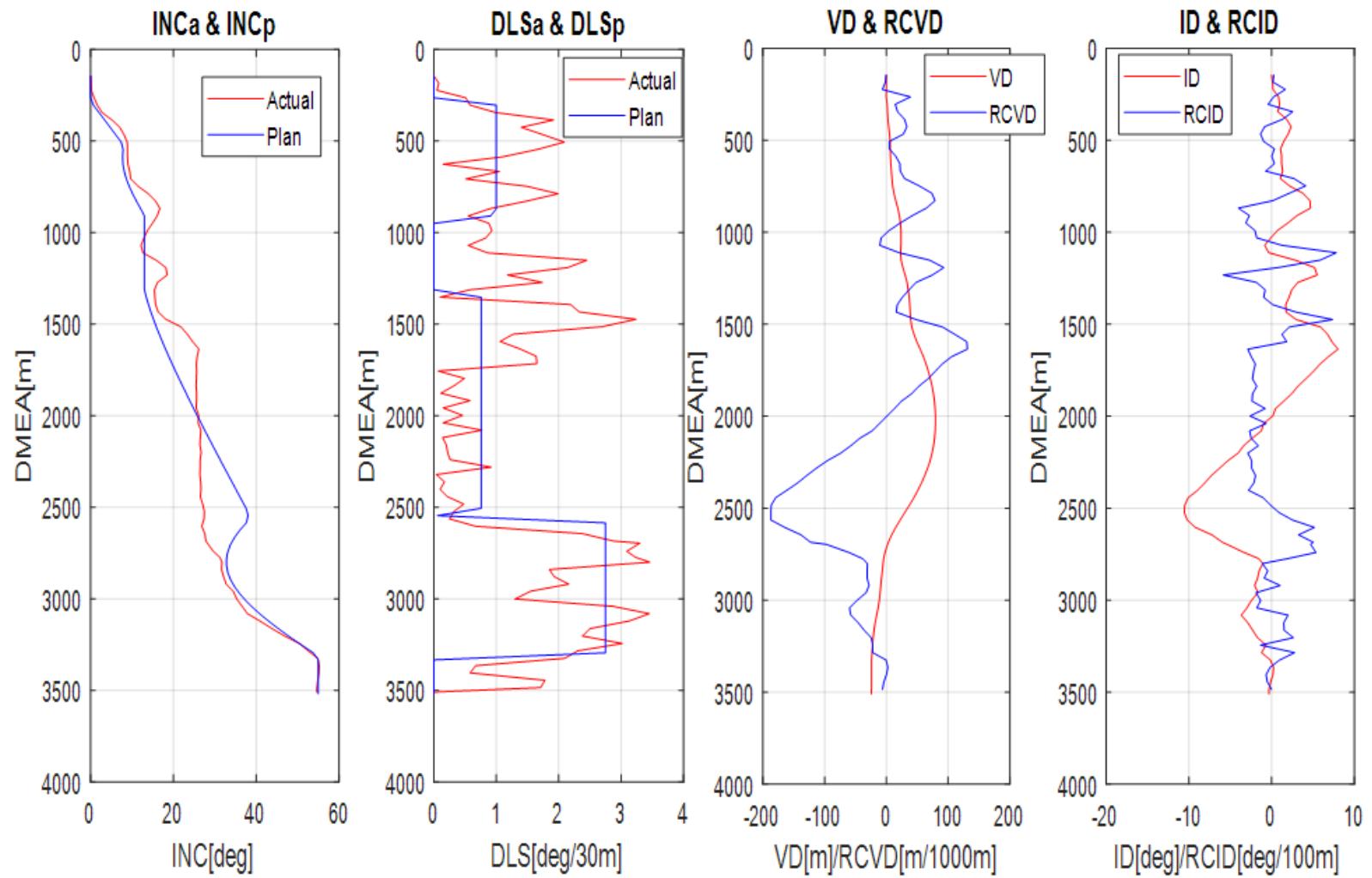


Figure 72: Vertical hole deviation log for well 15/9-F-4

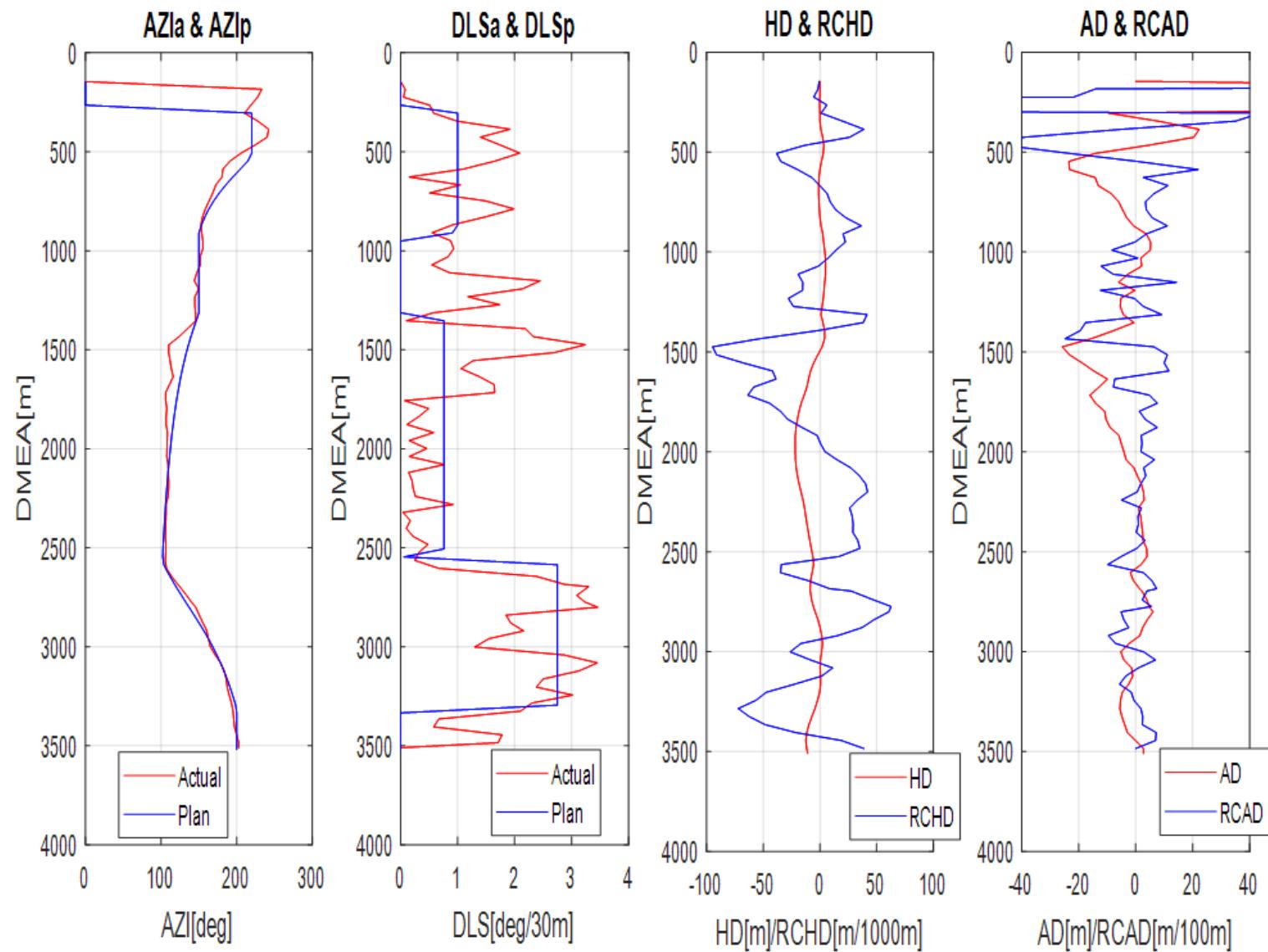


Figure 73: Horizontal hole deviation log for well 15/9-F-4

4.1.9.2. Deviation logs for well 15/9-F-5

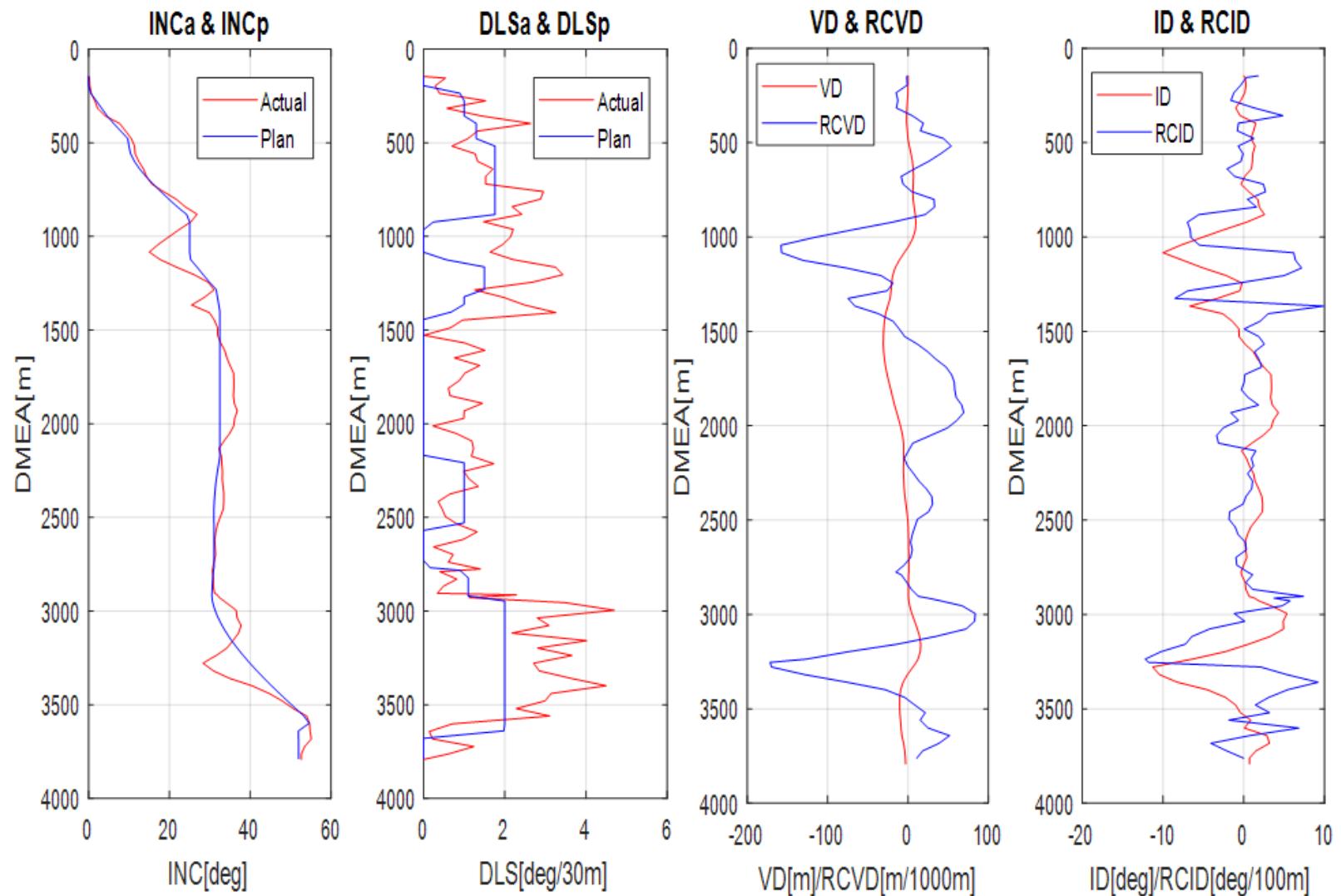


Figure 74: Vertical hole deviation log for well 15/9-F-5

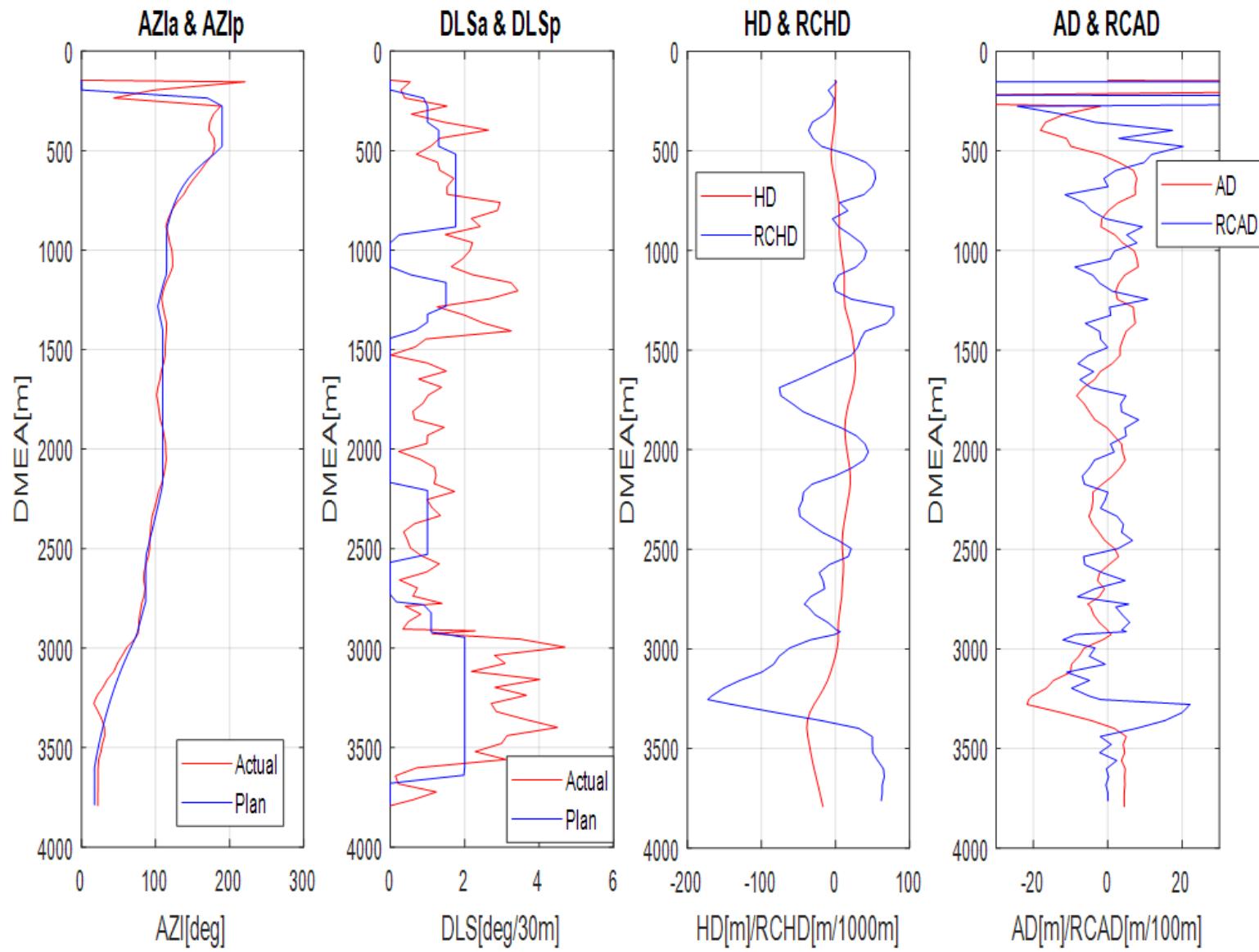


Figure 75: Horizontal hole deviation log for well 15/9-F-5

4.1.9.3. Deviation logs for well 15/9-F-10

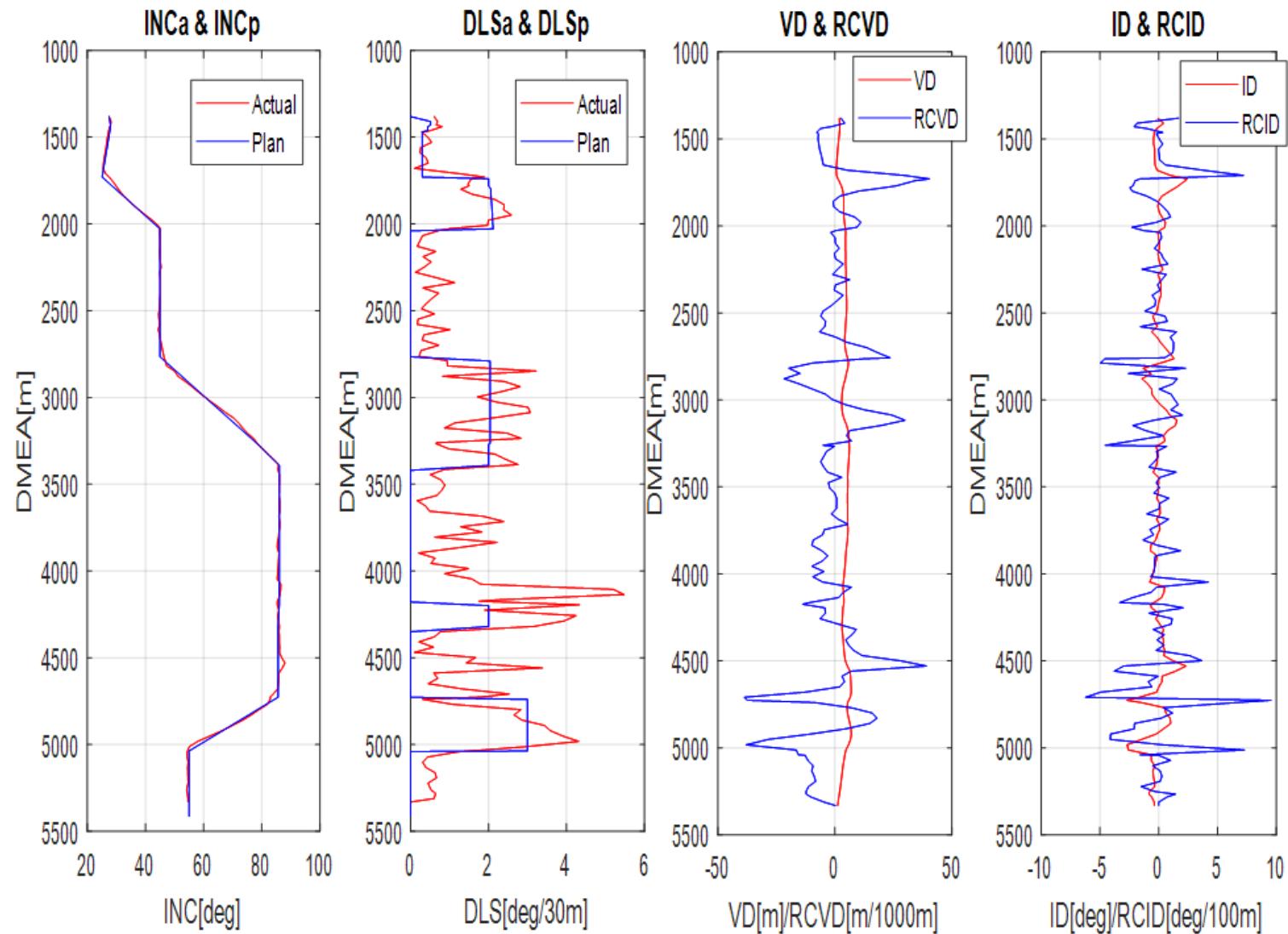


Figure 76: Vertical hole deviation log for well 15/9-F-10

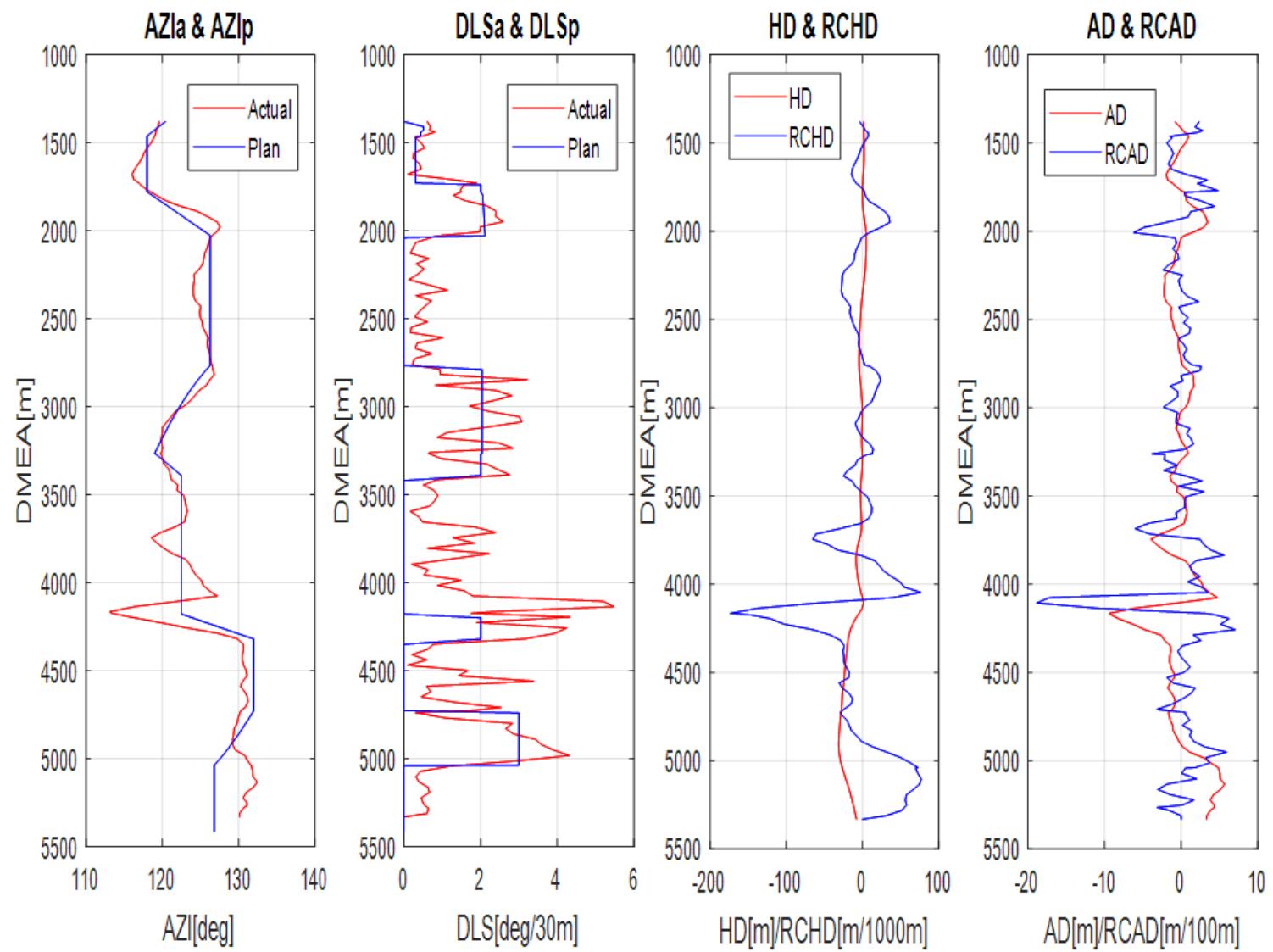


Figure 77: Horizontal hole deviation log for well 15/9-F-10

4.1.9.4. Deviation logs for well 15/9-F-11T2

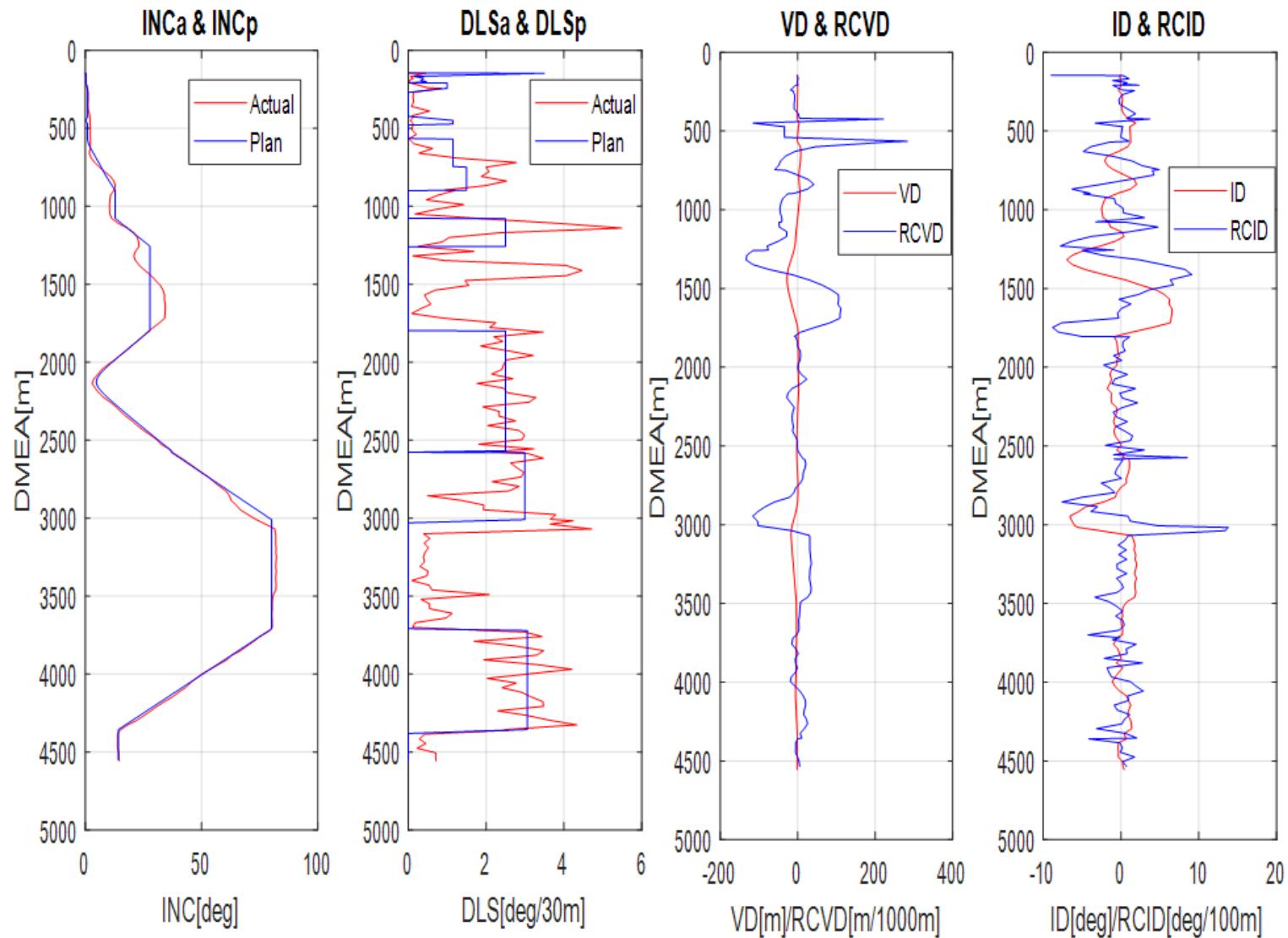


Figure 78: Vertical hole deviation log for well 15/9-F-11T2

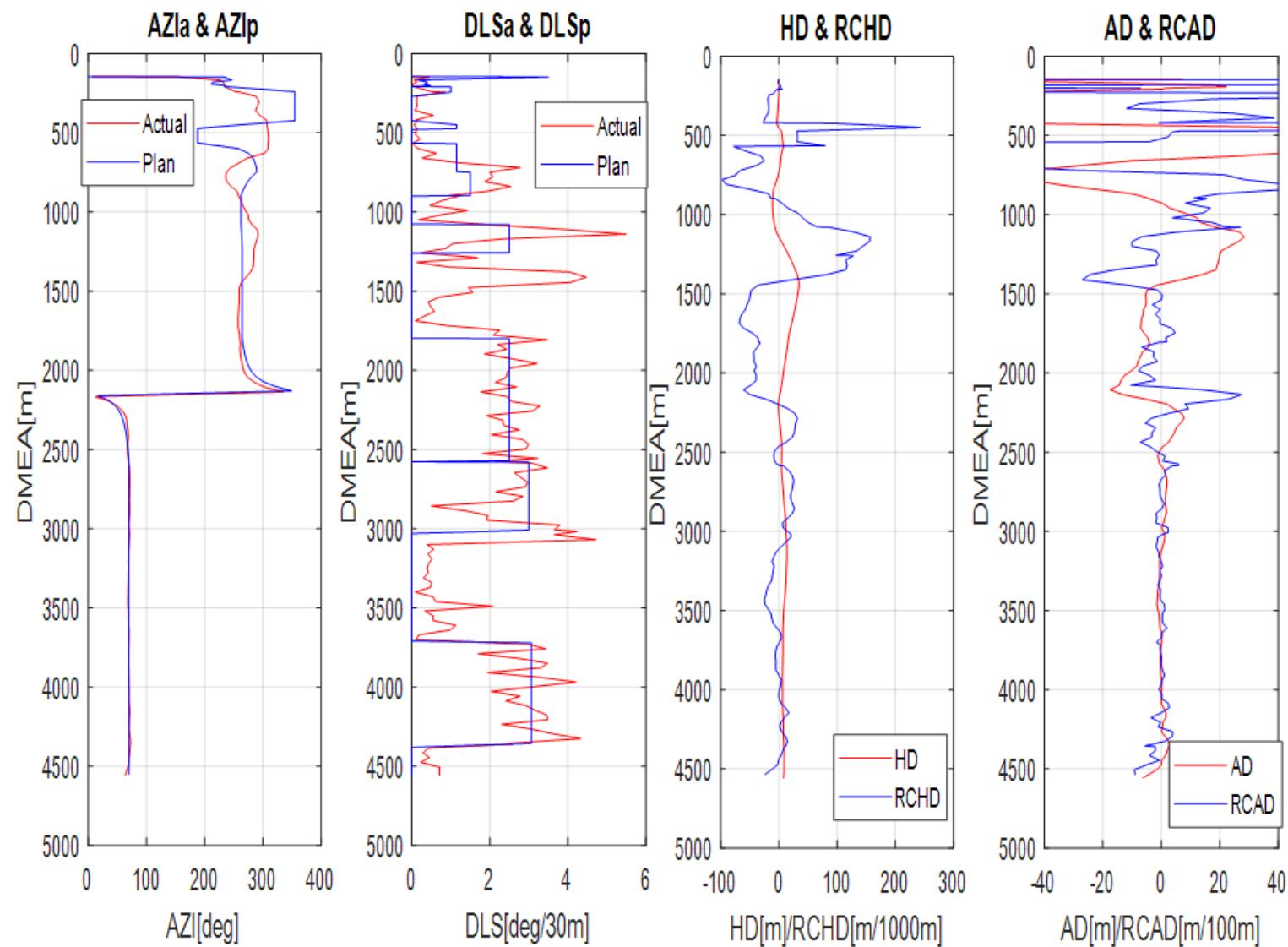


Figure 79: Horizontal hole deviation log for well 15/9-F-11T2

4.1.9.5. Deviation logs for well 15/9-F-12

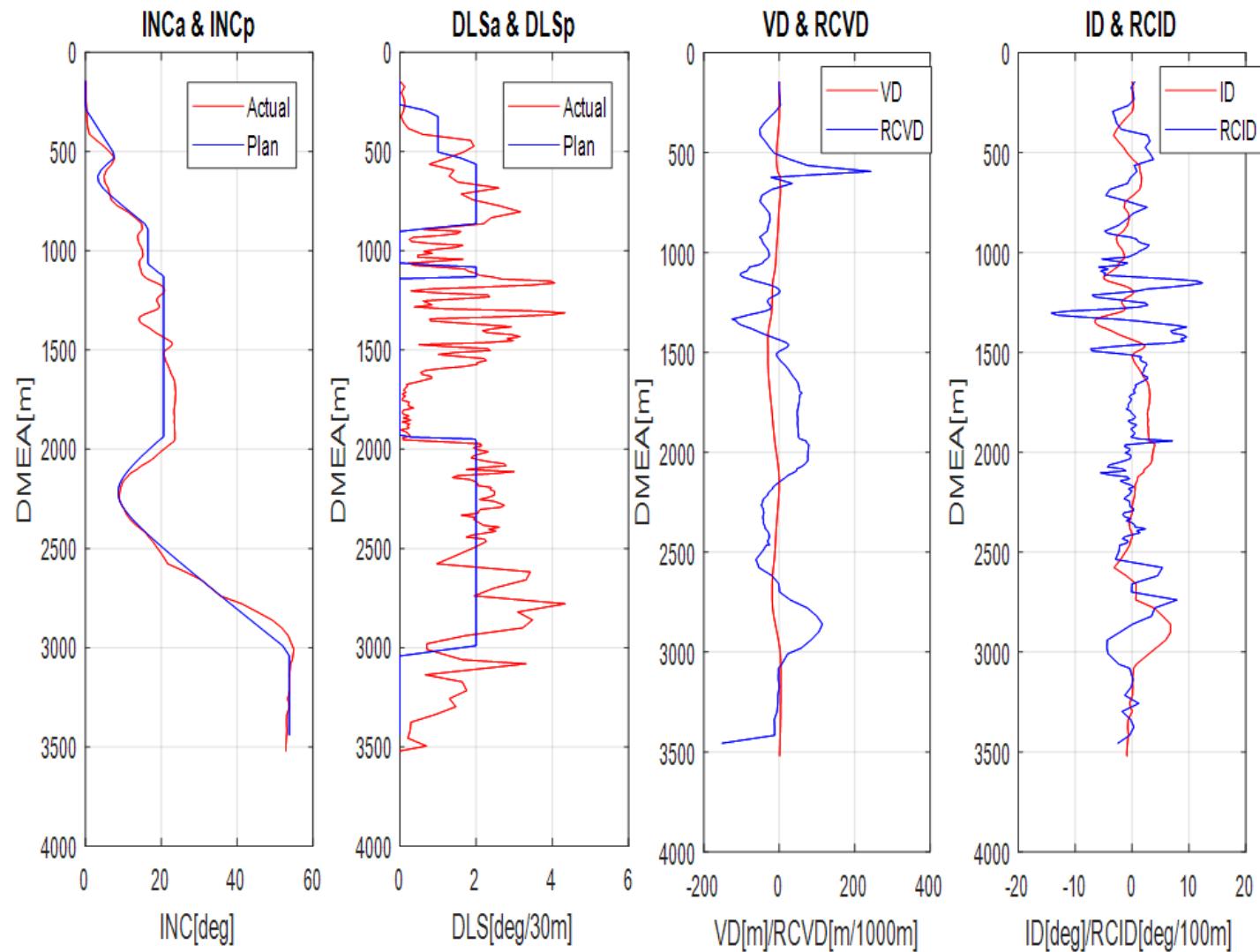


Figure 80: Vertical hole deviation log for well 15/9-F-12

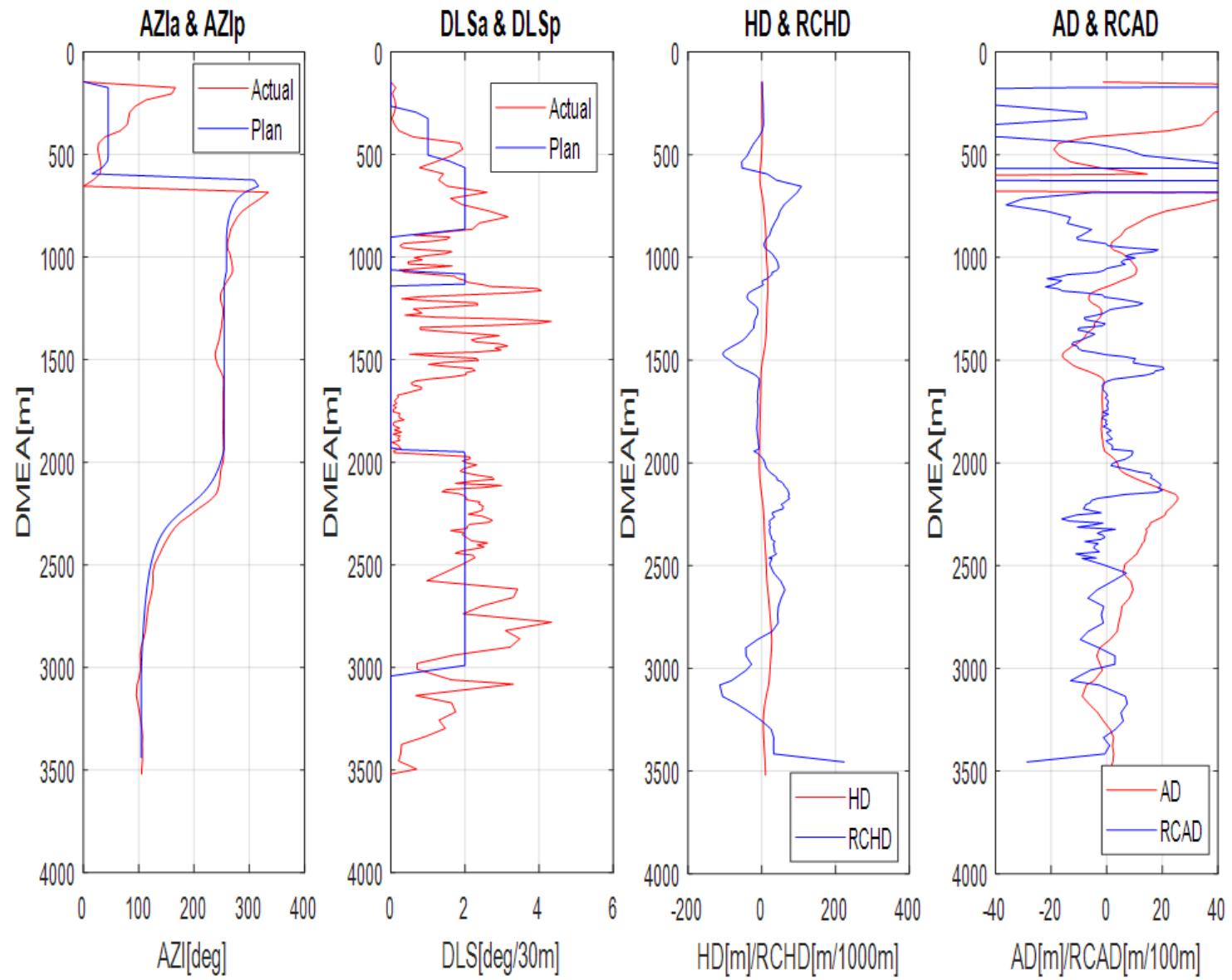


Figure 81: Horizontal hole deviation log for well 15/9-F-12

4.1.9.6. Deviation logs for well 15/9-F-14

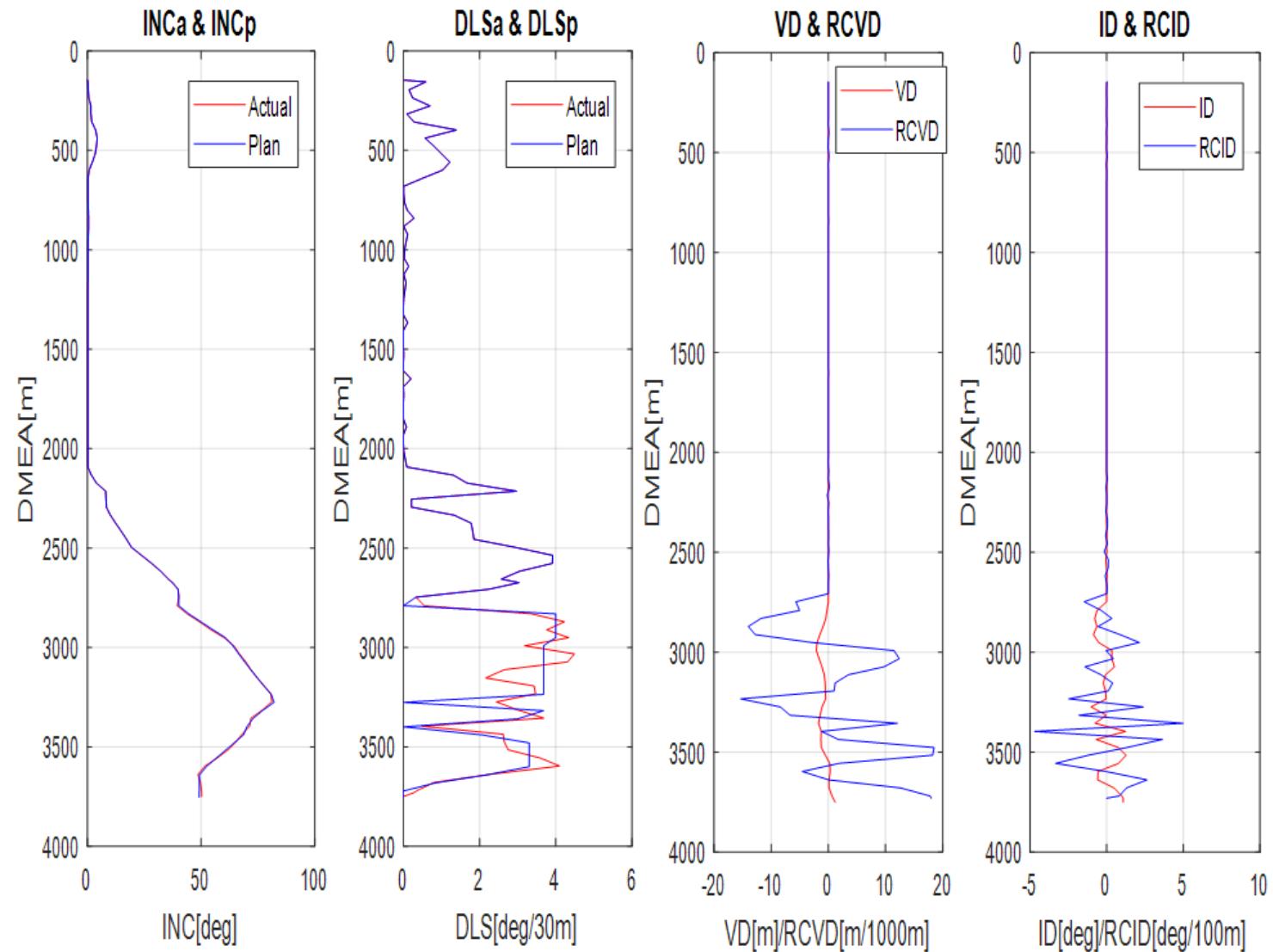


Figure 82: Vertical hole deviation log for well 15/9-F-14

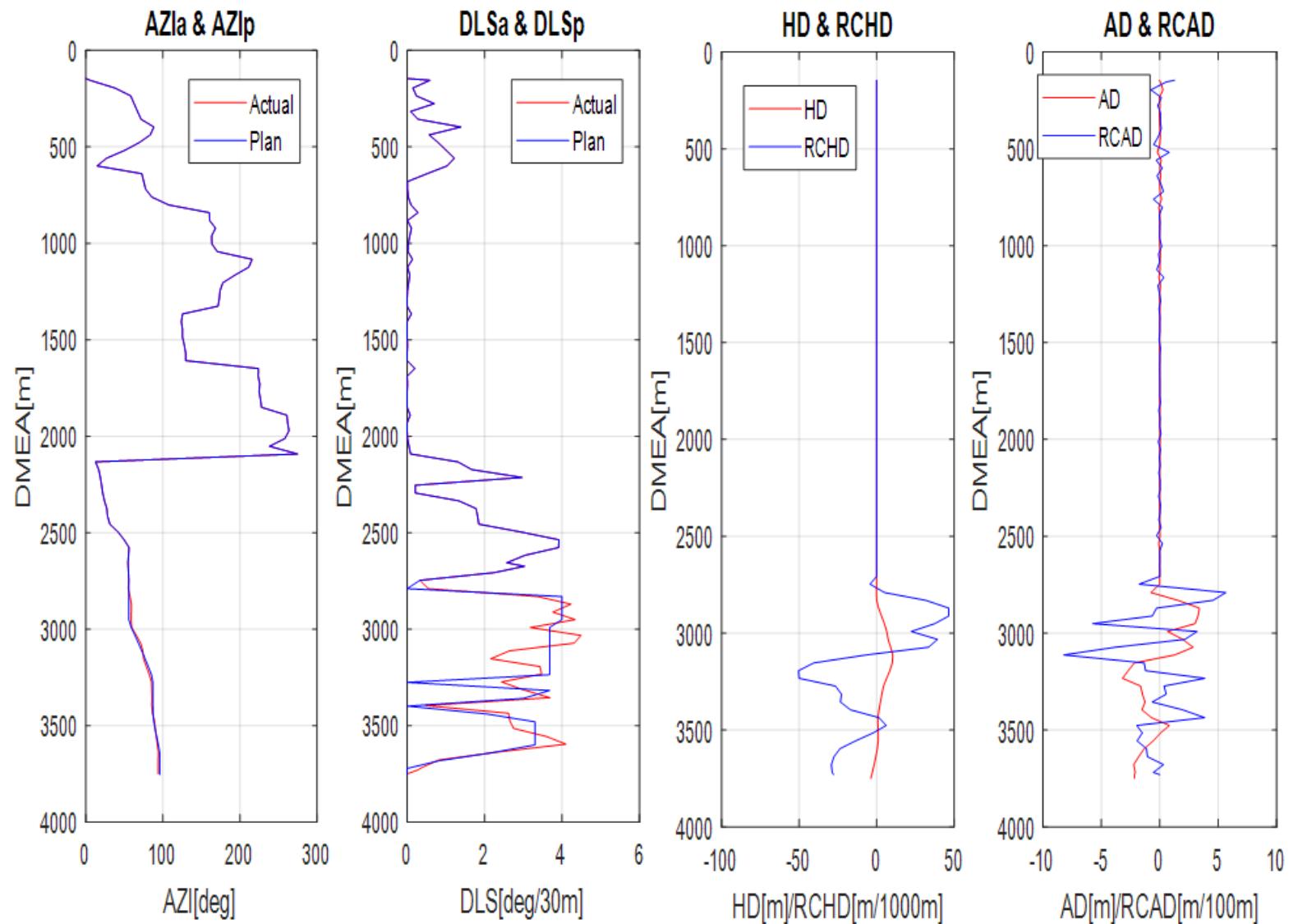


Figure 83: Horizontal hole deviation log for well 15/9-F-14

4.2. Discussion of results

4.2.1. Discussion of results from actual and estimated inclination

Based on inclination plots (Figures 37 through 40), estimated inclination observed to be equal to actual inclination as small deviation of estimated inclination from actual inclination observed. Both have the same variation with depth except for well 34/10-C-47 (Figure 37) at depth intervals (3270-3720) m MD and (3895-4355) m MD. Different variation between actual and estimated inclination at these intervals can be due to errors made in recording the data during MWD. Inclination angle was high from 1500m MD to total drilled depth for well 34/10-C-47 but it varied from low to medium for wells 15/9-F-4, 15/9-F-5 and 15/9-F-12 and varied between low, medium and high for all wells 15/9-F-10, 15/9-F-11T2 and 15/9-F-14.

4.2.2. Discussion of results from well projection

Based on vertical projection plots (Figures 41 through 44), wells 34/10-C-47, 15/9-F-5, 15/9-F-11T2 and 15/9-F-14 observed to depart highly from the referencing point while 15/9-F-4, 15/9-F-10 and 15/9-F-12 were observed to be drilled towards the reference coordinate point.

Horizontal projection plots (Figures 45 through 48) shows paths of the wells along the horizontal (east and north coordinates). Well 34/10-C-47 observed to be drilled towards south/east, well 15/9-F-4 was drilled toward north/east and then south/west at high TVD, well 15/9-F-5 was drilled towards south/east and then towards north/east. Well 15/9-F-10 was drilled towards south/east whereas 15/9-F-11T2 was initially drilled towards north /west and then drilled towards north/east. Well 15/9-F-12 was initially drilled towards north/east, south/east and finally towards south/east whereas well 15/9-F-14 was drilled towards north/east direction and finally deviated few meters towards south.

Three dimension views of wells show how the wells changed direction during drilling including both horizontal and vertical displacements (Figures 49 through 52).

4.2.3. Discussion of results, TVD variation with MD

True Vertical Depth observed to vary directly proportional with Measured Depth for all wells (Figures 53 through 55) such that as measured depth increase during drilling, the true vertical depth also observed to increase.

4.2.4. Discussion of results, inclination and azimuth variation with depth

Both azimuth and inclination plots (Figures 56 through 58) for both actual and planned trajectory shows how the inclination and azimuth varied during drilling. Also depicts how these both actual inclination and azimuth deviated from plan values as it is confirmed though deviation logs.

4.2.5. Discussion of results, Dogleg severity variation with depth

Dogleg Severity plots (Figures 59 through 61) shows that the planned trajectory dogleg severity was not higher than 3 deg/ 30m in all wells except for wells 15/9-F-14 at depth intervals (2500 - 2617) m MD, (2831-3236) m MD, 3318m MD and (3480- 3600) m MD and for well 15/9-F-11T2 at 147.7m MD. The actual dogleg severity observed to be higher than critical values at some depths in all wells as could not be maintained below critical value during drilling operation.

4.2.6. Discussion of results, Minimum distance between the planned and actual trajectory points (horizontal/vertical deviation)

Despite of absence of survey file data to compute wellbore deviation in well 34/10-C-47, high TVD deviation up to 40 m from the prognosis is observed in this well (refer table 4) as stated by (Christophersen, Gjerde, & Valdem, 2007). This deviation is confirmed by figures 22 and 23 and presence of faults (table 3) in the formation which could attribute to deviation of BHA during drilling.

Referring to figures 62 and 63, high minimum distance between actual and planned trajectory points at (1000 -2800) m MD depth interval of the well 15/9-F-4 , indicate large linear deviation. This is confirmed by unacceptable vertical deviation at this depth interval (table 20) and vertical hole deviation log (VD and RCVD track) for well 15/9-F-4.

High minimum distance at depth intervals (1000-2374) m MD and (3036-3600) m MD for well 15/9-F-5, depict large linear deviation hence unacceptable vertical deviation as it is confirmed by table 20 and vertical hole deviation log (VD and RCVD track) for well 15/9-F-5.

Low minimum distance of actual points from the planned trajectory points for well 15/9-F-10, indicate small deviation of the wellbore from the plan except at (4250-5200) m MD depth interval. This confirmed by both vertical hole deviation log (VD and RCVD track) and horizontal hole deviation (HD & RCHD track and AD & RCHD track) at (4000-4300) m MD depth interval.

In well 15/9-F-11T2 high minimum distance is observed at (1200-1600) m MD depth interval. This indicate presence of unacceptable vertical deviation at this interval as confirmed by vertical hole deviation log (VD and RCVD track) of this well.

Presence of smaller minimum distance of actual points from the plan in the wells 15/9-F-12 and 15/9-F-14 indicates less linear deviation of these wells from the plan. This is confirmed by vertical and horizontal hole deviation logs for the two wells

4.2.7. Discussion of results, Difference in minimum distances before and after interpolation (Effect of interpolation)

Figures 64 and 65 indicates how interpolation reduces the linear distance between actual and planned trajectory points in deviation analysis of a given well. In well 15/9-F-4, a maximum extra linear distance of 14m at shallow part could be increased to linear deviation if interpolation of planned data points was not to be performed.

In well 15/9-F-5, a maximum extra linear distance of 22m at 1500m MD could be increased to linear deviation if interpolation was not to be performed. For well 15/9-F-10 a maximum extra linear distance of 11 m at 5250m MD could be increased to linear deviation if interpolation of planned data points was not involved.

For wells 15/9-F-11T2, 15/9-F-12 and 15/9-F-14, the maximum increments in linear deviation of 3.8m at 2250 m MD, 9.5 m at 2150 m MD and 11 m at 3600 m MD respectively could be resulted when the planned data points were not to be interpolated.

4.3. Self –Assessment

4.3.1. Quality of data

The data which were used in present master thesis are from the well 34/10-C-47 in Gullfaks field and other six wells (15/9-F-4, 15/9-F-5, 15/9-F-10, 15/9-F-11T2, 15/9-F-12 and 15/9-F-14) from Volve field. These data present two different geological formations such that geological effect on drilling operation is analyzed well by comparison method. Also the RTDD and survey file data used to estimate inclination and deviation parameters were actual representation of the field data as they were all used in analysis without random selection although interpolation was done to get more data for easier visualization of the reality of the wellbore hence these data are of great quality.

4.3.2. Quality of method

The mathematical models used in the two agents are different. These are based on either the model is used for inclination estimation or deviation calculation.

4.3.2.1. Quality of mathematical model for inclination estimation.

The model behind the inclination classification agent is composed of inclination estimation and sorting of inclination as low, medium or high. Sub-chapter 4.2, section 4.2.1 presented a quite good estimation done by inclination estimation model where estimated inclination is almost equal to the actual value. This could be due absence of any assumptions made in using this model.

4.3.2.2. Quality of mathematical models for deviation parameters calculation.

The models behind the deviation classification agent were composed of formulas for calculations of vertical, horizontal, inclinational and azimuthal deviations. Also involved calculations of relative changes in these fore mentioned deviation parameters. These models worked better as there were no assumptions made in computations.

4.3.3. Potential improvements

4.3.3.1. Potential improvement for inclination reporting agent

The agent used for inclination classification works better to provide results but it uses specific file format and is slow especially when running large files for example in well 37/10-C-47. This situation makes thinking of some future improvements to increase the relevance of this master thesis and its agent for inclination classification when drilling operation is in progress. In order to improve the analysis for the present master thesis the following should be done:

- Increasing the time efficiency of the agent, the number of loops created is reduced but this result into classification of inclination for only few meters (shallow parts of the well). The best option is to improve hardware quality of the computer for example its processing power, this could ensure a significant reduction of time consumed in running.
- Present inclination classification agent works for a specific format type (.mat file). Since RTDD are monitored following different formats depending on the companies, thus the Matlab code for the inclination classification agent in section 8.2.3 of appendix B could be improved to allow all types of RTDD files to be directly loaded without specific pre-processing on it.

4.3.3.2. Potential improvement for deviation reporting agent

The agent used for reporting deviation as acceptable or unacceptable is based on unacceptable deviation parameter values determined from a single well (well 15/9-F-5). Since these unacceptable values are not the standard known values in drilling industry, using them in other wells for deviation classification/reporting seem to be irrelevant. So the well-known unacceptable deviation parameter values should be established for general use worldwide according to international standard organization (ISO).

5. Conclusion

Based on work performed in the present master thesis, the main struggles were to estimate and classify inclination, compute deviation parameters and classify them as acceptable or unacceptable. All work was done with the use of Matlab in which the data both in Matlab format (.mat files) and in Notepad format (text files) were used. Present work describes different findings as shown below:

- The model selected to calculate the inclination, provided the intended result (valid) as the estimated and actual inclinations shows the same trend and nearly the same values.
- The numbers of loops used in the inclination classification agent affect agent running time such that for large number of loops used, longer running time is expected.
- Also hole deviation classification agent can made to run in a single loop such that short time is consumed in running and execution of different models involved.
- From eight calculated deviation parameters and hole deviation logs, directional driller can interpret the hole deviation in order to take the deviation control response such as tool setting.
- The inputs (metrics) for the automated directional drilling systems to determine control output (tool settings) are made available from determined deviation parameters.

6. Nomenclature

6.1. List of Symbols

Latin

a_c (t)	Centrifugal acceleration	(m/s ²)
B	Build rate	(deg/30m)
B	Buoyancy force	(N)
d	Displacement volume	(lt)
F	Ratio Factor	(-)
F_{dl}	Deadline Tension	(N)
G	Gravity force	(N)
H	Horizontal Deviation	(m)
ΔH_r	Relative change in horizontal deviation	(m)
HKL_{drill}	Hook Load during drilling	(tonne)
HKL_{off}	Hook Load when the bit is off bottom	(tonne)
l	Depth penetrated	(m)
L	Length of the drillstring component/planned hole drilled	(m)
ΔL	Change in planned measured depth	(m)
n	Pump speed	(st/min)
N	Number of lines between blocks	
ΔP	Pressure loss	(bar)
Q	Flow rate	(l/min)
r	Accelerometer distance from vertical axis of rotation	(m)
r	Radius of circular arc	(m)
R	Radius of curvature	(m)
t	Time taken	(s)
V	True Vertical Depth/Vertical Deviation	(m)
ΔV_r	Relative change in vertical deviation	(m)
W	Hook Load	(N)
x	East	(m)
y	North	(m)
z	True Vertical Depth	(m)

Greek

Δ	Change/Difference	
$\Delta\phi$	Inclinalional Deviation	(deg)
$\Delta\theta$	Azimuthal Deviation	(deg)
$\Delta\Delta\phi_r$	Relative change in inclinalional deviation	(deg/m)
$\Delta\Delta\theta_r$	Relative change in azimuthal deviation	(deg/m)
α	Inclination angle	(deg)
β	Azimuth angle	(deg)
π	3.1416	.(-)
ρ	Mass density	(kg/m ³)
ϕ	Dogleg/Inclination angle	(deg)
θ	Azimuth angle	(deg)

Subscripts (Abbreviated) referring to:

1	Starting Point/Initial Value
2	Final Point/Value
a	Actual
p	Planned
r	Relative

Superscripts (Abbreviated) referring to:

o	Degree
n	Current Value
n-1	Previous Value

6.2. Abbreviations

A	Azimuth	(deg)
AHD	A long hole depth	(m)
ANTHEI	Angolan Norwegian Tanzanian Higher Education Initiative	
BHA	Bottom Hole Assembly	
BOP	Blowout Preventer	
BITA	Bit Azimuth	(deg)
BITI	Bit Inclination	(deg)
BPOS	Block Position	(m)
CL	Curve length	(m)
DBTM	Bit Depth	(m)
DLS	Dogleg Severity	(deg/ 30 m)
DMEA	Measured depth	(m)
3DRSS	Three Dimensional Rotary Steerable System	
E	East	(m)
E-W	East – West	
EOB	End of Build	
EOW	End of well	
ESP	Electric Submersible Pump	
FWR	Final Well Report	
HD	Horizontal deviation	(m)
HKL	Hook Load	(tonne)
HSE	Health safety and Environment	
I	Inclination	(deg)
IGP	Institute of Geoscience and Petroleum	
ISO	International Standard Organization	
KOP	Kick Off Point	
Matlab	Matrix laboratory	
MD	Measured depth	(m)
MFI	Mud Flow in average	(l/min)
MWD	Measurement while drilling	
N	North	(m)
N-S	North - South	
NNE-SSW	North North East – South South West	
NPT	Non-Productive Time	(s)
NTNU	Norwegian University of Science and Technology	
OD	Outer diameter of the drill-string	(m)

P&A	Plug and abandon	
PDC	Polycrystalline Diamond Compact	
PDM	Positive Displacement Motor	
RCAD	Relative Change in Azimuthal Deviation	
RCHD	Relative Change in Horizontal Deviation	
RCID	Relative Change in Inclinalional Deviation	
RCVD	Relative Change in Vertical Deviation	
ROP	Rate of Penetration	(m/h)
RPM	Average Rotary Speed	(rev/min)
RPMB	Bit RPM average	(rpm)
RSS	Rotary steerable system	
RTDD	Real time drilling data	
S	South	(m)
SPP	Stand Pipe Pressure average	(bar)
TRQ	Torque	(KN.m)
TVD	True Vertical Depth	(m)
UTM	Universal Transverse Mercator	(m)
W	West	(m)
WBM	Water Based Mud	
WOB	Weight on bit	(tonne)

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8. Appendices

8.1. Appendix A

Matlab code to estimate inclination along the well path and create well projections (vertical, horizontal and three dimensional views)

8.1.1. Matlab code for inclination estimation and well projection of well 34/10-C-47

```
clear all
%This example use well 34/10-C-47.In order to use the code in
other wells, the well name is changed.
load C47IncAzDLS-8_5
Z=X;
load C47IncAzDLS-12_25
Y=X;
load C47IncAzDLS-17_5
f=fieldnames(X);
for i=1:length(f)
W.(f{i})=[X.(f{i});Y.(f{i});Z.(f{i})];
end
% Creating clean lists of RTTD by removing data from non-
drilling operations:
BD=[];MD=[];IN=[];AZ=[];DLS=[];
for i=1:length(W.DMEA)
if W.DBTM(i)==W.DMEA(i)
    BD=[BD W.DBTM(i)];
    MD=[MD W.DMEA(i)];
    IN=[IN W.INC(i)];
    AZ=[AZ W.AZI(i)];
    DLS=[DLS W.DLS(i)];
end
end
%Create a Matrix B
B=zeros(length(MD),5);
%Define parameters in Matrix B
B(1:end,1)=BD;          %Bit Measured Depth
B(1:end,2)=MD;          %Measured Depth
B(1:end,3)=IN;          %Wellbore Inclination
B(1:end,4)=AZ;          %Wellbore Azimuth
B(1:end,5)=DLS;         %Wellbore Dogleg Severity
%Define necessary parameters of actual data (RTDD):
I=unique(B(1:end,3),'stable'); %Wellbore Inclination
L_q=unique(B(1:end,2),'stable'); %Measured Depth
L=L_q(1:length(I));           %Make matrix dimension agree
A_q=unique(B(1:end,4),'stable'); %Wellbore Azimuth
A=A_q(1:length(I));           %Make matrix dimension agree
```

```

%Define consecutive points of Measured Depth, Inclination and
Azimuth
I1=I(1:end-1);
I2=I(2:end);
A1=A(1:end-1);
A2=A(2:end);
L1=L(1:end-1);
L2=L(2:end);
%Calculate the dogleg angle denoted by Phi and ratio factor, let
Phi=Q;
Q=acosd(cosd(I1).*cosd(I2)+sind(I1).*sind(I2).*cosd(A2-A1));
F=(2./Q).* (180./pi).*tand(Q./2);
% Calculate change in N, E, & TVD denoted by NS, EW & VD
respectively:
NS=(F.* (L2-L1)./2.* (sind(I1).*cosd(A1)+sind(I2).*cosd(A2)));
EW=(F.* (L2-L1)./2.* (sind(I1).*sind(A1)+sind(I2).*sind(A2)));
VD=(F.* (L2-L1)./2.* (cosd(I1)+cosd(I2)));
% Final Well position coordinates(N,E,TVD):
N=cumsum(NS);
E=cumsum(EW);
TVD=cumsum(VD);
% Estimated Inclination from the model(Ie):
Ie=abs(atand((sqrt((NS).^2+(EW).^2))./VD));
figure(1);
plot(L,I,'r');
hold on
plot(L(1:end-1),Ie,'b');
title('INCLINATION AGAINST MEASURED DEPTH-WELL 34/10-C-47');
xlabel('Measured Depth[m]');
ylabel('Inclination[deg]');
legend('Actual','Estimated');
grid on
% Projection of the well:
% 1.Vertical projection:
D=sqrt(N.^2+E.^2);
figure(2);
plot(D,TVD);
title('VERTICAL PROJECTION FOR WELL 34/10-C-47');
xlabel('Horizontal Departure[m]');
ylabel('True Vertical Depth[m]');
set(gca,'ydir','reverse');
grid on
%2.Plan View/Horizontal projection of the Well
figure(3)
plot(N,E);
title('PLAN VIEW OF WELL 34/10-C-47');
xlabel('North[m]');
ylabel('East[m]');

```

```

set(gca,'ydir','reverse');
grid on
% 3D-view of the well:
figure(4);
plot3(N,E,TVD);
title('THREE DIMENSIONAL VIEW OF WELL 34/10-C-47')
xlabel('North[m]');
ylabel('East[m]');
zlabel('True Vertical Depth[m]');
set(gca,'ydir','reverse');
set(gca,'zdir','reverse');
grid on

```

8.2. Appendix B

Matlab code reporting whenever inclination of the well path is high, medium or low

8.2.1. Matlab code to report high, medium or low wellbore inclination for well 34/10-C-47

```

clear all
%This example use well 34/10-C-47 such that using the code in
other wells, the well name is changed.
load C47IncAzDLS-8_5
Z=X;
load C47IncAzDLS-12_25
Y=X;
load C47IncAzDLS-17_5
f=fieldnames(X);
for k=1:length(f)
    W.(f{k})=[X.(f{k});Y.(f{k});Z.(f{k})];
end
% Creating clean lists of RTTD by removing data from other
operations except drilling:
TM=[];BD=[];MD=[];IN=[];AZ=[];DL=[];
for k=1:length(W.DMEA)
    if W.DBTM(k)==W.DMEA(k)
        TM=[TM W.Time(k)];
        BD=[BD W.DBTM(k)];
        MD=[MD W.DMEA(k)];
        IN=[IN W.INC(k)];
        AZ=[AZ W.AZI(k)];
        DL=[DL W.DLS(k)];
    end
end
%Create a list of first 200 points for the agent:
Time1=[];DBTM1=[];DMEA1=[];INC1=[];AZI1=[];DLS1=[];
for k = 1:200
    Time1=[Time1 TM(k)];

```

```

DBTM1=[DBTM1 BD(k)];
DMEA1=[DMEA1 MD(k)];
INC1=[INC1 IN(k)];
AZI1=[AZI1 AZ(k)];
DLS1=[DLS1 DL(k)];
end
%Create a matrix B
B=zeros(length(Time1),6);
%Define Columns in Matrix B
B(1:end,1)=Time1;
B(1:end,2)=DBTM1;
B(1:end,3)=DMEA1;
B(1:end,4)=INC1;
B(1:end,5)=AZI1;
B(1:end,6)=DLS1;
%Define necessary parameters of actual data(RTDD):
T=unique(B(1:end,1),'stable'); %Time
I=unique(B(1:end,4),'stable'); %Wellbore Inclination
A_q=unique(B(1:end,5),'stable'); %Wellbore Azimuth
A=A_q(1:length(I));
L_q=unique(B(1:end,3),'stable'); %Measured Depth
L=L_q(1:length(I));
%Define consecutive points Measured Depth, Inclination and
Azimuth
I1=I(1:end-1);
I2=I(2:end);
A1=A(1:end-1);
A2=A(2:end);
L1=L(1:end-1);
L2=L(2:end);
%Calculate the Dogleg Angle denoted by Phi and ratio factor
%Let Phi=Q;
Q=acosd(cosd(I1).*cosd(I2)+sind(I1).*sind(I2).*cosd(A2-A1));
F=(2./Q).* (180./pi).*tand(Q./2);
% calculate change in N, E, & TVD denoted by NS, EW & VD
respectively:
NS=(F.* (L2-L1)./2.* (sind(I1).*cosd(A1)+sind(I2).*cosd(A2)));
EW=(F.* (L2-L1)./2.* (sind(I1).*sind(A1)+sind(I2).*sind(A2)));
VD=(F.* (L2-L1)./2.* (cosd(I1)+cosd(I2)));
% %Final Well position coordinates(N,E,TVD):
N=cumsum(NS);
E=cumsum(EW);
TVD=cumsum(VD);
% Estimated Inclination from the model(Ie):
Ie=abs(atand(sqrt((NS).^2+(EW).^2)./VD));
%Reporting inclination of the path as high, medium or low:
Inclination=INC1;
Measured_Depth=DMEA1;

```

```

%Classifying Inclination angle:
Inclination(k)=0;
Inclination_classification(k)=0;
for k=1:length(Inclination)
if Inclination(k) < 30
    Inclination_classification(k)=1;
elseif Inclination(k)>=30 && Inclination(k )<=60
    Inclination_classification(k)=2;
elseif Inclination(k) > 60
Inclination_classification(k)=3;
end
%Warning message program based on Inclination:
if Inclination_classification(k)>=0.1 &&
Inclination_classification(k)<=1
    disp 'Inclination is low at this point'
elseif Inclination_classification(k)>=1.1 &&
Inclination_classification(k)<=2
    disp 'Inclination is medium at this point'
elseif Inclination_classification(k)>=2.1 &&
Inclination_classification(k)<=3
    disp 'Inclination is high at this point'
end
end
% Make a table of Results
Ia=Inclination;
MDa=Measured_Depth;
T1=table((MDa(1:length(Ie)))',(Ia(1:length(Ie)))',Ie);
writetable(T1,'INC_ALL.xlsx','sheet',1);
T_incl=table(Inclination_classification',Measured_Depth');
writetable(T_incl,'INC_ALL.xlsx','sheet',2);

```

8.2.2. Matlab code of the agent to estimate and report inclination class/level for wells (15/9-F-4, 15/9-F-5, 15/9-F-10, 15/9-F-11T2, 15/9-F-12, 15/9-F-14)

```

clear all
This example use well 15/9-F-4 such that using the code in other
wells, the well name is changed.
%Define actual parameters from survey file.
A=importdata('F-4_ACTUAL.txt');
%Actual Parameters:
MDa=A(1:end,1); %Measured Depth
Ia=A(1:end,2); %Wellbore Inclination
Aa=A(1:end,3); %Wellbore Azimuth
Ea=A(1:end,7); %East coordinate
Na=A(1:end,8); %North coordinate
TVDa=A(1:end,4); %True Vertical Depth
DLSa=A(1:end,9); %Wellbore Dogleg Severity
%Define the consecutive terms of north ,East and True vertical
depth:
E1=Ea(1:end-1);
E2=Ea(2:end);
N1=Na(1:end-1);
N2=Na(2:end);
TVD1=TVDa(1:end-1);
TVD2=TVDa(2:end);
% Estimated Inclination from the model(Ie):
Ie=abs(atand((sqrt((N2-N1).^2+(E2-E1).^2))./(TVD2-TVD1)));
figure(1);
plot(MDa,Ia,'r');
hold on
plot(MDa(1:length(Ie)),Ie,'b');
title('INCLINATION AGAINST MEASURED DEPTH-WELL 15/9-F4')
xlabel('Measured Depth[m]');
ylabel('Inclination[deg]');
legend('Actual','Estimated');
grid on
%Classification of inclination:
Inclination_classification(1:length(MDa))=0;
for i=1:length(MDa)
if Ia(i) < 30
    Inclination_classification(i)=1;
elseif Ia(i)>=30 && Ia(i )<=60
    Inclination_classification(i)=2;
elseif Ia(i) > 60
    Inclination_classification(i)=3;
end
%Warning message program based on Inclination:
if Inclination_classification(i)>=0.1 &&
Inclination_classification(i)<=1

```

```

        disp 'Inclination is low at this point'
elseif Inclination_classification(i)>=1.1 &&
Inclination_classification(i)<=2
    disp 'Inclination is medium at this point'
elseif Inclination_classification(i)>=2.1 &&
Inclination_classification(i)<=3
    disp 'Inclination is high at this point'
end
end
% Make a table of Results
T2=table(MDa(1:length(Ie)),Ia(1:length(Ie)),Ie);
writetable(T2,'INC_ALL1.xlsx','sheet',3);
T_inc2=table(Inclination_classification',MDa);
writetable(T_inc2,'INC_ALL1.xlsx','sheet',4);

```

8.2.3. Main Code of Inclination classification agent

```

clear all
%This example uses Well 15/9-F5, such that using the code in
other wells, the well name is changed.
load F5IncAzDLS-PA-12_25
Y=X;
load F5IncAzDLS-PA-17_5
f=fieldnames(X);
for i=1:length(f)
    W.(f{i})=[X.(f{i});Y.(f{i})];
end
% Creating clean lists of RTTD by removing data from other
operations except drilling:
TM=[];BD=[];MD=[];IN=[];AZ=[];DL=[];
for i=1:length(W.DMEA)
    if W.DBTM(i)==W.DMEA(i)
        TM=[TM W.Time(i)];
        BD=[BD W.DBTM(i)];
        MD=[MD W.DMEA(i)];
        IN=[IN W.INC(i)];
        AZ=[AZ W.AZI(i)];
        DL=[DL W.DLS(i)];
    end
end
%Create a list of first 100 points for the agent:
Time1=[];DBTM1=[];DMEA1=[];INC1=[];AZI1=[];DLS1=[];
for i = 1:100
Time1=[Time1 TM(i)];
DBTM1=[DBTM1 BD(i)];
DMEA1=[DMEA1 MD(i)];

```

```

INC1=[INC1 IN(i)];
AZI1=[AZI1 AZ(i)];
DLS1=[DLS1 DL(i)];
end
%Create Matrix B
B=zeros(length(Time1),6);
%Define Columns in Matrix B
B(1:end,1)=Time1;
B(1:end,2)=DBTM1;
B(1:end,3)=DMEA1;
B(1:end,4)=INC1;
B(1:end,5)=AZI1;
B(1:end,6)=DLS1;
%Define necessary parameters of actual data(RTDD):
T=unique(B(1:end,1),'stable'); %Time
I=unique(B(1:end,4),'stable'); %Wellbore Inclination
A=unique(B(1:end,5),'stable'); %Wellbore Azimuth
L=unique(B(1:end,3),'stable'); %Measured Depth

%Compute number of loops required to simulate the whole wellbore
path:
N_loops=length(TM)-100;
%Start simulation of RTDD with a new input at every loop
for k=100:N_loops
Inclination(1:length(I))=0;
Measured_Depth(1:length(I))=0;
for i=1:length(I)
Inclination(i)=I(i);
Measured_Depth(i)=L(i);
end
%Classifying Inclination angle:
Inclination_classification(1:length(Inclination))=0;
for i=1:length(Inclination)
if Inclination(i) < 30
    Inclination_classification(i)=1;
elseif Inclination(i)>=30 && Inclination(i )<=60
    Inclination_classification(i)=2;
elseif Inclination(i) > 60
    Inclination_classification(i)=3;
end
end

%Warning message program based on Inclination:
if Inclination_classification(i)>=0.1 &&
Inclination_classification(i)<=1
    disp 'Inclination is low at this point'
elseif Inclination_classification(i)>=1.1 &&
Inclination_classification(i)<=2
    disp 'Inclination is medium at this point'
else
    disp 'Inclination is high at this point'
end

```

```

    disp 'Inclination is medium at this point'
elseif Inclination_classification(i)>=2.1 &&
Inclination_classification(i)<=3
    disp 'Inclination is high at this point'
end
%Inclination classification based on curve colour in the plot:
Ih=I>60;
Im=(30<=I&I<=60);
Il=I<30;
figure(1);
plot(L(Ih),I(Ih),'r',L(Im),I(Im),'b',L(Il),I(Il),'g');
title('INCLINATION AGAINST DEPTH-WELL 34/10-C-47')
xlabel('Measured Depth[m]');
ylabel('Inclination[deg]');
legend('Inclination from data');
grid on
%Create table of results of inclination classification
T_inc=table(Inclination_classification',Measured_Depth');
%Acquisition of the new data as the drilling operation is not
over:
Time1=[Time1 TM(k)];
DBTM1=[DBTM1 BD(k)];
DMEA1=[DMEA1 MD(k)];
INC1=[INC1 IN(k)];
AZI1=[AZI1 AZ(k)];
DLS1=[DLS1 DL(k)];
end

```

8.3. Appendix C

8.3.1. Results, Actual and Estimated Inclination and Inclination Classification for well 34/10-C-47

Table 9: Results, Detailed Actual and Estimated Inclination and Inclination Classification for well 34/10-C-47

Actual and estimated inclination and its classification for well 34/10-C-47			
Denotation: 1=Low, 2= Medium & 3=High			
Measured depth [m]	Actual inclination [deg]	Estimated inclination [deg]	Inclination classification
1496.63	60.4965	60.4975	3
1496.95	60.4986	60.5008	3
1497.59	60.5030	60.5041	3
1497.91	60.5052	60.5062	3
1498.21	60.5073	60.5083	3
1498.5	60.5094	60.5101	3
1498.69	60.5108	60.5110	3
1498.75	60.5112	60.5119	3
1498.94	60.5126	60.5138	3
1499.26	60.5150	60.5155	3
1499.26	60.5150	60.5169	3
1499.39	60.5159	60.5199	3
1499.65	60.5179	60.5220	3
1500.17	60.5219	60.5227	3
1500.18	60.5220	60.5237	3
1500.36	60.5234	60.5240	3
1500.43	60.5239	60.5245	3
1500.44	60.5240	60.5258	3
1500.56	60.5250	60.5271	3
1500.76	60.5266	60.5281	3
1500.89	60.5276	60.5294	3
1501.01	60.5285	60.5304	3
1501.21	60.5302	60.5309	3
1501.27	60.5306	60.5314	3
1501.33	60.5311	60.5320	3
1501.4	60.5317	60.5326	3
1501.47	60.5323	60.5336	3
1501.54	60.5329	60.5347	3
1501.73	60.5344	60.5352	3
1501.8	60.5350	60.5360	3
1501.86	60.5355	60.5370	3
1501.98	60.5365	60.5379	3

1502.11	60.5376	60.5390	3
1502.19	60.5382	60.5401	3
1502.38	60.5398	60.5407	3
1502.45	60.5404	60.5415	3
1502.5	60.5409	60.5424	3
1502.64	60.5421	60.5429	3
1502.71	60.5427	60.5432	3
1502.71	60.5427	60.5435	3
1502.77	60.5432	60.5441	3
1502.77	60.5432	60.5446	3
1502.77	60.5432	60.5449	3
1502.78	60.5433	60.5458	3
1502.84	60.5438	60.5510	3
1502.91	60.5444	60.5515	3
1502.97	60.5449	60.5518	3
1502.98	60.5450	60.5535	3
1503.17	60.5466	60.5555	3
1503.17	60.5466	60.5560	3
1503.18	60.5467	60.5572	3
1503.23	60.5471	60.5587	3
1503.24	60.5472	60.5608	3
1503.3	60.5478	60.5614	3
1503.36	60.5483	60.5639	3
1503.43	60.5489	60.5654	3
1503.5	60.5495	60.5657	3
1503.51	60.5496	60.5659	3
1503.56	60.5500	60.5667	3
1503.63	60.5507	60.5682	3
1503.64	60.5507	60.5693	3
1503.7	60.5513	60.5704	3
1503.76	60.5518	60.5713	3
1503.77	60.5519	60.5717	3
1504.14	60.5552	60.5720	3
1504.14	60.5552	60.5722	3
1504.2	60.5557	60.5730	3
1504.26	60.5563	60.5740	3
1504.46	60.5581	60.5745	3
1504.59	60.5593	60.5760	3
1504.65	60.5598	60.5781	3
1504.73	60.5605	60.5792	3
1504.79	60.5611	60.5799	3
1504.79	60.5611	60.5810	3

1504.85	60.5616	60.5816	3
1504.86	60.5617	60.5824	3
1504.92	60.5623	60.5831	3
1505.06	60.5636	60.5833	3
1505.12	60.5641	60.5841	3
1505.19	60.5648	60.5850	3
1505.25	60.5653	60.5855	3
1505.26	60.5654	60.5862	3
1505.31	60.5659	60.5867	3
1505.31	60.5659	60.5884	3
1505.32	60.5660	60.5903	3
1505.39	60.5666	60.5908	3
1505.41	60.5668	60.5912	3
1505.49	60.5676	60.5920	3
1505.62	60.5688	60.5942	3
1505.73	60.5698	60.5961	3
1505.86	60.5711	60.5974	3
1505.92	60.5716	60.5995	3
1505.94	60.5718	60.6014	3
1505.94	60.5718	60.6026	3
1505.97	60.5721	60.6032	3
1505.99	60.5723	60.6039	3
1506.13	60.5736	60.6049	3
1506.21	60.5744	60.6059	3
1506.24	60.5747	60.6066	3
1506.51	60.5773	60.6071	3
1506.69	60.5790	60.6078	3
1506.72	60.5793	60.6097	3
1506.85	60.5806	60.6114	3
1506.93	60.5813	60.6118	3
1506.99	60.5819	60.6124	3
1507.09	60.5829	60.6140	3
1507.12	60.5832	60.6154	3
1507.14	60.5834	60.6159	3
1507.14	60.5834	60.6174	3
1507.28	60.5848	60.6190	3
1507.33	60.5853	60.6203	3
1507.38	60.5858	60.6217	3
1507.46	60.5866	60.6243	3
1507.49	60.5869	60.6263	3
1507.81	60.5900	60.6265	3
1507.86	60.5905	60.6268	3

1507.91	60.5910	60.6270	3
1507.94	60.5913	60.6271	3
1508.07	60.5926	60.6273	3
1508.37	60.5957	60.6277	3
1508.45	60.5965	60.6282	3
1508.63	60.5983	60.6284	3
1508.85	60.6006	60.6287	3
1509.01	60.6022	60.6336	3
1509.01	60.6022	60.6387	3
1509.09	60.6030	60.6390	3
1509.12	60.6034	60.6392	3
1509.23	60.6045	60.6395	3
1509.31	60.6053	60.6401	3
1509.42	60.6065	60.6408	3
1509.44	60.6067	60.6438	3
1509.52	60.6075	60.6472	3
1509.58	60.6081	60.6477	3
1509.88	60.6113	60.6480	3
1509.9	60.6115	60.6511	3
1509.96	60.6121	60.6545	3
1510.01	60.6127	60.6552	3
1510.26	60.6153	60.6556	3
1510.28	60.6155	60.6594	3

8.4. Appendix D

8.4.1. Results, detailed Actual and Estimated Inclination and Inclination Classification for six wells (15/9-F-4, 15/9-F-5, 15/9-F-10, 15/9-F-11T2, 15/9-F-12 and 15/9-F-14)

Table 10: Results, detailed Actual and Estimated Inclination and Inclination Classification for well 15/9-F-4 and 15/9-F-5

Denotation: 1=low inclination, 2=medium inclination and 3=high inclination							
Well 15/9-F-4				Well 15/9-F-5			
MD	Actual Inc	Estimated Inc	Inc-Classif	MD	Actual Inc	Estimated Inc	Inc-Classif
[m]	[deg]	[deg]		[m]	[deg]	[deg]	
145.9	0.000	0.049	1	145.9	0	0.00	1
184.12	0.100	0.130	1	146	0	0.08	1
224.45	0.160	0.499	1	154.9	0.16	0.12	1
264.79	0.840	1.217	1	195.3	0.28	0.42	1
305.1	1.600	2.154	1	235.6	0.64	0.53	1
345.45	2.760	3.936	1	276	1.51	1.85	1
385.8	5.170	6.103	1	316.4	2.21	3.16	1
426.12	7.040	7.474	1	356.7	4.11	5.88	1
466.4	8.060	8.345	1	397.1	7.66	8.38	1
506.65	8.850	8.800	1	437.5	9.13	9.85	1
546.96	8.900	8.872	1	477.8	10.58	10.96	1
587.28	8.910	8.953	1	518.2	11.35	11.39	1
627.54	9.000	9.196	1	558.5	11.51	11.91	1
667.63	9.450	9.556	1	598.9	12.38	12.93	1
707.96	9.680	10.564	1	639.3	13.56	13.89	1
748.28	11.470	12.681	1	679.6	14.3	14.94	1
788.57	13.920	14.788	1	720	15.63	17.01	1
828.91	15.680	16.200	1	760.4	18.5	20.02	1
869.25	16.740	16.393	1	800.7	21.63	22.72	1
909.6	16.060	15.499	1	841.1	23.86	25.34	1
949.94	14.950	14.323	1	881.5	26.84	26.07	1
990.29	13.700	13.284	1	921.8	25.33	23.89	1
1030.7	12.890	12.516	1	962.2	22.47	21.13	1
1071	12.150	12.379	1	1003	19.82	18.50	1
1111.4	12.640	14.228	1	1043	17.2	16.10	1
1151.7	15.840	16.987	1	1083	15	16.35	1
1192.1	18.180	18.310	1	1124	17.73	19.73	1
1232.4	18.490	17.315	1	1164	21.77	23.93	1
1272.7	16.150	15.778	1	1204	26.13	27.85	1
1313.1	15.420	15.477	1	1245	29.6	30.31	1
1353.4	15.540	15.538	1	1285	31.04	29.81	2

1393.7	15.680	15.917	1	1326	28.6	27.03	1
1434.1	16.310	17.120	1	1366	25.5	27.69	1
1474.4	18.160	19.963	1	1406	29.89	30.48	1
1514.8	21.780	22.552	1	1447	31.1	31.50	2
1555.1	23.340	23.959	1	1487	31.91	31.91	2
1595.5	24.600	25.348	1	1527	31.93	32.29	2
1635.8	26.120	25.902	1	1568	32.67	33.16	2
1676.1	25.750	25.628	1	1608	33.69	33.95	2
1716.5	25.560	25.568	1	1648	34.24	34.60	2
1756.8	25.590	25.556	1	1689	34.99	35.43	2
1797.2	25.550	25.506	1	1729	35.88	35.89	2
1837.6	25.470	25.535	1	1770	35.93	35.93	2
1877.9	25.620	25.585	1	1810	35.95	35.88	2
1918.3	25.570	25.526	1	1850	35.83	35.92	2
1958.6	25.500	25.800	1	1891	36.05	36.41	2
1999	26.110	26.024	1	1931	36.8	36.47	2
2039.3	25.960	26.293	1	1971	36.16	36.02	2
2079.7	26.640	26.546	1	2012	35.9	35.38	2
2120	26.480	26.443	1	2052	34.88	34.19	2
2160.4	26.410	26.543	1	2092	33.5	32.86	2
2200.7	26.700	26.579	1	2133	32.25	32.53	2
2241.1	26.470	26.443	1	2173	32.85	32.87	2
2281.4	26.440	26.416	1	2213	32.96	33.03	2
2321.8	26.410	26.488	1	2254	33.13	33.08	2
2362.2	26.580	26.617	1	2294	33.06	33.15	2
2402.6	26.670	26.573	1	2334	33.27	33.36	2
2442.9	26.500	26.769	1	2375	33.48	33.46	2
2483.3	27.050	27.249	1	2415	33.45	33.37	2
2523.6	27.470	27.429	1	2456	33.33	32.96	2
2564	27.400	27.107	1	2496	32.61	32.24	2
2604.3	26.840	27.163	1	2536	31.9	31.67	2
2644.7	27.580	27.651	1	2577	31.49	31.34	2
2685	27.860	28.016	1	2617	31.21	31.23	2
2696.4	28.190	28.827	1	2657	31.29	31.34	2
2740.8	29.630	30.376	1	2698	31.42	31.22	2
2773.9	31.220	31.438	2	2738	31.03	30.83	2
2800.7	31.750	31.660	2	2776	30.68	30.66	2
2840.3	31.620	31.829	2	2789	30.65	30.76	2
2879.9	32.110	32.401	2	2830	30.89	30.87	2
2920.1	32.760	33.588	2	2867	30.86	31.02	2
2959.1	34.440	34.854	2	2904	31.2	31.50	2
3001.1	35.310	35.907	2	2913	31.86	32.12	2

3041.5	36.600	37.179	2	2928	32.38	33.18	2
3081.3	37.880	39.341	2	2955	34.03	35.15	2
3121.8	40.870	42.322	2	2995	36.51	36.59	2
3162.8	43.810	45.329	2	3036	36.77	37.20	2
3203.5	46.880	48.641	2	3077	37.73	37.39	2
3244.1	50.420	51.466	2	3117	37.11	36.32	2
3284.8	52.560	53.690	2	3157	35.73	34.92	2
3325.1	54.850	55.032	2	3197	34.2	32.83	2
3365.1	55.230	55.179	2	3237	31.59	30.87	2
3404.8	55.150	55.002	2	3254	30.18	29.24	2
3444.8	54.880	54.758	2	3278	28.32	29.57	1
3485	54.670	54.657	2	3319	30.91	32.88	2
3510	54.670	89.972	2	3359	34.92	37.66	2
				3398	40.44	42.57	2
				3440	44.73	46.31	2
				3479	47.93	49.28	2
				3520	50.65	52.30	2
				3560	53.98	54.33	2
				3602	54.71	54.77	2
				3642	54.84	54.97	2
				3682	55.13	54.29	2
				3723	53.47	53.06	2
				3762	52.67	52.66	2

Table 11: Results, detailed Actual and Estimated Inclination and Inclination Classification for well 15/9-F-10 and 15/9-F-11T2

Denotation: 1=low inclination, 2=medium inclination and 3=high inclination							
Well 15/9-F-10				Well 15/9-F-11T2			
MD	Actual Inc	Estimated Inc	Inc-Classif	MD	Actual Inc	Estimated Inc	Inc-Classif
[m]	[deg]	[deg]		[m]	[deg]	[deg]	
145.9	0	0.020	1	145.9	0	0.040	1
150	0.02	0.033	1	150	0.09	0.150	1
160	0.05	0.044	1	160	0.2	0.190	1
170	0.04	0.037	1	170	0.19	0.211	1
180	0.03	0.033	1	180	0.23	0.229	1
190	0.04	0.041	1	190	0.23	0.226	1
200	0.04	0.049	1	200	0.22	0.234	1
210	0.06	0.099	1	210	0.24	0.286	1
220	0.14	0.164	1	220	0.34	0.379	1
230	0.2	0.236	1	230	0.42	0.492	1
240	0.27	0.270	1	240	0.57	0.735	1
250	0.28	0.285	1	250	0.92	1.016	1
260	0.28	0.288	1	260	1.13	1.146	1
270	0.3	0.305	1	270	1.16	1.181	1
280	0.31	0.326	1	280	1.2	1.221	1
290	0.34	0.375	1	290	1.24	1.214	1
300	0.41	0.480	1	300	1.2	1.195	1
310	0.55	0.694	1	310	1.19	1.171	1
320	0.84	1.015	1	320	1.15	1.136	1
330	1.2	1.372	1	330	1.12	1.110	1
340	1.54	1.819	1	340	1.1	1.089	1
350	2.1	2.369	1	350	1.08	1.074	1
360	2.64	2.762	1	360	1.07	1.085	1
370	2.89	3.177	1	370	1.1	1.143	1
380	3.46	3.759	1	380	1.19	1.256	1
390	4.06	4.187	1	390	1.33	1.526	1
400	4.32	4.428	1	400	1.73	1.797	1
410	4.53	4.650	1	410	1.86	1.874	1
420	4.78	4.874	1	420	1.89	1.924	1
430	4.98	5.033	1	430	1.96	1.976	1
440	5.08	5.227	1	440	1.99	1.995	1
450	5.39	5.592	1	450	2.01	2.002	1
460	5.79	5.918	1	460	1.99	2.006	1
470	6.04	6.165	1	470	2.03	2.042	1
480	6.31	6.467	1	480	2.06	2.058	1

490	6.62	6.802	1	490	2.05	2.072	1
500	6.99	7.060	1	500	2.1	2.104	1
510	7.14	7.259	1	510	2.11	2.115	1
520	7.38	7.583	1	520	2.12	2.106	1
530	7.79	8.089	1	530	2.09	2.106	1
540	8.4	8.631	1	540	2.13	2.133	1
550	8.86	9.079	1	550	2.13	2.121	1
560	9.3	9.500	1	560	2.12	2.127	1
570	9.71	9.905	1	570	2.13	2.140	1
580	10.1	10.380	1	580	2.16	2.148	1
590	10.68	10.950	1	590	2.14	2.162	1
600	11.23	11.563	1	600	2.18	2.166	1
610	11.89	12.009	1	610	2.15	2.140	1
620	12.15	12.265	1	620	2.13	2.067	1
630	12.39	12.572	1	630	2.01	1.819	1
640	12.77	12.945	1	640	1.68	1.646	1
650	13.11	13.192	1	650	1.63	1.650	1
660	13.29	13.366	1	660	1.66	1.719	1
670	13.46	13.583	1	670	1.79	1.944	1
680	13.71	13.802	1	680	2.11	2.272	1
690	13.91	13.965	1	690	2.45	2.608	1
700	14.02	14.102	1	700	2.77	2.977	1
710	14.19	14.305	1	710	3.19	3.591	1
720	14.44	14.587	1	720	4.01	4.338	1
730	14.75	14.863	1	730	4.67	5.027	1
740	14.97	15.126	1	740	5.38	5.694	1
750	15.31	15.552	1	750	6.03	6.460	1
760	15.8	16.061	1	760	6.89	7.285	1
770	16.34	16.608	1	770	7.68	8.022	1
780	16.87	17.169	1	780	8.37	8.850	1
790	17.5	17.950	1	790	9.33	9.758	1
800	18.4	18.755	1	800	10.21	10.499	1
810	19.13	19.372	1	810	10.79	11.051	1
820	19.61	19.835	1	820	11.33	11.629	1
830	20.09	20.353	1	830	11.93	12.106	1
840	20.61	20.810	1	840	12.31	12.414	1
850	21.04	21.219	1	850	12.52	12.643	1
860	21.4	21.528	1	860	12.79	12.807	1
870	21.66	21.661	1	870	12.84	12.793	1
880	21.71	21.698	1	880	12.75	12.639	1
890	21.7	21.482	1	890	12.55	12.358	1
900	21.25	20.831	1	900	12.18	11.788	1

910	20.45	20.099	1	910	11.4	11.151	1
920	19.76	19.554	1	920	10.91	10.829	1
930	19.35	19.185	1	930	10.76	10.664	1
940	19.05	18.928	1	940	10.58	10.552	1
950	18.82	18.795	1	950	10.53	10.524	1
960	18.76	18.752	1	960	10.52	10.496	1
970	18.76	18.780	1	970	10.48	10.416	1
980	18.83	18.850	1	980	10.36	10.323	1
990	18.87	18.901	1	990	10.31	10.307	1
1000	18.94	18.954	1	1000	10.29	10.306	1
1010	18.99	19.049	1	1010	10.34	10.357	1
1020	19.11	19.241	1	1020	10.39	10.438	1
1030	19.38	19.587	1	1030	10.48	10.462	1
1040	19.81	19.989	1	1040	10.47	10.483	1
1050	20.19	20.308	1	1050	10.49	10.571	1
1060	20.45	20.509	1	1060	10.66	10.829	1
1070	20.56	20.628	1	1070	11.01	11.231	1
1080	20.72	20.825	1	1080	11.46	11.735	1
1090	20.96	21.123	1	1090	12.02	12.522	1
1100	21.31	21.544	1	1100	13.04	13.605	1
1110	21.8	22.107	1	1110	14.19	14.650	1
1120	22.42	22.662	1	1120	15.14	15.717	1
1130	22.93	23.190	1	1130	16.29	17.190	1
1140	23.46	23.830	1	1140	18.12	18.754	1
1150	24.23	24.621	1	1150	19.37	19.779	1
1160	25.03	25.353	1	1160	20.2	20.544	1
1170	25.65	25.975	1	1170	20.94	21.344	1
1180	26.32	26.552	1	1180	21.74	21.888	1
1190	26.84	27.079	1	1190	22.06	22.172	1
1200	27.31	27.588	1	1200	22.3	22.420	1
1210	27.87	28.118	1	1210	22.53	22.640	1
1220	28.39	28.697	1	1220	22.78	22.828	1
1230	29.01	29.340	1	1230	22.91	22.940	1
1240	29.71	29.984	1	1240	22.99	23.045	1
1250	30.28	30.477	2	1250	23.1	23.055	1
1260	30.7	30.768	2	1260	23.02	22.713	1
1270	30.84	30.704	2	1270	22.4	22.216	1
1280	30.61	30.384	2	1280	22.06	21.761	1
1290	30.14	29.794	2	1290	21.49	21.216	1
1300	29.48	29.256	1	1300	20.95	20.891	1
1310	29.02	28.881	1	1310	20.83	20.825	1
1320	28.79	28.660	1	1320	20.85	20.927	1

1330	28.51	28.171	1	1330	21.02	21.167	1
1340	27.89	27.577	1	1340	21.31	21.445	1
1350	27.26	27.228	1	1350	21.61	21.798	1
1360	27.2	27.187	1	1360	21.97	22.199	1
1370	27.23	27.314	1	1370	22.45	22.810	1
1380	27.38	27.497	1	1380	23.22	23.520	1
1390	27.64	27.771	1	1390	23.84	24.177	1
1400	27.93	28.054	1	1400	24.53	24.953	1
1410	28.16	28.162	1	1410	25.42	25.899	1
1420	28.21	28.094	1	1420	26.38	26.771	1
1430	27.99	27.850	1	1430	27.21	27.575	1
1440	27.72	27.619	1	1440	27.94	28.328	1
1450	27.54	27.450	1	1450	28.74	29.094	1
1460	27.36	27.302	1	1460	29.48	29.680	1
1470	27.29	27.242	1	1470	29.92	30.170	1
1480	27.2	27.116	1	1480	30.4	30.798	2
1490	27.05	26.982	1	1490	31.22	31.539	2
1500	26.93	26.883	1	1500	31.87	32.106	2
1510	26.85	26.830	1	1510	32.35	32.495	2
1520	26.81	26.722	1	1520	32.72	32.955	2
1530	26.64	26.559	1	1530	33.21	33.326	2
1540	26.54	26.542	1	1540	33.41	33.492	2
1550	26.52	26.474	1	1550	33.61	33.775	2
1560	26.44	26.356	1	1560	33.95	33.994	2
1570	26.29	26.234	1	1570	34.05	34.014	2
1580	26.2	26.148	1	1580	34.02	34.012	2
1590	26.13	26.085	1	1590	34.03	33.992	2
1600	26.06	25.995	1	1600	33.97	33.978	2
1610	25.95	25.898	1	1610	34	34.096	2
1620	25.84	25.785	1	1620	34.2	34.286	2
1630	25.78	25.745	1	1630	34.38	34.401	2
1640	25.69	25.610	1	1640	34.44	34.415	2
1650	25.56	25.480	1	1650	34.42	34.381	2
1660	25.44	25.431	1	1660	34.35	34.316	2
1670	25.43	25.427	1	1670	34.31	34.272	2
1680	25.43	25.464	1	1680	34.23	34.215	2
1690	25.53	25.691	1	1690	34.23	34.241	2
1700	25.86	26.057	1	1700	34.3	34.362	2
1710	26.26	26.578	1	1710	34.41	34.209	2
1720	26.89	27.171	1	1720	34.04	33.562	2
1730	27.5	27.743	1	1730	33.09	32.692	2
1740	28.01	28.247	1	1740	32.35	31.989	2

1750	28.5	28.750	1	1750	31.64	31.110	2
1760	28.97	29.181	1	1760	30.59	30.121	2
1770	29.41	29.599	1	1770	29.68	29.380	1
1780	29.85	30.085	1	1780	29.07	28.796	1
1790	30.32	30.515	2	1790	28.52	28.013	1
1800	30.7	30.905	2	1800	27.54	26.928	1
1810	31.13	31.355	2	1810	26.37	26.034	1
1820	31.61	31.818	2	1820	25.69	25.397	1
1830	32.07	32.313	2	1830	25.1	24.684	1
1840	32.58	32.865	2	1840	24.31	23.860	1
1850	33.17	33.466	2	1850	23.4	23.085	1
1860	33.78	34.088	2	1860	22.79	22.343	1
1870	34.41	34.726	2	1870	21.92	21.438	1
1880	35.08	35.400	2	1880	20.98	20.601	1
1890	35.74	36.070	2	1890	20.23	19.935	1
1900	36.39	36.749	2	1900	19.65	19.320	1
1910	37.11	37.453	2	1910	19.02	18.597	1
1920	37.85	38.173	2	1920	18.16	17.729	1
1930	38.51	38.893	2	1930	17.32	16.941	1
1940	39.27	39.657	2	1940	16.56	16.083	1
1950	40.09	40.493	2	1950	15.62	15.084	1
1960	40.87	41.261	2	1960	14.58	14.172	1
1970	41.72	42.057	2	1970	13.75	13.421	1
1980	42.38	42.706	2	1980	13.12	12.611	1
1990	43.08	43.418	2	1990	12.11	11.497	1
2000	43.74	44.034	2	2000	10.9	10.470	1
2010	44.38	44.669	2	2010	10.04	9.657	1
2020	44.97	45.011	2	2020	9.28	8.876	1
2030	45.09	44.990	2	2030	8.48	7.992	1
2040	44.9	44.845	2	2040	7.52	7.196	1
2050	44.83	44.903	2	2050	6.87	6.570	1
2060	44.96	44.939	2	2060	6.28	5.964	1
2070	44.98	44.981	2	2070	5.66	5.440	1
2080	44.96	44.979	2	2080	5.24	5.000	1
2090	44.99	45.003	2	2090	4.77	4.472	1
2100	45.05	45.019	2	2100	4.19	3.769	1
2110	45.04	45.004	2	2110	3.37	3.116	1
2120	45	45.005	2	2120	2.89	2.825	1
2130	45.05	45.133	2	2130	2.79	2.841	1
2140	45.17	45.155	2	2140	2.93	3.137	1
2150	45.15	45.015	2	2150	3.39	3.643	1
2160	44.93	44.924	2	2160	3.94	4.126	1

2170	44.95	44.988	2	2170	4.35	4.592	1
2180	45.03	45.000	2	2180	4.85	5.115	1
2190	44.99	44.979	2	2190	5.41	5.695	1
2200	44.96	45.007	2	2200	6	6.275	1
2210	45.07	45.082	2	2210	6.56	6.923	1
2220	45.12	45.107	2	2220	7.3	7.760	1
2230	45.17	45.234	2	2230	8.25	8.742	1
2240	45.31	45.319	2	2240	9.24	9.685	1
2250	45.35	45.239	2	2250	10.14	10.614	1
2260	45.14	45.012	2	2260	11.11	11.580	1
2270	44.93	44.917	2	2270	12.04	12.393	1
2280	44.92	44.968	2	2280	12.77	13.027	1
2290	44.98	44.929	2	2290	13.29	13.604	1
2300	44.91	45.005	2	2300	13.92	14.296	1
2310	45.14	45.319	2	2310	14.69	15.068	1
2320	45.51	45.496	2	2320	15.47	15.823	1
2330	45.53	45.327	2	2330	16.18	16.541	1
2340	45.15	44.991	2	2340	16.93	17.331	1
2350	44.84	44.969	2	2350	17.72	18.160	1
2360	45.06	45.089	2	2360	18.61	19.063	1
2370	45.16	45.010	2	2370	19.52	19.964	1
2380	44.89	44.917	2	2380	20.43	20.826	1
2390	44.97	45.081	2	2390	21.25	21.577	1
2400	45.21	45.303	2	2400	21.92	22.263	1
2410	45.38	45.244	2	2410	22.61	23.022	1
2420	45.14	45.076	2	2420	23.43	23.868	1
2430	45.02	45.081	2	2430	24.36	24.840	1
2440	45.17	45.086	2	2440	25.31	25.777	1
2450	45.03	44.944	2	2450	26.29	26.775	1
2460	44.94	44.961	2	2460	27.23	27.699	1
2470	44.92	44.877	2	2470	28.23	28.661	1
2480	44.93	44.893	2	2480	29.08	29.559	1
2490	44.84	44.825	2	2490	30.08	30.549	2
2500	44.8	44.700	2	2500	31.02	31.325	2
2510	44.68	44.584	2	2510	31.64	31.886	2
2520	44.49	44.582	2	2520	32.15	32.510	2
2530	44.67	44.680	2	2530	32.87	33.430	2
2540	44.71	44.668	2	2540	34.06	34.704	2
2550	44.65	44.681	2	2550	35.36	35.792	2
2560	44.75	44.773	2	2560	36.24	36.573	2
2570	44.84	44.879	2	2570	36.93	37.304	2
2580	44.87	44.858	2	2580	37.65	38.175	2

2590	44.9	44.817	2	2590	38.72	39.133	2
2600	44.72	44.527	2	2600	39.63	40.151	2
2610	44.39	44.430	2	2610	40.65	41.224	2
2620	44.49	44.603	2	2620	41.83	42.339	2
2630	44.76	44.821	2	2630	42.86	43.341	2
2640	44.86	44.919	2	2640	43.82	44.207	2
2650	45.01	45.020	2	2650	44.66	45.155	2
2660	45.09	45.135	2	2660	45.66	46.122	2
2670	45.15	45.180	2	2670	46.6	47.059	2
2680	45.27	45.306	2	2680	47.52	47.932	2
2690	45.33	45.416	2	2690	48.39	48.844	2
2700	45.54	45.634	2	2700	49.32	49.823	2
2710	45.74	45.796	2	2710	50.34	50.860	2
2720	45.86	45.879	2	2720	51.38	51.831	2
2730	45.9	45.959	2	2730	52.35	52.829	2
2740	46.03	46.120	2	2740	53.31	53.683	2
2750	46.22	46.214	2	2750	54.04	54.395	2
2760	46.26	46.280	2	2760	54.76	55.103	2
2770	46.32	46.426	2	2770	55.47	55.859	2
2780	46.52	46.626	2	2780	56.24	56.692	2
2790	46.83	46.913	2	2790	57.17	57.645	2
2800	47	46.984	2	2800	58.13	58.597	2
2810	46.99	47.202	2	2810	59.11	59.531	2
2820	47.38	47.689	2	2820	60	60.446	2
2830	48.02	48.537	2	2830	60.84	61.189	3
2840	49.07	49.597	2	2840	61.65	61.878	3
2850	50.14	50.445	2	2850	62.04	61.972	3
2860	50.83	50.928	2	2860	62	62.083	3
2870	51.01	51.098	2	2870	62.16	62.280	3
2880	51.24	51.608	2	2880	62.42	62.730	3
2890	52.02	52.536	2	2890	63.01	63.382	3
2900	53.05	53.408	2	2900	63.81	64.140	3
2910	53.79	54.119	2	2910	64.47	64.778	3
2920	54.47	54.875	2	2920	65.09	65.407	3
2930	55.24	55.672	2	2930	65.71	65.980	3
2940	56.18	56.547	2	2940	66.31	66.660	3
2950	56.9	57.171	2	2950	66.97	67.412	3
2960	57.46	57.854	2	2960	67.89	68.462	3
2970	58.29	58.789	2	2970	69.05	69.690	3
2980	59.29	59.657	2	2980	70.33	70.849	3
2990	60.01	60.252	3	2990	71.42	71.934	3
3000	60.49	60.854	3	3000	72.46	73.075	3

3010	61.29	61.769	3	3010	73.71	74.448	3
3020	62.3	62.602	3	3020	75.14	75.815	3
3030	62.91	63.247	3	3030	76.59	77.226	3
3040	63.59	64.073	3	3040	77.77	78.342	3
3050	64.51	64.976	3	3050	78.92	79.452	3
3060	65.51	65.846	3	3060	80.1	80.905	3
3070	66.18	66.478	3	3070	81.65	81.891	3
3080	66.79	67.349	3	3080	82.12	82.008	3
3090	67.9	68.463	3	3090	81.91	81.834	3
3100	69.07	69.326	3	3100	81.84	81.948	3
3110	69.64	70.051	3	3110	81.98	82.007	3
3120	70.42	70.910	3	3120	82.05	82.008	3
3130	71.46	71.689	3	3130	81.99	82.007	3
3140	71.83	71.940	3	3140	81.99	81.950	3
3150	72.15	72.473	3	3150	82.01	81.950	3
3160	72.75	73.017	3	3160	81.88	81.949	3
3170	73.28	73.319	3	3170	82.01	81.950	3
3180	73.45	73.552	3	3180	81.92	82.007	3
3190	73.6	74.094	3	3190	82.09	82.122	3
3200	74.64	74.982	3	3200	82.06	82.006	3
3210	75.28	75.459	3	3210	81.96	81.951	3
3220	75.66	76.110	3	3220	82	82.065	3
3230	76.61	77.052	3	3230	82.13	82.123	3
3240	77.52	77.813	3	3240	82.11	82.181	3
3250	78.06	78.166	3	3250	82.23	82.239	3
3260	78.27	78.343	3	3260	82.28	82.239	3
3270	78.47	79.044	3	3270	82.21	82.123	3
3280	79.66	79.976	3	3280	82.08	82.065	3
3290	80.27	80.383	3	3290	81.99	82.008	3
3300	80.48	80.674	3	3300	82.04	81.950	3
3310	80.87	81.485	3	3310	81.94	81.891	3
3320	82.06	82.123	3	3320	81.8	81.891	3
3330	82.23	82.528	3	3330	82.01	82.122	3
3340	82.87	83.162	3	3340	82.17	82.008	3
3350	83.39	83.914	3	3350	81.9	81.891	3
3360	84.45	84.489	3	3360	81.85	81.892	3
3370	84.59	84.777	3	3370	82	82.064	3
3380	84.95	85.467	3	3380	82.09	82.065	3
3390	85.99	85.927	3	3390	82.03	82.007	3
3400	85.9	85.755	3	3400	82	82.066	3
3410	85.6	85.582	3	3410	82.18	82.239	3
3420	85.55	85.812	3	3420	82.26	82.180	3

3430	86.03	85.985	3	3430	82.1	82.124	3
3440	85.95	86.042	3	3440	82.21	82.181	3
3450	86.13	86.272	3	3450	82.16	82.065	3
3460	86.45	86.329	3	3460	81.96	81.950	3
3470	86.18	86.042	3	3470	81.97	81.833	3
3480	85.93	85.870	3	3480	81.63	81.255	3
3490	85.8	85.812	3	3490	80.95	80.848	3
3500	85.83	85.984	3	3500	80.72	80.615	3
3510	86.12	85.985	3	3510	80.48	80.443	3
3520	85.84	85.755	3	3520	80.5	80.558	3
3530	85.78	86.042	3	3530	80.61	80.557	3
3540	86.22	86.157	3	3540	80.52	80.441	3
3550	86.14	85.985	3	3550	80.35	80.441	3
3560	85.83	85.870	3	3560	80.5	80.557	3
3570	85.96	86.100	3	3570	80.58	80.443	3
3580	86.23	86.214	3	3580	80.42	80.442	3
3590	86.12	86.100	3	3590	80.46	80.499	3
3600	86.14	86.100	3	3600	80.54	80.383	3
3610	86.03	86.042	3	3610	80.22	80.266	3
3620	86.1	86.157	3	3620	80.24	80.325	3
3630	86.18	86.100	3	3630	80.43	80.326	3
3640	85.99	85.985	3	3640	80.3	80.326	3
3650	86	86.157	3	3650	80.35	80.383	3
3660	86.32	86.099	3	3660	80.42	80.441	3
3670	85.85	85.755	3	3670	80.43	80.384	3
3680	85.76	85.927	3	3680	80.39	80.383	3
3690	86.02	86.157	3	3690	80.38	80.382	3
3700	86.3	86.157	3	3700	80.36	80.209	3
3710	86.05	86.157	3	3710	80.05	79.743	3
3720	86.23	86.444	3	3720	79.41	78.869	3
3730	86.7	86.502	3	3730	78.41	77.815	3
3740	86.35	86.157	3	3740	77.22	76.638	3
3750	85.93	85.697	3	3750	76.04	75.459	3
3760	85.48	85.697	3	3760	74.9	74.389	3
3770	85.93	85.927	3	3770	73.85	73.435	3
3780	85.89	85.698	3	3780	73.03	72.720	3
3790	85.55	85.697	3	3790	72.47	72.053	3
3800	85.75	85.755	3	3800	71.61	71.030	3
3810	85.8	85.640	3	3810	70.48	69.997	3
3820	85.46	85.352	3	3820	69.58	69.198	3
3830	85.24	85.410	3	3830	68.8	68.340	3
3840	85.58	85.640	3	3840	67.9	67.288	3

3850	85.72	85.525	3	3850	66.71	65.975	3
3860	85.31	85.352	3	3860	65.24	64.643	3
3870	85.39	85.583	3	3870	64	63.444	3
3880	85.88	85.870	3	3880	62.93	62.470	3
3890	85.86	85.927	3	3890	62	61.645	3
3900	85.92	85.870	3	3900	61.38	61.096	3
3910	85.81	85.870	3	3910	60.74	60.071	3
3920	85.95	85.812	3	3920	59.52	58.850	2
3930	85.73	85.755	3	3930	58.14	57.639	2
3940	85.71	85.697	3	3940	57.12	56.692	2
3950	85.71	85.697	3	3950	56.28	55.539	2
3960	85.7	85.525	3	3960	54.9	54.187	2
3970	85.38	85.352	3	3970	53.5	52.887	2
3980	85.32	85.582	3	3980	52.22	51.613	2
3990	85.83	85.927	3	3990	51.08	50.566	2
4000	86.07	85.870	3	4000	50.05	49.525	2
4010	85.64	85.525	3	4010	49.03	48.540	2
4020	85.44	85.582	3	4020	48.09	47.772	2
4030	85.69	85.525	3	4030	47.48	47.142	2
4040	85.41	85.352	3	4040	46.81	46.335	2
4050	85.24	85.353	3	4050	45.82	45.346	2
4060	85.53	85.927	3	4060	44.94	44.599	2
4070	86.26	86.444	3	4070	44.29	43.922	2
4080	86.62	86.444	3	4080	43.56	43.119	2
4090	86.34	86.444	3	4090	42.72	42.235	2
4100	86.47	86.444	3	4100	41.73	41.224	2
4110	86.49	86.386	3	4110	40.74	40.265	2
4120	86.26	86.157	3	4120	39.82	39.359	2
4130	86.04	86.214	3	4130	38.9	38.469	2
4140	86.42	86.387	3	4140	38.08	37.512	2
4150	86.34	86.157	3	4150	36.96	36.454	2
4160	85.94	85.640	3	4160	35.94	35.338	2
4170	85.39	85.352	3	4170	34.79	34.205	2
4180	85.31	85.295	3	4180	33.64	33.111	2
4190	85.27	85.352	3	4190	32.56	32.066	2
4200	85.5	85.697	3	4200	31.64	30.997	2
4210	85.83	85.927	3	4210	30.37	29.859	2
4220	86.06	85.927	3	4220	29.35	28.921	1
4230	85.75	85.697	3	4230	28.5	28.135	1
4240	85.67	85.697	3	4240	27.8	27.299	1
4250	85.75	85.582	3	4250	26.78	26.257	1
4260	85.46	85.467	3	4260	25.77	25.234	1

4270	85.41	85.409	3	4270	24.74	24.342	1
4280	85.42	85.640	3	4280	23.95	23.369	1
4290	85.86	85.870	3	4290	22.81	22.211	1
4300	85.95	85.812	3	4300	21.59	20.970	1
4310	85.62	85.870	3	4310	20.38	19.654	1
4320	86.08	86.214	3	4320	18.96	18.243	1
4330	86.4	86.272	3	4330	17.51	17.001	1
4340	86.13	85.985	3	4340	16.53	16.140	1
4350	85.89	85.927	3	4350	15.74	15.303	1
4360	85.98	86.099	3	4360	14.89	14.493	1
4370	86.21	86.100	3	4370	14.1	13.990	1
4380	86.01	85.869	3	4380	13.88	13.865	1
4390	85.7	85.812	3	4390	13.86	13.877	1
4400	85.96	85.985	3	4400	13.92	13.877	1
4410	85.99	85.927	3	4410	13.85	13.823	1
4420	85.9	85.984	3	4420	13.8	13.827	1
4430	85.97	86.042	3	4430	13.87	13.908	1
4440	86.13	86.099	3	4440	13.93	13.863	1
4450	86.07	86.042	3	4450	13.81	13.832	1
4460	86.09	86.100	3	4460	13.87	13.843	1
4470	86.06	86.157	3	4470	13.82	13.858	1
4480	86.24	86.272	3	4480	13.91	14.051	1
4490	86.31	86.559	3	4490	14.2	14.296	1
4500	86.86	86.846	3	4500	14.4	14.367	1
4510	86.82	87.190	3	4510	14.36	14.387	1
4520	87.53	87.764	3	4520	14.4	14.398	1
4530	87.97	87.994	3	4530	14.42	14.444	1
4540	88.09	88.051	3	4540	14.47	14.520	1
4550	88	87.477	3	4550.7	14.59	14.580	1
4560	86.93	86.329	3				
4570	85.77	85.812	3				
4580	85.83	85.869	3				
4590	85.92	85.812	3				
4600	85.76	85.755	3				
4610	85.73	85.812	3				
4620	85.92	86.042	3				
4630	86.12	85.927	3				
4640	85.71	85.640	3				
4650	85.63	85.755	3				
4660	85.8	85.812	3				
4670	85.86	85.640	3				
4680	85.42	85.295	3				

4690	85.22	84.950	3
4700	84.7	84.316	3
4710	83.9	83.567	3
4720	83.23	82.990	3
4730	82.81	82.874	3
4740	82.87	82.644	3
4750	82.45	82.355	3
4760	82.23	82.129	3
4764.1	82.2	81.545	3
4777.6	80.87	79.130	3
4818	77.41	75.485	3
4858.4	73.57	71.485	3
4894.4	69.4	66.841	3
4936.1	64.3	61.363	3
4977.6	58.44	56.634	2
5017.9	54.86	54.545	2
5058.3	54.24	54.444	2
5098.6	54.66	54.565	2
5139	54.49	54.530	2
5179.3	54.59	54.610	2
5219.4	54.66	54.388	2
5259.7	54.14	54.368	2
5300.1	54.61	54.605	2

Table 12: Results, detailed Actual and Estimated Inclination and Inclination Classification for wells 15/9-F-12 and 15/9-F-14

Denotation: 1=low inclination, 2=medium inclination and 3=high inclination							
Well 15/9-F-12				Well 15/9-F-14			
MD	Actual Inc	Estimated Inc	Inc-Classif	MD	Actual Inc	Estimated Inc	Inc-Classif
[m]	[deg]	[deg]		[m]	[deg]	[deg]	
145.9	0	0.063	1	145.9	0	0.088	1
174	0.12	0.102	1	155.09	0.18	0.246	1
204	0.08	0.104	1	195.44	0.33	0.462	1
234	0.15	0.199	1	235.8	0.61	1.080	1
264	0.25	0.298	1	276.2	1.55	1.547	1
294	0.34	0.352	1	316.6	1.55	1.722	1
324	0.36	0.414	1	356.9	1.9	2.729	1
354	0.46	0.556	1	397.3	3.61	3.956	1
384	0.65	0.847	1	437.7	4.31	4.121	1
414	1.09	1.992	1	478	4	3.633	1
444	2.91	3.877	1	518.4	3.37	2.704	1
474	4.85	5.664	1	558.7	2.15	1.463	1
504	6.49	7.086	1	599.1	0.79	0.477	1
534	7.69	7.315	1	639.5	0.26	0.260	1
564	6.95	6.241	1	679.8	0.26	0.264	1
594	5.54	5.188	1	720.2	0.27	0.280	1
624	4.9	4.932	1	760.5	0.29	0.313	1
654	5.08	5.380	1	800.9	0.35	0.369	1
684	5.95	6.119	1	841.3	0.47	0.474	1
714	6.39	6.523	1	881.7	0.48	0.414	1
744	6.8	7.546	1	922	0.35	0.304	1
774	8.44	9.754	1	962.4	0.26	0.240	1
804	11.14	12.119	1	1002.8	0.22	0.225	1
834	13.14	13.949	1	1043.2	0.23	0.226	1
864	14.81	14.895	1	1083.5	0.26	0.259	1
893	14.99	14.744	1	1123.9	0.26	0.228	1
903	14.51	14.287	1	1164.2	0.2	0.192	1
913	14.08	13.935	1	1204.6	0.19	0.189	1
923	13.81	13.793	1	1245	0.19	0.191	1
933	13.78	13.819	1	1285.4	0.19	0.189	1
943	13.86	13.897	1	1325.8	0.19	0.170	1
953	13.96	14.042	1	1366.1	0.18	0.181	1
963	14.13	14.279	1	1406.5	0.18	0.180	1
973	14.43	14.556	1	1446.8	0.18	0.180	1
983	14.7	14.812	1	1487.2	0.18	0.180	1

993	14.91	14.969	1	1527.5	0.18	0.180	1
1003	15.04	15.068	1	1567.9	0.18	0.180	1
1013	15.13	15.134	1	1608.2	0.18	0.126	1
1023	15.14	15.092	1	1648.6	0.19	0.191	1
1033	15.07	14.792	1	1689	0.19	0.190	1
1043	14.54	14.387	1	1729.3	0.19	0.190	1
1053	14.23	14.175	1	1769.7	0.19	0.190	1
1063	14.15	14.190	1	1810	0.19	0.190	1
1073	14.22	14.293	1	1850.4	0.19	0.182	1
1083	14.38	14.471	1	1890.8	0.19	0.190	1
1093	14.59	14.634	1	1931.1	0.19	0.190	1
1103	14.67	14.737	1	1971.5	0.19	0.190	1
1113	14.82	14.971	1	2011.8	0.19	0.186	1
1123	15.14	15.417	1	2052.5	0.19	0.166	1
1133	15.71	16.064	1	2092.5	0.16	0.862	1
1143	16.43	17.000	1	2132.9	1.74	2.859	1
1153	17.58	18.188	1	2173.2	3.98	5.978	1
1163	18.82	19.313	1	2213.6	7.98	8.058	1
1173	19.84	20.169	1	2253.9	8.15	8.243	1
1183	20.52	20.658	1	2294.3	8.34	9.209	1
1193	20.78	20.813	1	2334.6	10.09	11.242	1
1203	20.87	20.726	1	2375	12.41	13.621	1
1213	20.57	20.204	1	2415.3	14.84	16.008	1
1223	19.87	19.546	1	2455.8	17.2	18.200	1
1233	19.22	19.049	1	2496.1	19.35	21.508	1
1243	18.88	18.841	1	2536.5	23.77	25.947	1
1253	18.83	18.957	1	2576.9	28.22	30.256	1
1263	19.07	19.197	1	2617.3	32.3	33.929	2
1273	19.35	19.409	1	2655.9	35.58	36.479	2
1283	19.47	19.272	1	2673.9	37.39	38.605	2
1293	19.09	18.532	1	2706.97	39.85	40.008	2
1303	17.98	17.265	1	2747.16	40.19	39.862	2
1313	16.56	15.906	1	2790.39	39.56	41.676	2
1323	15.24	14.794	1	2830.75	43.81	46.529	2
1333	14.36	14.213	1	2870.67	49.28	51.831	2
1343	14.09	14.147	1	2911.52	54.4	57.227	2
1353	14.2	14.396	1	2950.8	60.08	62.209	3
1363	14.61	14.972	1	2991.49	64.34	65.557	3
1373	15.35	15.829	1	3032.17	66.85	68.238	3
1383	16.31	16.700	1	3072.79	69.7	70.790	3
1393	17.11	17.440	1	3112.44	71.9	73.303	3
1403	17.79	18.144	1	3153.53	74.71	76.211	3

1413	18.5	18.941	1	3193.66	77.75	79.253	3
1423	19.4	19.878	1	3233.21	80.75	80.897	3
1433	20.36	20.782	1	3273.3	81.08	78.995	3
1443	21.22	21.678	1	3314.97	76.91	74.425	3
1453	22.14	22.474	1	3355.37	71.94	71.628	3
1463	22.83	22.818	1	3395.93	71.34	69.651	3
1473	22.85	22.634	1	3436.15	67.98	66.611	3
1483	22.44	22.080	1	3476.5	65.26	63.548	3
1493	21.71	21.340	1	3514.77	61.86	59.464	3
1503	21.01	20.846	1	3555.95	57.08	54.372	2
1513	20.67	20.650	1	3596.23	51.69	50.154	2
1523	20.66	20.739	1	3638.07	48.65	49.162	2
1533	20.83	20.896	1	3678.39	49.69	49.918	2
1543	20.97	21.025	1	3718.84	50.17	50.212	2
1553	21.13	21.247	1	3729.86	50.26	50.264	2
1563	21.38	21.509	1				
1573	21.64	21.743	1				
1583	21.87	21.970	1				
1593	22.08	22.182	1				
1603	22.29	22.369	1				
1613	22.47	22.570	1				
1623	22.66	22.784	1				
1633	22.93	23.061	1				
1643	23.2	23.274	1				
1653	23.4	23.465	1				
1663	23.53	23.546	1				
1673	23.59	23.622	1				
1683	23.66	23.663	1				
1693	23.7	23.716	1				
1703	23.73	23.755	1				
1713	23.78	23.744	1				
1723	23.76	23.742	1				
1733	23.71	23.688	1				
1743	23.7	23.703	1				
1753	23.68	23.646	1				
1763	23.63	23.574	1				
1773	23.56	23.516	1				
1783	23.5	23.449	1				
1793	23.4	23.375	1				
1803	23.37	23.357	1				
1813	23.36	23.368	1				
1823	23.39	23.427	1				

1833	23.45	23.446	1
1843	23.48	23.448	1
1853	23.41	23.382	1
1863	23.39	23.434	1
1873	23.47	23.463	1
1883	23.51	23.494	1
1893	23.49	23.493	1
1903	23.5	23.515	1
1913	23.55	23.567	1
1923	23.58	23.555	1
1933	23.56	23.575	1
1943	23.58	23.563	1
1953	23.57	23.369	1
1963	23.19	22.842	1
1973	22.48	22.110	1
1983	21.77	21.470	1
1993	21.15	20.820	1
2003	20.52	20.162	1
2013	19.83	19.540	1
2023	19.24	18.942	1
2033	18.67	18.373	1
2043	18.09	17.757	1
2053	17.42	17.028	1
2063	16.64	16.174	1
2073	15.74	15.280	1
2083	14.82	14.450	1
2093	14.11	13.826	1
2103	13.55	13.050	1
2113	12.56	12.162	1
2123	11.76	11.524	1
2133	11.3	11.099	1
2143	10.9	10.632	1
2153	10.37	10.148	1
2163	9.96	9.817	1
2173	9.68	9.586	1
2183	9.51	9.399	1
2193	9.3	9.232	1
2203	9.2	9.130	1
2213	9.1	9.048	1
2223	9.02	8.970	1
2233	8.95	8.920	1
2243	8.91	8.938	1

2253	8.98	9.041	1
2263	9.11	9.188	1
2273	9.31	9.426	1
2283	9.55	9.701	1
2293	9.88	10.068	1
2303	10.25	10.353	1
2313	10.48	10.577	1
2323	10.69	10.838	1
2333	10.99	11.194	1
2343	11.41	11.581	1
2353	11.77	12.004	1
2363	12.25	12.520	1
2373	12.79	13.062	1
2383	13.35	13.687	1
2393	14.04	14.354	1
2403	14.66	14.989	1
2413	15.34	15.594	1
2423	15.89	16.110	1
2433	16.32	16.505	1
2443	16.72	16.930	1
2453	17.17	17.413	1
2463	17.67	17.789	1
2464.55	17.75	18.255	1
2493.74	18.8	19.578	1
2536.07	20.39	21.038	1
2576.99	21.7	24.008	1
2617.92	26.34	28.438	1
2658.3	30.56	31.808	2
2699.07	33.11	34.301	2
2738.83	35.52	38.371	2
2779.26	41.25	43.281	2
2820.02	45.33	47.235	2
2860.02	49.2	50.467	2
2900.45	51.78	52.612	2
2939.72	53.48	53.900	2
2980.29	54.35	54.648	2
3008.61	54.95	54.728	2
3060.63	54.55	54.293	2
3081.25	54.06	53.933	2
3136.6	53.84	53.861	2
3172.51	53.9	53.861	2
3216.39	53.86	53.586	2

3257.05	53.34	53.558	2
3297.38	53.81	53.441	2
3337.63	53.1	53.043	2
3375.41	53.01	53.072	2
3416.55	53.14	53.047	2
3456.15	52.97	52.906	2
3495.52	52.87	52.855	2

8.5. Appendix E

8.5.1. Determination of unacceptable deviation from well 15/9-F-5

According to the End of Well report for well 15/9-F-5, in drilling of 8½" section communication/directional information to the Xceed BHA was lost at 3076m and the well trajectory was off at 3292m because of inability to control the Xceed BHA thus new BHA was made. Taking 3292m MD as the critical point such that deviation values measured at this depth are unacceptable. These values assumed to be used in all other wells under consideration.

8.5.2. Matlab code to calculate unacceptable deviation values of the well path

```
clear all
%Define actual parameters from survey file.
A=importdata('F-5_ACTUAL.txt');
%Actual Parameters:
MDa=A(1:end,1); %Measured Depth
Ia=A(1:end,2); %Wellbore Inclination
Aa=A(1:end,3); %Wellbore Azimuth
Ea=A(1:end,7); %East coordinate
Na=A(1:end,8); %North coordinate
TVDa=A(1:end,4); %True Vertical Depth
DLSa=A(1:end,9); %Wellbore Dogleg Severity
%Define planned parameters from survey file.
P=importdata('F-5_PLAN.txt');
%Planned Parameters from planned trajectory file:
MD_p=P(1:end,1); %Measured Depth
I_p=P(1:end,2); %Wellbore Inclination
A_p=P(1:end,3); %Wellbore Azimuth
E_p=P(1:end,7); %East coordinate
N_p=P(1:end,8); %North coordinate
TVD_p=P(1:end,4); %True Vertical Depth
DLS_p=P(1:end,9); %Wellbore Dogleg Severity
%Interpolated Planned Parameters to make planned trajectory
close to the actual path:
MD_pinterp=(1:1:P(end,1))';
I_pinterp=interp1(MD_p,I_p,MD_pinterp,'pchip');
A_pinterp=interp1(MD_p,A_p,MD_pinterp,'pchip');
E_pinterp=interp1(MD_p,E_p,MD_pinterp,'pchip');
N_pinterp=interp1(MD_p,N_p,MD_pinterp,'pchip');
TVD_pinterp=interp1(MD_p,TVD_p,MD_pinterp,'pchip');
DLS_pinterp=interp1(MD_p,DLS_p,MD_pinterp,'pchip');
%Create parameters for column 5 and 6 in the interpolated matrix
u=size(MD_pinterp);
v=zeros(u);
```

```

P_interp=([MD_pinterp,I_pinterp,A_pinterp,TVD_pinterp,v,v,E_pint
erp,N_pinterp,DLS_pinterp]);
Pt=P_interp;
MDt=Pt(1:end,1);
It=Pt(1:end,2);
At=Pt(1:end,3);
Et=Pt(1:end,7);
Nt=Pt(1:end,8);
TVDt=Pt(1:end,4);
DLSt=Pt(1:end,9);
%Calculate minimum distance before interpolation
Mb(1:length(MDa))=0;
Ib(1:length(MDa))=0;
for n=1:length(MDa)
    [Mb(n), Ib(n)]=min(sqrt((Na(n,1)-N_p).^2+(Ea(n,1)-
E_p).^2+(TVDa(n,1)-TVD_p).^2));
end
%Calculate minimum distance after interpolation
M(1:length(MDa))=0;
I(1:length(MDa))=0;
for n=1:length(MDa)
    [M(n), I(n)]=min(sqrt((Na(n,1)-Nt).^2+(Ea(n,1)-
Et).^2+(TVDa(n,1)-TVDt).^2));
end
%Planned parameters that minimize the straight line distance
after interpolation:
MDp=Pt(I,1);      %Measured Depth
Ip=Pt(I,2);       %Wellbore Inclination
Ap=Pt(I,3);       %Wellbore Azimuth
Ep=Pt(I,7);       %East coordinate
Np=Pt(I,8);       %North coordinate
TVDp=Pt(I,4);     %True Vertical Depth
DLSp=Pt(I,9);     %Wellbore Dogleg Severity
%Calculate the Linear Deviation both horizontally and
vertically:
%1. Horizontal Deviation:
HD=(Ea-Ep).*cosd(Ap)-(Na-Np).*sind(Ap);
%2. Vertical Deviation:
VD=(Na-Np).*cosd(Ap).*cosd(Ip)+(Ea-Ep).*sind(Ap).*cosd(Ip)-
(TVDA-TVDp).*sind(Ip);
%Calculate the Angular Deviation both horizontally and
vertically:
%1. Azimuthal Deviation(Horizontally):
AD=Aa-Ap;
%2. Inclination Deviation(Vertically):
ID=Ia-Ip;
%Calculate the Relative Change in Deviation both horizontally
and vertically:

```

```

%Define parameters for computation;
HD1=HD(1:end-1);
HD2=HD(2:end);
VD1=VD(1:end-1);
VD2=VD(2:end);
ID1=ID(1:end-1);
ID2=ID(2:end);
AD1=AD(1:end-1);
AD2=AD(2:end);
MDp1=MDp(1:end-1);
MDp2=MDp(2:end);
%(a) Horizontally:
%1. Relative change in Horizontal Deviation:
RCHD=1000.* (HD2-HD1)./(MDp2-MDp1);
%2. Relative change in Azimuthal Deviation:
RCAD=100.* (AD2-AD1)./(MDp2-MDp1);
%(b) Vertically:
%1. Relative change in Vertical Deviation:
RCVD=1000.* (VD2-VD1)./(MDp2-MDp1);
%2. Relative change in Inclinational Deviation:
RCID=100.* (ID2-ID1)./(MDp2-MDp1);
%Calculate unacceptable VD, ID, HD & AD at 3292m MD
VD_unacceptable=interp1(MDa,VD,3292,'pchip');
HD_unacceptable=interp1(MDa,HD,3292,'pchip');
ID_unacceptable=interp1(MDa,ID,3292,'pchip');
AD_unacceptable=interp1(MDa,AD,3292,'pchip');
%Make a table of Results
T_unacceptable=table(VD_unacceptable,HD_unacceptable,ID_unacceptable,AD_unacceptable);
writetable(T_unacceptable, 'DEV_ALL.xlsx', 'sheet', 4);

```

Table 13: Unacceptable deviation parameters

Unacceptable parameters of deviation determined from well 15/9-F-5			
VD_unacceptable	HD_unacceptable	ID_unacceptable	AD_unacceptable
[m]	[m]	[deg]	[deg]
3.7374	-31.0639	-11.1472	-19.9456

8.6. Appendix F

Matlab code to report whenever deviation of the path is unacceptable, create well projections in 2D and 3D, True Vertical Depth variation with Measured Depth, well inclination, azimuth, dogleg severity, deviation logs and minimum distance between planned and actual well path

8.6.1. Matlab code of the agent to report unacceptable deviation

```
clear all
%This example use well 15/9-F-4.In order to use the code in
other wells, the well name is changed in importing the data.
%Define actual parameters from survey file.
A=importdata('F-4_ACTUAL.txt');
%Actual Parameters:
MDa=A(1:end,1);           %Measured Depth
Ia=A(1:end,2);            %Wellbore Inclination
Aa=A(1:end,3);            %Wellbore Azimuth
Ea=A(1:end,7);            %East coordinate
Na=A(1:end,8);            %North coordinate
TVDa=A(1:end,4);          %True Vertical Depth
DLSa=A(1:end,9);          %Wellbore Dogleg Severity
%Define planned parameters from survey file.
P=importdata('F-4_PLAN.txt');
%Planned Parameters from planned trajectory file:
MD_p=P(1:end,1);          %Measured Depth
I_p=P(1:end,2);            %Wellbore Inclination
A_p=P(1:end,3);            %Wellbore Azimuth
E_p=P(1:end,7);            %East coordinate
N_p=P(1:end,8);            %North coordinate
TVD_p=P(1:end,4);          %True Vertical Depth
DLS_p=P(1:end,9);          %Wellbore Dogleg Severity
%Interpolate planned Parameters:
MD_pinterp=(1:1:P(end,1))';
I_pinterp=interp1(MD_p,I_p,MD_pinterp,'pchip');
A_pinterp=interp1(MD_p,A_p,MD_pinterp,'pchip');
E_pinterp=interp1(MD_p,E_p,MD_pinterp,'pchip');
N_pinterp=interp1(MD_p,N_p,MD_pinterp,'pchip');
TVD_pinterp=interp1(MD_p,TVD_p,MD_pinterp,'pchip');
DLS_pinterp=interp1(MD_p,DLS_p,MD_pinterp,'pchip');
%Create parameters for column 5 and 6 in the interpolated matrix
u=size(MD_pinterp);
v=zeros(u);
P_interp=([MD_pinterp,I_pinterp,A_pinterp,TVD_pinterp,v,v,E_pint
erp,N_pinterp,DLS_pinterp]);
Pt=P_interp;
MDt=Pt(1:end,1);
It=Pt(1:end,2);
```

```

At=Pt(1:end,3);
Et=Pt(1:end,7);
Nt=Pt(1:end,8);
TVDt=Pt(1:end,4);
DLSt=Pt(1:end,9);
%Calculate minimum distance before interpolation
Mb(1:length(MDa))=0;
Ib(1:length(MDa))=0;
for n=1:length(MDa)
    [Mb(n), Ib(n)]=min(sqrt((Na(n,1)-N_p).^2+(Ea(n,1)-
E_p).^2+(TVDa(n,1)-TVD_p).^2));
end
%Calculate minimum distance after interpolation
M(1:length(MDa))=0;
I(1:length(MDa))=0;
for n=1:length(MDa)
    [M(n), I(n)]=min(sqrt((Na(n,1)-Nt).^2+(Ea(n,1)-
Et).^2+(TVDa(n,1)-TVDt).^2));
end
%Planned Parameters that minimize the straight line distance
after interpolation:
MDp=Pt(I,1);      %Measured Depth
Ip=Pt(I,2);        %Wellbore Inclination
Ap=Pt(I,3);        %Wellbore Azimuth
Ep=Pt(I,7);        %East coordinate
Np=Pt(I,8);        %North coordinate
TVDp=Pt(I,4);      %True Vertical Depth
DLSp=Pt(I,9);      %Wellbore Dogleg Severity
%Calculate the Linear Deviation both horizontally and
vertically:
%1. Horizontal Deviation:
HD=(Ea-Ep).*cosd(Ap)-(Na-Np).*sind(Ap);
%2. Vertical Deviation:
VD=(Na-Np).*cosd(Ap).*cosd(Ip)+(Ea-Ep).*sind(Ap).*cosd(Ip)-
(TVDA-TVDp).*sind(Ip);
%Calculate the Angular Deviation both horizontally and
vertically:
%1. Azimuthal Deviation(Horizontally):
AD=Aa-Ap;
%2. Inclinational Deviation(Vertically):
ID=Ia-Ip;
%Calculate the Relative Change in Deviation both horizontally
and vertically:
%Define parameters for computation;
HD1=HD(1:end-1);
HD2=HD(2:end);
VD1=VD(1:end-1);
VD2=VD(2:end);

```

```

ID1=ID(1:end-1);
ID2=ID(2:end);
AD1=AD(1:end-1);
AD2=AD(2:end);
MDp1=MDp(1:end-1);
MDp2=MDp(2:end);
%(a) Horizontally:
%1. Relative change in Horizontal Deviation:
RCHD=1000.* (HD2-HD1)./(MDp2-MDp1);
%2. Relative change in Azimuthal Deviation:
RCAD=100.* (AD2-AD1)./(MDp2-MDp1);
%(b) Vertically:
%1. Relative change in Vertical Deviation:
RCVD=1000.* (VD2-VD1)./(MDp2-MDp1);
%2. Relative change in Inclinational Deviation:
RCID=100.* (ID2-ID1)./(MDp2-MDp1);

%3D view of the well
figure(1)
plot3(Na,Ea,TVDa,'r');
hold on
plot3(N_p,E_p,TVD_p,'b');
title('3D VIEW OF WELL15/9-F-4');
xlabel('North[m]');
ylabel('East[m]');
zlabel('True Vertical Depth[m]');
legend('Actual','plan');
set(gca,'ydir','reverse');
set(gca,'zdir','reverse');
grid on
%Plan View of the Well
figure(2)
plot(Na,Ea,'r');
hold on
plot(Np,E_p,'b');
title('PLAN VIEW OF WELL 15/9-F-4');
xlabel('North[m]');
ylabel('East[m]');
set(gca,'ydir','reverse');
legend('Actual','Plan')
grid on
%Vertical Sectional view of the Well
Da=sqrt(Na.^2+Ea.^2);
Dp=sqrt(Np.^2+E_p.^2);
figure(3)
plot(Da,TVDa,'r');
hold on
plot(Dp,TVDp,'b');

```

```

title('VERTICAL SECTION VIEW OF WELL 15/9-F-4');
xlabel('Horizontal Departure[m]');
ylabel('True Vertical Depth[m]');
set(gca,'ydir','reverse');
legend('Actual','Plan')
grid on

%Relation of TVD with MD
figure(4)
plot(MDa,TVDa,'r');
hold on
plot(MDp,TVDp,'b');
title('TVD AGAINST MD OF WELL 15/9-F-4');
xlabel('Measured Depth[m]');
ylabel('True Vertical Depth[m]');
set(gca,'ydir','reverse');
legend('Actual','Plan')
grid on
%Inclination & Azimuth of the Well
figure(5)
plot(MDa,Ia,'r');
txt={'Inclination'};
text(1000,32,txt);
hold on
plot(MDp,Ip,'b');
plot(MDa,Aa,'r');
plot(MDp,Ap,'b');
txt={'Azimuth'};
text(1000,125,txt)
title('INCLINATION AND AZIMUTH OF WELL 15/9-F-4');
xlabel('Measured Depth[m]');
ylabel('Inclination and Azimuth[deg]');
xlim([300 4000]);
legend('Actual','Plan')
grid on

%Dogleg Severity of the well
figure(6)
plot(MDa,DLSa,'r');
hold on
plot(MDp,DLSp,'b');
title('DOGLEG SEVERITY AGAINST MEASURED DEPTH FOR WELL 15/9-F-4');
xlabel('Measured Depth[m]');
ylabel('Dogleg Severity[deg/30m]');
legend('Actual','Plan')
grid on

```

```

%Creation of both Vertical & Horizontal hole deviation logs
%1.Vertical Hole Deviation Log
figure(7)
subplot(1,2,1);
plot(Ia,MDa,'r');
hold on
plot(Ip,MDp,'b');
title('INCa & INCp');
xlabel('INC[deg]');
ylabel('DMEA[m]');
set(gca,'ydir','reverse');
legend('Actual','Plan')
grid on
subplot(1,2,2);
plot(DLSa,MDa,'r');
hold on
plot(DLSp,MDp,'b');
title('DLSa & DLSp');
xlabel('DLS[deg/30m]');
ylabel('DMEA[m]');
set(gca,'ydir','reverse');
legend('Actual','Plan')
grid on

figure(8)
subplot(1,2,1);
plot(VD,MDa,'r');
hold on
plot(RCVD,MDa(1:end-1),'b');
title('VD & RCVD');
xlabel('VD[m]/RCVD[m/1000m]');
ylabel('DMEA[m]');
set(gca,'ydir','reverse');
legend('VD','RCVD')
grid on
subplot(1,2,2);
plot(ID,MDa,'r');
hold on
plot(RCID,MDa(1:end-1),'b');
title('ID & RCID');
xlabel('ID[deg]/RCID[deg/100m]');
ylabel('DMEA[m]');
set(gca,'ydir','reverse');
legend('ID','RCID')
grid on

%2.Horizontal Hole Deviation Log
figure(9)

```

```

subplot(1,2,1);
plot(Aa,MDa,'r');
hold on
plot(AP,MDp,'b');
title('AZIa & AZIp');
xlabel('AZI[deg]');
ylabel('DMEA[m]');
set(gca,'ydir','reverse');
legend('Actual','Plan')
grid on
subplot(1,2,2);
plot(DLSa,MDa,'r');
hold on
plot(DLSp,MDp,'b');
title('DLSa & DLSp');
xlabel('DLS[deg/30m]');
ylabel('DMEA[m]');
set(gca,'ydir','reverse');
legend('Actual','Plan')
grid on

figure(10)
subplot(1,2,1);
plot(HD,MDa,'r');
hold on
plot(RCHD,MDa(1:end-1),'b');
title('HD & RCHD');
xlabel('HD[m]/RCHD[m/1000m]');
ylabel('DMEA[m]');
set(gca,'ydir','reverse');
legend('HD','RCHD')
grid on
subplot(1,2,2);
plot(AD,MDa,'r');
hold on
plot(RCAD,MDa(1:end-1),'b');
title('AD & RCAD');
xlabel('AD[m]/RCAD[m/1000m]');
ylabel('DMEA[m]');
xlim([-40 40]);
set(gca,'ydir','reverse');
legend('AD','RCAD')
grid on
%Make a table of Results
T1=table(MDa,VD,HD,ID,AD);

%Minimum distance after interpolation:
figure(11);

```

```

plot(MDa,M);
xlabel('Measured Depth[m]');
ylabel('Minimum distance[m]');
title('MINIMUM DISTANCE AGAINST MEASURED DEPTH FOR WELL 15/9-F-4');
grid on
%Difference in minimum distance before and after interpolation:
%Mb=Minimum distance before interpolation
%M=Minimum distance after interpolation
Diff_M=Mb-M;
figure(12);
plot(MDa,Diff_M);
xlabel('Measured Depth[m]');
ylabel('Difference in Minimum distance[m]');
title('DIFFERENCE IN MINIMUM DISTANCE FOR WELL 15/9-F-4 ');
grid on
%Presentation of both vertical and horizontal deviation on the
figure using end points
figure(13)
plot3(Na(85:end),Ea(85:end),TVDa(85:end),'r','linewidth',2);
hold on
plot3(Np(85:end),Ep(85:end),TVDp(85:end),'b','linewidth',2);
plot3(Na(end),Ea(end),TVDa(end),'o','linewidth',2);
plot3(Np(end),Ep(end),TVDp(end),'o','linewidth',2);
plot3(Np(end),Ep(end),TVDa(end),'b','linewidth',2); %create
third point
plot3([Na(end) Np(end)], [Ea(end) Ep(end)], [TVDa(end)
TVDp(end)], 'k--');
plot3([Np(end) Np(end)], [Ep(end) Ep(end)], [TVDp(end)
TVDa(end)], 'k--');
plot3([Na(end) Np(end)], [Ea(end) Ep(end)], [TVDa(end)
TVDa(end)], 'k--');
title('HD and VD OF WELL 15/9-F-4');
xlabel('North[m]');
ylabel('East[m]');
zlabel('True Vertical Depth[m]');
legend('Actual','plan');
set(gca,'ydir','reverse');
set(gca,'zdir','reverse');
grid on
%Reporting deviation of the path as acceptable or not:
VD_deviation_level(1:length(MDa))=0;
HD_deviation_level(1:length(MDa))=0;
ID_deviation_level(1:length(MDa))=0;
AD_deviation_level(1:length(MDa))=0;
for i=1:length(MDa)
if abs(VD(i))>=3.7374
    VD_deviation_level(i)=1;
end

```

```

elseif abs(VD(i))<3.7374
    VD_deviation_level(i)=2;
end
if abs(HD(i))>=31.0639
    HD_deviation_level(i)=1;
elseif abs(HD(i))<31.0639
    HD_deviation_level(i)=2;
end
if abs(ID(i))>=11.1472
    ID_deviation_level(i)=1;
elseif abs(ID(i))<11.1472
    ID_deviation_level(i)=2;
end
if abs(AD(i))>=19.9456
    AD_deviation_level(i)=1;
elseif abs(AD(i))<19.9456
    AD_deviation_level(i)=2;
end
%Warning message program based on deviation determined:
if VD_deviation_level(i)>=0 && VD_deviation_level(i)<=1
    disp 'VD is unacceptable at this point'
elseif VD_deviation_level(i)>=1.1 && VD_deviation_level(i)<=2
    disp 'VD is acceptable at this point'
end
if HD_deviation_level(i)>=0 && HD_deviation_level(i)<=1
    disp 'HD is unacceptable at this point'
elseif HD_deviation_level(i)>=1.1 && HD_deviation_level(i)<=2
    disp 'HD is acceptable at this point'
end
if ID_deviation_level(i)>=0 && ID_deviation_level(i)<=1
    disp 'ID is unacceptable at this point'
elseif ID_deviation_level(i)>=1.1 && ID_deviation_level(i)<=2
    disp 'ID is acceptable at this point'
end
if AD_deviation_level(i)>=0 && AD_deviation_level(i)<=1
    disp 'AD is unacceptable at this point'
elseif AD_deviation_level(i)>=1.1 && AD_deviation_level(i)<=2
    disp 'AD is acceptable at this point'
end
end
%Create table of results for defining deviation and its
parameters.
T1=table(MDa,VD,HD,ID,AD);
T2=table(RCVD,RCHD,RCID,RCAD);
writetable(T1,'DEV_ALL.xlsx','sheet',1);
writetable(T2,'DEV_ALL.xlsx','sheet',2);

```

```

Measured_Depth=MDa;
T_dev=table(VD_deviation_level',HD_deviation_level',ID_deviation
_level',AD_deviation_level',Measured_Depth);
writetable(T_dev,'DEV_ALL.xlsx','sheet',3);

```

8.7. Appendix G

8.7.1. Deviation results for well 15/9-F-4

Table 14: Results, deviation parameters for well 15/9-F-4

Deviation parameters for well 15/9-F-4								
MD	VD	HD	ID	AD	RCVD	RCHD	RCID	RCAD
[m]	[m]	[m]	[deg]	[deg]	[m/1000m]	[m/1000m]	[deg/100m]	[deg/100m]
145.90	0.00	0.00	0.00	0.00	-0.53	-0.68	0.26	613.82
184.12	-0.02	-0.03	0.10	233.25	-1.47	-1.75	0.15	-14.18
224.45	-0.08	-0.10	0.16	227.58	-6.56	-5.51	1.66	-21.71
264.79	-0.35	-0.32	0.84	218.68	38.99	6.14	0.23	-570.73
305.10	1.21	-0.08	0.93	-9.61	14.18	0.97	-0.43	43.83
345.45	1.78	-0.04	0.76	7.92	18.14	20.07	2.54	35.00
385.80	2.52	0.79	1.80	22.27	29.27	38.76	1.34	-4.68
426.12	3.69	2.34	2.34	20.40	33.13	26.04	-0.85	-39.44
466.40	5.05	3.40	1.99	4.23	27.71	-13.73	-1.36	-45.95
506.65	6.16	2.85	1.45	-14.15	4.72	-38.24	-0.96	-23.23
546.96	6.35	1.32	1.07	-23.44	4.68	-34.53	0.33	0.56
587.28	6.54	-0.06	1.20	-23.22	15.14	-19.87	0.01	21.93
627.54	7.16	-0.87	1.20	-14.23	21.84	-7.12	0.33	2.69
667.63	8.03	-1.16	1.33	-13.16	22.42	-0.18	-0.73	11.30
707.96	8.93	-1.16	1.04	-8.64	29.38	6.36	2.68	6.43
748.28	10.13	-0.90	2.14	-6.00	53.08	8.97	4.10	3.42
788.57	12.25	-0.54	3.78	-4.63	73.82	13.81	2.12	3.71
828.91	15.21	0.01	4.63	-3.15	78.70	22.90	0.11	5.82
869.25	18.43	0.95	4.67	-0.76	64.64	36.51	-4.03	11.10
909.60	21.02	2.41	3.06	3.68	42.12	20.31	-2.71	3.73
949.94	22.75	3.24	1.95	5.21	22.35	22.48	-3.13	-0.20
990.29	23.64	4.14	0.70	5.13	4.66	14.19	-2.03	-8.37
1030.67	23.83	4.71	-0.11	1.78	-8.36	7.19	-1.80	0.78
1071.00	23.48	5.00	-0.85	2.10	-10.86	-1.44	1.23	-12.18
1111.37	23.05	4.94	-0.36	-2.77	20.42	-19.26	7.80	-7.90
1151.73	23.89	4.15	2.84	-6.01	69.84	-15.17	5.85	14.33
1192.07	26.68	3.55	5.18	-0.28	93.05	-15.40	0.77	-12.40
1232.42	30.40	2.93	5.49	-5.24	74.63	-27.85	-5.85	-0.47

1272.73	33.39	1.82	3.15	-5.43	48.05	-23.48	-1.83	2.67
1313.08	35.31	0.88	2.42	-4.36	36.50	41.52	-0.78	9.15
1353.43	36.81	2.58	2.10	-0.61	25.76	38.20	-0.98	-17.56
1393.74	37.86	4.15	1.70	-7.81	17.67	-2.21	0.12	-19.48
1434.06	38.57	4.06	1.75	-15.60	16.01	-53.06	2.94	-24.81
1474.42	39.23	1.88	2.95	-25.77	48.10	-94.71	7.38	6.34
1514.76	41.15	-1.90	5.91	-23.23	90.71	-91.26	2.14	11.09
1555.11	44.78	-5.55	6.76	-18.80	110.99	-67.70	1.24	9.96
1595.46	49.33	-8.33	7.27	-14.71	130.20	-41.85	1.81	11.65
1635.81	54.67	-10.05	8.01	-9.94	131.03	-38.78	-2.89	-7.35
1676.14	59.91	-11.60	6.86	-12.88	105.69	-58.40	-2.47	-7.82
1716.50	64.24	-13.99	5.85	-16.08	90.27	-63.55	-1.98	4.81
1756.82	67.94	-16.60	5.04	-14.11	78.87	-44.49	-2.19	7.62
1797.22	71.26	-18.47	4.12	-10.91	67.26	-34.85	-2.33	1.29
1837.56	74.01	-19.90	3.16	-10.38	52.43	-28.40	-1.80	3.33
1877.90	76.21	-21.09	2.41	-8.98	40.81	-15.87	-2.32	7.56
1918.25	77.89	-21.74	1.46	-5.88	24.46	-2.48	-2.38	1.90
1958.61	78.91	-21.84	0.46	-5.09	13.14	0.47	-0.78	2.21
1998.97	79.47	-21.82	0.13	-4.16	0.87	4.39	-2.62	1.82
2039.32	79.50	-21.64	-0.97	-3.40	-10.77	14.93	-0.65	6.61
2079.67	79.05	-21.01	-1.24	-0.62	-23.11	27.06	-2.68	2.79
2120.01	78.08	-19.88	-2.37	0.55	-43.14	34.75	-2.49	3.52
2160.35	76.31	-18.45	-3.39	2.00	-57.63	40.29	-1.62	1.75
2200.70	73.89	-16.76	-4.07	2.73	-74.05	41.96	-2.89	0.51
2241.06	70.78	-15.00	-5.28	2.94	-95.50	32.97	-2.42	-4.96
2281.44	66.87	-13.64	-6.27	0.91	-112.97	26.18	-2.43	1.97
2321.84	62.23	-12.57	-7.27	1.72	-128.83	28.39	-1.95	0.81
2362.19	56.95	-11.41	-8.07	2.05	-143.63	29.28	-2.15	0.96
2402.55	51.06	-10.21	-8.95	2.44	-161.23	28.95	-2.78	0.15
2442.90	44.45	-9.02	-10.09	2.51	-179.40	33.27	-1.03	3.31
2483.25	37.28	-7.69	-10.51	3.83	-186.55	35.20	-0.14	0.35
2523.62	29.81	-6.28	-10.56	3.97	-187.35	16.88	0.88	-5.07
2563.96	22.32	-5.60	-10.21	1.94	-186.94	-34.04	2.51	-9.82
2604.31	15.03	-6.93	-9.23	-1.89	-164.61	-34.82	5.16	2.70
2644.66	8.61	-8.29	-7.22	-0.83	-138.28	-10.44	3.24	5.65
2685.02	3.22	-8.70	-5.96	1.37	-122.87	8.62	5.02	7.35
2696.43	1.86	-8.60	-5.40	2.18	-97.23	27.29	4.70	3.94
2740.79	-2.41	-7.40	-3.34	3.91	-60.69	47.25	5.35	2.29
2773.90	-4.42	-5.84	-1.57	4.67	-38.51	62.73	1.94	5.52
2800.66	-5.42	-4.21	-1.06	6.11	-30.74	60.72	-1.14	-5.12
2840.30	-6.65	-1.78	-1.52	4.06	-31.20	47.73	-0.46	-4.17
2879.85	-7.86	0.08	-1.70	2.43	-31.26	37.05	-0.90	-2.46

2920.07	-9.11	1.56	-2.06	1.45	-28.15	15.56	1.04	-9.57
2959.08	-10.21	2.17	-1.66	-2.29	-32.93	-16.72	-1.89	-7.06
3001.10	-11.60	1.47	-2.45	-5.25	-47.78	-26.28	-1.33	2.77
3041.46	-13.51	0.41	-2.98	-4.15	-59.85	-8.30	-1.79	6.94
3081.29	-15.84	0.09	-3.68	-1.44	-57.60	11.23	1.98	0.94
3121.75	-18.14	0.54	-2.89	-1.06	-45.75	1.68	1.46	-3.47
3162.81	-19.97	0.61	-2.31	-2.45	-36.11	-22.44	1.50	-5.66
3203.53	-21.42	-0.29	-1.71	-4.71	-24.53	-47.34	2.62	-1.56
3244.08	-22.38	-2.14	-0.69	-5.32	-22.05	-56.54	-1.35	-0.62
3284.75	-23.26	-4.40	-1.23	-5.57	-22.01	-72.10	2.77	1.82
3325.09	-24.12	-7.21	-0.15	-4.86	-0.54	-62.36	0.95	2.48
3365.11	-24.14	-9.70	0.23	-3.87	2.33	-48.43	-0.20	2.33
3404.82	-24.05	-11.64	0.15	-2.94	0.08	-21.51	-0.67	7.18
3444.78	-24.04	-12.50	-0.12	-0.07	-4.12	18.94	-0.53	6.97
3484.98	-24.21	-11.74	-0.33	2.72	-6.38	38.75	0.00	0.00
3510.00	-24.37	-10.78	-0.33	2.72				

8.7.2. Deviation results for well 15/9-F-5

Table 15: Results, deviation parameters for well 15/9-F-5

Deviation parameters for well 15/9-F-5								
MD	VD	HD	ID	AD	RCVD	RCHD	RCID	RCAD
[m]	[m]	[m]	[deg]	[deg]	[m/1000m]	[m/1000m]	[deg/100m]	[deg/100m]
145.90	0.00	0.00	0.00	0.00	-1.00	-0.89	1.78	2455.89
146.00	0.00	0.00	0.00	0.00	-1.43	1.53	0.30	-307.20
154.90	-0.01	-0.01	0.16	221.03	-0.92	-9.64	-0.38	-548.17
195.30	-0.07	0.05	0.28	98.15	-14.74	-2.19	-1.21	311.58
235.60	-0.10	-0.34	0.13	-126.60	-12.57	-4.39	-1.58	-24.30
276.00	-0.69	-0.43	-0.36	-1.97	-14.44	-13.97	1.30	-12.24
316.40	-1.20	-0.61	-0.99	-11.69	5.26	-31.31	4.87	-3.45
356.70	-1.79	-1.18	-0.46	-16.71	19.15	-36.36	-0.66	17.43
397.10	-1.58	-2.43	1.49	-18.09	15.40	-30.53	-0.80	2.98
437.50	-0.81	-3.88	1.22	-11.12	44.21	-18.76	1.26	20.29
477.80	-0.18	-5.14	0.90	-9.90	53.79	16.54	-0.69	11.75
518.20	1.59	-5.89	1.40	-1.78	40.78	41.43	-0.10	9.76
558.50	3.79	-5.21	1.12	3.03	25.79	52.59	-0.34	2.08
598.90	5.42	-3.55	1.08	6.94	8.02	54.05	-2.07	-1.07
639.30	6.48	-1.40	0.94	7.79	-8.53	49.69	-1.11	0.09
679.60	6.80	0.77	0.11	7.37	-5.99	38.26	2.44	-11.49
720.00	6.45	2.80	-0.35	7.40	5.06	5.66	2.69	-6.51
760.40	6.21	4.33	0.63	2.81	32.43	16.73	0.45	-4.38

800.70	6.42	4.57	1.73	0.14	33.12	-4.13	1.58	-0.50
841.10	7.72	5.24	1.92	-1.61	21.29	4.25	-5.58	9.35
881.50	9.08	5.07	2.56	-1.82	-19.61	20.33	-6.98	5.10
921.80	9.93	5.24	0.33	1.92	-69.57	34.79	-6.63	7.85
962.20	9.12	6.07	-2.53	4.01	-116.69	41.76	-6.55	1.80
1002.60	6.34	7.46	-5.18	7.15	-158.14	38.74	-5.50	0.60
1043.00	1.67	9.13	-7.80	7.87	-157.36	27.75	6.18	-8.88
1083.30	-4.65	10.68	-10.00	8.11	-130.94	4.12	6.40	-4.04
1123.70	-10.95	11.79	-7.53	4.56	-76.68	-2.17	7.17	-2.17
1164.10	-16.05	11.95	-5.03	2.98	-33.49	0.07	5.00	1.21
1204.40	-19.12	11.87	-2.16	2.11	-18.61	21.95	-0.72	10.78
1244.80	-20.43	11.87	-0.21	2.59	-25.97	78.41	-6.93	0.47
1285.20	-21.17	12.75	-0.50	6.90	-74.70	78.35	-8.53	0.78
1325.60	-22.21	15.88	-3.27	7.09	-65.97	69.24	9.92	-6.02
1365.90	-25.20	19.02	-6.69	7.40	-36.76	39.95	3.03	-2.18
1406.30	-27.90	21.86	-2.62	4.93	-18.54	33.85	2.03	-1.90
1446.60	-29.37	23.45	-1.41	4.06	-10.86	29.92	0.05	0.00
1487.00	-30.11	24.81	-0.60	3.30	-4.10	21.08	1.85	-5.28
1527.30	-30.56	26.03	-0.58	3.30	11.65	-4.14	2.55	-8.02
1567.70	-30.72	26.88	0.16	1.19	24.42	-26.86	1.34	-3.78
1608.00	-30.26	26.71	1.18	-2.02	35.07	-50.72	1.88	-7.48
1648.40	-29.26	25.61	1.73	-3.57	47.29	-75.87	2.23	-4.50
1688.80	-27.85	23.58	2.48	-6.56	54.25	-73.88	0.12	4.90
1729.10	-25.96	20.55	3.37	-8.36	57.67	-58.15	0.05	3.50
1769.50	-23.74	17.52	3.42	-6.35	58.20	-43.44	-0.30	3.70
1809.80	-21.43	15.19	3.44	-4.95	60.03	-18.67	0.55	8.28
1850.20	-19.10	13.45	3.32	-3.47	67.01	8.10	1.83	4.61
1890.60	-16.70	12.71	3.54	-0.16	69.38	28.47	-1.60	4.95
1930.90	-13.95	13.04	4.29	1.73	60.92	39.98	-0.65	0.75
1971.30	-11.18	14.18	3.65	3.71	49.15	44.24	-2.55	1.70
2011.70	-8.74	15.78	3.39	4.01	27.86	38.40	-3.37	-3.56
2052.00	-6.78	17.55	2.37	4.69	5.97	21.56	-3.13	-4.95
2092.40	-5.63	19.12	0.99	3.23	0.58	-1.29	1.50	-6.85
2132.70	-5.39	19.98	-0.26	1.25	-4.71	-31.73	0.95	-6.27
2173.00	-5.37	19.93	0.34	-1.49	-0.34	-43.28	1.21	0.04
2213.40	-5.56	18.66	0.72	-4.00	6.98	-44.61	0.49	-0.73
2253.70	-5.57	16.93	1.21	-3.98	13.84	-49.42	1.10	-1.95
2294.10	-5.29	15.15	1.40	-4.28	22.86	-48.18	0.98	2.50
2334.40	-4.74	13.17	1.84	-5.06	29.69	-34.07	0.27	4.20
2374.80	-3.83	11.24	2.23	-4.06	30.56	-17.58	-0.08	3.74
2415.20	-2.64	9.88	2.34	-2.38	25.69	3.93	-1.74	6.67
2455.60	-1.39	9.16	2.31	-0.84	11.69	21.21	-1.83	2.75

2496.00	-0.36	9.32	1.61	1.83	8.51	17.27	-1.07	-6.51
2536.30	0.11	10.16	0.88	2.92	5.33	-8.38	-0.70	-6.18
2576.70	0.45	10.86	0.45	0.32	3.21	-21.94	0.20	-1.54
2617.10	0.66	10.52	0.17	-2.15	5.32	-16.87	0.33	4.70
2657.40	0.79	9.62	0.25	-2.78	3.17	-14.60	-0.98	-3.50
2697.80	1.01	8.95	0.38	-0.90	-4.77	-33.74	-0.87	-8.18
2738.20	1.13	8.36	-0.01	-2.30	-15.11	-42.12	0.49	5.67
2775.50	0.95	7.08	-0.34	-5.41	-8.30	-37.05	1.10	2.15
2789.43	0.74	6.49	-0.27	-4.62	-1.59	-27.15	0.26	3.96
2829.57	0.41	5.01	0.17	-3.76	4.16	-10.50	1.10	5.88
2866.88	0.35	4.00	0.27	-2.29	13.07	1.34	7.42	3.76
2904.41	0.50	3.61	0.67	-0.12	24.97	6.48	3.72	5.02
2913.31	0.62	3.63	1.34	0.22	40.72	-0.91	5.76	-8.58
2927.67	0.97	3.72	1.86	0.92	67.63	-33.99	4.75	-12.09
2954.56	2.07	3.69	3.41	-1.40	83.74	-61.91	-1.18	-3.41
2995.22	4.84	2.30	5.36	-6.35	82.96	-76.02	0.13	-4.98
3036.42	8.28	-0.24	4.88	-7.75	72.45	-83.58	-4.24	-0.68
3076.71	11.60	-3.28	4.93	-9.74	33.85	-99.98	-6.43	-11.07
3117.15	14.49	-6.62	3.24	-10.01	-13.16	-129.06	-7.22	-4.90
3157.49	15.88	-10.72	0.60	-14.55	-73.71	-151.54	-10.24	-9.71
3197.04	15.36	-15.88	-2.29	-16.51	-126.53	-167.60	-12.20	-4.91
3236.87	12.41	-21.95	-6.38	-20.40	-171.60	-172.65	-11.77	-1.87
3253.79	10.26	-24.80	-8.46	-21.23	-169.96	-139.92	2.09	22.11
3278.34	6.14	-28.94	-11.28	-21.68	-128.39	-80.67	5.35	19.99
3318.98	-0.83	-34.68	-10.42	-12.62	-75.74	-19.45	9.21	15.36
3359.21	-6.09	-37.98	-8.23	-4.42	-28.56	31.29	5.45	7.72
3398.47	-9.12	-38.76	-4.54	1.72	-4.09	49.56	3.08	-2.03
3439.55	-10.32	-37.45	-2.25	4.97	8.44	49.74	1.44	0.94
3479.32	-10.49	-35.47	-1.02	4.16	21.48	50.10	3.20	-2.19
3520.35	-10.13	-33.38	-0.41	4.55	15.17	56.94	-1.86	2.41
3559.87	-9.27	-31.37	0.86	3.68	25.15	64.73	6.82	-0.39
3601.65	-8.64	-28.98	0.08	4.69	51.70	65.90	0.72	0.23
3642.07	-7.61	-26.33	2.88	4.53	38.67	63.15	-4.07	-0.49
3682.43	-5.54	-23.69	3.17	4.62	18.25	63.08	-2.11	0.00
3722.88	-3.95	-21.10	1.50	4.42	10.84	61.78	0.00	0.03
3761.77	-3.26	-18.70	0.70	4.42	3792.00	-2.93	-16.85	0.70
3792.00	-2.93	-16.85	0.70	4.43				

8.7.3. Deviation results for well 15/9-F-10

Table 16: Results, deviation parameters for well 15/9-F-10

Deviation parameters for well 15/9-F-10								
MD	VD	HD	ID	AD	RCVD	RCHD	RCID	RCAD
[m]	[m]	[m]	[deg]	[deg]	[m/1000m]	[m/1000m]	[deg/100m]	[deg/100m]
1381.00	1.94	1.64	-0.07	-0.80	2.60	-3.43	1.69	2.34
1410.00	2.01	1.54	0.41	-0.13	4.20	1.15	-1.85	1.80
1430.00	2.10	1.56	0.04	0.23	-1.64	4.00	-2.10	2.80
1440.00	2.08	1.60	-0.17	0.51	-6.02	7.29	-1.07	2.19
1463.00	1.94	1.77	-0.41	1.01	-7.81	7.74	0.36	-1.48
1470.00	1.89	1.83	-0.39	0.91	-7.02	6.27	-0.20	-1.17
1500.00	1.68	2.01	-0.45	0.56	-7.20	1.95	0.03	-1.87
1530.00	1.46	2.07	-0.44	0.00	-6.84	-1.72	0.33	-1.33
1560.00	1.25	2.02	-0.34	-0.40	-6.51	-4.15	-0.03	-1.00
1590.00	1.06	1.90	-0.35	-0.70	-5.85	-6.83	0.03	-1.37
1620.00	0.88	1.69	-0.34	-1.11	-5.40	-10.37	0.07	-1.67
1650.00	0.72	1.38	-0.32	-1.61	-4.93	-13.66	0.57	-1.20
1680.00	0.57	0.97	-0.15	-1.97	5.28	-14.39	3.77	0.77
1710.00	0.73	0.54	0.98	-1.74	29.60	-11.18	7.20	3.40
1730.00	1.32	0.32	2.42	-1.06	40.44	-7.85	-1.60	2.10
1740.00	1.73	0.24	2.26	-0.85	34.37	-4.51	-2.00	2.83
1770.00	2.76	0.10	1.66	0.00	26.24	2.00	-2.20	4.80
1780.00	3.02	0.12	1.44	0.48	21.13	2.81	-2.45	0.40
1800.00	3.45	0.18	0.95	0.56	10.23	3.83	-2.26	0.55
1829.00	3.75	0.29	0.27	0.73	2.12	8.50	-1.01	2.64
1859.00	3.82	0.55	-0.03	1.52	-0.71	19.62	-0.15	4.34
1889.00	3.79	1.14	-0.08	2.82	-0.53	29.50	0.35	1.24
1919.00	3.78	2.02	0.03	3.19	2.08	34.74	0.77	0.90
1949.00	3.84	3.06	0.26	3.46	8.45	36.04	1.01	-1.86
1979.00	4.09	4.14	0.56	2.90	11.12	23.73	-0.19	-4.88
2008.00	4.43	4.86	0.51	1.44	9.36	9.13	-2.28	-6.19
2027.00	4.60	5.03	0.08	0.28	0.42	1.77	-1.28	-2.42
2038.00	4.61	5.05	-0.07	0.01	-1.74	-1.25	0.15	-0.78
2068.00	4.56	5.01	-0.02	-0.23	0.08	-4.20	0.23	-0.61
2099.00	4.56	4.88	0.05	-0.41	0.20	-7.60	-0.02	-1.09
2129.00	4.56	4.66	0.04	-0.74	1.86	-10.11	-0.36	-0.45
2159.00	4.62	4.35	-0.06	-0.87	-0.25	-10.55	0.19	-0.32
2189.00	4.61	4.04	-0.01	-0.97	0.31	-14.41	0.40	-1.59
2219.00	4.62	3.60	0.12	-1.44	3.57	-22.64	0.78	-2.34
2249.00	4.73	2.93	0.35	-2.15	1.19	-26.39	-1.43	0.19
2279.00	4.77	2.13	-0.08	-2.09	-0.95	-26.67	0.63	-0.36

2309.00	4.74	1.33	0.11	-2.20	6.34	-27.37	0.26	-0.15
2339.00	4.93	0.51	0.19	-2.24	0.31	-27.73	-0.10	0.13
2369.00	4.94	-0.32	0.16	-2.20	-0.26	-25.76	0.10	0.82
2399.00	4.93	-1.09	0.19	-1.96	3.57	-19.93	-0.55	2.30
2429.00	5.04	-1.69	0.02	-1.27	0.95	-15.54	-0.26	-0.31
2459.00	5.06	-2.16	-0.06	-1.36	-1.56	-16.79	-0.32	0.07
2489.00	5.02	-2.66	-0.15	-1.34	-5.03	-14.83	-1.18	0.89
2519.00	4.87	-3.11	-0.51	-1.07	-6.02	-12.65	0.53	0.31
2549.00	4.69	-3.48	-0.35	-0.98	-3.95	-9.62	0.72	1.21
2579.00	4.57	-3.77	-0.13	-0.62	-4.33	-5.76	-1.57	1.05
2609.00	4.44	-3.95	-0.60	-0.30	-6.55	-4.28	1.51	-0.34
2639.00	4.24	-4.07	-0.15	-0.40	0.33	-5.27	0.98	0.30
2669.00	4.25	-4.23	0.14	-0.31	5.13	-3.30	1.25	0.73
2699.00	4.40	-4.33	0.52	-0.09	13.52	-1.25	1.25	0.28
2729.00	4.81	-4.37	0.89	-0.01	18.33	0.89	1.19	0.54
2758.00	5.36	-4.34	1.25	0.15	23.70	2.79	0.49	1.46
2764.00	5.49	-4.33	1.28	0.23	12.35	9.04	-4.58	2.56
2788.00	5.79	-4.11	0.16	0.86	-9.45	17.11	-4.97	2.49
2818.00	5.51	-3.59	-1.33	1.61	-19.67	22.15	2.29	-0.03
2848.00	4.92	-2.93	-0.64	1.60	-14.85	23.70	-2.59	0.23
2878.00	4.47	-2.22	-1.42	1.67	-21.67	20.13	1.58	-1.44
2908.00	3.82	-1.61	-0.95	1.23	-15.22	17.24	1.18	-0.45
2938.00	3.37	-1.10	-0.60	1.10	-9.58	14.84	0.05	-0.45
2967.00	3.08	-0.65	-0.58	0.96	-4.00	11.66	1.05	-1.36
2997.00	2.96	-0.30	-0.27	0.56	-1.16	3.55	1.32	-2.32
3027.00	2.93	-0.19	0.13	-0.14	4.53	-2.05	1.65	-0.48
3057.00	3.06	-0.26	0.63	-0.28	12.59	-4.79	1.02	-0.62
3087.00	3.44	-0.40	0.93	-0.47	24.40	-9.32	2.03	-0.67
3117.00	4.17	-0.68	1.54	-0.67	29.98	-7.11	-0.44	1.16
3147.00	5.07	-0.89	1.41	-0.32	19.68	-3.56	-2.20	0.73
3176.00	5.66	-1.00	0.75	-0.10	6.47	1.71	-1.13	1.28
3206.00	5.85	-0.95	0.41	0.28	4.97	9.80	0.40	1.59
3236.00	6.00	-0.65	0.53	0.76	7.11	14.16	-2.29	0.46
3261.00	6.18	-0.30	-0.04	0.87	-5.01	12.51	-4.56	-3.79
3266.00	6.16	-0.24	-0.27	0.68	-0.11	4.98	0.69	-2.10
3296.00	6.15	-0.09	-0.06	0.05	-3.57	-6.56	-0.19	-2.20
3326.00	6.05	-0.29	-0.12	-0.61	-4.81	-9.99	-0.05	-0.46
3355.00	5.90	-0.58	-0.13	-0.75	-6.08	-19.52	-0.37	-2.29
3387.00	5.71	-1.21	-0.25	-1.48	-4.71	-24.86	-0.83	0.65
3415.00	5.58	-1.91	-0.49	-1.30	-3.10	-13.72	1.49	2.73
3445.00	5.48	-2.32	-0.04	-0.48	2.95	-9.23	0.11	-0.37
3475.00	5.57	-2.59	-0.01	-0.59	-2.74	-1.73	-0.21	2.96

3505.00	5.49	-2.65	-0.07	0.30	-2.26	6.35	0.06	0.56
3535.00	5.42	-2.46	-0.05	0.47	-0.07	9.55	-0.42	0.50
3565.00	5.42	-2.17	-0.18	0.62	0.75	12.29	0.86	0.48
3595.00	5.44	-1.80	0.08	0.76	0.77	11.98	0.06	-0.68
3625.00	5.46	-1.44	0.10	0.56	0.65	8.40	0.04	-0.55
3655.00	5.48	-1.19	0.11	0.39	-1.45	-2.02	-1.02	-4.31
3685.00	5.44	-1.25	-0.19	-0.90	1.34	-29.59	0.84	-5.99
3715.00	5.48	-2.14	0.06	-2.70	5.62	-60.86	0.13	-4.11
3745.00	5.65	-3.96	0.10	-3.93	-4.45	-65.38	-0.76	2.44
3775.00	5.52	-5.92	-0.13	-3.20	-5.23	-45.25	-0.45	2.95
3805.00	5.36	-7.28	-0.27	-2.31	-9.19	-33.23	-1.33	3.81
3835.00	5.08	-8.28	-0.66	-1.17	-9.88	-2.87	-0.14	5.61
3866.00	4.79	-8.36	-0.71	0.51	-5.63	16.14	1.86	1.97
3896.00	4.62	-7.88	-0.15	1.11	-3.06	22.28	-0.29	1.10
3926.00	4.53	-7.21	-0.24	1.44	-5.41	28.13	-0.35	1.44
3956.00	4.36	-6.37	-0.34	1.87	-9.76	37.88	-0.34	2.46
3986.00	4.07	-5.23	-0.45	2.60	-4.67	49.19	-0.40	0.87
4016.00	3.93	-3.76	-0.57	2.87	-9.42	54.67	-0.68	2.64
4046.00	3.65	-2.12	-0.77	3.66	-5.27	76.61	4.20	3.52
4076.00	3.49	0.18	0.49	4.72	7.09	39.31	-0.18	-17.21
4106.00	3.70	1.36	0.44	-0.44	3.62	-57.34	-0.67	-18.85
4136.00	3.81	-0.36	0.24	-6.10	1.61	-137.15	-2.21	-10.97
4165.00	3.86	-4.47	-0.43	-9.39	-10.91	-173.52	-3.33	3.13
4174.00	3.77	-5.92	-0.70	-9.13	-13.78	-146.48	0.34	4.45
4195.00	3.47	-9.09	-0.63	-8.16	-4.27	-120.77	2.09	6.23
4226.00	3.34	-12.72	0.00	-6.29	-4.02	-102.72	-0.84	5.15
4257.00	3.22	-15.80	-0.25	-4.75	-6.34	-65.35	1.14	7.04
4288.00	3.03	-17.76	0.09	-2.64	1.41	-42.00	1.05	1.58
4319.00	3.07	-19.04	0.41	-2.16	9.21	-28.50	-0.48	2.58
4349.00	3.35	-19.88	0.26	-1.39	7.30	-23.96	0.47	0.14
4379.00	3.57	-20.60	0.41	-1.35	4.68	-25.56	-0.15	-0.46
4409.00	3.71	-21.36	0.36	-1.49	5.94	-24.52	0.46	-0.06
4439.00	3.88	-22.10	0.50	-1.51	7.96	-24.68	-0.22	0.55
4469.00	4.12	-22.84	0.43	-1.34	11.68	-21.22	2.62	1.16
4499.00	4.47	-23.48	1.22	-0.99	28.01	-17.18	3.67	0.37
4529.00	5.31	-23.99	2.32	-0.88	39.18	-17.99	-3.00	-1.86
4559.00	6.49	-24.53	1.42	-1.44	6.89	-30.58	-3.79	-1.05
4588.00	6.70	-25.45	0.28	-1.75	3.08	-26.23	-0.05	1.83
4619.00	6.79	-26.24	0.27	-1.20	4.14	-17.36	-0.89	1.24
4649.00	6.91	-26.76	0.00	-0.83	2.10	-12.88	-0.59	0.18
4679.00	6.98	-27.14	-0.18	-0.78	-12.52	-15.03	-4.93	-1.20
4709.00	6.60	-27.59	-1.65	-1.14	-38.71	-24.60	-6.24	-3.17

4726.00	5.94	-28.02	-2.72	-1.68	-37.43	-28.92	9.55	0.53
4739.00	5.45	-28.39	-1.49	-1.61	-8.54	-27.55	6.62	0.56
4769.00	5.20	-29.21	0.49	-1.44	7.03	-20.69	0.38	1.12
4799.00	5.41	-29.84	0.61	-1.11	15.96	-17.43	1.18	0.18
4829.00	5.89	-30.36	0.96	-1.05	18.02	-14.49	0.20	1.37
4859.00	6.43	-30.79	1.02	-0.64	14.97	-7.57	-2.07	1.12
4890.00	6.88	-31.02	0.40	-0.31	4.78	-1.27	-2.09	1.65
4920.00	7.02	-31.06	-0.23	0.19	-10.38	13.06	-4.09	3.02
4951.00	6.71	-30.67	-1.45	1.09	-28.49	31.78	-4.13	5.92
4982.00	5.86	-29.71	-2.69	2.87	-37.94	50.27	0.38	3.21
5012.00	4.72	-28.20	-2.58	3.83	-16.52	62.79	7.29	3.71
5039.00	4.27	-26.50	-0.60	4.84	-15.56	72.88	-1.59	1.82
5042.00	4.22	-26.29	-0.64	4.89	-12.73	69.56	-0.02	0.53
5072.00	3.84	-24.21	-0.65	5.05	-11.53	72.67	1.01	0.07
5102.00	3.50	-22.03	-0.34	5.07	-9.34	77.02	-0.51	2.01
5132.00	3.22	-19.72	-0.50	5.68	-9.91	75.01	0.12	-1.82
5162.00	2.92	-17.47	-0.46	5.13	-8.86	66.89	0.27	-3.04
5192.00	2.65	-15.46	-0.38	4.22	-8.22	57.64	0.12	-1.41
5222.00	2.41	-13.73	-0.35	3.80	-11.26	56.18	-1.50	1.68
5251.00	2.07	-12.04	-0.80	4.30	-12.38	57.85	-0.30	0.15
5265.00	1.90	-11.25	-0.84	4.32	-12.21	54.63	1.42	-3.15
5281.00	1.70	-10.36	-0.61	3.81	-10.33	51.78	0.72	-1.59
5311.00	1.39	-8.81	-0.39	3.33	-4.65	30.76	0.00	0.00
5331.00	1.25	-7.88	-0.39	3.33	0.23	-0.01	0.00	0.00
5331.00	1.26	-7.88	-0.39	3.33	0.23	-0.01	0.00	0.00
5331.00	1.26	-7.88	-0.39	3.33	-0.01	0.02	0.00	0.00
5331.00	1.26	-7.88	-0.39	3.33				

8.7.4. Deviation results for well 15/9-F-11T2

Table 17: Results, deviation parameters for well 15/9-F-11T2

Deviation parameters for well 15/9-F-11T2								
MD	VD	HD	ID	AD	RCVD	RCHD	RCID	RCAD
[m]	[m]	[m]	[deg]	[deg]	[m/1000m]	[m/1000m]	[deg/100m]	[deg/100m]
146.00	0.00	0.00	0.00	7.23	-2.05	-0.20	-8.97	-4795.15
148.00	0.00	0.00	-0.16	-79.08	-1.76	-0.47	0.30	297.03
168.00	-0.04	-0.01	-0.10	-19.68	0.59	-1.98	1.05	300.21
180.00	-0.03	-0.03	0.03	17.25	-0.92	1.30	-1.09	38.84
193.00	-0.04	-0.02	-0.11	22.30	-1.40	3.20	0.81	-235.43
202.00	-0.06	0.01	-0.04	1.11	-0.45	-0.12	0.22	-7.07
209.00	-0.06	0.01	-0.02	0.62	0.86	6.30	2.33	-595.60
210.00	-0.06	0.02	0.00	-5.34	-5.84	-3.44	-1.03	-318.70
240.00	-0.23	-0.09	-0.31	-100.95	-18.94	-10.43	0.22	176.30
244.00	-0.30	-0.12	-0.30	-94.48	-12.35	-16.65	1.75	103.72
270.00	-0.63	-0.56	0.16	-67.17	-8.15	-18.88	0.13	17.90
300.00	-0.87	-1.13	0.20	-61.80	-7.83	-17.95	-0.27	-7.40
330.00	-1.11	-1.67	0.12	-64.02	-9.53	-17.30	-0.17	-11.83
360.00	-1.39	-2.19	0.07	-67.57	-9.15	-18.50	0.87	24.17
390.00	-1.67	-2.74	0.33	-60.32	1.40	-23.60	1.87	38.50
420.00	-1.63	-3.45	0.89	-48.77	4.78	-27.26	0.73	-0.86
424.00	-1.61	-3.55	0.92	-48.80	221.75	92.64	3.73	351.43
450.00	4.23	-1.11	1.90	43.73	-115.31	243.17	-3.29	330.47
473.00	1.58	4.49	1.14	119.81	-33.63	31.11	0.26	6.23
480.00	1.34	4.70	1.16	120.24	-34.39	31.12	0.17	3.70
510.00	0.31	5.64	1.21	121.35	-34.69	31.56	0.07	2.30
540.00	-0.73	6.58	1.23	122.04	-34.30	31.01	-0.03	-4.08
565.00	-1.61	7.38	1.22	121.00	283.77	79.34	1.05	-242.85
570.00	-0.34	7.73	1.27	110.19	233.17	-77.76	-1.40	-195.47
600.00	6.65	5.40	0.85	51.55	45.61	-56.21	-3.90	-82.30
630.00	8.02	3.71	-0.32	26.86	-7.74	-31.08	-4.83	-123.97
660.00	7.79	2.78	-1.77	-10.33	-31.92	-25.35	-1.10	-56.10
690.00	6.83	2.02	-2.10	-27.16	-44.08	-38.39	1.40	-55.37
720.00	5.51	0.87	-1.68	-43.77	-49.66	-65.26	2.73	-30.37
745.00	4.22	-0.82	-0.97	-51.64	-59.44	-73.78	4.94	16.00
750.00	3.98	-1.13	-0.77	-50.98	-30.98	-73.05	4.04	21.74
779.00	3.05	-3.32	0.44	-44.46	-0.72	-97.27	4.24	28.37
809.00	3.03	-6.24	1.71	-35.95	27.96	-90.88	0.96	42.45
839.00	3.86	-8.96	2.00	-23.21	41.80	-51.53	-2.54	44.68
869.00	5.12	-10.51	1.24	-9.81	25.29	-17.29	-6.29	19.51
896.00	5.79	-10.97	-0.44	-4.59	-9.16	-14.72	-3.94	11.07

899.00	5.76	-11.02	-0.57	-4.23	-26.21	-5.88	-4.84	15.51
929.00	4.98	-11.19	-2.02	0.42	-38.69	5.58	-0.85	8.16
959.00	3.82	-11.03	-2.28	2.87	-43.67	15.30	-0.70	16.83
990.00	2.51	-10.57	-2.49	7.92	-46.02	32.30	0.27	14.33
1020.00	1.13	-9.60	-2.41	12.22	-45.30	40.64	0.33	3.83
1050.00	-0.23	-8.38	-2.31	13.37	-41.05	49.92	3.04	17.22
1077.00	-1.34	-7.03	-1.49	18.04	-41.26	65.13	-3.25	21.82
1080.00	-1.46	-6.84	-1.58	18.67	-48.70	85.57	0.77	27.03
1110.00	-2.93	-4.27	-1.35	26.78	-47.63	128.98	4.77	5.40
1140.00	-4.35	-0.40	0.08	28.40	-27.81	156.51	1.10	-6.70
1170.00	-5.19	4.29	0.41	26.39	-28.75	155.80	-3.80	-9.97
1200.00	-6.05	8.97	-0.73	23.40	-50.14	143.69	-6.30	-10.03
1230.00	-7.56	13.28	-2.62	20.39	-79.07	133.79	-7.78	-1.65
1257.00	-9.71	16.93	-4.74	19.94	-76.11	98.04	-0.90	-0.74
1259.00	-9.92	17.19	-4.77	19.92	-115.75	127.90	-4.96	-0.92
1289.00	-13.39	21.03	-6.25	19.65	-131.39	114.38	-2.35	-1.77
1318.00	-17.33	24.46	-6.96	19.11	-133.49	117.42	2.34	-1.44
1348.00	-21.34	27.99	-6.25	18.68	-116.08	114.87	5.34	-15.61
1379.00	-24.82	31.43	-4.65	14.00	-74.64	82.22	8.20	-24.41
1412.00	-27.06	33.90	-2.19	6.68	-15.47	22.05	9.10	-27.01
1445.00	-27.52	34.56	0.54	-1.43	28.89	-35.44	6.32	-11.55
1477.00	-26.66	33.50	2.44	-4.89	61.78	-47.44	6.76	-1.27
1508.00	-24.80	32.07	4.46	-5.27	86.19	-49.48	3.69	0.35
1538.00	-22.22	30.59	5.57	-5.17	104.60	-50.76	2.25	0.04
1569.00	-19.08	29.07	6.25	-5.16	105.89	-54.92	-0.26	-3.01
1599.00	-15.90	27.42	6.17	-6.06	103.52	-57.52	1.28	-0.33
1628.00	-12.80	25.69	6.56	-6.16	111.70	-63.65	0.02	-2.00
1658.00	-9.45	23.78	6.56	-6.76	109.40	-67.14	-0.44	-0.42
1688.00	-6.16	21.77	6.43	-6.89	109.49	-67.89	-0.28	-0.53
1718.00	-2.88	19.73	6.35	-7.04	83.70	-60.54	-7.58	3.55
1747.00	-0.37	17.92	4.07	-5.98	44.51	-45.95	-8.77	4.73
1777.00	0.97	16.54	1.44	-4.56	7.89	-36.15	-8.04	1.54
1804.00	1.18	15.56	-0.74	-4.14	-8.57	-34.94	-5.09	1.80
1807.00	1.16	15.46	-0.89	-4.09	-5.08	-32.57	1.13	-0.95
1837.00	1.00	14.48	-0.55	-4.38	-0.99	-36.72	0.28	-6.63
1867.00	0.97	13.38	-0.46	-6.37	-0.51	-43.52	0.22	-2.51
1897.00	0.96	12.07	-0.40	-7.12	6.40	-43.19	0.54	-2.78
1927.00	1.15	10.78	-0.23	-7.95	7.20	-42.94	-0.96	-1.30
1957.00	1.37	9.49	-0.52	-8.35	5.77	-38.57	0.10	-6.31
1986.00	1.54	8.33	-0.49	-10.24	0.28	-42.24	-2.22	-7.81
2016.00	1.55	7.06	-1.16	-12.58	0.72	-38.83	-0.93	-3.94
2046.00	1.57	5.90	-1.44	-13.76	9.38	-39.06	0.83	-1.96

2076.00	1.85	4.73	-1.19	-14.35	23.53	-47.69	-0.81	-10.39
2106.00	2.56	3.30	-1.43	-17.47	7.84	-60.89	-1.14	14.01
2136.00	2.79	1.47	-1.77	-13.27	-14.85	-49.86	1.89	27.43
2166.00	2.35	-0.03	-1.20	-5.04	-25.74	-22.09	-0.17	22.88
2196.00	1.57	-0.69	-1.26	1.82	-27.77	-2.23	0.20	8.12
2226.00	0.74	-0.76	-1.19	4.26	-18.12	15.61	2.15	9.31
2256.00	0.20	-0.29	-0.55	7.05	-8.73	27.22	0.17	2.30
2286.00	-0.06	0.53	-0.50	7.74	-13.06	31.70	-1.00	-3.39
2316.00	-0.46	1.48	-0.80	6.72	-14.62	28.95	-0.56	-5.49
2346.00	-0.90	2.35	-0.96	5.08	-13.58	27.68	0.83	-1.93
2376.00	-1.30	3.18	-0.72	4.50	-11.29	26.67	-0.63	-3.17
2406.00	-1.64	3.98	-0.91	3.55	-13.43	22.76	0.51	-3.30
2436.00	-2.04	4.66	-0.75	2.55	-6.97	12.65	1.51	-7.09
2466.00	-2.25	5.04	-0.30	0.43	-0.50	-1.13	1.22	-3.76
2496.00	-2.27	5.01	0.06	-0.70	-1.46	-7.82	-2.00	-1.59
2526.00	-2.31	4.77	-0.54	-1.18	-0.21	-8.87	3.02	1.37
2556.00	-2.32	4.51	0.37	-0.77	6.55	-7.29	-0.95	0.56
2574.00	-2.20	4.38	0.20	-0.67	11.48	-4.06	8.54	5.75
2584.00	-2.09	4.34	1.06	-0.09	14.96	0.00	-0.88	5.91
2586.00	-2.05	4.34	1.03	0.05	18.20	7.42	0.26	3.83
2616.00	-1.51	4.56	1.11	1.20	20.92	16.89	-0.14	1.13
2646.00	-0.88	5.07	1.07	1.54	17.79	22.71	-0.54	1.41
2676.00	-0.34	5.75	0.91	1.96	13.77	25.29	-0.77	-0.23
2706.00	0.07	6.51	0.68	1.89	13.19	24.41	0.06	-0.78
2736.00	0.46	7.24	0.70	1.66	6.73	22.55	-2.54	-0.47
2766.00	0.67	7.92	-0.07	1.51	-5.46	20.24	-1.46	-0.52
2796.00	0.50	8.52	-0.51	1.36	-9.59	20.18	-0.78	0.03
2826.00	0.21	9.13	-0.74	1.37	-20.79	23.16	-4.98	0.96
2856.00	-0.41	9.82	-2.24	1.66	-60.28	26.87	-7.58	0.24
2886.00	-2.22	10.63	-4.51	1.73	-84.31	22.96	-2.98	-1.73
2916.00	-4.75	11.32	-5.41	1.21	-102.41	15.49	-3.86	-1.54
2946.00	-7.82	11.78	-6.56	0.75	-116.42	6.29	0.90	-1.86
2977.00	-11.31	11.97	-6.29	0.19	-104.09	7.29	1.19	2.29
3007.00	-14.43	12.19	-5.93	0.87	-102.23	17.35	4.75	2.31
3017.00	-15.40	12.36	-5.49	1.09	-71.07	20.27	13.79	0.62
3038.00	-16.86	12.77	-2.65	1.22	-14.48	20.34	13.40	-1.18
3069.00	-17.29	13.38	1.37	0.86	30.72	11.31	0.93	-1.45
3100.00	-16.37	13.72	1.65	0.43	31.37	3.00	0.50	-1.73
3130.00	-15.43	13.81	1.80	-0.09	31.05	-4.56	-0.37	-0.90
3160.00	-14.50	13.68	1.69	-0.36	31.03	-8.58	0.70	-0.77
3190.00	-13.57	13.42	1.90	-0.59	32.36	-11.85	-0.30	-0.07
3220.00	-12.60	13.06	1.81	-0.61	33.72	-8.47	0.77	0.40

3250.00	-11.59	12.81	2.04	-0.49	35.07	-9.86	-0.50	-0.53
3280.00	-10.54	12.51	1.89	-0.65	31.70	-11.32	-0.47	0.03
3310.00	-9.58	12.17	1.75	-0.64	31.02	-12.61	0.77	-0.60
3340.00	-8.65	11.79	1.98	-0.82	30.34	-17.68	-0.57	-1.13
3370.00	-7.74	11.26	1.81	-1.16	32.34	-20.89	0.00	-0.27
3400.00	-6.77	10.64	1.81	-1.24	34.69	-22.41	0.33	-0.50
3430.00	-5.73	9.97	1.91	-1.39	33.67	-25.22	-0.47	-0.40
3460.00	-4.72	9.21	1.77	-1.51	25.94	-23.91	-3.37	0.97
3490.00	-3.94	8.49	0.76	-1.22	7.75	-18.31	-1.50	1.27
3520.00	-3.71	7.94	0.31	-0.84	5.73	-13.66	-0.50	0.43
3550.00	-3.54	7.53	0.16	-0.71	5.06	-11.98	0.23	0.33
3580.00	-3.39	7.17	0.23	-0.61	4.39	-10.09	-0.67	0.50
3610.00	-3.26	6.87	0.03	-0.46	2.36	-3.29	0.27	1.97
3640.00	-3.19	6.77	0.11	0.13	3.38	2.97	0.43	0.23
3670.00	-3.08	6.86	0.24	0.20	3.39	4.21	-0.23	0.07
3700.00	-2.98	6.99	0.17	0.22	-2.60	1.33	-4.24	-1.62
3718.00	-3.03	7.01	-0.63	-0.09	-12.07	-1.76	-0.12	-0.22
3730.00	-3.17	6.99	-0.64	-0.11	-13.47	-3.79	-1.10	-0.47
3759.00	-3.57	6.88	-0.97	-0.25	-15.22	-5.33	1.95	-0.39
3789.00	-4.03	6.72	-0.39	-0.37	-4.74	-6.27	0.66	0.09
3819.00	-4.17	6.53	-0.19	-0.34	1.32	-5.12	0.79	0.06
3849.00	-4.13	6.38	0.05	-0.33	-6.37	-5.29	-2.16	0.02
3878.00	-4.32	6.22	-0.60	-0.32	-5.84	-4.91	2.77	0.47
3908.00	-4.50	6.07	0.23	-0.18	-0.84	0.00	-1.76	1.08
3938.00	-4.52	6.07	-0.29	0.15	-5.97	4.08	-1.55	0.25
3968.00	-4.70	6.19	-0.76	0.22	-17.08	2.95	-1.19	-0.08
3997.00	-5.21	6.28	-1.12	0.20	-19.07	1.42	1.21	-0.83
4027.00	-5.78	6.32	-0.75	-0.05	-5.93	-0.38	1.97	0.20
4057.00	-5.96	6.31	-0.16	0.01	5.64	0.46	2.88	0.15
4087.00	-5.79	6.33	0.71	0.06	14.42	3.91	0.86	2.50
4116.00	-5.36	6.44	0.96	0.81	19.64	11.89	1.01	2.60
4146.00	-4.77	6.80	1.27	1.59	20.28	16.82	-0.87	-0.08
4176.00	-4.16	7.31	1.00	1.56	16.86	9.83	-0.49	-3.47
4206.00	-3.66	7.60	0.86	0.52	15.34	3.10	1.13	-0.28
4235.00	-3.20	7.69	1.20	0.43	22.68	1.43	0.47	-1.06
4265.00	-2.52	7.74	1.34	0.12	25.20	4.53	0.12	3.90
4295.00	-1.76	7.87	1.37	1.29	16.95	11.57	-3.14	3.78
4325.00	-1.25	8.22	0.43	2.42	6.32	14.48	0.58	1.28
4355.00	-1.06	8.65	0.61	2.81	10.56	11.88	2.04	-5.57
4360.00	-1.01	8.72	0.71	2.52	-0.23	9.44	-4.12	-2.01
4385.00	-1.01	8.95	-0.31	2.02	-5.57	6.92	-0.16	-2.04
4415.00	-1.18	9.16	-0.36	1.41	-5.49	3.46	0.17	-4.10

4445.00	-1.35	9.26	-0.31	0.18	-5.91	-0.48	-0.07	-0.62
4475.00	-1.52	9.25	-0.33	-0.01	-0.33	-2.61	1.77	-5.15
4505.00	-1.53	9.17	0.20	-1.55	3.55	-12.80	0.20	-9.26
4535.00	-1.43	8.78	0.26	-4.33	4.79	-24.02	0.72	-8.94
4556.00	-1.33	8.28	0.41	-6.19				

8.7.5. Deviation results for well 15/9-F-12

Table 18: Results, deviation parameters for well 15/9-F-12

Deviation parameters for well 15/9-F-12								
MD	VD	HD	ID	AD	RCVD	RCHD	RCID	RCAD
[m]	[m]	[m]	[deg]	[deg]	[m/1000m]	[m/1000m]	[deg/100m]	[deg/100m]
145.90	0.000	0.000	-0.002	-0.055	0.000	0.000	0.033	1.269
155.09	0.000	0.000	0.001	0.059	-0.002	-0.004	0.004	0.541
195.44	0.000	0.000	0.002	0.276	0.002	0.007	-0.010	-0.757
235.80	0.000	0.000	-0.002	-0.035	-0.022	-0.003	0.006	0.142
276.20	-0.001	0.000	0.000	0.022	0.011	-0.001	0.000	-0.163
316.60	-0.001	0.000	0.000	-0.045	0.006	-0.009	-0.004	0.067
356.90	0.000	0.000	-0.001	-0.018	-0.044	-0.020	0.022	0.051
397.30	-0.002	-0.001	0.008	0.002	0.088	0.029	-0.018	0.122
437.70	0.002	0.000	0.000	0.052	-0.040	-0.001	0.000	-0.131
478.00	0.000	0.000	0.000	0.000	-0.069	-0.002	-0.021	-0.520
518.40	-0.003	0.000	-0.008	-0.208	0.106	-0.006	0.043	0.801
558.70	0.002	0.000	0.010	0.121	-0.043	0.014	-0.029	-0.302
599.10	0.000	0.000	-0.002	0.000	0.004	-0.018	0.004	0.210
639.50	0.000	0.000	0.000	0.084	0.000	0.011	0.000	-0.235
679.80	0.000	0.000	0.000	-0.012	0.000	0.001	0.000	0.078
720.20	0.000	0.000	0.000	0.019	0.000	0.004	0.001	0.313
760.50	0.000	0.000	0.000	0.144	0.002	-0.004	-0.001	-0.540
800.90	0.000	0.000	0.000	-0.077	-0.014	-0.009	0.001	0.224
841.30	0.000	0.000	0.000	0.013	0.016	0.007	0.000	-0.047
881.70	0.000	0.000	0.000	-0.007	-0.005	0.002	0.000	0.016
922.00	0.000	0.000	0.000	0.000	0.001	0.001	-0.001	-0.004
962.40	0.000	0.000	-0.001	-0.001	-0.002	-0.002	0.001	-0.003
1002.80	0.000	0.000	0.000	-0.003	0.000	0.004	0.000	0.158
1043.20	0.000	0.000	0.000	0.060	-0.007	-0.016	0.000	-0.104
1083.50	0.000	-0.001	0.000	0.019	0.009	0.014	0.000	-0.003
1123.90	0.000	0.000	0.000	0.018	-0.001	-0.002	0.000	-0.252
1164.20	0.000	0.000	0.000	-0.083	0.000	0.000	0.000	0.347
1204.60	0.000	0.000	0.000	0.059	0.000	0.001	0.000	-0.148
1245.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.029

1285.40	0.000	0.000	0.000	-0.012	0.002	0.001	0.000	0.074
1325.80	0.000	0.000	0.000	0.019	-0.003	0.000	0.000	-0.069
1366.10	0.000	0.000	0.000	-0.009	0.001	-0.001	0.000	0.021
1406.50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1446.80	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1487.20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.060
1527.50	0.000	0.000	0.000	-0.025	0.000	0.000	0.000	0.059
1567.90	0.000	0.000	0.000	-0.001	-0.008	0.008	0.000	0.008
1608.20	0.000	0.000	0.000	0.002	0.024	0.008	0.000	-0.005
1648.60	0.001	0.001	0.000	0.000	-0.016	-0.016	0.000	0.000
1689.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1729.30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001
1769.70	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1810.00	0.000	0.000	0.000	0.000	-0.002	0.005	0.000	0.063
1850.40	0.000	0.000	0.000	0.025	0.003	-0.004	0.000	-0.087
1890.80	0.000	0.000	0.000	-0.011	-0.001	-0.001	0.000	0.034
1931.10	0.000	0.000	0.000	0.003	0.000	-0.001	0.000	-0.007
1971.50	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.101
2011.80	0.000	0.000	0.000	0.042	-0.005	0.009	0.000	-0.124
2052.50	0.000	0.000	0.000	-0.008	-0.030	-0.009	0.000	0.062
2092.50	-0.001	0.000	0.000	0.017	0.051	0.004	-0.011	-0.042
2132.90	0.001	0.000	-0.005	0.000	-0.027	-0.007	0.047	0.035
2173.20	0.000	0.000	0.014	0.014	0.195	0.004	-0.042	-0.078
2213.60	0.008	0.000	-0.003	-0.018	-0.191	-0.001	0.007	0.036
2253.90	0.000	0.000	0.000	-0.004	0.046	0.003	0.007	0.042
2294.30	0.002	0.000	0.003	0.013	-0.049	-0.008	-0.055	-0.095
2334.60	0.000	0.000	-0.020	-0.026	0.004	0.005	0.050	0.065
2375.00	0.000	0.000	0.000	0.000	-0.014	0.017	0.044	0.026
2415.30	-0.001	0.001	0.018	0.010	0.036	-0.058	-0.071	-0.083
2455.80	0.001	-0.002	-0.011	-0.024	-0.013	0.031	0.046	0.115
2496.10	0.000	0.000	0.007	0.022	0.063	0.035	-0.151	-0.271
2536.50	0.003	0.001	-0.055	-0.089	-0.062	0.010	0.111	0.221
2576.90	0.000	0.001	-0.011	0.000	-0.042	-0.037	0.096	-0.013
2617.30	-0.001	0.000	0.028	-0.005	0.042	-0.004	-0.095	0.014
2655.90	0.000	0.000	-0.009	0.000	-0.027	0.011	0.004	-0.007
2673.90	0.000	0.000	-0.009	-0.001	0.011	0.002	0.025	0.003
2706.97	0.000	0.000	0.000	0.000	-0.014	-0.005	0.001	0.001
2747.16	0.000	0.000	0.000	0.000	-5.683	-4.230	-1.465	-1.767
2790.39	-0.245	-0.182	-0.630	-0.760	-5.041	5.088	-0.357	5.659
2830.75	-0.451	0.027	-0.776	1.560	-11.797	31.748	0.343	4.550
2870.67	-0.923	1.296	-0.639	3.380	-14.007	46.502	-0.561	-0.275
2911.52	-1.483	3.157	-0.863	3.270	-12.796	46.535	0.870	-0.641

2950.80	-1.982	4.971	-0.524	3.020	-2.928	37.546	2.129	-5.756
2991.49	-2.103	6.511	0.349	0.660	11.491	22.328	-0.039	3.198
3032.17	-1.631	7.426	0.333	1.971	12.405	39.265	0.433	2.142
3072.79	-1.123	9.036	0.511	2.849	9.728	33.462	-1.424	-3.810
3112.44	-0.724	10.408	-0.073	1.287	3.489	-6.692	-0.367	-8.230
3153.53	-0.577	10.127	-0.227	-2.170	1.182	-40.607	0.386	-1.330
3193.66	-0.530	8.503	-0.073	-2.702	1.010	-50.394	0.102	-1.210
3233.21	-0.490	6.487	-0.032	-3.186	-15.360	-50.052	-2.470	3.864
3273.30	-1.104	4.485	-1.020	-1.640	-8.415	-26.564	2.393	0.368
3314.97	-1.458	3.369	-0.015	-1.485	-6.712	-22.705	-1.817	0.550
3355.37	-1.733	2.438	-0.760	-1.260	12.085	-23.361	5.000	-0.650
3395.93	-1.249	1.504	1.240	-1.520	-1.204	-16.847	-4.694	1.962
3436.15	-1.299	0.813	-0.685	-0.716	1.744	1.464	3.636	3.839
3476.50	-1.229	0.872	0.770	0.820	18.488	6.192	1.316	-1.969
3514.77	-0.526	1.107	1.270	0.072	18.235	-2.258	-1.179	-1.492
3555.95	0.239	1.012	0.775	-0.555	1.821	-13.471	-3.337	-1.938
3596.23	0.312	0.473	-0.560	-1.330	-4.569	-23.657	-0.048	-1.143
3638.07	0.120	-0.520	-0.580	-1.810	0.043	-27.582	2.631	-1.050
3678.39	0.122	-1.624	0.472	-2.230	12.602	-29.192	1.294	0.325
3718.84	0.626	-2.791	0.990	-2.100	17.796	-28.664	0.818	-0.545
3729.86	0.822	-3.107	1.080	-2.160	17.995	-27.781	0.000	0.000
3750.00	1.200	-3.690	1.080	-2.160	14.393	-27.247	2.600	16.900
1573.00	-29.630	-2.422	1.000	-3.420	19.070	-17.570	2.300	14.000
1583.00	-29.440	-2.598	1.230	-2.020	23.234	-10.513	2.100	8.000
1593.00	-29.207	-2.703	1.440	-1.220	26.905	-7.219	2.100	2.300
1603.00	-28.938	-2.775	1.650	-0.990	30.143	-6.559	1.800	0.200
1613.00	-28.637	-2.841	1.830	-0.970	33.636	-6.782	1.900	-1.100
1623.00	-28.300	-2.909	2.020	-1.080	37.400	-7.869	2.700	-1.600
1633.00	-27.926	-2.987	2.290	-1.240	42.211	-9.050	2.700	-1.400
1643.00	-27.504	-3.078	2.560	-1.380	45.960	-10.014	2.000	-1.500
1653.00	-27.045	-3.178	2.760	-1.530	49.299	-10.894	1.300	-0.700
1663.00	-26.552	-3.287	2.890	-1.600	50.773	-11.183	0.600	-0.100
1673.00	-26.044	-3.399	2.950	-1.610	52.039	-11.108	0.700	0.300
1683.00	-25.524	-3.510	3.020	-1.580	52.679	-11.310	0.400	-0.600
1693.00	-24.997	-3.623	3.060	-1.640	53.519	-11.466	0.300	0.200
1703.00	-24.462	-3.738	3.090	-1.620	60.269	-12.396	0.556	0.667
1713.00	-23.919	-3.849	3.140	-1.560	54.208	-10.881	-0.200	0.300
1723.00	-23.377	-3.958	3.120	-1.530	54.173	-10.699	-0.500	0.100
1733.00	-22.835	-4.065	3.070	-1.520	53.229	-10.450	-0.100	0.400
1743.00	-22.303	-4.170	3.060	-1.480	53.330	-10.287	-0.200	0.400
1753.00	-21.770	-4.272	3.040	-1.440	52.313	-10.573	-0.500	-1.500
1763.00	-21.247	-4.378	2.990	-1.590	51.125	-10.944	-0.700	0.700

1773.00	-20.735	-4.488	2.920	-1.520	50.200	-11.060	-0.600	-1.200
1783.00	-20.233	-4.598	2.860	-1.640	49.034	-11.952	-1.000	-1.700
1793.00	-19.743	-4.718	2.760	-1.810	47.732	-12.527	-0.300	0.000
1803.00	-19.266	-4.843	2.730	-1.810	47.296	-12.710	-0.100	-0.500
1813.00	-18.793	-4.970	2.720	-1.860	47.451	-12.741	0.300	0.200
1823.00	-18.318	-5.097	2.750	-1.840	48.461	-13.280	0.600	-1.300
1833.00	-17.834	-5.230	2.810	-1.970	48.931	-13.483	0.300	0.400
1843.00	-17.344	-5.365	2.840	-1.930	48.975	-12.862	-0.700	1.600
1853.00	-16.855	-5.494	2.770	-1.770	47.850	-12.251	-0.200	0.000
1863.00	-16.376	-5.616	2.750	-1.770	48.642	-11.994	0.800	0.600
1873.00	-15.890	-5.736	2.830	-1.710	49.189	-11.506	0.400	1.300
1883.00	-15.398	-5.851	2.870	-1.580	49.704	-10.315	-0.200	2.000
1893.00	-14.901	-5.954	2.850	-1.380	49.686	-9.590	0.100	-0.200
1903.00	-14.404	-6.050	2.860	-1.400	50.053	-9.582	0.500	0.600
1913.00	-13.903	-6.146	2.910	-1.340	51.020	-8.701	0.300	1.800
1923.00	-13.393	-6.233	2.940	-1.160	50.181	-7.702	-0.200	2.200
1933.00	-12.891	-6.310	2.920	-0.940	54.924	-8.004	1.170	1.818
1943.00	-12.342	-6.390	3.037	-0.758	70.514	-21.458	7.096	9.348
1953.00	-11.637	-6.605	3.747	0.177	72.863	-11.915	2.520	9.264
1963.00	-10.835	-6.736	4.024	1.196	78.635	-6.024	-1.197	9.024
1973.00	-10.049	-6.796	3.904	2.098	77.432	-0.232	-1.242	7.819
1983.00	-9.275	-6.798	3.780	2.880	77.431	4.361	-0.374	6.499
1993.00	-8.500	-6.755	3.743	3.530	76.286	7.204	-0.518	3.816
2003.00	-7.738	-6.683	3.691	3.911	76.205	9.114	-1.209	2.085
2013.00	-6.976	-6.592	3.570	4.120	75.956	10.076	-0.308	1.532
2023.00	-6.216	-6.491	3.539	4.273	75.432	11.720	-0.195	4.874
2033.00	-5.462	-6.374	3.520	4.761	76.356	15.717	-0.397	8.094
2043.00	-4.698	-6.216	3.480	5.570	75.206	20.972	-1.381	11.150
2053.00	-3.946	-6.007	3.342	6.685	70.895	27.280	-2.578	15.619
2063.00	-3.237	-5.734	3.084	8.247	65.268	35.054	-3.941	16.331
2073.00	-2.584	-5.383	2.690	9.880	57.349	41.259	-4.297	15.725
2083.00	-2.011	-4.971	2.260	11.452	46.335	41.750	-1.709	17.232
2093.00	-1.501	-4.512	2.072	13.348	45.512	53.621	-1.082	18.273
2103.00	-1.046	-3.975	1.964	15.175	36.661	58.566	-5.542	19.304
2113.00	-0.680	-3.390	1.410	17.106	24.831	61.573	-3.844	19.342
2123.00	-0.431	-2.774	1.026	19.040	18.144	66.658	-0.793	18.554
2133.00	-0.250	-2.107	0.946	20.895	11.837	70.349	-0.450	20.081
2143.00	-0.131	-1.404	0.901	22.903	3.553	72.387	-2.034	18.003
2153.00	-0.096	-0.680	0.698	24.704	-3.151	74.583	-1.326	6.958
2163.00	-0.127	0.066	0.565	25.399	-9.825	71.494	-0.308	2.007
2173.00	-0.226	0.781	0.534	25.600	-16.045	75.727	0.289	-3.319
2183.00	-0.370	1.462	0.560	25.301	-18.060	67.774	-0.605	-5.514

2193.00	-0.551	2.140	0.500	24.750	-23.916	60.989	-0.033	-5.816
2203.00	-0.790	2.750	0.497	24.168	-29.022	52.742	-0.261	-7.492
2213.00	-1.080	3.277	0.471	23.419	-30.954	58.251	-0.506	-7.892
2223.00	-1.390	3.860	0.420	22.630	-35.987	57.890	-1.095	-8.398
2233.00	-1.749	4.439	0.310	21.790	-41.858	42.192	-1.373	-5.497
2243.00	-2.168	4.861	0.173	21.240	-43.788	28.103	-0.531	-1.905
2253.00	-2.606	5.142	0.120	21.050	-44.775	29.397	-0.416	-10.691
2263.00	-3.054	5.436	0.078	19.981	-47.542	35.076	-0.391	-13.550
2273.00	-3.529	5.786	0.039	18.626	-45.431	26.479	-0.293	-16.259
2283.00	-3.983	6.051	0.010	17.000	-42.797	20.135	0.285	-13.365
2293.00	-4.411	6.253	0.038	15.664	-42.106	22.224	0.231	-1.300
2303.00	-4.832	6.475	0.062	15.534	-40.800	20.185	-1.416	-5.335
2313.00	-5.240	6.677	-0.080	15.000	-42.055	23.336	-1.618	-10.571
2323.00	-5.619	6.887	-0.226	14.049	-43.600	20.753	-1.252	3.166
2333.00	-6.055	7.094	-0.351	14.365	-42.894	21.380	-0.242	-1.525
2343.00	-6.484	7.308	-0.375	14.213	-41.911	21.812	-0.995	-3.412
2353.00	-6.903	7.526	-0.475	13.871	-42.575	24.391	0.000	-1.213
2363.00	-7.329	7.770	-0.474	13.750	-40.264	25.851	0.447	-0.696
2373.00	-7.731	8.029	-0.430	13.681	-37.904	27.534	0.490	-2.259
2383.00	-8.110	8.304	-0.381	13.455	-37.074	36.068	2.394	-7.868
2393.00	-8.444	8.628	-0.165	12.747	-31.827	31.069	0.833	-3.021
2403.00	-8.762	8.939	-0.082	12.445	-28.363	32.144	1.371	-4.245
2413.00	-9.046	9.261	0.055	12.020	-27.144	33.971	-0.021	-4.734
2423.00	-9.317	9.600	0.053	11.547	-26.329	34.108	-1.300	-3.752
2433.00	-9.581	9.941	-0.077	11.171	-27.725	34.250	-1.678	-2.584
2443.00	-9.858	10.284	-0.245	10.913	-30.923	39.719	-0.758	-11.153
2453.00	-10.136	10.641	-0.313	9.909	-29.856	31.520	-0.816	-7.876
2463.00	-10.435	10.957	-0.395	9.122	-25.484	18.828	-1.842	-3.690
2464.55	-10.486	10.994	-0.432	9.048	-34.239	27.325	-2.174	-8.876
2493.74	-11.444	11.759	-1.040	6.563	-44.016	21.144	-2.284	-1.714
2536.07	-13.293	12.647	-2.000	5.843	-61.856	32.503	-2.907	7.127
2576.99	-15.767	13.947	-3.162	8.694	-54.022	52.014	5.338	1.998
2617.92	-17.928	16.028	-1.027	9.493	-19.107	62.701	4.484	-3.449
2658.30	-18.673	18.473	0.722	8.148	-1.306	52.608	-0.006	-6.761
2699.07	-18.726	20.578	0.719	5.443	0.824	44.970	-0.084	-1.066
2738.83	-18.694	22.287	0.687	5.038	29.045	42.892	7.888	-1.961
2779.26	-17.532	24.002	3.843	4.254	74.496	44.276	3.995	-1.209
2820.02	-14.627	25.729	5.401	3.783	99.394	28.283	3.436	-6.621
2860.02	-10.751	26.832	6.741	1.200	114.585	-11.827	0.087	-9.514
2900.45	-6.282	26.371	6.775	-2.510	104.209	-43.529	-2.149	-2.784
2939.72	-2.218	24.673	5.937	-3.596	83.783	-42.669	-4.358	3.031
2980.29	1.134	22.966	4.193	-2.384	58.112	-27.805	-4.419	2.938

3008.61	2.761	22.188	2.956	-1.561	22.326	-41.922	-4.204	-5.806
3060.63	3.922	20.008	0.770	-4.580	6.539	-82.567	-2.333	-13.048
3081.25	4.059	18.274	0.280	-7.320	-1.950	-114.156	-0.400	-2.727
3136.60	3.952	11.995	0.060	-8.820	-2.526	-106.581	0.167	6.750
3172.51	3.861	8.159	0.120	-6.390	-0.132	-69.081	-0.093	7.349
3216.39	3.855	5.188	0.080	-3.230	-3.511	-30.469	-1.268	5.098
3257.05	3.711	3.939	-0.440	-1.140	-3.868	0.760	1.175	5.950
3297.38	3.556	3.969	0.030	1.240	-5.775	25.694	-1.732	3.073
3337.63	3.320	5.023	-0.680	2.500	-13.486	32.454	-0.243	-1.189
3375.41	2.821	6.223	-0.770	2.060	-12.525	31.822	0.317	1.049
3416.55	2.307	7.528	-0.640	2.490	-12.838	32.458	-0.425	-0.700
3456.15	1.794	8.827	-0.810	2.210	-151.781	223.969	-2.500	-28.750
3495.52	1.186	9.722	-0.910	1.060	65535.000	65535.000		
3520.00	0.789	10.084	-0.910	1.060				

8.7.6. Deviation results for well 15/9-F-14

Table 19: Results, deviation parameters for well 15/9-F-14

Deviation parameters for well 15/9-F-14								
MD	VD	HD	ID	AD	RCVD	RCHD	RCID	RCAD
[m]	[m]	[m]	[deg]	[deg]	[m/1000m]	[m/1000m]	[deg/100m]	[deg/100m]
145.90	0.000	0.000	-0.002	-0.055	0.000	0.000	0.033	1.269
155.09	0.000	0.000	0.001	0.059	-0.002	-0.004	0.004	0.541
195.44	0.000	0.000	0.002	0.276	0.002	0.007	-0.010	-0.757
235.80	0.000	0.000	-0.002	-0.035	-0.022	-0.003	0.006	0.142
276.20	-0.001	0.000	0.000	0.022	0.011	-0.001	0.000	-0.163
316.60	-0.001	0.000	0.000	-0.045	0.006	-0.009	-0.004	0.067
356.90	0.000	0.000	-0.001	-0.018	-0.044	-0.020	0.022	0.051
397.30	-0.002	-0.001	0.008	0.002	0.088	0.029	-0.018	0.122
437.70	0.002	0.000	0.000	0.052	-0.040	-0.001	0.000	-0.131
478.00	0.000	0.000	0.000	0.000	-0.069	-0.002	-0.021	-0.520
518.40	-0.003	0.000	-0.008	-0.208	0.106	-0.006	0.043	0.801
558.70	0.002	0.000	0.010	0.121	-0.043	0.014	-0.029	-0.302
599.10	0.000	0.000	-0.002	0.000	0.004	-0.018	0.004	0.210
639.50	0.000	0.000	0.000	0.084	0.000	0.011	0.000	-0.235
679.80	0.000	0.000	0.000	-0.012	0.000	0.001	0.000	0.078
720.20	0.000	0.000	0.000	0.019	0.000	0.004	0.001	0.313
760.50	0.000	0.000	0.000	0.144	0.002	-0.004	-0.001	-0.540
800.90	0.000	0.000	0.000	-0.077	-0.014	-0.009	0.001	0.224
841.30	0.000	0.000	0.000	0.013	0.016	0.007	0.000	-0.047
881.70	0.000	0.000	0.000	-0.007	-0.005	0.002	0.000	0.016

922.00	0.000	0.000	0.000	0.000	0.001	0.001	-0.001	-0.004
962.40	0.000	0.000	-0.001	-0.001	-0.002	-0.002	0.001	-0.003
1002.80	0.000	0.000	0.000	-0.003	0.000	0.004	0.000	0.158
1043.20	0.000	0.000	0.000	0.060	-0.007	-0.016	0.000	-0.104
1083.50	0.000	-0.001	0.000	0.019	0.009	0.014	0.000	-0.003
1123.90	0.000	0.000	0.000	0.018	-0.001	-0.002	0.000	-0.252
1164.20	0.000	0.000	0.000	-0.083	0.000	0.000	0.000	0.347
1204.60	0.000	0.000	0.000	0.059	0.000	0.001	0.000	-0.148
1245.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.029
1285.40	0.000	0.000	0.000	-0.012	0.002	0.001	0.000	0.074
1325.80	0.000	0.000	0.000	0.019	-0.003	0.000	0.000	-0.069
1366.10	0.000	0.000	0.000	-0.009	0.001	-0.001	0.000	0.021
1406.50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1446.80	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1487.20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.060
1527.50	0.000	0.000	0.000	-0.025	0.000	0.000	0.000	0.059
1567.90	0.000	0.000	0.000	-0.001	-0.008	0.008	0.000	0.008
1608.20	0.000	0.000	0.000	0.002	0.024	0.008	0.000	-0.005
1648.60	0.001	0.001	0.000	0.000	-0.016	-0.016	0.000	0.000
1689.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1729.30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001
1769.70	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1810.00	0.000	0.000	0.000	0.000	-0.002	0.005	0.000	0.063
1850.40	0.000	0.000	0.000	0.025	0.003	-0.004	0.000	-0.087
1890.80	0.000	0.000	0.000	-0.011	-0.001	-0.001	0.000	0.034
1931.10	0.000	0.000	0.000	0.003	0.000	-0.001	0.000	-0.007
1971.50	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.101
2011.80	0.000	0.000	0.000	0.042	-0.005	0.009	0.000	-0.124
2052.50	0.000	0.000	0.000	-0.008	-0.030	-0.009	0.000	0.062
2092.50	-0.001	0.000	0.000	0.017	0.051	0.004	-0.011	-0.042
2132.90	0.001	0.000	-0.005	0.000	-0.027	-0.007	0.047	0.035
2173.20	0.000	0.000	0.014	0.014	0.195	0.004	-0.042	-0.078
2213.60	0.008	0.000	-0.003	-0.018	-0.191	-0.001	0.007	0.036
2253.90	0.000	0.000	0.000	-0.004	0.046	0.003	0.007	0.042
2294.30	0.002	0.000	0.003	0.013	-0.049	-0.008	-0.055	-0.095
2334.60	0.000	0.000	-0.020	-0.026	0.004	0.005	0.050	0.065
2375.00	0.000	0.000	0.000	0.000	-0.014	0.017	0.044	0.026
2415.30	-0.001	0.001	0.018	0.010	0.036	-0.058	-0.071	-0.083
2455.80	0.001	-0.002	-0.011	-0.024	-0.013	0.031	0.046	0.115
2496.10	0.000	0.000	0.007	0.022	0.063	0.035	-0.151	-0.271
2536.50	0.003	0.001	-0.055	-0.089	-0.062	0.010	0.111	0.221
2576.90	0.000	0.001	-0.011	0.000	-0.042	-0.037	0.096	-0.013

2617.30	-0.001	0.000	0.028	-0.005	0.042	-0.004	-0.095	0.014
2655.90	0.000	0.000	-0.009	0.000	-0.027	0.011	0.004	-0.007
2673.90	0.000	0.000	-0.009	-0.001	0.011	0.002	0.025	0.003
2706.97	0.000	0.000	0.000	0.000	-0.014	-0.005	0.001	0.001
2747.16	0.000	0.000	0.000	0.000	-5.683	-4.230	-1.465	-1.767
2790.39	-0.245	-0.182	-0.630	-0.760	-5.041	5.088	-0.357	5.659
2830.75	-0.451	0.027	-0.776	1.560	-11.797	31.748	0.343	4.550
2870.67	-0.923	1.296	-0.639	3.380	-14.007	46.502	-0.561	-0.275
2911.52	-1.483	3.157	-0.863	3.270	-12.796	46.535	0.870	-0.641
2950.80	-1.982	4.971	-0.524	3.020	-2.928	37.546	2.129	-5.756
2991.49	-2.103	6.511	0.349	0.660	11.491	22.328	-0.039	3.198
3032.17	-1.631	7.426	0.333	1.971	12.405	39.265	0.433	2.142
3072.79	-1.123	9.036	0.511	2.849	9.728	33.462	-1.424	-3.810
3112.44	-0.724	10.408	-0.073	1.287	3.489	-6.692	-0.367	-8.230
3153.53	-0.577	10.127	-0.227	-2.170	1.182	-40.607	0.386	-1.330
3193.66	-0.530	8.503	-0.073	-2.702	1.010	-50.394	0.102	-1.210
3233.21	-0.490	6.487	-0.032	-3.186	-15.360	-50.052	-2.470	3.864
3273.30	-1.104	4.485	-1.020	-1.640	-8.415	-26.564	2.393	0.368
3314.97	-1.458	3.369	-0.015	-1.485	-6.712	-22.705	-1.817	0.550
3355.37	-1.733	2.438	-0.760	-1.260	12.085	-23.361	5.000	-0.650
3395.93	-1.249	1.504	1.240	-1.520	-1.204	-16.847	-4.694	1.962
3436.15	-1.299	0.813	-0.685	-0.716	1.744	1.464	3.636	3.839
3476.50	-1.229	0.872	0.770	0.820	18.488	6.192	1.316	-1.969
3514.77	-0.526	1.107	1.270	0.072	18.235	-2.258	-1.179	-1.492
3555.95	0.239	1.012	0.775	-0.555	1.821	-13.471	-3.337	-1.938
3596.23	0.312	0.473	-0.560	-1.330	-4.569	-23.657	-0.048	-1.143
3638.07	0.120	-0.520	-0.580	-1.810	0.043	-27.582	2.631	-1.050
3678.39	0.122	-1.624	0.472	-2.230	12.602	-29.192	1.294	0.325
3718.84	0.626	-2.791	0.990	-2.100	17.796	-28.664	0.818	-0.545
3729.86	0.822	-3.107	1.080	-2.160	17.995	-27.781	0.000	0.000
3750.00	1.200	-3.690	1.080	-2.160				

8.7.7. Unacceptable/acceptable deviation results for wells 15/9-F-4 and 15/9-F-5

Table 20: Wells 15/9-F-4 and 15/9-F-5 deviation definition

Deviation reported as acceptable/unacceptable									
Well 15/9-F-4					Well 15/9-F-5				
Denotation: 1 = Unacceptable deviation					Denotation: 1 = Unacceptable deviation				
2= Acceptable deviation					2= Acceptable deviation				
VD	HD	ID	AD	Measured Depth	VD	HD	ID	AD	Measured Depth
[m]	[m]	[deg]	[deg]	[m]	[m]	[m]	[deg]	[deg]	[m]
2	2	2	2	145.9	2	2	2	2	145.90
2	2	2	1	184.12	2	2	2	2	146.00
2	2	2	1	224.45	2	2	2	1	154.90
2	2	2	1	264.79	2	2	2	1	195.30
2	2	2	2	305.1	2	2	2	1	235.60
2	2	2	2	345.45	2	2	2	2	276.00
2	2	2	1	385.8	2	2	2	2	316.40
2	2	2	1	426.12	2	2	2	2	356.70
1	2	2	2	466.4	2	2	2	2	397.10
1	2	2	2	506.65	2	2	2	2	437.50
1	2	2	1	546.96	2	2	2	2	477.80
1	2	2	1	587.28	2	2	2	2	518.20
1	2	2	2	627.54	1	2	2	2	558.50
1	2	2	2	667.63	1	2	2	2	598.90
1	2	2	2	707.96	1	2	2	2	639.30
1	2	2	2	748.28	1	2	2	2	679.60
1	2	2	2	788.57	1	2	2	2	720.00
1	2	2	2	828.91	1	2	2	2	760.40
1	2	2	2	869.25	1	2	2	2	800.70
1	2	2	2	909.6	1	2	2	2	841.10
1	2	2	2	949.94	1	2	2	2	881.50
1	2	2	2	990.29	1	2	2	2	921.80
1	2	2	2	1030.67	1	2	2	2	962.20
1	2	2	2	1071	1	2	2	2	1002.60
1	2	2	2	1111.37	2	2	2	2	1043.00
1	2	2	2	1151.73	1	2	2	2	1083.30
1	2	2	2	1192.07	1	2	2	2	1123.70
1	2	2	2	1232.42	1	2	2	2	1164.10
1	2	2	2	1272.73	1	2	2	2	1204.40
1	2	2	2	1313.08	1	2	2	2	1244.80
1	2	2	2	1353.43	1	2	2	2	1285.20
1	2	2	2	1393.74	1	2	2	2	1325.60
1	2	2	2	1434.06	1	2	2	2	1365.90

1	2	2	1	1474.42	1	2	2	2	1406.30
1	2	2	1	1514.76	1	2	2	2	1446.60
1	2	2	2	1555.11	1	2	2	2	1487.00
1	2	2	2	1595.46	1	2	2	2	1527.30
1	2	2	2	1635.81	1	2	2	2	1567.70
1	2	2	2	1676.14	1	2	2	2	1608.00
1	2	2	2	1716.5	1	2	2	2	1648.40
1	2	2	2	1756.82	1	2	2	2	1688.80
1	2	2	2	1797.22	1	2	2	2	1729.10
1	2	2	2	1837.56	1	2	2	2	1769.50
1	2	2	2	1877.9	1	2	2	2	1809.80
1	2	2	2	1918.25	1	2	2	2	1850.20
1	2	2	2	1958.61	1	2	2	2	1890.60
1	2	2	2	1998.97	1	2	2	2	1930.90
1	2	2	2	2039.32	1	2	2	2	1971.30
1	2	2	2	2079.67	1	2	2	2	2011.70
1	2	2	2	2120.01	1	2	2	2	2052.00
1	2	2	2	2160.35	1	2	2	2	2092.40
1	2	2	2	2200.7	1	2	2	2	2132.70
1	2	2	2	2241.06	1	2	2	2	2173.00
1	2	2	2	2281.44	1	2	2	2	2213.40
1	2	2	2	2321.84	1	2	2	2	2253.70
1	2	2	2	2362.19	1	2	2	2	2294.10
1	2	2	2	2402.55	1	2	2	2	2334.40
1	2	2	2	2442.9	1	2	2	2	2374.80
1	2	2	2	2483.25	2	2	2	2	2415.20
1	2	2	2	2523.62	2	2	2	2	2455.60
1	2	2	2	2563.96	2	2	2	2	2496.00
1	2	2	2	2604.31	2	2	2	2	2536.30
1	2	2	2	2644.66	2	2	2	2	2576.70
2	2	2	2	2685.02	2	2	2	2	2617.10
2	2	2	2	2696.43	2	2	2	2	2657.40
2	2	2	2	2740.79	2	2	2	2	2697.80
1	2	2	2	2773.9	2	2	2	2	2738.20
1	2	2	2	2800.66	2	2	2	2	2775.50
1	2	2	2	2840.3	2	2	2	2	2789.43
1	2	2	2	2879.85	2	2	2	2	2829.57
1	2	2	2	2920.07	2	2	2	2	2866.88
1	2	2	2	2959.08	2	2	2	2	2904.41
1	2	2	2	3001.1	2	2	2	2	2913.31
1	2	2	2	3041.46	2	2	2	2	2927.67
1	2	2	2	3081.29	2	2	2	2	2954.56

1	2	2	2	3121.75	1	2	2	2	2995.22
1	2	2	2	3162.81	1	2	2	2	3036.42
1	2	2	2	3203.53	1	2	2	2	3076.71
1	2	2	2	3244.08	1	2	2	2	3117.15
1	2	2	2	3284.75	1	2	2	2	3157.49
1	2	2	2	3325.09	1	2	2	2	3197.04
1	2	2	2	3365.11	1	2	2	1	3236.87
1	2	2	2	3404.82	1	2	2	1	3253.79
1	2	2	2	3444.78	1	2	1	1	3278.34
1	2	2	2	3484.98	2	1	2	2	3318.98
1	2	2	2	3510	1	1	2	2	3359.21
					1	1	2	2	3398.47
					1	1	2	2	3439.55
					1	1	2	2	3479.32
					1	1	2	2	3520.35
					1	1	2	2	3559.87
					1	2	2	2	3601.65
					1	2	2	2	3642.07
					1	2	2	2	3682.43
					1	2	2	2	3722.88
					2	2	2	2	3761.77
					2	2	2	2	3792.00

8.7.8. Unacceptable/acceptable deviation results for wells 15/9-F-10 and 15/9-F-11T2

Table 21: Wells 15/9-F-10 and 15/9-F-11T2 deviation definition

Deviation reported as acceptable/unacceptable									
Well 15/9-F-10					Well 15/9-F-11T2				
Denotation: 1 = Unacceptable deviation					Denotation: 1 = Unacceptable deviation				
2= Acceptable deviation					2= Acceptable deviation				
VD	HD	ID	AD	Measured Depth	VD	HD	ID	AD	Measured Depth
[m]	[m]	[deg]	[deg]	[m]	[m]	[m]	[deg]	[deg]	[m]
2	2	2	2	1381	2	2	2	2	146
2	2	2	2	1410	2	2	2	1	148
2	2	2	2	1430	2	2	2	2	168
2	2	2	2	1440	2	2	2	2	180
2	2	2	2	1463	2	2	2	1	193
2	2	2	2	1470	2	2	2	2	202
2	2	2	2	1500	2	2	2	2	209
2	2	2	2	1530	2	2	2	2	210
2	2	2	2	1560	2	2	2	1	240
2	2	2	2	1590	2	2	2	1	244
2	2	2	2	1620	2	2	2	1	270
2	2	2	2	1650	2	2	2	1	300
2	2	2	2	1680	2	2	2	1	330
2	2	2	2	1710	2	2	2	1	360
2	2	2	2	1730	2	2	2	1	390
2	2	2	2	1740	2	2	2	1	420
2	2	2	2	1770	2	2	2	1	424
2	2	2	2	1780	1	2	2	1	450
2	2	2	2	1800	2	2	2	1	473
1	2	2	2	1829	2	2	2	1	480
1	2	2	2	1859	2	2	2	1	510
1	2	2	2	1889	2	2	2	1	540
1	2	2	2	1919	2	2	2	1	565
1	2	2	2	1949	2	2	2	1	570
1	2	2	2	1979	1	2	2	1	600
1	2	2	2	2008	1	2	2	1	630
1	2	2	2	2027	1	2	2	2	660
1	2	2	2	2038	1	2	2	1	690
1	2	2	2	2068	1	2	2	1	720
1	2	2	2	2099	1	2	2	1	745
1	2	2	2	2129	1	2	2	1	750
1	2	2	2	2159	2	2	2	1	779
1	2	2	2	2189	2	2	2	1	809

1	2	2	2	2219	1	2	2	1	839
1	2	2	2	2249	1	2	2	2	869
1	2	2	2	2279	1	2	2	2	896
1	2	2	2	2309	1	2	2	2	899
1	2	2	2	2339	1	2	2	2	929
1	2	2	2	2369	1	2	2	2	959
1	2	2	2	2399	2	2	2	2	990
1	2	2	2	2429	2	2	2	2	1020
1	2	2	2	2459	2	2	2	2	1050
1	2	2	2	2489	2	2	2	2	1077
1	2	2	2	2519	2	2	2	2	1080
1	2	2	2	2549	2	2	2	1	1110
1	2	2	2	2579	1	2	2	1	1140
1	2	2	2	2609	1	2	2	1	1170
1	2	2	2	2639	1	2	2	1	1200
1	2	2	2	2669	1	2	2	1	1230
1	2	2	2	2699	1	2	2	2	1257
1	2	2	2	2729	1	2	2	2	1259
1	2	2	2	2758	1	2	2	2	1289
1	2	2	2	2764	1	2	2	2	1318
1	2	2	2	2788	1	2	2	2	1348
1	2	2	2	2818	1	1	2	2	1379
1	2	2	2	2848	1	1	2	2	1412
1	2	2	2	2878	1	1	2	2	1445
1	2	2	2	2908	1	1	2	2	1477
2	2	2	2	2938	1	1	2	2	1508
2	2	2	2	2967	1	2	2	2	1538
2	2	2	2	2997	1	2	2	2	1569
2	2	2	2	3027	1	2	2	2	1599
2	2	2	2	3057	1	2	2	2	1628
2	2	2	2	3087	1	2	2	2	1658
1	2	2	2	3117	1	2	2	2	1688
1	2	2	2	3147	2	2	2	2	1718
1	2	2	2	3176	2	2	2	2	1747
1	2	2	2	3206	2	2	2	2	1777
1	2	2	2	3236	2	2	2	2	1804
1	2	2	2	3261	2	2	2	2	1807
1	2	2	2	3266	2	2	2	2	1837
1	2	2	2	3296	2	2	2	2	1867
1	2	2	2	3326	2	2	2	2	1897
1	2	2	2	3355	2	2	2	2	1927
1	2	2	2	3387	2	2	2	2	1957

1	2	2	2	3415	2	2	2	2	1986
1	2	2	2	3445	2	2	2	2	2016
1	2	2	2	3475	2	2	2	2	2046
1	2	2	2	3505	2	2	2	2	2076
1	2	2	2	3535	2	2	2	2	2106
1	2	2	2	3565	2	2	2	2	2136
1	2	2	2	3595	2	2	2	2	2166
1	2	2	2	3625	2	2	2	2	2196
1	2	2	2	3655	2	2	2	2	2226
1	2	2	2	3685	2	2	2	2	2256
1	2	2	2	3715	2	2	2	2	2286
1	2	2	2	3745	2	2	2	2	2316
1	2	2	2	3775	2	2	2	2	2346
1	2	2	2	3805	2	2	2	2	2376
1	2	2	2	3835	2	2	2	2	2406
1	2	2	2	3866	2	2	2	2	2436
1	2	2	2	3896	2	2	2	2	2466
1	2	2	2	3926	2	2	2	2	2496
1	2	2	2	3956	2	2	2	2	2526
1	2	2	2	3986	2	2	2	2	2556
1	2	2	2	4016	2	2	2	2	2574
2	2	2	2	4046	2	2	2	2	2584
2	2	2	2	4076	2	2	2	2	2586
2	2	2	2	4106	2	2	2	2	2616
1	2	2	2	4136	2	2	2	2	2646
1	2	2	2	4165	2	2	2	2	2676
1	2	2	2	4174	2	2	2	2	2706
2	2	2	2	4195	2	2	2	2	2736
2	2	2	2	4226	2	2	2	2	2766
2	2	2	2	4257	2	2	2	2	2796
2	2	2	2	4288	2	2	2	2	2826
2	2	2	2	4319	2	2	2	2	2856
2	2	2	2	4349	2	2	2	2	2886
2	2	2	2	4379	1	2	2	2	2916
2	2	2	2	4409	1	2	2	2	2946
1	2	2	2	4439	1	2	2	2	2977
1	2	2	2	4469	1	2	2	2	3007
1	2	2	2	4499	1	2	2	2	3017
1	2	2	2	4529	1	2	2	2	3038
1	2	2	2	4559	1	2	2	2	3069
1	2	2	2	4588	1	2	2	2	3100
1	2	2	2	4619	1	2	2	2	3130

1	2	2	2	4649	1	2	2	2	3160
1	2	2	2	4679	1	2	2	2	3190
1	2	2	2	4709	1	2	2	2	3220
1	2	2	2	4726	1	2	2	2	3250
1	2	2	2	4739	1	2	2	2	3280
1	2	2	2	4769	1	2	2	2	3310
1	2	2	2	4799	1	2	2	2	3340
1	2	2	2	4829	1	2	2	2	3370
1	2	2	2	4859	1	2	2	2	3400
1	2	2	2	4890	1	2	2	2	3430
1	2	2	2	4920	1	2	2	2	3460
1	2	2	2	4951	1	2	2	2	3490
1	2	2	2	4982	2	2	2	2	3520
1	2	2	2	5012	2	2	2	2	3550
1	2	2	2	5039	2	2	2	2	3580
1	2	2	2	5042	2	2	2	2	3610
1	2	2	2	5072	2	2	2	2	3640
2	2	2	2	5102	2	2	2	2	3670
2	2	2	2	5132	2	2	2	2	3700
2	2	2	2	5162	2	2	2	2	3718
2	2	2	2	5192	2	2	2	2	3730
2	2	2	2	5222	2	2	2	2	3759
2	2	2	2	5251	1	2	2	2	3789
2	2	2	2	5265	1	2	2	2	3819
2	2	2	2	5281	1	2	2	2	3849
2	2	2	2	5311	1	2	2	2	3878
2	2	2	2	5331	1	2	2	2	3908
2	2	2	2	5331	1	2	2	2	3938
2	2	2	2	5331	1	2	2	2	3968
2	2	2	2	5331	1	2	2	2	3997
					1	2	2	2	4027
					1	2	2	2	4057
					1	2	2	2	4087
					1	2	2	2	4116
					1	2	2	2	4146
					1	2	2	2	4176
					2	2	2	2	4206
					2	2	2	2	4235
					2	2	2	2	4265
					2	2	2	2	4295
					2	2	2	2	4325
					2	2	2	2	4355

					2	2	2	2	4360
					2	2	2	2	4385
					2	2	2	2	4415
					2	2	2	2	4445
					2	2	2	2	4475
					2	2	2	2	4505
					2	2	2	2	4535
					2	2	2	2	4556

8.7.9. Unacceptable/acceptable deviation results for wells 15/9-F-12 and 15/9-F-14

Table 22: Wells 15/9-F-12 and 15/9-F-14 deviation definition

Deviation reported as acceptable/unacceptable									
Well 15/9-F-12					Well 15/9-F-14				
Denotation: 1 = Unacceptable deviation					Denotation: 1 = Unacceptable deviation				
2= Acceptable deviation					2= Acceptable deviation				
VD	HD	ID	AD	Measured Depth	VD	HD	ID	AD	Measured Depth
[m]	[m]	[deg]	[deg]	[m]	[m]	[m]	[deg]	[deg]	[m]
2	2	2	2	145.9	2	2	2	2	145.9
2	2	2	2	155.09	2	2	2	2	155.09
2	2	2	2	195.44	2	2	2	2	195.44
2	2	2	2	235.8	2	2	2	2	235.8
2	2	2	2	276.2	2	2	2	2	276.2
2	2	2	2	316.6	2	2	2	2	316.6
2	2	2	2	356.9	2	2	2	2	356.9
2	2	2	2	397.3	2	2	2	2	397.3
2	2	2	2	437.7	2	2	2	2	437.7
2	2	2	2	478	2	2	2	2	478
2	2	2	2	518.4	2	2	2	2	518.4
2	2	2	2	558.7	2	2	2	2	558.7
2	2	2	2	599.1	2	2	2	2	599.1
2	2	2	2	639.5	2	2	2	2	639.5
2	2	2	2	679.8	2	2	2	2	679.8
2	2	2	2	720.2	2	2	2	2	720.2
2	2	2	2	760.5	2	2	2	2	760.5
2	2	2	2	800.9	2	2	2	2	800.9
2	2	2	2	841.3	2	2	2	2	841.3
2	2	2	2	881.7	2	2	2	2	881.7
2	2	2	2	922	2	2	2	2	922
2	2	2	2	962.4	2	2	2	2	962.4

2	2	2	2	1002.8	2	2	2	2	1002.8
2	2	2	2	1043.2	2	2	2	2	1043.2
2	2	2	2	1083.5	2	2	2	2	1083.5
2	2	2	2	1123.9	2	2	2	2	1123.9
2	2	2	2	1164.2	2	2	2	2	1164.2
2	2	2	2	1204.6	2	2	2	2	1204.6
2	2	2	2	1245	2	2	2	2	1245
2	2	2	2	1285.4	2	2	2	2	1285.4
2	2	2	2	1325.8	2	2	2	2	1325.8
2	2	2	2	1366.1	2	2	2	2	1366.1
2	2	2	2	1406.5	2	2	2	2	1406.5
2	2	2	2	1446.8	2	2	2	2	1446.8
2	2	2	2	1487.2	2	2	2	2	1487.2
2	2	2	2	1527.5	2	2	2	2	1527.5
2	2	2	2	1567.9	2	2	2	2	1567.9
2	2	2	2	1608.2	2	2	2	2	1608.2
2	2	2	2	1648.6	2	2	2	2	1648.6
2	2	2	2	1689	2	2	2	2	1689
2	2	2	2	1729.3	2	2	2	2	1729.3
2	2	2	2	1769.7	2	2	2	2	1769.7
2	2	2	2	1810	2	2	2	2	1810
2	2	2	2	1850.4	2	2	2	2	1850.4
2	2	2	2	1890.8	2	2	2	2	1890.8
2	2	2	2	1931.1	2	2	2	2	1931.1
2	2	2	2	1971.5	2	2	2	2	1971.5
2	2	2	2	2011.8	2	2	2	2	2011.8
2	2	2	2	2052.5	2	2	2	2	2052.5
2	2	2	2	2092.5	2	2	2	2	2092.5
2	2	2	2	2132.9	2	2	2	2	2132.9
2	2	2	2	2173.2	2	2	2	2	2173.2
2	2	2	2	2213.6	2	2	2	2	2213.6
2	2	2	2	2253.9	2	2	2	2	2253.9
2	2	2	2	2294.3	2	2	2	2	2294.3
2	2	2	2	2334.6	2	2	2	2	2334.6
2	2	2	2	2375	2	2	2	2	2375
2	2	2	2	2415.3	2	2	2	2	2415.3
2	2	2	2	2455.8	2	2	2	2	2455.8
2	2	2	2	2496.1	2	2	2	2	2496.1
2	2	2	2	2536.5	2	2	2	2	2536.5
2	2	2	2	2576.9	2	2	2	2	2576.9
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2	2	2	2	2655.9	2	2	2	2	2655.9

2	2	2	2	2673.9	2	2	2	2	2673.9
2	2	2	2	2706.97	2	2	2	2	2706.97
2	2	2	2	2747.16	2	2	2	2	2747.16
2	2	2	2	2790.39	2	2	2	2	2790.39
2	2	2	2	2830.75	2	2	2	2	2830.75
2	2	2	2	2870.67	2	2	2	2	2870.67
2	2	2	2	2911.52	2	2	2	2	2911.52
2	2	2	2	2950.8	2	2	2	2	2950.8
2	2	2	2	2991.49	2	2	2	2	2991.49
2	2	2	2	3032.17	2	2	2	2	3032.17
2	2	2	2	3072.79	2	2	2	2	3072.79
2	2	2	2	3112.44	2	2	2	2	3112.44
2	2	2	2	3153.53	2	2	2	2	3153.53
2	2	2	2	3193.66	2	2	2	2	3193.66
2	2	2	2	3233.21	2	2	2	2	3233.21
2	2	2	2	3273.3	2	2	2	2	3273.3
2	2	2	2	3314.97	2	2	2	2	3314.97
2	2	2	2	3355.37	2	2	2	2	3355.37
2	2	2	2	3395.93	2	2	2	2	3395.93
2	2	2	2	3436.15	2	2	2	2	3436.15
2	2	2	2	3476.5	2	2	2	2	3476.5
2	2	2	2	3514.77	2	2	2	2	3514.77
2	2	2	2	3555.95	2	2	2	2	3555.95
2	2	2	2	3596.23	2	2	2	2	3596.23
2	2	2	2	3638.07	2	2	2	2	3638.07
2	2	2	2	3678.39	2	2	2	2	3678.39
2	2	2	2	3718.84	2	2	2	2	3718.84
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1	2	2	2	1583					
1	2	2	2	1593					
1	2	2	2	1603					
1	2	2	2	1613					
1	2	2	2	1623					
1	2	2	2	1633					
1	2	2	2	1643					
1	2	2	2	1653					
1	2	2	2	1663					
1	2	2	2	1673					
1	2	2	2	1683					
1	2	2	2	1693					

1	2	2	2	1703				
1	2	2	2	1713				
1	2	2	2	1723				
1	2	2	2	1733				
1	2	2	2	1743				
1	2	2	2	1753				
1	2	2	2	1763				
1	2	2	2	1773				
1	2	2	2	1783				
1	2	2	2	1793				
1	2	2	2	1803				
1	2	2	2	1813				
1	2	2	2	1823				
1	2	2	2	1833				
1	2	2	2	1843				
1	2	2	2	1853				
1	2	2	2	1863				
1	2	2	2	1873				
1	2	2	2	1883				
1	2	2	2	1893				
1	2	2	2	1903				
1	2	2	2	1913				
1	2	2	2	1923				
1	2	2	2	1933				
1	2	2	2	1943				
1	2	2	2	1953				
1	2	2	2	1963				
1	2	2	2	1973				
1	2	2	2	1983				
1	2	2	2	1993				
1	2	2	2	2003				
1	2	2	2	2013				
1	2	2	2	2023				
1	2	2	2	2033				
1	2	2	2	2043				
1	2	2	2	2053				
2	2	2	2	2063				
2	2	2	2	2073				
2	2	2	2	2083				
2	2	2	2	2093				
2	2	2	2	2103				
2	2	2	2	2113				

2	2	2	2	2123				
2	2	2	1	2133				
2	2	2	1	2143				
2	2	2	1	2153				
2	2	2	1	2163				
2	2	2	1	2173				
2	2	2	1	2183				
2	2	2	1	2193				
2	2	2	1	2203				
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2	2	2	1	2223				
2	2	2	1	2233				
2	2	2	1	2243				
2	2	2	1	2253				
2	2	2	1	2263				
2	2	2	2	2273				
1	2	2	2	2283				
1	2	2	2	2293				
1	2	2	2	2303				
1	2	2	2	2313				
1	2	2	2	2323				
1	2	2	2	2333				
1	2	2	2	2343				
1	2	2	2	2353				
1	2	2	2	2363				
1	2	2	2	2373				
1	2	2	2	2383				
1	2	2	2	2393				
1	2	2	2	2403				
1	2	2	2	2413				
1	2	2	2	2423				
1	2	2	2	2433				
1	2	2	2	2443				
1	2	2	2	2453				
1	2	2	2	2463				
1	2	2	2	2464.55				
1	2	2	2	2493.74				
1	2	2	2	2536.07				
1	2	2	2	2576.99				
1	2	2	2	2617.92				
1	2	2	2	2658.3				
1	2	2	2	2699.07				

1	2	2	2	2738.83					
1	2	2	2	2779.26					
1	2	2	2	2820.02					
1	2	2	2	2860.02					
1	2	2	2	2900.45					
2	2	2	2	2939.72					
2	2	2	2	2980.29					
2	2	2	2	3008.61					
1	2	2	2	3060.63					
1	2	2	2	3081.25					
1	2	2	2	3136.6					
1	2	2	2	3172.51					
1	2	2	2	3216.39					
2	2	2	2	3257.05					
2	2	2	2	3297.38					
2	2	2	2	3337.63					
2	2	2	2	3375.41					
2	2	2	2	3416.55					
2	2	2	2	3456.15					
2	2	2	2	3495.52					
2	2	2	2	3520					

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